Liberty Reservoir
Small Watershed Action Plan

Volume I

Prepared for:

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List of Acronyms and Abbreviations

BMP	Best Management Practice
CBP	Chesapeake Bay Program
CRP	Community Reforestation Program
CWA	Clean Water Act
CWP	Center for Watershed Protection
DA	Drainage Area
DNR	Department of Natural Resources
EPS	Environmental Protection and Sustainability
ESD	Environmental Site Design
GIS	Geographic Information System
HSI	Hotspot Site Investigation
ISI	Institutional Site Investigation
LU/LC	Land Use/ Land Cover
MDA	Maryland Department of Agriculture
MDE	Maryland Department of the Environment
MDP	Maryland Department of Planning
NPDES	National Pollutant Discharge Elimination System
NPS	Nonpoint Source
NSA	Neighborhood Source Assessment
PAA	Pervious Area Assessment
PSI	Pollution Severity Index
ROI	Restoration Opportunity Index
SCA	Stream Corridor Assessment
SCD	Soil Conservation District
SHA	State Highway Administration
SWAP	Small Watershed Action Plan
SWM	Stormwater Management
TMDL	Total Maximum Daily Loads
TN	Total Nitrogen
TP	Total Phosphorus
TSS	Total Suspended Solids
URDL	Urban/Rural Demarcation Line
USEPA	United States Environmental Protection Agency
WIP	Watershed Implementation Plan

ACKNOWLEDGEMENTS

LIBERTY RESERVOIR STEERING COMMITTEE

Organization	*Representative*
Carroll County Government	Janet O'Meara
Patapsco Heritage Greenway	Betsy McMillion
Hanover Road Association	Paul Joyce, S. Glenn Elseroad
Reisterstown Improvement Association	Carin Smith
Baltimore City – Department of Public Works – Reservoir Natural Resources	Clark Howells, Bill Felter, Kelly Spencer, Mike Luh
Pearlstone Center	Miriam Glaser
Baltimore County Department of Planning	Wallace Lippincott
Holbrook Community	Bill Klingelhofer, David Schloss
Franklin County High School Student	Sylvie Lass
Gunpowder Valley Conservancy	Charlie Conklin
Baltimore County Soil Conservation District	Jim Ensor
Baltimore County Department of Environmental Protection and Sustainability (EPS)	Erin Wisnieski, Steve Stewart
Parsons Brinckerhoff	Kate Klavon, Kristine Bronnenkant

TECHNICAL ASSISTANCE/REPORTS

Technical Report	*Representative*
Upland Surveys (Neighborhood Source Assessments, Hotspot Assessments, and Institutional Site Assessments) and Stream Corridor Assessments	Erin Wisnieski, Steve Stewart - EPS Parsons Brinckerhoff, Inc. in association with NMP Engineering Consultants, Inc. and Coastal Resources, Inc.
Watershed Characterization	Parsons Brinckerhoff, Inc.

CHAPTER 1: INTRODUCTION

1.1 Purpose

This Small Watershed Action Plan (SWAP) is a strategy for the restoration of the Liberty Reservoir watershed. This report presents recommendations for watershed restoration, describes management strategies for each of the 14 subwatersheds comprising Liberty Reservoir, and identifies priority projects for implementation. A schedule for implementation through 2030 is presented in addition to planning level cost estimates where feasible. Financial and technical partners for plan implementation are suggested for the various recommendations. This SWAP is intended to assist the Baltimore County Department of Environmental Protection and Sustainability (EPS) and other partners to keep moving forward with restoration of Liberty Reservoir. Figure 1-1 provides a graphic representation of the planning area covered in this SWAP.

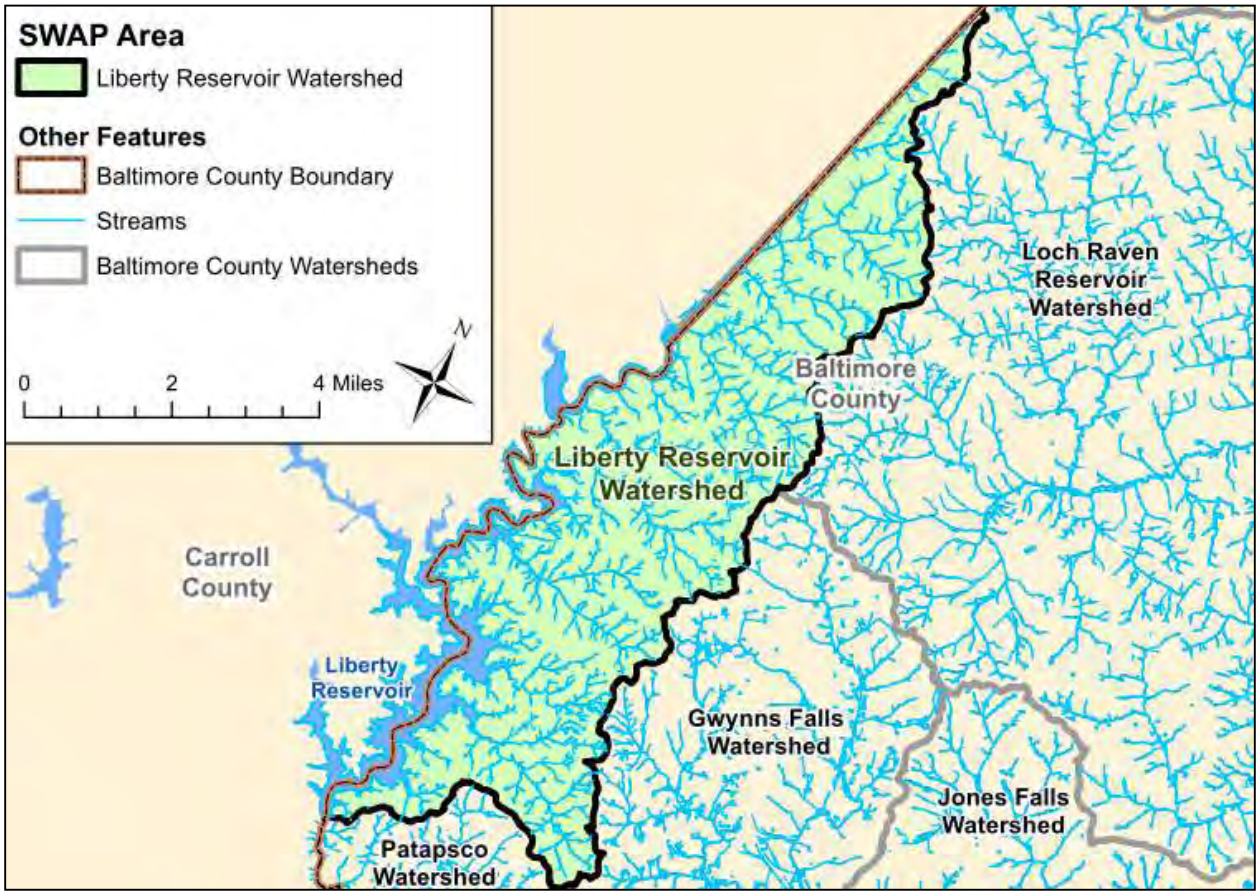

Figure 1-1: Location of Liberty Reservoir Watershed

1.2 Background

A SWAP identifies strategies for bringing a small watershed into compliance with water quality criteria. Strategies include a combination of government capital projects, actions in partnership with local citizens groups, citizen awareness campaigns, and volunteer activities. Effective implementation of watershed

restoration strategies requires the coordination of all watershed partners and the participation of many stakeholders.

Over the past six months, Liberty Reservoir 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 key watershed partners, was formed to develop the Liberty Reservoir SWAP. This includes Baltimore County personnel and leaders from the local community. The Steering Committee met regularly throughout SWAP development. Liberty Reservoir Steering Committee members are listed below:

Baltimore City – Department of Public Works – Reservoir Natural Resources	……	Clark Howells, Bill Felter, Kelly Spencer, Mike Luh
Baltimore County Department of Environmental Protection and Sustainability (EPS)	……	Erin Wisnieski, Steve Stewart
Baltimore County Department of Planning	……	Wallace Lippincott
Baltimore County Soil Conservation District	……	Jim Ensor
Carroll County Government	……	Janet O'Meara
Gunpowder Valley Conservancy	……	Charlie Conklin
Hanover Road Association	……	Paul Joyce, S. Glenn Elseroad
Holbrook Community	……	Bill Klingelhofer, David Schloss
Parsons Brinckerhoff	……	Kate Klavon, Kristine Bronnenkant
Patapsco Heritage and Greenway	……	Betsy McMillion
Pearlstone Center	……	Miriam Glaser
Reisterstown Improvement Association	……	Carin Smith
Franklin High School Student	……	Sylvie Lass

In addition, since the participation of many stakeholders is an essential component for effective watershed restoration, two stakeholder meetings were held during SWAP development. Stakeholder meetings are intended to raise citizen awareness and solicit feedback from neighborhood residents, local community leaders, institutions, and business associations regarding watershed restoration strategies. A description of each stakeholder meeting including date, approximate number of attendees and topics covered, is provided below:

- ***Stakeholder Meeting #1*** (February 2, 2015; 24 attendees): This meeting included an introduction of the SWAP process and the Liberty Reservoir SWAP Steering Committee

members. A description of the watershed, the county's goals, environmental requirements (see Section 1.3), and a SWAP framework were presented. The current conditions of the Liberty Reservoir watershed were also presented based on desktop analyses and field assessments conducted. Bill Ensor, from Baltimore County EPS, presented an overview on septic system maintenance. A Vision & Goals Questionnaire was conducted during the meeting where attendees were asked to rate the importance of a list of four watershed goals. Attendees were also given an opportunity to fill out a "blue card" to report the type and location of environmental problems (e.g. dumping, erosion, illicit discharges, etc.) in the watershed. An "actions survey" was conducted to gage citizens' interest in potential restoration activities. The results of the surveys were used later to identify rates of participation for certain restoration actions that are recommended for the watershed.

- ***Stakeholder Meeting #2*** (Scheduled for March 18, 2015)

1.3 Environmental Requirements

The SWAP was developed to satisfy environmental program requirements while also meeting citizen needs for a healthy environment, clean water, and an aesthetically pleasing community. The following environmental program requirements were considered during the development of this SWAP and are briefly described in the subsequent sections:

- National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) permit assessment and planning requirements
- Local Total Maximum Daily Load (TMDL) reductions for the Liberty Reservoir including total phosphorus, sediment, and fecal bacteria

1.3.1 NPDES MS4 Permits

Many requirements of Baltimore County's NPDES permit (11-DP-3317, MD0068314) will be addressed by this plan. One of these requirements is the systematic assessment of water quality and development of restoration plans for all watersheds within the County. This assessment must include the following:

- Source identification information based on GIS data
- Determination of current water quality conditions
- Identification and ranking of water quality problems
- Results of visual watershed inspections
- Identification of structural and non-structural water quality improvement opportunities
- Specification of overall watershed restoration goals

The County's NPDES permit (effective December 2013) also requires the County to address 20% of the untreated impervious cover during each 5-year permit term (MDE, 2013). It is anticipated that future permits will have the same requirement. To date, restoration projects have addressed 17.6% of the impervious cover county-wide and 2.4% of the impervious cover in the entire Liberty Reservoir watershed with the majority of restoration being done outside of the Liberty Reservoir watershed and within the Urban/Rural Demarcation Line (URDL) (EPS, 2014). As of October 2013, restoration actions and

stormwater management have reduced county-wide urban stormwater loads of phosphorus by 17.8% and nitrogen by 6.4% (EPS, 2013).

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.

1.3.2 303(d) Listing and Total Maximum Daily Loads (TMDLs)

The 303(d) list is comprised of waters that are impaired or threatened by a pollutant and are in need of a TMDL. According to the United States Environmental Protection Agency (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 Liberty Reservoir planning area (Area S) contains approximately 16% of the total Liberty Reservoir drainage area, which includes portions of Baltimore and Carroll counties. The Liberty Reservoir impoundment is listed as impaired for numerous pollutants of concern including: sedimentation and siltation (1996 listing) and total phosphorus (1996 listing). The Liberty Reservoir tributaries, are listed as impaired for fecal coliform (2002 listing), chlorides (2012 listing), and temperature (2014 listing).

Every two years, the 303 (d) list within *Maryland's Integrated Report (IR) of Surface Water Quality* is updated. While Maryland's Final 2012 IR is the latest finalized report (MDE, 2012), Maryland's Draft 2014 IR is currently under review by the USEPA and is available for viewing at this time (MDE, 2014b). Once the USEPA approves the IR, it will become the Final 2014 IR. The impairment listings for Liberty Reservoir are shown in Table 1-1.

Table 1-1: Liberty Reservoir Watershed Water Quality Impairment Listing and Status

		2012 Final Integrated Report			2014 Draft Integrated Report		
Impairment	Applicable Segment	Listing Category	Status	Approval Date	Listing Category	Status	Approval Date
Escherichia coli	MD-02130907	4a	TMDL	2009	4a	TMDL	2009
Sedimentation/ siltation	MD-02130907	5	Impaired	N/A	4a	TMDL	2014
Phosphorus	MD-02130907	5	Impaired	N/A	4a	TMDL	2014
Mercury	MD-02130907	5	Impaired	N/A	2	Removed	2014
Chlorides	MD-02130907	5	Impaired	N/A	5	Impaired	N/A
Temperature	MD-021309071046-Locust Run	-	-	-	5	Impaired	N/A
Temperature	MD-021309071048-Keyser Run	-	-	-	5	Impaired	N/A
Temperature	MD-021309071048-Timber Run	-	-	-	5	Impaired	N/A
Temperature	MD-021309071048-Glen Falls Run	-	-	-	5	Impaired	N/A

Note that in 2014, a Water Quality Assessments (WQA) was approved for the Liberty Reservoir impoundment in response to impairment listings for mercury. The WQA justified the classification of mercury under category 2 of the Integrated Report listings, meaning the Liberty Reservoir was meeting water quality standards for mercury (MDE, 2014d).

In addition to the impairments listed for the watershed, Liberty Reservoir has three additional listings. Chromium, lead, and polychlorinated biphenyl (PCB) in fish tissue were listed under Category 2, meaning the reservoir meets the criteria for these pollutants, as documented in a WQA accepted in 2003 for chromium and lead (MDE, 2003). PCBs were listed with concentrations below the threshold and therefore a Water Quality Report was not required.

Nutrient and sediment, particularly addressing the Liberty Reservoir TMDL for phosphorus and sediment load reduction requirements, are the main focus of this SWAP document. The Liberty Reservoir TMDL is broken up by land use. The agricultural source sector reductions are developed and tracked by the Maryland Department of Agriculture with input from the local Soil Conservation Districts. Baltimore County is responsible for producing a strategy addressing its required urban stormwater load reductions of 49% for total phosphorus and 38% for sediment (MDE, 2014e). Typically, these reduction goals also yield credit toward the Chesapeake Bay restoration; however, the Liberty Reservoir dam and on-going release of water to the municipal water supply system prevents the delivery of any phosphorus and

sediment to the Chesapeake Bay. As a result, the local reductions in the Liberty Reservoir will not provide any credit towards the Chesapeake Bay reduction goals. Baltimore County is addressing the Chesapeake Bay TMDL through its Watershed Implementation Plan (WIP) in two-year milestones.

1.4 USEPA Watershed Planning A-I Criteria

The Clean Water Act (CWA) was amended in 1987 to establish the Section 319 Nonpoint Source Management Program, after recognizing the need for federal assistance to focus state and local nonpoint source efforts. Under this section, states, tribes, and territories can receive grant money for the development and implementation of programs aimed at reducing nonpoint source (NPS) pollution. NPS pollution comes from many different sources and is a result of human activities on the land. It is caused by pollutants from human activities and atmospheric deposition that are deposited on the ground and eventually carried to receiving waters by stormwater runoff. Common NPS pollutants and sources include (USEPA, 2012):

- Excess fertilizers, herbicides, and insecticides from agricultural lands and residential areas
- Oil, grease, and toxic chemicals from urban runoff and energy production
- Sediment from improperly managed construction sites, crop and forest lands, and eroding stream banks
- Salt from irrigation practices and winter road clearing activities
- Bacteria and nutrients from livestock, pet wastes, and failing septic systems

CWA Section 319 grant funds can be requested to support various activities such as technical assistance, financial assistance, education, training, technology transfer, restoration projects, and monitoring to assess the success of specific nonpoint source implementation projects. Watershed-based plans to restore impaired water bodies and address NPS pollution using incremental Section 319 funds must meet the United States Environmental Protection Agency's (USEPA) A through I criteria for watershed planning (USEPA, 2003):

A. An identification of the causes and sources or groups of 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 NPS management measures

C. A description of the NPS management measures that will need to be implemented

D. An estimate of the amounts of technical and financial assistance 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 for the NPS management measures

H. A set of criteria to determine load reductions and track substantial progress towards attaining water quality standards

I. A monitoring component to evaluate effectiveness of the implementation records over time

Table 1-2 summarizes the location(s) within this document where each criterion is addressed.

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	✓		✓						
Appendix F									
Appendix G									
Appendix H									
Appendix I									
Appendix J									

1.5 Regional Reservoir Agreement and County Master Plan

The Reservoir Watershed Management Agreement and the Baltimore County Master Plan are two formal documents that address water quality and land use in the Liberty Reservoir watershed. The Reservoir Watershed Agreement was signed in 2005 by multiple government agencies including Baltimore County, Baltimore City, Carroll County, Maryland Department of the Environment, Maryland Department of Agriculture, Baltimore and Carroll Counties Soil Conversation Districts, Reservoir Watershed Protection Committee (RWPC) and Baltimore Metropolitan Council (BMC). As a participating partner, Baltimore County has agreed to make voluntary commitments to implement actions to reach established water quality goals in the reservoir watersheds. Actions include monitoring the reservoirs and major tributaries, watershed modeling, issuing discharge permits (NPDES), promoting agricultural Best Management Practices (BMPs), continuing the implementation of stormwater management regulations, administering sewer and septic regulations and inspections, aiding urban nutrient reductions, and overall land management through conservation and strategic development (BRWMP, 2005). Supporting the Reservoir Agreement and implementing proposed water quality action strategies will also help the county meet local and regional TMDL goals.

The Baltimore County Master Plan is a guiding document for future development within Baltimore County with the goal of protecting the environment, preserving agriculture, and ensuring a safe and attractive place to live and work (DP, 2010). The plan aims to concentrate development and redevelopment within the URDL. The report also emphasizes the importance of resource conservation with a preservation goal of at least 80,000 acres of land to protect agriculture and natural resources (DP, 2010). Supporting the

Baltimore County Master Plan to limit development outside the URDL and promote land preservation will help maintain the rural nature of the watershed and prevent further deterioration in water quality.

1.6 Partner Capabilities

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

1.6.1 Baltimore County

Baltimore County has a waterway restoration program to implement restoration projects, including stream restoration, stormwater conversions and retrofits, and reforestation projects. Baltimore County has an extensive monitoring program that assesses the current ambient water quality, efficiency of various restoration projects in relation to pollutant removal and biological community improvement, and tracks trends over time. The County also has an illicit discharge and elimination program that monitors and rates storm drain outfalls, tracks pollutant sources, and coordinates remediation.

1.6.2 Baltimore City Reservoir Natural Resources Section

Baltimore City's Reservoir Natural Resources Section is responsible for the management and protection of the Loch Raven, Prettyboy, and Liberty Reservoirs and their surrounding City-owned buffer lands. The Liberty Reservoir planning area drains to the Liberty Reservoir. The Reservoir Natural Resources Section is committed to the protection of the reservoirs and contiguous watershed lands from outside influences that would adversely impact the drinking water resource and interfere with providing the highest quality public water supply to approximately 1.8 million consumers within the Baltimore metropolitan area.

1.6.3 Local Businesses and Civic Organizations

A variety of community businesses and civic organizations in the Liberty Reservoir planning area have a vested interest in improving water quality in the watershed. Each of these organizations will have an important role in achieving the goals and objectives of the SWAP. Community representatives involved with the planning process include representatives from Reisterstown Improvement Association (RIA), Hanover Road Association, and the Holbrook Community.

1.6.4 Maryland State Highway Administration

Maryland's State Highway Administration (SHA) operates and maintains several major roadways in the watershed including I-795. As a public entity possessing its own NPDES permit for stormwater discharges, SHA is also subject to the pollution reduction requirements of the Chesapeake Bay TMDL. In addition, as chlorides from road salts are a major pollutant of concern in the watershed, coordination of water quality improvements between Baltimore County and SHA is important in achieving restoration of surface and ground waters in the area.

1.6.5 Baltimore County Soil Conservation District

The Soil Conservation District (SCD) of Maryland work with local, State, and Federal authorities as well as the private sector to address each County's soil and water conservation needs. Local landowners and residents have access to technical services through the soil conservation district that help them install soil conservation practices on their lands that reduce erosion and improve water quality. Specifically, the SCD aims to work with farmers to install conservation practices on agricultural land.

1.7 Liberty Reservoir Watershed Overview

The total study area of the Liberty Reservoir SWAP is comprised of 14 subwatersheds that drain to the Liberty Reservoir. The total planning area is approximately 16,449 acres (26 square miles) as shown in Table 1-3.

Table 1-3: Liberty Reservoir Subwatershed Areas

Subwatershed	Area (Acres)	Area (Sq Miles)
Board-Aspen Run	758	1.18
Cliffs Branch	3,142	4.91
Glen Falls Run	2,059	3.22
Liberty Reservoir-B	638	1.00
Keyser Run	1,006	1.57
Liberty Reservoir-E	280	0.44
Norris Run	1,790	2.80
Liberty Reservoir-C	391	0.61
Timber Run	932	1.46
Cooks Branch	786	1.23
Liberty Reservoir-F	2,014	3.15
Chimney Branch	439	0.69
Liberty Reservoir-A	786	1.23
Locust Run	1,428	2.23
Total	***16,449***	***25.70***

As shown in Figure 1-2, the Liberty Reservoir watershed was subdivided for planning and management purposes into 14 subwatersheds. The smaller drainage areas of the subwatersheds are intended to focus restoration, preservation, and monitoring efforts. The *Liberty Reservoir Watershed Characterization Report* includes detailed analyses and descriptions of the current watershed conditions and potential water quality issues and is included as Appendix E of this report. A summary of the key watershed characteristics for the Liberty Reservoir watershed based on the characterization report is provided in Table 1-4.

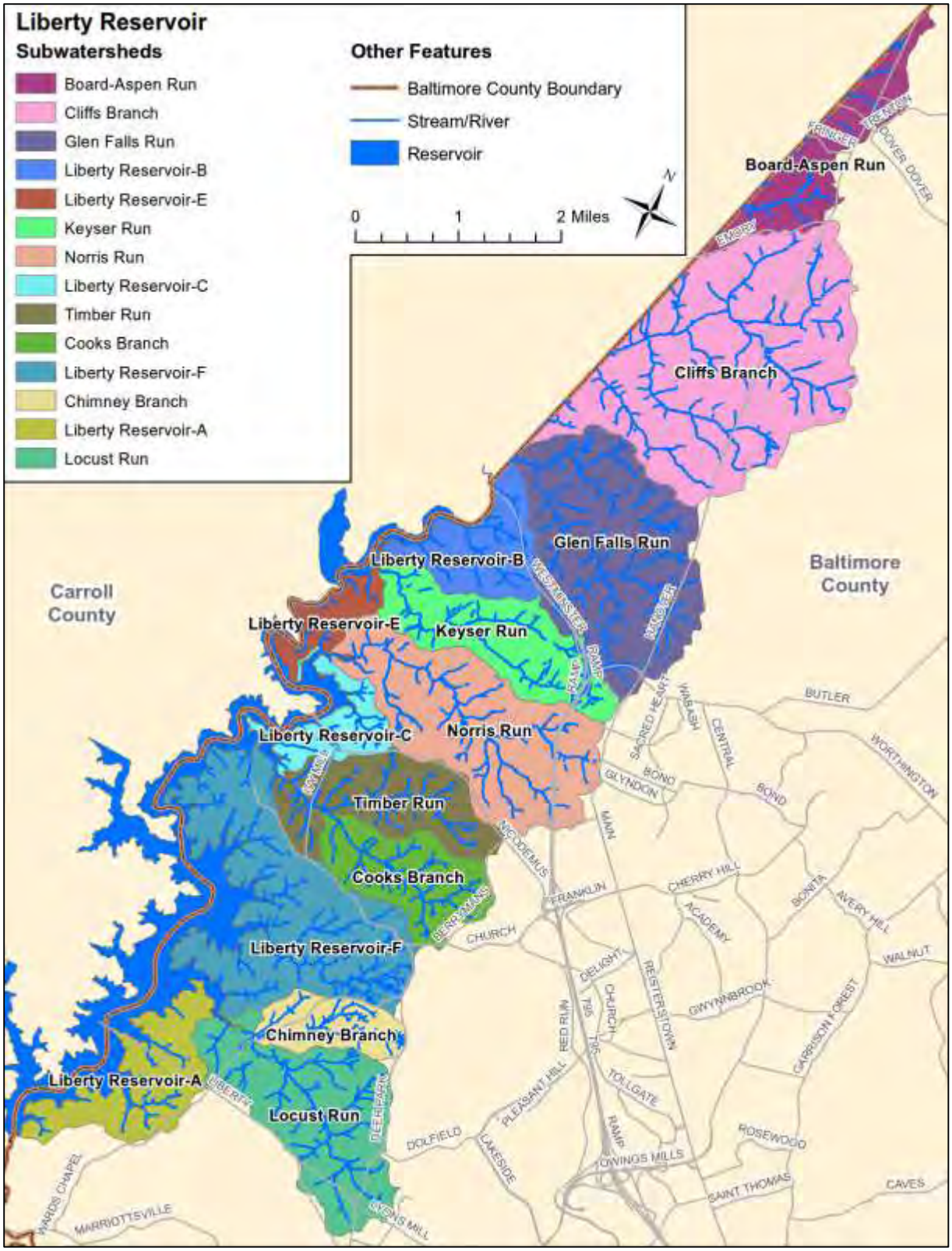

Figure 1-2: Liberty Reservoir SWAP Planning Area and Subwatersheds

Table 1-4: Liberty Reservoir Key Watershed Characteristics

Drainage Area	16,449	Acres	
	25.70	sq. mi.	
Stream Length	157.1	Miles	
Population	14,633	(2010 Census)	
	0.89	persons/acre	
Land Use/Land Cover	Very Low Density Residential:		9.3%
	Low Density Residential:		14.8%
	Medium/High Density Residential:		1.5%
	Commercial:		1.6%
	Industrial:		0.0%
	Institutional:		1.6%
	Open Urban:		1.5%
	Agriculture:		24.5%
	Forest:		42.1%
	Transportation:		0.5%
	Other:		2.5%
Land in Easement	6,570	Acres	39.9%
Impervious Cover	709	Acres	4.3%
Soils	A Soils (low runoff potential):		0.0%
	B Soils:		64.8%
	C Soils:		16.0%
	C/D Soils:		2.9%
	D Soils (high runoff potential):		15.5%
	Water:		0.9%

1.8 Report Organization

This report is organized into the following five major chapters:

Chapter 1 explains the purpose of this report including underlying environmental requirements and key watershed characteristics.

Chapter 2 presents the watershed vision, goals, and objectives for restoring the Liberty Reservoir watershed.

Chapter 3 describes the types of watershed restoration practices recommended for the Liberty Reservoir and estimated pollutant load reductions.

Chapter 4 discusses prioritization of the 14 subwatersheds in the Liberty Reservoir watershed and summarizes subwatershed-specific restoration strategies.

Chapter 5 presents the implementation plan restoration evaluation criteria and monitoring framework.

This volume (Volume I) also includes the following appendices with additional, detailed information used to develop and support this SWAP:

- Appendix A: Liberty Reservoir Action Strategies
- Appendix B: Cost Analysis and Potential Funding Sources
- Appendix C: Pollutant Load Reduction Efficiencies
- Appendix D: Liberty Reservoir SWAP Uplands Assessment Map

A second volume (Volume II) includes the following appendices with supporting documentation related to the current conditions of the Liberty Reservoir watershed:

- Appendix E: Liberty Reservoir Watershed Characterization Report
- Appendix F: Total Maximum Daily Loads of Phosphorus and Sediments for Liberty Reservoir, Baltimore and Carroll Counties, Maryland and Technical Memorandum: Significant Phosphorus and Sediment Point Sources in the Liberty Reservoir Watershed
- Appendix G: Total Maximum Daily Loads of Fecal Bacteria for the Liberty Reservoir Basin in Carroll and Baltimore County, Maryland
- Appendix H: Water Quality Analysis of Chromium and Lead for the Liberty Reservoir Impoundment in Baltimore and Carroll Counties, Maryland
- Appendix I: Water Quality Analysis of Mercury in Fish Tissue in Liberty Reservoir in Baltimore and Carroll Counties, Maryland
- Appendix J: Watershed Report for Biological Impairment of the Liberty Reservoir Watershed in Baltimore and Carroll Counties, Maryland Biological Stressor Identification Analysis Results and Interpretation

CHAPTER 2: VISION, GOALS AND OBJECTIVES

2.1 Vision Statement

The Liberty Reservoir Steering Committee adopted the following vision statement that served as a guide in the development of the SWAP:

> *We envision that the people who live, work, and visit in the watershed will protect and preserve the land and water in a way that supports clean drinking water and healthy streams and forest for generations to come.*

2.2 Liberty Reservoir SWAP Goals & Objectives

A total of four goals were identified for restoring the Liberty Reservoir watershed based on the vision statement and input from both Steering Committee and Stakeholder meetings. The goals were developed through discussions with the Liberty Reservoir SWAP Steering Committee and refined based on feedback from watershed residents at the Stakeholder meetings. Stakeholders were given the opportunity to rank the importance of goals, raise additional issues important to the community, and indicate restoration activities of interest to achieve watershed goals. Stakeholder participation is important to ensure the implementation and success of the plan.

The following sections present a discussion of each of the four goals for restoring and preserving the Liberty Reservoir watershed. For each goal, a series of objectives was developed to ensure that the plan will meet each goal. 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 "implement stormwater retrofits to treat runoff" in a given watershed. The action strategies developed to achieve these objectives and goals are summarized in Appendix A and discussed further in Chapter 3.

When possible, action strategies are expressed as quantifiable measures (e.g., linear feet of forested buffer planted). However, the numerical 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, Table A-1 list the action strategies proposed for Liberty Reservoir and their applicable goals and objectives.

The general types of restoration strategies proposed for the Liberty Reservoir watershed are discussed further in Chapter 3.

Goal 1: Restore and maintain clean water to applicable water quality standards

As part of the Liberty Reservoir TMDL requirements, Baltimore County is required to reduce the phosphorus and sediment loadings into the Liberty Reservoir impoundment by the year 2030. Percentage reductions will be measured against the baseline year of 2009. In addition, as part of the Liberty Reservoir watershed non-tidal tributaries TMDL requirements, Baltimore County is also required to reduce the fecal coliform within the watershed that drains to the impoundment. Other impairments in the watershed that do not yet have TMDL reduction requirements include chloride and temperature. The objectives below are designed to meet the phosphorous and sediment TMDL reduction requirements in the watershed while also decreasing the release of other toxins causing impairments to the watershed.

Objectives:

1. Reduce annual average Total Phosphorous urban loads by 49% to meet the reservoir TMDL goals.
2. Reduce annual average Total Sediment urban loads by 38% to meet the reservoir TMDL goals.
3. Reduce the presence of Bacteria in tributaries from urban stormwater to meet TMDL goals.
4. Reduce annual average Total Chloride urban loads.
5. Decrease the average annual Temperature in waterways.

Goal 2: Increase citizen awareness and participation through outreach and restoration projects

Successful watershed restoration and preservation can only occur when current and future generations develop a commitment to the resolution of environmental issues. Only by increasing citizen awareness of the Liberty Reservoir watershed condition and engaging citizens to participate in restoration and preservation activities can watershed restoration be achieved and maintained in the future.

Objectives:

1. Coordinate with local citizen groups to encourage participation in local restoration opportunities to increase the number and variety of watershed restoration projects in the watershed.
2. Raise awareness among citizen groups and local families concerning watershed and habitat degradation and encourage modified behaviors.

Goal 3: Improve and maintain the biological health of local streams and their riparian buffers

Physical damage to streams has resulted over time from the development, poor land management practices, introduction of invasive species, and other human interactions. The objectives for this goal relate to the improvement of degraded surface waters that result in poor conditions for habitat.

Objectives:

1. Encourage riparian buffer preservation and plantings to help stabilize stream banks, lower water temperatures, and reduce pollutant laden sediment from entering the stream channels
2. Develop and sustain healthy populations of aquatic and terrestrial wildlife by improving the physical habitat of streams.
3. Protect the Tier II streams located in the watershed

Goal 4: Restore and maintain tree canopy and forest coverage in the watershed

Healthy, vibrant forests create significant ecological impact on a watershed through influences on air quality, water quality, and wildlife habitat. From absorbing pollutants in the air to pollutants in rainfall and runoff, trees are a vital part of decreasing nutrient loads in watersheds. In addition, planting trees in neighborhoods can increase property values and reduce energy use. The objectives below promote tree health in the watershed including neighborhoods, businesses, and institutions.

Objectives:

1. Improve and maintain tree canopy and forest coverage on public and private land.
2. Manage deer at a healthy herd population that reduces their impacts on forest habitat.

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 and preserving the Liberty Reservoir watershed. A complete list of actions proposed for the watersheds 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 restoration of the Liberty Reservoir watershed will occur as a partnership between the local government, citizens groups, and businesses. 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. Citizens' groups are able to implement locally-based programs such as tree plantings, storm drain marking, 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 is 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 and septic sources within the Liberty Reservoir watershed is discussed in Section 3.5.1. Section 3.5.2 discusses the pollutant removal calculations for proposed practices (i.e., key restoration strategies discussed in Sections 3.2, 3.3, and 3.4) to ensure that regulatory requirements are met in Liberty Reservoir.

3.2 Municipal Strategies

Baltimore County works to restore local streams and improve water quality through capital improvement projects and municipal management activities (e.g. development review, street sweeping, illicit connection programs, etc.). This plays an important role in the SWAP implementation process. Key municipal strategies proposed for restoring Liberty Reservoir are discussed in the following sections.

3.2.1 Stormwater Management

Increased importance of water quality and water resource protection has led to the development of the Maryland Stormwater Design Manual which provided BMP design standards and environmental incentives (MDE, 2000). Since that time there has been a general shift towards adopting low-impact practices that mimic natural hydrologic processes and achieve pre-development conditions. The Maryland Stormwater Act of 2007 takes those principles one step further and requires that environmental site design (ESD) be implemented to the maximum extent practicable via nonstructural BMPs and/or other better site design techniques. The intent of ESD BMPs is to distribute flow throughout a development site

and reduce stormwater runoff leaving the site. This will also reduce pollutant loads and prevent stream channel erosion.

3.2.1.1 Existing Stormwater Management

A total of 101 existing stormwater management facilities are located within the Liberty Reservoir watershed including dry ponds, underground detention, wetlands, infiltration practices, filtration practices, extended detention, and grass swales. Existing stormwater management (SWM) facilities treat a total drainage area of approximately 582 acres of land or approximately 4% of the watershed.

3.2.1.2 Stormwater Retrofits

Stormwater retrofits involve implementing BMPs in existing developed areas where SWM practices do not currently exist to help improve water quality. Stormwater retrofits improve water quality by capturing and treating runoff before it reaches receiving water bodies. Based on initial field and desktop evaluations, several sites with sufficient open space for stormwater retrofits to treat runoff from impervious parking lots or roadways were identified. These sites were located in multiple upland institutional areas surveyed. Although not included in pollutant reduction calculations, privately owned hotspots with potential for stormwater retrofits were also identified.

3.2.1.3 Impervious Cover Removal

Impervious surfaces include roadways, parking lots, roofs, and other paved surfaces that prevent precipitation from naturally seeping into the ground. As a result, impervious surface runoff can result in erosion, flooding, habitat destruction, and increased pollutant loads to receiving water bodies. Subwatersheds with higher amounts of impervious cover are more likely to have degraded stream systems and contribute significantly to water quality problems in a watershed. Removing impervious cover and converting to pervious or forested land promotes infiltration of runoff and reduces pollutant loads. Unused or unmaintained impervious surfaces with the potential for removal were identified at several institutions. The areas of these impervious surfaces were used to estimate potential pollutant load reductions as a result of impervious cover removal activities.

3.2.1.4 Stormwater Education and Outreach

While not included in pollutant reduction calculations, education and outreach tools can 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.

3.2.2 Stream Restoration

Stream restoration practices are used to enhance the aquatic function, appearance, and stability of stream corridors. Stream restoration practices range from routine, simple stream repairs such as vegetative bank stabilization and localized grade control to comprehensive repairs such as full channel redesign and realignment. Stream corridor assessments (SCAs) performed in the Liberty Reservoir watershed identified restoration opportunities for stream repair and buffer reforestation. Stream segments identified during the SCAs with significant erosion and channel alteration are used to estimate pollutant load reductions which would result from stream repair efforts. Stabilizing the stream channel improves water quality by

preventing soil and the pollutants contained in them, from eroding into the stream and receiving waters. Lengths of eroded and altered channel segments were recorded during the SCAs.

3.2.3 Reforestation

Trees provide air and water quality benefits, as well as aesthetic value. They provide habitat for terrestrial and aquatic wildlife and shade that helps keep water temperatures low. Trees also help slow runoff and absorb nutrients through their root systems. Tree planting incentive programs can help increase the success of planting efforts. Converting open pervious areas into forested areas through tree planting can reduce pollutant loads to nearby water bodies and also reduce erosion. Eight out of the nine pervious area assessments (PAAs) in the Liberty Reservoir planning area had potential for tree planting. Out of the eight PAAs with potential for tree planting, five sites within the Liberty Reservoir watershed are publicly-owned and should be targeted for initial restoration efforts. This would provide approximately 68 acres of county or state-owned acres available for planting.

3.2.4 Illicit Connection Detection/Disconnection

An Illicit Discharge Detection and Elimination program has been developed by Baltimore County to find and remediate discharges into streams that are harmful to aquatic life and water quality or that are causing erosion/sedimentation problems. The County will continue their 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 analysis due to the uncertainty in the contributions of illicit connection to overall pollutant loading rates. However, this program will provide a margin of safety in the overall nutrient reduction strategy.

3.2.5 Sanitary Sewer Consent Decree

In September 2005, USEPA and the Maryland Department of the Environment (MDE) issued a consent decree to Baltimore County with deadlines to reduce and eliminate sanitary sewer overflows (SSOs). 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 Liberty Reservoir surface waters. A summary of the SSOs in Liberty Reservoir watershed can be found in the *Watershed Characterization Report* (Appendix E). As no SSOs have occurred in the Liberty Reservoir watershed since the consent decree was issued in 2005, no potential pollutant load reductions were calculated for SSO elimination.

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 a watershed that would not be possible otherwise. Citizen participation and stewardship is critical to the implementation and long-term

maintenance of restoration activities. Key citizen-based strategies proposed for Liberty Reservoir watershed are discussed in the following sections.

3.3.1 Reforestation

Trees improve water quality by capturing and removing pollutants in runoff including excess nutrients through their roots before the pollutants enter groundwater and streams. Tree leaves and stems also intercept precipitation, reducing the energy of raindrops and preventing excess erosion 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 the Department of Natural Resources (DNR's) Tree-Mendous Maryland program for planting on public or common spaces and Baltimore County's "Big Trees Sale" for planting on private property, can help increase the success of planting efforts. Additionally, for planting on larger properties, especially for reforestation greater than one acre, citizens can contact EPS about opportunities for reforestation "turf-to-trees" projects funded through the stormwater remediation fees. These projects cover site preparation, planting, deer shelters, and monitoring and maintenance for three years.

Riparian Buffer

Stream riparian buffers are critical to maintaining healthy streams and rivers. Forested buffer areas along streams improve water quality and prevent flooding by filtering pollutants, reducing surface runoff, stabilizing stream banks, trapping sediment, and providing habitat for various types of terrestrial and aquatic life. Buffer encroachment as a result of development and agriculture was noted during upland and stream surveys conducted throughout the watershed. Areas on privately-owned land (e.g. residential properties) can be targeted for buffer awareness initiatives to encourage landowners to plant and/or create a no-mow area adjacent to streams. Approximately 39,700 linear feet of inadequate buffer was identified during the SCAs and approximately 860 acres of stream buffer were categorized as open pervious area during desktop analysis. These are good candidates for tree planting and are targeted for initial buffer reforestation efforts.

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. Unutilized, large open areas on private land should be investigated for tree planting potential. Three out of nine PAAs within the Liberty Reservoir watershed are privately owned and should be investigated for restoration efforts.

Shade Tree Plantings

Several opportunities for neighborhood tree plantings were identified during the NSAs. Opportunities for open space, shade tree plantings were also identified at several institutional and hotspot sites. Open space trees provide aesthetic value in addition to air and water quality benefits. They provide shade and absorb nutrients through their root systems while also providing habitat for wildlife. Canvassing residents and/or contacting homeowner associations can be effective techniques for implementing an open space 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

Disconnected downspouts that direct rooftop runoff to pervious surfaces can help reduce runoff and pollutants introduced to local streams. This can be achieved through downspout redirection (from impervious to pervious areas, i.e. driveways to lawns), rain barrels, and/or rain gardens. A combination of outreach and awareness techniques and financial incentives can be used to implement a downspout disconnection program in neighborhoods identified as potential candidates during NSAs. Pilot disconnection programs have been conducted in Upper Back River by Blue Water Baltimore (BWB) and the Center for Watershed Protection (CWP). Results from these programs can be used to inform successful techniques and strategies for Liberty Reservoir.

Rain Gardens

Although not all the neighborhoods were recommended for downspout disconnection, over 31% of the 32 neighborhoods had ample space for rain garden implementation. Rain gardens have many water quality benefits such as filtration of pollutants from runoff, recharging groundwater supply, and reducing total runoff and flooding potential. They also provide beautification to yards, attract and provide habitat for pollinators and birds, and do not require mowing.

3.3.3 Residential 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 a vital, citizen-based strategy. Yards and lawns represent a significant portion of the pervious cover in a subwatershed and act as a major source of polluted 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 trash/yard waste disposal. Residential nutrient management efforts related to lawn maintenance and bayscaping can help reduce polluted runoff to nearby streams.

Lawn Maintenance 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 indicate high lawn maintenance activities. With the passage of Maryland's Fertilizer Use Act in 2011, the amount of phosphorus and nitrogen contained in fertilizers sold in Maryland is regulated, limiting the amounts of nutrients that can be applied to lawns (MDA, 2011). Neighborhoods identified as having high lawn maintenance practices should still be targeted for awareness programs emphasizing responsible fertilizing techniques such as proper application amount, proper time of year for fertilization, 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. Due to the

enactment of the 2011 Fertilizer Use Act, specific pollution reductions for lawn maintenance education are not computed for Liberty Reservoir.

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 stormwater pollution and lawn maintenance requirements. Bayscaping is also beneficial to wildlife. 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 the NSAs. Specific pollution reductions for bayscaping were not computed for Liberty Reservoir.

3.4 Agricultural Best Management Practices

Agriculture makes up approximately 25% of the total land use in the Liberty Reservoir watershed, covering approximately 3,527 total acres. There are many agricultural BMPs used by farmers aimed to reduce soil loss, trap nutrients, and minimize nutrient and pesticide use on land. Chapter 2 of the *Liberty Reservoir Watershed Characterization Report* (Appendix E) lists the current agricultural BMPs being used on farmland throughout the watershed. The Maryland Department of Agriculture in conjunction with the Baltimore County Soil Conservation District works with farms to implement BMPs in an effort to meet water quality standards. While the county does not receive pollution reduction credit for implemented agricultural BMPs, it will continue to work with the agricultural community to help achieve overall pollution reduction goals for the watershed. A few of the major agricultural BMPs being applied in the watershed are explained below.

3.4.1 Farm Conservation Plans

Farm conservation plans are agronomic, management, and engineered practices that protect and improve soil and water quality and prevent deterioration of natural resources on or adjacent to farms. Plans include BMPs to manage the farm's resources, control soil erosion, and protect water quality. The Maryland Department of Agriculture refers to these plans as Soil Conservation and Water Quality plans (SCWQP). These plans are required on farmland enrolled in the Maryland Agricultural Land Preservation Foundation Program and by the Federal Food Security Act on all highly erodible lands. Some of the BMPs that can be included in a farm conservation plan that apply to the Liberty Reservoir planning area are discussed below.

Agricultural Riparian Forest/Grass Buffers

Riparian buffers are wooded or grassy areas along streams that help filter nutrients, sediments, and other pollutants from upland areas and help remove nutrients from groundwater. Forest buffers also help control flooding and reduce erosion while creating habitat for wildlife. Mature forest buffers can help

remove nutrients in stormwater runoff. Grass buffers, have these same advantages but forested buffers are preferable. Agricultural open pervious areas identified within the 100-foot stream buffer during SCAs and through GIS analysis are good candidates for tree planting and should be targeted for initial buffer restoration efforts.

Cover Crops

Implementation of cover crops improves water quality by recycling unused plant nutrients and protecting fields against wind and water erosion. The crops retain excess nitrogen and phosphorus that would likely runoff with stormwater during rain events. This practice can also increase the productivity of farmland and improve the soil for the next year's crops. Maryland nutrient management regulations require farmers to plant cover crops when organic nutrient sources are applied to the field in the fall.

Stream Protection with Fencing

Stream protection with fencing restricts livestock access to waterways. Limited access protects stream buffers from livestock and reduces the effects large animals can have on bank erosion and bacterial contamination from animal waste.

3.4.2 Nutrient Management Plans

As a requirement of the Maryland Water Quality Improvement Act of 1998, all Maryland farmers grossing $2,500 or more annually or raising 8,000 pounds or more of live animal weight are required to produce and operate using a nutrient management plan that addresses nitrogen and phosphorus inputs. The nutrient management plans aim to specify the amount of nutrient sources (i.e. fertilizer, manure, etc.) that can safely be applied to farmland in order to achieve yields and prevent excess nutrients from entering waterways.

3.5 Pollutant Loading & Removal Analyses

This section presents results of the watershed pollutant loading analysis performed to estimate current nutrient and sediment loads generated by the various non-point and septic sources within the Liberty Reservoir watershed. Also discussed are the pollutant removal calculations for proposed BMPs to ensure that TMDL requirements are met in the Liberty Reservoir planning area.

3.5.1 Pollutant Loading Analysis

A pollutant loading analysis was performed to estimate total nitrogen, total phosphorus, and total sediment loads currently generated by all non-point and septic sources present within the Liberty Reservoir watershed.

3.5.1.1 Land-Use Pollutant Loading

Land-use pollutant loading estimates were based on Maryland Department of Planning's (MDP) 2010 Land Use/Land Cover (LU/LC) GIS layer and pollutant loading rates derived by Baltimore County from the Chesapeake Bay Program October 2011 Watershed Model. The pollutant loading analysis is described in detail in Chapter 3.3 of the *Watershed Characterization Report* (Appendix E). Table 3-1 summarizes the

results from the watershed pollutant loading analysis including areas, pollutant loading rates, and annual pollutant load for each nonpoint source/land use type.

Table 3-1: Liberty Reservoir Land-Use Nitrogen, Phosphorus, and Total Suspended Solids Loads

WRE Land Use	Area (acres)	NITROGEN Loading Rate (lbs/ac)	NITROGEN Load (lbs)	PHOSPHORUS Loading Rate (lbs/ac)	PHOSPHORUS Load (lbs)	SEDIMENT Loading Rate (lbs/ac)	SEDIMENT Load (lbs)
Impervious Urban	709	17.36	12,304	1.51	1,073	1,705	1,208,297
Pervious Urban	3,019	11.56	34,887	0.30	896	233	702,809
Cropland	3,659	23.08	84,423	1.32	4,822	1,157	4,234,501
Pasture	786	7.97	6,258	0.74	578	285	223,955
Livestock (AFO/CAFO)	18	162.66	2,878	23.92	423	4,291	75,920
Forest and Wetlands	7,933	2.79	22,157	0.04	312	71	562,111
Water*	325	-	-	-	-	-	-
Total	***16,449***		***162,906***		***8,104***		***7,007,594***

* Nutrient loadings from water were not included in the analysis

3.5.1.2 Septic System Pollutant Loading

Homes, businesses, and institutions which manage wastewater from their site through the utilization of septic systems contribute nitrogen loading in the watershed through groundwater deposition. Nearly 2,300 septic systems are used in the Liberty Reservoir watershed. Septic systems are classified by their location in the watershed as either within 1,000 feet of a stream, within the Critical Area buffer, or greater than 1,000 feet of a stream. Unique loading rates were developed for each category to determine the nitrogen loading from individual septic systems, described in detail in Section 3.3.2 of the *Watershed Characterization Report* (Appendix E). Table 3-2 summarizes the estimated nitrogen pollutant loading from septic systems in Liberty Reservoir developed by the Chesapeake Bay Program (CBP), MDE, and EPS.

Table 3-2: Liberty Reservoir Pollutant Loads from Septic Systems

Pollution Source	Total # of Septic Systems	Total Nitrogen Load (lb/year)	Total Phosphorus Load (lb/year)	Total Sediment Load (lb/year)
Septic Systems	2,286	23,336	-	-

3.5.2 Pollutant Removal Analysis

As discussed in Chapter 1, as part of the local Liberty Reservoir TMDL, a reduction in phosphorus and sediment loads from stormwater discharges is necessary to meet water quality standards. The load reductions needed within the Liberty Reservoir watershed to achieve this are summarized in Table 3-3. Full implementation is required for the Liberty Reservoir TMDL by 2030.

Table 3-3: Liberty Reservoir Urban Load Reductions Based on Liberty Reservoir TMDL

Source	Area (acres)	Total Nitrogen (lbs/yr)	Total Phosphorus (lbs/yr)	Total Sediment (lbs/yr)
Total Urban Load	3,728	47,190	1,969	1,911,106
2030 Reduction Goal:		***-***	***965***	***726,220***

The following sections present a quantitative analysis of pollutant removal capabilities of proposed BMPs

to ensure that the required reductions in nutrient loads from urban runoff in the Liberty Reservoir watershed are achieved. Note that many of the removal efficiencies used to estimate pollutant reductions are based on the peer-reviewed and CBP-approved nonpoint source BMP tables developed for the Phase 5.0 CBP Watershed Model. Additional pollutant reductions from the 2011 MDE *Draft Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated,* the 2014 MDE *Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated*, and the 2013 *Recommendations of the Expert Panel to Define Removal Rates for Urban Nutrient Management* were used if values were not available in the BMP tables. These documents are included in Appendix C. Also note that the calculations and estimates presented in the following subsections represent maximum potential pollutant removal 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 the projected implementation schedule to meet the 2030 milestone.

3.5.2.1 Existing Urban Restoration Practices

Stormwater Management (SWM)

As described in Section 2.3.7.2 of the *Watershed Characterization Report* (Appendix E), there are 101 existing SWM facilities in the Liberty Reservoir watershed including dry ponds, underground detention, wetlands, infiltration and filtration practices, extended detention, grass swales and channels, and other types of SWM facilities (i.e. environmentally sensitive design). The pollutant removal capability of existing SWM facilities in the watershed is not accounted for in the pollutant 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 recommended by CBP for the various types of SWM facilities. The equation used to estimate total nitrogen (TN) load reductions for a particular type of SWM facility is expressed as:

[12.66 (*lbs/ac/yr*) x *DA (acres)*] x *efficiency (%)*

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

[0.53 (*lbs/ac/yr*) x *DA (acres)*] x *efficiency (%)*

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

[513 (*lbs/ac/yr*) x *DA (acres)*] x *efficiency (%)*

The pollutant load received from the drainage area contributing to the SWM facility is denoted by the first expression in brackets in each of the above equations. The pollutant loading rates shown, 12.66 lbs TN/ac/yr, 0.53 lbs TP/ac/yr, and 513 lbs TSS/ac/yr, represent weighted averages 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

Phase 5.3 Watershed Model run from October of 2011. The percent pollutant removal efficiency depends on the type of facility and is based on the values shown in Appendix C under CBP's BMP Table for *Urban BMPs*. 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 are shown in Table 3-4.

Table 3-4: Existing SWM Load Reductions

SWM Facility Type	No. (#)	DA (acres)	TN Load from DA (lbs/ac/yr)*	TN Removal Efficiency (%)	Max Potential TN Load Reduction (lbs/yr)	TP Load from DA (lbs/ac/yr)*	TP Removal Efficiency (%)	Max Potential TP Load Reduction (lbs/yr)	TSS Load from DA (lbs/ac/yr)*	TSS Removal Efficiency (%)	Max Potential TSS Load Reduction (lbs/yr)
Dry Pond	5	31.3	12.66	5%	20	0.53	10%	1.7	513	10%	1,604
Underground Detention	2	1.4	12.66	5%	1	0.53	10%	0.1	513	10%	72
Wetland	1	21.9	12.66	20%	55	0.53	45%	5.2	513	60%	6,736
Infiltration	24	53.2	12.66	80%	539	0.53	85%	23.9	513	95%	25,924
Filtration	30	194.6	12.66	40%	985	0.53	60%	61.7	513	80%	79,806
Extended Detention	21	238.8	12.66	20%	605	0.53	20%	25.2	513	60%	73,451
Grassed Swale/Channel	8	20.1	12.66	10%	25	0.53	10%	1.1	513	50%	5,139
Other	10	20.9	12.66	50%	132	0.53	60%	6.6	513	90%	9,651
Totals:	***101***	***582.2***			***2,363***			***125.4***			***202,383***

*Based on weighted average of impervious and pervious urban loading rates

County Restoration Programs

Baltimore County tracks the annual sale of rain barrels and estimates the rate of installation and corresponding pollutant reductions attributed to each sale. It is estimated that each barrel drains 250 square feet of rooftop for pollutant reductions purposes. Since 2011, nine barrels have been sold in the Liberty Reservoir planning area. Pollutant reduction for rain barrels were calculated using the BMP removal efficiencies reported by MDE (MDE, 2011) as shown in Appendix C. The equation used to estimate total nitrogen (TN) load reductions due to rain barrels is expressed as:

[17.36 *(lbs/ac/yr)* x *DA (acres)*] x 50%

The equation used to estimate total phosphorus (TP) load reductions due to rain barrels is expressed as:

[1.51 *(lbs/ac/yr)* x *DA (acres)*] x 60%

The equation used to estimate total suspended solids (TSS) load reductions due to rain barrels is expressed as:

[1,705 *(lbs/ac/yr)* x *DA (acres)*] x 90%

The pollutant load received from the rooftop drainage area contributing to the rain barrels is denoted by the first expression in brackets in each of the above equations, which is the impervious urban loading rate.

Twice a year, Baltimore County EPS hosts a Big Tree Sale and tracks the trees being sold to addresses in Baltimore County. Since 2009, 33 trees have been bought at the sale and planted in the Liberty Reservoir watershed. Nutrient reductions for tree sales were estimated based on 100 trees being equivalent to one acre of land use change of pervious urban to forest. It is assumed that all trees are planted in upland areas and not in stream buffers. The equation used to estimate TN load reductions for Big Tree Sales is expressed as:

[11.56 *(lbs/ac/yr)* – 2.79 *(lbs/ac/yr)*] x [# Trees x (1 acre)/100 Trees]

The equation to estimate TP load reductions for Big Tree Sales is expressed as:

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

The equation used for TSS load reductions for Big Tree Sales is expressed as:

[233 *(lbs/ac/yr)* – 71 *(lbs/ac/yr)*] x [# Trees x (1 acre)/100 Trees]

The loading rate is 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 rate multiplied by the estimated area planted based on the number of trees sold (i.e. the expression in the second brackets in the equations above). A summary of existing rain barrel sale and Big Tree Sales load reduction calculations and results are shown in Table 3-5.

Table 3-5: Existing Pollutant Load Reductions from rain Barrel Sales and Big Tree Sales

Pollutant	Rain Barrels Sold (#)	Load Reduction from Rain Barrels (lbs/yr)	Trees sold at Big Trees Sale (#)	Load Reduction from Big Trees Sale (lbs/yr)	*Total Load Reduction (lbs/yr)*
TN	9	0.4	33	2.9	***3.3***
TP	9	0.0	33	0.1	***0.1***
TSS	9	79.3	33	53.4	***132.7***

3.5.2.2 Agricultural Best Management Practices

The Liberty Reservoir watershed is approximately 25% agricultural land use. As of August 2014, there were approximately 30 documented agricultural BMPs in the Liberty Reservoir watershed as reported in Chapter 2 of the *Liberty Reservoir Watershed Characterization Report* (Appendix E). The Maryland Department of Agriculture and the Baltimore County Soil Conservation district will continue to work with farmers throughout the County to track and encourage BMP implementation on farmland in an effort to achieve agricultural TMDL pollutant reductions. Baltimore County will work with the agricultural community to help achieve the Liberty Reservoir TMDLs.

3.5.2.3 Proposed Urban Restoration Practices

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, roadways), which are currently untreated. This includes sites identified for retrofit potential during the uplands surveys for institutions. Pollutant reductions for stormwater retrofits are calculated based on the approximate pollutant load received from the impervious drainage area (DA) and removal efficiency of infiltration type BMPs. The equation used to estimate TN load reductions for stormwater retrofits is expressed as:

[17.36 *(lbs/ac/yr)* x *DA (acres)*] x 50%

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

[1.51 *(lbs/ac/yr)* x *DA (acres)*] x 60%

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

[1,705 *(lbs/ac/yr)* x *DA (acres)*] x 90%

The pollutant load received from the drainage area contributing to the SWM facility is denoted by the first expression in brackets in the equations above. The pollutant loading rates shown, 17.36 lbs TN/ac/yr, 1.51 lbs TP/ac/yr, and 1,705 lbs TSS/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 provided by MDE for BMP practices as shown in Appendix C (MDE, 2011). A summary of stormwater retrofit load reduction calculations and results for the Liberty Reservoir SWAP area are shown in Table 3-6.

Table 3-6: Stormwater Retrofit (Bioretention Practices) Load Reductions

Pollutant	Impervious Urban Loading Rate (lbs/ac/yr)	Impervious Area for SW Retrofit (acres)	Load from DA (lbs/yr)	Removal Efficiency (%)	Max Potential Load Reduction (lbs/yr)
TN	17.36	5.1	89	50%	45
TP	1.51	5.1	8	60%	5
TSS	1,705	5.1	8,763	90%	7,886

Impervious Cover Removal

Potential sites for impervious cover removal were identified at multiple institutions. Pollutant reductions for impervious cover removal are calculated based on a land use conversion from impervious to pervious urban. The equation used to estimate TN load reductions for impervious cover removal is expressed as:

[17.36 *(lbs/ac/yr)* – 11.56 *(lbs/ac/yr)*] x *Impervious Area (acres)*

The equation used to estimate TP load reductions for impervious cover removal is expressed as:

[1.51 *(lbs/ac/yr)* – 0.30 *(lbs/ac/yr)*] x *Impervious Area (acres)*

The equation used to estimate TSS load reductions for impervious cover removal is expressed as:

[1,705 *(lbs/ac/yr)* – 233 *(lbs/ac/yr)*] x *Impervious Area (acres)*

Impervious cover removal involves converting impervious surfaces to pervious surfaces such as turf or permeable paving. Therefore, the loading rate would be reduced by a factor equal to the difference between impervious and pervious urban loading rates used in the watershed pollutant loading analysis (Table 3-1) 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. Because removal of impervious cover is more realistically implemented on public land, any impervious cover removal noted on private properties was not included in the calculation. A summary of impervious cover removal calculations and results are shown in Table 3-7.

Table 3-7: Impervious Cover Removal Load Reductions

Pollutant	Impervious Urban Loading Rate (lbs/ac/yr)	Pervious Urban Loading Rate (lbs/ac/yr)	Reduction in Loading Rate (lbs/ac/yr)	Impervious Area Removed (acres)	Max Potential Load Reduction (lbs/yr)
TN	17.36	11.56	5.80	0.58	3.35
TP	1.51	0.30	1.22	0.58	0.70
TSS	1,705	233	1,471.98	0.58	849.20

Downspout Disconnection

A total of three neighborhoods (out of 32 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 assessments, 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).

Pollution reductions for downspout disconnection are calculated based on the pollutant load received from the total rooftop DA recommended for disconnection and the removal efficiency cited by MDE for "Disconnection of Rooftop Runoff" as shown in Appendix C (MDE, 2011). The equation used to estimate TN load reductions for downspout disconnection is expressed as:

[17.36 *(lbs/ac/yr)* x *DA (acres)*] x 50%

The equation to estimate TP load reductions for downspout disconnection is expressed as:

[1.51 *(lbs/ac/yr)* x *DA (acres)*] x 60%

The equation used for TSS load reductions for downspout disconnection is expressed as:

[1,705 *(lbs/ac/yr)* x *DA (acres)*] x 90%

The pollutant load received from the impervious rooftop drainage area recommended for disconnection is denoted by the first expression in brackets in the equation above. The pollutant loading rates show, 17.36 lbs TN/ac/yr, 1.51 lbs TP/ac/yr, and 1,705 lbs TSS/ac/yr, are the impervious urban rates used in the pollutant loading analysis. A summary of downspout disconnection load reduction calculations and results are shown in Table 3-8.

Table 3-8: Downspout Disconnection Load Reductions

Pollutant	Impervious Urban Loading Rate (lbs/ac/yr)	DA (Rooftop area recommended for downspout disconnect) (acres)	Removal Efficiency (%)	Max Potential Load Reduction (lbs/yr)
TN	17.36	4.3	50%	37
TP	1.51	4.3	60%	4
TSS	1,705	4.3	90%	6,608

Stream Buffer Reforestation

The current vegetative condition of the stream riparian buffer (100 feet on either side of a stream system) was analyzed in Section 2.2.7.2 of the *Watershed Characterization Report* (Appendix E). Buffer conditions were either classified as impervious, open pervious, or forested areas. Open pervious areas are the best areas to initially target for restoration. Approximately 860 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. The equation used to estimate TN load reductions for the land use conversion portion of stream buffer reforestation is expressed as:

[11.56 *(lbs/ac/yr)* – 2.79 *(lbs/ac/yr)*] x *Open Pervious Area (acres)*

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

[0.30 *(lbs/ac/yr)* – 0.04 *(lbs/ac/yr)*] x *Open Pervious Area (acres)*

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

[233 *(lbs/ac/yr)* – 71 *(lbs/ac/yr)*] x *Open Pervious Area (acres)*

The first expression in brackets in the equations above represents the difference between pervious urban and forest loading rates used in the watershed pollutant loading analysis (Table 3-1). This reduction in loading rate is then multiplied by the available open pervious area for reforestation to determine the load reductions 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 performance guidance in CBP's BMP Table for *Urban BMPs* shown in Appendix C, 1 acre of buffer treats approximately 1 acre of upland area for nitrogen, phosphorus, and sediment with varying efficiencies for urban and mixed open buffers. The weighted loading rate for the entire watershed is used to represent this upland area and is the final number in brackets in the equations below. The TN total reductions for the removal efficiency portion of buffer reforestation can be expressed as:

$$\left[Open\ Pervious\ Area\ (acres) \times \frac{1\ (upland\ acres)}{1\ (buffer\ acre)} \times 12.66\ (lbs/ac/yr) \right] \times 25\%$$

The TP load reductions for the removal efficiency portion of buffer reforestation can be expressed as:

$$\left[Open\ Pervious\ Area\ (acres) \times \frac{1\ (upland\ acres)}{1\ (buffer\ acre)} \times 0.53\ (lbs/ac/yr) \right] \times 50\%$$

The TSS load reductions for the removal efficiency portion of buffer reforestation can be expressed as:

$$\left[Open\ Pervious\ Area\ (acres) \times \frac{1\ (upland\ acres)}{1\ (buffer\ acre)} \times 513\ (lbs/ac/yr) \right] \times 50\%$$

The loading rates shown in the equations above represent the overall urban loading rates. This is estimated as the weighted average of urban impervious and urban pervious land use within the watershed. These are used to calculate the pollutant load from the upland area that would be treated by buffer reforestation of urban pervious land. There are 860 areas of open pervious area identified, which was reduced by 379 acres available for agricultural stream buffer restoration for a total of 481 acres. 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 calculations and results are shown in Table 3-9.

Table 3-9: Stream Buffer Reforestation Load Reductions

		LU CONVERSION			BUFFER BMP REMOVAL			
Pollutant	Open Pervious Area (acres)	Pervious Urban Loading Rate (lbs/ac/yr)	Forest Loading Rate (lbs/ac/yr)	Land Use Conversion Reduction (lbs/yr)	Reduction Efficiency (%)	Overall Urban Loading Rate (lbs/ac/yr)	Efficiency Load Reduction (lbs/yr)	Max Potential Load Reduction (lbs/yr)
TN	481	11.56	2.79	4,215	25%	12.66	1,522	5,738
TP	481	0.30	0.04	124	50%	0.53	127	251
TSS	481	233	70.85	77,903	50%	512.65	123,314	201,217

Tree Plantings

Several opportunities for planting open space trees were identified in neighborhoods and institutions during the upland assessments. Tree planting opportunities were also identified for pervious areas through desktop analysis. For neighborhood, institution, and pervious area tree planting opportunities, the number of trees was estimated based on a density of 100 trees per acre. 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 TN load reductions for tree plantings is expressed as:

[11.56 *(lbs/ac/yr)* – 2.79 *(lbs/ac/yr)*] x [# Trees x (1 acre)/100 Trees]

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

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

The equation used for TSS load reductions for tree plantings is expressed as:

[233 *(lbs/ac/yr)* – 71 *(lbs/ac/yr)*] x [# Trees x (1 acre)/100 Trees]

Tree plantings 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 rate multiplied by the open pervious area available for reforestation (i.e. the expression in the second brackets in the equations above). Any tree planting in the 100 foot stream buffer was excluded from the reductions to avoid double counting. A summary of tree planting load reduction calculations and results are shown in Table 3-10, Table 3-11, and Table 3-12.

Table 3-10: Neighborhood Open Space and Tree Canopy Planting Load Reductions

Pollutant	Pervious Urban Loading Rate (lbs/ac/yr)	Forest Loading Rate (lbs/ac/yr)	Reduced Loading Rate (lbs/ac/yr)	Estimated Tree for NSAs (#)	Estimated Acres for Planting (acres)	Total Max. Potential for NSAs (lbs/yr)
TN	11.56	2.79	8.76	28,456	285	2,493
TP	0.30	0.04	0.26	28,456	285	73
TSS	233	71	162	28,456	285	46,079

Table 3-11: 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 for ISIs (#)	New Forested Area (acres)	Max Potential Load Reduction (lbs/yr)
TN	11.56	2.79	8.76	1,259	12.59	110
TP	0.30	0.04	0.26	1,259	12.59	3
TSS	233	71	162	1,259	12.59	2,038

Table 3-12: Pervious Area 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 for PAAs (#)	New Forested Area (acres)	Max Potential Load Reduction (lbs/yr)
TN	11.56	2.79	8.76	5,666	57	496
TP	0.30	0.04	0.26	5,666	57	15
TSS	233	71	162	5,666	57	9,175

Stream Corridor Restoration

Stream corridor restoration practices are used to enhance the appearance, stability, and aquatic function of stream corridors. These practices include stream stabilization (i.e. grading and vegetative stabilization) and stream restoration (i.e. redesign and realignment). Several potential stream restoration sites were identified during the stream corridor assessments (SCAs) to improve water quality and address potential environmental problem sites, such as significant erosion and channel alterations. The SCAs are explained in Section 3.6 of the *Watershed Characterization Report* (Appendix E). Stream corridor assessments were conducted in three subwatersheds: Cliffs Branch, Keyser Run, and Norris Run. Pollutant reduction for stream corridor restoration are calculated based on EPA approved interim load reduction factors reported in the 2014 MDE report, *Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated* (MDE, 2014a) shown in Appendix C and are multiplied by the linear feet of identified significant erosion and channel alteration sites. The equation used to estimate TN load reductions for stream restoration is expressed as:

0.075 *(lbs/ft)* x *Restoration Length (ft)*

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

0.068 *(lbs/ft)* x *Restoration Length (ft)*

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

44.900 *(lbs/ft)* x *Restoration Length (ft)*

Very severe, severe, or moderately severe erosion lengths were documented for approximately 4.48% of the total surveyed stream length (5,399 feet) during the Liberty Reservoir SCA. There were no channel alterations with very severe or severe ratings and moderate channel alterations were not considered. A summary of stream corridor restoration reduction calculations and results are shown in Table 3-13.

Table 3-13: Stream Restoration Load Reductions for Surveyed Stream Reaches in the Liberty Reservoir Watershed

Pollutant	Reduction in Loading Rate (lbs/ft/yr)	Length of Very Severe, Severe, and Moderate Sites (ft)	Max. Potential Load Reduction (lbs/yr)
TN	0.075	5,399	405
TP	0.068	5,399	367
TSS	44.900	5,399	242,437

To meet water quality goals, additional stream corridor restorations will likely need to occur in the remaining subwatersheds that have not yet been surveyed. Assuming the same approximate percentage of very severe, severe, or moderately severe erosion lengths (4.48%) are found in the remaining subwatersheds, an additional 10,528 feet of stream corridor is available for restoration. A summary of additional stream corridor restoration reduction calculations and results are shown in Table 3-14. These results are the maximum potential load reduction assuming all estimated very severe, severe, and moderately severe erosion sites are addressed. A participation percentage, or probable amount of total stream length to be restored, will be used to calculate estimated lengths of restored stream. The participation percentage for the un-surveyed streams will be half that of the participation percentage for the surveyed streams (discussed further in Section 3.5.2.4) as the surveyed streams were located in the worst subwatersheds for biological condition and their conditions have been field verified.

Table 3-14: Stream Restoration Load Reductions for Un-surveyed Stream Reaches in the Liberty Reservoir Watershed

Pollutant	Reduction in Loading Rate (lbs/ft/yr)	Length of Very Severe, Severe, and Moderate Sites (ft)	Max. Potential Load Reduction (lbs/yr)
TN	0.075	10,528	790
TP	0.068	10,528	716
TSS	44.900	10,528	472,728

Fertilizer Act of 2011

On May 19, 2011, Governor Martin O'Malley signed the Fertilizer Use Act of 2011, an environmental law designed to reduce the amount of nutrients washing into the Chesapeake Bay from lawns, golf courses, parks, recreation areas, and other non-agricultural sources. The law limits the amount of phosphorus contained in lawn fertilizer products sold to the public, establishes a training, verification, and licensing program for people who are hired to apply fertilizer to non-agricultural landscapes, limits fertilizer amounts applied to turf, and requires the implementation of a homeowner education program about best management practices to be followed when using fertilizers (MDA, 2011). The Fertilizer Act was fully implemented in October of 2013 and contains new content requirements and labeling instructions including restricting phosphorus and decreasing nitrogen amounts in fertilizer sold in Maryland.

Pollutant reductions from the Fertilizer Act of 2011 are calculated based on the 2013 CBP approved study entitled *Recommendations of the Expert panel to Define Removal Rates for Urban Nutrient Management* (Schueler & Lane, 2013) shown in Appendix C. For states with fertilizer legislation, a 25% reduction in

phosphorus was recommended from urban pervious land uses. For nitrogen, a 9% reduction was estimated for commercial areas and a 4.5 rate was recommended for "do-it-yourself" land uses. To reach a blended nitrogen reduction weight, a weighted average was calculated based on the amount of commercial and residential land use within the study area. The equation used to estimate TN load reductions from the Fertilizer Act of 2011 is expressed as:

[11.56 *(lbs/ac/yr)* x *Urban Pervious Area (acres)*] x 4.90%

The equation used to estimate TP load reductions from the Fertilizer Act of 2011 is expressed as:

[0.30 *(lbs/ac/yr)* x *Urban Pervious Area (acres)*] x 25%

It is assumed that no reduction in TSS will occur because of the new law. Calculations and results of the nutrient reductions derived from the Fertilizer Act of 2011 are summarized in Table 3-15.

Table 3-15: Load Reductions from the Fertilizer Act of 2011

Pollutant	Pervious Urban Loading Rate (lbs/ac/yr)	Pervious Urban Area (acres)	Removal Efficiency (%)	Max Potential Load Reduction (lbs/yr)
TN	11.56	3,019	4.90%	1,710
TP	0.30	3,019	25.00%	224
TSS	233	3,019	0.00%	-

MS4 Retrofits

Baltimore County, as part of its NPDES permit, is currently assessing the condition of each of the county's outfalls to determine if there is retrofit potential at the outfall and restoration potential in the downstream drainage way. As part of its permit, the county is responsible for addressing 20% of the impervious area in the county. Since potential outfall retrofits are located within the urban land area in the Liberty Reservoir watershed, pollutant reductions were estimated from the urban land use in the watershed.

As shown in Table 3-1, the Liberty Reservoir planning area contains 3,728 acres of urban land. Of this land, 582 acres are already being treated by existing stormwater facilities, as described in Section 3.5.2.1. Of the remaining 3,146 acres of untreated urban area, 229 acres are owned by the State Highway Administration (SHA). As SHA is responsible for meeting its own reductions, SHA lands were not included in the county urban land area available for MS4 retrofits, but were rather included as their own line item.

Pollutant reductions for outfall retrofits are calculated based on the approximate pollutant load received from urban areas within the watershed and removal efficiency of urban BMP retrofits from the June 2011 draft document, *Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated* shown in Appendix C (MDE, 2011). The equation used to estimate TN load reductions for outfall retrofits and state owned property is expressed as:

[12.66 *(lbs/ac/yr)* x *Urban Area (acres)*] x 25%

The equation used to estimate TP load reductions for stormwater retrofits and state owned property is expressed as:

[0.53 *(lbs/ac/yr)* x *Urban Area (acres)*] x 35%

The equation used to estimate TSS load reductions for stormwater retrofits and state owned property is expressed as:

[513 *(lbs/ac/yr)* x *Urban Area (acres)*] x 65%

The pollutant load received from the urban land use is denoted by the first expression in brackets in the equations above. The pollutant loading rates shown, 12.66 lbs TN/ac/yr, 0.53 lbs TP/ac/yr, and 513 lbs TSS/ac/yr are the weighted average of impervious and pervious urban rates used in the pollutant loading analysis (Table 3-1) since this represents the source of runoff being treated. A summary of stormwater retrofit load reduction calculations and results for the Liberty Reservoir SWAP area are shown in Table 3-16.

Table 3-16: MS4 Outfall Retrofit Load Reductions

Pollutant	Urban Loading Rate (lbs/ac/yr)	Urban Drainage Area (acres)	Load from Drainage Area (lbs/yr)	Removal Efficiency (%)	Max Potential Load Reduction (lbs/yr)
TN	12.66	2,916	36,918	25%	9,229
TP	0.53	2,916	1,541	35%	539
TSS	513	2,916	1,495,104	65%	971,817

SHA Owned Properties Restoration

As mentioned previously, SHA owns approximately 299 acres of land within the Liberty Reservoir planning area. As SHA has responsibility for the pollution reduction requirements on its own property, it was assumed the state would reduce pollutant runoff from its lands by the SHA Phase I MS4 reduction requirement of 45% for Phosphorus and Sediment (MDE, 2014e).

Pollutant reductions for SHA owned property are calculated based on the approximate pollutant load received from SHA owned urban area within the watershed and the 45% reduction requirements for Phosphorus and Sediment (MDE, 2014e). A reduction of 45% for Nitrogen was also assumed. The equation used to estimate TN load reductions for SHA owned property is expressed as:

[12.66 *(lbs/ac/yr)* x *Urban Area (acres)*] x 45%

The equation used to estimate TP load reductions for stormwater retrofits and state owned property is expressed as:

[0.53 *(lbs/ac/yr)* x *Urban Area (acres)*] x 45%

The equation used to estimate TSS load reductions for stormwater retrofits and state owned property is expressed as:

[513 *(lbs/ac/yr)* x *Urban Area (acres)*] x 45%

The pollutant load received from the urban land use is denoted by the first expression in brackets in the equations above. The pollutant loading rates shown, 12.66 lbs TN/ac/yr, 0.53 lbs TP/ac/yr, and 513 lbs TSS/ac/yr are the weighted average of impervious and pervious urban rates used in the pollutant loading analysis (Table 3-1) since this represents the source of runoff being treated. A summary of SHA owned property load reduction calculations and results for the Liberty Reservoir SWAP area are shown in Table 3-17 .

Table 3-17: SHA Owned Properties Load Reductions

Pollutant	Urban Loading Rate (lbs/ac/yr)	SHA Drainage Area (acres)	Load from Drainage Area (lbs/yr)	Removal Efficiency (%)	Max Potential Load Reduction (lbs/yr)
TN	12.66	229	2903	45%	1,306
TP	0.53	229	121	45%	55
TSS	513	229	117,551	45%	52,898

3.5.2.4 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 3-18. Participation rates for existing measures that have already been implemented are 100%.

Table 3-18: Projected Participation Factors

BMP	Projected Participation	Basis of Assumption
Completed Measures		
Existing SWM	100%	Existing – BMPs already implemented
Existing County Restoration Programs	100%	Existing - Rain Barrels and Big Tree Sales reductions
Proposed Urban Measures		
SW Retrofits (ISI)	50%	General estimate to achieve reduction goal
ISI Impervious Cover Removal	25%	General estimate to achieve reduction goal
NSA Downspout Disconnection	14%	57% willingness factor, 25% participation
Reforest Urban Stream Buffers	28%	50% participation on public land, 15% participation on private land
NSA Tree Plantings (Open Space)	25%	50% willingness factor open space NSA planting, 50% participation
NSA Tree Plantings (Lot Canopy)	5%	50% willingness factor, 10% participation
ISI Tree Plantings	50%	of estimated trees on public lands
PAA Tree Planting	50%	of estimated trees on public lands
Stream Restoration (SCA)	28%	General estimate based on field results (50% of Very Severe and Severe; 8% of Moderate)
Stream Restoration (Remaining Subwatersheds)	14%	Half of SCA projected participation
Credits for Fertilizer Act of 2011	100%	participation as part of Maryland law
MS4 Retrofits	51%	General estimate to achieve reduction goal (minimum 20%)
State Owned Properties Restoration	100%	TMDL reduction requirement (45% load reduction)

Table 3-19 presents a summary of estimated pollutant load reductions for two scenarios – maximum implementation and projected practicable implementation by 2030 – including how reductions were credited, pollutant removal efficiencies, maximum potential load reductions, units available for restoration, projected participation, and projected load reductions. Currently, the project implementation plan shown in Table 3-19 meets the 2030 Liberty Reservoir TMDL reduction goals for both phosphorus and sediment.

Table 3-19: Summary of Pollutant Load Reduction Estimates

BMP	How Credited	TN Efficiency	TP Efficiency	TSS Efficiency	Total Units Available		Projected Participation	Units Proposed		Max Potential TN Load Reduction	Max Potential TP Load Reduction	Max Potential TSS Load Reduction	Projected 2030 TN Load Reduction	Projected 2030 TP Load Reduction	Projected 2030 TSS Load Reduction
Completed Measures															
Existing SWM	Efficiency	varies	varies	varies	582	acres	100%	582	acres	2,363	125	202,383	2,363	125	202,383
Existing County Restoration Programs	Efficiency	varies	varies	varies	varies		100%			3	0	133	3	0	133
Proposed Urban Measures															
SW Retrofits (ISI)	Efficiency	50%	60%	90%	5.1	acres	50%	2.6	acres	45	5	7,886	22	2	3,943
ISI Impervious Cover Removal	LU Conversion	N/A	N/A	N/A	0.6	acre	25%	0.1	acre	3.35	0.70	849	1	0.18	212
NSA Downspout Disconnection	Efficiency	50%	60%	90%	4.3	acres	14%	0.6	acres	37	4	6,608	5	1	942
Reforest Urban Stream Buffers	LU Conversion + Efficiency	25%	50%	50%	481	acres	28%	135	acres	5,738	251	201,217	1,607	70	56,341
NSA Tree Plantings (Open Space)	LU Conversion	N/A	N/A	N/A	0.4	acres	25%	0.1	acres	4	0	67	1	0	17
NSA Tree Plantings (Lot Canopy)	LU Conversion	N/A	N/A	N/A	284	acres	5%	14	acres	2,490	73	46,012	124	4	2,301
ISI Tree Plantings	LU Conversion	N/A	N/A	N/A	13	acres	50%	6.3	acres	110	3	2,038	55	2	1,019
PAA Tree Planting	LU Conversion	N/A	N/A	N/A	57	acres	50%	28	acres	496	15	9,175	248	7	4,588
Stream Restoration (SCA)	Lbs per Ln Ft	0.075	0.068	44.900	5,399	ft	28%	1,520	ft	405	367	242,437	114	103	68,230
Stream Restoration (Remaining Subwatersheds)	Lbs per Ln Ft	0.075	0.068	44.900	10,528	ft	14%	1,482	ft	790	716	472,728	111	101	66,521
Credits for Fertilizer Act of 2011	Efficiency	4.90%	25%	0%	3,019	acres	100%	3,019	acres	1,710	224	0	1,710	224	0
MS4 Retrofits	Efficiency	25%	35%	65%	2,916	acres	51%	1,487	acres	9,229	539	971,817	4,707	275	495,627
SHA Owned Properties Restoration	Efficiency	45%	45%	45%	229	acres	100%	229	acres	1,306	55	52,898	1,306	55	52,898
									Total Load Reduction (lbs/yr):	***24,730***	***2,378***	***2,216,248***	***12,378***	***969***	***955,153***
									Total Existing Urban Load (lbs/yr)	47,190	1,969	1,911,106	47,190	1,969	1,911,106
									Local Reduction Achieved *(Local Reduction Goal)*:	***52%***	***121%***	***116%***	***26%*** *(-)*	***49%*** *(49%)*	***50%*** *(38%)*
									Local Urban TMDL Reduction Goals (lbs/yr)				-	965	726,220

CHAPTER 4: SUBWATERSHED MANAGEMENT STRATEGIES

4.1 Introduction

This chapter describes the criteria and methodology used to rank the 14 subwatersheds comprising the Liberty Reservoir planning area (see Figure 1-2). The subwatershed ranking provides a tool for targeting restoration actions by location and water body. This chapter also summarizes management strategies and implementation priorities within each subwatershed. Individual subwatershed summaries also include key subwatershed characteristics. More detailed information on a subwatershed basis can be found in the *Liberty Reservoir Watershed Characterization Report* included as (Appendix E).

4.2 Subwatershed Prioritization

A ranking methodology was developed to prioritize subwatersheds within this study in terms of restoration need and potential. Subwatersheds were evaluated based on 16 criteria. Each criterion was scored from 1 to 4 with scores of 0 given if the criterion was not applicable. The sum of the criteria for each subwatershed was used to prioritize subwatersheds within this study in terms of restoration need and potential.

Subwatersheds are represented by an overall prioritization score on a scale of 64, where 0 denotes the least significant impacts to water quality and 64 corresponds to the greatest water quality improvement potential. The total prioritization score for a subwatershed is comprised of the following ranking criteria:

- Nitrogen Loads
- Phosphorus Loads
- Sediment Load
- Impervious Surfaces
- Neighborhood Restoration Opportunity/Pollution Source Indexes
- Neighborhood Downspout Disconnection
- Institutional Site Index
- Forest Coverage
- Illicit Discharge Data
- Stream Buffer Improvement
- Stream Corridor Restoration
- Conservation Easements
- Hotspot Site Index
- Pervious Area Index
- Septic Systems
- Biological Indicators

Each criterion has a maximum possible score of 4. In general, subwatersheds were divided 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, 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 clustered or cases where zero values were assigned to subwatersheds with 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.

4.2.1 Nitrogen, Phosphorus, and Sediment Loads

One of the main objectives to improve and maintain water quality and meet pollution reduction requirements in Liberty Reservoir is to reduce annual average total nitrogen, phosphorus, and sediment loads. Annual pollutant loads (lbs/year) for total nitrogen, phosphorus, and sediment were calculated for each subwatershed based on loading rates established by MDE and CBP for various land use types and subwatershed land distributions. The pollutant loading analysis for the Liberty Reservoir watershed is explained in further detail in Section 3.3 of the *Watershed Characterization Report* (Appendix E).

For each subwatershed, annual nitrogen, phosphorus, and sediment loads were divided by the subwatershed's area. This represents pollutant loading rates (lbs/acre/year) and allows a direct comparison between the 14 subwatersheds, regardless of size. Subwatersheds with higher pollutant loading rates are higher priorities for restoration within the Liberty Reservoir planning area. Therefore, higher pollutant loading rates were assigned higher scores to denote greater water quality impacts and restoration need.

Subwatershed nitrogen loading rates ranged from 6.57 to 16.77 lbs/acre/year. The following point system was used to assign nitrogen load scores to the 14 subwatersheds based on the range and distribution of subwatershed nitrogen loading rates:

- ≥ 11.00 lbs/acre/year = 4 pts
- 10.99 – 9.00 lbs/acre/year = 3 pts
- 8.99 – 7.00 lbs/acre/year = 2 pts
- ≤ 6.99 lbs/acre/year = 1 pt

Subwatershed phosphorus loading rates ranged from 0.25 to 0.93 lbs/acre/year. The following point system was used to assign phosphorus load scores to the 14 subwatersheds based on the range and distribution of subwatershed phosphorus loading rates:

- ≥ 0.60 lbs/acre/year = 4 pts
- 0.59 – 0.40 lbs/acre/year = 3 pts
- 0.39 – 0.30 lbs/acre/year = 2 pts
- ≤ 0.29 lbs/acre/year = 1 pt

Subwatershed sediment loading rates ranged from 245 to 829 lbs/acre/year. The following point system was used to assign sediment load scores to the 14 subwatersheds based on the range and distribution of subwatershed sediment loading rates:

- ≥ 550 lbs/acre/year = 4 pts
- 549 – 350 lbs/acre/year = 3 pts
- 349 – 250 lbs/acre/year = 2 pts
- ≤ 249 lbs/acre/year = 1 pt

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

Table 4-1: Nitrogen, Phosphorus, and Sediment Load Scores

SUBWATERSHED	Nitrogen Loading Rate (lbs/acre/yr)	Nitrogen Load Score	Phosphorus Loading Rate (lbs/acre/yr)	Phosphorus Load Score	Sediment Loading Rate (lbs/acre/yr)	Sediment Load Score
Board-Aspen Run	16.77	4	0.93	4	828.98	4
Cliffs Branch	15.34	4	0.84	4	728.67	4
Glen Falls Run	9.04	3	0.41	3	378.46	3
Liberty Reservoir-B	10.24	3	0.77	4	362.65	3
Keyser Run	10.81	3	0.54	3	463.74	3
Liberty Reservoir-E	7.80	2	0.38	2	359.86	3
Norris Run	9.49	3	0.42	3	396.76	3
Liberty Reservoir-C	6.57	1	0.35	2	286.48	2
Timber Run	6.71	1	0.25	1	247.79	1
Cooks Branch	7.67	2	0.31	2	278.58	2
Liberty Reservoir-F	6.68	1	0.30	2	269.12	2
Chimney Branch	7.02	2	0.29	1	277.22	2
Liberty Reservoir-A	7.42	2	0.41	3	287.90	2
Locust Run	6.73	1	0.26	1	244.91	1

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 degradation from the high energy flow and is likely more polluted than runoff generated from pervious areas.

Less developed watersheds, such as Liberty Reservoir, 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. Maryland DNR has found that brook trout populations are eliminated in watersheds with impervious surfaces exceeding 4% (DNR, 2006). Less developed watersheds are susceptible to an increase in stream degradation through development and urbanization.

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 it allows a direct comparison between the 14 subwatersheds. Subwatersheds with higher percentages of impervious cover are higher priorities for restoration within Liberty Reservoir watershed. Therefore, higher percentages of imperviousness are assigned higher scores to denote greater water quality impacts and restoration need.

Impervious cover represents approximately 4.3% of the overall Liberty Reservoir watershed. Subwatershed percent impervious values range from 1.6 to 8.1%. The following point system was used to assign impervious cover scores to the 14 subwatersheds based on the range and percentage for each subwatershed:

- ≥ 8.0% = 4 pts
- 7.9 – 4.0% = 3 pts
- 3.9 – 3.0% = 2 pts
- < 2.9% = 1 pt

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

Table 4-2: Percent Impervious Scores

SUBWATERSHED	% Impervious	% Impervious Score
Board-Aspen Run	6.4%	3
Cliffs Branch	3.8%	2
Glen Falls Run	5.7%	3
Liberty Reservoir-B	5.2%	3
Keyser Run	8.1%	4
Liberty Reservoir-E	1.6%	1
Norris Run	6.4%	3
Liberty Reservoir-C	3.2%	2
Timber Run	3.5%	2
Cooks Branch	3.1%	2
Liberty Reservoir-F	2.4%	1
Chimney Branch	2.1%	1
Liberty Reservoir-A	2.4%	1
Locust Run	3.0%	2

4.2.3 Neighborhood Restoration Opportunity/Pollution Source Indexes

As described in Chapter 4 of the *Watershed Characterization Report* (Appendix E), neighborhood pollution severity and restoration potential were rated during NSAs. The severity of pollution generated by a neighborhood is denoted by the Pollution Severity Index (PSI) and was rated as severe, high, moderate, or low. A neighborhood's potential for residential restoration projects is denoted by the Restoration Opportunity Index (ROI) and was rated as high, moderate, or low. Out of the 32 neighborhoods assessed, the majority were rated as either a moderate PSI with high ROI or moderate PSI with moderate ROI. None

of the neighborhoods were rated as high for both PSI and ROI, seven were rated as moderate for PSI with a high ROI, and eight were rated as a moderate PSI and a moderate ROI. Neighborhoods with high PSI and moderate ROI ratings or moderate PSI and high ROI represent the best areas to initially target for restoration. Because some of the neighborhoods were encompassed within multiple subwatersheds, those neighborhoods were counted for each subwatershed to portray a more accurate subwatershed ranking.

Neighborhoods were weighted based on potential restoration. The weighting assigned to each PSI/ROI rating is shown in Table 4-3. Two subwatersheds, Glen Falls Run and the Norris Run subwatershed, were given a score of 4. Both contain two neighborhoods with moderate PSI and high ROI, while the Glen Falls Run subwatershed contains an additional neighborhood with high PSI and moderate ROI and the Norris Run subwatershed contains an additional two neighborhoods with moderate PSI and moderate ROI. These subwatersheds also included some of the highest total number of NSAs within a subwatershed at 10 and 6, respectively. The NSA PSI and ROI scores are summarized in Table 4-3.

Table 4-3: NSA PSI/ROI Scores

	# of NEIGHBORHOODS FOR PSI/ROI RATINGS										
SUBWATERSHED	**High/ High**	**High/ Mod**	**High/ Low**	**Mod/ High**	**Mod/ Mod**	**Mod/ Low**	**Low/ High**	**Low/ Mod**	**Low/ Low**	**Weighted Score**	**NSA PSI/ROI Score**
Weight assigned to each PSI/ROI Rating	*16*	*8*	*4*	*8*	*2*	*1*	*2*	*1*	*0*	-	-
Board-Aspen Run	0	0	0	0	1	0	0	0	0	2	1
Cliffs Branch	0	0	0	0	2	0	0	1	0	5	2
Glen Falls Run	0	1	0	2	0	0	2	1	0	29	4
Liberty Reservoir-B	0	1	0	1	0	0	0	1	0	17	3
Keyser Run	0	0	1	2	0	0	0	2	1	22	3
Liberty Reservoir-E	0	0	0	0	0	0	0	1	0	1	1
Norris Run	0	0	0	2	2	0	1	2	3	24	4
Liberty Reservoir-C	0	0	0	1	1	0	0	0	0	10	2
Timber Run	0	0	0	2	0	2	0	0	1	18	3
Cooks Branch	0	0	0	0	1	1	0	0	1	3	1
Liberty Reservoir-F	0	0	0	1	1	0	0	0	1	10	2
Chimney Branch	0	1	0	0	0	0	0	0	0	8	2
Liberty Reservoir-A	0	0	0	0	1	0	0	0	0	2	1
Locust Run	0	0	0	0	1	0	0	1	1	3	1

4.2.4 Neighborhood Downspout Disconnection

Connected downspouts discharge rooftop runoff either directly to the storm drain system or to impervious surfaces. In both cases, 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 to local streams during storm events and reduces pollutant loads to streams.

Downspout disconnection was recommended for neighborhoods where at least 25 percent of the

downspouts are connected to impervious areas or directly connected 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. This criterion is used for subwatershed prioritization because it has a quantitative pollution reduction efficiency related to nutrient reduction goals.

The acres of rooftop addressed if downspout disconnection were implemented in the recommended neighborhood were calculated in the *Watershed Characterization Report* (Appendix E). The percentage of subwatershed rooftop area addressed was also calculated and was used to compare the restoration potential among the 14 subwatersheds. Subwatersheds with the highest percentages of impervious rooftop acres addressed through downspout disconnection denote the greatest restoration potential and therefore, were scored the highest. Percentages of subwatershed areas addressed through downspout disconnection range from approximately 0 – 18.5%. The following point system was used to assign downspout disconnect scores to the 14 subwatersheds based on the distribution and range of percentages of subwatershed rooftop areas addressed:

- ≥ 15.0% = 4 pts
- 14.9 – 10.0% = 3 pts
- 9.9 – 5.0% = 2 pts
- 4.9 – 0.1% = 1 pt
- No NSAs recommended in subwatershed = 0 pts

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

Table 4-4: NSA Downspout Disconnect Scores

SUBWATERSHED	% Rooftop Area Addressed	NSA Downspout Disconnect Score
Board-Aspen Run	0.0%	0
Cliffs Branch	0.0%	0
Glen Falls Run	5.1%	2
Liberty Reservoir-B	0.0%	0
Keyser Run	15.2%	4
Liberty Reservoir-E	0.0%	0
Norris Run	18.5%	4
Liberty Reservoir-C	0.0%	0
Timber Run	0.0%	0
Cooks Branch	0.0%	0
Liberty Reservoir-F	0.0%	0
Chimney Branch	0.0%	0
Liberty Reservoir-A	0.0%	0
Locust Run	0.0%	0

4.2.5 Institutional Site Index

Institutions offer unique opportunities for watershed restoration. Typically, institutional properties encompass considerable portions of land including various natural resources. In addition, they offer the opportunity to engage a wide range of citizens in restoration activities. This raises citizen awareness while also providing water quality improvement benefits in the watershed. A total of 24 community-based facilities were surveyed during Institutional Site Investigations (ISIs) including faith-based facilities, municipal facilities, and schools. The focus of ISIs is to identify potential restoration opportunities, educate the community, and provide water quality benefits. Subwatersheds with more institutional sites present more opportunities for implementing restoration actions (i.e. 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 these reasons, subwatershed prioritization for this criterion was based on the number of institutions and considering public versus private ownership.

For purposes of this prioritization, publicly owned ISIs are given a greater score because they have the greatest restoration potential. The number of publically owned institutions were summed and then multiplied by two to give them a weighted score. The number of privately owned institutions was then added to this number to give a total weighted number. The following point system was used to assign institutional site scores to the 14 subwatersheds based on the distribution and range ISIs addressed:

- ≥ 10 = 4 pts
- 5-9 = 3 pts
- 3-4 = 2 pts
- 1-2 = 1 pt
- No ISIs located in subwatershed = 0pts

The total number of institutions including public versus private ISIs and corresponding institutional site index scores are summarized by subwatershed in Table 4-5.

Table 4-5: ISI Scores

SUBWATERSHED	# of Public ISIs	Weighted # of Public ISIs (x2)	# of Private ISIs	Total Weighted # of ISIs	ISI Score
Board-Aspen Run	0	0	1	1	1
Cliffs Branch	0	0	5	5	3
Glen Falls Run	0	0	3	3	2
Liberty Reservoir-B	0	0	0	0	0
Keyser Run	0	0	0	0	0
Liberty Reservoir-E	0	0	0	0	0
Norris Run	3	6	6	12	4
Liberty Reservoir-C	0	0	0	0	0
Timber Run	0	0	0	0	0
Cooks Branch	0	0	2	2	1
Liberty Reservoir-F	0	0	0	0	0
Chimney Branch	0	0	0	0	0
Liberty Reservoir-A	0	0	1	1	1
Locust Run	0	0	3	3	2

4.2.6 Forest Coverage

The forests that once dominated the landscape of the Liberty Reservoir watershed, while still dense in some areas, have mostly been converted to agriculture or developed areas throughout much of the watershed. Forests have a monumentally positive impact to the hydrology of upland areas from the stream hydraulics to terrestrial habitat. A major goal identified for the Liberty Reservoir planning area is to restore and maintain native forest coverage. This watershed feature was identified for subwatershed prioritization based on the percentage of subwatershed forest cover as calculated in the *Watershed Characterization Report* (Appendix E).

For purposes of this prioritization, subwatersheds with smaller percentages of forest cover are given a greater score because there is a higher percentage of area that can be converted to tree cover. Percentages of forest cover area in the 14 Liberty Reservoir subwatersheds range from approximately 15% to 66%. The following point system was used to assign forest coverage scores to the 14 subwatersheds based on the range of percentages in each subwatershed:

- ≤ 25% = 4 pts
- 26 – 40% = 3 pts
- 41 – 50% = 2 pts
- ≥ 51% = 1 pt

Forest coverage percentages and corresponding scores are summarized in Table 4-6 by subwatershed.

Table 4-6: Forest Coverage Scores

SUBWATERSHED	% of Subwatershed with Forest Cover	Forest Cover Score
Board-Aspen Run	15%	4
Cliffs Branch	22%	4
Glen Falls Run	44%	2
Liberty Reservoir-B	42%	2
Keyser Run	25%	4
Liberty Reservoir-E	61%	1
Norris Run	36%	3
Liberty Reservoir-C	50%	2
Timber Run	62%	1
Cooks Branch	42%	2
Liberty Reservoir-F	58%	1
Chimney Branch	66%	1
Liberty Reservoir-A	59%	1
Locust Run	60%	1

4.2.7 Illicit Discharge Data

Baltimore County tracks illicit discharges through a program of routine outfall screenings. Illicit discharges refer to a leaking pipe or incorrectly connected pipes. The County has an outfall prioritization system based on data from the outfall screening. Under this system, major outfalls (greater than 3 feet in diameter) and minor outfalls (less than 3 feet in diameter) are assigned one of the following priority ratings: critical, high, low, or none. Critical outfalls are those with problems that require immediate correction and/or close monitoring, or outfalls with reoccurring problems. These are sampled the most frequently (4 times a year). On the other end of the rating scheme, outfalls that are not prioritized have insufficient data to determine a priority rating.

There is one major outfall in the Liberty Reservoir planning area, located in the Norris Run subwatershed. This outfall is rated as Priority 2. There are 30 minor outfalls throughout the watershed. All of the minor outfalls are unrated (Priority 0) except for one minor outfall (Priority 3) in the Norris Run subwatershed. The major and minor outfalls were used to prioritize the subwatersheds. The Norris Run subwatershed was given the highest score because it is the only subwatershed to contain a major outfall and it contains both priority outfalls. The total number of minor outfalls was used to assign scores for the remaining subwatersheds as the greater the number of outfalls in a subwatershed the greater the opportunity for potential illicit discharge. The following point system was used to assign illicit discharge scores to the 14 watersheds based on the Priority 0, minor outfalls:

- Priority outfalls (Priority 1-3) = 4 pts
- >5 outfalls (Priority 0) = 3 pts
- 3-5 outfalls (Priority 0) = 2 pts

- 1-2 outfalls (Priority 0) = 1 pt
- No minor or major outfalls in subwatershed = 0 pts

The number of outfalls associated with various County outfall prioritization ratings and corresponding illicit discharge data scores are shown in Table 4-7 by subwatershed.

Table 4-7: Illicit Discharge Data Scores

SUBWATERSHED	COUNTY OUTFALL PRIORITIZATION RATINGS				Illicit Discharge Data Score
	Priority 1 (Critical)	Priority 2 (High)	Priority 3 (Low)	Priority 0 (None)	
Board-Aspen Run	0	0	0	1	1
Cliffs Branch	0	0	0	2	1
Glen Falls Run	0	0	0	8	3
Liberty Reservoir-B	0	0	0	2	1
Keyser Run	0	0	0	3	2
Liberty Reservoir-E	0	0	0	0	0
Norris Run	0	1	1	3	4
Liberty Reservoir-C	0	0	0	0	0
Timber Run	0	0	0	2	1
Cooks Branch	0	0	0	3	2
Liberty Reservoir-F	0	0	0	2	1
Chimney Branch	0	0	0	0	0
Liberty Reservoir-A	0	0	0	3	2
Locust Run	0	0	0	0	0

4.2.8 Stream Buffer Improvements

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. Maintaining healthy streams and forest buffers are important for reducing nutrient and sediment loadings to the Liberty Reservoir. When stream buffers are converted from forest to agriculture or developed areas, many of these benefits are lost and stream health declines. Riparian buffer zones can be reestablished or preserved as a BMP to reduce land use impacts by intercepting and controlling pollutants before entering a water body.

In the *Watershed Characterization Report* (Appendix E), the vegetation condition of stream buffers was analyzed based on a 100-foot buffer on either side of the stream system. Three classifications 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 classifications. Open pervious (e.g. mowed lawns) represents the greatest potential for stream buffer reforestation. Therefore, the percentages of open pervious buffer area were used to prioritize restoration potential among subwatersheds. 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 percentages range from approximately 5 to 46%. The following point system

was used to assign stream buffer improvement scores to the 14 subwatersheds based on the distribution and range of open pervious buffer area percentages:

- ≥ 35% = 4 pts
- 34 – 25% = 3 pts
- 24 – 15% = 2 pts
- ≤ 14% = 1 pt

Percentages of open pervious stream buffer areas and corresponding scores are summarized in Table 4-8 by subwatershed.

Table 4-8: Stream Buffer Improvement Scores

SUBWATERSHED	% Open Pervious Stream Buffer Area	Stream Buffer Improvement Score
Board-Aspen Run	46%	4
Cliffs Branch	41%	4
Glen Falls Run	17%	2
Liberty Reservoir-B	26%	3
Keyser Run	33%	3
Liberty Reservoir-E	25%	3
Norris Run	19%	2
Liberty Reservoir-C	5%	1
Timber Run	7%	1
Cooks Branch	10%	1
Liberty Reservoir-F	17%	2
Chimney Branch	24%	2
Liberty Reservoir-A	14%	1
Locust Run	14%	1

4.2.9 Stream Corridor Restoration

Stream Corridor Assessments (SCAs) were conducted based on the Maryland Department of Natural Resources (DNR) survey protocols to quickly assess physical stream conditions and identify common environmental problems in the stream corridor. This included documentation of erosion sites, inadequate stream buffers, fish migration barriers, exposed or discharging pipes, channelized or altered stream sections, trash dumping sites, in or near stream construction, and unusual conditions. SCAs were focused in three subwatersheds with the greatest length of wadeable streams best suited for the survey method and for identifying stream corridor restoration efforts: Cliffs Branch, Keyser Run, and Norris Run. As previously mentioned, maintaining healthy streams is fundamental to improving water quality in the Liberty Reservoir watershed. This criterion relates to other watershed goals such as restoring and maintaining the biological health of local streams and their riparian buffers and improving water quality.

Along the 22.8 miles of stream walked in the Liberty Reservoir watershed, a total of 597 potential environmental problems were observed. The most frequently observed problems were erosion sites, inadequate buffers, fish barriers, channel alterations, and trash dumping. Because stream buffer improvement is addressed in a separate criterion, it is not included in the stream corridor restoration ranking criterion. The remaining four frequently observed problems were evaluated/scored separately and then combined to determine an overall stream corridor restoration score. Erosion, fish barriers, channel alterations, and trash dumping are good indicators of potential pollution sources and restoration needs. Each problem category and overall stream corridor restoration criterion scoring are described below.

Erosion

Erosion can destabilize stream banks, impact habitat, and cause sediment pollution problems downstream. Significant erosion problems are often a result of land use changes in a watershed. Since erosion is also a natural process, it was not the purpose of the SCA survey to identify every occurrence of erosion. Erosion was documented for unstable stream reaches with significant amounts of erosion along the stream's banks such as vertical stream banks and where vegetative roots along a reach were unable to hold soil onto the banks. Very severe and severe eroded stream length percentages (based on surveyed stream miles) were used to directly compare and rank subwatersheds. A higher percentage of stream length that is significantly eroded represents a greater need and potential for stream corridor restoration.

The percentages of significant erosion within each subwatershed range from 0 to 13.3 percent. While Norris Run did not have very severe or severe eroded streams, it did contain some minor erosion. As a result, Norris Run was given a score of 1. All subwatersheds that were not surveyed were given a score of zero. The following point system was used to assign erosion scores to the 14 subwatersheds based on the percentage of erosion.

- ≥ 10.1% = 4 pts
- 3.1 – 10% = 3 pts
- 1 – 3% = 2 pts
- ≤ 0.9% = 1 pt
- No erosion in subwatershed = 0 pts

Percentages of very severe and severe erosion and corresponding sub-criterion scores are summarized in Table 4-9 by subwatershed.

Table 4-9: SCA Erosion Scores

SUBWATERSHED	% Very Severe and Severe Erosion	Erosion Score
Board-Aspen Run	0.0%	0
Cliffs Branch	13.3%	4
Glen Falls Run	0.0%	0
Liberty Reservoir-B	0.0%	0
Keyser Run	2.9%	2
Liberty Reservoir-E	0.0%	0
Norris Run	0.0%	1
Liberty Reservoir-C	0.0%	0
Timber Run	0.0%	0
Cooks Branch	0.0%	0
Liberty Reservoir-F	0.0%	0
Chimney Branch	0.0%	0
Liberty Reservoir-A	0.0%	0
Locust Run	0.0%	0

Fish Migration Barriers

Fish migration barriers are obstacles or impediments that interfere with the upstream movement of fish. Many species of fish depend upon the ability to migrate into the upper reaches of streams to spawn. By limiting the length of streams available to these species, fish barriers decrease the population sizes of fish and in turn the health and biodiversity of aquatic habitats. Fish barriers include any manmade or natural structure that prevents fish from swimming over or through. During the SCAs, 78 fish barriers were identified, all within the three subwatersheds. The subwatersheds were ranked based on the number of fish barriers found during the SCAs. The following point system was used to assign fish barrier scores to the 14 subwatersheds based on the number of fish barriers.

- ≥ 31 = 4 pts
- 21 – 30 = 3 pts
- 11 – 20 = 2 pts
- ≤ 10 = 1 pt
- Subwatershed not surveyed = 0 pts

Table 4-10 summarizes the number of fish barriers in surveyed stream corridors and the corresponding fish barrier sub-criterion scores by subwatershed.

Table 4-10: SCA Fish Barrier Scores

SUBWATERSHED	# Fish Barriers	Fish Barrier Score
Board-Aspen Run	0	0
Cliffs Branch	35	4
Glen Falls Run	0	0
Liberty Reservoir-B	0	0
Keyser Run	17	2
Liberty Reservoir-E	0	0
Norris Run	26	3
Liberty Reservoir-C	0	0
Timber Run	0	0
Cooks Branch	0	0
Liberty Reservoir-F	0	0
Chimney Branch	0	0
Liberty Reservoir-A	0	0
Locust Run	0	0

Channel Alteration

Sections of stream where the banks or channel have been significantly modified from their naturally occurring structure or condition can have adverse impacts on stream health. This includes channels that have been dredged, widened, straightened, and/or covered with concrete. While often intended to convey more water and prevent flooding, habitat impairments and downstream instabilities may result. During the SCAs, the field team documented 38 channel alteration lengths. The total length of channel alteration observed and percentage of the total stream length surveyed that is altered were calculated in the *Watershed Characterization Report* (Appendix E). Altered stream length percentages (based on surveyed stream miles) were used to directly compare and rank subwatersheds. A higher percentage of stream length that is significantly altered represents a greater need and potential for stream corridor restoration. Subwatersheds were ranked according to this percentage, where 4 points was assigned to the subwatershed with the highest percentage of altered stream length and 1 point was assigned to the subwatershed with the lowest percentage of altered stream length. The following point system was used to assign channel alteration scores to the 14 subwatersheds based on the percentage of altered stream lengths.

- ≥ 1.01% = 4 pts
- 0.61 – 1% = 3 pts
- 0.31 – 0.6% = 2 pts
- ≤ 0.3% = 1 pt
- Subwatershed not surveyed = 0 pts

Table 4-11 summarizes the percentages of altered stream lengths in surveyed stream corridors and the corresponding channel alteration sub-criterion scores by subwatershed.

Table 4-11: SCA Channel Alteration Scores

SUBWATERSHED	% Altered	Channel Alteration Score
Board-Aspen Run	0.0%	0
Cliffs Branch	0.6%	4
Glen Falls Run	0.0%	0
Liberty Reservoir-B	0.0%	0
Keyser Run	0.7%	2
Liberty Reservoir-E	0.0%	0
Norris Run	1.8%	1
Liberty Reservoir-C	0.0%	0
Timber Run	0.0%	0
Cooks Branch	0.0%	0
Liberty Reservoir-F	0.0%	0
Chimney Branch	0.0%	0
Liberty Reservoir-A	0.0%	0
Locust Run	0.0%	0

* % altered based on altered length observed in the field divided by total stream length surveyed.

Trash Dumping

Trash dumping sites are places where large amounts of trash have been dumped or have accumulated inside the stream corridor. Identifying these sites helps identify areas where limiting access is necessary to reduce trash dumping and locations suitable for stream clean-ups. Trash dumping sites were frequently located on private property where volunteers would not be allowed assess. During the SCAs, field teams estimated the number of pick-up truck loads they deemed necessary to remove all trash/debris from a given site. Greater numbers of pick-up truck loads denote greater amounts of trash within a stream and a higher need for restoration. Subwatersheds were ranked according to the total number of estimated pick-up truck loads, where 4 points were assigned to the subwatershed with the most pick-up truck loads and 0 points were assigned to the subwatersheds that were not surveyed. The following point system was used to assign trash dumping scores to the 14 subwatersheds based on the number of truck loads of trash in the subwatershed.

- ≥ 41 = 4 pts
- 21 – 40 = 3 pts
- 11 – 20 = 2 pts
- ≤ 10 = 1 pt
- Subwatershed not surveyed = 0 pts

Table 4-12 summarizes the total number of pick-up truck loads estimated to remove trash/debris in stream corridors and the corresponding trash dumping sub-criterion scores by subwatershed.

Table 4-12: SCA Trash Dumping Scores

SUBWATERSHED	# Truck Loads	Trash Dumping Score
Board-Aspen Run	0	0
Cliffs Branch	59	4
Glen Falls Run	0	0
Liberty Reservoir-B	0	0
Keyser Run	17	2
Liberty Reservoir-E	0	0
Norris Run	1	1
Liberty Reservoir-C	0	0
Timber Run	0	0
Cooks Branch	0	0
Liberty Reservoir-F	0	0
Chimney Branch	0	0
Liberty Reservoir-A	0	0
Locust Run	0	0

Overall Stream Corridor Restoration Score

Stream corridor restoration may involve addressing all four environmental problem categories. Therefore, to determine the overall score for the stream corridor restoration criterion, subwatersheds were ranked according to the sum of the sub-criterion scores. The subwatershed with the highest total sub-criteria score received the highest ranking (4 points). The subwatershed with the lowest total sub-criteria score received the lowest ranking for this criterion (1 point). The following point system was used to assign overall stream corridor restoration scores to the 14 subwatersheds based on the total sub-criteria score for each subwatershed.

- ≥ 16 = 4 pts
- 12 – 15 = 3 pts
- 7 – 11 = 2 pts
- ≤ 6 = 1 pt
- Subwatershed not surveyed = 0 pts

Table 4-13 summarized sub-criteria totals and overall stream corridor restoration scores by subwatershed.

Table 4-13: SCA Stream Corridor Restoration Scores

SUBWATERSHED	Total of Sub-Criteria Score	Overall Stream Corridor Restoration Score
Board-Aspen Run	0	0
Cliffs Branch	16	4
Glen Falls Run	0	0
Liberty Reservoir-B	0	0
Keyser Run	8	2
Liberty Reservoir-E	0	0
Norris Run	6	1
Liberty Reservoir-C	0	0
Timber Run	0	0
Cooks Branch	0	0
Liberty Reservoir-F	0	0
Chimney Branch	0	0
Liberty Reservoir-A	0	0
Locust Run	0	0

4.2.10 Conservation Areas

There are many programs working to conserve land in the Liberty Reservoir watershed. These conservation efforts include county zoning, agricultural land preservation programs, local land trusts, and rural land conservation easements. Approximately 40% of the Liberty Reservoir watershed is held under some type of conservation easements, and several plots of land are held under multiple easements. One of the primary goals for the Liberty Reservoir watershed is to maintain tree canopy and forest coverage. Ensuring that the natural resources in the watershed are protected benefits both terrestrial and aquatic health and improving overall water quality.

In the *Watershed Characterization Report* (Appendix E), conservation areas throughout the watershed are quantified and the different types of easements are explained in detail. The total acreage of conservation areas in each watershed was calculated, and the overall percentage of land in conservation was used to compare subwatersheds. The percentages of current land in conservation for subwatersheds ranged from 17 to 84%. The lower the total percentage of conservation land in a subwatershed, the more land available to place in conservation, and therefore, a higher conservation score was given. The following point system was used to assign conservation area scores to the 14 subwatersheds based on the distribution and range of percentages currently in conservation:

- ≤ 30% = 4 pts
- 31 – 45% = 3 pts
- 46 – 60% = 2 pts
- > 61% = 1 pt

Percentages of land in conservation areas and corresponding scores are summarized in Table 4-14 by subwatershed.

Table 4-14: Conservation Easement Scores

SUBWATERSHED	% of Land in Conservation	Conservation Easement Score
Board-Aspen Run	36%	3
Cliffs Branch	43%	3
Glen Falls Run	21%	4
Liberty Reservoir-B	48%	2
Keyser Run	17%	4
Liberty Reservoir-E	84%	1
Norris Run	21%	4
Liberty Reservoir-C	55%	2
Timber Run	29%	4
Cooks Branch	40%	3
Liberty Reservoir-F	62%	1
Chimney Branch	74%	1
Liberty Reservoir-A	54%	2
Locust Run	43%	3

4.2.11 Hotspot Site Index

Stormwater hotspots are areas that have potential to generate higher concentrations of stormwater pollutants than typically found in runoff from developed areas or have a higher risk of spill, leaks, or illicit discharges due to the nature of the facility (CWP, 2004). Stormwater pollutants generated at hotspots vary depending on the activities at each location, but they can include nutrients, hydrocarbons, metals, chloride, pesticides, bacteria, and trash. Hotspots are categorized by their function and include commercial, municipal, transport-related, golf courses, and industrial facilities. The purpose of the HSIs is to evaluate pollution potential from hotspot operations and identify potential restoration practices that may be necessary.

A total of 20 hotspots were assessed in the Liberty Reservoir watershed. Common operations observed at these hotspots that had potential for pollutant runoff included vehicle operations, outdoor material storage, waste management, physical plant, turf/landscape management, and stormwater infrastructure. Using these categories, the hotspots were ranked as a severe hotspot, confirmed hotspot, potential hotspot, or not a hotspot. Some hotspots were listed under follow up indicating that the site was inaccessible to the field workers. These rankings were used to determine the hotspot index score to prioritize subwatersheds. The Norris Run subwatershed was the only subwatershed with a confirmed hotspot and was given a prioritization ranking of 4. The remaining subwatershed hotspot scores were based on the total number of potential sites in each subwatershed according to the following point system:

- Contained “confirmed hotspots” = 4 pts
- Contained >3 “potential hotspots”= 3 pts
- Contained 3-1 “potential hotspots”= 3 pts

- Contained "not a hotspot" = 1 pt
- No HSIs in subwatershed = 0 pts

The number of hotspot sites and corresponding rating are shown in Table 4-15 by subwatershed.

Table 4-15: HSI Site Index Scores

SUBWATERSHED	Hotspot Rating					HSI Score
	Not a Hotspot	Potential	Confirmed	Severe	Follow Up	
Board-Aspen Run	1	0	0	0	0	1
Cliffs Branch	1	2	0	0	0	2
Glen Falls Run	1	5	0	0	1	3
Liberty Reservoir-B	0	0	0	0	0	0
Keyser Run	0	2	0	0	0	2
Liberty Reservoir-E	0	0	0	0	0	0
Norris Run	1	1	1	0	0	4
Liberty Reservoir-C	0	0	0	0	0	0
Timber Run	0	0	0	0	1	1
Cooks Branch	0	0	0	0	0	0
Liberty Reservoir-F	0	2	0	0	0	2
Chimney Branch	0	0	0	0	0	0
Liberty Reservoir-A	0	0	0	0	0	0
Locust Run	0	1	0	0	0	2

4.2.12 Pervious Area Index

The most likely candidates for successful pervious area restoration efforts are those on public lands with minimal site preparation required. Baltimore County has an aggressive reforestation program using grants and Stormwater Remediation Fee Funds. The County collaborates routinely with organizations and citizens to reforest on a variety of sites. For community open space reforestation sites, DNR's "Tree-mendous Maryland" program is a source for trees. 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 restoration was based on the total acres of land within a subwatershed available for planting. Publicly owned lands were given a higher weighted value than land that are privately owned. The following point system was used to assign pervious area scores to the 14 subwatersheds based on the distribution and range of percentages of subwatershed areas addressed:

- ≥ 4.00% = 4 pts
- 2.00 – 3.99% = 3 pts
- 0.10 – 1.99% = 2 pts

- 0.01 – 0.09% = 1 pt
- No PAAs in subwatershed = 0 pts

Pervious area percentages and corresponding scores are summarized in Table 4-16 by subwatershed. These ranking scores are comparable to the PAA restoration ranking performed in Section 4.5 of the *Watershed Characterization Report* (Appendix E).

Table 4-16: Pervious Area Restoration Scores

SUBWATERSHED	Acres Planting Public	Weighted Public (x2)	Acres Planting Private	Total Weighted Acres	% weighted acres per % subwatershed acres	Pervious Area Score
Board-Aspen Run	0	0	0	0	0.00%	0
Cliffs Branch	0	0	0	0	0.00%	0
Glen Falls Run	0	0	0	0	0.00%	0
Liberty Reservoir-B	0	0	0	0	0.00%	0
Keyser Run	36.5	73	0	73	7.25%	4
Liberty Reservoir-E	0	0	0	0	0.00%	0
Norris Run	0.5	1	0	1	0.06%	1
Liberty Reservoir-C	0	0	0	0	0.00%	0
Timber Run	0	0	1	1	0.11%	2
Cooks Branch	0	0	0	0	0.00%	0
Liberty Reservoir-F	0	0	2	2	0.10%	2
Chimney Branch	0	0	0.5	0.5	0.11%	2
Liberty Reservoir-A	0	0	0	0	0.00%	0
Locust Run	27.5	55	0	55	3.85%	3

4.2.13 Septic Systems

The majority of the Liberty Reservoir watershed relies on septic systems for waste treatment. Septic systems can increase the nitrogen load that enters a stream system, especially if the system is not functioning properly. These systems can also increase the bacterial contamination of nearby streams. According to Baltimore County EPS, there are approximately 2,300 septic systems in the Liberty Reservoir watershed.

Subwatersheds with a greater number of septic systems have the greatest potential to be a nutrient and pathogenic pollutant source and were assigned a higher restoration score. For septic systems that are within 1,000 feet of the stream, the nitrogen load that enters the stream system is nearly twice as much as septic systems located greater than 1,000 feet from the stream. To account for higher nitrogen loads near streams, septic systems within 1,000 feet of the stream were weighted by multiplying by two. The remaining septic systems, greater than 1,000 feet from the stream, were added to the weighted septic systems to reach the total weighted septic system number. The following point system was used to assign septic system scores to the 14 subwatersheds:

- ≥ 500 = 4 pts
- 499 – 300 = 3 pts
- 299 – 150 = 2 pts
- < 150 = 1 pt

Number of septic systems and corresponding restoration scores are summarized in Table 4-17 by subwatershed.

Table 4-17: Septic System Scores

SUBWATERSHED	Total # of Septic Systems	# of Septic Systems < 1000' from stream	Total Weighted Septic Systems	Septic System Restoration Score
Board-Aspen Run	143	137	280	2
Cliffs Branch	397	385	782	4
Glen Falls Run	330	330	660	4
Liberty Reservoir-B	73	73	146	1
Keyser Run	166	166	332	3
Liberty Reservoir-E	6	6	12	1
Norris Run	334	324	658	4
Liberty Reservoir-C	32	32	64	1
Timber Run	146	140	286	2
Cooks Branch	151	151	302	3
Liberty Reservoir-F	168	168	336	3
Chimney Branch	29	29	58	1
Liberty Reservoir-A	65	65	130	1
Locust Run	246	240	486	3

4.2.14 Biological Indicators

Stream biological health is an important indicator of water quality. Baltimore County takes macroinvertebrate samples throughout the Liberty Reservoir watershed to determine Benthic Index of Biotic Integrity (BIBI) scores. Biological monitoring currently does not take place in several of the subwatersheds in Liberty Reservoir watershed. For these subwatersheds, a score of 0 was given. For all subwatersheds, BIBI scores fall in the “Poor”, “Fair”, and “Good” condition ratings with average scores from 2.82 to 4.25. The higher the BIBI score, the better the overall water quality and aquatic habitat in that stream system. Therefore, high scores were given to subwatersheds with lower BIBI scores. The following point system was used to assign BIBI scores for the 14 subwatersheds based on the distribution and range of values:

- < 3.00 = 4 pts
- 3.01 – 3.49 = 3 pts
- 3.50 – 3.99 = 2 pts

- ≥ 4.00 = 1 pt
- No biological monitoring stations in the subwatershed = 0 pts

Average BIBI values and corresponding scores are summarized in Table 4-18 by subwatershed.

Table 4-18: Benthic Index of Biotic Integrity Scores

SUBWATERSHED	# of Samples	Avg BIBI Value	Rating	BIBI Score
Board-Aspen Run	0	0.00	N/A	0
Cliffs Branch	10	2.82	Poor	4
Glen Falls Run	12	3.67	Fair	2
Liberty Reservoir-B	0	0.00	N/A	0
Keyser Run	8	3.10	Fair	3
Liberty Reservoir-E	0	0.00	N/A	0
Norris Run	18	3.39	Fair	3
Liberty Reservoir-C	0	0.00	N/A	0
Timber Run	3	3.95	Fair	2
Cooks Branch	2	4.25	Good	1
Liberty Reservoir-F	10	3.55	Fair	2
Chimney Branch	1	4.17	Good	1
Liberty Reservoir-A	0	0.00	N/A	0
Locust Run	13	4.15	Good	1

4.2.15 Subwatershed Prioritization Summary

The 14 subwatersheds that make up the Liberty Reservoir planning area are ranked according to their total prioritization score (i.e. the sum of prioritization criterion scores) based on their need and restoration potential. Subwatershed ranking results are summarized in Table 4-19 including criterion scores, total scores, and ranking by subwatershed.

Subwatersheds were placed into one of five priority categories based on ranking results: very high, high, medium, medium-low, and low. Subwatersheds given a very high priority are those with greater pollution and restoration potential, while those with low priority are those with lower pollution and restoration potential. These results are summarized in Table 4-20 and illustrated in Figure 4-1.

Subwatershed prioritization scores range from 15 to 46 points. The following point system was used to assign prioritization categories for the 14 subwatersheds based on the distribution and range of prioritization scores:

- ≥ 45 = Very High
- 35 – 44 = High
- 25 – 34 = Medium
- 20 – 24 = Medium-Low
- < 20 = Low

Table 4-19: Subwatershed Ranking Results

SUBWATERSHED	Nitrogen Load	Phosphorus Load	Sediment Load	% Impervious	NSA PSI/ROI	NSA Downspout Disconnect	ISI Site Index	Forest Cover	Illicit Discharge Data	Stream Buffer Improvement	Stream Corridor Restoration	Conservation Areas	Hotspot Site Index	Pervious Area Index	Septic System	BIBI	TOTAL SCORE	SUBWATERSHED RANK
Board-Aspen Run	4	4	4	3	1	0	1	4	1	4	0	3	0	0	2	0	***31***	***5***
Cliffs Branch	4	4	4	2	2	0	3	4	1	4	4	3	0	0	4	4	***43***	***3***
Glen Falls Run	3	3	3	3	4	2	2	2	3	2	0	4	1	0	4	2	***38***	***4***
Liberty Reservoir-B	3	4	3	3	3	0	0	2	1	3	0	2	0	0	1	0	***25***	***6***
Keyser Run	3	3	3	4	3	4	0	4	2	3	2	4	0	4	3	3	***45***	***2***
Liberty Reservoir-E	2	2	3	1	1	0	0	1	0	3	0	1	0	0	1	0	***15***	***13***
Norris Run	3	3	3	3	4	4	4	3	4	2	1	4	0	1	4	3	***46***	***1***
Liberty Reservoir-C	1	2	2	2	2	0	0	2	0	1	0	2	0	0	1	0	***15***	***13***
Timber Run	1	1	1	2	3	0	0	1	1	1	0	4	1	2	2	2	***22***	***7***
Cooks Branch	2	2	2	2	1	0	1	2	2	1	0	3	0	0	3	1	***22***	***7***
Liberty Reservoir-F	1	2	2	1	2	0	0	1	1	2	0	1	0	2	3	2	***20***	***9***
Chimney Branch	2	1	2	1	2	0	0	1	0	2	0	1	0	2	1	1	***16***	***12***
Liberty Reservoir-A	2	3	2	1	1	0	1	1	2	1	0	2	0	0	1	0	***17***	***11***
Locust Run	1	1	1	2	1	0	2	1	0	1	0	3	0	3	3	1	***20***	***9***

Table 4-20: Subwatershed Prioritization

Rank	Subwatershed	Total Score	Prioritization Category
1	Norris Run	46	Very High
2	Keyser Run	45	Very High
3	Cliffs Branch	43	High
4	Glen Falls Run	38	High
5	Board-Aspen Run	31	Medium
6	Liberty Reservoir-B	25	Medium
7	Timber Run	22	Medium-Low
7	Cooks Branch	22	Medium-Low
9	Liberty Reservoir-F	20	Medium-Low
9	Locust Run	20	Medium-Low
11	Liberty Reservoir-A	17	Low
12	Chimney Branch	16	Low
13	Liberty Reservoir-C	15	Low

13	Liberty Reservoir-E	15	Low

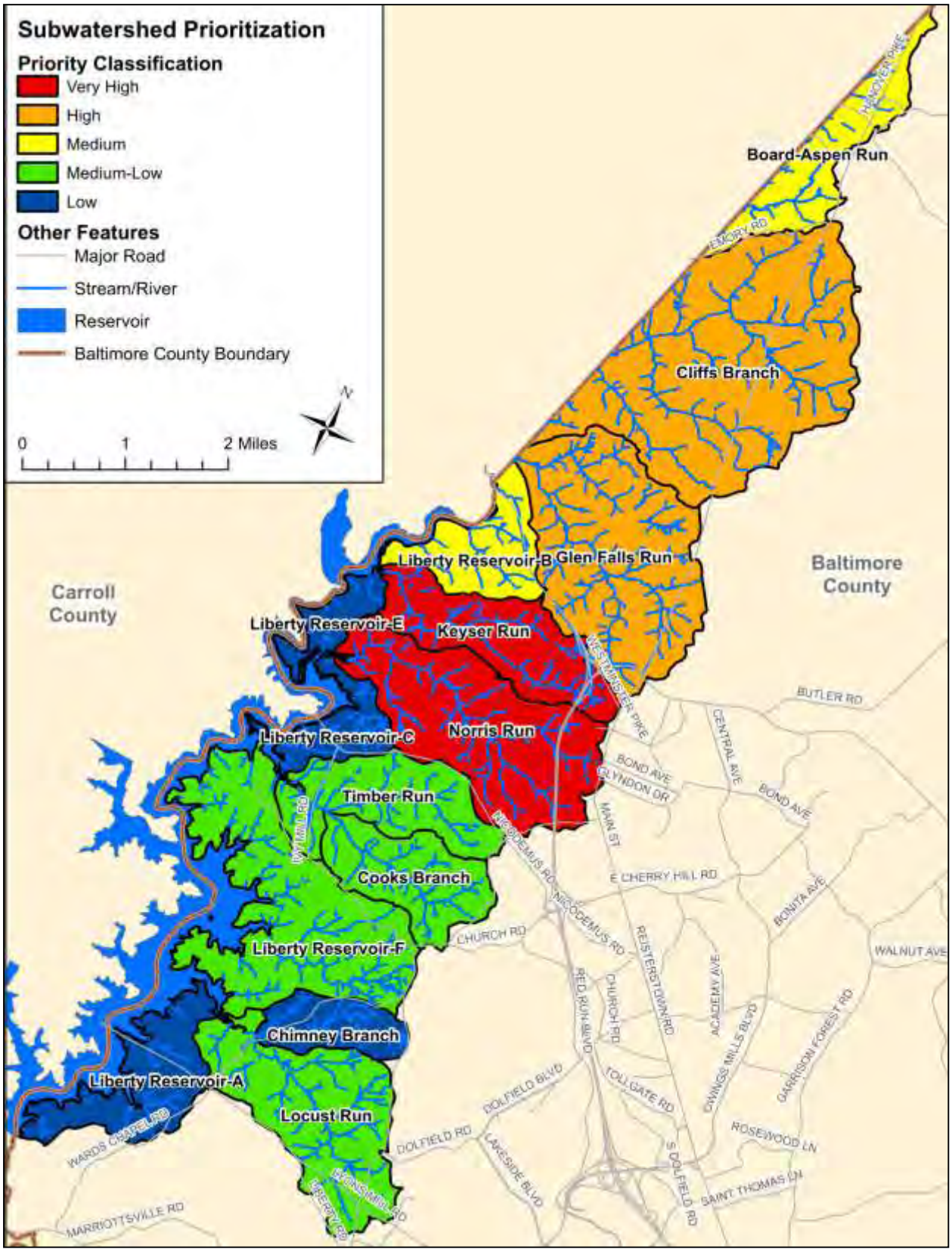

Figure 4-1: Liberty Reservoir Subwatershed Prioritization

4.3 Subwatershed Restoration Strategies

Restoration strategies for each subwatershed are presented in the following subsections. Subwatersheds are presented in the numerical order based on the unique ID numbers assigned during the field assessments and summarized in Section 4.2.1 of the *Watershed Characterization Report* (Appendix E). A description of key watershed characteristics is presented for each subwatershed including drainage area, stream length, population, land use/land cover, land in conservation easements, impervious cover, and soils. Assessment results for neighborhoods, hotspots, institutions, pervious areas, illicit discharges, and stream corridors are also summarized for each subwatershed. Finally, a subwatershed management strategy including recommended citizen and municipal actions are presented at the end of each subsection.

Several of the assessment categories that were considered only examined a percentage of opportunities within a given subwatershed. These categories include neighborhoods, hotspots, and institutions. The objective of the assessments is to review a representative sample of the neighborhoods, businesses and institutions in the watershed to identify the most likely opportunities to limit pollution sources and implement pollution reduction measures.

For example, because there are numerous operations that qualify as stormwater hotspots, not all could be individually evaluated during the uplands survey. The assessments are intended to represent common types of hotspot operations located throughout the watershed and help develop an overall strategy to encompass all hotspot operations.

4.3.1 Board-Aspen Run

The Board-Aspen Run subwatershed is the 5th smallest subwatershed in the Liberty Reservoir planning area and is comprised of nearly 56% agricultural land use. Very low density residential, low density residential, and forest land uses occupy the majority of the remaining subwatershed area. The Board-Aspen Run subwatershed has the 3rd highest percentage of impervious surface (6.4%). Key characteristics regarding the Board-Aspen Run subwatershed are summarized in Table 4-21.

Table 4-21: Key Subwatershed Characteristics – Board-Aspen Run

Drainage Area	757.8	acres	
	1.18	sq. mi.	
Stream Length	5.2	miles	
Population	438	(2010 Census)	
	0.58	persons/acre	
Land Use/Land Cover	Very Low Density Residential:		10.5%
	Low Density Residential:		13.5%
	Medium/High Density Residential:		2.6%
	Commercial:		1.5%
	Industrial:		0.0%
	Institutional:		0.9%
	Open Urban:		0.3%
	Agriculture:		55.9%
	Forest:		14.9%
	Transportation:		0.0%
	Other:		0.0%
Land in Easement	270	acres	35.6%
Impervious Cover	49	acres	6.4%
Soils	A Soils (low runoff potential):		0.0%
	B Soils:		67.5%
	C Soils:		9.6%
	C/D Soils:		0.0%
	D Soils (high runoff potential):		22.6%
	Water:		0.4%

4.3.1.1 Neighborhoods

One neighborhood was identified and assessed within the Board-Aspen Run subwatershed during the uplands assessment of the Liberty Reservoir watershed. Characteristics such as lot size, age, and type were used to delineate neighborhoods rather than subwatershed boundaries. As a result, some neighborhoods overlap multiple subwatersheds. Qualitative descriptions of neighborhoods and recommendations are included within the subwatershed restoration strategy for the subwatershed where the majority of the neighborhood resides. While descriptions are not repeated for neighborhoods overlapping multiple subwatersheds, calculations presented in the *Watershed Characterization Report* (Appendix E) were based on the fraction of the NSA area within respective watersheds.

Recommendations for addressing stormwater volume and pollutants within this subwatershed include rain gardens and public education (i.e., bayscaping and increasing lot tree canopy). A summary of neighborhood recommended actions is presented in Table 4-22.

Table 4-22: NSA Recommendations – Board-Aspen Run

NSA_ID	Lot Size (Acres)	Rain Garden	Bayscaping	Increase Lot Canopy	Notes
NSA_S_0101	1-3	X	X	X	-

The neighborhood assessed in the Board-Aspen Run subwatershed was recommended for rain garden implementation due to the large lot sizes and grassed lawns (Figure 4-2). The large lot sizes also contributed to recommendations of bayscaping and increasing lot canopy (Figure 4-2).

Figure 4-2: Large Lots with Potential for Bayscaping, Lot Canopy Improvement and Rain Garden Implementation at NSA_S_0101

4.3.1.2 Hotspots

One hotspot investigation was performed within the Board-Aspen Run subwatershed. Table 4-23 summarizes the potential pollution sources found at the site.

Table 4-23: HSI Results Summary – Board-Aspen Run

HSI_ID	HSI Status	Description		Vehicle Operations	Outdoor Materials	Waste Management	Physical Plant	Turf/Landscape Management	Storm Water	Notes
HSI_S_0101	Not a Hotspot	Commercial	Roller Skating Rink			X	X			Open space available for tree planting and possible SWM retrofit

HSI_S_0101 is a roller skating rink located on Hanover Pike in the Board-Aspen Run subwatershed. Potential pollution activities include physical plant and waste management. Specific observations made at this site include downspouts connected directly to impervious surfaces; however, there was no alternative for disconnection. Garbage collection was also observed on site, although the dumpster was in good condition with the lid closed and no overflowing garbage.

Figure 4-3: Downspout Discharging to Impervious (left) and Open Pervious Area Available for Potential Tree Planting or SWM Retrofit (right)

4.3.1.3 Institutions

One faith-based institutional site was assessed for retrofit opportunities in the Board-Aspen Run subwatershed during the uplands assessment of the Liberty Reservoir watershed. Table 4-24 summarizes recommendations for the institutional sites assessed in the Board-Aspen Run subwatershed.

Table 4-24: ISI Recommendations – Board-Aspen Run

Site ID	Name	Public/ Private	# Trees for Planting	Storm water Retrofit	Downspout Disconnection	Notes
ISI_S_0101	St. Paul's Evangelical Lutheran Church	Private	28	X	X	Potential SWM retrofit to treat parking lot sheet flow.

ISI_S_0101 is a faith-based institution located on Dover Road. Restoration opportunities at this location involve stormwater retrofit, downspout disconnection, and tree planting. Open space is available at the rear of the lot for planting an estimated 28 trees (Figure 4-4). Open space on the opposite side of the parking lot also allows room for a potential stormwater retrofit to treat the impervious surface using a sheet flow BMP.

Figure 4-4: Potential Tree Planting for ISI_S_0101 (left) and Open Space Available to Treat Parking Lot Sheet Flow (right)

4.3.1.4 Pervious Areas

No pervious areas were assessed in the Board-Aspen Run subwatershed.

4.3.1.5 Illicit Discharges

Baltimore County tracks illicit discharges through a program of routine screening at major and minor outfalls. The County uses a prioritization system based on this data where outfalls are assigned one of the following priority ratings: none (priority 0), low (priority 3), high (priority 2), and critical (priority 1). Priority 1 outfalls have major problems that require immediate correction and/or close monitoring, or have recurring problems. These outfalls are sampled four times each year. Priority 2 outfalls have moderate to minor problems and potential to become more severe. These are sampled once a year. Priority 3 outfalls have minor to no problems and are monitored on a 10-year cycle. Priority 0 outfalls lack sufficient data to determine a priority rating. More information on Baltimore County's Illicit Discharge Elimination program can be found in Section 3.4.3 of the *Watershed Characterization Report*.

No major outfalls are located within the Board-Aspen Run subwatershed.

4.3.1.6 Stream Corridors

A stream corridor assessment was not completed in this subwatershed.

4.3.1.7 Subwatershed Management Strategy

<u>Engaging Citizens' Groups</u>

1. Educate citizens about the benefits and importance of rain gardens.

2. Educate citizens about the benefits and importance of bayscaping.

3. Increase tree canopies on private lots by educating citizens on the benefits of trees and raising awareness of programs such as Baltimore County's "Big Trees Sale".

4. Inform citizens of the importance of septic system maintenance.

Municipal Actions

1. Work with the hotspots indicated and similar businesses to implement appropriate practices for vehicle operations, outdoor materials storage, management of waste, their physical plant, and stormwater maintenance, where appropriate.

2. Engage hotspot HSI_S_0101 on the potential of tree planting and/or a stormwater retrofit.

3. Investigate the potential for a SWM retrofit at ISI_S_0101.

4. Educate institution ISI_S_0101 on potential downspout disconnection and tree planting.

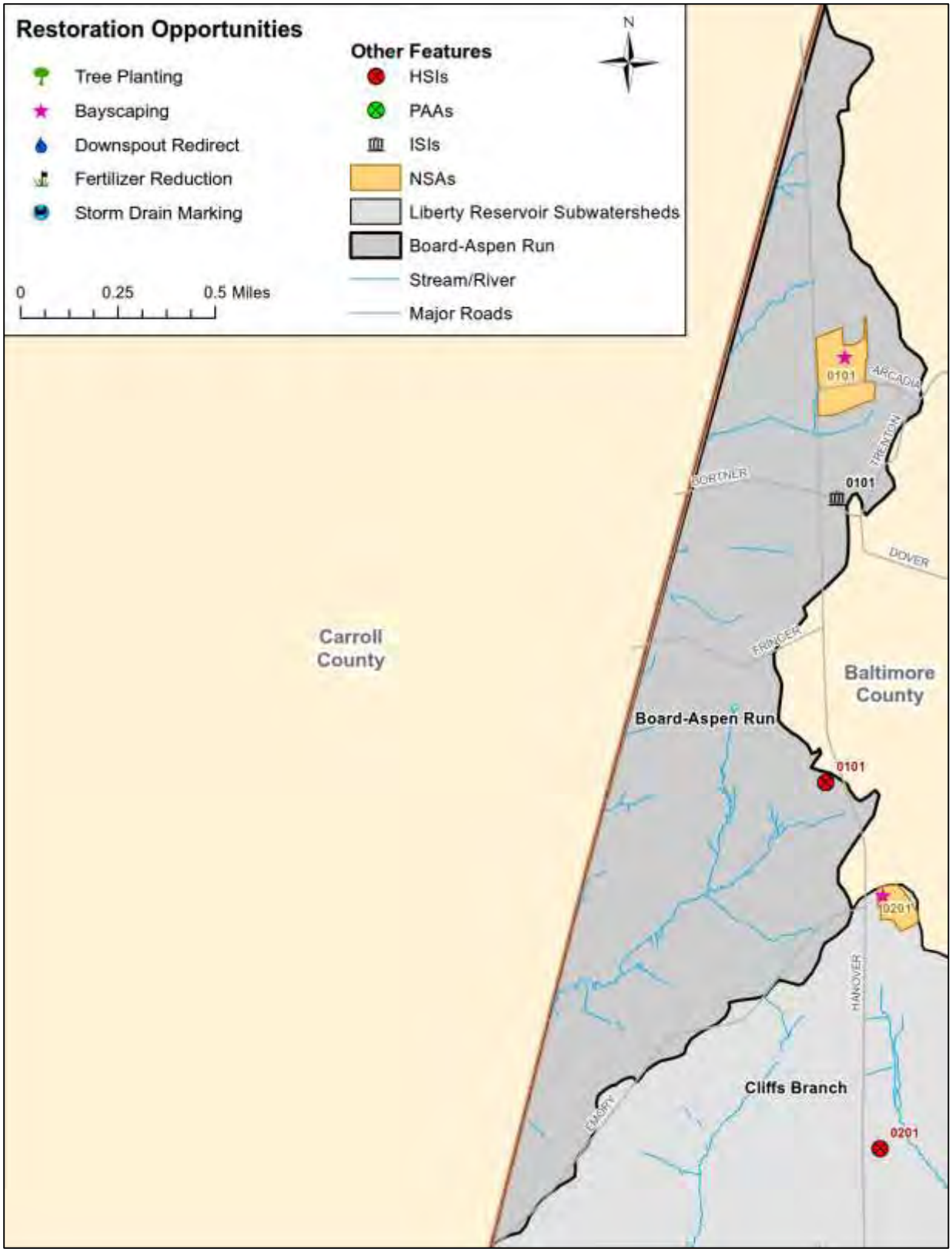

Figure 4-5: Restoration Opportunities in Board-Aspen Run

4.3.2 Cliffs Branch

The Cliffs Branch subwatershed is the largest subwatershed in the Liberty Reservoir watershed with 3,142 acres and ranks 13th in population density. Approximately 57% of the Cliffs Branch subwatershed is occupied by agricultural land uses, the highest of any subwatershed. Other significant land uses include low density residential (12.5%) and forest (21.8%). The Cliffs Branch subwatershed also contains the most stream miles, the most acres in conservation easements, and the most impervious surfaces of any subwatershed in the Liberty Reservoir watershed. Key characteristics regarding the Cliffs Branch subwatershed are summarized in Table 4-25.

Table 4-25: Key Subwatershed Characteristics – Cliffs Branch

Drainage Area	3,142.3	acres	
	4.91	sq. mi.	
Stream Length	27.2	miles	
Population	1,153	(2010 Census)	
	0.37	persons/acre	
Land Use/Land Cover	Very Low Density Residential:		4.3%
	Low Density Residential:		12.5%
	Medium/High Density Residential:		0.8%
	Commercial:		1.1%
	Industrial:		0.1%
	Institutional:		2.4%
	Open Urban:		0.0%
	Agriculture:		56.5%
	Forest:		21.8%
	Transportation:		0.0%
	Other:		0.5%
Land in Easement	1,356	acres	43.2%
Impervious Cover	119	acres	3.8%
Soils	A Soils (low runoff potential):		0.0%
	B Soils:		67.4%
	C Soils:		10.4%
	C/D Soils:		0.0%
	D Soils (high runoff potential):		22.1%
	Water:		0.1%

4.3.2.1 Neighborhoods

A total of three distinct neighborhoods were identified and assessed within the Cliffs Branch subwatershed during the uplands assessment of the Liberty Reservoir watershed. Recommendations for addressing stormwater volume and pollutants within this subwatershed include rain gardens and public education (i.e., bayscaping, increasing lot tree canopy, and fertilizer reduction on lawns). A summary of

neighborhood recommended actions is presented in Table 4-26.

Table 4-26: NSA Recommendations – Cliffs Branch

NSA_ID	Lot Size (Acres)	Rain Garden	Bayscaping	Increase Lot Canopy	Fertilizer Reduction	Notes
NSA_S_0201	1/2	X	X	X		Not enough room to retrofit along roadside ditch
NSA_S_0202	1		X	X		7 cars on one property; pallets by road; some equipment in yards
NSA_S_0203	1-3	X	X	X	X	-

All three neighborhoods in the Cliffs Branch subwatershed are recommended for public education related to bayscaping and increasing lot tree canopy. Two neighborhoods, NSA_S_0201 and NSA_S_0203 are recommended for rain garden implementation (Figure 4-6, right).

Figure 4-6: Large Lots with Potential for Bayscaping, Lot Canopy Improvement, and Rain Garden Implementation at NSA_S_0202 (left) and NSA_S_0203 (right)

4.3.2.2 Hotspots

Three hotspot investigations were performed within the Cliffs Branch subwatershed. The assessments include a lawn equipment store, auto repair shop, and propane tank shop. Table 4-27 summarizes the potential pollution sources found at the site.

Table 4-27: HSI Results Summary – Cliffs Branch

HSI_ID	HSI Status	Description		Vehicle Operations	Outdoor Materials	Waste Management	Physical Plant	Turf/Landscape Management	Storm Water	Notes
HSI_S_0201	Not a Hotspot	Commercial	Lawn Equipment Store		X	X				Potential tree planting along the side and back of lot
HSI_S_0202	Potential Hotspot	Commercial	Auto Repair Shop	X	X					Majority of site could not be viewed. Follow up inspection.
HSI_S_0203	Potential Hotspot	Commercial	Propane Tank Shop	X	X	X				Could not tour property. Head waters behind site.

HSI_S_0201 is a commercial lawn equipment store located on Hanover Pike. Potential pollution sources at this hotspot include outdoor material storage and waste management. Uncovered outdoor material storage was observed at this site (Figure 4-7). From the aerial maps there appears to be a substainal part of the property that is open pervious space and abuts a stream buffer. This land area could potential be used for tree plantings.

HSI_S_0202 is a commercial auto repair shop located on Hanover Pike. Potential pollution sources at this hotspot include vehicle operations and outdoor material storage. Staining on pavement is evident on the parking lot in front of the shop (Figure 4-7). A significant portion of the site could not be viewed due to a high fence. A follow up inspection is recommended at this site.

Figure 4-7: Outdoor Material Storage at HSI_S_0201 (left) and Asphalt Staining at HSI_S_0202 (right)

HSI_S_0203 is a commercial propane tank shop located on Old Hanover Road. Potential pollution sources at this hotspot include vehicle operations, outdoor material storage, and waste management. A headwater channel runs behind the property, and it was unclear if the downspouts from the building drain

directly to a channel. Also an uncovered pile of gravel was visible without apparent erosion and sediment control measures. A follow up inspection is recommend.

4.3.2.3 Institutions

Four faith-based institutional sites and one cemetery were assessed for retrofit opportunities in the Cliffs Branch subwatershed during the uplands assessment of the Liberty Reservoir watershed. Table 4-28 summarizes recommendations for the institutional sites assessed in the Cliffs Branch subwatershed.

Table 4-28: ISI Recommendations – Cliffs Branch

Site ID	Name	Public/ Private	# Trees for Planting	Storm water Retrofit	Impervious Cover Removal	Storm Drain Marking	Buffer Improvement	Notes
ISI_S_0201	Boring United Methodist Church	Private	0					Only portion of parking lot is in watershed
ISI_S_0202	Living Hope Baptist Church	Private	104	X				Potential SWM to treat roof and lawn runoff
ISI_S_0203	Camp Milldale/Pearlstone Retreat	Private	268			X	X	About 50 trees remaining from original 600 tree planting
ISI_S_0204	Woodenburg Cemetery	Private	0		X			Strip of asphalt can potentially be removed
ISI_S_0205	Mt. Gilead United Methodist Church	Private	0					No space for retrofits or plantings

ISI_S_0202 is a faith-based facility located off of Old Hanover Road. Restoration opportunities at this location involve stormwater retrofit and tree plantings. A large open space on the lot offers the potential for tree plantings along the drive as well as in the back corner of the lot. There is also room for a potential stormwater facility to treat runoff from the roof of the facility as well as part of the lawn. Substantial grass clippings were noted in the existing downstream inlet and subsequent outfall.

Figure 4-8: Potential Tree Planting along Drive and Back Corner of lot (left) and potential SWM retrofit (right) at ISI_S_0202

ISI_S_0203 is a faith-based facility located off of Mount Gilead Road. Restoration opportunities at this location involve storm drain marking, stream buffer improvement, and tree planting. Reforestation has been implemented in the last few years; however, the majority of the trees have not survived (Figure 4-9) according to the maintenance supervisor. The staff does not mow the buffer area (Figure 4-9). There is an opportunity to improve buffer maintenance, replant the buffer area, and expand the buffer area in one portion of the property. There is potential for storm drain marking around the conference center.

Figure 4-9: Reforestation Project and Potential Educational Effort at ISI_S_0203

ISI_S_0204 is a cemetery located off of Mount Gilead Road. The only potential restoration opportunity at this location is impervious cover removal. There is currently a section of pavement that has the potential to be removed from the site.

4.3.2.4 Pervious Areas

No pervious areas were assessed in the Cliffs Branch subwatershed.

4.3.2.5 Illicit Discharges

No major outfalls are located within the Cliffs Branch subwatershed.

4.3.2.6 Stream Corridors

Assessment teams walked approximately 11.1 miles of stream within the Cliffs Branch subwatershed to identify water quality issues and restoration opportunities. A total of 337 potential environmental problems were identified in the Cliffs Branch subwatershed. The most prominent environmental problems encountered were erosion sites, inadequate buffers, and fish barriers. Table 4-29 summarizes the results of the SCA survey and restoration opportunities for this subwatershed.

Table 4-29: Summary of Stream Conditions – Cliffs Branch

OPPORTUNITIES (# of Environmental Problem Sites)								
Inadequate Buffer	Erosion Sites	Trash Dumping	Fish Barriers	Pipe Outfalls	Exposed Pipes	Channel Alteration	Unusual Conditions or Comments	Total
54	198	9	35	7	1	19	14	**337**

Length of Channel Alteration (ft)	Length of Erosion (ft)	Length of Inadequate Buffer (ft)
351	17,734	26,463

4.3.2.7 Subwatershed Management Strategy

<u>Engaging Citizens' Groups</u>

1. Educate citizens about the benefits and importance of rain gardens.
2. Educate citizens about the benefits and importance of bayscaping.
3. Increase tree canopies on private lots by educating citizens on the benefits of trees and raising awareness of programs such as Baltimore County's "Big Trees Sale".
4. Inform citizens of the importance of septic system maintenance.

<u>Municipal Actions</u>

1. Work with the hotspots indicated and similar businesses to implement appropriate practices for vehicle operations, outdoor materials storage, and management of waste, their physical plant, and stormwater maintenance, where appropriate.
2. Engage hotspot HSI_S_0201 on the potential of tree planting.
3. Engage institutions ISI_S_0202 and ISI_S_0203 in potential tree plantings and educate institution ISI_S_0203 on the benefits of forested stream buffers.

4. Educate institution ISI_S_0203 to participate in storm drain marking.

5. Investigate the potential for a SWM retrofit at ISI_S_0202 and impervious removal at ISI_S_0204.

6. Investigate potential stream restoration along reaches within the Cliffs Branch subwatershed noted for environmental problems in Table 4-29.

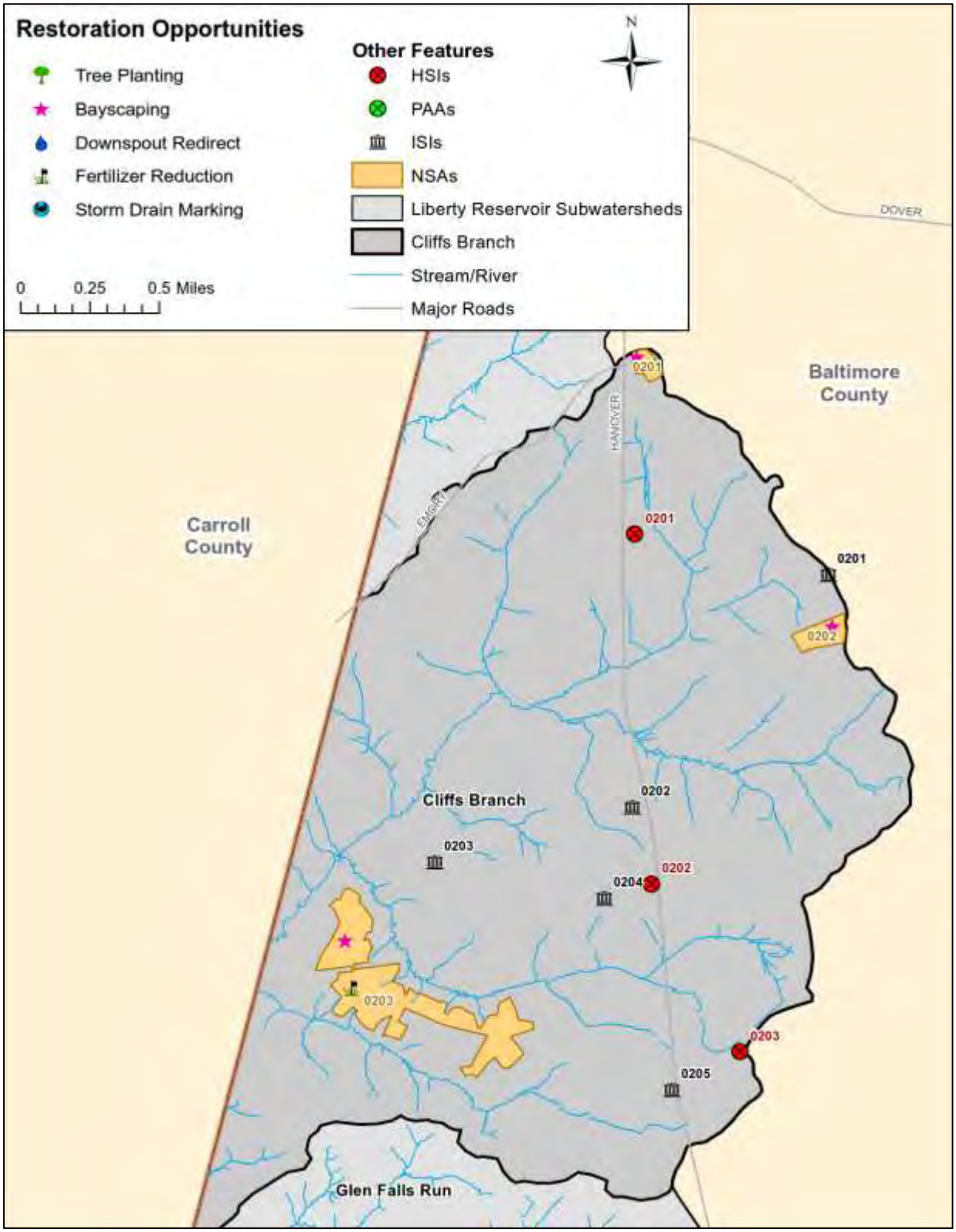

Figure 4-10: Restoration Opportunities in Cliffs Branch

4.3.3 Glen Falls Run

The Glen Falls Run subwatershed is the 2nd largest subwatershed in the Liberty Reservoir watershed, encompassing approximately 2,060 acres of land. Within the Glen Falls Run watershed, a high percentage of the subwatershed is comprised of forest (44%) and residential (28.9%) land uses. Glens Fall Run has the 2nd largest length of streams, 4th highest acreage in conservation easements and percentage of impervious surface in the Liberty Reservoir watershed; while, the population density ranks 8th. Key characteristics regarding the Glen Falls Run subwatershed are summarized in Table 4-30.

Table 4-30: Key Subwatershed Characteristics – Glen Falls Run

Drainage Area	2,059.4	acres	
	3.22	sq. mi.	
Stream Length	24.5	miles	
Population	1,954	(2010 Census)	
	0.95	persons/acre	
Land Use/Land Cover	Very Low Density Residential:		10.3%
	Low Density Residential:		16.5%
	Medium/High Density Residential:		2.1%
	Commercial:		3.3%
	Industrial:		0.0%
	Institutional:		5.5%
	Open Urban:		0.0%
	Agriculture:		16.2%
	Forest:		44.0%
	Transportation:		0.9%
	Other:		1.2%
Land in Easement	439	acres	21.3%
Impervious Cover	117	acres	5.7%
Soils	A Soils (low runoff potential):		0.0%
	B Soils:		71.0%
	C Soils:		13.4%
	C/D Soils:		0.0%
	D Soils (high runoff potential):		15.3%
	Water:		0.3%

4.3.3.1 Neighborhoods

Six neighborhoods were identified and assessed within the Glen Falls Run subwatershed during the uplands assessment of the Liberty Reservoir watershed. Recommendations for addressing stormwater volume and pollutants within this subwatershed include downspout disconnection, buffer improvement, tree planting, storm drain marking, and public education (i.e., bayscaping, increasing lot tree canopy, trash management, and fertilizer reduction). A summary of neighborhood recommended actions is presented

in Table 4-31.

Table 4-31: NSA Recommendations – Glen Falls Run

NSA_ID	Lot Size (Acres)	Trash Management	Rain Garden	Storm Drain Marking	Bayscaping	Opportunity for Downspout Redirect	Increase Lot Canopy	Buffer Improvement	Fertilizer Reduction	# of Street Trees	Notes
NSA_S_0301	3-5		X	X	X		X				-
NSA_S_0302	1/2	X	X		X		X	X			Two lots with long-term car parking
NSA_S_0303	3-5		X	X	X		X		X		-
NSA_S_0304	1-3		X	X	X		X				-
NSA_S_0305	<1/4				X		X			4	Tree planting in open space along road
NSA_S_0306	1/2		X	X	X	X	X				Multiple homes' downspouts drain to driveways

All of the NSAs assessed in the Glen Falls Run subwatershed were recommended for bayscaping and increased lot canopy. All but one of the NSAs were recommended for rain garden installation due to large lot sizes and sufficient land down gradient from the downspouts. Approximately 67% of the NSAs assessed in the Glen Falls Run subwatershed were recommended for storm drain marking. Only one neighborhood was recommended in each of the following restoration opportunities: trash management, buffer improvement, and fertilizer reduction. NSA_S_0305 has available space suitable for street planting.

Figure 4-11: Potential Street Tree Planting Location (left) at NSA_S_0305 and Potential Public Education for Bayscaping, Increasing Lot Canopy, and Fertilizer Reduction (right) at NSA_S_0303.

4.3.3.2 Hotspots

Seven hotspot investigations were performed within the Glen Falls Run subwatershed. Table 4-32

summarizes the potential pollution sources found at the site.

Table 4-32: HSI Results Summary - Glen Falls Run

HSI_ID	HSI Status	Description		Vehicle Operations	Outdoor Materials	Waste Management	Physical Plant	Turf/Landscape Management	Storm Water	Notes
HSI_S_0301										Unable to assess site. Private driveway. Significant gravel from driveway washing into street
HSI_S_0302	Potential Hotspot	Commercial	Restaurant	X		X	X			Secondary driveway breaking-up
HSI_S_0303	Potential Hotspot	Industrial	Agricultural Business	X	X	X	X			Excessive sediment
HSI_S_0304	Potential Hotspot	Landscaping	Garden Center	X	X	X	X	X	X	Significant sediment near stormdrain inlet
HSI_S_0305	Potential Hotspot	Commercial	Construction	X	X	X	X	X	X	Could not access majority of site. Sediment observed near storm drain inlet
HSI_S_0306	Not a Hotspot	Transport-Related	N/A							Possible inlet overgrown and covered with trees
HSI_S_0307	Potential Hotspot	Commercial	Lumber Mill and Shop	X	X	X	X			Excessive sediment observed near inlet

HSI_S_0301 is listed as a nursery located off of Old Hanover Road; however, due to the long private driveway, the site is far removed from the road and was unable to be assessed. Significant sediment and gravel from the driveway was observed washing into the street. A follow up inspection is recommended to assess potential pollution sources on the lot.

HSI_S_0302 is a commercial restaurant located off of Old Hanover Road. Potential pollution sources at this hotspot include vehicle operations, waste management, and the physical plant. Portions of the secondary driveway show signs of deterioration and were breaking apart (Figure 4-12). Additionally, while the dumpsters appeared in good condition, they were unable to be close completely due to overflowing trash.

Figure 4-12: Private Gravel Driveway Observed Washing into Street (left) at HSI_S_0301 and Broken Up Asphalt at HSI_S_0302 (right)

HSI_S_0303 is an industrial agricultural business located off of Hanover Pike. Potential pollution sources at this hotspot include vehicle operations, outdoor material storage, physical plant, and waste management. Uncovered construction materials are located on site and sediment was observed on portions of the pavement (Figure 4-13). Based on aerial images, the site appears to drain towards a stream where there appears to be erosion and sediment control measures in place. There is open pervious space available for tree planting between the asphalt lot and the stream buffer. A follow-up inspection is recommended to investigate erosion and sediment control measures and potential tree plantings.

Figure 4-13: Uncovered Construction Materials (left) and Excess Sediment on Pavement (right) at HSI_S_0303

HSI_S_0304 is a commercial landscaping business located on Hanover Pike. Potential pollution sources at this hotspot include vehicle operations, outdoor material storage, waste management, the phsycial plant, landscape management, and stormdrain system. The majority of the potential polution sources were not observed as existing issues. For example, garbage collection was observed on site, but the dumpster was in good condition and maintained propoerty. Additionally, the majority of outdoor materials were stored outside without a cover, but they were stored properly on pallets and not connected to the stormdrain

system (Figure 4-14). The exception to this was an observed pile of soil in the parking lot that was stored uncovered next to a storm drain inlet (Figure 4-14).

Figure 4-14: Properly Stored Material on Pallets (left) and a Pile of Soil Stored Uncovered Next to Storm Drain Inlet (right) at HSI_S_0304

HSI_S_0305 is a commercial construction company located on Westminster Pike. Potential pollution sources at this hotspot include vehicle operations, outdoor material storage, waste management, downspout disconnection, landscape management, and onsite storm drains. Uncovered construction materials are located on site, and there is evidence of sediment accumulation near a storm drain (Figure 4-15). The majority of the site could not be assessed, but from aerial images there appears to be a large open pervious area on the northeast corner of the property that may be available for tree planting. Planting this area would expand existing forest cover. Additionally, the southwest corner of the property is well maintained lawn (Figure 4-15). A follow up site visit is recommend to investigate sediment on the property, investigate the potential of tree planting in the rear of the property, and education on lawn maintain and possible bayscaping in the front of the property.

Figure 4-15: Sediment Observed Near Storm Drain (left) and Well Maintained Lawn with Potential for Bayscaping (right) at HSI_S_0305

HSI_S_0306 is a parking lot located on Old Hanover Road. The site is adjacent to hotspot sites HSI_S_0302 and HSI_S_0307. Sediment accumulation was observed in the road along the curb and gutter of the parking lot. Both the road and the parking drain to a swale that appears to drain to an inlet. The inlet has a tree growing out of it and the exact condition of the inlet could not be determined. There is potential

for a SWM retrofit, possibly a bioswale, to treat the road and parking lot runoff before it enters the inlet. The property also contains a large open pervious area that has potential for tree planting.

Figure 4-16: Roadway and Parking Lot Draining to Swale Could Potentially be Treated by a Bioswale (left) and Open Pervious Area for Potential Tree Planting (right) at HSI_S_0306

HSI_S_0307 is a commercial lumber mill and shop located off of Old Hanover Road. Potential pollution sources at this hotspot include vehicle operations, outdoor material storage, waste management, and physical plant. While on-site dumpsters at this hotspot are managed properly and outdoor materials are stored on pallets, there is excessive sediment on pavement and near storm drain inlet (Figure 4-17). A follow up site inspection and future education is recommended to address sediment issues.

Figure 4-17: Excessive Sediment Observed Near Storm Drain at HSI_S_0307 (left) and Inside Downstream Inlet (right)

4.3.3.3 Institutions

Two faith-based institutional sites were assessed for retrofit opportunities in the Glen Falls Run subwatershed during the uplands assessment of the Liberty Reservoir watershed. Table 4-33 summarizes recommendations for the institutional sites assessed in the Glen Falls Run subwatershed.

Table 4-33: ISI Recommendations - Glen Falls Run

Site ID	Name	Public/ Private	# Trees for Planting	Nutrient Management	Buffer Improvement	Tree planting	Invasive Removal	Notes
ISI_S_0301	Owings Mills Harvest Church of God	Private	103	X	X	X		Large mowed lawn. Possible tree planting.
ISI_S_0302	Northwest Baptist Church	Private			X		X	Invasive species removal from stream buffer. SWM maintenance

Both ISI_S_0301 and ISI_S_0302 are faith-based facilities with the potential for stream buffer improvement. ISI_S_0301 has a large lawn that encroaches a stream, providing an opportunity for reforesting the stream buffer. The large lawn also provides potential for nutrient management education efforts with the facility. ISI_S_0302 has an existing extended detention pond treating its parking lot and rooftop runoff. The pond is overgrown and appears to need maintenance (Figure 4-18). Invasive species were also observed around the site and along a stream buffer. ISI_S_0302 provides an opportunity for education regarding pond maintenance and invasive species control.

Figure 4-18: Extended Detention Pond at ISI_S_0302

4.3.3.4 Pervious Areas

No pervious areas were assessed in the Glen Falls Run subwatershed.

4.3.3.5 Illicit Discharges

No major outfalls are located within the Glen Falls Run watershed.

4.3.3.6 Stream Corridors

A stream corridor assessment was not completed in this subwatershed.

4.3.3.7 Subwatershed Management Strategy

Engaging Citizens' Groups

1. Conduct appropriate downspout disconnection measures in neighborhoods according to Table 4-31 and educate citizens on the benefits of rain barrels and rain gardens.

2. Engage citizens in a storm drain marking program and conduct marking activities in the neighborhoods indicated in Table 4-31.

3. Educate citizens about the benefits and importance of proper lawn care, bayscaping, and trash management in the neighborhoods specified in Table 4-31.

4. Increase tree canopies on private lots by educating citizens on the benefits of trees and raising awareness of programs such as Baltimore County's "Big Trees Sale".

5. Educate the residents of neighborhoods indicated in Table 4-31 about the importance of stream buffers and encourage more environmentally friendly stream treatments.

6. Engage residents in NSA_S_0305 for participation in possible tree planting events.

7. Inform citizens of the importance of septic system maintenance.

Municipal Actions

1. Work with the hotspots indicated and similar businesses to implement appropriate practices for vehicle operations, outdoor materials storage, and management of waste, their physical plant, landscapes, and stormwater maintenance, where appropriate.

2. Engage hotspots HSI_S_0302, HSI_S_0305, and HSI_S_0306 on the potential of tree planting and HSI_S_0306 on a stormwater retrofit.

3. Educate institutions in Table 4-33 on the benefits of forested steam buffers and potential tree plantings.

4. Encourage invasive species removal at ISI_S_0302.

5. Educate institution ISI_S_0301 about the benefits and importance of proper lawn care.

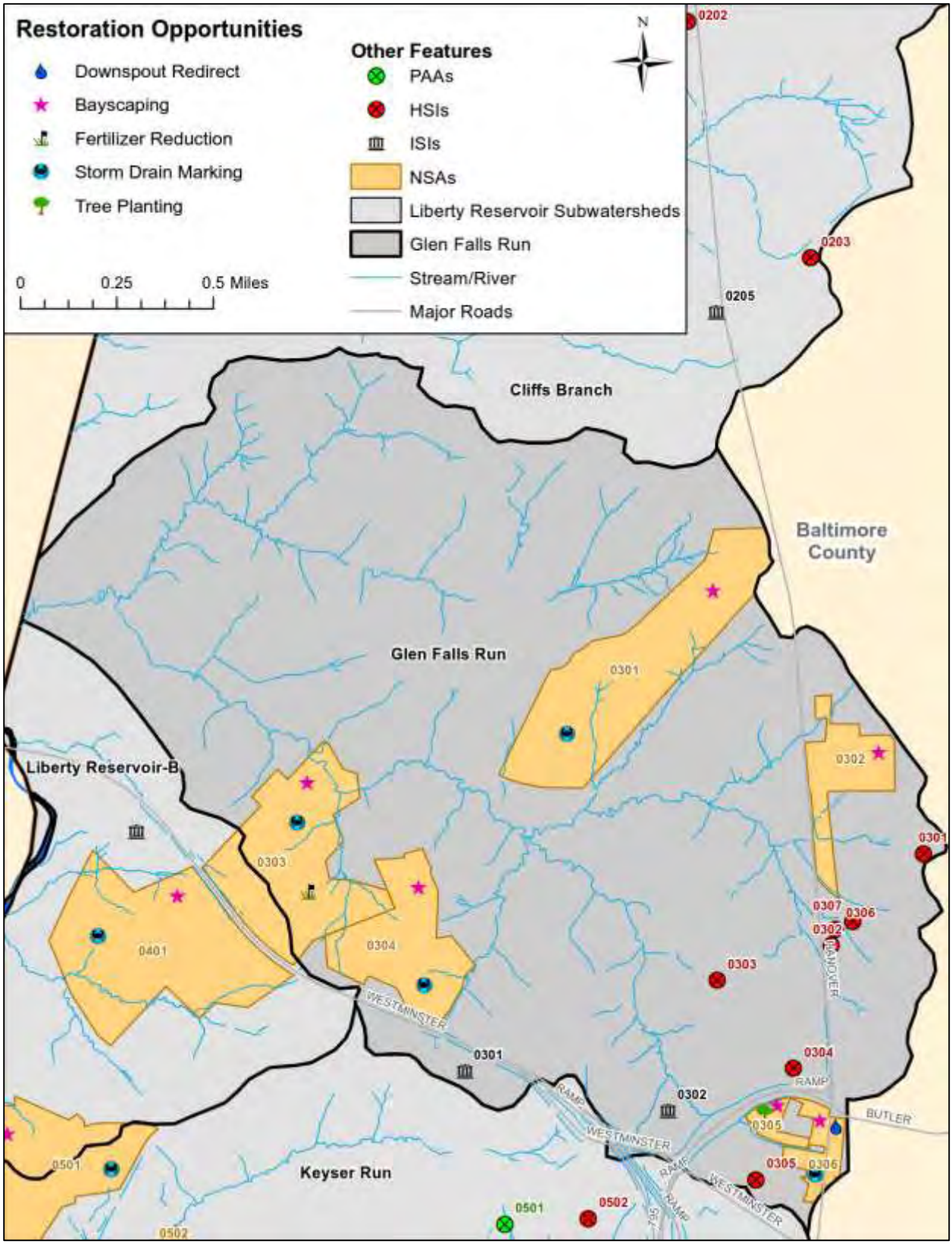

Figure 4-19: Restoration Opportunities in Glen Falls Run

4.3.4 Liberty Reservoir-B

The Liberty Reservoir-B subwatershed is the 4th smallest subwatershed in the Liberty Reservoir watershed with a high percentage of the drainage area in the Reservoir Lands easement (48%). The land use in the Liberty Reservoir-B subwatershed is primarily forest and residential; however, the Liberty Reservoir-B subwatershed does have the 2nd largest percentage of land in "other" uses. In the Liberty Reservoir-B subwatershed, the other uses are water and wetlands from the reservoir. The Liberty Reservoir-B subwatershed also has the third lowest percentage of agricultural uses (9.7%) as well as the 5th largest percentage of impervious surface. Key characteristics regarding the Liberty Reservoir-B subwatershed are summarized in Table 4-34.

Table 4-34: Key Subwatershed Characteristics – Liberty Reservoir-B

Drainage Area	637.5	acres	
	1.00	sq. mi.	
Stream Length	5.3	miles	
Population	637	(2010 Census)	
	1.00	persons/acre	
Land Use/Land Cover	Very Low Density Residential:		10.2%
	Low Density Residential:		23.8%
	Medium/High Density Residential:		0.0%
	Commercial:		0.7%
	Industrial:		0.0%
	Institutional:		0.8%
	Open Urban:		0.0%
	Agriculture:		9.7%
	Forest:		42.0%
	Transportation:		2.0%
	Other:		10.8%
Land in Easement	307	acres	48.1%
Impervious Cover	33	acres	5.2%
Soils	A Soils (low runoff potential):		0.0%
	B Soils:		76.6%
	C Soils:		10.6%
	C/D Soils:		0.0%
	D Soils (high runoff potential):		7.7%
	Water:		5.1%

4.3.4.1 Neighborhoods

One neighborhood was identified and assessed within the Liberty Reservoir-B subwatershed during the uplands assessment of the Liberty Reservoir watershed. Recommendations for addressing stormwater volume and pollutants within this subwatershed include storm drain marking and public education efforts

(i.e., bayscaping). A summary of neighborhood recommended actions is presented in Table 4-35.

Table 4-35: NSA Recommendations – Liberty Reservoir-B

NSA_ID	Lot Size (Acres)	Storm Drain Marking	Bayscaping	Notes
NSA_S_0401	3-5	X	X	Large lots with shared driveways. Could not observe 40% of homes or streams.

NSA_S_0401 was recommended for storm drain marking and bayscaping, which can be accomplished through educational outreach. While the lots within this NSA are large and mostly forested, there are properties that could benefit from bayscaping.

4.3.4.2 Hotspots

No HSIs were assessed in the Liberty Reservoir-B subwatershed.

4.3.4.3 Institutions

One faith-based institutional site was assessed for retrofit opportunities in the Liberty Reservoir-B subwatershed during the uplands assessment of the Liberty Reservoir watershed. Table 4-36 summarizes recommendations for the institutional sites assessed in the Liberty Reservoir-B subwatershed.

Table 4-36: ISI Recommendations – Liberty Reservoir-B

Site ID	Name	Public/ Private	# Trees for Planting	Notes
ISI_S_0401	Moose Lodge 1577	Private	33	May be opportunity to reach community members for outreach.

ISI_S_0401 is substantially forested but has some opportunity to expand the forest edges into a central open area. The large open area appears to be used for recreational purposes and plantings were only recommend along the edges. Recreational vehicles are also stored on-site. The organization may be an opportunity for community outreach.

4.3.4.4 Pervious Areas

No pervious areas were assessed in the Liberty Reservoir-B subwatershed.

4.3.4.5 Illicit Discharges

No major outfalls are located within the Liberty Reservoir-B subwatershed.

4.3.4.6 Stream Corridors

A stream corridor assessment was not completed in this subwatershed.

4.3.4.7 Subwatershed Management Strategy

Engaging Citizens' Groups

1. Engage citizens in a storm drain marking program and conduct marking activities in the neighborhood NSA_S_0401.

2. Educate citizens about the benefits and importance of bayscaping.

3. Inform citizens of the importance of septic system maintenance.

Municipal Actions

1. Engage institutions ISI_S_0401 in potential tree plantings.

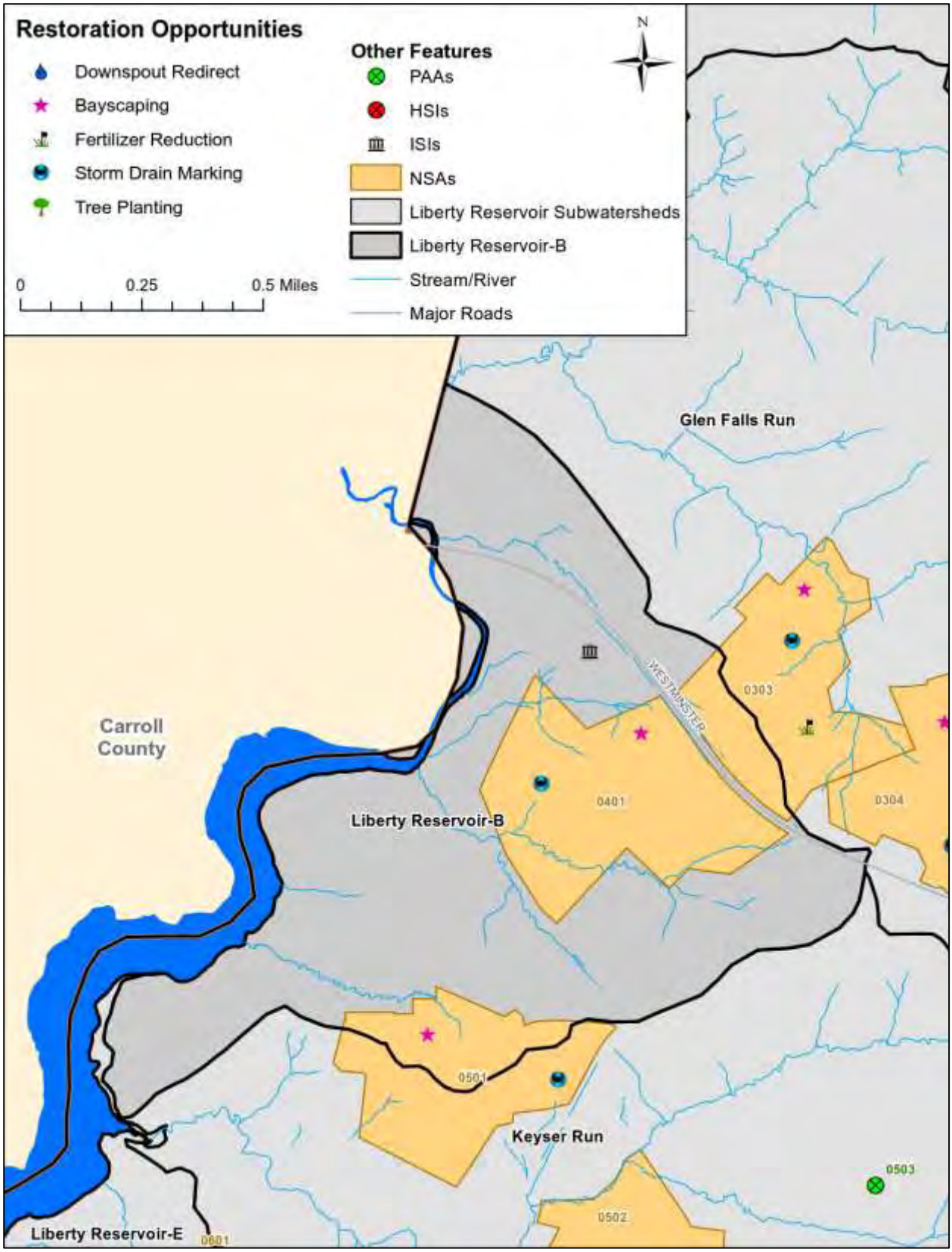

Figure 4-20: Restoration Opportunities in Liberty Reservoir-B

4.3.5 Keyser Run

The Keyser Run subwatershed is the 6th largest subwatershed in the Liberty Reservoir watershed. The subwatershed is evenly distributed amongst agriculture, forest, and residential land uses at 25.1%, 24.7%, and 30.5%, respectively. The Keyser Run subwatershed also has the 2nd largest percentage of commercial land at 4.4%. It has the highest percentage of impervious surface and lowest percentage of land in easements of any subwatershed in Liberty Reservoir watershed. The Keyser Run subwatershed also has the highest population density of in the Liberty Reservoir watershed. Key characteristics regarding the Keyser Run subwatershed are summarized in Table 4-37.

Table 4-37: Key Subwatershed Characteristics - Keyser Run

Drainage Area	1,006.3	acres	
	1.57	sq. mi.	
Stream Length	11.1	miles	
Population	2,229	(2010 Census)	
	2.21	persons/acre	
Land Use/Land Cover	Very Low Density Residential:		11.3%
	Low Density Residential:		16.4%
	Medium/High Density Residential:		2.8%
	Commercial:		4.4%
	Industrial:		0.0%
	Institutional:		0.2%
	Open Urban:		12.9%
	Agriculture:		25.1%
	Forest:		24.7%
	Transportation:		2.3%
	Other:		0.1%
Land in Easement	174	acres	17.3%
Impervious Cover	81	acres	8.1%
Soils	A Soils (low runoff potential):		0.0%
	B Soils:		69.2%
	C Soils:		17.8%
	C/D Soils:		0.0%
	D Soils (high runoff potential):		13.0%
	Water:		0.0%

4.3.5.1 Neighborhoods

Four neighborhoods were identified and assessed within the Keyser Run subwatershed during the uplands assessment of the Liberty Reservoir. Recommendations for addressing stormwater volume and pollutants within this subwatershed include downspout disconnection, rain barrels, buffer improvement, storm drain markings, and public education (i.e., bayscaping, fertilizer reduction, and increasing lot tree canopy).

A summary of neighborhood recommended actions is presented in Table 4-38.

Table 4-38: NSA Recommendations – Keyser Run

NSA_ID	Lot Size (Acres)	Storm Drain Marking	Bayscaping	Opportunity for Downspout Redirect	Increase Lot Canopy	Rain Barrel	Buffer Improvement	Fertilizer Reduction	Notes
NSA_S_0501	1-3	X	X		X		X		More trees/buffers recommended. Education to stop mowing up to stream edge
NSA_S_0502	3-5		X						Difficult to see lots. Possible room for rain gardens
NSA_S_0503	-	X	X					X	Roof drains discharge to gravel/dirt patches before entering storm drains
NSA_S_0504	-		X	X	X	X			-

All of the NSAs assessed in the Keyser Run subwatershed were recommended for public education in the form of bayscaping. Other public education efforts for several of the NSAs assessed in the Keyser Run subwatershed include reducing fertilizer use on highly maintained lawns and installation of rain barrels in neighborhoods where greater than 25% of the downspouts are directed to storm drains or impervious surface. Storm drain disconnection in the form of rain barrels was recommended in one neighborhood of townhomes (Figure 4-21, left), while stream buffer improvement was recommended at another neighborhood where the lawn has been mowed up to the stream channel (Figure 4-21, right).

Figure 4-21: Downspout Disconnection Recommended at NSA_S_0504 (left) and Potential Stream Buffer Improvement (right) at NSA_S_0501

4.3.5.2 Hotspots

Two hotspot investigations were performed within the Keyser Run subwatershed. Table 4-39 summarizes the potential pollution sources found at the site.

Table 4-39: HSI Results Summary - Keyser Run

HSI_ID	HSI Status	Description		Vehicle Operations	Outdoor Materials	Waste Management	Physical Plant	Turf/Landscape Management	Storm Water	Notes
HSI_S_0501	Potential Hotspot	Commercial	Grocery Store		X	X	X	X	X	Possibility for tree planting next to building.
HSI_S_0502	Potential Hotspot	Golf Course	Golf Course	X		X		X		Potential to convert pond to treatment pond. Stream erosion observed.

HSI_S_0501 is a commercial grocery store located on Village Center Road. Potential pollution sources at this hotspot include outdoor material storage, waste management, physcial plant, landscape management, and storm drains. A dumpster onsite was observed with the lid open and staining was observed at mutliple dumpsters. Additionally, a grease spill was observed at the rear of the building (Figure 4-22, right). Clean up measures had taken place to some degree; however, the oil soaked cat litter had never been removed. The downspouts on the back of the building discharge to impervious surface just uphill of a storm drain; however, there is no area available for downspout disconnection. The parking lot was observed breaking up in spots; however, shortly after the field visit, the lot was repaved.

Figure 4-22: Potential Tree Planting along Building (left) and Grease Spill (right) at HSI_S_0501

HSI_S_0502 is a private golf course located off of Mitchell Drive. Potential pollution sources at this hotspot include vehicle operations, waste management, and landscape management. Golf carts and lawn equipment are stored on the property. The golf cart parking area drains to an open pervious area. A

dumpster was observed on site in good condition and well maintained with the lid closed. The site, by design, has a significant amount of lawn. There is an opportunity for tree planting in the open space around the parking lot. Also, there is an existing pond located down gradient of the golf course that may have the potential to be converted to a treatment pond. Running parallel to the pond, there is a stream with observed erosion that may present an opportunity for stream bank stabilization (Figure 4-23, right).

Figure 4-23: Potential Stormwater Retrofit (left) and Stream Bank Stabilization (right) at HSI_S_0502

4.3.5.3 Institutions

No ISIs were assessed in the Keyser Run subwatershed.

4.3.5.4 Pervious Areas

Three pervious area assessments (PAAs) were conducted in the Keyser Run subwatershed. Further descriptions along with pictures and restoration rankings can be found in the *Watershed Characterization Report* (Appendix E). PAA_S_0501 is the Reisterstown Regional Park, which is owned and maintained by Baltimore County. The site has approximately 1,500 feet of stream without adequate forest buffer. Additionally, the site has 3.5 acres of forest gap that can be planted in the southern portion of the parcel. An additional two acres of space is available west of the ball fields. Together, the planting sites expand 12.5 acres of forest but do not expand forest interior.

PAA_S_0502 is located off of Cockeys Mill Road and straddles the Keyser Run and Norris Run subwatersheds. The property is used as an easement for Baltimore Gas and Electric power lines. Due to the presence of the power lines, there is no potential for restoration and this site was not assessed further.

PAA_S_0503 is a county owned property located off of Cockeys Mill Road. Approximately 24 acres of open space are available for planting. The parcel is zoned agricultural and currently appears to be used for agricultural purposes. Further investigation would determine the extent of land being actively cultivated. If all of the open space is being used for crops, trees will likely not be planted on the parcel.

4.3.5.5 Illicit Discharges

No major outfalls are located within the Keyser Run subwatershed.

4.3.5.6 Stream Corridors

Field teams assessed approximately 3.9 miles of streams within the Keyser Run subwatershed to identify water quality problems and restoration opportunities. A total of 173 potential environmental problems were identified in the Keyser Run subwatershed. The most frequent water quality and environmental issues observed were erosion sites. Table 4-40 summarizes the results of the Keyser Run subwatershed SCA survey.

Table 4-40: Summary of Stream Conditions – Keyser Run

Inadequate Buffer	Erosion Sites	Trash Dumping	Fish Barriers	Pipe Outfalls	Exposed Pipes	Channel Alteration	Unusual Conditions or Comments	Total
16	106	5	17	5	0	8	16	**173**

Length of Channel Alteration (ft)	Length of Erosion (ft)	Length of Inadequate Buffer (ft)
154	8,133	9,761

4.3.5.7 Subwatershed Management Strategy

Engaging Citizens' Groups

1. Conduct appropriate downspout disconnection measures in neighborhoods according to Table 4-38 and educate citizens on the benefits of rain barrels.

2. Engage citizens in a storm drain marking program and conduct marking activities in the neighborhood NSA_S_0501.

3. Educate citizens about the benefits and importance of proper lawn care and bayscaping.

4. Increase tree canopies on private lots by educating citizens on the benefits of trees and raising awareness of programs such as Baltimore County's "Big Trees Sale".

5. Educate the residents of neighborhoods indicated in NSA_S_0501 about the importance of stream buffers and encourage more environmentally friendly stream treatments.

6. Inform citizens of the importance of septic system maintenance.

Municipal Actions

1. Work with the hotspots indicated and similar businesses to implement appropriate practices for vehicle operations, outdoor materials storage, and management of waste, their physical plant, landscapes, and stormwater maintenance, where appropriate.

2. Engage hotspots HSI_S_0501 on the potential of tree planting and HSI_S_0502 on a stormwater

retrofit.

3. Investigate potential for tree planting at PAA_S_0501 and PAA_S_0503.

4. Investigate potential stream restoration along reaches within the Keyser Run subwatershed noted for environmental problems in Table 4-40.

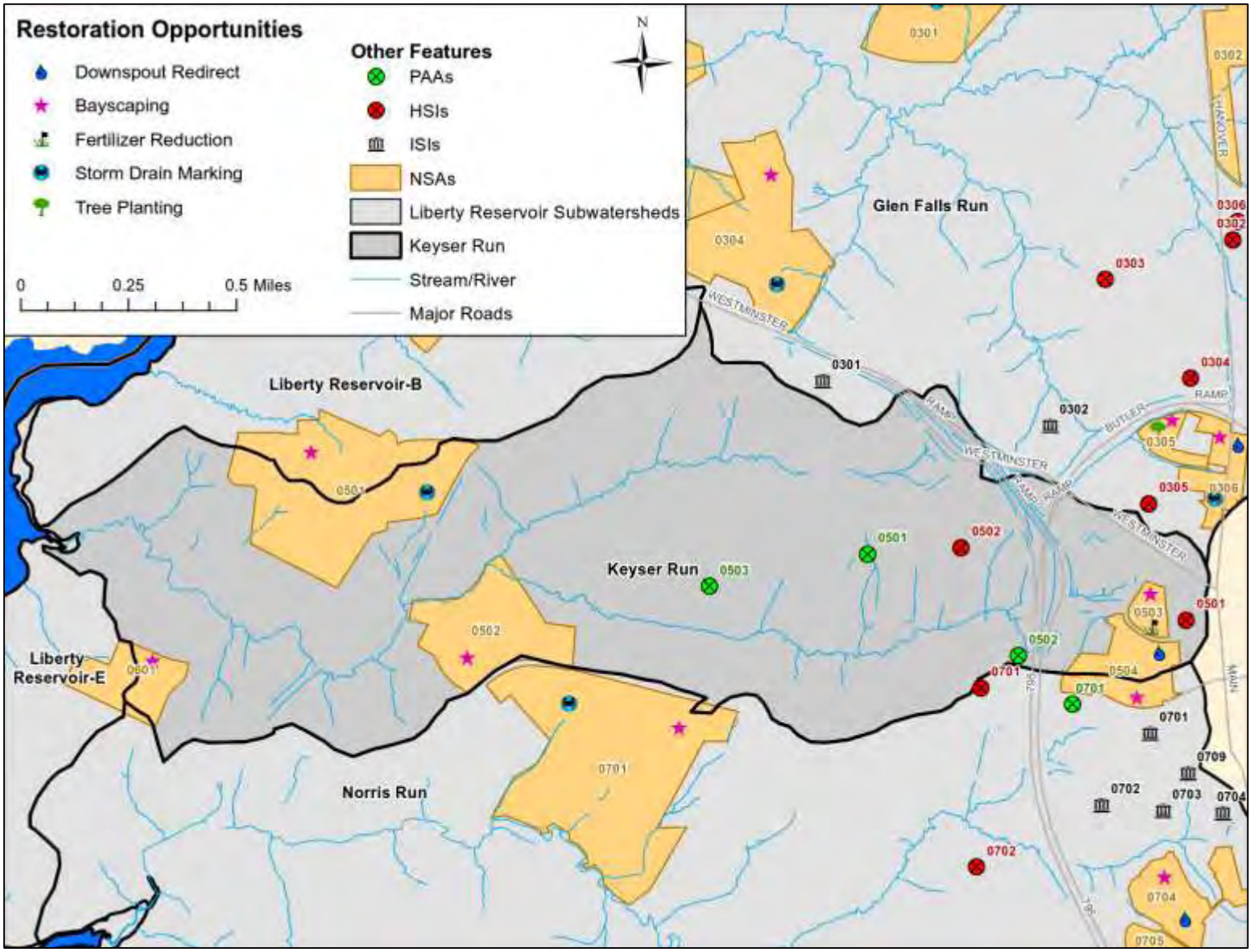

Figure 4-24: Restoration Opportunities in Keyser Run

4.3.6 Liberty Reservoir-E

The Liberty Reservoir-E subwatershed is the smallest subwatershed in Liberty Reservoir watershed, with the majority of the drainage area falling under the reservoir easement (84%). The Liberty Reservoir-E subwatershed contains the least amount of stream miles and percentage of impervious surface, and the 6th highest population density in the Liberty Reservoir watershed. The Liberty Reservoir-E subwatershed also contains 3rd highest percentage of forest (60.9%) and the highest percentage of "other" uses in the Liberty Reservoir watershed. The "other" uses consist of water and wetlands in the Liberty Reservoir that border the Liberty Reservoir-E subwatershed. Key characteristics regarding the Liberty Reservoir-E subwatershed are summarized in Table 4-41.

Table 4-41: Key Subwatershed Characteristics – Liberty Reservoir-E

Drainage Area	280.0	acres	
	0.44	sq. mi.	
Stream Length	2.4	miles	
Population	323	(2010 Census)	
	1.15	persons/acre	
Land Use/Land Cover	Very Low Density Residential:		1.2%
	Low Density Residential:		1.9%
	Medium/High Density Residential:		0.0%
	Commercial:		0.0%
	Industrial:		0.0%
	Institutional:		0.0%
	Open Urban:		0.0%
	Agriculture:		24.6%
	Forest:		60.9%
	Transportation:		0.0%
	Other:		11.4%
Land in Easement	235	acres	83.8%
Impervious Cover	4	acres	1.6%
Soils	A Soils (low runoff potential):		0.0%
	B Soils:		60.8%
	C Soils:		25.1%
	C/D Soils:		0.0%
	D Soils (high runoff potential):		3.4%
	Water:		10.8%

4.3.6.1 Neighborhoods

One distinct neighborhood was identified and assessed within the Liberty Reservoir-E subwatershed during the uplands assessment of the Liberty Reservoir watershed. Recommendations for addressing stormwater volume and pollutants within this subwatershed include public education efforts (i.e.,

bayscaping and increasing lot tree canopy). A summary of neighborhood recommended actions is presented in Table 4-42.

Table 4-42: NSA Recommendations – Liberty Reservoir-E

NSA_ID	Lot Size (Acres)	Bayscaping	Lot Canopy Improvement	Notes
NSA_S_0601	1-3	X	X	Could not view stream, but buffer appears appropriate from aerials

NSA_S_0601 is a small neighborhood located near the reservoir. The lots have approximately 20% forest canopy and educational outreach about bayscaping and improved lot canopy are recommended. There is a headwater stream that starts in the neighborhood, and it appears to have a sufficient buffer.

4.3.6.2 Hotspots

No HSIs were assessed in the Liberty Reservoir-E subwatershed.

4.3.6.3 Institutions

No ISIs were assessed in the Liberty Reservoir-E subwatershed.

4.3.6.4 Pervious Areas

No pervious areas were assessed in the Liberty Reservoir-E subwatershed.

4.3.6.5 Illicit Discharges

No major outfalls are located within the Liberty Reservoir-E subwatershed.

4.3.6.6 Stream Corridors

A stream corridor assessment was not completed in this subwatershed.

4.3.6.7 Subwatershed Management Strategy

<u>Engaging Citizens' Groups</u>

1. Educate citizens about the benefits and importance of proper lawn care and bayscaping.

2. Increase tree canopies on private lots by educating citizens on the benefits of trees and raising awareness of programs such as Baltimore County's "Big Trees Sale".

3. Inform citizens of the importance of septic system maintenance.

Municipal Actions

There are no Municipal Actions recommended for this subwatershed.

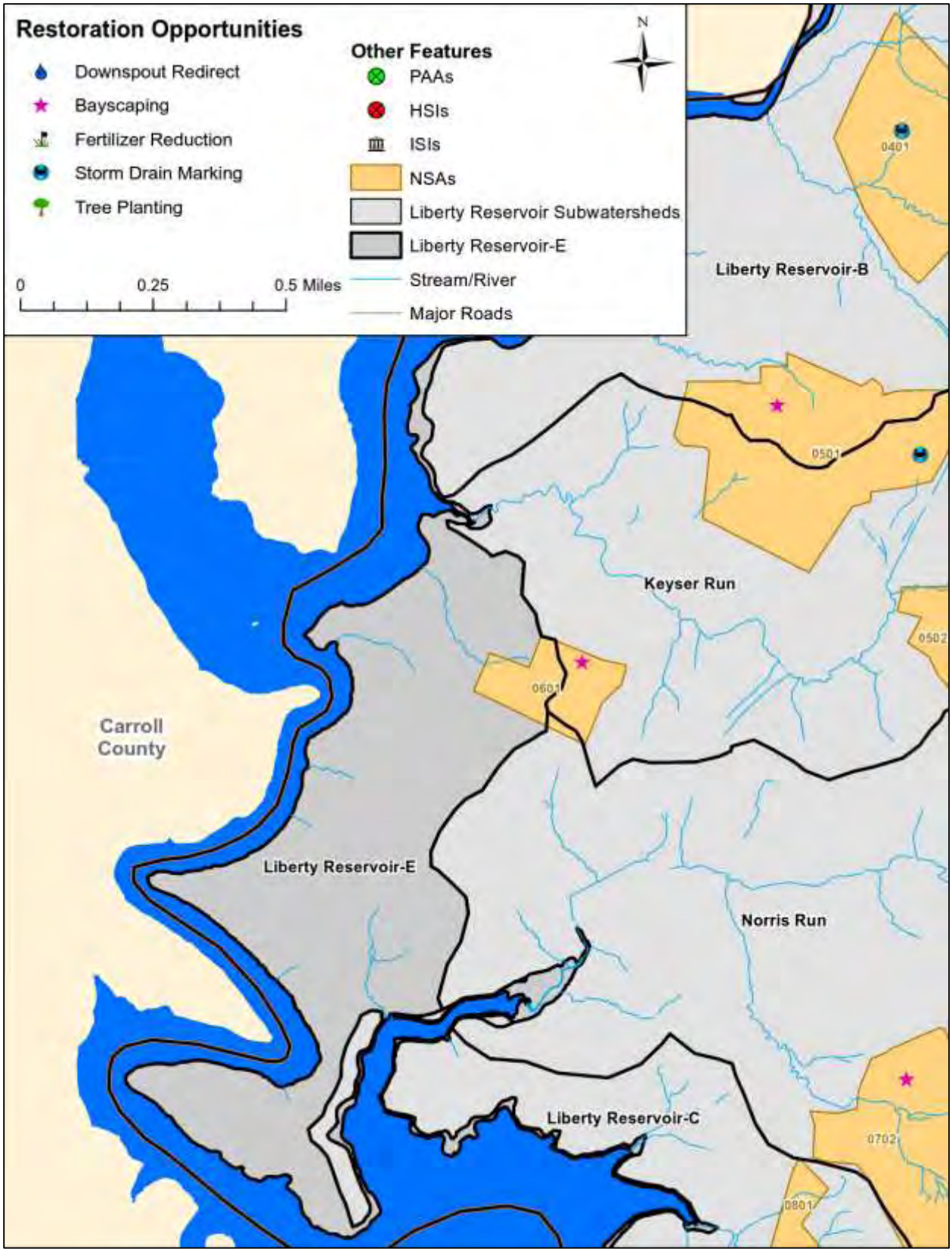

Figure 4-25: Restoration Opportunities in Liberty Reservoir-E

4.3.7 Norris Run

The Norris Run subwatershed is the 4th largest subwatershed in the Liberty Reservoir watershed with a large percentage of the subwatershed consisting of residential and forest uses. The Norris Run subwatershed has the 2nd largest percentage of additional urban uses including, low/medium/high residential, industrial, commercial, institutional, and open urban uses (31%), the 2nd highest percentage of impervious surface (6.4%), and the 3rd highest population density in the Liberty Reservoir watershed. In contrast, the Norris Run subwatershed has the 2nd lowest percentage of lands in easements. Key characteristics regarding the Norris Run subwatershed are summarized in Table 4-43.

Table 4-43: Key Subwatershed Characteristics – Norris Run

Drainage Area	1,790.4	acres	
	2.80	sq. mi.	
Stream Length	15.0	miles	
Population	2,577	(2010 Census)	
	1.44	persons/acre	
Land Use/Land Cover	Very Low Density Residential:		15.8%
	Low Density Residential:		17.1%
	Medium/High Density Residential:		5.3%
	Commercial:		1.5%
	Industrial:		0.0%
	Institutional:		3.0%
	Open Urban:		4.1%
	Agriculture:		14.9%
	Forest:		36.2%
	Transportation:		1.7%
	Other:		0.4%
Land in Easement	369	acres	20.6%
Impervious Cover	115	acres	6.4%
Soils	A Soils (low runoff potential):		0.0%
	B Soils:		63.4%
	C Soils:		23.1%
	C/D Soils:		0.0%
	D Soils (high runoff potential):		13.5%
	Water:		0.0%

4.3.7.1 Neighborhoods

Six neighborhoods were identified and assessed within the Norris Run subwatershed during the uplands assessment of the Liberty Reservoir watershed. Recommendations for addressing stormwater volume and pollutants within this subwatershed include downspout disconnection, storm drain marking, tree planting, and public education (i.e., bayscaping, rain barrels, rain gardens, fertilizer reduction, and

increasing lot tree canopy). A summary of neighborhood recommended actions is presented in Table 4-44.

Table 4-44: NSA Recommendations – Norris Run

NSA_ID	Lot Size (Acres)	Rain Garden	Storm Drain Marking	Bayscaping	Opportunity for Downspout Redirect	Rain Barrel	Increase Lot Canopy	Fertilizer Reduction	# of Street Trees	Notes
NSA_S_0701	1-3		X	X						-
NSA_S_0702	5-10	X	X	X			X	X		-
NSA_S_0703	1-3		X	X						Forested neighborhood. Low potential
NSA_S_0704	<1/8			X	X	X				Trees planted in all open spaces
NSA_S_0705	1/4			X			X		16	SWM facilities unmaintained; Tree planting along Diploma Drive
NSA_S_0706	1/2			X			X			-

All of the NSAs assessed in the Norris Run subwatershed were recommended for public education in the form of bayscaping. Conveying the importance of planting on private property can also help introduce lot canopy improvements in neighborhoods. Additionally, NSA_S_0704 and NSA_S_0705 have existing stormwater facilities and could potentially benefit from education on proper facility maintenance (Figure 4-26, left). NSA_S_0705 has space along one street within the neighborhood suitable for street tree planting (Figure 4-26, right).

Figure 4-26: Unmaintained Extended Detention Pond (left) and Potential Street Tree Planting (right) in NSA_S_0705

4.3.7.2 Hotspots

Three hotspot investigations were performed within the Norris Run subwatershed. Table 4-45 summarizes the potential pollution sources found at the sites.

Table 4-45: HSI Results Summary – Norris Run

HSI_ID	HSI Status	Description		Vehicle Operations	Outdoor Materials	Waste Management	Physical Plant	Turf/Landscape Management	Storm Water	Notes
HSI_S_0701	Potential Hotspot	Commercial	Landscaping	X	X	X		X		Improve trash management by emptying dumpsters more regularly
HSI_S_0702	Not a Hotspot	Industrial	Power Plant	X		X				-
HSI_S_0703	Confirmed Hotspot	Municipal	Baltimore County Highway Shop	X	X	X	X			Better trash management and stockpiling. Review SWPPP due to high sediment on site

HSI_S_0701 is a commercial landscaping business located off of Cockeys Mill Road. Potential pollution sources at this hotspot include vehicle operations, outdoor material storage, waste management, and landscape management. Work vehicles appeared to be stored and fueled onsite. Landscaping materials are stored outdoors uncovered. Some are in large stockpiles and it would be difficult to cover them. Additionally, large uncovered dumpsters are overflowing with trash (Figure 4-27, left) and appear to need more regular trash pick-up. A significant portion of the site is bare soil, but due to the nature of the facility, it is unlikely turf could be maintained.

HSI_S_0702 is an industrial power plant located off of Cockeys Mill Road. Potential pollution sources at this hotspot include vehicle operations and waste management. Due to a full uncovered dumpster and additional trash scattered on site, this hotspot could benefit from improved trash management (Figure 4-27, right).

Figure 4-27: Overflowing Dumpsters at HSI_S_0701 (left) and HSI_S_0702 (right)

At the time of the site inspection, HSI_S_0703, a municipal Baltimore County Highway shop located off of Nicodemus Road, had potential pollution sources including vehicle operations, outdoor material storage, physical plant management, waste management, and landscape management. Highway maintenance vehicles are stored and fueled onsite. Stockpiles of materials are also stored onsite (Figure 4-28, right). Trash was also observed throughout the site with the dumpsters overflowing (Figure 4-28, left). There is a stormwater facility treating the site, but the facility appeared to have sediment buildup. Due to a high volume of sediment found on the pavement, a review of the Stormwater Pollution Prevention Plan (SWPPP) was recommended at this site. Since the time of the site inspection, the pollution issues observed have been addressed.

Figure 4-28: Overflowing Dumpsters and High Volume of Sediment on Drive at HSI_S_0703

4.3.7.3 Institutions

Four faith-based institutional sites, two schools and two cemeteries, and one library were assessed for retrofit opportunities in the Norris Run subwatershed during the uplands assessment of the Liberty Reservoir watershed. Table 4-46 summarizes recommendations for the institutional sites assessed in the Norris Run subwatershed.

Table 4-46: ISI Recommendations - Norris Run

Site ID	Name	Public/ Private	# Trees for Planting	Storm water Retrofit	Downspout Disconnection	Impervious Cover Removal	Trash Management	Storm Drain Marking	Buffer Improvement	Follow-up Inspection	Invasive Removal	Notes
ISI_S_0701	Franklin Middle School	Public	137			X		X	X		X	Removal of broken up pavement near baseball field could be replaced with permeable pavers
ISI_S_0702	I.S.S.O. Kalupur Dham Shree Swaminarayan Hindu Temple	Private	53	X			X	X				Potential SWM retrofit and tree plantings.
ISI_S_0703	Franklin Elementary School	Public	58		X	X		X	X		X	Removal of invasive species and impervious surface
ISI_S_0704	Reisterstown United Methodist Church	Private		X		X		X				Potential SWM retrofit. Future education for sediment build-up in inlet.
ISI_S_0705	Baltimore Hebrew Congregation	Private	88	X				X				Possible SWM retrofit at inlets near stream headwaters
ISI_S_0706	Bible Fellowship Church	Private	202	X								Potential SWM retrofit to treat parking lot and tree planting (without blocking view to religious monument)
ISI_S_0707	Oheb Shalom Memorial park	Private	96					X				-
ISI_S_0708	Covenant of Grace Presbyterian Church in America	Private	110	X								Convert existing pond into SWM facility to treat parking lot
ISI_S_0709	Reisterstown Library	Public	5			X		X		X	X	Follow-up to evaluate outfall erosion

ISI_S_0701 is a middle school located on Cockeys Mill Road. Restoration opportunities at this location involve impervious cover removal, storm drain marking, stream buffer improvement, invasive species removal, and tree plantings. Open space is available for tree planting to expand the stream buffer on the west side of the property and additional plantings on the north side of the property (Figure 4-29, right). As a result, forest connectivity would also increase. There is also a need for invasive species removal in the stream buffer area. There are several sections of impervious cover that may be removed. A parking lot that services the athletic fields is breaking apart and could potentially be replaced with pervious pavers (Figure 4-29, left). Removal of the impervious pavement and replacement with gravel or pervious pavers

may help to reduce nutrient and sediment runoff. Marking the storm drains provides an educational benefit to those who come into contact with the school.

Figure 4-29: Potential Impervious Cover Removal (left) and Buffer Improvement (right) at ISI_S_0701

ISI_S_0702 is a faith-based facility located on Cockeys Mill Road. Restoration opportunities at this location involve tree planting, stormwater retrofit, trash management, and storm drain marking. There is an opportunity to expand existing forest on the back of the property (Figure 4-30). There is also an opportunity for a stormwater retrofit. The curb at the lower end of the parking lot is broken up to allow concentrated flow into the grass. There is significant sediment buildup at the curb and an existing inlet and pipe in the downstream grassy area (Figure 4-30). Instead of replacing the curb, a stormwater facility may be installed to increase infiltration and decrease runoff.

Figure 4-30: Potential for Forest Canopy Expansion Along the Back of the Property (left) and Potential for SWM Retrofit (right) to Treat Parking Lot at ISI_S_0702

ISI_S_0703 is an elementary school located on Cockeys Mill Road. Restoration opportunities at this location involve downspout disconnection, impervious cover removal, storm drain marking, stream buffer improvement, invasive species removal, and tree planting. Part of the school parking lot is already being treated by a rain garden and additional SWM retrofits were not recommended. Storm drain marking at a public facility increases the educational outreach into the community (Figure 4-31). An impervious

sidewalk leading towards the stream buffer is breaking up and provides an opportunity to be replaced with pervious pavers or grass (Figure 4-31).

Figure 4-31: Storm Drain Marking (left) and Impervious Cover Removal (right) at ISI_S_0703

ISI_S_0704 is a faith-based facility located on Main Street. Restoration opportunities at this location involve stormwater retrofit, impervious cover removal, and storm drain marking. There is an opportunity to remove a portion of the parking lot and replace with a stormwater retrofit, such as a bioretention facility (Figure 4-32, left). Educational efforts may be directed towards decrease sediment near inlets with storm drain marking also being recommended.

ISI_S_0705 is cemetery located on Berryman's Lane. Restoration opportunities at this location involve stormwater retrofit, storm drain marking, and tree planting. There is potential to treat a portion of the cemetery road that currently drains to one of two inlets that daylight into the lawn or the stream headwaters (Figure 4-32, right). The site has significant open space, but it was assumed much of the space was being reserved for future grave plots. There were already newly planted trees around the site and additional tree planting was only recommended in the traffic circle.

Figure 4-32: Potential Impervious Cover Removal and Stormwater Retrofit Installation at ISI_S_0704 and Potential Stormwater Retrofit at ISI_S_0705

ISI_S_0706 is a faith-based facility located on Berryman's Lane. Restoration opportunities at this location involve a potential stormwater retrofit and tree planting. There is potential at this site to treat runoff from

impervious parking lots without curbs with a sheet flow BMP such as urban filter strips. Additionally, there is open pervious space in the back of the institution that could potentially be used for tree planting. The back of the site drains to two headwater channels. There is a religious monument erected in the rear of the site and any tree plantings would need to be done in such a way as to not block access or view of the monument.

ISI_S_0707 is another cemetery located on Berryman's Lane. Restoration opportunities at this location involve storm drain marking and tree planting. While there is significant open space on the property, it was assumed much of the space was being reserved for future grave plots. Therefore, only open space at the rear of the property expanding existing forest cover was recommended for tree plantings. These plantings would also expand the stream buffer.

ISI_S_0708 is a faith-based facility located on Berryman's Lane. Restoration opportunities at this location involve stormwater retrofit and tree planting. Open space is available near the street and in the large lawn for approximately 110 tree plantings (Figure 4-33, left). Converting an existing pond on the site to a treatment facility would provide additional water quality improvements. The pond is located next to the parking lot and drains via a culvert to the headwaters of the Norris Run subwatershed (Figure 4-33, right).

Figure 4-33: Open Space Available for Potential Tree Planting (left) and a Potential Stormwater Management Conversion (right) at ISI_S_0708

ISI_S_0709 is a public library located on Cockeys Mill Road. Restoration opportunities at this location involve impervious cover removal, storm drain marking, invasive species removal, and tree planting. It is recommended that a follow up inspection take place at ISI_S_0709 to evaluate outfall erosion and the potential for a stormwater retrofit.

4.3.7.4 Pervious Areas

The Norris Run subwatershed contains one pervious area that was assessed in the Liberty Reservoir watershed. PAA_S_0701 is a county owned, 3.6 acre lot with approximately 0.5 acres of open space available for tree planting.

4.3.7.5 Illicit Discharges

The Norris Run subwatershed contains one Priority 2 major outfall and one Priority 3 minor outfall. Priority 2 indicates moderate to minor problems that have the potential to become severe and are monitored

annually, while Priority 3 indicates outfalls with minor to no problems. Baltimore County will continue their Illicit Discharge Detection and Elimination program while seeking to improve techniques for more effective reductions of these discharges.

4.3.7.6 Stream Corridors

Field teams walked approximately 7.8 miles of stream within the Norris Run subwatershed to identify potential water quality problems and restoration opportunities. A total of 87 potential environmental problems were identified in this subwatershed. The most predominant water quality issues included fish barriers and inadequate buffers. Table 4-47 summarizes the results of the SCA survey in the Norris Run subwatershed.

Table 4-47: Summary of Stream Conditions – Norris Run

Inadequate Buffer	Erosion Sites	Trash Dumping	Fish Barriers	Pipe Outfalls	Exposed Pipes	Channel Alteration	Unusual Conditions or Comments	Total
21	10	1	26	3	0	11	15	**87**

Length of Channel Alteration (ft)	Length of Erosion (ft)	Length of Inadequate Buffer (ft)
729	693	3,457

4.3.7.7 Subwatershed Management Strategy

<u>Engaging Citizens' Groups</u>

1. Conduct appropriate downspout disconnection measures in neighborhoods according to Table 4-44 and educate citizens on the benefits of rain barrels and rain gardens.

2. Engage citizens in a storm drain marking program and conduct marking activities in the neighborhoods indicated in Table 4-44.

3. Educate citizens about the benefits and importance of proper lawn care and bayscaping.

4. Increase tree canopies on private lots by educating citizens on the benefits of trees and raising awareness of programs such as Baltimore County's "Big Trees Sale".

5. Engage residents in NSA_S_0705 for participation in possible tree planting events.

6. Inform citizens of the importance of septic system maintenance.

<u>Municipal Actions</u>

1. Work with the hotspots indicated and similar businesses to implement appropriate practices for vehicle operations, outdoor materials storage, and management of waste, their physical plant,

and landscapes, where appropriate.

2. Engage ISI_S_0702 on proper trash management and potential downspout disconnection.

3. Educate institutions indicated in Table 4-46 about benefits of tree plantings. Educate those institutions that were noted for stream buffer improvements on the benefits of forested stream buffers.

4. Investigate invasive species removal for the institutions listed in Table 4-46.

5. Investigate the removal of impervious cover at the institutions listed in Table 4-46.

6. Investigate potential stormwater retrofit and storm drain markings at the institutions indicated in Table 4-46.

7. Follow-up with the on-site inspection to further evaluate outfall erosion and possible stabilization and SWM facility at institution ISI_S_0709.

8. Investigate potential for tree planting at PAA_S_0701.

9. Continue monitoring outfalls through the Illicit Discharge Detection and Elimination program and seek to improve techniques for more effective reductions of these discharges.

10. Investigate potential stream restoration along reaches within the Norris Run subwatershed noted for environmental problems in Table 4-47.

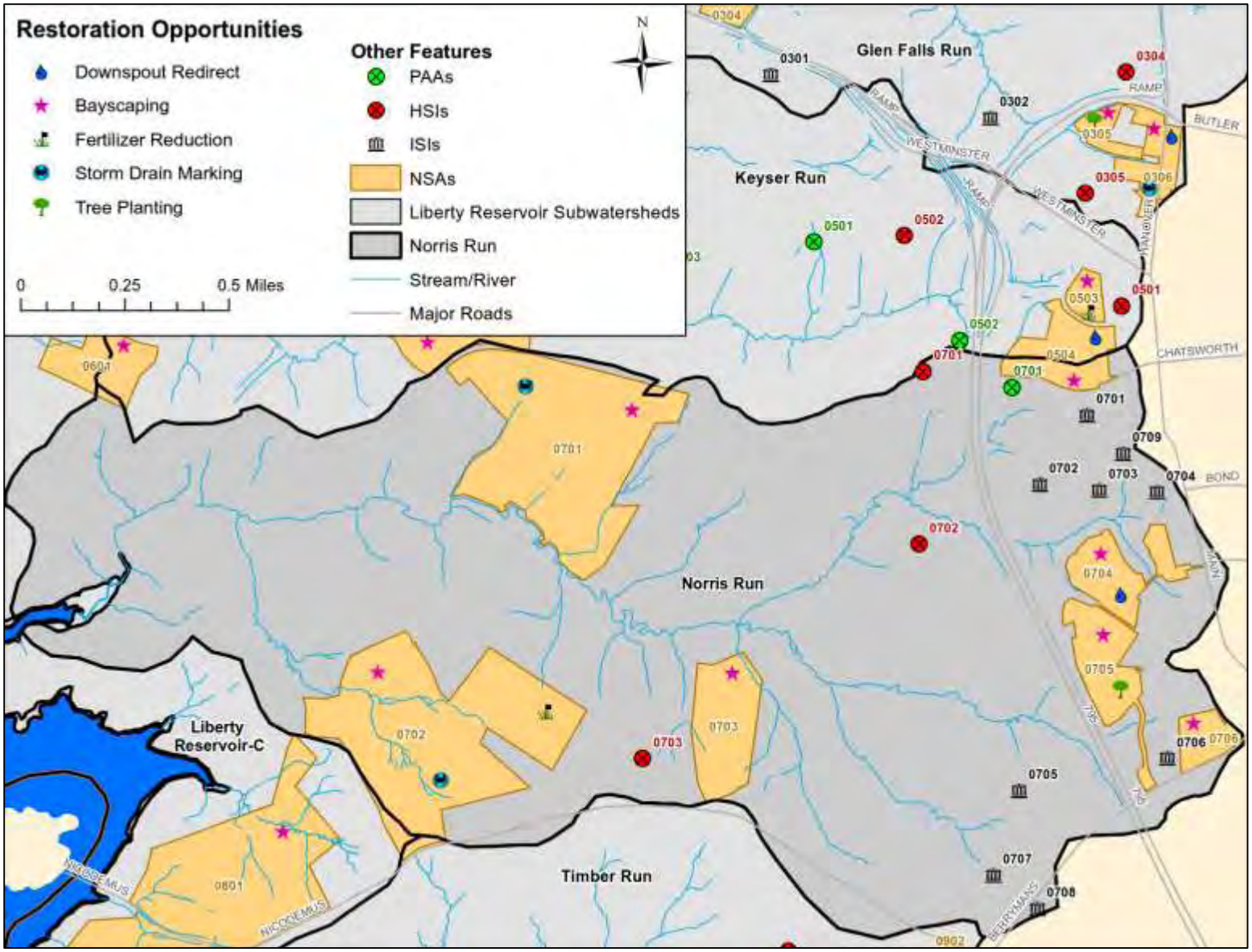

Figure 4-34: Restoration Opportunities in Norris Run

4.3.8 Liberty Reservoir-C

The Liberty Reservoir-C subwatershed is the 2nd smallest subwatershed in the Liberty Reservoir watershed. The majority of the drainage area is comprised of forest (50.3%). Residential, agriculture, and other uses are also found in the Liberty Reservoir-C subwatershed. More than half of the Liberty Reservoir-C subwatershed falls within the reservoir buffer and forest conservation easements (55%), but the subwatershed has the 2nd highest population density within the Liberty Reservoir watershed. Key characteristics regarding the Liberty Reservoir-C subwatershed are summarized in Table 4-48.

Table 4-48: Key Subwatershed Characteristics – Liberty Reservoir-C

Drainage Area	390.6	acres	
	0.61	sq. mi.	
Stream Length	4.6	miles	
Population	605	(2010 Census)	
	1.55	persons/acre	
Land Use/Land Cover	Very Low Density Residential:		10.5%
	Low Density Residential:		5.3%
	Medium/High Density Residential:		0.0%
	Commercial:		0.3%
	Industrial:		0.0%
	Institutional:		0.0%
	Open Urban:		0.0%
	Agriculture:		25.0%
	Forest:		50.3%
	Transportation:		0.0%
	Other:		8.5%
Land in Easement	216	acres	55.4%
Impervious Cover	12	acres	3.2%
Soils	A Soils (low runoff potential):		0.0%
	B Soils:		86.1%
	C Soils:		10.9%
	C/D Soils:		0.0%
	D Soils (high runoff potential):		2.8%
	Water:		0.3%

4.3.8.1 Neighborhoods

One neighborhood was identified and assessed within the Liberty Reservoir-C subwatershed during the uplands assessment of the Liberty Reservoir watershed. Recommendations for addressing stormwater volume and pollutants within this subwatershed include public education in the form of bayscaping. A summary of the neighborhood recommended actions is presented in Table 4-49.

Table 4-49: NSA Recommendations – Liberty Reservoir-C

NSA_ID	Lot Size (Acres)	Bayscaping	Notes
NSA_S_0801	3-5	X	-

The neighborhood located in the Liberty Reservoir-C subwatershed is located directly next to the reservoir and has approximately 50% forest canopy and approximately 95% of the downspouts discharge to a pervious area. Bayscaping was recommended due to the large lawns (Figure 4-35).

Figure 4-35: While NSA_S_0801 is Approximately 50% Forest Canopy, Large Areas of Lawn are Available for Further Planting and Bayscaping

4.3.8.2 Hotspots

No HSIs were assessed in the Liberty Reservoir-C subwatershed.

4.3.8.3 Institutions

No ISIs were assessed in the Liberty Reservoir-C subwatershed.

4.3.8.4 Pervious Areas

No pervious areas were assessed in the Liberty Reservoir-C subwatershed.

4.3.8.5 Illicit Discharges

No major outfalls are located within the Liberty Reservoir-C subwatershed.

4.3.8.6 Stream Corridors

A stream corridor assessment was not completed in this subwatershed.

4.3.8.7 Subwatershed Management Strategy

Engaging Citizens' Groups

1. Educate citizens about the benefits and importance of bayscaping.
2. Inform citizens of the importance of septic system maintenance.

Municipal Actions

There are no Municipal Actions recommended for this subwatershed.

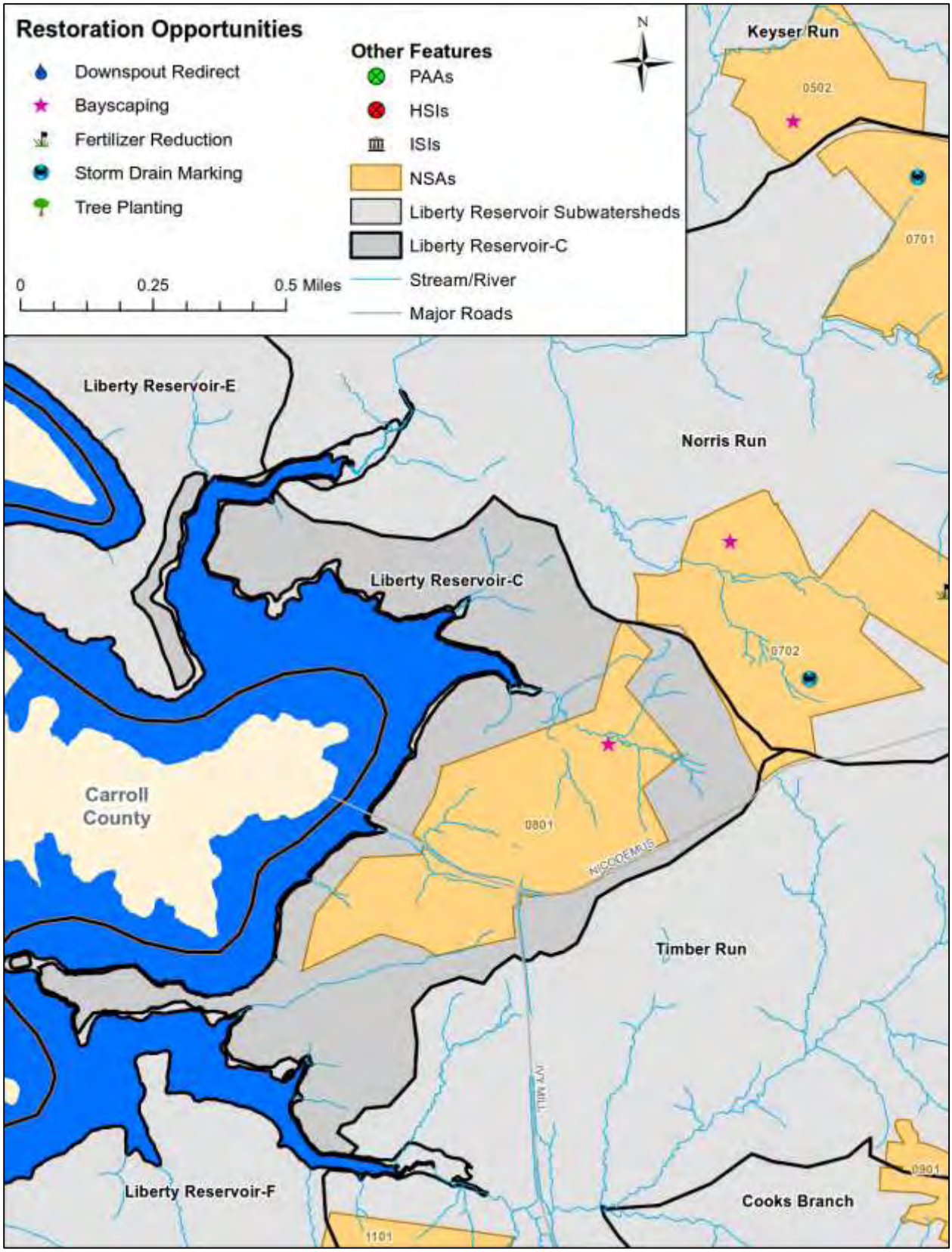

Figure 4-36: Restoration Opportunities in the Liberty Reservoir-C subwatershed

4.3.9 Timber Run

The Timber Run subwatershed is the 7th largest subwatershed out of 14 subwatersheds. The Timber Run subwatershed has the 2nd largest percentage of forested land in the Liberty Reservoir watershed and ranks 11th for percentage of land in easements (29%), 7th for length of stream in subwatershed (62.2%) and for percentage of impervious surface (3.5%), and 4th for population density for the Liberty Reservoir watershed. Key characteristics regarding the Timber Run subwatershed are summarized in Table 4-50.

Table 4-50: Key Subwatershed Characteristics – Timber Run

Drainage Area	932.3	acres	
	1.46	sq. mi.	
Stream Length	10.9	miles	
Population	1,332	(2010 Census)	
	1.43	persons/acre	
Land Use/Land Cover	Very Low Density Residential:		7.5%
	Low Density Residential:		22.5%
	Medium/High Density Residential:		0.0%
	Commercial:		0.1%
	Industrial:		0.0%
	Institutional:		0.0%
	Open Urban:		0.2%
	Agriculture:		7.6%
	Forest:		62.2%
	Transportation:		0.0%
	Other:		0.0%
Land in Easement	269	acres	28.9%
Impervious Cover	33	acres	3.5%
Soils	A Soils (low runoff potential):		0.0%
	B Soils:		67.6%
	C Soils:		22.4%
	C/D Soils:		0.0%
	D Soils (high runoff potential):		10.0%
	Water:		0.0%

4.3.9.1 Neighborhoods

Two neighborhoods were identified and assessed within the Timber Run subwatershed during the uplands assessment of the Liberty Reservoir watershed. Recommendations for addressing stormwater volume and pollutants within this subwatershed include open space tree plantings and public education (i.e., bayscaping, rain gardens, fertilizer reduction, and increasing lot tree canopy). A summary of neighborhood recommended actions is presented in Table 4-51.

Table 4-51: NSA Recommendations – Timber Run

NSA_ID	Lot Size (Acres)	Rain Garden	Bayscaping	Increase Lot Canopy	Fertilizer Reduction	# of Open Space Trees	Notes
NSA_S_0901	1-3	X	X	X	X	46	Open space surrounding SWM facilities
NSA_S_0902	1		X	X			-

The two neighborhoods assessed in the Timber Run subwatershed were both recommended for bayscaping and increased lot canopy as a result of large mowed lawns. High lawn maintenance at NSA_S_0901 led to the recommendation for fertilizer reduction in this neighborhood. Large open spaces surrounding two stormwater management facilities in NSA_S_0901 provide the opportunity for tree plantings without decreasing accessibility or damaging the structure (Figure 4-37).

Figure 4-37: Large Lots Available for Bayscaping and Potential Open Space Tree Plantings at NSA_S_0901

4.3.9.2 Hotspots

One hotspot investigation was performed within the Timber Run subwatershed. The site was inaccessible because it was located on private property with no trespassing signs posted and the site was not visible from the road.

4.3.9.3 Institutions

No ISIs were assessed in the Timber Run subwatershed.

4.3.9.4 Pervious Areas

One privately owned pervious area was assessed in the Timber Run subwatershed. PAA_S_0901 is a 14.6 acre property owned by the Green Valley Swim Club. While there are no streams crossing the property and 4.55 acres of the property is already under a Forest Conservation Easement, there is still approximately 1 acre of open land available for additional tree plantings. These plantings would extend the existing forested stream buffer.

4.3.9.5 Illicit Discharges

No major outfalls are located within the Timber Run subwatershed.

4.3.9.6 Stream Corridors

A stream corridor assessment was not completed in this subwatershed.

4.3.9.7 Subwatershed Management Strategy

<u>Engaging Citizens' Groups</u>

1. Educate citizens about the benefits and importance of rain gardens.
2. Educate citizens about the benefits and importance of proper lawn care and bayscaping.
3. Increase tree canopies on private lots by educating citizens on the benefits of trees and raising awareness of programs such as Baltimore County's "Big Trees Sale".
4. Engage residents in NSA_S_0901 for participation in possible tree planting events.
5. Inform citizens of the importance of septic system maintenance.

<u>Municipal Actions</u>

1. Follow up investigation at hotspot HSI_S_0901 to determine potential pollution sources and restoration opportunities.
2. Investigate potential for tree planting at PAA_S_0901.

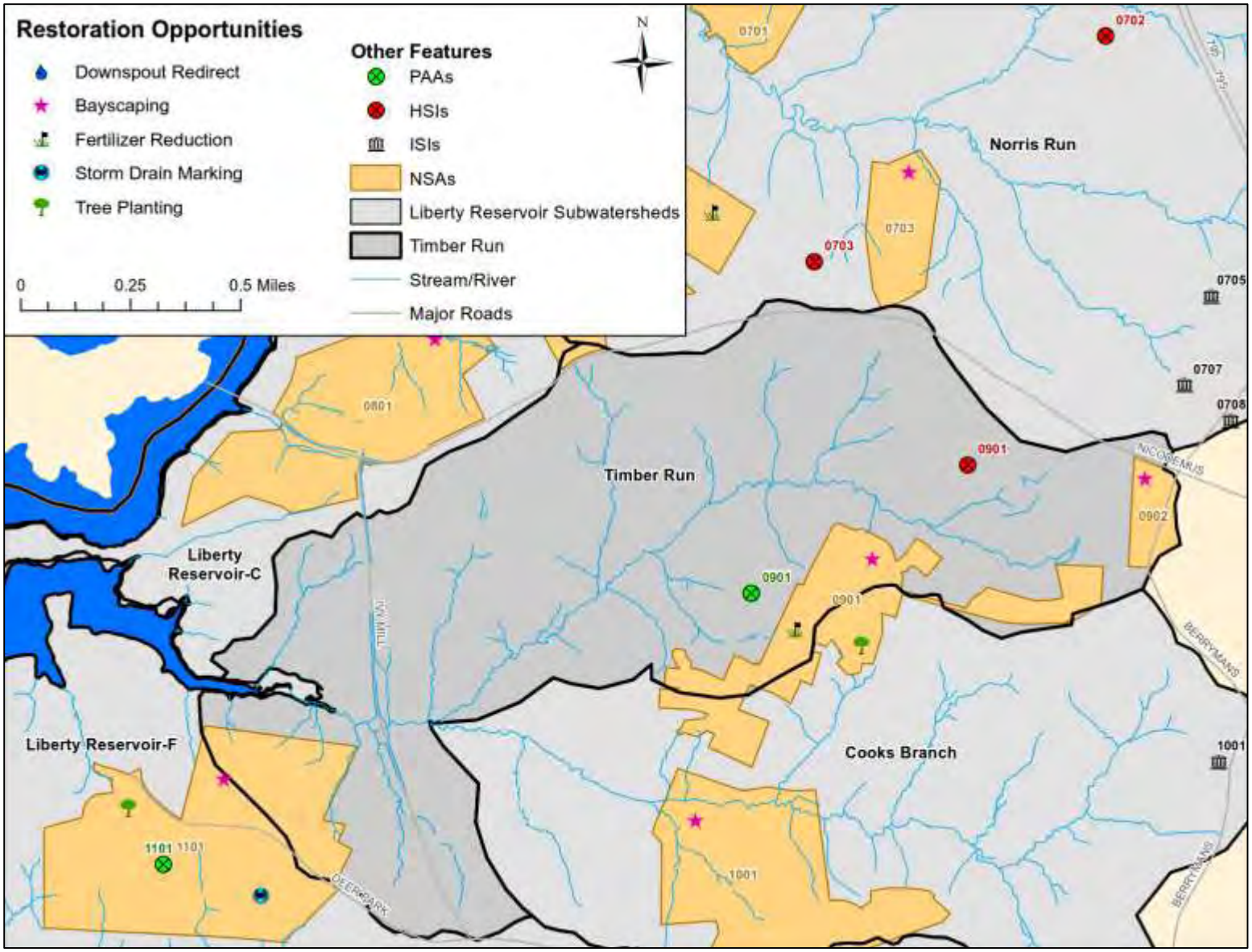

Figure 4-38: Restoration Opportunities in the Timber Run Subwatershed

4.3.10 Cooks Branch

The Cooks Branch subwatershed is the 6th smallest subwatershed in the Liberty Reservoir watershed and consists largely of forest and residential land uses. The Cooks Branch subwatershed falls in the middle when it comes to length of stream miles in the subwatershed (8th), percentage of land in easements (9th), and percentage of impervious surface (9th). The Cooks Branch subwatershed has the 5th highest population density in the Liberty Reservoir watershed. Key characteristics regarding the Cooks Branch subwatershed are summarized in Table 4-52.

Table 4-52: Key Subwatershed Characteristics – Cooks Branch

Drainage Area	785.5	acres	
	1.23	sq. mi.	
Stream Length	8.4	miles	
Population	1,000	(2010 Census)	
	1.27	persons/acre	
Land Use/Land Cover	Very Low Density Residential:		20.4%
	Low Density Residential:		25.7%
	Medium/High Density Residential:		0.3%
	Commercial:		0.1%
	Industrial:		0.0%
	Institutional:		0.0%
	Open Urban:		0.0%
	Agriculture:		11.4%
	Forest:		42.1%
	Transportation:		0.0%
	Other:		0.0%
Land in Easement	311	acres	39.6%
Impervious Cover	25	acres	3.1%
Soils	A Soils (low runoff potential):		0.0%
	B Soils:		63.9%
	C Soils:		19.9%
	C/D Soils:		4.7%
	D Soils (high runoff potential):		11.5%
	Water:		0.0%

4.3.10.1 Neighborhoods

One neighborhood was identified and assessed within the Cooks Branch subwatershed during the uplands assessment of the Liberty Reservoir watershed. Recommendations for addressing stormwater volume and pollutants within this subwatershed primarily include public education in the form of bayscaping. A summary of the neighborhood recommended actions is presented in Table 4-53.

Table 4-53: NSA Recommendations – Cooks Branch

NSA_ID	Lot Size (Acres)	Bayscaping	Notes
NSA_S_1001	1-3	X	-

NSA_S_1001 was observed to have approximately 50% forest canopy and 85% of the downspouts discharge to pervious areas. Bayscaping was recommended due to the large lawns observed throughout the neighborhood.

4.3.10.2 Hotspots

No HSIs were assessed the Cooks Branch subwatershed.

4.3.10.3 Institutions

Two faith-based institutional sites were assessed for retrofit opportunities in the Cooks Branch subwatershed during the uplands assessment of the Liberty Reservoir watershed. Table 4-54 summarizes recommendations for the institutional sites assessed in the Cooks Branch subwatershed.

Table 4-54: ISI Recommendations - Cooks Branch

Site ID	Name	Public/ Private	# Trees for Planting	Downspout Disconnection	Notes
ISI_S_1001	Reisterstown Evergreen Church of the Brethren	Private	4	X	A few downspouts have room for disconnection, not all
ISI_S_1002	Deer park United Methodist Church	Private	3		-

ISI_S_1001 and ISI_S_1002 are faith-based facilities. Restoration opportunities at this location involve downspout disconnection and tree planting. At ISI_S_1001, there is enough open space to redirect a few downspouts, which will allow the runoff from the roof and road to infiltration into the ground (Figure 4-39). Replacing pavement that is breaking up will reduce sediment and nutrient transport. There is also space for approximately 4 trees along the edge of the property at both ISI_S_1001 and ISI_S_1002.

Figure 4-39: Potential Downspout Disconnection at ISI_S_1001

4.3.10.4 Pervious Areas

No pervious areas were assessed in the Cooks Branch subwatershed.

4.3.10.5 Illicit Discharges

There are no major outfalls in the Cooks Branch subwatershed.

4.3.10.6 Stream Corridors

A stream corridor assessment was not completed in this subwatershed.

4.3.10.7 Subwatershed Management Strategy

<u>Engaging Citizens' Groups</u>

1. Educate citizens about the benefits and importance of bayscaping.
2. Inform citizens of the importance of septic system maintenance.

<u>Municipal Actions</u>

1. Educate ISI_S_1001 on potential downspout disconnection.
2. Educate institutions ISI_S_1001 and ISI_S_1002 on importance of tree plantings.

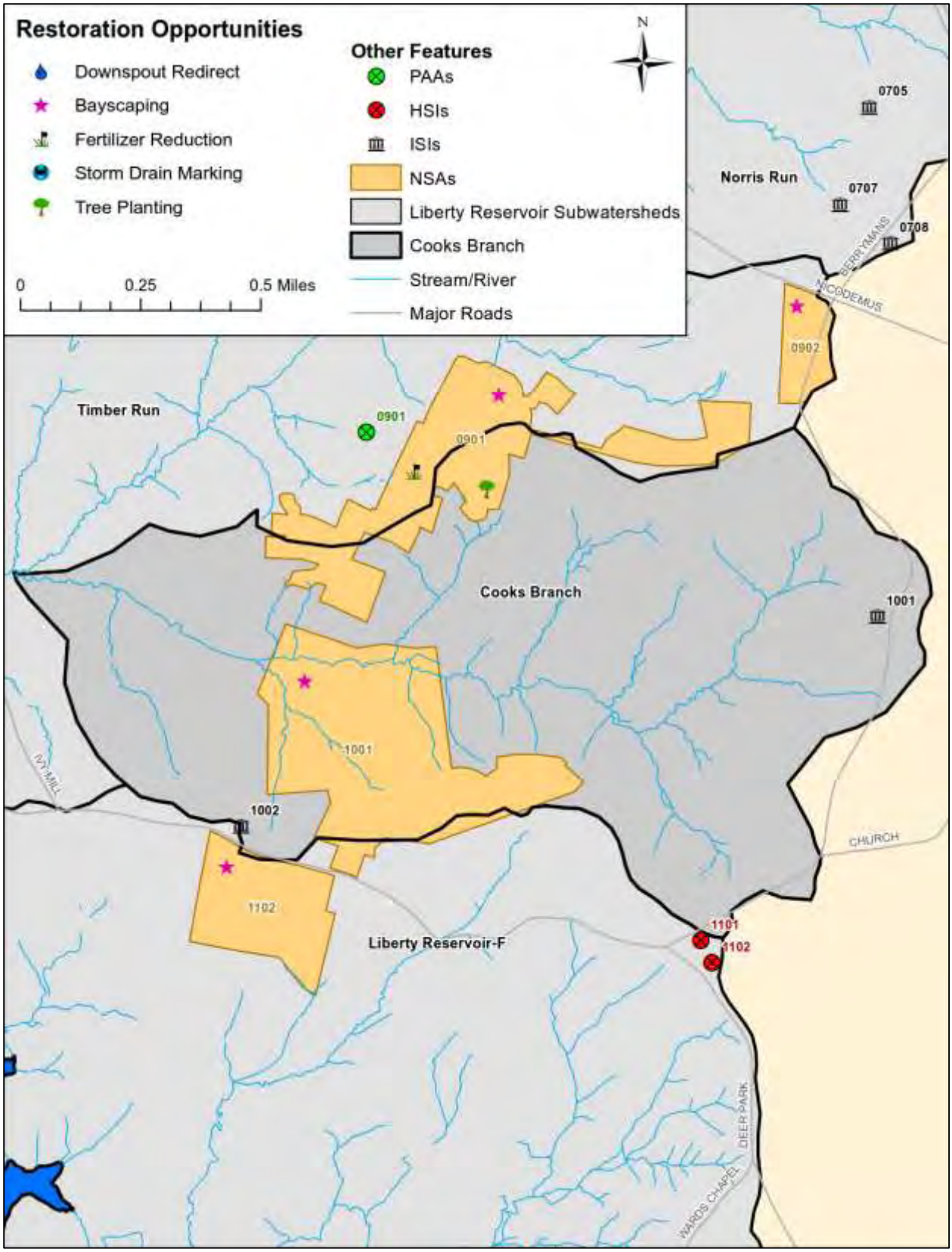

Figure 4-40: Restoration Opportunities in the Cooks Branch Subwatershed

4.3.11 Liberty Reservoir-F

The Liberty Reservoir-F subwatershed is the 3rd largest subwatershed in the Liberty Reservoir watershed and consists largely of forested uses. Residential and other land uses are also found in the subwatershed. Other land uses in the Liberty Reservoir-F subwatershed are water and wetlands found in the Liberty Reservoir. The Liberty Reservoir-F subwatershed has the 3rd largest stream network in the Liberty Reservoir watershed and the 3rd highest percentage of land in conservation easements (62%). Due in part to the large percentage of land in easements and forested uses, the Liberty Reservoir-F subwatershed has the 3rd lowest percentage of impervious surface (2.4%) and population density in the Liberty Reservoir watershed. Key characteristics regarding the Liberty Reservoir-F subwatershed are summarized in Table 4-55.

Table 4-55: Key Subwatershed Characteristics – Liberty Reservoir-F

Drainage Area	2,013.5	Acres	
	3.15	sq. mi.	
Stream Length	17.8	Miles	
Population	961	(2010 Census)	
	0.48	persons/acre	
Land Use/Land Cover	Very Low Density Residential:		9.5%
	Low Density Residential:		11.1%
	Medium/High Density Residential:		0.0%
	Commercial:		0.2%
	Industrial:		0.0%
	Institutional:		0.0%
	Open Urban:		0.0%
	Agriculture:		14.6%
	Forest:		58.1%
	Transportation:		0.0%
	Other:		6.5%
Land in Easement	1,255	Acres	62.3%
Impervious Cover	48	Acres	2.4%
Soils	A Soils (low runoff potential):		0.0%
	B Soils:		59.7%
	C Soils:		20.1%
	C/D Soils:		5.9%
	D Soils (high runoff potential):		11.7%
	Water:		2.6%

4.3.11.1 Neighborhoods

Two neighborhoods were identified and assessed within the Liberty Reservoir-F subwatershed during the uplands assessment of the Liberty Reservoir watershed. Recommendations for addressing stormwater

volume and pollutants within this subwatershed include storm drain marking, buffer improvement, tree planting, and public education (i.e., bayscaping and increasing lot tree canopy). A summary of neighborhood recommended actions is presented in Table 4-56.

Table 4-56: NSA Recommendations – Liberty Reservoir-F

NSA_ID	Lot Size (Acres)	Storm Drain Marking	Bayscaping	Increase Lot Canopy	Buffer Improvement	# of Open Space Trees	Notes
NSA_S_1101	1-3	X	X	X	X	X	Potential tree planting in traffic circle
NSA_S_1102	3-5		X	X			-

Both NSAs located in the Liberty Reservoir-F subwatershed have large lot sizes with large grass yards. This presents an excellent opportunity to encourage bayscaping and increased lot canopy. Educational outreach will also help encourage residents to plant trees where possible, especially along stream buffers. Additionally, there is potential for storm drain marking at NSA_S_1101 as the inlets are currently unmarked.

4.3.11.2 Hotspots

Two hotspot investigations were performed within the Liberty Reservoir-F subwatershed. Table 4-57 summarizes the potential pollution sources found at the sites.

Table 4-57: HSI Results Summary – Liberty Reservoir-F

HSI_ID	HSI Status	Description		Vehicle Operations	Outdoor Materials	Waste Management	Physical Plant	Turf/Landscape Management	Storm Water	Notes
HSI_S_1101	Potential Hotspot	Commercial	Nursery	X	X	X	X	X		-
HSI_S_1102	Potential Hotspot	Commercial	Auto Repair Shop	X	X	X	X			Potential for tree planting, better trash management

HSI_S_1101 is a commercial nursery located on Berryman's Lane. Potential pollution sources at this hotspot include vehicle operations, outdoor material storate, waste management, physical plant management, and landscape management. A couple of vehicles on the site appear to have been stored there long-term (Figure 4-41, left). Outdoor materials are stored uncovered around the site.

HSI_S_1102 is a commercial auto repair shop located on Deer Park Road. Potential pollution sources at this hotspot include vehicle operations, outdoor material storage, waste management and physical plant management. In general, the site appeared well maintained and there was minimal staining on the parking lot. The site's parking lot is breaking up in some spots and the dumpster lid is broken. A large portion of the property is mowed lawn that could potentially be planted (Figure 4-41, right).

Figure 4-41: Long-term Vehicles Stored at HSI_S_1101 (left) and Open Space Available for Potential Planting at HSI_S_1102 (right)

4.3.11.3 Institutions

No ISIs were assessed the Liberty Reservoir-F subwatershed.

4.3.11.4 Pervious Areas

One pervious area assessment was conducted in the Liberty Reservoir-F subwatershed. PAA_S_1101 is a privately owned swim club in the Folly Quarter neighborhood. Tree planting can be completed on approximately 2 acres of open space. Planting this area will also expand existing forest but will not expand interior forest or exterior forest gap.

4.3.11.5 Illicit Discharges

No major outfalls are located within the Liberty Reservoir-F subwatershed.

4.3.11.6 Stream Corridors

A stream corridor assessment was not completed in this subwatershed.

4.3.11.7 Subwatershed Management Strategy

<u>Engaging Citizens' Groups</u>

1. Engage citizens in a storm drain marking program and conduct marking activities in the neighborhood NSA_S_1101.

2. Educate citizens about the benefits and importance of bayscaping.

3. Increase tree canopies on private lots by educating citizens on the benefits of trees and raising awareness of programs such as Baltimore County's "Big Trees Sale".

4. Educate residents about the importance of stream buffers and encourage more environmentally friendly stream treatments in the neighborhoods specified in Table 4-56.

5. Engage residents in NSA_S_1101 for participation in possible tree planting events.

6. Inform citizens of the importance of septic system maintenance.

Municipal Actions

1. Work with the hotspots indicated and similar businesses to implement appropriate practices for vehicle operations, outdoor materials storage, and management of waste, their physical plant, landscapes, and stormwater maintenance, where appropriate.

2. Engage hotspot HSI_S_1102 on the potential of tree planting.

3. Investigate potential for tree planting at PAA_S_1101.

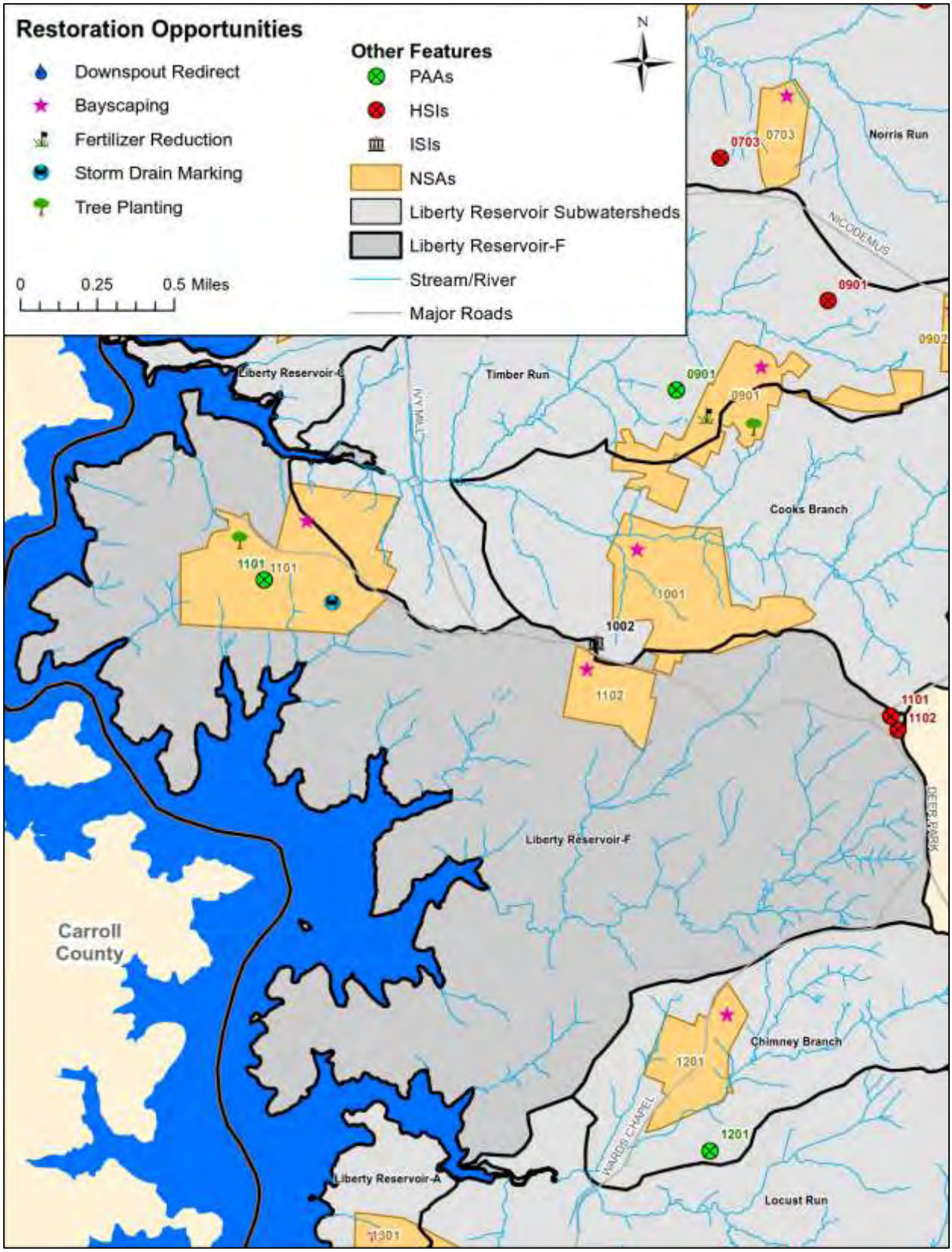

Figure 4-42: Restoration Opportunities in the Liberty Reservoir-F Subwatershed

4.3.12 Chimney Branch

The Chimney Branch subwatershed is the 3rd smallest subwatershed in the Liberty Reservoir watershed with the highest percentage of forested land use of any subwatershed. Agriculture and residential uses are also found in the Chimney Branch subwatershed. The Chimney Branch subwatershed has the 2nd highest percentage of land in conservation easements (74%) and the 2nd lowest percentage of impervious surface (2.1%) in the Liberty Reservoir watershed. Key characteristics regarding the Chimney Branch subwatershed are summarized in Table 4-58.

Table 4-58: Key Subwatershed Characteristics – Chimney Branch

Drainage Area	439.0	acres	
	0.69	sq. mi.	
Stream Length	6.7	miles	
Population	409	(2010 Census)	
	0.93	persons/acre	
Land Use/Land Cover	Very Low Density Residential:		8.3%
	Low Density Residential:		12.0%
	Medium/High Density Residential:		0.0%
	Commercial:		0.0%
	Industrial:		0.0%
	Institutional:		1.1%
	Open Urban:		0.0%
	Agriculture:		13.0%
	Forest:		65.5%
	Transportation:		0.0%
	Other:		0.0%
Land in Easement	326	acres	74.3%
Impervious Cover	9	acres	2.1%
Soils	A Soils (low runoff potential):		0.0%
	B Soils:		9.6%
	C Soils:		30.9%
	C/D Soils:		15.9%
	D Soils (high runoff potential):		43.6%
	Water:		0.0%

4.3.12.1 Neighborhoods

One neighborhood was identified and assessed within the Chimney Branch subwatershed during the uplands assessment of the Liberty Reservoir watershed. Recommendations for addressing stormwater volume and pollutants within this subwatershed include buffer improvement and public education (i.e., bayscaping and increasing lot tree canopy). A summary of neighborhood recommended actions is presented in Table 4-59.

Table 4-59: NSA Recommendations – Chimney Branch

NSA_ID	Lot Size (Acres)	Bayscaping	Increase Lot Canopy	Buffer Improvement	Notes
NSA_S_1201	1-3	X	X	X	-

The neighborhood located in the Chimney Branch subwatershed has large lot sizes (1-3 acres) with large grass yards. This presents an excellent opportunity to encourage bayscaping. Educational outreach will also help encourage residents to plant trees where possible, especially along stream buffers.

4.3.12.2 Hotspots

No HSIs were assessed in the Chimney Branch subwatershed.

4.3.12.3 Institutions

No ISIs were assessed in the Chimney Branch subwatershed.

4.3.12.4 Pervious Areas

One pervious area assessment was performed in the Chimney Branch subwatershed. PAA_S_1201 is privately owned by the Knights of Columbus. This 8.1 acre parcel of land is bordered to the north by Soldiers Delight Natural Environmental Area. Approximately 0.5 acres of open space is located adjacent to the Soldiers Delight land that is potentially available for tree planting. This tree planting will minimize the existing exterior forest gap. Planting this area will also expand existing forest but will not expand interior forest land.

4.3.12.5 Illicit Discharges

There are no major outfalls in the Chimney Branch subwatershed.

4.3.12.6 Stream Corridors

A stream corridor assessment was not completed in this subwatershed.

4.3.12.7 Subwatershed Management Strategy

<u>Engaging Citizens' Groups</u>

1. Educate citizens about the benefits and importance of bayscaping.

2. Increase tree canopies on private lots by educating citizens on the benefits of trees and raising awareness of programs such as Baltimore County's "Big Trees Sale".

3. Educate residents about the importance of stream buffers and encourage more environmentally

friendly stream treatments in neighborhood NSA_S_1201.

4. Inform citizens of the importance of septic system maintenance.

Municipal Actions

1. Investigate potential for tree planting at PAA_S_1201.

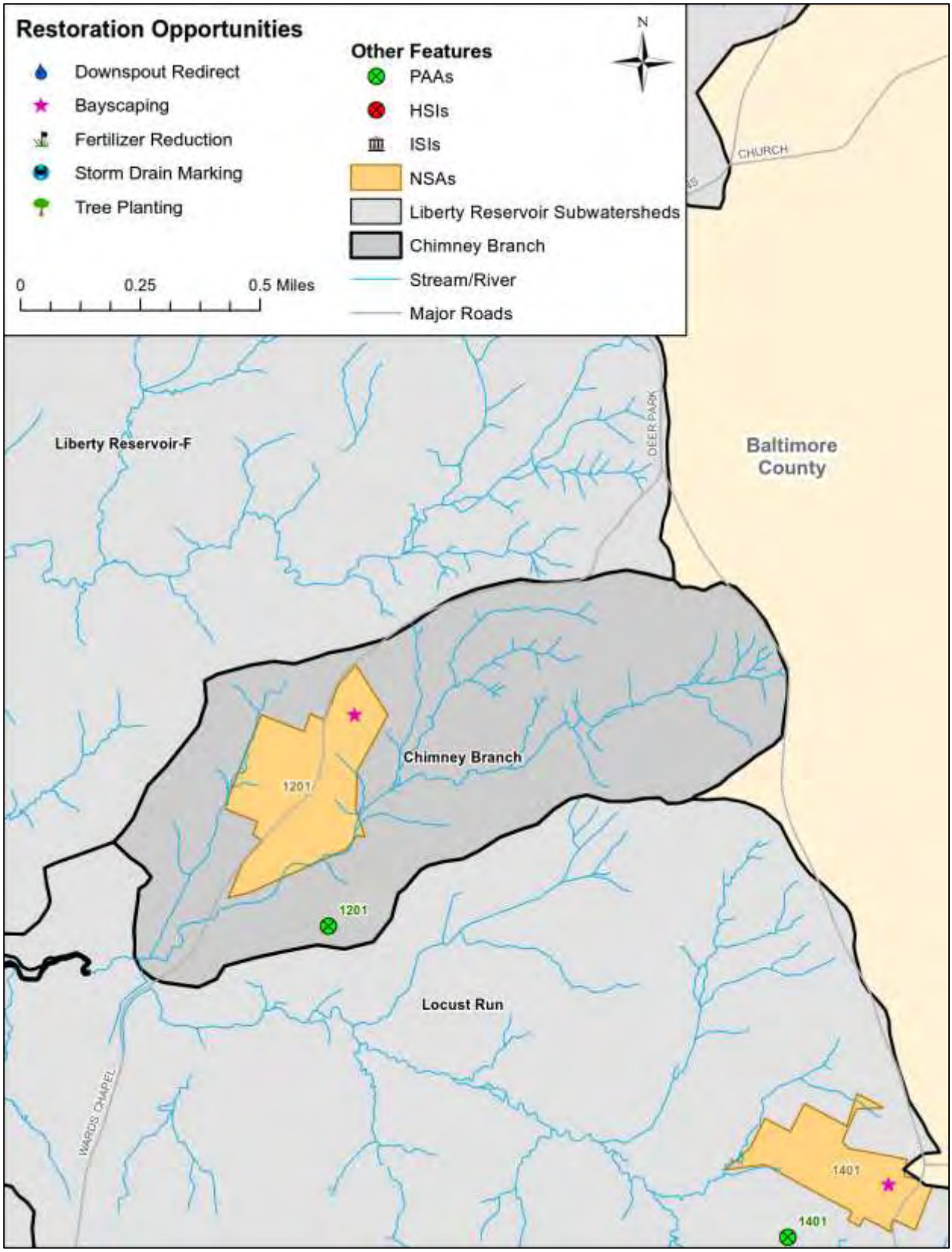

Figure 4-43: Restoration Opportunities in the Chimney Branch Subwatershed

4.3.13 Liberty Reservoir-A

The Liberty Reservoir-A subwatershed is the 8th largest subwatershed in the Liberty Reservoir watershed. It has the lowest population density of all the subwatersheds. Similar to many of the other subwatersheds, the Liberty Reservoir-A subwatershed is primarily forest (59.2%). The subwatershed also includes residential and agricultural uses (30.8%). The Liberty Reservoir-A subwatershed also has the 5th highest percentage of land in conservation easements (54%) and the 4th lowest in percentage impervious area (2.4%). Key characteristics regarding the Liberty Reservoir-A subwatershed are summarized in Table 4-60.

Table 4-60: Key Subwatershed Characteristics – Liberty Reservoir-A

Drainage Area	786.2	Acres	
	1.23	sq. mi.	
Stream Length	3.4	Miles	
Population	125	(2010 Census)	
	0.16	persons/acre	
Land Use/Land Cover	Very Low Density Residential:		5.8%
	Low Density Residential:		11.5%
	Medium/High Density Residential:		0.0%
	Commercial:		0.0%
	Industrial:		0.0%
	Institutional:		0.0%
	Open Urban:		0.0%
	Agriculture:		13.5%
	Forest:		59.2%
	Transportation:		0.0%
	Other:		10.0%
Land in Easement	422	Acres	53.7%
Impervious Cover	19	Acres	2.4%
Soils	A Soils (low runoff potential):		0.0%
	B Soils:		93.6%
	C Soils:		1.0%
	C/D Soils:		2.3%
	D Soils (high runoff potential):		0.9%
	Water:		2.1%

4.3.13.1 Neighborhoods

One neighborhood was identified and assessed within the Liberty Reservoir-A subwatershed during the uplands assessment of the Liberty Reservoir watershed. Recommendations for addressing stormwater volume and pollutants within this subwatershed include storm drain marking and public education (i.e., bayscaping and increasing lot tree canopy). A summary of neighborhood recommended actions is presented in Table 4-61.

Table 4-61: NSA Recommendations – Liberty Reservoir-A

NSA_ID	Lot Size (Acres)	Storm Drain Marking	Bayscaping	Increase Lot Canopy	Notes
NSA_S_1301	3-5	X	X	X	Large lots with houses set back from road. Shared driveways. Could not view majority of downspouts

The neighborhood located in the Liberty Reservoir-A subwatershed had large grass yards. This presents an excellent opportunity to encourage bayscaping. Educational outreach will also help encourage residents to plant trees where possible to increase forest canopy. Additionally, there is potential for storm drain marking at NSA_S_1301 as the inlets are currently unmarked.

4.3.13.2 Hotspots

No HSIs were assessed in the Liberty Reservoir-A subwatershed.

4.3.13.3 Institutions

One faith-based institutional site was assessed for retrofit opportunities in the Liberty Reservoir-A subwatershed during the uplands assessment of the Liberty Reservoir watershed. Table 4-62 summarizes recommendations for the institutional sites assessed in the Liberty Reservoir-A subwatershed.

Table 4-62: ISI Recommendations – Liberty Reservoir-A

Site ID	Name	Public/ Private	# Trees for Planting	Storm water Retrofit	Impervious Cover Removal	Storm Drain Marking	Notes
ISI_S_1301	Liberty Church, PCA and Christian School	Private	37	X	X	X	Potential to reconfigure parking lot for SWM retrofit and impervious surface removal

ISI_S_1301 is a faith-based facility located off of Liberty Road. Restoration opportunities at this location involve stormwater retrofit, impervious cover removal, storm drain marking, and tree planting. Currently, the parking lot is extensive with large parking spaces and grass medians. There is potential to replace a portion of the existing parking lot with stormwater retrofits to treat runoff from the parking lot and roof of the building. Open space allows for approximately 37 trees to be planted along one side of the parking lot.

Figure 4-44: Rooftop and Drive Drain to Inlet Located at the Corner of the Building (left) and Parking Lot with Grass Medians that Could be Converted to Stormwater Treatment (right) at ISI_S_1301

4.3.13.4 Pervious Areas

No pervious areas were assessed in the Liberty Reservoir-A subwatershed.

4.3.13.5 Illicit Discharges

No major outfalls are located within the Liberty Reservoir-A subwatershed.

4.3.13.6 Stream Corridors

A stream corridor assessment was not completed in this subwatershed.

4.3.13.7 Subwatershed Management Strategy

Engaging Citizens' Groups

1. Engage citizens in a storm drain marking program and conduct marking activities in the neighborhood NSA_S_1301.
2. Educate citizens about the benefits and importance of bayscaping.
3. Increase tree canopies on private lots by educating citizens on the benefits of trees and raising awareness of programs such as Baltimore County's "Big Trees Sale".
4. Inform citizens of the importance of septic system maintenance.

Municipal Actions

1. Engage institution ISI_S_1301 on potential tree plantings.
2. Investigate potential stormwater retrofit, impervious removal, and storm drain marking at institutional site ISI_S_1301.

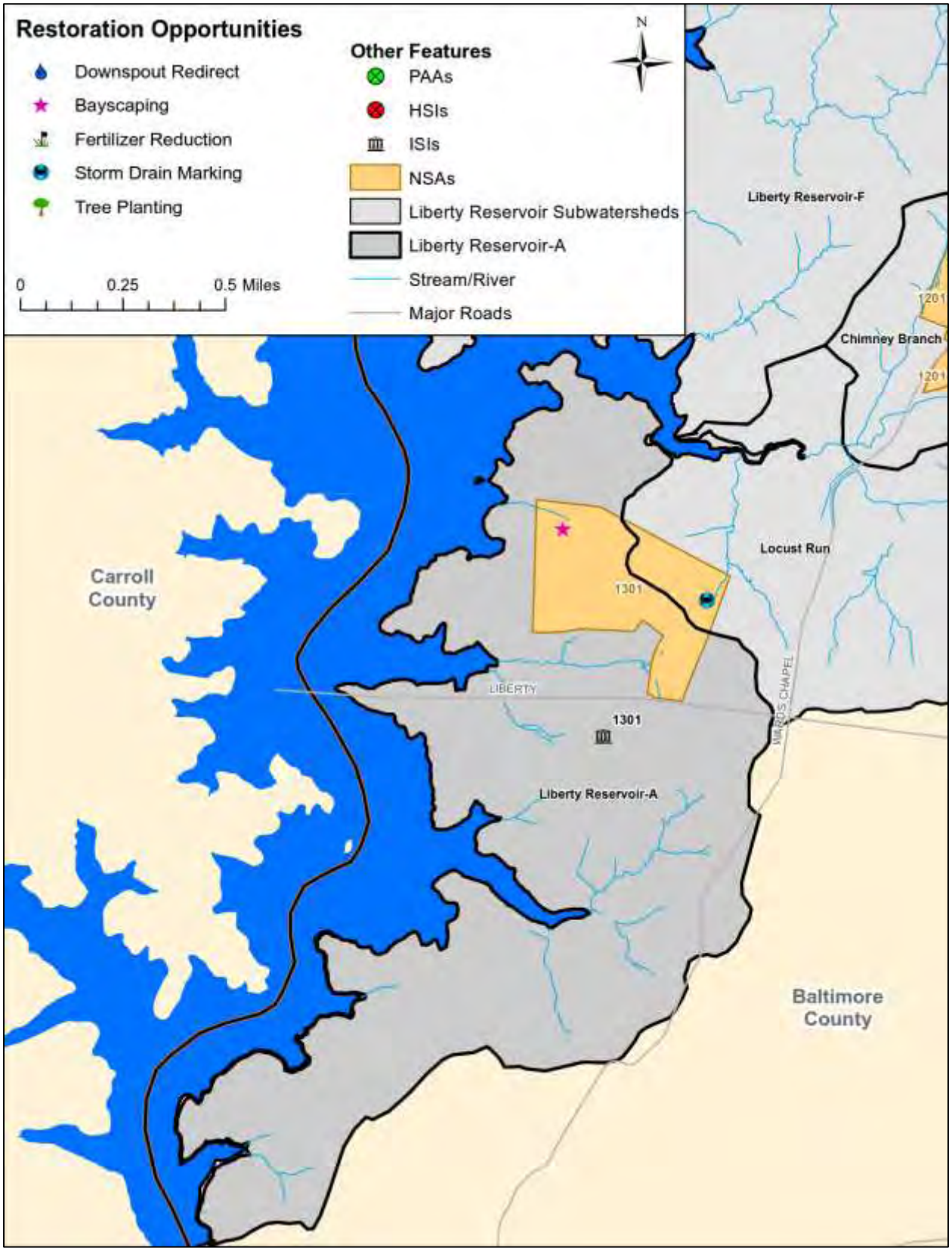

Figure 4-45: Restoration Opportunities in the Liberty Reservoir-A Subwatershed

4.3.14 Locust Run

The Locust Run subwatershed is the 5th largest subwatershed with the 4th largest percentage of forested land use (60.2%) in the Liberty Reservoir watershed. The Locust Run subwatershed has the 5th lowest percentage of impervious surface (3.0%) and population density in the Liberty Reservoir watershed. Key characteristics regarding the Locust Run subwatershed are summarized in Table 4-63.

Table 4-63: Key Subwatershed Characteristics – Locust Run

Drainage Area	1,427.76	acres	
	2.23	sq. mi.	
Stream Length	14.6	miles	
Population	889	(2010 Census)	
	0.62	persons/acre	
Land Use/Land Cover	Very Low Density Residential:		6.3%
	Low Density Residential:		12.1%
	Medium/High Density Residential:		2.3%
	Commercial:		4.6%
	Industrial:		0.0%
	Institutional:		0.3%
	Open Urban:		2.9%
	Agriculture:		9.3%
	Forest:		60.2%
	Transportation:		0.0%
	Other:		2.0%
Land in Easement	621	acres	43.5%
Impervious Cover	43	acres	3.0%
Soils	A Soils (low runoff potential):		0.0%
	B Soils:		44.2%
	C Soils:		18.9%
	C/D Soils:		15.9%
	D Soils (high runoff potential):		20.9%
	Water:		0.2%

4.3.14.1 Neighborhoods

Two neighborhoods were identified and assessed within the Locust Run subwatershed during the uplands assessment of the Liberty Reservoir watershed. Recommendations for addressing stormwater volume and pollutants within this subwatershed include public education efforts (i.e., bayscaping and increasing lot tree canopy). A summary of neighborhood recommended actions is presented in Table 4-64.

Table 4-64: NSA Recommendations – Locust Run

NSA_ID	Lot Size (Acres)	Bayscaping	Increase Lot Canopy	Notes
NSA_S_1401	1-3	X		-
NSA_S_1402	1/2	X	X	No stream buffers in neighborhood

Both neighborhoods located in the Locust Run subwatershed were recommended for bayscaping. Additionally, less than 40% of the average lot in NSA_S_1402 contained forest canopy, leading to a recommendation for increased forest canopy.

4.3.14.2 Hotspots

One hotspot investigation was performed within the Locust Run subwatershed. Table 4-65 summarizes the potential pollution sources found at the site.

Table 4-65: HSI Results Summary – Locust Run

HSI_ID	HSI Status	Description		Vehicle Operations	Outdoor Materials	Waste Management	Physical Plant	Turf/Landscape Management	Storm Water	Notes
HSI_S_1401	Potential Hotspot	Commercial	RV Company	X	X	X	X			Better trash management

HSI_S_1401 is a commercial RV company located on Liberty Road. Potential pollution sources at this hotspot include vehicle operations, outdoor material storage, waste management, and physical plant management. An uncovered dumpster is located on site with additional trash found on the surrounding pavement (Figure 4-46). Downspouts discharge directly to impervious surfaces. There is pervious area available for downspout disconnect, but future education was recommended to improve trash management.

Figure 4-46: Uncovered Dumpster and Unaddressed Trash and Downspouts Discharging to Impervious Surface at HSI_S_1401

4.3.14.3 Institutions

Three faith-based institutional sites were assessed for retrofit opportunities in the Locust Run subwatershed during the uplands assessment of the Liberty Reservoir watershed. Table 4-66 summarizes recommendations for the institutional sites assessed in the Locust Run subwatershed.

Table 4-66: ISI Recommendations – Locust Run

Site ID	Name	Public/ Private	# Trees for Planting	Downspout Disconnection	Trash Management	Storm Drain Marking	Notes
ISI_S_1401	Roman Catholic Church	Private					Retired church used for rosary and cemetery only. No recommended actions.
ISI_S_1402	Baltimore Christian Faith Center	Private	100	X	X	X	Curb cuts not flush with existing parking lot surface
ISI_S_1403	Emmaus Missionary Baptist Church	Private					Recent tree planting. Parking lot recent repaved. No recommended actions.

Neither ISI_S_1401 nor ISI_S_1403 had any noted pollution sources or possible restoration opportunities. ISI_S_1401 is a small church with a cemetery that is currently used for rosary prayers. ISI_S_1403 is a small church that has recent tree plantings. ISI_S_1402 is a faith-based facility located off of Liberty Road. The building and parking lot look recently constructed and the parking lot has curb cuts to drain runoff to a pervious area, although they are not flush with the pavement. Restoration opportunities at this location involve downspout disconnection, trash management, storm drain marking, and tree planting. There are multiple locations surrounding the facility where additional tree plantings can extend forest connectivity.

4.3.14.4 Pervious Areas

Two pervious areas were assessed in the Locust Run subwatershed. The first, PAA_S_1401, is the Under Armour Performance Center for the Baltimore Ravens. This parcel is owned by Baltimore County and borders the Soldiers Delight Natural Environmental Area to the north. With approximately 24 acres available for tree planting, exterior forest gaps could be minimized. There is the potential for tree plantings along 400 feet of streams with inadequate buffers. Also, there are three existing storm water management facilities on-site to treat runoff.

PAA_S_1402 is the county managed Northwest Regional Park. Three existing storm water management facilities treat the runoff from the site. Four open space locations on the site provide approximately 3.5 acres for potential tree planting. Three of these sites would expand continuous forest but not forest interior, and one of the sites would minimize an existing forest gap. Streams are located on this parcel; however, all the streams have adequate forest buffer.

4.3.14.5 Illicit Discharges

There are no major outfalls in the Locust Run subwatershed.

4.3.14.6 Stream Corridors

A stream corridor assessment was not completed in this subwatershed.

4.3.14.7 Subwatershed Management Strategy

<u>Engaging Citizens' Groups</u>

1. Educate citizens about the benefits and importance of bayscaping.
2. Increase tree canopies on private lots by educating citizens on the benefits of trees and raising awareness of programs such as Baltimore County's "Big Trees Sale".
3. Inform citizens of the importance of septic system maintenance.

<u>Municipal Actions</u>

1. Work with the hotspots indicated and similar businesses to implement appropriate practices for vehicle operations, outdoor materials storage, and management of waste, their physical plant, and stormwater maintenance, where appropriate.
2. Educate ISI_S_1402 on proper trash management.
3. Engage institution ISI_S_1402 on potential tree plantings, downspout disconnection, and storm drain marking.
4. Investigate potential for tree planting at PAA_S_1401 and PAA_S_1402.

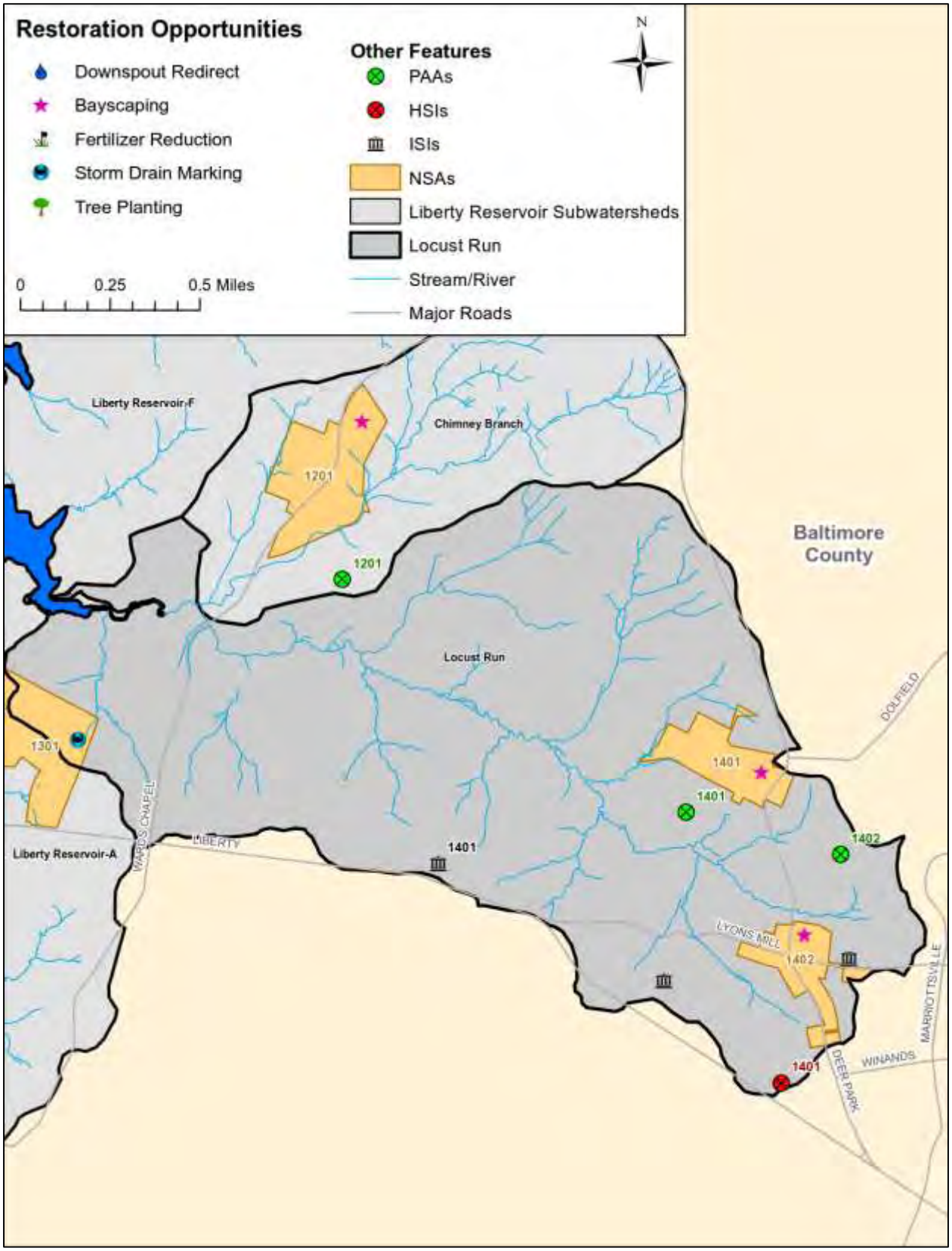

Figure 4-47: Restoration Opportunities Locust Run

CHAPTER 5: IMPLEMENTATION AND EVALUATION PLAN

5.1 Introduction

The Liberty Reservoir SWAP is based on an implementation schedule with an anticipated endpoint of 2030. This time frame is necessary to implement restoration measures that will meet the reservoir TMDLs. The ability to implement this plan within the specified timeframe is dependent upon the availability of staff and sufficient funding. The Liberty Reservoir 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, any completed projects will be recorded in the county's annual NPDES report. An adaptive management approach will be used to meet watershed goals and objectives based on SWAP evaluation data. The Liberty Reservoir SWAP Implementation Committee will initiate a revision of the plan within six months of when additional TMDLs are developed and approved or when a water quality issue arises.

Progress and success of the Liberty Reservoir SWAP will be evaluated during implementation based on the following: interim measureable 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. The progress and success of actions in Appendix A will be evaluated every year. 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 a semiannual basis and modified as necessary to meet watershed goals and objectives.

2-year milestones will also be developed for the Liberty Reservoir TMDL using the same schedule as other local TMDLs and the Chesapeake Bay TMDL. The first 2-year milestone period for the Liberty Reservoir TMDL for restoration actions will be fiscal years 2016-2017 (July 1, 2015 – July 30, 2017) and for programmatic actions will be calendar years 2016-2017.

5.3 Pollutant Load Reduction Criteria

Current pollutant load reduction scenarios and calculations for proposed actions are presented in Chapter 3. The removal efficiencies used to estimate pollutant reductions are based on the peer-reviewed and CBP-approved nonpoint source BMP tables developed for the Phase 5.0 CBP Watershed Model. Additional pollutant reductions from the 2011 MDE *Draft Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated,* the 2014 MDE *Accounting for Stormwater Wasteload Allocations and Impervious Acres,* the 2013 CBP Approved final report *Recommendations of the Expert Panel to Define Removal Rates for Urban Nutrient Management*, and the 2014 *Recommendations of the Expert Panel to Define Removal Rates for Individual Stream Restoration Projects* were used if values were not available in the BMP tables. These references are available in Appendix C.

5.4 Implementation Tracking

Implementation of restoration actions for the Liberty Reservoir SWAP will be overseen by the Implementation Committee. The committee will assess progress with individual actions related to the

percentage completed and the ease of implementation. Overall progress with meeting pollutant reductions will also be assessed. The assessment of implementation progress is based on two aspects; progress in meeting programmatic, management, and restoration actions; and progress in meeting water quality standards and any interim water quality benchmarks. The assessment of progress in meeting the restoration actions includes setting up methods of data tracking, validation of projects, and pollutant load reductions associated with the actions (5.4.1) and will be consistent across all TMDL Implementation Plans. The assessment of progress in meeting water quality standards and interim milestones (5.4.2) is the data analysis associated with the monitoring plan specific to each TMDL Implementation Plan. 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. If additional water quality issues arise, the Liberty Reservoir SWAP Implementation Committee will initiate revisions of the plan.

5.4.1 Implementation Progress: Data Tracking, Validation, Load Reduction Calculation, and Reporting

The Baltimore County Department of Environmental Protection and Sustainability – Watershed Management and Monitoring Section is currently preparing a document entitled *Baltimore County Method for Pollutant Load Calculations, Pollutant Load Reduction Calculations, and Impervious Area Treated*. This document will detail the data sources, data analysis (including pollutant load calculations, and pollutant load reductions calculations), validation of the practices, and reporting of progress made. It was determined that a document was needed to keep a record how Baltimore County calculated pollutant loads and pollutant load reductions from the implementation of various best management practices, as guidance from the state and Chesapeake Bay Program continue to evolve. The document will be updated annually to account for any changes that may have occurred during the previous year. Due to the fact that implementation is being achieved through the actions of many county agencies, it was also determined that the means of data acquisition, any data manipulation, and the means of data analysis needs to be documented on an annual basis to provide consistency and track changes in the process over time. The overall result is intended to provide transparency for the general public and users of reports.

The Maryland Department of the Environment (MDE) has provided a guidance document for NPDES – MS4 permits entitled: *Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated*. The draft document was released in June 2011, followed by a final release in August 2014. The document is intended to provide consistency among the MS4 jurisdictions in calculating baselines and reporting implementation progress. The August 2014 edition includes the Chesapeake Bay Program (CBP) recent recommendations for nutrient and sediment reductions for various practices. It is anticipated that the document will be updated on a periodic basis to reflect new information on restoration practice efficiencies in pollutant load reductions. MDE also provides guidance through its web site, with a webpage entitled *Maryland TMDL Data Center*. This site provides guidance on the development of the TMDL Implementation Plans and is updated on a regular basis.

The Chesapeake Bay Program (CBP) has developed a process whereby through the formation of Expert Panels, the scientific literature is reviewed to determine pollutant load reductions for various types of restoration practices. The Expert Panels provide reports on the load reduction calculations for the various practices, along with supporting documentation; these reports are then reviewed by a series of CBP workgroups and when approved, become the basis for pollutant load reduction credits. The completed documents are posted on the web along with a description of the process, see:

<http://stat.chesapeakebay.net/?q=node/130&quicktabs_10=3>. Completed reviews of restoration practices applicable to the urban sector include:

- New State Stormwater Performance Standards,
- Urban Stormwater Retrofits,
- Urban Nutrient Management,
- Urban Stream Restoration,
- Enhanced Erosion and Sediment Controls, and
- Urban Filter Strip/Stream Buffer Upgrades.

Expert Panel reports essentially complete and awaiting approval include:

- Urban Shoreline Management, and
- Illicit Discharge Elimination (Nutrient Discharges from Grey Infrastructure).

Expert Panel reports in development include:

- Street Sweeping (including catch-basin clean outs and bulk sediment removal),
- Floating Wetlands,
- Urban Tree Planting/Expanded Tree Canopy, and
- Riparian Forest Buffers.

In addition to the changes in the pollutant removal efficiencies, the CBP is in the process of developing the next phase of the Watershed Model (Phase 6) to be used in the mid-point assessment to determine progress being made for the Chesapeake Bay TMDL. There will likely be changes in the land use categories designed to improve the model with respect to the pollutant loads associated with land use types. When the model is calibrated and run in 2017 there will likely be changes in the loads with respect to land use. This will necessitate a recalculation of the nutrient and sediment loads and the reductions associated with practices that treat the various land uses.

The document *Baltimore County Method for Pollutant Load Calculations, Pollutant Load Reduction Calculations, and Impervious Area Treated* will be posted for review and comment in the spring of 2015. It will be modified on an annual basis to take into account any future Expert Panel documents, modifications to any guidance documents and future calculations will reference the edition on which the calculations were based.

5.4.2 Reporting

Baltimore County will prepare two-year milestones for each local TMDL in conformance with the Chesapeake Bay TMDL two-year milestone process. Programmatic actions and monitoring data analysis will be based on the calendar year, while restoration actions will be based on the fiscal year (July 1 – June 30). The current two-year milestone period was developed in January 2014. These milestones include programmatic actions covering January 2014 through December 2015, and restoration actions for the July 1, 2013 through June 30, 2015 period. When the next two-year milestones are developed in 2016, they will be presented by watershed and will include each of the local TMDLs.

Reporting will be done through the annual NPDES – MS4 Permit Report. This is technically due on the anniversary date of the permit renewal, but will be completed for submittal to MDE in October each year. The report will detail progress made in meeting each of the local TMDLs and the Chesapeake Bay TMDL. The analysis will include progress in meeting the two-year milestone programmatic and restoration

actions, along with the calculated load reduction. It will also present the results of the monitoring conducted the previous year. See below for TMDL specific monitoring.

In January of each year, a progress report (mostly extracted from the MS4 report) will be prepared and posted on the web.

5.5 Monitoring

SWAP implementation monitoring activities will focus on project specific monitoring and targeted subwatershed monitoring. Project specific monitoring will be indentified as restoration progresses. It will not be possible to monitor all restoration projects due to the number of actions proposed. 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. There is potential to coordinate a citizen-based stream watch program since existing water quality monitoring stations are limited in the Baltimore County portion of the Liberty Reservoir watershed. Monitoring activities will be coordinated among SWAP participants through participation in the Liberty Reservoir SWAP Implementation Committee.

5.5.1 SWAP Implementation Monitoring

The rationale for the development of the Liberty Reservoir Phosphorus TMDL was the level of chlorophyll *a* in the epilimnion (algal blooms) and the seasonal lack of dissolved oxygen in the hypolimnion. Phosphorus is linked to the algal blooms (measured by chlorophyll *a*), and with the subsequent die-off the algae, low dissolved oxygen levels in the hypolimnion (bottom water) of the reservoir. The appropriate measures for meeting the water quality standards are the level of chlorophyll a in the epilimnion and the dissolved oxygen concentration in the hypolimnion. Specifically, the standards related to the chlorophyll a concentration are:

1) The arithmetic mean of a representative number of samples of chlorophyll *a* concentrations, measured during the growing season (May 1 to September 30) as a 30-day moving average may not exceed 10 micrograms per liter (10 µg/l); and

2) The 90th-percentile of measurements taken during the growing season may not exceed 30 micrograms per liter (30 µg/l) (Source: COMAR 26.08.02.03-3).

The dissolved oxygen standard is a minimum of 5 mg/L for all waters. However, given the natural stratification of reservoirs, this standard is not expected to be met, but the dissolved oxygen concentration is expected to improve with the reduction of phosphorus. These measurements need to be taken within the reservoir itself, along with the reservoir phosphorus concentration.

The rationale for the development of the Liberty Reservoir Sediment TMDL is to increase the useful life of the reservoir for water supply purposes by preserving storage capacity. This TMDL is based on the calculated phosphorus TMDL and the amount of phosphorus which is bound to sediment.

Monitoring for the Liberty Reservoir phosphorus and sediment impairments will consist of tributary monitoring (Section 5.5.2) to assess the progress in reducing phosphorus and sediment loads, and in-lake

monitoring (Section 5.5.3) to assess the phosphorus and sediment concentrations and the end point water quality standards.

Due to algal blooms in the 1970s in the three drinking water reservoirs serving the Baltimore metropolitan area, an initial Reservoir Watershed Agreement was signed in 1979 to address water quality issues within the reservoirs. The most recent agreement, Reservoir Watershed Management Agreement of 2005 called for continued and improved water-quality monitoring in the reservoirs and selected watershed tributaries. Coordination among the local jurisdictions and state agencies, and local soil conservation districts in meeting the Watershed Management Agreement provisions is provided by the Baltimore Metropolitan Council. In order to address the provisions of the agreement, the Baltimore Metropolitan Council has formed a Reservoir Technical Group (RTG), which in turn has developed the 2005 Action Strategy for the Reservoir Watersheds that details the actions necessary to meet the agreement requirements. One of the actions under *Reservoir and Watershed Assessment 1.1*(3) was a provision to evaluate the existing reservoir monitoring programs and develop a collaborative monitoring strategy for the reservoirs and their tributaries. In order to meet this action, in 2007, Baltimore City, Baltimore County, and Carroll County jointly funded an agreement with the U.S. Geological Survey (USGS) to assess the current monitoring programs and make recommendations for monitoring program improvements to meet a number of objectives, including, "to ensure that water quality in the three reservoirs and their tributaries consistently meet all applicable water quality standards established by Federal and State regulation". The resulting publication The Water-Quality Monitoring Program for the Baltimore Reservoir System, 1981-2007 – Description, Review and Evaluation, and Framework Integration for Enhanced Monitoring (Koterba, 2011) provided an assessment of current monitoring programs and made recommendations for improvements. Since the publication of the report, a subcommittee of the RTG has assessed the information in the report and, based on the recommendations, has developed a monitoring frame-work. The next stage will be the hiring of a consultant to develop a Watershed Monitoring Plan document based on what has been developed to date. The Watershed Monitoring Plan will then be used as the basis for hiring a contractor to perform the sample collection, analysis, and data management. In accordance with the future Watershed Monitoring Plan, some of the following monitoring elements may be replaced.

5.5.2 Tributary Monitoring

There are two entities that conduct monitoring programs to assess water quality conditions in the Liberty Reservoir tributaries: Baltimore County and Baltimore City Reservoir Office. The established programs used by these government agencies are discussed below.

5.5.2.1 Baltimore County Tributary Monitoring

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

- Chemical Trend Monitoring – The Baltimore County Chemical Trend Monitoring Program is conducted throughout the county. The Program was initiated in 2010 and consists of a fixed-interval, fixed-site design with 40 sites countywide. Three of the sites are located within the Liberty Reservoir watershed. Monitoring will continue at these sites and will be used to assess ambient chemical conditions and assess trends in chemical concentrations and loads (EPS, 2013).

- Biological Monitoring – Conducted since 2003 following the Maryland Biological Stream Survey (MBSS) probabilistic monitoring methods to assess ecological health in local streams, assess the effectiveness of stream restoration projects, and provide data on the best streams in the county to serve as bench marks for other stream assessments (EPS, 2013).

- Bacterial Monitoring – Baltimore County conducts Bacteria Trend Monitoring in response to the development of bacteria TMDLs. Beginning in June of 2010, Baltimore County EPS has coordinated with the Baltimore City Surface Water Management Division to monitor bacteria trend levels at 35 sites throughout the county and are proposing 19 new locations in Liberty Reservoir. Currently, all five active monitoring sites within the overall Liberty Reservoir watershed are within Carroll County (EPS, 2013).

- Illicit Discharge Detection and Elimination Program – Routine outfall screening and prioritization system to track and reduce illicit connections and discharges are conducted in the Liberty Reservoir watershed.

Additional monitoring is anticipated to assess the effectiveness of restoration projects and progress in meeting TMDL reductions.

5.5.2.2 Baltimore City Reservoir Office Tributary Monitoring

The Baltimore City Reservoir Office Tributary Monitoring Program collects samples from major tributaries to each of the reservoirs. Dry weather samples were collected from six major tributaries in the Liberty Reservoir watershed, none of which were located in the Baltimore County portion of the watershed (Koterba, 2011).

5.5.3 In-lake Monitoring

The Baltimore City Reservoir Office – Reservoir Natural Resources Section is responsible for conducting the in-lake monitoring. There are four sites monitored within the Liberty Reservoir as shown in Figure 5-1. Sampling is conducted at the surface and at depth intervals to include chlorophyll *a* at the surface and 10 foot intervals down to 50 feet. Chemical and dissolved oxygen samples are collected at specified intervals that span the thermocline, and therefore include samples in both the epilimnion and the hypolimnion. This sampling design will determine if the end-point water quality standards are being met.

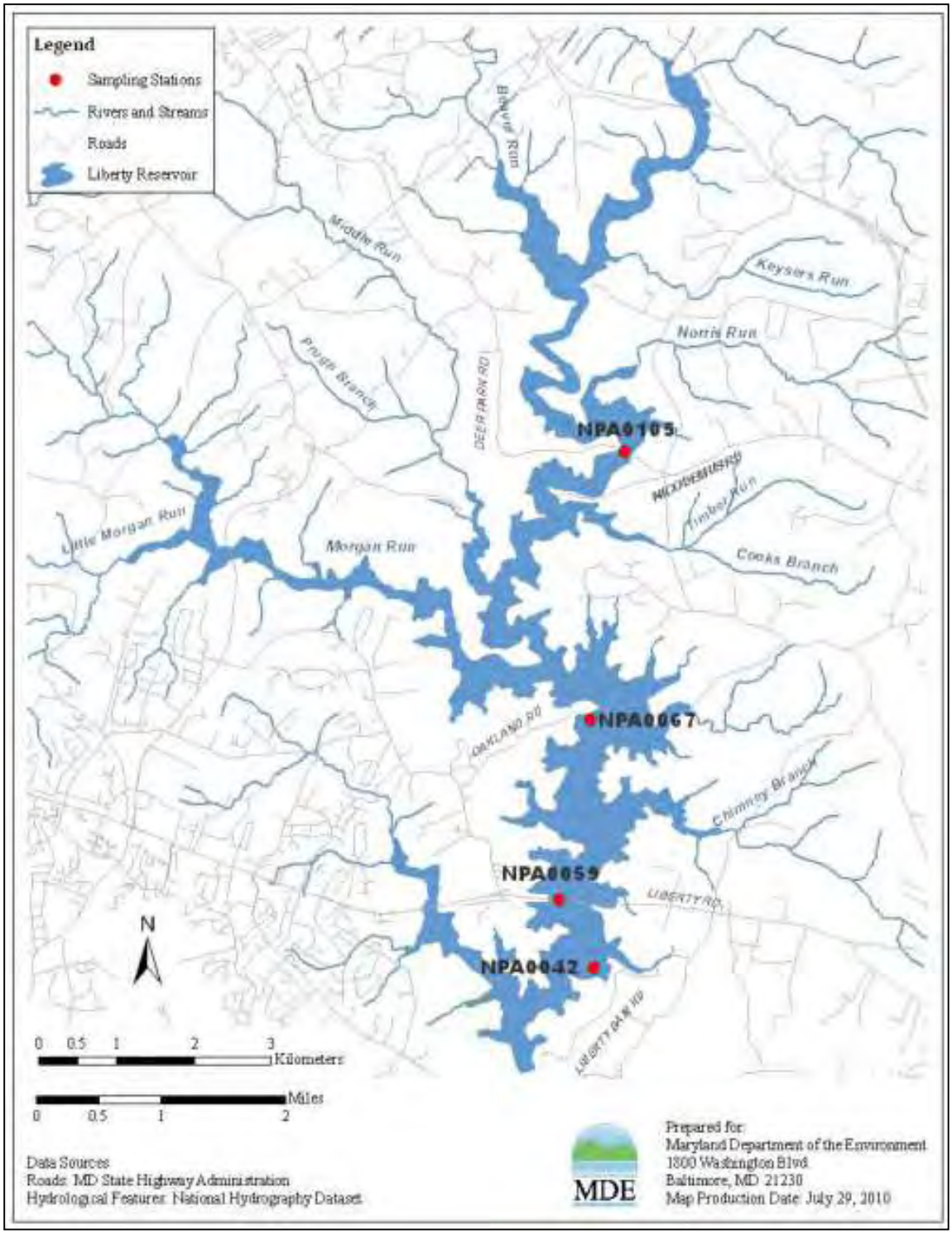

Figure 5-1: Sampling Locations within the Liberty Reservoir Lake (Source: (MDE, 2014c))

5.6 Continuing Public Outreach Plan

In order to engage the public in the TMDL implementation process this continuing public outreach plan will be implemented upon approval of this TMDL Implementation Plan. The continuing public outreach plan is applicable to all TMDL Implementation Plans that are currently being developed and those developed in the future, as well as the Trash and Litter Reduction Strategy. This continuing public outreach plan is meant to engage county agencies, environmental groups, the business community, and the general public.

5.6.1 County Agencies

County agencies will be engaged through two regularly scheduled NPDES Management Committee meetings per year and other agency meetings as necessary to move implementation forward.

5.6.1.1 NPDES Management Committee

The NPDES Management Committee is composed of representative agencies that are involved in meeting the NPDES – MS4 Permit requirements. This committee has met irregularly in the past, generally to review information on permit requirements and other upcoming regulatory requirements, such as, the General Industrial Stormwater Discharge Permit. In the future this committee will meet twice per year and will discuss not only the NPDES – MS4 Permit requirements, but also the TMDL Implementation Plans and progress being made in meeting the implementation strategy. In order to address all components of the TMDL Implementation Plans the committee membership will be expanded to include any county agency that has some responsibility for TMDL implementation. Examples being, the County Police Department and the Department of Environmental Protection and Sustainability – Groundwater Management Section. Prior to the development of the TMDL Implementation Plans and the Trash and Litter Reduction Strategy, these agencies were not specifically engaged in NPDES – MS4 Permit activities.

The first yearly meeting will be held in January of each year. The focus of this meeting will be to review the implementation plan 2-year milestones for each plan; provide a forum for discussion of the ability to meet the implementation actions; and determine any revisions necessary to meet the interim implementation milestones set in the plan. This meeting is also the forum for discussion of data tracking and reporting to ensure that the implementation actions are properly credited.

The second yearly meeting will be held in July of each year and will provide the forum for determining data submittal for the yearly progress report on the implementation actions and the resulting load reductions. The monitoring data from the previous calendar year will be presented and contrasted with the interim water quality milestones that are detailed in each implementation plan.

5.6.1.2 Other Agency Meetings

In order to move forward with implementation, agency meetings regarding specific implementation actions are anticipated. These will be scheduled as needed, and tracked by meeting date, attendance, TMDL Implementation Plans discussed, and topic. Meeting minutes will be reported in the Annual NPDES – MS4 Report submitted to Maryland Department of the Environment. This report is also posted on the County website for public access.

5.6.2 Environmental Groups

Baltimore County is currently engaged with local watershed associations through its funding of *Watershed Association Restoration Planning and Implementation Grants*, and through inclusion of watershed association members on the Steering Committees of the Small Watershed Action Plans. Formerly, this engagement and support was coordinated through the *Baltimore Watershed Agreement*. As part of that engagement, periodic Watershed Advisory Group (WAG) meetings were held. As part of this continuing public outreach plan, WAG participation will be formalized with two meetings per year. Although a watershed association for the Liberty Reservoir watershed had not yet been formed as of the creation of this implementation plan, in the event a watershed association is formed for the Liberty Reservoir watershed, it will be encouraged to participate in WAG.

The first meeting will be held in March of each year and focus on the local and Chesapeake Bay TMDL implementation actions and implementation progress, including an analysis of the pollutant load reduction calculations from the previous fiscal year. The watershed associations are currently engaged in citizen-based restoration activities and report their implementation progress to the county for inclusion in the Annual NPDES – MS4 Report. This meeting will provide a forum for discussion of the progress being made, coordination between the watershed associations, and any changes to the *Watershed Association Restoration Planning and Implementation Grant* being considered for the next grant period.

The second meeting will be held in November of each year and will focus on the water quality monitoring results from the previous calendar year. The results presented will compare trends and measures against the TMDL Implementation Plans water quality benchmarks and water quality standards.

5.6.3 Business Community

The business community will be engaged through various business forums, targeted outreach and education efforts on specific topics, and hosting workshops on specific topics as necessary.

5.6.3.1 Business Forums

Business forums, such as the Hunt Valley Business Forum with greater than 200 business members, provide opportunities to present the TMDL Implementation Plans and the Trash and Litter Reduction Strategy, and discuss the role of business in helping improve water quality. These forums will be convened as the opportunities arise. Summaries of these meetings will be reported in the annual NPDES – MS4 Report and will include the name of the forum (or other business organization), approximate number in attendance, the topic presented, and audience responses.

5.6.3.2 Targeted Business Outreach and Education

The Small Watershed Action Plan (SWAP) process includes an upland assessment of potential pollution hotspots. Often, these potential hotspots are commercial or industrial sites. The information derived from this assessment will be used to target outreach and education to businesses specific to the issue(s) at the location identified in each SWAP. These actions will be tracked and reported in the annual NPDES – MS4 Report.

5.6.3.3 Business Workshops

There are certain issues that may be pervasive through a segment of the business community that can most effectively be addressed through hosting workshop education on the specific topic. These issues will be identified as SWAP implementation moves forward, but one potential topic for a business workshop is related to the recently renewed *General Discharge Permit for Stormwater Associated with Industrial Activities.* A workshop designed in conjunction with Maryland Department of the Environment would not only result in improved water quality, but it would also benefit the business community through increased understanding of the requirements of the permit.

5.6.4 General Public

The general public will be engaged through a number of mechanisms, including:

- WIP Team meetings
- Targeted outreach and education efforts on specific topics
- Steering Committee meetings and stakeholder meetings in the development of Small Watershed Action Plans
- Meetings of the Implementation Committee for completed Small Watershed Action Plans
- Displays at various events
- Annual progress reports posted on the county website and placed in our libraries
- A biennial *State of Our Watersheds* conference.

5.6.4.1 Watershed Implementation Plan (WIP) Team Meetings

Baltimore County has assembled a Watershed Implementation Plan (WIP) team to serve as a sounding board for the development of the WIP to address the Chesapeake Bay TMDL. Members of the team include representatives from various county agencies, business community representatives (particularly the environmental engineering community), watershed associations, representatives from the agricultural community, and Baltimore County citizens.

The county will schedule at least one meeting annually to present implementation progress and to address specific topics related to the TMDL Implementation Plans and the Trash and Litter Reduction Strategy. Meetings will be scheduled as issues arise. It is anticipated that the WIP team will provide initial review of newly developed outreach and education materials, in order to provide feedback from a variety of perspectives.

5.6.4.2 Targeted Outreach and Education

The Small Watershed Action Plan development process includes upland assessments of neighborhoods to identify pollution sources and restoration opportunities. This information will be used to prioritize and target outreach and education efforts specific to the issue(s) in neighborhoods with the intent to affect behavioral change and/or increase citizen based restoration actions. These actions will be tracked and reported in the annual NPDES – MS4 Report.

5.6.4.3 Small Watershed Action Plans (SWAPs)

Baltimore County has been developing Small Watershed Action Plans since 2008. There are 23 planning areas in the county, with 14 completed plans, 5 plans in development, and 4 areas pending. These planning areas cover the entire county. The planning process includes the development of a steering committee, the composition of which is determined by the issues, and land ownership within the planning area. At a minimum, membership consists of agency representatives, watershed associations, and citizen representatives. Each SWAP takes about a year to complete. During this time, the steering committee typically meets six times. The Liberty Reservoir SWAP was completed in six months with the steering committee meeting a total of five times to accommodate the implementation plan schedule. The process also includes a number of stakeholder meetings, open to all planning area residents and businesses, which provide information on the plan and solicit input. Once the SWAP is complete, the steering committee becomes the implementation committee. As designed, the implementation committee is to meet twice per year; however, most implementation committees have not met this goal.

The plans have addressed to varying degrees the TMDLs that are applicable within the planning area. Some of the TMDLs have been developed subsequent to the specific SWAP development or did not address the full range of TMDLs that were applicable to the planning area. The TMDL Implementation Plans are built on incorporation of the actions from each SWAP within the applicable TMDL area. In some cases, additional actions have been identified in order to meet water quality standards.

Small Watershed Action Plans in Development and Future Plans

For SWAPs currently under development, and for plans developed in the future, the steering committee and stakeholder meetings will be used for outreach regarding the TMDL Implementation Plans and the progress being made in achieving water quality standards. The meeting participants will be informed on where they can access the TMDL Implementation Plans, the Trash and Litter Reduction Strategy and any Progress Reports that have been developed.

Applicable TMDL Implementation Plan actions will be incorporated into the SWAP based on the assessment of applicable restoration actions within the SWAP planning area. Since the SWAPs incorporate field assessments of streams and uplands, they provide more detailed information on applicable restoration actions, both on quantity and location. The accelerated schedule for developing TMDL Implementation Plans precluded conducting field work to build the plans.

Small Watershed Action Plans Already Developed

For those SWAPs already developed, the implementation committee meetings will be scheduled twice per year. The first meeting will be held in winter and will present the implementation progress not only of the SWAP, but also any applicable TMDL Implementation Plan progress. The progress analysis will be based on fiscal year. This meeting will also provide the opportunity to discuss any changes in the SWAP or the TMDL Implementation Plan based on an analysis of what actions have been successful and what actions have been more difficult to implement.

The second implementation committee meeting will be held in the fall of each year and will present the monitoring data with progress being made in relation to interim milestones and water quality standards.

5.6.4.4 Educational Displays at Events

Educational displays and handouts will continue to be used at applicable events as they occur. The particular display and handout materials will be determined by the location and focus of the event. The location and focus of the event, number of citizens engaging staff at the display, and the number of handouts taken by citizens will be tracked for annual reporting in the NPDES – MS4 Report.

5.6.4.5 TMDL Implementation Plan, Trash and Reduction Strategy, and Progress Report Availability

The TMDL Implementation Plans and the Trash and Litter Reduction Strategy will be posted on the Baltimore County website with hard copies placed in county libraries. The hard copies in the libraries will be specific to the watershed in which the library is located. Progress reports will be posted on the County website and placed in libraries. A set of hard copy plans will be kept at the Baltimore County Department of Environmental Protection and Sustainability.

5.6.4.6 Biennial State of Our Watersheds Conference

Baltimore County, in conjunction with Baltimore City, has held *State of Our Watershed* conferences in the past to present information to county and city citizens on water quality issues applicable to the watersheds in these jurisdictions. Future conferences will be held in early March of even numbered years. Information on implementation progress for local TMDLs and the Bay TMDL will be presented, along with other topics of interest. These conferences will be organized with the assistance of the Watershed Advisory Group (WAG), and the surrounding local jurisdictions (Baltimore City, Howard County, Carroll County, Harford County, and York County, PA) will be invited to participate in the organization and presentation of the conference.

The timing of even years is related to the 2-year milestone process set up by the Maryland Chesapeake Bay TMDL Watershed Implementation Plan (WIP) whereby in January of even calendar years, progress in meeting the previous 2-year milestone programmatic and restoration implementation is reported and the next 2-year programmatic and restoration implementation milestones are proposed by the local jurisdictions. The timing of the conference not only permits reporting on the progress made in meeting the previous 2-year milestones but also what is planned for the next two years.

5.6.5 Summary of Continuing Public Outreach Plan

A summary of the continuing public outreach plan, by component, element and frequency is presented in Table 5-1.

Table 5-1: Continuing Public Outreach Plan Summary

Plan Component	Plan Element	Frequency
Agencies	NPDES Management Committee	2x per year
	Other Agency meetings	As needed
Environmental Groups	Watershed Advisory Group (WAG) meetings	2x per year
Business Community	Business Forums	As identified
	Targeted Business Outreach and Education	As identified
	Topical Workshop	As identified
General Public	WIP Team meetings	1x per year
	Targeted Outreach and Education	As identified
	SWAP – Steering Committee meetings	6x per SWAP, each
	SWAP – Stakeholder meetings	2x per SWAP, each
	SWAP – Implementation Committee meetings	2x per year, each
	Educational Displays at Events	As identified
	Document availability (various)	As needed
	Biennial Conference	Even # Years

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APPENDIX A:

Liberty Reservoir Action Strategies

Liberty Reservoir Action Strategies

This appendix presents the actions related to the goals and objectives presented in Chapter 2 of the Liberty Reservoir SWAP. A complete list of actions proposed for the watershed including timelines, performance measures, unit cost estimates, responsible parties, and goals and objectives is included in Table A-1. Some of the key columns included in Table A-1 are briefly described below.

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
  - Stormwater Management
  - Tree Canopy
  - Trash Management
  - Stream Corridor Restoration
  - Land Preservation
  - Bacteria Reductions
  - Chloride/Sodium Reductions
  - Deer Management
  - Sustainable Agricultural Practices
- 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.

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.

Total Number Units to Reach 2030 Goal

The total number of units represents the actions needed to meet local TMDL reduction goals.

Unit Cost

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

Responsible Party

Those responsible for ensuring the success/completion of a given action are denoted by their acronym in this column. Responsible parties are indicated by numerals as follows:

- DP - Baltimore County Department of Planning
- EPS - Baltimore County Department of Environmental Protection and Sustainability
- Public Works - Baltimore County Department of Public Works
- SCD - Baltimore County Soil Conservation District
- SHA - Maryland State Highway Administration
- SWAP – SWAP Implementation Committee

Table A-1: Liberty Reservoir Action Strategies – Action Detail Matrix

	Action	Basis for Performance Measure	Performance Measure	Total Number Units to Reach 2030 Goal	Unit Cost	Respons. Party*	Applicable to Implementation Plan	Goal 1					Goal 2				Goal 3				Goal 4	
								1	2	3	4	5	1	2	3	4	1	2	3	4	1	2
RESTORATION ACTIONS																						
	Nutrient Reduction																					
1	Introduce bayscapes on large lawns in the 32 neighborhoods identified	Continue outreach efforts to educate residents on bayscaping including e-mail blasts, web-based flyers, mailbox flyers, and outreach events, as appropriate	# of outreach efforts performed	2 efforts	$500 / effort	EPS, SWAP		X	X				X	X					X			
2	Work with community groups to educate about proper fertilizer use in the 5 neighborhoods identified.	Continue outreach efforts to educate residents on bayscaping including e-mail blasts, web-based flyers, mailbox flyers, and outreach events, as appropriate	# of outreach efforts performed	1 effort	$500 / effort	EPS, SWAP		X	X				X	X					X			
	Stormwater Management																					
3	Investigate the feasibility of implementing stormwater retrofits for parking lots and/or roads at the 8 institutional sites identified (0 public, 8 private)	8 potential institution sites identified	8 institutions investigated	8 investigations	Existing Staff	EPS		X	X	X									X			
4	Design and implement stormwater retrofits at feasible sites identified in Action 3	8 sites identified x 50% participation rate = 4 stormwater retrofits	50% participation x 8 retrofit sites	4 sites	$75,000 / retrofit	EPS	X	X	X	X									X			
5	Investigate in coordination with institutional partners the feasibility of reducing impervious cover at the 6 institutional sites identified (3 public, 3 private)	Maximum potential of 0.58 acres of impervious cover removal identified x 25% participation rate; Work with institutions to remove impervious cover and meet 0.14 acres reduction goal	25% participation x 0.58 acres	0.14 acres	$25,000 / acre	EPS, SWAP	X	X	X	X	X	X							X			
6	Develop and implement a downspout disconnection program. Use rain barrels, rain gardens, and/or redirection for downspout disconnection in the 3 recommended neighborhoods	4.31 acres of impervious rooftop identified x 14.25% participation rate = 0.61 acres	14.25% participation x 4.31 acres	0.61 acres	$300 / house	EPS, SWAP	X	X	X	X			X	X					X			
7	Design and implement MS4 retrofits as appropriate throughout the watershed	2916 acres of urban land use x 51% participation rate = 1487 acres	51% participation x 2916 acres	1,487 acres	$10,000 / acre	EPS, SWAP	X	X	X	X	X	X							X			
	Tree Canopy																					
8	Investigate the feasibility of planting riparian stream buffers on open pervious land (not including agricultural land)	481 acres of open pervious land identified within the 100-foot stream buffer through GIS analysis	Feasible buffer planting sites identified	481 acres	Existing Staff	EPS	X	X	X	X	X	X					X	X	X		X	
9	Reforest stream buffers at feasible sites with a minimum width of 35 feet	481 acres of open pervious stream buffer identified in the GIS analysis x 28% participation rate = 135 acres	28% participation x 481 acres	135 acres	$10,000 / acre	EPS, SWAP	X	X	X	X	X	X					X	X	X		X	
10	Encourage shade tree planting in the 10 recommended neighborhoods*	Maximum potential of 42 trees x (1 acre/100 trees) = 0.4 acres x 25% participation rate = 0.1 acres	25% participation x 0.4 acres	10 trees	$350 / tree	EPS, SWAP	X	X	X	X				X					X		X	
11	Encourage homeowners to increase lot canopy on private land in the 36 recommended neighborhoods*	Maximum potential of acres for planting (assuming goal of 40% lot canopy) = 284 acres x 5% participation rate = 14 acres (or 1421 trees)	5% participation x 284 acres	1,421 trees	$350 / tree	EPS, SWAP	X	X	X	X				X					X		X	
12	Encourage institutions to plant trees on available open space at the 13 sites identified*	Maximum potential of 1259 trees x (1 acre/100 trees) = 13 acres x 50% participation rate = 629.31 acres (or 629 trees)	50% participation x 1259 trees	629 trees	$350 / tree	EPS, SWAP	X	X	X	X				X					X		X	
13	Plant trees on the recommended PAA sites on open space*	57 acres of open pervious land identified through GIS analysis	50% participation x 57 acres	28 acres	$10,000 / acre	EPS	X	X	X	X									X		X	
14	Continue requiring riparian buffers and forest conservation for all new and re-development	On-going, keep track of existing riparian buffer and forest preserved	Acres preserved	On-going	Existing Staff	EPS		X	X	X	X	X					X	X	X		X	

	Action	Basis for Performance Measure	Performance Measure	Total Number Units to Reach 2030 Goal	Unit Cost	Respons. Party*	Applicable to Implementation Plan	Goal 1					Goal 2				Goal 3				Goal 4	
								1	2	3	4	5	1	2	3	4	1	2	3	4	1	2
15	Promote awareness of forest sustainability programs and tree planting opportunities available to landowners	Publicize forest sustainability programs and funding sources available for tree planting and reforestation on private property via e-mail blasts, web-based flyers, and outreach events, as appropriate	# of outreach efforts performed	30 efforts	$500 / effort	EPS, SWAP		X	X	X				X					X		X	
	*Acreage does not include potential area within riparian stream buffer that is already counted for in Actions 8 and 9.																					
	Trash Management																					
16	Educate for better trash management at the 2 private institutional sites identified and 16 stormwater hotspots identified	2 potential institution sites and 16 hotspots identified	Perform 1-2 site visits per year	18 sites	Existing Staff	EPS								X					X			
17	Encourage and support waterway cleanups in streams	Conduct annual stream cleanups	1 cleanup per year	15 cleanups	$1,000 / cleanup	EPS, SWAP							X	X				X	X			
	Stream Corridor Restoration																					
18	Complete stream restoration projects at feasible sites based on 0.49 miles of Very Severe, Severe, and Moderate erosion sites identified during the SCAs	Stabilize and restore 1.02 miles (5399 L.F.) of unstable streams in Cliffs Branch, Keyser Run, and Norris Run subwatersheds to provide water quality improvement x 28% participation = 1520 L.F.	28% participation x 5399 L.F.	1,520 LF	$350 / linear foot	EPS	X	X	X			X						X	X			
19	Complete stream restoration projects at feasible sites based on 0.96 miles of Very Severe, Severe, and Moderate erosion sites estimated in un-surveyed streams	Stabilize and restore 1.99 miles (10528 L.F.) of unstable streams in Cliffs Branch, Keyser Run, and Norris Run subwatersheds to provide water quality improvement x 14% participation = 1482 L.F.	14% participation x 10528 L.F.	1,482 LF	$350 / linear foot	EPS	X	X	X			X						X	X			
	Land Preservation																					
20	Work with landowners to place perpetual land preservation easements on forested and agricultural lands, seeking to preserve 80% of the Agricultural Preservation Priority Areas (County Master Plan) in accordance with State goals	Identify and assist privately-owned properties within the watershed to enroll in private and public programs available for preservation of their lands	Actively work with interested landowners to protect private properties based on financial resources and landowner participation	Ongoing	Existing Staff	DP, SCD											X	X	X		X	
21	Explore the possibility of expanding the Rural Legacy boundaries to include more of the Liberty SWAP area	Changes made to Rural Legacy boundaries to add land in the watershed	Actively work with conservancy and environmental groups to determine if there is interest in Rural Legacy expansion	Ongoing	Existing Staff	DP, EPS											X	X	X		X	
	Bacteria Reductions																					
22	Identify non-point sources of *E. Coli* through reach scale monitoring and sanitary surveys and investigate remedial actions	Based on subwatershed monitoring results, identify sources of bacteria and investigate reduction actions	Investigation completed and sources identified	Ongoing	Existing Staff	EPS				X									X			
	Chloride/Sodium Reductions																					
23	Continue monitoring chloride and sodium levels through the trend monitoring program	Continue monthly monitoring of existing monitoring sites located in the watershed	Ongoing	Ongoing	Existing Staff	EPS					X								X			
24	Investigate how to reduce salt usage on roads to decrease sodium levels	Work with SHA to identify potential alternatives to salting roadways, such as improving equipment, in extreme winter weather to reduce the dependence on salt	Alternative Salting Practices Identified	Ongoing	Existing Staff	EPS, Public Works, SHA					X								X			
	Deer Management																					
25	Coordinate with DNR to expand outreach effort to inform residents of existing DNR regulated deer management programs on public and private property	Promote awareness of DNR regulated programs to hunters, animal control businesses, and producers (farmers, arborists) and distribute educational materials to the public about the current conditions and risks of an overabundance of deer	# of outreach efforts performed	30 efforts	$500 / effort	EPS, SCD				X				X								X

	Action	Basis for Performance Measure	Performance Measure	Total Number Units to Reach 2030 Goal	Unit Cost	Respons. Party*	Applicable to Implementation Plan	Goal 1					Goal 2				Goal 3				Goal 4	
								1	2	3	4	5	1	2	3	4	1	2	3	4	1	2
26	Encourage increased deer management in coordination with DNR on public land	Explore opportunities to increase the use of DNR regulated programs to government land managers (federal, state, county, and local) and accessibility to land	Contact DNR regarding existing programs	Ongoing	Existing Staff	EPS				X												X
	Sustainable Agricultural Practices																					
27	Seek to preserve high-value agricultural land within the Liberty Reservoir watershed	Promote land conservation for high-value agricultural land	Acres preserved	Ongoing	Existing Staff	EPS, SCD								X								
28	Convene an Agricultural - TMDL workgroup	Promote coordination between the county and the agricultural community to reach TMDL goals	Establish a workgroup and meet	Within 1 year, then on-going	Existing Staff	EPS, SCD		X	X	X												
OUTREACH & AWARENESS																						
29	Assess interest in forming a local watershed association.	Reach out to local citizen's groups and community leaders about forming a Liberty Reservoir watershed association	Local groups/individuals contacted	2 meetings	Existing Staff	EPS, SWAP							X	X								
30	Distribute pollution prevention information to facilities falling within hotspot categories identified in the 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.	14 confirmed or potential hotspot sites assessed; Categories identified: transport-related, commercial, industrial, and municipal; Conduct 3 workshops and distribute outreach material	3 workshops	3 workshops	$500 / workshop	EPS, SWAP		X	X					X					X			
31	Form partnerships with community groups and discuss the BMP recommendations from the neighborhood assessments and implementation options	32 neighborhoods assessed - targeting all neighborhoods	1 neighborhood meeting	1 meetings	$500 / meeting	EPS, SWAP		X	X	X			X	X			X		X		X	
32	Form partnerships with institutions and discuss the BMP recommendations from the institutional assessments and implementation options. Include implementing/enhancing recycling programs on their properties.	13 institutions recommended	1-2 institution meetings per year	13 meetings	$500 / meeting	EPS, SWAP		X	X	X			X	X			X		X		X	
33	Develop a pet waste outreach program to address proper pet waste management in neighborhoods with waste issues	Develop a pet waste outreach program to reach neighborhoods identified for pet waste management	Develop program	Ongoing	Existing Staff	EPS				X			X	X					X			
34	Work with community groups to install storm drain markers in the 11 recommended neighborhoods	Install markers in 11 neighborhoods identified	1 neighborhood per year	11 sites	$400 / event (site)	EPS, SWAP		X	X	X			X	X					X			
35	Work with institutional sites to install storm drain markers at the 10 recommended sites 3 public, 7 private)	Install markers at 10 institutions identified	1 institutions per year	10 sites	$400 / event (site)	EPS, SWAP		X	X	X			X	X					X			
36	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)	1 tour per 10 years	2 tours	Existing Staff	EPS								X					X			
37	Continue educational outreach to inform the public on proper septic system maintenance for the estimated 2,286 septic systems in the planning area	Continue outreach efforts including e-mail blasts, web-based flyers, and outreach events, as appropriate	# of outreach efforts performed	30 efforts	$500 / effort	EPS				X				X					X			
38	Increase homeowner awareness of the proper buffer, forest, and wetland management including invasive species removal	Distribute educational materials including via e-mail blasts, web-based flyers, mailbox flyers, and outreach events, as appropriate, about proper buffer management and invasive species removal	# of outreach efforts performed	30 efforts	$500 / effort	EPS, SWAP		X	X	X		X		X					X		X	

	Action	Basis for Performance Measure	Performance Measure	Total Number Units to Reach 2030 Goal	Unit Cost	Respons. Party*	Applicable to Implementation Plan	Goal 1					Goal 2				Goal 3				Goal 4	
								1	2	3	4	5	1	2	3	4	1	2	3	4	1	2
39	Increase citizen awareness of the current road salting practices and the potential public health risk related to increased sodium in the Reservoir as outlined in the *Road Salt Recommendations to the Baltimore County Council* publication	Distribute educational materials including via e-mail blasts, web-based flyers, mailbox flyers, and outreach events, as appropriate, about current road salting practices and their implications	# of outreach efforts performed	30 efforts	$500 / effort	EPS					X			X					X		
MONITORING																						
40	Continue to monitor and remove illicit connections through the Illicit Connections Program	Inspect one major outfalls annually and the 30 minor outfalls according to their designated inspection schedule as per the NPDES permit	31 outfalls assessed	Ongoing	Existing Staff	EPS		X	X	X								X	X			
41	Expand the Stream Watch program, a citizen-based program to increase the ability to monitor/identify sources of water quality and habitat degradation	Implement a program based on number of stream miles with Very Severe or Severe erosion	3 miles of stream adopted	3 miles adopted	Existing Staff	EPS, SWAP		X	X	X			X	X					X			
42	Continue stormwater facility maintenance and inspection program	Assure continued function of Stormwater Facilities as required as part of the NPDES MS4 permit.	Continue routine inspections	Ongoing	Existing Staff	EPS		X	X	X									X			
43	Continue biological monitoring program	Biological monitoring stations in Area S are assessed in even-numbered years and a report generated	Stations monitored and report generated	Ongoing	Existing Staff	EPS													X			
44	Conduct subwatershed prioritization monitoring	Perform bacteria monitoring to identify which subwatersheds exceed water quality standards	Stations monitored and reported in the MS4 report	Ongoing	Existing Staff	EPS				X									X			
45	Perform synoptic survey within the watershed	Complete synoptic survey within the watershed	completed synoptic survey	1 survey	Existing Staff	EPS		X	X	X	X	X							X			
FUNDING																						
46	Coordinate grant funding requests to secure funding and implement restoration projects to meet TMDL nutrient reductions requirements	Seek a minimum of 1 grant per year to meet nutrient reduction goals within 20 years	1 grant proposal per year	15 proposals	Existing Staff	EPS, SWAP		X	X										X			
47	Support an increase in funding requests for environmental education in the watershed	Seek a minimum of 1 grant per year to improve environmental education within 20 years	1 grant proposal per year	15 proposals	Existing Staff	EPS		X	X	X	X	X		X					X			X
48	Support an increase in funding applications for the Maryland Department of Natural Resources Land Conservation Programs including Program Open Space, Rural Legacy, Maryland Environmental Trust, and Baltimore County	Submit a minimum of 1 application per year	1 application per year	15 applications	Existing Staff	EPS, SWAP		X	X	X	X	X					X				X	
REPORTING																						
49	Liberty Reservoir Implementation Committee will meet to discuss implementation progress and assess any changes needed to meet the goals	Conduct meetings in a semi-annual basis	2 meetings per year	30 meetings	Existing Staff	SWAP		X	X	X												
50	Develop a unified restoration tracking system to track progress toward meeting TMDL reduction requirements	Tracking system currently being developed for similar SWAPs (e.g., Back River, Jones Falls)	Tracking system developed	On-going	Existing Staff	EPS, SWAP		X	X	X												
51	Update the status of restoration projects and BMPs on an annual basis	Provide progress update in annual NPDES Report	NPDES annual report	Annual Reports	Existing Staff	EPS		X	X	X												

APPENDIX B:

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 Liberty Reservoir SWAP. Each is described below.

Cost Analysis

The cost analysis is based on the actions detailed in Appendix A. Cost estimates are summarized in Tables B-1 and B-2. Table B-1 presents cost estimates based on the maximum implementation scenario described in Chapter 3. Table B-2 presents costs estimates based on the projected participation rates (refer to Chapter 3) in nutrient and sediment loads from urban stormwater runoff. For each scenario, estimates are provided in 2014 dollars and represent total cost estimates for the anticipated implementation timeframe. Unit costs are based on a combination of local information and previous SWAPs completed for other local watersheds. BMP costs are not annualized over the implementation timeframe and do not include costs of existing staff. Costs are also presented in dollars per pound of nitrogen, phosphorus, and sediment 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 $51,340,046 for maximum implementation and $18,694,294 based on projected participation rates for 2030.

Table B-1: Maximum Estimated Costs for Liberty Reservoir SWAP Implementation

Action	Unit Cost		Max Quantity		Max Total Cost	Max TN Load Reduction (lbs / yr)	Max TP Load Reduction (lbs / yr)	Max TSS Load Reduction (lbs / yr)	Max Cost / lb of TN Removal per year	Max Cost / lb of TP Removal	Max Cost / lb of TSS Removal
SW Retrofits	$ 75,000	/ retrofit	8	retrofits	$ 600,000	45	5	7,886	$ 13,449	$ 128,487	$ 76
ISI Impervious Cover Removal	$ 25,000	/ acre	0.6	acre	$ 14,423	3	1	849	$ 4,308	$ 20,537	$ 17
NSA Downspout Disconnection	$ 300	/ house	436	houses	$ 130,938	37	4	6,608	$ 3,503	$ 33,464	$ 20
Reforest Urban Stream Buffer	$ 10,000	/ acre	481	acres	$ 4,810,824	5,738	251	201,217	$ 838	$ 19,168	$ 24
NSA Tree Plantings (Open Space)	$ 350	/ tree	42	trees	$ 14,587	4	0	67	$ 3,994	$ 135,897	$ 216
NSA Tree Plantings (Lot Canopy)	$ 350	/ tree	28,414	trees	$ 9,944,867	2,490	73	46,012	$ 3,994	$ 135,897	$ 216
ISI Tree Planting	$ 350	/ tree	1,259	trees	$ 440,520	110	3	2,038	$ 3,994	$ 135,897	$ 216
PAA Tree Planting	$ 10,000	/ acre	57	acres	$ 566,593	496	15	9,175	$ 1,141	$ 38,828	$ 62
Stream Restoration (SCA)	$ 350	/ ln ft	5,399	ln ft	$ 1,889,818	405	367	242,437	$ 4,667	$ 5,147	$ 8
Stream Restoration (Remaining Subwatersheds)	$ 350	/ ln ft	10,528	ln ft	$ 3,684,961	790	716	472,728	$ 4,667	$ 5,147	$ 8
MS4 Retrofits	$ 10,000	/ acre	2,916	acres	$ 29,164,115	9,229	539	971,817	$ 3,160	$ 54,080	$ 30
Outreach Efforts	$ 500	/ effort	93	efforts	$ 46,500	N/A	N/A	N/A	N/A	N/A	N/A
Pollution Prevention Workshops	$ 500	/ workshop	3	workshops	$ 1,500	N/A	N/A	N/A	N/A	N/A	N/A
Neighborhood BMP Meetings	$ 500	/ meeting	1	meetings	$ 500	N/A	N/A	N/A	N/A	N/A	N/A
ISI Recommendation Meetings	$ 500	/ meeting	13	meetings	$ 6,500	N/A	N/A	N/A	N/A	N/A	N/A
Storm Drain Markers	$ 400	/ site	21	sites	$ 8,400	N/A	N/A	N/A	N/A	N/A	N/A
Waterway Cleanups	$ 1,000	/ cleanup	15	cleanups	$ 15,000	N/A	N/A	N/A	N/A	N/A	N/A
				Total:	***$ 51,340,046***	***19,347***	***1,974***	***1,960,834***			

Note: 'NA" denotes not assessed in the pollutant removal analysis.

Table B-2: 2030 Projected Estimated Costs for Liberty Reservoir SWAP Implementation

Action	Unit Cost		Proj. 2030 Quantity		Proj. 2030 Total Cost	Proj. 2030 TN Load Reduction (lbs / yr)	Proj. 2030 TP Load Reduction (lbs / yr)	Proj. 2030 TSS Load Reduction (lbs / yr)	Proj. 2030 Cost / lb of TN Removal per year	Proj. 2030 Cost / lb of TP Removal per year	Proj. 2030 Cost / lb of TSS Removal per year
SW Retrofits	$ 75,000	/ retrofit	4	retrofits	$ 300,000	22	2	3,943	$ 13,449	$ 128,487	$ 76
ISI Impervious Cover Removal	$ 25,000	/ acre	0.1	acre	$ 3,500	1	0.18	212	$ 4,181	$ 19,935	$ 16
NSA Downspout Disconnection	$ 300	/ house	62	houses	$ 18,659	5	1	942	$ 3,503	$ 33,464	$ 20
Reforest Urban Stream Buffer	$ 10,000	/ acre	135	acres	$ 1,350,000	1,607	70	56,341	$ 840	$ 19,210	$ 24
NSA Tree Plantings (Open Space)	$ 350	/ tree	10	trees	$ 3,647	1	0	17	$ 3,994	$ 135,897	$ 216
NSA Tree Plantings (Lot Canopy)	$ 350	/ tree	1,421	trees	$ 497,243	124	4	2,301	$ 3,994	$ 135,897	$ 216
ISI Tree Planting	$ 350	/ tree	629	trees	$ 220,150	55	2	1,019	$ 3,992	$ 135,830	$ 216
PAA Tree Planting	$ 10,000	/ acre	28	acres	$ 283,297	248	7	4,588	$ 1,141	$ 38,828	$ 62
Stream Restoration (SCA)	$ 350	/ ln ft	1,520	ln ft	$ 532,000	114	103	68,230	$ 4,668	$ 5,148	$ 8
Stream Restoration (Remaining Subwatersheds)	$ 350	/ ln ft	1,482	ln ft	$ 518,700	111	101	66,521	$ 4,668	$ 5,149	$ 8
MS4 Retrofits	$ 10,000	/ acre	1,487	acres	$ 14,873,699	4,707	275	495,627	$ 3,160	$ 54,080	$ 30
Outreach Efforts	$ 500	/ effort	123	efforts	$ 61,500	N/A	N/A	N/A	NA	NA	NA
Pollution Prevention Workshops	$ 500	/ workshop	3	workshops	$ 1,500	N/A	N/A	N/A	NA	NA	NA
Neighborhood BMP Meetings	$ 500	/ meeting	1	meetings	$ 500	N/A	N/A	N/A	NA	NA	NA
ISI Recommendation Meetings	$ 500	/ meeting	13	meetings	$ 6,500	N/A	N/A	N/A	NA	NA	NA
Storm Drain Markers	$ 400	/ site	21	sites	$ 8,400	N/A	N/A	N/A	NA	NA	NA
Waterway Cleanups	$ 1,000	/ cleanup	15	cleanups	$ 15,000	N/A	N/A	N/A	NA	NA	NA
				Total:	***$ 18,694,294***	***6,996***	***565***	***699,739***			

Note: 'NA" denotes not assessed in the pollutant removal analysis.

Potential Funding Sources

Funding sources for the implementation of the Liberty Reservoir SWAP includes local government funding for Baltimore County and various grants as described below.

Baltimore County uses general funds to support staff, whose responsibility it 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 $6.7 million per year is allocated for various restoration projects throughout the County. 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 B-2, additional funding from grants will be required. Table B-3 presents potential funding sources to support the implementation of the Liberty Reservoir 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:*** The Trust Fund was established 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, including Maryland Department of Environment (MDE), Department of Natural Resources (DNR), Maryland Department of Agriculture (MDA), and Maryland Department of Planning (MDP).

  http://www.dnr.maryland.gov/ccs/funding/trust_fund.asp

- ***319 Non-point Pollution Grants:*** Federal money for restoration implementation is available annually through MDE.

  http://www.mde.state.md.us/programs/Water/319NonPointSource/Pages/Programs/WaterPrograms/319nps/factsheet.aspx

- ***Bay Restoration Fund (MDE):*** This is a dedicated fund, financed by wastewater treatment plant users, to upgrade Maryland's wastewater treatment plants with enhanced nutrient removal technology. In addition, a similar fee paid by septic system users is utilized to upgrade onsite systems and to pay for cover crops to reduce nitrogen loading to the Bay. Proposed modifications to the fund will allow the fund to be used for implementation of stormwater restoration projects.

  http://www.mde.state.md.us/programs/Water/BayRestorationFund/Pages/index.aspx

  Linked Deposit (MDE): The Linked Deposit mechanism was designed to provide a source of low interest financing to encourage private landowners to implement capital improvements that will reduce delivery of nutrients to the Chesapeake Bay and its tributaries, and provide safe drinking water.
  http://www.mde.state.md.us/programs/Water/QualityFinancing/LinkedDeposit/Pages/Programs/WaterPrograms/Water_Quality_Finance/link_deposit/index.aspx

- ***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.
  http://mde.maryland.gov/programs/ResearchCenter/ReportsandPublications/Pages/ResearchCenter/publications/general/emde/vol3no3/capital.aspx
- ***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 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), the U.S. Department of Agriculture Forest Service (USFS), and the National Oceanic and Atmospheric Administration (NOAA).

  http://www.nfwf.org/chesapeake/Pages/home.aspx
- ***MD State Highway Administration (SHA) Transportation Alternatives Program (TAP)*:** This is a reimbursable, federal-aid funding program for transportation-related community projects designed to strengthen the intermodal transportation system. The TAP 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 TAP categories is environmental mitigation to address water pollution due to highway runoff or to reduce vehicle-caused wildlife mortality while maintaining habitat connectivity.

  http://www.sha.maryland.gov/Index.aspx?PageId=144
- ***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.

  http://www.cbtrust.org/site/c.miJPKXPCJnH/b.5457271/k.C58E/Grants.htm

- ***Natural Resources Conservation Service:*** The US Department of Agriculture Natural Resources Conservation Service (NRCS) provides financial assistance to landowners to protect and conserve natural resources. The programs are voluntary to eligible landowners and agricultural producers. NRCS delivers conservation technical assistance through its voluntary Conservation Technical Assistance Program (CTA). CTA is available to any group or individual interested in conserving our natural resources and sustaining agricultural production in this country.

  http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/

Table B-3: Liberty Reservoir 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 for areas with 20 acres or more of plantable land	Varies	Covers tree planting costs In-Kind: Yes	None specified
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	$600,000	25% In-Kind: Yes	3 years
Chesapeake Bay Trust	Capacity Building Initiative Grant Program	Non-profits 501(c) with a board on which half the members participate meaningfully and at least one paid staff (or a part-time paid staff and volunteer)	Strengthen an organization through management operations, technology, governance, fundraising, and communications	$15,000 per year	0% In-Kind: No	3 years
Chesapeake Bay Trust	Stewardship Grant Program	Non-profits 501(c) Schools/Universities Soil/Water Conservation Districts Local Government State Government	Improve local waters that contribute to the overall health of the Chesapeake Bay, while building citizen-based resource stewardship; Restore and protect vital habitats; Improve conservation on private lands; Improve urban stormwater management	$20,000 to $200,000	25% In-Kind: ?	1 Year
Maryland Department of Natural Resources	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
Maryland Department of the Environment	Bay Restoration Fund	Local Governments	Fees from wastewater treatment plant users and septic systems users pay fee to fund upgrades to systems and implement cover crops to reduce nitrogen loading to the bay	None specified	50% In-Kind: YES	None specified

Managing Agency	Funding Source	Application Eligibility	Eligible Projects	Funding Amount	Cost Share/ In - Kind	Project Period
National Fish and Wildlife Foundation	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
National Fish and Wildlife Foundation	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% In-Kind: YES	2-3 years
Natural Resources Conservation Service	Watershed 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	Varies	None specified
United States Environmental Protection Agency	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% In-Kind: YES	2 years
United States Environmental Protection Agency	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% In-Kind: YES	3-5 years

APPENDIX C:

Pollutant Load Reduction Efficiencies

Pollutant reductions for the Liberty Reservoir watershed were estimated using available literature approved by the Chesapeake Bay Program. The following reports and tables were referenced in the Section 3.5.2 Pollutant Removal Analysis of the Liberty Reservoir SWAP and relevant portions are presented in this Appendix:

- Chesapeake Bay Program Pollutant Load Reduction Efficiencies currently used in Scenario Builder (MAST)
- Chesapeake Bay Program Approved Recommendations of the Expert Panel to Define Removal Rates for Urban Nutrient Management
- Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated (Final)
- Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated (Draft)

Non-Point Source Best Management Practices and Efficiencies currently used in Scenario Builder

Values in parentheses are in progress of official approval

Agriculture BMPs		*How Credited*	*TN Reduction Efficiency*	*TP Reduction Efficiency*	*SED Reduction Efficiency*
Nutrient Management		Landuse Change	N/A	N/A	N/A
Forest Buffers (varies by region; see Appendix 2)		Efficiency, Landuse Change	19-65%	30-45%	40-60%
Wetland Restoration (varies by region; see Appendix 2)		Efficiency	7-25%	12-50%	4-15%
Land Retirement		Landuse Change	N//A	N/A	N/A
Grass Buffers (varies by region; see Appendix 2)		Efficiency, Landuse Change	13-46%	30-45%	40-60%
Non-Urban Stream Restoration		Mass reduction/length	0.02 lb/ft	0.003 lb/ft	2 lb/ft
Tree Planting		Landuse Change	N/A	N/A	N/A
Carbon Sequestration/Alternative Crops		Landuse Change	N/A	N/A	N/A
Conservation Tillage		Landuse Change	N/A	N/A	N/A
Continuous No-Till (varies by region; see Appendix 2)		Efficiency	(10-15%)	(20-40%)	(70%)
Enhanced Nutrient Management		Efficiency	(7%)	(N/A)	(N/A)
Decision Agriculture		Efficiency	(4%)	(N/A)	(N/A)
Conservation Plans	High-till	Efficiency	8%	15%	25%
	Low-till	Efficiency	3%	5%	8%
	All hay	Efficiency	3%	5%	8%
	Pasture	Efficiency	5%	10%	14%
Cover Crops (see Appendix 1)		Efficiency	Varies	Varies	Varies
Commodity Cover Crops (see Appendix 2)		Efficiency	Varies	Varies	Varies
Stream Access Control with Fencing (see Grass Buffers)		Efficiency, Landuse Change	13-46%	30-45%	40-60%
Alternative Watering Facility		Efficiency	5%	8%	10%
Prescribed Grazing & PIRG(varies by region; see Appendix 2)		Efficiency	9-11%	24%	30%
Horse Pasture Management		Efficiency	N/A	20%	40%
Animal Waste Management Livestock		Application Reduction	75%	75%	N/A
Animal Waste Management Poultry		Application Reduction	75%	75%	N/A
Barnyard Runoff Control		Efficiency	20%	20%	40%
Loafing Lot Management		Efficiency	20%	20%	40%
Mortality Composters		Efficiency	40%	10%	N/A
Water Control Structures		Efficiency	33%	N/A	N/A
Poultry Phytase		Application Reduction	N/A	N/A	N/A
Swine Phytase		Application Reduction	N/A	N/A	N/A

Dairy Precision Feeding and Forage Management	Application Reduction	N/A	N/A	N/A
Poultry Litter Transport	Application Reduction	N/A	N/A	N/A
Ammonia Emissions Reduction (alum, biofilters, lagoon covers)	Application Reduction	15-60%	N/A	N/A
Poultry Litter Injection (interim)	Efficiency	25%	0%	0%
Liquid Manure Injection (interim)	Efficiency	25%	0%	0%
Phosphorus Sorbing Materials in Ditches (interim)	Efficiency	0%	40%	0%
Crop Irrigation management (interim)	Efficiency	4%	0%	0%
Capture Reuse Nurseries (interim)	Efficiency	75%	75%	0%
Resource BMPs	***How Credited***	***TN Reduction Efficiency***	***TP Reduction Efficiency***	***SED Reduction Efficiency***
Forest Harvesting Practices	Efficiency	50%	60%	60%
Dirt & Gravel Road Erosion & Sediment Control – Driving Surface Aggregate + Raising the Roadbed	Mass reduction/length	0	0	2.96lb/ft
Dirt & Gravel Road Erosion & Sediment Control – with outlets	Mass reduction/length	0	0	3.6lb/ft
Dirt & Gravel Road Erosion & Sediment Control – outlets only	Mass reduction/length	0	0	1.76lb/ft
Urban BMPs	***How Credited***	***TN Reduction Efficiency***	***TP Reduction Efficiency***	***SED Reduction Efficiency***
Forest Conservation	Landuse Change	N/A	N/A	N/A
Urban Growth Reduction	Landuse Change	N/A	N/A	N/A
Impervious Urban Surface Reduction	Landuse Change	N/A	N/A	N/A
Forest Buffers	Efficiency, Landuse Change	25%	50%	50%
Tree Planting	Landuse Change	N/A	N/A	N/A
Abandoned Mine Reclamation	Landuse Change	N/A	N/A	N/A
Wet Ponds and Wetlands	Efficiency	20%	45%	60%
Dry Detention Ponds and Hydrodynamic Structures	Efficiency	5%	10%	10%
Dry Extended Detention Ponds	Efficiency	20%	20%	60%
Infiltration Practices w/o Sand, Veg.	Efficiency	80%	85%	95%
Infiltration Practices w/ Sand, Veg.	Efficiency	85%	85%	95%
Filtering Practices	Efficiency	40%	60%	80%
Erosion and Sediment Control	Efficiency	25%	40%	40%
Nutrient Management	Efficiency	17%	22%	N/A
Street Sweeping	Efficiency	3%	3%	9%
Urban Stream Restoration	Load reduction/length	0.02lb/ft	0.003lb/ft	2lb/ft

Septic Connections		Systems Change	N/A	N/A	N/A
Septic Denitrification		Efficiency	50%	N/A	N/A
Septic Pumping		Efficiency	5%	N/A	N/A
Bioretention	C/D soils, underdrain	Efficiency	25%	45%	55%
	A/B soils, underdrain	Efficiency	70%	75%	80%
	A/B soils, no underdrain	Efficiency	80%	85%	90%
Vegetated Open Channels	C/D soils, no underdrain	Efficiency	10%	10%	50%
	A/B soils, no underdrain	Efficiency	45%	45%	70%
Bioswale		Efficiency	70%	75%	80%
Permeable Pavement w/o Sand, Veg.	C/D soils, underdrain	Efficiency	10%	20%	55%
	A/B soils, underdrain	Efficiency	45%	50%	70%
	A/B soils, no underdrain	Efficiency	75%	80%	85%
Permeable Pavement w/ Sand, Veg.	C/D soils, underdrain	Efficiency	20%	20%	55%
	A/B soils, underdrain	Efficiency	50%	50%	70%
	A/B soils, no underdrain	Efficiency	80%	80%	85%

Appendix 2 **BMPs**	**Hydrogeomorphic Region(s)**	***TN Reduction Efficiency***	***TP Reduction Efficiency***	***SED Reduction Efficiency***
Forest Buffers	Appalachian Plateau Siliciclastic Non-Tidal; Appalachian Plateau Carbonate Non-Tidal	54%	42%	56%
	Blue Ridge Non-Tidal; Mesozoic Lowlands Non-Tidal; Valley and Ridge Carbonate Non-Tidal	34%	30%	40%
	Coastal Plain Dissected Uplands Non-Tidal	65%	42%	56%
	Coastal Plain Dissected Uplands Tidal; Coastal Plain Lowlands Tidal; Coastal Plain Uplands Tidal; Piedmont Crystalline Tidal	19%	45%	60%
	Coastal Plain Lowlands Non-Tidal	56%	39%	52%
	Piedmont Crystalline Non-Tidal	56%	42%	56%
	Coastal Plain Uplands Non-Tidal	31%	45%	60%
	Piedmont Carbonate Non-Tidal	46%	36%	48%
	Valley and Ridge Siliciclastic Non-Tidal	46%	39%	52%
Grass Buffers	Appalachian Plateau Siliciclastic Non-Tidal; Appalachian Plateau Carbonate Non-Tidal	38%	42%	56%
	Blue Ridge Non-Tidal; Mesozoic Lowlands Non-Tidal; Valley and Ridge Carbonate Non-Tidal	24%	30%	40%

	Coastal Plain Dissected Uplands Non-Tidal	46%	42%	56%
	Coastal Plain Dissected Uplands Tidal; Coastal Plain Lowlands Tidal; Coastal Plain Uplands Tidal; Piedmont Crystalline Tidal	13%	45%	60%
	Coastal Plain Lowlands Non-Tidal	39%	39%	52%
	Piedmont Crystalline Non-Tidal	39%	42%	56%
	Coastal Plain Uplands Non-Tidal	21%	45%	60%
	Piedmont Carbonate Non-Tidal	32%	36%	48%
	Valley and Ridge Siliciclastic Non-Tidal	32%	39%	52%
Prescribed Grazing & PIRG	Coastal Plain Dissected Uplands Non-Tidal; Appalachian Plateau Carbonate Non-Tidal; Coastal Plain Dissected Uplands Tidal; Coastal Plain Lowlands Tidal; Coastal Plain Uplands Tidal; Coastal Plain Lowlands Non-Tidal; Coastal Plain Uplands Non-Tidal; Valley and Ridge Carbonate Non-Tidal; Piedmont Carbonate Non-Tidal	9%	24%	30%
	Appalachian Plateau Siliciclastic Non-Tidal; Blue Ridge Non-Tidal; Mesozoic Lowlands Non-Tidal; Piedmont Crystalline Tidal; Piedmont Crystalline Non-Tidal; Valley and Ridge Siliciclastic Non-Tidal	11%	24%	30%
Wetland Restoration (Ag & Urban)	Appalachian Plateau Siliciclastic Non-Tidal ; Appalachian Plateau Carbonate Non-Tidal	7%	12%	4%
	Coastal Plain Dissected Uplands Non-Tidal; Coastal Plain Dissected Uplands Tidal; Coastal Plain Lowlands Tidal; Coastal Plain Uplands Tidal; Coastal Plain Lowlands Non-Tidal; Coastal Plain Uplands Non-Tidal	25%	50%	15%
	Blue Ridge Non-Tidal; Mesozoic Lowlands Non-Tidal; Valley and Ridge Carbonate Non-Tidal; Piedmont Crystalline Tidal; Piedmont Crystalline Non-Tidal; Piedmont Carbonate Non-Tidal; Valley and Ridge Siliciclastic Non-Tidal	14%	26%	8%
Continuous No-till	Coastal Plain Dissected Uplands Non-Tidal; Coastal Plain Dissected Uplands Tidal; Coastal Plain Lowlands Tidal; Coastal Plain Uplands Tidal; Coastal Plain Lowlands Non-Tidal; Coastal Plain Uplands Non-Tidal	10%	20%	70%
	Appalachian Plateau Siliciclastic Non-Tidal; Appalachian Plateau Carbonate Non-Tidal; Blue Ridge Non-Tidal; Mesozoic Lowlands Non-Tidal; Valley and Ridge Carbonate Non-Tidal; Piedmont Crystalline Tidal; Piedmont Crystalline Non-Tidal; Piedmont Carbonate Non-Tidal; Valley and Ridge Siliciclastic Non-Tidal	15%	40%	70%
Cover Crop Early Drilled Rye (Low-till gets only TN efficiency)	Coastal Plain/Piedmont Crystalline/Karst Settings*	45%	15%	20%
	Mesozoic Lowlands/Valley and Ridge Siliciclastic**	34%	15%	20%

Cover Crop Early Other Rye (Low-till gets only TN efficiency)	Coastal Plain/Piedmont Crystalline/Karst Settings*	38%	15%	20%
	Mesozoic Lowlands/Valley and Ridge Siliciclastic**	29%	15%	20%
Cover Crop Early Aerial Soy Rye (Low-till gets only TN efficiency)	Coastal Plain/Piedmont Crystalline/Karst Settings*	31%	15%	20%
	Mesozoic Lowlands/Valley and Ridge Siliciclastic**	24%	15%	20%
Cover Crop Early Aerial Corn Rye (Low-till gets only TN efficiency)	Coastal Plain/Piedmont Crystalline/Karst Settings*	18%	15%	20%
	Mesozoic Lowlands/Valley and Ridge Siliciclastic**	14%	15%	20%
Cover Crop Standard Drilled Rye (Low-till gets only TN efficiency)	Coastal Plain/Piedmont Crystalline/Karst Settings*	41%	7%	10%
	Mesozoic Lowlands/Valley and Ridge Siliciclastic**	31%	7%	10%
Cover Crop Standard Other Rye (Low-till gets only TN efficiency)	Coastal Plain/Piedmont Crystalline/Karst Settings*	35%	7%	10%
	Mesozoic Lowlands/Valley and Ridge Siliciclastic**	27%	7%	10%
Cover Crop Late Drilled Rye (Low-till gets only TN efficiency)	Coastal Plain/Piedmont Crystalline/Karst Settings*	19%	N/A	N/A
	Mesozoic Lowlands/Valley and Ridge Siliciclastic**	15%	N/A	N/A
Cover Crop Late Other Rye (Low-till gets only TN efficiency)	Coastal Plain/Piedmont Crystalline/Karst Settings*	16%	N/A	N/A
	Mesozoic Lowlands/Valley and Ridge Siliciclastic**	12%	N/A	N/A
Cover Crop Early Drilled Wheat (Low-till gets only TN efficiency)	Coastal Plain/Piedmont Crystalline/Karst Settings*	31%	15%	20%
	Mesozoic Lowlands/Valley and Ridge Siliciclastic**	24%	15%	20%
Cover Crop Early Other Wheat (Low-till gets only TN efficiency)	Coastal Plain/Piedmont Crystalline/Karst Settings*	27%	15%	20%
	Mesozoic Lowlands/Valley and Ridge Siliciclastic**	20%	15%	20%

Cover Crop Early Aerial Soy Wheat (Low-till gets only TN efficiency)	Coastal Plain/Piedmont Crystalline/Karst Settings*	22%	15%	20%
	Mesozoic Lowlands/Valley and Ridge Siliciclastic**	17%	15%	20%
Cover Crop Early Aerial Corn Wheat (Low-till gets only TN efficiency)	Coastal Plain/Piedmont Crystalline/Karst Settings*	12%	15%	20%
	Mesozoic Lowlands/Valley and Ridge Siliciclastic**	10%	15%	20%
Cover Crop Standard Drilled Wheat (Low-till gets only TN efficiency)	Coastal Plain/Piedmont Crystalline/Karst Settings*	29%	7%	10%
	Mesozoic Lowlands/Valley and Ridge Siliciclastic**	22%	7%	10%
Cover Crop Standard Other Wheat (Low-till gets only TN efficiency)	Coastal Plain/Piedmont Crystalline/Karst Settings*	24%	7%	10%
	Mesozoic Lowlands/Valley and Ridge Siliciclastic**	19%	7%	10%
Cover Crop Late Drilled Wheat (Low-till gets only TN efficiency)	Coastal Plain/Piedmont Crystalline/Karst Settings*	13%	N/A	N/A
	Mesozoic Lowlands/Valley and Ridge Siliciclastic**	10%	N/A	N/A
Cover Crop Late Other Wheat (Low-till gets only TN efficiency)	Coastal Plain/Piedmont Crystalline/Karst Settings*	11%	N/A	N/A
	Mesozoic Lowlands/Valley and Ridge Siliciclastic**	9%	N/A	N/A
Cover Crop Early Drilled Barley (Low-till gets only TN efficiency)	Coastal Plain/Piedmont Crystalline/Karst Settings*	38%	20%	20%
	Mesozoic Lowlands/Valley and Ridge Siliciclastic**	29%	20%	20%
Cover Crop Early Other Barley (Low-till gets only TN efficiency)	Coastal Plain/Piedmont Crystalline/Karst Settings*	32%	15%	20%
	Mesozoic Lowlands/Valley and Ridge Siliciclastic**	25%	15%	20%
Cover Crop Early Aerial Soy	Coastal Plain/Piedmont Crystalline/Karst Settings*	27%	15%	20%

Barley (Low-till gets only TN efficiency)	Mesozoic Lowlands/Valley and Ridge Siliciclastic**	20%	15%	20%
Cover Crop Early Aerial Corn Barley (Low-till gets only TN efficiency)	Coastal Plain/Piedmont Crystalline/Karst Settings*	15%	15%	20%
	Mesozoic Lowlands/Valley and Ridge Siliciclastic**	12%	15%	20%
Cover Crop Standard Drilled Barley (Low-till gets only TN efficiency)	Coastal Plain/Piedmont Crystalline/Karst Settings*	29%	7%	10%
	Mesozoic Lowlands/Valley and Ridge Siliciclastic**	22%	7%	10%
Cover Crop Standard Other Barley (Low-till gets only TN efficiency)	Coastal Plain/Piedmont Crystalline/Karst Settings*	24%	7%	10%
	Mesozoic Lowlands/Valley and Ridge Siliciclastic**	19%	7%	10%
Commodity Cover Crop Early Drill Wheat	Coastal Plain/Piedmont Crystalline/Karst Settings*	17%	(N/A)	(N/A)
	Mesozoic Lowlands/Valley and Ridge Siliciclastic**	13%	(N/A)	(N/A)
Commodity Cover Crop Early Other Wheat	Coastal Plain/Piedmont Crystalline/Karst Settings*	15%	(N/A)	(N/A)
	Mesozoic Lowlands/Valley and Ridge Siliciclastic**	11%	(N/A)	(N/A)
Commodity Cover Crop Early Aerial Soy Wheat	Coastal Plain/Piedmont Crystalline/Karst Settings*	15%	(N/A)	(N/A)
	Mesozoic Lowlands/Valley and Ridge Siliciclastic**	12%	(N/A)	(N/A)
Commodity Cover Crop Early Aerial Corn Wheat	Coastal Plain/Piedmont Crystalline/Karst Settings*	7%	(N/A)	(N/A)
	Mesozoic Lowlands/Valley and Ridge Siliciclastic**	6%	(N/A)	(N/A)
Commodity Cover Crop Standard Drill Wheat	Coastal Plain/Piedmont Crystalline/Karst Settings*	15%	(N/A)	(N/A)
	Mesozoic Lowlands/Valley and Ridge Siliciclastic**	11%	(N/A)	(N/A)
Commodity Cover Crop	Coastal Plain/Piedmont Crystalline/Karst Settings*	12%	(N/A)	(N/A)

Standard Other Wheat	Mesozoic Lowlands/Valley and Ridge Siliciclastic**	9%	(N/A)	(N/A)
Commodity Cover Crop Late Drill Wheat	Coastal Plain/Piedmont Crystalline/Karst Settings*	7%	(N/A)	(N/A)
	Mesozoic Lowlands/Valley and Ridge Siliciclastic**	6%	(N/A)	(N/A)
Commodity Cover Crop Late Other Wheat	Coastal Plain/Piedmont Crystalline/Karst Settings*	13%	(N/A)	(N/A)
	Mesozoic Lowlands/Valley and Ridge Siliciclastic**	11%	(N/A)	(N/A)
Commodity Cover Crop Early Drill Barley	Coastal Plain/Piedmont Crystalline/Karst Settings*	9%	(N/A)	(N/A)
	Mesozoic Lowlands/Valley and Ridge Siliciclastic**	6%	(N/A)	(N/A)
Commodity Cover Crop Early Aerial Soy Barley	Coastal Plain/Piedmont Crystalline/Karst Settings*	6%	(N/A)	(N/A)
	Mesozoic Lowlands/Valley and Ridge Siliciclastic**	5%	(N/A)	(N/A)
Commodity Cover Crop Early Aerial Corn Barley	Coastal Plain/Piedmont Crystalline/Karst Settings*	13%	(N/A)	(N/A)
	Mesozoic Lowlands/Valley and Ridge Siliciclastic**	11%	(N/A)	(N/A)
Commodity Cover Crop Standard Drill Barley	Coastal Plain/Piedmont Crystalline/Karst Settings*	15%	(N/A)	(N/A)
	Mesozoic Lowlands/Valley and Ridge Siliciclastic**	11%	(N/A)	(N/A)
Commodity Cover Crop Standard Other Barley	Coastal Plain/Piedmont Crystalline/Karst Settings*	12%	(N/A)	(N/A)
	Mesozoic Lowlands/Valley and Ridge Siliciclastic**	10%	(N/A)	(N/A)
Commodity Cover Crop Standard Other Rye	Coastal Plain/Piedmont Crystalline/Karst Settings*	18%	(N/A)	(N/A)
	Mesozoic Lowlands/Valley and Ridge Siliciclastic**	14%	(N/A)	(N/A)
Commodity Cover Crop Early Other Rye	Coastal Plain/Piedmont Crystalline/Karst Settings*	21%	(N/A)	(N/A)
	Mesozoic Lowlands/Valley and Ridge Siliciclastic**	16%	(N/A)	(N/A)

Commodity Cover Crop Early Other Barley	Coastal Plain/Piedmont Crystalline/Karst Settings*	15%	(N/A)	(N/A)
	Mesozoic Lowlands/Valley and Ridge Siliciclastic**	11%	(N/A)	(N/A)

* Appalachian Plateau Carbonate Non-Tidal; Coastal Plain Dissected Uplands Non-Tidal; Coastal Plain Dissected Uplands Tidal; Coastal Plain Lowlands Tidal; Coastal Plain Uplands Tidal; Coastal Plain Lowlands Non-Tidal; Coastal Plain Uplands Non-Tidal; Valley and Ridge Carbonate Non-Tidal; Piedmont Crystalline Non-Tidal; Piedmont Carbonate Non-Tidal

** Appalachian Plateau Siliciclastic Non-Tidal; Mesozoic Lowlands Non-Tidal; Piedmont Crystalline Tidal; Valley and Ridge Siliciclastic Non-Tidal; Blue Ridge Non-Tidal

Recommendations of the Expert Panel to Define Removal Rates for Urban Nutrient Management

CBP APPROVED FINAL REPORT

Marc Aveni, Karl Berger, Jonathan Champion, Gary Felton, Mike Goatley, William Keeling, Neely Law and Stuart Schwartz

Approved by Urban Stormwater Work Group: 2/9/2013
Approved by Watershed Technical Work Group: 3/4/2013
Approved by Water Quality Goal Implementation Team: 3/11/2013

Prepared by:
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Appendix A Mass Balance Check on UNM Rates
Appendix B Nutrient Management on Public Lands: A Review
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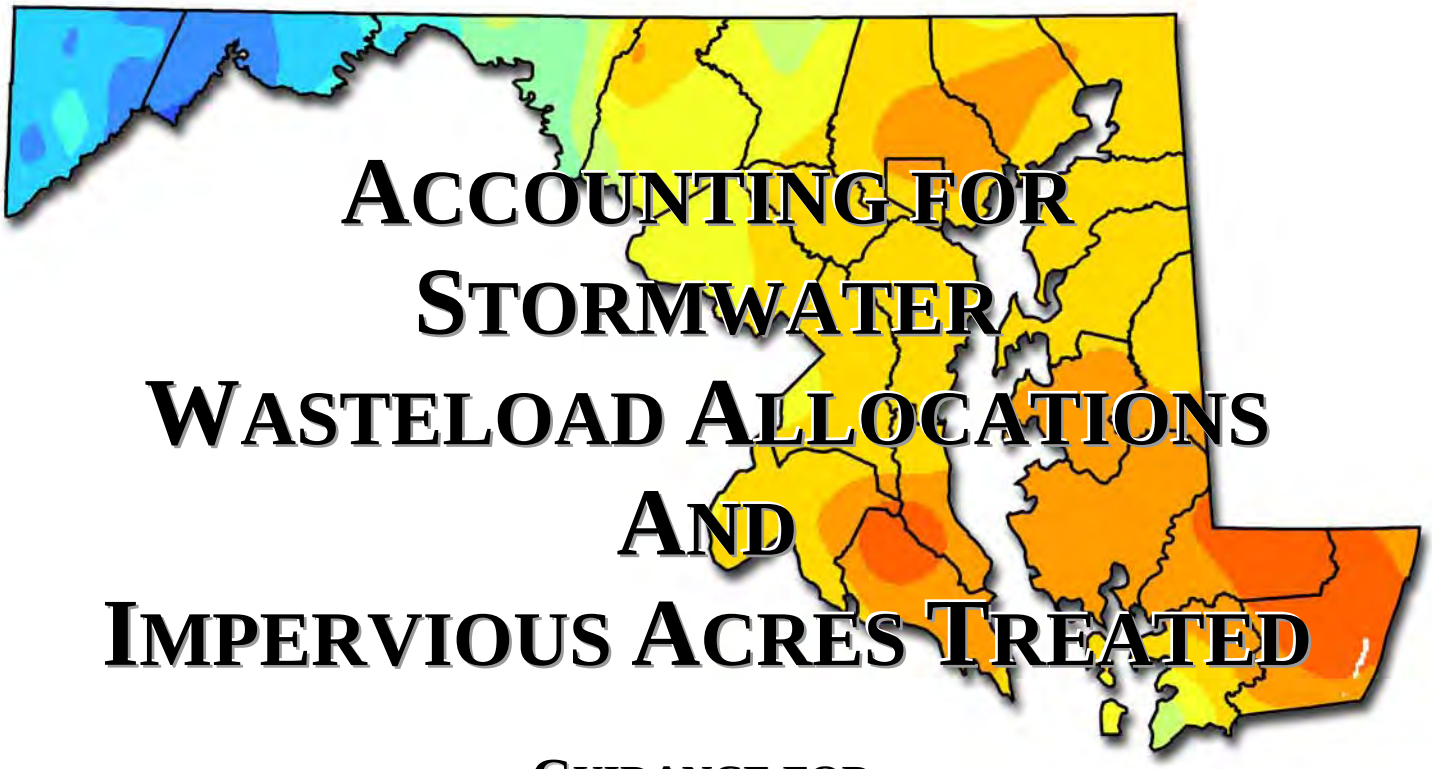
List of common acronyms used throughout the text:

BMP	Best Management Practice
CAST	Chesapeake Assessment Scenario Tool
CBP	Chesapeake Bay Program
CBWM	Chesapeake Bay Watershed Model
DIY	Do it Yourself
GIS	Geographic Information Systems
HOA	Homeowner Association
MS4	Municipal Separate Storm Sewer System
Rv	Runoff Coefficient
RT VM	Reporting, Tracking, Verification and Monitoring
Sf	Square feet
SRP	Soluble Reactive Phosphorus
TMDL	Total Maximum Daily Load
TN or N	Total Nitrogen
TP or P	Total Phosphorus
TSS	Total Suspended Solids
UNM	Urban Nutrient Management
WIN	Water Insoluble Nitrogen
WIP	Watershed Implementation Plan
WQGIT	Water Quality Goal Implementation Team
WTM	Watershed Treatment Model

Summary of Urban Fertilizer Management Credits for Phosphorus and Nitrogen			
Nutrient	*Statewide with P fertilizer legislation*	*Statewide without P fertilizer legislation*	*Urban Nutrient Management UNM*[2]
Phosphorus	25%	20%	Low risk: 3% High risk: 10% Blended: 4.5%
Notes & Conditions of Credit	Effective 2013 for 3 years. In 2016 , need to show reduction in P using two years of fertilizer sales data		Need to survey high-risk every 5 years; Renew UNM every 3 years
Nitrogen	For States with N fertilizer legislation: 9% reduction for qualifying acres by commercial applicators, 4.5% reduction for do-it-yourselfer acres For all other States: 3% load reduction for every 10% decrease in N urban fertilizer input from CBWM benchmark		Low risk: 6% High risk: 20% Blended: 9%
Notes & Conditions of Credit	Effective 2014, need to show N reduction using two consecutive years sales data		Need to survey high-risk every 5 years; Renew UNM every 3 years

The Panel developed methods for reporting, tracking and verifying the credits to ensure the UNM practices achieve their intended pollutant reduction. The Panel acknowledged that there are still many unknowns when it comes to the UNM practice, and adopted an adaptive management approach as it developed its recommendations.

The Panel also recommended improvements to the CBWM model and priority research projects that could improve confidence in its representation of UNM. Lastly, the Panel recommended several ways to improve Bay-wide communication of the UNM message, and improve the capacity to deliver UNM practices to meet the future demand for this practice.



ACCOUNTING FOR STORMWATER WASTELOAD ALLOCATIONS AND IMPERVIOUS ACRES TREATED

GUIDANCE FOR NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM STORMWATER PERMITS

JUNE (DRAFT) 2011

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localities to demonstrate how the 20% impervious cover restoration requirement is being met and also to prevent the double reporting of structural BMPs. Additionally, local governments shall use the previously calculated baseline pollutant loads, BMP implementation rates, and the efficiencies provided in Table 4 to show progress toward meeting NPDES stormwater WLAs.

Table 4. Structural BMP Retrofit Matrix

BMP Practice	TN	TP	TSS
CBP Structural BMPs			
Dry Detention Ponds	5%	10%	10%
Hydrodynamic Structures	5%	10%	10%
Dry Extended Detention Ponds	20%	20%	60%
Wet Ponds and Wetlands	20%	45%	60%
Infiltration Practices	80%	85%	95%
Filtering Practices	40%	60%	80%
Vegetated Open Channels	45%	45%	70%
Erosion and Sediment Control	25%	40%	40%
Stormwater Management by Era			
Development Between 1985 - 2002	17%	30%	40%
Urban BMP Retrofit	25%	35%	65%
Development Between 2002 and 2010	30%	40%	80%
Development After 2010	50%	60%	90%
ESD to the MEP from the *Manual*			
Green Roofs	50%	60%	90%
Permeable Pavements	50%	60%	90%
Reinforced Turf	50%	60%	90%
Disconnection of Rooftop Runoff	50%	60%	90%
Disconnection of Non-Rooftop Runoff	50%	60%	90%
Sheetflow to Conservation Areas	50%	60%	90%
Rainwater Harvesting	50%	60%	90%
Submerged Gravel Wetlands	50%	60%	90%
Landscape Infiltration	50%	60%	90%
Infiltration Berms	50%	60%	90%
Dry Wells	50%	60%	90%
Micro-Bioretention	50%	60%	90%
Rain Gardens	50%	60%	90%
Grass, Wet, or Bio-Swale	50%	60%	90%
Enhanced Filters	50%	60%	90%
Additional Structural BMP Guidance			
Redevelopment (MDE)	50%	60%	90%
Existing Roadway Disconnect (MDE)	50%	60%	90%
Step Pool Storm Conveyance (MDE)	50%	60%	90%

(Adapted from CBP Urban BMP Efficiencies, and Stormwater Management by Era, MDE 2009)

Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated

Guidance for National Pollutant Discharge Elimination System Stormwater Permits

August 2014

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Table 3.E. Alternative Urban BMPs

	Notes	Efficiency Per Acre			Impervious Acre Equivalent
		TN	TP	TSS	
Mechanical Street Sweeping	High density urban areas where sweeping occurs 2x/month	4%	4%	10%	0.07
Regen/Vacuum Street Sweeping	High density urban areas where sweeping occurs 2x/month	5%	6%	25%	0.13
Reforestation on Pervious Urban	Survival rate of 100 trees/acre or greater; at least 50% of trees have two inch diameter or greater (4.5 ft. above ground)	66%	77%	57%	0.38
Impervious Urban to Pervious	Remove pavement and provide vegetative cover for 95% of area	13%	72%	84%	0.75
Impervious Urban to Forest	Survival rate of 100 trees/acre or greater; at least 50% of trees have two inch diameter or greater (4.5 ft. above ground)	71%	94%	93%	1.00
Regenerative Step Pool Storm Conveyance (SPSC)[1]	Located in dry or ephemeral channels; nutrient removal and impervious area credit is based on runoff depth treated	57%	66%	70%	1.00
		Lbs Reduced / Ton			Impervious Acre Equivalent
		TN	TP	TSS	
Catch Basin Cleaning	High density urban areas; storm drains are routinely maintained	3.5	1.4	420	0.40
Storm Drain Vacuuming	High density urban areas; storm drains are routinely maintained	3.5	1.4	420	0.40
Mechanical Street Sweeping	High density urban areas where sweeping occurs 2x/month	3.5	1.4	420	0.40
Regen/Vacuum Street Sweeping	High density urban areas where sweeping occurs 2x/month	3.5	1.4	420	0.40
		Lbs Reduced / Linear Ft			Impervious Acre Equivalent
		TN	TP	TSS	
Stream Restoration: load reductions for interim rate[2]	Schueler and Stack (2014) specify qualifying conditions and protocols to calculate individual load reductions per project	0.075	0.068	15/45	0.01
Outfall Stabilization	Stabilization or repair of localized areas of erosion below a storm drain outfall; max credit is 2 acres per project	n/a	n/a	n/a	0.01
Shoreline Management [3]	Revised protocols are pending CBP approval	0.075	0.068	137	0.04
		Lbs Reduced / Unit			Impervious Acre Equivalent
		TN	TP	TSS	
Septic Pumping	Pumping system is maintained and verified for annual credit	0[4]	0	0	0.03
Septic Denitrification	Permanent credit for installing enhanced septic denitrification	0[4]	0	0	0.26
Septic Connections to WWTP	Permanent credit for septic system connected to a WWTP	0[4]	0	0	0.39

1. Efficiencies and impervious acre equivalents shown are based on treating 1 inch of rainfall. When less than 1 inch of rainfall is treated, then refer to Table 2 for impervious acre equivalent and Table 6 for nutrient and sediment removal efficiencies.
2. Load reductions are based on current proposal under consideration by CBP. TSS is based on coastal plain and non-coastal plain applications. (Refer to Appendix E, Stream Restoration).
3. Load reductions are based on current proposal under consideration by CBP based on Drescher and Stack (2014). (Refer to Appendix E, Shoreline Management).
4. Actual load reductions shall be reported through local health department. Septic system credits only apply to impervious acre requirements.

6. Stream Restoration

a. **Impervious Area Equivalent**: The impervious area equivalent for stream restoration was originally developed using the Spring Branch efficiency data (approved by the CBP in 2003). Using the method described in Appendix D, MDE calculated an impervious acre credit of 0.01 acres per linear foot of restoration (noted in Table 7). MDE believes that this is a fair credit, as stream restoration should not be considered a substitute for providing adequate attenuation of untreated impervious area in the upland. Therefore, the impervious acre credit of 1.0 acre per 100 linear feet of stream channel will remain.

   Outfall stabilization typically entails the repair of localized areas of erosion below a storm drain pipe and often involves exposed infrastructure. Most outfall stabilization activities do not fit the qualifying conditions of a stream restoration project (as noted in Appendix F) because there are insufficient data available to provide allowable nutrient and sediment removal rates. However, MDE will allow these projects to take credit toward impervious area restoration according to the credit of 1 acre per 100 linear feet of the project. The maximum credit granted for these projects is 2 acres.

b. **New Pollutant Load Reduction Efficiencies**: New pollutant removal credits for stream restoration are described in the CBP approved document "Recommendations of the Expert Panel to Define Removal Rates for Individual Stream Restoration Projects" (Schueler and Stack, 2014). This report describes four protocols for defining pollutant load reductions for stream restoration projects. The protocols allow individual project credit toward nutrient and sediment removal through the use of field data and specific calculations. This replaces the former policy of accepting a universal removal rate for all stream restoration projects.

   MDE recommends that the procedures outlined in Schueler and Stack (2014) should be followed for calculating nutrient and sediment load reductions for individual projects. However, MS4 jurisdictions may propose an alternative approach for calculating credit under the protocols. Any MS4 jurisdiction interested in pursuing alternative monitoring or technical procedures to calculate credit under each of the protocols should submit a formal proposal for MDE review and comment.

   Schueler and Stack (2014) provide a literature review, references, and the scientific basis behind the protocols. The design examples provided in the report shall be referenced by all MS4 jurisdictions in order to calculate nutrient and sediment removal credits for individual projects.

c. **Using the Revised Interim Rate for Current Projects and Planning**: In the past, the CBP had approved a universal removal rate for stream restoration based on the Spring Branch studies (Baltimore County Department of Environmental Protection and Sustainability, 2008). This allowed jurisdictions to use a simple calculation to determine nutrient load reductions for any stream restoration project. Schueler and Stack (2014) may be referenced for a historic overview of the universal stream restoration rate and a discussion involving recent revisions. Table E.4 provides the "revised interim rate" which is scheduled for final voting by the CBP WQGIT on August 11, 2014. After the final voting by CBP, MDE will advise MS4 jurisdictions on the status of the approval.

Table E.4 Stream Restoration Revised Interim Removal Rates per Linear Foot (lb/ft/yr)				
Source	**TN**	**TP**	**TSS[1]**	
			Coastal Plain	Non-Coastal Plain
Revised Interim Rate	0.075	0.068	15.1	44.9

[1] The TSS removal rates are based on whether a project is located in the coastal plain or non-coastal plain. Schueler and Stack (2014) provides a discussion of the TSS removal rate and application of a sediment delivery ratio based on the location of the project. The TSS removal rates shown above were derived by multiplying 248 lb/ft/yr by the average CBWM (version 5.3.2) sediment delivery ratio for projects located in the coastal plain (0.061) and non-coastal plain (0.181).

The revised interim removal rates may be used by local programs for assessing stormwater WLA credit for stream restoration under certain conditions. Some projects may be too far along in the design and planning process to undergo the full evaluation using the procedures outlined in Schueler and Stack (2014). MDE supports allowing projects to proceed without delay (provided that they satisfy all regulatory requirements) and will allow the revised interim rate in Table E.4 to be used for calculating stormwater WLA credit for new stream restoration projects through the end of 2015. MS4 jurisdictions may also use removal rates in Table E.4 to quickly estimate load reductions during the planning phase for future projects. The revised interim rate may also be used for historic projects that meet all of the qualifying conditions described in Schueler and Stack (2014).

After 2015, site specific data must be used to calculate credit according to the protocols outlined in Schueler and Stack (2014). Use of the interim rate in combination with the protocols is not allowed. The interim rate may only be used after 2015 based on exceptional circumstances when compiling the data needed for the protocols may not be practical in order to keep project implementation on schedule. However, the long term use of the interim rate will be limited.

d. Regulatory Authorization of Projects: Page 5 of Schueler and Stack (2014) provides the following disclaimer: "The Panel recognizes that stream restoration projects as defined in this report may be subject to authorization and associated requirements from federal, State, and local agencies. The recommendations in this report are not intended to supersede any other requirements or standards mandated by other government authorities. Consequently, some stream restoration projects may conflict with other regulatory requirements and may not be suitable or authorized in certain locations."

Each State has a regulatory process to address any activity that may result in stream, wetland, floodplain or waterway impacts. MDE's review process evaluates each project on a case by case basis for impacts associated with flooding, adjacent property owners, impacts to high functioning portions of the stream and wetland/floodplain ecosystem, and other regulatory considerations. Stream restoration efforts should focus on areas of severe degradation and demonstrate potential benefits to the stream ecosystem.

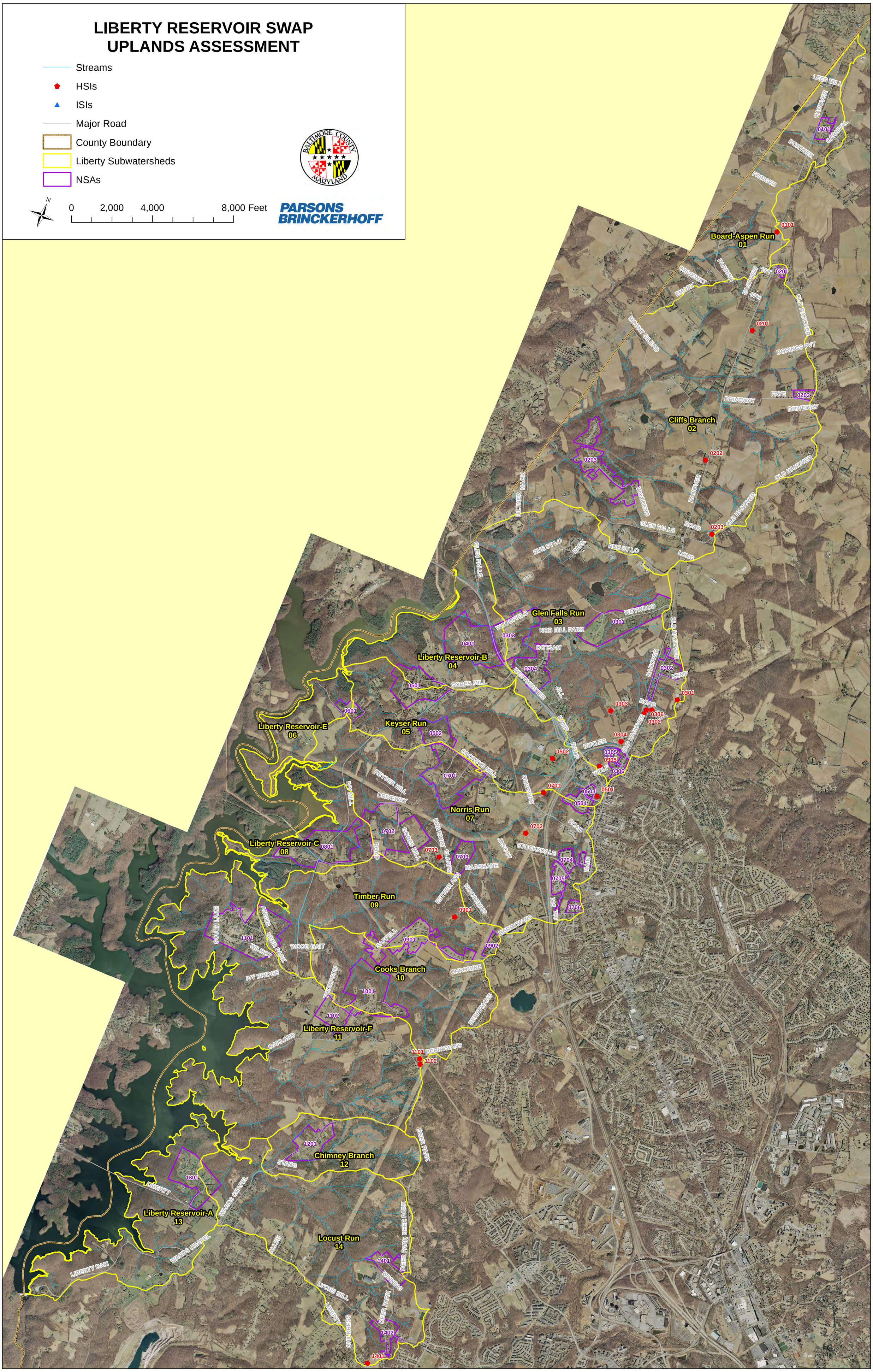
APPENDIX D:

Liberty Reservoir SWAP Uplands Assessment Map

LIBERTY RESERVOIR SWAP UPLANDS ASSESSMENT

Streams
HSIs
ISIs
Major Road
County Boundary
Liberty Subwatersheds
NSAs

N

0 2,000 4,000 8,000 Feet

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