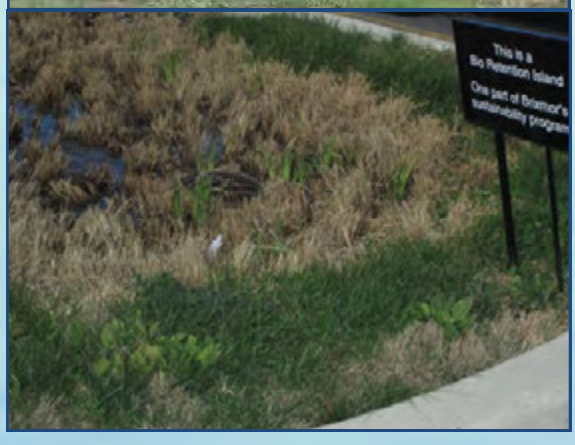

Upper Patapsco River SMALL WATERSHED ACTION PLAN

Volumes I and II

April 2017

Baltimore County Executive Kevin Kamenetz
and the County Council

Prepared for

Baltimore County Department of
Environmental Protection and Sustainability

Prepared by

VERSAR

with

Coastal Resources, Inc. and McCormick Taylor

CLEAN GREEN COUNTY

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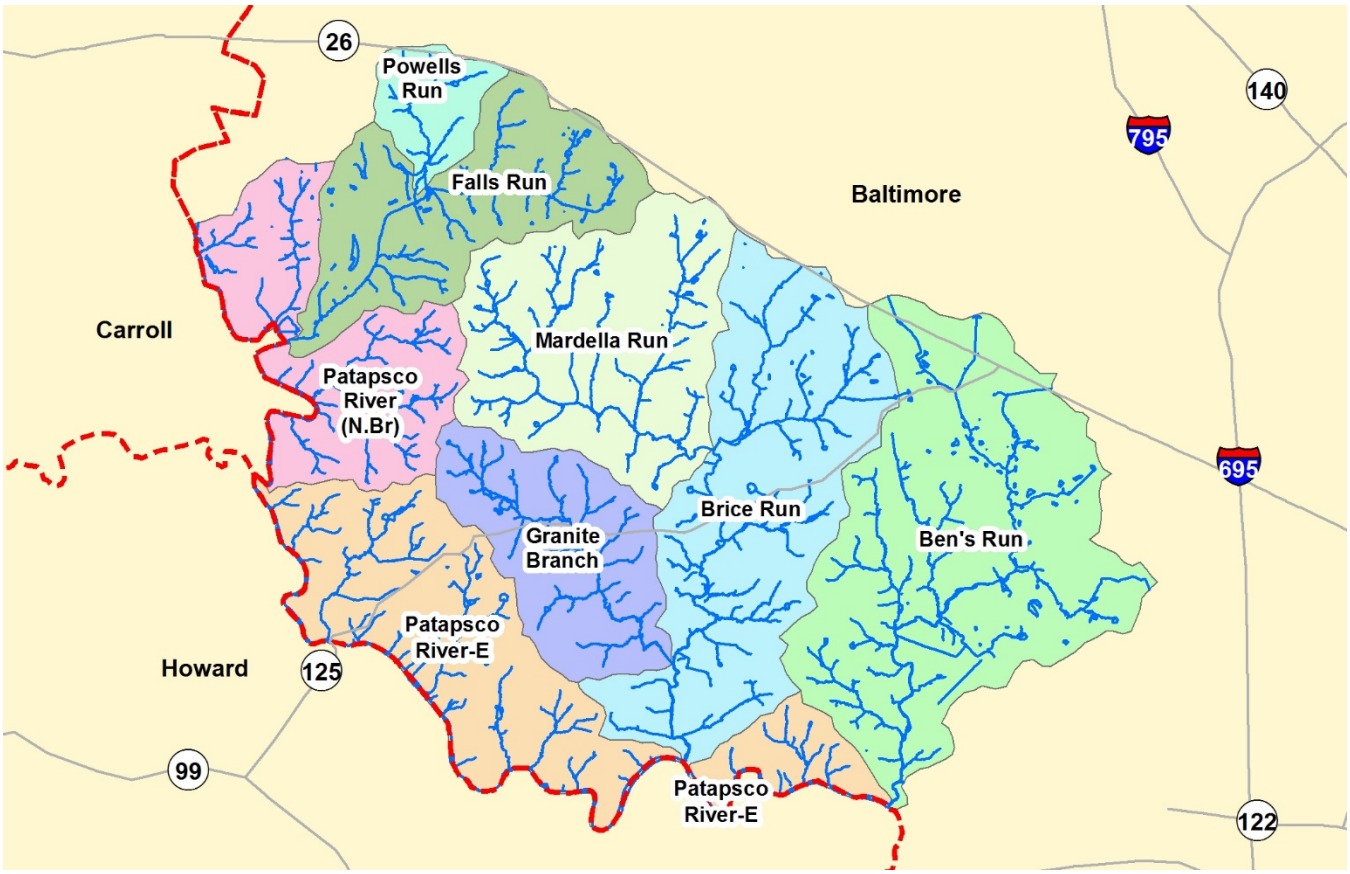

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CHAPTER 1: INTRODUCTION

1.1 PURPOSE

The purpose of the Upper Patapsco Small Watershed Action Plan (SWAP) is to provide guidance on the restoration of the Upper Patapsco watershed. This report outlines a series of strategies for watershed restoration, describes management strategies for each of the eight subwatersheds within the Upper Patapsco watershed, and identifies priority projects for implementation. The SWAP includes the identification of potential stormwater management conversion sites, stream restoration sites, and other capital projects, as well as citizen-based restoration opportunities, operational program implementation, and an implementation schedule. Planning-level cost estimates are provided where feasible and a preliminary schedule for implementation over a ten-year horizon is outlined. Financial and technical partners for plan implementation are suggested for various strategies and projects. The watershed plan is intended to assist Baltimore County and other organizations, such as the Patapsco Heritage Greenway, in moving forward with restoration of the Upper Patapsco watershed.

1.2 BACKGROUND

In 2005, Baltimore County initiated a new round of watershed planning, to develop Small Watershed Action Plans (SWAPs). A SWAP identifies strategies for bringing a small watershed into compliance with water quality standards and to meet other watershed management goals. Strategies include a combination of government capital projects, actions in partnership with local watershed associations, educational outreach, and volunteer activities. Effective implementation of watershed restoration strategies will require the coordination of all watershed partners and the participation of many stakeholders.

Baltimore County's SWAP planning process is intended to address the many mandates that the County is charged to meet in each individual watershed. These include the requirements of the County's National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) permit, watershed-specific Total Maximum Daily Loads (TMDLs), and the Chesapeake Bay TMDL. The small watershed action planning process is designed to bring all these individual mandates together at a subwatershed level that will facilitate implementation. The SWAP will inform residents about the intent of each program, examine how to most efficiently meet the goals, and define the roles of the partners.

Over the past year, the Upper Patapsco watershed partners have worked together conducting assessments, identifying restoration opportunities, and engaging the community, in order to build a successful plan. A Steering Committee, consisting of various watershed partners, was formed to aid in developing the Upper Patapsco SWAP. This included Baltimore County personnel, members of local organizations, and citizens and leaders from the local community. The Steering Committee met regularly throughout the SWAP development process. Upper Patapsco SWAP Steering Committee members are:

- <u>Baltimore County Department of Environmental Protection and Sustainability (EPS)</u>
  - Haley Amini
  - Erin Wisnieski
  - Steve Stewart

- Baltimore County Soil Conservation District
  - Jim Ensor

- Greater Patapsco Community Association (GPCA)
  - Marie Cignatta
  - Bob Teller
  - Jeffrey Follweiler

- Neighborhood Safety Team Baltimore County
  - Walter B. Hollman

- Patapsco Heritage Greenway
  - Betsy McMillion
  - Hannah Zinnert

- University of Maryland Extension
  - Kristian Varsa

- Public Citizens
  - Ann Pinto

In addition, because the participation of the local stakeholders is an essential component for effective watershed restoration, two community meetings were held during SWAP development. These community meetings were intended to raise citizen awareness and solicit feedback from residents, local community leaders, institutions, and business associations regarding watershed restoration strategies. Descriptions of the community meetings, including date, approximate number of attendees, and topics covered, are provided below.

1) ***Community Meeting #1*** (May 13, 2016; 9 attendees): A presentation was given by Baltimore County staff to explain why a SWAP is developed and why watersheds are important to communities and the environment. Representatives of the Versar consultant team then presented a general review of existing conditions, including photographs of watershed features and maps of subwatersheds and land use characteristics. This was followed by a presentation of work to date on the SWAP, including the status of field work, analysis, and reporting. Joe Davis, of Baltimore County Public Schools Environmental Program, gave a presentation on integrating environmental issues into the school's curriculum. His ideas included having students identify environmental issues, such as those facing the Upper Patapsco Watershed. The team also presented the project schedule, "next steps", and plans for future stakeholder meetings. There was a question and answer session. Following the presentation, the Versar team provided an interactive electronic map where participants could provide information on improvements in the watershed that should be addressed, either generally or at specific locations.

2) ***Community Meeting #2*** (April 10, 2017): A second presentation was given by Baltimore County staff to approximately 30 members of the Greater Patapsco Community Association

during their April community meeting in Granite, MD. The staff member began the presentation by reviewing the purpose of the SWAP, then after questions from Association members, continued with an overview of the proposed plan and highlighted some of the project's findings. Following the presentation, the floor was opened to questions and comments from Association members.

1.3 ENVIRONMENTAL REQUIREMENTS

This SWAP was developed to satisfy various regulatory drivers. They include:

- Baltimore County's NPDES municipal stormwater permit (MS4) assessment and planning requirements;
- Watershed-specific impairment listings for total suspended solids (TSS), sulfates, chlorides, fecal bacteria, sediment, and other impairments in the Upper Patapsco watershed; and
- TMDL for the Chesapeake Bay for nutrient (nitrogen and phosphorus) and sediment reductions to meet water quality standards.

1.3.1 NPDES MS4 Permits

Baltimore County's NPDES permit (11-DP-3317, MD0068314) requires completion of detailed watershed assessments for all watersheds within the County. Assessments are to be developed to:

- Determine current water quality conditions;
- Identify and rank water quality problems;
- Include the results of visual watershed inspections;
- Prioritize all structural and nonstructural water quality improvement projects; and
- Specify pollutant load reduction benchmarks and deadlines that demonstrate progress toward meeting all applicable stormwater wasteload allocations (WLAs).

The County's NPDES permit also requires the County to treat 20 percent of the untreated impervious area during the 5-year permit term. This SWAP meets the systematic assessment and planning requirements of the NPDES permit and provides strategies for how Baltimore County will meet the goals for addressing impervious cover.

1.3.2 Watershed-Specific Impairments

Section 303(d) of the 1972 Clean Water Act requires states to develop (and periodically update) a list of impaired waters that fail to meet applicable state water quality standards which are defined by their designated uses. States must also establish priority rankings and develop Total Maximum Daily Loads (TMDLs) for waters on the 303(d) list. According to USEPA, a TMDL is a calculation of the maximum amount of a pollutant that a water body can receive in a day and still safely meet state water quality standards. TMDLs can be developed for a single pollutant or group of pollutants of concern which generally include sediment, metals, bacteria, nutrients, and pesticides.

The Upper Patapsco SWAP area (also known as Baltimore County's SWAP Area B) makes up the northern portion of Maryland's **"**02130906" 8-digit watershed. SWAP Area B consists of the streams and catchments that drain south into the Upper Patapsco River on the north side of Interstate 70. The Upper Patapsco has been listed as impaired in the Maryland 303(d) list of impaired waters for the following pollutants of concern: fecal bacteria*,* sediment, sulfates, and chloride, as well as for nutrients and sediment as part of the Chesapeake Bay TMDL. A previous listing for fecal bacteria was removed for the middle portion of the Lower North Branch Patapsco watershed in 2012, following a Water Quality Assessment (WQA). Following WQAs, a listing for PCB in fish tissue was also removed in 2012 for the entire Lower North Branch Patapsco watershed, as well as phosphorous and heavy metals in 2009 and 2005, respectively. WQAs are performed by the state to determine if the pollutant of concern is actually impairing the waters. If it is determined that the pollutant of concern is not contributing to water impairment, a WQA report documenting the findings is submitted to USEPA for concurrence.

The mainstem Upper Patapsco is designated as *Use IV: Recreational Trout Waters;* the tributary non-tidal streams (including Falls Run, Powells Run, Patapsco River North Branch, Patapsco River-E, and Ben's Run in the watershed are designated as *Use I: Water Contact Recreation, and Protection of Nontidal Warmwater Aquatic Life.* The Mardella Run, Granite Branch, and Brice Run streams are designated as *Use III: Nontidal Cold Water* according to Maryland water quality standards. Impairment listings reflect the inability to meet water quality standards for these designated uses. Table 1-1 summarizes the status of the various impairment listings for the Upper Patapsco.

As shown in the table above, the Upper Patapsco watershed has six impairment listings and two WQAs have been completed. TMDLs or WQAs will be developed at some point in the future for the sulfate, chloride and channelization impairment listings.

1.3.3 Chesapeake Bay TMDL

The Upper Patapsco River drains to the Lower Patapsco River, Baltimore Harbor, and then to the Chesapeake Bay, the largest estuary in North America. In 1975, the United States Congress directed the Environmental Protection Agency (EPA) to conduct a comprehensive study of the most important problems affecting the Chesapeake Bay. The findings of this study formed the crux of the first Chesapeake Bay Agreement, signed in 1983 by Maryland, Virginia, Pennsylvania, Washington DC, the Chesapeake Bay Commission and the EPA. Additional scientific information gained from monitoring data and modeling efforts was used to amend that Agreement, resulting in the 2000 Chesapeake Bay Agreement and the interagency efforts that continue today with the development of the Chesapeake Bay TMDL and Watershed Implementation Plans (WIPs).

Scientific studies have shown that three of the biggest problems facing the health of the Chesapeake Bay and its tributaries (the rivers and streams that flow into the Bay) are excess nitrogen, phosphorus, and sediments. The nutrients nitrogen and phosphorus fuel excessive algae growth. These algae, as well as suspended sediments, cloud the water and prevent bay grasses from getting enough light. When healthy, bay grasses provide essential habitat for crabs and fish as well as food for waterfowl. When algae die, they decompose using up essential oxygen. This lack of oxygen kills bottom-dwellers such as clams and sometimes fish. In addition, excess nutrients sometimes favor the growth of harmful algae. Harmful algae can be toxic to aquatic animals and even humans.

Table 1-1: Upper Patapsco Water Quality Impairment Listings and Status

Impairment	Applicable Segment	Regulatory Status	Approval Date
TSS	Patapsco River Lower N. Br.	Impaired; the Biostressor analysis indicates that TSS is a major stressor affecting biological integrity in this watershed	September 2011
Fecal bacteria	Patapsco River Lower N. Br. (lower/upper)	Impaired; this listing was split out of the previous watershed-wide listing for fecal bacteria in the Lower North Branch Patapsco watershed	2009
Nitrogen/ Phosphorus	Baltimore Harbor	Impaired; TMDL completed	December 2007
Channelization	Patapsco River Lower N. Br.	Impaired, The Biostressor analysis indicates that stream channelization due to urban development is a major stressor affecting biological integrity in this watershed.	2012 Listing
Sulfates and Chlorides	Patapsco River Lower N. Br.	Impaired, TMDL required; The Biostressor analysis indicates that sulfates and chlorides are major stressors affecting biological integrity in this watershed	2010 Listing
Phosphorus	Patapsco River Lower N. Br.	WQA – water quality standard is being met	September 2009
Heavy Metals	Patapsco River Lower N. Br.	WQA – water quality standard is being met	January 2005

EPA established the Chesapeake Bay TMDL, a historic and comprehensive “pollution diet” with rigorous accountability measures to initiate sweeping actions to restore clean water in the Chesapeake Bay and the region’s streams, creeks, and rivers.

Concurrent with the development of the Bay TMDL, EPA charged the Bay watershed states and the District of Columbia with developing Watershed Implementation Plans (WIPs) to provide adequate “reasonable assurance” that the jurisdictions can and will achieve the nutrient and sediment reductions necessary to implement the TMDL within their respective boundaries.

Maryland’s Phase I WIP provided a series of proposed strategies that will collectively meet the 2017 target (70% of the total nutrient and sediment reductions needed to meet final 2020 goals). After more than a year of cooperative work, MDE and the Departments of Natural Resources, Agriculture, and Planning, submitted Maryland’s Final Phase I WIP to EPA in December 2010.

Baltimore County's Phase I plan required reductions equivalent to retrofit of 30% of pre-1985 developed land.

MDE worked with the other Maryland Bay agencies and many partners in local jurisdictions to develop Phase II WIPs with more detailed reduction targets and specific strategies to further ensure that the water quality goals of the Bay TMDL will be met. Baltimore County completed its Phase II WIP in July 2012, which was incorporated into the Maryland Phase II WIP that was finalized in October 2013. Phase II WIP reduction targets for the Baltimore County watershed urban areas are: 32.2% for nitrogen and 47.0% for phosphorus. The Phase II process will continue through 2017.

1.4 U.S. EPA WATERSHED PLANNING "A-I CRITERIA"

This watershed plan is written to meet EPA guidance published in the October 23, 2003 Federal Register. The guidance requires watershed-based plans to restore waters impaired by nonpoint source (NPS) pollution using incremental Section 319 funds to include particular "components of a watershed based plan". Baltimore County will request EPA review and acceptance of this watershed plan based on their A-I Criteria, so that NPS implementation projects consistent with this watershed plan will be eligible for 319(h) Grant funding. The watershed plan components listed in EPA's guidance, which are commonly called the "A-through-I Criteria", are summarized below:

a) Identification of the causes and sources that will need to be controlled to achieve the load reductions estimated in the watershed plan;

b) Estimates of pollutant load reductions expected through implementation of proposed nonpoint source (NPS) management measures;

c) A description of the NPS management measures that will need to be implemented;

d) An estimate of the amount of technical and financial assistance needed to implement the plan;

e) An information/education component that will be used to enhance public understanding and encourage participation;

f) A schedule for implementing the NPS management measures;

g) A description of interim, measurable milestones;

h) A set of criteria to determine load reductions and track substantial progress towards attaining water quality standards; and

i) A monitoring component to determine whether the watershed plan is being implemented.

This watershed plan meets the A-I criteria. Table 1-2 shows where these criteria are addressed throughout this watershed plan.

Table 1-2: Where to Locate Information for USEPA's A-I Criteria

Report Section	USEPA Criteria								
	A	B	C	D	E	F	G	H	I
Chapter 1		✓							
Chapter 2		✓							
Chapter 3	✓	✓	✓		✓				
Chapter 4			✓		✓				
Chapter 5							✓	✓	✓
Appendix A			✓	✓	✓	✓	✓		
Appendix B									
Appendix C				✓					
Appendix D		✓						✓	
Appendix E	✓								

1.5 PARTNER CAPABILITIES

In order to achieve effective watershed restoration, the capabilities of many organizations must be brought together and coordinated. Within the Baltimore region, a great deal of cooperation and coordination has been advancing in recent years as common goals in water quality improvement in local streams and rivers are sought.

1.5.1 Baltimore County

Baltimore County has a watershed restoration program to implement restoration projects, including stream restoration, stormwater conversions and retrofits, reforestation, and shoreline enhancement projects. The Patapsco River Watershed Water Quality Management Plan was completed by the County in 2000. Based on the recommendations from this watershed study, as well as other evaluation efforts, one of the highest need stream reaches has already been restored; this restoration project included areas of Ben's Run. A total of 2,000 linear feet of stream channel have been restored in the Ben's Run subwatershed, with another 15,558 linear feet recommended for restoration.

Baltimore County has an extensive monitoring program that assesses the current ambient water quality, evaluates efficiency of various restoration projects in relation to pollutant removal efficiency and biological community improvement, and tracks trends over time. The County also has an Illicit Connection Program that monitors storm drain outfalls, tracks pollution sources, and coordinates remediation.

Baltimore County is under a consent decree to address Sanitary Sewer Overflows (SSOs). The consent decree has specific requirements for improvements to pumping stations, remediation of sanitary sewer lines, maintenance, and inspection. Implementation of the consent decree requirements will help reduce bacteria contamination, as well as reduce nitrogen and phosphorus in the streams.

The County operates street sweeping and inlet cleaning programs throughout the county that remove sediment, nitrogen, and phosphorus before they reach the waterways. These programs are tracked and estimates of the pollution removal are calculated (EPS 2014).

1.5.2 Patapsco Heritage Greenway

The Patapsco Heritage Greenway (Patapsco.org) is dedicated to preserving, protecting, interpreting and restoring the environment, history and culture of the Patapsco River Valley. Its emphasis is on education, land preservation, restoration, stream cleanups, native species planting, and recreation.

Patapsco Heritage Greenway has been working since 1997 to preserve land, improve water quality, and protect the Patapsco River Valley and its associated watershed. Their major concern has been the impact within the watershed that development has had on increasing stormwater runoff and pollutants. PHG has established good working relationships with Baltimore, Anne Arundel, and Howard counties, the State of Maryland, and other various land preservation/ environmental organizations. PHG has been responsible for the removal of tons of waste in the Patapsco River watershed, as well as for tree plantings, invasive plant removal, and storm drain stenciling. Volunteers conduct stream reconnaissance visits to identify environmental trouble spots along streams which lead to the Patapsco River. They use this information to prioritize stream cleanups, tree plantings, and other events. PHG has invested time and effort to alert and educate the community to the harm that trash and oil cause when carried into our streams through stormwater runoff.

1.6 THE UPPER PATAPSCO WATERSHED OVERVIEW

The Upper Patapsco watershed is located entirely within the Eastern Piedmont region of Maryland, and lies west of the City of Baltimore (Figure 1-1). Table 1-3 summarizes key watershed characteristics of the Upper Patapsco, which flows into the Lower Patapsco River. The 180,555 acres of the Patapsco River Watershed (including the tidal portions) are located within Anne Arundel, Baltimore, Carroll, and Howard counties, as well as Baltimore City, Maryland. The South branch of the Patapsco River (and thus the main stem of the Patapsco) flows about 35 miles from Parr's Spring in Carroll County to Baltimore City. The North branch of the Patapsco is formed at the confluence of the East and West branches, flows through Liberty Reservoir and then joins the South branch near Sykesville. In Baltimore County, along with the Upper Patapsco watershed area, the Lower Patapsco and Liberty Reservoir watersheds compose the Patapsco River watershed. SWAPs for these areas have been completed.

The Upper Patapsco SWAP area comprises the middle section of the Patapsco River basin, including the area of Granite and part of Randallstown, and is approximately 15,898 acres (24.8 square miles) or 8.8 percent of the overall Patapsco River watershed.

This SWAP focuses on the eight northern most subwatersheds of the Patapsco 8-digit watershed that drain directly to the mainstem Patapsco River, where land use/land cover is predominantly urban and forest. A detailed review of the natural resources and landscape of the watershed is provided in the Upper Patapsco Watershed Characterization report (Appendix E).

The Upper Patapsco watershed contains eight smaller drainage areas called subwatersheds (Figure 1-2). In addition to characterizing the entire watershed, analyses were conducted on a subwatershed scale to provide detailed information for smaller areas and to focus restoration and preservation efforts. Also, success of restoration efforts can be more easily monitored and measured on this smaller scale.

Table 1-3: Key Characteristics of Upper Patapsco Watershed

Drainage Area	15,898 acres (24.8 sq. mi.)	
Stream Length	127.8 miles	
Subwatersheds	8	
Jurisdictions	Baltimore County	
Population	36,654 (2010 census)	
Land Use/Land Cover	Very Low Density Residential:	8.9%
	Low Density Residential:	16.9%
	Medium Density Residential:	6.3%
	High Density Residential:	1.5%
	Commercial:	1.6%
	Industrial:	0.3%
	Institutional:	1.5%
	Extractive:	1.6%
	Open Urban Land:	2.2%
	Agriculture:	17.9%
	Forest:	39.9%
	Barren Land:	1.4%
	Water/Wetlands:	0.0%
Impervious Cover	96.2 acres (2.6% of watershed)	
Soils	A Soils (low runoff potential):	1.2%
	B Soils:	71.4%
	C Soils:	21.0%
	D Soils (high runoff potential):	6.53%
Note: Totals may not add up to 100% due to rounding discrepancies.		

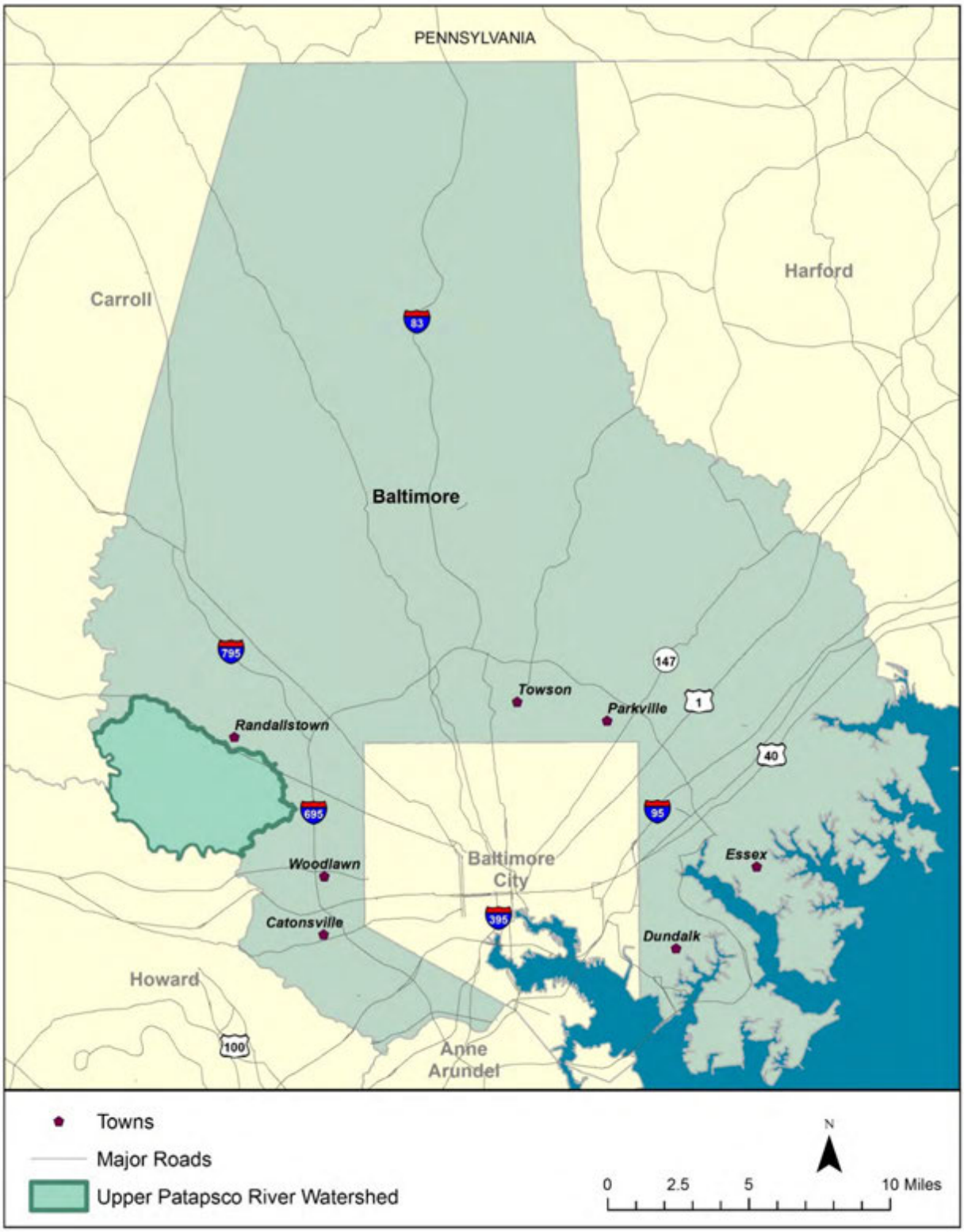

Figure 1-1: Upper Patapsco SWAP Area

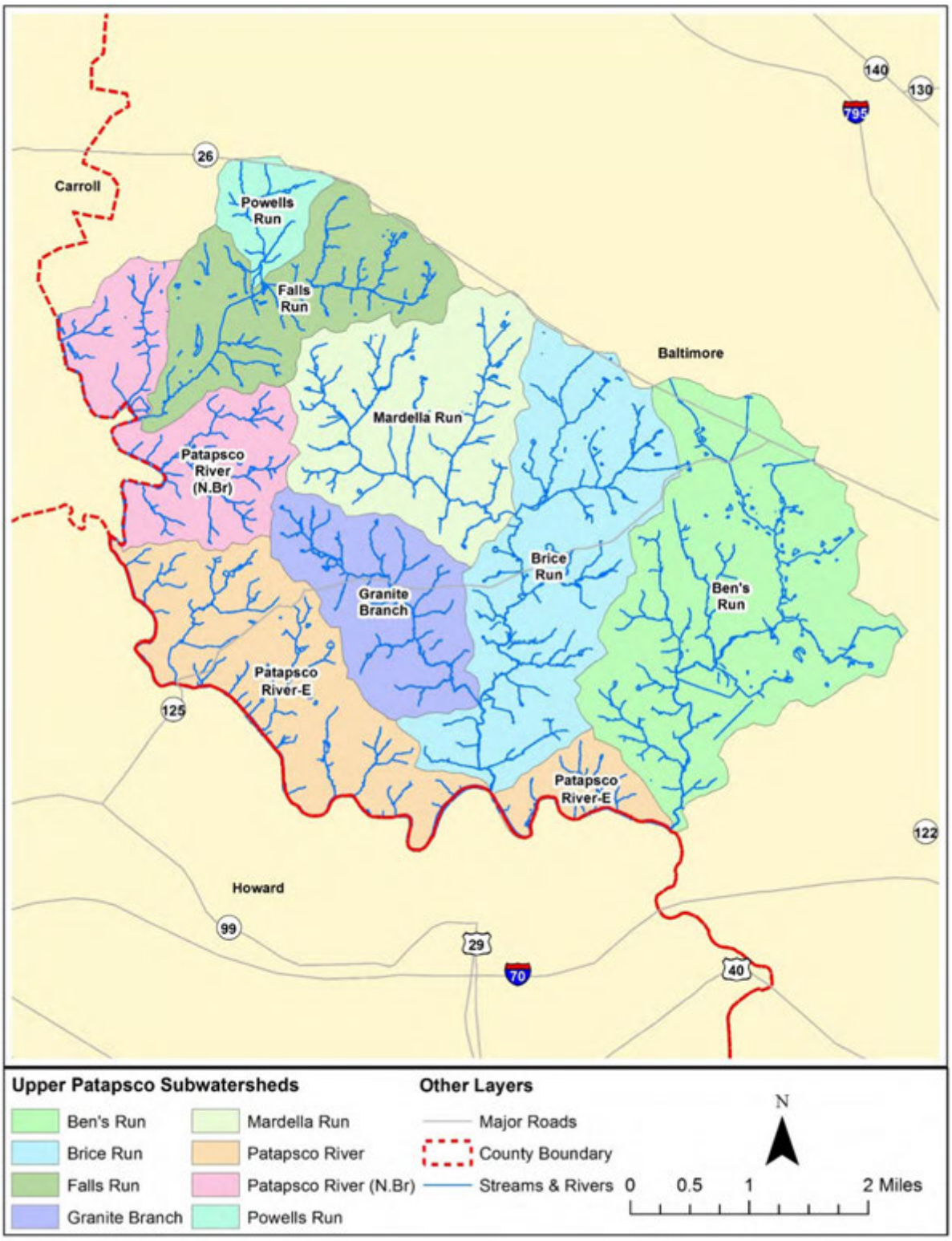

Figure 1-2: Upper Patapsco Subwatersheds

1.7 REPORT ORGANIZATION

The SWAP consists of two volumes. Volume 1 is the Small Watershed Action Plan and is organized into 5 major chapters. Volume 2 includes supporting materials as appendices.

1.7.1 Volume 1: The SWAP

Chapter 1 is a short introduction chapter explaining the background and purpose of the Small Watershed Action Plan (SWAP), the environmental mandates, partner organizations, and an overview of the report and the planning area.

Chapter 2 covers the Vision, Goals, and Objectives for the SWAP agreed upon by the steering committee and members of the local community.

Chapter 3 describes the restoration strategies deemed as feasible by the steering committee and members of the local community. Those strategies are categorized as municipal actions and citizen-based actions. Computations for estimating nutrient and sediment reductions from the proposed actions across the entire watershed are included in this section. Identified stream enhancement and restoration projects are also included, along with corresponding estimated loading reductions.

Chapter 4 presents restoration strategies by subwatershed and ranks the subwatersheds based on various evaluation criteria. A map showing the location of proposed restoration strategies, photos, and supporting narrative for the recommendations is included here.

Chapter 5 details how implementation of the SWAP will be evaluated long-term via monitoring and includes a discussion of performance measures.

This volume also includes the following appendices with additional, detailed information used to develop and support this SWAP.

- Appendix A consists of a table of all actions identified for implementation towards meeting goals divided into four categories: Restoration, Outreach and Awareness, Funding, and Reporting. The table includes the action, the performance measure, and schedule for implementation, unit cost, and the responsible party. The goal and objective of each action are described here.

- Appendix B provides information on how the development of the SWAP addresses EPA A-I criteria for watershed planning and serves as a guide to the location within the document where each criterion is addressed.

- Appendix C provides an analysis of the potential cost of implementation of the plan and a list of potential funding sources.

- Appendix D includes a table showing the most current Chesapeake Bay Program Best Management Practice (BMP) pollutant reduction efficiencies.

1.7.2 Volume 2: Characterization Report

This volume includes the following appendices with supporting documentation related to the current conditions of the Upper Patapsco watershed.

- Appendix E contains the Upper Patapsco Watershed Characterization report.
- Appendix F contains Upland Survey Data Summaries.
- Appendix G contains supporting calculations for Neighborhood Source Assessment Analyses.
- Appendix H provides copies of current TMDLs and WQAs applicable to the planning area.
- Appendix I contains Access databases, scanned copies of Upland Assessment field datasheets, digital photographs from Upland Assessment field visits, datasheets and other supporting materials from the stream assessment evaluation, and photos from the stream assessment evaluations.

CHAPTER 2: VISION, GOALS, AND OBJECTIVES

2.1 VISION STATEMENT

The Upper Patapsco River Watershed Steering Committee adopted the following vision statement that served as a guide in the development of the SWAP:

> *Our vision for the Upper Patapsco Watershed is clean, trash-free waters stemming from an enhanced connection between communities and the watershed by implementing eco-friendly education, increasing public awareness and continued communication between the County and the community about the protection, preservation and enhancement of the Upper Patapsco Watershed.*

2.2 UPPER PATAPSCO RIVER WATERSHED SWAP GOALS & OBJECTIVES

A total of five goals were identified for restoring the Upper Patapsco River watershed based on the vision statement and input from the Steering Committee meetings and Community meeting. The goals were developed through discussions with the Upper Patapsco River SWAP Steering Committee and refined based on feedback from watershed residents at the first SWAP community meeting. Community stakeholders were given the opportunity to rank the importance of goals developed by the Steering Committee, raise any additional issues that are important to the community, and indicate the type of restoration activities that are of interest to achieve watershed goals. Community participation is important to ensure the implementation and success of the plan.

The following sections present a discussion of each of the five goals for restoring the Upper Patapsco River watershed. For each goal, a series of objectives was developed to ensure that the plan will meet each goal. An objective is a measurable statement such as “reduce total phosphorus loading in the watershed by 45.1%.” Action strategies describe the method that will be used to achieve the objective and ultimately, the water quality goal. An example of an action strategy for phosphorus reduction could be “reforestation of 25 acres of open pervious area” in a given subwatershed. The action strategies developed to achieve these objectives and goals are summarized in Appendix A and discussed further in Chapter 4.

When possible, action strategies are expressed as quantifiable measures (e.g., linear feet of forested buffer planted). However, the numeric values assigned to these actions are intended to serve as a guide, rather than an absolute measure, in achieving watershed goals and objectives. Many actions address multiple watershed goals and objectives. Appendix A provides a table that lists the action strategies proposed for the Upper Patapsco River watershed and their applicable goals and objectives.

The general types of restoration strategies proposed for the Upper Patapsco River watershed are discussed further in Chapter 3. An adaptive management approach will be emphasized as SWAP implementation progresses. This approach includes evaluating the success of SWAP implementation over time (see Chapter 5) and modifying action strategies based on community acceptance and availability of funding.

2.2.1 Goal 1: Improve and maintain water quality

The Upper Patapsco River is identified as being impaired by nutrients, sediment, and bacteria, as indicated in the Maryland 303 (d) list of impaired waters. To rectify these impairments, a TMDL analysis has been completed for Total Nitrogen (TN), Total Phosphorus (TP), Total Suspended Solids (TSS), and bacteria. The objectives below are designed to meet the TMDL reduction requirements in the Upper Patapsco River watershed. Meeting these TMDL goals will go a long way toward improving overall water quality in the Upper Patapsco River and achieving the community's vision of a healthy river.

Objectives:

1. Reduce annual nitrogen and phosphorous loadings from urban land in the Upper Patapsco SWAP area by 32.2% and 47.0% respectively to meet the requirements of the Chesapeake Bay TMDL.
2. Reduce sediment flowing into the Upper Patapsco River.
3. Reduce the amount of sewage entering the river.
4. Reduce the impact of impervious surfaces on water quality in the Upper Patapsco River.

2.2.2 Goal 2: Maintain and improve aquatic biodiversity

Healthy ecosystems have a robust and diverse community of plants and animals; aquatic biodiversity is the living proof of the health and vitality of a river system. Physical damage to aquatic habitats has resulted over time from development of land and shorelines, poor land management practices, introduction of exotic invasive species, and obstructions to upstream breeding sites, etc. The objectives for this goal relate to the improvement of degraded river conditions that result in poor conditions for aquatic life.

Objectives:

1. Restore and protect streams to encourage robust aquatic communities.
2. Create riparian buffers and enhance existing buffers to quality forests to filter runoff and provide habitat.

2.2.3 Goal 3: Encourage community involvement in the protection, preservation, and enhancement of the Upper Patapsco River Watershed

There is no substitute for engaged and involved citizens participating in the protection of their local watersheds. However, the first step to engaging citizens is making them aware of their connections to the Upper Patapsco River and the problems particular to this watershed. In a modern, urbanized landscape, it is easy to become disconnected from the natural environment, since few people have a stream running through their backyard. In addition, the thought of tackling challenges, like those faced by the Chesapeake Bay, can be overwhelming for most people. By raising awareness about the issues facing a nearby stream, citizens are given an opportunity to take action on a local, more manageable scale, where they are more likely to see the positive effects their actions produce, and thus continue their efforts.

Objectives:

1. Outreach to commercial, farming, industrial, and institutional communities throughout the watershed to educate and encourage actions that reduce pollutant loads to the river.
2. Provide opportunity for neighborhood involvement in the outreach and education regarding pollution reduction in the watershed.
3. Use restoration activities in the watershed as opportunities to educate the community about issues facing the Upper Patapsco River.
4. Educate and engage the community in the benefits of forest creation and preservation.

2.2.4 Goal 4: Reduce the amount of litter in the Upper Patapsco River Watershed through public education and community involvement.

Trash is one of the most noticeable pollutants in the Upper Patapsco River. Trash is generated throughout the watershed and readily moves through storm drains, entering small streams and the river, and ultimately the Chesapeake Bay. Besides the glaring visual detriment to the River's natural beauty, trash contributes toxins and presents a hazard to water fowl, other wildlife and people. Reducing trash and increasing recycling is mainly an issue of public awareness and stewardship. By engaging citizens of all ages to help clean up the trash and to dispose of trash responsibly, the stage will be set to change behaviors, leading to other positive actions for a healthier Patapsco River.

Objectives:

1 Promote preventative practices for litter and support awareness campaigns to reduce litter in the Upper Patapsco River watershed.

2 Reduce illegal dumping of trash.

3 Encourage community stewardship through stream adoption and cleanup programs.

2.2.5 Goal 5: Promote the protection and preservation of agricultural land and sustainable agricultural practices.

Smart growth strategies focus on development of communities in a way that benefits and promotes human and environmental health. In the Upper Patapsco River watershed, an Urban Rural Demarcation Line (URDL) separates the highly developed northern part of the watershed, from the rural southern portion. South of this URDL, there is no public water or sewer, thus less urban and suburban development. Smart growth would continue to focus development and redevelopment north of this line, and thus preserve the agricultural heritage which exists in the southern portion of the watershed.

Aside from the preservation of agricultural heritage, focusing development to inside the URDL would preserve green space in watershed which has many environmental and community based benefits. Farmland and green space provide food and cover for wildlife, reduce flood impacts through better groundwater infiltration, and provide fresh local food for rural areas.

Objectives:

1. Promote awareness of the benefits of redevelopment in the URDL.
2. Educate the community on the environmental impacts development has on a stream or watershed.
3. Outreach to the agricultural community to promote environmentally friendly farming practices and BMPs on agricultural land.

CHAPTER 3: RESTORATION STRATEGIES

3.1 INTRODUCTION

This chapter presents an overview of the key restoration strategies and associated pollutant load reductions proposed for restoring the Upper Patapsco River watershed. A complete list of actions proposed for the watershed including goals and objectives targeted, timelines, performance measures, cost estimates, and responsible parties is included in Appendix A. Although only key, quantifiable restoration strategies are the focus of this chapter, it is important to remember that a combination and variety of restoration practices, from capital stream restoration projects to public education and outreach, are needed to engage citizens and meet watershed-based goals and objectives.

The Upper Patapsco River watershed restoration will occur as a partnership between the local government, watershed groups, and citizens. The actions of each partner are critical to the success of the overall watershed restoration strategy. Local governments are able to implement large capital projects such as stream restoration, large-scale stormwater retrofits, changes in municipal operations, and large-scale public awareness campaigns. Watershed groups and citizens are able to implement locally-based programs such as tree plantings and downspout disconnection. Therefore, key restoration strategies are divided into two broad categories: municipal strategies (Section 3.2) and citizen-based strategies (Section 3.3). It is important that restoration occurs at all levels to ensure that a wide range and variety of projects are implemented. This will encourage citizen participation and awareness, which are also critical to the success of restoration efforts.

The watershed pollutant loading analysis performed to estimate current nutrient loads generated by the various non-point sources within the Upper Patapsco River watershed is discussed in Section 3.4. Section 3.4 also discusses the pollutant removal calculations for proposed BMPs (i.e., key restoration strategies discussed in Sections 3.2 and 3.3) to address TMDL pollutant reduction targets for the Upper Patapsco River.

3.2 MUNICIPAL STRATEGIES

Baltimore County is working to improve watershed health and water quality by restoring local streams, through capital improvement projects and municipal management activities (e.g., development review, street sweeping, illicit connection programs, etc.). Key municipal strategies proposed for restoring the Upper Patapsco River watershed are discussed in the following sections.

3.2.1 Stormwater Management

Increased importance of water quality and water resource protection led to the development of the Maryland Stormwater Design Manual, which provided BMP design standards and environmental incentives (MDE 2000; 2009 revisions). There has been a general shift toward adopting practices that mimic natural hydrologic processes, are low impact, and achieve pre-development conditions. Building upon the approaches in the 2000 Manual, the Maryland Stormwater Act of 2007 (and 2009 revisions to the Manual) takes those principles one step further and requires that Environmental Site Design (ESD) be implemented to the maximum extent practicable (MEP) via the comprehensive use of non-structural BMPs and/or other better site

design techniques that mimic predevelopment hydrology. The intent of ESD is to distribute flow throughout a development site and reduce stormwater runoff leaving that site. This will also reduce pollutant loads and prevent stream channel erosion.

A total of 158 existing stormwater management (SWM) facilities are located within the Upper Patapsco River watershed including dry and wet ponds, wetlands, infiltration/filtration practices, extended detention, bioretention, and proprietary BMPs. Existing SWM facilities treat a total drainage area of approximately 347 acres of urban land or 32.6 percent of the total urban land use in the watershed.

3.2.2 Stormwater Management Conversions

Detention ponds are typically designed to address water quantity only (channel protection and/or flood control) and therefore provide almost no pollutant removal. Because they have already been created for water treatment purposes, and because they have established maintenance agreements they are excellent candidates for conversion to a type of facility that provides pollution control benefits in addition to quantity control. Conversion is relatively simple and certainly cheaper than permitting and constructing a new BMP. For example, dry extended detention ponds are designed to capture and retain stormwater runoff from a storm to allow sediment and pollutants to settle out while also being able to simultaneously provide flood control. Baltimore County identified 11 existing stormwater management facilities in the Upper Patapsco River watershed as being suitable for conversion.

3.2.3 Stormwater Retrofits

Stormwater management retrofits involve implementing BMPs in existing developed areas where SWM practices do not currently exist in order to help improve water quality. Stormwater retrofits improve water quality by capturing and treating runoff before it reaches receiving water bodies. For example, based on initial field and desktop evaluations, Neighborhood Source Assessments (NSAs) identified nine sites as having sufficient open space for stormwater retrofits to treat runoff from impervious parking lots or alleys. Candidate sites for stormwater retrofits will be drawn from all four upland components surveyed: neighborhoods, hotspots, institutions, and pervious areas.

Impervious surfaces, including roads, parking lots, roofs and other paved surfaces, prevent precipitation from infiltrating into the ground as it would naturally in a forest or meadow in good condition. As a result, impervious surface runoff can result in decreased times of concentration of stormwater to receiving streams (“flashy flows”) leading to erosion, flooding, habitat destruction, and increased pollutant loads to receiving water bodies. Subwatersheds with high proportions of impervious cover are more likely to have degraded stream systems and be significant contributors to water quality problems in a watershed than those that are less developed. Removing impervious cover and converting it to pervious or forested land will help promote infiltration of runoff and reduce pollutant loads.

Unused or unmaintained (broken, crumbling) impervious surfaces with the potential for removal were identified at three institutional locations. The areas of these impervious surfaces were used to estimate potential pollutant load reductions that would result from impervious cover removal activities.

While not included in pollutant reduction calculations, education and outreach tools could be used to inform residents of the water quality impacts associated with large impervious parking lots,

driveways, or patios and options available for conversion to or incorporating more permeable surfaces.

3.2.4 Stream Restoration

Stream restoration practices are used to enhance the appearance, stability and aquatic function of urban stream corridors. Stream restoration practices can include vegetative bank stabilization, localized grade control and comprehensive repairs, such as full channel redesign and realignment. As part of the SWAP process, a review of previous watershed studies, and the restoration recommendations that resulted from them, was completed for the Upper Patapsco River watershed. Stabilizing stream channels improves water quality in many ways including preventing eroded soils, and the pollutants contained in them, from entering the stream and making their way to the Patapsco River and Chesapeake Bay.

3.2.5 Street Sweeping and Trash Reduction

Street sweeping removes floatable trash, sediment, heavy metals and nutrients associated with sediment particles, petroleum associated with sediment, and organic matter such as leaves and twigs from the curb and gutter system, preventing them from entering storm drains and nearby streams. Decay of a disproportionate amount of organic matter in the stream can take away oxygen needed for supporting aquatic life. Additionally, excessive organic matter can clog streams and storm drains, causing flooding resulting in costly maintenance. There were no neighborhoods during the survey of Upper Patapsco River watershed that had significant trash and/or organic matter build-up along curbs, so in this case, none were recommended for additional street sweeping.

While trash was not identified as a major issue from our neighborhood assessments, there was a stream area noted as heavily littered by a citizen at the first Community Meeting and the SWAP steering committee has identified it as an issue. Baltimore County's approach to trash and litter reduction is a multi-faceted approach. The County is currently in the planning stages of an effort that will possibly include public service advertising, a trash treaty, celebrity encouragement, clean-ups, and targeted enforcement.

A citizen awareness campaign is part of the overall strategy and focuses on better stewardship regarding trash issues. Advertising includes different media for different audiences. Other elements may include trash can signs, point-of-sale displays and print ads.

A trash treaty encourages citizens not to litter. Volunteers lead the effort by gathering the signatures. In some programs, those that sign up receive a gift such as a reusable grocery bag or recycling & litter bags for cars. Data indicate that if someone signs a treaty they are much more likely to act upon the issue.

Clean-ups, promoted as Quick Pick-It-Ups (e.g. Baltimore County's Clean Green 15 program), include all audiences. Groups may include recreation councils, scout troops, businesses and religious organizations. A model used in Howard County was very successful where specific dates and times are promoted; however, it is clear that any clean-up will be counted towards the goal. Additional clean-ups are encouraged through Project Clean Stream, Stream Watch and the County's Adopt-a Road program.

Enforcement is the stick that every institution hopes is unneeded, but recognizes is necessary. Baltimore County uses local police and staff from its Code Enforcement unit to carry out enforcement when needed. Enforcement actions usually address businesses or apartments with consistent litter problems, overflowing dumpsters, and dumping.

3.2.6 Illicit Connection Detection/Disconnection

An Illicit Discharge Detection and Elimination program has been developed by Baltimore County to find and stop discharges into streams that are harmful to aquatic life and water quality or that are causing erosion/sedimentation problems. The County will continue its Illicit Discharge Detection and Elimination program, seeking to improve techniques and methodologies for more effective reductions of these discharges. Pollutant reductions associated with this program are not included in pollutant removal analyses due to the uncertainty in the contribution of illicit connections to overall pollutant loading rates. However, this program will provide a margin of safety in the overall nutrient reduction strategy.

3.2.7 Sanitary Sewer Consent Decree

In September 2005, USEPA and MDE issued a consent decree to Baltimore County with deadlines to reduce and eliminate sanitary sewer overflows (SSOs) by 2020. Implementation of work (capital projects, equipment, operations and maintenance improvements) in compliance with the consent decree will result in a reduction of nutrients and bacteria entering streams in the Upper Patapsco River watershed.

3.3 CITIZEN-BASED STRATEGIES

The participation of citizens in watershed restoration is an essential part of the SWAP process. When large numbers of individuals become involved in citizen-based water quality improvement initiatives, changes can be made to the aesthetic and chemical aspects of waterways within the watershed that would not be possible without public participation. Citizen participation is critical to the implementation and long-term maintenance of restoration activities. Key citizen-based strategies proposed for restoring Upper Patapsco River are discussed in the following sections.

3.3.1 Reforestation

Trees help improve water quality by capturing and removing pollutants in runoff including removal of excess nutrients through their roots before the pollutants enter groundwater and streams. Tree leaves and stems also intercept precipitation which helps to reduce the energy of raindrops and prevent any erosion resulting from their impact on the ground. In addition to water quality improvement, trees provide air quality, aesthetic and economic benefits. For example, trees strategically planted around a house can form windbreaks to reduce heating costs in the winter and can provide shade, reducing cooling costs in the summer. Incentive programs, such as Tree-Mendous Maryland and State Highway Administration's (SHA) Partnership Program for public property, can help increase the success of planting efforts. Several areas throughout the watershed are targeted for reforestation opportunities and are described below.

3.3.1.1 Riparian Buffer

Stream and shoreline riparian buffers are critical to maintaining healthy streams and rivers. Forested buffer areas along streams and shorelines can improve water quality and prevent flooding since they can filter pollutants, reduce surface runoff, stabilize stream banks, trap

sediment, and provide habitat for various types of terrestrial and aquatic life including fish. Buffer encroachment as a result of development was noted during upland and stream surveys conducted throughout the watershed. Areas on privately-owned land (e.g., residential properties) can be recommended for buffer awareness initiatives to encourage landowners to plant trees and/or create a no-mow area adjacent to streams and shorelines. Open pervious areas identified within the 100-foot stream and shoreline buffer areas via a GIS analysis in the Watershed Characterization Report (Appendix E) are good candidates for tree planting and are targeted for initial buffer reforestation efforts.

3.3.1.2 Upland Pervious Areas

Converting open areas in the upland portion of the watershed to forested areas through tree plantings can also reduce nutrient inputs to nearby streams and reduce erosion. Large open areas identified in the Pervious Area Assessments (PAAs) should be further investigated for tree planting potential. Publicly-owned lands requiring minimal site preparation (low-hanging fruit) are targeted for initial reforestation efforts.

3.3.1.3 Street and Open Space Tree Plantings

A few opportunities for neighborhood street tree plantings were identified during NSAs. Opportunities for open space tree plantings were also identified at several institutional sites and in some neighborhoods with multi-family housing. Street trees and open space trees provide aesthetic value and air and water quality benefits. They provide shade thereby reducing urban heat-island effect while also providing habitat for wildlife. They also absorb nutrients through their root systems.

Canvassing residents and/or contacting homeowner associations can be effective techniques for implementing a street tree planting program within a neighborhood. Tree planting incentive programs mentioned previously can also help increase the success of planting efforts.

3.3.2 Downspout Disconnection

Downspout disconnection can help reduce runoff and pollutants introduced to local streams. This can be achieved through downspout redirection (from impervious to pervious areas), rain barrels, and/or rain gardens. A combination of outreach/awareness techniques and financial incentives can be used to implement a downspout disconnection program in neighborhoods identified as potential candidates during NSAs.

3.3.3 Urban Nutrient Management

Raising awareness among citizens about some of the common activities around their homes and how those activities can negatively affect water quality is an excellent citizen-based strategy. Yards and lawns typically represent a significant portion of the land cover in an urban subwatershed and therefore, can be a major source of nutrients, pesticides, sediment, and runoff. Fertilization, pesticide use, watering, landscaping, and trash/yard waste disposal all impact subwatershed quality. Urban nutrient management efforts related to lawn maintenance and using natural “Bayscaping” (defined below) as opposed to manicured monocultures of lawn grass can help reduce nutrient inputs to nearby streams.

3.3.3.1 Lawn Maintenance Education

Lawn maintenance activities often involve over-fertilization, poor pest management, and over-watering resulting in excess pollutant runoff to local streams. Lawns with a dense, uniform grass cover or signs designating chemical lawn care treatment indicate high-maintenance lawn care activities. Neighborhoods identified as having high lawn maintenance issues should be targeted for awareness programs emphasizing responsible fertilizing techniques such as proper application and timing, soil testing for nutrient requirements, and keeping fertilizers away from impervious surfaces. Lawn maintenance education can be achieved through door-to-door canvassing, informational brochures/mailings, excerpts in community newsletters, or demonstrations at community meetings. Information on organic alternatives to chemical lawn treatments should also be included in these outreach efforts.

3.3.3.2 Bayscaping

Reducing the amount of mowed lawn and increasing landscaping features provides water quality benefits through interception and filtration of stormwater runoff. Bayscaping refers to the use of plants native to the Chesapeake Bay watershed for landscaping. Because they are native to the region, these plants require less irrigation, fertilizers, and pesticides to maintain as compared to non-native or exotic plants. This means less maintenance and therefore less stormwater pollution. Bayscaping is also beneficial to wildlife because it creates pockets of native habitat. Similar to lawn maintenance education, Bayscaping awareness can be raised through informational brochures/mailings, excerpts in community newsletters, or demonstrations at community meetings. A combination of outreach/awareness techniques and financial incentives can be used to implement a Bayscaping program in neighborhoods identified as potential candidates during NSAs.

3.4 POLLUTANT LOADING AND REMOVAL ANALYSES

This section presents results of the watershed pollutant loading analysis performed to estimate current nutrient loads generated by the various non-point sources within the Upper Patapsco River watershed. Also discussed are the pollutant removal calculations for proposed BMPs to ensure the TMDL requirements are met in the Upper Patapsco River watershed.

3.4.1 Pollutant Loading Analysis

A pollutant loading analysis was performed to estimate total nitrogen, phosphorus, and sediment loads currently generated by all non-point sources (i.e., runoff from all land uses) present within the Upper Patapsco River watershed. Estimates were based on Maryland Department of Planning's (MDP) 2010 Land Use/Land Cover (LU/LC) GIS layer and pollutant loadings rates developed by CBP for all land uses. The pollutant loading analysis is described in detail in Chapter 3.3 of the Watershed Characterization Report (Appendix E).

Table 3-1 summarizes results from the watershed pollutant loading analysis including areas, nutrient loadings rates, and annual nutrient loads for each nonpoint source/land use type.

Table 3-1: Upper Patapsco River Watershed Nitrogen, Phosphorus, and Sediment Loads Estimated Using 2010 MDP Land Use/Land Cover (see Appendix E for details)

Source	Area (acres)	Nitrogen		Phosphorus		Sediment	
		Rate (lbs/ac)	Load (lbs/yr)	Rate (lbs/ac)	Load (lbs/yr)	Rate (lbs/ac)	Load (lbs/yr)
Impervious Urban	4,165.1	17.36	72,306	1.514	6,305.96	1,856	7,730,426
Pervious Urban	1,063.0	11.55	12,278	0.235	249.81	247	262,561
Cropland	2,159.1	23.53	50,804	1.274	2,750.69	1,250	2,698,875
Pasture	1,180.1	8.66	10,220	0.737	869.73	326	384,713
Livestock	0.2	171.58	34	25.086	5.02	4,591	918
Forest	7,068.5	2.78	19,650	0.039	275.67	88	622,028
Water	5.1	10.26	52	0.605	3.09	--	--
Wetlands	0.0	10.26	0	0.605	0.00	--	--
Bare Soil	48.0	32.30	1,550	5.151	247.25	11,557	554,736
Totals	15,689.1		166,895		10,707.22		12,254,256

TMDL analysis has shown stormwater runoff is the primary contributor to nutrient and sediment inputs to the Upper Patapsco River watershed. The bulk of the nitrogen, phosphorus, and sediment reductions required to meet the Chesapeake Bay TMDL and water quality standards for the Upper Patapsco River watershed will come from control of stormwater runoff. The Chesapeake Bay TMDL analysis determined that a 32.2% reduction in nitrogen and a 47.0% reduction in phosphorus loads from urban stormwater discharges are necessary to meet Bay water quality standards. The load reductions needed within the urban portion of the Upper Patapsco River watershed to achieve these reductions are summarized in Table 3-2**.**

Table 3-2: Upper Patapsco River Watershed Nitrogen, Phosphorus, and Sediment Load Reductions

Source	Area (acres)	TN Load (lbs/yr)	TP Load (lbs/yr)	Sediment Load (lbs/yr)
Urban	5,228.1	84,584	6,556	7,992,987
Reduction Needed:		27,236	3,081	--

3.4.2 Pollutant Removal Analysis

The following sections present a quantitative analysis of pollutant removal capabilities of the proposed BMPs to ensure that the required reduction in nutrient loads from urban runoff in the Upper Patapsco River watershed is achieved. Note that many of the removal efficiencies used to estimate pollutant reductions are based on peer-reviewed and CBP-approved nonpoint source BMP tables developed for the Phase 5.3 CBP Watershed Model. These tables are included in Appendix D. Also note that the calculations and estimates presented in the following subsections represent maximum potential pollutant capabilities. A summary of overall pollutant load reduction estimates is presented at the end of this section for two scenarios: a maximum implementation scenario and one based on projected participation for each BMP.

3.4.2.1 Implemented Capital Improvement Projects

Baltimore County has implemented many capital improvement projects in the county's various watersheds including stream restoration, stormwater facility retrofits and conversions, and shoreline enhancements. The County has implemented 1 stream restoration project (totaling 2,000 linear feet of stream) in the Upper Patapsco River watershed. Pollutant loads were estimated by the County based on the contributing drainage area (DA) and the corresponding project type's land use-specific pollutant loading rates. Load reduction is calculated as the product of the pollutant load and removal efficiency. For the BMP retrofits, filtration pollutant removals are 40% for nitrogen, 60% for phosphorus, and 80% for sediment per the values shown in Appendix D under Urban and Mixed Open BMPs, Stormwater Management. For stream restoration projects, nutrient reduction credits are based on the length of stream restored. A summary of existing load reductions is shown in Table 3-3.

Table 3-3: Load Reductions Estimated for Completed Stream Restoration Projects in Upper Patapsco River Watershed

Project	TN Reduction (lbs/yr)	TP Reduction (lbs/yr)	Sediment Reduction (lbs/yr)
Stream Restorations			
Ben's Run BE1	150.0	136.0	89760

3.4.2.2 Existing Stormwater Management (SWM)

As described in detail in Section 2.3 of the Watershed Characterization Report (Appendix E), there are 154 existing SWM facilities in the Upper Patapsco River watershed including dry ponds, infiltration/filtration practices, extended detention, proprietary BMPs and other types of SWM facilities (i.e., underground detention). The pollutant removal capability of the existing SWM in the watershed is not fully accounted for in the baseline loading analysis; therefore, it is included in the pollutant removal analysis.

Pollutant reductions for existing SWM are calculated based on the approximate pollutant load received from the drainage area (DA) and removal efficiencies (RE) recommended by CBP for the various types of SWM faculties. The equation used to estimate total nitrogen (TN) load reductions for a particular type of SWM facility is expressed as:

[16.18 (lbs/ac/yr)*DA (acres)]*RE (%)

The equation used to estimate total phosphorus (TP) load reductions for a particular type of SWM facility is expressed as:

[1.25 (lbs/ac/yr)*DA (acres)]* RE (%)

The equation used to estimate sediment load reductions for a particular type of SWM facility is expressed as:

[1529 (lbs/ac/yr)*DA (acres)]* RE (%)

The pollutant load received from the drainage area contributing to the SWM facility is denoted by the first expression in brackets in the above equations. The pollutant loading rates shown, 16.18 lbs TN/ac/yr, 1.25 lbs TP/ac/yr, and 15228.5 lbs sediment/ac/yr, represent the weighted average of impervious and pervious urban rates used in the pollutant loading analysis (Table 3-1) since this represents the likely sources of runoff being treated. Note that impervious and pervious urban loading rates are based on CBP's Watershed Model Phase 5.3, as implemented in the Maryland Assessment Scenario Tool (MAST) run from February 2016 for the 2010 revised progress scenario. The percent pollutant removal efficiency depends on the type of facility and is based on the values shown in Appendix D under Urban and Mixed Open BMPs, Stormwater Management. The total pollutant load reduction expected from existing SWM is a sum of the removal capacities of the individual facilities. A summary of existing SWM load reduction calculations and results is shown in the Table 3-4.

3.4.2.3 Stormwater Management Conversions

Two dry ponds and 9 extended detention ponds could be converted to facilities with higher capacity for nutrient removal. Pollutant reductions for SWM conversions are calculated based on the approximate pollutant load received from the drainage area (DA) and the increase in removal efficiency (RE) based on BMP efficiencies by CBP for detention and extended detention facilities (http://www .mastonline.org/Documentation.aspx). The equation used to estimate total nitrogen (TN) load reductions for SWM conversion is expressed as:

[16.18 (lbs/ac/yr)*DA (acres)]*RE (%)

The equation used to estimate total phosphorus (TP) load reductions for SWM conversion is expressed as:

[1.25 (lbs/ac/yr)*DA (acres)]* RE (%)

The equation used to estimate sediment load reductions for SWM conversion is expressed as:

[1529 (lbs/ac/yr)*DA (acres)]* RE (%)

The pollutant load received from the drainage area contribution to the SWM facility is denoted by the first expression in brackets in the equations above. Similar to existing SWM, the pollutant loading rates, 16.18 lbs TN/ac/yr, 1.25 lbs TP/ac/yr, and 1529 lbs sediment/ ac/yr, represent the weighted average of impervious and pervious urban rates in the pollutant loading analysis (Table 3-1) since this represents the likely sources of runoff being treated. The increased in pollutant removal efficiency is represented by the third expression in the equations above. This is the difference between percent pollutant removal efficiencies of the facilities, based on CBP guidance shown in Appendix D under Urban and Mixed Open BMPs, Stormwater Management. A summary of SWM conversion load reduction calculations and results are shown in Table 3-5.

Table 3-4: Existing SWM Load Reductions

SWM Facility Type	#	DA (acres)	Total Nitrogen			Total Phosphorus			Sediment		
			Load from DA (lbs/yr)	RE	Max Potential Load Reduction (lbs/yr)	Load from DA (lbs/yr)	RE	Max Potential Load Reduction (lbs/yr)	Load from DA (lbs/yr)	RE	Max Potential Load Reduction (lbs/yr)
Bioretention	3	9.7	156.9	25%	39.2	12.2	45%	5.47	14,829.9	55%	8,156.4
Dry Pond	12	230.6	3730.8	5%	186.5	289.2	10%	28.92	352,553.1	10%	35,255.3
Dry Well	15	4.3	69.6	5%	3.5	5.4	10%	0.54	6,574.1	10%	657.4
Extended Detention	57	521.4	8435.6	20%	1687.1	653.8	20%	130.76	797,143.0	60%	478,285.8
Infiltration Basin	10	51.5	833.2	85%	708.2	64.6	85%	54.89	78,735.8	95%	74,799.0
Infiltration Trench	5	11.9	192.5	80%	154.0	14.9	85%	12.68	18,193.3	95%	17,283.7
Proprietary BMP	2	2.1	34.0	5%	1.7	2.6	10%	0.26	3,210.6	10%	321.1
Sand Filter	37	274.3	4437.8	40%	1775.1	344.0	60%	206.37	419,363.9	80%	335,491.1
Swale	4	4.1	66.3	70%	46.4	5.1	75%	3.86	6,268.3	80%	5,014.6
Wet Pond	5	190.5	3082.0	20%	616.4	238.9	45%	107.49	291,246.1	60%	174,747.7
Wetland	8	64.9	1050.0	20%	210.0	81.4	45%	36.62	99,222.4	60%	59,533.5
TOTAL	158	1365	22,089		5,428	1,712		588	2,087,340		1,189,546

Table 3-5: SWM Conversion Load Reductions for Individual Ponds

Pond #	Potential for Conversion	Total DA for SWM Conv. (acres)	RE for Nitrogen Reduct.	Nitrogen Load Reduct. (lbs/yr)	RE for Phosphorous Reduct.	Phosphorus Load Reduct. (lbs/yr)	RE for Sediment Load Reduct.	Sediment Load Reduct. (lbs/yr)
636	High	15.39	40%	87.15	40%	11.65	80%	19,995
837	High	7.6	40%	43.04	40%	5.75	80%	9,874
272	High	10.57	40%	34.20	40%	6.40	80%	3,924
273	High	12.6	40%	40.77	40%	7.63	80%	4,677
2906	High	12.14	40%	39.28	40%	7.35	80%	4,506
2907	High	8.47	40%	27.41	40%	5.13	80%	3,144
3302	High	6.77	40%	21.91	40%	4.10	80%	2,513
4228	High	14.35	40%	46.43	40%	8.69	80%	5,327
4229	High	14.72	40%	47.63	40%	8.91	80%	5,464
2953	High	17.27	40%	55.88	40%	10.46	80%	6,411
3055	High	5.16	40%	16.70	40%	3.12	80%	1,915
Total		**125.04**		**460.39**		**79.20**		**67750**

3.4.2.4 Stormwater Retrofits

Proposed stormwater retrofits for the purposes of this SWAP refer to implementing BMPs to capture and treat runoff from impervious surfaces (i.e., parking lots, alleys) which are currently untreated. This includes sites identified for retrofit potential during uplands surveys for neighborhoods, institutions, hotspots, and pervious areas. Pollutant reductions for stormwater retrofits are calculated based on the approximated pollutant load received from the impervious drainage area (DA) and removal efficiency (RE) of bioretention and underground structure type BMPs. The equation used to estimate total nitrogen (TN) load reductions for stormwater retrofits is expressed as:

[17.36 (lbs/ac/yr)*DA (acres)]*RE (%)

The equation used to estimate total phosphorus (TP) load reductions for stormwater retrofits is expressed as:

[1.51 (lbs/ac/yr)*DA (acres)]*RE (%)

The equation used to estimate sediment load reductions for stormwater retrofits is expressed as:

[1856 (lbs/ac/yr)*DA(acres)]*RE(%)

The pollutant load received from the drainage area contributing to the SWM facility is denoted by the first expression in brackets in the equation above. The pollutant loading rates shown, 17.36 lbs TN/ac/yr, 1.51 lbs TP/ac/yr, and 1,947 lbs sediment/ac/yr, are the impervious urban rates used in the pollutant loading analysis (Table 3-1) since this represents the source of runoff being treated. Pollutant removal efficiencies are those reported for bioretention and infiltration basin, based on CBP guidance shown in Appendix D under Urban and Mixed Open BMPs, Stormwater Management. A summary of stormwater retrofit load reduction calculations and results are shown in Table 3-6.

Table 3-6: Stormwater Retrofit Load Reduction

Pollutant	Impervious Urban Loading Rate (lbs/ac/yr)	Impervious Area for SW Retrofit (acres)	Load for DA (lbs/yr)	RE (%)	Max Potential Load Reduction (lbs/yr)
Bioretention/Rain Gardens					
TN	17.36	4.13	71.6	25%	17.9
TP	1.51	4.13	6.2	45%	2.8
Sediment	1,856	4.13	7,658.0	55%	4211.9
Infiltration Basins					
TN	17.40	0.35	6.1	85%	5.18
TP	1.51	0.35	0.5	85%	0.45
Sediment	1,947	0.35	682.5	95%	648

3.4.2.5 Impervious Cover Removal

Potential sites for impervious cover removal were identified at several institutions. Pollutant reductions for impervious cover removal are calculated based on a land conversion from impervious to pervious urban. The equation used to estimate total nitrogen (TN) load reductions for stormwater retrofit is expressed as:

[17.36 (lbs/ac/yr) – 11.55 (lbs/ac/yr)]*Impervious Area (acres)

The equation used to estimate total phosphorus (TP) load reductions for stormwater retrofits is expressed as:

[1.51 (lbs/ac/yr) - 0.24 (lbs/ac/yr)]*Impervious Area (acres)

The equation used to estimate sediment load reductions for stormwater retrofits is expressed as:

[1,856 (lbs/ac/yr) - 247 (lbs/ac/yr)]*Impervious Area (acres)

Impervious cover removal would involve converting impervious surfaces to pervious surfaces. Therefore, the loading rate would be reduced by a factor equal to the difference between impervious and pervious urban loading rates in the watershed pollutant loading analysis as shown in the first expression in brackets in the equations above. The approximate reduction in pollutant load is then the reduced loading rate multiplied by the area proposed for impervious cover removal. A summary of impervious cover removal reduction calculations and results are shown in Table 3-7.

Table 3-7: Impervious Cover Removal Load Reductions

k	Impervious Urban Loading Rate (lbs/ac/yr)	Pervious Urban Loading Rate (lbs/ac/yr)	Reduction in Loading Rate (lbs/ac/yr)	Impervious Area (acres)	Max Potential Load Reduction (lbs/yr)
TN	17.36	11.55	5.81	0.111	0.6
TP	1.51	0.24	1.28	0.111	0.1
Sediment	1856	247	1609	0.111	179

3.4.2.6 Stream Buffer Reforestation

The current vegetative condition of the stream riparian buffer (100 feet on either side of the stream system, total area 744 acres) was analyzed in Chapter 2 of the Watershed Characterization Report (Appendix E). Buffer conditions were classified as impervious, open pervious, or forested areas. Open pervious areas are the best areas to initially target for restoration. Approximately 744 acres of open pervious area were identified within the stream buffer zone.

Pollutant reductions for stream buffer reforestation are calculated based on a land use conversion from pervious urban to forest plus an additional reduction efficiency per BMP performance guidance from CBP (Appendix D). The equation used to estimate total nitrogen (TN) load reductions for the land use conversion portion of stream buffer reforestation is expressed as:

Land Use Conversion (TN) = [11.55 (lbs/ac/yr) – 2.78 (lbs/ac/yr)]* Open Pervious Area (acres)

The equation used to estimate total phosphorus (TP) load reductions for the land use conversion portion of stream buffer reforestation is expressed as:

Land Use Conversion (TP) = [0.24 (lbs/ac/yr) – 0.04 (lbs/ac/yr)]* Open Pervious Area (acres)

The equation used to estimate sediment load reductions for the land use conversion portion of stream buffer reforestation is expressed as:

Land Use Conversion (sediment) = [247 (lbs/ac/yr) – 88 (lbs/ac/yr)]* Open Pervious Area (acres)

The first expression in brackets in the equation above represents the difference between pervious urban and forest loading rates used in the watershed pollutant loading analysis. This reduction in loading rate is then multiplied by the available open pervious area for reforestation to determine the loads from land use conversion.

An additional pollutant removal factor is added to the land use conversion to determine the total removal capacity of buffer reforestation. Per the BMP performance guidance in Appendix D, <u>one acre of buffer treats approximately one acre of upland area for nitrogen</u> with an efficiency of 25 percent for urban and mixed open buffers. The total nitrogen (TN) load reduction for the removal efficiency portion of buffer reforestation can be expressed as:

Buffer BMP Removal (TN) = [Open Pervious Area (acres)*10.64 (lbs/ac/yr]*25%

Similarly, <u>one acre of buffer treats approximately one acre of upland area for phosphorus</u> with an efficiency of 50 percent for urban and mixed open buffers. The total phosphorus (TP) load reductions for the removal efficiency portion of buffer reforestation can be expressed as:

Buffer BMP Removal (TP) = [Open Pervious Area (acres)*0.68 (lbs/ac/yr]*50%

Similarly, <u>one acre of buffer treats approximately one acre of upland area for sediment</u> with an efficiency of 50 percent for urban and mixed open buffers. The sediment load reductions for the removal efficiency portion of buffer reforestation can be expressed as:

Buffer BMP Removal (sediment) = [Open Pervious Area (acres)*781 (lbs/ac/yr]*50%

The loading rates shown in the equation above, 10.64 lbs TN/ac/yr, 0.68 TP/ac/yr, and 781 lbs sediment/ac/yr, represent overall watershed loading rates. This is estimated as the total watershed nutrient load (168,429 lbs TN/yr, 11,387 lbs TP/yr, and 14,062,263 lbs sediment/yr) divided by the total area (15,689 acres), which is the area used to calculate the pollutant load

from the upland area that would be treated by buffer reforestation. As mentioned, the land use conversion and additional removal efficiency are added to yield a total pollutant load reduction. A summary of stream buffer reforestation reduction calculations and results are shown in Table 3-8.

Table 3-8: Stream Buffer Reforestation Load Reductions

Pollutant	Open Pervious Area (acres)	Land Use Conversion		Buffer BMP Removal			Max Potential Load Reduction (lbs/yr)
		Reduced Loading Rate (lbs/ac/yr)	Land Use Conversion Reduction (lbs/yr)	RE (%)	Overall Watershed Loading Rate (lbs/ac/yr)	Overall Watershed Load (lbs/yr)	
TN	743.8	8.77	6,523.1	25%	10.64	7,912	8,501
TP	743.8	0.196	145.8	50%	0.68	508	400
Sediment	743.8	159	118,264.2	50%	781	580,958	408,743

3.4.2.7 Urban Nutrient Management – Maryland Fertilizer Use Act of 2011

The State of Maryland passed the Maryland Fertilizer Use Act of 2011 (the Act) that took effect in October 2013. The Act bans phosphorus and provides a greater percentage of slow release nitrogen in lawn fertilizer. The fertilizer bags have better labeling and lawn care professionals are required to be certified in proper fertilizer application. The Chesapeake Bay Program Urban Nutrient Management Expert Panel Report recommendations include TN reductions of 9 percent for commercial applicators of fertilizer and 4.5 percent for “do-it yourself” fertilizer applicators for the State of Maryland (Schueler and Lane, 2013). A 25% reduction is given to TP for urban nutrient management. In Upper Patapsco River, this reduction will apply to an estimated 107 acres of residential parcels (lawns), and 0 acres of non-residential parcels (pervious area of the golf course, open urban areas, institutional and commercial areas). Pollutant reductions applied for the Act are calculated based on the urban pervious pollutant load multiplied by the acres of managed turf, then the pollutant reduction efficiency. The equation used to estimate total nitrogen (TN) load reductions for commercial applicators, on non-residential parcels is expressed as:

[11.55 (lbs/acre/yr) x managed turf (acres)] x 9%

The equation used to estimate total nitrogen (TN) load reductions for residential applicators, on residential parcels is expressed as:

[11.55 (lbs/acre/yr) x managed turf (acres)] x 4.5%

The equation used to estimate total phosphorus (TP) load reductions for the Act reduction is expressed as:

[0.24 (lbs/acre/yr) x managed turf (acres)] x 25%

The pollutant load received from the urban pervious area that the Act will be applied to is denoted by the first expression in brackets in the equations above. The pollutant loading rates shown, 11.55 lbs/ac/yr of TN and 0.24 lbs/ac/yr of TP, are the pervious urban rates used in the pollutant loading analysis. Pollutant removal efficiencies are those reported by the State to be applied from the Act. A summary of fertilizer load reduction calculations and results are shown in Table 3-9.

Table 3-9: Maryland Fertilizer Use Act of 2011 Load Reductions

Pollutant	Pervious Urban Loading Rate (lbs/ac/yr)	Acres of Managed Turf	RE (%)	Max Potential Load Reduction (lbs/yr)
TN (Residential)	11.55	107	4.5%	56
TN (Non-residential)	11.55	0	9.0%	0
TP	0.24	107	25.0%	6

3.4.2.8 Pervious Area Reforestation

Open pervious areas with reforestation potential have been identified in the Upper Patapsco River watershed equaling 63 acres. Pollutant reductions for pervious area reforestation are calculated based on land use conversion from pervious urban to forest. The equation used to estimate total nitrogen (TN) load reductions for pervious area reforestation is expressed as:

Land Use Conversion (TN) = [11.55 (lbs/ac/yr) – 2.78 (lbs/ac/yr)]* Open Pervious Area (acres)

The equation used to estimate total phosphorus (TP) load reductions for the land use conversion portion of stream buffer reforestation is expressed as:

Land Use Conversion (TP) = [0.24 (lbs/ac/yr) – 0.04 (lbs/ac/yr)]* Open Pervious Area (acres)

The equation used to estimate sediment load reductions for the land use conversion portion of stream buffer reforestation is expressed as:

Land Use Conversion (sediment) = [247 (lbs/ac/yr) – 88(lbs/ac/yr)]* Open Pervious Area (acres)

Pervious area reforestation would involve converting open pervious area to forest. Therefore, the loading rate would be reduced by a factor equal to the difference between pervious urban and forest loading rates used in the watershed pollutant analysis as shown in the first expression in brackets in the equations above. The approximate reduction in pollutant load is then the reduced loading rate multiplied by the open pervious area available for reforestation. A summary of pervious area reforestation reduction calculations and results are shown in Table 3-10. Note that assessments were performed and plantings recommended at four Patapsco Valley State Park properties. While the County may encourage plantings at these sites, Maryland DNR Park Service would need to approve these plantings.

Table 3-10: Pervious Area Reforestation Load Reductions

Pollutant	Pervious Urban Loading Rate (lbs/ac/yr)	Forest Loading Rate (lbs/ac/yr)	Reduced Loading Rate (lbs/ac/yr)	Open Pervious Area (acres)	Max Potential Load Reduction (lbs/yr)
TN	11.55	2.78	8.77	62.8	550.8
TP	0.24	0.04	0.196	62.8	12.31
Sediment	247	88	159	62.8	9985

3.4.2.9 Stream Corridor Restoration

Several potential stream restoration sites were identified during the review of a previous study: the Patapsco River Water Quality Management Study (WQMS) by Tetra Tech (2000). These sites are discussed in Section 3.6 of the Watershed Characterization Report (Appendix E). Pollutant load reduction estimates in pounds per linear foot of stream restoration were developed by Schueler and Stack (2013; 2014 revisions). These were also used to calculate load reductions for proposed stream restoration activities (i.e., restoration lengths (RL)) in the Upper Patapsco River watershed. The equation used to estimate total nitrogen (TN) reductions for stream restoration is expressed as:

$$0.075 \text{ (lbs/ft)} * \text{RL (ft)}$$

The equation used to estimate total phosphorus (TP) load reductions for stream restoration is expressed as:

$$0.068 \text{ (lbs/ft)} * \text{RL (ft)}$$

The equation used to estimate sediment load reductions for stream restoration is expressed as:

$$44.88 \text{ (lbs/ft)} * \text{RL (ft)}$$

Edge-of-Stream 2014 interim approved removal rates per linear foot of qualifying stream restoration were obtained from Table 3 in Schueler and Stack (2013; 2014 revisions).

Lower severity impairments were not included in the model. A summary of stream corridor restoration reduction calculations and results are shown in Table 3-11.

Table 3-11: Stream Corridor Restoration Load Reduction

Pollutant	Reduction in Loading Rate (lbs/ft)	Total Stream Length in Watershed (ft)	Potential Stream Restoration Length (ft)	Max Potential Load Reduction (lbs/yr)
TN	0.075	17,558	15,558	1,167
TP	0.068	17,558	15,558	1,058
Sediment	44.88	17,558	15,558	698,243

3.4.2.10 Downspout Disconnection

A total of 13 neighborhoods (out of 20 surveyed) have potential for downspout disconnection. A neighborhood is recommended for disconnection if at least 25 percent of the downspouts are directly and/or indirectly connected to the storm drain system and the average lot has at least 15 feet of pervious area available down gradient from the downspout. During the uplands survey, the percentage of homes with connected downspouts was noted. This percentage was used to determine the rooftop area that could be addressed by disconnection in recommended neighborhoods. This is explained in further detail in Chapter 4 of the Watershed Characterization Report (Appendix E).

Pollutant reductions for downspout disconnection are calculated based on the pollutant load received from the total rooftop drainage area (DA) recommended for disconnection and the removal efficiency (RE) of based on removal efficiency for environmental site design (ESD) to the maximum extent practicable (MEP; MDE 2014). The equation used to estimate total nitrogen (TN) load reductions for downspout disconnection is expressed as:

[17.36 (lbs/ac/yr)*DA (acres)]*RE (%)

The equation used to estimate total phosphorus (TP) load reduction for downspout disconnection is expressed as:

[1.51 (lbs/ac/yr)*DA (acres)]*RE (%)

The equation used to estimate sediment load reduction for downspout disconnection is expressed as:

[1,856 (lbs/ac/yr)*DA (acres)]*RE (%)

The pollutant load received from the impervious rooftop drainage area recommended for disconnection is denoted by the first expression in brackets in the equations above. The pollutant loading rates shown (17.34 lbs TN/ac/yr, 1.51 lbs TP/ac/yr, and 1,856 lbs sediment/ac/yr) are the impervious urban rates used in the pollutant loading analysis. Pollutant removal efficiencies are those reported for filtration practices, based on CBP guidance shown in Appendix D under Urban and Mixed Open BMPs, Stormwater Management. A summary of downspout disconnection load reduction calculations and results are shown in Table 3-12.

Table 3-12: Downspout Disconnection Load Reductions

Pollutant	Impervious Urban Loading Rate (lbs/ac/yr)	DA (Rooftop Area Recommended for Downspout Disconnect) (acres)	RE (%)	Max Potential Load Reduction (lbs/yr)
TN	17.36	13.92	50%	121
TP	1.51	13.92	60%	13
Sediment	1,856	13.92	90%	23,252

3.4.2.11 Tree Plantings

Several opportunities for planting street and open space shade trees were identified in neighborhoods throughout the watershed. Similarly, tree planting opportunities were also identified at

many institutional sites. For both neighborhood and institutional tree planting opportunities, the number of trees was estimated based on a spacing of one tree per 15 to 20 feet. Pollutant reductions for pervious area reforestation are calculated based on a land use conversion from pervious urban to forest. An approximation of 100 trees per acre is used to calculate the area available for conversion. The equation used to estimate total nitrogen (TN) load reductions for tree plantings is expressed as:

[11.55 (lbs/ac/yr) – 2.78 (lbs/ac/yr)] * [# Trees * (1 acre/100 trees)]

The equation used to estimate total phosphorus (TP) load reductions for tree plantings is expressed as:

[0.24 (lbs/ac/yr) – 0.04 (lbs/ac/yr)] * [# Trees * (1 acre/100 trees)]

The equation used to estimate sediment load reductions for tree plantings is expressed as:

[247 (lbs/ac/yr) – 88 (lbs/ac/yr)] * [# Trees * (1 acre/100 trees)]

Tree plantings would involve converting open pervious area to forest. Therefore, the loading rate would be reduced by a factor equal to the difference between pervious urban and forest loading rates used in the watershed pollutant loading analysis, as shown in the first expression in brackets in the equations above. The approximate reduction in pollutant load is then the reduced loading rates multiplied by the open pervious available for reforestation (i.e., the expression in the second brackets in the equations above). A summary of tree planting load reduction calculations and results are shown in Table 3-13 and Table 3-14.

Table 3-13: Neighborhood Tree Planting Load Reductions

Pollutant	Pervious Urban Loading Rate (lbs/ac/yr)	Forest Loading Rate (lbs/ac/yr)	Reduced Loading Rate (lbs/ac/yr)	Estimated # Trees	Equivalent Forest Area (acres)	Max Potential Load Reduction (lbs/yr)
TN	11.55	2.78	8.77	2,275	23	200
TP	0.24	0.04	0.20	2,275	23	4.46
Sediment	247	88	159	2,275	23	3,617

Table 3-14: Institution Tree Planting Load Reductions

Pollutant	Pervious Urban Loading Rate (lbs/ac/yr)	Forest Loading Rate (lbs/ac/yr)	Reduced Loading Rate (lbs/ac/yr)	Estimated # Trees	Equivalent Forest Area (acres)	Max Potential Load Reduction (lbs/yr)
TN	11.55	2.78	8.77	381	3.81	33
TP	0.24	0.04	0.20	381	3.81	0.75
Sediment	247	88	159	381	3.81	606

3.4.2.12 Street Sweeping

Approximately 15.3 Equivalent Impervious Urban Acres (EUIA) were reported to have street sweeping in the Upper Patapsco River watershed. For the purposes of this watershed plan, the overall Upper Patapsco River watershed was divided into two portions. Load reductions for street sweeping were pro-rated for the Upper Patapsco River portion of the overall watershed based on the proportion of EUIA within that portion of the watershed; 23% of EIUA in the overall watershed area were within Upper Patapsco River. Records from the Department of Public Works (DPW) Street Sweeping Program (EPS 2016) showed that 190.9 lbs TN, 76.3 lbs TP, and 22,904.7 lbs TSS were removed overall; the allocations to the Upper Patapsco River watershed based on 3.6 EIUA of street sweeping were 44.4 lbs TN, 17.8 lbs TP, and 5332.6 lbs TSS. A summary of street sweeping reduction calculations and results are shown in Table 3-15. Further information on how the Baltimore County calculates pollutant load reductions for street sweeping can be found in Baltimore County SOP PLRC_SOP_RT—021.02.

Table 3-15: Street Sweeping Load Reductions

Pollutant	Equivalent	
TN	3.6	44
TP	3.6	18
Sediment	3.6	5,332

As noted in Section 4.2 of the Watershed Characterization Report, no neighborhoods were recommended during Neighborhood Source Assessments (NSAs) for street sweeping. In addition, it should be noted that in FY 2014 the previous metric of “Miles Swept” was replaced with EIUA for reporting purposes.

3.4.2.13 Sanitary Sewer Overflows

Sanitary sewer overflows over the past 14 years have been an on-going issue in many of the County’s watersheds. These are assumed to be eliminated by 2020 through sewer line upgrades occurring as a result of the consent decree.

A total of 4 sanitary sewer overflow (SSO) events were documented between 2000 and 2015 within Upper Patapsco River watershed. An estimated 3,275 gallons were discharged over this 15-year period. Pollutant loads associated with these SSO events and volume were calculated

based on the following assumptions (more detail can be found in Section 3.5 of the Watershed Characterization Report, found in Appendix E):

- Total Nitrogen (TN): A conversion factor of 2.5 x 10^{-4} was used to convert gallons of overflow to pounds of pollutant. This is based on a 30 mg/L TN concentration for raw sewage and a multiplier of 8.3 x 10^{-6} lb•L/mg•gal.

- Total Phosphorus (TP): A conversion factor of 8.3 x 10^{-5} was used to convert gallons of overflow to pounds of pollutant. This is based on a 10 mg/L TP concentration for raw sewage and a multiplier of 8.3 x 10^{-6} lb•L/mg•gal.

Based on these conversion factors, approximately 0.32 lbs of total nitrogen and 0.11 lbs of total phosphorus were released over the 14-year period as a result of SSOs. This is equivalent to pollutant reduction capabilities of 0.023 lbs TN/yr (i.e., 0.32 lbs TN/14 yrs) and 0.008 lbs TP/yr (i.e., 0.11 lbs TP/14 yrs). Note that TN and TP concentrations shown above are values for waste and wash water combined from CWP's Watershed Treatment Model version 3.1.

Table 3-16: Sanitary Sewer Overflow Incidents

Year	# of Events	Gallons
2002	1	125
2006	1	150
2009	1	1000
2015	1	2000
Total	**4**	**3275**

3.4.2.14 Overall Pollutant Load Reductions

The sum of maximum potential pollutant load reductions calculated for individual BMPs represents the overall pollutant removal capacity for a maximum implementation scenario (i.e., 100% of the projects implemented). A practicable pollutant load reduction was estimated for each BMP as the maximum potential load reduction multiplied by a projected participation factor. An overall projected pollutant removal capacity is the sum of practicable pollutant load reductions for individual BMPs. Projected participation factor assumptions are described in Table 3-16.

Table 3-17 presents a summary of estimated pollutant load reductions for both scenarios – maximum implementation and projected practicable – including how reductions were credited, pollutant removal efficiencies, maximum potential load reductions, units available for restoration, projected participation, and projected load reductions.

The projected, practicable implementation of proposed restoration BMPs, shown in Table 3 18, would fall short of meeting the 32 percent reduction for nitrogen and the 47 percent reduction for phosphorus needed to meet water quality standards for the Upper Patapsco River watershed as specified by Chesapeake Bay TMDL for nutrients (Appendix J). There is opportunity to achieve greater reductions if more stormwater retrofit opportunities are identified or are implemented to a greater extent than those assumed by projected participation factors. Greater reductions that might be achieved through additional structural restoration actions could include, for example, a combination of the following: 1) converting additional dry ponds and extended detention ponds to add addition water quality benefits; 2) increasing the amount of stream buffer areas restored; and

3) increasing the amount of stream miles restored. These opportunities may be limited in this watershed since much of it is not urbanized or some actions may not be feasible. Other non-structural actions are not included in this analysis such as public education/ outreach efforts (e.g., watershed trash and recycling campaign and tours of completed projects). These types of actions are not included in the pollutant removal analysis because reductions efficiencies are not well known and are difficult to estimate.

Table 3-16: Projected Participation Factors

BMP	Projected Participation	Basis of Assumption
Capital Investment – Filtration	100	Existing - pond retrofits already implemented
Existing SWM	100	Existing - BMP already implemented
SWM Conversion	100	Completion of 11 conversions recommended
SW Retrofits (NSA, ISI, PAA, HSI)*	50	General estimate to achieve reduction goal
ISI Impervious Cover Removal	50	General estimate to achieve reduction goal
Reforest Stream Buffer	80	General estimate to achieve reduction goal
Pervious Area Reforestation	75	General estimate to achieve reduction goal
Stream Restoration	100	General estimate to achieve reduction goal
NSA Downspout Disconnection	66	General estimate to achieve reduction goal
NSA Tree Plantings	50	General estimate to achieve reduction goal
ISI Tree Plantings	75	75% of estimated trees located on public lands
Urban Nutrient Management	100	State Mandate
Street Sweeping	100	General estimate to achieve reduction goal
SSO Reduction/Elimination	100	Consent Decree requirements

* NSA (Neighborhood Source Assessment); ISI (Institutional Site Investigation); PAA (Pervious Area Assessment); HSI (Hotspot Investigation)

Table 3-17: Summary of Pollutant Load Reduction Estimates

BMP	How Credited	TN Efficiency	TP Efficiency	Sediment Efficiency	Max Potential TN Load Reduction (lbs/yr)	Max Potential TP Load Reduction (lbs/yr)	Max Potential Sediment Load Reduction (lbs/yr)	Units Available		Projected Participation (%)	Projected TN Load Reduction (lbs/yr)	Projected TP Load Reduction (lbs/yr)	Projected Sediment Load Reduction (lbs/yr)
Existing Retrofits	Efficiency	varies	varies	varies	0	0	0	0	acres	100	0	0	0
Existing Stream Restoration	lbs per Ln Ft	0.075	0.068	44.88	150	136	89,760	2,000	ft	100	150	136	89,760
Existing SWM	Efficiency	varies	varies	varies	5,428	588	1,189,546	1,365	acres	100	5,428	588	1,189,546
SWM Conversion	Efficiency	varies	varies	varies	460	79	67,750	125	acres	100	460	79	67,750
New SW Retrofits (NSA, ISI, PAA, HIS)	Efficiency	varies	varies	varies	23.1	3.3	4,860	4.48	acres	50	11.5	1.63	2,430
ISI Impervious Cover Removal	LU Conversion	N/A	N/A	N/A	0.65	0.14	179	0.11	acres	50	0.32	0.07	89
Reforest Stream Buffer	LU Conversion + Efficiency	25%	50%	50%	8,501	400	408,743	744	acres	80	6,801	320	326,995
Urban Nutrient Management	Efficiency	varies	varies	N/A	56	6	N/A	107	acres	100	56	6	N/A
Pervious Area Reforestation	LU Conversion	N/A	N/A	N/A	551	12	9,985	63	acres	75	413	9.23	7,489
New Stream Restoration	lbs per Ln Ft	0.075	0.068	44.88	1,167	1,058	698,243	15,558	ft	100	1,167	1,058	698,243
NSA Downspout Disconnection	Efficiency	50%	60%	90%	121	13	23,252	14	acres	66	80	8	15,346
NSA Tree Plantings	LU Conversion	N/A	N/A	N/A	200	4	3,617	23	acres	50	100	2	1,809
ISI Tree Plantings	LU Conversion	N/A	N/A	N/A	33	0.75	606	3.81	acres	75	25	0.56	454
Street Sweeping	Direct Removal	N/A	N/A	N/A	44	18	5,332	4	EUIA	100	44	18	5,332
SSO Reduction/Elimination	Direct Removal	N/A	N/A	N/A	0.019	0.058	N/A	3,275	gallons	100	0	0	N/A
				Total	16,735	2,318	2,501,872				14,736	2,227	2,405,242
				Total Existing Urban Load (lbs/yr)	84,584	6,556	7,992,987				84,584	6,556	7,992,987
				Reduction Achieved	19.8%	35.4%	31.3%				17.4%	34.0%	30.1%

CHAPTER 4: SUBWATERSHED MANAGEMENT STRATEGIES

4.1 INTRODUCTION

This chapter describes the criteria and methodology used to rank the eight subwatersheds within the Upper Patapsco River watershed (Figure 4-1). The subwatershed ranking provides a tool for targeting restoration actions by location/waterbody. This chapter also summarizes management strategies and implementation priorities within each subwatershed.

Individual subwatershed summaries include key subwatershed characteristics. More detailed information on a subwatershed basis can be found in the Watershed Characterization Report, included as Appendix E.

4.2 SUBWATERSHED PRIORITIZATION

A ranking methodology was developed to prioritize subwatersheds in terms of restoration need and potential. Subwatersheds are represented by an overall prioritization score on a scale of 44, based on a set of 11 criteria each worth a maximum of four points. Lower scores denote the least significant impacts to water quality and a total score of 44 corresponds to the greatest water quality improvement potential. The total prioritization score for a subwatershed comprises the following ranking criteria:

- Phosphorus and Nitrogen Loads,
- Impervious Surfaces,
- Neighborhood Restoration Opportunity/Pollution Source Indexes,
- Neighborhood Downspout Disconnection,
- Institutional Site Investigations,
- Pervious Area Assessments,
- Stormwater Pond Conversions,
- Illicit Discharge Data,
- Stream Buffer Improvement, and
- Stream Restoration Potential.

In general, subwatersheds were grouped into quartiles based on supporting criterion data to yield an even distribution of the number of watersheds per possible score (i.e., 1, 2, 3, and 4). In some cases, criterion data did not support dividing the subwatersheds into four equal parts. Examples include a distribution of data that is too narrow or clustered, or cases where zero values were assigned to subwatersheds that had no recommended action for a particular criterion.

Criteria used to calculate overall prioritization scores were selected considering SWAP goals and information compiled during watershed characterization and field efforts. Criteria and scoring designations are described in the sections below. Subwatershed restoration prioritization scoring and ranking results are summarized at the end of this section.

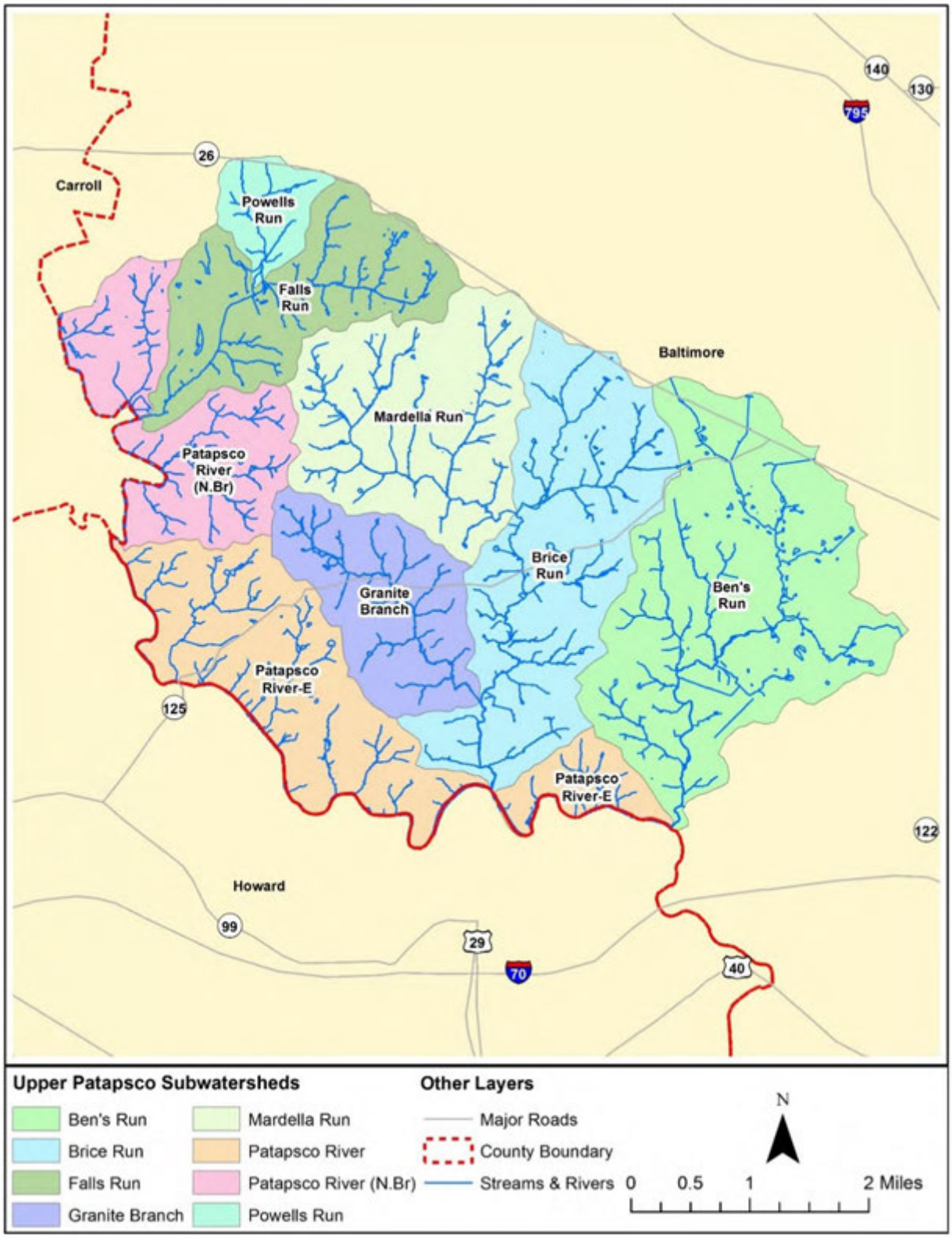

Figure 4-1: Upper Patapsco River Subwatersheds

4.2.1 Phosphorus and Nitrogen Loads

One of the objectives that will improve and maintain water quality in the Upper Patapsco River watershed streams and help meet the Chesapeake Bay TMDLs is to reduce annual average total phosphorus and nitrogen loads. Annual pollutant loads (lbs/year) for total nitrogen and total phosphorus were calculated for each subwatershed based on loading rates established by MDE and the Chesapeake Bay Program (CBP) for various land use types and subwatershed land use distributions. The pollutant loading analysis for Upper Patapsco River watershed is explained in further detail in Section 3.3 of the Watershed Characterization Report (Appendix E).

For each subwatershed, annual nitrogen and phosphorus loads were divided by the subwatershed's area. This represents pollutant loading rates (lbs/acre/year) and allows a direct comparison among the eight subwatersheds since they vary in size. Subwatersheds with higher pollutant loading rates are higher priorities for restoration within the Upper Patapsco River watershed. Therefore, higher pollutant loading rates are assigned high scores to denote greater water quality impacts and restoration needs.

Subwatershed nitrogen loading rates ranged from 6.5 to 15.1 lbs/acre/year. The following point system was used to assign nitrogen load scores to the eight subwatersheds based on the range and distribution of subwatershed nitrogen loading rates:

- > 12 lbs/acres/year = 4 pts;
- 11.0 – 12.0 lbs/acre/year = 3 pts;
- 9.0 – 10.9 lbs/acre/year = 2 pts;
- < 9.0 lbs/acre/year = 1 pt.

Subwatershed phosphorus loading rates ranged from 0.24 – 1.12 lbs/acre/year. The following point system was used to assign phosphorus load scores to the eight subwatersheds based on the range and distribution of subwatershed phosphorus loading rates:

- ≥ 0.60 lbs/acres/year = 4 pts;
- 0.50 – 0.60 lbs/acre/year = 3 pts;
- 0.40 – 0.49 lbs/acre/year = 2 pts;
- ≤ 0.40 lbs/acre/year = 1 pt.

Nitrogen and phosphorus loading rates and corresponding scores are summarized in Table 4-1 by subwatershed.

Table 4-1: Nitrogen and Phosphorus Load Scores

Subwatershed	Nitrogen Loading Rate (lbs/acre/yr)	Nitrogen Load Score	Phosphorus Loading Rate (lbs/acre/yr)	Phosphorus Load Score
Ben's Run	9.36	2	0.44	2
Brice Run	9.95	2	0.50	3
Falls Run	10.22	2	0.42	2
Granite Branch	11.37	3	0.56	3
Mardella Run	11.84	3	0.52	3
Patapsco River (N.Br)	7.72	1	0.37	1
Patapsco River-E	6.54	1	0.24	1
Powells Run	15.14	4	1.12	4

4.2.2 Impervious Surfaces

Various studies have shown a correlation between the amount of impervious surface within a watershed and water quality degradation. Impervious surfaces prevent precipitation from naturally infiltrating into the ground, which prohibits the natural filtration of pollutants and conveys concentrated, accelerated stormwater runoff directly to the stream system. Consequently, stormwater runoff from impervious surfaces can cause stream erosion and habitat destruction from the high energy flow, and is likely more polluted than runoff generated from pervious areas. Undeveloped watersheds with small amounts of impervious cover are more likely to have better water quality in local streams than urbanized watersheds with greater amounts of impervious cover.

As described in the Watershed Characterization Report (Appendix E), roads and buildings data layers were used to derive impervious surface areas and the percent impervious area for each subwatershed. Similar to the pollutant load criteria, percentages of impervious area for subwatersheds were used to assign scores, as this indicator allows a direct comparison between the seven subwatersheds. Subwatersheds with higher percentages of impervious cover are higher priorities for restoration and were assigned high scores to denote greater water quality impacts and restoration needs.

Impervious surfaces cover about 6.6% of the overall Upper Patapsco River watershed. Subwatershed impervious values range from approximately 2% to 12%. The following point system was used to assign percent impervious scores to the eight subwatersheds based on CWP's Impervious Cover model (see Chapter 2.3.3 of Appendix E) and subwatershed impervious surface percentages:

- > 25% = 4 pts;
- 16 – 25% = 3 pts;
- 11 – 15% = 2 pts;
- < 11% = 1 pt.

Percent impervious values and corresponding scores are summarized in Table 4-2 by subwatershed.

Table 4-2: Percent Impervious Cover Scores

Subwatershed	% Impervious	% Impervious Score
Ben's Run	12.1%	2
Brice Run	6.6%	1
Falls Run	5.0%	1
Granite Branch	4.1%	1
Mardella Run	8.1%	1
Patapsco River (N.Br)	1.9%	1
Patapsco River-E	3.2%	1
Powells Run	5.8%	1

4.2.2 Neighborhood Pollution Source/Restoration Opportunity Indices

As described in the Watershed Characterization Report, neighborhood pollution severity and restoration potential were rated during neighborhood source assessments (NSA). The severity of potential pollution generated by a neighborhood is denoted by the Pollution Severity Index (PSI) and was rated as severe, high, moderate, or none. A neighborhood's potential for residential restoration projects was also rated as high, moderate, or low according to the Restoration Opportunity Index (ROI). None of the 20 neighborhoods assessed received a PSI rating of severe. Two were rated as high for both PSI and ROI, and 4 neighborhoods were rated as a high PSI with a moderate ROI. Neighborhoods with high PSI and high ROI ratings represent the best areas to initially target for restoration. Neighborhoods that had PSI ratings of low were discarded from this ranking.

Subwatersheds with the most neighborhoods rated as high for both pollution severity and restoration potential received the highest score (4 points). Subwatersheds with a single neighborhood rated as high for both pollution severity and restoration received the second highest score (3 points). Subwatersheds with no neighborhoods rated as high for both PSI and ROI but with five or more neighborhoods rated as high for pollution severity and moderate for restoration potential, or moderate for pollution severity and high for restoration potential, were assigned the third highest score or moderate for (2 points). All other subwatersheds were assigned 1 point unless they had no NSA areas (0 points).

The following point system summarizes PSI/ROI rating scores to the seven subwatersheds:

- High/High; ≥2 NSAs = 4 pts;
- High/High; 1 NSA = 3 pts;
- High/Moderate or Moderate/High; >5 NSAs = 2 pts;
- All other ratings = 1 pt.
- No NSAs = 0 pt.

The number of NSAs associated with various PSI/ROI ratings and corresponding PSI/ROI scores are summarized by subwatershed in Table 4-3.

Table 4-3: NSA PSI/ROI Scores

Subwatershed	# of NSAs by PSI/ROI Rating			NSA PSI/ROI Score
	High/ High	High/ Moderate	Moderate/ High	
Ben's Run	1	1	1	3
Brice Run	0	1	0	1
Falls Run	0	0	0	0
Granite Branch	1	0	0	1
Mardella Run	0	1	1	2
Patapsco River (N.Br)	0	0	0	0
Patapsco River-E	0	1	0	1
Powells Run	0	0	0	0
Total	2	4	2	8

4.2.3 Neighborhood Downspout Disconnection

Connected downspouts discharge rooftop runoff either directly to the storm drain system or to impervious surfaces. In either case, there is little to no treatment of stormwater runoff before it reaches the stream system. Disconnected downspouts drain to pervious areas such as yards and

lawns, rain barrels, or rain gardens, all of which allow rooftop runoff to infiltrate into the ground and enter streams through the groundwater system in a slower, more natural fashion. Downspout disconnection is desirable because it decreases flow and reduces pollutant loads to streams during storm events.

Downspout disconnection was recommended for neighborhoods where at least 25 percent of the downspouts are connected to impervious area or directly to the storm drain system and where the average lot has at least 15 feet of pervious area available down gradient from the connected downspout for redirection. Similar to lawn fertilizer reduction, this criterion is used for subwatershed prioritization because it has a quantitative pollution reduction efficiency related to nutrient reduction goals.

The acres of rooftop that would be addressed if downspout disconnection were initiated in the recommended neighborhoods were calculated in the Watershed Characterization Report. The percentage of subwatershed rooftop area addressed was also calculated and used to compare the restoration potential among the seven subwatersheds. Subwatersheds with the highest percentages of impervious rooftop acres and greatest acres of rooftop addressed through downspout disconnection denote the greatest restoration potential and therefore, received the highest scores. Rooftop areas addressed through downspout disconnection range from approximately 0% to 19.9%, by subwatershed.

The following point system was used to assign downspout disconnection scores to the seven subwatersheds based on the distribution and range of percentages of subwatershed rooftop area addressed:

- ≥ 20% and ≥ 15 acres = 4 pts;
- ≥ 35% and 5 - 15 acres = 3 pts;
- ≥ 10% = 2 pts;
- <10% = 1 pt.

Percentage of rooftop area addressed by downspout disconnection and corresponding scores are summarized by subwatershed in Table 4-4.

Table 4-4: NSA Downspout Disconnection Scores

Subwatershed	Rooftop Acres Addressed	% of Total NSA Rooftop Acres Addressed	NSA Downspout Disconnection Score
Ben's Run	9.01	19.9%	2
Brice Run	0.15	1.3%	1
Falls Run	0.31	3.0%	1
Granite Branch	0.00	0.0%	0
Mardella Run	4.28	13.3%	2
Patapsco River (N.Br)	0.00	0.0%	0
Patapsco River-E	0.17	5.0%	1
Powells Run	0.00	0.0%	0
Total	13.92	13.1%	7

4.2.4 Institutional Site Index

Institutions offer unique opportunities for watershed restoration. Typically, institutional properties encompass considerable portions of land that contain various natural resources. In addition, they offer the opportunity to engage a wide range of citizens in restoration activities. This raises community awareness while also providing water quality improvement benefits in the watershed. A total of 20 community-based facilities were surveyed during Institutional Site Investigations (ISIs) including faith-based facilities, public schools, and municipal facilities (e.g., swim clubs). The focus of an ISI is to identify potential restoration opportunities, particularly those with opportunities both for community education and water quality benefits. Subwatersheds with more institutional sites present more opportunities for implementing restoration actions (e.g., tree planting, stormwater retrofits, community cleanups, etc.) and encouraging citizen participation. Public institutional sites are good candidates for initial restoration efforts because there are opportunities to make use of and build upon existing partnerships, and in many cases, incorporate student projects. While private institutions also have restoration potential, they will require a different approach and the development of new partnerships to implement restoration efforts.

For all of these reasons, prioritization for this criterion was based on the number of institutions and ownership (public versus private), according to the following point system:

- At least 2 public ISIs = 4 pts;
- 1 public ISI = 3 pts;
- Only private ISIs = 2 pts;
- No ISIs = 1 pt.

The total numbers of institutions, including ownership and corresponding institutional site index scores, are summarized by subwatershed in Table 4-5

Table 4-5: ISI Scores

Subwatershed	# of Public ISIs	# of Private ISIs	Total # of ISIs	ISI Score
Ben's Run	5	5	10	4
Brice Run	0	3	3	2
Falls Run	0	0	0	0
Granite Branch	0	0	0	1
Mardella Run	1	1	2	3
Patapsco River (N.Br)	0	0	0	0
Patapsco River-E	0	0	0	0
Powells Run	0	1	1	2
Total	6	10	16	12

4.2.5 Pervious Area Reforestation

The most likely candidates for successful pervious area reforestation efforts are those on public lands with minimal site preparation required. Public sites are eligible for tree planting through DNR's "Tree-Mendous Maryland" program and are good opportunities for volunteer or community projects. Privately-owned lands are often planned for future development or expansion of an existing facility. In addition, larger open parcels have greater potential for reforestation and water quality benefits than smaller areas.

Subwatershed prioritization related to pervious area reforestation was based on the total acres of reforestation recommended during PAAs. Recommended acreage for reforestation all fell within four of the seven subwatersheds. Scoring for this criterion is as follows:

- ≥ 40 acres = 4 pts;
- ≥ 10 acres = 3 pts;
- > 0 acres = 2 pts;
- 0 acres = 1 pts.

Pervious reforestation acreages and corresponding scores are summarized by subwatershed in Table 4-6.

Table 4-6: Pervious Area Reforestation Scores

Subwatershed	Acres Recommended for Reforestation	Pervious Area Reforestation Score
Ben's Run	6.16	2
Brice Run	0	1
Falls Run	0	1
Granite Branch	0	1
Mardella Run	5.36	2
Patapsco River (N.Br)	3.24	2
Patapsco River-E	48.04	4
Powells Run	0	1
Total	62.80	14

4.2.6 Stormwater Pond Conversions

Existing dry detention ponds within the Upper Patapsco River watershed were investigated for potential conversion to water quality management facilities. Dry ponds were assessed since they have the greatest potential for conversion to a type of facility, such as a dry extended detention facility, that provides water quality benefits in addition to quantity control. Dry extended detention ponds are designed to capture and retain stormwater runoff from a storm for a minimum duration, in order to allow sediment and pollutants to settle out while also providing flood control. Of the 37 dry ponds in the watershed, 11 were found to have potential for conversion to an extended detention facility with sand filters.

The following point system was used to assign stormwater conversion scores to the seven subwatersheds based on conversion potential of ponds within the subwatershed:

- ≥ 1 pond selected for conversion = 4 pts;
- 1 pond selected for conversion = 2 pts;
- No ponds selected for conversion = 1 pt;
- No ponds in subwatershed = 0 pts.

The number of dry ponds and their conversion potential, along with corresponding scores are summarized by subwatershed in Table 4-7.

Table 4-7: Stormwater Pond Conversion Scores

Subwatershed	# of Dry Ponds in Subwatershed	# of Dry Ponds Selected for Conversion	Stormwater Pond Conversion Score
Ben's Run	20	5	4
Brice Run	4	1	2
Falls Run	4	0	1
Granite Branch	2	1	2
Mardella Run	4	4	4
Patapsco River (N.Br)	0	0	0
Patapsco River-E	2	0	1
Powells Run	1	0	1
Total	37	11	15

4.2.7 Illicit Discharge Data

Baltimore County tracks illicit discharges through a program of routine outfall screening. Illicit discharges refer to any inputs to the storm sewer system that are not stormwater, or otherwise permitted (illicit discharges may also include leaky or incorrectly connected pipes). The County has an outfall prioritization system based on data from the outfall screening. Under this system, major outfalls are assigned one of the following priority ratings: none, low, high, or critical. Critical outfalls are those with major problems that require immediate correction and/or close monitoring, or outfalls with recurring problems. These are sampled the most frequently (four times per year). On the other end of the rating scheme, outfalls that are not prioritized have insufficient data to determine a priority rating. More information regarding the County's outfall screening and prioritization system is included in the Watershed Characterization Report (Appendix E).

There are 13 major outfalls in the Upper Patapsco River watershed. Subwatersheds with the most illicit discharge data and highest prioritization ratings represent the best areas to target for restoration initially. The following point system was used to rank illicit discharge connection data scores in the seven subwatersheds based on the number of major outfalls and their prioritization rankings:

- ≥ 2 outfalls ranked Critical = 4 pts;
- = 1 outfall ranked Critical = 3 pts;
- ≥ 1 outfalls ranked High = 2 pts;
- No ranked outfalls = 1 pt;
- No outfalls = 0 pts.

The number of major outfalls associated with various County outfall prioritization ratings and corresponding illicit discharge data scores are summarized by subwatershed in Table 4-8.

Table 4-8: Illicit Discharge Data Scores

Subwatershed	County Outfall Prioritization Rankings				Illicit Discharge Data Score
	Critical	High	Low	None	
Ben's Run	0	2	0	15	2
Brice Run	0	0	0	0	0
Falls Run	0	0	0	5	0
Granite Branch	0	0	0	5	0
Mardella Run	0	1	0	19	2
Patapsco River (N.Br)	0	0	0	0	0
Patapsco River-E	0	0	0	0	0
Powells Run	0	0	0	4	0
Total	0	3	0	48	4

4.2.8 Stream Buffer Improvements

Forested buffers along streams play a crucial role in improving water quality and flood mitigation. They can reduce surface runoff and pollutant loads, stabilize stream banks, trap sediment, and provide habitat for various types of terrestrial and aquatic life, including fish. Maintaining healthy streams and forest buffers is important for reducing nutrient and sediment loadings to the Patapsco River and the Chesapeake Bay. When forested stream buffers are cleared and developed, their beneficial functions are lost and stream health declines. Riparian buffer zones can be re-established or preserved as a BMP, reducing land use impacts by intercepting and controlling pollutants entering a water body.

In the Watershed Characterization Report, the vegetative condition of a 100-foot buffer zone on either side of the stream system was analyzed. Three conditions were used to classify stream buffer conditions: impervious, open pervious, or forested. For each subwatershed, acreages and percentages of stream buffer area were determined for the three conditions. Open pervious areas (e.g., mowed lawns) represent the greatest potential for stream buffer reforestation. Subwatersheds with greater percentages of open pervious buffer areas denote the greatest potential for stream buffer improvement and were scored the highest.

Open pervious buffer area ranges from 15% to 28% of the buffer zone. The following point system was used to assign stream buffer improvement scores to the seven subwatersheds based on the distribution and range of open pervious buffer area percentages:

- > 27% = 4 pts;
- 25-27% = 3 pts;
- 20-25% = 2 pts;
- < 20% = 1 pt.

Percentages of open pervious stream buffer areas and corresponding scores are summarized by subwatershed in Table 4-9.

Table 4-9: Stream Buffer Improvement Scores

Subwatershed	% Open Pervious Stream Buffer Area	Stream Buffer Improvement Score
Ben's Run	21.57	2
Brice Run	20.84	2
Falls Run	27.34	4
Granite Branch	23.53	2
Mardella Run	27.52	4
Patapsco River (N.Br)	15.40	1
Patapsco River-E	20.48	2
Powells Run	18.58	1

4.2.9 Stream Restoration Potential

In Section 3.6 of the Watershed Characterization Report (Appendix E), the Patapsco River Water Quality Management Study (WQMS) by Tetra Tech (2000) was reviewed. The purpose of this review was to identify previously recommended stream restoration projects that were the best opportunities for future restoration efforts. The stabilization of streambanks and other channel restoration measures can provide numerous benefits, including nutrient and sediment load reductions and improved habitat health for aquatic biota.

The length of stream restoration recommended, not including those subwatersheds without restoration recommendations, ranged from 600 feet to over 4,500 feet. Extensive stream restoration projects have already been undertaken in the Ben's Run subwatershed, where 2,000 linear feet were restored in the headwaters. There were no stream restoration opportunities identified in the Granite Branch and Patapsco River (N. Br) subwatersheds. The following point system was used to assign stream restoration potential scores to the seven subwatersheds based on the distribution and range of length of recommended stream restoration:

- ≥ 3,500 feet = 4 pts;
- 2,000 – 3,499 feet = 3 pts;
- 1,000 – 1,999 feet = 2 pts;
- ≤ 1,000 feet = 1 pt.;
- No restoration recommended in subwatershed = 0 pts.

The lengths of streams exhibiting erosion or alterations, which may have potential for restoration, are summarized by subwatershed in Table 4-10 along with corresponding scores.

4.2.10 Subwatershed Prioritization Summary

The Upper Patapsco River watershed comprises eight subwatersheds that are ranked according to the total restoration prioritization score (i.e., the sum of prioritization criterion scores). Subwatershed restoration ranking results are summarized in Table 4-11 including individual criterion scores, total scores, and rankings by subwatershed. In the event of a subwatershed rank tie, rankings were then decided based on area.

Table 4-10: Stream Restoration Potential Scores

Subwatershed	Linear Feet of Stream Restoration Recommended	Stream Restoration Potential Score
Ben's Run	3,450	3
Brice Run	4,508	4
Falls Run	3,600	4
Granite Branch	0	0
Mardella Run	3,450	3
Patapsco River (N.Br)	0	0
Patapsco River-E	600	1
Powells Run	1,950	2
Total	15,558	17

Table 4-11: Subwatershed Ranking Results

Subwatershed	Nitrogen Load	Phosphorus Load	% Impervious Cover	NSA PSI/ROI	NSA Downspout Disconnection	ISI Site Index	Pervious Area Reforestation	Stormwater Conversion	Illicit Discharge Data	Stream Buffer Improvement	Stream Restoration Potential	TOTAL SCORE	SUBWATERSHED RANK
Ben's Run	2	2	2	3	2	4	2	4	2	2	3	28	2
Brice Run	2	3	1	1	1	2	1	2	0	2	4	19	3
Falls Run	2	2	1	0	1	0	1	1	0	4	4	16	4
Granite Branch	3	3	1	1	0	0	1	2	0	2	0	13	7
Mardella Run	3	3	1	2	2	3	2	4	2	4	3	29	1
Patapsco River (N.Br)	1	1	1	0	0	0	2	0	0	1	0	6	8
Patapsco River-E	1	1	1	1	1	0	4	1	0	2	1	13	6
Powells Run	4	4	1	0	0	2	1	1	0	1	2	16	5
Total	**18**	**19**	**9**	**8**	**7**	**11**	**14**	**15**	**4**	**18**	**17**		

Subwatersheds were placed into one of four restoration priority categories based on ranking results: very high, high, medium, and low. These results are summarized in Table 4-12 and illustrated in Figure 4-2.

Subwatersheds with a total prioritization score greater than 25 received a priority rating of Very High (Ben's Run and Mardella Run). A rating of High was assigned to the only subwatershed (Brice Run) with total prioritization score of 19-25. Subwatersheds with a total score of 14-18 received ratings of Medium (Falls Run, Granite Branch, and Powells Run). Subwatersheds with total prioritization scores of less than 14 were assigned a priority rating of Low (Patapsco River (N. Br) and Patapsco River-E). Restoration actions will have to occur throughout the entire Upper Patapsco River watershed in order to meet environmental goals and requirements. However, subwatershed prioritization provides a tool/framework for focusing initial restoration efforts.

Table 4-12: Subwatershed Restoration Prioritization

Rank	Subwatershed	Total Score	Prioritization Category
1	Mardella Run	29	Very High
2	Ben's Run	28	Very High
3	Brice Run	19	High
4	Falls Run	16	Medium
5	Powells Run	16	Medium
6	Patapsco River-E	13	Low
7	Granite Branch	13	Low
8	Patapsco River (N.Br.)	6	Low

As noted in the goals for the SWAP laid out in Chapter 2, in addition to improving the quality of Upper Patapsco River and the impaired sections of the watershed it is also important to protect those areas that are in good condition. Degradation of streams and subwatersheds that are in relatively good condition already will only make attaining the goals set for the Upper Patapsco River watershed that much harder. For this reason, the subwatersheds were also ranked in order of protection priorities (Table 4-13). Identifying these subwatersheds is simply a matter of reversing the subwatershed restoration prioritization. For example, a watershed with a lesser amount of impervious surface and fewer areas of inadequate stream buffer would receive fewer points, indicating less impairment and degradation. These subwatersheds would be ideal targets for protective measures such as pursuing conservation easements and enforcing stricter riparian buffer regulations.

Table 4-13: Subwatershed Protection Prioritization

Rank	Subwatershed	Total Score	Prioritization Category
2	Ben's Run	28	Low
3	Brice Run	19	Medium
4	Falls Run	16	High
7	Granite Branch	13	Very High
1	Mardella Run	29	Low
8	Patapsco River (N.Br)	6	Very High
6	Patapsco River-E	13	Very High
5	Powells Run	16	High

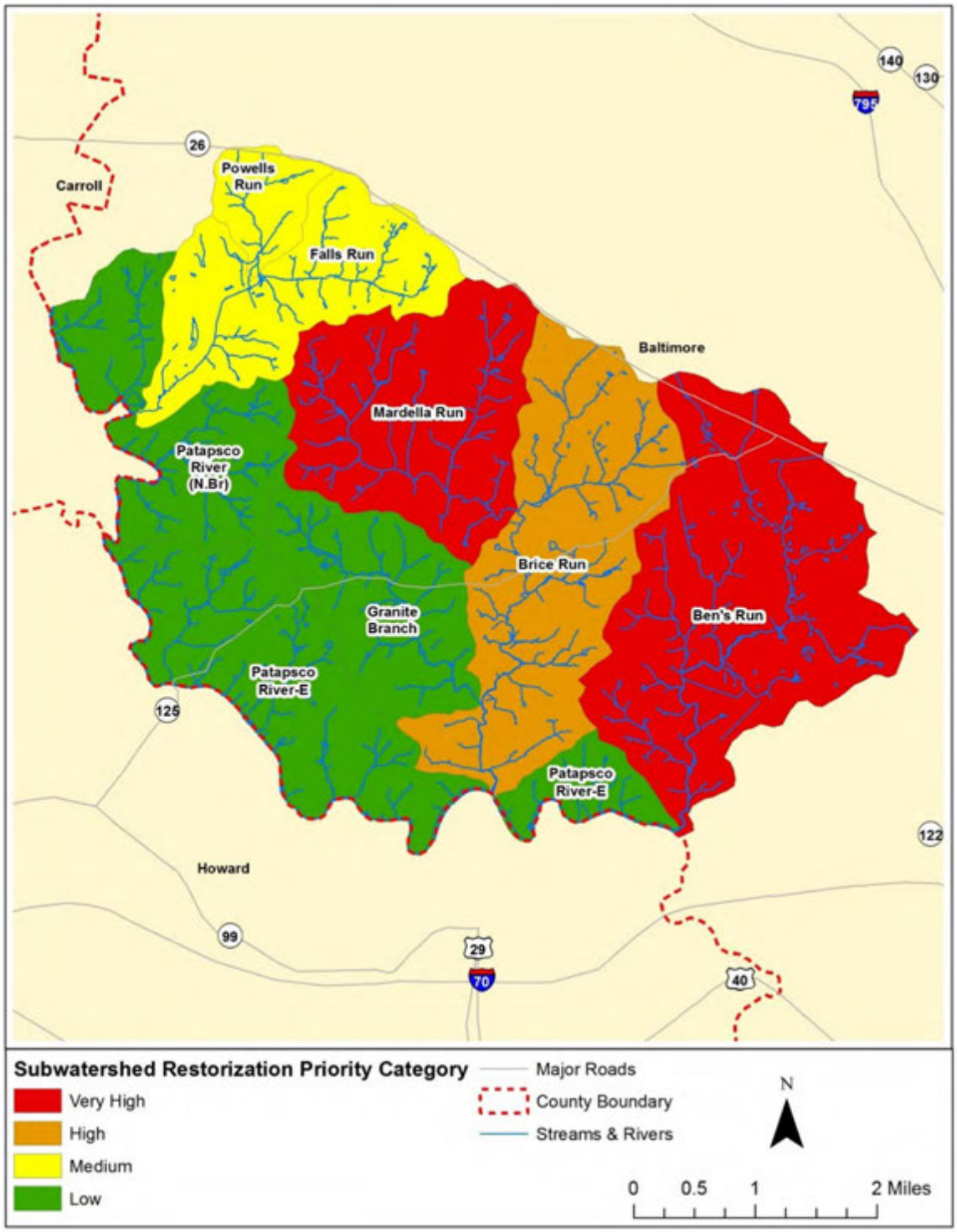

Figure 4-2: Upper Patapsco River Subwatershed Restoration Prioritization

4.3 SUBWATERSHED RESTORATION STRATEGIES

Restoration strategies for each subwatershed are presented in the following subsections. Subwatersheds are presented in order of their "Subwatershed Code," a number assigned to the watershed by Baltimore County. A description of key watershed characteristics is presented for each subwatershed including drainage area, stream length, population, land use/land cover, impervious cover, soils, and stormwater management (SWM) facilities. Assessment results for neighborhoods, hotspots, institutions, pervious areas, potential stream restoration sites, illicit discharges, and stormwater conversions are also summarized for each subwatershed. Details on these assessment techniques can be found in Chapter 4 of the Watershed Characterization Report (Appendix E). Finally, a subwatershed management strategy including recommended citizen and municipal actions is presented at the end of each subsection.

Note that because there are numerous operations in the Upper Patapsco River watershed that might qualify as stormwater hotspots, not all could be individually evaluated during the uplands survey. Hotspot Site Investigations (HSIs) were focused on 21 sites identified through desktop GIS analysis and through crew leaders' best professional judgment. This sample assessment is intended to represent common types of hotspot operations located throughout the watershed and help develop an overall strategy to encompass all hotspot operations occurring in the watershed.

Likewise, there are a large number of institutions (i.e. community-based facilities) in the Upper Patapsco River watershed; however, only 16 of those were surveyed in order to determine which retrofit and restoration strategies are best-suited to the Upper Patapsco River SWAP area. In order to be as representative as possible, a range of institutions were surveyed, including faith-based facilities, public schools, and municipal facilities.

On a similar note, there are various open pervious areas throughout the watershed with reforestation potential. Nine pervious area assessments (PAAs) were conducted, via desktop analysis, all of which are large (< 1 acre) open parcels, and most with minimal site preparation required for reforestation. PAA priority was determined using a rubric score based on parameters for stream buffer presence and length, proximity to forest interior, exterior forest gap, planting area and ownership. Assessment parameters and scores are shown in Table 4-14 below. Five of these PAAs were ranked as medium priority opportunities for reforestation, and four as low priority opportunities, although there are likely many more opportunities throughout the watershed. Low priority equates to a restoration score of 0-32, medium priority equates to 33-66, and high priority equates to 67-100.

Table 4-14: Parameters and Scores for Pervious Area Assessment

Parameter	Points
A. Is there:	
• a stream on the property with no forest buffer?	10
• a stream on or adjacent to the property with an inadequate forest buffer (< 100') and potential to expand it?	5
• no unforested stream or stream buffer (Skip to C)	0
B. Length of stream that could be buffered?	
> 2,500'	25
1,000-2,500'	20
500-1,000'	15
< 500'	10
C. Is the property: (pick one)	
• contiguous to existing forest with the potential to expand interior forest acreage?	15
• contiguous to existing forest (w/out the potential to expand interior forest)?	5
• not contiguous with any forest?	0
D. Is the area in an exterior forest gap?	
Yes	15
No	0
E. Size of potential planting area?	
> 25 acres	25
10 – 24.9 acres	20
5.0 – 9.9 acres	15
2 – 4.9 acres	10
< 2 acres	5
F. Ownership	
Public	10
Private	0
Restoration Score	=Total Points

4.3.1 Powells Run (Subwatershed Code 100)

Powells Run is in the northwest corner of the Upper Patapsco River watershed, and is the smallest of the eight subwatersheds in the SWAP area, and has the lowest population. This subwatershed has the smallest area of impervious surface, 24.8 acres, along with Patapsco River N. Branch (30.8 acres). Land use is primarily split up between low density residential, agriculture, and forest, although Powells Run has the lowest percentage of forest land use out of all the Upper Patapsco River subwatersheds. Table 4-15 summarizes key subwatershed characteristics of Powells Run.

Neighborhoods

No distinct neighborhoods were identified and assessed within Powells Run during the uplands assessment of the Upper Patapsco River watershed.

Hotspots

One facility was assessed in the Powells Run subwatershed during the uplands assessment of the Upper Patapsco River watershed. This facility was considered a potential hotspot. Table 4-16 summarizes Powell Run potential pollution sources from the facility visited.

Table 4-15: Key Subwatershed Characteristics – Powells Run

Drainage Area	419.37 acres (0.66 sq. mi.)	
Stream Length	3.56 miles	
Population	563 (2010 Census) 1.3 people/acre	
Land Use/Land Cover	Very Low Density Residential:	12.8%
	Low Density Residential:	38.3%
	Medium Density Residential:	0.8%
	High Density Residential:	0.0%
	Commercial:	1.4%
	Industrial:	0.0%
	Institutional:	3.4%
	Extractive:	0.0%
	Open Urban Land:	0.0%
	Agriculture:	24.1%
	Forest:	19.2%
	Barren Land:	0.0%
	Water/Wetlands:	0.0%
	Transportation:	0.0%
Impervious Cover	5.9% of subwatershed	
Soils	A Soils (low runoff potential):	0.0%
	B Soils:	79.2%
	C Soils:	20.6%
	D Soils (high runoff potential):	0.2%
SWM Facilities	5% of urban land use treated	
Restoration Priority Rating	Medium	

Table 4-16: Hotspot Summary – Powells Run

Site ID	HSI Status (# filled circles)	Description	POTENTIAL POLLUTION SOURCES						Notes
			Vehicle Operations	Outdoor Materials	Waste Management	Physical Plant	Turf / Landscaping	Stormwater	
HSI_B_121	Potential (8)	Commercial - Car maintenance and repair							Could install rain barrels on right side of business. Liquid storage containers need secondary containment devices installed.

Observations at the potential hotspot included vehicle activities (maintained, repaired and stored on site), outdoor storage of solid and liquid materials, a dumpster with a lid open, and storage without secondary containment or cover (Figure 4-3).

Figure 4-3: Dumpster with lid open and adjacent trash (left) and uncovered liquid storage containers (right).

Institutions

In the Powells Run subwatershed, field staff performed one ISI at a privately-owned place of worship. A summary of restoration opportunities that were identified at the site is presented in Table 4-17.

Table 4-17: ISI Recommendations – Powells Run

Site ID	Institution	Public/ Private	RECOMMENDED ACTIONS							Notes
			Storm Drain Marking	# Trees for Planting	Downspout Disconnection	Stormwater Retrofit	Impervious Cover Removal	Buffer Improvement	Trash Management	
ISI_B_112	Place of Worship	Private		7		✓			N/A	Bioretention at the edge of lower lot. Berm at top end of conservation area adjacent to top lot.

Investigators identified several areas that could afford better stormwater treatment practices at a place of worship (ISI_B_112). Multiple areas could accommodate tree planting efforts, and an area of bioretention could be installed between the two parking lots on the property (Figure 4-4). The large area of green space can be utilized to increase tree canopy cover, which will loosen the soil and thereby promote infiltration and slow down storm runoff and consequent erosion to receiving channels. The bioretention area will help provide reductions in pollutant concentrations, such as nutrients, hydrocarbons, metals, and suspended solids.

Figure 4-4: Bioretention installation between parking lots (left) and area eligible for tree planting efforts (right) at ISI_B_112

Pervious Areas

Pervious area restoration has the potential to convert areas of turf, often with high nutrient inputs, to forest, which can instead absorb and filter nutrients. However, no pervious areas were assessed for restoration potential in Powells Run.

Stream Restoration Recommendations

In Section 3.6 of the Watershed Characterization Report (Appendix E), a past study was reviewed: the Patapsco River Watershed Water Quality Management Plan (WQMP) by Tetra Tech (2000). The purpose of this review was to identify previously recommended stream restoration projects that were the best opportunities for future restoration efforts. 1,950 linear feet of stream in Powells Run were recommended for restoration.

Illicit Discharges

Powells Run subwatershed contains no major outfalls. Baltimore County will continue its Illicit Discharge Detection and Elimination program while seeking to improve techniques for more effective reductions of these discharges.

Stormwater Conversions

Powells Run subwatershed contains 1 stormwater management dry pond. Baltimore County EPS did not select this dry pond as a priority for conversion.

Subwatershed Management Strategy

Figure 4-5 provides a visual summary of restoration opportunities in the subwatershed.

<u>Engaging Citizens & Watershed Groups</u>

1. Engage institutional site listed in Table 4-17 in tree planting.

Municipal Actions

1. Continue to monitor conditions at potential hotspot indicated in Table 4-16.
2. Distribute pollution prevention material to commercial property owners about importance of proper trash management and outdoor material storage techniques at hotspot identified in Table 4-16.
3. Investigate feasibility of retrofits and work with the institution owners to pursue retrofit opportunities and tree planting at institution noted in Table 4-17.
4. Consider stream restoration options for the 1,950 feet of stream identified in this study.

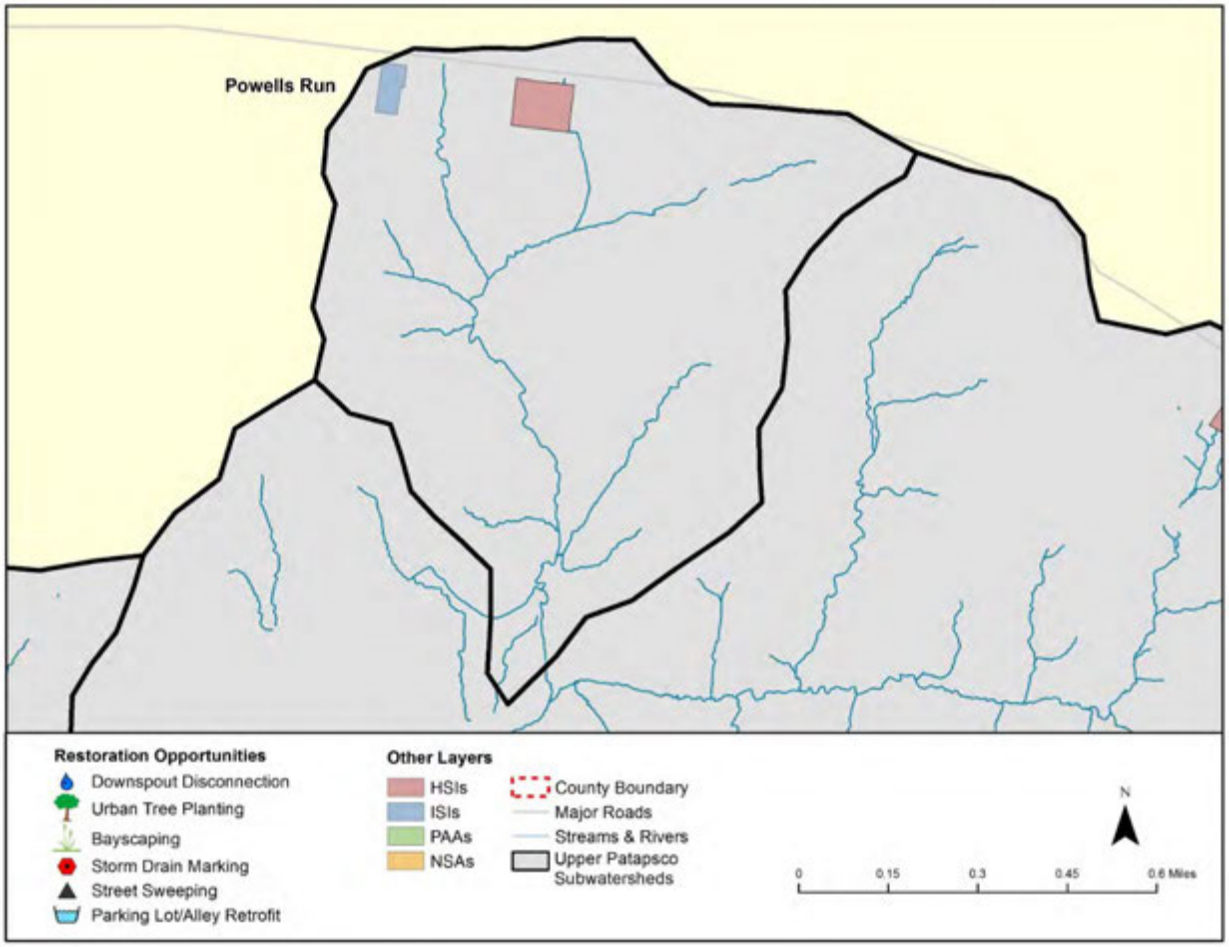

Figure 4-5: Restoration Opportunities in Powells Run

4.3.2 Falls Run (Subwatershed Code 200)

Falls Run is the fourth smallest subwatershed in the Upper Patapsco River watershed, and is located in the northwestern portion of the watershed. Land use in this subwatershed is primarily forest, low-density residential, and agriculture, though it also has the highest percentage of extractive land of any of the subwatersheds. Table 4-18 summarizes key subwatershed characteristics of Falls Run.

Table 4-18: Key Subwatershed Characteristics – Falls Run

Drainage Area	1,642.4 acres (2.57 sq. mi.)	
Stream Length	12.6 miles	
Population	2,433 (2010 Census)	
	1.5 people/acre	
Land Use/Land Cover	Very Low Density Residential:	9.5%
	Low Density Residential:	20.2%
	Medium Density Residential:	3.5%
	High Density Residential:	0.0%
	Commercial:	1.0%
	Industrial:	0.0%
	Institutional:	0.1%
	Extractive:	14.9%
	Open Urban Land:	0.0%
	Agriculture:	18.0%
	Forest:	32.6%
	Barren Land:	0.2%
	Water/Wetlands:	0.0%
	Transportation:	0.0%
Impervious Cover	4.9% of subwatershed	
Soils	A Soils (low runoff potential):	0.0%
	B Soils:	66.9%
	C Soils:	16.9%
	D Soils (high runoff potential):	16.2%
SWM Facilities	21% of urban land use treated	
Restoration Priority Rating	Medium	

Neighborhoods

One distinct neighborhood was identified and assessed within Falls Run during the uplands assessment of the Upper Patapsco River watershed. Recommendations for addressing stormwater volume and pollutants within this subwatershed include redirecting downspouts, rain barrels, storm drain marking, and Bayscaping. A summary of neighborhood recommended actions is presented in Table 4-19.

Storm drain marking is recommended throughout the neighborhood (Figure 4-6). Storm drain marking is popular because this relatively easy and inexpensive action can have a great effect by reminding residents not to dump potentially dangerous materials into the storm drain. It can also be easily paired with other education efforts, for example, with education regarding the benefits of Bayscaping and using native plants for landscaping. Rain barrels serve as temporary storage of roof runoff, decreasing the volume of stormwater running off site.

Table 4-19: NSA Recommendations – Falls Run

Site ID	Lot Size (acres)*	RECOMMENDED ACTIONS												Notes
		% Opportunity for Downspout Disconnection	Rain Barrels	Rain Gardens	Storm Drain Marking	Bayscaping	Pet Waste	Trash Management	Buffer Improvement	Parking Lot/Alley Retrofit	Street Sweeping	# of Street Trees	# of Open Space Trees	
NSA_B_19	1/2	3	✓		✓	✓						0	0	Curb and gutter only present west of Sheraton Rd. Reported possible water leak in front of 9908 Braewood Rd.

*Lot sizes are only available for single family homes – blanks indicated apartments or condominiums.

Figure 4-6: Storm Drains Recommended for Marking in NSA_B_19

Hotspots

There were a total of two facilities assessed in the Falls Run subwatershed during the uplands assessment of the Upper Patapsco River watershed. No facilities were found to be confirmed hotspots, though both were found to be potential hotspots.

Table 4-20 summarizes the potential pollution sources from facilities visited. Additional details about the hotspots visited are available in Section 4.3 of the Watershed Characterization Report (Appendix E).

Table 4-20: Hotspot Summary – Falls Run

Site ID	HSI Status (# filled circles)	Description	POTENTIAL POLLUTION SOURCES						Notes
			Vehicle Operations	Outdoor Materials	Waste Management	Physical Plant	Turf / Landscaping	Stormwater	
HSI_B_218	Potential (8)	Commercial - Towing and impound company							Owner said fueling area is being removed. Add rain barrels if runoff is not diverted to pervious/grassy area. Request better waste containment practices.
HSI_B_220	Potential (8)	Commercial - Towing, impound, and vehicle maintenance							Add rain barrels at downspouts. Check around wrecked/impounded cars for fluid leaks. Add secondary containment for liquid storage.

While neither of the locations visited required immediate response by the County, both of them exhibited poor practices that would benefit from follow up, outreach and increased education regarding waste management practices and facility hygiene. In one instance, a towing company (HSI_B_218) had no formal dumpster, with trash laying on the ground and an outside fueling area without a cover (Figure 4-7). At another location (HSI_N_220), large quantities of tires were stored on the premise without a cover and severely damaged vehicles with the potential to leak chemicals were stored without secondary containment (Figure 4-8).

Figure 4-7: Trash laying on the ground without a dumpster (left) and outside fueling area without a cover (right)

Figure 4-8: Tire storage without a cover (left) and severely damaged vehicles which could potentially leak chemicals without containment (right)

Institutions

No institutional site investigations were performed within Falls Run during the uplands assessments.

Pervious Areas

No pervious areas were assessed for restoration potential in Falls Run.

Stream Restoration Recommendations

In Section 3.6 of the Watershed Characterization Report (Appendix E), a past study was reviewed: the Patapsco River Watershed Water Quality Management Plan (WQMP) by Tetra Tech (2000). The purpose of this review was to identify previously recommended stream restoration projects that were the best opportunities for future restoration efforts. 3,600 linear feet of stream in Falls Run were recommended for restoration.

Illicit Discharges

Falls Run subwatershed contains no major outfalls. Baltimore County will continue its Illicit Discharge Detection and Elimination program while seeking to improve techniques for more effective reductions of these discharges.

Stormwater Conversions

Falls Run subwatershed contains four stormwater management dry ponds. Baltimore County EPS did not select any of these dry ponds as a priority for conversion.

Subwatershed Management Strategy

Figure 4-9 provides a visual summary of restoration opportunities in the subwatershed.

Engaging Citizens & Watershed Groups

1. Conduct appropriate downspout rain barrel installation measures in neighborhoods according to Table 4-19.
2. Engage citizens in a storm drain marking program and conduct marking activities in the neighborhoods indicated in Table 4-19.
3. Raise awareness among citizens about the benefits and importance of Bayscaping for the recommended neighborhoods in Table 4-19.

Municipal Actions

1. Continue to monitor conditions at potential hotspots indicated in Table 4-20. Pursue outreach and raise awareness regarding site housekeeping practices, and improved outdoor materials storage and vehicle operations.
2. Consider stream restoration options for the 3,600 feet of stream identified in this study.
3. Continue to monitor illicit discharges.

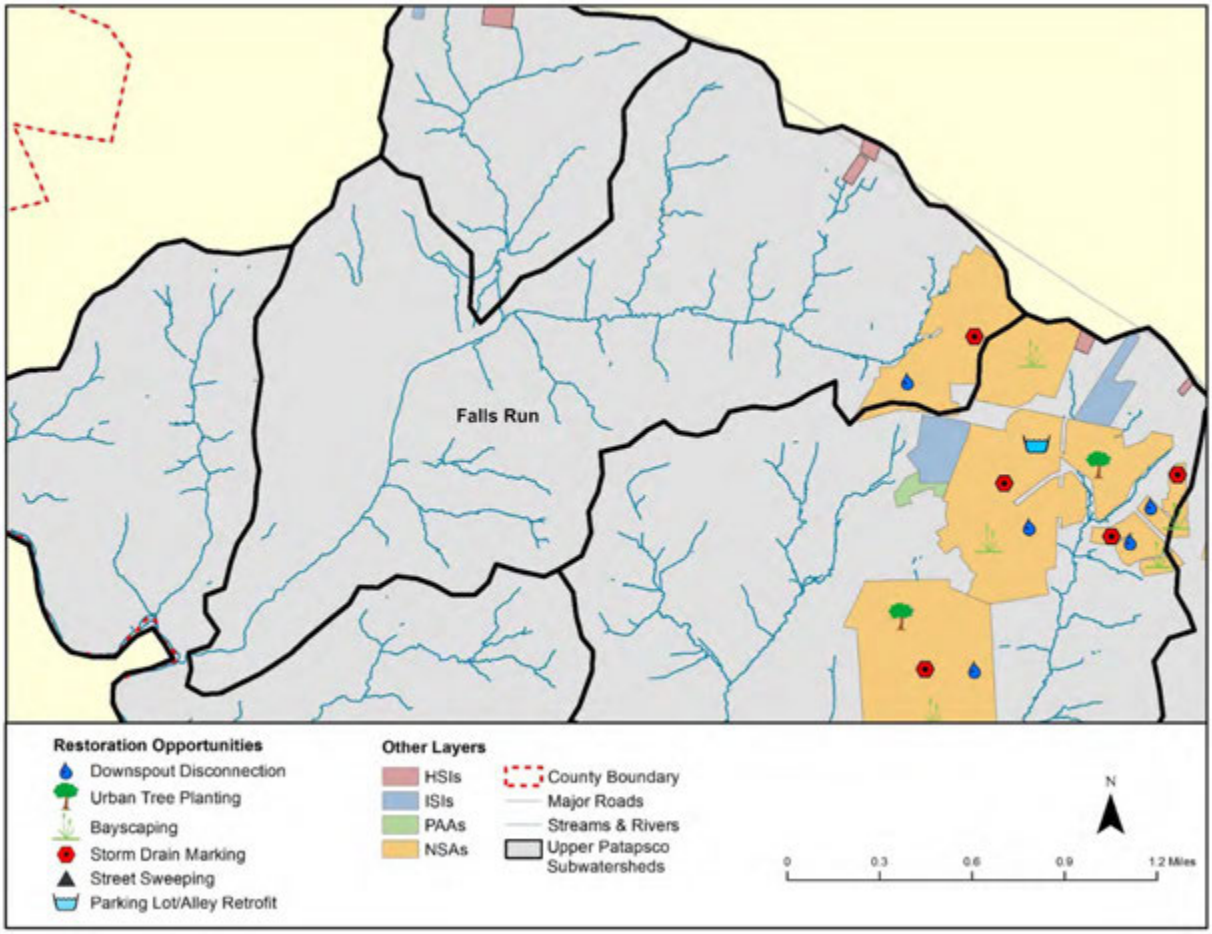

Figure 4-9: Restoration Opportunities in Falls Run

4.3.3 Patapsco River (N. Br.) (Subwatershed Code 300)

Patapsco River (N. Br.) is the third smallest subwatershed in Upper Patapsco River watershed, and is on the western edge of the watershed. Land use within the subwatershed is primarily forest; Patapsco River (N. Br.) and Patapsco River-E have the highest percentage of forest land use (~64%) of any of the subwatersheds. Patapsco River (N. Br.) has the highest percentage of barren land use, the lowest impervious percentage, and the lowest population density. Table 4-21summarizes key subwatershed characteristics of Patapsco River (N. Br.).

Table 4-21: Key Subwatershed Characteristics – Patapsco River (N. Br.)

Drainage Area	1,583.3 acres (2.47 sq. mi.)	
Stream Length	15.6 miles	
Population	951 (2010 Census)	
	0.6 people/acre	
Land Use/Land Cover	Very Low Density Residential:	6.4%
	Low Density Residential:	3.5%
	Medium Density Residential:	0.0%
	High Density Residential:	0.0%
	Commercial:	0.0%
	Industrial:	0.0%
	Institutional:	0.0%
	Extractive:	0.5%
	Open Urban Land:	0.0%
	Agriculture:	14.6%
	Forest:	63.6%
	Barren Land:	11.1%
	Water/Wetlands:	0.3%
	Transportation:	0.0%
Impervious Cover	1.9% of subwatershed	
Soils	A Soils (low runoff potential):	0.0%
	B Soils:	70.0%
	C Soils:	27.4%
	D Soils (high runoff potential):	2.6%
SWM Facilities	2% of urban land use treated	
Restoration Priority Rating	Low	

Neighborhoods

No distinct neighborhoods were identified and assessed within Patapsco River (N. Br.) during the uplands assessment of the Upper Patapsco River watershed.

Hotspots

No hotspot investigations were performed within Patapsco River (N. Br.) during the uplands assessments.

Institutions

No institutional site investigations were performed within Patapsco River (N. Br.) during the uplands assessments.

Pervious Areas

No pervious areas were assessed for restoration potential in Patapsco River (N. Br.).

Stream Restoration Recommendations

There were no stream restoration projects recommended for Patapsco River (N. Br.).

Illicit Discharges

Patapsco River (N. Br.) subwatershed contains no major outfalls. Baltimore County will continue its Illicit Discharge Detection and Elimination program while seeking to improve techniques for more effective reductions of these discharges.

Stormwater Conversions

Patapsco River (N. Br.) subwatershed contains no stormwater management dry ponds, therefore there were no dry ponds for Baltimore County EPS to select as a priority for conversion.

Subwatershed Management Strategy

As indicated in Figure 4-10, there were no restoration opportunities in this subwatershed.

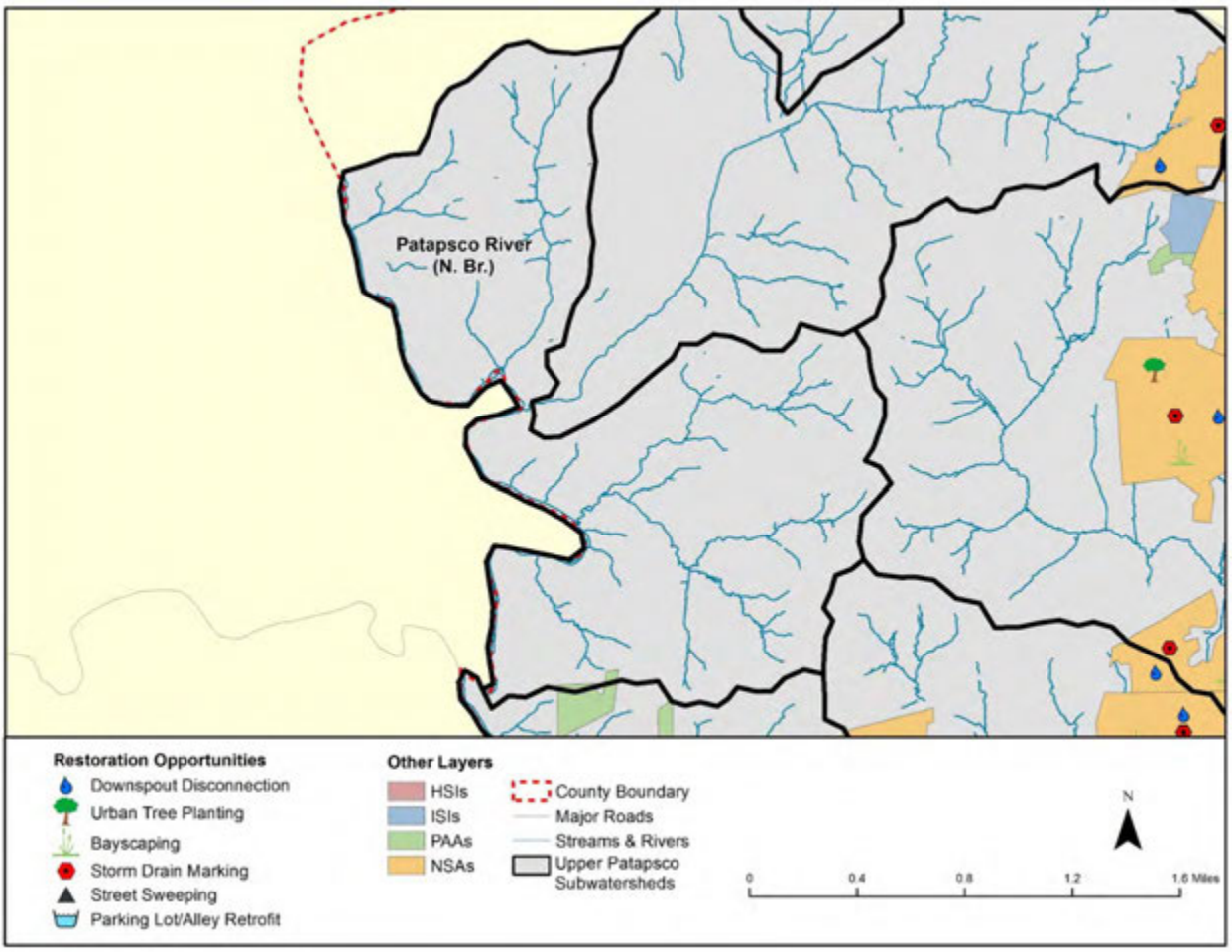

Figure 4-10: Restoration Opportunities in Patapsco River (N. Br.)

4.3.4 Mardella Run (Subwatershed Code 400)

Mardella Run is the fourth largest subwatershed with the second largest population and population density in the Upper Patapsco River watershed; it is situated in the north central portion of the watershed. The subwatershed is primarily residential, with the second highest low-density residential land use (27.4%) and medium-density residential land use (12.7%) of any subwatershed; this accounts for it also having the second largest population among the subwatersheds. Table 4-22 summarizes key subwatershed characteristics of Mardella Run.

Table 4-22: Key Subwatershed Characteristics – Mardella Run

Drainage Area	2,163.5 acres (3.38 sq. mi.)	
Stream Length	17.05 miles	
Population	6,697 (2010 Census)	
	3.1 people/acre	
Land Use/Land Cover	Very Low Density Residential:	7.0%
	Low Density Residential:	27.4%
	Medium Density Residential:	12.7%
	High Density Residential:	1.9%
	Commercial:	0.9%
	Industrial:	0.7%
	Institutional:	0.8%
	Extractive:	0.0%
	Open Urban Land:	0.2%
	Agriculture:	22.0%
	Forest:	26.3%
	Barren Land:	0.1%
	Water/Wetlands:	0.0%
	Transportation:	0.0%
Impervious Cover	8.1% of subwatershed	
Soils	A Soils (low runoff potential):	1.9%
	B Soils:	69.6%
	C Soils:	23.2%
	D Soils (high runoff potential):	5.3%
SWM Facilities	20% of urban land use treated	
Restoration Priority Rating	Very High	

Neighborhoods

A total of 5 distinct neighborhoods were identified and assessed within Mardella Run during the uplands assessment of the Upper Patapsco River watershed. Recommendations for neighborhoods in this subwatershed included: downspout disconnection, rain barrels, rain gardens, storm drain marking, improved lawn nutrient management, Bayscaping, tree planting, and parking lot and outfall retrofits. A summary of neighborhood recommended actions is presented in Table 4-23.

All of the neighborhoods assessed within Mardella Run had opportunities for improvement. In a couple of neighborhoods downspout disconnection was recommended where the average lot had at least 15 feet of pervious area available down gradient from the connected downspout for redirection (Figure 4-11). Storm drain marking was recommended in every neighborhood. Storm drain marking is popular because this relatively easy and inexpensive action can have a great effect by reminding residents not to dump potentially dangerous materials into the storm drain. It can also be easily paired with other education efforts, for example, with education regarding the effects of pet waste on water quality, in neighborhoods where both were recommended. Rain

barrels serve as temporary storage of roof runoff, decreasing the volume of stormwater running off site. One neighborhood had multiple recommendations for potential BMP retrofit opportunities (Figure 4-12).

Table 4-23: NSA Recommendations – Mardella Run

Site ID	Lot Size (acres)*	RECOMMENDED ACTIONS												Notes
		% Opportunity for Downspout Disconnection	Rain Barrels	Rain Gardens	Storm Drain Marking	Bayscaping	Pet Waste	Trash Management	Buffer Improvement	Parking Lot/Alley Retrofit	Street Sweeping	# of Street Trees	# of Open Space Trees	
NSA_B_8	1/4	15	✓		✓	✓				✓		800	0	Two cul-du-sacs have concrete islands that could be converted to rain gardens, bio-retention cells or impervious surface removal.
NSA_B_10		25	✓		✓	✓						0	0	Infrastructure for downspouts drain to the road but all have at least 15 feet of lawn available for disconnect.
NSA_B_17	>1	5	✓	✓	✓	✓						0	50	Possible BMPs on Peddicoat Ct. and Zodoc Ct.
NSA_B_11	>1	2	✓	✓	✓	✓						0	0	Large grass lots.
NSA_B_9		15	✓		✓	✓						0	0	Infrastructure for downspouts drain to the road but all have at least 15 feet of lawn available for disconnect.

*Lot sizes are only available for single family homes – blanks indicated apartments or condominiums.

Two neighborhoods were also noted as providing an opportunity to plant approximately 50 open space trees and 800 street trees (Figure 4-13). Projects on this scale may encourage widespread community engagement and are ideal opportunities for children and families to participate and become involved with their watershed in a concrete way.

Figure 4-11: Space for Downspout Disconnection Found in Some Neighborhoods Such as in NSA_B_9

Figure 4-12: Examples of Potential BMP Retrofit Opportunities Found in NSA_B_17

Figure 4-13: Excellent Opportunities for Street Tree Planting Such as at NSA_B_8 (Left) and Open Space Tree Planting Such as at NSA_B_17 (Right)

Hotspots

There were two facilities assessed in the Mardella Run subwatershed during the uplands assessment of the Upper Patapsco River watershed. Both facilities were considered to be potential hotspots. Table 4-24 summarizes the potential pollution sources from facilities visited in Mardella Run. The field crew reports are documented in Section 4.3 of the Watershed Characterization Report (Appendix E).

Table 4-24: Hotspot Summary – Mardella Run

			POTENTIAL POLLUTION SOURCES						
Site ID	HSI Status (# filled circles)	Description	Vehicle Operations	Outdoor Materials	Waste Management	Physical Plant	Turf / Landscaping	Stormwater	Notes
HSI_B_410	Potential (9)	Commercial - Vehicle maintenance							Secondary containment for batteries/used oil storage. Evidence that kitty litter is used to absorb liquids. Property shared with another auto repair shop.
HSI_B_412	Potential (6)	Commercial - Collision repair shop							Need containment for wash water coming from shed. Need better garbage storage procedures. Half of site outside of watershed, assessed full property.

The first potential hotspot (HSI_B_410) is a vehicle maintenance shop where outside storage of chemicals, car parts, and batteries were found without a cover and secondary containment (Figure 4-14). The second potential hotspot (HSI_B_412) was a collision repair center which had its dumpsters situated near a building used for washing vehicles. The dumpsters were uncovered with trash overflowing onto the ground, and wash water from the structure had evidence of wash water running out on the ground, through the dumpsters/trash, and entering a riparian area behind the business (Figure 4-15). Both businesses could benefit from increased education and outreach regarding potential pollution sources.

Figure 4-14: Chemical storage without a cover or secondary containment (left) and car parts and batteries stored outside with partial cover and no secondary containment (right)

Figure 4-15: Structure leaking wash water into dumpster area (left) and dumpsters with no lid and overflowing trash (right)

Institutions

Two institutions were assessed in Mardella Run subwatershed, consisting of a private cemetery and an elementary school. Recommended actions at the above sites are summarized in Table 4-25.

Opportunities to plant a large number of trees are available at an elementary school (ISI_B_401), and a few trees could be planted at a cemetery (ISI_B_423). At both locations, large areas of green space can be utilized to increase tree canopy cover, which will loosen the soil and thereby promote infiltration and slow down storm runoff and consequent erosion to receiving channels (Figure 4-16**,** left). Investigators identified stormwater retrofit possibilities at the elementary school. Two areas were identified for bioretention, one adjacent to the west entrance and one adjacent to the tennis courts, and one area by the faculty lot was identified as having the potential for a surface sand filter (Figure 4-16, right). Both of these stormwater retrofit types will provide reductions in pollutant concentrations, such as hydrocarbons, metals, and suspended solids.

Table 4-25: ISI Recommendations – Mardella Run

Site ID	Institution	Public/ Private	RECOMMENDED ACTIONS							Notes
			Storm Drain Marking	# Trees for Planting	Downspout Disconnection	Stormwater Retrofit	Impervious Cover Removal	Buffer Improvement	Trash Management	
ISI_B_401	School	Public	✓	72		✓				Install 3 retention areas: 1-West entry drive (bioretention), 2-Southwest faculty lot (surface sand filter), 3-Adjacent tennis court (bioretention)
ISI_B_423	Cemetery	Private		6					N/A	Suggested follow up inspection to check sediment piles in woods

Figure 4-16: Tree planting opportunities (left) and area for bioretention (right) at ISI_B_401

Pervious Areas

Pervious area restoration has the potential to convert areas of turf, often with high nutrient inputs to forest, which can absorb and filter rather than contribute nutrients. One pervious area was assessed for restoration potential in Mardella Run: a County owned open space in a neighborhood adjacent to the elementary school. This area was ranked as medium priority due to a moderately large planting area (> 5 acres) and contiguity with existing forest and the potential to expand interior forest.

A summary of the site is provided in Table 4-26.

Table 4-26: PAA Summaries – Mardella Run

Site ID	Ownership	Acres	Buffer Length	SW Retrofit Potential	A	B	C	D	E	F	Restoration Score
PAA_B_201	Public	5	0	No	0	0	15	0	15	10	40

Stream Restoration Recommendations

In Section 3.6 of the Watershed Characterization Report (Appendix E), a past study was reviewed: the Patapsco River Watershed Water Quality Management Plan (WQMP) by Tetra Tech (2000). The purpose of this review was to identify previously recommended stream restoration projects that were the best opportunities for future restoration efforts. 3,450 linear feet of stream in Mardella Run were recommended for restoration.

Illicit Discharges

Mardella Run subwatershed contains four major outfalls; two were priority 1 and two were priority 2. Priority 1 outfalls have major problems that require immediate correction and/or close monitoring, or outfalls with recurring problems. These outfalls are sampled four times each year. Priority 2 outfalls have minor to moderate problems that have the potential to become severe and are sampled once a year. Baltimore County will continue its Illicit Discharge Detection and Elimination program while seeking to improve techniques for more effective reductions of these discharges.

Stormwater Conversions

Mardella Run subwatershed contains 4 stormwater management dry ponds. Baltimore County EPS has selected all four of these dry ponds as a priority for conversion.

Subwatershed Management Strategy

Figure 4-17 provides a visual summary of restoration opportunities in the watershed.

<u>Engaging Citizens & Watershed Groups</u>

1. Conduct appropriate downspout rain barrel and rain garden installation measures in neighborhoods according to Table 4-23.
2. Engage citizens in a storm drain marking program and conduct marking activities in the neighborhoods indicated in Table 4-23.
3. Raise awareness among citizens about the benefits and importance of Bayscaping in the neighborhoods indicated in Table 4-23.
4. Raise awareness among property owners about improving stream buffer management at locations indicated in Table 4-23.
5. Encourage communities to plant open space and street trees. Table 4-23 shows potential neighborhoods for planting as many as 800 street trees and 50 open space trees.
6. Engage institutional sites listed in Table 4-25 in storm drain marking and tree planting.

Municipal Actions

1. Distribute pollution prevention material to commercial property owners about importance of proper trash management and outdoor material storage techniques at hotspots identified in Table 4-24.
2. Continue to monitor conditions at potential hotspots indicated in Table 4-24.
3. Continue to monitor illicit discharges.
4. Work with the institution owners to pursue retrofit and tree planting opportunities noted in Table 4-25.
5. Conduct follow-up investigations of outfalls as described above and in the Watershed Characterization Report.
6. Consider stream restoration options for the 3,450 feet of stream identified in this study.
7. Investigate the pervious areas described in Table 4-26 for potential tree planting.

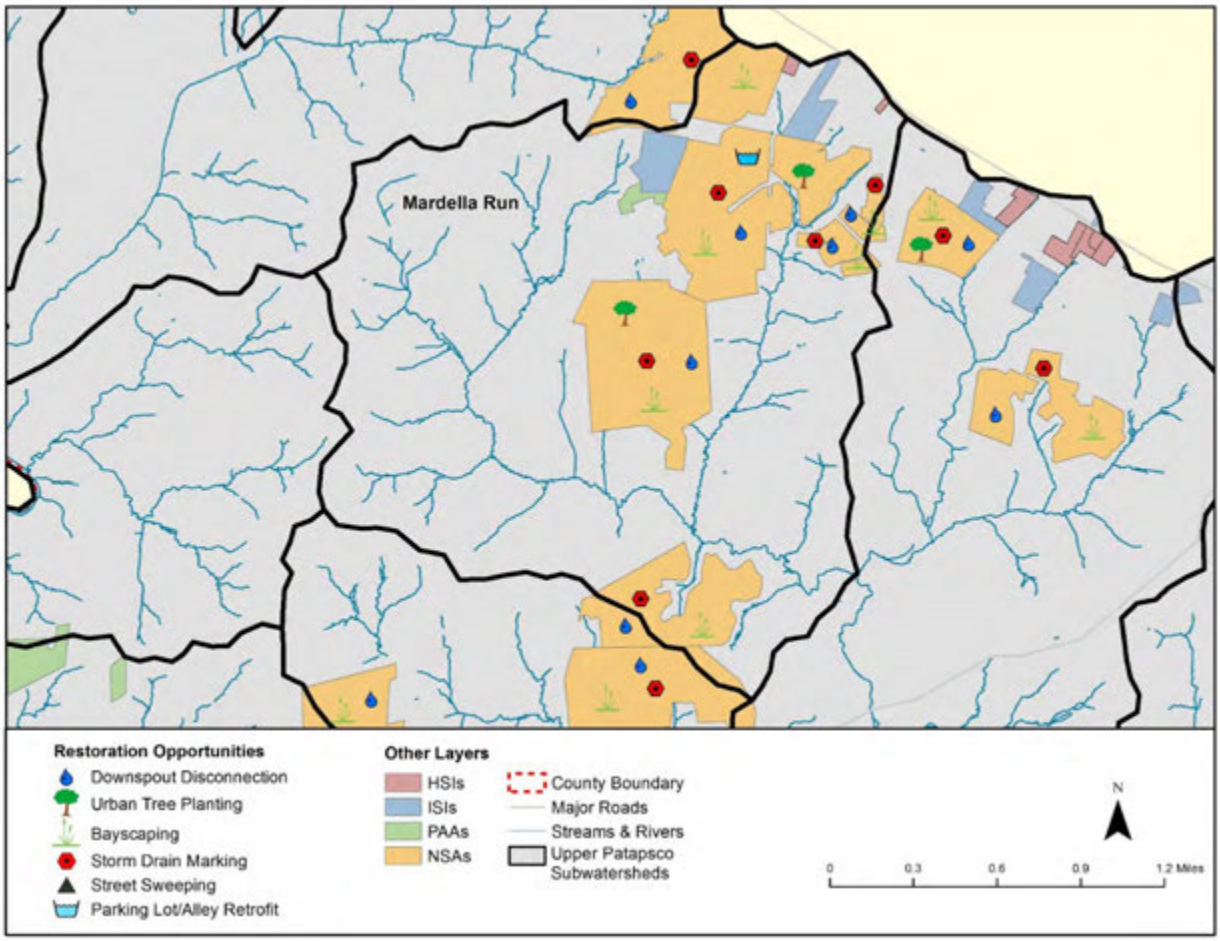

Figure 4-17: Restoration Opportunities in Mardella Run

4.3.5 Granite Branch (Subwatershed Code 500)

Granite Branch is the second smallest subwatershed and ranks third in population size and percent impervious area. The land use in this subwatershed is split between residential, forest and agriculture, although Granite Branch has the highest percentage of agricultural land use among the Upper Patapsco River subwatersheds. Table 4-27 summarizes key subwatershed characteristics of Granite Branch.

Table 4-27: Key Subwatershed Characteristics – Granite Branch

Drainage Area	1327.6 acres (2.07 sq. mi.)	
Stream Length	10.7 miles	
Population	1,889 (2010 Census)	
	1.4 people/acre	
Land Use/Land Cover	Very Low Density Residential:	14.5%
	Low Density Residential:	20.1%
	Medium Density Residential:	0.0%
	High Density Residential:	0.0%
	Commercial:	0.6%
	Industrial:	0.9%
	Institutional:	0.0%
	Extractive:	0.0%
	Open Urban Land:	0.1%
	Agriculture:	36.5%
	Forest:	27.3%
	Barren Land:	0.0%
	Water/Wetlands:	0.0%
	Transportation:	0.0%
Impervious Cover	4.2% of subwatershed	
Soils	A Soils (low runoff potential):	0.0%
	B Soils:	68.9%
	C Soils:	28.0%
	D Soils (high runoff potential):	3.1%
SWM Facilities	5% of urban land use treated	
Restoration Priority Rating	Low	

Neighborhood

Two distinct neighborhoods were identified and assessed within Granite Branch during the uplands assessment of the Upper Patapsco River watershed. Recommendations for these neighborhoods included rain barrels, rain gardens, storm drain marking, Bayscaping, and buffer improvement. A summary of neighborhood recommended actions is presented in Table 4-28.

Storm drain marking was recommended for one of the neighborhoods in this subwatershed, which offers an opportunity to not only engage residents, but to serve as a visual reminder of the downstream effects of residents' actions. It also can be combined with additional education on the benefits of rain barrels and rain gardens for local water quality and stream health. Bayscaping was also recommended in both neighborhoods (Figure 4-18). This practice provides an attractive way for landscaping to improve stormwater infiltration, nutrient absorption and pollutant filtration on-site, while also enhancing the aesthetic value of the property. In addition, the conversion of at least one existing storm water facility was recommended in one of the neighborhoods (Figure 4-19).

Table 4-28: NSA Recommendations – Granite Branch

Site ID	Lot Size (acres)*	RECOMMENDED ACTIONS												Notes
		% Opportunity for Downspout Disconnection	Rain Barrels	Rain Gardens	Storm Drain Marking	Bayscaping	Pet Waste	Trash Management	Buffer Improvement	Parking Lot/Alley Retrofit	Street Sweeping	# of Street Trees	# of Open Space Trees	
NSA_B_20	>1	0	✓	✓	✓	✓			✓			0	0	Existing storm water facilities could be converted to rain gardens.
NSA_B_7	>1	0	✓	✓		✓						0	0	-

*Lot sizes are only available for single family homes – blanks indicated apartments or condominiums.

Figure 4-18: Opportunities to Reduce Turf and Increase Native Plant Cover through Bayscaping in NSA_B_7 (Left) and NSA_B_20 (Right)

Figure 4-19: Existing Storm Water Facility Conversion Opportunity in NSA_B_20

Hotspots

No hotspot investigations were performed within Granite Branch during the uplands assessments.

Institutions

No institutional site investigations were performed within Granite Branch during the uplands assessments.

Pervious Areas

No assessments of pervious areas were performed within Granite Branch subwatershed during the uplands assessments.

Stream Restoration Recommendations

In Section 3.6 of the Watershed Characterization Report (Appendix E), a past study was reviewed: the Patapsco River Watershed Water Quality Management Plan (WQMP) by Tetra Tech (2000). The purpose of this review was to identify previously recommended stream restoration projects that were the best opportunities for future restoration efforts. No stream reaches in Granite Branch were recommended for restoration.

Illicit Discharges

Granite Branch subwatershed contains no major outfalls. Baltimore County will continue its Illicit Discharge Detection and Elimination program while seeking to improve techniques for more effective reductions of these discharges.

Stormwater Conversions

Granite Branch subwatershed contains 2 stormwater management dry ponds. Baltimore County EPS has selected one of these dry ponds as a priority for conversion.

Subwatershed Management Strategy

Figure 4-20 provides a visual summary of restoration opportunities in the watershed.

<u>Engaging Citizens & Watershed Groups</u>

1. Conduct appropriate downspout rain barrel and rain garden installation measures in neighborhoods according to Table 4-28.
2. Engage citizens in a storm drain marking program and conduct marking activities in according to Table 4-28.
3. Raise awareness among citizens about the benefits and importance of Bayscaping and stream buffer management according to Table 4-28.

<u>Municipal Actions</u>

1. Investigate feasibility of retrofit for NSA_B_20.

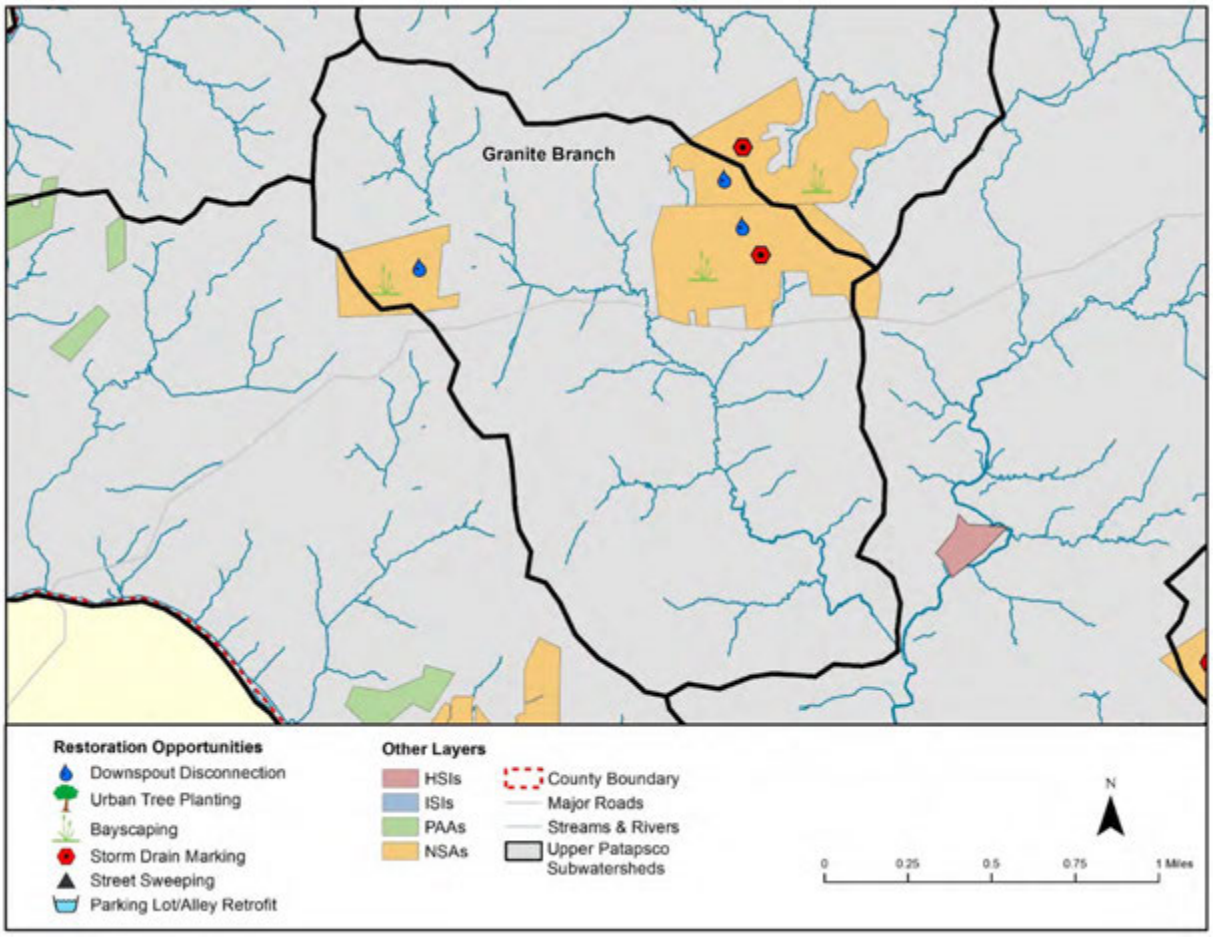

Figure 4-20: Restoration Opportunities in Granite Branch

4.3.6 Patapsco River-E (Subwatershed Code 600)

Patapsco River-E is the third largest subwatershed and covers the southern edge of the Upper Patapsco River watershed. This watershed has the second lowest population density and percent impervious area, and the highest percent forested land use among the Upper Patapsco River subwatersheds. Table 4-29 summarizes key subwatershed characteristics of Patapsco River-E.

Neighborhoods

One distinct neighborhood was identified and assessed within Patapsco River-E during the uplands assessment of the Upper Patapsco River watershed. The primary recommendations for the neighborhood in this subwatershed included rain barrels, rain garden, storm drain marking, Bayscaping, and tree planting. A summary of neighborhood recommended actions is presented in Table 4-30.

Storm drain marking was recommended for the neighborhood in this subwatershed, which offers an opportunity to not only engage residents, but to serve as a visual reminder of the downstream effects of residents' actions.

Table 4-29: Key Subwatershed Characteristics – Patapsco River-E

Drainage Area	2,491.4 acres (3.89 sq. mi.)	
Stream Length	22.6 miles	
Population	1,946 (2010 Census) 0.8 people/acre	
Land Use/Land Cover	Very Low Density Residential:	6.2%
	Low Density Residential:	18.8%
	Medium Density Residential:	0.2%
	High Density Residential:	0.5%
	Commercial:	0.0%
	Industrial:	0.0%
	Institutional:	1.2%
	Extractive:	0.0%
	Open Urban Land:	0.6%
	Agriculture:	8.8%
	Forest:	63.7%
	Barren Land:	0.0%
	Water/Wetlands:	0.0%
	Transportation:	0.0%
Impervious Cover	3.2% of subwatershed	
Soils	A Soils (low runoff potential):	0.2%
	B Soils:	79.6%
	C Soils:	19.1%
	D Soils (high runoff potential):	1.1%
SWM Facilities	37% of urban land use treated	
Restoration Priority Rating	Low	

Table 4-30: NSA Recommendations – Patapsco River-E

		RECOMMENDED ACTIONS												
Site ID	Lot Size (acres)*	% Opportunity for Downspout Disconnection	Rain Barrels	Rain Gardens	Storm Drain Marking	Bayscaping	Pet Waste	Trash Management	Buffer Improvement	Parking Lot/Alley Retrofit	Street Sweeping	# of Street Trees	# of Open Space Trees	Notes
NSA_B_6	>1	5	✓	✓	✓	✓						0	110	Opportunity for open space tree planting.

*Lot sizes are only available for single family homes – blanks indicated apartments or condominiums.

Bayscaping was recommended for this neighborhood Figure 4-21. This practice provides an attractive way for landscaping to improve stormwater infiltration, nutrient absorption and pollutant filtration on-site, while also enhancing the aesthetic value of the property. Tree planting opportunities were also recommended for the planting of more than 100 trees (Figure 4-22). Projects on this scale may encourage widespread community engagement and are ideal opportunities for children and families to participate and become involved with their watershed in

a direct way. In addition, actions as simple as adjusting mowing practices and tree plantings along stream channels and drainage ditches may help to slow down high stream flows that cause bank erosion and intercept nutrients and toxins before they enter the aquatic ecosystem.

Figure 4-21: Area Recommended for Bayscaping in NSA_B_6

Figure 4-22: Tree Planting Opportunity in NSA_B_6

Hotspots

No hotspot investigations were performed within Patapsco River-E during the uplands assessments.

Institutions

No institutional site investigations were performed within Patapsco River-E during the uplands assessments.

Pervious Areas

Four pervious area assessments were performed within Patapsco River-E subwatershed. All 4 sites were un-forested patches within a state park with unknown land use but the potential to expand interior forest acreage and reduce forest edge. All sites ranked as medium priority as shown in Table 4-31.

Table 4-31: PAA Summaries – Patapsco River-E

Site ID	Ownership	Acres	Buffer Length	SW Retrofit Potential	A	B	C	D	E	F	Restoration Score
PAA_B_606	Public	18	0	No	0	0	15	15	20	10	60
PAA_B_607	Public	21	0	No	0	0	15	15	20	10	60
PAA_B_608	Public	5	0	No	0	0	15	15	15	10	55
PAA_B_609	Public	7	0	No	0	0	15	15	15	10	55

Stream Restoration Recommendations

In Section 3.6 of the Watershed Characterization Report (Appendix E), a past study was reviewed: the Patapsco River Watershed Water Quality Management Plan (WQMP) by Tetra Tech (2000). The purpose of this review was to identify previously recommended stream restoration projects that were the best opportunities for future restoration efforts. Only 600 linear feet of stream in Granite Branch were recommended for restoration.

Illicit Discharges

There are no major outfalls in Patapsco River-E subwatershed; for that reason, illicit discharge screening is not performed in this subwatershed.

Stormwater Conversions

Patapsco River-E subwatershed contains 2 stormwater management dry ponds. Baltimore County EPS did not select either of these dry ponds as a priority for conversion.

Subwatershed Management Strategy

Figure 4-23 provides a visual summary of restoration opportunities in the watershed.

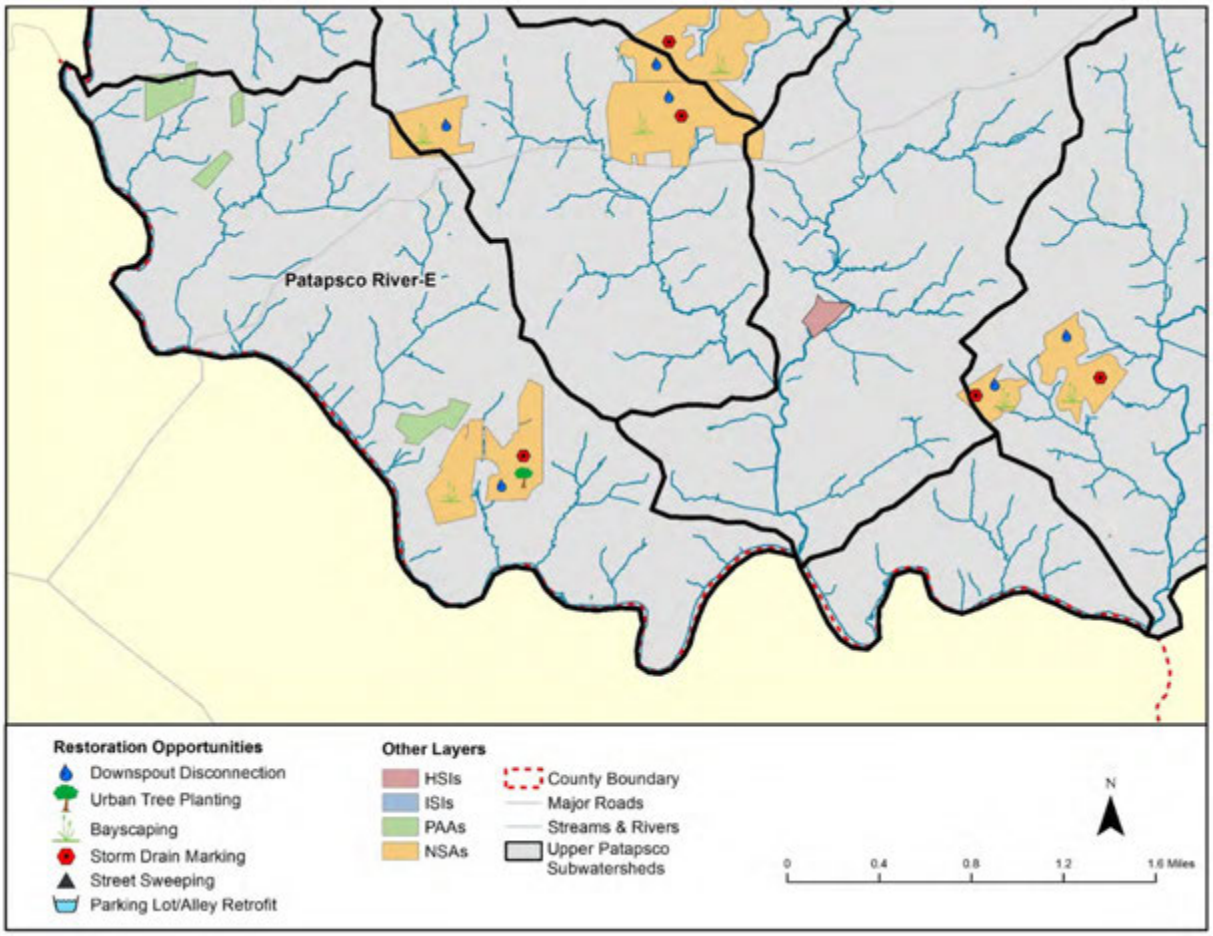

Figure 4-23: Restoration Opportunities in Patapsco River-E

Engaging Citizens & Watershed Groups

1. Conduct appropriate rain barrel and rain garden installation measures according to Table 4-30.
2. Engage citizens in a storm drain marking program and conduct marking activities according to Table 4-30.
3. Raise awareness among citizens about the benefits and importance of Bayscaping according to Table 4-30.
4. Encourage communities and neighborhoods to plant open space trees. Table 4-30 shows the potential for 110 open space trees.

Municipal Actions

1. Consider stream restoration options for the 600 feet of stream identified in this study.
2. Investigate the pervious areas described in Table 4-31 for potential tree planting.

4.3.7 Brice Run (Subwatershed Code 700)

Brice Run is the second largest subwatershed in the SWAP area and is in the central-eastern portion of the Upper Patapsco River watershed. It has the third largest population and impervious area among the subwatersheds. Land use is split between residential, agriculture and forest. Although industrial land use is small (1%), Brice Run has the highest percent of industrial land use among the subwatersheds. Over 50% of the urban land use in Brice Run is treated by SWM facilities; the highest percent in the SWAP area. Table 4-32 summarizes key subwatershed characteristics of Brice Run.

Table 4-32: Key Subwatershed Characteristics – Brice Run

Drainage Area	2,718.0 acres (4.25 sq. mi.)	
Stream Length	21.1 miles	
Population	6,094 (2010 Census)	
	2.2 people/acre	
Land Use/Land Cover	Very Low Density Residential:	9.8%
	Low Density Residential:	16.5%
	Medium Density Residential:	2.8%
	High Density Residential:	2.4%
	Commercial:	1.6%
	Industrial:	0.9%
	Institutional:	1.2%
	Extractive:	0.0%
	Open Urban Land:	0.2%
	Agriculture:	23.0%
	Forest:	40.7%
	Barren Land:	0.9%
	Water/Wetlands:	0.0%
	Transportation:	0.0%
Impervious Cover	6.8% of subwatershed	
Soils	A Soils (low runoff potential):	2.5%
	B Soils:	72.9%
	C Soils:	17.3%
	D Soils (high runoff potential):	7.3%
SWM Facilities	53% of urban land use treated	
Restoration Priority Rating	High	

Neighborhoods

Two distinct neighborhoods were identified and assessed within Brice Run during the uplands assessment of the Upper Patapsco River watershed. Recommendations for this neighborhood included rain barrels, rain gardens, storm drain marking, Bayscaping, and stream buffer improvements. A summary is presented in the Table 4-33.

Table 4-33: NSA Recommendations – Brice Run

Site ID	Lot Size (acres)*	RECOMMENDED ACTIONS												Notes
		% Opportunity for Downspout Disconnection	Rain Barrels	Rain Gardens	Storm Drain Marking	Bayscaping	Pet Waste	Trash Management	Buffer Improvement	Parking Lot/Alley Retrofit	Street Sweeping	# of Street Trees	# of Open Space Trees	
NSA_B_12		10		✓	✓	✓			✓			0	45	Opportunity for open space tree planting and rain gardens.
NSA_B_13	>1	5	✓	✓	✓	✓						0	0	Potential storm inlet retrofit.

*Lot sizes are only available for single family homes – blanks indicated apartments or condominiums.

There are several opportunities for action in the neighborhoods assessed. Rain barrels could serve as temporary storage of roof runoff, decreasing the volume of stormwater running off site. Rain gardens may provide an area for roof runoff to infiltrate, as well as plants that can absorb excess nutrients and filter out pollutants. Bayscaping was also recommended in this neighborhood (Figure 4-24). This practice provides an attractive way for landscaping to improve stormwater infiltration, nutrient absorption and pollutant filtration on-site, while also enhancing the aesthetic value of the property.

Figure 4-24: Typical Yard in NSA_B_12 (Left) and NSA_B_13 (Right) with Opportunities for Rain Barrels, Rain Gardens, and/or Bayscaping

One neighborhood had open space tree planting opportunities, though not on as large a scale (< 100 trees) as those in other subwatersheds. Still, these small-scale projects may encourage greater community engagement and are great opportunities for children and families to participate and become involved with their watershed in a direct way. In addition, actions as simple as adjusting mowing practices and tree plantings along stream channels and drainage ditches may help to slow down high stream flows that cause bank erosion and intercept nutrients and toxins before they enter the aquatic ecosystem.

Hotspots

There were seven facilities assessed in the Brice Run subwatershed during the uplands assessment of the Upper Patapsco River watershed. One facility was found to be a confirmed hotspot with immediate response needed from Baltimore County, three facilities were considered to be potential hotspots, and three facilities were found to not be hotspots. Table 4-34 summarizes the potential pollution sources from facilities visited in Brice Run. The field crew reports are documented in Section 4.3 of the Watershed Characterization Report (Appendix E).

The confirmed hotspot (HSI_B_708) was a self-service car wash. Many infractions were noted at this facility, including outdoor storage of liquids in unmarked containers and without a cover, observed detergent spilling on the pavement with obvious staining, and a non-operational sump pump which could lead to wash water overflowing into the parking lot (Figure 4-25).

Figure 4-25: Detergent spilling onto the pavement with obvious staining (left) and non-operational sump pump (right)

The first potential hotspot (HSI_B_701) was a vehicle maintenance shop where outside storage of liquids and tires were found without a cover and secondary containment (Figure 4-26). The second potential hotspot (HSI_B_706) was a vehicle dealership and repair center which had its dumpsters situated near a small tributary and were open and overflowing with trash. The facility also had outside storage of liquids that lacked a cover and secondary containment (Figure 4-27). The final potential hotspot (HSI_B_709) was a lumberyard which had an uncovered dumpster, outside storage of treated lumber without a cover, and outside storage of chemicals without secondary containment (Figure 4-28). All three facilities could benefit from increased education and outreach regarding potential pollution sources.

Table 4-34: Hotspot Summary – Brice Run

Site ID	HSI Status (# filled circles)	Description	POTENTIAL POLLUTION SOURCES						Notes
			Vehicle Operations	Outdoor Materials	Waste Management	Physical Plant	Turf / Landscaping	Stormwater	
HSI_B_701	Potential (6)	Commercial - Vehicle maintenance shop							Put in secondary containment for outdoor storage area. Install rain barrels in some downspouts.
HSI_B_706	Potential (8)	Commercial - Vehicle dealership and repair shop							Suggest moving dumpsters away from stream and put bioretention pond behind business. Add secondary contain-ment in outdoor storage area. Cover this area too.
HSI_B_707	Not a Hotspot (3)	Commercial - Storage facility		N/A					
HSI_B_708	Confirmed (10)	Commercial - Self-service car wash		✓					A few areas have potential for increased stormwater treatment. See map for more details on bioretention/ sand filter locations. Observed suds/ detergent and spilling onto parking lot, lots of staining, non-operational sump pump which may cause wash water to overflow into parking lot and into MS4. Outdoor storage of liquids in unmarked containers.
HSI_B_709	Potential (10)	Commercial - Lumberyard							Recommend to keep storm drain inlets clean. Better garbage practices. Store large dumpster under cover. Secondary contain-ment installed under flammable gas storage box. Install covers for lumber stored outside.

Table 4-34: Hotspot Summary – Brice Run

Site ID	HSI Status (# filled circles)	Description	POTENTIAL POLLUTION SOURCES						Notes
			Vehicle Operations	Outdoor Materials	Waste Management	Physical Plant	Turf / Landscaping	Stormwater	
HSI_B_725	Not a Hotspot (4)	Commercial - Nursey/Landscaping	N/A						Clean garbage up off of the ground. Dispose of old heating oil tank. Burned house should be fully demolished.
HSI_B_726	Not a Hotspot (3)	Commercial - Storage facility		N/A					

Figure 4-26: Outdoor storage of liquids (left) and tires (right) without a cover or secondary containment

Figure 4-27: Dumpsters with no lid and overflowing trash beside a small tributary (left) and outside storage of liquids without a cover or secondary containment (right)

Figure 4-28: Outside storage of treated lumber (left) and chemical storage without secondary containment (right)

Two facilities that were not hotspots (HSI_B_707 and HSI_B_726) were storage facilities. Both facilities were clean and well kept, but did have vehicles stored without runoff diversion methods and large numbers of downspouts discharging to impervious surfaces (Figure 4-29). The third facility that was not a hotspot (HSI_B_725) appeared to be a nursery or landscaping company, though it was labelled as a moving company. This facility had large piles of trash located throughout the property (Figure 4-30), but did store all of their machinery outside under a cover. All three of these facilities could benefit from increased education and outreach regarding potential pollution sources and runoff diversion measures.

Figure 4-29: Vehicles stored without runoff diversion methods (left) and downspouts discharging to impervious surface (right)

Figure 4-30: Large areas of trash on ground throughout property

Institutions

Four institutions were assessed in Brice Run subwatershed, all of which were privately owned churches or faith-based facilities. Recommended actions at the above sites are summarized in Table 4-35.

Table 4-35: ISI Recommendations – Brice Run

Site ID	Institution	Public/ Private	RECOMMENDED ACTIONS							Notes
			Storm Drain Marking	# Trees for Planting	Downspout Disconnection	Stormwater Retrofit	Impervious Cover Removal	Buffer Improvement	Trash Management	
ISI_B_703	Place of Worship	Private		40	✓	✓				Install bioretention on southeast corner of lot to treat drainage for most of the lot; updated stormwater management will address gully formation at the foot of asphalt gutter.
ISI_B_706	Place of Worship	Private	✓	2						
ISI_B_714	Place of Worship	Private		15						
ISI_B_722	Place of Worship	Private		0		✓				Install rain garden on west side of parking lot at natural concentration area.

Opportunities to plant a large number of trees are available at two places of worship (ISI_B_703, ISI_B_714). At both locations, large areas of green space can be utilized to increase tree canopy cover, which will loosen the soil and thereby promote infiltration and slow down storm runoff and consequent erosion to receiving channels. At ISI_B_703, tree plantings would be appropriate mainly on the southern portion of the property, which at present does not have parking areas or other buildings (Figure 4-31, left). At ISI_B_714, available areas for tree planting are present on the northern and southeastern portions of the property (Figure 4-31, right).

Figure 4-31: Tree Planting Opportunities at ISI_B_703 (left) and ISI_B_714 (right)

Investigators identified stormwater retrofit opportunities at places of worship ISI_B_703 and ISI_B_722. Installation of a bioretention stormwater retrofit at the southeast corner of the ISI_B_703 parking lot will likely address the gutter formation at the foot of the asphalt gutter (Figure 4-32, left). Presently nearly all impervious cover drains to this receiving channel. At ISI_B_722, a portion of the parking lot can be treated by placing a raingarden area along the western edge of the parking lot (Figure 4-32, right).

Figure 4-32: Bioretention opportunity at ISI_B_703 (left) and raingarden installation location at ISI_B_722 (right)

Pervious Areas

No assessments of pervious areas were performed within Brice Run during the uplands assessments.

Stream Restoration Recommendations

In Section 3.6 of the Watershed Characterization Report (Appendix E), a past study was reviewed: the Patapsco River Watershed Water Quality Management Plan (WQMP) by Tetra Tech (2000). The purpose of this review was to identify previously recommended stream restoration projects that were the best opportunities for future restoration efforts. A total of 4,508 linear feet of stream in Brice Run were recommended for restoration.

Illicit Discharges

Brice Run subwatershed contains one major outfall rated as priority 1. Priority 1 outfalls have major problems that require immediate correction and/or close monitoring, or outfalls with recurring problems. These outfalls are sampled four times each year. Baltimore County will continue its Illicit Discharge Detection and Elimination program while seeking to improve techniques for more effective reductions of these discharges.

Stormwater Conversions

Brice Run subwatershed contains 4 stormwater management dry ponds. Baltimore County EPS has selected one of these dry ponds as a priority for conversion.

Subwatershed Management Strategy

Figure 4-33 provides a visual summary of restoration opportunities in the watershed.

<u>Engaging Citizens & Watershed Groups</u>

1. Conduct appropriate rain barrel and rain garden installation measures as indicated in Table 4-33.
2. Raise awareness among citizens about the benefits and importance of Bayscaping.
3. Engage citizens in a storm drain marking program and conduct marking activities as indicated in Table 4-33.
4. Raise awareness among residents about the importance of streamside buffers and encourage more environmentally friendly buffer treatments as indicated in Table 4-33.
5. Encourage communities to plant open space trees. Table 4-33 shows potential planting of as many as 45 open space trees.
6. Engage institutional sites listed in Table 4-35 in recommended restoration actions including downspout disconnection, storm drain marking, and tree planting.

<u>Municipal Actions</u>

1. Follow up regarding conditions at the confirmed hotspots and continue to monitor conditions at potential hotspots indicated in Table 4-34. Pursue outreach and raise awareness regarding site housekeeping practices and improved outdoor materials storage.
2. Investigate feasibility of retrofits as noted in Table 4-34.

3. Work with institution owners to pursue retrofit and tree planting opportunities at public institutions noted in Table 4-35.
4. Consider stream restoration options for the 4,508 feet of stream identified in this study.
5. Address issues at outfalls with major problems. Conduct follow-up investigations at those outfalls as described above and in the Watershed Characterization Report and continue outfall monitoring.

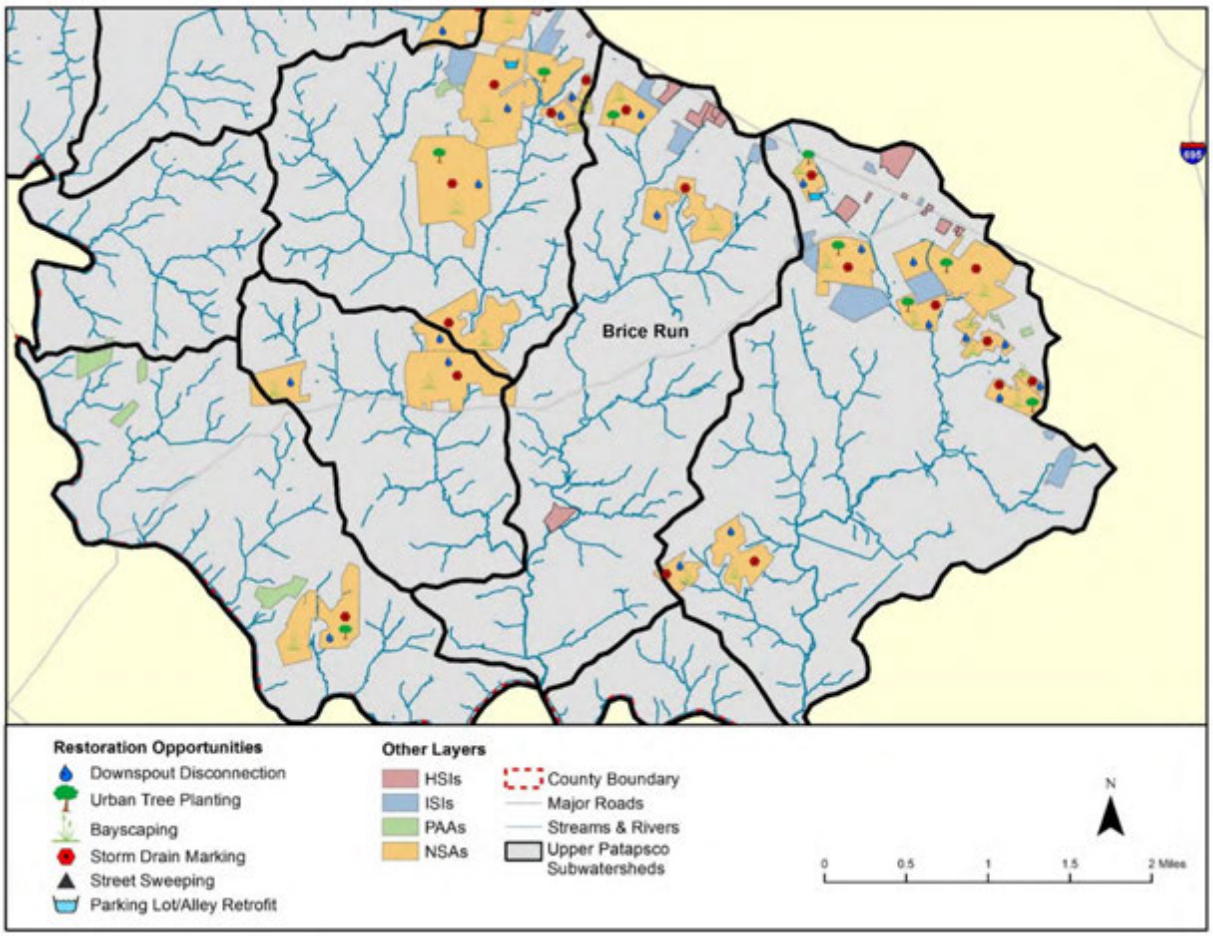

Figure 4-33: Restoration Opportunities in Brice Run

4.3.8 Ben's Run (Subwatershed Code 800)

Ben's Run is the largest subwatershed in the SWAP area and comprises the eastern portion of the Upper Patapsco River watershed. It has the largest population, population density and percent impervious area among the subwatersheds. Ben's Run has the highest percent of land use in the medium-density residential, high-density residential, commercial, institution, and open urban land categories. Table 4-36 summarizes key subwatershed characteristics of Ben's Run.

Table 4-36: Key Subwatershed Characteristics – Ben's Run

Drainage Area	3,552.6 acres (5.55 sq. mi.)	
Stream Length	24.52 miles	
Population	16,081 (2010 Census) 4.5 people/acre	
Land Use/Land Cover	Very Low Density Residential:	9.6%
	Low Density Residential:	10.1%
	Medium Density Residential:	16.5%
	High Density Residential:	3.2%
	Commercial:	4.5%
	Industrial:	0.1%
	Institutional:	3.9%
	Extractive:	0.0%
	Open Urban Land:	9.0%
	Agriculture:	11.6%
	Forest:	31.0%
	Barren Land:	0.5%
	Water/Wetlands:	0.0%
	Transportation:	0.0%
Impervious Cover	12.2% of subwatershed	
Soils	A Soils (low runoff potential):	0.4%
	B Soils:	66.5%
	C Soils:	16.5%
	D Soils (high runoff potential):	16.6%
SWM Facilities	28% of urban land use treated	
Restoration Priority Rating	Very High	

Neighborhoods

A total of nine distinct neighborhoods were identified and assessed within Ben's Run during the uplands assessment of the Upper Patapsco River watershed. Recommendations for this neighborhood included rain barrels, rain gardens, Bayscaping, stream buffer improvements and parking lot retrofits. A summary is presented in Table 4-37.

All of the neighborhoods accessed within Ben's Run watershed had at least some opportunities for improvement. Storm drain marking, rain barrels, and Bayscaping were widely recommended. Storm drain marking is popular because this relatively easy and inexpensive action can have a great effect by reminding residents not to dump potentially dangerous materials into the storm drain. Rain barrels could serve as temporary storage of roof runoff, decreasing the volume of stormwater running off site. Rain gardens may provide an area for roof runoff to infiltrate, as well as plants that can absorb excess nutrients and filter out pollutants. Bayscaping provides an attractive way for landscaping to improve stormwater infiltration, nutrient absorption and pollutant filtration on-site, while also enhancing the aesthetic value of the property.

Table 4-37: NSA Recommendations – Ben's Run

Site ID	Lot Size (acres)*	RECOMMENDED ACTIONS												Notes
		% Opportunity for Downspout Disconnection	Rain Barrels	Rain Gardens	Storm Drain Marking	Bayscaping	Pet Waste	Trash Management	Buffer Improvement	Parking Lot/Alley Retrofit	Street Sweeping	# of Street Trees	# of Open Space Trees	
NSA_B_2	< 1/4	2	✓		✓	✓						0	0	Neighborhood already has abundance of street trees.
NSA_B_18	1/2	5	✓	✓		✓						0	0	-
NSA_B_16		40	✓	✓	✓	✓						0	200	Open space tree planting opportunities. Possible BMP retrofit.
NSA_B_15	1/4	25	✓		✓	✓			✓			400	0	Houses built on either side of stream buffer. Street tree planting opportunities.
NSA_B_14	1/4	5	✓		✓	✓			✓	✓		70	0	Possible pavement removal at end of Stonehaven Rd. Street tree planting opportunities.
NSA_B_3	< 1/4	5	✓		✓	✓						0	0	Neighborhood already has abundance of street trees.
NSA_B_4	< 1/4	10	✓		✓	✓						180	0	All streets are suitable for tree planting but already have a scattered amount of trees.
NSA_B_1	< 1/4	35	✓		✓	✓			✓			420	0	Street tree planting along most streets. Evidence of long term parking on Greenmeade Rd.
NSA_B_5	> 1	5	✓	✓	✓	✓						0	0	-

*Lot sizes are only available for single family homes – blanks indicated apartments or condominiums.

Four neighborhoods were also noted as providing an opportunity to plant at least 100 trees (Table 4-37 and Figure 4-35). Projects on this scale may encourage widespread community engagement and are ideal opportunities for children and families to participate and become involved with their watershed in a direct way. A BMP retrofit was recommended in NSA_B_14 at the dead end of a street (Figure 4-36), which would allow for increased stormwater treatment and infiltration. In addition, actions as simple as adjusting mowing practices and tree plantings along stream channels and drainage ditches may help to slow down high stream flows that cause bank erosion and intercept additional nutrients and pollutants before they enter the aquatic ecosystem.

Figure 4-34: Typical Yard in NSA_N_14 (Left) and NSA_B_16 (Right) with Opportunities for Rain Barrels, Rain Gardens, and/or Bayscaping

Figure 4-35: Opportunities for Open Space Tree Planting Such as in NSA_B_16 (Left) and Street Tree Planting as in NSA_B_4 (Right)

Figure 4-36: Area for Potential Retrofit at Dead-end Road in NSA_B_14

Hotspots

There were nine facilities assessed in Ben's Run subwatershed during the uplands assessment of the Upper Patapsco River watershed. One facility was found to be a confirmed hotspot, three facilities were considered to be potential hotspots, and five facilities were not considered as hotspots. Table 4-38 summarizes the potential pollution sources from facilities visited in Ben's Run. The field crew reports are documented in Section 4.3 of the Watershed Characterization Report (Appendix E).

Table 4-38: Hotspot Summary – Ben's Run

Site ID	HSI Status (# filled circles)	Description	POTENTIAL POLLUTION SOURCES						Notes
			Vehicle Operations	Outdoor Materials	Waste Management	Physical Plant	Turf / Landscaping	Stormwater	
HSI_B_804	Potential (8)	Commercial - Home improvement store							Sod sitting uncovered in front parking lot. Sediment and debris squeezing out of trash compactor in back. Outdoor storage of lots of bulk materials.
HSI_B_805	Not a Hotspot (4)	Commercial - Fast food restaurant	N/A	N/A					Clean site, no issue other than open dumpster.
HSI_B_814	Not a Hotspot (3)	Commercial - Gas station		N/A					Clean up loose trash behind dumpster.
HSI_B_815	Not a Hotspot (2)	Commercial - Restaurant and other shops in the building	N/A	N/A					Repave parking lot, make a pervious surface.
HSI_B_816	Potential (7)	Commercial - Superstore	N/A						Check hydraulic trash compactor for fluid leak. Sludge in channel to dry pond by trash area with unknown origin.
HSI_B_817	Not a Hotspot (4)	Commercial - Fast food restaurant	N/A	N/A					Did not rank as a hotspot but dumpster area is messy and needs to be cleaned up.
HSI_B_822	Not a Hotspot (4)	Commercial - Fast food restaurant	N/A	N/A					Maybe include in education effort due to wash water staining. Could add filtration in catch basin to treat stormwater runoff from facility and adjacent business.

Table 4-38: Hotspot Summary – Ben's Run

Site ID	HSI Status (# filled circles)	Description	POTENTIAL POLLUTION SOURCES						Notes
			Vehicle Operations	Outdoor Materials	Waste Management	Physical Plant	Turf / Landscaping	Stormwater	
HSI_B_823	Confirmed (13)	Commercial - Auto repair shop							Lots of stains from liquids running out of the bays and into gutters. Worker said that they paint tires outdoors. Leave paint liquids outdoors and many tires are stored outdoors. Trash stored on the ground. Opportunity to add sand filter or filtration system in either onsite catch basin or adjacent business catch basin. Could also replace broken up pavement in the back with pervious pavement. Suggested to worker that they either move materials and paint operations indoors or add canopy. Add trench drains around bays.
HSI_B_824	Potential (8)	Commercial - Strip shopping center							Follow up with appliances store about trash storage in back. Add some plants/ shrubs to area with bare soil.

The confirmed hotspot (HSI_B_823) was an auto repair shop. Many infractions were noted at this facility, including staining of the pavement from liquids running out of the service bays, trash stored on the ground and not in a dumpster, and storage of liquids and tires outside without a cover and secondary containment (Figure 4-37). Field crew informed a worker that the tires and liquids should be stored under a cover and with secondary containment. This facility could benefit from increased education and outreach regarding potential pollution sources, runoff diversion measures, and stormwater treatment practices.

Figure 4-37: Detergent spilling onto the pavement with obvious staining (left) and liquids stored without secondary containment (right)

The first potential hotspot (HSI_B_804) was a home improvement store where the trash compactor was leaking liquids near a storm drain and outside storage of building materials were observed without a cover (Figure 4-38). The second potential hotspot (HSI_B_816) was a superstore which had compacted trash and store products stored outside without a cover (Figure 4-39). The facility also had potential hydraulic fluid leak associated with its compactor. The superstore did however have numerous bioretention areas and a dry pond which would treat an estimated 90% of stormwater runoff from the property. The final potential hotspot (HSI_B_824) was a strip shopping center which had a row of dumpsters behind it, several of which were uncovered, and outside storage of broken appliances without a cover or secondary containment (Figure 4-40).

Figure 4-38: Trash compactor leaking liquids (left) outdoor building materials without a cover (right)

Figure 4-39: Compacted trash (left) and outside storage of building materials and landscaping products (right) without a cover

Figure 4-40: Outside storage of appliances without cover (left) and row of dumpsters, some of which had open/no lids (right)

There were five facilities that were considered not to be hotspots. Three facilities that were not hotspots (HSI_B_805, HSI_B_817, and HSI_B_822) were fast food restaurants. All three facilities were fairly clean and well kept. HSI_B_805 had an open dumpster, HSI_B_817 had a used cooking oil dumpster that was leaking, and HSI_B_822 had outdoor storage of liquids without a cover or secondary containment and evidence of wash water being dumped on the pavement causing staining (Figure 4-41). The fourth facility that was not a hotspot (HSI_B_814) was a gas station. This facility had was well kept, but did have trash stored on the ground beside the dumpster (Figure 4-42, left). The final facility that was not considered a hotspot (HSI_B_815) was a restaurant with other businesses adjoining in a strip shopping center. This facility was fairly clean, but there was evidence that used cooking oil was leaking around the base of the storage dumpster (Figure 4-42, right); this strip shopping center could also install pervious pavement in the large parking lot to the side to help with stormwater runoff. All three of these facilities could benefit from increased education and outreach regarding better trash storage practices and potential pollution sources.

Figure 4-41: Used cooking oil dumpster leaking onto pavement at HSI_B_817 (left) and wash water staining of pavement at HSI_B_822 (right)

Figure 4-42: Trash beside dumper at HSI_B_814 (left) and evidence of used cooking oil leaking from dumpster at HSI_B_815 (right)

Institutions

Nine institutions were assessed in Ben's Run subwatershed, consisting of four privately owned churches, two public elementary schools and one public middle school, one public library, and one fire station. Recommended actions at the above sites are summarized in Table 4-39.

Opportunities to plant a large number of trees are available at two schools (ISI_B_807, ISI_B_808), and one place of worship (ISI_B_810). At all three locations, large areas of green space can be utilized to increase tree canopy cover, which will loosen the soil and thereby promote infiltration and slow down storm runoff and consequent erosion to receiving channels. At ISI_B_807, tree plantings would be appropriate mainly on the southern portion of the property, adjacent to the parking lot and school building, although multiple small patches of tree plantings were noted throughout the property. At ISI_B_808, available areas for tree planting are present on the northern and eastern portion of the property, and several other small areas around the school (Figure 4-43). At ISI_B_810, tree plantings would be appropriate mainly on the southern and western portions of the property. Five other institutions have the possibility for tree plantings, though in smaller amounts.

Table 4-39: ISI Recommendations – Ben's Run

Site ID	Name	Public/ Private	RECOMMENDED ACTIONS							Notes
			Storm Drain Marking	# Trees for Planting	Downspout Disconnection	Stormwater Retrofit	Impervious Cover Removal	Buffer Improvement	Trash Management	
ISI_B_804	Place of Worship	Private	✓	15		✓				Retrofit linking pond to sand filter and/or bioretention.
ISI_B_805	Place of Worship	Private	✓	15		✓				Northeast edge of stormwater management eroding; recommend bioretention on southeastern slope of northeast parking lot to replace riprap channel. Retrofit dry pond to bioretention and/or sand filter and install internal berm to direct flow and increase capacity.
ISI_B_807	School	Public	✓	52		✓	✓			Install five bioretention at various locations over existing yard drains, two can expand existing demonstration rain gardens.
ISI_B_808	School	Public	✓	96		✓		✓		Retrofit larger dry pond facility to wet pond with filtration forebay. Retrofit new dry pond (next to parking lot) to surface sand filter or bioretention. Install demonstration rain garden next to concrete apron on south corner of school building near iconic tree. Install bioretention in courtyard over yard drain.

Table 4-39: ISI Recommendations – Ben's Run

Site ID	Name	Public/ Private	RECOMMENDED ACTIONS							Notes
			Storm Drain Marking	# Trees for Planting	Downspout Disconnection	Stormwater Retrofit	Impervious Cover Removal	Buffer Improvement	Trash Management	
ISI_B_810	Place of Worship	Private	✓	37		✓	✓	✓		Improve existing bioretention at front of channel. Install bioretention along lower periphery of rear lot to intercept flow from lot before external channel (need to remove some parking). Augment existing overgrown channel servicing the southern portion of school building. Add biore-tention to west edge of lot and regrade access drive to direct flow.
ISI_B_811	Place of Worship	Private		5		✓				Install swale on downslope periphery of lot and redirect to bioretention area to southeast of parcel.
ISI_B_813	School	Public	✓	17		✓	✓			Install bioretention area to south of ballfields to capture flow from site and reduce impact to stream channel (redirect existing pipe). Install bioreten-tion in courtyard area next to heat exchange unit to capture parking lot flow. Replace gutters for tennis court with grassy swales to inlet.
ISI_B_816	Fire Station	Public	✓	2		✓				Forebay at bottom of swale at rear of lot. Underground storage with pre-treatment in grassy area on south side of site.

Table 4-39: ISI Recommendations – Ben's Run

Site ID	Name	Public/ Private	RECOMMENDED ACTIONS							Notes
			Storm Drain Marking	# Trees for Planting	Downspout Disconnection	Stormwater Retrofit	Impervious Cover Removal	Buffer Improvement	Trash Management	
ISI_B_818	Library	Public	✓	0		✓	✓			Install bioretention at existing yard inlet on south side of building.

Figure 4-43: Tree Planting Opportunities at ISI_B_807 (left) and ISI_B_808 (right)

Investigators identified stormwater retrofits at all nine of the assessed institutions. At place of worship ISI_B_804 investigators suggest that the existing pond be retrofitted into either a surface sand filter or bioretention area (Figure 4-44, left). At place of worship ISI_B_805, erosion was noted at the northeast edge of the existing stormwater pond. Investigators recommend replacing the riprap channel with a bioretention area, and retrofitting the pond to a bioretention or surface sand filter, with an internal berm installed to direct flow and increase capacity (Figure 4-44, right). At school ISI_B_807, recommendations were made to install five bioretention areas over the existing storm drains, two of which could expand upon the existing demonstration rain gardens (Figure 4-45, left). At school ISI_B_808, recommendations were made to retrofit the existing large dry pond to a wet pond with a filtration forebay, retrofit the newer dry pond beside the parking lot into a surface sand filter or bioretention area, and to install demonstration rain gardens at several areas around the concrete apron of the school (Figure 4-45, right). Several bioretention retrofit opportunities were noted at place of worship ISI_B_810. The existing bioretention area at the front of the channel should be updated, and bioretention areas could be installed along the lower periphery of the rear lot, intercepting flow before it reaches the channel, as well as along the west edge of the lot. Some parking would need to be removed if a bioretention area was installed along the rear lot (Figure 4-18 left). For place of worship ISI_B_811, a swale could be added to redirect flow to the existing bioretention area at the southeast portion of the parcel (Figure 4-46, right). At school ISI_B_813, recommendations were made to install bioretention areas below the

ball fields and around the heat exchange unit, as well as replacing the impervious gutters around the tennis courts with grassy swales. Installation of the bioretention area below the ball fields is the highest priority, as it will help to reduce the impact to the eroding stream channel below (Figure 4-47). At the fire station (ISI_B_816), investigators suggest that an underground storage with cartridge system be installed at the southeastern edge of the property, utilizing the grassy area for pretreatment (Figure 4-48, left). Lastly, at the Library (ISI_B_818), the space in front of the building surrounding the yard inlet was identified as an installation location for a bioretention area (Figure 4-48, right).

Figure 4-44: Existing pond for surface sand filter or bioretention retrofit at ISI_B_804 (left) and channel erosion and pond available for retrofit at ISI_B_805 (right)

Figure 4-45: Bioretention installation/expansion opportunity at ISI_B_807 (left) and bioretention or surface sand filter retrofit opportunity at ISI_B_808 (right)

Figure 4-46: Bioretention opportunity with impervious cover removal at ISI_B_810 (left) and swale installation opportunity at ISI_B_811 (right)

Figure 4-47: Bioretention (left) and grassy swale replacement of impervious gutter (right) opportunities at ISI_B_813

Figure 4-48: Underground storage with cartridge system potential location at ISI_B_816 (left) and bioretention installation opportunity at ISI_B_818 (right)

Pervious Areas

Four pervious area assessments were performed within the Ben's Run subwatershed. Three of the sites were open space owned by the Baltimore County Board of Education, while the remaining site was County owned open space. Only one of the sites was contiguous with existing forest, and none of the sites had potential to expand interior forest, provide riparian buffer, or reduce forest edge. All sites ranked as low priority as shown in Table 4-40.

Table 4-40: PAA Summaries – Ben's Run

Site ID	Owner ship	Acres	Buffer Length	SW Retrofit Potential	A	B	C	D	E	F	Restoration Score
PAA_B_802	Public	1	0	No	0	0	0	0	5	10	15
PAA_B_803	Public	1	0	No	0	0	5	0	5	10	20
PAA_B_804	Public	2	0	No	0	0	0	0	10	10	20
PAA_B_804	Public	2	0	No	0	0	0	0	10	10	20

Stream Restoration Recommendations

In Section 3.6 of the Watershed Characterization Report (Appendix E), a past study was reviewed: the Patapsco River Watershed Water Quality Management Plan (WQMP) by Tetra Tech (2000). The purpose of this review was to identify previously recommended stream restoration projects that were the best opportunities for future restoration efforts. A total of 3,450 linear feet of stream in Ben's Run were recommended for restoration. As stated in Section 3.6 the Upper Patapsco Steering Committee was particularly concerned with Ben's Run and how conditions have further degraded since surveyed for the 2000 study. Additional assessments of areas not identified for restoration potential will be needed to address degraded stream segments not identified in the 2000 study.

Illicit Discharges

Ben's Run subwatershed contains 8 major outfalls, two of which are rated priority 0, one of which is rated priority 1, two of which are rated priority 2, and the other three of which are rated priority 3. Priority 0 outfalls are outfalls with insufficient data to determine a priority rating. This may be due to inaccessibility or if there has been only a single screening. Priority 1 outfalls have major problems that require immediate correction and/or close monitoring, or outfalls with recurring problems. These outfalls are sampled four times each year. Priority 2 outfalls have minor to moderate problems that have the potential to become severe and are sampled once a year. Priority 3 outfalls with minor or no problems that do not require close monitoring. These outfalls are sampled on a 10-year cycle. Baltimore County will continue its Illicit Discharge Detection and Elimination program while seeking to improve techniques for more effective reductions of these discharges.

Stormwater Conversions

Ben's Run subwatershed contains 20 stormwater management dry ponds. Baltimore County EPS has selected five of these dry ponds as a priority for conversion.

Subwatershed Management Strategy

Figure 4-49 provides a visual summary of restoration opportunities in the watershed.

Engaging Citizens & Watershed Groups

1. Conduct appropriate downspout rain barrel and rain garden installation measures in neighborhoods according to Table 4-37.
2. Engage citizens in a storm drain marking program and conduct marking activities in the neighborhoods indicated in Table 4-37.
3. Raise awareness among citizens about the benefits and importance of Bayscaping for the recommended neighborhoods in Table 4-37.
4. Raise awareness among property owners about improving stream buffer management at locations indicated in Table 4-37.
5. Encourage communities to plant trees. Table 4-37 shows potential neighborhoods for planting as many as 1,270 open space and street trees.
6. Engage institutional sites listed in Table 4-39 in the recommended restoration actions including storm drain marking and tree planting, and stream buffer improvement.

Municipal Actions

1. Investigate the retrofit opportunity for the parking lot noted Table 4-37 and, if possible, engage the communities and pursue those opportunities.
2. Investigate the feasibility of the pavement removal, tree plantings and numerous retrofits described in Table 4-37 and Table 4-38.
3. Follow-up regarding conditions at the confirmed hotspots and continue to monitor conditions at potential hotspots indicated in Table 4-38. Pursue outreach and raise awareness regarding site housekeeping practices, and improved outdoor materials storage and vehicle operations.
4. Work with the institution owners to pursue retrofit, impervious cover removal, tree planting and buffer improvement opportunities at public institutions noted in Table 4-39.
5. Investigate the low priority pervious areas described in Table 4-40.
6. Consider stream restoration options for the 3,450 feet of stream identified in this study.
7. Address issues at outfalls with major problems. Conduct follow-up investigations at those outfalls with problems that have the potential to become severe as described above and in the Watershed Characterization Report, as well as those outfalls with insufficient data for prioritization. Continue to monitor illicit discharges.

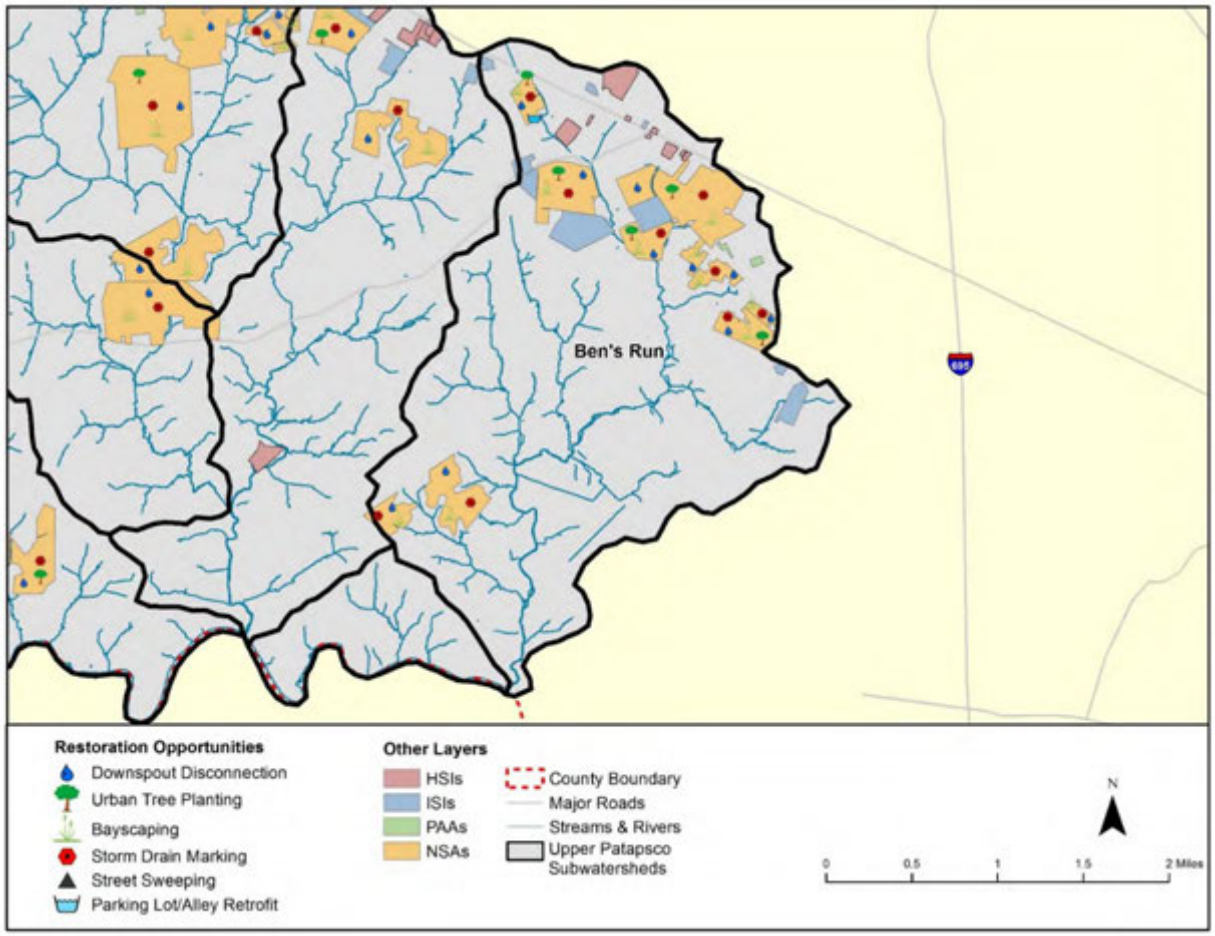

Figure 4-49: Restoration Opportunities in Ben's Run

CHAPTER 5: PLAN EVALUATION

5.1 INTRODUCTION

The Upper Patapsco River SWAP is based on an implementation schedule with an anticipated endpoint of 2025. This timeframe is necessary to implement restoration measures that meet the Chesapeake Bay nutrient TMDL and address other impairments. The ability to implement this plan within this timeframe is dependent upon the availability of staff and sufficient funding. The Upper Patapsco River SWAP Implementation Committee (an outgrowth of the Steering Committee) will meet twice per year to assess progress in meeting watershed goals and objectives and to discuss funding options. In addition, an annual progress report and a biennial report on water quality monitoring results will be produced. An adaptive management approach will be used to meet watershed goals and objectives based on SWAP evaluation data. Adaptive management will allow the committee to discuss changes to the action schedule depending on the success of individual actions and the overall progress with the plan. As the Phase II Watershed Implementation Plan (WIP) addressing the Chesapeake Bay TMDL is implemented, or if other water quality issues arise, the Upper Patapsco River SWAP Implementation Committee will initiate a revision of the plan within six months of new TMDL approval or when a water quality issue arises.

Progress and success of the Upper Patapsco River SWAP will be evaluated during implementation based on the following: interim measurable milestones, pollutant load reduction criteria, implementation tracking, and monitoring. These evaluation components are described in the following sections.

5.2 INTERIM MEASURABLE MILESTONES

Performance measures have been developed for each action listed in Appendix A and will be used to gage the progress and success of proposed restoration strategies. Actions will be organized into two year milestones, with the first interval being December 1, 2017 – November 30, 2019, and the final interval being December 1, 2023 – November 30, 2025. The progress and success of actions in Appendix A will be evaluated on an annual basis. Action strategies may be modified and/or new actions may be proposed based on this annual evaluation. New actions proposed will also be evaluated on an annual basis and modified as necessary to meet watershed goals and objectives.

5.3 POLLUTANT LOAD REDUCTION CRITERIA

Current pollutant load reduction scenarios and calculations for proposed actions are presented in Chapter 3. These are mainly based on pollutant removal efficiencies used in the Chesapeake Bay Program's (CBP) Phase 5.3 Watershed Model for various nonpoint source BMPs. These pollutant removal efficiencies will continue to be used to measure progress in meeting the TMDL reduction goals (i.e., 32% reduction in Total Nitrogen (TN) loads from urban stormwater discharges). CBP-approved BMP removal efficiencies are summarized in the tables included as Appendix D. Actions and associated pollutant load reductions will be reevaluated if CBP revises/updates pollutant removal efficiencies to ensure that the nutrient TMDL reductions are met.

5.4 IMPLEMENTATION TRACKING

Baltimore County intends to track implementation of the SWAP using a Geographic Information System (GIS), which will allow the County to record and map actions taken per the SWAP. The

data generated from the GIS will be provided to the Upper Patapsco River SWAP Implementation Committee to assess annual progress through a comparison between completed restoration activities and the performance measures detailed in Appendix A. Pollutant load reductions that have been achieved through implementation of various restoration projects will also be calculated and tracked.

5.5 MONITORING

Baltimore County currently conducts water quality monitoring programs within the Upper Patapsco River watershed. Additional monitoring is anticipated to assess the effectiveness of restoration projects and progress in meeting nutrient TMDL reductions.

5.5.1 Existing Monitoring

Baltimore County conducts chemical, biological, bacteria, and illicit connection monitoring within the Upper Patapsco River watershed. These are described in detail in Chapter 3.4 of the Upper Patapsco River Watershed Characterization Report (Appendix E) and listed below:

- County Trend Chemical Monitoring Program – One sampling location (Ben's Run site PA04), measuring chemical concentrations and pollutant loads over time, including nutrients, suspended solids, and metals;

- County Biological Monitoring Program – Randomly selected locations in the Upper Patapsco River watershed using characteristics of benthic macroinvertebrates as a water quality indicator; and

- Illicit Discharge Detection and Elimination Program – Routine outfall screening and prioritization system to track and reduce illicit connections and discharges. Future Hotspot Site Investigations (HSIs) will also be conducted under this program.

- County Bacteria Trend Monitoring Program - One sampling location (PAT0347, Patapsco River at Old Court Rd) to determine Escherichia coli (E. coli) levels.

5.5.2 SWAP Implementation Monitoring

SWAP implementation monitoring activities will focus on project specific monitoring and targeted subwatershed monitoring. Project-specific monitoring will be identified as restoration progresses. It will not be possible to monitor all restoration projects due to the number of actions proposed. Project specific monitoring will target activities with limited data regarding removal efficiencies, such as street sweeping. Subwatershed monitoring will measure overall improvement in water quality as a result of multiple restoration activities within a subwatershed. There is potential to coordinate a citizen-based stream monitoring program, as the County has an active and interested partner in Patapsco Heritage Greenway (PHG). The group currently organizes workshops, tree plantings and stream cleanups throughout the Patapsco River watershed. Monitoring activities will be coordinated among SWAP participants (Baltimore County and PHG) through participation in the Upper Patapsco River SWAP Implementation Committee.

CHAPTER 6: REFERENCES

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APPENDIX A: UPPER PATAPSCO RIVER WATERSHED ACTION STRATEGIES

Upper Patapsco River Watershed Action Strategies

This appendix presents the actions related to the goals and objectives presented in Chapter 2 of the Upper Patapsco River Small Watershed Action Plan (SWAP). A complete list of actions proposed for the watershed including timelines, performance measures, unit cost estimates, and responsible parties is included in Table A-1. In many cases, actions relate to multiple goals and objectives, as indicated in the table. Some of the key columns included in Table A-1 are briefly described below.

Goals and Objectives

Overall goals and objectives are listed in Chapter 2 of the SWAP report, and are referred to by number in Table A-1.

Action

Actions developed to achieve watershed goals and objectives are grouped in Table A-1 according to the type of activity. Actions are grouped according to the following categories (and subcategories for restoration actions):

- Restoration Actions
  - Nutrient Reduction
  - Sediment Reduction
  - Stormwater Management
  - Urban Tree Canopy
  - Trash Management
  - Stream Corridor Restoration
- Outreach & Awareness
- Monitoring
- Funding
- Reporting

Basis for Performance Measure

This column describes how performance measures were developed for each action. Performance measures were developed using the information in this column in conjunction with the action timeline.

Timeline

This column denotes the timeline over which an action will be performed.

Performance Measure

This column describes how the success/completion of a given action will be measured. In many cases, it is the numeric basis of the performance measure divided by the proposed timeline.

Unit Cost

Unit costs are used to develop overall cost estimates for proposed watershed action strategies (see Appendix B).

Partners

Those tasked with a given action are denoted by a numeric code in this column. This does not imply a legal obligation. Partners are indicated by numerals as follows:

1. Baltimore County EPS,
2. Patapsco Heritage Greenway (PHG), and
3. Upper Patapsco River SWAP Implementation Committee.

Table A-1: Upper Patapsco River Watershed Action Strategies

Goal	Objective	Action	Basis for Performance Measure	Timeline	Performance Measure	Unit Cost	Partners
RESTORATION ACTIONS							
Nutrient Reductions							
1	1,2,4	Continue municipal road maintenance street sweeping activities	Existing Operations – bulk removal rates reported	On-going	Pounds removed	Existing staff	1
1	1,2	Develop a community awareness program which discusses the impacts of nutrients to the watershed, Patapsco River and Chesapeake Bay	Community awareness work plan developed	2 years	Awareness program developed	Existing staff	1, 2
5	1,2						
1	1,3	Continue to meet the requirements of the consent decree for the elimination of sanitary sewer overflows	Status report	On-going	Status Report	Existing staff	1
Stormwater Management							
1	1,2,4	Convert 11 existing dry detention ponds identified for water quality treatment; continue evaluation other dry ponds for conversion	11 existing detention ponds identified as having physical expansion x 100% projected participation = 11 conversions	8 years	1 -2 conversions per year	$3,200 per drainage area acre treated	1
2	1						
1	1,2,4	Work with institutional partners and to reduce impervious cover at the 4 institutional sites identified	Maximum potential of 0.11 acre of impervious cover removal identified x 50% participation rate (assumes 50% of acreage) = removal of 0.06 acres	4 years	1 institution per year	$25,000 per acre	1
2	1						
1	1,2,4	Develop and implement a downspout disconnection program; promote redirection of downspouts for downspout disconnection in the 13 recommended neighborhoods	13.92 acres of impervious rooftop identified x 66% participation rate = 9.19 acres	2 years	Address 5 rooftop acres per year	$152,374/acre	3
2	1						
3	2						
1	1,2,4	Promote rain barrel and/or rain garden use in the 20 neighborhoods where such actions were recommended	Conduct 2 rain barrel and/or rain garden awareness seminars targeting 10 neighborhoods per event (106.2 acres of area of impervious rooftop identified x 10% participation rate = 10.62 acres)	2 years	1 event per year	$500 / event	3
2	1						
3	2						

Goal	Objective	Action	Basis for Performance Measure	Timeline	Performance Measure	Unit Cost	Partners
1	1,2,4	Investigate the feasibility of implementing stormwater retrofits to treat runoff from impervious surfaces (parking lots, rooftops) at the 3 hotspots identified as having retrofit potential	3 hotspot sites investigated for feasibility of stormwater retrofits	2 years	Feasible retrofit sites identified	Existing staff	1
2	1						
3	1						
1	1,2,4	Investigate the feasibility of implementing stormwater retrofits to treat runoff from impervious surfaces (parking lots, rooftops) at the 13 institutional sites identified	13 institutional sites identified as being possible for stormwater retrofits	2 years	Feasible retrofit sites identified	Existing staff	1
2	1						
3	1						
1	1,2,4	Design and implement stormwater retrofits at all feasible sites	13 Institutions + 3 Hotspots x 50% participation rate = 8 stormwater retrofits	8 years	1 retrofits per year	$3,200 per drainage area acre treated	1
2	1						
1	1,2,5	Triennial Inspection and maintenance of stormwater conversions and retrofits	11 conversions + 16 retrofits = 27 projects	8 years	3-4 inspections per year	Existing staff	1
Urban Tree Cover							
1	1,2,4	Investigate the feasibility of planting riparian stream buffers on open pervious land	744 acres of open pervious land identified within the 100-foot stream buffer through GIS analysis	2 years	Feasible buffer planting sites identified	Existing staff	1
2	1,2						
3	1						
4	1						
1	1,2,4	Reforest stream buffer at feasible sites with a minimum width of 35 feet	744 acres of open pervious land identified in the GIS analysis x 80% participation rate = 595.2 acres	8 years	Reforest 74 acres per year	$15,000 per acre	1
2	1,2						
1	1,2,4	Plant trees on Pervious Area Assessment (PAA) sites, focusing efforts on sites identified as mostly open pervious cover type requiring minimal site preparation; this includes working with MD SHA to plant trees in suitable medians and rights-of-way	63 acres of PAA sites x 75% = 47.25 acres	8 years	Reforest 6 acres per year	$6,000 per acre	1
2	1,2						
1	1,2,4	Encourage street and open space tree planting in the 18 recommended neighborhoods	Maximum potential of 2,275 trees x (1 acre/100 trees) = 22.8 acres x 50% participation rate = 11.4 acres (or 1,140 trees)	8 years	Plant 143 trees per year	$175 per tree	1,2,3
2	1,2						
3	1,2,4						

Goal	Objective	Action	Basis for Performance Measure	Timeline	Performance Measure	Unit Cost	Partners
1	1,2,4	Encourage institutions to plant trees on available open space at the 16 sites identified	Maximum potential of 381 trees x (1 acre/100 trees) = 3.8 acres x 75% participation rate = 2.85 acres (or 285 trees)	8 years	Plant 36 trees per year	$175 per tree	1,2,3
2	1,2						
3	1						
1	1,2,4	Baltimore County shall continue to require riparian buffers and forest conservation for all new and re- development	On-going, keep track of existing riparian buffer and forest preserved	On-going	Acres preserved	Existing staff	1
2	1,2						
5	2						
1	1,2,4	Maintain trees planted at reforestation/tree planting sites	Tree maintenance (watering, mowing, weeding, etc.) is required for the first 5 years to ensure successful growth; projected number of acres to be reforested = 822.2 acres	5 years	Maintain 164.4 acres per year	$1300 per acre per year	1,3
2	1,2						
3	3,4	Improve forest habitat by organizing exotic invasive species removal activities every year	Organize 1 exotic species removal activity addressing 1 acre per year	8 years	Exotic species removed from 1 acre per year	$500 per year	3
1	1,2,4	Support the state's No-Net-Loss of Forest Policy	On-going, keep track of existing forest coverage; prioritize forest conservation; off-set all forest losses	On-going	Stabilization of the rate of loss by 2020 with the goal of maintaining the County's existing forest coverage	Existing staff	1
2	2						
3	1,3,4						
5	3						
Trash Management							
3	1,2	Develop a trash and litter management work plan	Work plan developed	2 years	Plan completed	Existing staff	1
4	1,2,3						
3	2,3	Implement recycling and add separate receptacles for recycling on public properties such as parks and county-owned golf courses	Add recycling receptacles at public parks, county-owned golf courses, and other feasible sites	5 years	Recycling implemented at feasible sites	Existing staff	1
4	1,2						
Stream Corridor Restoration							
1	1,2	Evaluate the restoration potential and feasibility of restoring eroded stream banks and channel alterations identified in the stream corridor assessments and those identified after the study.	Identify feasible restoration projects at any Countywide stream survey sites that noted severely eroding/unstable banks	2 years	Feasible restoration projects identified	Existing staff	1
2	1,2						
4	3						

Goal	Objective	Action	Basis for Performance Measure	Timeline	Performance Measure	Unit Cost	Partners
1	1,2,4	Conduct a follow up inspection of the outfalls rated as potentially severe or severe-moderate issues identified during outfall screening in the Illicit Discharge and Elimination Program	3 outfall locations rated as Priority 2 (High)	1 year	Conduct 3 inspections per year	Existing staff	1
2	1						
1	1,2	Complete stream restoration identified in the stream corridor assessments where feasible	Stabilize and restore all unstable stream reaches in the Upper Patapsco River watershed (15,558) identified during previous studies that are considered to still be viable projects streams to provide water quality improvement	8 years	1,945 Ln ft per year	$350 / Ln ft	1
2	1,2						
3	4	Develop plan to increase community awareness of the benefits of forest creation and preservation	Provide education to the community	2 years	Work plan developed	Existing staff	1, 3
OUTREACH & AWARENESS							
1	1,2,4	Distribute pollution prevention information to facilities falling within hotspot categories identified in watershed and provide guidance/workshops; include working with business partners to cut off stream access in areas with dumping issues and encourage them to keep parking lots free of trash and debris	2 confirmed and 11 potential hotspot sites assessed; Categories identified: shopping centers, restaurants, car repair, lumberyards, and commercial services; Conduct 3 workshops and distribute outreach material	6 years	Conduct 1 workshop every 2 years	$500 /workshop	1,2,3
2	1						
4	1,2						
1	1	Develop a community outreach campaign to raise awareness about homeowner actions aimed towards nutrient reduction	Publicize several actions in E-News Stream and other media, and at environmental events	On-going	4 announcements per year	Existing Staff	1,2,3
2	1						
4	2						
1	1,2,4	Form partnerships with institutions and discuss the best management practice (BMP) recommendations from the institutional assessments and implementation options; include implementing/enhancing recycling programs on their properties	13 institutions assessed with potential for stormwater management retrofit	5 years	3 institution meetings per year	Existing staff	1,3
2	1						
4	1						

Goal	Objective	Action	Basis for Performance Measure	Timeline	Performance Measure	Unit Cost	Partners
1	1,2,4	Work with community groups to install storm drain markers in the 18 recommended neighborhoods.	Mark storm drains in 25% (5 of the 18) potential neighborhoods identified	3 years	2 neighborhoods per year	$400 /neighborhood	3
2	1						
3	2,3						
1	1,2,4	Work with the institutional sites to install storm drain markers at the 10 recommended sites	Mark storm drains at the 10 institutional sites identified	5 years	2 institutions per year	$400 /institution	1,3
2	1						
3	1						
3	2,3	Develop and implement signs and educational material for a recycling campaign in the watershed	Develop signs and post throughout watershed	3 years	Develop material, post signs	Existing staff	1,3
4	1,2						
1	1	Implement trash and litter management work plan	Submit in the NPDES Report the progress toward implementing the trash and litter work plan	5 years	Annual	Existing staff	1
2	1						
4	1,2,3						
3	1,2,3	Encourage institutional partners, community groups, and patrons of public properties to sign and support a trash treaty (a pledge to implement strategies aimed at reducing litter and promoting awareness on the effects of pollution)	Have sign-up events	8 years	1 sign-up event per year	Existing staff	1,3
4	1,2,3						
5	1	Develop awareness plan for the commercial and agricultural communities to promote awareness of the benefits of redevelopment in the URDL	Provide education to commercial and agricultural community	2 years	Work plan developed	Existing staff	N/A
1	4	Encourage and support waterway cleanups in streams	Conduct at least three waterway cleanups per year; cost includes supplies and tire removal	8 years	3 waterway cleanups per year	$1000 per cleanup	1,2,3
2	1						
3	3						
4	3						
3	1,2	Conduct a tour of a completed water quality project/BMP on public property	Conduct two tours of completed watershed restoration projects (e.g., stormwater retrofit, stormwater conversion)	8 years	1 tour per 4 years	Existing staff	1
5	3						

Goal	Objective	Action	Basis for Performance Measure	Timeline	Performance Measure	Unit Cost	Partners
3	1	Using various media, develop and distribute information about public access points along the Upper Patapsco River for recreational purposes	Distribute information to the public on access points.	8 years	1 per year	Existing staff	1,2,3
3	All	Increase public awareness about the Upper Patapsco River SWAP (in an easily digestible format) and promote awareness about the extent of and connection to the Upper Patapsco River	SWAP Implementation Committee to design a messaging campaign (including pamphlet about the SWAP and signs to inform people they are entering or within the Upper Patapsco River watershed, as well as a strategy for distribution and placement)	2 years	Design, creation and distribution/posting of pamphlets and signs	Existing staff	1,2,3
1 3	1,2 1,2	Encourage lawn reduction and promote Bayscaping in the 20 neighborhoods identified	Conduct 4 Bayscaping awareness events targeting 5-6 recommended neighborhoods per event (654.8 acres of lawn identified for Bayscaping x 5% participation rate = 32.7 acres)	2 years	2 events every year	$500 per event	2,3
4	1,2,3	Direct some of the outreach and education events to areas that are presently still in good condition and use those opportunities to inform residents of their ability to prevent impairment/degradation of the healthy resources in their area	Pursue education and outreach efforts within the very high priority “Protection Subwatersheds” listed in Section 4.2.11 of SWAP Report	8 years	1 event per year in each of the top three priority protection subwatersheds (total of 3 events per year)	Cost already noted above	2,3
3	2	PHG to help facilitate a meeting between Upper Patapsco River SWAP Implementation Committee and Clear Creeks representatives	Meeting held where productive and successful strategies used by Clear Creeks may be shared Upper Patapsco River SWAP Implementation Committee in order to help guide the Committee as they begin working towards achieving the SWAP goals	1 year	Meeting held with Clear Creeks group	Existing staff	2,3
MONITORING							
1	1,2,4	Continue to remove illicit connections when discovered through the Illicit Connect Program	As per NPDES Permit, perform 150 screenings County-wide per year	On-going	Reported annually in NPDES Permits	Existing staff	1

Goal	Objective	Action	Basis for Performance Measure	Timeline	Performance Measure	Unit Cost	Partners
1	1,2,4	Continue the illicit connection monitoring at the major outfalls in the watershed and complete one inspection at each of the minor outfalls	13 major outfall locations and 51 minor outfall locations = 64 outfall inspections	8 years	8 outfalls per year	Existing staff	1
1	1,2,4	Continue to implement the citizen-based stream watch program to increase the ability to monitor/identify sources of water quality and habitat degradation	Promote watershed awareness and additional identification on sources of impairment, and potential restoration locations	8 years	Number of stream watcher volunteers	Existing staff	1,2,3
2	1						
3	3						
4	1,3						
1	1,2,4	Conduct periodic inspection of BMPs and provide on-going maintenance to assure their continued proper functioning	Assure that each facility is inspected every 3 years	On-going	Inspections completed	Existing staff	1
2	1	Continue probabilistic biological monitoring program	Biological monitoring stations in the Upper Patapsco River watershed are monitored in even-numbered years – report produced	Odd-numbered years	Stations monitored, report produced	Existing staff	1
1	1,2,4	Work with teachers to develop meaningful watershed environmental education (MWEE) activities for students at Baltimore County public schools	3 public schools identified as having education opportunities for possible BMP monitoring (among other potential action opportunities at these sites)	6 years	1 school every 2 years	Existing staff	1,2,3
3	1						
FUNDING							
1	1	Coordinate grant funding requests to secure funding and implement restoration projects to meet TMDL nutrient reduction requirements	Seek a minimum of 1 grant per year to meet the TMDL requirements within 10 years	8 years	1 grant proposal per year	Existing staff	3
1	1,2	Support Soil Conservation District (SCD) and their ability to reduce pollution from agriculture lands and increasing Critical Area enforcement by supporting increased funding and staffing within State budget	Increase in number of staff within Soil Conservation District office	On-going	Contacting local legislators regarding State budget priorities	Existing staff	3
2	1,2						
5	3						

Goal	Objective	Action	Basis for Performance Measure	Timeline	Performance Measure	Unit Cost	Partners
1	1,2	Increase applications for the Baltimore County – Green Building Tax Credit Program	Provide incentive for landowners to install BMPs to address water quality and habitat	5 years	# of applications	Existing staff	1,2,3
REPORTING							
All	All	Upper Patapsco River SWAP Implementation Committee will meet to discuss implementation progress and assess any changes needed to meet the goals	Meet on a semi-annual basis	8 years	2 meetings per year	Existing staff	3
All	All	Coordinate restoration activities between and among Baltimore County and PHG	Documented in NPDES annual report	On-going	NPDES annual report	Existing staff	1,2
1	4	Designate county personnel to provide updates to the SWAP Implementation Committee on the status of the consent decree projects for sewer infrastructure repair	Present updates at the semi-annual SWAP Implementation Committee meetings	8 years	2 meetings per year	Existing staff	1
All	All	Produce State of Our Watersheds report	Report is produced biennially	2 years	Report is produced every 2 years	$11,000 per 2 years	1
All	All	Track progress toward meeting TMDL reduction requirements using GIS and other data tracking tools	Track progress using system similar to that being used for similar SWAPs (e.g., Northeastern Jones Falls, Bird River, Middle Gwynns Falls, etc.)	2 years	Annual update to Upper Patapsco River SWAP Implementation Committee	Existing staff	1,3
1	1,2,4	Update the status of citizen-based restoration projects and BMPs	Provide update of progress made in annual NPDES report	On-going	NPDES annual report	Existing staff	1,2
2	1,2						
3	2						
1	All	Continue to update status of county capital budget restoration projects and BMPs	Provide update of progress made in annual NPDES report	On-going	NPDES annual report	Existing staff	1
2	1,2						

APPENDIX B: U.S. ENVIRONMENTAL PROTECTION AGENCY A THROUGH I CRITERIA FOR WATERSHED PLANNING

U.S. Environmental Protection Agency
A Through I Criteria for Watershed Planning

Background

EPA's Section 319 Grant program was established to provide funding for efforts to reduce nonpoint source (NPS) pollution, including that which occurs though stormwater runoff. The EPA provides funds to state and tribal agencies, which are then allocated via a competitive grant process to organizations to address current or potential NPS concerns.

Section 319 funds may be used to demonstrate innovative best management practices (BMPs), support education and outreach programs, establish TMDLs for a watershed, or to restore impaired streams or other water resources. 303(d) listed waters approved by the EPA are the top priority for incremental funds.

The EPA requires that nine elements (labeled "a" though "i") be included in a watershed plan for impaired waters funded using Section 319 funds. Although there is no formal requirement for EPA to approve watershed plans, the plans must address the nine elements discussed below if they are developed in support of a section 319-funded project. Below, we review how the development of the Upper Patapsco River Small Watershed Action Plan addresses each of the nine elements.

Addressing the Nine Elements for the Upper Patapsco River Watershed

The County's progress in addressing the nine elements ("a" thru "i") required for 319 funding is described below:

a) ***Causes of Impairment:*** *Identification of causes of impairment and pollutant sources or groups of similar sources that need to be controlled to achieve needed load reductions, and any other goals identified in the watershed plan. Sources that need to be controlled should be identified at the significant subcategory level along with estimates of the extent to which they are present in the watershed.*

   This element will usually include an accounting of the significant point and nonpoint sources in addition to the natural background levels that make up the pollutant loads causing problems in the watershed. If a TMDL exists, this element may be adequately addressed. (USEPA 2008)

Impairments to Chesapeake Bay are well recognized and are being addressed by multiple agency efforts under the Chesapeake Bay TMDL for nitrogen, phosphorus, and sediment. There is currently a bacteria impairment listed for the area covered by the Upper Patapsco River SWAP.

Section 1.3.3 of the SWAP contains further information on the Chesapeake Bay TMDL, a copy of which is in the Appendix H of the Characterization Report (Appendix E). Chapter 3 of the Characterization Report includes estimates of pollutant loads.

b) ***Estimate Load Reductions:*** *On the basis of the existing source loads estimated for element "a" above, you will similarly determine the reductions needed to meet the water quality standards. You will then identify various management measures (see element "c" below) that will help to reduce the pollutant loads and estimate the load reductions expected as a result of these management measures to be implemented, recognizing the difficulty in precisely predicting the performance of management measures over time. In cases where a TMDL for affected waters has already been developed and approved or is being developed, the watershed plan should be crafted to achieve the load reductions called for in the TMDL.* (EPA 2008)

Expected nitrogen and phosphorus load reductions were calculated based on Maryland Assessment Scenario Tool (MAST) load reduction criteria. These load reduction criteria are presented in Appendix D. The nitrogen, phosphorus, and sediment load reductions for the various proposed actions in the Upper Patapsco River watershed were calculated and summarized in Chapter 3 of the SWAP.

Estimated load reductions needed are as follows:

- Reduce annual Total Nitrogen (TN) and Total Phosphorus (TP) loadings from urban land in the Upper Patapsco River SWAP area by 32.2% and 47.0% respectively to meet the requirements of the Chesapeake Bay TMDL.

MAST (CBP-approved) BMP removal efficiencies are summarized in the tables included as Appendix D. These pollutant removal efficiencies will continue to be used to measure progress in meeting the nutrient TMDL reduction goal. Actions and associated pollutant load reductions will be reevaluated if CBP revises/updates pollutant removal efficiencies within the 10-year timeframe to ensure that the TMDL reductions are met.

c) ***Description and location of NPS management measures:*** *A description of the NPS management measures that will need to be implemented to achieve load reductions, and a description of the critical areas in which those measures will be needed to implement this plan. This description should be detailed enough to guide implementation activities and can be greatly enhanced by identifying on a map priority areas and practices.* (EPA 2008)

This Small Watershed Action Plan, by definition, identifies strategies for bringing a small watershed into compliance with water quality criteria. The strategies employed in this SWAP include a combination of government capital projects, actions in partnership with local watershed associations, citizen awareness campaigns and volunteer activities. Chapter 3 summarizes restoration strategies/NPS management measures. Specifically, information on the achievement of the phosphorus and nitrogen reduction goals is provided in Section 3.4. Chapter 4 specifies implementation locations, by subwatershed, detailing management measures recommended for each subwatershed in the SWAP study area. The management measures that will need to be implemented to achieve the goals are detailed further in Appendix A.

Note that the projected, practicable implementation of proposed restoration BMPs, shown in Table 3-17 and Table 3-18 will only achieve slightly more than half of the 32.2% reduction for nitrogen and will exceed the 47.0% reduction for phosphorus loads needed to meet water quality standards for the Upper Patapsco River watershed as specified by Chesapeake Bay TMDL for nutrients (Appendix E).

Greater reductions may also be achieved through restoration actions not included in this analysis such as public education/outreach efforts (e.g., watershed trash and recycling campaign and tours of completed projects). However, these types of actions are not included in the pollutant removal analysis because reductions efficiencies are not well known and difficult to estimate.

d) ***Estimate of the amounts of technical and financial assistance*** *needed associated costs, and/or the sources and authorities that will be relied upon to implement this plan. This includes implementation and long-term operation and maintenance of management measures, information/education activities, monitoring, and evaluation activities. You should also document which relevant authorities might play a role in implementing the plan. Plan sponsors should consider the use of federal, state, local, and private funds or resources that might be available to assist in implementing the plan. Shortfalls between needs and available resources should be identified and addressed in the plan. The estimate of financial and technical assistance should take into account the following* (EPA 2008)*:*

- *Administration and management services, including salaries, regulatory fees, and supplies, as well as in-kind services efforts, such as the work of volunteers and the donation of facility use;*
- *I/E efforts;*
- *The installation, operation, and maintenance of management measures; and*
- *Monitoring, data analysis, and data management activities.*

Appendix A details the anticipated cost for each action on an annual or unit basis and details the organizations that will be responsible for implementation of each action. Appendix C provides a cost analysis and anticipated funding sources to implement the actions.

Baltimore County's NPDES program generally, as well the program infrastructure needed to implement this SWAP, is already well-established as demonstrated by previously completed technical Water Quality Management Plans, such as the 2000 Patapsco River Water Quality Management Study, which this effort builds upon. Additionally, Upper Patapsco River watershed partners have worked together over the past year, conducting assessments, identifying restoration opportunities, and engaging the community, in order to build a successful SWAP.

An Upper Patapsco River SWAP Steering Committee, consisting of various watershed partners, was formed to develop this SWAP. This includes Baltimore County EPS, Patapsco Heritage Greenway, Baltimore County Soil Conservation District, Greater Patapsco Community Association, Neighborhood Safety Team Baltimore County, University of Maryland Extension and various community associations and concerned citizens. The Steering Committee met regularly throughout the SWAP development and will form the basis for a similar group to carry out SWAP implementation.

e) ***An information and education component*** *used to enhance public understanding of the project and encourage their early and continued participation in selecting, designing, and implementing the NPS management measures that will be implemented*. (EPA 2008)

The participation of citizens in watershed restoration is an essential part of the SWAP process. Citizen participation is critical to the implementation and long-term maintenance of restoration activities. Two citizen stakeholder meetings were held as part of the SWAP process (see Chapter 1). Key citizen-based strategies have been proposed for restoring Upper Patapsco River including nutrient management, lawn maintenance education, Bayscaping, downspout disconnection, tree planting, stream buffer management (see Chapter 3). This demands continued participation by citizen stakeholders. Specific strategies by subwatershed which include an information and education component are detailed in Chapter 4. Outreach and awareness components by action are detailed in Appendix A.

f) ***Schedule for implementing the NPS management measures*** *identified in this plan that is reasonably expeditious. The schedule should reflect the milestones you develop in measure "g".* (EPA 2008)

Each action strategy listed in Appendix A has a timeline and where appropriate, a temporal performance measure. It is anticipated that the restoration will require a 8-year timeframe. Some actions have a shorter time frame based on sequencing of actions, or on the urgency of the actions. However, most management measures have annual performance measures that will determine if the restoration is on pace to be completed within the time frame. The limitations on the pace of the implementation include staffing, and funding. Increases in staffing and funding will be used to accelerate the restoration timeline. Chapter 5 presents an adaptive management approach to implementation.

g) ***A description of interim measurable milestones*** *for determining whether NPS management measures or other control actions are being implemented. These milestones will measure the implementation of the management measures, such as whether they are being implemented on schedule, whereas element h (see below) will measure the effectiveness of the management measures, for example, by documenting improvements in water quality. (EPA 2008)*

Actions will be organized into two year milestones, with the first interval being July 1, 2017 - June 30, 2019, and the final interval being July 1, 2024 – June 30, 2025. Additionally, most action strategies (listed in Appendix A) have an associated time-sensitive performance measure. Additionally, each will be evaluated on an annual basis and may be modified and/or new actions may be proposed based on this annual evaluation. New actions proposed will also be evaluated on an annual basis and modified as necessary to meet watershed goals and objectives and if new TMDLs are approved.

Chapter 5 provides a plan for evaluation of NPS management measures implementation. This includes formation of the Upper Patapsco River SWAP Implementation Committee which will meet twice per year to assess progress in meeting watershed goals and objectives and generation of an annual progress report. A biennial report on water quality monitoring results will be produced as well.

Additionally, Baltimore County intends to track implementation of the SWAP using a Geographic Information System (GIS), which will allow the County to record and map all actions taken per the SWAP. The data generated from the GIS will be provided to the Upper Patapsco River SWAP Implementation Committee to assess annual progress through a comparison between completed restoration activities and the performance measures detailed in Appendix A. Pollutant load

reductions that have been achieved through implementation of various restoration projects will also be calculated and tracked.

h) ***A set of criteria that can be used to determine whether loading reductions are being achieved*** *over time and substantial progress is being made toward attaining water quality standards (WQS). The criteria in element h (not to be confused with water quality criteria in state regulations) are the benchmarks or waypoints to measure against through monitoring. These interim targets can be direct measurements (e.g., fecal coliform concentrations) or indirect indicators of load reduction (e.g., number of beach closings). You should also indicate how you'll determine whether the watershed plan needs to be revised if interim targets are not met. (EPA 2008)*

Appendix A gives a "performance measure" which describes how the success/completion of a given action will be measured. In many cases, it is the numeric basis of the performance measure divided by the proposed timeline.

Current pollutant load reduction scenarios and calculations for proposed actions are presented in Chapter 3 of the SWAP. These are mainly based on CBP-approved, pollutant removal efficiencies for various nonpoint source BMPs used in the Maryland Assessment Scenario Tool (MAST). These pollutant removal efficiencies will continue to be used to measure progress in meeting the nutrient TMDL reduction goals. Actions and associated pollutant load reductions will be reevaluated if CBP revises/updates pollutant removal efficiencies within the 10-year timeframe to ensure that the nutrient TMDL reductions are met.

As mentioned in element "g" above, the Upper Patapsco River SWAP Implementation Committee will generate a biennial report on water quality monitoring results and action strategies will be modified as required to respond to a lack of substantial progress and/or new TMDL.

i) ***A monitoring component*** *to evaluate the effectiveness of the implementation efforts over time, measured against the criteria established under item h immediately above. The monitoring component should be designed to determine whether loading reductions are being achieved over time and substantial progress in meeting water quality standards is being made. (EPA 2008)*

Chapter 5 details the monitoring that will occur to evaluate the effectiveness of implementation. The monitoring results will be compared to the predicted load reductions determined under item (h), above. Baltimore County conducts chemical, biological, and illicit connection monitoring within the Upper Patapsco River watershed which are appropriate for measuring changes in loading. Additional monitoring is anticipated in order to assess the effectiveness of restoration projects and progress in meeting nutrient TMDL reductions. Current applicable monitoring is described in detail in Chapter 3.4 of the Watershed Characterization Report (Appendix E) and listed below:

- County Trend Chemical Monitoring Program – 1 sampling location (PA04 – Ben's Run), measuring total suspended solids (TSS), nutrients, metals, and chloride;
- County Biological Monitoring Program – Randomly selected locations in the Upper Patapsco River watershed using characteristics of benthic macroinvertebrates as a water quality indicator; and

- Illicit Discharge Detection and Elimination Program – Routine outfall screening and prioritization system to track and reduce illicit connections and discharges.

Project specific monitoring will be identified as restoration progresses. It will not be possible to monitor all restoration projects due to the number of actions proposed. Project specific monitoring will target activities with limited data regarding removal efficiencies such as lawn care education. Subwatershed monitoring will measure overall improvement in water quality as a result of multiple restoration activities within a subwatershed. This will also be developed as restoration progresses.

Monitoring activities will be coordinated among SWAP participants (e.g., Baltimore County, Maryland DNR, and PHG) through participation in the Upper Patapsco River SWAP Implementation Committee. There is potential to coordinate a citizen-based stream watch program since the existing water quality monitoring stations are limited in the Upper Patapsco River watershed.

APPENDIX C: COST ANALYSIS AND POTENTIAL FUNDING SOURCES

Cost Analysis and Potential Funding Sources

This appendix presents cost estimates and potential funding sources for the implementation of proposed restoration BMPs in the Upper Patapsco River SWAP. Each is described below. The cost analysis is based on the actions detailed in Appendix A. Cost estimates are summarized in Tables C-1 and C-2.

Table C-1 presents cost estimates based on the maximum implementation scenario described in Chapter 3. Table C-2 presents costs estimates based on the projected participation rates needed to achieve the reduction in nutrient loads and sediment from urban runoff, also described in Chapter 3.

For both scenarios, estimates provided are in current dollars and represent total cost estimates for the anticipated 10-year implementation timeframe. Unit costs are based on a combination of local information and previous SWAPs completed for other local watersheds (e.g., Tidal Back River, Lower Patapsco River, and Bird River). BMP costs are not annualized over the 10-year implementation timeframe and do not include costs of existing staff. Costs are also presented in dollars per pound of nitrogen, phosphorus, and TSS removal for those BMPs where pollutant removal calculations were possible (refer to Chapter 3). This provides an additional tool for the assessment and selection of BMPs.

The total cost of implementation exclusive of staffing costs is approximately **$19,863,326** for maximum implementation and **$16,806,323** based on projected participation rates. This does not include cost associated with sanitary sewer overflow prevention.

Potential Funding Sources

Funding sources for the implementation of the Upper Patapsco River SWAP include local government funding for Baltimore County, monetary and time contributions to the Upper Patapsco River SWAP Implementation Committee, and various grants as described below. Baltimore County uses general funds to support staff, whose responsibility is to monitor and improve water quality through implementation of various programs including capital restoration projects. Baltimore County has a Waterway Improvement Capital Program that is funded by a combination of general funds and bonds. Approximately $4 million per year is allocated for various restoration projects throughout the county. The capital budget is projected for six years, with a two-year cycle for changes. The Upper Patapsco River watershed as a whole currently has $1.1 million allocated for restoration projects over the six-year period. Baltimore County provides grants to local watershed organizations through its Watershed Association Citizen Restoration Planning and Implementation Grant Program. These funds provide staffing for restoration project implementation and education and outreach programs.

In order to implement all of the actions listed in Appendix A and to meet the anticipated funding needs summarized in Table C-2, additional funding from grants will be required. Table C-3 presents potential funding sources to support the implementation of the Upper Patapsco River SWAP including funding source, applicant eligibility, eligible projects, funding amount, cost share requirements, and grant cycle. The anticipated major grant funding sources include the following:

- **The Chesapeake and Atlantic Coastal Bays Trust Fund (Trust Fund):** Established during the 2008 Legislative Session by Senate Bill 213 to provide financial assistance to local governments and political subdivisions for the implementation of nonpoint source pollution control projects. These are intended to achieve the state's tributary strategy developed in accordance with the Chesapeake 2000 Agreement and to improve the health of the Atlantic Coastal Bays and their tributaries. The BayStat Program directs the administration of the Trust Fund, with multiple state agencies receiving moneys from the Trust Fund, including Maryland Department of Environment (MDE), Department of Natural Resources (DNR), Maryland Department of Agriculture (MDA), and Maryland Department of Planning (MDP).

- **319 Non-point Pollution Grants:** Approximately $1,000,000 of federal money for restoration implementation is available annually through MDE.

- **Bay Restoration Fund (MDE):** The Bay Restoration Fund offers financial assistance to local governments for voluntary stream and creek restoration projects that improve water quality and restore habitat. Funds are targeted to seriously degraded water bodies in Maryland. Types of projects funded include: stream channel reconstruction, stream bank stabilization, vegetative buffers, wetlands creation, treatment of acid mine drainage, and dredging.

- **Stormwater Pollution Control Cost Share Program (MDE):** The Maryland Stormwater Pollution Control Cost-Share Program provides grant funding for stormwater management retrofit and conversion projects in urban areas developed prior to 1984. These projects reduce nutrients, sediments and other pollutant loads entering the state's waterways through the use of infiltration basins, infiltration trenches, vegetated swales, extended detention ponds, bioretention basins, wetlands and other innovative structures.

- **Innovative Nutrient and Sediment Reduction Program (National Fish and Wildlife Foundation):** The National Fish and Wildlife Foundation (NFWF), in partnership with U.S. Environmental Protection Agency (USEPA) and the Chesapeake Bay Program, will award grants on a competitive basis of between $200,000 and $1,000,000 each to support the demonstration of innovative approaches to expand the collective knowledge about the most cost effective and sustainable approaches to dramatically reduce or eliminate nutrient and sediment pollution to the Chesapeake Bay and its tributaries.

- **Chesapeake Bay Stewardship Fund:** The goal of the Chesapeake Bay Stewardship Fund is to accelerate local implementation of the most innovative, sustainable and cost effective strategies to restore and protect water quality and vital habitats within the Chesapeake Bay watershed. The Stewardship Fund offers four grant programs: the Chesapeake Bay Small Watershed Grant Program, the Chesapeake Bay Targeted Watersheds Grant Program, the Chesapeake Bay Conservation Innovation Grant Program and the Innovative Nutrient and Sediment Reduction Program. Major funding for the Chesapeake Bay Stewardship Fund comes from the USEPA, the U.S. Department of Agriculture Natural Resources Conservation Service (NRCS), and the U.S. Department of Administration (NOAA).

- **MD State Highway Administration (SHA) Transportation Enhancement Program (TEP):** This is a reimbursable, federal-aid funding program for transportation-related

community projects designed to strengthen the intermodal transportation system. The TEP supports communities in developing projects that improve the quality of life for their citizens and enhance the travel experience for people traveling by all modes. Among the qualifying TEP categories is environmental mitigation to address water pollution due to highway runoff or to reduce vehicle-caused wildlife mortality while maintaining habitat connectivity.

- **Chesapeake Bay Trust:** Provides grants through a variety of grant programs that focus on environmental education, urban greening, fisheries, and remediation of water quality issues. Specifically, the Targeted Watershed Grant Program provides funding for on-the ground solutions that address the most pressing nonpoint source pollution challenges facing a small watershed, and that result in measurable improvements in water quality and wildlife habitat. The program also seeks to support cost effective approaches to Chesapeake Bay restoration actions at the small watershed scale and establish a replicable model of restoration that can be transferred and used throughout the region.

Table C-1. Maximum Estimated Costs for Upper Patapsco River SWAP Implementation

BMP or Action	Cost	Unit	Projected	Quantity	Proj. Total Cost	Proj. TN Load Reduction (lbs/year)	Proj. Cost/ lb of TN Removal*	Proj. TP Load Reduction (lbs/year)	Proj. Cost/lb of TP Removal*	Proj. TSS Load Reduction (lbs/year)	Proj. Cost/lb of TSS Removal*
Dry pond Conv.	$3,200	/acre	230.6	acres	$737,952	172	$4,290.42	14	$52,710.86	16,459	$44.84
Stormwater Retrofits: Bioretention	$3,200	/acre	4.48	acres	$14,336	31.6	$453.67	4.33	$3,310.85	6,705	$2.14
Stream Buffer Reforestation (pervious areas)	$15,000	/acre	744	acres	$11,160,000	3,647	$3,060.05	143	$78,041.96	165,327	$67.50
Pervious Area Reforestation	$6,000	/acre	63	acres	$378,000	246	$1,536.59	5.54	$68,231.05	5,344	$70.73
Stream Corridor Restoration	$350	/Linear foot	15,558	ft	$5,445,300	714	$7,626.47	647	$8,416.23	427,078	$12.75
Downspout Disconnection	$152,374	/acre	13.92	acres	$2,121,046	461	$4,600.97	48	$44,188.46	92,868	$22.84
Neighborhood Tree Plantings	$175	/tree	23	acres	$4,025	276	$14.58	6	$670.83	6,004	$0.67
Institution Tree Plantings	$175	/tree	3.81	acres	$667	12	$55.56	0.27	$2,469.44	257	$2.59
Bayscaping Education	$500	/event	4	Events	$2,000	**	**	**	**	**	**
Street Sweeping	***	EUIA	4	EUIA	***	343	***	137	***	41,132	***
				Total:	**$19,863,326**						

* This projected cost is for the first year. Cost per pound removed decreases for every subsequent year the device is functioning.

** Removal efficiencies for BayScaping have not been set and incorporated into MAST at this time, so estimated load reductions could not be calculated.

*** Street sweeping does not add to the cost of the SWAP Implementation. It is assumed that existing Baltimore County staff would be responsible for the action, and therefore not additional cost would be incurred.

Table C-2. Projected Estimated Costs for Upper Patapsco River SWAP Implementation

BMP or Action	Cost	Unit	Projected	Quantity	Proj. Total Cost	Proj. TN Load Reduction (lbs/year)	Proj. Cost / lb of TN Removal*	Proj. TP Load Reduction (lbs/year)	Proj. Cost/lb of TP Removal*	Proj. TSS Load Reduction (lbs/year)	Proj. Cost/lb of TSS Removal*
Dry pond Conv.	$3,200	/acre	230.6	acres	$737,952	172	$4,290.42	14	$52,710.86	16,459	$44.84
Stormwater Retrofits: Bioretention	$3,200	/acre	2.2	acres	$7,168	31.6	$226.84	4.33	$1,655.43	6,705	$1.07
Stream Buffer Reforestation (pervious areas)	$15,000	/acre	595.2	acres	$8,928,000	3,647	$2,448.04	143	$62,433.57	165,327	$54.00
Pervious Area Reforestation	$6,000	/acre	47.3	acres	$283,500	246	$1,152.44	5.54	$51,173.29	5,344	$53.05
Stream Corridor Restoration	$350	/Linear foot	15558.0	ft	$5,445,300	714	$7,626.47	647	$8,416.23	427,078	$12.75
Downspout Disconnection	$152,374	/acre	9.2	acres	$1,399,890	461	$3,036.64	48	$29,164.38	92,868	$15.07
Neighborhood Tree Plantings	$175	/tree	11.5	acres	$2,013	276	$7.29	6	$335.42	6,004	$0.34
Institution Tree Plantings	$175	/tree	2.9	acres	$500	12	$41.67	0.27	$1,852.08	257	$1.95
Bayscaping Education	$500	/event	4.0	Events	$2,000	**	**	**	**	**	**
Street Sweeping	***	EUIA	4.0	EUIA	***	343	***	137	***	41,132	***
				Total:	**$16,806,323**						

* This projected cost is for the first year. Cost per pound removed decreases for every subsequent year the device is functioning.

** Removal efficiencies for BayScaping have not been set and incorporated into MAST at this time, so estimated load reductions could not be calculated.

*** Street sweeping does not add to the cost of the SWAP Implementation. It is assumed that existing Baltimore County staff would be responsible for the action, and therefore not additional cost would be incurred.

Table C-3: Upper Patapsco River SWAP Potential Funding Sources

Managing Agency	Funding Source	Application Eligibility	Eligible Projects	Funding Amount	Cost Share / In-Kind	Project Period
American Forests	Global ReLeaf Program (American Forests)	All public lands or public accessible lands Local government State government	Public Lands Restoration Projects which include local organizations; use innovative restorative practices with potential for general application; minimum 20 acre project area	$1 per tree planted	Covers tree planting costs / YES	1 Year
Chesapeake Bay Trust	Targeted Watershed Initiative Grant Program	Non-profits 501(c) Institutions Soil/-Water Conservation Districts Local government	Involve local organizations; address non-point source pollution; projects related to water quality and habitat restoration	$50 to $200,000	0% / YES	1-2 years
Chesapeake Bay Trust	Capacity Building Initiative Grant Program	Non-profit 501(c) with a board on which half the members participate meaningfully and at least one paid staff (or a part-time paid volunteer)	Strengthen an organization through management operations, technology, governance, fundraising and communications	$15,000 per year	0% / YES	3 years
Chesapeake Bay Trust	Stewardship Grant Program	Non-profits 501(c), Schools/universities, Soil/Water Conservation Districts, Local government, State government	Raise awareness about watershed restoration; design plans which educate citizens on things they can do to aid watershed restoration; educate students about local watersheds, projects geared towards watershed restoration and protection	$5,000 to $25,000	0% / YES	1 year

Table C-3: Upper Patapsco River SWAP Potential Funding Sources (Cont.)

Managing Agency	Funding Source	Application Eligibility	Eligible Projects	Funding Amount	Cost Share / In-Kind	Project Period
DNR	Clean Water Action Plan Nonpoint Source Program 319 Grant	Non-profits 501(c) Universities Soil/Water Conservation Districts Local government State government	Located in a Category I and Category III watershed as outlined in the MD unified watershed assessment; establish cover crops; address stream restoration and riparian buffers	$5,000 to $40,000	40%	Annual
MDE	Bay Restoration Fund	Local Government	Green restoration projects	None specified	50% / YES	None specified
MDE/DNR	Chesapeake and Atlantic Coastal Bays Trust Fund	Non-profits 501(c) Local government	Non-point source best manage-ment practices reducing nitrogen, phosphorous and sediment	None specified	Unknown	Annual
NFWF	Chesapeake Bay Small Watersheds Grant Program	Non-profits 501(c) Local government	Community-based projects that improve the condition of local watersheds while building stewardship among citizens; watershed restoration, conservation, and planning	$20,000 to $200,000	25%	1-5 years
NFWF	Chesapeake Bay Targeted Watersheds Grant Program	Non-profits 501(c) Universities Local government State government	Innovative demonstration type restoration projects	$ 400,000 to $1,000,000	25% / YES	2-3 years
NRCS	Watersheds Operations Program	Local government State government Tribes	Address watershed protection, flood mitigation, water quality, soil erosion, sediment control, habitat enhancement, and wetland creation and restoration	None specified	Unknown	None specified
USEPA	Targeted Watersheds Grant Program – Capacity Building Grant Program	Non-profits 501(c) Institutions Local government State government	Promote organizational development of local watershed partnerships; provide training and assistance to local watershed groups	$400,000 to $800,000	25% / YES	2 years

Table C-3: Upper Patapsco River SWAP Potential Funding Sources (Cont.)

Managing Agency	Funding Source	Application Eligibility	Eligible Projects	Funding Amount	Cost Share / In-Kind	Project Period
USEPA	Targeted Watersheds Grant Program – Implementation Grant Program	Non-profits 501(c) Universities Local government State government	Watershed restoration and/or protection projects (must include a monitoring component)	$600,000 to $900,000	25% / YES	3-5 years

APPENDIX D: POLLUTANT REMOVAL EFFICIENCIES FROM THE MARYLAND ASSESSMENT SCENARIO TOOL (MAST)

(Approved by the Chesapeake Bay Program)

Table D-1: Pollutant Removal Efficiencies from MAST*

BMP	Nitrogen Effectiveness (%)	Phosphorus Effectiveness (%)	Sediment Effectiveness (%)
Bioretention/rain gardens - A/B soils, no underdrain	80	85	90
Bioretention/rain gardens - A/B soils, underdrain	70	75	80
Bioretention/rain gardens - C/D soils, underdrain	25	45	55
Bioswale	70	75	80
Dry Detention Ponds and Hydrodynamic Structures	5	10	10
Dry Extended Detention Ponds	20	20	60
MS4 Permit-Required Stormwater Retrofit	25	35	65
Permeable Pavement w/ Sand, Veg. - A/B soils, no underdrain	80	80	85
Permeable Pavement w/ Sand, Veg. - A/B soils, underdrain	50	50	70
Permeable Pavement w/ Sand, Veg. - C/D soils, underdrain	20	20	55
Permeable Pavement w/o Sand, Veg. - A/B soils, no underdrain	75	80	85
Permeable Pavement w/o Sand, Veg. - A/B soils, underdrain	45	50	70
Permeable Pavement w/o Sand, Veg. - C/D soils, underdrain	10	20	55
Stormwater Management by Era 1985 to 2002 MD	17	30	40
Stormwater Management by Era 2002 to 2010 MD	30	40	80
Stormwater to the Maximum Extent Practicable (SW to the MEP)	50	60	90
Street Sweeping 25 times a year-acres (formerly called Street Sweeping Mechanical Monthly)	3	3	9
Urban Filtering Practices	40	60	80
Urban Forest Buffers	25	50	50
Urban Infiltration Practices w/ Sand, Veg. - A/B soils, no underdrain	85	85	95
Urban Infiltration Practices w/o Sand, Veg. - A/B soils, no underdrain	80	85	95
Vegetated Open Channels - A/B soils, no underdrain	45	45	70
Vegetated Open Channels - C/D soils, no underdrain	10	10	50
Wet Ponds and Wetlands	20	45	60

*MAST values as of June 2015; additional information on MAST, visit http://www.mastonline.org/

Upper Patapsco River SMALL WATERSHED ACTION PLAN

Volume II

April 2017

Baltimore County Executive Kevin Kamenetz
and the County Council

Prepared for

Baltimore County Department of
Environmental Protection and Sustainability

Prepared by

VERSAR

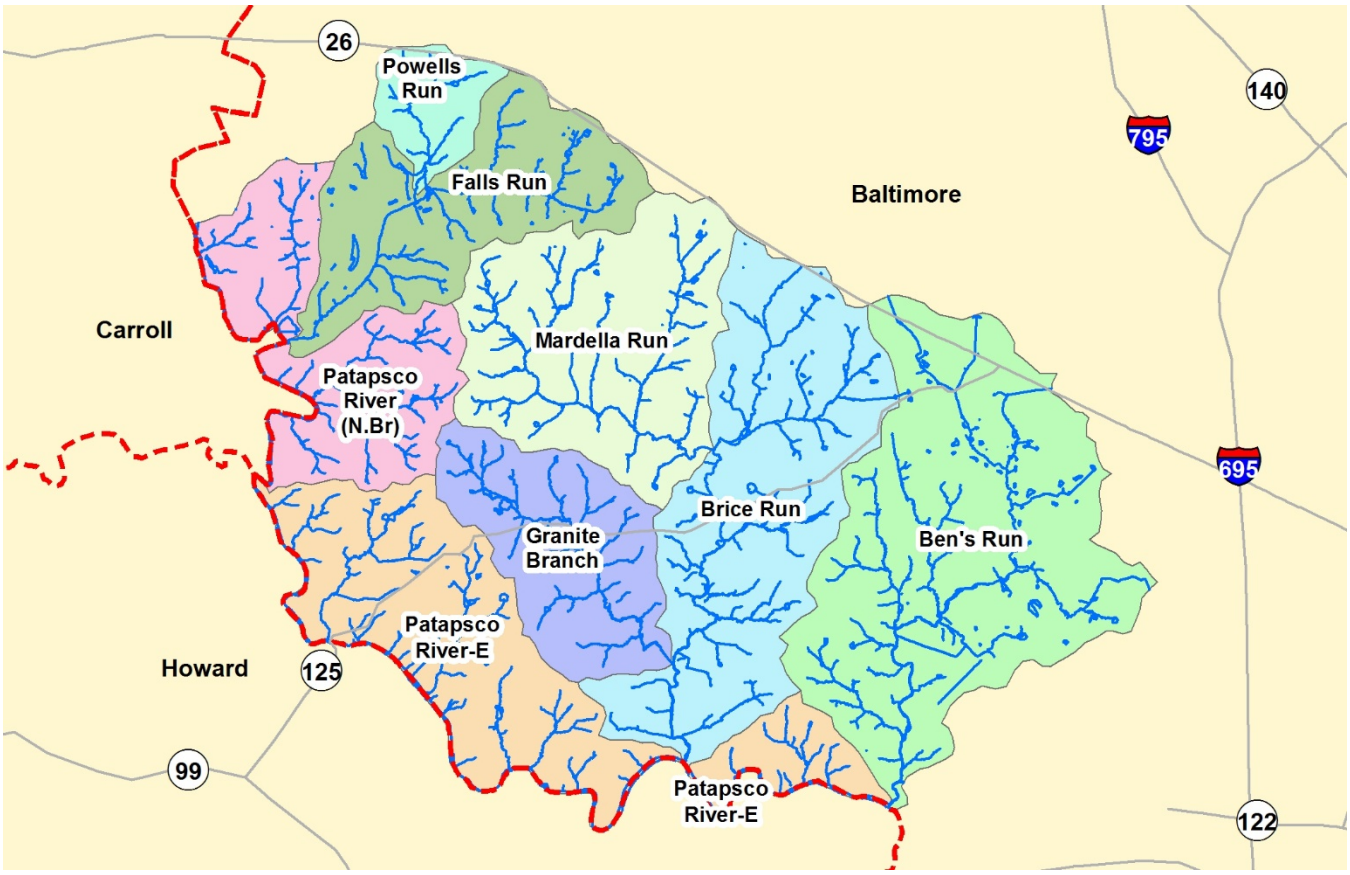
with

Coastal Resources, Inc. and McCormick Taylor

CLEAN GREEN COUNTY

APPENDIX E:
WATERSHED CHARACTERIZATION REPORT

UPPER PATAPSCO RIVER
SMALL WATERSHED ACTION PLAN



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CHAPTER 1: INTRODUCTION

1.1 PURPOSE

The purpose of the Upper Patapsco River Watershed Characterization Report is to:

1. Summarize the factors that may affect the water quality of the Upper Patapsco River, such as landscape, geomorphology, hydrology, and biological characteristics; and
2. Explain the current conditions of the watershed and its natural resources.

This report also describes human-induced effects on the watershed and identifies restoration and preservation strategies appropriate for accomplishing watershed goals. A Small Watershed Action Plan (SWAP) for the Upper Patapsco River watershed will be developed based on the information provided in this watershed characterization report.

1.2 WATERSHED LOCATION AND SCALE

The Upper Patapsco River watershed is within the Eastern Piedmont region of Maryland, located west of the City of Baltimore (Figure 1-1). It drains to the tidal Patapsco River and eventually, the Baltimore City harbor and Chesapeake Bay. The Upper Patapsco River SWAP area is approximately 15,898 acres (24.84 mi^2), including a developed part of Randallstown in the north, and a large rural portion in the south. The Upper Patapsco River SWAP area makes up 3.7% of the overall Patapsco River watershed.

The Upper Patapsco River watershed contains eight smaller drainage areas called subwatersheds (Figure 1-2). In addition to characterizing the entire watershed, analyses were conducted on a subwatershed scale to provide detailed information for smaller areas and to focus restoration and preservation efforts. Also, success of restoration efforts can be more easily monitored and measured on this smaller scale. Subwatersheds and corresponding acreages are listed in (Table 1-1). Watershed and subwatershed delineation is explained further in Chapter 2.

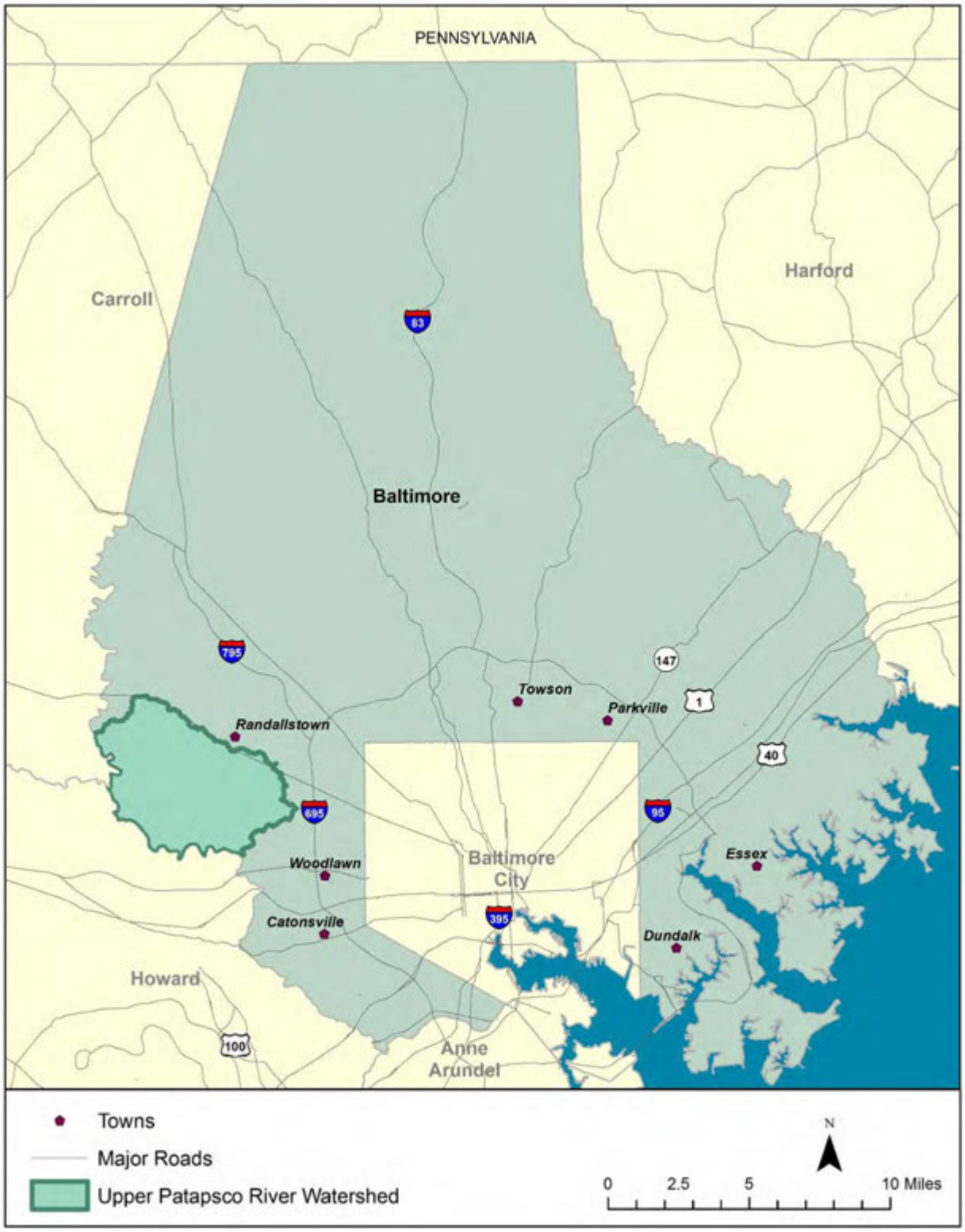

Figure 1-1: Upper Patapsco River Watershed Location

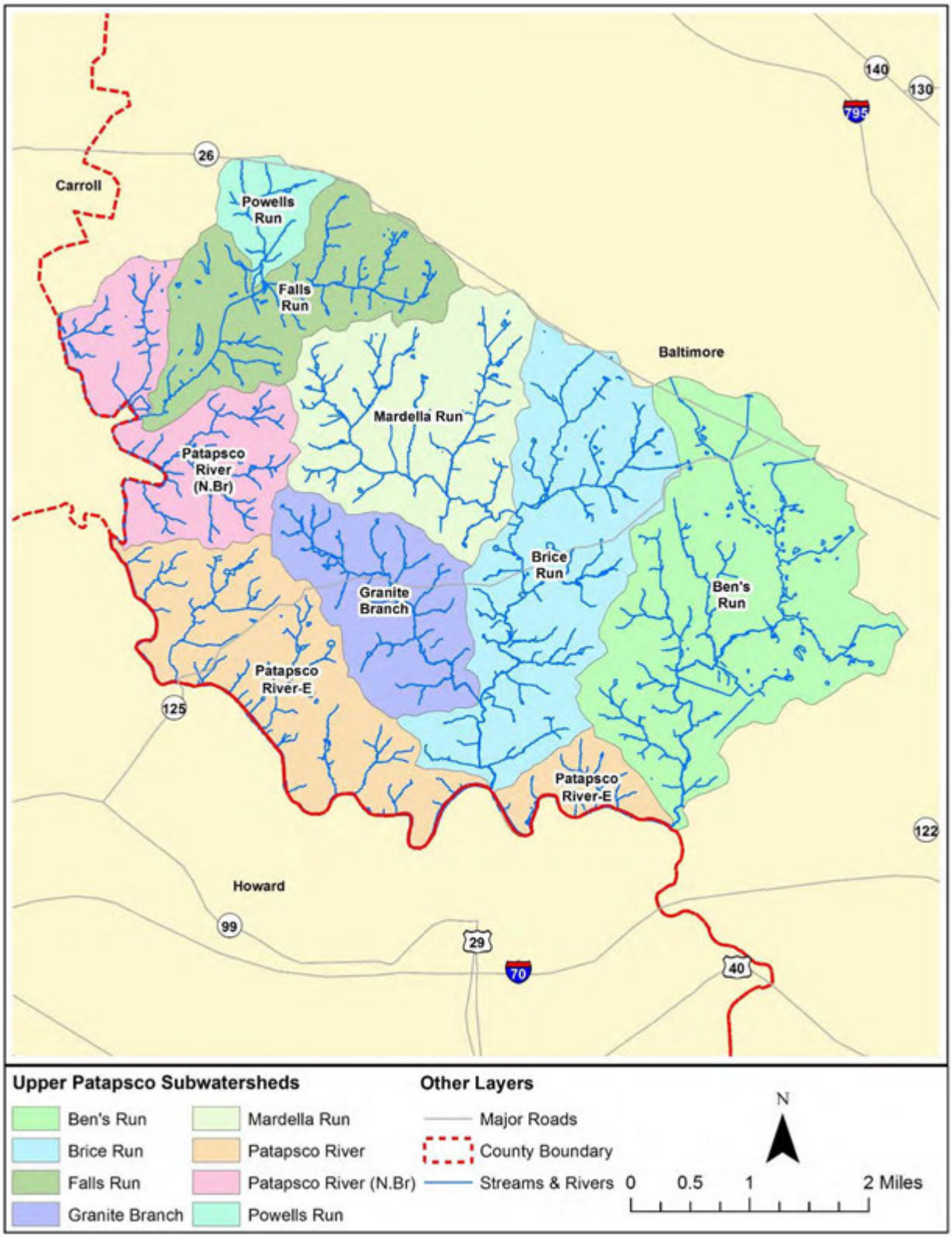

Figure 1-2: Upper Patapsco River Subwatersheds

Table 1-1: Upper Patapsco River Subwatershed Areas

Subwatershed	Area (Acres)	Area (Sq. Miles)
Ben's Run	3,552.59	5.55
Brice Run	2,718.00	4.25
Falls Run	1,642.40	2.57
Granite Branch	1,327.64	2.07
Mardella Run	2,163.49	3.38
Patapsco River (N.Br)	1,583.28	2.47
Patapsco River-E	2,491.36	3.89
Powells Run	419.37	0.66
Total	15,898.13	24.84

1.3 REPORT ORGANIZATION

This report is organized into the following six major chapters:

Chapter 1 explains the purpose of this report, the watershed location, and the scope of the watershed characterization.

Chapter 2 summarizes watershed characteristics related to landscape and land use that may affect natural resources and water quality. This chapter contains landscape information related to natural features such as geology, soils, forest cover, and streams, as well as information pertaining to human influences such as land use, population, impervious cover, water distribution, and stormwater infrastructure.

Chapter 3 includes an analysis of pollutant loads, as calculated through modeling efforts, and discusses water quality and quantity conditions based on available monitoring and stream assessment data. This chapter also includes results of stormwater management facility evaluations and ranks facilities by conversion potential. Additional details are presented for top-rated facilities.

Chapter 4 describes the uplands assessment conducted to identify pollutant sources and restoration opportunities for neighborhoods, institutions, pervious areas, and hotspots.

Chapter 5 presents an overview of the key best management practice (BMP) recommendations appropriate for accomplishing watershed goals developed by the community and the Upper Patapsco River SWAP Steering Committee.

Chapter 6 contains a list of references consulted during the development of this report.

CHAPTER 2: LANDSCAPE AND LAND USE

2.1 INTRODUCTION

This chapter describes land cover and land use in the Upper Patapsco River watershed, including natural land surface characteristics and development activities. Characteristics such as soil type and impervious cover strongly influence the quantity and quality of stormwater runoff in the watershed. For example, the amount and rate at which precipitation will be absorbed by the ground surface depends on the infiltration capacity of a soil for pervious areas; impervious (e.g., paved) surfaces impede rainfall infiltration which can result in flooding, erosion, and a decrease in groundwater supply. In addition, the type and extent of pollutants carried by stormwater is affected by land use characteristics. For example, residential or agricultural areas may contribute fertilizers and pesticides to stormwater runoff. Developed areas may transmit various types of pollutants directly to receiving water bodies such as trash, bacteria (livestock and pet waste), and chemicals, depending on specific land use activities, since there is often inadequate buffer or vegetation to filter pollutants. The information presented in this chapter provides the physical setting and background necessary to evaluate other watershed components including water quality, natural resources, restoration, and management.

2.2 NATURAL LANDSCAPE

Natural climate and land surface characteristics relevant to watershed properties and processes are described in the following sections.

2.2.1 Climate

Climate is an important consideration since it can influence soil and erosion processes, stream flow patterns, and topography. In addition, climate affects vegetative growth and determines the species composition of the terrestrial and aquatic life of a region.

This region can be described as a humid continental climate with four distinct seasons (DEPRM 2008). It has a relatively temperate climate due to the combined effects of the Appalachian Mountains to the west and the Chesapeake Bay and the Atlantic Ocean to the east. According to the National Climatic Data Center (NCDC), it is also in the path of the low pressure systems that move across the country, which results in frequent changes in wind direction and weather (NCDC 2013). Average annual rainfall in Baltimore, Maryland is 41.94 inches based on 30 years of data (1971-2000) collected by the Northeast Regional Climate Center (NRCC 2013). Monthly average rainfall is 3.5 inches based on the same data set. Rainfall is uniformly distributed through the year, with monthly averages ranging from 3.00 inches in April to 3.98 inches in September. Most snowfall occurs in December, January, February, and March; an average annual snowfall of 21.4 inches is based on 58 years of data (1950-2008).

2.2.2 Watershed Delineation

A watershed-based approach for evaluating water quality conditions and improvement potential involves determining the drainage area that contributes runoff and groundwater to a specific water body. Drainage areas vary greatly depending on the scale of the stream system of interest. Drainage areas for large river, estuary and lake systems are typically on the order of several thousand square miles, and usually referred to as basins. For example, the Chesapeake Bay basin covers over 64,000 square miles, including over 100,000 tributaries (i.e., rivers and

streams) and includes portions of six different states (CBP 2011). Basins consist of sub-basins, which are on the order of several hundred square miles and may consist of one or more major stream networks. Maryland has 13 sub-basins, including the Patapsco/Back River sub-basin, of which the Patapsco River is a part (CWP 2005). These units are then further subdivided into watersheds and subwatersheds, which are a practical size for watershed assessment, management, and restoration planning.

The Upper Patapsco River watershed covers 24.8 square miles in western Baltimore County. For the purposes of the Upper Patapsco River Small Watershed Action Plan, Baltimore County used stream maps and topography to divide the watershed into 8 subwatersheds, ranging in size from 419 acres to 3,552 acres (Figure 1-2; Table 1-1).

2.2.3 Topography

The topography of a region describes the relative elevations of surface features, such as ridges and valleys. Land surface shape, including degree of slope and concavity, is important as it affects the flow of surface water, soil erosion patterns, and suitability for development. For example, steep slopes are more prone to overland flow and soil erosion than flatter slopes, and thus have a greater potential for generating pollutants. Slopes were determined based on Baltimore County's Geographic Information System (GIS) soils data and divided into the following six categories, derived from slope class definitions provided in the U.S. Department of Agriculture (USDA) *Soil Survey Manual* (USDA 1993):

- Nearly level (0-3% slope);
- Gently sloping, undulating (1-8% slopes);
- Strongly sloping, rolling (4-16% slopes);
- Moderately steep, hilly (10-30% slopes);
- Steep (20-60% slopes); and
- Very steep (> 45% slope).

Table 2-1 summarizes the percent breakdown of each soil slope category by subwatershed. The distribution of these slope categories within the Upper Patapsco River watershed is depicted in Figure 2-1. Most of the watershed is categorized as "Nearly level" to "Strongly sloping." Only a few small blocks of land are categorized as "Steep" or "Very steep" and would be more prone to erosion, depending on development and land use.

Figure 2-1: Upper Patapsco River Watershed Topography Based on Soil Slopes

Table 2-1: Upper Patapsco River Subwatershed Slope Categorization

Subwatershed	Slope Category (% of Subwatershed)						
	Water/Pavement	Nearly Level (0-3%)	Gently Sloping (1-8%)	Strongly Sloping (4-16%)	Moderately-Steep (10-30%)	Steep (20-60%)	Very Steep (> 45%)
Ben's Run	0.0	6.2	53.4	21.0	11.6	7.7	0.0
Brice Run	0.1	9.7	32.0	31.4	16.8	9.4	0.6
Falls Run	0.0	4.6	25.7	27.5	14.8	11.3	16.2
Granite Branch	0.2	6.7	50.8	29.4	10.0	2.9	0.0
Mardella Run	0.0	9.8	54.3	25.0	9.1	1.8	0.0
Patapsco River (N.Br)	1.4	8.3	22.0	24.5	19.2	22.3	2.3
Patapsco River-E	1.9	6.6	19.6	30.9	20.0	17.7	3.4
Powells Run	0.0	6.8	34.8	33.9	15.2	9.1	0.2
Total	0.5	7.3	36.6	28.0	14.6	10.3	2.8

2.2.4 Geology

Geology effects the chemical composition of surface and groundwater, as well as the recharge rate to groundwater and wells. It is also key in soil formation and influences the buffering of pollution to water bodies in developed areas. Consequently, geology is closely related to water quality. The Upper Patapsco River watershed lies entirely within the Piedmont region. Table 2-2 displays the geology of the subwatersheds, showing both the percent distribution and the geological type. This area of the Piedmont is characterized by hard igneous and metamorphic rocks, with areas of gneiss, quartzite, marble and schist (MGS 2009). These varying rock types have different erosion potentials, and are a big factor in the unusual topography in this part of the Piedmont.

The geological formations of the Upper Patapsco River watershed are shown in Figure 2-2.

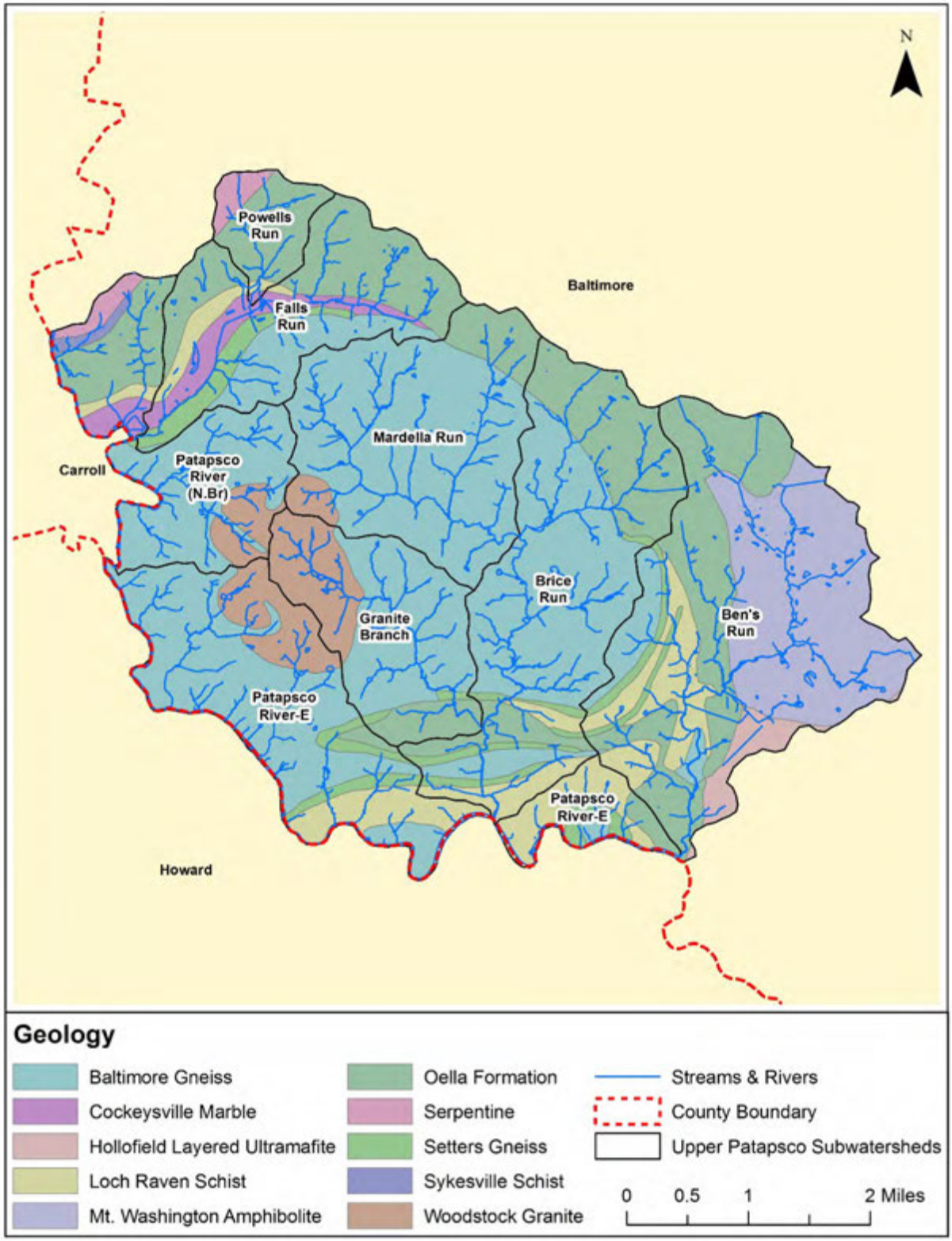

Figure 2-2: Upper Patapsco River Watershed Geology

Table 2-2: Geological Composition by Subwatershed (%)

Geology	Type	Bens Run	Brice Run	Falls Run	Granite Branch	Mardella Run	Patapsco River (N. Branch)	Patapsco River-E	Powells Run
Baltimore Gneiss	Metamorphic	6.1	57.3	22.4	58.9	86.7	52.9	55.8	0
Cockeysville Marble	Metamorphic	0	0	15	0	0	5	0	1.4
Hollofield Layered Ultramafite	Igneous	5.1	0	0	0	0	0	0	
Loch Raven Schist	Sedimentary	12	7.1	6.5	0	0	2.6	20.9	2.6
Mt. Washington Amphibolite	Metamorphic	42.9	0	0	0	0	0	0	0
Oella Formation	Metasedimentary	31	30.3	45.2	12.3	9.7	21.7	3.4	77
Serpentine	Metamorphic	0	0	0	0	0	4.6	0	19
Setters Gneiss	Metamorphic	2.9	5.3	10.9	1.6	0	0.3	7.7	0
Sykesville Schist	Sedimentary	0	0	0	0	0	2.8	0	0
Woodstock Granite	Igneous	0	0	0	27.2	3.6	10.2	12.2	0

2.2.5 Soils

Soil conditions are important when evaluating water quantity and quality in streams and rivers. Soil type and moisture conditions, for example, affect how land may be used and its potential for vegetation and habitat. Soils are an important consideration for projects aimed at improving water quality and/or habitat. Baltimore County's GIS soils layer was used for the soils data analysis and is a representation of the Baltimore County Soil Survey, published by USDA/Natural Resources Conservation Service (NRCS) in 1976.

Urbanization has an impact on soil conditions within a watershed (Konrad 2003). In addition to increasing the amount of impervious surfaces, which prevent infiltration, construction and development result in soil compaction and the thinning of soil surface layers. These thinner soil layers are quickly saturated and result in increased overland flow, when compared to the natural, vegetated landscape that existed before urbanization.

2.2.5.1 Hydrologic Soil Groups

The Natural Resource Conservation Service (NRCS) classifies soils into four hydrologic soil groups (HSG) based on runoff potential. Runoff potential is the opposite of infiltration capacity (ability for the soil to absorb precipitation). Soils with high infiltration capacity will have low runoff potential, and vice versa. Infiltration rates are highly variable among soil types and are also influenced by disturbances to the soil profile (e.g., land development activities). For example, urbanization in watersheds with high infiltration rates (e.g., sands and gravels) will have a greater impact than urbanization in watersheds consisting mostly of silts and clays, which have low infiltration rates. The four hydrologic soil groups are A, B, C, and D, where group A soils generally have the lowest runoff potential and Group D soils have the greatest.

Brief descriptions of each hydrologic soil group are provided below. Areas of open water did not receive a classification. Further explanation of each can be found in the USDA/NRCS publication, *Urban Hydrology for Small Watersheds*, also called Technical Release 55 (USDA 1986).

- **Group A** soils include sand, loamy sand, or sandy loam types. These soils have a high infiltration rate and low runoff potential even when thoroughly wet. These consist mainly of deep, well to excessively drained sands or gravel. These soils have a high rate of water transmission.
- **Group B** soils include silt loam or loam types. They have a moderate infiltration rate when thoroughly wet. These soils mainly consist of somewhat deep to deep, moderately well to well drained soils with moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.
- **Group C** soils are sandy clay loam. These soils have a low infiltration rate when thoroughly wet. These types of soils typically have a layer that hinders downward movement of water and soils with moderately fine or fine texture. These soils have a low rate of water transmission.
- **Group D** soils include clay loam, silty clay loam, sandy clay, silty clay, or clay types. These soils have a very low infiltration rate and high runoff potential when thoroughly wet. These consist mainly of clays with high swell potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very low rate of water transmission.

Table 2-3 and Figure 2-3, the soils in the Upper Patapsco River watershed are mostly divided between soil groups B and C (those with moderate and low infiltration rates, respectively). The distribution of hydrologic soil groups is patchy, with a few solid blocks of soils in groups A and D, the very well drained soils and very low infiltration rate soils. The large blocks of Group D correspond to areas of dense urbanization and large areas of impervious surface.

Table 2-3: Upper Patapsco River Subwatershed Hydrologic Soil Group Categorization

Subwatershed	Hydrologic Soil Group (% of Subwatershed)				
	A	B	C	D	Water
Ben's Run	0.37	66.53	16.51	16.55	0.05
Brice Run	2.51	72.87	17.25	7.28	0.09
Falls Run	0.00	66.92	16.94	16.14	0.00
Granite Branch	0.00	68.72	27.94	3.12	0.23
Mardella Run	1.87	69.63	23.18	5.32	0.00
Patapsco River (N.Br)	0.00	69.09	27.00	2.57	1.35
Patapsco River-E	0.22	78.09	18.68	1.09	1.93
Powells Run	0.00	79.21	20.57	0.21	0.00
Total	1.24	71.38	21.01	6.53	0.73

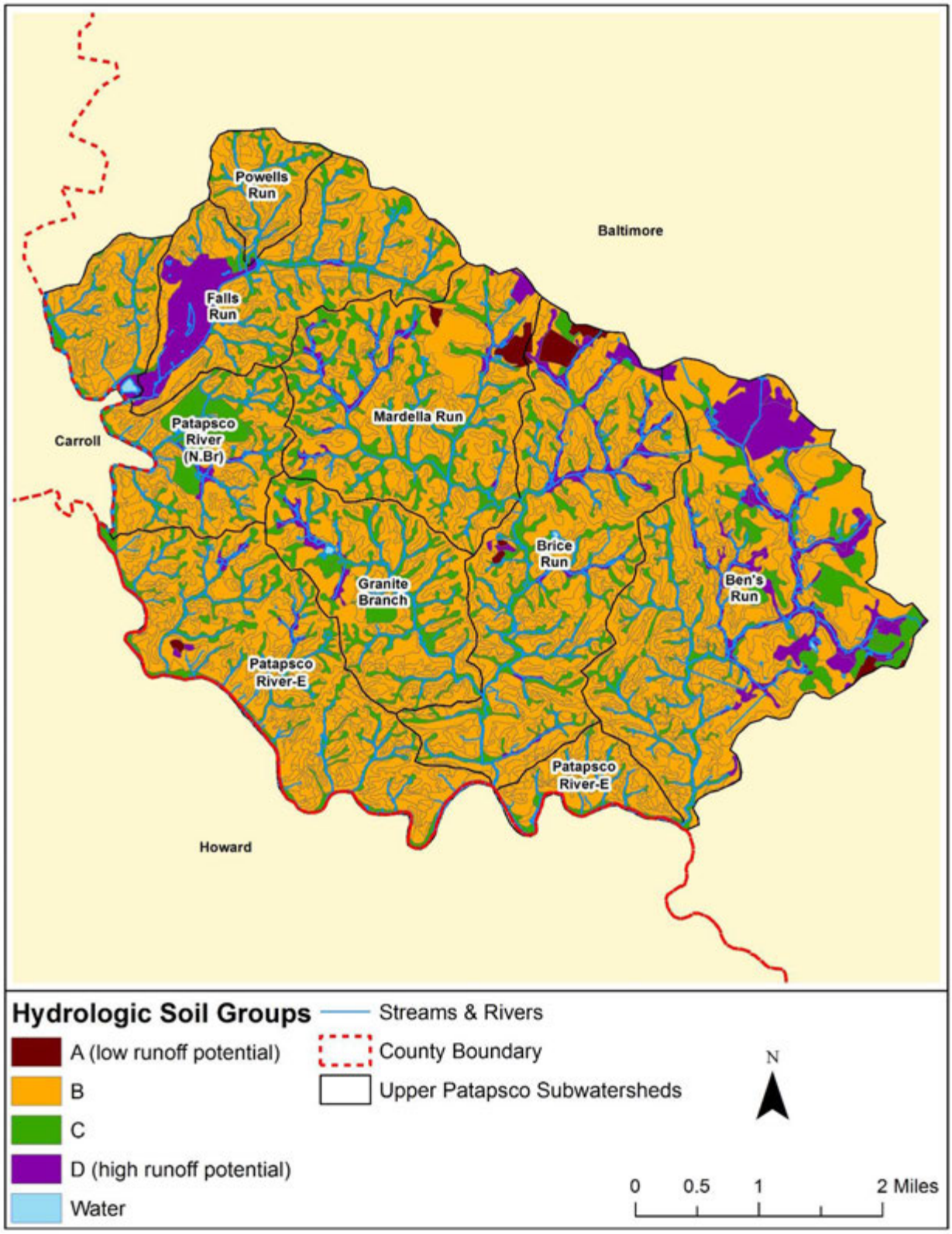

Figure 2-3: Upper Patapsco River Watershed Hydrologic Soil Groups

2.2.5.2 Erodibility

Erodibility is the susceptibility of soil to erosion. It is quantified by the K factor, which is part of the Universal Soil Loss Equation (USLE) developed by USDA's Agricultural Research Service to estimate rate of erosion and soil loss for a particular site. Low K factor values indicate low erodibility or high resistance to detachment and high K factors represent high erodibility potential. Erodibility is based on the physical and chemical properties of the soil, which determine how strongly soil particles cohere with one another. For example, clay soils are cohesive or resistant to detachment and have low K values on the order of 0.05 to 0.15 (Ouyang 2002).

Soil erodibility was divided into the following three categories, based on the soils data obtained from Baltimore County's Office of Information Technology (OIT) for the Upper Patapsco River watershed:

- Low Erodibility (K factor < 0.24);
- Medium Erodibility (0.24 ≤ K factor ≤ 0.32); and
- High Erodibility (K factor > 0.32).

Figure 2-4 shows the distribution of soil erodibility in the Upper Patapsco River watershed based on these categories and a summary by subwatershed is shown in Table 2-4. Subwatersheds with the largest fractions of highly erodible soils present the greatest potential for addressing soil conservation issues via best management practices (BMPs) such as minimizing bare soil and keeping topsoil in place. Soil erodibility data are also useful in combination with other information such as location of cropland, slope steepness, and distance to streams to determine where retirement of highly erodible land, another BMP, is appropriate. High K factor values can also serve as a warning for urban activities planned near streams such as road construction or utility placements.

As shown in Table 2-4 and Figure 2-4, medium and high erodibility categories represent over 91 percent of the soil erodibility distribution in this watershed. This indicates that most of the watershed's soils are prone to moderate or high erosion. Significant portions (> 28%) of the Mardella Run and Granite Branch subwatersheds consist of highly erodible soils. These subwatersheds should be ranked high as a priority for maintaining protective land cover such as forested area.

Table 2-4: Upper Patapsco River Subwatershed Soil Erodibility Categorization

Subwatershed	Water/ Pavement/ Urban Land (%)	Soil Erodibility Category (K Factor) (% of Subwatershed)		
		Low (< 0.24)	Medium (0.24-0.32)	High (> 0.32)
Ben's Run	6.23	25.00	44.84	23.92
Brice Run	3.57	0.00	73.05	23.37
Falls Run	15.78	0.00	66.13	18.09
Granite Branch	0.23	0.00	71.60	28.17
Mardella Run	2.76	0.00	68.88	28.36
Patapsco River (N.Br)	12.71	0.52	67.01	19.77
Patapsco River-E	2.34	0.00	78.14	19.52
Powells Run	0.21	3.50	73.03	23.25
Total	5.48	3.63	67.84	23.06

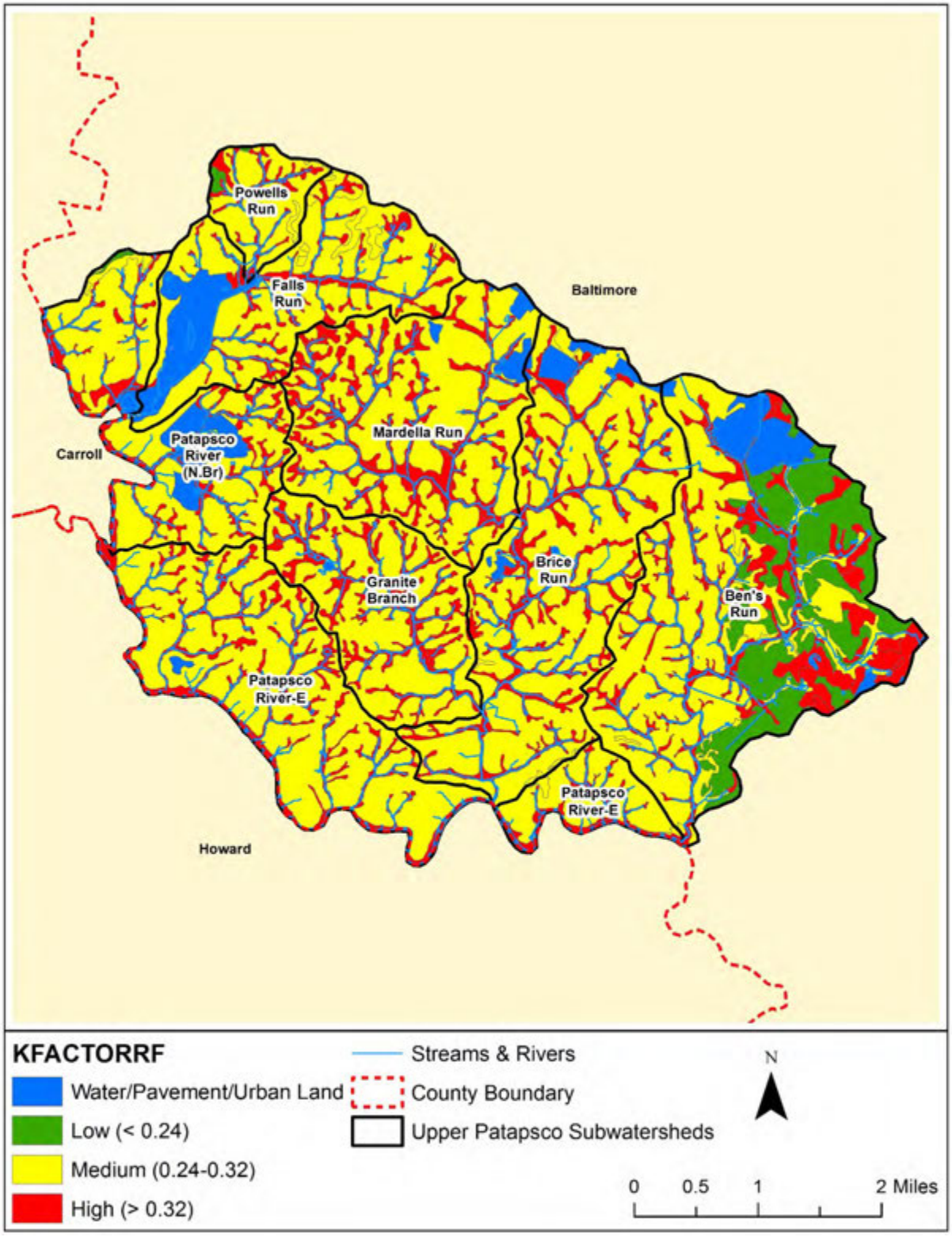

Figure 2-4: Upper Patapsco River Watershed Soil Erodibility (based on the soil K factor)

2.2.6 Forest Cover

Forest provides the greatest protection among land cover types for water and soil quality. In pristine systems, forest and soils co-evolve, shaping the hydrologic cycle; these systems operate within a natural range of variability, assuring healthy habitat and water quality. The entire Chesapeake Bay basin, including the Upper Patapsco River watershed, consisted overwhelmingly of old-growth forest at the time of European settlement. In human-impacted systems, forest cover can still provide many benefits and protect water quality if judiciously planned and conserved.

While the forested area has been greatly reduced in this watershed since European settlement, some subwatersheds have maintained a relatively high percentage of forest cover (e.g., Patapsco River-E, Patapsco River (N.Br)) compared to the other more densely urbanized watersheds in this area. This is mainly due to the fact that a large portion of these two watersheds is within Patapsco Valley State Park. Table 2-5 summarizes forested acres and percent forested area by subwatershed, and Figure 2-5 shows the distribution of forest cover within the Upper Patapsco River watershed based on Baltimore County's wooded GIS layer. Data used to calculate and display forest cover were developed by the University of Vermont (UVM) Spatial Analysis Laboratory in 2008. LiDAR images from 2005 and National Agricultural Imagery Program (NAIP) data from 2007 were used to create this high resolution land cover dataset.

Table 2-5 shows that the Upper Patapsco River watershed has approximately 9,202 acres of forested area, which is 58% of the total watershed area. This is higher than the Maryland Department of Planning's (MDP) 2010 land use/land cover classification scheme, which estimates that just under 40% of forest cover remains in this watershed. (Slight variations between the UVM land cover/canopy cover dataset and MDP land use/land cover scheme result from different scales and photo sources used.)

Table 2-5: Upper Patapsco River Subwatershed Forest Cover

Subwatershed	Total Acres	Forested Acres	% Forested
Ben's Run	3,553	1,896	53
Brice Run	2,718	1,608	59
Falls Run	1,642	876	53
Granite Branch	1,328	683	51
Mardella Run	2,163	996	46
Patapsco River-E	2,491	1,773	71
Patapsco River (N.Br)	1,583	1,138	72
Powells Run	419	233	56
Total	15,898	9,202	58

Figure 2-5: Upper Patapsco River Watershed Forest Cover

2.2.7 Stream Systems

Stream systems are a watershed's circulatory system, and the most visible part of the hydrologic cycle. Streams are the flowing surface waters, and while they are distinct from groundwater and standing surface water such as lakes, they are closely connected to both. The stream system is an intrinsic part of the landscape and closely reflects conditions on the land. Streams are a fundamental natural resource with numerous benefits for plants, animals, and humans. Maintaining a healthy stream system is a priority for many individuals and organizations, and requires ensuring that stream flows and water quality closely mimic the conditions found in un-impacted watersheds.

2.2.7.1 Stream System Characteristics

The Upper Patapsco River watershed is part of a state-defined, 8-digit watershed (Patapsco River Lower North Branch) and, as discussed in Section 2.2.2, is part of the Chesapeake Bay basin. This watershed is subdivided into eight subwatersheds and contains approximately 128 miles of stream (Figure 2-6). These streams all drain to the Patapsco River, which ultimately drains to the Chesapeake Bay. A summary of stream mileage and density by subwatershed is included in Table 2-6. The Ben's Run and Patapsco River-E subwatersheds have the largest number of stream miles, with more than five times the stream miles of the smallest subwatershed, Powells Run.

Table 2-6: Upper Patapsco River Watershed Stream Mileage and Density

Subwatershed	Area (square miles)	Stream Miles	Stream Density (miles/square mile)
Ben's Run	5.55	24.52	4.42
Brice Run	4.25	21.10	4.97
Falls Run	2.57	12.59	4.90
Granite Branch	2.07	10.70	5.16
Mardella Run	3.38	17.05	5.04
Patapsco River (N.Br)	2.47	15.61	6.31
Patapsco River-E	3.89	22.64	5.82
Powells Run	0.66	3.56	5.43
Total	24.84	127.77	5.14

Figure 2-6: Upper Patapsco River Watershed Stream System and Subwatersheds

2.2.7.2 Stream Riparian Buffers

Riparian buffers are the vegetated areas adjacent to streams that protect water bodies from toxins and excessive nutrients, while also providing bank stabilization and habitat. Forested buffer areas along streams play a crucial role in improving water quality and flood mitigation since they can reduce surface runoff, stabilize stream banks, trap sediment, and provide habitat for various types of terrestrial and aquatic life including fish. Tree roots, for example, capture and remove pollutants including excess nutrients (e.g., nitrogen) from shallow flowing water; the tree root structure also impedes erosion and water flow, which in turn reduces sediment load and the risk of flooding. Tree canopy provides shading and results in cooler water temperatures required by a variety of stream biota, particularly cold-water species like trout. In smaller streams such as the ones surveyed, terrestrial plant material falling into the stream is the primary source of food for stream fauna. Trees provide seasonal food in the form of leaves and plant parts for stream life at the base of the food chain, while fallen tree branches and trunks provide a more consistent, slow-release food source throughout the year. Tree roots and snags offer habitat for fish and other aquatic species. Maintaining healthy, forested buffers is important for reducing nutrient and sediment loadings to the Patapsco River and to the Chesapeake Bay. When stream riparian buffers are converted from forest to agriculture or urban land uses (e.g., residential), many of these benefits are lost and stream health declines. Riparian buffer zones can be re-established or preserved as a BMP to reduce land use impacts by intercepting and controlling the pollutants entering a water body.

The vegetative condition of the riparian buffer was analyzed based on a 100-ft buffer on either side of the stream system. Three conditions were used to classify stream buffer conditions: impervious, open pervious, or forested. Impervious areas were determined by overlaying the roads and buildings data layers over the 100-ft stream buffer layer. Similarly, the forested areas were determined using the UVM land cover layer and removing any impervious area footprint. Remaining areas were classified as open pervious areas. Stream buffer conditions are summarized by subwatershed in terms of acres and percentages in Table 2-7. The distribution of land cover classes within the 100-ft stream buffer is shown in Figure 2-7. As expected, streams in the highly urbanized subwatersheds, such as Ben's Run and Brice Run, have the highest percentage of impervious surface within the 100-ft buffer corridor. The Patapsco River-E, Patapsco River (N.Br) and Powells Run subwatersheds have the highest proportion of forested stream buffer.

Table 2-7: Upper Patapsco River Subwatershed Land Use in the 100-ft Stream Buffer

	Forest		Open Pervious		Impervious	
Subwatershed	Acres	%	Acres	%	Acres	%
Ben's Run	503.2	72.8	149.0	21.6	38.7	5.6
Brice Run	424.1	75.6	116.9	20.8	20.1	3.6
Falls Run	240.5	69.9	94.1	27.3	9.5	2.8
Granite Branch	197.2	75.4	61.5	23.5	2.8	1.1
Mardella Run	294.3	70.4	115.0	27.5	8.6	2.1
Patapsco River (N.Br)	333.9	82.5	62.4	15.4	8.7	2.1
Patapsco River-E	494.4	78.6	128.7	20.5	5.5	0.9
Powells Run	68.6	78.7	16.2	18.6	2.4	2.7
Total	2,556.3	75.5	743.8	21.9	96.2	2.6

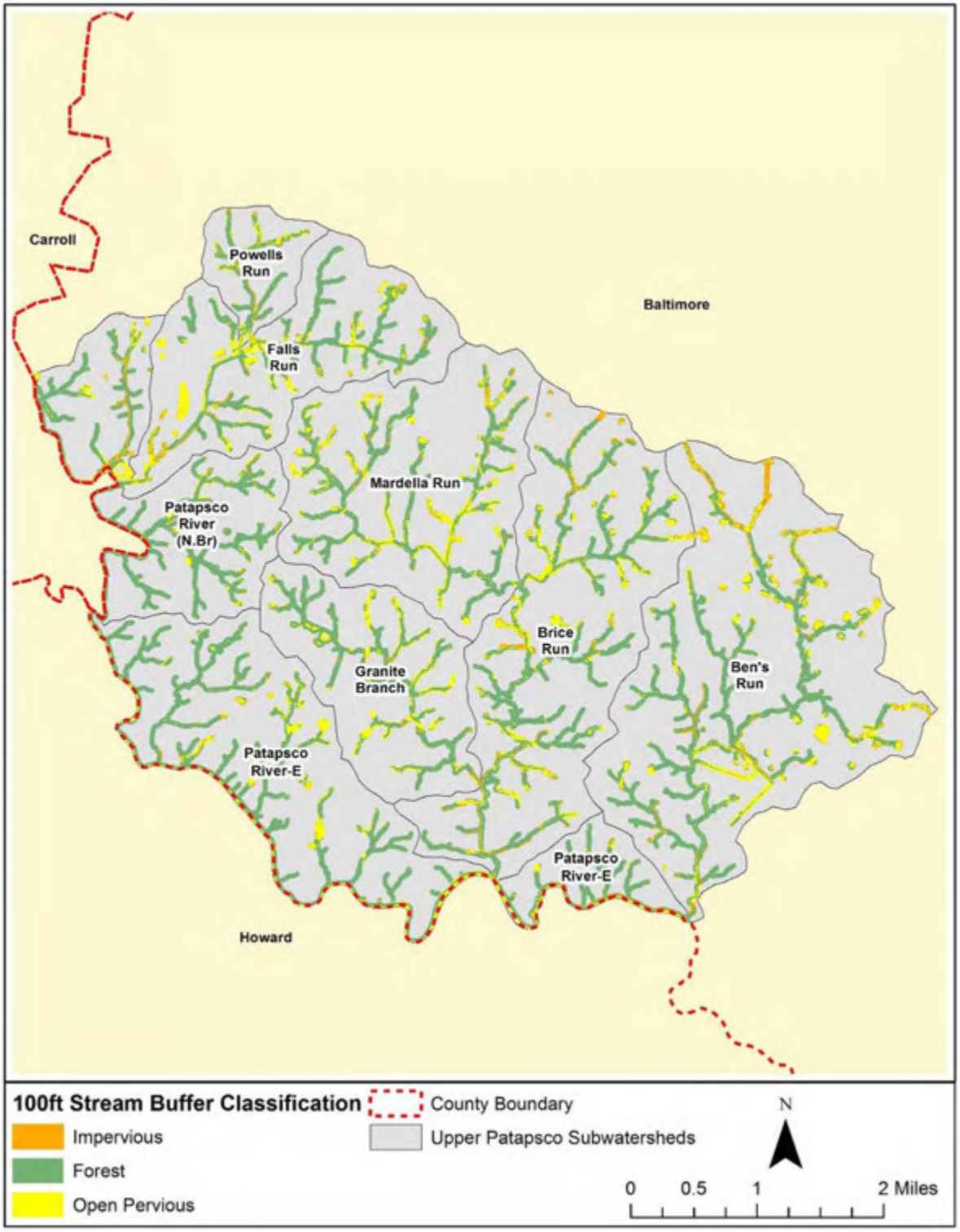

Figure 2-7: Upper Patapsco River Watershed 100-ft Stream Buffer Land Use

2.3 THE HUMAN MODIFIED LANDSCAPE

The natural landscape has been modified for human use over time. The intensity of development activities has increased, starting with the colonization of Maryland in the 1600s. This modification has resulted in environmental impacts to both terrestrial and aquatic ecosystems. This section describes the characteristics of the human modified landscape and how it is associated with impacts to the natural ecosystem. This includes a general description of land use and land cover and more specific issues such as population, impervious cover, drinking water and wastewater, stormwater systems, discharge permits, zoning, and build-out analysis.

This section also demonstrates how pollutants may enter waterways from both point and non-point sources. Point sources of pollution are those that may be easily traced to a single, easily-defined origin, for example a wastewater treatment plant or a leaking barrel. Non-point sources (NPS) are those that originate from a diffuse area and are typically carried by precipitation or snowmelt into storm drain systems and/or waterways. NPS pollutants may include chemicals that wash off of roadways, including oils, salt and other de-icing agents that are used to treat roadways during winter storms. Other common NPS pollutants are the fertilizers and pesticides used on residential lawns, commercial landscaping, and cropfields; improper or excessive application of these chemicals often results in increased NPS pollution.

2.3.1 Land Use and Land Cover

Land use has pronounced impacts on water quality and habitat. Different land uses generate different types and amounts of pollutants. As discussed in the previous section, a forested watershed has the capacity to absorb pollutants such as sediment and nutrients and reduce the flow rate of water into streams. Developed areas with impervious surfaces, such as roads, parking lots, and roofs, block the natural seepage of precipitation into the ground. Unlike most natural surfaces, impervious surfaces tend to concentrate stormwater runoff, accelerate flow rates, and direct stormwater to the nearest stream. This can cause bank erosion and destruction of in-stream and riparian habitat. Undeveloped watersheds and those with small amounts of impervious surfaces tend to have better water quality in local streams than developed watersheds with larger amounts of impervious surfaces. In addition, agricultural land uses can contribute to increases in nutrients and coliform bacteria in streams, if not properly managed.

MDP develops a statewide land use/land cover GIS layer every five years to provide a general overview of predominant land cover/usage (interpreted from aerial photography and satellite imagery) and to monitor development activities throughout the state. The most recent update available and used for this characterization report is the 2010 MDP land use/land cover scheme. This was a revision of the 2002 land use/land cover GIS layer, updated using a combination of aerial imagery and parcel information. These data are for use by government agencies and other stakeholders to assess trends in land development and consumption of undeveloped/natural resources over time. Two new land use/land cover categories were introduced in the draft 2007 GIS layer and were also included in the 2010 dataset: very low density residential (large lot subdivision, 5 to 20 acres) and transportation (major highways and miscellaneous transportation features not classified elsewhere). The large area of ‘bare ground’ in subwatershed Patapsco River N. Br. was reclassified as ‘cropland’ based on review of aerial photography from 2009 to present. A summary of land use/land cover percentages by subwatershed is included in Table 2-8. A map and pie chart of land use/land cover according to MDP’s 2010 scheme is shown in Figure 2-8.

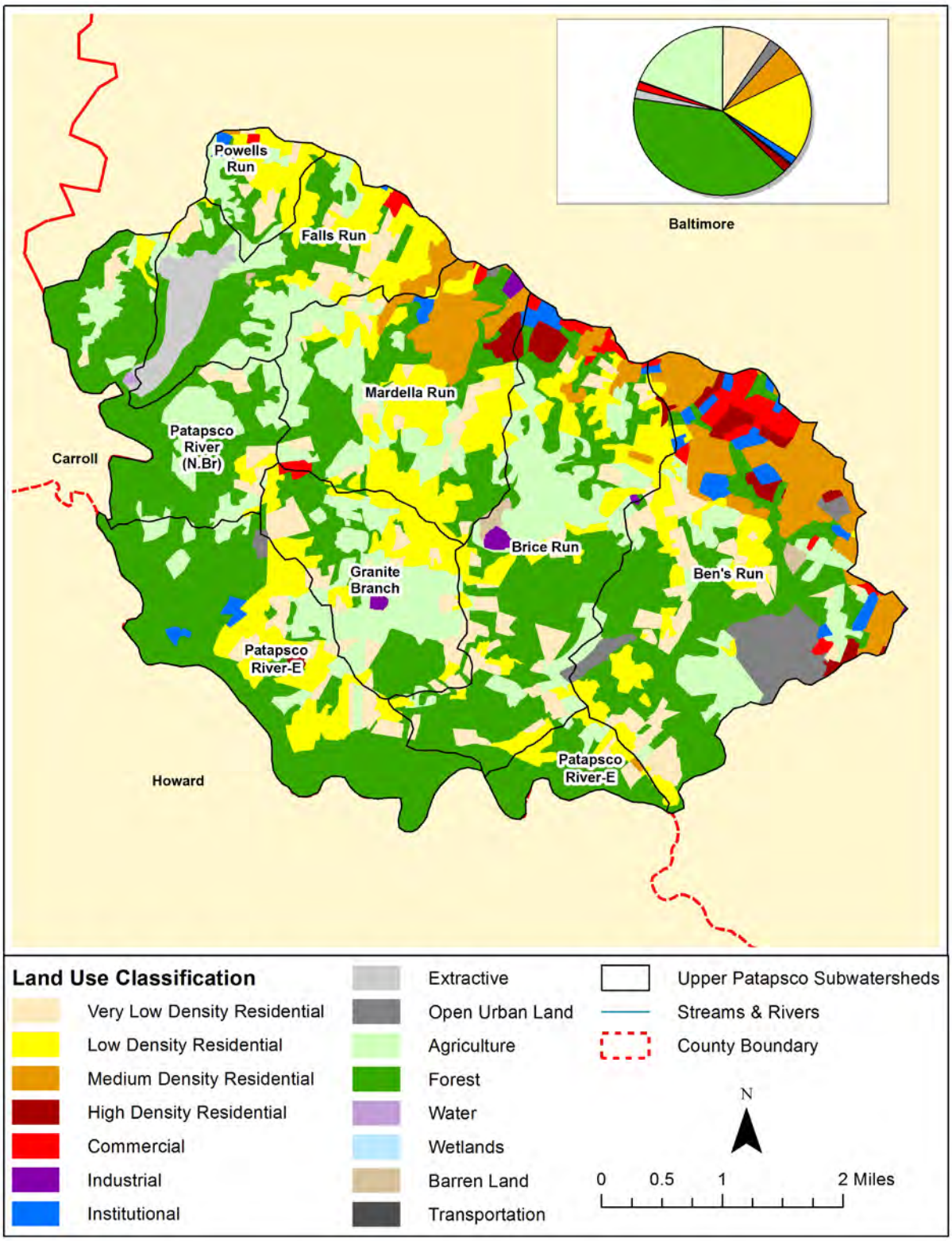

Figure 2-8: Map and Pie Chart of Upper Patapsco River Watershed Land Use/Land Cover

Table 2-8: Upper Patapsco River Land Use/Land Cover Classification (%)

Land Use	Subwatershed								
	Ben's Run	Brice Run	Falls Run	Granite Branch	Mardella Run	Patapsco River (N.Br)	Patapsco River-E	Powells Run	Total
Agricultural Buildings	0.0	0.5	0.0	0.0	0.3	0.0	0.0	0.0	0.1
Bare Ground	0.5	0.9	0.2	0.0	0.1	0.0	0.0	0.0	0.2
Brush	0.0	0.5	0.0	0.0	0.9	0.0	0.0	0.0	0.2
Commercial	4.5	1.6	1.0	0.6	0.9	0.0	0.0	1.4	1.3
Cropland	3.3	17.4	14.3	25.2	20.1	18.7	6.0	13.0	14.7
Deciduous Forest	31.0	40.2	32.5	27.3	24.0	63.6	63.7	19.2	37.7
Extractive	0.0	0.0	14.9	0.0	0.0	0.5	0.0	0.0	1.9
Feeding Operations	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.7	0.3
High-density Residential	3.2	2.3	0.0	0.0	1.9	0.0	0.5	0.0	1.0
Industrial	0.0	0.9	0.0	0.9	0.7	0.0	0.0	0.0	0.3
Institutional	3.9	1.2	0.1	0.0	0.8	0.0	1.2	3.4	1.3
Low-density Residential	10.1	16.5	20.2	20.1	27.4	3.5	18.8	38.3	19.4
Medium-density Residential	16.5	2.8	3.5	0.0	12.7	0.0	0.2	0.8	4.6
Mixed Forest	0.0	0.0	0.0	0.0	1.4	0.0	0.0	0.0	0.2
Open Urban Land	9.0	0.2	0.0	0.1	0.2	0.0	0.6	0.0	1.3
Pasture	8.3	5.1	3.7	11.3	1.6	7.0	2.8	8.4	6.0
Very Low-density Residential	9.6	9.8	9.5	14.5	7.0	6.4	6.2	12.8	9.5
Water	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0

The Upper Patapsco River watershed encompasses approximately 15,898 acres (24.8 square miles) of land. The primary land uses in the watershed are Deciduous Forest (38%), Low Density Residential (19%), and Cropland (15%) which occur in large patches that are spread throughout the watershed. Forest land use is concentrated near the southwestern border of the watershed in Patapsco Valley State Park. Commercial development is concentrated primarily along the northern eastern border of the watershed in the vicinity of Liberty Road.

Table 2-8 shows that the MDP dataset estimates the Upper Patapsco River watershed is 38% forested. This is lower than the 58% forest cover presented in Section 2.2.6, Table 2-5, which was calculated using the UVM land cover dataset. Variations between the UVM land cover dataset and MDP land use/land cover scheme result from different scales and photo sources used during their development.

A total of 1,863 acres of this watershed are contained within state and County parks (Figure 2-9), primarily Patapsco Valley State Park. Parks account for 12% of the total watershed area; most of this parkland is adjacent to the mainstem Patapsco River.

Figure 2-9: Upper Patapsco River Watershed Parklands

2.3.2 Population

Population data provides another way to evaluate the intensity of land use. As previously mentioned, much of the degradation from urban/suburban land uses (where population is mainly concentrated) is related to the extent of impervious cover and also conversion of land uses that protect water resources such as forest. A higher population density (persons per acre) represents a more intense use of the land and potential for environmental degradation. On the other hand, urban planning and smart growth initiatives, which concentrate development and maximize land use in some areas, are ways of preserving open spaces and protecting areas outside of the growth zone, leaving them undisturbed and undeveloped. Much of the development in the watershed pre-dates the recent push for smart growth, but the principles may still be of use. Smart growth principles are aimed at directing future growth to areas of existing services and where development has already occurred. This will result in less land conversion to residential and supporting urban development such as commercial areas and therefore, conservation of land uses with less environmental impacts such as forest and agriculture. Population density in the Upper Patapsco River watershed was estimated based on the 2010 U.S. Census. Table 2-9 summarizes population density by subwatershed with respect to total area and impervious area. Population density distribution for the watershed is shown in Figure 2-10. In general, higher population densities correspond to the areas designated as high density residential land use discussed in the last section. Population density is greatest in Ben's Run and Mardella Run where residential land use is most common.

Table 2-9: Upper Patapsco River Watershed Population Data

Subwatershed	Total Population (2010 census)	Total Area (acres)	Population Density (per acre)	Impervious Area (acres)	Population Density (per impervious acre)
Ben's Run	16,081.0	3,552.6	4.5	432.0	37.2
Brice Run	6,094.0	2,718.0	2.2	183.6	33.2
Falls Run	2,433.0	1,642.4	1.5	80.2	30.3
Granite Branch	1,889.0	1,327.6	1.4	55.1	34.3
Mardella Run	6,697.0	2,163.5	3.1	175.7	38.1
Patapsco River (N.Br)	951.0	1,583.3	0.6	30.8	30.8
Patapsco River-E	1,946.0	2,491.4	0.8	80.7	24.1
Powells Run	563.0	419.4	1.3	24.8	22.7
Total	36,654.0	15,898.1	1.9	1,063.0	31.3

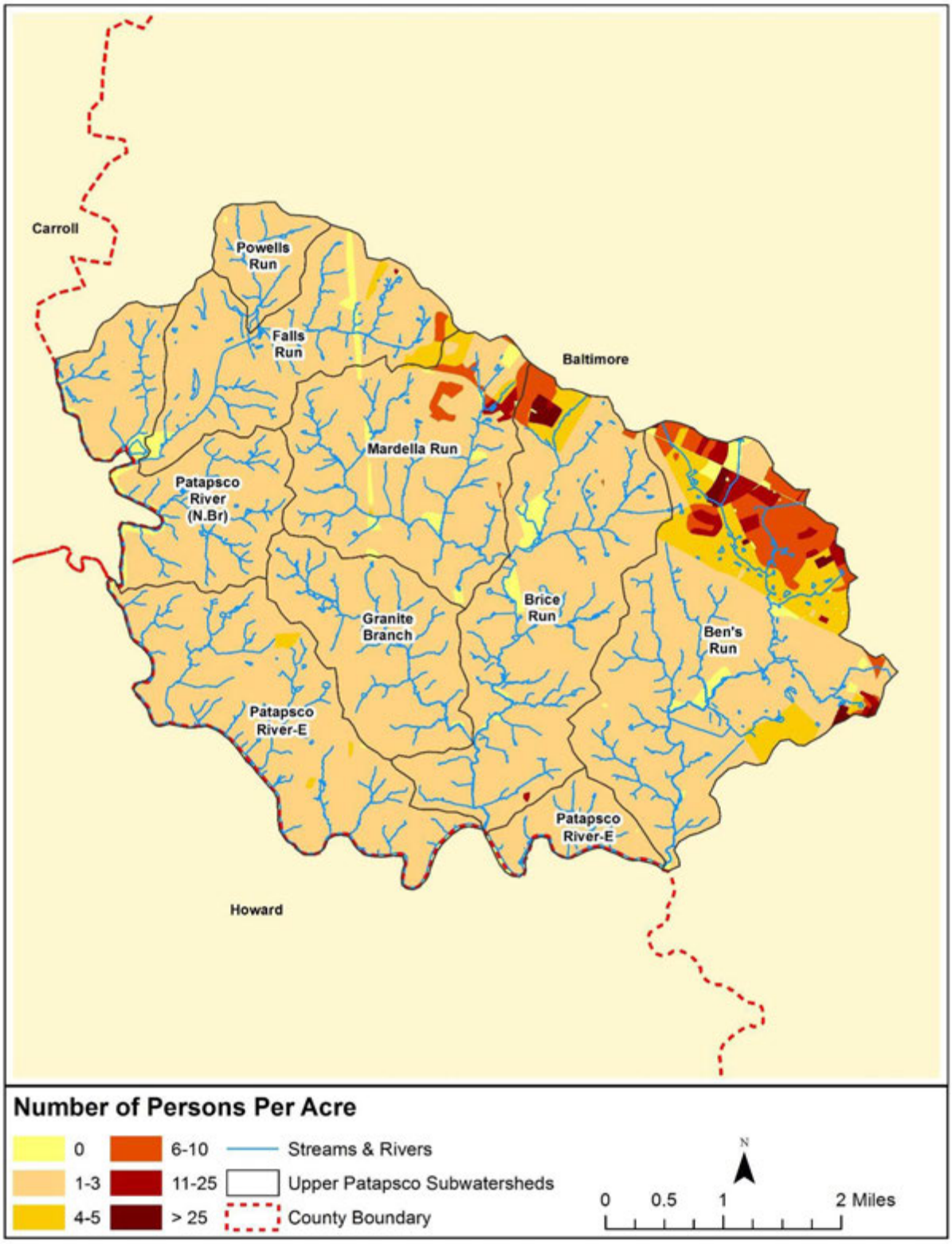

Figure 2-10: Upper Patapsco River Watershed Population Distribution

2.3.3 Impervious Surfaces

Impervious surfaces prevent precipitation from naturally infiltrating into the ground; these types of surfaces include roads, parking areas, roofs, and other paved surfaces. When precipitation cannot infiltrate, it is typically concentrated, accelerated and conveyed directly to the nearest stream. Consequently, stormwater and snowmelt runoff from impervious surfaces can cause stream erosion and habitat destruction from the high energy flow and is likely more polluted than runoff generated from pervious areas. Undeveloped watersheds with small amounts of impervious cover are likely to have better water quality in local streams than urbanized watersheds with greater amounts of impervious cover. Impervious cover is a primary factor when determining pollutant characteristics and amounts in stormwater runoff. Research has been conducted to link the degree of urbanization (typically measured by amount of impervious cover) with various watershed-based indicators of water quality such as the diversity and abundance of aquatic and terrestrial life. The Center for Watershed Protection (CWP) compiled stream research conducted in various parts of the country and developed a simple model that relates stream quality to percentage of impervious cover in a watershed. Studies used to develop the impervious cover model measured stream quality based on a variety of indicators such as number of aquatic insect species, stream temperature, channel stability, aquatic habitat, wetland plant density, and fish communities. CWP's impervious cover model is illustrated in Figure 2-11.

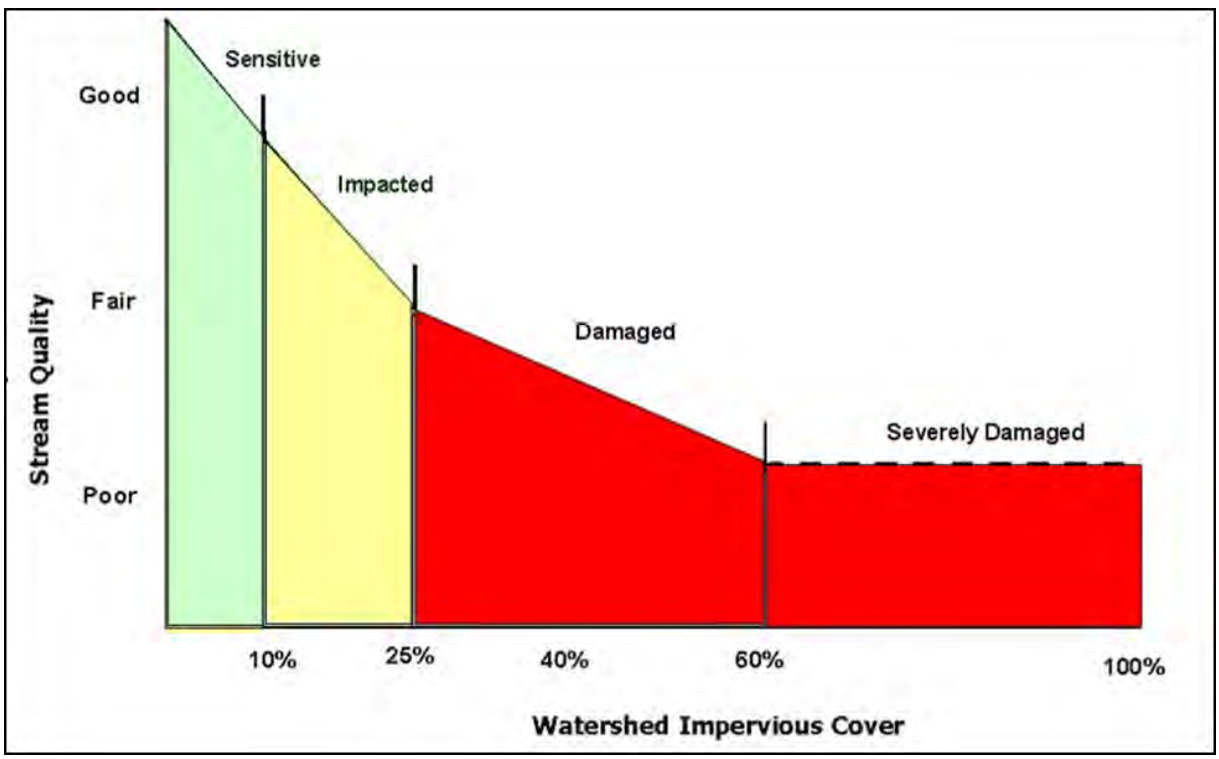

Figure 2-11: Impervious Cover Model (adapted from CWP 2003)

Based on the research compiled, CWP determined three general categories to classify and predict stream quality in terms of impervious cover. Watersheds with less than 10 percent impervious cover are referred to as sensitive and typically have high quality streams with stable channels, good habitat conditions, and good to high water quality; sensitive watersheds are susceptible to environmental degradation with urbanization and increases in impervious cover. The model predicts that between 10 and 25 percent impervious cover, watersheds become impacted and

would show clear signs of degradation such as erosion, channel widening, and a decline in stream habitat. There is a possibility to restore streams to a somewhat natural functioning system within this category. When a watershed has more than 25 percent impervious cover, streams are classified as damaged which are characterized by fair to poor water quality, unstable channels, severe erosion, and inability to support aquatic life and provide habitat; many streams in this category are typically piped or channelized.

Figure 2-11 shows that when impervious cover exceeds 60 percent, a watershed is classified as severely damaged and means that most of the natural stream system is gone. Management of damaged and severely damaged streams may focus on decreasing pollutant loads to downstream receiving waters (e.g., installing BMPs) but the ability to restore natural functions, such as habitat, is unlikely. Restoration efforts may also focus on making the remaining stream systems stable, aesthetically pleasing and an amenity to the community. It should be noted that the impervious cover model is a simplified approach for classifying the quality of urban streams. Although it is based on research, there are inherent model assumptions and limitations that should be considered such as regional variations and scale effects. In addition, while impervious cover is a relevant and significant indicator for watershed health, it is only one of many different factors affecting stream health and contributing to the cumulative impacts of development on water quality. For example, agricultural land uses contribute sediment and nutrient loads to receiving waters depending on management practices. Also, the ability of BMPs to offset adverse impacts from urbanized areas is not specifically accounted for in this model.

The roads and buildings (including parking lots) GIS data layers from Baltimore County were used to derive impervious surface areas within the Upper Patapsco River watershed (Figure 2-12). Data for sidewalks were unavailable so they are not accounted for in this analysis. The area for each layer was determined and then combined to obtain estimates of impervious cover areas on a subwatershed scale. Table 2-10 summarizes the area of roads and buildings, total impervious area, and percent impervious area for each subwatershed. Impervious cover represents about 6.7 percent of the watershed or 1,063 acres. Subwatershed ratings according to the CWP impervious cover model and these impervious area estimates are shown in Figure 2-13.

Table 2-10: Upper Patapsco River Subwatershed Impervious Area Estimates

Subwatershed	Total Area (acres)	Road (acres)	Building (acres)	Other (acres)	Impervious Area (acres)	% Imper vious
Ben's Run	3,552.6	152.9	270.1	9.0	432.0	12.2
Brice Run	2,718.0	58.9	123.4	1.3	183.6	6.8
Falls Run	1,642.4	21.1	59.2	0.0	80.2	4.9
Granite Branch	1,327.6	12.4	31.8	10.9	55.1	4.2
Mardella Run	2,163.5	67.0	104.9	3.8	175.7	8.1
Patapsco River (N.Br)	1,583.3	6.0	24.8	0.0	30.8	1.9
Patapsco River-E	2,491.4	25.3	55.1	0.2	80.7	3.2
Powells Run	419.4	7.0	17.9	0.0	24.8	5.9
Total	15,898.1	350.6	687.2	25.2	1,063.0	6.7

Figure 2-12: Upper Patapsco River Watershed Impervious Surface

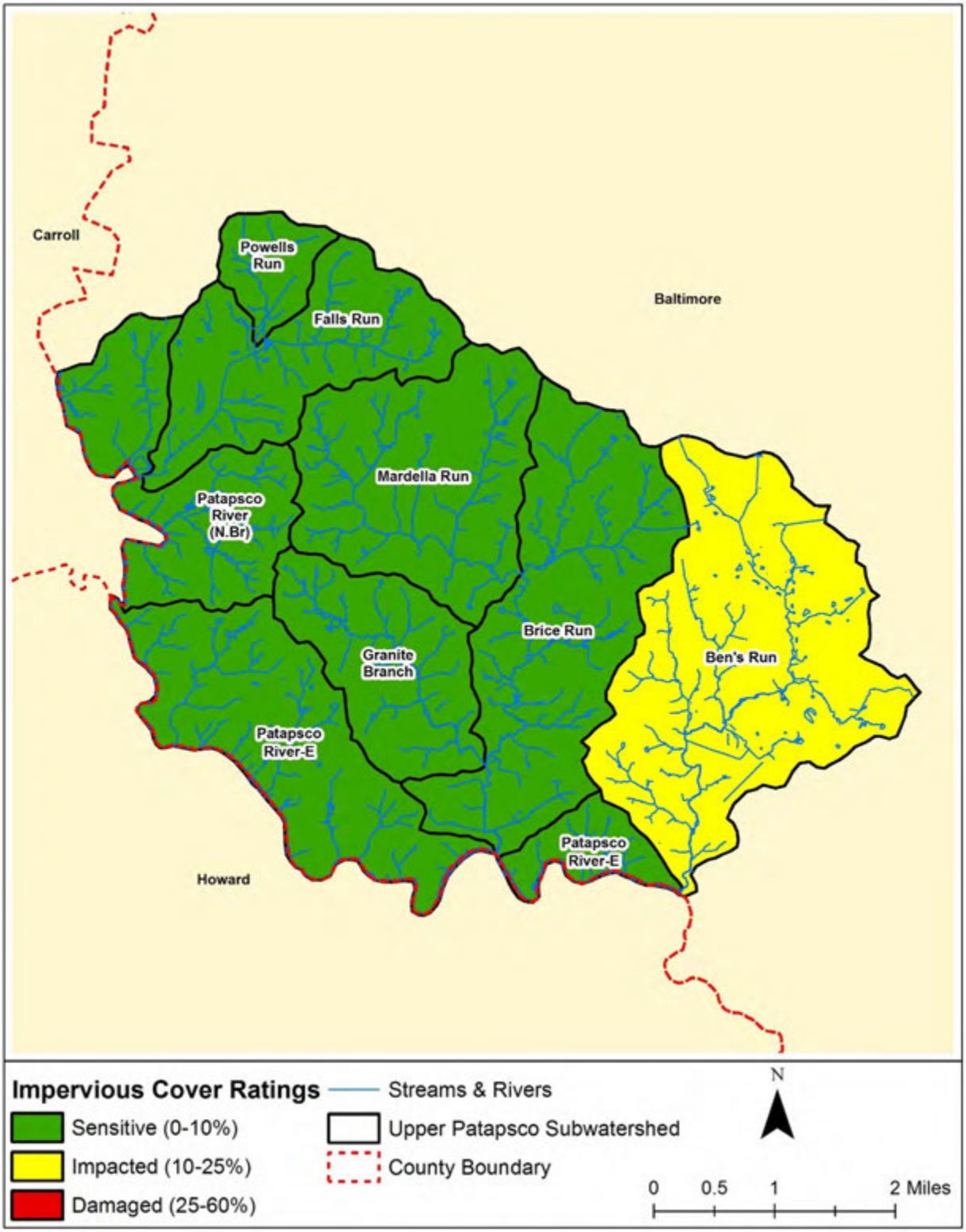

Figure 2-13: Upper Patapsco River Watershed Impervious Cover Ratings

2.3.4 Stormwater

Stormwater is water generated during and immediately after storm events. Stormwater that does not seep into the ground becomes stormwater runoff and goes directly to receiving water bodies. The amount and characteristics of stormwater runoff is affected by rainfall amount and intensity, soil properties, slope, and land use/land cover. Concerns associated with stormwater include rate and volume of runoff and water pollution. For example, more runoff is generated from impervious cover and agricultural land than from forested land. As previously mentioned, impervious surfaces do not allow any water to infiltrate into the ground and runoff is conveyed more rapidly into the stream system. The increase in runoff rate and volume can cause flooding and stream erosion which in turn, results in the destruction of habitat and natural stream functions such as nutrient reduction. In addition, there is less potential for groundwater recharge when there is little or no infiltration of stormwater.

Stormwater runoff can also carry various contaminants depending on land use characteristics and human activities. Pollutants deposited on impervious surfaces and other developed lands from daily human activities are often carried by stormwater to stream systems. For example, common constituents in impervious surface (e.g., highways, parking lots) runoff include sediment, metals, bacteria, nutrients, and petroleum; pollutants such as these build up over time from various sources such as maintenance activities (de-icing, roadside fertilizer use), vehicles (exhaust, leaks), and accidents/spills and are washed off during storm events. While the runoff from other developed areas, agriculture operations and residential areas for example, may be moderate compared to highly impervious areas, it can still carry pollutants such as nutrients, bacteria, and chemicals to receiving water bodies.

2.3.4.1 Storm Drainage System

The storm drainage system consists of either drainage swales (roadside ditches) or a curb and gutter system including inlets, piping, and outfalls. Both methods are intended to prevent flooding and potentially hazardous situations by removing water quickly from roadways. However, the efficiency and environmental impacts associated with each method are different. The curb and gutter system removes stormwater from impervious surfaces quickly and typically conveys water directly to the stream system. While the curb and gutter system removes stormwater quickly from roadways, it delivers increased runoff volumes and untreated pollutants to receiving water bodies. Drainage swales do not convey water as quickly as the curb and gutter system and the stormwater flow is somewhat reduced before entering the stream system. Drainage swales also allow some infiltration into the ground unlike the curb and gutter system; this reduces the amount of water delivered and provides some filtering of pollutants.

Curb and gutter system components in the Upper Patapsco River watershed are summarized in Table 2-11 by subwatershed. This includes an estimate of the number of major (> 3 feet in diameter) and minor (< 3 feet in diameter) storm drain outfalls and corresponding number of inlets and length of storm drain pipe. Storm drain system databases used to compile this table were created in 1992 with periodic updates according to county storm drain plans. These data provide a reasonable approximation of storm drain pipe data for this analysis and the numbers presented in Table 2-11 where pipe lengths were rounded to the nearest tens of feet. Table 2-12 provides a summary of the proportion of subwatershed area covered by the storm drain system (stormwater drainage area within subwatershed divided by total subwatershed area) and the number of inlets per square mile for each subwatershed. Figure 2-14 shows the location of major (> 3 feet) and minor (< 3 feet) outfalls within the watershed.

Table 2-11: Upper Patapsco River Subwatershed Storm Drain System Components

Subwatershed	Major Outfalls (> 3 ft diameter)			Minor Outfalls (< 3 ft diameter)			All Outfalls		
	Out falls (#)	Inlets (#)	Pipes (ft)	Out falls (#)	Inlets (#)	Pipes (ft)	Total Out falls (#)	Total Inlets (#)	Total Pipes (ft)
Ben's Run	8	33	4,099	17	46	6,670	25	79	10,769
Brice Run	1	1	600	0	0	0	1	1	600
Falls Run	0	0	0	5	24	3,470	5	24	3,470
Granite Branch	0	0	0	5	12	685	5	12	685
Mardella Run	4	22	3,920	20	67	10,520	24	89	14,440
Patapsco River (N.Br)	0	0	0	0	0	0	0	0	0
Patapsco River-E	0	0	0	0	0	0	0	0	0
Powells Run	0	0	0	4	6	375	4	6	375
Total	13	56	8,619	51	155	21,720	64	211	30,339

Note: Baltimore County is currently updating their storm drain data and although this current dataset is incomplete and in draft form, it is more accurate and complete than the County's historic storm drain data.

Table 2-12: Upper Patapsco River Subwatershed Stormwater System Coverage

Subwatershed	Stormwater System Drainage Area (acres)	% of Watershed Covered by Stormwater System	Total Inlets (#)	Inlet Density (#/sq. mi.)
Ben's Run	501.9	14.1	79	18.4
Brice Run	15.0	0.6	1	0.2
Falls Run	65.1	4.0	24	1.9
Granite Branch	22.4	1.7	12	2.4
Mardella Run	300.8	13.9	89	21.2
Patapsco River (N.Br)	0.0	0.0	0	0
Patapsco River-E	0.0	0.0	0	0
Powells Run	21.3	5.1	6	6.1
Total	926.5	5.8	211	8.6

Note: Baltimore County is currently updating their storm drain data and although this current dataset is incomplete and in draft form, it is more accurate and complete than the County's historic storm drain data.

The subwatershed with the most storm drain system coverage is Mardella Run. This coincides with the high concentration of residential and commercial development that is present in this area. Mardella and Ben's Run have the highest number of outfalls.

Figure 2-14: Upper Patapsco River Watershed Storm Drain Outfalls

2.3.4.2 Stormwater Management Facilities

Maryland was the first state to adopt stormwater quality regulations more than 20 years ago. Stormwater management (SWM) practices evolve as technology and research advance. It continues to be a significant consideration for new construction and re-development within the state. Management of stormwater runoff is required to reduce erosion, sedimentation, pollution, and flooding per Title 4, Subtitle 2 of the Environment Article of The Annotated Code of Maryland. Increased importance of water quality and water resource protection led to the development of the Maryland Stormwater Design Manual to provide BMP design standards and environmental incentives (MDE 2000) and a general shift toward adopting practices that mimic natural hydrologic processes, are low impact, and achieve pre-development conditions. The latter is evident in the Maryland "Stormwater Management Act of 2007," which requires that environmental site design (ESD) be implemented to the maximum extent practicable via nonstructural BMPs and/or other better site design techniques. Maryland Department of the Environment is responsible for implementing this regulation and issued an update to the Design Manual in May 2009.

There are many types of BMPs available for managing stormwater runoff and providing stormwater quality treatment. SWM can target specific objectives depending on the BMP type such as stormwater quality, soil stabilization, stormwater flow control, and stream restoration. In addition, different SWM facilities have different pollutant removal capabilities. For example, initial dry pond designs for SWM typically have low pollutant removal efficiency compared to practices that filter the stormwater or allow it to infiltrate into the ground or through plant roots. Several considerations are taken into account when selecting appropriate stormwater treatment measures such as space requirements, maintenance, cost, and community acceptance. Table 2-13 provides a summary of the different SWM facilities located within the Upper Patapsco River watershed by subwatershed including dry and wet ponds, wetlands, infiltration/filtration practices, extended detention, bioretention, and proprietary BMPs. The distribution of SWM facilities throughout the watershed is illustrated in Figure 2-15.

Dry ponds, extended detention facilities, and filtration/infiltration practices are common types of SWM within the SWAP area. More acreage drains to dry ponds than any other type of SWM facility. The dry pond facilities represent the best opportunity for conversion to BMPs with higher pollutant removal capabilities. Every subwatershed has some form of SWM, though Powells Run and the Patapsco River (N.Br) subwatersheds contain only one facility each. This is likely due to the fact that these subwatersheds' land use/land cover is mostly forest. The proprietary BMPs in the watershed are Stormceptor devices, which remove sediment, oil and grease through hydrodynamic separation. Sediment particles and oil and grease settle out as flow circulates in a swirling path; floatable and settled debris collected in the treatment chamber are typically removed by a vacuum truck at regular intervals.

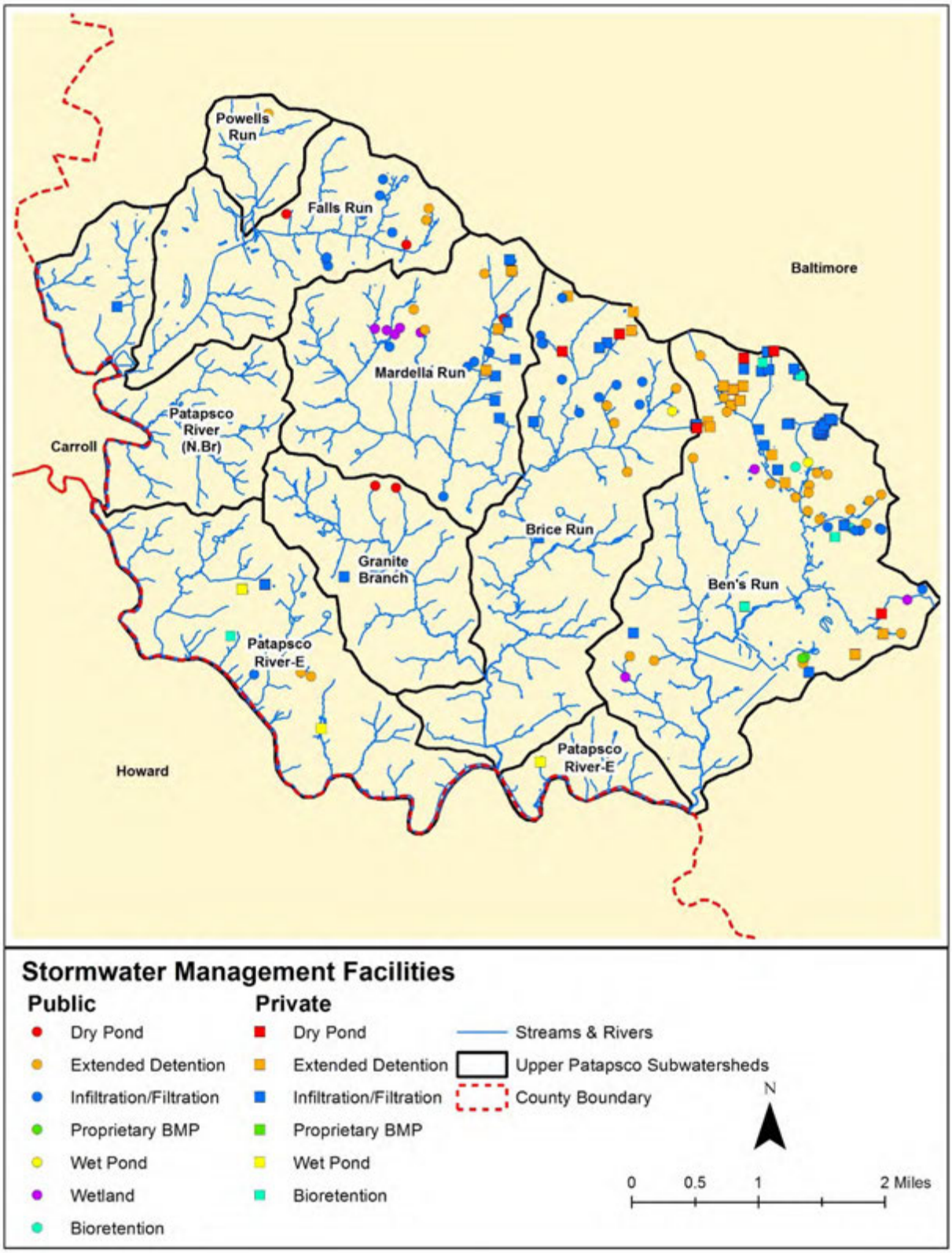

Figure 2-15: Stormwater Management Facilities in Upper Patapsco River Watershed

Table 2-13: Upper Patapsco River Stormwater Management Facilities by Subwatershed

SWM Facility Type	Subwatersheds								
	Bens Run	Brice Run	Falls Run	Granite Branch	Mardella Run	Patapsco River E	Patapsco River (N.Br)	Powells Run	Total
Dry Pond (#)	6	0	0	0	0	1	0	0	7
Extended Detention (#)	3	3	2	2	2	0	0	0	12
Infiltration/Filtration (#)	31	7	2	0	6	2	0	1	49
Proprietary BMP (#)	37	17	6	1	11	2	1	0	75
Wet Pond (#)	2	0	0	0	0	0	0	0	2
Wetland (#)	1	1	0	0	0	3	0	0	5
Bioretention (#)	3	0	0	0	5	0	0	0	8
Total (#)	83	28	10	3	24	8	1	1	158
Dry Pond Drainage Area (acres)	17.1	0.0	0.0	0.0	0.0	0.4	0.0	0.0	17.4
Extended Detention Drainage Area (acres)	19.6	123.6	34.3	14.8	38.4	0.0	0.0	0.0	230.6
Infiltration/Filtration Drainage Area (acres)	251.0	95.1	22.4	0.0	81.5	14.9	0.0	8.6	473.5
Proprietary BMP Drainage Area (acres)	127.6	146.2	42.7	0.6	54.4	14.7	0.1	0.0	386.3
Wet Pond Drainage Area (acres)	2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.1
Wetland Drainage Area (acres)	15.3	11.2	0.0	0.0	0.0	164.1	0.0	0.0	190.5
Bioretention Drainage Area (acres)	49.5	0.0	0.0	0.0	15.4	0.0	0.0	0.0	64.9
Total Drainage Area (acres)	482.1	376.0	99.4	15.4	189.6	194.1	0.1	8.6	1365.4

The total area treated by SWM and the proportion of urban area treated by SWM is summarized in Table 2-14 by subwatershed. Note that for this analysis urban land use includes the following MDP land use categories: low, medium and high residential, commercial, industrial, institutional, open urban, and transportation. Table 2-14 shows that urban land use encompasses about 30 percent of the Upper Patapsco River watershed and only 28% of that is treated by SWM practices. This indicates an opportunity to implement SWM (BMPs or treatment devices) in existing developed areas where no practices are currently in place or to retrofit facilities that are not providing adequate treatment before stormwater reaches the stream system. Refer to Section 3.7 for more details on assessed SWM facilities within the watershed.

Table 2-14: Upper Patapsco River Stormwater Management by Subwatershed

Subwatershed	Area (acres)	Urban Land Use (acres)	Area Treated by SWM (acres)	Urban Land Use Treated by SWM (%)
Ben's Run	3,553	1,677	475	28
Brice Run	2,718	695	365	53
Falls Run	1,642	407	84	21
Granite Branch	1,328	289	15	5
Mardella Run	2,163	966	190	20
Patapsco River-E	2,491	530	194	37
Patapsco River (N.Br)	1,583	56	1	2
Powells Run	419	184	9	5
Total	15,898	4,804	1,334	28

2.3.5 NPDES Discharge Permits

Facilities that discharge municipal or industrial wastewater or conduct activities that can contribute pollutants to a waterway are required to obtain a National Pollutant Discharge Elimination System (NPDES) permit. The number and type of NPDES-permitted facilities within each subwatershed are summarized in Table 2-15.

Table 2-15: NPDES-Permitted Facilities in Upper Patapsco River Subwatersheds

Subwatershed	# General Permits	# Individual Industrial Permits	# Municipal Surface Discharge Permits	# Groundwater Discharge Permits	Total # of Permits
Ben's Run	4	0	0	0	4
Brice Run	3	0	0	0	3
Falls Run	3	0	0	0	3
Granite Branch	0	0	0	0	0
Mardella Run	0	0	0	0	0
Patapsco River-E	1	0	1	0	2
Patapsco River (N.Br)	0	1	0	0	1
Powells Run	0	0	0	0	0
Total	11	1	1	0	13

As of 2014, there are currently 13 active NPDES-permitted facilities within the Upper Patapsco River watershed (Figure 2-16). These permitted facilities include 11 with general permits, one with an individual industrial permit, and one with a municipal surface discharge permit. Industrial surface water discharge permits are issued for industrial facilities that discharge process water to State surface waters which must meet applicable federal effluent guidelines and/or State water quality standards.

Figure 2-16: Locations of NPDES-Permitted Facilities in Upper Patapsco River Watershed.

2.3.6 Wastewater

Wastewater created through human use must be treated and disposed. This is accomplished either through public conveyance to a treatment facility or through individual wastewater treatment systems (septic systems). Residential wastewater consists of all water typically used by residents including wash water, bathing water, human waste disposal water, and any other rinse water (paint brush, floor washing, etc.). Industrial wastewater depends on the operation and could contain various contaminants such as metals, organic compounds, detergents, or synthetic compounds. All of these types of wastewater have the potential to adversely impact the natural environment.

2.3.6.1 Septic Systems

Properly functioning septic systems provide treatment for nearly all of the phosphorus present in wastewater, but can leak nitrogen in the form of nitrate. Depending on the location of the system, nitrate may be reduced or eliminated through de-nitrification as the treated water passes through riparian buffers, particularly forested riparian buffers (i.e., septic systems in closer proximity to streams will generally contribute more nitrogen to local waterways). Failing systems can release nitrogen, phosphorus, and other chemicals and in turn, contaminate the aquatic environment. They can also result in increased bacterial contamination of nearby streams and therefore, potential for human health concerns. Table 2-16 summarizes the approximate number of septic systems by subwatershed.

Table 2-16: Upper Patapsco River Septic Systems by Subwatershed

Subwatershed	No. of Septic Systems	No. of Septic Systems within 100 ft. of a Stream
Ben's Run	286	28
Brice Run	499	73
Falls Run	321	29
Granite Branch	147	15
Mardella Run	460	27
Patapsco River-E	300	21
Patapsco River (N.Br)	65	24
Powells Run	104	9
Total	2,182	226

Maryland requires all new construction and failing systems to have a Best Available Technology (BAT) system installed rather than a traditional septic system. BAT systems are required to remove at least 50% of total nitrogen (TN). The Bay Restoration Fund (BRF) offers grants for qualifying applicants that need a BAT systems. See the MDE Website for more information: http://www.mde.state.md.us/programs/Water/BayRestorationFund/OnsiteDisposalSystems/Pages/Water/cbwrf/index.aspx

2.3.6.2 Public Sewer

A public sewer system conveys wastewater from individual households or businesses to a facility that treats the wastewater prior to discharge. It consists of the piping system within the public right-of-way and cleanouts on individual properties. Property owners are responsible for the maintenance of the latter part of the system, their individual cleanouts. The portion of the system within the public right-of-way is owned and maintained by the local government. This includes gravity piping system, access manholes, pumping stations, and force mains. Table 2-17 summarizes the types and lengths of public sewer piping by subwatershed in the Upper Patapsco River watershed. This includes force (pressure) and gravity main lines and portions of the gravity main that have been abandoned or removed. Table 2-18 includes sewer piping density, or length per square mile, for each subwatershed.

Table 2-17: Public Sewer Piping in Upper Patapsco River Subwatersheds

Subwatershed	Pressurized Main (ft)	Pressurized Main Abandoned (ft)	Gravity Main (ft)	Gravity Main Abandoned (ft)	Total (ft)
Ben's Run	0	0	111,757	1,314	113,071
Brice Run	0	0	9,519	0	9,519
Falls Run	0	0	0	0	0
Granite Branch	0	0	0	0	0
Mardella Run	0	0	39,625	0	39,625
Patapsco River-E	0	0	0	0	0
Patapsco River (N.Br)	0	0	0	0	0
Powells Run	0	0	0	0	0
Total	0	0	160,901	1,314	162,215

Table 2-18: Public Sewer Piping Density in Upper Patapsco River Subwatersheds

Subwatershed	Area (sq. miles)	Gravity Main (ft/sq. mi.)	Pressurized Main (ft/sq. mi.)
Ben's Run	5.55	20,133	0
Brice Run	4.25	2,241	0
Falls Run	2.57	0	0
Granite Branch	2.07	0	0
Mardella Run	3.38	11,722	0
Patapsco River-E	3.89	0	0
Patapsco River (N.Br)	2.47	0	0
Powells Run	0.66	0	0
Total	24.84	1,373	0

Environmental impacts associated with public sewer are usually the result of sewage overflows. Overflows typically result from blockages within the sewage system, pumping station failure, or rainwater inflows exceeding pipe capacity. Dry weather flows can also have potential impacts due to leaks in the sewer system. Environmental concerns related to sewer overflows and leaks

include high bacteria concentrations, release of nutrients, elevated turbidity (cloudiness), and low dissolved oxygen.

2.3.7 Drinking Water

Drinking water is a fundamental need for human development. It can be supplied either by public distribution systems or by wells associated with individual developed properties. Having an adequate supply of drinking water is essential to maintaining the human population in a region.

2.3.7.1 Public Water Supply

Environmental impacts associated with public supply of water include the potential for increased residential development with the associated impervious cover effects discussed in the previous section and the potential for leaks from the system. Leaks from public water supply systems introduce chlorine into the aquatic system which can result in the death of aquatic organisms. In addition, major leaks can cause erosion which contributes to the sediment load in stream channels; this can bury aquatic benthic communities and degrade habitat.

2.3.8 Zoning

According to the Baltimore County Office of Planning (2011), zoning is defined as “a system of land use regulation that controls the physical development of land and a legal mechanism by which local government is able to regulate an owner’s right to use privately owned land for the sake of protecting the public health, safety, and/or general welfare.” In other words, zoning manages development patterns over time throughout the county. The current zoning for the Upper Patapsco River watershed is shown in Figure 2-17. A summary of zoning category acreages and proportions within the Upper Patapsco River watershed is included in Table 2-19. As shown in the table, a variety of zoning categories are represented in the watershed however, the dominant category is Agriculture (‘RC 2’ codes).

The majority of land south of the Urban Rural Demarcation Line (URDL) is zoned as either Resource Conservation, or Resource Conservation - Agriculture. This area includes Patapsco Valley State Park land. Urban development is concentrated in the Liberty Road area (Figure 2-17).

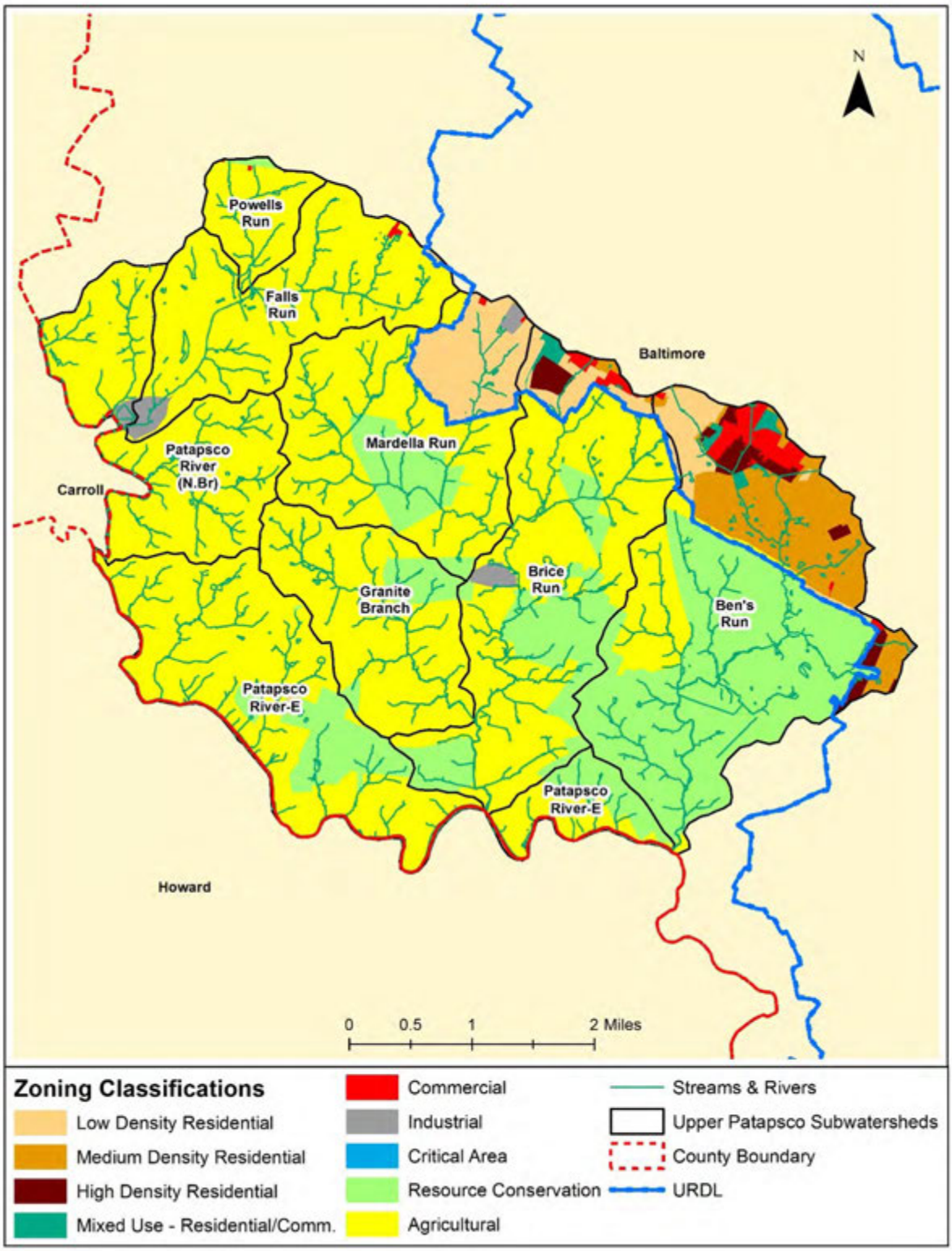

Figure 2-17: Upper Patapsco River Watershed Zoning

Table 2-19: County Zoning in Upper Patapsco River Watershed

Zoning Description	Zoning Codes	Acres	% of Watershed
Business Local	BL,BLR	20.98	0.1
Business Major	BM	75.83	0.5
Business Roadside	BR	70.62	0.4
Community Business	CB	0.42	0.0
Low Density Residential	DR 1, DR 2	54.16	0.3
Medium Density Residential	DR 3.5, DR 5.5	1,427.18	9.0
High Density Residential	DR 10.5	42.99	0.3
Very High Density Residential	DR 16	133.85	0.8
Manufacturing Heavy	MH	46.92	0.3
Manufacturing Light	ML	39.49	0.2
Manufacturing Light Restricted	MLR	42.05	0.3
Office Park	O 3	0.93	0.0
Office/Residential - High Density	OR 1	20.81	0.1
Office/Residential - Medium Density	OR 2	39.28	0.2
Resource Conservation - Agricultural	RC 2	7,543.94	47.3
Resource Conservation - Deferral of Pl. and Devel.	RC 3	359.95	2.3
Resource Conservation - Watershed Protection	RC 4	15.06	0.1
Resource Conservation - Rural Residential	RC 5	2,636.51	16.6
Resource Conservation - Rural Cons. & Reside.	RC 6	3,305.67	20.9
Resource Conservation – Resource Preservation	RC 7	0.00	0.0
Resource Conservation - Commercial	RCC	1.32	0.0
Residential Office	RO, ROA	20.15	0.1
Service Employment	SE	0	0.0
Total		15898	100.0

CHAPTER 3: WATER QUALITY AND LIVING RESOURCES

3.1 INTRODUCTION

This chapter describes the water quality, living resources, and habitat for the Upper Patapsco River watershed based on existing conditions. In addition to water quality maintenance and improvement, the SWAP aims to provide for plants, animals, and their habitat. Natural communities require many habitat characteristics for survival. This includes land, water, and biological conditions that provide their needs for food, water, shelter, and reproduction. Water is an integral part of the habitat of all species. Living resources, including all animals and plants, require water to survive. Living resources and their habitat are intimately connected to water quality and availability. They respond to changes in water quality and habitat conditions in ways that indicate the status of water bodies and the effects of watershed characteristics and activities. In some cases, water quality is measured in terms of its ability to support living resources such as trout or shellfish. Information on living resources is presented in this chapter to indicate water quality status and to evaluate habitat conditions in the watershed. This information can help to determine if current watershed management practices are adequately providing for the needs of natural communities.

The following sections include descriptions of the following with respect to the Upper Patapsco River watershed: impairments per Maryland's 303(d) listing, water quality monitoring data available to date, pollutant loadings analysis for total nitrogen, total phosphorus, and sediment, sewer overflow occurrences and impacts, stream corridor assessments, and stormwater management facility assessments.

3.2 303(D) LISTINGS AND TOTAL MAXIMUM DAILY LOADS (TMDLS)

Section 303(d) of the 1972 Clean Water Act requires states to develop (and periodically update) a list of impaired waters that fail to meet applicable state water quality standards which are defined by their designated uses. States must also establish priority rankings and develop Total Maximum Daily Loads (TMDLs) for waters on the 303(d) list. According to USEPA, a TMDL is a calculation of the maximum amount of a pollutant that a water body can receive and still safely meet state water quality standards. TMDLs can be developed for a single pollutant or group of pollutants of concern which generally include sediment, metals, bacteria, nutrients, and pesticides.

The Patapsco River Lower North Branch (LNB), which includes the Upper Patapsco (SWAP area B), is listed as impaired in the Maryland 303(d) list of impaired waters for various pollutants of concern including: total suspended solids (1996 listing), biological impacts (2008 listing), fecal coliform (2008 listing), polychlorinated biphenyls in fish tissue (PCBs, 2008 listing), chlorides (2010 listing), and sulfates (2010 listing). In addition, the Baltimore Harbor is listed as impaired for nutrients (phosphorus and nitrogen), whose source includes the Patapsco LNB watershed.

The Patapsco River LNB mainstem is designated as *Use IV: Recreational Trout Waters*, except for the lower tidal portion in the County which is designated as *Use I: Water Contact Recreation, and Protection of Nontidal Warmwater Aquatic Life* and *Use II: Support of Estuarine and Marine Aquatic Life,* according to Maryland water quality standards. Brice Run, Mardella Run, and Granite Branch are designated as *Use III Nontidal Cold Water*; the remaining tributaries in the Upper Patapsco watershed are designated Use I.

Impairment listings reflect the inability to meet water quality standards for these designated uses. Impairment in the tidal receiving waters is related to pollutants coming from the entire watershed; therefore, TMDLs developed for this segment will require watershed pollutant load reductions. Water Quality Assessments (WQAs) are performed to determine if the pollutant of concern is actually impairing the waters. If it is determined that the pollutant of concern is not contributing to water impairment, a report documenting the findings is submitted to USEPA for concurrence. Table 3-1 summarizes the status of the various impairment listings for the Patapsco River.

Table 3-1: Patapsco River Water Quality Impairment Listings and Status

Impairment	Applicable Segment	Status	Approval Date
Chlorides	Patapsco LNB	Impaired	
Sulfates	Patapsco LNB	Impaired	
Channelization	Patapsco LNB	Impaired (habitat modification)	
Heavy Metals	Patapsco LNB	WQA	January 2005
Phosphorus	Patapsco LNB	WQA	September 2009
Fecal bacteria	Patapsco LNB	TMDL completed	December 2009
TSS	Patapsco LNB	TMDL completed	September 2011
Nitrogen/Phosphorus	Baltimore Harbor	TMDL completed	December 2007

TSS – Total Suspended Solids

As shown in the table above, the Patapsco River watershed has eight impairment listings. Three TMDLs and two WQAs have been completed; heavy metals were delisted in 2005 based on the WQA and the phosphorus WQA received EPA concurrence in 2009 so these pollutants are no longer result in an impairment. There is insufficient evidence for PCBs at this time and further analysis is being conducted to evaluate this pollutant. TMDLs or WQAs will be developed at some point in the future for chlorides, sulfates, and channelization impairment listings. The three TMDLs that have been submitted to or approved by USEPA are briefly discussed in the following sections; full TMDL and WQA reports completed are included in Appendix J.

3.2.1 Biological Impairments

The Patapsco LNB watershed was previously listed as not attaining its designated use of protection of aquatic life because of biological impairments (MDE, 2015). As an indicator of designated use attainment, Maryland Department of the Environment (MDE) uses Benthic and Fish Indices of Biotic Integrity (BIBI/FIBI) developed by the Maryland Department of Natural Resources Maryland Biological Stream Survey (MDDNR MBSS). The previous listings for biological impairments represent degraded biological conditions for which the stressors, or causes, are unknown. Data suggest that the degradation of biological communities in the Patapsco LNB is strongly associated with urban land use and its concomitant effects: altered hydrology and elevated levels of sulfate, chlorides, and conductivity (a measure of the presence of dissolved substances). The urbanization of landscapes creates broad and interrelated forms of degradation (i.e., hydrological, morphological, and water chemistry) that can affect stream ecology and biological composition. Future monitoring of these inorganic pollutants will help in determining the spatial and temporal extent of this impairment in the watershed. This listing was changed in the current water quality report as impaired due to channelization. The biostressor analysis indicates that stream channelization due to urban development is a major stressor affecting biological integrity in this watershed (MDE, 2015).

3.2.2 Heavy Metals

The WQA conducted by MDE supported the conclusion that a TMDL for metals is not necessary to achieve water quality standards in the Patapsco LNB (MDE, 2005). The Patapsco LNB had been identified by the State as impaired by heavy metals (1996 listing). The WQA provides an analysis of heavy metals monitoring data, including hardness data. The study found that the applicable aquatic life criteria for heavy metals and the designated uses supported by those criteria were being met in the Patapsco LNB except for Herbert Run in Lower Patapsco (SWAP area A) where a single exceedance of copper (Cu) was found. Therefore a TMDL for heavy metals was not required. Following further analysis, Herbert Run was delisted for Cu and lead (Pb) impairments in 2008 (MDE, 2009a).

3.2.3 Nutrients

The WQA conducted by the Maryland Department of the Environment (MDE) supported the conclusion that a TMDL for nutrients is not necessary to achieve water quality standards in the Patapsco LNB (MDE, 2014). Although the waters of the Patapsco LNB do not display signs of eutrophication, the State reserved the right to require future controls if evidence suggested that nutrients from the basin are contributing to downstream water quality problems. In December 2007, EPA approved TMDLs of nitrogen and phosphorus for the Baltimore Harbor. The Patapsco LNB watershed is located upstream of the Baltimore Harbor and drains into the Harbor's tidal waters. Although the amount of nutrients entering the Patapsco LNB is not causing localized impairments, it is contributing to the eutrophication of the downstream tidal waters of the Harbor. Therefore, the TMDL for the Baltimore Harbor requires nutrient reductions in the Patapsco LNB necessary to meet water quality standards in the Harbor. By the same principle, additional reductions are also required by the Chesapeake Bay TMDL established by EPA in 2010.

Baltimore Harbor (basin number 02130903) was identified on the State's 1996 list of water quality limited segments (WQLSs) submitted to the U.S. EPA by MDE as impaired by nutrients (MDE, 2006). The TMDLs for the nutrients nitrogen and phosphorus were determined using a water quality eutrophication model package. Loading caps for total nitrogen and total phosphorus entering the Baltimore Harbor were established for growing season conditions and for average annual flow conditions. The average annual TMDL for nitrogen is 5,323,963 lbs/year, and the average annual TMDL for phosphorus is 324,309 lbs/year. The allowable loads have been allocated between point and nonpoint sources. The nonpoint source loads are allocated 1,246,036 lbs/year of total nitrogen and 34,654 lbs/year of total phosphorus. The point sources, including NPDES WWTP loads, NPDES industrial discharge loads and NPDES urban stormwater loads, are allocated 3,976,215 lbs/year of total nitrogen and 243,127 lbs/year of total phosphorus. The urban stormwater loads of nitrogen and phosphorus simulated in the Baltimore Harbor TMDL scenario are reduced 15% from the baseline urban stormwater loads. A future allocation (FA) load to account for future growth and an explicit margin of safety comprises the remainder of the nitrogen and phosphorus allocations. The water quality goal of these TMDLs is to reduce excessive algal blooms that result in high chlorophyll a concentrations, and maintain the dissolved oxygen concentrations at levels above the water quality criteria for the specific designated uses of the Baltimore Harbor.

MDE has described the legislative and policy-derived programs that will result in significant nutrient reductions and the achievement of water quality standards for all designated uses in the Baltimore Harbor except the Deep Channel. The implementation of nutrient controls that will be an integral component to achieve water quality standards in the Harbor will be executed through

several approaches, including stormwater NPDES permits and cooperative agricultural reductions. In November 1990, EPA required jurisdictions with a population greater than 100,000 to apply for NPDES Permits for stormwater discharges. The five jurisdictions where the Baltimore Harbor watershed is located, Baltimore City, Baltimore County, Anne Arundel County, Carroll County and Howard County, are required to participate in the stormwater NPDES program, and must comply with the NPDES Permit regulations for stormwater discharges. Subsequently, stormwater management programs have been implemented by the Counties and the City to control MS4 discharges to the maximum extent practicable. For example, the Baltimore County stormwater management program encompasses numerous elements including: erosion and sediment control, post-construction runoff management, controlling pollutants associated with road maintenance activities, public education and outreach, and illicit discharge detection and elimination. Additionally, in targeted watersheds, Baltimore County is required to implement watershed restoration for 10% of the County's total impervious surface cover. Baltimore County's load allocation for the Baltimore Harbor TMDL is listed in Table 3-2.

Table 3-2: Loads Attributed to Point Sources (Urban Stormwater) Used to Compute the TMDL for the Baltimore County Portion of the Baltimore Harbor TMDL

	TN	TP
Growing Season (May 1st - October 31st), lbs/growing season	167,784	16,662
Average Annual Conditions, lbs/year	362,890	39,279

EPA established the Chesapeake Bay TMDL in 2010, a historic and comprehensive "pollution diet" with rigorous accountability measures to initiate sweeping actions to restore clean water in the Chesapeake Bay and the region's streams, creeks, and rivers. Concurrent with the development of the Bay TMDL, EPA charged the Bay watershed states and the District of Columbia with developing watershed implementation plans (WIPs) to provide adequate "reasonable assurance" that the jurisdictions can and will achieve the nutrient and sediment reductions necessary to implement the TMDL within their respective boundaries. Maryland's Phase I WIP provided a series of proposed strategies that will collectively meet the 2017 target (70% of the total nutrient and sediment reductions needed to meet final 2025 goals). Baltimore County's Phase I plan required reductions equivalent to retrofit of 30% of pre-1985 developed land. Current reduction targets for the Patapsco watershed urban areas are: 32.2 percent for nitrogen and 47.0 percent for phosphorus. The Phase II WIP process will continue in 2017.

3.2.4 Bacteria

MDE identified the waters of the Patapsco LNB watershed on the State's 303(d) list as impaired by fecal bacteria in 2008 (MDE, 2009b). MDE proposed to establish a TMDL for fecal bacteria in the Patapsco River LNB watershed that will allow for attainment of the beneficial use designation of water contact recreation. MDE monitored the Patapsco LNB watershed from 2002-2003 for fecal bacteria. A data solicitation for fecal bacteria was conducted by MDE in 2007, and all readily available data from the five years since that time were considered. For this TMDL analysis, the Patapsco LNB watershed was divided into five subwatersheds. For convenience, each subwatershed is referenced by the downstream bacteria monitoring station's name and location. The subwatersheds are PAT0148 (Patapsco River at Hammonds Ferry Rd.), PAT0176 (Patapsco River at Rt. 1), PAT0222 (Patapsco River at Ilchester Rd.), PAT0285 (Patapsco River at Old Frederick Rd.) and PAT0347 (Patapsco River at Old Court Rd.). The pollutant loads set forth in the TMDL are for these five subwatersheds. The sources of fecal bacteria were estimated at five representative stations in the Patapsco LNB watershed where samples were collected for one

year; only one of these stations is in this SWAP area. Multiple antibiotic resistance analysis (ARA) source tracking was used to determine the relative proportion of domestic (pets and human associated animals), human (human waste), livestock (agriculture-related animals), and wildlife (mammals and waterfowl) source categories. The largest category of potential sources in the SWAP watershed area was wildlife (53%), followed by pet (20.1%), human (14.7%), and livestock (12.2%). The maximum annual loads of fecal bacteria for the Patapsco LNB watershed were determined to be 388,160 billion most probable number (MPN) E. coli/year, for the stormwater loads, of which 192,971 billion MPN E. coli/year are for Baltimore County, or nearly 50% of the total. To meet the TMDL, the county will have to reduce bacterial loads from this SWAP area by about 13% of the baseline load, based on station PAT0347.

Stormwater BMPs and programs implemented as required by MS4 permits are to be consistent with available WLAs developed under the TMDL. Where fecal bacteria are transported through an MS4 conveyance system, stormwater BMPs implemented to control urban runoff should help in reducing fecal bacteria loads in the Patapsco LNB watershed. Baltimore County is under a Consent Decree regarding its sanitary sewer overflows. Implementation of the conditions of the Consent Decree should assist in addressing the bacteria sources, particularly the human sources, in the sewered portion of the watershed.

3.2.5 TSS

MDE identified the waters of the Patapsco LNB watershed on the State's 303(d) list as impaired by sediment in 1996 (MDE, 2011). The objective of the TMDL is to ensure that there will be no sediment impacts affecting aquatic health, thereby establishing a sediment load that supports the Use I/III designations for the Patapsco River LNB watershed. Biological monitoring results from the DNR Core/Trend stations along the mainstem of the Patapsco River Lower North Branch indicate that mainstem water quality can be classified as good. Based on this information, MDE concluded that the sediment impairment in the Patapsco River Lower North Branch watershed is restricted to the lower order (smaller) streams within the watershed. Additionally, the forest normalized sediment load for TMDL Segment 1 (corresponding to SWAP area B) is below the reference watershed sediment loading threshold. Consequently, sediment reductions have been applied to the loads transported via the lower order stream network within TMDL Segment 2 (corresponding to SWAP area A) only and not the loads transported to the main channel of the Patapsco River Lower North Branch from the South Branch Patapsco River and TMDL Segment 1.

3.3 POLLUTANT LOADING ANALYSIS

Pollutant loading analyses are underway for each of the Maryland designated 8-digit watersheds located entirely or in part within Baltimore County. Analyses are intended to assess the impacts of current and future development on water quality. To support these analyses, Baltimore County has derived watershed-specific pollutant loading rates for nitrogen and phosphorus based on the Chesapeake Bay Program (CBP; USEPA 2010) – Watershed Model Phase 5.3, July 2011 model run, using specific rates from Patapsco Lower North Branch HUC8 number 02130906. The Maryland Assessment Scenario Tool (MAST) based on the CBP's model was used to develop loadings rates for all land uses except for wetlands, the rate for which was set the same as forest land cover. Pollutant loading rates for different land cover types in the Patapsco LNB and used to estimate pollutant loadings from the Patapsco SWAP B watershed are summarized in the Table 3-3.

Table 3-3: Annual Pollutant Loadings Rates for the Upper Patapsco River (lbs/acre/year)

Land Use	Nitrogen	Phosphorus	Sediment
Urban Impervious	17.36	1.51	1,856.0
Urban Pervious	11.55	0.24	247.0
Crop	23.53	1.27	1,250.0
Pasture	8.66	0.74	326.0
AFO/CAFO	171.58	25.09	4,591.0
Forest	2.78	0.04	88.0
Water	10.26	0.61	N/A
Wetlands	10.26	0.61	N/A
Bare Ground	32.30	5.15	11,557.0

As discussed in Chapter 2.3.1, land use information for the Upper Patapsco River watershed was obtained from MDP's 2010 LU/LC GIS layer. For the purposes of watershed-scale pollutant loading analyses, Baltimore County uses a consolidated version of MDP's 2010 land use classifications since loading rates do not differ significantly between certain land use classes (e.g., various forest types). The MDP LU/LC categories present in the Patapsco River and the corresponding MAST land cover classes used for the pollutant loading analyses are summarized in Table 3-4.

Table 3-4: Reclassification of MDP 2010 LU/LC to MAST Land Cover for the Patapsco River Watershed

MDP LU/LC Classification	MAST Land Cover Type
191 Very Low Density Residential (agriculture)	Urban*
192 Very Low Density Residential (forest)	Urban*
11 Low Density Residential	Urban*
12 Medium Density Residential	Urban*
13 High Density Residential	Urban*
14 Commercial	Urban*
15 Industrial	Urban*
16 Institutional	Urban*
17 Extractive	Urban*
18 Open Urban Land	Urban*
21 Cropland	Cropland
22 Pasture	Pasture
41 Deciduous Forest	Forest and Wetlands
43 Mixed Forest	Forest and Wetlands
44 Brush	Forest and Wetlands
50 Water	Water
60 Wetlands	Forest and Wetlands
73 Bare Ground	Bare Ground
80 Transportation	Urban*

* These categories were split into pervious urban and impervious urban areas using Baltimore County's roads and buildings GIS layers.

Consolidated land uses were used to determine the total acreage for each MAST land cover category. These were multiplied by the corresponding loading rates presented in Table 3-3. Resulting annual pollutant loads for total nitrogen, total phosphorus, and sediment from the Patapsco River SWAP B watershed are summarized by land use in Table 3-5 and for the entire watershed in Table 3-6.

Table 3-5: Total Annual Nutrient and Sediment Loads by Land Use from the Upper Patapsco River (SWAP B) Watershed

Land Use		Nitrogen		Phosphorus		Sediment	
	Area (acres)	Rate (lbs/ac/yr)	Load (lbs/yr)	Rate (lbs/ac/yr)	Load (lbs/yr)	Rate (lbs/ac/yr)	Load (lbs/yr)
Urban Pervious	4,165	11.55	48,107	0.24	979	247.0	1,028,788
Urban Impervious	1,063	17.36	18,453	1.51	1,609	1856.0	1,972,877
Crop	2,159	23.53	52,172	1.27	2,825	1250.0	2,771,583
Pasture/Orchards/ Ag Build.	1,180	8.66	10,588	0.74	901	326.0	398,595
Livestock	0	171.58	1,980	25.09	289	4591.0	52,974
Forest	7,069	2.78	19,977	0.04	280	88.0	632,358
Water	5	10.26	52	0.61	3		
Wetlands	0	10.26	0	0.61	0		
Bare Ground	48	32.30	1,549	5.15	247	11557.0	554,365
Totals	15,689		152,879		7,134		7,411,539

Table 3-6: Estimated Nutrient and Sediment Loads from the Upper Patapsco (SWAP B) Watershed

	Total Nitrogen	Total Phosphorus	Total Sediment
Edge of Stream Load (lbs/yr)	152,827	7,131	7,411,539
Edge of Stream Load (lbs/acre/yr)	9.60	0.45	466
Delivered Loads (lbs/yr)	74,584	1,940	3,508,358
Delivered Loads (lbs/acre/yr)	4.69	0.12	220

Loads delivered to the Chesapeake Bay from urban stormwater for average annual flow totaled 76,002 lbs/year for total nitrogen, 2,124 lbs/year for total phosphorus, and 4,363,707 lbs/year for total sediment. These loads represent 49 percent of total nitrogen edge of stream (EOS) loads, 27 percent of total phosphorus EOS loads, and 47 percent of total sediment EOS loads. Nutrient loadings were also calculated on a subwatershed basis using the same loading rates and land cover designations. These estimates will provide baseline nutrient loads before implementation of restoration projects and will allow a better assessment of both progress made to date and further progress needed to meet TMDL goals for urban nonpoint source reduction. Table 3-7 summarizes acreages of land cover categories by subwatershed.

Table 3-7: Upper Patapsco River SWAP Area B Land Use (acres) by Subwatershed

Land Use	Ben's Run	Brice Run	Falls Run	Granite Branch	Mardella Run	Patapsco River (N.Br)	Patapsco River-E	Powells Run	Total
Urban Pervious	1,287	542	592	256	811	43	469	165	4,165
Urban Impervious	432	184	80	55	176	31	81	25	1,063
Crop	148	493	249	350	451	303	165	58	2,217
Pasture/Orchards/ Ag Build.	368	195	96	184	86	143	108	43	1,223
Livestock	0	0	0	0	0	0	0	11	12
Forest	1,298	1,282	622	482	637	1,079	1,667	117	7,186
Water	0	0	0	0	0	5	0	0	5
Wetlands	0	0	0	0	0	0	0	0	0
Bare Ground	19	24	3	0	2	0	0	0	48
Totals	3,553	2,718	1,642	1,328	2,163	1,604	2,491	419	15,919

The resulting annual nutrient loads (lbs/yr) for the 8 subwatersheds in the Upper Patapsco River SWAP B area are summarized in the tables below. These tables also include nitrogen, phosphorus, and sediment loading rates (lbs/ac/yr) for each subwatershed. Table 3-8 to Table 3-10 show that the subwatersheds generating the greatest annual pollutant loads are Ben's Run, Brice Run, and Mardella Run. Note, however, that these subwatersheds also are among the larger acreage subwatersheds in comparison to the remaining subwatersheds.

Powells Run, Mardella Run and Patapsco River subwatersheds generate the highest amount of nutrients per acre (lbs/acre/yr), while the Patapsco River subwatershed generates the highest amount of sediment per acre, primarily because it has the largest amount of bare ground in that subwatershed. Subwatershed pollutant loadings and rates will be used to prioritize restoration efforts. The total planning level pollutant load estimate will be used to determine necessary reductions to meet local TMDL and Chesapeake Bay TMDL reductions.

3.4 WATER QUALITY MONITORING DATA

Baltimore County conducts chemical, biological, and illicit connection monitoring within the Upper Patapsco River watershed. Section 3.4.1 summarizes the chemical data available for Upper Patapsco River and Section 3.4.2 summarizes the biological monitoring program. Section 3.4.3 discusses the illicit connection program.

Table 3-8: Annual Nitrogen Loads by Subwatershed

Subwatershed	Total Area (acres)	Annual Nitrogen Loads by Land Cover (lbs/yr)									Edge of Stream		Delivered	
		Impervious Urban	Pervious Urban	Crop land	Pasture/ Orchards/ Ag Buildings	Live stock	Forest	Water*	Wet lands	Bare Ground	Total lbs/yr	Total lbs/acre/ yr	Total lbs/yr	Total lbs/acre/ yr
Ben's Run	3,553	7,500	14,866	3,482	3,188	0	3,609	0	0	617	33,261	9.36	17,820	5.02
Brice Run	2,718	3,187	6,255	11,592	1,685	0	3,563	0	0	772	27,054	9.95	12,831	4.72
Falls Run	1,642	1,393	6,834	5,855	832	31	1,729	0	0	108	16,782	10.22	8,291	5.05
Granite Branch	1,328	957	2,960	8,242	1,592	0	1,340	0	0	0	15,091	11.37	6,752	5.09
Mardella Run	2,163	3,050	9,369	10,622	747	0	1,772	0	0	53	25,612	11.84	12,565	5.81
Patapsco River (N.Br)	1,604	535	497	7,118	1,243	0	3,001	52	0	0	12,394	7.72	5,295	3.30
Patapsco River-E	2,491	1,401	5,419	3,893	934	0	4,636	0	0	0	16,282	6.54	8,078	3.24
Powells Run	419	431	1,907	1,369	368	1,949	326	0	0	0	6,350	15.14	2,952	7.04
Total	15,499	18,023	46,200	50,803	10,220	31	19,650	52	0	1,549	146,477	9.60	71,632	4.69

* Load from "Water" category is not included in edge of stream or delivered load totals.

Table 3-9: Annual Phosphorus Loads by Subwatershed

Subwatershed	Total Area (acres)	Annual Phosphorus Loads by Land Cover (lbs/yr)									Edge of Stream		Delivered	
		Impervious Urban	Pervious Urban	Crop land	Pasture/ Orchards/ Ag Buildings	Live stock	Forest	Water*	Wet lands	Bare Ground	Total lbs/yr	Total lbs/acre/ yr	Total lbs/yr	Total lbs/acre/ yr
Ben's Run	3,553	654	302	189	271	0	51	0	0	98	1,565	0.44	426	0.12
Brice Run	2,718	278	127	628	143	0	50	0	0	123	1,349	0.50	367	0.14
Falls Run	1,642	121	139	317	71	5	24	0	0	17	694	0.42	189	0.12
Granite Branch	1,328	83	60	446	135	0	19	0	0	0	744	0.56	202	0.15
Mardella Run	2,163	266	191	575	64	0	25	0	0	9	1,129	0.52	307	0.14
Patapsco River (N.Br)	1,604	47	10	385	106	0	42	3	0	0	590	0.37	161	0.10
Patapsco River-E	2,491	122	110	211	79	0	65	0	0	0	588	0.24	160	0.06
Powells Run	419	76	39	74	31	285	5	0	0	0	0	1.12	128	0.31
Total	15,919	1,648	979	2,825	901	289	280	3	0	247	6,660	0.45	1,940	0.12

* Load from "Water" category is not included in edge of stream or delivered load totals.

Table 3-10: Annual Sediment Loads by Subwatershed

Subwatershed	Total Area (acres)	Annual Sediment Loads by Land Cover (lbs/yr)							Edge of Stream		Delivered_	
		Imper vious Urban	Pervious Urban	Cropland	Pasture/ Orchards/ Ag Buildings	Live stock	Forest	Bare Ground	Total lbs/yr	Total lbs/acre/ yr	Total lbs/yr	Total lbs/acre/ yr
Ben's Run	3,553	801,839	317,912	184,963	119,996	0	114,253	220,588	1,759,550	495	832,903	234
Brice Run	2,718	340,709	133,767	615,801	63,432	0	112,794	276,140	1,542,643	568	730,091	269
Falls Run	1,642	148,915	146,150	311,026	31,338	829	54,736	38,531	731,524	445	346,271	211
Granite Branch	1,328	102,323	63,308	437,824	59,933	0	42,425	0	705,812	532	333,956	252
Mardella Run	2,163	326,078	200,352	564,261	28,108	0	56,089	19,106	1,193,994	552	565,025	261
Patapsco River (N.Br)	1,604	57,218	10,624	378,156	46,779	0	94,994	0	587,772	366	278,329	173
Patapsco River-E	2,491	149,755	115,896	206,809	35,143	0	146,738	0	654,342	263	310,156	125
Powells Run	419	46,039	40,780	72,743	13,866	52,145	10,329	0	235,902	563	111,627	266
Total	15,919	1,972,877	1,028,788	2,771,583	398,595	52,974	632,358	554,365	7,411,539	466	3,508,358	220

3.4.1 Chemical Data

Various chemical monitoring data are available for the Upper Patapsco River, including a program administered by Baltimore County. Chemical water quality data available to date in the watershed are summarized in the following sections.

3.4.1.1 County Recreational Water Sampling Program

From 1999-2010 Baltimore County maintained a baseflow monitoring program that evolved several times over the years (EPS 2013). In 1999, sampling targeted the Lower Gunpowder, Little Gunpowder, Middle River, and Baltimore Harbor watersheds, as these areas had Water Quality Management plans under development at that time. In the fall of 2000, baseflow monitoring shifted to the Back River, Jones Falls, and Gwynns Falls watersheds. The program was re-designed in 2003, and through 2010, baseflows were monitored in the Patapsco/ Back River Basin in odd-numbered years and in the Gunpowder/Deer Creek Basin in even-numbered years.

In January 2011, Baltimore County's baseflow monitoring program was replaced with a water quality trend monitoring program. The trend monitoring program observes ambient chemical conditions and determines trends in chemical concentrations and pollutant loads over time. This data is used to determine areas to target restoration, assess the impact of implemented restoration activities, and determine the amount of progress made towards meeting TMDLs and other restoration goals. Forty monitoring sites are visited on the same day, once per month. One of those trend sites, PA04, is within the Upper Patapsco River watershed, and is located on Ben's Run near Dogwood and Hollofield Roads (Figure 3-1). Trend chemical monitoring results collected for these sites are summarized in Table 3-11.

Water quality parameters measured as part of the County's trend monitoring program include total suspended solids (TSS), nutrients, metals, and chloride. The importance of each of these parameters is briefly described below.

- Suspended Solids: Excessive suspended solids in water bodies can adversely impact aquatic life as it affects the light available for photosynthesis by plants and visual capacity of aquatic life. Decreased light can lead to an increase in algae communities and resulting decrease in abundance and diversity of invertebrate and fish communities. Excessive sediment can also negatively affect habitat structure, by filling in the niche spaces used by organisms for feeding and protection from predators.

- Nutrients: As discussed previously, over-enrichment of water bodies by excessive nutrient input can cause excessive algal growth and bacterial consumption of dissolved oxygen when the algae decompose. This can lead to significant reductions in water quality, as well as abundance and diversity of aquatic life communities.

- Metals: Metals are a concern because they may dissolve in water and are easily absorbed by aquatic organisms such as fish. Even low concentrations of metals in water bodies can be toxic to aquatic life and human health. While metals may not directly kill organisms, they may adversely affect an organism's health and interfere with growth and reproduction.

Table 3-11: Upper Patapsco River Trend Monitoring Results at Site PA04 on Ben's Run - (mg/L)

DATE	CFS	TEMP (c)	PH	TSS	TS	TKN	NO_2 NO_3	NO_2	NO_3	TP	OP	CD	CD_D	CU	CU_D	PB	PB_D	ZN	ZN_D	BOD	COD	CL	NA	HARDNESS	Mg	Ca	SO_4	Fl	TN
1/20/11	3.815	3.3	8.68	0.5	830	0.3	0.06	0.03	0.03	0.025	0.05	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.001	0.0005	1	18	432.48	252.5	170.88	30.55	18.05	20.34		0.36
2/8/11	12.889	2.7	7.97	0.5	438	0.44	0.61	0.03	0.58	0.025	0.05	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.001	0.001	1	18	179.27	130.4	136.48	18.5	24.15	18.59		1.05
3/17/11	11.491	8.3	7.2	0	180	0.1	0.67	0.03	0.64	0.025	0.05	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	1	10	65.78	44.2	111.57	16.3	17.8	17.37		0.77
4/12/11	8.688	14.4	7.93	0.5	218	0.2	0.62	0.03	0.59	0.025	0.05	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.014	0.002	1	19	60.54	37	178.83	21.9	35.5	19.3		0.82
5/24/11	5.026	19	7.71	0.5	312	0.29	1.04	0.03	1.01	0.025	0.05	0.0005	0.0005	0.001	0.0005	0.0005	0.0005	0.004	0.001	1	9	77.81	31.6	179.24	21.48	36.36	19.34		1.33
6/15/11	2.25	17.9	7.9	0.5	348	0.23	0.80	0.03	0.77	0.025	0.05	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.002	0.0005	1	2.5	63.78	41.4	190.09	22.73	38.64	20.77		1.03
7/12/11	4.381	24	7.6	4	214	0.33				0.025		0.0005	0.0005	0.001	0.0005	0.0005	0.0005	0.003	0.001	2	18		22.2	116.14	13.19	24.76			
8/9/11	1.236	22.8	7.74	0.5	212	0.23				0.025		0.0005		0.001		0.0005		0.003		1	10		24.7	136.84	14.73	30.51			
9/20/11	5.554	16.4	7.84	0.5	244	0.23				0.025		0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.002	0.0005	1	10		16.2	110.95	17.12	35.25			
10/18/11	4.298	13.4	7.43	0.5	268	0.26				0.025		0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.001	0.0005	1	8		14.6	156.85	18.28	32.67			
11/15/11	4.426	12.2	7.61	0.5	188	0.1				0.025		0.0005	0.0005	0.001	0.0005	0.0005	0.0005	0.009	0.002	1	2.5		14.9	182	20.67	38.8			
12/20/11	2.81	6.5	7.26	0.5	168	0.1				0.025		0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.001	0.001	1	9		12.3	155.22	20.77	27.91			
1/17/12		5.2	7.44	0.5	192	0.1				0.025		0.0005	0.0005	0.008	0.0005	0.0005	0.0005	0.012	0.002	1	10		14.1	182.27	23.27	34.62			
2/14/12	3.58	3.2	8.44	0.5	244					0.025		0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	1	16		26.4	141.71	18.21	26.72			
3/13/12	3.49	11.9	8.3	0.5	234	0.1	0.82	0.03	0.79	0.025	0.05	0.002		0.006		0.003		0.007		1	2.5	38.36	14.6	161.54	19.57	32.42	15.42		0.92
4/17/12	2.12	17	8.04	0.5	222	0.2	0.63	0.03	0.6	0.025	0.05	0.0005		0.0005		0.0005		0.005		1	2.5	43.2	13	173.06	18.68	38.5	15.86		0.83
5/8/12	2.19	15.9	8.14	0.5	212	0.21	0.68	0.03	0.65	0.025	0.05	0.0005		0.005		0.0005		0.002		1	2.5	40.35	12.4	144.61	17.52	29.02	15.3		0.89
6/12/12	1.63	19.8	8.32	2	192	0.1	0.73	0.03	0.7	0.025	0.05	0.0005		0.0005		0.0005		0.0005		1	12	39.16	12	170.93	17.4	39.76	14.93		0.83
7/17/12	0.63	23.1	7.84	0.5	162	0.1	0.36	0.03	0.33	0.025	0.05	0.0005		0.0005		0.0005		0.004		1	9	31	9.6	129.56	14.21	28.45	12.28		0.46
8/14/12	0.49	21.6	7.72	0.5	234	0.1				0.025		0.0005		0.0005		0.0005		0.005		1	10		11.3	145.47	16.17	31.59			
9/11/12	1.566	15.8	7.92	0.5	208	0.2	0.52	0.03	0.49	0.025	0.05	0.0005		0.001		0.0005		0.006		1	5	24.45	9.49	130.28	15.52	26.58	15.8		0.72
10/16/12	3.412	12.1	7.93	0.5	164	0.24	0.38	0.03	0.35	0.025	0.05	0.0005		0.001		0.0005		0.002		1	2.5	33.14	8.7	128.55	15.44	26.02	12.15		0.62
11/20/12	3.571	7.2	8.36	0.5	188	0.1	0.96	0.03	0.93	0.025	0.05	0.0005		0.001		0.0005		0.0005		1	7	47.37	9.6	158.97	17.63	34.59	16.09		1.06
12/11/12	3.879	8.8	8.2	0.5	206	0.1		0.03		0.025	0.05	0.0005		0.0005		0.0005		0.0005		1	2.5	35.7	10.7	153.7	19.36	29.62	13.6		
1/15/13	11.949	7.1	7.51	0.5	208	0.24	0.61	0.03	0.58	0.025	0.05	0.0005		0.0005		0.0005		0.005		1	7	49.51	10.1	87.4	11.39	16.233	12.1		0.85
2/12/13		6.2	8.7	0.5	230		1.81	0.73	1.08		0.05	0.0005		0.0005		0.0005		0.003		1	2.5	81.53	40.7	133.6	15.59	27.8	17.54		
3/19/13	9.793	5.4	7.63	0.5	190	0.25	1.41	0.66	0.75	0.05	0.05	0.0005		0.0005		0.0005		0.004		1	9	56.81	31.8	110.1	13.9	21.16	14.14		1.66
4/9/13	5.718	13.9	7.88	2	222	0.1	1.64	0.63	1.01	0.06	0.05	0.0005		0.0005		0.0005		0.0005		1	6	55.34	18.9	134.6	17.35	25.31	19.44		1.74
5/14/13	8.562	10.3	8.45	0.5	174		1.44	0.65	0.79		0.05	0.0005		0.0005		0.0005		0.011		1	2.5	35.12	16.4	148.5	16.37	32.47	13.37		
6/11/13	28.446	19.8	7.54	1	158	0.8	0.88	0.36	0.52	0.025	0.05	0.0005		0.001		0.0005		0.006		1	19	23.88	14.3	99.2	11.63	20.55	11.54		1.68
7/9/13	2.972	21.8	7.67	1	295	0.1	1.59	0.51	1.08	0.025	0.05	0.0005		0.0005		0.0005		0.003		1	6	52.18	16.8	175.8	21.42	35.06	17.87		1.69
8/13/13	5.119	21	7.19	5	180	0.2	1.53	0.54	0.99	0.025	0.05	0.0005		0.0005		0.0005		0.008		1	8	42.9	15.8	221.8	21.65	53.11	16.53	0.25	1.73
9/10/13	1.785	19.9	8.09	0.5	206	0.1	1.05	0.59	0.46	0.025	0.05	0.0005		0.0005		0.0005		0.0005		1	2.5	30.32	11.5	180.8	18.94	41.19	12.3	0.25	1.15
10/8/13	4.429	14.6	7.77	23	190	0.36	0.75	0.46	0.29	0.025	0.05	0.0005		0.0005		0.002		0.005		1	2.5	38.43	17.25	143.5	17.11	29.25	15.71	0.25	1.11
11/12/13	2.507	5.8	8.14	0.5	214	0.1	1.25	0.44	0.81	0.025	0.05	0.0005		0.0005		0.0005		0.078		1	6	49.38	12.26	176.2	22.08	34.14	20.78	0.25	1.35
12/17/13	6.213			0.5	320	0.1	1.04	0.03	1.01	0.05	0.05	0.0005		0.0005		0.0005		0.0005		1	11	129.79	82.76	199	22.23	43.02	20.45	0.25	1.14
1/14/14	12.936	6.2	8.09	0.5	284	0.22	0.1	0.05	0.05	0.06	0.05	0.0005		0.002		0.0005		0.003		1	15	100.62	43.5	151.2	13.9	37.63	20.6	0.25	0.32

Table 3-11: Upper Patapsco River Trend Monitoring Results at Site PA04 on Ben's Run - (mg/L)

DATE	CFS	TEMP (c)	PH	TSS	TS	TKN	NO_2 NO_3	NO_2	NO_3	TP	OP	CD	CD_D	CU	CU_D	PB	PB_D	ZN	ZN_D	BOD	COD	CL	NA	HARDNESS	Mg	Ca	SO_4	Fl	TN
2/11/14	7.68	0.3	8.25	1	448	0.25	1.5	0.05	1.45	0.025	0.05	0.0005		0.0005		0.0005		0.003		1	6	181.47	113.6	152.8	17.73	31.97	21.67	0.25	1.75
3/18/14	8.663	3.6	8.87	12	1501	0.35	3.63	2.42	1.21	0.025	0.05	0.0005		0.0005		0.0005		0.001		1	12	881.1	789.3	281	25.1	71.14	27.35	0.25	
4/8/14	12.454	10.6	9.19	3	232	0.32	1.41	0.5	0.91	0.025	0.05	0.0005		0.0005		0.0005		0.001		1	7	85.88	53.9	124.8	13.91	27.05	18.76	0.25	
5/13/14	11.843	18.3	8.53	6	201	0.21	1.32	0.47	0.85	0.025	0.05	0.0005		0.0005		0.0005		0.0005		1	7	53.93	21.4	114.9	12.33	25.69	17.06	0.25	
6/10/14	5.328	19	7.93	0.5	173	0.1	1.86	0.48	1.38	0.025	0.05	0.0005		0.003		0.004		0.016		1	2.5	47.5	16.8	133.5	15.18	28.44	17.8	0.25	
7/8/14	4.206	21.2	8.12	3	244	0.1	1.3	0.05	1.25	0.84	0.05	0.0005		0.0005		0.0005		0.002		1	8	47.83	15.8	139.3	15.63	30.02	16.7	0.25	
8/12/14	5.351	19.6	8.05	2	175	0.29	1.03	0.05	0.98	0.09	0.05	0.0005		0.0005		0.001		0.002		1	12	43.48	12.6	126.9	14.42	27.04	15.56	0.25	
9/9/14	2.306	19.1	8.07	0.5	192	0.72	0.97	0.05	0.92	0.025	0.05	0.0005		0.0005		0.0005		0.002		1	2.5	45.19	15	134.6	17.01	25.87	16.67	0.25	
10/14/14	2.594	17.1	8.34	0.5	254	0.1	0.78	0.05	0.73	0.025	0.05									1	7	45.06					16.67	0.25	
11/12/14	3.079	11.7		0.5	170	0.24	0.76	0.05	0.71	0.025	0.05									1	10	50.07					18.19	0.25	
12/16/14	4.821	5.8	8.95	0.5	202	2.77	1.08	0.05	1.03	0.025	0.05	0.0005		0.0005		0.0005		0.0005		1	6	54.29	0.1	0.25	0.002	0.04	19.55	0.25	
1/20/15	5.819	3	8.26	0.5	302	0.1	1.35	0.05	1.3	0.25	0.05	0.0005		0.001		0.0005		0.001		1	6	125.81	37.4	130.4	14.77	27.87	25.8	0.25	
2/18/15		2.2	8.01	4	1239	0.4	1.66	0.05	1.61	0.025	0.05	0.0005		0.0005		0.0005		0.001		1	11	742.77	377.5	327.4	48.4	51.28	21.93	0.25	
3/10/15	18.301	2.7	7.92	0.5	263	0.31	0.81	0.05	0.76	0.2	0.05	0.0005		0.004		0.0005		0.002		1	6	161.26	91.4	105.2	18.88	11	14.02	0.61	
4/14/15	7.23	13.9	6.58	0.5	260	0.2	0.91	0.05	0.86		0.05	0.0005		0.005		0.0005		0.011		1	10	72.51	24	232.2	32.57	39.29	18	0.25	
5/12/15	4.513	19.3	8.11	0.5	231	0.33	1.24	0.05	1.19	0.23	0.05	0.0005		0.006		0.002		0.004		1	2.5	61.88	17.5	205.2	29.69	38.16	17.62	0.25	
6/9/15	19.357	20.1	7.97	0.5	186	0.49	0.56	0.05	0.51		0.05	0.0005		0.007		0.0005		0.002		3	14	52.93	25.7	119.1	16.2	20.97	10.06	0.25	
7/14/15	3.725	21.2	8.36	0.5	262	0.21	0.82	0.05	0.77	0.025	0.05	0.0005		0.002		0.0005		0.001		2	12	58.84	16.3	195	30.55	27.71	16.44	0.25	
8/11/15	2.849	21.1	8.22	0.5	289	0.1	1.06	0.05	1.01	0.025	0.05	0.0005		0.003		0.0005		0.0005		1	2.5	55.41	15.3	259.1	32.79	49.7	17.25	0.25	
9/8/15	1.322	20.7	8.18	0.5	290	0.1	0.65	0.05	0.6	0.025	0.05	0.0005		0.002		0.002		0.0005		1	6	61.69	16.2	274.5	35.46	51.46	19.35	0.25	
10/14/15	2.766	13.5	8.08	0.5	28	0.1	0.61	0.05	0.56	0.025	0.05	0.0005		0.0005		0.0005		0.001		1	2.5	62.68	14.8	211.1	35	26.82	18.97	0.25	
11/16/15	4.274	7.4	8.1	0.5	258	0.1	0.57	0.05	0.52	0.025	0.05	0.0005		0.0005		0.0005		0.0005		1	2.5	62.85	9.4	172.5	29.13	21.04	18.7	0.25	
12/8/15	4.308	3.9	8.61	0.5	235	0.1	0.95	0.05	0.9	0.025	0.05	0.0005		0.0005		0.0005		0.002		1	8	60.19	11.1	192	32.86	22.72	18.63	0.25	
MIN	**0.49**	**0.3**	**6.58**	**0**	**28**	**0.1**	**0.06**	**0.03**	**0.03**	**0.025**	**0.05**	**0.0005**	**0.0005**	**0.0005**	**0.0005**	**0.0005**	**0.0005**	**0.0005**	**0.0005**	**1**	**2.5**	**23.88**	**0.1**	**0.25**	**0.002**	**0.04**	**10.06**	**0.25**	**0.32**
MAX	**28.446**	**24**	**9.19**	**23**	**1501**	**2.77**	**3.63**	**2.42**	**1.61**	**0.84**	**0.05**	**0.002**	**0.0005**	**0.008**	**0.0005**	**0.004**	**0.0005**	**0.078**	**0.002**	**3**	**19**	**881.1**	**789.3**	**327.4**	**48.4**	**71.14**	**27.35**	**0.61**	**1.75**
Median	**4.308**	**13.9**	**8.045**	**0.5**	**220**	**0.2**	**0.93**	**0.05**	**0.78**	**0.025**	**0.05**	**0.0005**	**0.0005**	**0.0005**	**0.0005**	**0.0005**	**0.0005**	**0.002**	**0.001**	**1**	**7**	**54.29**	**16.25**	**152**	**17.97**	**29.435**	**17.37**	**0.25**	**1.04**

Figure 3-1: Baltimore County Trend Monitoring Location in Upper Patapsco River Watershed

- Chloride: Chlorides come from various sources such as agricultural runoff, waste water, and road salting. High levels of chlorides can be toxic to aquatic communities including fish.

The Patapsco River mainstem (Lower North Branch, downstream of the confluence with South Branch at Marriottsville) is designated as *Use IV: Recreational Trout Waters.* Brice Run, Granite Branch and Mardella Run are all designated as *Use III Nontidal Cold Water*. The remaining tributaries are designated as *Use I: Water Contact Recreation, and Protection of Nontidal Warmwater Aquatic Life*. Per COMAR, these designations are subject to toxic substance criteria established for ambient surface waters, pertaining to aquatic life in fresh water. EPA National Recommended Water Quality Criteria (USEPA 2014) and reporting limits for measured water quality parameters in Upper Patapsco River are summarized in Table 3-12.

Table 3-12: Numeric Water Quality Criteria and Report Limits (mg/L)

Parameter	CMC (acute)	CCC (chronic)	Reporting Limit
Suspended Solids	N/A	N/A	1
Total Phosphorus	N/A	N/A	0.02
Total Nitrogen	N/A	N/A	0.2
Cadmium	0.0018	0.00072	0.00001
Copper	0.013	0.009	0.001
Lead	0.065	0.0025	0.0001
Zinc	0.12	0.12	0.001
Chloride	860	230	-

CMC: Criteria Maximum Concentration is an estimate of the highest concentration to which an aquatic community can be exposed briefly without resulting in an unacceptable effect.
CCC: Criterion Continuous Concentration is an estimate of the highest concentration to which an aquatic community can be exposed indefinitely without resulting in an unacceptable effect.

3.4.1.2 Patapsco/Back River Tributary Strategy Data

To help achieve Maryland's portion of the reductions in nitrogen, phosphorus and sediment to the Chesapeake Bay, a Tributary Strategy Team was created for each of the 10 basins that make up the Chesapeake Bay, including the Patapsco/Back River Basin. Each Team consisted of local citizens, farmers, business leaders, and state and local government officials appointed by the Governor. The Teams helped implement pollution prevention measures and supported local water quality programs including water quality monitoring. To assist the Tributary Team, Maryland DNR documented Patapsco/Back River basin characteristics including available water quality monitoring results in their report, Maryland Tributary Strategy Patapsco/Back Rivers Basin Summary Report for 1985-2005 Data (DNR 2007).

Water quality parameters of nitrogen, phosphorous and total suspended solids were collected from five long-term, non-tidal monitoring stations in the Patapsco/Back Rivers Basin. One of these stations, Patapsco River Hollofield (PAT0285), was located at the downstream end of the Upper Patapsco SWAP area. The water quality parameters were assigned a relative status of good, fair or poor compared to baseline conditions.

Figures 3-2, 3-3, and 3-4 show the water quality monitoring results reported by Maryland DNR for the Patapsco/Back Rivers Basin. Relative status is reported for 2003-2005, and linear trends

significant at p ≤ 0.01 are reported for 1995-2005. Conditions were generally fair to good and improving for the Patapsco Hollofield station.

Figure 3-5 shows the water quality monitoring results reported by Maryland DNR for Patapsco River Hollofield (Station PAT0285, Hollofield) during the period 1985-2005. Note that the black lines denote concentrations for each sampling date and the annual medians of these values are shown as red bars. Total nitrogen concentrations ranged from 4.4 mg/L to 0.8 mg/L, and seem to be showing a downward trend. Total phosphorus concentrations ranged from approximately 0.01 mg/L to 0.36 mg/L with a general decreasing trend in more recent years, and fewer high spikes. Total suspended solids (TSS) concentrations are variable, ranging from 0 mg/L to 80 mg/L. Despite occasional spikes in TSS, the data suggests a downward trend.

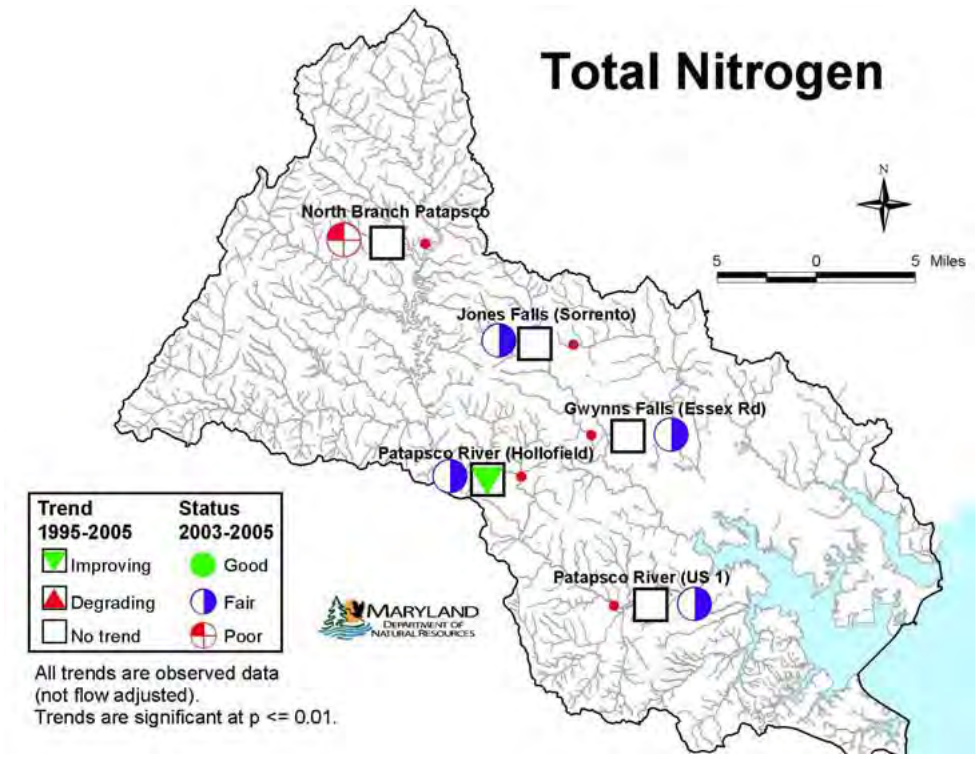

Figure 3-2: Total Nitrogen, Non-Tidal Monitoring Results in Patapsco/Back River Basin

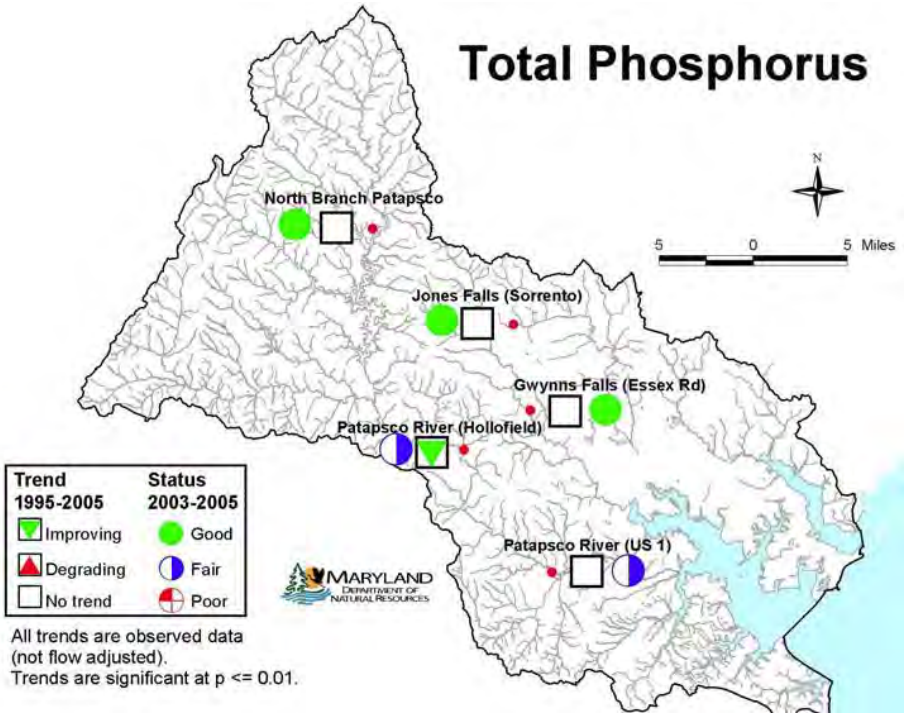

Figure 3-3: Total Phosphorous, Non-Tidal Monitoring Results in Patapsco/Back River Basin

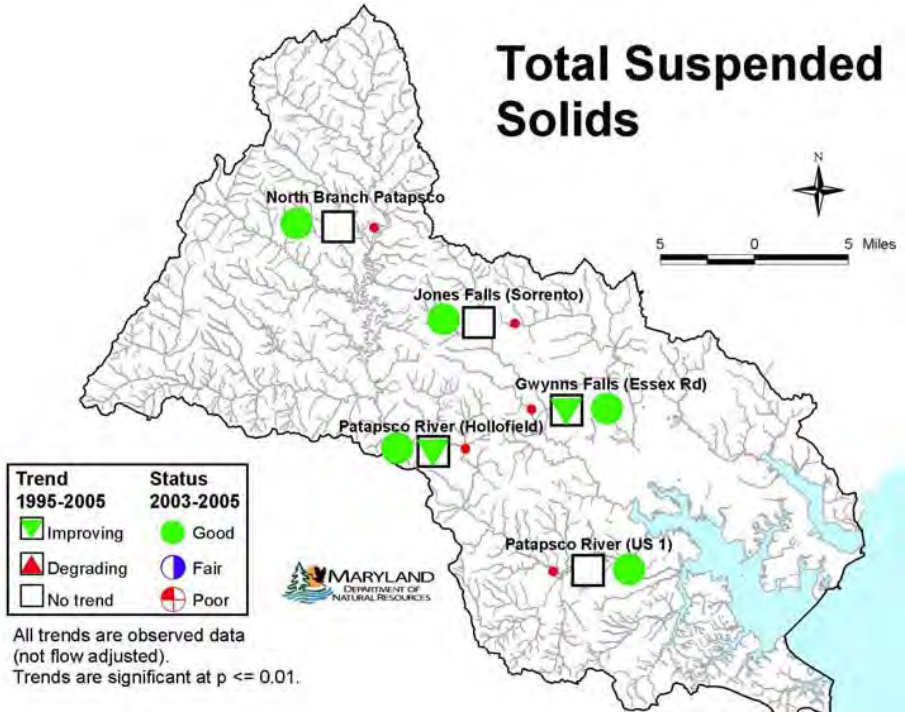

Figure 3-4: Total Suspended Solids, Non-Tidal Monitoring Results in Patapsco/Back River Basin

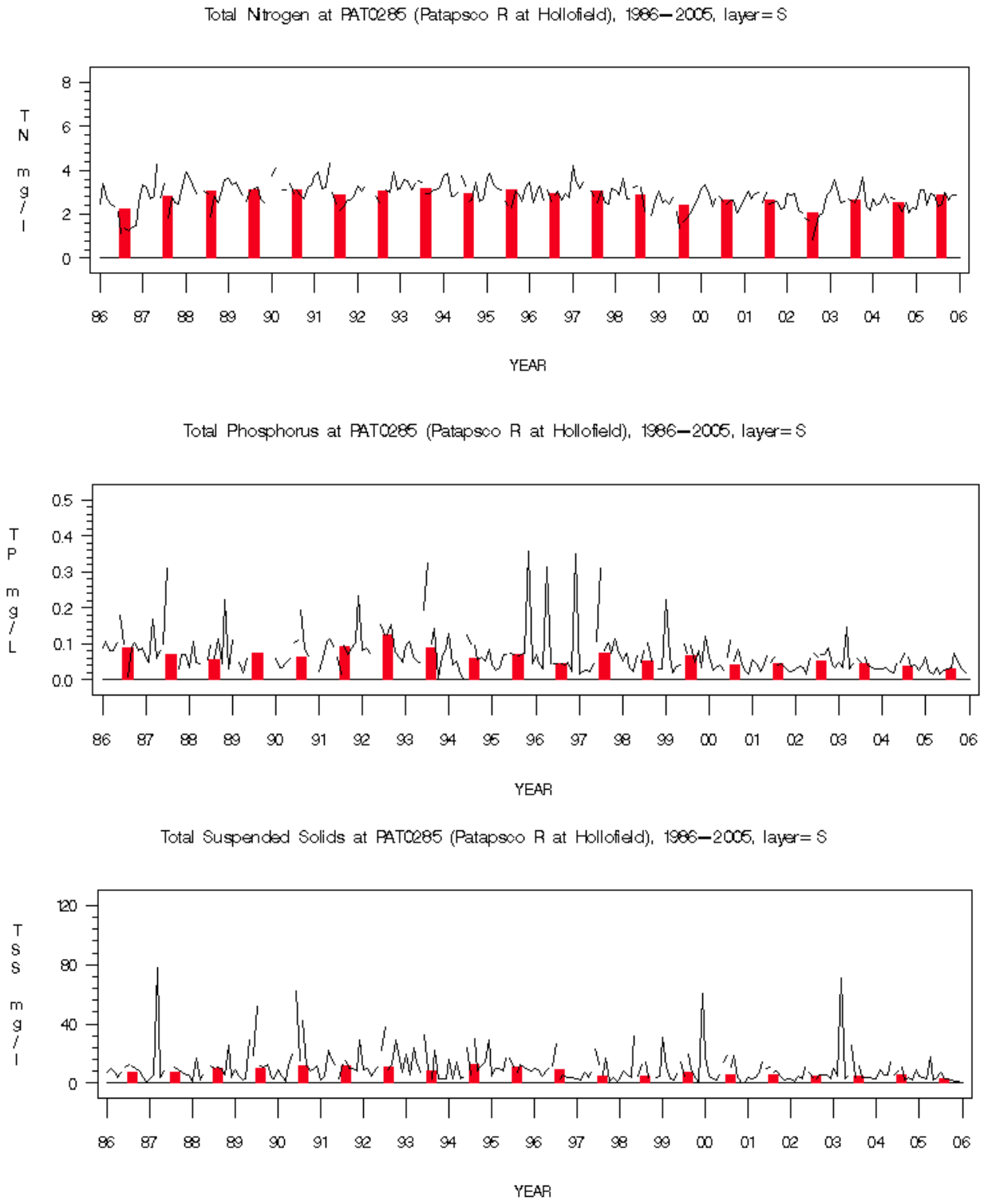

Figure 3-5: Total Nitrogen, Phosphorus, and Suspended Solids. Non-Tidal Monitoring Results in Patapsco/Back River Basin, Station PAT0285 (Patapsco Hollofield)

In addition to non-tidal monitoring, DNR maintained a network of long-term, tidal monitoring stations. Water quality parameters including nitrogen, phosphorus, chlorophyll-a (algal abundance), total suspended solids, water clarity and dissolved oxygen were measured at long-term, tidal monitoring stations in the Patapsco/Back River Basin, one of which was located on the Patapsco River mainstem, downstream of the Upper Patapsco River watershed (Station 2 in Figure 3-6). Results were assigned a current status of good, fair or poor relative to baseline data or scientifically based benchmarks (e.g., applicable state thresholds) depending on the parameter. For example, concentrations of dissolved oxygen (DO) were compared to ecologically meaningful thresholds available: good (DO > 5 mg/L); fair (DO = 2-5 mg/L); and poor (DO < 2 mg/L). Since scientific benchmarks were not available for the remaining parameters, a Chesapeake Bay-wide scale was developed for each parameter based on salinity zone. All data available for the Chesapeake Bay between 1985 and 1990 were used to establish a baseline for rating water quality at each station. Three cutoff points were derived to define good, fair, and poor ratings from a cumulative logistic function for the monthly medians of the baseline data. Monthly medians from the most recent data set (2003-2005) at a given station were compared to these cutoff points to establish water quality status ratings. Water quality ratings are indicators relative to similar stations in the Chesapeake Bay during the baseline time period (1985-1990); therefore, a good rating does not necessarily reflect levels needed to sustain healthy, living resource populations.

Figure 3-7, Figure 3-8, and Figure 3-9 show the water quality monitoring results reported by Maryland DNR for Patapsco River (Station WT5.1, labeled as Station 2 in Figure 3-6) during the period 1985-2005. Note that the black lines in Figure 3-7, Figure 3-8, and Figure 3-9 denote concentrations for each sampling date and annual medians of these values are shown as red bars. Total nitrogen concentrations ranged from over 4 mg/l in 1989 to as low as 0.8 mg/l in 1992. Total phosphorus concentrations ranged from approximately 0.01 mg/l to 0.3 mg/l with a general decreasing trend in more recent years, and fewer high spikes. Chlorophyll concentrations were as high as150 µg/l in 1995, and continued to spike periodically through the years. On more than 20 occasions, chlorophyll a levels exceeded 50 µg/l, the concentration associated with excessive eutrophication (nutrient enrichment). Total suspended solids concentrations are generally less than 40 mg/l at this location. Since 1998, TSS has generally remained between 10-20 mg/l. Water clarity is measured in terms of Secchi depth or the depth of water transparency. Water clarity is generally consistent from 1985 to 2005, where the Secchi depth varies from 0.5-1.5 meters, seasonally. Low dissolved oxygen is a chronic problem in the Baltimore Harbor portion of the Patapsco River, with values rarely reaching above 5 mg/l, the concentration known to be necessary for many aquatic organisms. For more information, please refer to the Maryland Tributary Strategy Patapsco/Back Rivers Basin Summary Report for 1985-2005 Data (DNR 2007).

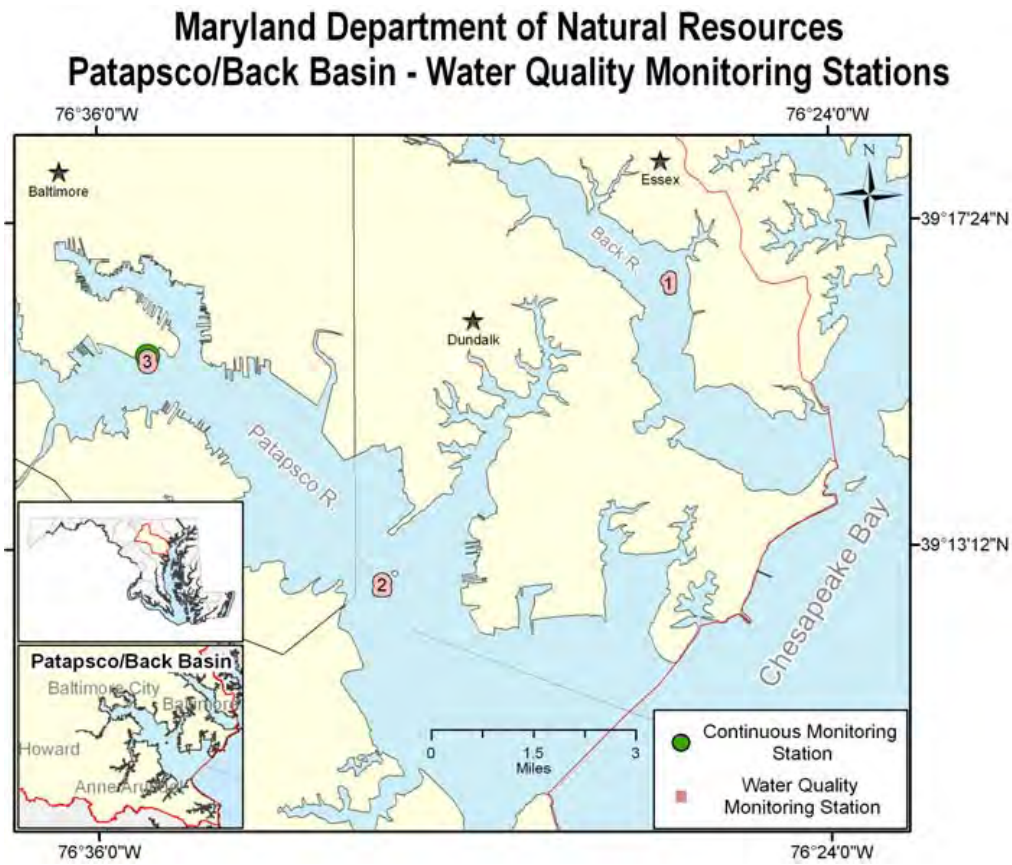

Figure 3-6: Location of Maryland DNR's Long-Term Fixed Monitoring Stations (figure from DNR 2007)

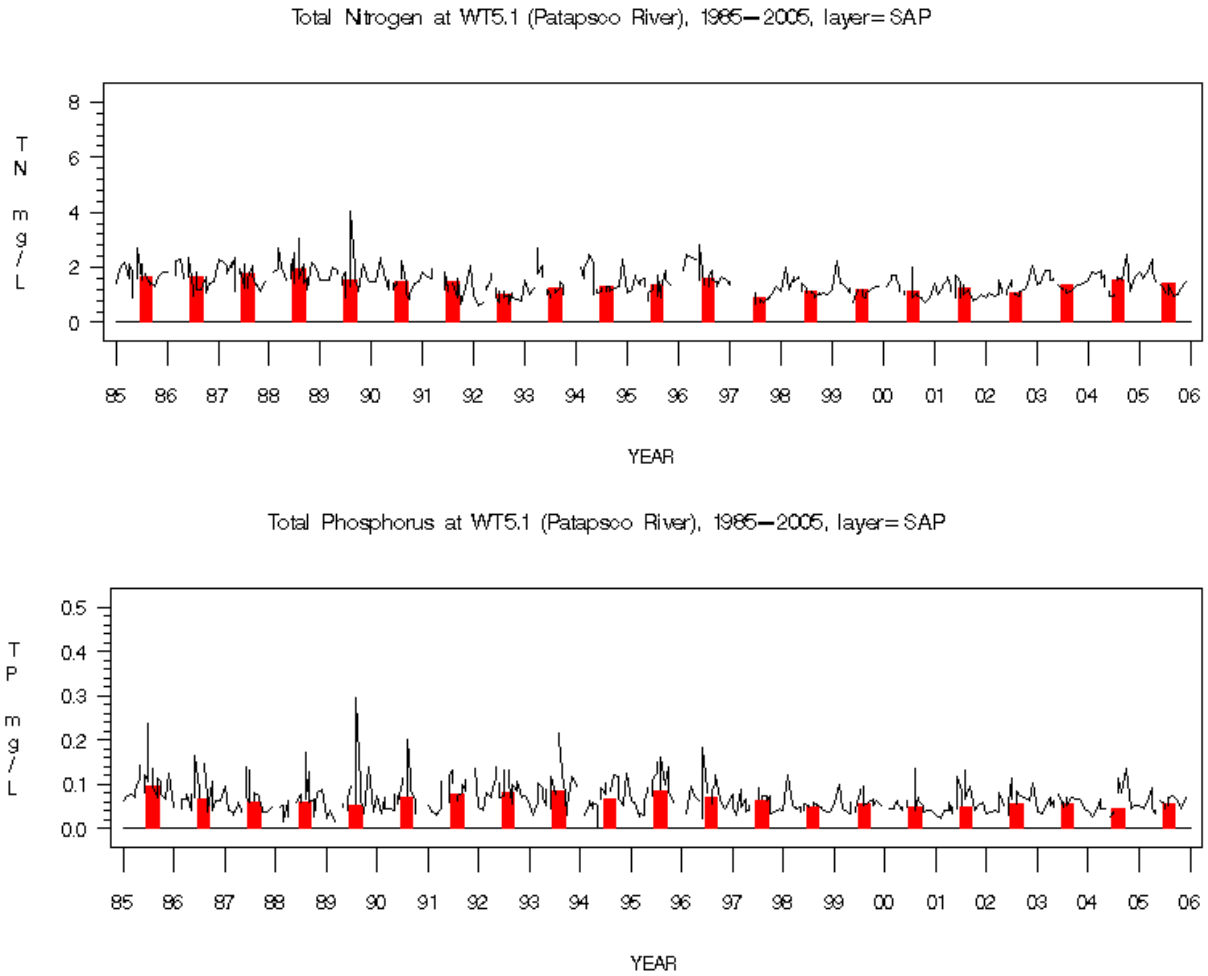

Figure 3-7: Total Nitrogen and Phosphorus Tidal Monitoring Results in Lower Patapsco River

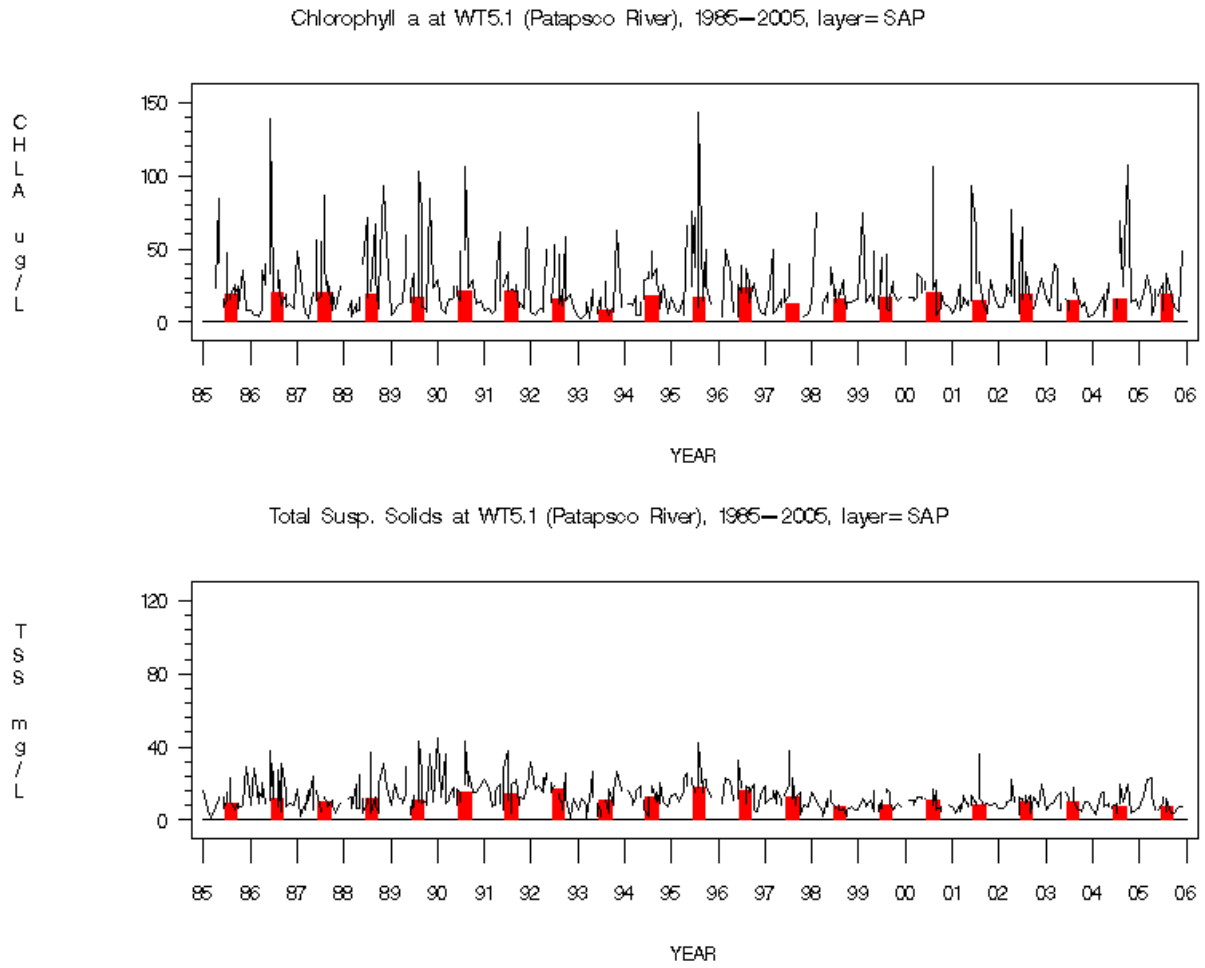

Figure 3-8: Chlorophyll-a and Total Suspended Solids Tidal Monitoring Results in Lower Patapsco River

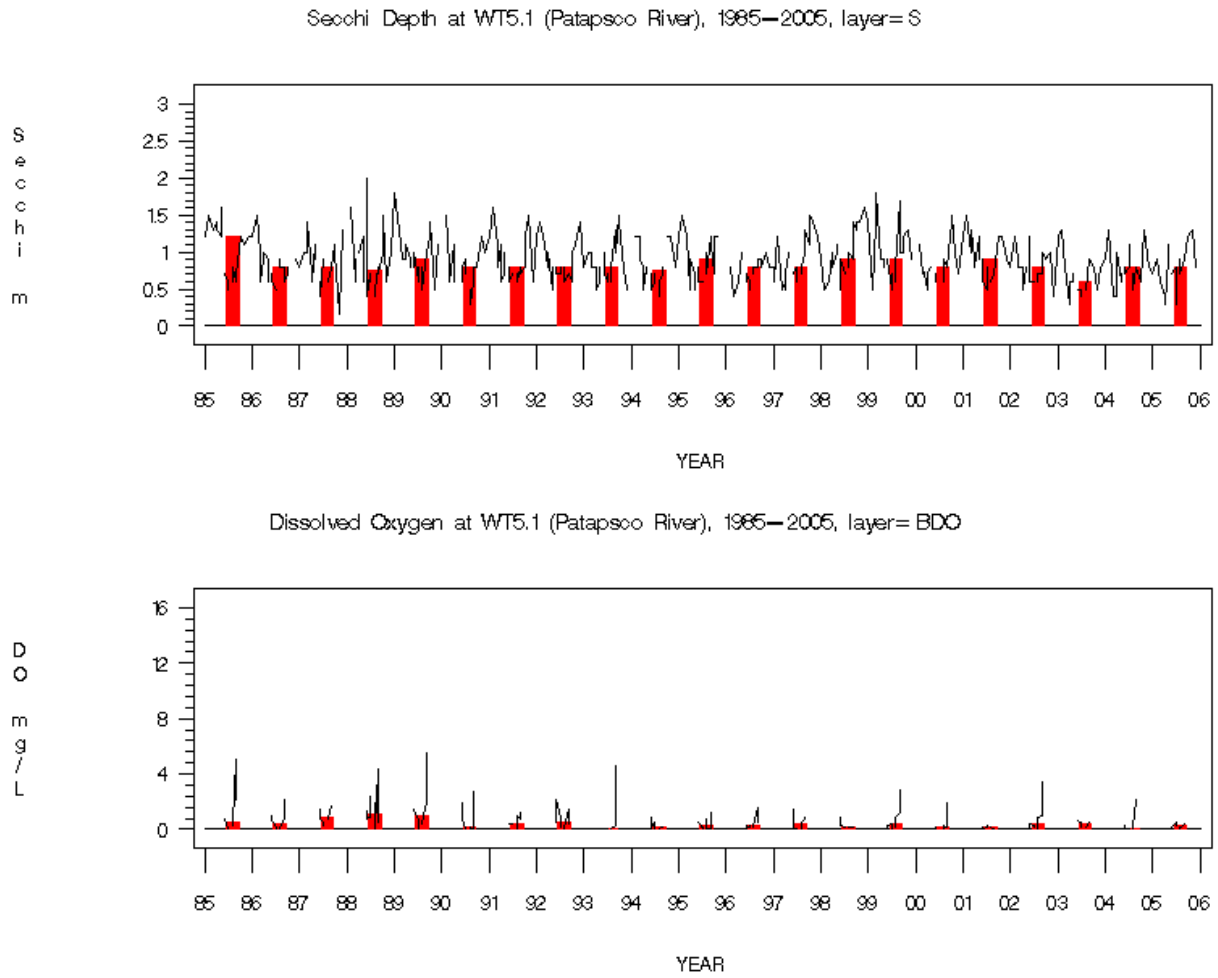

Figure 3-9: Water Clarity and Dissolved Oxygen Tidal Monitoring Results in Lower Patapsco River

3.4.2 Biological Data

Baltimore County conducts biological monitoring of benthic macroinvertebrates on an annual basis using the Maryland Biological Stream Survey (MBSS) protocols (Stranko 2007). The MBSS is a random design stream sampling program that was initiated by the Maryland DNR in 1993. It is intended to provide unbiased, statewide estimates of the biological resources in streams and rivers.

Benthic macroinvertebrates are organisms without a backbone that live on the bottom of streams and can be seen with the naked eye. They are an important part of stream ecosystems as they are a source of food for other aquatic life, including fish. The presence, numbers, and types of benthic macroinvertebrates also convey information about a water body's quality. Results of the MBSS protocol include a benthic Index of Biological Integrity (BIBI) score based on the benthic community at a sampling site. Qualitative ratings of stream biological integrity are based on IBI scores and range from good (4.0 – 5.0), denoting minimally impacted conditions, to very poor (1.0 – 1.9), indicating severe degradation.

Sites for the Baltimore County biological sampling program are randomly selected, focusing on the Patapsco/Back River Basin in odd years and the Gunpowder/Deer Creek Basin in even years. Between 2003 and 2013, 72 sites were randomly sampled in the Upper Patapsco River watershed by Baltimore County. Figure 3-10 shows the distribution of sites, as well as their BIBI narrative ratings. Of the 72 sites, 13 received a rating of Good, 27 received a rating of Fair, 22 received a rating of Poor, and 10 received a rating of Very Poor. In addition to data collected by the County, Maryland DNR sampled six random sites in the watershed through the MBSS program between 1995 and 2009, and an additional six mainstem sites as part of a special study between 2009 and 2014 (Figure 3-11; if a station was sampled more than once, only the most recent results for that station were mapped). Both the Baltimore County and the DNR data reflect a wide degree of variation in the condition of streams throughout the watershed.

3.4.3 Illicit Discharge and Elimination Data

Baltimore County tracks illicit discharges through a program of routine outfall screening. The program consists of three parts:

1. A quantitative analysis of the effluent that includes measuring the effluent flow rate, temperature and pH, and field testing for parts per million (ppm) of chlorine, phenols, ammonia, and copper using a specially configured LaMotte NPDES test kit;
2. A qualitative assessment of the effluent, outfall structure, and receiving channel, noting conditions such as water color, odor, vegetative condition, sedimentation, erosion, damage, etc.; and
3. A visual inspection of each outfall that identifies any structural damage.

The County has an outfall prioritization system based on data from the outfall screening. There are approximately 64 outfalls in Upper Patapsco River watershed. About 80% (51) of these are minor outfalls (less than three feet in diameter). The remaining 13 outfalls are classified as major (greater than three feet in diameter); 13 of these have a prioritization rating (Table 3-13, Figure 3-12). The prioritization system allows for a more streamlined approach in selecting outfalls to screen and provides a more efficient use of manpower.

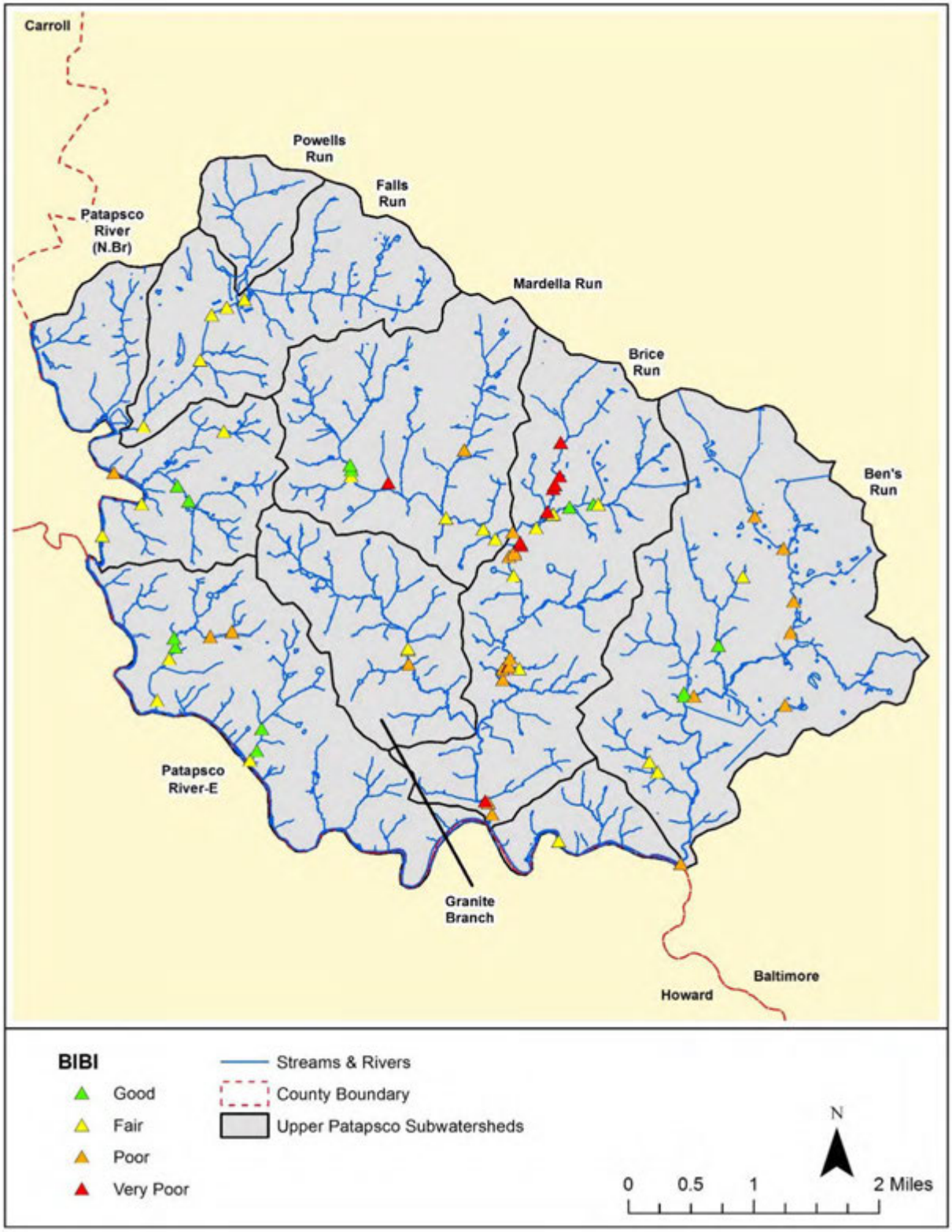

Figure 3-10: Results at Biological Monitoring Locations Sampled by Baltimore County in Upper Patapsco River Watershed (2003-2013)

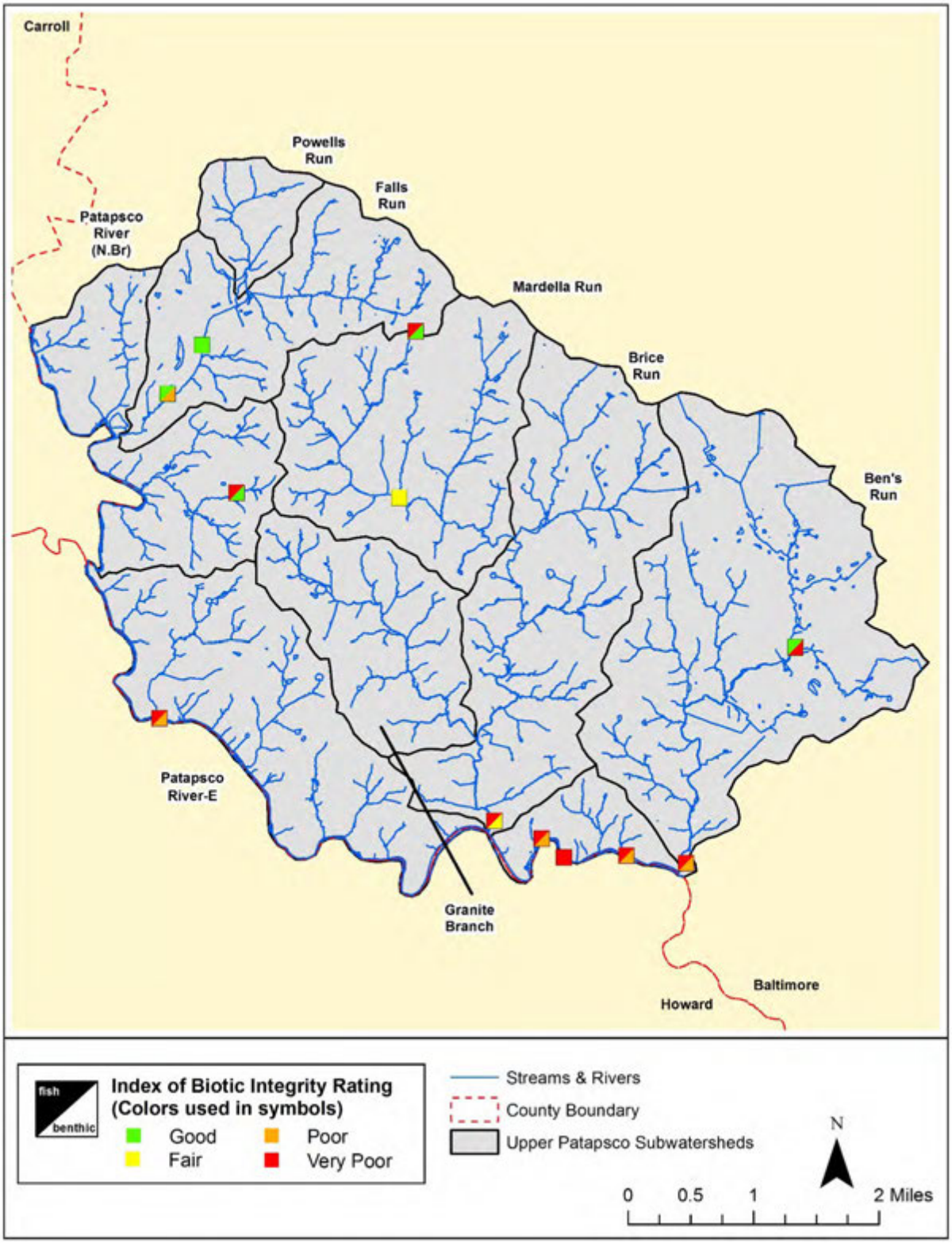

Figure 3-11: Results at Monitoring Locations Sampled by the Maryland Biological Stream Survey (1995-2014)

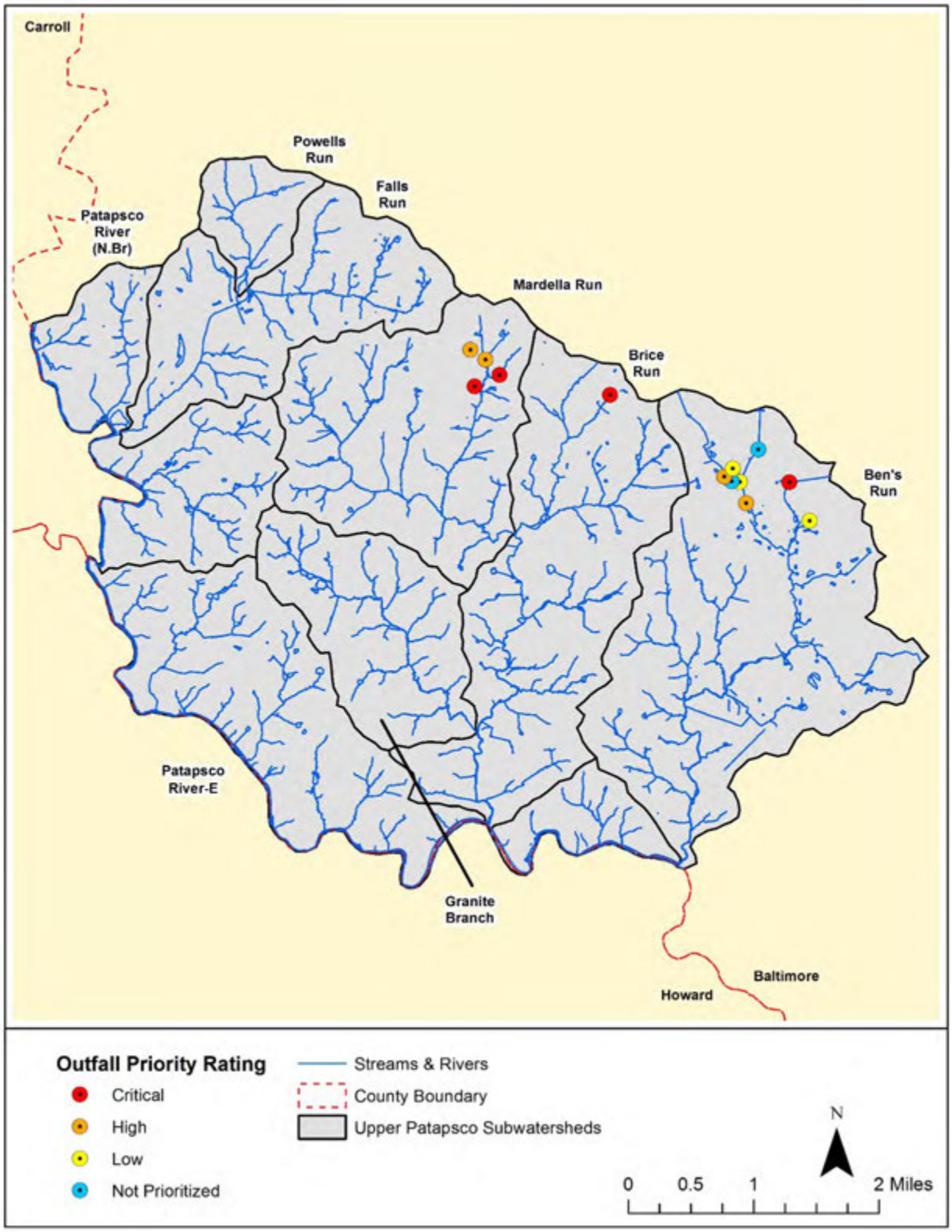

Figure 3-12: Major Outfalls by Priority Level in Upper Patapsco River Watershed

Table 3-13: Major Outfalls by Priority Level in Upper Patapsco River Subwatersheds

Outfall Priority Rating	Ben's Run	Brice Run	Falls Run	Granite Branch	Mardella Run	Patapsco River-E	Patapsco River (N.Br)	Powells Run	Total
Priority 0	2	0	0	0	0	0	0	0	2
Priority 1	1	1	0	0	2	0	0	0	4
Priority 2	2	0	0	0	2	0	0	0	4
Priority 3	3	0	0	0	0	0	0	0	3
Total	8	1	0	0	4	0	0	0	13

Under that outfall prioritization system, major outfalls that have not been screened at least three times are not prioritized. Outfalls that are inaccessible are removed from the database. Prioritized major outfalls, those screened three or more times, are assigned one of the following priority ratings:

- **Priority 0 (Not Prioritized)**: Outfalls with insufficient data to determine a priority rating. This may be due to the outfall only having been screened once.

- **Priority 1 (Critical)**: Outfalls with major problems that require immediate correction and/or close monitoring, or outfalls with recurring problems. These outfalls are sampled four times each year.
- **Priority 2 (High)**: Outfalls with moderate to minor problems that have the potential to become severe. These outfalls are sampled once a year.

- **Priority 3 (Low)**: Outfalls with minor or no problems that do not require close monitoring. These outfalls are sampled on a 10-year cycle.

A second screening is conducted if nearly a decade has passed since the previous screening. If no pollution problems were indicated, then the outfall is considered a low priority. This allows more focus on outfalls with greater potential of an illicit connection. A second screening is also performed at an outfall when prior screening indicates that one or more of the water quality criteria were exceeded. The second screening helps determine whether the pollutant is a persistent constituent of the effluent or simply an anomaly. No remedial action is taken if the second screening indicates that the pollutant is within acceptable levels; however, the outfall is considered to have a potential illicit connection and is automatically queued for re-screening within one year. If the problem is severe enough to warrant immediate correction, an investigation begins immediately. Some sites are determined to have problems severe enough to warrant immediate investigation and/or corrective action only after one screening.

3.5 SEWER OVERFLOW IMPACTS

At present, sanitary sewer overflows (SSOs) and combined sewer overflows (CSOs) are byproducts of the area's expanding population and aging sewer systems. Sewer overflows can

be caused by various factors such as severe weather, insufficient maintenance, pumping station equipment malfunction, electrical outage, sewer line breaks, improper disposal of fats and grease, and vandalism. Raw sewage can enter nearby streams when a sanitary sewer system is overwhelmed by volume or if the infrastructure fails. EPA reports that there are at least 40,000 of these incidents per year nationwide. Environmental and human health consequences of these overflows can be serious. *E. coli* bacteria and other pathogens are typically present in raw sewage and can pose health risks to individuals who come into contact with contaminated water. Sewer overflows can also contain high levels of nutrients (nitrogen and phosphorus), which are toxic to aquatic life and feed organisms that deplete oxygen in waterways. High levels of sediment are also present in sewer overflows and may clog streams and block sunlight from reaching essential aquatic plants.

In September 2005, EPA and MDE issued a consent decree to Baltimore County with deadlines to reduce and eliminate sanitary sewer overflows. Implementation of work (capital, equipment, operations improvements) in compliance with the consent decree will result in a reduction of nutrients and bacteria entering streams in the Upper Patapsco River watershed. However, this may not address all impacts associated with the sanitary sewer system, as the consent decree is targeted at overflows. For example, the sanitary sewer system may leak without resulting in an overflow. Depending on the locations of the leaks, which are typically at joints, there may still be adverse impacts to the stream system from the sanitary sewer system.

Figure 3-13 shows the locations of sanitary sewer pump stations throughout the Upper Patapsco River watershed. The number of SSO events documented and approximate volume discharged between 2002 and 2015 is summarized in Table 3-14 based on Baltimore County's SSO GIS layer. Table 3-15 summarizes the estimated volume and pollutant loads associated during this 14-year period by subwatershed.

Sewage overflows are decreasing both in frequency and volume. Since 2001, sewage spills for a given year have generally not exceeded 2,000 gallons, with a total of 3,275 gallons through 2015 within the Upper Patapsco River watershed. Figure 3-14 shows the location of SSOs in the Upper Patapsco River watershed, all of which were in Ben's Run.

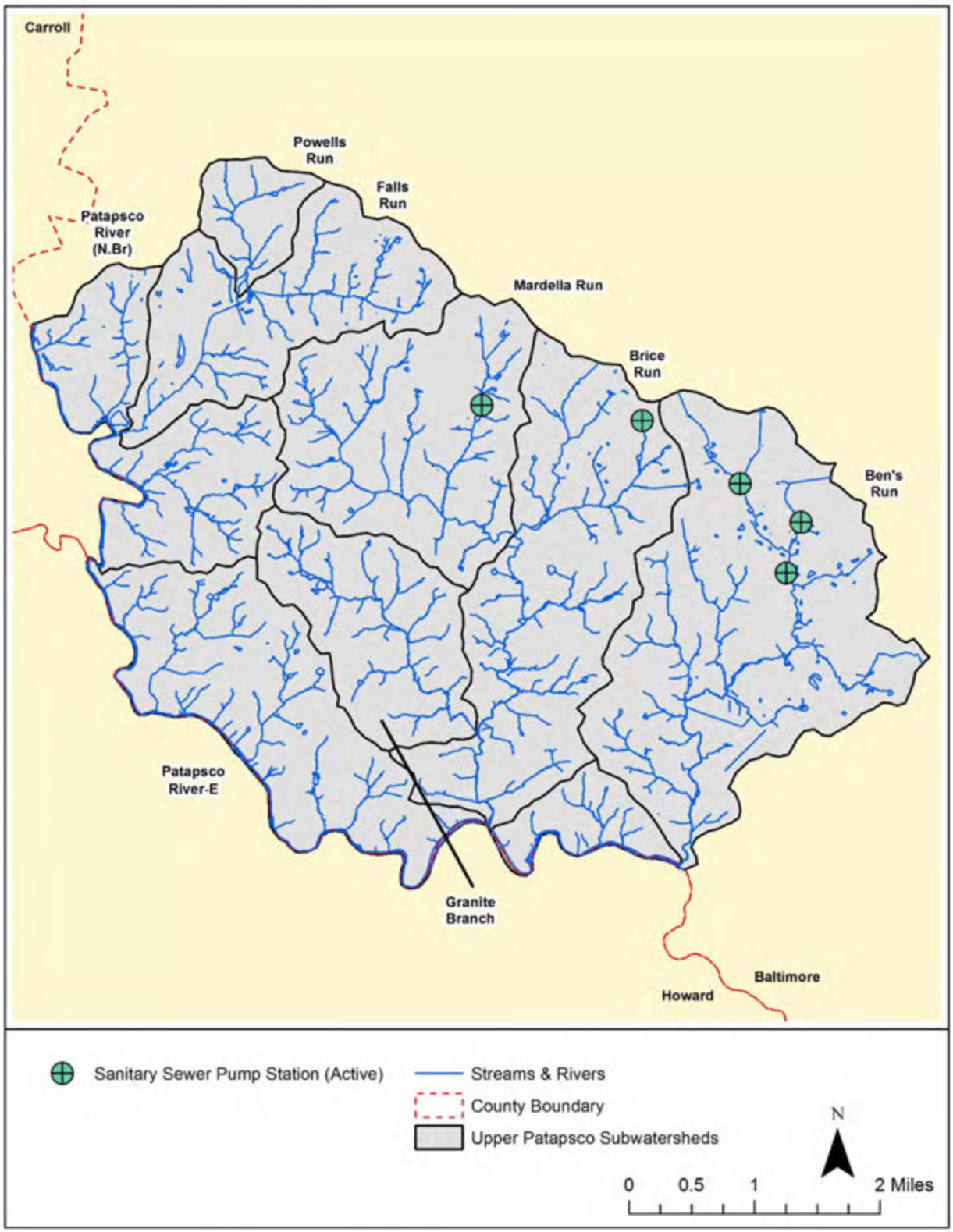

Figure 3-13: Sanitary Sewer Pump Station in Upper Patapsco River Watershed

Table 3-14: Sanitary Sewer Overflow Events and Volumes in Upper Patapsco River Watershed, 2002-2015

Year	# of SSO Events	Volume (gallons)
2002	1	150
2006	1	125
2009	1	1000
2015	1	2000
Total	4	3275

Table 3-15: Sanitary Sewer Overflow Volumes and Pollutant Loads by Subwatershed, 2000-2011

Subwatershed	# of SSO Events	Volume (gallons)	TP (lbs)	TN (lbs)	FC (MPN)
Ben's Run	4	3275	0.27	0.82	7.86E+11
Total	4	3275	0.27	0.82	7.86E+11

Pollutant load estimates were calculated based on the following assumptions:

- **Total Phosphorus (TP**): A conversion factor of 8.3 x 10^{-5} was used to convert gallons of overflow to pounds of pollutant. This is based on a 10 mg/L TP concentration for raw sewage and a multiplier of 8.3 x 10^{-6} lb•L/mg•gal.

- **Total Nitrogen (TN**): A conversion factor of 2.5 x 10^{-4} was used to convert gallons of overflow to pounds of pollutant. This is based on a 30 mg/L TN concentration for raw sewage and a multiplier of 8.3 x 10^{-6} lb•L/mg•gal.

- **Fecal Coliform (FC)**: A conversion factor of 2.4 x 10^{8} was used to convert gallons of overflow to MPN fecal coliform. This is based on a multiplier of 6.4 x 10^{6} MPN/ 100 ml.

Figure 3-14: Sanitary Sewer Overflow Locations in Upper Patapsco River Watershed (2000-2015)

3.6 STREAM CORRIDOR ASSESSMENTS

Stream stability in the Patapsco River watershed was studied extensively for the Patapsco River Watershed Water Quality Management Plan (WQMP; Tetra Tech, 2000). The WQMP was prepared as part of Baltimore County's strategy for managing and protecting its portion of the Patapsco River watershed. The major elements of the WQMP were a watershed characterization, hydrologic and water quality modeling analyses, detailed fluvial geomorphic assessment, identification of water quality problems and restoration measures, prioritization of alternative watershed management scenarios, and preparation of the watershed management plan. The methods used for the stream assessments and the resulting recommended restoration projects are described below.

3.6.1 Assessment Protocol

The Baltimore County portion of the Patapsco River watershed was studied for the WQMP, including the eight subwatersheds that comprise the Upper Patapsco planning area (Area B). These subwatersheds (Powells Run, Falls Run, Granite Branch, Patapsco River-E, Brice Run, Ben's Run, Patapsco River N. Br, and Mardella Run) were also broken down into a total of 116 smaller drainage areas called subsheds for more detailed study and analysis purposes in the WQMP.

The WQMP used Rosgen methodology to identify stream types present in the watershed (Rosgen, 1996) for the detailed fluvial geomorphic assessment. Elements of the assessment included a Rosgen Level I assessment, calibration of bankfull discharge data, representative reach analysis, extrapolated reach analysis, and reach analysis via remote sensing. The assessments created an inventory of existing problems which formed the framework for future stream restoration efforts.

Rosgen Level I delineations were performed through a desktop survey using available data and mapping to classify streams by major type (A through G), as shown in Figure 3-15. Examples of each stream type identified in the Level I analysis were studied in greater detail, including field measurements taken during the representative reach analysis (a simplified version of Rosgen's Reference Reach analysis). Bankfull channel dimensions were calibrated at three stream gage stations, though none of these were within the Upper Patapsco SWAP area.

A set of reaches called extrapolated reaches were then classified by visual assessment and abbreviated Rosgen Level II and III field measurements. Data and observations were compared to previously assessed representative reaches to confirm the results. Level III assessments included a modified Bank Erosion Hazard Index (BEHI) summary. Extrapolated reaches were mostly first and second order streams.

Lastly, a set of reaches had stream type (Level II) classified by remote sensing. Comparisons of landforms, soil and channel patterns, geologic and soil survey maps, and the field data collected from representative and extrapolated reaches built on the Level I assessments to quickly classify the remotely sensed reaches. This set of reaches focused on higher order streams because they typically have more definition in mapping.

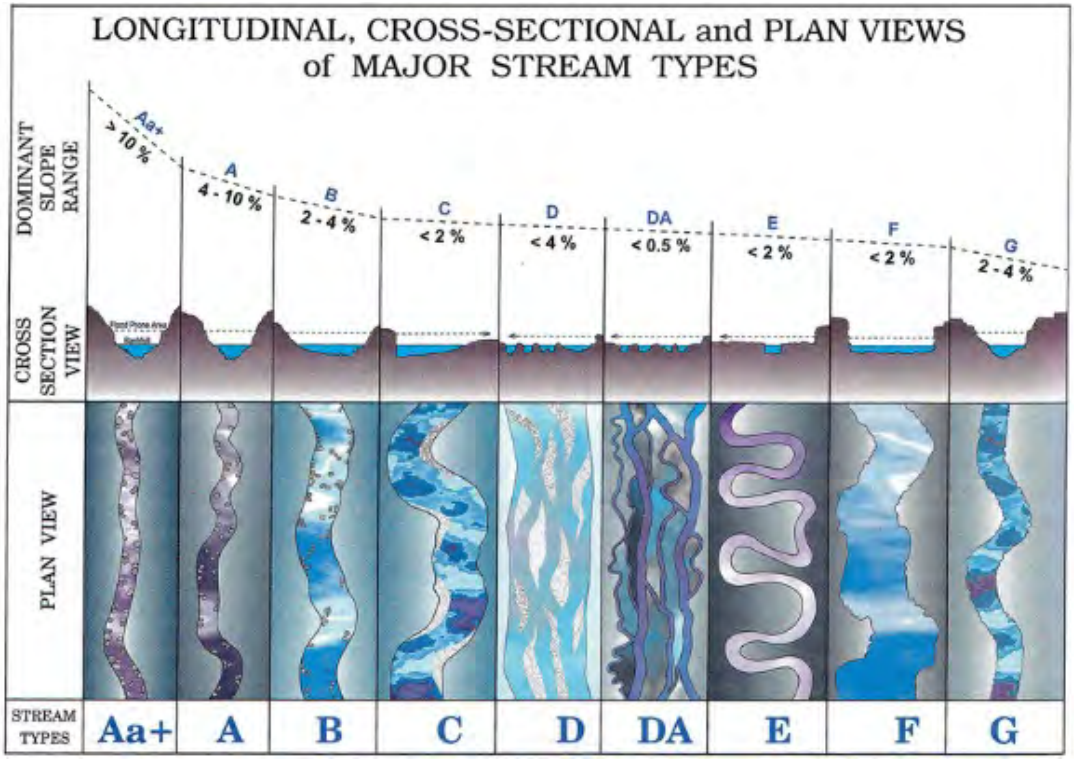

Figure 3-15: Longitudinal, Cross-Sectional and Plan Views of Major Stream Types (Rosgen, 1996)

Due to the diversity of land uses and existing problems, a three phase approach was used to assess the streams that drain directly to the Patapsco River (Tetra Tech, 2000). Phase I consisted of subsheds in the Sensitive category (0-10% impervious cover), with the goal of protecting the most pristine areas. These subsheds are located mostly in the northern and central portions of the watershed. Streams in Patapsco River (North Branch) and Patapsco River-E subwatersheds were analyzed in Phase I. The second phase evaluated Impacted subsheds (10-25% impervious), with the goal of stabilization to prevent further degradation. The third phase addressed the Non-Supporting subsheds (>25% impervious) with the goals of minimizing downstream pollutant loads, alleviating downstream flooding, improving aesthetic appeal, and promoting greenways. These subsheds were located mostly in the southern portion of the watershed (the Lower Patapsco SWAP area).

Results of the stream assessments were reviewed along with other factors to identify practical restoration sites in each subwatershed. Both subwatersheds and subsheds were ranked based on water quality problems to prioritize the potential restoration sites. In the WQMP, Patapsco River North Branch, Powells Run, and Falls Run were grouped; Brice Run and its tributaries Mardella Run and Granite Branch were grouped; and Ben's Run was grouped with Dogwood Branch, the latter of which is part of the Lower Patapsco planning area. Three projects, comprised of a combination of stormwater management and stream restoration projects, were recommended for each subwatershed group. Cost estimates for stream restoration projects were developed using $180 per linear foot as a guide, based on past DEPRM (now known as EPS) projects.

3.6.2 General Findings

All subwatersheds and stream orders were included in the geomorphic assessment, and all major Rosgen stream types were found except the D type (braided channels). Representative reaches for stream types B, C, E, F, and G were located for each substrate present in the watershed (ex. E3, E4, E4b, etc.). No representative reaches of the A type were measured, because representative reaches thought to be A actually fell within the parameters of the B type after the measurements were analyzed. Representative reaches included first- through fourth-order streams.

All subwatersheds in the Upper Patapsco planning area, except Bens Run, fell into the Sensitive stream category because less than 10% of the land cover in the subwatershed was impervious surface. Ben's Run fell in the impacted category with 12% impervious surface. On the subshed level, some areas had a greater relative percentage of impervious cover, especially in more developed areas of the headwaters. The WQMP determined that the water quality priorities for Sensitive stream subwatersheds should focus on channel stability issues first, and nonpoint source pollutant loadings second.

Moderate or severe streambank erosion was found to some extent in all subwatersheds. Stream stability issues were attributed to a combination of uncontrolled (no stormwater management) and under-controlled (existing management is providing inadequate channel protection) stormwater runoff. Though all subwatersheds would benefit from stormwater management, many of the impacted streams are in headwater areas that have limited opportunities for onsite or regional stormwater management due to existing development. Therefore, stream restoration projects were prioritized in these subwatersheds to stabilize the streams under existing hydrologic conditions, a process which would take many years to happen naturally. Stormwater facility retrofits were also recommended in some subwatersheds (see Table 9.6 in the WQMP). Other management strategies that were recommended for all subwatersheds included stream buffer plantings, afforestation, and improved land uses practices such as agricultural best management practices (BMPs) and stormwater management for quarries and barren land.

The WQMP recommended seven stream restoration projects within the Upper Patapsco planning area (Figure 3-16 and Table 3-16). Six of these projects are headwater streams, and the other is a reach draining directly to the Patapsco River (project PA2). It was assumed that 30% of each impacted area would require restoration (assumes spot fixes as opposed to channel restoration for the entire reach). With this taken into account, more than 17,000 linear feet (3.3 miles) of stream are recommended for restoration. See Table 9.5 in the WQMP for prioritization of all stream restoration alternatives. Appendix C of the WQMP shows the individual subshed ranking factors and results.

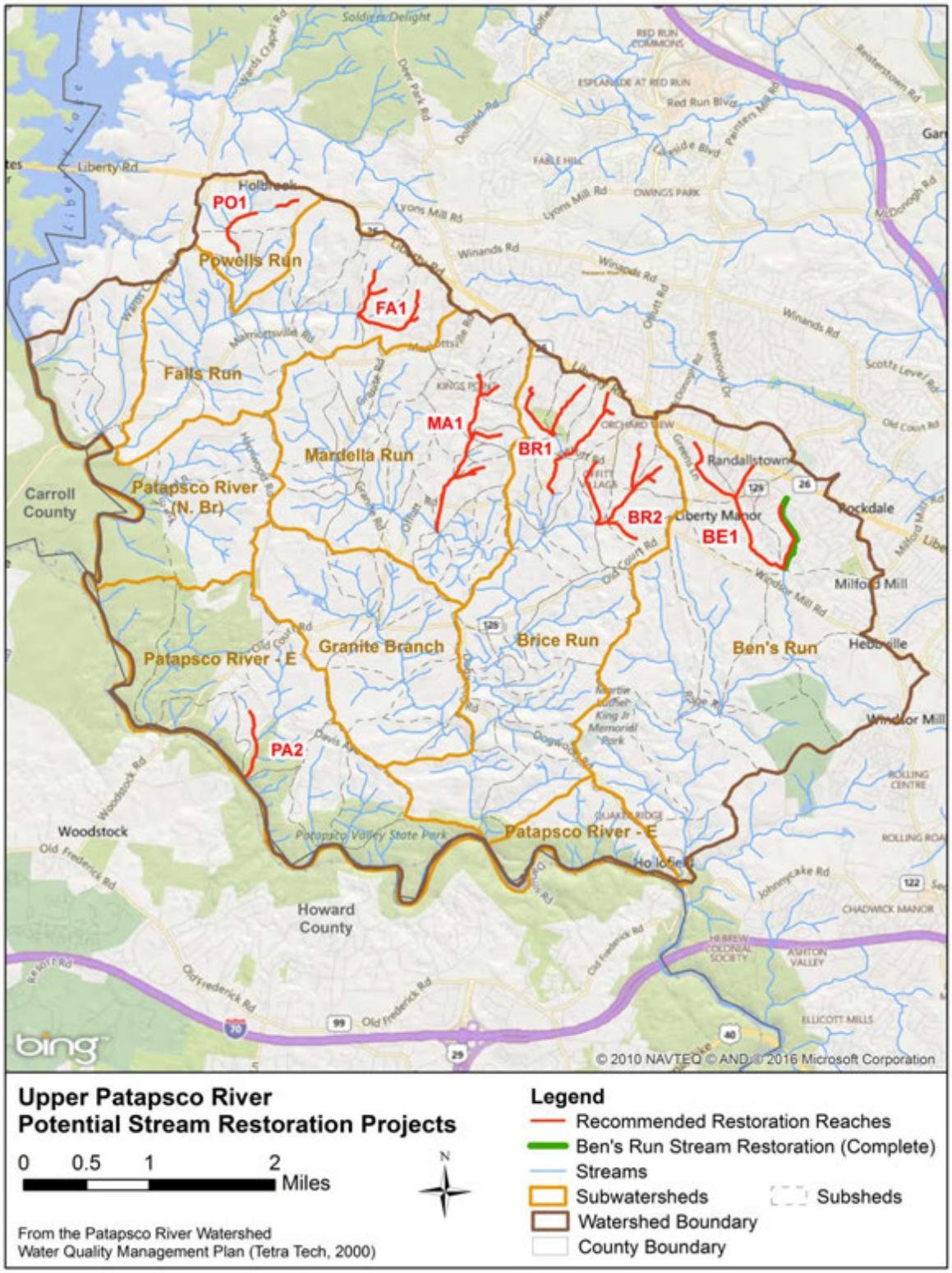

Figure 3-16: Recommended Stream Restoration Projects from the Patapsco River Watershed Water Quality Management Plan (Tetra Tech, 2000)

Table 3-16: Miles of Stream Assessed by Subwatershed in the Upper Patapsco SWAP Area

Project ID	Subwatershed	Subshed(s)	Total Impacted Stream Length (LF)	Proposed Restoration Length (LF)*	Relative Cost ($180/LF)
BR1	Brice Run	117-01 to 117-05	7,600	2,280	$410,000
BR2	Brice Run	117-08	7,425	2,228	$401,000
MA1	Mardella Run	116-12	11,500	3,450	$621,000
BE1	Ben's Run	123-01 to 123-04	11,500	3,450	$621,000
PA2	Patapsco River E.	149-04	2,000	600	$108,000
FA1	Falls Run	109-01 and 109-02	12,000	3,600	$648,000
PO1	Powells Run	110-01 and 110-02	6,500	1,950	$351,000
Total			**58,525**	**17,558**	**$3,160,000**

*Assumes only 30% of the reach will need restoration.
Source: Patapsco River Watershed Water Quality Management Plan (Tetra Tech, 2000)

One stream restoration project has been completed in the Upper Patapsco watershed since the WQMP in 2000. Ben's Run stream restoration, completed in 2004, restored approximately 2,000 linear feet in the headwaters (EPS, 2014). This project restored part of the reaches included in project BE1 (Figure 3-16).

Stream channel conditions have likely changed in the years since they were surveyed for the 2000 WQMP. Streams that appeared unstable may have reached a new equilibrium, while previously stable streams could now be degrading. Development is ongoing in parts of the watershed and actively changing the hydrologic regime. Stormwater management facilities associated with new development may be protecting channels from the degradation that can be caused by increased volumes of runoff from impervious surfaces. Field verification is necessary to determine if the need for restoration still exists in any of the locations described in Table 3-16.

The Upper Patapsco Steering Committee was particularly concerned with Ben's Run and how conditions have further degraded since surveyed for the 2000 study. The damage from the July 30th, 2016 storm event was specifically discussed. This storm event, also known as the Ellicott City flood, caused notable erosion to streams. The National Weather Service's analysis of the event concluded that it was a 1 in 1000 year storm meaning that the probability of it occurring was one in one thousand years. At its strongest point up to 6 inches of rain fell in less than 90 minutes (NOAA 2016). The large amount of rain in a short time period flooded streets and stormwater was directed to streams causing increased flows and by consequence severe erosion as described by stakeholders. Additional assessments of areas not identified for restoration potential will be needed to address degraded stream segments not identified in the 2000 study. It is important to consider this event in prioritization and implementation because the stream assessments presented in this report were conducted prior to this event and do not reflect the effects. It is also important to consider this event when prioritizing restoration opportunities as increased stormwater remediation practices may have lessened the effects of the storm.

3.7 STORMWATER MANAGEMENT FACILITIES

As part of the characterization of Upper Patapsco River watershed and development of the SWAP, existing publicly-owned detention and extended detention stormwater management facilities were investigated for potential conversion to improve water quality treatment within the study area. Baltimore County EPS identified 37 existing stormwater management facilities to be further evaluated. These existing facilities, listed in Table 3-17, may not have been designed for water quantity management, or minimal management, so are being assessed to determine if water quality benefits could be achieved through a conversion.

Table 3-17: SWM Detention Ponds in Upper Patapsco River Watershed Evaluated for Conversion Potential, by Subwatershed

Subwatershed	Drainage Area to SWM Ponds Evaluated (acres)	Number of SWM Ponds Evaluated for Potential Conversion
Ben's Run	198.8	20
Brice Run	47.9	4
Falls Run	56.7	4
Granite Branch	14.8	2
Mardella Run	49.6	4
Patapsco River	14.9	2
Powells Run	8.6	1
Totals	391.4	37

The County GIS information for each pond will be reviewed in office prior to the field investigations. Field maps are created for each site detailing the pond location, drainage area, existing storm drain systems (if applicable) and streams on aerial photos. A Storm Water Management Facility Conversion Evaluation Sheet (developed by Baltimore County EPS) is filled out for each site and includes pond type, location, and drainage area. The pond locations are located on ADC maps in order maximize the efficiency of the field investigation work. Prior to design of any pond conversions, further analysis should be completed to determine the existing pond storage and freeboard

CHAPTER 4: UPLANDS ASSESSMENT

4.1 INTRODUCTION

Upland areas were assessed according to the Unified Subwatershed and Site Reconnaissance (USSR) Manual developed by CWP (CWP 2004) to identify potential pollution sources influencing water quality and to identify restoration project opportunities. The USSR manual is the last manual in a series of 11 regarding techniques for restoring urban watersheds. It provides detailed guidance for field survey techniques and was developed to help watershed groups, municipal staff, and consultants to quickly identify major stormwater pollution sources and to assess subwatershed restoration potential for source controls, pervious area management, and improved municipal maintenance such as education, retrofits, street sweeping, and open space management.

The field survey of upland areas in the Upper Patapsco River watershed included three major components:

- Neighborhood Source Assessments (NSAs),
- Hotspot Site Investigations (HSIs), and
- Institutional Site Investigations (ISIs)

A desktop, GIS analysis was used to evaluate pervious areas for reforestation in place of traditional Pervious Area Assessment (PAA) field visits. Each of these components is described in detail in the following sections.

Subwatersheds were assigned the following unique numbers for the purposes of assigning site identification numbers for HSIs and ISIs: Powells Run (100), Falls Run (200), Patapsco River N.Br (300), Mardella Run (400), Granite Branch (500), Patapsco River-E (600), Brice Run (700), and Ben's Run (800).

4.2 NEIGHBORHOOD SOURCE ASSESSMENTS (NSA)

NSAs describe pollution source areas, stewardship behaviors, and restoration opportunities within individual neighborhoods. Each neighborhood has unique characteristics that are to be considered in deciding if it is possible and/or necessary to implement restoration projects, source controls, and stewardship practices. The sections below describe the methods used to delineate and assess individual neighborhoods in the Upper Patapsco River watershed.

4.2.1 Assessment Protocol

Prior to conducting NSAs in the field, neighborhoods were delineated using GIS data such as tax parcels, roads, historical development information, and aerial photographs. A neighborhood was delineated based on a group of homes with similar characteristics including lot sizes, road widths, set-backs, year built, and type (apartment complex, rowhomes, single family detached, etc.). NSAs were identified using the classification scheme "NSA_B_12", where 'B' denotes the Upper Patapsco River watershed and neighborhoods were then numbered sequentially as delineated. The accuracy of these defined neighborhoods was verified in the field. Adjustments were made as necessary to group similar neighborhoods or ungroup dissimilar neighborhoods.

Field investigations were conducted from November and December 2015, using the NSA protocol documented in the USSR (CWP 2004). The field team drove through every street in a defined neighborhood to identify potential pollution sources and restoration opportunities. To standardize the NSA process, and be able to prioritize potential restoration efforts, data were collected in each neighborhood for four main source areas: yards and lawns; driveways, sidewalks, and curbs; rooftop runoff; and common areas. These are each described briefly below. Opportunities for planting street and shade trees were also noted.

Yards and Lawns

Yards and lawns typically represent a significant portion of the pervious cover in an urban subwatershed and therefore can be a major source of nutrients, pesticides, sediment, and runoff. Maintenance behaviors tend to be similar within individual neighborhoods and certain activities can impact subwatershed quality such as fertilization, pesticide use, watering, landscaping, and waste. Potential pollution sources evaluated under this source category include grass cover and management status (fertilization and irrigation methods), bare soil, outdoor swimming pools, and uncontained junk or trash. The amount of existing shade tree cover and landscaping in neighborhoods were also evaluated, and locations for possible new plantings were noted. These plantings would provide water quality benefits through interception and filtration of stormwater runoff.

Driveways, Sidewalks, and Curbs

Driveways, sidewalks, and curbs are common in many urban subwatersheds and link neighborhood runoff to the storm drain system. Activities such as car washing, deicing, and improper chemical storage can contribute pollutants such as nutrients, oil, sediment, and chlorides into the storm drain system. Data were collected for potential pollution sources including stained/dirty driveways, sidewalks covered with lawn clippings/leaves or receiving non-target irrigation (source of nutrients and sediment), pet waste (bacteria), long-term car parking (unused old cars with potential to leak chemicals, oil, and/or grease) and the amount of sediment, organic matter, and/or trash present along curbs. Potential for street tree planting and street sweeping was also evaluated based on some of these factors.

Rooftops

Rooftop runoff is another contributor to stormwater runoff and pollutants in neighborhoods. Downspout retrofits can help reduce runoff and pollutants introduced to local streams. The field crews identified whether downspouts discharged rooftop runoff to pervious areas, rain barrel, impervious surfaces (driveways, street), and/or directly to the storm drain system, and the proportion of each within a neighborhood. The potential for disconnecting and redirecting downspouts from impervious surfaces or the storm drain system was also evaluated.

Common Areas

Common areas such as community parks, parking lots and alleys are good opportunities to observe community behaviors such as pet waste disposal, stormwater management, storm drain marking, and how natural areas or buffers are managed. Good upkeep of these areas indicates that residents or a homeowner’s association (HOA) are active and may represent opportunities for restoration projects. Data was collected on the condition of storm drain inlets (whether they were clean or filled with debris) and presence of pet waste or dumping in common areas to identify potential pollution sources in a neighborhood. The potential for storm drain marking, stormwater

management practices, and stream buffer planting was also evaluated. In addition to these four source areas, potential pollution sources were identified in individual neighborhoods by collecting basic information regarding the presence of sewer service and amount of remodeling or redevelopment activities.

Basic neighborhood information collected to help rate restoration potential included lot size, house types, fraction of houses with basements and garages, and whether a homeowner's association exists for the community. After driving around the entire neighborhood and completing the basic information and four major source area sections, any major pollutants that were potentially being generated by the neighborhood were indicated on the field form including nutrients, oil and grease, trash/litter, bacteria, and sediment. For example, if a neighborhood had several stained driveways and/or several long-term parked vehicles/ boats, oil and grease would be flagged as a potential major pollutant being generated in that neighborhood. The presence of trash in several yards or dumping in common areas would be a significant indicator for trash/litter generated in a neighborhood. Sediment was flagged as a major pollutant source if several areas of erosion or bare soil were observed, significant amount of remodeling/redevelopment was occurring, and/or a considerable portion of the curb and gutters were covered with sediment.

After driving through and evaluating an entire neighborhood, specific actions were recommended for neighborhoods in the Upper Patapsco River watershed included:

- Downspout disconnection, rain barrels, and rain gardens;
- Fertilizer reduction/education;
- BayScaping;
- Storm drain marking;
- Street tree planting;
- Trash management; and
- Multi-family parking lot or alley retrofit.

The last step of the NSA involved rating the overall neighborhood pollution severity and restoration potential. The severity of pollution generated by a neighborhood is denoted by the Pollution Severity Index (PSI) based on benchmarks and scoring system in the USSR manual (CWP 2004). An NSA PSI is rated as severe, high, moderate, or low. A neighborhood's potential for residential restoration projects is rated as high, moderate, or low according to the Restoration Opportunity Index (ROI). The USSR also provides benchmarks and guidelines to establish NSA ROI ratings.

4.2.2 Summary of Sites Investigated

A total of 20 neighborhoods were assessed throughout the Upper Patapsco River watershed (Figure 4-1). The number of neighborhoods within each subwatershed is summarized in Table 4-1. Note that a neighborhood may exist in more than one subwatershed; in this case the neighborhood was assigned to the subwatershed containing the largest portion of the neighborhood. Six of the neighborhoods were rated as having a high PSI. Of these six, two neighborhoods are considered as having a high ROI and four have a moderate ROI. The two neighborhoods with high PSI and high ROI ratings represent the best areas to target for restoration initially. The distribution of PSI and ROI ratings among the NSAs are shown in Figure 4-2.

Table 4-1: Neighborhoods Surveyed in Upper Patapsco River by Subwatershed

Subwatershed	# of NSAs
Ben's Run	9
Brice Run	2
Falls Run	1
Granite Branch	2
Mardella Run	5
Patapsco River (N.Br)	1
Patapsco River-E	0
Powells Run	0
Total	20

4.2.3 General Findings

The following subsections describe the actions recommended based on the NSAs. This includes an explanation of the methodologies and criteria used to evaluate the potential for recommended actions and results expected if these actions were applied. Figures showing general locations of NSAs recommended for certain actions are included in each subsection. Appendix F includes a summary of NSA data collected and recommended actions by individual neighborhoods. Calculations supporting estimates of results for recommended actions are included in Appendix G.

4.2.3.1 Downspout Retrofits: Downspout Redirection, Rain Barrels, and Rain Gardens

Rooftop runoff is managed via downspouts which are considered as either connected or disconnected. Directly connected downspouts extend underground, discharging runoff directly to the storm drain system without treatment. Indirectly connected downspouts drain to impervious surfaces such as paved driveways, sidewalk, or curb and gutter system with little or no treatment. Disconnected downspouts allow rooftop runoff to infiltrate into the ground and enter streams through the groundwater system in a slower more natural fashion. Downspout retrofitting is desirable because it decreases flow to local streams during storm

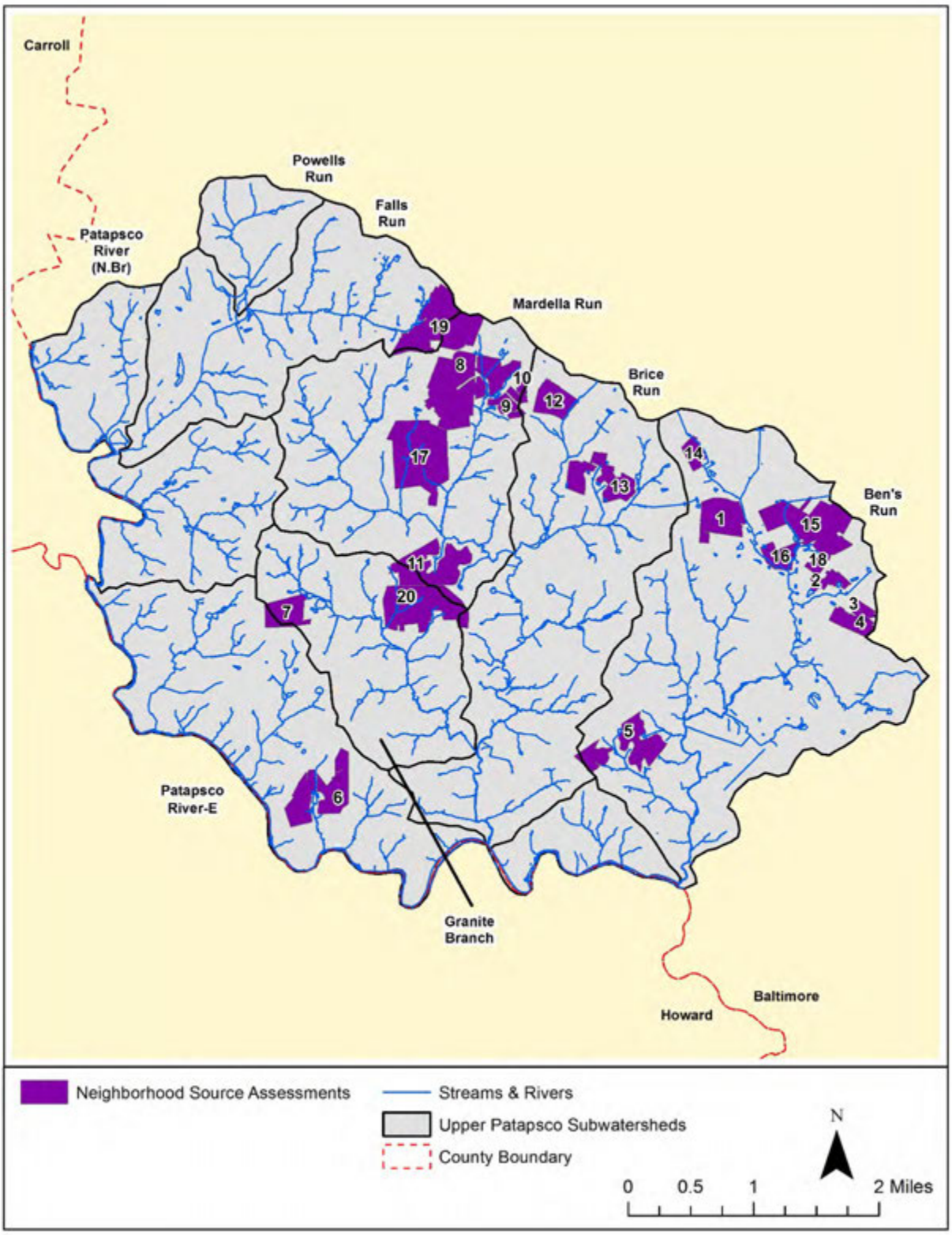

Figure 4-1: Location of NSAs in Upper Patapsco River Watershed

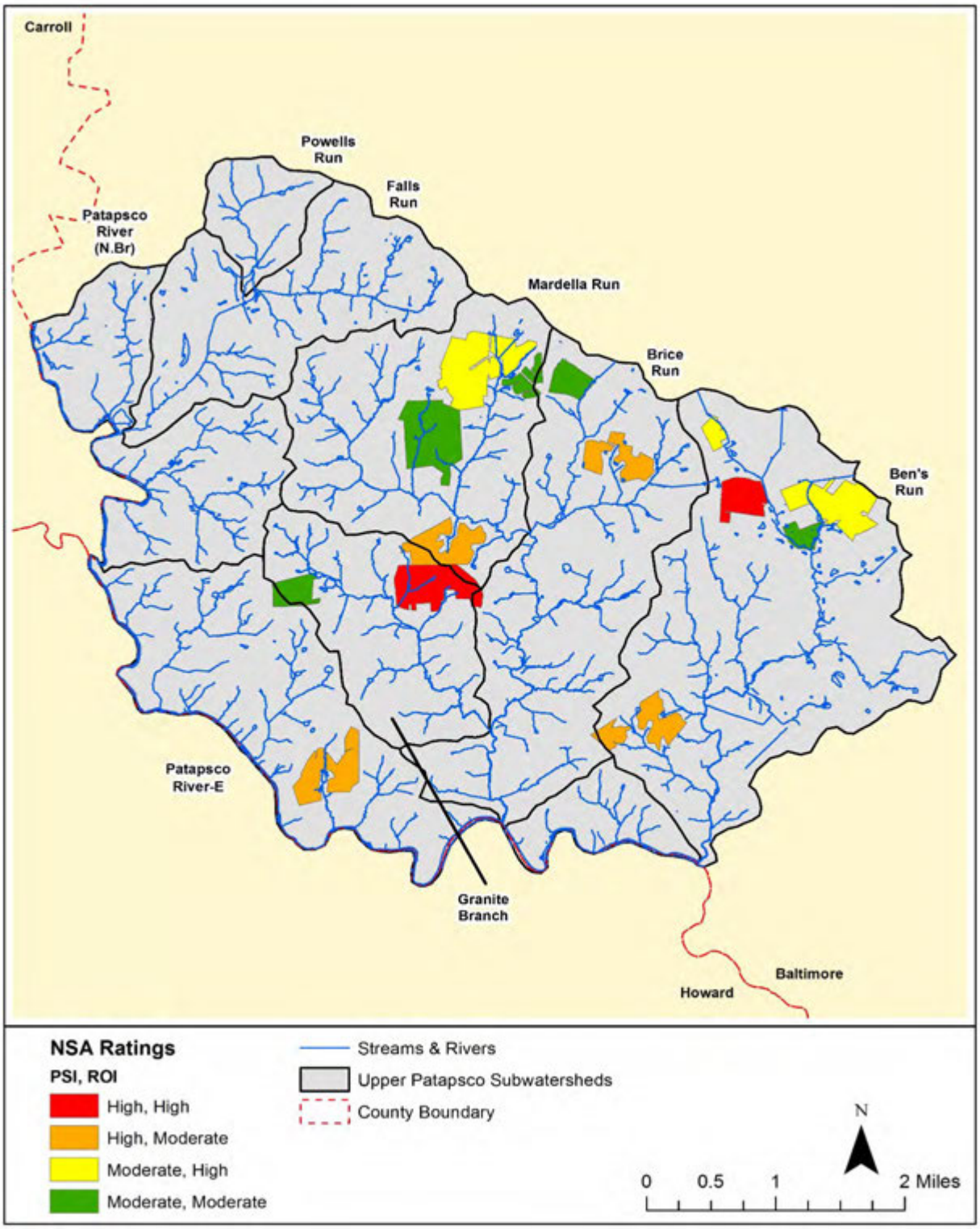

Figure 4-2: Top Target Areas for Restoration Based on NSA Pollution Severity and Restoration Opportunity Indices in Upper Patapsco River Watershed

events; this helps prevent erosion and reduces pollutant loads to streams. Retrofitting may involve redirecting connected downspouts from impervious areas or the storm drain system onto pervious areas such as yards and lawns. Infiltration of rooftop runoff requires at least 15 linear feet of pervious area down gradient from the downspout. Under certain conditions, rain barrels and rain gardens are also retrofit options and may be recommended in lieu of redirection. Rain barrels, for example, may be used to store rooftop runoff for irrigation if there is limited pervious area available for downspout redirection. Rain gardens are the most desirable option in terms of water quality because they consist of amended soils and native plants that capture and treat runoff; this is a potential option for disconnection if the typical neighborhood has several hundred square feet of lawn area available down gradient from the downspout. Rain gardens are also an option in areas where downspouts are already disconnected, and are useful for capturing other types of impervious runoff. They also provide an opportunity for education and outreach, and can be a hands-on activity that opens the door for discussion of other best management practices with homeowners.

Downspout redirection is recommended for neighborhoods where at least 25 percent of the downspouts are connected to impervious area or directly to the storm drain system and where the average lot has at least 15 feet of pervious area available down gradient from the connected downspout for redirection. Table 4-2 includes a summary of the number of neighborhoods recommended for downspout disconnections and the acres of rooftop that would be addressed if implemented. Figure 4-3 shows an example of downspouts draining directly to an impervious driveway. A neighborhood identified for downspout disconnection may also be recommended for rain gardens and/or rain barrels, which are also noted in the table.

Table 4-2: Downspout Retrofit Recommendations

Subwatershed	# of NSAs Recom-mended for Downspout Redirection	# of NSAs Recom-mended for Rain Barrels	# of NSAs Recom-mended for Rain Gardens	Rooftop Acres Addressed by Downspout Redirection
Ben's Run	3	1	3	8.28
Brice Run	0	0	0	0.00
Falls Run	0	0	0	0.00
Granite Branch	0	0	0	0.00
Mardella Run	1	0	1	0.65
Patapsco River (N.Br)	0	0	0	0.00
Patapsco River-E	0	0	0	0.00
Powells Run	0	0	0	0.00
Total	4	1	4	8.93

Figure 4-3: Example of a House Where Downspout Drains Directly to Impervious Driveway in NSA_B_4

Figures 4-4- 4-5, and 4-6 show the location of neighborhoods recommended for downspout redirection, rain barrels, and rain gardens. Out of the 20 neighborhoods assessed, 4 have the potential for downspout disconnection through redirection, 1 is recommended for rain barrels, and 4 are recommended for rain gardens.

4.2.3.2 Fertilizer Reduction/Education

A well-maintained lawn can be beneficial to the watershed. However, lawn maintenance activities often involve over-fertilization, poor pest-management, and over-watering resulting in polluted stormwater runoff to local streams. Lawns with a dense, uniform grass cover or signs designating poisonous lawn care chemicals indicate high lawn maintenance activities. Neighborhoods where 20 percent or more of the homes appeared to employ high lawn maintenance practices were recommended for fertilizer reduction/education. Table 4-3 includes a summary of the number of neighborhoods recommended for fertilizer reduction/ education and the acres of lawn addressed if implemented. Figure 4-7 shows the location of neighborhoods recommended for fertilizer reduction/education (any neighborhood with 20 – 100 percent high maintenance lawns). Seven neighborhoods were recommended for fertilizer reduction/education.

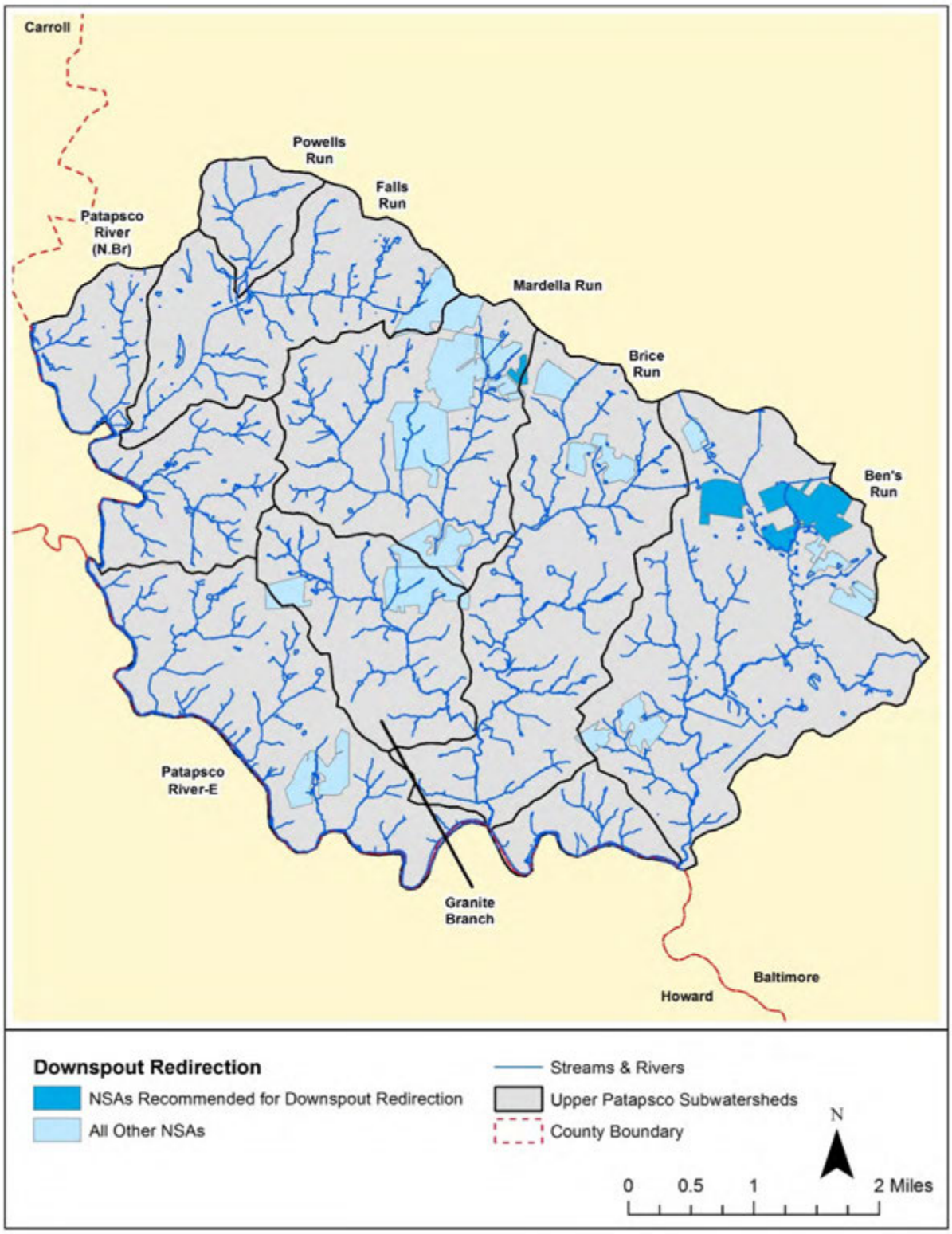

Figure 4-4: Neighborhoods Recommended for Downspout Redirection

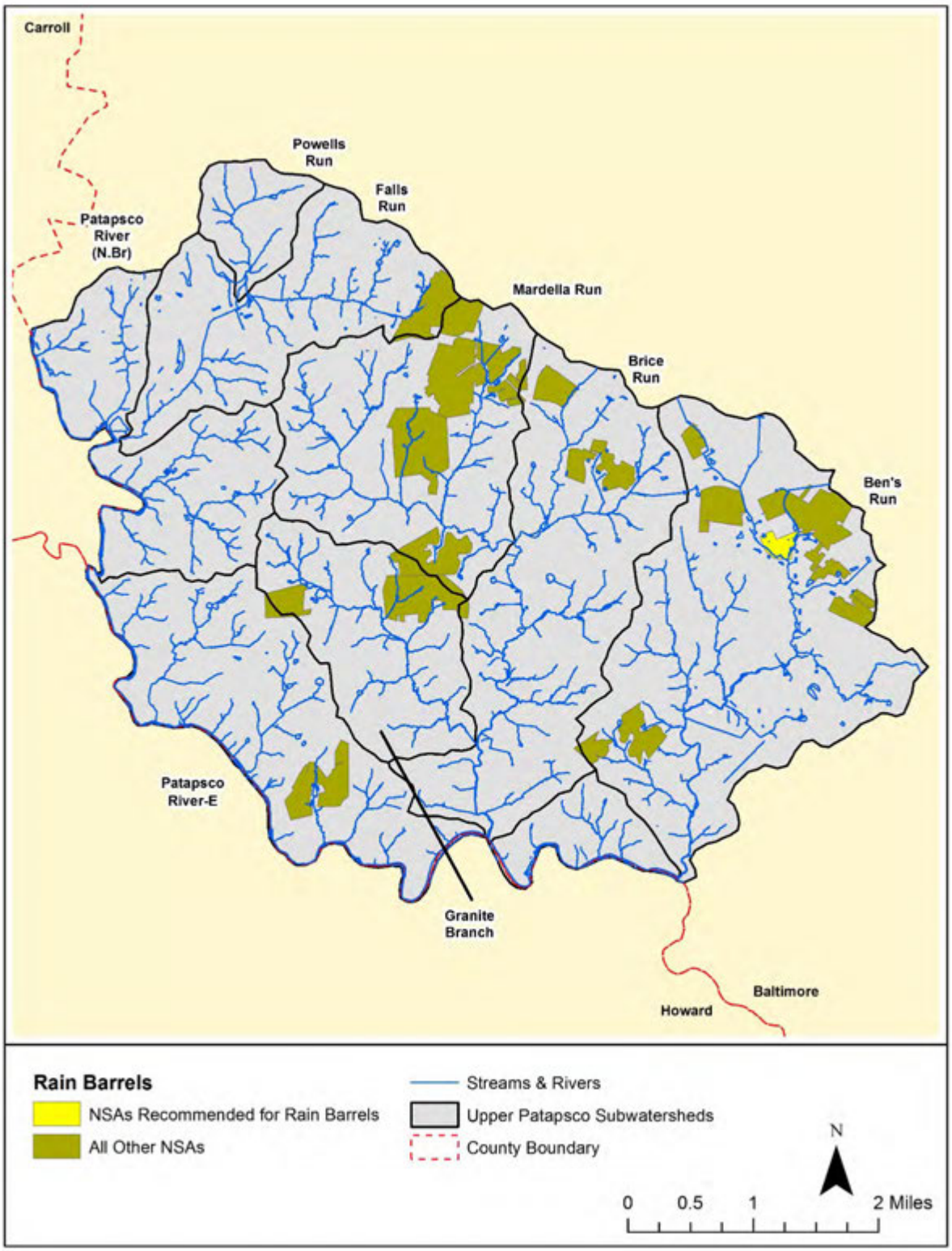

Figure 4-5: Neighborhoods Recommended for Rain Barrels

Figure 4-6: Neighborhoods Recommended for Rain Gardens

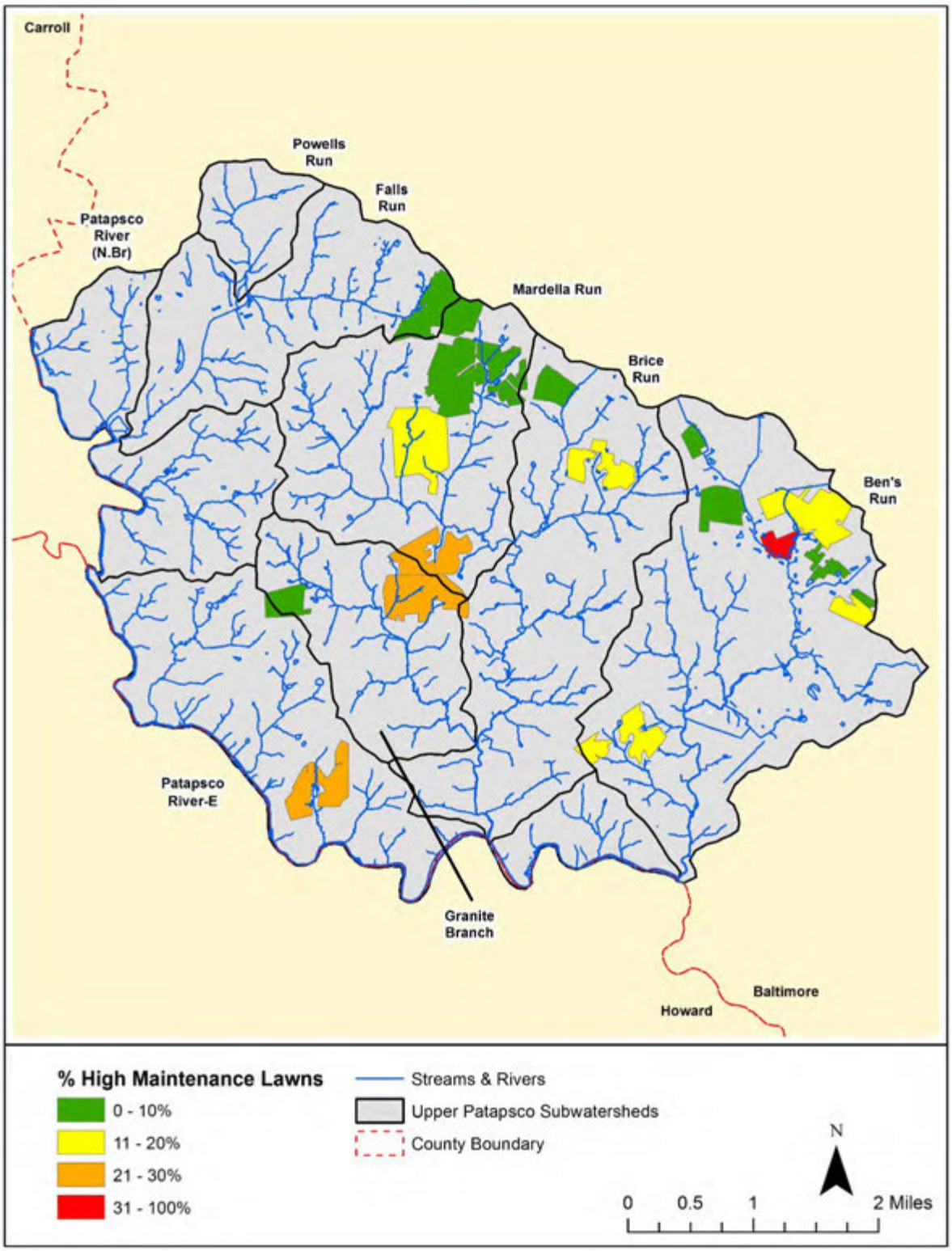

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Figure 4-7: Neighborhoods by Percentage of High Maintenance Lawns

Table 4-3: Fertilizer Reduction Recommended in Subwatersheds

Subwatershed	# of NSAs Recommended for Fertilizer Reduction	Acres of Lawn Addressed
Ben's Run	2	16
Brice Run	1	9.7
Falls Run	0	0
Granite Branch	1	26.6
Mardella Run	2	37.9
Patapsco River (N.Br)	1	17.1
Patapsco River-E	0	0
Powells Run	0	0
Total	7	107.3

4.2.3.3 BayScaping

BayScaping refers to the use of plants native to the Chesapeake Bay watershed for landscaping (Figure 4-8). Because they are native to the region, these plants require less irrigation, fertilizers, and pesticides to maintain as compared to non-native or exotic plants. This means less stormwater pollution and lawn maintenance requirements. BayScaping is also beneficial to wildlife.

Figure 4-8: Example of BayScaping. Photo Credit: U.S. Fish and Wildlife Service BayScape at Maryland State Treasury Building

All neighborhoods could use more BayScaping; however, the benefits and feasibility of this action are limited by several factors. BayScaping was recommended in neighborhoods where the typical lot was at least ¼ acre in size, was less than 25 percent landscaped, and where there was sufficient grass area available (i.e., where impervious cover on the lot would not inhibit improvement of this percentage).

Table 4-4 includes a summary of the number of neighborhoods recommended for BayScaping and the acres of land addressed if implemented. Figure 4-9 shows the location of neighborhoods recommended for BayScaping. Out of the 20 neighborhoods assessed, 19 met the criteria and were recommended for BayScaping.

Table 4-4: BayScaping Recommendations

Subwatershed	# of NSAs Recommended for BayScaping	Acres of Land Addressed
Ben's Run	8	154.6
Brice Run	2	56.9
Falls Run	1	47.4
Granite Branch	2	112.7
Mardella Run	5	215.0
Patapsco River (N.Br)	1	63.8
Patapsco River-E	0	0.0
Powells Run	0	0.0
Total	19	650.4

4.2.3.4 Storm Drain Marking

Most of the neighborhoods in the Upper Patapsco River watershed consist of curb and gutter systems. These include storm drain inlets that convey stormwater runoff quickly and directly to the stream system and ultimately into the river and Chesapeake Bay. Marking these inlets is an excellent way to educate the public about the connection between their storm drain inlets and the Bay. Knowing this helps them to understand that anything building up along the curbs and gutters, such as trash and lawn clippings (potential for nutrient pollution), will be washed away after a storm event and end up in the Patapsco River and/or the Bay. Many neighborhoods had inlets with faded storm drain markings, or no markings at all. Particularly in areas with little or no infiltration of stormwater, there is more potential for pollutants to be carried to the stream system.

Neighborhoods recommended for storm drain marking had curb and gutter systems with inlets appropriate for marking and where less than 10 percent of the existing inlets were already marked (and legible). Table 4-5 includes a summary of the number of neighborhoods recommended for storm drain marking and the inlets addressed if implemented. Figure 4-10 shows the location of neighborhoods recommended for storm drain marking. Out of the 20 neighborhoods assessed, 18 met the criteria and were recommended for storm drain marking.

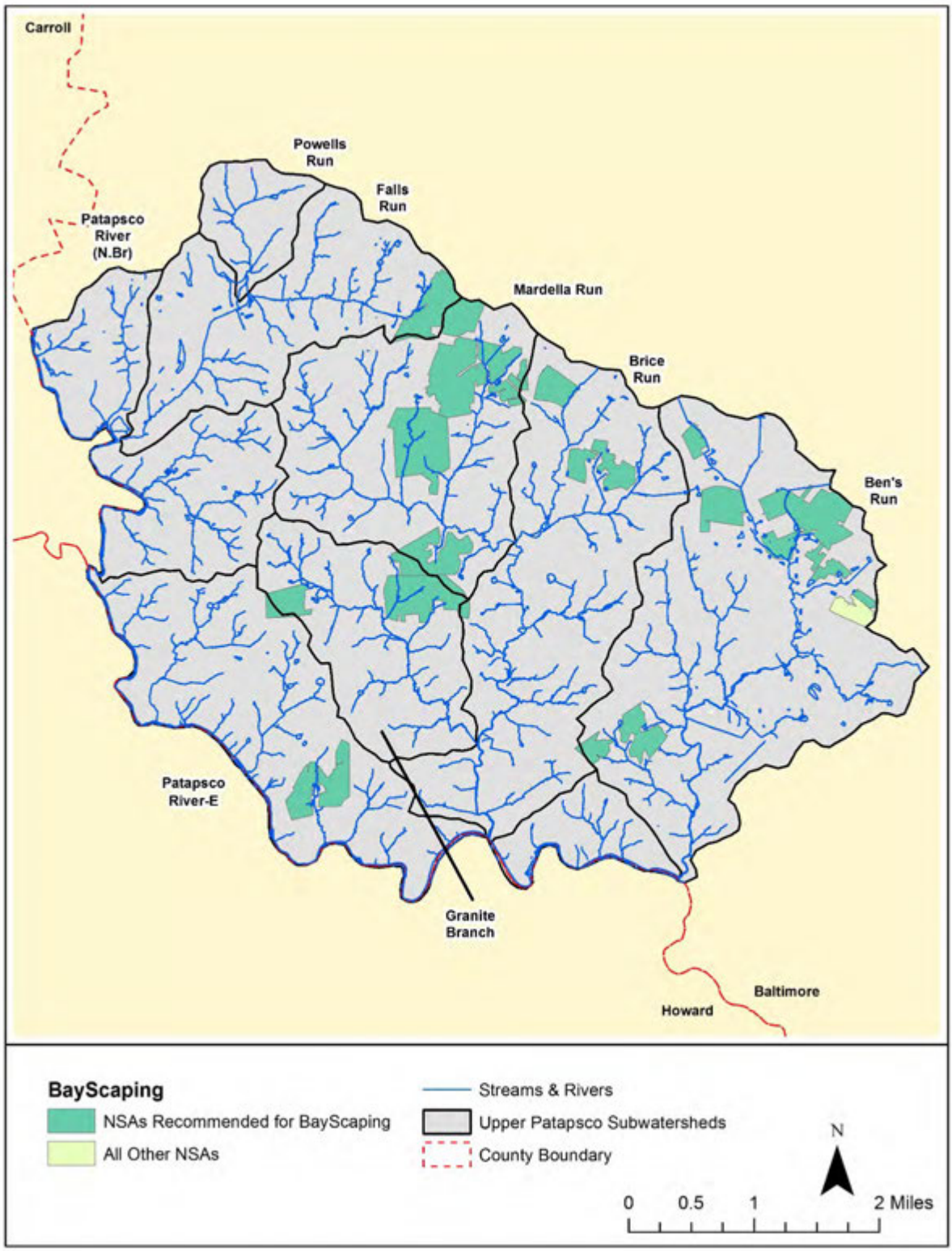

Figure 4-9: Neighborhoods Recommended for BayScaping

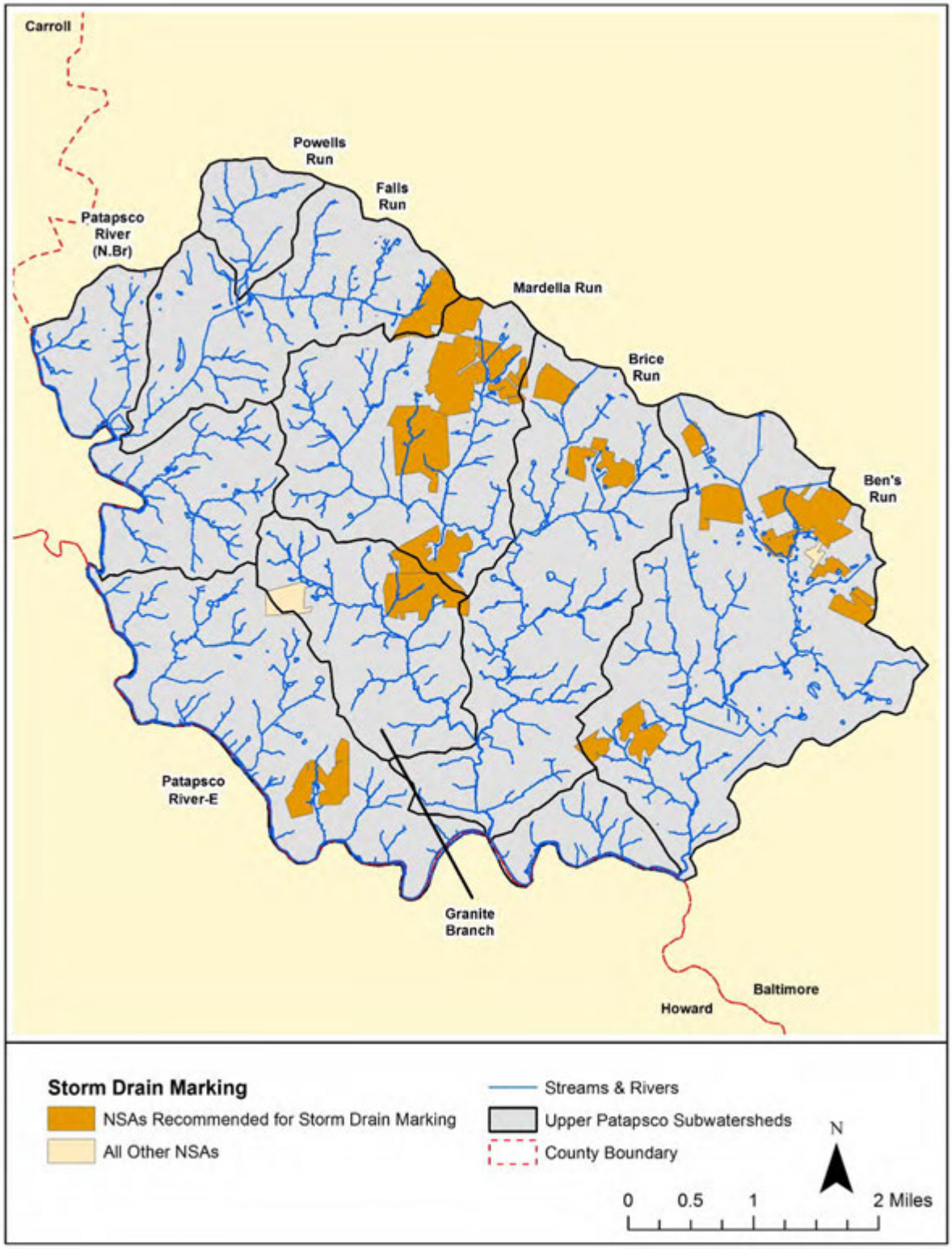

Figure 4-10: NSAs Recommended for Storm Drain Marking

Table 4-5: Storm Drain Marking Recommendations

Subwatershed	# of NSAs Recommended for Storm Drain Marking	Approximate No. of Inlets Addressed	Percent of Subwatershed Inlets Addressed
Ben's Run	8	280	44
Brice Run	2	27	33
Falls Run	1	44	55
Granite Branch	1	22	61
Mardella Run	5	139	50
Patapsco River (N.Br)	1	32	57
Patapsco River-E	0	0	0
Powells Run	0	0	0
Total	18	544	45

Note: Baltimore County is currently updating their storm drain data and although this current dataset is incomplete and in draft form, it is more accurate and complete than the County's historic storm drain data.

4.2.3.5 Tree Planting Opportunities

Trees are an asset to a neighborhood aesthetically, and they also improve air and water quality as they intercept precipitation with their leaves and can absorb precipitation and nutrients through their root systems. Interception of precipitation by leaves or infiltration through the root systems slows stormwater runoff and provides some treatment before it reaches the stream system. Street trees were recommended for neighborhoods where at least 25 percent of the streets had a minimum of 6 feet of greenspace between the sidewalk and curb and less than 75 percent of the suitable areas had trees planted. The number of trees was estimated based on a spacing of one tree per 15 to 20 feet. Street tree estimates would be capped at a maximum of 100 per neighborhood and the potential for more than 100 street trees would be noted in these cases; however, no neighborhoods reached this number. Open space trees were recommended for neighborhoods where there were open pervious areas that were not being used by the community for other purposes (Figure 4-11 4-11). The recommended planting density on open space land is 200 trees per acre, or a spacing of approximately 15 to 25 feet between trees.

Table 4-6 includes a summary of the number of neighborhoods recommended for tree planting and the number of street and open space trees proposed per subwatershed. Figure 4-12 illustrates the location of neighborhoods where street or open space trees could be planted. Out of the 20 neighborhoods assessed, 9 met the criteria and were recommended for tree planting. Neighborhoods not recommended for street trees did not have sidewalks and a curb and gutter system, had insufficient greenspace between the sidewalk and curb, or lawn trees already provided shade for the street. In several areas, most of the appropriate areas had been planted. There is potential for planting 1,870 street trees and 405 open space trees throughout the watershed. Table 4-7 lists tree species appropriate for tree plantings within the Upper Patapsco River watershed.

Figure 4-11: Examples of Excellent Tree Planting Opportunities in NSA_B_17 (top) and NSA_B_6 (bottom)

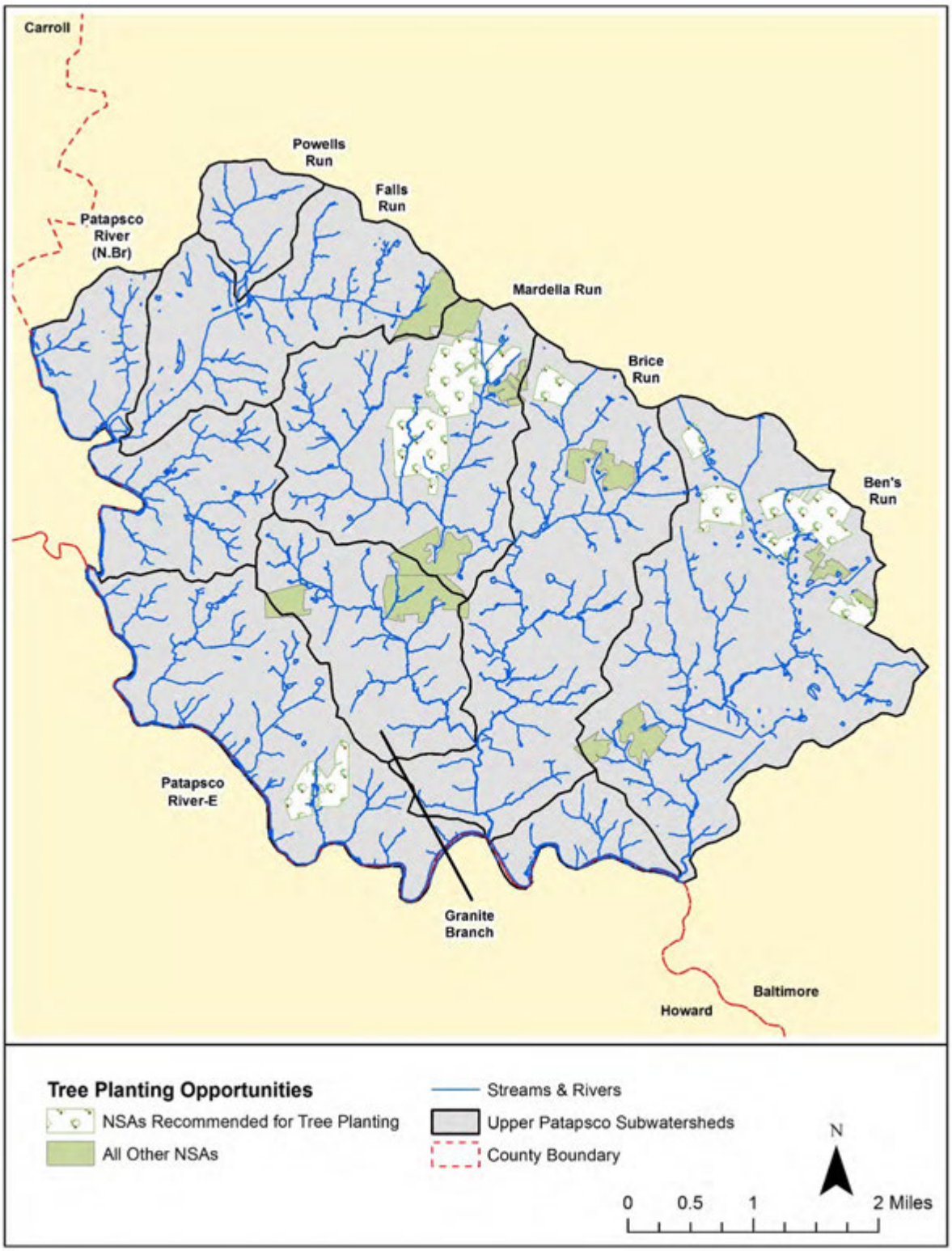

Figure 4-12: Neighborhoods Recommended for Tree Planting

Table 4-6: Tree Planting Potential by Subwatershed

Subwatershed	# of NSAs Recommended for Tree Planting	# of Potential Street Trees	# of Potential Open Space Trees
Ben's Run	5	1,070	200
Brice Run	1	0	45
Falls Run	0	0	0
Granite Branch	0	0	0
Mardella Run	2	800	50
Patapsco River (N.Br)	1	0	110
Patapsco River-E	0	0	0
Powells Run	0	0	0
Total	9	1,870	405

Table 4-7: Native Tree Species Recommended for Street Tree Plantings within the Upper Patapsco River Watershed

Common Name	Scientific Name	Positive Attributes
Black gum	*Nyssa sylvatica*	Strong trunks; summer fruits; fall color
Downy juneberry	*Amelanchier arborea*	Small tree; edible fruits; earlier flowerer
Hackberry	*Celtis occidentalis*	Strong trunks; interesting bark pattern
Musclewood	*Carpinus caroliniana*	Strong trunk; slow grower; interesting trunk shapes
Pin oak	*Quercus palustris*	Strong trunks; slow grower; small acorns
Red maple	*Acer rubrum*	Fast grower; good shade tree; fall color
Redbud	*Cercis canadensis*	Small; shade tree
Sassafras	*Sassafras albidum*	Small; shade tree; fall color
Scarlet oak	*Quercus coccinea*	Fast growing tough oak, resists drought
Serviceberry	*Amelanchier canadensis*	Small tree; edible fruits; earlier flowerer
Slippery elm	*Ulmus rubra*	Strong trunks; fast grower; good wildlife species
Sourwood	*Oxydendron arboreum*	Moderate size; fall color
Sugar maple	*Acer saccharum*	Strong trunks; fall color
Swamp white oak	*Quercus bicolor*	Tolerates variety of habitats
Yellowwood	*Cladrastis kentukea*	Small tree; interesting showy, fragrant flowers

4.2.3.6 Street Sweeping

Street sweeping helps remove trash, sediment and other organic matter, such as leaves and grass clippings, from the curb and gutter system and prevents them from entering the storm drain system and nearby streams. Street sweeping also reduces other materials, like oil and metals, from being washed into the stream by stormwater runoff. Excessive organic matter, sediment, and trash can clog streams and the storm drain system and result in costly maintenance and stream health impairment. As the excess organic matter in the stream begins to decay, oxygen in the water is depleted, which in turn harms fish and other organisms living in the stream. An aggressive street sweeping initiative can ease the effects of a curb and gutter storm drain system on receiving streams.

Neighborhoods where 20 percent or more of the curbs and gutters were covered with excessive trash, sediment, and/or organic matter were recommended for street sweeping. Out of the 20 neighborhoods assessed, none met the criteria for street sweeping. Gutters in all neighborhoods were found have little or no debris and sediment in them.

4.2.3.7 Neighborhood Trash Management

Trash is one of the many types of pollution that may affect a watershed. Neighborhoods where junk or trash was observed in at least 25 percent of yards would be recommended for trash management initiatives. The upland NSA survey revealed that there were no neighborhoods where trash management was an issue. Any ongoing efforts such as community cleanups, trash management education, and working with the Department of Public Works (DPW) to manage any bulk trash pick-up programs should be continued in order to prevent the occurrence of trash pollution in the future.

4.2.3.8 Parking Lot Retrofits

There are apartment, townhouse, and condo complexes in the Upper Patapsco watershed. Multi-family parking lots in these types of neighborhoods can be an opportunity for stormwater retrofits to address runoff from impervious surfaces. This type of retrofit can address a large area of impervious cover within a single design plan. As discussed previously in Chapter 2, infiltration/filtration practices such as bioretention areas with native plantings could be used to capture and treat stormwater runoff from impervious parking lots and alleys while requiring minimal maintenance.

Neighborhoods where sufficient greenspace was available down gradient of a multi-family parking lot were recommended for stormwater retrofits. There are two neighborhoods with appropriate areas for parking lot retrofits: one location in the Ben's Run subwatershed, and one location in the Mardella Run subwatershed.

4.3 HOTSPOT SITE INVESTIGATIONS (HSI)

Hotspots are areas that have the potential to generate higher concentrations of stormwater pollutants than typically found in urban runoff because they run higher risk of spills, leaks, or illicit discharges due to the nature of their operations (CWP 2007). These generally include commercial, industrial, municipal, or transport-related operations. The purpose of hotspot

investigations is to evaluate pollution potential from hotspot operations and identify potential restoration practices that may be necessary.

Hotspots can be either unregulated or regulated by a permit for discharge under the National Pollutant Discharge Elimination System (NPDES). These permits allow for certain amounts of effluent discharge to the storm drain system which would be regulated by the State (or in some cases to a sanitary sewer connection which would be regulated locally). Stormwater pollutants generated as a result of hotspot operations depend on the specific activities but typically include nutrients, hydrocarbons, metals, chloride, pesticides, bacteria, and trash.

Some types of operations, such as retail and wholesale establishments, lawns, employee/ customer parking, or roofs of administrative buildings are not regulated, but the nature of their operations makes them likely to be potential pollutant sources, and so they may be monitored locally to ensure compliance with applicable laws.

Regulated hotspots are known sources of pollution that are subject to applicable federal or state laws. In 1990, the USEPA issued regulations requiring that all stormwater associated with industrial activity be regulated by discharge permits, either by individual permits or general permits. General permits are also known as a Multi-Sector General Permit (MSGP). Maryland's new MSGP is permit No. 12-SW. A permit is required if there is an opportunity for pollutants from the industrial facility to be carried away by stormwater runoff ("exposure"). Generally, if all operations, movement of materials, and storage of materials are under a roof, then a permit is not needed. However, as long as there is any potential for exposure, a permit is required.

The EPA has identified six types of activities at industrial facilities that have the potential to be major sources of pollutants in stormwater (EPA 2009):

- Loading and Unloading Operations

  Loading and unloading operations can include pumping of liquids or gases from tankers to storage facilities, pneumatic transfer of dry chemicals, transfer by mechanical conveyor systems, or transfer of bags, boxes, drums or other containers by forklift or other material handling equipment. Material spills or losses in these areas can accumulate and be washed away during a storm.

- Outdoor Storage

  Outdoor storage activities include storage of fuels, raw materials, by-products, intermediate products, final products, and process residuals. Materials may be stored in containers, on platforms or pads, in bins, boxes or silos, or as piles. Storage areas that are exposed to rainfall and/or runoff can contribute pollutants to stormwater when solid materials wash off or materials dissolve into solution.

- Outdoor Process Activities

  Although many manufacturing activities are performed indoors, some activities, such as timber processing, rock crushing, and concrete mixing, occur outdoors. Outdoor

processing activities can result in liquid spillage and losses of material solids, which makes associated pollutants available for discharge in runoff.

- Dust or Particulate Generating Processes

  Dust or particulate generating processes include industrial activities with stack emissions or process dusts that settle on surfaces. Some industries, such as mines, cement manufacturing, and refractories, also generate significant levels of dust that can be mobilized in stormwater runoff.

- Illicit Connections and Non-Stormwater Discharges

  Illicit connections of process wastes or other pollutants to stormwater collection systems, instead of to sanitary sewers, can be a significant source of stormwater pollution. Non-stormwater discharges include any discharge from the facility that is not generated by rainfall runoff (for example, wash water from industrial processes). With few exceptions, these non-stormwater discharges are prohibited. Permits include a list of authorized non-stormwater discharges.

- Waste Management

  Waste management practices include everything from landfills to waste piles to trash containment. All industrial facilities conduct some type of waste management at their site, much of it outdoors, which must be controlled to prevent pollutant discharges in stormwater.

While these HSIs are not focused on permitted industrial facilities, which already have rigorous self-inspection requirements, we can look for the same opportunities for illicit discharges throughout the watershed at commercial, institutional, municipal and transportation-related sites that engage in the activities listed above. Additionally, oil spill prevention laws in Maryland require that facilities with 1,320 gallons of oily liquids stored above ground receive permits and develop Spill Prevention Control and Countermeasures plans (SPCCs). Hotspot investigations are also an opportunity to note any obvious violations of SPCC requirements or bad housekeeping practices for those facilities where storage of oily liquids exceeds 1,320 gallons. Moreover, some private facilities may be storing more than the 1,320 gallon threshold and may not know that they are required to apply for a permit and develop an SPCC. The HSI field work is a good opportunity to bring these situations to the County's attention as these sites have potential for significant non-stormwater discharges.

4.3.1 Field Investigation Protocol

A field crew was tasked with investigating potential hotspots throughout the Upper Patapsco watershed; field visits employed a hotspot investigation form modified by the County for previous SWAPs. The following subsections describe the methods used to identify and assess hotspots.

The types of parcels or land use categories that are typically associated with pollution activity include the following:

Commercial hotspots include a range of businesses and activities but are often grouped together in subwatersheds. Operations characteristic of commercial hotspots include waste or wash water generation, outdoor material storage, fuel handling, and auto/boat repair. Common commercial hotspots include auto repair shops, car dealers, car washes, parking facilities, gas stations, marinas, garden centers, construction equipment and building material lots, swimming pools, and restaurants.

Industrial operations utilize, generate, handle, and/or store pollutants that can be washed off with stormwater, spilled, or mistakenly discharged into the storm drain. Many industrial hotspots are regulated under NPDES industrial discharge permits and include various manufacturing operations such as metal production, chemical manufacturing, and food processing.

Municipal hotspots typically refer to local government operations such as solid waste, wastewater, road and vehicle maintenance, and yard waste. Like industrial operations, many municipal hotspots are subject to NPDES stormwater permits.

Transport-related hotspots normally include areas of significant impervious cover and extensive private storm drain systems. Many are regulated and include uses such as airports, ports, highway construction, and trucking centers.

Following the Baltimore County HSI protocol, which is largely based on the CWP USSR Manual, each hotspot investigation involved an evaluation of six common operations at each potential hotspot: vehicle operations, outdoor materials, waste management, physical plant, turf/ landscaping, and stormwater infrastructure. The field team conducted windshield surveys and walked as much of the property of each potential hotspot as was accessible to look for potential or confirmed pollution sources and document them with photographs. Parameters evaluated within each operation category are described briefly below.

1. Vehicle Operations

For each site, any vehicle operations done outdoors (e.g., maintenance, repair, recycling, fueling, washing or long-term parking) were noted since they can be a major source of hydrocarbons and nutrients. Connections between outdoor vehicle operations exposed to precipitation and the storm drain system without any site-specific or regional stormwater water quality management facilities are the main focus of this category.

2. Outdoor Materials

Water quality issues can result from improper handling or storage of outdoor materials at hotspots. Locations where materials were loaded or unloaded were examined to see if liquid or transportable materials could be exposed to rain and drain to a storm drain. The field team also looked for improperly labeled storage containers, lack of secondary containment for liquids, and whether the storage area was directly or indirectly connected to the storm drain system.

3. Waste Management

Businesses typically generate waste as a result of daily operations, which can be potentially hazardous sources of stormwater pollution depending on the type of waste and how it is stored. The field team noted the type of waste generated (e.g., consumer packaging, food products, used cooking oils, construction materials etc.) and the condition of dumpsters. Dumpsters exposed to

precipitation with no runoff diversion methods and with no cover or open lids, with leaks, damaged/in poor condition, and/or overflowing were noted as potential pollution sources.

4. Physical Plant

Common physical plant practices include cleaning, maintaining, or repairing the building, outdoor work areas, and parking lots. These activities can be a source of sediment, nutrients, paints, and solvents in stormwater runoff. For each hotspot, the condition of the building itself was evaluated. Stained, dirty, or damaged buildings were noted as evidence of potential pollution sources, as well as staining or discoloration around a building, which is evidence that maintenance activities (e.g., painting, power-washing, resealing, etc.) may discharge to storm drains. Similarly, parking lots that were stained, dirty, and/or breaking up, were recorded as potential pollution sources. Downspouts connected to impervious surfaces or connected directly to the storm drain system were also recorded.

5. Turf/Landscaping

Maintenance of turf/landscaped areas was also evaluated. High maintenance turf and improper irrigation practices were noted since they are potential pollution sources of nutrients, fertilizer, and pesticides. The field team also determined whether landscaped areas drained directly to storm drains or if organics (leaves, grass) accumulated on impervious surfaces. Areas of more than 20 percent of bare soil in turf/landscaped areas were flagged as a sediment pollution source.

6. Stormwater Infrastructure

If stormwater management practices were not present, the location was flagged as a potential pollution source. Private storm drains with considerable amounts of sediment, organics, and/or trash were identified as potential pollution sources.

For each operation listed on the HSI field form, there are observed pollution source indices and potential pollution source indices which can be checked off and summed to calculate a “Hotspot status” for the site. Finally, one or more of the follow-up actions listed below could be recommended based on initial field observations:

- Refer for immediate enforcement,
- Follow-up on-site inspection,
- Test for illicit discharge,
- Future education effort, and
- On-site non-residential retrofit.

4.3.2 Summary of Sites Investigated

Field investigations were conducted in December 2015 and January 2016. Table 4-8 shows the list of the 21 sites visited, which included sites selected during a GIS desktop analysis and sites that the field teams discovered while in the field. The table also details the type of facility; its “Hotspot Status” and number of potential pollution sources (i.e., number of circles filled-in on the HSI forms); any observed pollution sources; and follow-up actions and notes. Figure 4-13 shows the location of each hotspot investigated within the watershed.

Unique ID numbers were assigned to HSI sites using the classification scheme “HSI_B_101”, where ‘B’ denotes the Upper Patapsco watershed and the first digit of the site number corresponds to a specific subwatershed. The eight subwatersheds were assigned unique numbers (100 to 800) for the purposes of the upland assessments, as described in Section 4.1. For example, HSI locations in Powells Run (subwatershed 100) would be identified as 101, 102, 103, etc.

4.3.3 General Findings

An initial GIS desktop analysis identified 25 potential hotspots to be selected from for field investigations. Of the 25 sites identified through the desktop analysis, 20 were investigated in the field. Field crews also investigated one additional area that was adjacent to a pre-selected HSI site. Access was denied by one landowner to a property, though the cursory survey during the inspectors brief visit to the site didn’t reveal any apparent issues. In the end a total of 21 hotspot investigation were performed.

All of the investigated sites were commercial-type land uses, and most sites were located along Liberty Road (MD Route 26) in Randallstown and Milford Mill. In terms of severity, two locations were categorized as “Confirmed Hotspots.” Eleven sites were identified as “Potential Hotpots” and eight sites visited were not considered to be a hotspot. Crews noted certain conditions during the field investigations that they felt merited immediate notification of Baltimore County for further investigation and/or follow-up action. A summary of the HSI data may be found in Appendix F. All of the completed HSI forms can be found in Appendix I.

Selected photographs of the commercial HSIs are included below (Figures 4-14 through 4-21).

Table 4-8: Summary of Hotspot Investigations, December 2015-January 2016, Upper Patapsco Watershed

Site ID	Date of Investigation	Type Description	Hotspot Status (# filled circles)	Observed Pollution Source?	Recommended Follow up Actions / Notes
HSI_B_121	1/5/2016	Commercial - Auto Repair Shop	Potential (8)	No	Numerous liquid storage containers need secondary containment, or should be removed if they are not in use. Install rain barrels on west side of building where downspouts discharge to impervious surface in storage area.
HSI_B_218	1/5/2016	Commercial - Towing and Impound Lot	Potential (8)	No	Large above-ground fuel storage tank and pump lack secondary containment; owner indicated it is empty and slated for removal. Install rain barrels or divert runoff to pervious/grassy area. Recommend better waste containment practices, as there are a number of bags of trash on the ground.
HSI_B_220	1/5/2016	Commercial - Towing, Impound Lot, and Auto Repair Shop	Potential (8)	No	Inspect wrecked/impounded cars for fluid leaks; field crew was denied access to impound lot due to its use for vehicles involved with police investigations/seizure. Install rain barrels where downspouts discharge to impervious surfaces. Add secondary containment for liquid storage.
HSI_B_410	1/5/2016	Commercial - Two Auto Repair Shops	Potential (9)	No	Add secondary containment for used oil storage where staining was noted. Old batteries require proper disposal. Kitty litter was used to absorb a recent oil spill, indicative of good practices. Storm drain inlets were located near the spill; inlets appear to house an oil/water separator. A worker informed the field crew that major work on Liberty Road will realign the storm drains in the near future.
HSI_B_412	1/5/2016	Commercial - Collision Repair Shop	Potential (6)	No	Facility lacks containment for wash water coming from garage/shed vehicles are washed; sudsy water flows directly underneath dumpsters and appears to flow off-site, though a trench drain in the vicinity may capture some of the runoff. Recommend improvements to garbage storage procedures. Half of the site lies outside of watershed, however, full property was assessed.
HSI_B_701	1/5/2016	Commercial - Auto Repair Shop	Potential (6)	No	Add secondary containment around outdoor storage area; many liquid materials were observed neatly inside of a garage, so outdoor drums not likely to be involved with spillage. Install rain barrels on north side of building, where downspouts discharge to impervious surfaces.
HSI_B_706	1/5/2016	Commercial - Ford Dealer and Repair Shop	Potential (8)	No	Dumpsters located extremely close to stream and should be relocated. Improve housekeeping practices to limit piles of trash and scrap metal. Parcel extends into wooded area to the south of back lot where a BMP pond could be built. Add secondary containment and/or cover to outdoor storage area where “used oil filter” bin is located.
HSI_B_707	1/8/2016	Commercial - Self Storage Facility	Not a hotspot (3)	No	No issues noted.
HSI_B_708	11/16/2015	Commercial - Self-Service Car Wash	Confirmed (10)	Yes	Observed suds/detergent spilling onto parking lot – evidence of staining. Non-operational sump pump may cause wash water to overflow into storm drains. Some liquids stored in unmarked containers and are lacking secondary containment. A few areas have potential for increased stormwater treatment via bioretention and sand filters.

Table 4-8: Summary of Hotspot Investigations, December 2015-January 2016, Upper Patapsco Watershed

Site ID	Date of Investigation	Type Description	Hotspot Status (# filled circles)	Observed Pollution Source?	Recommended Follow up Actions / Notes
HSI_B_709	1/8/2016	Commercial - Lumberyard	Potential (10)	No	Keep storm drain inlets and dry detention pond clean; inlets are partially blocked by leaves and the pond contains numerous pieces of trash. Recommend improved garbage management. Large dumpster could be moved under cover. Install secondary containment around flammable gas storage box adjacent to pond. Install covers for lumber stored outside.
HSI_B_725	1/5/2016	Commercial - Nursery/Landscaping?	Not a hotspot (4)	No	Unclear what the nature of this site is – what appears to be a residential house seems to have been destroyed by a fire. Garbage strewn around site should be cleaned up. Dispose of old heating oil tank. Burned house should be fully demolished, as it appears unsafe.
HSI_B_726	1/8/2016	Commercial - Self Storage Facility	Not a hotspot (3)	No	No issues noted.
HSI_B_804	11/16/2015	Commercial - Home Improvement store	Potential (8)	No	Sediment and debris leaking out of trash compactor. Outdoor, uncovered storage of bulk materials. Sod sitting uncovered in front parking lot.
HSI_B_805	12/15/2015	Commercial - Fast Food Restaurant	Not a hotspot (4)	No	Dumpster lids left open, creating potential for contaminated runoff to flow offsite.
HSI_B_814	12/15/2015	Commercial - Gas Station	Not a hotspot (3)	No	Clean up loose trash bags behind dumpster.
HSI_B_815	1/8/2016	Commercial - Strip Shopping Center Restaurant and other shops in the building	Not a hotspot (2)	No	Dumpsters are in good condition, but a lot of loose trash has accumulated in various corners of the property. Part of the parking lot is breaking up creating an opportunity to install pervious pavement during re-surfacing. Install rain barrels where downspouts discharge to impervious surfaces.
HSI_B_816	12/15/2015	Commercial - Department Store	Potential (7)	No	Outdoor materials stored uncovered, including about a dozen car batteries. Inspect hydraulic trash compactor for fluid leak. Sludge (origin unknown) in channel that runs along the trash area and into a dry pond. Parking lot contains numerous small bioretention areas at the end of each aisle.
HSI_B_817	12/15/2015	Commercial - Fast Food Restaurant	Not a hotspot (4)	No	Dumpster area is messy and needs to be cleaned up, particularly near the grease bin where the crew noted grease overflowing and staining the ground.
HSI_B_822	12/15/2015	Commercial - Fast Food Restaurant	Not a hotspot (4)	No	Apparent wash water staining where staff may be improperly disposing of mop water. Grease barrels are uncovered. Filtration or a catch basin could be added to treat both HSI_B_822 and HSI_B_823 stormwater runoff.

Table 4-8: Summary of Hotspot Investigations, December 2015-January 2016, Upper Patapsco Watershed

Site ID	Date of Investigation	Type Description	Hotspot Status (# filled circles)	Observed Pollution Source?	Recommended Follow up Actions / Notes
HSI_B_823	12/15/2015	Commercial - Auto Repair Shop	Confirmed (13)	No	Lots of stains from liquids running out of the repair bays and into gutters. Worker indicated that they paint tires outdoors. Paints and other liquids are stored uncovered outdoors; many tires are stored outdoors, as well. Dumpster very over-loaded, with bags of trash sitting outside of it on the ground. Opportunity to add sand filter or filtration system either onsite or at HSI_B_823 and HSI_B_822. Part of the parking lot is breaking up, so there is an opportunity to introduce permeable pavement during re-surfacing. Recommend the addition of trench drains around repair bays.
HSI_B_824	12/15/2015	Commercial - Strip Shopping Center	Potential (8)	No	Approximately ten assorted large appliances located behind the appliance store; they appear to be trash and should be disposed of properly. Lots of loose trash around at the back of the site. Add plants/shrubs to area with bare soil to stabilize and prevent further erosion.

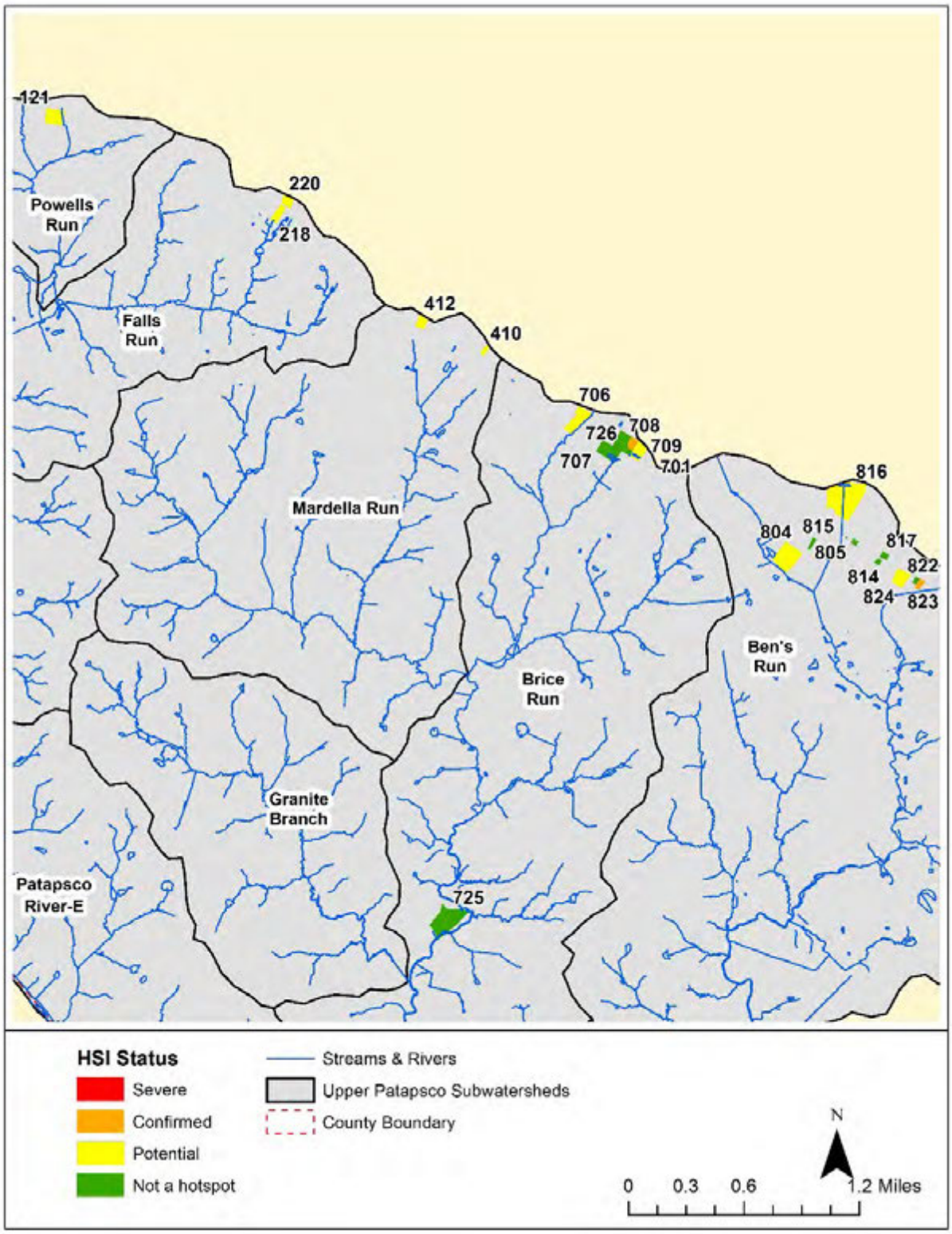

Figure 4-13: Location of Hotspots Investigated in Upper Patapsco Watershed

Figure 4-14: Fuel and Oil Tanks Lacking Secondary Containment in the Upper Patapsco River Watershed, January 2016

Figure 4-15: Typical Cooking Oil Disposal Areas Observed in the Upper Patapsco River Watershed, December 2015

Figure 4-16: Sudsy Water Running Out From Car Wash Shed Passing Under Dumpsters and Exiting the Parcel Observed in the Upper Patapsco River Watershed, January 2016

Figure 4-17: Dumpster with Staining on Ground, Located Immediately Adjacent to Stream in the Upper Patapsco River Watershed, January 2016

Figure 4-18: Staining From Wash Water Being Improperly Dumped in Parking Lot in the Upper Patapsco River Watershed, December 2015

Figure 4-19: Oil Spillage Observed in the Upper Patapsco River Watershed, January 2016

Figure 4-20: Good Spill Practices, in the Form of Absorbent Material, Observed in the Upper Patapsco River Watershed, January 2016

Figure 4-21: Leaking Hydraulic Fluid Behind a Shopping Center Observed in the Upper Patapsco River Watershed, December 2015

4.4 INSTITUTIONAL SITE INVESTIGATIONS (ISI)

The USSR manual does not treat institutional sites as a separate component of the uplands survey; instead, institutions can be assessed using protocols adapted from the HSI protocols. Consistent with all previous Baltimore County SWAPs, a modified version of the HSI field form was used to assess institutional sites since HSI protocols do not exactly match conditions encountered on institutional properties and because institutional areas make up 1.8 percent of the watershed area. The ISI method was first developed and implemented for the Lower Jones Falls and Upper Back River studies and was also used for this Upper Patapsco study. Institutions surveyed as part of this study include the following types of community-based facilities: faith-based facilities, public schools, a cemetery, and community facilities (e.g., public library, fire station). The following subsections describe the methods used to identify and evaluate pollution sources and restoration potential at institutional facilities.

4.4.1 Assessment Protocol

Twenty-four examples of institutional properties were identified and selected in the office prior to conducting the field assessment using GIS tax parcel information, land use data, aerial photographs, and an ADC map. These were shown and labeled on aerial field maps created for each site and on larger base maps showing the entire watershed. Unique ID numbers were assigned to ISIs using the classification scheme “ISI_B_701”, where ‘B’ denotes the Upper Patapsco watershed and the first digit of the number corresponds to a specific subwatershed. Institutional sites were numbered sequentially in the order they were identified within the

watershed. For example, ISIs located in Ben's Run subwatershed (subwatershed code 700) would be identified as 702, 703, etc.

In most cases and when practical, the entire property of an institutional site was walked by the field team to collect necessary data and take photographs. Basic information was filled out first including type of institution, address, and ownership (public or private). Ownership is important because different approaches may be used to contact and work with private versus public institutions. For example, a message may be received differently when the source is from the government or from a non-profit group. Strategies for individual institutions will incorporate these different approaches. The ISI field form includes many of the pollution source categories used on the HSI form. Some of the restoration opportunities and recommended actions from the NSAs are also incorporated into the ISI. The focus of ISIs is to identify potential restoration opportunities, educate the community, and provide water quality benefits. The information collected for each of the pollution source and restoration categories are briefly described below.

Tree Planting

Potential tree planting locations at an ISI site were marked on aerial photographs while walking the property. After walking the entire site, the total number of trees that could be planted at the site was estimated based on a 40-foot spacing between trees. Note that previous SWAPs, including Lower Patapsco, estimated potential trees per site based on 15-foot spacing. More accurate numbers of trees can be determined during the post-fieldwork desktop analysis after restoration opportunities have been selected and prioritized.

Exterior

The exterior category is similar to the physical plant category in the HSI, except that it also includes restoration opportunities. The condition of the building(s) and parking lot(s) were noted. Stained, dirty, and damaged/breaking up surfaces were noted as potential pollution sources for both of these components. If no stormwater management was provided for impervious parking areas, this was also considered as a potential pollution source. Aged, cracked, and breaking up paved surfaces were noted at several sites, both privately owned and public. Exterior storm drain inlets were inspected for evidence of maintenance or wash water dumping and poor erosion/ sediment control, cleaning, or material storage practices for construction activities. Any observations of staining, discoloration, or mop threads around a storm drain inlet indicated a potential pollution source as a result of these activities. Building downspouts that were directly connected to the storm drain system or indirectly connected to impervious surfaces were also recorded as potential pollution sources.

Potential restoration opportunities that were evaluated in the exterior category included impervious cover removal and downspout disconnection. Locations where excess impervious cover could be removed were marked on aerial field maps. Examples include concrete gutters around tennis courts or excess sidewalk areas.

Waste Management

Every institution generates waste as a result of daily operations, but unlike hotspots, it is typically just ordinary garbage. The field team noted the type of waste generated (e.g., hazardous, garbage, etc.) and the condition of the dumpsters. Dumpsters with no cover or open lids, with

leaks, damaged/in poor condition, and/or overflowing were noted as potential pollution sources. The field team also observed whether trash was present that could leave the site with wind or rain. Dumpsters located near storm drain inlets or lacking runoff diversion methods were also recorded as potential pollution sources.

Vehicle Operations

Vehicle operations include maintenance, repair, recycling, fueling, washing, or long-term parking. The presence of any of these activities was noted for each site since they can be a source of metals, oil and grease, and hydrocarbons. Five of the institutions investigated operated fleet vehicles, including three large faith-based facilities with vehicles for congregants, one middle school with Baltimore County Public School maintenance vehicles used onsite, and the Baltimore County Fire Department Station #18.

Outdoor Materials

Materials such as mulch piles, storage drums, cleaning supplies, discarded equipment, and surplus building materials are examples of materials stored on institution grounds. Locations where materials were loaded or unloaded were examined to determine if areas were uncovered and draining toward a storm drain inlet. Storage areas were evaluated for types of materials stored outdoors and their potential for entering the storm drain system. Uncovered materials and stained storage areas were used as indicators of poor outdoor storage practices and potential pollution sources.

Turf/Landscaping

The percentage of forest canopy, turf grass, landscaping, and bare soil covering the pervious area of a site was recorded on the field form. Sites with more than 20 percent of bare soil were noted as potential sources of sediment pollution. No institutional facilities exceeded this criterion, but extensive bare ground areas were found at, for example, high-foot traffic areas of an elementary school and a soil disposal areas of a cemetery. Ground maintenance activities for turf/landscaped areas were also evaluated. High turf management and improper irrigation practices (non-target/over-watering) were noted, if present, since they are potential sources of nutrient, fertilizer, and pesticide pollution. The field team also determined whether landscaped areas drained directly to storm drains or if organics (leaves, grass) accumulated on impervious surfaces. Evidence of stream buffer encroachment and whether a buffer was adequately planted was also recorded for evaluating restoration potential.

Stormwater Infrastructure

The field team checked whether storm drains were marked and whether stormwater treatment practices were present. These were evaluated for restoration potential. Stormwater treatment was present at several sites in the watershed, such as dry or wet ponds at public schools or recently-built or redeveloped faith-based facilities. Several institutions had stormwater infrastructure but no treatment, such as an elementary school, whose network discharged to an eroding dry channel. Many sites had no infrastructure, such as a church, which relies instead on sheetflow of stormwater runoff to turf or armored areas. Investigators found a church had what appeared to be

a bioretention facility, but it was failing. Nearly all storm drain inlets found during the investigations were not marked.

After walking an entire property, and evaluating the categories discussed above, one or more of the follow-up actions listed below were recommended based on initial field observations:

- Tree planting
- Storm drain marking
- Downspout disconnection
- Stormwater retrofit
- Education
- Impervious cover removal
- Stream buffer improvement
- Develop a Pollution Prevention Plan
- Trash management

4.4.2 Summary of Sites Investigated

A total of 16 institutions were assessed throughout the Upper Patapsco watershed. The number and type of institutions assessed within each subwatershed is summarized in Table 4-9. No institutions were assessed in the Granite Branch or Patapsco River (North Branch) subwatersheds due to the lack of institutional land use in those areas. Sites were identified during the desktop analysis in the Falls Run and Patapsco River-E subwatersheds but were not visited.

Figure 4-22 shows the distribution of the various types of institutions assessed throughout the watershed.

Table 4-9: Types of Institutions Assessed by Subwatershed

Subwatershed	Faith based	Hospital/ Care Center	Public School	College/ Research Facility	Municipal Facility	Other	Total
Ben's Run	5	0	3	0	2	0	10
Brice Run	3	0	0	0	0	0	3
Mardella Run	0	0	1	0	0	1	2
Powells Run	1	0	0	0	0	0	1
Total	9	0	4	0	2	1	16

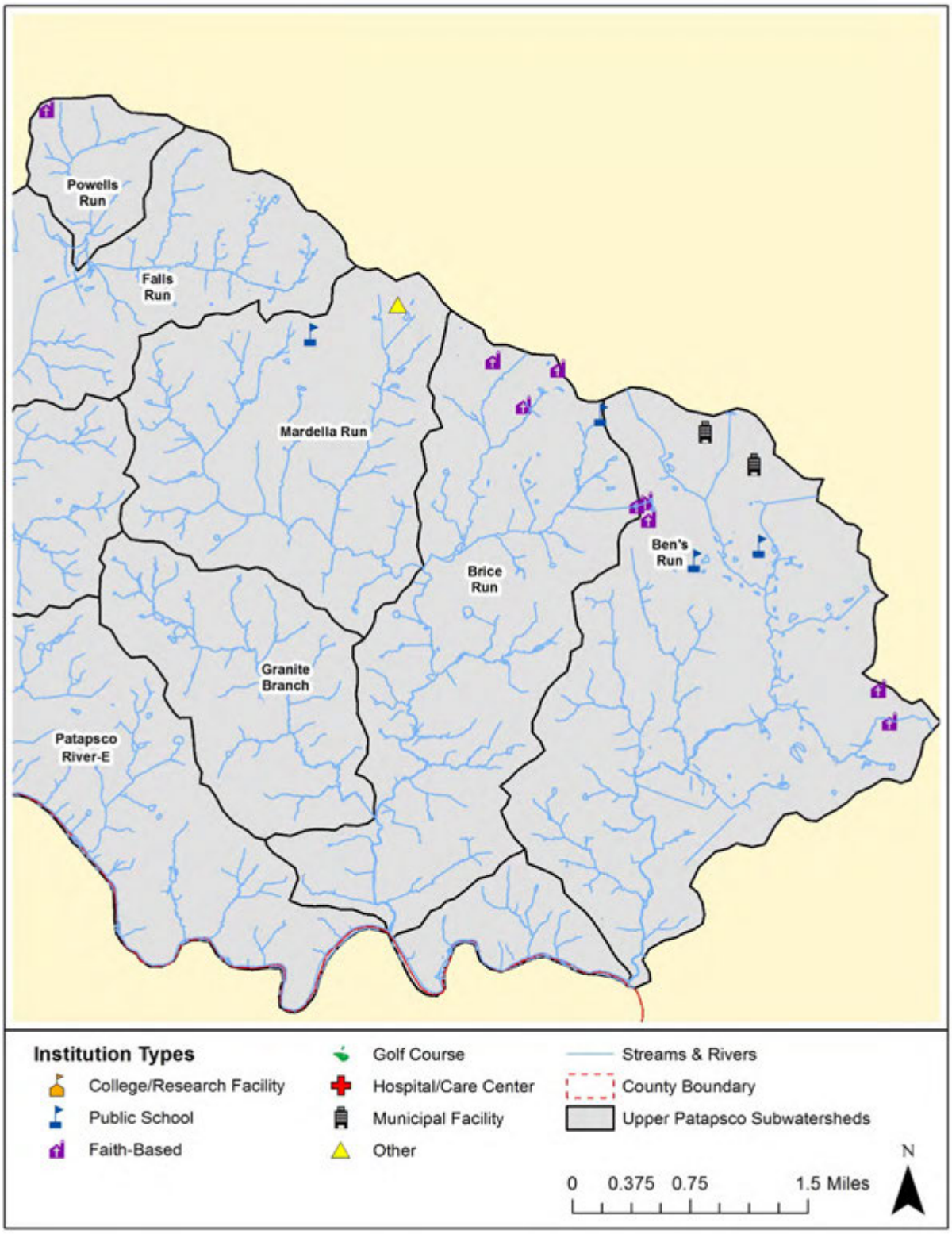

Figure 4-22: ISI Locations in Upper Patapsco Watershed

4.4.3 General Findings

The number of the different types of recommended actions for ISIs is summarized in Table 4-10 by subwatershed.

Table 4-10: ISI Recommended Actions by Subwatershed

Subwatershed	# of Trees	Storm Drain Marking	Down spout Disconnect	SW Retrofit	Future Education	Impervious Cover Removal	Buffer Improvement	Pollution Prevention Plan	Trash Management
Ben's Run	241	9	0	9	2	4	2	1	3
Brice Run	55	0	1	2	2	0	0	0	2
Mardella Run	78	1	0	1	1	0	0	0	1
Powells Run	7	0	0	1	0	0	0	0	0
Total	381	10	1	13	5	4	2	1	6

4.4.3.1 Tree Planting

An estimated 381 trees can be planted at institutions within the Upper Patapsco watershed. Trees were recommended for 14 out of the 16 institutions assessed. Tree planting sites, such as areas of turf, especially near existing tree canopy, were identified in the field and noted on field maps. Small quantities (i.e., less than 10) of trees were generally recommended for smaller-acreage institutions such as smaller faith-based organizations; greater numbers of trees were recommended for faith facilities with large properties. Two examples of potential tree planting areas are shown in Figure 4-23. The number of trees was estimated based on 40-foot spacing between trees. Table 4-10 presents planning-level estimates that would be refined through follow-up site investigations if a site is selected for a restoration/ improvement project(s). Like street trees, open space shade trees are not only an asset aesthetically but they also provide air and water quality improvement since they intercept precipitation with their leaves and can absorb precipitation and nutrients through their root systems. This infiltration of precipitation through leaves or the root systems slows flow rates and provides some treatment before stormwater runoff reaches the stream network.

Figure 4-23: Potential Tree Planting Areas at ISI-B-401 (left) and at ISI-B-714 (right)

4.4.3.2 Stormwater Retrofits

As presented in Table 4-10, the action that was recommended the most after tree planting was stormwater retrofits (13 sites). Stormwater retrofits were recommended at six public institutions and seven private facilities. Storm drain inlet stenciling was recommended at 10 sites.

Bioretention incorporates vegetation and filter media through which stormwater infiltrates for pollutant removal prior to groundwater recharge or entering the stream system. Examples of bioretention retrofit opportunities are presented in Figure 4-24. At the church (below, left), a large, open turf area on the southeast portion of the property provides a good opportunity to treat runoff from the parking surface. At present stormwater flows to the south corner of the lot and enters an old asphalt-lined channel before distribution into woods. At the church (below, right), available and strategically located turf is not as plentiful; however, sheetflow can be redirected to a linear bioretention facility along the west edge of the property to slow, absorb, and treat water before it enters the stream that crosses the site. These actions also present an opportunity to educate the community about the connection between the storm drain system and Patapsco River and how their individual actions can improve its water quality.

Figure 4-24: Opportunities for Bioretention Stormwater Retrofits at ISI-B-703 (left) and at ISI-B-810 (right)

4.4.3.3 Impervious Cover Removal

As discussed previously, impervious surfaces prevent precipitation from naturally infiltrating into the ground. Because runoff from impervious surfaces is often accelerated and concentrated when it reaches the storm drain and stream systems, it can contribute to stream erosion, habitat destruction, and water pollution. Removing unused or underutilized impervious surfaces will help increase pervious area and the watershed's capacity for infiltrating and treating stormwater runoff.

Impervious cover removal was a recommended action at four of the 16 institutions investigated. Field investigators recommended impervious area removal in locations where impervious surfaces appeared to be abandoned, superfluous, or underutilized, such as drainage aprons around school tennis courts and outsized sidewalks. Of the three sites recommended for impervious cover removal, two were public schools, one was a County library branch, and one was a faith-based facility. Impervious cover removal opportunities were found at a middle school and a local branch of the County library (Figure 4-25). Frequently encountered at public schools

were tennis courts surrounded by concrete stormwater collection systems. Such concrete channels can be retrofit to grassy swales to both improve stormwater absorption and reduce the impervious footprint. At the County library branch, the sidewalk on the north side of the building was found to be overly wide and could be decreased in area by half to improve stormwater infiltration.

Figure 4-25: Potential Impervious Cover Removal at ISI-B-807 (left) and at ISI-B-818 (right)

4.4.3.4 Buffer Improvement

Forested buffer areas along streams are important for improving water quality and flood mitigation since they can reduce surface runoff, stabilize stream banks with dense rooting systems, provide shade, remove pollutants including nutrients and sediment from runoff, and provide habitat for various types of terrestrial and aquatic life. Two institutions had streams running through their property which would be potential opportunities for improving inadequate stream buffers by introducing native vegetation and trees.

At a church and school site, a stream with little natural buffer bisects the property. As shown in the photo in Figure 4-26 (left), the channel is eroding and down-cutting from the volume of water entering from the church grounds and developed points upstream. Asphalt parking surface, two buildings, a playground, and grass turf have encroached on the stream buffer. At present the stream receives all of the runoff from the northern half of the site, which is over 80 percent impervious cover and includes extensive parking and the main church building. Along approximately one-half of the reach on the site, impervious parking surface is located within ten feet of the bank.

At Winfield Elementary School, areas of open turf are located at the north corner of the property (Figure 4-26 (right)), the closest of which is within approximately 30 feet of a stream. Tree planting is recommended and can easily be implemented for all of these open areas, which, along with additional native plantings, would improve the buffer, lower the volume of surface runoff, provide additional habitat for native species, and lower maintenance costs for the school.

Figure 4-26: Potential Stream Buffer Restoration at ISI-B-810 (left) and ISI-B-808 (right)

4.4.3.5 Pollution Prevention Planning

A Stormwater Pollution Prevention Plan (SWPPP) establishes procedures for minimizing the potential for pollutants to be washed into stream channels by stormwater runoff. These procedures emphasize the use of BMPs to provide the flexibility to address varying sources of pollutants at different categories of industrial facilities. One site, Baltimore County Fire Department Station #18 (Figure 4-27), is not an industrial site, but was found to be in likely need of a SWPPP because of the presence of a fueling station. Since the operation of the fueling station and other maintenance needs of the facility, a SWPPP is recommended to adequately address the potential for spills and to reduce their likelihood by implementing training programs for staff.

4.4.3.6 Trash and Other Waste Management

Trash/waste management is an area in need of improvement throughout various areas of the watershed, including institutions. A total of six institutional sites were recommended for trash management action. In general, waste management education is recommended to address leaking dumpsters, open or uncovered dumpsters where trash can leave the site, and dumpster placement near storm drain inlets or streams. When field investigators noted dumpsters that were open and overflowing with trash or were leaking, those institutions were identified as locations where trash management improvement was necessary (Figure 4-28). Signs of past leakage, such as stains or rust on impervious surfaces like that found at an elementary school were found at a small number of locations. Open dumpsters were found at two locations, including the facility, pictured below. Dumpsters in the near-vicinity of storm drain inlets were found at four public schools. Most problems with open dumpsters, residual staining on impervious surfaces, and situation of dumpsters near storm drain inlets, were found at public school sites. These trash management problems may be addressed through various measures such as trash campaigns, waste management education, improving bulk trash pick-up options, placement of secondary containment, and community clean-ups.

Figure 4-27: Potential SWPPP Opportunity at ISI-B-816

Figure 4-28: Trash Management Opportunities at ISI-B-714 (left) and ISI-B-813 (right)

4.5 PERVIOUS AREA ASSESSMENTS (PAA)

PAAs were conducted to identify and evaluate sites within the Upper Patapsco watershed with potential for reforestation or re-vegetation. The following subsections describe the methods used to identify and evaluate restoration potential of pervious areas.

4.5.1 Assessment Protocol

Sections of open land throughout the watershed were identified in the office. Although there are numerous open field areas in the Upper Patapsco, only public land or land owned by institutions was assessed for tree planting opportunity at this time. If additional tree planting is needed to meet pollution reduction goals, other pervious areas may be investigated in the future.

Unique ID numbers were assigned to PAAs using the classification scheme “PAA_B_101”, where ‘B’ denotes the Upper Patapsco watershed and the number corresponds to a specific subwatershed. As previously described, subwatersheds were assigned the following numbers for

the purposes of HSIs, ISIs, and PAAs: Powells Run– 100, Falls Run – 200, Patapsco River N.Br. – 300, Mardella Run – 400, Granite Branch – 500, Patapsco River-E – 600, Brice Run – 700, and Ben's Run – 800. Upper Patapsco watersheds were numbered numerically moving from north to south. Pervious areas were numbered sequentially in the order they were surveyed within a particular subwatershed.

A relatively new method of assessment was used on this SWAP area. It is a desktop method utilizing Geographic Information System (GIS) technology. Open pervious areas were identified by looking at the current aerial photography (2011). The parameters considered in the assessment are briefly described below.

Stream Buffer

It was indicated if a stream with no forest buffer is located on the site (highest score). Also indicated is whether there is a stream on or adjacent to the property with an inadequate forest buffer (< 100') and the potential to expand it. It is widely accepted that streams in our region should be buffered with forest cover, or natural vegetation, for at least 100 feet on either side to protect the stream environment and downstream conditions.

Length of Stream

An approximate linear distance of stream to be buffered with reforestation was recorded. The greater the distance of stream in need of forest cover protection, the higher the priority the PAA.

Proximity to Forest Interior

For purposes of this assessment, forest interior is defined as forested area which is at least 500 feet from any forest edge. Many forest dwelling plants and animals benefit by a continuous forest condition. It protects the ecosystem from invasive plant and animal species, which thrive in edge habitats and disturbed conditions. Invasive species compete with native species and have been documented in many cases to decimate native populations. Sites that have the potential to increase forest interior acreage are a higher priority than those that do not.

Exterior Forest Gap

An exterior forest gap is an unforested area located along the edge of a forest patch, but partially surrounded by the forest. Only exterior forest gaps with edges less than 500' apart were included. Similar to forest interior, it is beneficial to close forest gaps to increase the amount of contiguous forest, and decrease the amount of edge area. Forest edges are subject to colonization pressure from invasive plants, especially vines which can damage trees and encroach on the forest environment. Non-native animals are also more prevalent in areas with greater forest edge, such as the brown-headed cowbird, which lays its eggs in other birds' nests.

Planting Area

The size of the potential planting area is of importance. The more land available for reforestation, the greater the environmental benefit, although smaller planting sites are also valuable and may present opportunities for community-based projects.

Ownership

Restoration projects are typically easier to accomplish on publicly owned land for a variety of reasons. Projects on private land are not out of the question, but require additional steps, often making them more time consuming and costly.

Assessment Parameters

Assessment parameters and scoring are given in Table 4-11.

Summary of Sites Assessed

A total of nine pervious areas were assessed within the Upper Patapsco watershed totaling approximately 62 acres of potential tree plantings (Table 4-12). Figure 4-29 shows the location and size of PAAs within the watershed.

Prioritization of Tree Plantings on Pervious Areas

A Restoration Score was derived by a point system of parameters. The maximum score is 100 (greatest restoration benefit), and the minimum is 5. Restoration scores for Upper Patapsco PAAs range from 15 to 60. None of the sites assessed had potential to expand an inadequate stream buffer. Either streams were not present on these sites, or they already had sufficient buffers. Decreasing forest fragmentation is also paramount in protecting the populations of native species, including neo-tropical migrating birds. The priority ranking is determined by dividing the potential restoration scores into three categories: high, medium, and low. Restoration scores can range from 0 to 100. Low priority equates to a restoration score of 0-32, medium priority equates to 33-66, and high priority equates to 67-100. There were no high priority ranking sites. See Table 4-13 for prioritization results.

Table 4-11: Assessment Factors and Scoring for Pervious Area Tree Planting Opportunities

Parameter	Points
A. Is there:	
• a stream on the property with no forest buffer?	10
• a stream on or adjacent to the property with an inadequate forest buffer (< 100') and potential to expand it?	5
• no unforested stream or stream buffer (Skip to C)	0
B. Length of stream that could be buffered?	
> 2,500'	10
1,000-2,500'	
500-1,000'	5
< 500'	0
C. Is the property: (pick one)	
• contiguous to existing forest with the potential to expand interior forest acreage?	10
• contiguous to existing forest (w/out the potential to expand interior forest)?	5
• not contiguous with any forest?	0
D. Is the area in an exterior forest gap?	
Yes	15
No	0
E. Size of potential planting area?	
> 25 acres	25
10 – 24.9 acres	20
5.0 – 9.9 acres	15
2 – 4.9 acres	10
< 2 acres	5
F. Ownership	
Public	10
Private	0
Restoration Score	=Total Points

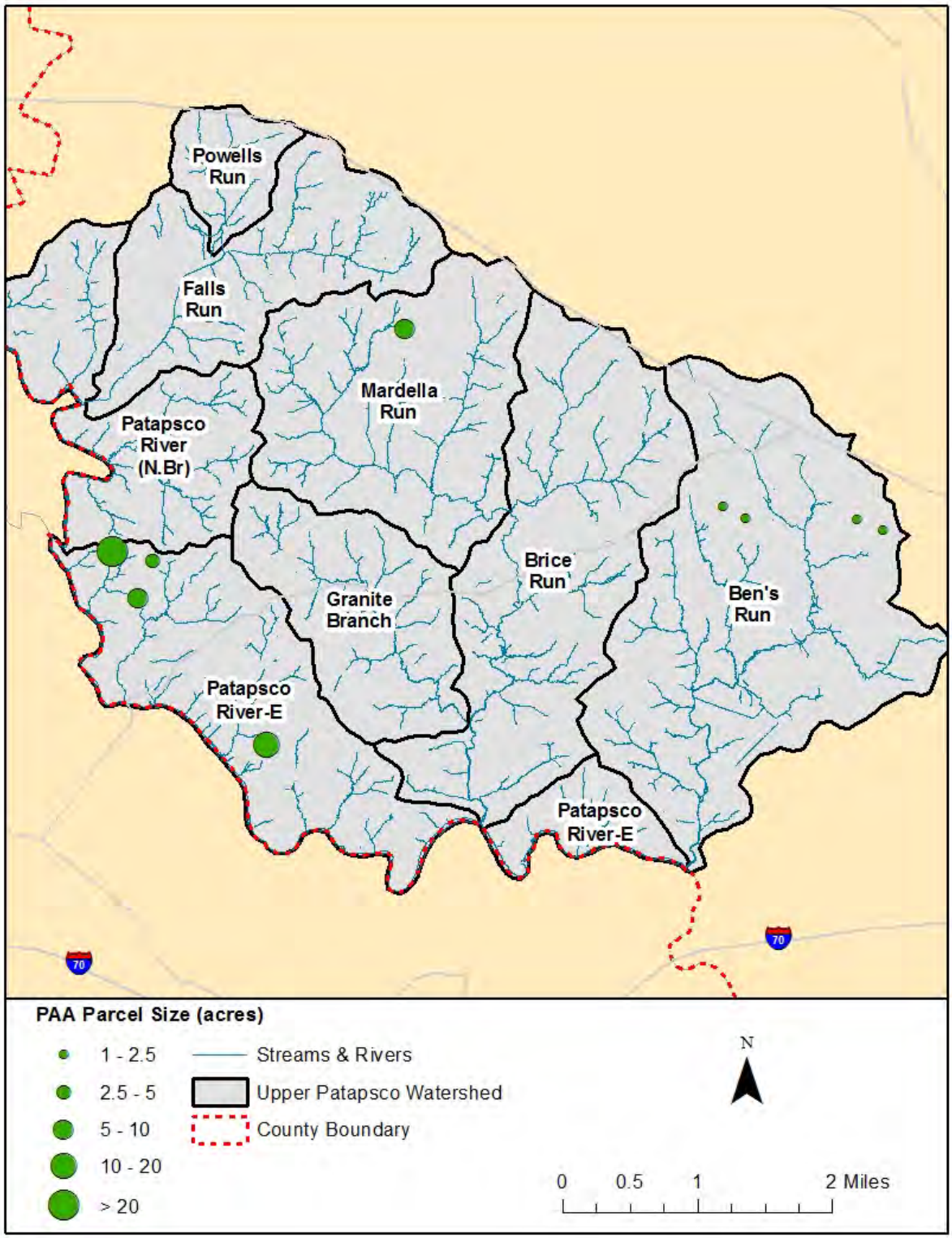

Figure 4-29: PAA Locations in Upper Patapsco Watershed

Table 4-12: PAA Results

PAA ID	Sub-watershed	Owner ship	Acres	Buffer Length	SW Retrofit Potential	A	B	C	D	E	F	Restoration Score
PAA_B_401	Mardella Run	Public	5	0	No	0	0	15	0	15	10	40
PAA_B_802	Ben's Run	Public	1	0	No	0	0	0	0	5	10	15
PAA_B_803	Ben's Run	Public	1	0	No	0	0	5	0	5	10	20
PAA_B_804	Ben's Run	Public	2	0	No	0	0	0	0	10	10	20
PAA_B_805	Ben's Run	Public	2	0	No	0	0	0	0	10	10	20
PAA_B_606	Patapsco River	Public	18	0	No	0	0	15	15	20	10	60
PAA_B_607	Patapsco River	Public	21	0	No	0	0	15	15	20	10	60
PAA_B_608	Patapsco River	Public	5	0	No	0	0	15	15	15	10	55
PAA_B_609	Patapsco River	Public	7	0	No	0	0	15	15	15	10	55

Table 4-13: PAA Priority Scores

PAA ID	Restoration Score	Priority
PAA_B_606	60	Medium
PAA_B_607	60	Medium
PAA_B_608	55	Medium
PAA_B_609	55	Medium
PAA_B_401	40	Medium
PAA_B_803	20	Low
PAA_B_804	20	Low
PAA_B_805	20	Low
PAA_B_802	15	Low

CHAPTER 5: RESTORATION AND PRESERVATION OPTIONS

5.1 INTRODUCTION

This chapter presents an overview of the best management practices (BMPs) potentially suitable for the Upper Patapsco River watershed. There is a significant difference in land cover and runoff characteristics between residential and agricultural areas, and the difference extends to stormwater BMPs as well. For that reason, potential treatment approaches for the Upper Patapsco River watershed are discussed based on those that apply to developed areas and those applicable to agricultural lands. In addition, citizen awareness activities, volunteer restoration programs, and land preservation options are discussed.

5.2 BEST MANAGEMENT PRACTICES FOR DEVELOPED AREAS

5.2.1 County Restoration Programs

5.2.1.1 Stormwater Management Upgrades

Stormwater Management Conversion

Older stormwater management facilities were typically designed only for flood control and have little to no pollutant removal capacity. However, these facilities can generally be altered to capture and retain stormwater runoff to provide water quality benefits. Consideration must be given to the pond's storage capacity and overflow outlets to ensure the structure is capable of handling large storm events. Conversion to an extended detention facility typically requires adjustments to the facility's outlet structure. This will result in water quality benefits by allowing sediments and pollutants to settle out, in addition to controlling the amount of runoff entering receiving waters. Wetland vegetation can be planted in and around an extended detention pond for additional environmental benefits. Dry detention ponds have the greatest potential for conversion to extended detention BMPs.

Stormwater Retrofits

Retrofitting involves the implementation of stormwater management controls in developed areas where previous practices did not exist. Stormwater retrofits improve water quality by capturing, slowing and treating runoff before it reaches receiving water bodies. Retrofits are targeted towards specific objectives, depending on BMP type; objectives may include water quality, soil stabilization, and runoff flow control. Several considerations must be taken into account to select appropriate stormwater treatment measures such as ecological benefit, available land area, cost, and community acceptance. There are factors which limit the effectiveness of stormwater retrofitting, such as insufficient land area in an appropriate portion of the subwatershed (i.e., no available area large enough to intercept a significant amount of runoff). Small-scale BMPs such as bioretention for parking lot/alley retrofits can be effective if space is limited. See Section 5.5 for more information about these and other citizen-led BMPs.

5.2.1.2 Stream Corridor Restoration

Stream corridor restoration practices are used to enhance the ecological function, stability, and riparian habitat of degraded stream corridors. These types of practices typically involve a

comprehensive approach using earth-moving equipment to address wide-spread channel degradation. Stream corridor restoration practices are often combined with stormwater management upgrades and riparian enhancement practices to meet watershed restoration objectives. Primary practices considered within Upper Patapsco River watershed stream corridors include stream restoration, buffer restoration, and wetland restoration.

Stream Restoration

Stream restoration projects are implemented to restore physical, biological, and/or ecological function to a natural watercourse which has become degraded. Degradation of a stream often occurs due to changes in the watershed, such as an increase in impervious surface and/or vegetation removal, and alterations made to the channel itself, such as straightening, lining with concrete or gabions, and/or culvert installation for road crossings.

The goal of stream restoration is to return a degraded channel to a stable state, one in which it does not significantly erode or fill with sediment, can convey runoff for a range of storm events, and has improved ecological function.

A sound restoration project should utilize native materials such as rock, wood, and vegetation to imitate a natural, self-sustaining and ecologically functional stream system. The design approach of a stream restoration project requires an extensive quantity of field collected data and scientifically defensible calculations to determine the appropriate size, shape, and planform of the degraded channel. The design should take into account existing and possible future land use within the watershed. Hydrology and stormwater management practices upstream of a restoration site will dictate the velocity and volume of runoff that will reach a site. In addition, the sediment supply of the upstream channel is also an important consideration during the design of a stream restoration.

Implementation of a stream restoration project usually involves grading of the earth to reconfigure the shape and planform of the degraded channel and/or using structural controls where required for optimal hydrological and ecological function. Stream restoration utilizes a number of techniques to stabilize eroded stream banks, prevent stream bed degradation, recreate habitat, and protect adjacent infrastructure such as utilities, roads and structures. Bank stabilization improves water quality by attenuating the erosion of soils and adhered pollutants, in addition to reducing the likelihood of sewer line breaks. Appropriate placement of bed features and the use of grading and/or structures dissipates energy, creates a variety of aquatic habitats, and oxygenates the water.

Buffer Restoration

Riparian buffers are vegetated areas along rivers, streams, and shorelines that help stabilize banks and prevent erosion; filter pollutants such as sediment and nutrients; provide wildlife habitat; and aid in regulating stream water temperatures. Several portions of the Upper Patapsco River watershed stream system have inadequate riparian buffers as a result of human activities.

This restoration strategy enhances or reforests areas adjacent to streams with a variety native trees, shrubs, and herbaceous plantings. Plants are selected based on the growing conditions at each site and the plant’s requirements. Implementation of targeted educational programs can teach private and institutional property owners that having vegetation along the stream can help

preserve their property, as well as about what plants are appropriate for their site and the water quality benefits of riparian buffers. The inclusion of stream buffer signs is one way to remind residents of the importance of this essential vegetation.

Wetland Creation

Wetlands are highly valuable lands in terms of their ability to both improve water quality by filtering and slowing runoff, and as critical habitat for many species. A wetland is an area of land that has a specific soil type that remains wet or covered with water, and native vegetation that is adapted to these conditions. Swamps, marshes, and bogs are all types of wetland. Unfortunately, many wetlands were drained and converted to land useable for agriculture or development before their importance was realized. One strategy entails the reintroduction of wetlands in settings where they have been lost in the past but favorable conditions still exist. Unfortunately, due to the very specific parameters required, it can be difficult to create and sustain new wetlands. Preservation of the few remaining wetlands and limiting changes to hydrology in the landscape adjacent to existing wetlands are key strategies for watershed protection.

5.2.1.3 Reforestation

The Community Reforestation Program (CRP) was established by Baltimore County's Department of Environmental Protection and Sustainability (EPS) to provide a dedicated workforce for planting, monitoring, and maintaining forest mitigation projects. The program is funded through fees-in-lieu of mitigation for forests removed as a result of public and private land development, as required by the implementation of the County's Forest Conservation Act and Chesapeake Bay Critical Area Regulations. The CRP is the only full-time county-wide reforestation mitigation program among Maryland's counties.

The CRP includes a four-person reforestation crew that carries out year-round reforestation operations. The crew is based at a one-acre site in eastern Baltimore County that is provided by the Department of Recreation and Parks. This home base houses a growing out nursery for 13,000 tree seedlings; equipment and machinery needed for planting, monitoring, and maintaining the reforestation projects; and office space for the reforestation team. Occasionally, the CRP will undertake special grant-funded projects to improve water quality and groundwater recharge, as well as wildlife habitat. The most recent example is the expansion of forest buffers and the reforestation of fields on private rural properties.

In addition to mitigatory reforestation, the Sustainability and Forest Management section of EPS is working to increase tree canopy in support of the County's Tree Canopy Goals announced in spring 2013, and to increase total tree cover by about 1,500 acres by 2025 as part of the County's Chesapeake Bay Watershed Implementation Plan (WIP). Planting in urban areas will include street trees; County facilities; and managed urban lands such as apartments, condominiums, businesses, and private institutions. Trees will also be planted by homeowners who purchase potted saplings through the County's Big Trees sales. EPS will also track citizen planting projects on County lands under the Policy & Guidelines for Community Tree Planting Projects. Contractor-installed planting in rural areas will include large-lot rural residential subdivisions, properties with conservation easements, and other properties where landowners want to increase tree cover.

5.2.2 County Management Programs

Municipal management programs can directly support watershed restoration efforts through services, monitoring, and development review. Street sweeping, inlet cleaning, and trash and recycling collection are services that help protect water quality. The Illicit Discharge Detection and Elimination (IDDE) Program monitors stormwater outfalls to identify any potential contamination. The land development review process imposes a rigorous review of impacts to natural resources. This section describes these municipal programs.

5.2.2.1 Street Sweeping

Baltimore County has an active street sweeping program to remove debris, dirt, and pollutants from the roads before they enter the storm drain system. Effective street sweeping usually involves using a vacuum assisted sweeper, and a schedule that takes into account factors such as trash pickup days and seasonal changes, such as leaf litter in the fall and more frequent lawn care activities by residents in spring and summer.

5.2.2.2 Inlet Cleaning

The Baltimore County storm drain system consists of approximately 1,760 miles of storm drain pipe, 72,096 inlets, and 8,640 outfalls. To keep the entire system clean of trash, debris, and sediment, the Department of Public Works maintains three storm drain cleaning vehicles. Each vehicle has a two-man crew and operates each day, cleaning the storm drains and pipes. Removing the material from the storm drain system reduces street flooding, a potential safety hazard, and aids in the detection of illicit connections.

5.2.2.3 Illicit Discharge Detection and Elimination Program

The county's illicit connection program ensures that all discharges to and from the municipal separate storm sewer system that are not stormwater are either permitted by the Maryland Department of the Environment (MDE) or eliminated. The County is required to screen a minimum of 150 storm drain outfalls annually for the purposes of detecting and removing these unpermitted discharges. The illicit connection program is responsible for performing outfall screenings, reporting screening data, and coordinating remedial actions. The illicit connection program also investigates illicit connection complaints from other agencies, citizens, or volunteers in the Stream Watch Program. Stream Watch allows citizens to adopt a stream, which includes tracking the health of that stream and reporting problems or potential problems they observe.
Routine outfall screenings for detection of illicit connections complements screenings and follow-up triggered by citizen reports of problems they observe. The routine outfall screenings catch the chronic problems that may be missed by the public, such as chlorine leaks from the municipal water supply. Citizens provide additional surveillance at a level beyond that of the monitoring staff. A majority of the time citizens call while they are actually observing a problem and often can provide immediate local information that increases the chance of eliminating illicit connections. The illicit connections program also recently began taking data on potential retrofit opportunities at the outfalls that are investigated.

5.2.2.4 Land Development Review

New development and redevelopment projects undergo a rigorous review for impacts to natural resources. Regulations are in place for the protection of stream buffers, forests, tidal shorelines, groundwater, and stormwater runoff. In addition, on-site inspections take place during the construction process for erosion and sediment control. Tidal shoreline protection must be inspected before a development project is released for occupancy. Stormwater facilities must be confirmed to be functional one year after construction before “close-out” can occur and security bonds are returned to the developer. After construction is complete, stream buffers and forest conservation areas are inspected on a random basis for compliance. The following are the current regulatory programs applicable to the development and redevelopment plan review process and follow-up inspections.

Riparian Forest Buffers

Baltimore County enacted the Regulations for the Protection of Water Quality, Streams, Wetlands and Floodplains in 1991. These regulations require development designs to include a 75- or 100-foot stream buffer and include provisions for expansion of the riparian buffer for steep slopes, wetlands, and floodplains. Development plans must minimize stream and buffer road crossings, have stormwater management facilities and outfalls outside of the riparian buffer, and place utilities outside the buffer to the extent possible. In cases where fish passage is an issue, stream crossings should be either open bottom bridges or provide for low flow fish passage. These regulations are intended to maintain the integrity of the riparian buffer.

Forest Conservation

The main purpose of the Maryland Forest Conservation Act, enacted in 1991, is to minimize the loss of Maryland's forest resources during land development by making the identification and protection of forests and other sensitive areas an integral part of the site planning process. EPS oversees local implementation of these regulations during the development review process and conducts inspections during the construction and post-construction closeout process. Of primary interest are areas adjacent to streams or wetlands; those on steep or erodible soils; or those within or adjacent to large contiguous blocks of forest or wildlife corridors. Identification of priority areas is completed prior to design of the development plan. Any construction activity or development proposal for an area that is 40,000 square feet (approximately one acre) or greater is subject to the Forest Conservation Act and requires a Forest Conservation Plan prepared by a licensed forester, licensed landscape architect, or other qualified professional.

Chesapeake Bay Critical Area

The Chesapeake Bay Critical Area law and criteria were designed to foster more sensitive land use and development activity along the tidal shorelines and to ensure the implementation of appropriate long-term conservation measures to protect important habitats. The law identified the "Critical Area" as all land within 1,000 feet of the mean high water line of tidal waters or the landward edge of tidal wetlands. The Critical Area Act, passed in 1984, was significant and far-reaching, and marked the first time that the state and local governments jointly addressed the impacts of land development on habitat and aquatic resources. Maryland Department of Natural Resources has developed an interactive map to show the critical area: http://webmaps.esrgc.org/cbca/desktop/Map.

Groundwater Management

The Groundwater Management section of EPS is charged with the responsibility of managing and protecting the groundwater resources of Baltimore County. It handles issues related to drinking water wells, septic systems, and removal of residential underground storage tanks. These systems are regulated during the development review process and property title transfers to protect residents and groundwater resources.

Stormwater Management

Stormwater management in the State of Maryland has evolved over time, with the initial emphasis on quantity control in the mid to late 1980s, to quantity and quality control in the 1990s, to the more recent emphasis on channel protection (one-year storm management) and diffusing stormwater over the site (Low Impact Development [LID]). The control of erosive flows through stormwater management augments the riparian forest buffer in the protection of natural resources. The latest state regulations, revised and updated by MDE in 2009, require Environmental Site Design (ESD) to the Maximum Extent Practicable (MEP). ESD is using a combination of planning practices, alternate ground cover, and small-scale practices, which in combination, are intended to retain, infiltrate, and treat as much runoff as possible on-site (MDE 2000). Development or redevelopment projects that were already in the process of seeking approval for stormwater management plans at the time the new regulations were enacted were "grandfathered" in under the older regulations – in other words, they were granted a waiver so that they could complete their projects without needing to seek additional funding or investment for regulations that did not exist at the time the projects were designed. These projects were required to attain final project approval by May 4, 2013, when all waivers were set to expire. Jurisdictions were permitted to grant extensions in special cases; no waivers were permitted to extend beyond May 4, 2017.

Erosion and Sediment Control

Baltimore County has authority delegated from the Maryland Department of the Environment to enforce the State Erosion and Sediment Control Program. The main function of this program is to monitor best management practices (BMPs) for sediment from new development and redevelopment during the construction phase. These practices prevent sediment and other pollutant inputs into the storm drain system and stream network. The sediment control BMPs are specified in the sediment and erosion control plan for each development site. Sediment control plans are required for any construction activity disturbing an area greater than 5,000 square feet. Standard Plans are used in lieu of Sediment and Erosion Control Plans approved by the Baltimore County Soil Conservation District for residential construction activities that disturb less than 30,000 square feet and for all other construction activities that disturb less than 20,000 square feet.

5.2.2.5 Trash and Recycling

Single Stream Recycling

Single stream recycling allows for the County to collect a mix of recyclable materials (e.g., plastics, glass, metals, paper, and cardboard) without the need for citizens to sort their recyclables prior to collection. Single-family homeowners set out one bin with all recyclables curbside or in the alley for single stream recycling collection each week. The majority of multifamily complexes

(apartments, condominiums) also have single stream recycling collection each week. Information on what materials are accepted and how to set them out for recycling are provided at: http://www.baltimorecountymd.gov/Agencies/publicworks /recycling/collectioninformation.html. Creating new products from recycled materials often requires less energy than manufacturing that uses virgin materials. Recycling saves energy, helps protect natural resources, reduces air and water pollution, extends the life of the Eastern Sanitary Landfill, and saves the County money, as landfill disposal is more expensive for the County than recycling.

Household Hazardous Waste Collection

In response to numerous requests from citizens and elected officials concerned with disposal of hazardous wastes from their own homes, Baltimore County citizens can drop off household hazardous waste materials for recycling or proper disposal at a permanent processing facility located at the Eastern Sanitary Landfill Solid Waste Management Facility. Materials dropped off for processing include unwanted household chemicals, such as paints, flammable cleaning solvents, automotive fluids, pesticides, pool chemicals, acids, mercury thermometers, gasoline, corrosive material, etc. In addition, EPS holds two one-day collection events annually, in the spring and fall, at different locations around Baltimore County.

Waterway Trash Boom

Trash can collect in storm drains and then enter waterways, where it poses additional hazards: fish, birds, and mammals may ingest plastic materials or become tangled in debris; garbage may smother or damage aquatic habitat; and waste materials may harbor pathogens or leach toxic substances into the aquatic environment. Refuse also detracts from the aesthetic and recreational value of streams and rivers. Floating trash booms may be installed on targeted waterways to intercept and corral trash and debris, preventing it from spreading throughout a river system. Designs vary, but a typical boom consists of a series of floats, a curtain that hangs below the water surface, and a bottom anchor to keep the boom in place. These booms require maintenance and frequent cleaning, particularly after rain events.

Baltimore County has installed and manages one trash boom located in the tidal Back River area. This boom was installed in 2010 and is maintained by a local citizen-based watershed group using grant funds supplied by Baltimore County.

5.3 BEST MANGEMENT PRACTICES FOR AGRICULTURAL AREA

There are a large number of agricultural practices that are used by farmers to reduce soil loss, trap nutrients, and minimize the amounts of nutrients and pesticides used on the land. For many of these agricultural best management practices (BMPs), the Chesapeake Bay Program has assigned specific reduction efficiencies for nitrogen, phosphorus, and sediment to each practice. The following descriptions of agricultural BMPs are derived from the Natural Resource Conservation Service (NRCS) and further information is available at: https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/technical/fotg/

5.3.1 Farm Conservation Plans

A Soil Conservation and Water Quality Plan (SCWQP) is a comprehensive plan that addresses natural resource management on agricultural lands and describes BMPs that will be used to

control erosion and sediment loss, and manage runoff. SCWQPs include management practices (e.g. crop rotations) and structural practices (e.g. grassed waterways and diversions). By request, a farmer will receive assistance from a Soil Conservation District (SCD), Maryland Department of Agriculture (MDA), or U.S. Department of Agriculture (USDA) NRCS professional to determine the group of practices needed to address environmental concerns specific to the farm. The practices are designed to reduce erosion to an acceptable level and to be compatible with management and cropping systems. A SCWQP can be used for up to ten years without revision, if substantial changes in the farm's operation or management do not occur. SCWQPs are required on agricultural land in the critical area by The Code of Maryland Regulations (COMAR 27.01.06.03 C). Also included in a SCWQP are recommendations concerning forestry management; wildlife habitat and plantings; and the management of other natural resources. These plans must be approved by the SCD and updated every five years; enforcement authority lies with MDE. Plans are also required on agricultural land under preservation easement, such as Coastal Rural Legacy, and enforcement of these plans are by the holder of the easement. BMPs commonly included in SCWQPs are detailed below.

Cover Crops

Use of cover crop entails growing a crop of grass, small grain or legumes and is primarily for seasonal protection and soil improvement. Cover crops act as a filter and reduce the movement of sediment and pathogens, as well as dissolved and sediment-attached pollutants.

Nutrient Management

Nutrient management involves managing the amount, placement, and timing of plant nutrients (e.g., fertilizers) in order to obtain optimum yields and minimize the risk of surface and groundwater pollution.

Integrated Pest Management (IPM)

IPM includes appropriate cultural, biological, and chemical controls, and combinations thereof. The pest management programs developed are designed to address both crop production goals and environmental concerns.

Residue and Tillage Management – Mulch Till

Mulch tilling is a technique used to manage crop residue on a year-round basis in order to limit erosion to an acceptable rate, conserve soil moisture, and maintain or improve soil tilth. This practice is generally applied to cropland but may also be used on other areas where field crops are grown, such as wildlife or recreation lands.

Residue and Tillage Management – No-Till

No till is a technique used to manage the amount, orientation, and distribution of crop and other plant residue on the soil surface year-round. Crops are planted and grown in narrow slots or tilled strips, established in the untilled seedbed of the previous crop. The objective of this practice is to maintain most of the crop residue on the soil surface throughout the year. The practice may be referred to as no-till, zero-till, slot plant, row-till, strip-till, or simply generic term conservation tillage.

Conservation Crop Rotation

Conservation crop rotation entails growing various crops on the same piece of land in a planned sequence. Perennial plants used for forage are very effective in crop rotations due to increases in organic matter and reduced soil erosion. In addition, crop rotations help break insect, disease and weed cycles. Additionally, practices such as residue management, contouring, stripcropping, diversions, terraces and grassed waterways may not function properly without a planned crop rotation.

Stripcropping

Stripcropping is growing crops in a systematic arrangement of strips across the field to reduce soil erosion by water and/or wind. This practice is used on cropland, as well as certain recreation and wildlife lands where field crops are grown. On sloping land where sheet and rill erosion are a concern, the strips are laid out on the contour or across the general slope. Where wind erosion is a concern, the strips are laid out as close to perpendicular as possible to the prevailing erosive wind direction.

5.3.2 Nutrient Management Plans

Nutrient management plans (NMPs) are comprehensive plans required by MDA that describe the optimum use of nutrient inputs for crop yield to minimize loss of excess nutrients to the environment. Plans are prepared either by University of Maryland Extension or by certified private consultants.

5.4 CITIZEN AWARENESS ACTIVITIES

Residents and businesses can engage in behaviors and activities that can negatively influence water quality, including over-fertilizing lawns, using excessive amounts of pesticides, poor housekeeping practices (such as inappropriate disposal of paints, household cleaners or automotive fluids), and dumping into storm drains. Alternatively, positive behaviors such as tree planting, disconnecting downspouts, and picking up pet waste can help improve water quality. Whether a pollution prevention program is designed to discourage negative behaviors or encourage positive ones, targeted education is needed to deliver messages that promote changes in behavior. Local watershed organizations and other civic groups, such as the Master Gardeners, are in a position to influence these changes using pollution prevention education and outreach to teach citizens how to properly care for the watershed.

5.4.1 Stormwater Runoff

A survey regarding people’s knowledge about stormwater was conducted in 2007 by the Herring Run Watershed Association and the Jones Falls Watershed Association (both organizations are now part of Blue Water Baltimore) in conjunction with OpinionWorks. It concluded that even citizens who want to reduce the negative impacts of stormwater runoff do not realize their role in controlling runoff. By slowing and reducing the amount of stormwater runoff, more water can infiltrate into the ground and lessen damaging stormwater surges into streams. Annually, Baltimore County holds a one-day truckload sale of rain barrels for citizens to purchase. There is more detail on this and other ways that homeowners can help reduce stormwater runoff in Section 5.5.

5.4.2 Pet Waste/Bacteria Awareness

Pet waste is one of the contributors of bacteria to streams and can cause health problems in humans. A pet waste station is a sign reminding pet owners of the importance of proper disposal of pet waste and it usually includes a supply of bags for pet waste cleanup. Often it is located next to an existing trashcan or it includes one. Pet waste stations can help neighborhoods to reduce bacteria flowing into their local streams and help to keep their neighborhood park or school site clean. Citizens can participate by monitoring the supply of bags to make sure they are continually available. In collaboration with other county agencies, EPS is developing an awareness campaign for better pet waste management.

5.4.3 Fertilizer Reduction

A well-manicured and responsibly maintained lawn can be an asset to the watershed. Too often, however, over fertilization and irresponsible pest management result in pollutant-charged runoff to local streams. Significant reductions of total nitrogen to stormwater can be achieved through careful fertilizer management. Homeowners should be reminded to follow the fertilizer application instructions so that it is applied in the correct amount, during the right season, and under the right conditions so that the fertilizer does not wash away in a rainstorm. Citizens can be more cognizant about fertilizer placement so that it doesn't land on driveways and sidewalks where it may wash directly into the street and storm drain system. The County also promotes eco-friendly lawn care, including the use of mulching lawn mowers that reduce the need for fertilizer and decrease the amount of material handled by the yard material collection program.

5.4.4 Trash and Recycling

Compost Bins

Baltimore County holds a one-day compost bin sale for residents to purchase bins for composting yard waste in their backyards. By composting leaves and weeds in backyard bins, the amount of material handled by the municipal yard material collection is reduced. Use of compost is an environmentally friendly way of improving soil and avoids the application of manufactured chemical fertilizer. This event is held in conjunction with the annual rain barrel sale.

Stewardship Projects

EPS provides assistance in planning and advertising local stewardship projects such as Project Clean Stream, an annual stream cleanup hosted by the Alliance for the Chesapeake Bay.

Reuse Directory

The Reuse Directory is a listing of reuse organizations for Baltimore County residents and businesses that is available online and in print. In it are all of the places that you can take unwanted items for reuse, including construction materials, appliances, office supplies, clothing, household items, automobiles, food, medical equipment, and more. By donating reusable items, you will: help other people and organizations, reduce disposal costs, reduce air and water pollution, and conserve space in the landfill. The directory is kept updated and published by the

Baltimore County Bureau of Solid Waste Management; it is linked to from this webpage: http://www.baltimorecountymd.gov/Agencies/publicworks/recycling/pubsanddownloads.html

The Re-Source Newsletter

The Re-Source Newsletter is an online resource that is published quarterly and provides information and updates about Baltimore County's solid waste reduction, reuse, recycling, and refuse disposal programs: http://www.baltimorecountymd.gov/Agencies/publicworks/recycling/newsletter/index.html

5.4.5 Environmental Awareness and Education

Outreach and education programs are intended to communicate to the public how to reduce the potential for pollutants to reach waterways. These programs are designed to change pollutant-causing behaviors by providing information on how certain habits and actions affect water quality and to recommend new behaviors that can reduce impacts. There are also a number of activities that can reduce runoff or improve water quality that don't involve pollution prevention, such as landscaping improvements, which could be the target of an outreach program.

A pollution prevention program can be designed to discourage negative behaviors and/or encourage positive behaviors. Either way, the goal is to deliver a tailored message through targeted education to promote behavior changes. Local watershed organizations can help influence these changes using pollution prevention education and outreach to teach citizens how to properly care for the watershed. The upland assessments described in Chapter 4 identified pollution prevention or source control education programs which could be effective in the Upper Patapsco River watershed.

Community-based facilities present good opportunities for educating the public about water quality issues and opportunities for improving the health of the watershed. This can be accomplished by implementing water quality BMPs such as rain gardens and bioretention areas at these sites. In addition to environmental education, these BMPs have water quality and aesthetic benefits for property users. Tree plantings present great opportunities for community involvement and education, as do water quality sampling and monitoring of stormwater management.

5.5 VOLUNTEER RESTORATION PROGRAMS

There are several restoration activities that citizens in the watershed can engage in to help restore and protect the watershed. These activities are described in the following sections and include downspout disconnection, BayScaping, tree canopy improvement, fertilizer reduction/education, planting open space trees, and participating in a citizen stream watch program. Local groups, such as the Master Gardeners, can provide education and workshops on these activities.

5.5.1 Downspout Disconnection

In addition to road runoff, rooftops can sometimes contribute stormwater directly into streams. Many downspouts are connected directly to the storm drain system through underground pipes, while others are funneled toward driveways and sidewalks, which then are connected to the

street. By redirecting downspouts to a pervious area, this runoff is allowed to infiltrate the ground in areas such as gardens and lawns.

Downspout disconnection refers to several practices that capture or treat rooftop runoff from individual downspouts through either a simple disconnection that allows the runoff to spread across the lawn or yard where it filters or infiltrates into the ground, a rain barrel that captures the runoff for re-use in watering gardens, or a rain garden that infiltrates the runoff. Several of the neighborhoods assessed in the Upper Patapsco River watershed were recommended for downspout disconnection because they are draining to impervious surfaces such as driveways, sidewalks, or the curb and gutter system.

Simple downspout disconnection can be achieved, where appropriate, if the downspouts are relocated to drain onto pervious areas (i.e., lawn). This will allow rooftop runoff to be filtered by vegetation, and soak into the ground. This decreases flow to local streams during storm events, reducing erosion and pollutant loads to streams.

The use of rain barrels for the collection and reuse of the runoff is a highly sustainable practice, and is effective when there is limited space on the property and other disconnection practices are not possible. Downspouts are directed into rain barrels, where rooftop water is captured and stored for later use to water the yard or garden, or simply to be released onto a pervious area on a dry day.

Finally, some of the residential lots in the watershed have sufficient room for rain gardens, which are the most desirable option in terms of water quality. Rain gardens capture runoff from impervious surfaces such as roofs, roads, patios and driveways. They are planted with native perennials and shrubs that are compatible with wet soils. A downhill area that naturally collects rain water is an ideal location for a rain garden. The garden temporarily holds runoff, allowing it to gradually percolate into the ground, thus replenishing groundwater and reducing floods. Garden plants naturally filter pollutants and improve the water quality.

5.5.2 BayScaping

Numerous water quality benefits are achieved from converting turf into landscaping and through increasing the area of urban tree canopy. A BayScape is a designed feature that uses plants native to the Chesapeake Bay watershed to provide habitat for local and migratory animals, improve water quality, and reduce the need for chemical pesticides and herbicides. BayScaping plants, such as trees, shrubs and perennials, are able to make better use of rain water than typical lawn grasses, and so require less watering once established. They are also better at trapping and removing nitrogen and pollutants from rain water so that it is not released into nearby waterbodies. A BayScape is also valuable for the gardener or landowner because it offers greater visual interest than lawn; reduces the time and expense of mowing, watering, fertilizing, and treating lawn and garden areas; and can address areas with problems such as erosion, poor soils, steep slopes, or poor drainage. The removal of exotic, invasive plant species also benefits native plant and animal communities.

5.5.3 Tree Canopy Improvement

Programs to promote tree planting in residential yards and commercial open space can increase the tree canopy, increase evapotranspiration and interception, slow runoff, and allow greater

infiltration of stormwater into the ground due to tree roots reducing soil compaction. Trees also reduce erosion by holding soil and by reducing the impact of rain to bare ground. These types of programs also provide an opportunity to involve volunteers from neighborhoods, businesses, and schools to help plant trees throughout the watershed while also educating the community about the importance of trees for air and water quality.

Baltimore County holds the Big Tree Sale; the County has its own native tree nursery for county reforestation projects. Twice a year, in the spring and fall, trees from the nursery are made available to the public to encourage planting of native trees, especially oaks, which have exceptional water quality, air quality, and wildlife benefits. Trees are sold at one-day sale events.

The State of Maryland's TREE-MENDOUS program provides high-quality, native trees and shrubs, available at reasonable prices, for plantings on public lands. The trees may be planted in places such as community open spaces, schools, government facilities, and rights-of-way. They may not be planted at private residences.

5.5.4 Fertilizer Reduction/Education

Proper lawn and turf care practices can reduce excess nitrogen, phosphorus, insecticides, and herbicides from getting into local streams. Education on soil testing, fertilizer application, and pesticide use is intended to reduce the amount of these materials applied to the land.

5.5.5 Stream Watch Program

The Stream Watch Program is intended to develop citizen stewardship through participation of citizen volunteers who actively assume the responsibility of caring for segments of the stream network by observing changes in the system, providing stream clean-ups, and participating in planting activities. The Stream Watch Program also includes identification of potential restoration projects for possible inclusion in the Waterway Capital Improvement Program and provides a valuable addition to the county’s Illicit Connection Program through reports of potential illicit discharges by Stream Watch participants. There is not currently a Stream Watch Team established in this SWAP area.

5.5.6 Open Space Trees

Open pervious areas (i.e., areas covered with turf grass, rather than pavement or forest) and natural area remnants provide important natural groundwater recharge functions within a subwatershed, and should be optimized to promote natural infiltration. These areas also present an opportunity for reforestation in the watershed. Reforestation is the best way to improve the infiltration, recharge function, and pollutant reduction capability of a site. Other techniques, such as soil aeration, amendments, and establishing native plantings or meadows may be used when reforestation is not an option, as all of these alternatives still provide greater benefit(s) than turf grass. Ideal sites for planting have little evidence of soil compaction, invasive plants, or trash/dumping, and can be reforested with minimal site preparation.

5.6 INSTITUTIONAL INITIATIVES

There are several restoration activities that institutions in the watershed such as churches and schools can engage in to help restore and protect the watershed. These activities are described in the following sections.

5.6.1 Parking Lot Retrofits

Often large parking surfaces are included in commercial and institutional development projects for events that occur very infrequently. If reducing the impervious cover is not an option, then filtering practices can provide a substantial benefit when applied over large areas. Onsite commercial and institutional retrofit practices often include the use of sand filters, bioretention, and grass swales adjacent to parking lots. Larger redevelopment projects often include underground storage or filtering systems. Several research groups are exploring innovative parking surfaces to develop a surface that is both durable and porous. These surfaces are another option for providing better filtration of runoff, while still allowing for the same number of parking spaces.

5.6.2 Open Space Planting

An increasing number of faith-based institutions are showing interest in adopting conservation landscaping practices. This often begins with removal of unused turf areas at these institutions. These areas are then replaced by an assortment of more sustainable and environmentally-friendly practices. Options include: planting trees, restoring wildlife habitat, introducing no-mow zones, and creating meadows, all of which also improve the quality and quantity of stormwater runoff. Trees planted near buildings provide wind protection and shade, which can reduce energy use, leading to lower heating and cooling costs. When lawn area is eliminated there is less mowing required, reducing fossil fuel consumption and the associated air pollution.

5.7 LAND PRESERVATION

Land preservation complements the implementation of BMPs by insuring that land use is stabilized over time. Unlike park land, land preservation maintains certain restrictions on the land's use in perpetuity. The restrictions range from limits on development to specific resource protection, such as forest, stream buffer or prime land protection.

These preservation areas may be large, multi-parcel blocks or small, individual parcels. Land preservation in Baltimore County complements the long-term multifaceted efforts to limit sprawl and protect rural resources, water supplies, and rural economies. The limitations on the property vary depending on the principle of the easement program, and as specifically limited by the Deed of Conservation Easement. For example, the Maryland Environmental Trust easements provide for a broad array of environmental protection restrictions. The Agricultural Protection programs focus on protection of prime and productive soils, while still permitting resource extraction. Rural Legacy blends these two objectives.

For purposes of watershed management, an understanding of existing protected lands can provide a starting point in prioritizing potential protection and restoration activities. In many cases, protected lands may provide a better opportunity for restoration projects simply because the risk of the land being converted to development is removed, thus the investment involved in the

implementation of the practice is secure. A summary of current conservation easements is provided in Chapter 2.

Descriptions of the land preservation programs in effect in the Upper Patapsco River watershed follow.

5.7.1 Maryland Environmental Trust and Local Land Trusts

Created by the Maryland General Assembly in 1967 to protect Maryland's natural environment, the Maryland Environmental Trust (MET) seeks donated easements on farms and forestlands, wildlife habitats, waterfront acreages, natural areas, historic sites, and other valuable and scenic features. In 1974, a landowner in Baltimore County was one of the first to protect their property through this program. Today, Baltimore County remains a leader in the state, with county landowners preserving over 18,500 acres through donations, 67 acres of which are in the Upper Patapsco River watershed. An additional 27 acres have been protected through other local land trusts. Although both MET and local land trusts prefer to accept donations on lands greater than 25 acres, local land trusts are often willing to work with smaller property owners. Donations are accepted throughout the year. Landowners may qualify for a significant tax deduction and/or credit. MET also provides loans to qualified groups for the purchase of land for preservation.

5.7.2 Maryland Agricultural Land Preservation Foundation

Created in 1979, this program has been dedicated to preserving farmland and fostering commercial agriculture. With joint funding by the county and the state, over 22,000 acres of farmland have been preserved in Baltimore County. To qualify for this program, a farm must be a minimum of 50 acres or located adjacent to a preserved property. Applications to sell development rights may be made annually by July 1st following enrollment in an Agricultural District. Landowners receive cash payments for participating in the easement program. Currently, there are 382 acres of land under easement within the Upper Patapsco River watershed based on state records.

5.7.3 Baltimore County Agricultural Land Preservation Program

Created in 1994 to preserve working family farms, this Baltimore County program has used innovative and collaborative funding mechanisms for land preservation. Landowners have protected over 5,600 acres through this program, though no farms within the Upper Patapsco River watershed are currently enrolled in this program. To participate, a farm must be 50 acres in size or located adjacent to a preserved property.

5.8 PUBLIC LANDS/OPEN SPACE

Lands in the SWAP area, owned by Baltimore County, Baltimore City, and the State of Maryland, meet various public needs as described.

Baltimore County Department of Recreation and Parks

Carriage Hills Park

Carriage Hills Park is a 17-acre park located in Randallstown. Amenities include athletic fields, multi-purpose fields, picnic areas, and playgrounds. The Liberty Road Recreation Office manages daily operations and reservations for this park.

Rockdale Park

Rockdale Park is a 22-acre park located in the Gwynn Oak community. Amenities include community gardens, walking paths, pavilions, picnic areas and playgrounds. The Liberty Road Recreation Office manages daily operations and reservations for this park.

Maryland Department of Natural Resources

Patapsco Valley State Park

Patapsco Valley State Park runs along 32 miles of the Patapsco River and encompasses over 16,000 acres, approximately 1,900 of which are located in the Upper Patapsco River watershed. The Daniels Area contains the Daniels Dam and fish ladder, with abundant opportunities for fishing (the area is stocked with rainbow and brown trout), canoeing, and kayaking. The McKeldin Area has youth camping facilities, pavilions, and trails for horseback riding, mountain biking, and hiking.

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APPENDIX F:
UPLAND ASSESSMENT DATA SUMMARY

Upper Patapsco River Upland Assessments
Hotspot Investigations (HSIs)

Site ID	Subshed	Hotspot Status	Category	Business Type	Vehicle Operations	Outdoor Materials	Waste Mgmt.	Physical Plant	Turf Land-scaping	Stormwater. Infrastructure	Refer for Enforcement
HSI_B_701	Brice Run	Potential hotspot	Commercial	Vehicle maintenance shop							
HSI_B_804	Ben's Run	Potential hotspot	Commercial	Home improvement store							
HSI_B_805	Ben's Run	Not a hotspot	Commercial	Fast food	N/A	N/A					
HSI_B_706	Brice Run	Potential hotspot	Commercial	Ford dealer and repair shop							
HSI_B_707	Brice Run	Not a hotspot	Commercial	Storage facility		N/A					
HSI_B_708	Brice Run	Confirmed hotspot	Commercial	Self-Service car wash		X					X
HSI_B_709	Brice Run	Potential hotspot	Commercial	Lumberyard							
HSI_B_410	Mardella Run	Potential hotspot	Commercial	Vehicle maintenance							
HSI_B_412	Mardella Run	Potential hotspot	Commercial	Collision repair shop							
HSI_B_814	Ben's Run	Not a hotspot	Commercial	Gas station		N/A					
HSI_B_815	Ben's Run	Not a hotspot	Commercial	Restaurant and other shops	N/A	N/A					

Upper Patapsco River Upland Assessments
Hotspot Investigations (HSIs)

Site ID	Subshed	Hotspot Status	Category	Business Type	Vehicle Operations	Outdoor Materials	Waste Mgmt.	Physical Plant	Turf Land-scaping	Stormwater. Infrastructure	Refer for Enforcement
HSI_B_816	Ben's Run	Potential hotspot	Commercial	Superstore	N/A						
HSI_B_817	Ben's Run	Not a hotspot	Commercial	Fast food	N/A	N/A					
HSI_B_218	Falls Run	Potential hotspot	Commercial	Towing and impound company							
HSI_B_220	Falls Run	Potential hotspot	Commercial	Towing, impound, and vehicle maintenance							
HSI_B_121	Powells Run	Potential hotspot	Commercial	Car maintenance and repair							
HSI_B_822	Ben's Run	Not a hotspot	Commercial	Fast food	N/A	N/A					
HSI_B_823	Ben's Run	Confirmed hotspot	Commercial	Auto repair							
HSI_B_824	Ben's Run	Potential hotspot	Commercial	Strip shopping center							
HSI_B_725	Brice Run	Not a hotspot	Commercial	Nursey/ Landscaping	N/A						
HSI_B_726	Brice Run	Not a hotspot	Commercial	Storage facility		N/A					

Upper Patapsco River Upland Assessments
Institutional Site Investigations (ISIs)

Site ID	Subshed	Name	Ownership	Waste Mgmt.	Vehicle Ops.	Outdoor Materials	Turf Land-scaping	Storm Drain Marking	Tree Planting	Downspout Disconnect	SW Retrofit	Imp. Cover Removal
ISI_B_401	Mardella Run	Hernwood Elementary School	Public		N/A			X	X		X	
ISI_B_703	Brice Run	Colonial Baptist Church	Private						X	X	X	
ISI_B_804	Ben's Run	New Antioch Church	Private			N/A		X	X		X	
ISI_B_805	Ben's Run	Community Baptist Church	Private		N/A	N/A		X	X		X	
ISI_B_706	Ben's Run	Jehovah's Witness Kingdom Hall	Private		N/A			X	X			
ISI_B_807	Ben's Run	Windsor Mill Middle School	Public					X	X		X	X
ISI_B_808	Ben's Run	Winfield Elementary School	Public		N/A			X	X		X	
ISI_B_810	Ben's Run	Arlington Baptist Church and Willow Park Academy	Private					X	X		X	X
ISI_B_811	Ben's Run	Salem United Methodist Church	Private		N/A	N/A			X		X	
ISI_B_112	Powells Run	Wards Chapel United Methodist Church	Private	N/A	N/A				X		X	

Upper Patapsco River Upland Assessments
Institutional Site Investigations (ISIs)

Site ID	Subshed	Name	Ownership	Waste Mgmt.	Vehicle Ops.	Outdoor Materials	Turf Land-scaping	Storm Drain Marking	Tree Planting	Downspout Disconnect	SW Retrofit	Imp. Cover Removal
ISI_B_813	Ben's Run	Randallstown Elementary School	Public		N/A			X	X		X	X
ISI_B_714	Brice Run	Sikh Association of Baltimore	Private		N/A				X			
ISI_B_816	Ben's Run	Baltimore County Fire Station 18	Public					X	X		X	
ISI_B_818	Ben's Run	Randallstown Branch of Balto. Co. Public Library	Public		N/A	N/A		X			X	X
ISI_B_722	Brice Run	Collective Christian Ministries	Private		N/A						X	
ISI_B_423	Mardella Run	Chevra Ahavas Cemetary	Private	N/A	N/A	N/A			X			

Upper Patapsco River Upland Assessments
Pervious Area Assessments (PAAs)

Site ID	Subshed	Site Name	Ownership	% Turf	Notes
PAA_B_401	Mardella Run	Baltimore County Maryland	Public	40	County owned open space
PAA_B_802	Ben's Run	Board of Education of Baltimore County	Public	15	Open space at edge of public school sports fields
PAA_B_803	Ben's Run	Board of Education of Baltimore County	Public	20	Open space next to school, away from sports fields
PAA_B_804	Ben's Run	Board of Education of Baltimore County	Public	20	Open space in park, not part of sports fields
PAA_B_805	Ben's Run	Baltimore County Maryland	Public	20	County owned open space
PAA_B_606	Patapsco River	State of Maryland	Public	60	un-forested patch in state park. use unknown
PAA_B_607	Patapsco River	State of Maryland	Public	60	un-forested patch in state park. use unknown
PAA_B_608	Patapsco River	State of Maryland	Public	55	un-forested patch in state park. use unknown
PAA_B_609	Patapsco River	State of Maryland	Public	55	un-forested patch in state park. use unknown

Upper Patapsco River Upland Assessments
Neighborhood Source Assessments (NSAs)

Site ID	Subshed	Name	Acres	PSI	ROI	Downspout Disconnect	Rain Barrel	Rain Garden	Storm Drain Marking	Bay-Scape	Fertilizer Reduc.	Pet Waste	Trash Mgmt.	Trees to Plant
NSA_B_1	Ben's Run	Liberty Manor	62.9	High	High	X	X		X	X			No	420
NSA_B_2	Ben's Run	Deer Run at Mayfield	16.9	Low	Mod.		X		X	X			No	0
NSA_B_3	Ben's Run	Deer Run at Mayfield	8.1	Low	Mod.		X		X	X			No	0
NSA_B_4	Ben's Run	Rolling Oaks, Nolanbrook	31.6	Low	Mod.	X	X		X	X			No	180
NSA_B_5	Ben's Run	Willow Creek	79.4	High	Mod.	X	X	X	X	X	X		No	0
NSA_B_6	Patapsco River-E	Sienna Way, Ramona Ln.	96.6	High	Mod.	X	X	X	X	X	X		No	110
NSA_B_7	Granite Branch	Offutt Manor	45.8	Mod.	Mod.		X	X		X			No	0
NSA_B_8	Mardella Run	Kings Park Estates	166.3	Mod.	High	X	X		X	X			No	800
NSA_B_9	Mardella Run	Birchwood at Kings Park	18.7	Mod.	Mod.	X	X		X	X			No	0
NSA_B_10	Mardella Run	Point of Woods	13.6	Mod.	Mod.	X	X		X	X			No	0
NSA_B_12	Brice Run	Carriage Hill Village Apartments	43.7	Mod.	Mod.			X	X	X			No	45
NSA_B_14	Ben's Run	Fieldstone	20.0	Mod.	High		X		X	X			No	70

Upper Patapsco River Upland Assessments
Neighborhood Source Assessments (NSAs)

Site ID	Subshed	Name	Acres	PSI	ROI	Downspout Disconnect	Rain Barrel	Rain Garden	Storm Drain Marking	Bay-Scape	Fertilizer Reduc.	Pet Waste	Trash Mgmt.	Trees to Plant
NSA_B_15	Ben's Run	Stevenswood, Woodmont, Kimberleigh West, Merrymount, Mayfield	121.9	Mod.	High	X	X		X	X			No	400
NSA_B_16	Ben's Run	Village of Pine Run Apartments	29.4	Mod.	Mod.	X	X	X	X	X	X		No	200
NSA_B_18	Ben's Run	Remington Ave., Parks Ln.	9.9	Low	Low		X	X		X			No	0
NSA_B_19	Falls Run	Forest Hills, Hernwood Heights	130.4	Low	Low	X	X		X	X			No	0
NSA_B_20	Granite Branch	Edrich Manor	120.0	High	High		X	X	X	X	X		No	0
NSA_B_11	Mardella Run	Edrich Manor	92.3	High	Mod.	X	X	X	X	X	X		No	0
NSA_B_13	Brice Run	Edrich Manor East, Offutt Village, The Preserve at Edrich Manor South	69.3	High	Mod.	X	X	X	X	X	X		No	0
NSA_B_17	Mardella Run	Offutt Ridge	149.4	Mod.	Mod.	X	X	X	X	X	X		No	50

APPENDIX G:

SUPPORTING CALCULATIONS FOR NSA ANALYSES

Supporting Calculations for NSA Analyses

Downspout Disconnection

Table 4-2 in the Upper Patapsco watershed characterization report summarizes rooftop acres addressed by downspout redirection for the recommended neighborhoods. The method by which this column was calculated is described below.

Rooftop Acres Addressed

NSAs not recommended for downspout disconnection contribute 0 acres to this analysis. Rooftop acres addressed by disconnecting downspouts in a recommended neighborhood were calculated as follows:

Acres of Buildings x %Connected Downspouts

For example, NSA_N_6 was recommended for downspout redirect and has a total of 8.80 acres of buildings (i.e., rooftop) based on Baltimore County's GIS buildings layer. During the uplands survey, it was estimated that 35% of the downspouts in NSA_B_1 were connected. Therefore, the total rooftop acres addressed by disconnecting downspouts in NSA_B_1 would be 8.80 acres x 0.35 = 3.08 acres.

% of Subwatershed NSA Rooftop Area Addressed

For a given subwatershed, the % of subwatershed rooftop area addressed was calculated as:

Σ Individual NSA Rooftop Acres Addressed / Total NSA Rooftop Acres

The total acres of rooftop within a subwatershed were determined using Baltimore County's GIS buildings layer.

Fertilizer Reduction/Education

Error! Reference source not found. in the Upper Patapsco watershed characterization report summarizes the acres of lawn addressed by fertilizer reduction for the recommended neighborhoods. The method by which this column was calculated is described below.

Acres of Lawn Addressed

NSAs not recommended for fertilizer reduction (i.e., have less than 20% high maintenance lawns) contribute 0 acres to this analysis. Acres of lawn addressed by fertilizer reduction/education in a recommended neighborhood were calculated as follows:

(NSA Total Acres - NSA Road Acres) x %Lot Grass Cover x %High Maintenance Lawns

The first expression in parentheses in the equation above represents the total acres of individual lots in an NSA. Multiplying this by the % of grass cover estimated for a typical lot in the NSA yields the total acres of lawn in an NSA. Finally, multiplying this result by the % of lawns using high management lawn practices yields the acres of lawn that would be addressed via fertilizer reduction.

For example, NSA_B_20 was recommended for fertilizer reduction and has a total area of 120.0 acres. Based on Baltimore County's GIS roads layer, there are approximately 4.8 acres of roads in this NSA. This means NSA_B_20 consists of approximately 120.0 – 4.8 = 115.2 acres for individual lots. During the uplands survey, it was estimated that the average lot in NSA_B_20 consists of 77% grass cover which equates to 115.2 acres x 0.77 = 88.7 total acres of lawn. It was also noted that about 30% of the lawns in NSA_N_1 were employing high maintenance practices. So, there are approximately 88.7 acres x 0.30 = 26.6 acres of high maintenance lawn that could be addressed by fertilizer reduction in NSA_B_20

<u>% of Subwatershed NSA Lawn Area Addressed</u>

For a given subwatershed, the % of the total NSA lawn area addressed was calculated as:

Σ Individual NSA Lawn Acres Addressed / Total NSA Lawn Acres

BayScaping

Table 4-4 in the Upper Patapsco watershed characterization report summarizes the acres of land addressed by BayScaping for the recommended neighborhoods. The method in which this column was calculated is described below.

<u>Acres of Land Addressed</u>

NSAs not recommended for BayScaping contribute 0 acres to this analysis. According to CWP, the minimum recommended proportion of BayScaping is 25% of an individual lot. To determine the percent of the lots available, the current landscaping percentage was subtracted from the current percentage of the lot covered in grass:

%Lot Available for BayScaping = %Lot Grass Cover - %Lot Landscaping

Acres of land addressed by BayScaping in a recommended neighborhood were calculated as follows:

(NSA Total Acres - NSA Road Acres) x %Lot Available for BayScaping

The first expression in parentheses in the equation above represents the total acres of individual lots in an NSA.

Multiplying these two factors yields the total acres of land in an NSA recommended/available for BayScaping. NSA_B_13 was 69.3 acres and was recommended for BayScaping. It has approximately 4.6 acres of roads. This means NSA_B_13 consists of approximately 69.3 – 4.6 = 64.7 acres for individual lots. During the uplands survey, it was estimated that the average lot in NSA_B_13 consists of 75% grass cover and 5% landscaping, which means 70% would be recommended for BayScaping. This equates to 64.7 acres x 0.70 = 45.3 acres of land that could be addressed by BayScaping in this NSA.

For a given subwatershed, the % of the total NSA area addressed was calculated as:

Σ Individual NSA Land Acres Addressed / Total NSA Acres

Storm Drain Marking

Table 4-5 in the Upper Patapsco watershed characterization report summarizes the number of inlets and % of subwatershed inlets addressed by storm drain marking for the recommended neighborhoods. The method in which these two columns were calculated is described below.

Approximate Number of Inlets Addressed

NSAs not recommended for storm drain marking contribute 0 inlets to this analysis. The approximate number of inlets addressed in a neighborhood recommended for storm drain marking was calculated as follows:

NSA # of Inlets x NSA % of Inlets Not Marked

For example, NSA_B_4 was recommended for storm drain marking and has a total of 59 inlets. 100% of the inlets in NSA_B_4 were determined to have no storm drain markings. Therefore, 59 inlets x 1.00 = 59 storm drain inlets need to be addressed in this NSA.

% of Subwatershed Inlets Addressed

For a given subwatershed, the % of the total subwatershed inlets addressed was calculated as:

Σ Individual NSA Inlets Addressed / Total Subwatershed Inlets

APPENDIX H:

WATER QUALITY ANALYSES (WQA) FOR THE UPPER PATAPSCO AND THE CHESAPEAKE BAY TOTAL MAXIMUM DAILY LOAD (TMDL)

(Available on CD)

APPENDIX I:

ACCESS DATABASES AND OTHER ELECTRONIC DOCUMENTS

(Available on CD)