Baltimore Harbor
Carroll County, Maryland
Interim Restoration Plan

2019

Prepared by
Carroll County Government Bureau of Resource Management

MDE Approved: May 2020

Forward

This document summarizes proposed and potential restoration strategies to meet local Total Maximum Daily Load (TMDL) requirements associated with the urban wasteload allocation (WLA) for the Baltimore Harbor Watershed. This document is an ongoing, iterative process that will be updated as needed to track implementation of structural and nonstructural projects, alternative Best Management Practices (BMP's), and any program enhancements that assist in meeting Environmental Protection Agency (EPA) approved TMDL stormwater WLAs. Updates will evaluate the success of Carroll County's watershed restoration efforts and document progress towards meeting approved stormwater WLAs. Some of the strategies presented in this document are considered "potential" and additional assessment will be required before any project is considered final or approved.

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I. Introduction

Baltimore Harbor (basin number 02130903) was identified on the State's 1996 list of water quality limited segments (WQLSs) submitted to the U.S. EPA by the Maryland Department of the Environment (MDE) as impaired by nutrients. The Baltimore Harbor has also been identified on the 303(d) list as impaired by bacteria (fecal coliform) (1998), toxics (polychlorinated biphenyls, or PCBs) (1998), metals (chromium, zinc and lead) (1998), suspended sediments (1996), and impacts to biological communities (2004). This document will address the water quality impairments associated with excess nutrient loadings.

The Bureau of Resource Management (BRM), in part to fulfill the County's regulatory requirements as designated through the National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) permit has initiated watershed restoration planning to address the developed and approved watershed TMDL Wasteload Allocations (WLA) within the Baltimore Harbor basin of Carroll County (Figure1). Additional stakeholders in this planning process include the Towns of Sykesville and Mount Airy, and the Patapsco Chapter of Trout Unlimited.

A. Purpose and Scope

This document presents restoration strategies that are proposed to meet watershed-specific water quality standards, associated TMDL WLAs for developed source types for Carroll County. This Watershed Restoration Plan also establishes a reporting framework for project tracking, monitoring, and reporting and was developed to meet the restoration plan requirement designated in the County's NPDES MS4 Permit (Section IV.E.2).

1. Document Organization

Section I: Introduction; discusses the history of TMDL development within the South Branch Patapsco Watershed, outlines the purpose and scope of this document, and provides a description of water quality standards and the TMDL's being addressed by this document.

Section II: Background; describes the location of the watershed and outlines any ecologically sensitive areas as well as locations of tier II waters within the watershed. This section will also summarize the stream corridor assessment (SCA) that was performed by the Bureau of Resource Management and identifies priority watersheds based on the assessment. The background section will also look at baseline and current land use within the Carroll County portion of the South Branch Patapsco Watershed.

Section III: New Development; this section will discuss the Chapter 154; Water Resource Ordinance and how easements are set aside in perpetuity during the development phase to protect ground and surface water resources across the watershed. This section will also summarize the build-out analysis done for the watershed and discuss the Rural Legacy Area that encompasses most of the watershed.

Section IV: Public Outreach and Education; summarizes the current outreach being undertaken by the County and discusses the various councils and the role they play in watershed restoration.

Section V: Restoration Implementation; Describes the BMPs and restoration projects that have been either completed or proposed to meet the local TMDL requirements for the South Branch Patapsco Watershed. Appendix A will also provide a complete list of restoration activities, their associated reduction values, subwatershed location, project status, and anticipated completion.

Section VI: Project Tracking, Reporting, and Monitoring; defines how data will be tracked and summarized to document the success of this plan in improving water quality conditions, and will document progress made through practice implementation, as well as discuss the current monitoring efforts within the watershed.

Section VII: Chesapeake Bay Restoration; describes progress towards achieving the County's TMDL requirements associated with the stormwater WLA for the Chesapeake Bay watershed; BMPs and restoration projects that have been either completed or proposed to address local TMDL's within the Watershed will ultimately reduce loadings to the Chesapeake Bay.

Section VIII: Caveats; explains that this document provides potential restoration strategies that require additional assessment, and that implementation of projects depends on funding and prioritization with other projects County-wide.

Section IX: Public Participation; public outreach of this restoration plan will focus on landowners who will potentially be affected by the watershed plan. Inputs from any stakeholder or the public will be gathered during the public comment period, and addressed before the final plan is released.

Section X: References; provides a list of the references sited in this document

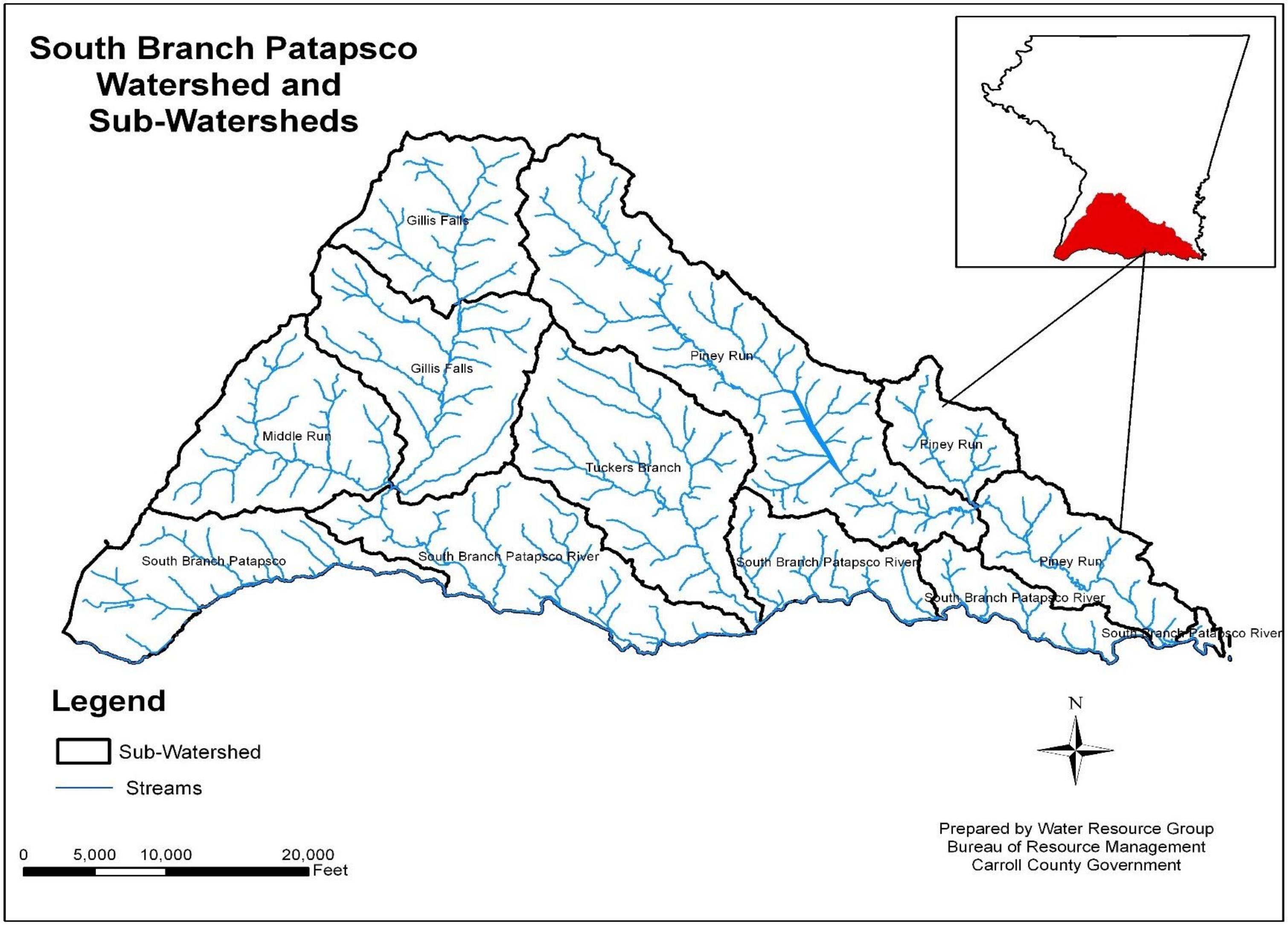


Figure 1: South Branch Patapsco Watershed and Subwatersheds Map

B. Regulatory Setting and Requirements

Maryland water quality standards have been adopted per the Federal Clean Water Act Section 101 to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters". Individual standards are established to support the beneficial uses of water bodies such as fishing, aquatic life, drinking water supply, boating, water contact recreation as well as terrestrial wildlife that depend on water.

The County's NPDES MS4 permit requires that a restoration plan for each stormwater WLA approved by EPA be submitted to MDE for approval. Any subsequent TMDL WLA approved by the EPA is required to be addressed in a restoration plan within one year of EPA approval.

1. Use Class Designations and Water Quality Standards

All bodies of water, including streams within Maryland and all other states, are each assigned a designated use. Maryland's designated water uses are identified in the Code of Maryland Regulations (COMAR) 26.08.02.08. The designated use of a water body refers to its anticipated use and any protections necessary to sustain aquatic life. Water quality standards refer to the criteria required to meet the designated use of a water body. A listing of Maryland's designated water uses are as follows:

- Use I: Water contact recreation, and protection of nontidal warm water aquatic life.
- Use II: Support of estuarine and marine aquatic life and shellfish harvesting (not all subcategories apply to each tidal water segment)
  - Shellfish harvesting subcategory
  - Seasonal migratory fish spawning and nursery subcategory (Chesapeake Bay only)
  - Seasonal shallow-water submerged aquatic vegetation subcategory (Chesapeake Bay only)
  - Open-water fish and shellfish subcategory (Chesapeake Bay only)
  - Seasonal deep-water fish and shellfish subcategory (Chesapeake Bay only)
  - Seasonal deep-channel refuge use (Chesapeake Bay only)
- Use III: Nontidal cold water – usually considered natural trout waters
- Use IV: Recreational trout waters – waters are stocked with trout

If the letter "P" follows the use class listing, that particular stream has been designated as a public water supply. The designated use and applicable use classes can be found in Table 1.

Table 1: Maryland Designated Uses

Designated Uses	I	I-P	II	II-P	III	III-P	IV	IV-P
	Use Classes							
Growth and Propagation of fish (not trout), other aquatic life and wildlife	✓	✓	✓	✓	✓	✓	✓	✓
Water Contact Sports	✓	✓	✓	✓	✓	✓	✓	✓
Leisure activities involving direct contact with surface water	✓	✓	✓	✓	✓	✓	✓	✓
Fishing	✓	✓	✓	✓	✓	✓	✓	✓
Agricultural Water Supply	✓	✓	✓	✓	✓	✓	✓	✓
Industrial Water Supply	✓	✓	✓	✓	✓	✓	✓	✓
Propagation and Harvesting of Shellfish			✓	✓				
Seasonal Migratory Fish Spawning and Nursery Use			✓	✓				
Seasonal Shallow-Water Submerged Aquatic Vegetation Use			✓	✓				
Open-Water Fish and Shellfish Use			✓	✓				
Seasonal Deep-Water Fish and Shellfish Use			✓	✓				
Seasonal Deep-Channel Refuge Use			✓	✓				
Growth and Propagation of Trout					✓	✓		
Capable of Supporting Adult Trout for a Put and Take Fishery							✓	✓
Public Water Supply		✓		✓		✓		✓

a. South Branch Patapsco Watershed Water Quality Standards

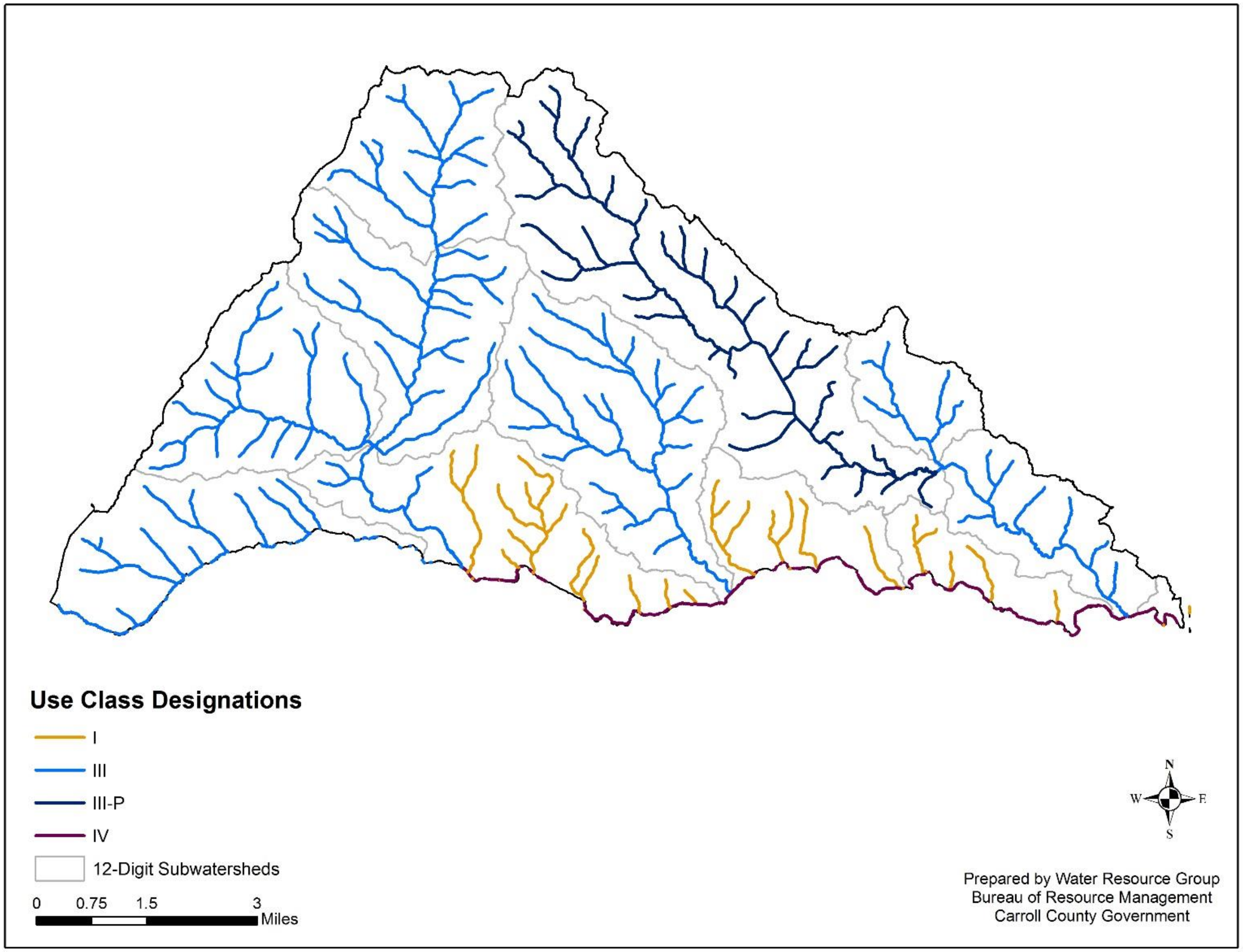
The South Branch Patapsco Watershed within Carroll County has multiple designated uses throughout the watershed and range from use I; non-tidal warm water to use IV-P; recreational trout waters and public water supply. The use III-P is capable of growing and propagating trout, whereas the use IV and IV-P are capable of supporting adult trout for a put-and-take fishery. The designated use for each stream segment within the South Branch Patapsco Watershed as determined by MDE can be found in Figure 2.

2. Water Quality Criteria

Water quality criteria is developed for each designated use and defines the level or pollutant concentration allowable to support that designated use (EPA, 2008). An example would be the human health criteria for bacteria, which are based on full body contact for a single sample or a steady state geometric mean of five samples. The freshwater criteria for bacteria are listed in Table 2.

Table 2: Freshwater Bacteria Criteria (MPN/100 mL)

Indicator	Steady State Geometric Mean Density	Maximum Allowable Density – Single Sample			
		Frequent Full Body Contact	Moderately Frequent Full Body Contact	Occasional Full Body Contact	Infrequent Full Body Contact
E. Coli	126	235	298	410	576



Source: MDE

Figure 2: South Branch Patapsco Watershed Designated Uses

3. Total Maximum Daily Loads (TMDLs)

A TMDL establishes the maximum amount of an impairing substance or stressor that a waterbody can assimilate and still meet Water Quality Standards (WQS). TMDLs are based on the relationship between pollution sources and in-stream water quality conditions (mde.state.md.us). TMDLs calculate pollution contributions from the entire watershed and then allocate reduction requirements to the various contributing sources. Within the South Branch Patapsco Watershed, these allocations are divided among counties and municipalities and then further divided by sources, including agricultural, wastewater, and stormwater. The Memorandum of Agreement (MOA) between the County and each of the Municipalities has combined the jurisdictions into one permit. This restoration plan will concentrate on joint requirements for reducing TMDL loadings associated with the stormwater WLA.

a. Phosphorus

The current estimated stormwater baseline load for Carroll County as determined by MDE TMDL Data Center is 7,889 lbs. /yr., the TMDL for the stormwater WLA was determined to be 6,706 lbs. /yr., which is a reduction of 1,183 lbs. /yr. (15%) from the current loading (Table 3). The baseline loads for the County and Towns were derived from the TMDL Data Center. Estimating a load contribution from the stormwater Phase I and II sources is imprecise, given the variability in sources, runoff volumes, and pollutant loads over time (MDE, 2008).

Table 3: Baltimore Harbor Watershed Phosphorus TMDL

Jurisdiction	Baseline	TMDL	Percent Reduction
Carroll County	7,889	6,706	15%
Total	**7,889**	**6,706**	**15%**

b. Nitrogen

The current estimated stormwater baseline load for Carroll County as determined by MDE TMDL Data Center is 72,890 lbs./yr., the TMDL for the stormwater WLA was determined to be 61,957 lbs./yr., which is a reduction of 10,933 lbs./yr. (15%) from the current loading (Table 4).

Table 4: Baltimore Harbor Watershed Nitrogen TMDL

Jurisdiction	Baseline	TMDL	Percent Reduction
Carroll County	72,890	61,957	15%
Total	**72,890**	**61,957**	**15%**

II. Background

A. Location and Subwatershed Map

The Carroll County portion of the Baltimore Harbor Watershed is located along the southern portion of the County. The watershed is within the Patapsco River Basin, which lies within the Piedmont physiographic province of Maryland. There are eleven (11) major sub-watersheds in the Watershed that cover a total land area of 38,735 acres.

B. Baseline and Current Land Cover

As the land use of a watershed is modified over time it will ultimately influence the water quality within that watershed. Natural landscapes, like forests and grasslands allow for infiltration of stormwater while absorbing excess nutrients. Unmanaged impervious surfaces don't allow for infiltration, causing stormwater to concentrate. The increased runoff velocity will de-stabilize stream banks, causing potential sedimentation problems downstream.

Within the South Branch Patapsco Watershed, agriculture is the dominant land cover at about 38.5 percent of the total land, followed by low density residential which accounts for 26.7 percent, and forest, which accounts for about 25 percent of the total land cover. Mixed urban accounts for approximately 5.5 percent of the total land cover, which represents the relatively rural nature of the South Branch Patapsco Watershed.

The 2011 National Land Cover Database (NLCD) data was compared to current property data and existing land uses within the county in order to identify any gaps in urban land cover. Additional areas identified as urban were based on Section II.4 (Table 1) of MDE's 2014 Accounting for Stormwater WLA document, and consisted of rural residential lots less than three (3) acres that were listed as non-urban land uses within the NLCD database. This analysis showed a 7% increase in low-density residential land cover since 2011, which has been incorporated into Table 6.

Table 5 shows the current land cover data for the South Branch Patapsco Watershed, as well as the changes in land cover over time since 2001. The current land cover, as of 2011, within the South Branch Patapsco Watershed can be found in Figure 3.

Table 5: South Branch Patapsco Watershed Baseline and Current Land Cover

Land Cover	Acres 2001	Percent 2001	Acres 2006	Percent 2006	Acres 2011	Percent 2011	Current Acres	Percent
Open Water	289.31	<1%	289.08	<1%	289.08	<1%	289.08	<1%
Low-Density Residential	6,101.55	15.8%	6,287.98	16.2%	7,629.91	19.7%	10,341.28	26.7%
Low-Density Mixed Urban	1,492.73	3.9%	1,635.29	4.2%	1,902.51	4.9%	1,660.10	4.3%
Medium-Density Mixed Urban	347.82	<1%	454.77	1.2%	540.31	1.4%	481.68	1.2%
High-Density Mixed Urban	48.81	<1%	79.58	<1%	91.05	<1%	86.44	<1%
Barren Land	11.04	<1%	16.17	<1%	20.75	<1%	10.77	<1%
Forest	11,307.70	29.2%	11,133.74	28.7%	11,143.46	28.8%	9,722.66	25.1%
Shrub/Scrub	311.61	<1%	298.71	<1%	315.38	<1%	245.58	<1%
Grassland	60.68	<1%	99.53	<1%	89.25	<1%	73.64	<1%
Pasture/Hay	8,456.01	21.8%	8,008.07	20.7%	8,200.84	21.2%	6,836.87	17.6%
Cropland	9,376.97	24.2%	9,505.51	24.5%	9,909.01	25.6%	8,111.94	20.9%
Wetland	906.19	2.3%	901.84	2.3%	909.10	2.3%	879.42	2.3%

Source: National Land Cover Database

1. Impervious Surfaces

An increase in impervious surface cover within a watershed alters the hydrology and geomorphology of streams; resulting in increased loadings of nutrients, sediment, and other contaminants to the stream (Paul and Meyer, 2001).

The South Branch Patapsco Watershed is estimated to have 2,522 acres of total impervious within the catchment and accounts for approximately 6.5 percent of the total land area. The impervious surface area within South Branch Patapsco, by subwatershed can be found in Table 6 and is shown in Figure 4.

Table 6: South Branch Patapsco Watershed Estimated Impervious Surface Area

DNR 12-digit Scale	Subwatershed	Acres	Impervious Acres	Percent Impervious
021309081031	Gills Falls Upper	3,118.40	174.35	5.6%
021309081030	Gills Falls Lower	4,243.17	113.21	2.7%
021309081029	Middle Run	3,781.73	186.83	4.9%
021309081021	Piney Run Lower	2,306.82	151.76	6.6%
021309081023	Piney Run Main	8,007.30	504.27	6.3%
021309081024	Piney Run Tributary	1,442.79	316.29	21.9%
021309081028	South Branch Patapsco	3,169.38	419.50	13.2%
021309081025	South Branch Patapsco River	4,116.38	157.95	3.8%
021309081022	South Branch Patapsco River	1,953.15	228.86	11.7%
021309081020	South Branch Patapsco River	1,430.57	38.36	2.7%
021309081026	Tuckers Branch	5,166.27	230.55	4.5%
South Branch Patapsco Watershed		**38,735.95**	**2,521.93**	**6.5%**

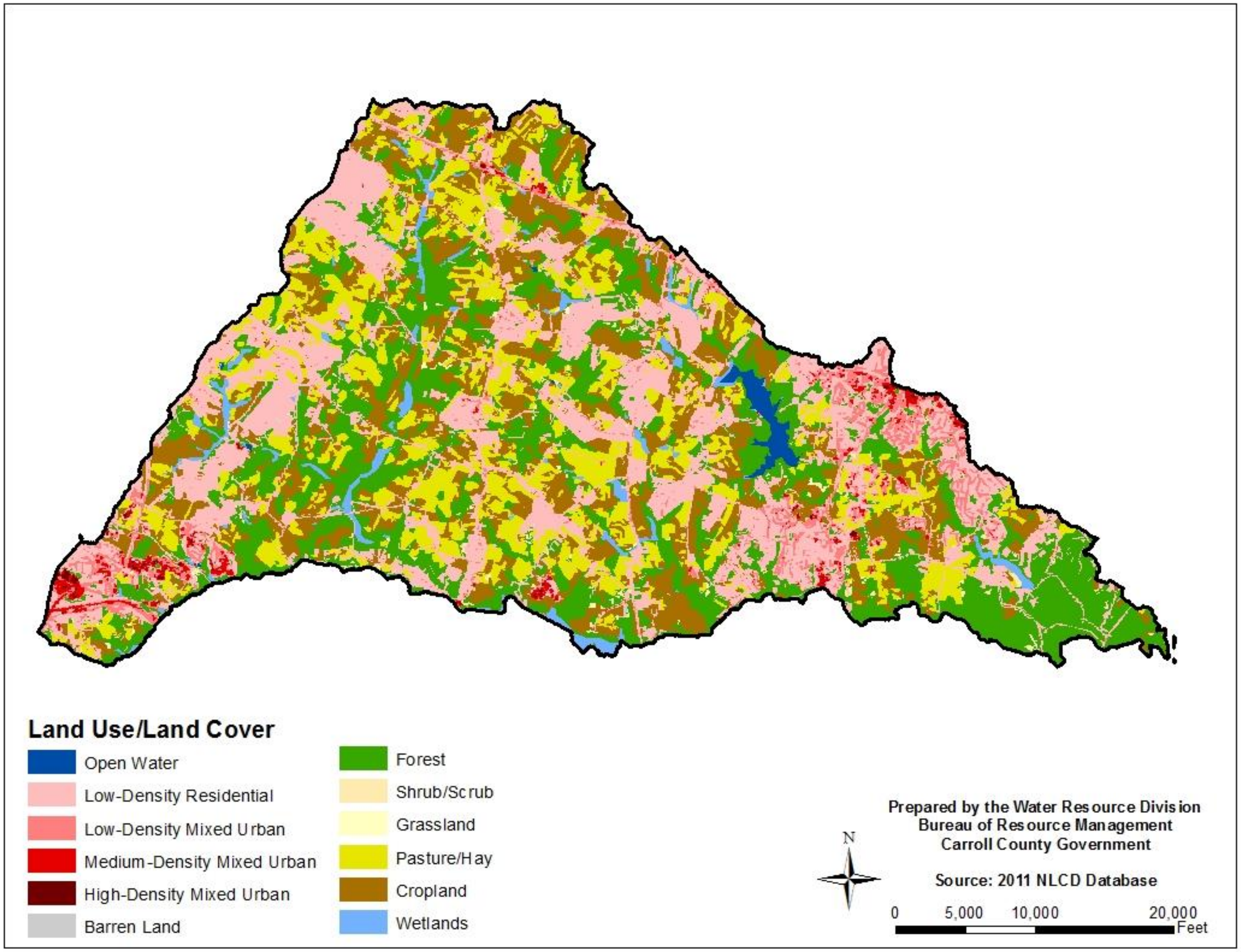


Figure 3: South Branch Patapsco Watershed Land Use/Land Cover

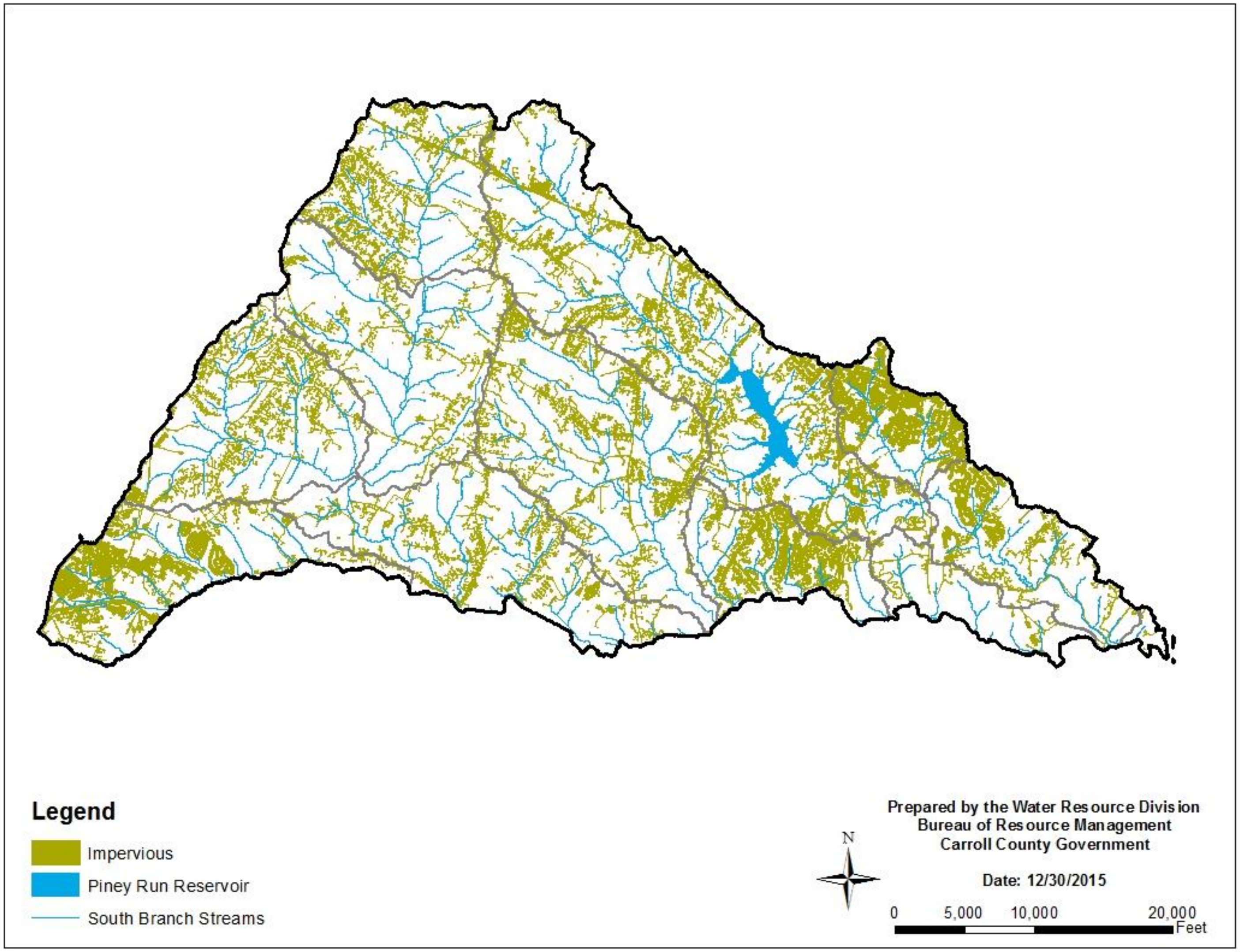


Figure 4: South Branch Patapsco Watershed Impervious Surface Area

C. Watershed Characterization

Following the South Branch Patapsco stream corridor assessment (SCA), completed in 2013, a Watershed Characterization for the South Branch Patapsco Watershed was completed. The characterization provides background on the natural and human characteristics of the watershed. The information provided in the characterization as well as information gathered during the South Branch Watershed SCA will be used as the foundation for the watershed restoration plan. The South Branch SCA and characterization documents can be found at:

http://ccgovernment.carr.org/ccg/resmgmt/southbranch/Assessment.aspx

http://ccgovernment.carr.org/ccg/resmgmt/southbranch/Character.aspx

1. Tier II Waters and Ecological Sensitive Areas

a. Tier II Waters

States are required by the federal Clean Water Act to develop policies, guidance, and implementation procedures to protect and maintain existing high quality waters and prevent them from degrading to the minimum allowable water quality. Tier II waters have chemical or biological characteristics that are significantly better than the minimum water quality requirements. All Tier II designations in Maryland are based on having healthy biological communities of fish and aquatic insects. Within the South Branch Patapsco Watershed, sections of Gillis Falls, Tuckers Branch, and Middle Run are listed as Tier II waters. Tier II designated stream segments for the South Branch Patapsco Watershed can be found in Figure 5.

b. Ecologically Sensitive Areas

Targeted Ecological Areas (TEAs) are lands and watersheds of high ecological value that have been identified as conservation priorities by the Maryland Department of Natural Resources (DNR) for natural resource protection. These areas represent the most ecologically valuable areas in the State (imap.maryland.gov). Targeted ecological areas within the South Branch Patapsco Watershed are shown in Figure 6.

For watershed restoration purposes, it is important to know and account for the habitats of sensitive species. Protecting and expanding these habitats help to preserve biodiversity and is a critical component in successfully restoring a watershed. DNR's Wildlife and Heritage Service identifies important areas for sensitive species conservation known as "stronghold watersheds". Stronghold watersheds are the places where rare, threatened, and endangered species have the highest abundance of natural communities. A complete list of all rare, threatened, and endangered plants and animals within Carroll County and throughout the state of Maryland can be found at:

http://www.dnr.state.md.us/wildlife/espaa.asp.

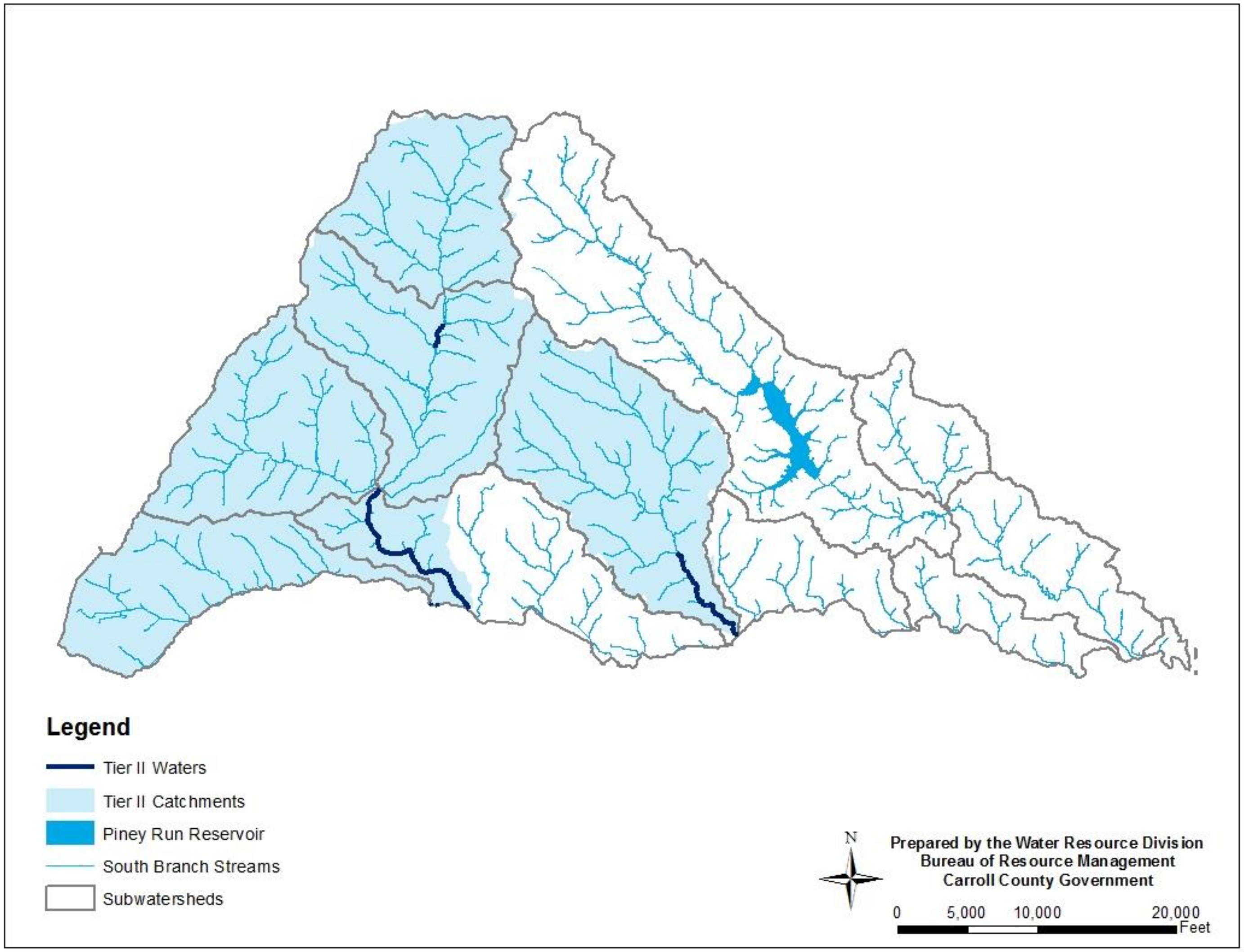


Figure 5: Tier II Waters

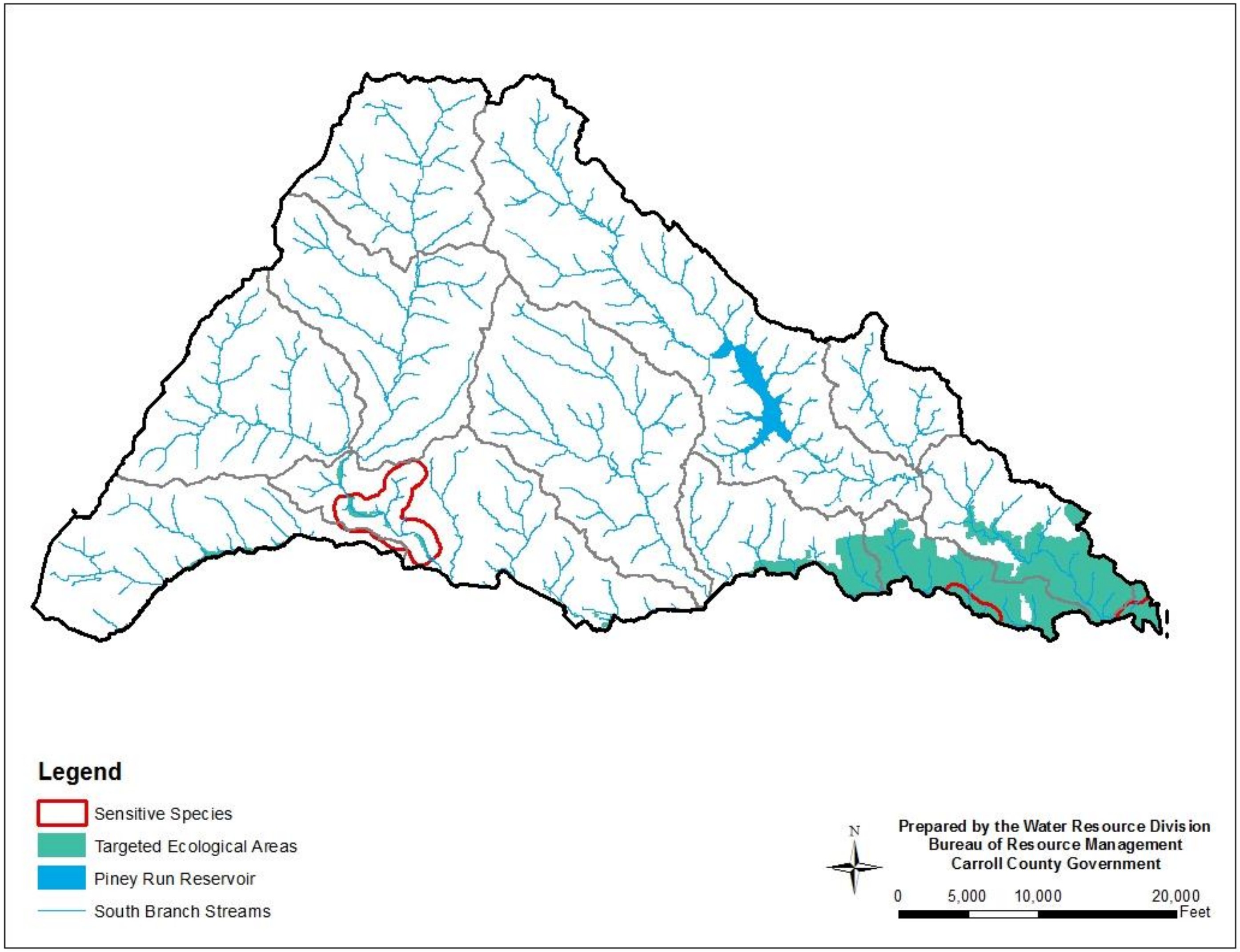


Figure 6: Targeted Ecological Areas

2. Stream Corridor Assessment (SCA)

A Stream Corridor Assessment (SCA) of the South Branch Patapsco Watershed was conducted during the winter of 2013 by Carroll County Bureau of Resource Management staff. The South Branch SCA was based on protocols developed by the Maryland Department of Natural Resources watershed restoration division (Yetman, 2001). The goal of this assessment was to identify and rank current impairments within the watershed to assist in prioritizing locations for restoration implementation. A summary of the entire South Branch SCA is available at:

http://ccgovernment.carr.org/ccg/resmgmt/southbranch/Assessment.aspx

3. Priority Watersheds

During the SCA, field crews identified erosion problems along approximately 54,500 linear feet of the corridor, 7.22% of the overall stream miles that were granted permission to assess. The highest percent of erosion based on the stream miles assessed were in Piney Run Main (1049) and Tucker's Branch (1059). Table 7 lists the total stream miles in each subwatershed, the amount of stream miles that were granted permission to assess within each subwatershed, as well as the total linear foot of erosion identified in each subwatershed, and what percent of the streams within each watershed were eroded based on the miles assessed.

Priority for restoration projects will be based on; the amount of impervious area in need of treatment and will focus on areas that will address significant downstream erosion that reduces nutrient and sediment loadings.

Table 7: Subwatershed Erosion Statistics

Stream Segment	12-Digit Stream Miles	Stream Miles Assessed (granted permission)	Erosion (Linear Ft.)	Percent of Erosion Within Assessed Corridor
Gills Falls Upper (1030)	20.39	13.49	6,060	8.51%
Gills Falls Lower (1031)	14.37	10.72	4,100	7.24%
Middle Run (1029)	18.36	14.71	3,370	4.34%
Piney Run Lower (1021)	11.46	12.66	5,170	7.73%
Piney Run Main (1023)	39.85	30.20	18,760	11.76%
Piney Run Tributary (1024)	7.15	5.51	0	0%

South Branch Patapsco (1028)	18.09	10.73	1,925	3.40%
South Branch Patapsco River (1020)	10.15	10.64	1,190	2.12%
South Branch Patapsco River (1022)	11.89	10.25	5,490	10.14%
South Branch Patapsco River (1025)	24.49	12.96	2,400	3.51%
Tuckers Branch (1026)	25.02	11.18	6,035	10.22%
Total	**201.22**	**143.05**	**54,500**	**7.22%**

III. New Development

A. Build-Out Analysis

Buildable Land Inventory (BLI) analyzes the number of residential lots that could be created, or single-family units constructed. The BLI is estimated based on the jurisdiction's current zoning and/or proposed future zoning (called "land use designation"). The BLI looks at existing development and, based on a yield calculation, determines how many more residential units can be built in the future. The BLI model does not include commercial or industrial development potential, but does contain information on land zoned and designated for these uses. Within the South Branch Patapsco Watershed there are 2,053 parcels remaining with potential development on 12,310 acres for an estimated lot yield of 4,581 (build out data was provided by the GIS group of Carroll County's Department of Land and Resource Management). This data is based on a medium range buildable land inventory estimate by land use designations. The medium range estimates have been determined to be the most accurate for build out. The full buildable land inventory report can be found at: http://ccgovernment.carr.org/ccg/compplanning/BLI/. Figure 7 shows the remaining parcels in South Branch Patapsco Watershed where residential units could be built.

In addition to the BLI, the Carroll County Department of Land and Resource Management, Bureau of Development Review oversees the division of land and lot yield potential for properties in Carroll County. A parcel's potential lot yield is dependent on its size, the zoning district, the history of the property and whether or not it has in-fee frontage on a publically maintained road. The development and subdivision of land is regulated under Carroll County Code Chapter 155, and the Zoning Regulations are regulated under Carroll County Code Chapter 158.

B. Stormwater Management

Stormwater runoff associated with new development is addressed through Chapter 151 of the Carroll County Code of Public Local Laws and Ordinances. The purpose of this chapter is to protect, maintain, and enhance the public health, safety, and general welfare by establishing minimum requirements and procedures to control the adverse impacts associated with increased stormwater runoff.

The goal of Chapter 151 is to manage stormwater by using environmental site design (ESD) to the maximum extent practicable (MEP) to maintain after development as nearly as possible, the predevelopment runoff characteristics, and to reduce stream channel erosion, pollution, and sedimentation, and use appropriate structural BMPs only when necessary. Implementation of Chapter 151 will help restore, enhance, and maintain the physical, chemical, and biological integrity of streams, minimize damage to public and private property, and reduce impacts of land development.

The current chapter was adopted in 2010 and was written to adopt the State of Maryland revisions to the design manual (MD Code, Environmental Article, Title 4, Subtitle 2), which mandated the use of non-structural ESD practices statewide to the MEP to mimic totally undeveloped hydrologic conditions.

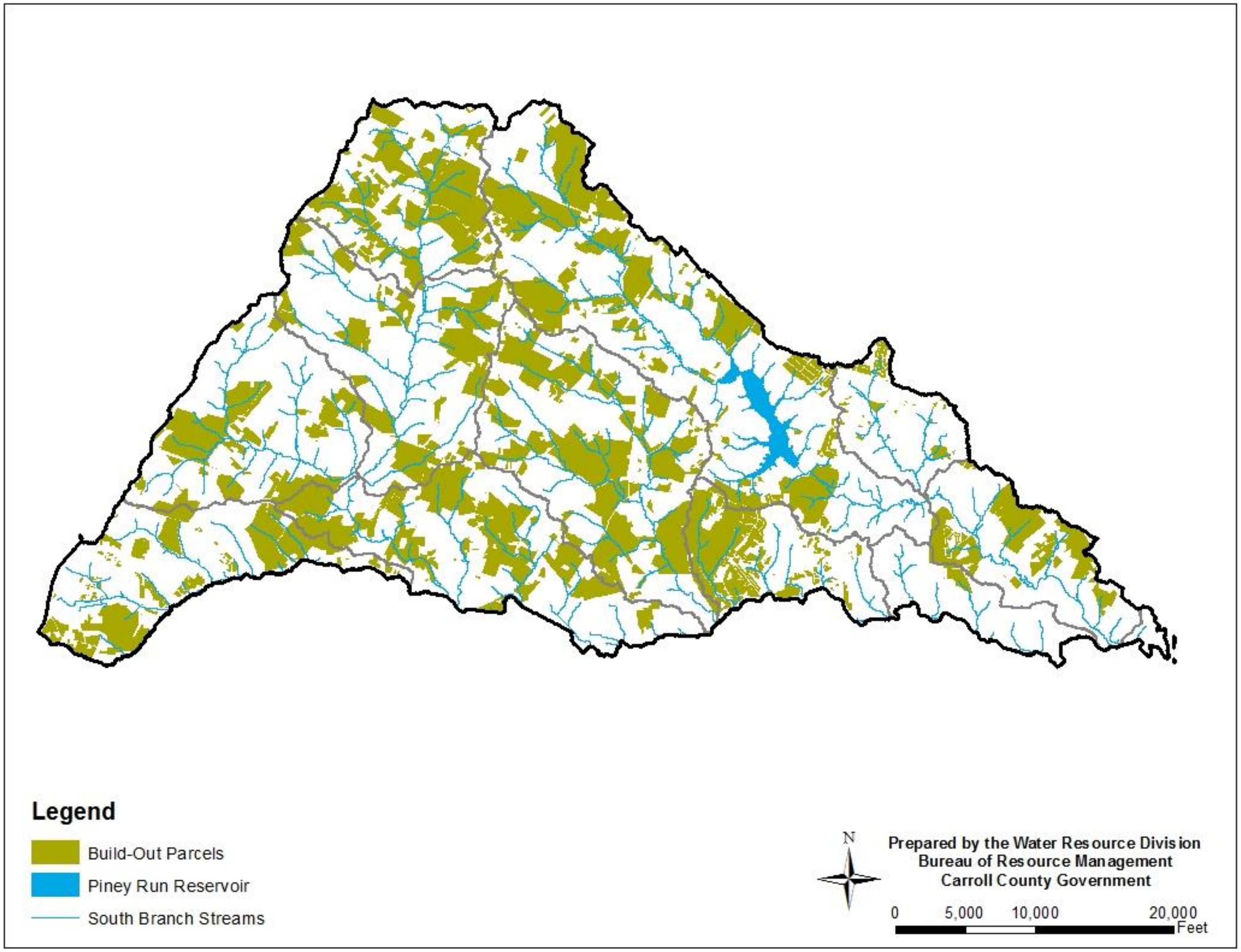


Figure 7: South Branch Patapsco Watershed Build-Out Parcels

C. County Easements

As part of the development process, Carroll County protects waterways and floodplains with perpetual easements to minimize the potential for impacts during and after construction to these sources. The purpose of the Carroll County Water Resource code (Chapter 154) is to protect and maintain ground and surface water resources of the County by establishing minimum requirements for their protection. Chapter 153 provides a unified, comprehensive approach to floodplain management. Floodplains are an important asset as they perform vital natural functions such as; temporary storage of floodwaters, moderation of peak flood flows, maintenance of water quality, and prevention of erosion. Within the South Branch Patapsco Watershed there are 158.72 acres of grass buffer and 272.17 acres of forest buffer protection easements. A list of the grass buffer and forest buffer protection easements within the South Branch Patapsco Watershed can be found in Appendix B, and are shown in Figure 8. These perpetually protected easements limit landowner use of environmentally sensitive areas and reduce the amount of nutrients entering the waterway.

D. Rural Legacy Areas

Maryland's Rural Legacy Program was created in 1997 to protect large, continuous tracts of land from sprawl development and to enhance natural resource, agricultural, forestry and environmental protection through cooperative efforts among state and local governments and land trusts. http://www.dnr.state.md.us/land/rurallegacy/index.asp

The goals of the rural Legacy Program are to:

- Establish greenbelts of forests and farms around rural communities in order to preserve their cultural heritage and sense of place;
- Preserve critical habitat for native plant and wildlife species;
- Support natural resource economies such as farming, forestry, tourism, and outdoor recreation, and;
- Protect riparian forests, wetlands, and greenways to buffer the Chesapeake Bay and its tributaries from pollution run-off.

The South Branch Patapsco watershed lies just south of the Little Pipe Creek Rural Legacy area but is not within the Rural Legacy Area. The location of South Branch Patapsco watershed in relation of the Rural Legacy Area can be found in Figure 9.

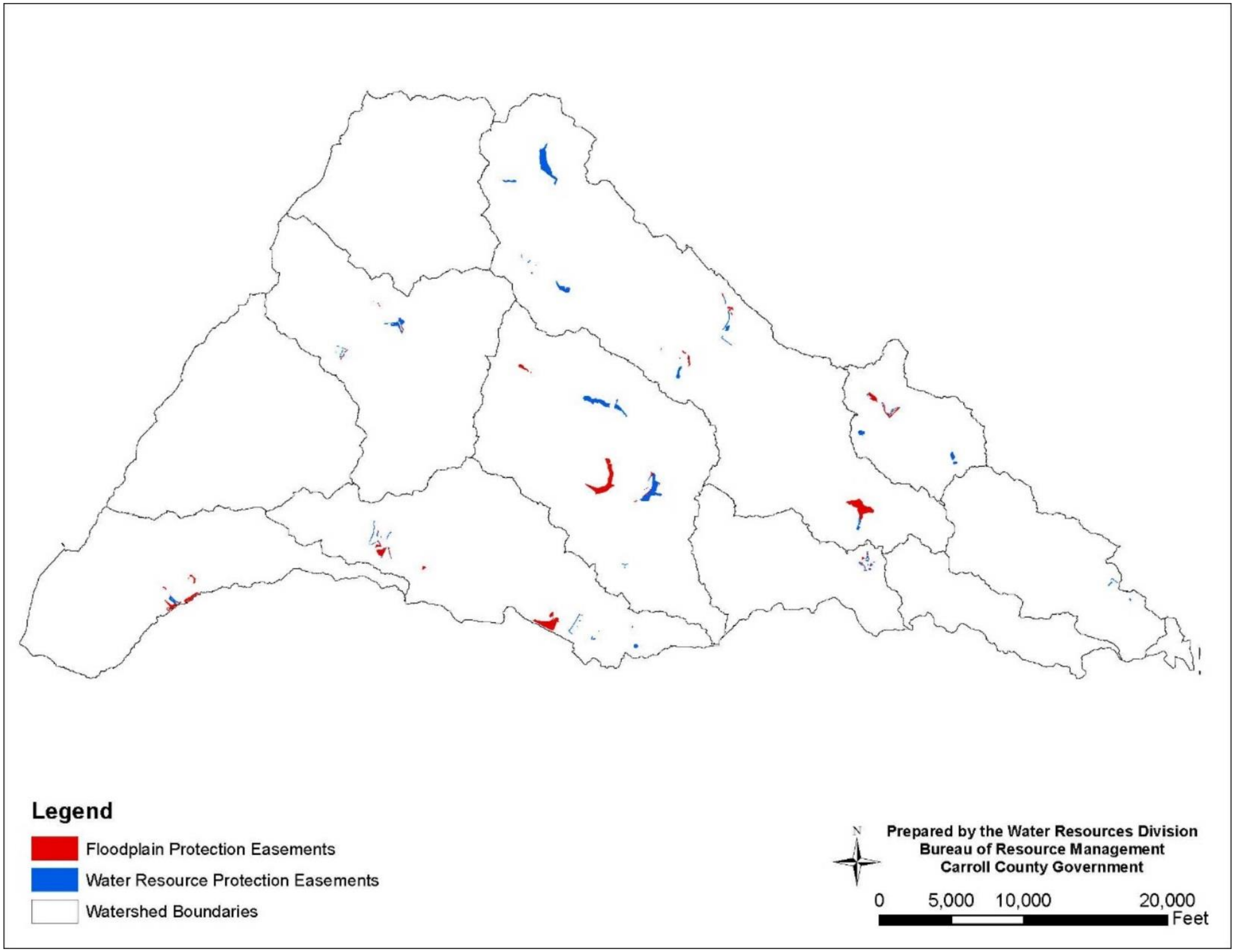


Figure 8: Water Resource and Floodplain Protection Easement Locations

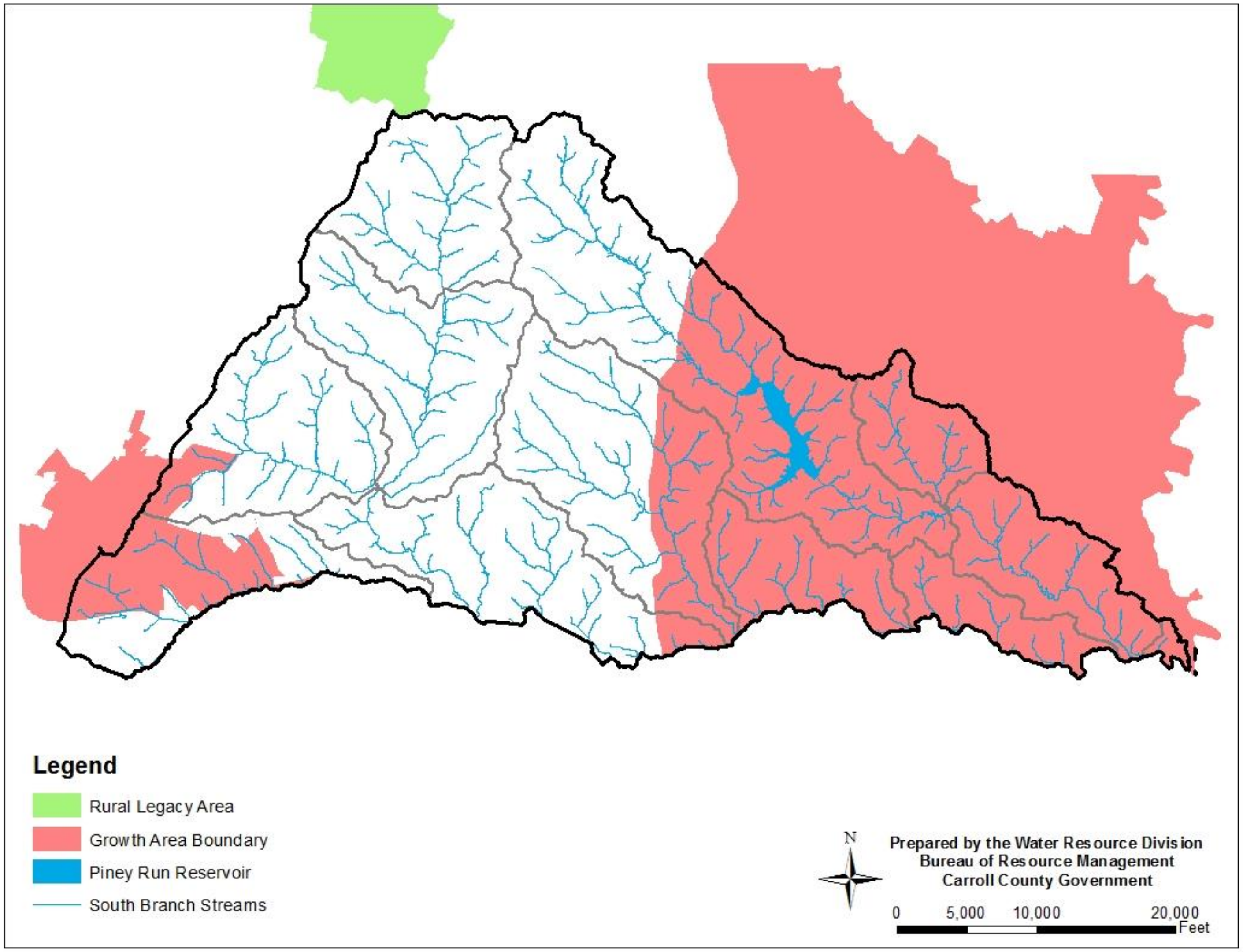


Figure 9: Upper Patapsco Rural Legacy Area

IV. Public Outreach and Education

An informed community is crucial to the success of any stormwater management program (US EPA, 2005). The benefits of public education are unmeasurable; the National Environmental Education & Training Foundation (NEETF) found that 78 percent of the American public does not understand that runoff from impervious surfaces, lawns, and agricultural lands, is now the most common source of water pollution (Coyle, 2005). Throughout the year, County staff regularly hosts or participates in events to help inform the public of the importance of stormwater management.

A. Water Resources Coordination Council

The Water Resources Coordination Council (WRCC) was formed by the County Commissioners, eight municipalities, and the Carroll County Health Department in February of 2007 through a cooperative partnership and by formal joint resolution to discuss and address issues related to water resources. The monthly meetings, composed of representatives from the eight municipalities, the County, and the Carroll County Health Department provide an excellent opportunity to discuss pertinent issues related to water, wastewater, and stormwater management.

WRCC took the lead in coordinating and developing a joint Water Resources Element (WRE), which was adopted by the County and seven municipalities. The WRCC also serves as the local Watershed Implementation Plan (WIP) team for development and implementation of Maryland's Phase III WIP and continues to address WIP related issues and tasks as they arise.

In FY 2013 and FY 2014, the WRCC collaborated to develop, sign, and implement a Memorandum of Agreement (MOA) to implement NPDES permit requirements with specific provisions to cost-share the capital costs of meeting the municipalities' stormwater mitigation requirements. The WRCC will act as the forum for setting project priorities, and the County will continue to provide administrative and operating support services for the stormwater mitigation program.

1. Carroll County NPDES MS4 Team

The NPDES team was formed following the issuance of the County's most recent MS4 permit, which became effective on December 29, 2014. The team meets on a quarterly basis to discuss goals and deadlines related to NPDES MS4 discharge permit compliance. The team consists of personnel from the Department of Land and Resource Management; administration, water resources, stormwater, grading, engineering, and compliance.

B. Environmental Advisory Council (EAC)

The Environmental Advisory Council (EAC) is currently the mechanism in which the County continues to provide an open forum on environmental issues and concerns. This Commissioner-appointed citizen board holds monthly meetings, which are open to the public. The EAC functions at the direction of the Carroll County Board of Commissioners; works cooperatively with County environmental staff to research environmental policy issues, advises the Board of County Commissioners on environmental issues, fosters environmental education, and generally acts in the best interest of County residents by promoting effective environmental protection and management principles. EAC has been regularly briefed on NPDES permit specifics and implementation.

1. Community Outreach

In its role to promote environmental awareness and outreach, every other year, the EAC accepts nominations for Environmental Awareness Awards. Winners are recognized in a joint ceremony with the Board of County Commissioners, in the press, and on the EAC's website.

Since 2014, the EAC annually prepares a Carroll County Environmental Stewardship booklet, which is made available on the website, as well as various other venues. The booklet describes various efforts and initiatives undertaken by the County to demonstrate environmental stewardship and protection, including stormwater mitigation, management projects, and progress.

C. Public Outreach Plan

The public outreach plan provides a holistic review of the public outreach opportunities currently provided and available to residents and businesses in Carroll County and its eight municipalities. The goal of the public outreach plan is to raise public awareness and encourage residents and businesses to take measures to reduce and prevent stormwater pollution.

Public outreach efforts will focus on the issues and topics prescribed in the County's MS4 permit. The permit requires outreach to County and municipal staff, general public, and the regulated community. Emphasis will be given to facilities and businesses at a higher risk for stormwater pollution or potential illicit discharges, as well as homeowner associations and school students.

D. Educational Venues

County staff is continuously involved in environmental education efforts such as regularly speaking at schools, community organizations, club meetings, and other venues in an effort to ensure that key environmental information is available to the community. An information booth is set up at events sponsored by the Towns and County providing citizens with informational materials relating to homeowner stewardship, restoration efforts throughout the County, and an opportunity to volunteer in these efforts. Educational events that County staff have participated in that are either held within the South Branch Patapsco Watershed or offered to citizens countywide can be found in Table 8.

Table 8: MS4 Public Outreach Events

Event	Year	Watershed
12SW/SR Permittee Workshop	2018	Countywide
Agricultural Tire Amnesty Program	2016	Countywide
Annual Backyard Buffers Education Day	2017, 2018, 2019	Countywide
Arbor Day Tree Planting Ceremony	2016	Countywide
America Recycles Day	2017, 2018	Countywide
Carroll Arts Council Festival of Wreaths	2015, 2017, 2018	Countywide
Carroll County 4H Fair	2015, 2016	Countywide
Carroll County NPDES MS4 Permit Annual Stormwater Pollution Prevention Compliance Training	2015, 2016, 2017, 2018	Countywide
Carroll County Employee Appreciation Day	2016, 2017, 2018, 2019	Countywide
Carroll County Envirothon	2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019	Countywide
Carroll County Home Show	2016, 2017, 2018, 2019	Countywide
Carroll County Household Hazardous Waste Fall Clean-Up	2016, 2017, 2018, 2019	Countywide
Carroll County Seniors on the Go Expo	2016, 2017, 2018, 2019	Countywide
Chesapeake Bay Awareness Week Stormwater Tour	2017	Countywide
Choose Clean Water Coalition NPDES MS4 Tour	2018	Countywide
Earth Day Celebration	2014, 2015, 2016, 2017, 2018, 2019	Countywide
Environmental Advisory Council	2014, 2015, 2016, 2017, 2018, 2019	Countywide
Environmental Awareness Awards Presentation	2016	Countywide
Hampstead Fall Fest	2016, 2017, 2018	Countywide
Hampstead-Manchester Business & Community Expo	2017, 2018, 2019	Countywide

Homeowners & Stormwater Workshop	2017	Countywide
Mid-Atlantic Car Wash Association "Wash to Save the Bay"	2019	Countywide
National Night Out	2014, 2015, 2016, 2017, 2018	Countywide
Rain Barrel & Composting Event	2015, 2016, 2017, 2018, 2019	Countywide
Scrap Tire Drop Off Day	2019	Countywide
Sykesville Annual Spring Clean-Up Day	2018, 2019	South Branch
Town Mall Earth Day Event	2016	Countywide
Westminster FallFest	2015, 2016, 2017, 2018	Countywide
Westminster Flower & Jazz Festival	2017, 2018, 2019	Countywide
Workshop: Businesses for Clean Water	2016	Countywide

The County continues to expand their education and outreach efforts within all watersheds, and always looks for additional opportunities to engage the public with water resource related issues.

V. Restoration Implementation

The following describes the BMPs and restoration projects that have been either completed or proposed to meet the local TMDL requirements for the Baltimore Harbor Watershed. Appendix A also provides a complete list of restoration activities, their associated reduction values, subwatershed location, project status, project cost and anticipated completion date.

A. Stormwater Management Facilities

When runoff from precipitation flows over impervious surfaces it can accumulate various debris, chemicals, sediment, or other pollutants that could adversely affect the water quality of a stream. If not controlled, there is a high potential for stream degradation. This is due not only to pollutants that are carried directly into the water, but also the volume and velocity of the water that physically cuts away the stream bank, which results in habitat degradation and sediment mobilization.

The State of Maryland began requiring stormwater management in the mid 1980's for new development to manage the quantity of runoff. These requirements were initially established for any subdivision with lots of less than 2 acres in size. For lots greater than 2 acres, stormwater management was only required to address road runoff. In 2000, Maryland Department of Environment (MDE) released a new design manual for stormwater (MDE, 2000). The new manual required greater water quality and quantity controls and included stormwater management for subdivisions with lots greater than 2 acres. The manual was then revised in 2009 to reflect the use of environmental site design (ESD) practices.

Chapter 151 of the Carroll County Code was adopted pursuant to the Environmental Article, Title 4, Subtitle 2 of the Annotated Code of Maryland. Municipalities in Carroll County have either delegated authority to implement Chapter 151, or have their own code to administer stormwater management. These codes apply to all development and establish minimum requirements to control the adverse impacts associated with increased stormwater runoff.

Properly designed and maintained stormwater ponds will help improve their performance (Clary et al. 2010; US EPA 2012). In 2007, the Department of Public Works provided BRM with a County-wide list of SWM facilities owned by the County which had issues relating to maintenance (i.e. no available easements for accessing the property, slopes too steep to mow, trees too large to remove, etc.) After reviewing the list, BRM performed a GIS exercise to determine the drainage areas and impervious acres associated with these facilities. Field investigations were performed to determine the existing conditions of the facilities and if additional drainage could be diverted into the facilities for treatment. A stormwater management facility retrofit program, which included a project schedule, was then established based on projected costs associated with the retrofits, outstanding compliance issues, and funding available in fiscal years 2008 thru 2013. This process and the SCA(s) have aided BRM in establishing projects to date for the program.

The facilities proposed for implementation to assist in addressing the Baltimore Harbor Watershed TMDL's, that have been either completed or planned, are listed in Table 9. The location of each facility can be found in Figure 10, the practice type and runoff depth treated for each facility can be found in Appendix C.

Table 9: Proposed Stormwater Management Projects

Project Name	Drainage Area	Impervious Area	Project Type	Implementation Status	Subwatershed
Arthurs Ridge	51.17	5.14	Retrofit	C	1023
South Carroll High-Fine Arts	24.22	12.94	Facility	C	1023
Brimfield	34.69	9.15	Retrofit	C	1021
Harvest Farms 1A	43.8	11.25	Retrofit	C	1021
Parrish Park	94.23	18.2	Retrofit	C	1024
Clipper Hills Gardenia	33.19	11.08	Retrofit	C	1021
Clipper hills Hilltop	80.17	18.54	Retrofit	C	1021
Carroltowne 2B	34.61	10.38	Retrofit	C	1024
Carroltowne 2A	87.73	34.43	Retrofit	C	1024
Benjamins Claim	47.1	15.78	Retrofit	C	1024
Eldersburg Estates 3-5	34.91	8.16	Retrofit	C	1024
Braddock Manor West	49.3	7.65	Retrofit	C	1023
Benjamins Claim Basin B	1.33	0.55	Retrofit	C	1024
Hawks Ridge	63.48	19.8	Retrofit	C	1022
Merridale Gardens	81	23.81	Retrofit	C	1028
Shannon Run	213.5	34.1	Retrofit	C	1022
Piney Ridge Village AB 57	25.7	8	Retrofit	P	1024
Woodyside Estates Small	9.02	2.11	Retrofit	P	1023
Woodyside Estates Large	63.36	14.02	Retrofit	P	1023
Lexington Run Section 1	12.87	2.62	Retrofit	P	1022
Waters Edge Section 4	72.4	21.19	Retrofit	P	1023
Melstone Valley	170	22.5	Retrofit	P	1021

IDA Property	75.5	10.5	Facility	P	1029
Winfield Fire Dept.	0.22	0.22	Facility	P	1023
Totals:	**1,403.50**	**322.12**			

B. Storm Drain Outfalls

During the South Branch Watershed SCA in 2013, erosion sites were documented and rated on severity. SCA identified erosion sites were analyzed in GIS to the location of existing stormwater management facilities and identified any gaps in the storm drain network that were then further investigated in the field. Storm drain outfalls that have no stormwater controls or where stormwater management is not up to current standards have been identified as possible locations where stormwater practices could be implemented as a way to reduce erosive flows and consequently allow for natural regeneration of vegetation to occur within the stream corridors.

C. Rain Gardens

Most elementary schools within Carroll County have planted a rain garden as part of the Science, Technology, Engineering, and Mathematics (STEM) program. Rain gardens are shallow depressions that assist with treating stormwater by using native plants to soak up and filter runoff from the surrounding impervious surfaces. Five elementary schools within the South Branch Patapsco Watershed have planted implemented rain gardens with a total drainage area of 2.59 acres.

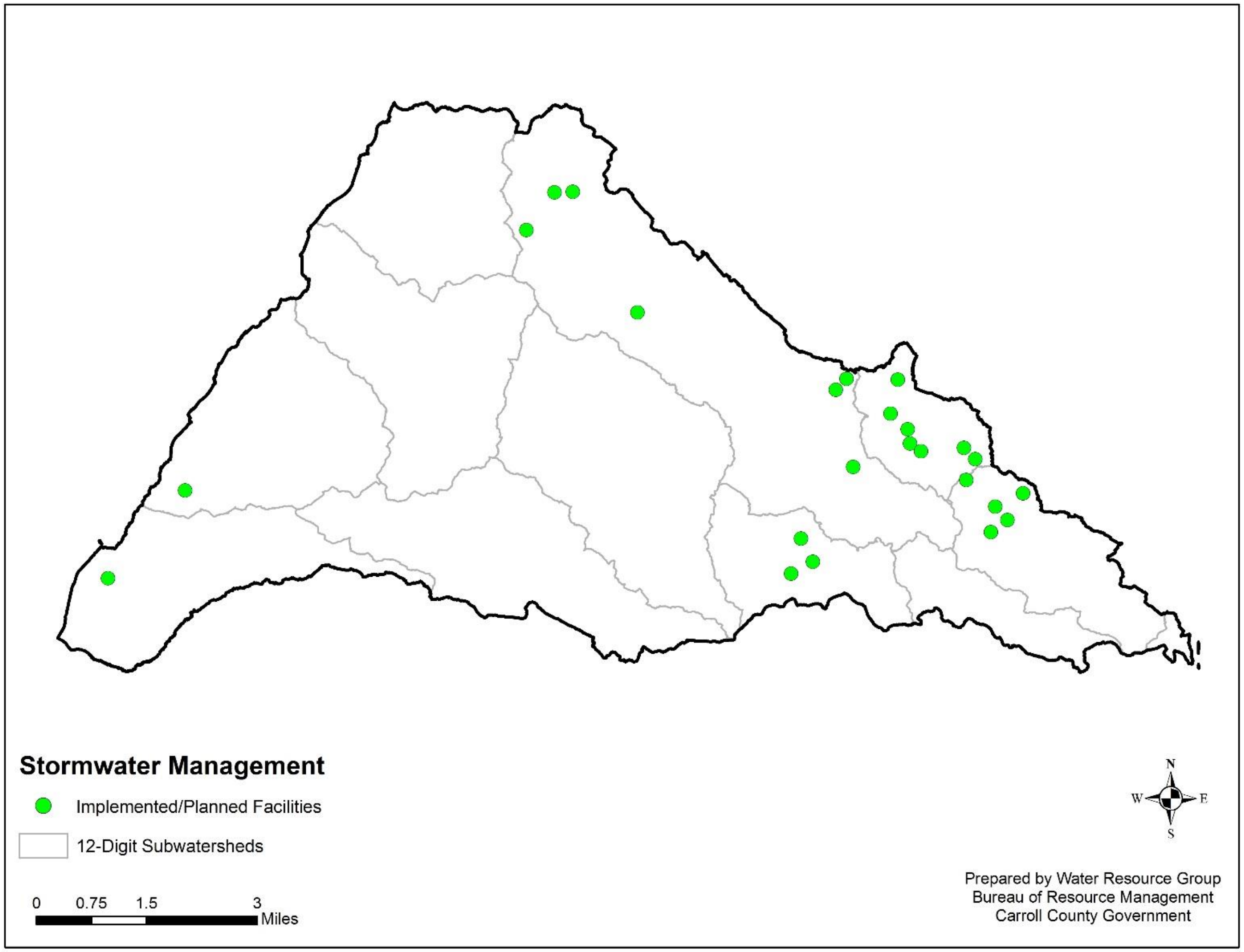


Figure 10: Stormwater Management Locations

D. Tree Planting and Reforestation

Stream buffers are vegetated areas along streams that reduce erosion, sedimentation and pollution of water (US EPA 2012a). Following the completion of the 2011 SCA in the Prettyboy Watershed, the BRM began a stream buffer initiative. This initiative is completely voluntary to landowners with a goal of re-establishing forested corridors along as many streams as possible utilizing native tree stocks.

1. Residential Buffer Plantings

The 2013 South Branch SCA determined that approximately 8 percent of stream miles walked were inadequately buffered. In an effort to address inadequately buffered streams, letters were mailed to landowners whose properties were identified as having an inadequate buffer. This letter provided education on the importance of stream buffers and offered grant-assisted buffer plantings at no cost to the homeowner. Nine properties participated in this initiative over three different planting cycles. The acreage planted for each location and the associated subwatershed can be found in Table 10. The approximate locations of the residential buffer plantings are shown in Figure 11.

Table 10: Stream Buffer Plantings (Municipal/Residential)

	Acres Planted	Buffer Length	Buffer Width	12- Digit Subwatershed	Date Planted
Planting 1	5.6	1,860	75	1023	Fall 2014
Plating 2	3.45	275	400	1031	Fall 2014
Planting 3	0.16	243	20	1026	Fall 2014
Planting 4	3.2	176	--	1028	Spring 2015
Planting 5	0.3	300	30	1025	Fall 2015
Planting 6	3	--	--	1023	Fall 2015
Planting 7	0.23	240	30	1023	Fall 2018
Planting 8	0.13	140	50	1023	Fall 2018
Planting 9	0.13	120	45	1023	Fall 2018

a. Monitoring Schedule & Implementation Assurance

Plantings implemented through the Bureau's stream buffer initiative include a maintenance term, which consists of mowing, stake repair, and shelter maintenance. Successful plantings require the survival of 100 trees per acre. Each planting will be inspected bi-annually for ten years to ensure the success of the program, and once every three years after the ten year period. In addition, the homeowners have signed agreements to ensure that the planting areas are maintained and protected.

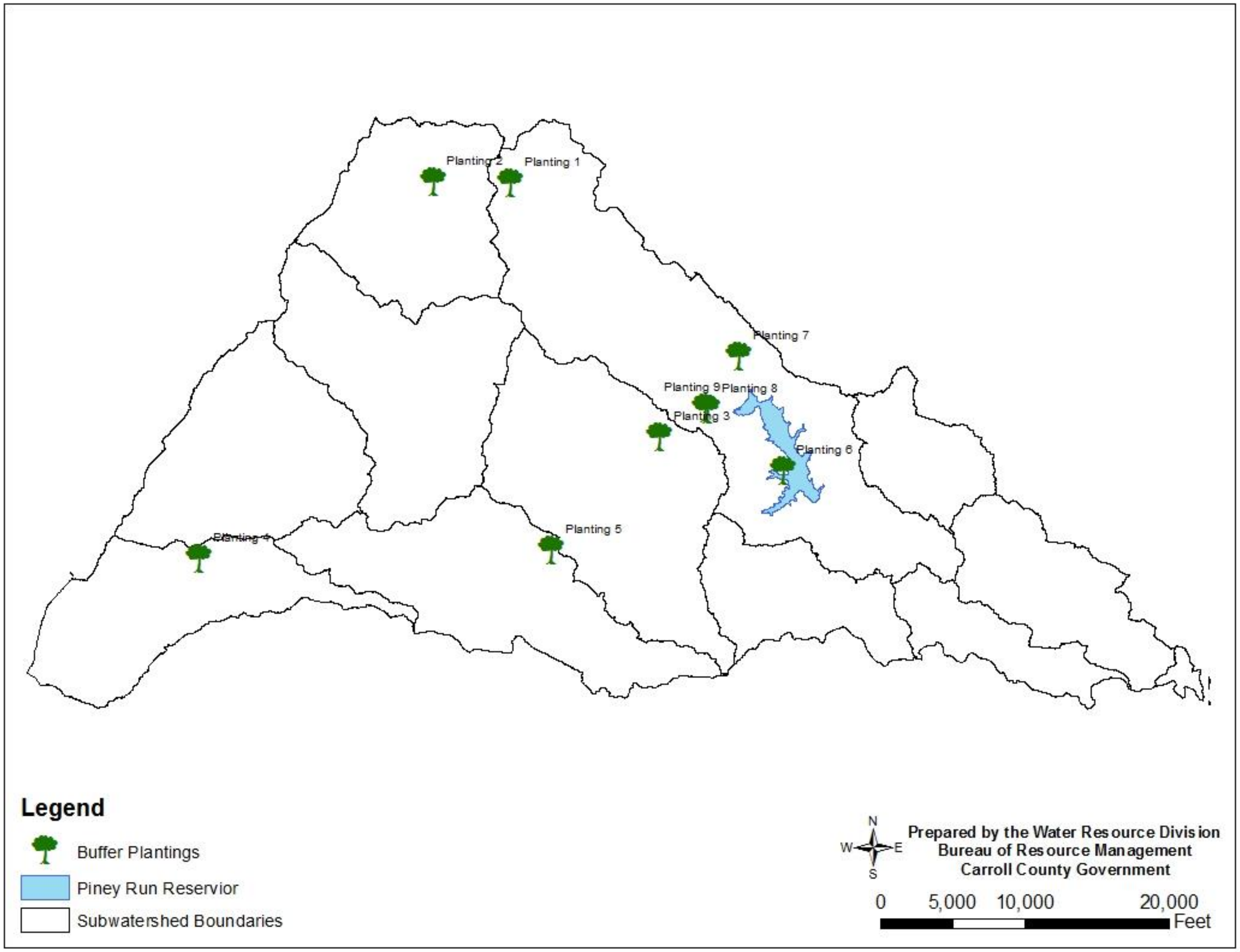


Figure 11: Stream Buffer Initiative Locations

E. Stream Restoration

Streams are dynamic systems that adjust to tectonic, climatic and environmental changes imposed upon them (Dollar, 2000). A stream system adjusts in order to maintain a steady state, or dynamic equilibrium between the driving mechanisms of flow and sediment transport and the resisting forces of bed and bank stability and resistance to flow (Soar et al., 2001).

Historic land use and more recently, urbanization, has deteriorated the quality of streams within the Piedmont. Booth and Henshaw (2001) documented the increase of sediment yield and channel erosion within urbanizing streams, and research has shown that sediment yields in urban streams are more than an order of magnitude higher when compared to rural streams (Langland and Cronin, 2003).

The County has identified the implementation of stream restoration practices as a method to potentially reduce nutrient and sediment loadings within the watershed.

F. Streambank Regeneration

Accelerated streambank erosion occurs downstream of inadequately managed impervious from development. The proportion of rain water that previously infiltrated into the ground is reduced. Thus, causing immediate runoff, and increasing the total amount and velocity of flow in the receiving channel, accelerating erosion and resulting in greater sediment loads within the stream corridor.

There are two effective ways to reduce the destabilizing velocity increases in the receiving channel. The first is traditional stream restoration, increasing the plan form and bank resistance. The second is upland stormwater management, storing the total runoff volume and dissipating the acquired kinetic energy as turbulence in the water pool.

In the Piedmont, many residential, institutional, or commercial areas were developed prior to 1982 without any stormwater management or subsequently with peak flow control that matched existing conditions only, not really returning the runoff characteristics to predevelopment, as required by COMAR 26.17.02.01. Matching the existing hydrologic runoff response in these areas does not address existing streambank instability and does nothing to help restore streams or reduce current nutrient and legacy sediment export to the Bay.

Carroll County has been experimenting with the use of enlarged, enhanced, sand filters as primary stormwater management for more than 10 years. In an effort to determine the cause of these unanticipated stormwater management/quality/stream restoration benefits, we reanalyzed the design information. This showed that the Carroll County standard design reduced the two-year storm peak flow below that of an equivalent forested watershed in good condition. This has always been the goal of stormwater management, returning the hydrologic condition to that assumed to exist in pre-contact times.

Since the two-year flow is thought to control bank geometry, it makes sense that this would be an unintended benefit of truly adequate stormwater management. How far downstream the effect extends is site specific and depends on the soil types and land uses in the unmanaged portion of the watershed below the sand filter.

Although streambank regeneration is not currently an approved practice in the 2014 MDE guidance document (MDE, 2014), the guidance states that innovative practices that are not approved under the Maryland Stormwater Design Manual (MDE, 2000) nor have an MDE or CBP assigned pollution removal efficiency can be used to offer jurisdictions additional options toward watershed restoration activities, provided that there is proper documentation and monitoring to verify pollutant removal efficiencies acceptable to MDE. The County has developed a paired watershed approach to evaluate the effectiveness of upland stormwater management practices on stream channel protection protection and began a 3-year study in 2016 collecting the necessary data to document the sediment and nutrient reduction benefits associated with this practice. The results will inform recommendations to credit upland stormwater practices as a hydrogeomorphic stream stabilization technique for sediment reductions.

Interim nutrient reductions associated with streambank regeneration are included in Appendix C in anticipation of the study results and are derived from the default stream restoration credit included in the 2014 MDE guidance.

G. Road Maintenance Projects

County and Municipal road crews perform regular maintenance to infrastructure such as; inlet cleaning, street sweeping, storm drain cleaning, and removal of impervious surfaces. Accounting for the number of inlets cleaned or the tons of debris removed provides an accurate measurement of how these particular practices reduce loadings within the watershed.

Street sweeping, using either mechanical or vacuum-assisted equipment will remove buildup of pollutants that have been deposited along the street or curb, whereas, the removal of impervious surfaces will improve water quality by changing the hydrologic conditions within the watershed. Road maintenance projects completed within the South Branch Patapsco Watershed are shown in Table 11.

Table 11: Road Maintenance Projects

Management Practice	**Inlet Cleaning**		
Town	Tons Removed	12-Digit Watershed	Date of Completion
Sykesville	0.25	1022	Annual

H. Septic Systems

With the decline in water quality to the Chesapeake Bay, Senate Bill 320, Bay Restoration Fund, was signed into law in May of 2004. The purpose of the Bay Restoration Fund (BRF) was to address a major contributor of nutrients to the Bay such as effluent discharge, by creating a dedicated fund to upgrade Maryland's wastewater treatment plants with enhanced nutrient removal (ENR) technology to improve wastewater effluent quality. A portion of the BRF also collects fees from septic system users that will be utilized to upgrade on-site disposal systems (OSDS) to best available technology (BAT) as the drainage from failed septic systems may make its way through the drain field and eventually into local waters (Clary, et al. 2008). New septic systems, repairs, and replacements are tracked through the County Health Department.

Nutrient loads from failing septic systems are not part of the MS4 load reduction requirements for the County or Towns. However, upgrading septic systems or connecting houses to a sanitary sewer system will help the overall achievability of the TMDLs. Since 2009, thirty one (31) septic systems within the South Branch Patapsco Watershed have been repaired and thirty five (35) new systems have been built utilizing Best Available Technology (BAT). Twenty nine (29) of these projects have been via the Bay Restoration Fund. BAT has been proven to be effective at nitrogen removal but has not been shown to reduce Phosphorus. Any reductions to bacteria loading are also unknown at this time. Septic systems that have been built or repaired utilizing BAT within the South Branch Pataspco Watershed are listed in Appendix C.

I. Agricultural Best Management Practices (BMPs)

Agricultural BMPs are on-the-ground practices that help minimize runoff and delivery of pollutants into our waterways. Practices can be categorized as soft BMPs such as streambank fencing and cover cropping or hard BMPs like heavy use areas and waste storage structures. Long term waste storage structures allows for manure to be applied during appropriate weather conditions to reduce runoff and allows some bacteria to die off during the storage practice (Walker, et al. 1990).

Farm conservation and nutrient management plans consist of a combination of agronomic and engineered management practices that protect and properly utilize natural resources in order to prevent deterioration of the surrounding soil and water. A conservation plan is written for each individual operation and dictates management practices that are necessary to protect and improve soil and water quality. A nutrient management plan is a plan written for the operator to manage the amount, timing, and placement of nutrients in order to minimize nutrient loss to the surrounding bodies of water while maintaining optimum crop yield.

This document presents restoration strategies that are proposed to meet water quality standards for developed source types. Nutrient reductions for agronomic practices are not quantified or used as credit to meet TMDLs for developed land.

VI. Local TMDL Project Tracking, Reporting, Modeling and Monitoring

The restoration projects listed in this plan and any future projects progress towards meeting the stormwater WLA will be documented through a combination of modeling and BMP reductions calculated based on the 2014 Maryland Department of the Environment (MDE) guidance document entitled: *Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated*, and all future guidance revisions. Project information will also be tracked through an Excel spreadsheet database. The database will track implementation data over time, such as drainage area, impervious area, runoff depth treated, project type, project location, inspection, maintenance, and performance. GIS will also be used to track the location of projects. Appendix A provides a complete list of restoration activities and project status. Appendix C provides the associated reduction values.

A. Data Reporting

Information derived from the baseline tracking and project monitoring will be updated and summarized in Appendix A of this document as needed. Implementation progress will also be included in the County's annual MS4 report, which will document the success to date of the plan in improving watershed conditions and progress towards meeting all applicable TMDL's as per section E.4 of the County's NPDES MS4 permit.

B. Modeling with Mapshed

The MapShed (version 1.3.0; MapShed, 2015) tool developed by Penn State University was utilized by the Bureau of Resource Management to document progress towards meeting the stormwater WLA. This modeling approach allowed for specific local data (streams, topology, and land use) to be used as the basis for TN, TP, and TSS reductions.

1. Model Description

MapShed is a customized GIS interface that is used to create input data for the enhanced version of the Generalized Watershed Loading Function (GWLF-E) watershed model. The MapShed tool uses hydrology, land cover, soils, topography, weather, pollutant discharges, and other critical environmental data to develop an input file for the GWLF-E model. The basic process when using MapShed is: 1) select an area of interest, 2) create GWLF-E model input files, 3) run the GWLF-E simulation model, and 4) view the output. The MapShed geospatial evaluator and the GWLF-E models have been used for TMDL studies in Pennsylvania (Betz & Evans, 2015), New York (Cadmus, 2009), and New England (Penn State, 2016). More information about model inputs and BMP assumptions can be found in Appendix D.

2. Restoration Progress: December 2019

Current restoration strategies outlined in this document are efforts initiated to meet Stormwater WLA TMDL requirements within the Liberty Watershed. As described in Section I, phosphorus and nitrogen loads within the watershed must be reduced in order to meet water quality standards.

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 local TMDL suggests an urban phosphorus load reduction of 15% and urban nitrogen load reduction of 15% from the 1995 baseline year. The GWLF-E modeling approach used has a different accounting procedure than the Chesapeake Bay Watershed Model, as the inputs, the load estimation algorithms, and the end-points are different. As the focus of this effort is on local TMDLs, with the assumption that meeting local TMDLs will lead to meeting the Chesapeake Bay TMDL requirements, the end point is the waterbody of concern (i.e. Liberty Reservoir). The GWLF-E model allowed for specific local GIS information (streams, topology, and land use) to be used as the basis for TN, TP, and TSS reductions while still maintaining the ability to estimate the relative urban load reductions from the baseline year. A baseline year of 2001 was used as a proxy for the 1995 baseline year in the TMDL, as land cover data from 2001 was the closest available for that time period. The modeled 2001 baseline scenario did not include any BMPs and therefore represents the land use loads with no treatment provided. Load reductions from BMPs installed after the 1995 TMDL baseline year can be counted toward load reductions necessary to meet the TMDL, even though 2001 was used as the baseline proxy year. For reference, the modeled baseline urban phosphorus load using the 2001 land cover was 861.77 lbs, which equates to a 15% reduction of 129.26 lbs and the modeled urban nitrogen load was 4,815.23 lbs., which equates to a 15% reduction of 722.28 lbs. (Table 12).

The projects completed as of December, 2019 are providing 108.75 pounds of TP reduction, and 431.61 pounds of TN reduction. The planned projects, would provide another 41.23 lbs of TP reduction and 136.93 pounds of TN reduction (Table 13). These reductions are delivered (i.e. they include the GWLF-E estimated TN, TP, and TSS delivery ratios). Refer to Appendix B for the complete documentation of load reductions from different practice types.

The current progress of implemented and planned projects is shown in Figures 12 and 13. To achieve remaining TMDL requirements, the county will utilize the MapShed tool to assist in selecting a mix of techniques and practice types for locations identified in future Community Investment Program (CIP) budgets to progress towards fully attaining the Baltimore Harbor TMDL. At this point it is not feasible, and is fiscally not possible to identify or specify the exact projects, or locations beyond the current CIP.

It is likely that these projects will also reduce bacteria contributions to the watershed. However, currently MDE does not provide guidance on bacteria reduction efficiencies.

Table 12: Total Phosphorus and Total Nitrogen Load Reduction in the South Branch Patapsco Watershed in Carroll County.

Total Phosphorus Load Reduction					
Modeled Baseline Load (lbs)	**% Required Reduction from TMDL**	**Required Load Reduction based on Modeled Baseline (lbs)**	**Reduction from Current BMPs (lbs)**	**Reduction from Planned Strategies (lbs)**	**Total % Reduction Achieved**
861.77	15%	129.26	108.75	41.23	17%
Total Nitrogen Load Reduction					
Modeled Baseline Load (lbs)	**% Required Reduction from TMDL**	**Required Load Reduction based on Modeled Baseline (lbs)**	**Reduction from Current BMPs (lbs)**	**Reduction from Planned Strategies (lbs)**	**Total % Reduction Achieved**
4,815.23	15%	722.28	431.61	136.93	12%

Table 13: Comparison of Total Phosphorus and Total Nitrogen Delivered Load Reductions by Restoration Strategies. This table includes both proposed and existing BMPs.

Total Phosphorus Delivered Load Reductions (lbs/yr)					
Status	**Pond Retrofits**	**Buffers**	**Stream Restoration**	**Catch Basin/ Inlet Cleaning**	**Easements**
Completed	76.74	1.14	14.44	0.02	16.41
Planned	28.49		12.74		
Total Nitrogen Delivered Load Reductions (lbs/yr)					
Completed	324.39	5.12	16.87	0.05	85.20
Planned	122.05		14.88		

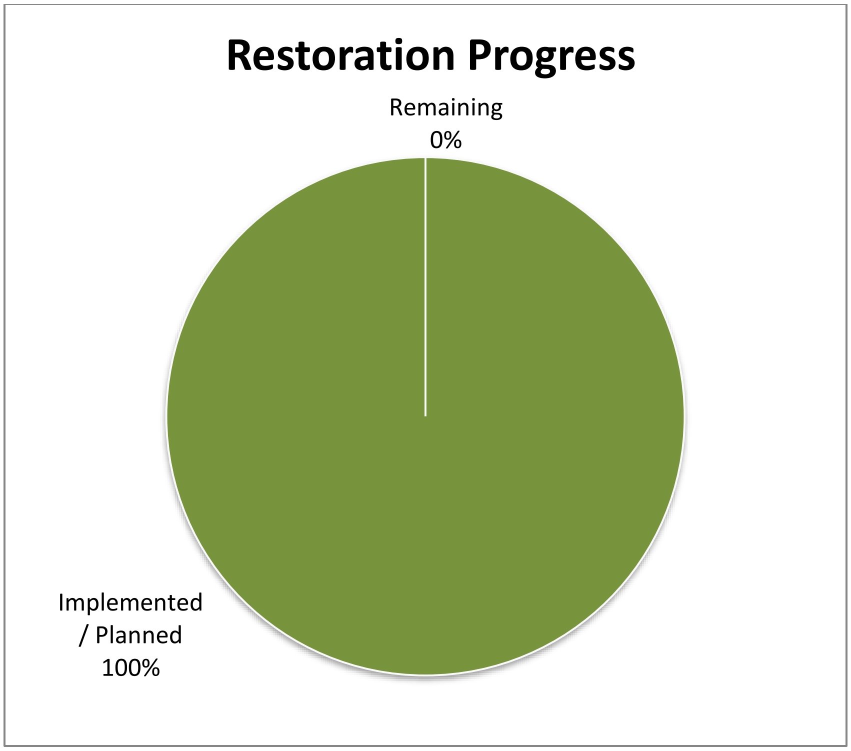


Figure 12: 2019 Restoration Progress-Phosphorus

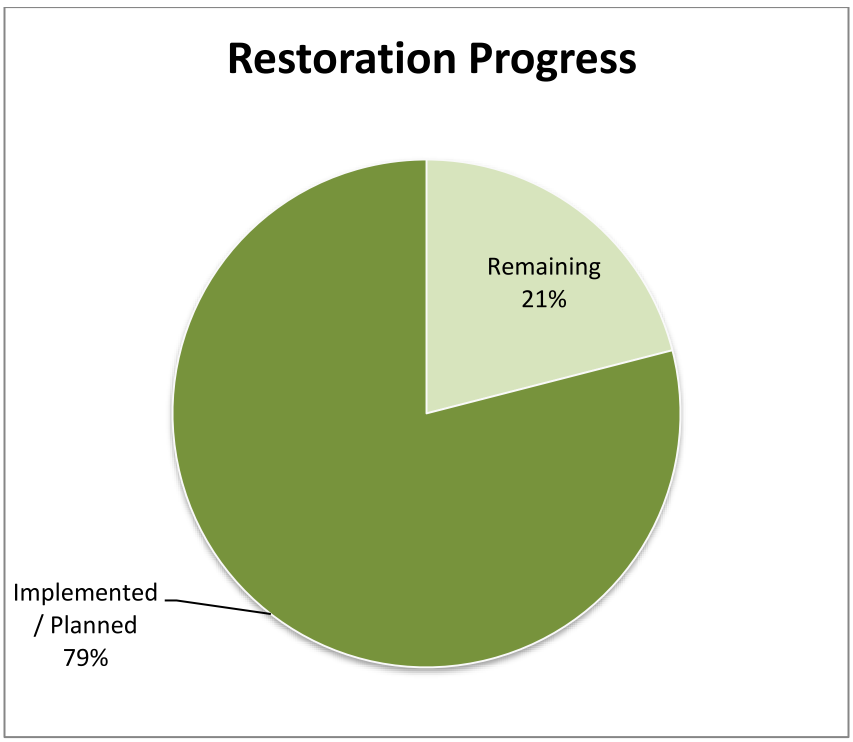


Figure 13: 2019 Restoration Progress-Nitrogen

3. Bacteria Load Reduction

The bacteria TMDL is calculated and broken down into four main sources; human, domestic pet, livestock and wildlife. While the County recognizes a need for bacteria reductions across all sources, this plan will focus primarily on the reduction of human related sources associated with the SW WLA.

c. Human Source Elimination

Elimination of human sources of bacteria within the South Branch Patapsco Watershed will occur through continued implementation of measures by the County and the municipalities public works departments. Replacing or repairing failing infrastructure within the service area will reduce the infiltration and inflow (I&I) being treated at the facility.

The Carroll County Bureau of Utilities is in the process of completely updating their Regulations and Standard Specifications and Design Details for water and sewer infrastructure for the first time since 1992.

Changes that shall be implemented with this update include increasing required sewer main encasements at all proposed stream crossings.

This shall include both more comprehensives encasement design requirements as well as an increase in the distance encasement shall be required to be extended beyond the edges of the stream crossing. Additionally, manhole design requirements shall now include factory installed epoxy coatings on new manholes to be installed on proposed or upgraded sewer mains.

Table 14 lists infrastructure related measures that have been implemented since the baseline year that would assist in reducing bacteria counts within the watershed.

Table 14: Waste Collection Infrastructure Upgrades

	County	Sykesville	Mount Airy
BAT Upgrades	66	0*	0*
Casings/Linings	TBD	TBD	TBD
Lateral line replacements	TBD	TBD	TBD
Pump Station upgrade	TBD	TBD	TBD

***upgrades occurred within corporate boundaries**

d. Domestic Pet Source Elimination

Bacteria contributions from domestic pets can potentially have a significant impact on receiving water bodies from runoff carrying waste into nearby streams. The County anticipates reductions from domestic pet sources to occur through education and outreach of the importance of eliminating this potential source.

e. Stormwater Source Elimination

It is likely that stormwater management projects will also reduce bacteria contributions within the watershed, particularly wet or failing facilities converted to surface sand filters. However, currently MDE does not provide guidance on bacteria reduction efficiencies or loading rates of bacteria by land use.

The County is focused on retrofitting older facilities to current standards, maintaining current facilities that will reduce and deter wildlife sources of bacteria from entering the County's MS4 network, as well as continuing to implement alternative practices such as street sweeping and inlet cleanings to minimize potential bacteria sources from entering the storm drain system.

C. Water Quality Monitoring

The County's current monitoring strategy is focused primarily around retrofit locations where reductions in loadings can be documented from the before and after study approach. This comprehensive monitoring program is intended to validate the overall effectiveness of BMPs and document the efficiency of innovations made to BMPs.

1. Retrofit Monitoring

The Bureau of Resource Management currently monitors one location within the South Branch Patapsco Watershed. The Meridale Gardens site, shown in Figure 14, is located within the South Branch Patapsco subwatershed (1028), and is located entirely within the corporate limits of the Town of Manchester.

This stormwater management facility was originally constructed as a detention facility in 1993 and was retrofitted in 2018 to a surface sand filter to provide water quality, recharge, and channel protection volume. The drainage area is approximately 81 acres, of which, 24 acres or 29.6% is impervious.

Bi-weekly monitoring at the Meridale Gardens site began in December of 2017 and consists of chemical grab samples with corresponding discharge measurements in order to calculate loadings. The chemical monitoring parameters, methods, and detection limits for the Meridale Gardens site can be found in Table 15. Additional monitoring at this location includes spring macro-invertebrate collection, which are based upon protocols set by Maryland's MBSS program (Stranko et al, 2014).

Table 15: Water Quality Parameters and Methods

Parameter	Reporting Limit	Method
Total Suspended Solids	1 mg/l	SM 2540 D-97
Total Phosphorus	0.01 mg/l	SM 4500-P E-99
Ortho Phosphorus	0.01 mg/l	SM 4500-P E-99
Nitrate-Nitrite	0.05 mg/l	SM 4500-NO3 H00

2. Bacteria Trend Monitoring

Carroll County's trend monitoring program is focused around showing long term trends of bacteria concentrations within the urbanized areas of Carroll County associated with the SW WLA. Monitoring within the South Branch Patapsco Watershed began in June of 2019, and is currently performed at seven locations, shown in Figure 15. Samples are currently collected on the 2nd Thursday of each month by the County's Bureau of Resource Management.

a. Monitoring Results

Sample results are reported in MPN/100mL. Table 16 shows the monitoring results for the entire year, whereas Table 17 displays only seasonal data (May 1st to September

30th). Both the annual and seasonal table differentiate samples between low flows, high flows, as well as all flows combined, and are reported as geometric means. Geometric means that are below the 126 MPN/100mL water quality standard are highlighted in blue.

Table 16: Bacteria Monitoring Annual Data MPN/100mL

Location	Flow Type	2019	
		# Samples	MPN
PRT06	Low	4	56
	High	0	n/a
	All	4	56
PRT07	Low	4	91
	High	0	n/a
	All	4	91
PRT08	Low	4	84
	High	0	n/a
	All	4	84
PRT09	Low	4	64
	High	0	n/a
	All	4	64
PRT10	Low	4	386
	High	0	n/a
	All	4	386
PRT11	Low	2	169
	High	0	n/a
	All	2	169
PRT12	Low	3	251
	High	0	n/a
	All	3	251

Table 17: Bacteria Monitoring Seasonal Data (May 1 – September 30) MPN/100mL

Location	Flow Type	2019	
		# Samples	MPN
PRT06	Low	4	56
	High	0	n/a
	All	4	56
PRT07	Low	4	91
	High	0	n/a
	All	4	91
PRT08	Low	4	84
	High	0	n/a
	All	4	84
PRT09	Low	4	64
	High	0	n/a
	All	4	64
PRT10	Low	4	386
	High	0	n/a
	All	4	386
PRT11	Low	2	169
	High	0	n/a
	All	2	169
PRT12	Low	3	251
	High	0	n/a
	All	3	251

In addition to geometric mean calculations, each individual sample was analyzed and compared to the single sample exceedance standards, as presented in Table 2 for full body contact. Table 18 shows the percentage of individual samples that exceeded the standards based on frequency of full body contact during the seasonal time period.

Table 18: Single Sample Exceedance Frequency

Location	MPN Criteria	Flow Type	2019	
			# Samples	% Exceeded
PRT06	576	low	4	0%
		high	n/a	n/a
	410	low	4	0%
		high	n/a	n/a
	298	low	4	0%
		high	n/a	n/a
	235	low	4	0%
		high	n/a	n/a
PRT07	576	low	4	0%
		high	n/a	n/a
	410	low	4	0%
		high	n/a	n/a
	298	low	4	0%
		high	n/a	n/a
	235	low	4	0%
		high	n/a	n/a
PRT08	576	low	4	0%
		high	n/a	n/a
	410	low	4	0%
		high	n/a	n/a
	298	low	4	0%
		high	n/a	n/a
	235	low	4	25%
		high	n/a	n/a
PRT09	576	low	4	0%
		high	n/a	n/a
	410	low	4	0%
		high	n/a	n/a

	298	low	4	0%
		high	n/a	n/a
	235	low	4	0%
		high	n/a	n/a
PRT10	576	low	4	25%
		high	n/a	n/a
	410	low	4	25%
		high	n/a	n/a
	298	low	4	25%
		high	n/a	n/a
	235	low	4	50%
		high	n/a	n/a
PRT11	576	low	2	0%
		high	n/a	n/a
	410	low	2	0%
		high	n/a	n/a
	298	low	2	0%
		high	n/a	n/a
	235	low	2	0%
		high	n/a	n/a
PRT12	576	low	3	0%
		high	n/a	n/a
	410	low	3	33%
		high	n/a	n/a
	298	low	3	33%
		high	n/a	n/a
	235	low	3	33%
		high	n/a	n/a

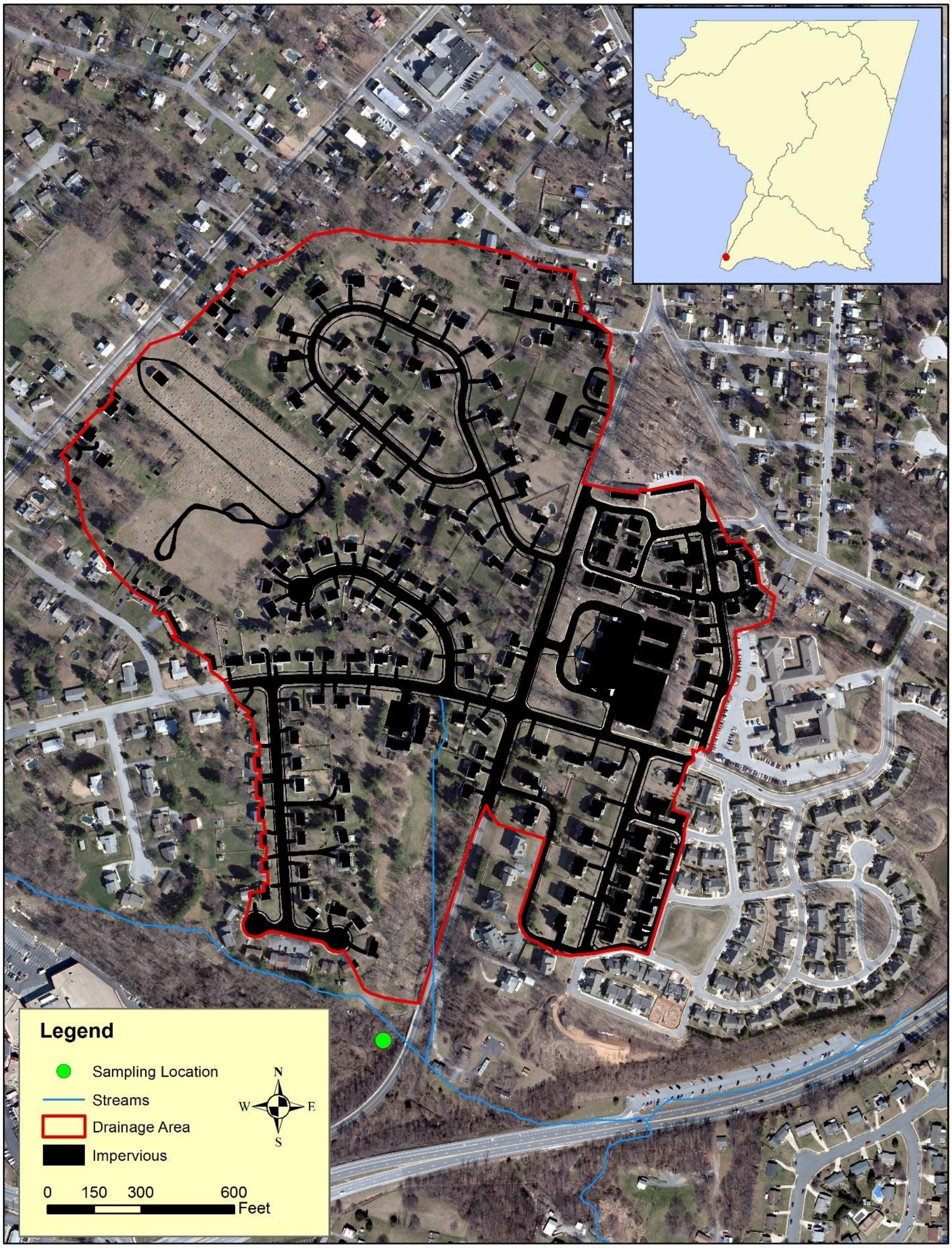


Figure 14: Retrofit Monitoring Location

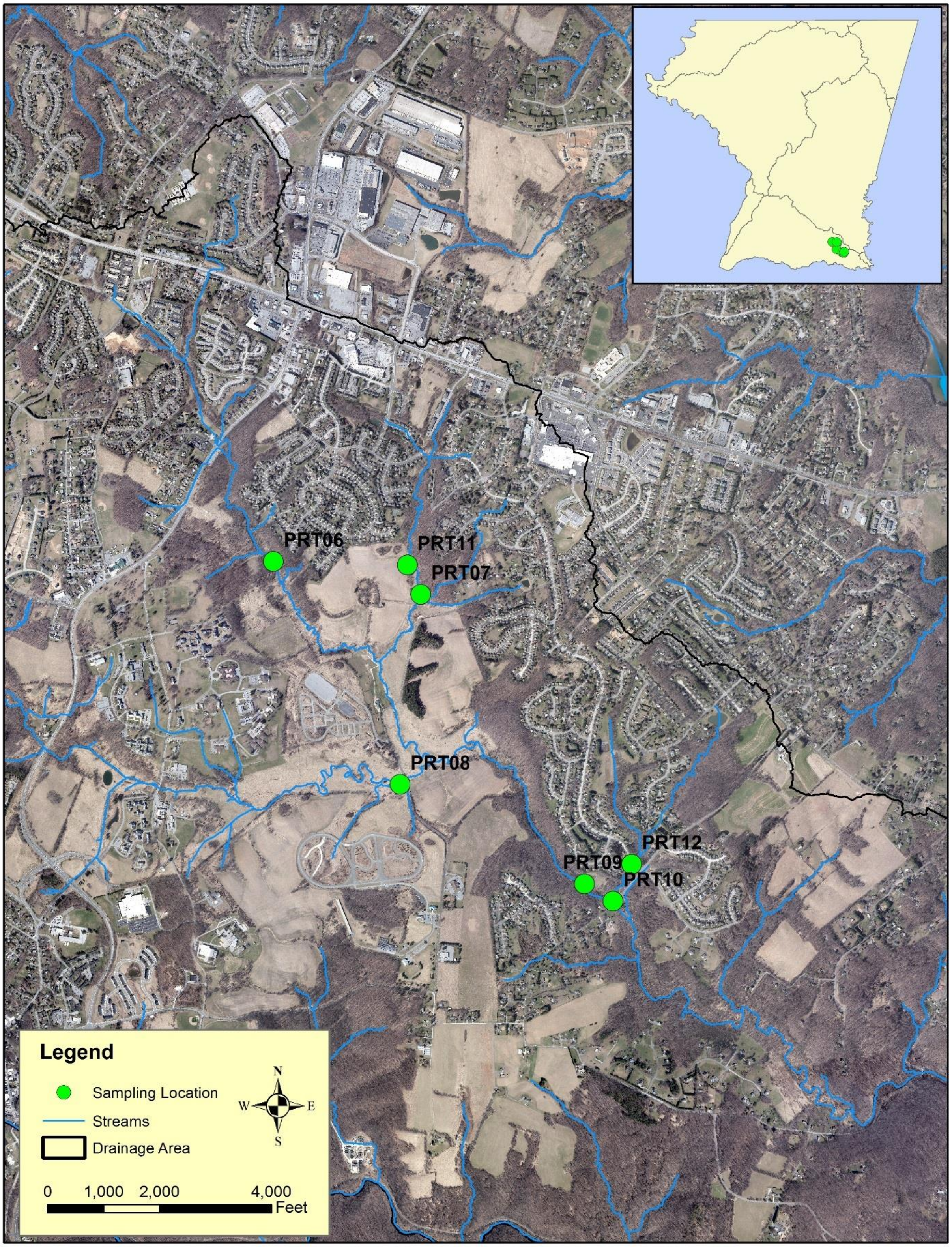


Figure 15: Bacteria Monitoring Locations

VII. Chesapeake Bay Restoration

This section describes progress towards achieving the County's TMDL requirements associated with the stormwater WLA for the Chesapeake Bay watershed (Table 20). BMPs and restoration projects that have been either completed or proposed to address local TMDL's within the South Branch Patapsco Watershed will ultimately reduce loadings to the Chesapeake Bay.

A. Purpose and Scope

The purpose of the Chesapeake Bay TMDL is to establish specific pollutant loadings for all 92 river segments within the Bay watershed in order to meet the individual designated uses within the Chesapeake Bay. The Chesapeake Bay TMDL is the largest in the country, covering 64,000 square miles across seven jurisdictions; Delaware, District of Columbia, Maryland, New York, Pennsylvania, Virginia, and West Virginia.

Each designated use has established water quality standards or criteria for supporting those uses, which is established by individual states within the Chesapeake Bay watershed. The requirement for States to establish water quality criteria to meet specific designated uses came from section 303(c) of the 1972 Clean Water Act (CWA) that requires all waters of the U.S. to be "fishable" or "swimmable".

B. Background

Despite restoration efforts over the last couple of decades to restore the Chesapeake Bay and its tributaries, the EPA, in December of 2010, established the Chesapeake TMDL. The Chesapeake Bay TMDL identified reductions necessary across all jurisdictions within the watershed, and set limits on nutrient loadings in order to meet the designated uses within the Bay and its tributaries.

The pollutants of concern for the Bay TMDL are sediment and nutrients; more specifically nitrogen and phosphorus. Excessive nitrogen and phosphorus in the Chesapeake Bay and its tidal tributaries promote a number of undesirable water quality conditions such as excessive algal growth, low dissolved oxygen (DO), and reduced water clarity (Smith et al. 1992; Kemp et al. 2005).

The TMDL sets Bay watershed limits of 185.9 million pounds of nitrogen, 12.5 million pounds of phosphorus and 6.45 billion pounds of sediment per year; a 25 percent reduction in nitrogen, 24 percent reduction in phosphorus and 20 percent reduction in sediment. The Bay TMDL further states that all necessary control measures to reduce loadings must be in place by 2025, with a 60% reduction in loadings by 2017.

1. Water Quality Standards and Designated Uses

EPA's water quality standards (WQS) regulation defines designated uses as the "uses specified in WQS for each waterbody or segment, whether or not they are being attained" (40 CFR131.3). The 1987 Chesapeake Bay Agreement included a commitment to "develop and adopt guidelines for the protection of water quality and habitat conditions necessary to support the living resources found in the Chesapeake Bay system, and to use these guidelines in the implementation of water quality and habitat quality programs" (CEC 1987). Chesapeake Bay designated uses, protection, habitats and locations are listed in Table 19, and the tidal water designated use zones are shown in Figure 16.

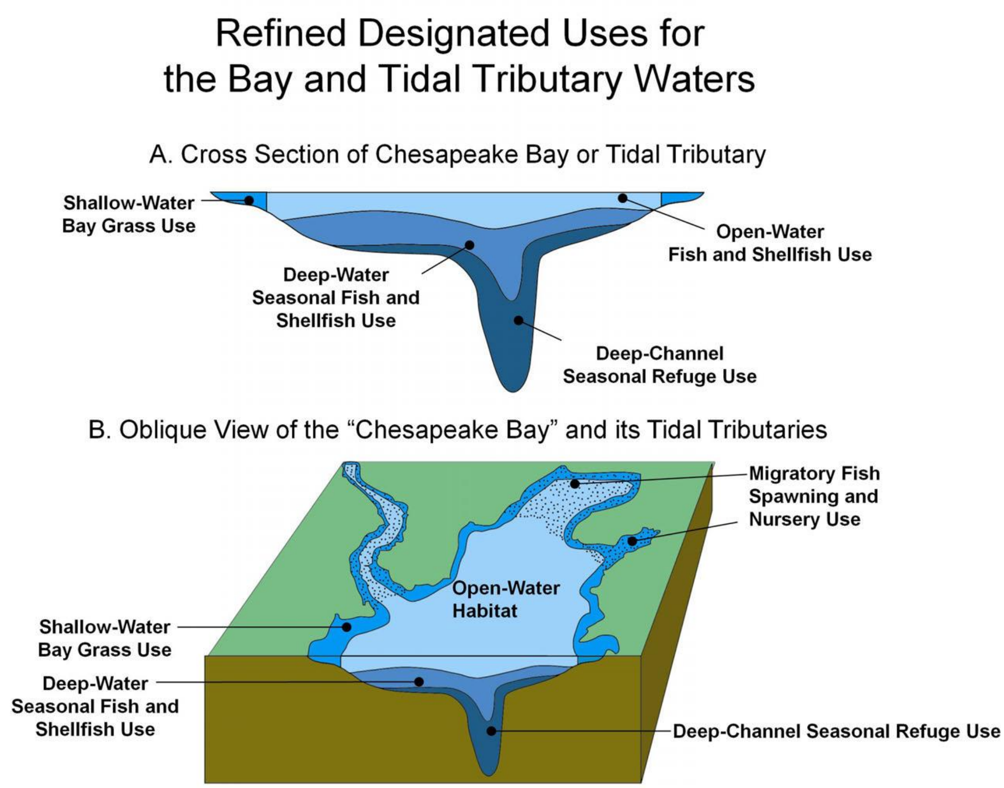


Figure 16: Chesapeake Bay Tidal Water Designated Use Zones (source: USEPA2003d)

The Chesapeake Bay designated use boundaries are based on a combination of natural factors, historical records, physical features, hydrology, and other scientific considerations (USEPA 2003d, 2004e, 2010a). The tidal water designated use zones for areas within Carroll County include; use 1, migratory fish and spawning nursery, use 2, shallow water, and use 3, open water fish and shellfish. Criteria for the migratory fish spawning and nursery, shallow-water Bay grass and open-water fish and shellfish designated uses were set at levels to prevent impairment of growth and to protect the reproduction and survival of all organisms living in the open-water column habitats (USEPA 2003a).

Table 19: Chesapeake Bay Designated Uses

Designated Use	What is Protected	Habitats and Locations
1. Migratory Fish Spawning and Nursery	Migratory fish including striped bass, perch, shad, herring and sturgeon during the late winter/spring spawning and nursery season.	In tidal freshwater to low-salinity habitats. This habitat zone is primarily found in the upper reaches of many Bay tidal rivers and creeks and the upper mainstem Chesapeake Bay.
2. Shallow-Water	Underwater bay grasses and the many fish and crab species that depend on this shallow-water habitat.	Shallow waters provided by grass beds near the shoreline.
3. Open-Water Fish and Shellfish	Water quality in the surface water habitats to protect diverse populations of sportfish, including striped bass, bluefish, mackerel and seatrout, bait fish such as menhaden and silversides, as well as the shortnose sturgeon, and endangered species.	Species within tidal creeks, rivers, embayments and the mainstem Chesapeake Bay year-round.
4. Deep-Water Seasonal Fish and Shellfish	The many bottom-feeding fish, crabs and oysters, and other important species such as the bay anchovy.	Living resources inhabiting the deeper transitional water column and bottom habitats between the well-mixed surface waters and the very deep channels during the summer months. The deep-water designated use recognizes that low dissolved oxygen conditions prevail during the summer due to a water density gradient (pycnocline) formed by temperature and salinity that reduces re-oxygenation of waters below the upper portion of the gradient.
5. Deep-Channel Seasonal Refuge	Bottom sediment-dwelling worms and small clams that act as food for bottom-feeding fish and crabs in the very deep channel in summer.	Deep-channel designated use recognizes that low dissolved oxygen conditions prevail in the deepest portions of this habitat zone and will naturally have very low to no oxygen during the summer.

C. River Segment Location

The South Branch Patapsco Watershed is located within the Patapsco River segment of the Chesapeake Bay. The Patapsco segment covers 374,186 acres, approximately 126,716 acres (34%) of this river segment is within Carroll County. The location of the Patapsco River segment is shown in Figure 17.

D. Restoration Progress

Chesapeake Bay TMDL baseline loads and required reductions for Carroll County were obtained from MDE and used in conjunction with the 2014 MDE Guidance document entitled: *Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated* to evaluate Bay restoration progress. Loading rates of TN, TP, and TSS for urban land were obtained from MDE (MDE, 2014) and used to calculate load reductions from BMPs. These loading rates from MDE were used instead of developing watershed-specific loading rates using MapShed because they correspond to the broader accounting procedure used by the Chesapeake Bay Watershed Model.

Delivered load ratios were applied to BMP load reductions (Appendix E) calculated using the 2014 MDE Guidance document so that they correspond to the Bay TMDL delivered load allocations and reductions shown in Table 20. A delivered load is the amount of pollutant delivered to the tidal waters of the Chesapeake Bay or its tidal tributaries from an upstream point (chesapeakebay.net). Delivery factors differ by land-river segment and are based upon the estimated amount of attenuation that occurs in the tributaries before it reaches the mainstem of the Chesapeake Bay due to natural in-stream processes. The delivered load ratios for the Patapsco River segment within the South Branch Patapsco Watershed are; 0.11 for nitrogen, 0.27 for phosphorus, and 0.47 for suspended sediment. Essentially, if one pound of nitrogen is discharged into a tributary within the South Branch portion of the Patapsco River segment, only 11% of that pound is reaching the Bay.

Table 20 shows the Chesapeake Bay TMDL for the Patapsco land river segment portion of Carroll County, as well as the progress toward meeting the TMDL from BMPs that are both implemented and planned within the South Branch Patapsco Watershed.

The baseline and reductions represent a combination of the County Phase I and Municipal Phase II based on the MOA between the County and each of the Municipalities that combined the jurisdictions into one permit. The aggregated load allocations for municipalities within the Potomac land river segment were added to the County load allocations obtained from the TMDL Data Center to determine the combined baseline loads and reductions.

The load reductions from BMPs implemented in the South Branch Patapsco Watershed show the restoration progress towards meeting the County's Bay TMDL reductions for the Patapsco segment shed. The South Branch Patapsco Watershed covers 30.57% of the Patapsco land-river segment within Carroll County.

Table 20: Carroll County[1] Bay TMDL Restoration Progress, including planned practices for the South Branch Patapsco Watershed based on Delivered Loads[2]

Total Phosphorus (TP)[3]					
2009 Delivered Baseline (lbs.)	% Reduction	Reduction (lbs.)	Reduction from BMPs implemented 2009-2019 (lbs.)	Reduction from BMPs implemented 2020-2025 (lbs.)	% Bay TMDL Red. by BMPs 2009-2025
1,752.52	35.26%	618.00	181.53	104.41	46.27%
Total Nitrogen (TN)					
2009 Delivered Baseline (lbs.)	% Reduction	Reduction (lbs.)	Reduction from BMPs implemented 2009-2019 (lbs.)	Reduction from BMPs implemented 2020-2025 (lbs.)	% Bay TMDL Red. by BMPs 2009-2025
16,038.74	13.79%	2,212.59	663.32	285.73	42.89%

[1]This table represents the combined County Phase I and Municipal Phase II loads and reductions for the Patapsco land river segment of Carroll County. The BMP load reductions represent the combined reductions for County and Municipal projects in the South Branch Patapsco Watershed.

[2]BMP load reductions reflect delivery ratios that have been applied to the edge-of-stream load reductions calculated in Appendix E.

[3]There is no Chesapeake Bay TMDL allocation for TSS. Per Maryland's Phase II WIP, if TP target is met, TSS target will be met.

Table 21: Carroll County Patapsco River Segment TMDL Restoration Progress, including planned practices for each watershed based on Delivered Loads[2]

8-Digit Watershed	Total Phosphorus (TP)[3]			Total Nitrogen (TN)		
	Reduction from BMPs implemented 2009-2019 (lbs.)	Reduction from BMPs implemented 2020-2025 (lbs.)	% Bay TMDL Red. by BMPs 2009-2025	Reduction from BMPs implemented 2009-2019 (lbs.)	Reduction from BMPs implemented 2020-2025 (lbs.)	% Bay TMDL Red. by BMPs 2009-2025
Liberty Reservoir Watershed	0	0	0%	0	0	0%
South Branch Patapsco Watershed	181.53	104.41	46.27%	663.32	285.73	42.89%
Total	**181.53**	**104.41**	**46.27%**	**663.32**	**285.73**	**42.89%**

[2]BMP load reductions reflect delivery ratios that have been applied to the edge-of-stream load reductions calculated in Appendix D.

[3]There is no Chesapeake Bay TMDL allocation for TSS. Per Maryland's Phase II WIP, if TP target is met, TSS target will be met.

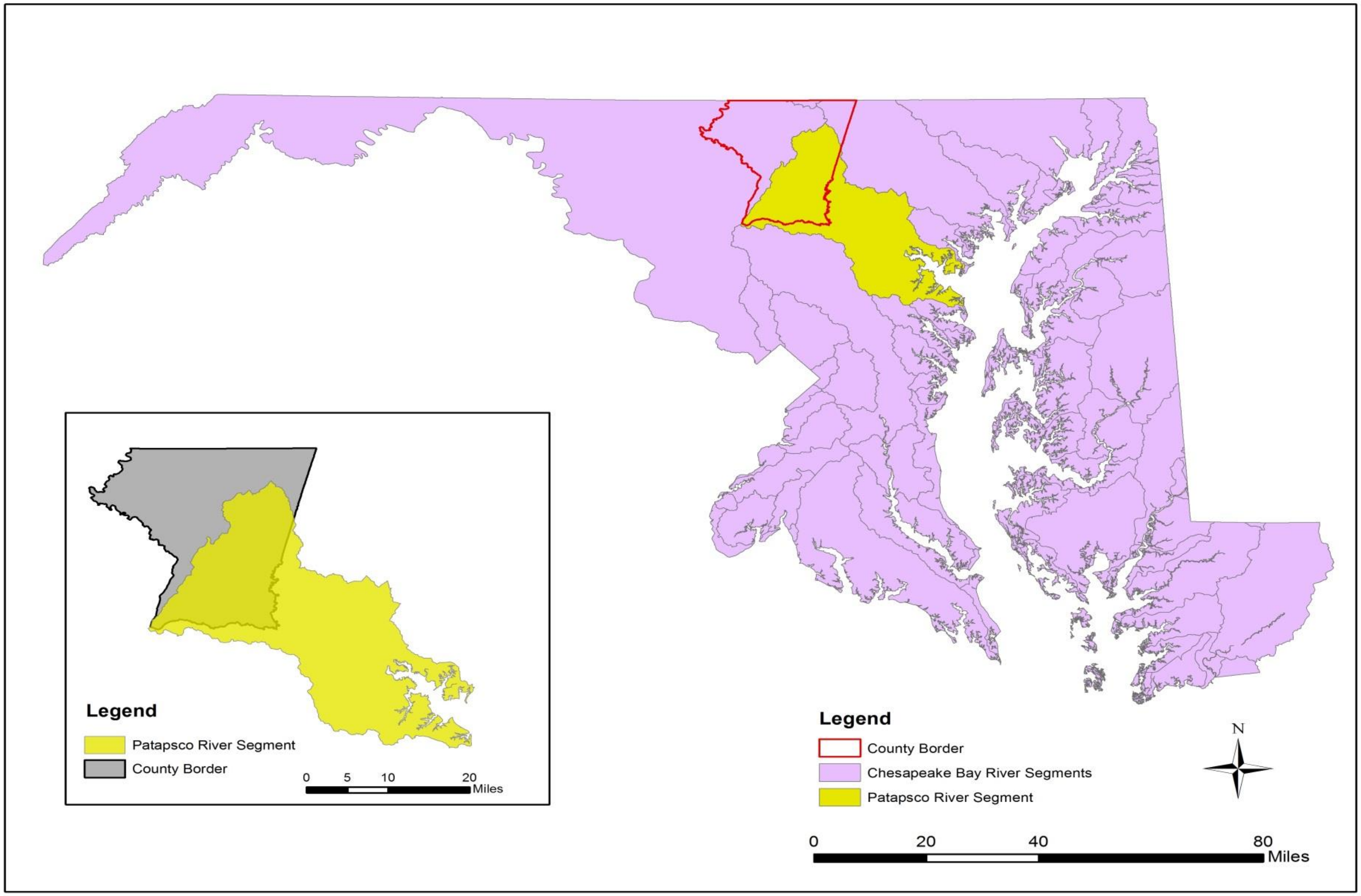


Figure 17: Chesapeake Bay River Segments

VIII. TMDL Implementation

Through the implementation of alternative BMPs, as well as the completed and planned stormwater management projects identified in the County's CIP, the phosphorus TMDL through 2019 will have achieved 94% of the required reductions since the baseline year of 1995. Based on currently identified projects, the required reduction is expected to be fully achieved by 2025. The implementation from baseline through the current CIP is achieving approximately 3.13% reduction in the TMDL/year since the baseline.

The nitrogen TMDL through 2019 will have achieved 62% of the required reduction since the baseline year of 1995. Based on current projects is expected to achieve 79% of the required reduction by 2025. The implementation from baseline through the current CIP is achieving approximately 2.63% reduction in the TMDL/year since the baseline.

If the County is able to maintain an approximate 2.63% reduction rate per year for nitrogen, the nitrogen TMDL in the Baltimore Harbor Watershed would be achieved by 2033. To achieve this goal, the County will continue to primarily focus on stormwater retrofits, implementing additional streamside buffer plantings, increased street sweeping and inlet cleaning, as well as potential stream restoration projects.

Table 22 lists the anticipated benchmark for each nutrient TMDL within the South Branch Patapsco Watershed, the current progress through the 2019 reporting year, the expected progress through the County's current CIP of 2025, and finally the projected end date of full implementation based on timeframe of implementation to date.

Table 22: Nutrient TMDL Benchmarks

Nutrient	2019	2025	2033
Phosphorus	94%	100%	100%
Nitrogen	62%	79%	100%

A. Bacteria Implementation

Through continued implementation of the County's restoration and programmatic programs to reduce pollutant loads within the watershed, the County anticipates a 2% reduction in the bacteria geometric mean per year during low flow conditions within the targeted monitoring locations associated with the County's SW WLA.

As more information regarding bacteria becomes better understood, the County will use an adaptive management process as to how to reach the pollutant target load.

IX. Caveats

While it is acknowledged lack of funding does not constitute a justification for noncompliance, this document provides potential restoration strategies that require additional assessment. Calculated nutrient reductions associated with projects that are in the preliminary planning stages may change as construction plans are finalized. It is not guaranteed that projects listed will be implemented. Implementation is contingent on approved funding and prioritization with other priorities County-wide.

In addition, Carroll County and its municipal partners still do not agree with the quantitative expectations related to Bay stormwater allocations (developed by MDE) for watersheds in Carroll County. Those objections have been forwarded to MDE by the Carroll County Water Resources Coordination Council via letters dated; November 11, 2011, June 27, 2012, and May 2, 2014. Therefore, the County and its municipal partners reserve the right to make future refinements to this plan based upon new or additional information, or should any previously designated allocation be found to be invalid by technical or legal processes.

X. Public Participation

Initial public outreach of this restoration plan will focus on landowners who will potentially be impacted by the watershed plan. Upon draft completion of the Baltimore Harbor Watershed restoration plan, the Bureau of Resource Management will post the plan for a period of thirty (30) days on the County’s website. During the thirty day public comment period, input from any stakeholder or others will be gathered and, as appropriate, may be incorporated into the plan before the final plan is released.

XI. References

Betz, D-E, B. Evans. 2015. Using MapShed Model for the Christina Basin TMDL Implementation and Water Quality Restoration. Villanova Urban Stormwater Partnership Symposium. Retrieved from https://www1.villanova.edu/content/dam/villanova/engineering/vcase/sym-presentations/2015/Presentationpdfs/3C4-Betz%20VILLANOVA10%2014%2015.pdf

CADMUS. 2009. Total Maximum Daily Load (TMDL) for Phosphorus in Summit Lake. The CADMUS Group, Inc., Waltham, MA. Retrieved from http://www.dec.ny.gov/docs/water_pdf/tmdlsummitlk09.pdf

Booth, D. and P. Henshaw. 2001. Rates of channel erosion in small urban streams. Water Science and Application. 2:17-38.

Clary, J., Jones, J. E., Urbonas, B. R., Quigley, M. M., stecker, E., & Wagner, T. (2008, May). Can Stormwater BMPs Remove Bacteria? New findings from the International Stormwater BMP Database. *Stormwater Magazine*. Retrieved from http://www.stormh2o.com/SW/Articles/Can_Stormwater_BMPs_Remove_Bacteria_203.aspx

CEC (Chesapeake Executive Council). 1987. *Chesapeake Bay Agreement*. Chesapeake Bay Program, Annapolis, MD.

Coyle, K. (2005). Environmental Literacy in America. Retrieved from http://www.neefusa.org/pdf/ELR2005.pdf

Dollar, E.S.J. 2000. Fluvial geomorphology. Progress in Physical Geography 24(3): 385-406.

Environmental Protection Agency. (2012, March 6). *Water: Monitoring & Assessment; 5.11 Fecal Bacteria*.

Evans, B. M., K. J. Corradini. 2015. MapShed Version 1.3 Users Guide. Penn State Institutes of Energy and the Environment. Retrieved from http://www.mapshed.psu.edu/Downloads/MapShedManual.pdf

Kemp, W.M., W.R. Boynton, J.E. Adolf, D.F. Boesch, W.C. Boicourt, G. Brush, J.C. Cornwell, T.R. Fisher, P.M. Glibert, J.D. Hagy, L.W. Harding, E.D. Houde, D.G. Kimmel, W.D. Miller, R.I.E. Newell, M.R. Roman, E.M. Smith, and J.C. Stevenson. 2005. Eutrophication of Chesapeake Bay: Historical trends and ecological interactions. *Marine Ecology Progress Series* 303:1–29.

Klein, R. 1979. Urbanization and stream quality impairment. Water Resources Bulletin 15:948–963.

Langland, M. and S. Cronin, 2003. A summary report of sediment processes in Chesapeake Bay and watershed. U.S. Geological Survey Water Resources Investigation Report 03-4123 Maryland Department of the Environment (MDE). (2000). Maryland Stormwater Design Manual , Volumes I and II.

MapShed [Computer Software]. 2015. Retrieved from http://www.mapshed.psu.edu/download.htm.

Maryland Assessment and Scenario Tool (MAST). 2016. MAST Source Data. Retrieved from http://www.mastonline.org/Documentation.aspx.

Maryland Department of the Environment (MDE). (2000). Maryland Stormwater Design Manual , Volumes I and II.

Maryland Department of the Environment (MDE). (2008). Total Maximum Daily Loads of Nitrogen and Phosphorus for the Baltimore Harbor in Anne Arundel, Baltimore, Carroll and Howard Counties and Baltimore City, Maryland.

Maryland Department of the Environment (MDE). (2011). Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated, Guidance for National Pollution Discharge Elimination System Stormwater Permits. Retrieved from: http://www.mde.state.md.us/programs/Water/StormwaterManagementProgram/Documents/NPDES%20Draft%20Guidance%206_14.pdf.

Maryland Department of the Environment (MDE). (2014). Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated. Retrieved from: http://www.mde.state.md.us/programs/Water/StormwaterManagementProgram/Documents/NPDES%20MS4%20Guidance%20August%2018%202014.pdf.

Paul, M. J., and J. L. Meyer. 2001. Streams in the urban landscape. Annual Review of Ecology and Systematics 32:333-65.

Penn State. 2016. Mapshed Overview. Retrieved from http://www.mapshed.psu.edu/overview.htm

Smith, D.E., M. Leffler, and G. Mackiernan, eds. 1992. *Oxygen Dynamics in the Chesapeake Bay: A Synthesis of Recent Research.* Maryland and Virginia Sea Grant College Program, College Park, MD.

Southerland, M., L. Erb, G. Rogers, R. Morgan, K. Eshleman, M. Kline, K. Kline, S. Stranko, P. Kazyak, J. Kilian, J. Ladell, and J. Thompson. 2005. Maryland Biological Stream Survey 2000-2004, Volume 14: Stressors Affecting Maryland Streams (CBWP-MANTA-EA-05-11). Report prepared for Maryland Department of Natural Resources, Monitoring and Non-Tidal Assessment Division, Annapolis, MD.

Scott Stranko, Dan Boward, Jay Kilian, Andy Becker, Matthew Ashton, Mark Southerland, Beth Franks, William Harbold, and Jason Cessna. 2014. Maryland Biological Stream Survey: Round Four Field Sampling Manual

Soar, P.J., and C.R. Thorne. September 2001. Channel restoration design for meandering rivers. U.S. Army Corp of Engineers. Report ERDC/CHL.

Tetra Tech Inc. 2014. Land Use Loading Literature Review Task Summary and Results. Retrieved from http://www.chesapeakebay.net/channel_files/21151/attachment_f--tetra_tech_urban_loads_literature_review_memo_20140331.pdf.

USEPA (U.S. Environmental Protection Agency). 2005. *Fact Sheet for public education and outreach minimum control measure revised.* EPA 833-F00-005.

USEPA (U.S. Environmental Protection Agency). 2003a. *Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity and Chlorophyll a for the Chesapeake Bay and Its Tidal Tributaries*. EPA 903-R-03-002. U.S. Environmental Protection Agency, Region 3, Chesapeake Bay Program Office, Annapolis, MD.

USEPA (U.S. Environmental Protection Agency). 2003d. *Technical Support Document for Identification of Chesapeake Bay Designated Uses and Attainability*. EPA 903-R-03-004. U.S. Environmental Protection Agency, Region 3, Chesapeake Bay Program Office, Annapolis, MD.

USEPA (U.S. Environmental Protection Agency). 2004e. *Technical Support Document for Identification of Chesapeake Bay Designated Uses and Attainability–2004 Addendum.* EPA 903-R-04-006. U.S. Environmental Protection Agency, Region 3 Chesapeake Bay Program Office, Annapolis, MD.

USEPA (U.S. Environmental Protection Agency). 2010a. *Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity and Chlorophyll a for the Chesapeake Bay and Its Tidal Tributaries: 2010 Technical Support for Criteria Assessment Protocols Addendum*. May 2010. EPA 903-R-10-002. CBP/TRS 301-10. U.S. Environmental Protection Agency, Region 3 Chesapeake Bay Program Office, Annapolis, MD.

Walker, S., Mostaghimi, S., Dillaha, T. A., & Woeste, R. E. (1990). MODELING ANIMAL WASTE MANAGEMENT PRACTICES: IMPACTS ON BACTERIA LEVELS IN RUNOFF FROM AGRICULTURAL LANDS. *American Society of Agricultural Engineers VOL. 33(3): MAY-JUNE 1990*

Yetman, K.T. 2001. Stream Corridor Assessment Survey, SCA Survey Protocols. Watershed Restoration Division, Annapolis, MD.

XII. Appendix A: Watershed Restoration Projects

Project Name	Town/County	Watershed	Project Status	Project Cost	Anticipated Completion
SWM Facilities	County	2130907	Completed	$7,999,941	Completed
Streambank Regeneration	County	2130907	Completed	N/A	Completed
Buffer Plantings	County	2130907	Completed	$119,352	Completed
Catch Basin/Inlet Cleaning	Mount Airy	2130907	Completed	**	Annual
Catch Basin/Inlet Cleaning	Sykesville	2130907	Completed	**	Annual
Street Sweeping		2130907	Completed	**	Annual
Water/floodplain Easement	Watershed	2130907	Completed	N/A	Completed
SWM (Planned)	County	2130907	Planning/Design	$5,486,614	FY20-25
TBD	Watershed	8-Digit	Planning	$3,700,000	TBD

***Costs for proposed Stormwater facilities are based on current FY20-FY25 project costs, which may be subject to change.**

****Project Costs not reported**

XIII. Appendix B: South Branch Patapsco BAT Septic Systems

DNR 12-digit scale	SubWatershed	Project Type	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Total 2009-2019
1030	Gills Falls Upper	Septic Repair	1							1			1	3
		New Construction							3	2				5
1031	Gills Falls Lower	Septic Repair								1				1
		New Construction												0
1029	Middle Run	Septic Repair	4				1			2				7
		New Construction							1	1	2			4
1021	Piney Run Lower	Septic Repair	1											1
		New Construction					1	1			1			3
1023	Piney Run Main	Septic Repair	2						1	1		1		5
		New Construction							2	3				5
1024	Piney Run Tributary	Septic Repair										1		1
		New Construction												0
1028	South Branch Patapsco	Septic Repair	2					2		1	1	1		7
		New Construction												0
1020	South Branch Patapsco River	Septic Repair												0
		New Construction												0
1022	South Branch Patapsco River	Septic Repair												0
		New Construction												0
1025	South Branch Patapsco River	Septic Repair						1			1			2
		New Construction				1			4					5
1026	Tuckers Branch	Septic Repair	1			2					2			5
		New Construction							2	9	1			12

XIV. Appendix C: Local TMDL Load Reduction Calculations with GWLF-E Land Cover Loading Rates and MDE (2014)

Stormwater Management

Project	Project Type	Drainage Area (Ac)	Impervious Area (Acres)	Practice Type	Runoff depth treated (In.)	% Urban TN Load Reduction	TN BMP Efficiency (%)	TN Pollutant Loads Reduced (lbs)	% Urban TP Load Reduction	TP BMP Efficiency	TP Pollutant Loads Reduced (lbs)	% Urban TSS Load Reduction	TSS BMP Efficiency	TSS Pollutant Loads Reduced (Tons)
Arthurs Ridge	Retrofit	51.17	5.14	ST	2.13	0.2083%	39%	10.03	0.3482%	62%	3.00	0.4749%	78%	7.33
South Carroll High-Fine Arts	New construction	24.22	12.94	RR	1.00	0.4840%	60%	23.31	0.4106%	70%	3.54	0.2346%	75%	3.62
Brimfield	Retrofit	34.69	9.15	RR	2.50	0.2443%	68%	11.76	0.3021%	79%	2.60	0.3480%	85%	5.37
Harvest Farms 1A	Retrofit	43.8	11.25	ST	1.00	0.1592%	35%	7.67	0.2658%	55%	2.29	0.3628%	70%	5.60
Parrish Park	Retrofit	94.23	18.2	ST	1.00	0.3426%	35%	16.50	0.5719%	55%	4.93	0.7805%	70%	12.04
Clipper Hills Gardenia	Retrofit	33.19	11.08	ST	2.50	0.4364%	39%	21.02	0.4991%	62%	4.30	0.3386%	79%	5.22
Clipper hills Hilltop	Retrofit	80.17	18.54	ST	2.50	0.3279%	39%	15.79	0.5492%	62%	4.73	0.7487%	79%	11.55
Carroltowne 2B	Retrofit	34.61	10.38	ST	2.50	0.1415%	39%	6.82	0.2371%	62%	2.04	0.3232%	79%	4.99
Carroltowne 2A	Retrofit	87.73	34.43	ST	2.49	1.1532%	39%	55.53	1.3185%	62%	11.36	0.8948%	79%	13.80
Benjamins Claim	Retrofit	47.1	15.78	ST	2.21	0.6167%	39%	29.70	0.7040%	62%	6.07	0.4780%	78%	7.37
Eldersburg Estates 3-5	Retrofit	34.91	8.16	ST	2.50	0.1428%	39%	6.87	0.2392%	62%	2.06	0.3260%	79%	5.03
Braddock Manor West	Retrofit	49.3	7.65	ST	2.50	0.2016%	39%	9.71	0.3377%	62%	2.91	0.4604%	79%	7.10
Benjamins Claim Basin B	Retrofit	1.33	0.55	ST	1.04	0.0157%	35%	0.76	0.0179%	56%	0.15	0.0122%	71%	0.19
Hawks Ridge	Retrofit	63.48	19.8	ST	2.07	0.8303%	39%	39.98	0.9472%	62%	8.16	0.6432%	78%	9.92
Merridale Gardens	Retrofit	81	23.81	RR	1.77	0.5589%	66%	26.91	0.6940%	78%	5.98	0.7968%	83%	12.29

Shannon Run	Retrofit	213.5	34.1	ST	2.50	0.8732%	39%	42.04	1.4627%	62%	12.60	1.9939%	79%	30.76
Piney Ridge Village AB 57	Retrofit	25.7	8	RR	2.50	0.5819%	68%	28.02	0.4912%	79%	4.23	0.2816%	85%	4.34
Woodyside Estates Small	Retrofit	9.02	2.11	RR	0.50	0.0421%	45%	2.03	0.0521%	52%	0.45	0.0598%	56%	0.92
Woodyside Estates Large	Retrofit	63.36	14.02	RR	2.50	0.4462%	68%	21.49	0.5518%	79%	4.76	0.6355%	85%	9.80
Lexington Run Section 1	Retrofit	12.87	2.62	ST	1.00	0.0468%	35%	2.25	0.0781%	55%	0.67	0.1066%	70%	1.64
Waters Edge Section 4	Retrofit	72.4	21.19	ST	1.00	0.2632%	35%	12.67	0.4394%	55%	3.79	0.5997%	70%	9.25
Melstone Valley	Retrofit	170	22.5	ST	1.00	0.6181%	35%	29.76	1.0317%	55%	8.89	1.4081%	70%	21.72
IDA Property	Facility	75.5	10.5	RR	2.50	0.5317%	68%	25.60	0.6575%	79%	5.67	0.7573%	85%	11.68
Winfield Fire Dept.	Facility	0.22	0.22	RR	1.14	0.0046%	62%	0.22	0.0039%	72%	0.03	0.0022%	77%	0.03
	Total:	**1,403.50**	**322.12**			**9.2712%**		**446.44**	**12.2109%**		**105.21**	**13.0674%**		**201.56**

Stream Buffer Plantings

Project	Acres	% Urban TN Load Reduced	TN BMP Efficiency (%)	TN Pollutant Load Reduced (lbs)	% Urban TP Load Reduced	TP BMP Efficiency	TP Pollutant Load Reduced (lbs)	% Urban TSS Load Reduced	TSS BMP Efficiency	TSS Pollutant Loads Reduced (Tons)
Planting 1	4.9	0.0336%	66	1.620	0.0417%	77	0.359	0.0331%	57	0.511
Planting 2	3.45	0.0237%	66	1.14	0.0294%	77	0.25	0.0233%	57	0.36
Planting 3	0.16	0.0011%	66	0.05	0.0014%	77	0.01	0.0011%	57	0.02
Planting 4	3.2	0.0220%	66	1.06	0.0272%	77	0.23	0.0216%	57	0.33
Planting 5	0.3	0.0021%	66	0.10	0.0026%	77	0.02	0.0020%	57	0.03
Planting 6	3	0.0206%	66	0.99	0.0255%	77	0.22	0.0203%	57	0.31
Planting 7	0.23	0.0016%	66	0.08	0.0020%	77	0.02	0.0016%	57	0.02
Planting 8	0.13	0.0009%	66	0.04	0.0011%	77	0.01	0.0009%	57	0.01
Planting 9	0.13	0.0009%	66	0.04	0.0011%	77	0.01	0.0009%	57	0.01
Total:	**15.50**	**0.1065%**		**5.12**	**0.1320%**		**1.129**	**0.1048%**		**1.601**

Catch Basin/inlet Cleaning

Location	Tons	TN lbs reduced/ton	TN Pollutant Loads Reduced [delivered] (lbs)	TP lbs reduced/ton	TP Pollutant Loads Reduced [delivered] (lbs)	TSS lbs reduced/ton	TSS Pollutant Loads Reduced [delivered] (lbs)	TSS Pollutant Loads Reduced [delivered] (Tons)
Sykesville	0.25	3.5	0.875 [0.04]	1.4	0.35 [0.01]	420	105 [11.88]	0.053 [0.01]
Total:			**0.875 [0.04]**		**0.35 [0.01]**		**105 [11.88]**	**0.053 [0.01]**

Stream Restoration

Location	Linear Feet	% Urban TN Load Reduction	TN Pollutant Loads Reduced (lbs)	% Urban TP Load Reduction	TP Pollutant Loads Reduced (lbs)	% Urban TSS Load Reduction	TSS Pollutant Loads Reduced (lbs)	TSS Pollutant Loads Reduced (tons)
Woodyside	2,100	0.3090%	14.88	1.4787%	12.74	0.1333%	4,114.29	2.06
Total:		**0.3090%**	**14.88**	**1.4787%**	**12.74**	**0.1333%**	**4,114.29**	**2.06**

Streambank Regeneration[1]

Location	Linear Feet	% Urban TN Load Reduction	TN Pollutant Loads Reduced (lbs)	% Urban TP Load Reduction	TP Pollutant Loads Reduced (lbs)	% Urban TSS Load Reduction	TSS Pollutant Loads Reduced (lbs)	TSS Pollutant Loads Reduced (tons)
Carroltonwe 2A	1100	0.1619%	7.79	0.7746%	6.68	0.0698%	2155.10	1.08
Eledersburg Estates 3-5	600	0.0883%	4.25	0.4225%	3.64	0.0381%	1175.51	0.59
Shannon Run	680	0.1001%	4.82	0.4788%	4.13	0.0432%	1332.25	0.67
Total:	**2,380**	**0.3503%**	**16.86**	**1.6759%**	**14.45**	**0.1511%**	**4,662.86**	**2.34**

[1]A study is currently underway by the County to evaluate streambank regeneration as an innovative practice following the guideline in MDE (2014). In the interim, the default stream restoration credit is combined with equivalent impervious area, as suggested in the 2014 MDE guidance, is used here to estimate nutrient and sediment reductions from this practice. Also see BMP Assumptions in Appendix D.

Grass Buffer Easements--Efficiency factors from 2011 Guidance

Subdivision	Acres	% Urban TN Load Reduction	TN BMP Efficiency (%)	TN Pollutant Loads Reduced (lbs)	% Urban TP Load Reduction	TP BMP Efficiency (%)	TP Pollutant Loads Reduced (lbs)	% Urban TSS Load Reduction	TSS BMP Efficiency (%)	TSS Pollutant Loads Reduced (tons)
Grass Buffer 1995-2008	89.080	0.2780%	30	13.39	0.3937%	40	3.39	0.5806%	55	8.96
Grass Buffer 2009-Current	69.640	0.2173%	30	10.46	0.3078%	40	2.65	0.4539%	55	7.00
Total:	**158.72**	**0.4953%**		**23.85**	**0.7015%**		**6.04**	**1.0345%**		**15.96**

Floodplain Easements--Efficiency factors from 2011 Guidance

Subdivision	Acres	% Urban TN Load Reduction	TN BMP Efficiency (%)	TN Pollutant Loads Reduced (lbs)	% Urban TP Load Reduction	TP BMP Efficiency (%)	TP Pollutant Loads Reduced (lbs)	% Urban TSS Load Reduction	TSS BMP Efficiency (%)	TSS Pollutant Loads Reduced (tons)
Forest Buffer 1995-2008	166.030	0.7772%	45	37.42	0.7339%	40	6.32	1.0821%	55	16.69
Forest Buffer 2009-Current	106.140	0.4969%	45	23.92	0.4692%	40	4.04	0.6917%	55	10.67
Total:	**272.17**	**1.2741%**		**61.34**	**1.2031%**		**10.36**	**1.7738%**		**27.36**

XV. Appendix D: GWLF-E Modeling Assumptions

1. Model Inputs

The GIS Data layers used for MapShed input are summarized below and include watershed boundaries (basins), Digital Elevation Model (DEM), land use, soils, streams, weather stations and directory, physiographic provinces, and counties.

- Watershed Boundaries: Maryland's 12 digit watersheds were obtained from https://data.maryland.gov/Energy-and-Environment/Maryland-s-Third-Order-12-Digit-Watersheds/wcjn-bzdz. The County also maintains a similar watershed boundary dataset, but its use for model input would require additional processing for topology correction. When 12 digit watersheds were larger than ~7000 acres or had a complex stream network, the MapShed model exhausted computer memory resources. These watersheds were broken into sub-basins to approximately split these into halves or quarters at natural stream and topographic breaks.
- Digital Elevation Model: The County's DEM derived from Lidar data was clipped to the Carroll County portion of the Liberty Reservoir watershed to speed processing time. This option was chosen over lowering resolution from 5 feet in order to maintain information on steep slopes for the modeling purposes.
- Land Use / Land Cover: Land cover data was obtained from the 2011 National Land Cover Database (NLCD). These data were used instead of County parcel data as NLCD does not consider political boundaries. NLCD data were reclassified using ArcMap 10.2 to fit into the MapShed land use/land cover classifications (Table D-1) following guidance in Appendix G of the MapShed documentation (Evans and Corradini, 2015).

Table D-1: NLCD Reclassification into MapShed Input

NLCD (2001) Classification	Corresponding GWLF-E Classification
Open Water	Open Water
Developed, Open Space	LD Residential
Developed Low Intensity	LD Developed
Developed Medium Intensity	MD Developed
Developed, High Intensity	HD Developed
Barren Land	Disturbed
Deciduous Forest	Forest
Evergreen Forest	Forest
Mixed Forest	Forest
Shrub/Scrub	Open Land
Herbaceous	Open Land

Hay/Pasture	Hay/Pasture
Cultivated Crops	Cropland
Woody Wetlands	Wetlands
Emergent Herbaceous Wetlands	Wetlands

- Soils: Soil data was obtained from the Natural Resources Conservation Service Soil Survey (SSURGO). The data required substantial formatting and aggregating to include needed model information and was completed, in part, with the USDA Soil Data Viewer (http://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/soils/home/?cid=nrcs142p2_053620) through ArcMap 10.2. Soil parameters required were area, available water-holding capacity, soil erodibility factor, and dominant hydrologic soil group.
- Streams: County stream data were visually evaluated to remove loops and parallel stream lines through reservoirs. These streams were generated from LIDAR data using ArcHydro. The stream locations are verified through a process that includes comparison with orthophotography and field stream walk maps.
- Weather Stations: The weather stations and the weather directory from Pennsylvania were previously developed by Penn State and are provided through the MapShed website (http://www.mapshed.psu.edu/download.htm). Hanover weather station data were used in the model and included a 22 year weather period from 1975 to 1996. The long weather period assured long-term averages were representative of wet, dry, and average years. The growing period was specified between April and September and primarily influences agricultural production and evapotranspiration.
- Physiographic Province: The physiographic province, another spatial MapShed input, from southcentral Pennsylvania was used to set the groundwater recession coefficient and rainfall coefficients (provided through the MapShed website). This shapefile was modified to include Carroll County. Soil loss coefficients, which are included in the physiographic province data, from southcentral Pennsylvania were also used for Carroll County.

Model default values were maintained for all parameters with the exception of the Universal Soil Loss Equation (USLE) practice factors for both Hay/Pasture and Cropland, the cover factor for Cropland, the dissolved P concentration of forest, and TSS accumulation on urban surfaces. Parameter adjustments from model defaults are shown in Table D-2 below and were based on literature and professional judgement.

Table D-2: Model parameter changes from default to better represent Carroll County.

Parameter	Default	New Value	Units	Comments
Practice Factor (pasture/hay)**	0.52	0.25	NA	Little disturbance and heavy forage assumed.
Practice Factor (cropland)**	0.52	0.25	NA	Assume contour farming and cover crops are broadly used.
Cover Factor (cropland)*	0.42	0.20	NA	Based on 2012 Agricultural Census for Corn, Beans, Canola, and Cereals acreage and state averages for no-till, conservation tillage and conventional tillage.
Dissolved P Concentration for Forest	0.01	0.1	mg/l	Assumed equal to the median open space concentration from Tetra Tech (2014). The increase accounts for potentially elevated P concentration from runoff contact with leaves.
TSS Accumulation	Imp. (Pervious) values	Imp. (Pervious) values	kg/ha/yr	EMCs from Tetra Tech (2014) used with GWLF-E runoff estimates. These adjustments were made by estimating runoff volume using GWLF-E default Curve Number (CN) values for impervious and pervious each land use and applying the average event mean concentration (EMC) of 140.44 mg/l.
LD Mixed	2.8 (0.8)	1.21 (0.19)		
MD Mixed	6.2 (0.8)	2.66 (0.30)		
HD Mixed	2.8 (0.8)	2.66 (0.30)		
LD Residential	2.5 (1.3)	1.21 (0.19)		

* Cropping factors for the USLE were area weighted based on county and state averages for crop type and tillage type, respectively (see www.nass.usda.gov/Statistics_by_State/Maryland/Publications/News_Releases/2012/mpr09-12tillage.pdf for tillage and see 2012 Carroll County Ag Census www.agcensus.usda.gov/Publications/2012/Full_Report/Volume_1,_Chapter_2_County_Level/Maryland/ for crop breakdown). Base cropping factors were compiled from www.omafra.gov.on.ca/english/engineer/facts/12-051.htm.

** The default was based on dominant parameter.

2. BMP Assumptions

There are seven primary categories of BMPs evaluated for this plan, though not all categories have implemented or planned BMPs. The assumptions listed here are intended to align the information available for each practice (i.e. drainage area), while following MDE guidance by using the state of the science BMP efficiencies. The MapShed/GWLF-E process allows for the development of spatially referenced land cover loading rates for subsequent use in BMP estimates. As BMPs were decoupled from GWLF-E, post processing of these BMP data allows for BMP efficiencies consistent with MDE guidance.

Land cover loading rates from GWLF-E were developed for urban land cover and are represented in Table D-3 for the Liberty Reservoir watershed. These categories and percent imperviousness are default GWLF-E values that were verified through literature review. Drainage areas for each BMP were lumped into these categories based on the percent impervious as shown in Table D-3 based on professional judgement.

Table D-3: GWLF-E impervious assumptions, BMP drainage area grouping, and urban land cover delivered loading rates. These rates include the urban portion of stream erosion.

Land Cover	% Impervious	BMP Drainage Area % Impervious Range	TN (lbs/ac)	TP (lbs/ac)	TSS (lbs/ac)
LD Mixed	15	>5 to <30	0.49	0.10	412.24
MD Mixed	52	>=30 to <70	1.60	0.21	446.90
HD Mixed	87	>=70	1.63	0.22	447.44
LD Residential	15	>5 to <30	0.49	0.10	412.24

The local TP and TSS TMDL baseline year is 2009, which means any retrofitted water quality BMPs installed since this year can be included in the accounting process to estimate TMDL reductions. BMP efficiencies were obtained from the 2014 Maryland Department of the Environment (MDE) guidance document entitled: *Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated*.

The load reductions from BMPs calculated based on the loading rates in Table D-3 (i.e., detention basin retrofits, infiltration, bioretention, etc.) represent delivered load reductions because the loading rates are delivered. However, a delivery ratio must be applied to any BMPs with edge of stream load reductions (i.e., stream restoration, street sweeping), as they are being done before any stream processing. In the Liberty Reservoir watershed, the load weighted average TN, TP, and TSS delivery ratios are 0.041, 0.040, and 0.130, respectively. Delivery ratios are based on total aerial deposited TN, TP, and sediment on urban areas (both impervious and pervious) compared to TN, TP, and TSS at the watershed outlet. These numbers were derived using the GWLF-E model.

Detention Basin Retrofits

Pond retrofits to a sand filter were assumed to be stormwater treatment (ST). The Chesapeake Bay retrofit curves were used along with County design volume to estimate relative TN, TP, and TSS reductions. These relative reductions were coupled with land cover loading rates from GWLF-E and drainage area characteristics to calculate a load reduction.

Water Resource, Floodplain Easements

These practices have previously agreed upon efficiencies of 30%, 40%, and 55% TN, TP, and TSS reductions, respectively (MDE, 2011). A Low Density Mixed land cover is used as the basis for loading rates.

Buffer Strips

Consistent with MDE guidance (MDE, 2014), this BMP has efficiencies of 66%, 77%, and 57%, for TN, TP, and TSS, respectively. A Low Density Mixed land cover is used as the basis for loading rates.

Stream Stabilization

For consistency with the Chesapeake Bay Program as well as taking into account potential headwater stabilization projects not reflected in the blue-line streams used in the MapShed/GWLF-E process, 1000 linear feet of stream stabilization/restoration was set equal to 4.9, 40.2, and 51.0 acres of high density mixed urban (87% impervious) for TN, TP, and TSS, respectively. These equivalencies were based on CBP river segment loading rates and the interim stream restoration credit of 75, 68, and 44,880 lbs of TN, TP, and TSS per 1000 linear feet of stream restoration (i.e. 68 lbs/1000 ft or1.69 lbs P/ac = 40.2 ac/1000 ft). Using this method, only linear feet of stabilization/restoration is needed for reporting. The delivery ratio described above was applied to these estimates as they are being done at the edge of stream before any stream processing.

Infiltration and Bioretention

All infiltration and bioretention projects are treated as runoff reduction (RR) projects. The Chesapeake Bay retrofit curves were used along with County design volume to estimate relative TN, TP, and TSS reductions. These relative reductions were coupled with land cover loading rates from GWLF-E and drainage area characteristics to calculate a load reduction.

Constructed Wetlands

Constructed wetlands were considered a stormwater treatment (ST) practice. The Chesapeake Bay retrofit curves were used along with County design volume to estimate relative TN, TP, and TSS reductions. These relative reductions were coupled with land cover loading rates from GWLF-E and drainage area characteristics to calculate a load reduction.

Street Sweeping and Catch Basin Cleaning

Total Nitrogen (3.5 lbs/ton), TP (1.4 lbs/ton), and TSS (420 lbs/ton) concentrations from catch basin cleaning solids, as reported in the 2014 MDE Guidance, were used along with County measured material removed to make edge of stream estimates. The delivery ratio described above was applied to these estimates as they are being done at the edge of stream before any stream processing. For qualifying street sweeping programs (25 times a year), TN, TP, and TSS reductions are 4%, 4%, and 10% respectively. Delivery ratios were also used to adjust these reductions.

Impervious Surface Reduction

Impervious surface reduction effectively changes the % impervious for the sub basin. The post processing procedure for this practice was simply the difference in land cover loading rate of high density mixed urban (87% impervious) and low density mixed urban (15% impervious).

XVI. Appendix E: Chesapeake Bay TMDL Edge-of-Stream Load Reduction Calculations

SWM Facilities Impervious Treatment

Project	Project Type	Drainage Area (Ac)	Impervious Area (Acres)	Practice Type	Runoff depth treated (In.)	TN Pollutant Runoff Load	Total Loads (lbs)	TN BMP Efficiency (%)	TN Pollutant Loads Reduced (lbs)	TP Pollutant Load	Total Loads (lbs)	TP BMP Efficiency	TP Pollutant Loads Reduced (lbs)	TSS Pollutant Load	Total Loads (tons)	TSS BMP Efficiency	TSS Pollutant Loads Reduced (Tons)
Arthurs Ridge	Retrofit	51.17	5.14	ST	2.13	15.3	78.6420	39%	30.7707	1.69	8.6866	62%	5.3487	0.44	2.2616	78%	1.7715
South Carroll High-Fine Arts	New construction	24.22	12.94	RR	1.00	15.3	197.9820	60%	118.2942	1.69	21.8686	70%	15.2862	0.44	5.6936	75%	4.2651
Brimfield	Retrofit	34.69	9.15	RR	2.50	15.3	139.9950	68%	94.7766	1.69	15.4635	79%	12.1871	0.44	4.0260	85%	3.4180
Harvest Farms 1A	Retrofit	43.8	11.25	ST	1.00	15.3	172.1250	35%	60.1577	1.69	19.0125	55%	10.4417	0.44	4.9500	70%	3.4601
Parrish Park	Retrofit	94.23	18.2	ST	1.00	15.3	278.4600	35%	97.3218	1.69	30.7580	55%	16.8923	0.44	8.0080	70%	5.5976
Clipper Hills Gardenia	Retrofit	33.19	11.08	ST	2.50	15.3	169.5240	39%	66.6484	1.69	18.7252	62%	11.6091	0.44	4.8752	79%	3.8422
Clipper hills Hilltop	Retrofit	80.17	18.54	ST	2.50	15.3	283.6620	39%	111.5217	1.69	31.3326	62%	19.4253	0.44	8.1576	79%	6.4292
Carroltowne 2B	Retrofit	34.61	10.38	ST	2.50	15.3	158.8140	39%	62.4377	1.69	17.5422	62%	10.8757	0.44	4.5672	79%	3.5995
Carroltowne 2A	Retrofit	87.73	34.43	ST	2.49	15.3	526.7790	39%	207.0259	1.69	58.1867	62%	36.0580	0.44	15.1492	79%	11.9343
Benjamins Claim	Retrofit	47.1	15.78	ST	2.21	15.3	241.4340	39%	94.5156	1.69	26.6682	62%	16.4347	0.44	6.9432	78%	5.4426
Eldersburg Estates 3-5	Retrofit	34.91	8.16	ST	2.50	15.3	124.8480	39%	49.0840	1.69	13.7904	62%	8.5497	0.44	3.5904	79%	2.8297

Braddock Manor West	Retrofit	49.3	7.65	ST	2.50	15.3	117.0450	39%	46.0162	1.69	12.9285	62%	8.0153	0.44	3.3660	79%	2.6528
Benjamins Claim Basin B	Retrofit	1.33	0.55	ST	1.04	15.3	8.4150	35%	2.9721	1.69	0.9295	56%	0.5159	0.44	0.2420	71%	0.1709
Hawks Ridge	Retrofit	63.48	19.8	ST	2.07	15.3	302.9400	39%	118.4601	1.69	33.4620	62%	20.5866	0.44	8.7120	78%	6.8188
Merridale Gardens	Retrofit	81	23.81	RR	1.77	15.3	364.2930	66%	241.6521	1.69	40.2389	78%	31.1985	0.44	10.4764	83%	8.7152
Shannon Run	Retrofit	213.5	34.1	ST	2.50	15.3	521.7300	39%	205.1181	1.69	57.6290	62%	35.7284	0.44	15.0040	79%	11.8249
Piney Ridge Village AB 57	Retrofit	25.7	8	RR	2.50	15.3	122.4000	68%	82.8648	1.69	13.5200	79%	10.6554	0.44	3.5200	85%	2.9884
Woodyside Estates Small	Retrofit	9.02	2.11	RR	0.50	15.3	32.2830	45%	14.4709	1.69	3.5659	52%	1.8638	0.44	0.9284	56%	0.5199
Woodyside Estates Large	Retrofit	63.36	14.02	RR	2.50	15.3	214.5060	68%	145.2206	1.69	23.6938	79%	18.6735	0.44	6.1688	85%	5.2372
Lexington Run Section 1	Retrofit	12.87	2.62	ST	1.00	15.3	40.0860	35%	14.0101	1.69	4.4278	55%	2.4317	0.44	1.1528	70%	0.8058
Waters Edge Section 4	Retrofit	72.4	21.19	ST	1.00	15.3	324.2070	35%	113.3103	1.69	35.8111	55%	19.6675	0.44	9.3236	70%	6.5172
Melstone Valley	Retrofit	170	22.5	ST	1.00	15.3	344.2500	35%	120.3154	1.69	38.0250	55%	20.8833	0.44	9.9000	70%	6.9201
IDA Property	Facility	75.5	10.5	RR	2.50	16.3	171.1500	68%	115.8686	2.69	28.2450	79%	22.2604	1.44	15.1200	85%	12.8366
Winfield Fire Dept.	Facility	0.22	0.22	RR	1.14	17.3	3.8060	62%	2.3500	3.69	0.8118	72%	0.5865	2.44	0.5368	77%	0.4156
Total:		**1,403.50**	**322.12**				**4,939.38**		**2,096.97**		**526.27**		**333.33**		**137.02**		**105.76**

SWM Facilities

Pervious Treatment

Project	Project Type	Drainage Area (Ac)	Pervious Area (Ac)	Practice Type	Runoff depth treated (In.)	TN Pollutant Runoff Load	Total Loads (lbs)	TN BMP Efficiency (%)	TN Pollutant Loads Reduced (lbs)	TP Pollutant Load	Total Loads (lbs)	TP BMP Efficiency	TP Pollutant Loads Reduced (lbs)	TSS Pollutant Load	Total Loads (tons)	TSS BMP Efficiency	TSS Pollutant Loads Reduced (Tons)
Arthurs Ridge	Retrofit	51.17	46.03	ST	2.13	10.8	497.1240	39%	194.5127	0.43	19.7929	62%	12.1873	0.07	3.2221	78%	2.5238
South Carroll High-Fine Arts	New construction	24.22	11.28	RR	1.00	10.8	121.8240	60%	72.7898	0.43	4.8504	70%	3.3904	0.07	0.7896	75%	0.5915
Brimfield	Retrofit	34.69	25.54	RR	2.50	10.8	275.8320	68%	186.7383	0.43	10.9822	79%	8.6553	0.07	1.7878	85%	1.5178
Harvest Farms 1A	Retrofit	43.8	32.55	ST	1.00	10.8	351.5400	35%	122.8632	0.43	13.9965	55%	7.6869	0.07	2.2785	70%	1.5927
Parrish Park	Retrofit	94.23	76.03	ST	1.00	10.8	821.1240	35%	286.9828	0.43	32.6929	55%	17.9549	0.07	5.3221	70%	3.7201
Clipper Hills Gardenia	Retrofit	33.19	22.11	ST	2.50	10.8	238.7880	39%	93.8795	0.43	9.5073	62%	5.8943	0.07	1.5477	79%	1.2198
Clipper hills Hilltop	Retrofit	80.17	61.63	ST	2.50	10.8	665.6040	39%	261.6822	0.43	26.5009	62%	16.4298	0.07	4.3141	79%	3.4000
Carroltowne 2B	Retrofit	34.61	24.23	ST	2.50	10.8	261.6840	39%	102.8811	0.43	10.4189	62%	6.4594	0.07	1.6961	79%	1.3367
Carroltowne 2A	Retrofit	87.73	53.3	ST	2.49	10.8	575.6400	39%	226.2284	0.43	22.9190	62%	14.2028	0.07	3.7310	79%	2.9392
Benjamins Claim	Retrofit	47.1	31.32	ST	2.21	10.8	338.2560	39%	132.4190	0.43	13.4676	62%	8.2996	0.07	2.1924	78%	1.7186
Eldersburg Estates 3-5	Retrofit	34.91	26.75	ST	2.50	10.8	288.9000	39%	113.5810	0.43	11.5025	62%	7.1312	0.07	1.8725	79%	1.4758
Braddock Manor West	Retrofit	49.3	41.65	ST	2.50	10.8	449.8200	39%	176.8467	0.43	17.9095	62%	11.1034	0.07	2.9155	79%	2.2978
Benjamins Claim Basin B	Retrofit	1.33	0.78	ST	1.04	10.8	8.4240	35%	2.9753	0.43	0.3354	56%	0.1861	0.07	0.0546	71%	0.0386

Hawks Ridge	Retrofit	63.48	43.68	ST	2.07	10.8	471.7440	39%	184.4683	0.43	18.7824	62%	11.5554	0.07	3.0576	78%	2.3932
Merridale Gardens	Retrofit	81	57.19	RR	1.77	10.8	617.6520	66%	409.7167	0.43	24.5917	78%	19.0667	0.07	4.0033	83%	3.3303
Shannon Run	Retrofit	213.5	179.4	ST	2.50	10.8	1937.5200	39%	761.7360	0.43	77.1420	62%	47.8259	0.07	12.5580	79%	9.8972
Piney Ridge Village AB 57	Retrofit	25.7	17.7	RR	2.50	10.8	191.1600	68%	129.4153	0.43	7.6110	79%	5.9984	0.07	1.2390	85%	1.0519
Woodyside Estates Small	Retrofit	9.02	6.91	RR	0.50	10.8	74.6280	45%	33.4520	0.43	2.9713	52%	1.5530	0.07	0.4837	56%	0.2709
Woodyside Estates Large	Retrofit	63.36	49.34	RR	2.50	10.8	532.8720	68%	360.7543	0.43	21.2162	79%	16.7209	0.07	3.4538	85%	2.9322
Lexington Run Section 1	Retrofit	12.87	10.25	ST	1.00	10.8	110.7000	35%	38.6897	0.43	4.4075	55%	2.4206	0.07	0.7175	70%	0.5015
Waters Edge Section 4	Retrofit	72.4	51.21	ST	1.00	10.8	553.0680	35%	193.2973	0.43	22.0203	55%	12.0935	0.07	3.5847	70%	2.5057
Melstone Valley	Retrofit	170	147.5	ST	1.00	10.8	1593.0000	35%	556.7535	0.43	63.4250	55%	34.8330	0.07	10.3250	70%	7.2172
IDA Property	Facility	75.5	65	RR	2.50	11.8	767.0000	68%	519.2590	1.43	92.9500	79%	73.2556	1.07	69.5500	85%	59.0466
Winfield Fire Dept.	Facility	0.22	0	RR	1.14	12.8	0.0000	62%	0.0000	2.43	0.0000	72%	0.0000	2.07	0.0000	77%	0.0000
Total:		**1,403.50**	**1,081.38**				**11,743.90**		**5,161.92**		**529.99**		**344.90**		**140.70**		**113.52**

Stream Restoration

Location	Linear Feet	TN lbs reduced/linear ft	TN Pollutant Loads Reduced (lbs)	TP lbs reduced/linear ft	TP Pollutant Loads Reduced (lbs)	TSS lbs reduced/linear ft	TSS Pollutant Loads Reduced (lbs)	TSS Pollutant Loads Reduced (Tons)
Woodyside	2100	0.075	157.500	0.068	142.800	248	520800	260.400
		Total:	**157.5000**		**142.8000**		**520,800**	**260.400**

Streambank Regeneration

Location	Linear Feet	TN lbs reduced/linear ft	TN Pollutant Loads Reduced (lbs)	TP lbs reduced/linear ft	TP Pollutant Loads Reduced (lbs)	TSS lbs reduced/linear ft	TSS Pollutant Loads Reduced (lbs)	TSS Pollutant Loads Reduced (Tons)
Carroltonwe 2A	1100	0.075	82.500	0.068	74.800	44.8	49280	24.640
Eledersburg Estates 3-5	600	0.075	45.000	0.068	40.800	44.8	26880	13.440
Shannon Run	680	0.075	51.000	0.068	46.240	44.8	30464	15.232
		Total:	**178.5000**		**161.8400**		**106,624**	**53.312**

Catch Basin/inlet Cleaning

Location	Tons*	TN lbs reduced/ton	TN Pollutant Loads Reduced (lbs)	TP lbs reduced/ton	TP Pollutant Loads Reduced (lbs)	TSS lbs reduced/ton	TSS Pollutant Loads Reduced (lbs)	TSS Pollutant Loads Reduced (Tons)
Sykesville	0.25	3.5	0.875	1.4	0.350	420	105	0.053
		Total:	**0.8750**		**0.3500**		**105**	**0.053**

Stream Buffer Plantings

Project	Acres	TN Pollutant Load	Total Loads (lbs)	TN BMP Efficiency (%)	TN Pollutant Loads Reduced (lbs)	TP Pollutant Load	Total Loads (lbs)	TP BMP Efficiency	TP Pollutant Loads Reduced (lbs)	TSS Pollutant Load	Total Loads (tons)	TSS BMP Efficiency	TSS Pollutant Loads Reduced (Tons)
Planting 1	4.9	10.8	52.9200	66	34.9272	0.43	2.1070	77	1.6224	0.07	0.3430	57	0.1955
Planting 2	3.45	10.8	37.2600	66	24.5916	0.43	1.4835	77	1.1423	0.07	0.2415	57	0.1377
Planting 3	0.16	10.8	1.7280	66	1.1405	0.43	0.0688	77	0.0530	0.07	0.0112	57	0.0064
Planting 4	3.2	10.8	34.5600	66	22.8096	0.43	1.3760	77	1.0595	0.07	0.2240	57	0.1277
Planting 5	0.3	10.8	3.2400	66	2.1384	0.43	0.1290	77	0.0993	0.07	0.0210	57	0.0120
Planting 6	3	10.8	32.4000	66	21.3840	0.43	1.2900	77	0.9933	0.07	0.2100	57	0.1197
Planting 7	0.23	10.8	2.4840	66	1.6394	0.43	0.0989	77	0.0762	0.07	0.0161	57	0.0092
Planting 8	0.13	10.8	1.4040	66	0.9266	0.43	0.0559	77	0.0430	0.07	0.0091	57	0.0052
Planting 9	0.13	10.8	1.4040	66	0.9266	0.43	0.0559	77	0.0430	0.07	0.0091	57	0.0052
Total:	**15.5**		**167.4000**		**110.4840**		**6.6650**		**5.1321**		**1.0850**		**0.6185**

Grass Buffer Easements

Subdivision	Acres	Recorded Date	TN Pollutant Load	Total Loads (lbs)	TN BMP Efficiency (%)	TN Pollutant Loads Reduced (lbs)	TP Pollutant Load	Total Loads (lbs)	TP BMP Efficiency	TP Pollutant Loads Reduced (lbs)	TSS Pollutant Load	Total Loads (tons)	TSS BM Efficien
Grass Buffer 1995-2008	89.080	1995-2008	11.7	1042.2360	30	312.67080	0.68	60.5744	40	24.2298	0.18	16.0344	55
Grass Buffer 2009-Current	69.640	2009 -current	11.7	814.7880	30	244.43640	0.68	47.3552	40	18.9421	0.18	12.5352	55
	158.720		**Total:**	**1857.0240**		**557.10720**		**107.9296**		**43.1718**		**28.5696**	

Forest Buffer Easements

Subdivision	Acres	Recorded Date	TN Pollutant Load	Total Loads (lbs)	TN BMP Efficiency (%)	TN Pollutant Loads Reduced (lbs)	TP Pollutant Load	Total Loads (lbs)	TP BMP Efficiency	TP Pollutant Loads Reduced (lbs)	TSS Pollutant Load	Total Loads (tons)	TSS BM Efficien
Forest Buffer 1995-2008	166.030	1995-2008	11.7	1942.5510	45	874.1480	0.68	112.9004	40	45.1602	0.18	29.8854	55
Forest Buffer 2009-Current	106.140	2009 -current	11.7	1241.8380	45	558.8271	0.68	72.1752	40	28.8701	0.18	19.1052	55
	272.170		**Total:**	**3184.3890**		**955.31670**		**185.0756**		**74.0302**		**48.9906**	

XVII. Appendix F: Forest Buffer and Grass Buffer Protection Easements

Forest Buffer Protection Easements

Project Name	Acres	Implementation Year
Piney Run	0.819519	1995
Piney Run	1.612281	1995
Middle Run	2.521235	1996
Piney Run	2.200353	1996
Middle Run	0.001568	1996
Piney Run	2.419142	1997
Piney Run	0.698063	1997
Piney Run	4.475535	1997
Piney Run	0.329898	1997
South Branch Patapsco Ri*	0.159596	1998
South Branch Patapsco Ri*	0.000167	1998
Gillis Falls	8.003215	1999
Middle Run	2.316767	1999
Middle Run	9.444429	1999
Piney Run	0.218304	1999
South Branch Patapsco Ri*	12.849819	1999
Piney Run	0.329898	1999
Middle Run	0.001568	1999
Middle Run	0.001759	1999
Middle Run	0.001759	1999
Middle Run	0.073559	1999
Middle Run	0.205668	1999

South Branch Patapsco Ri*	1.770189	2001
Piney Run	2.930098	2001
Piney Run	1.528832	2001
Middle Run	3.793286	2001
South Branch Patapsco Ri*	0.820609	2002
Middle Run	0.314362	2002
Pine Brook Farm, Section*	3.472799	2002
Pine Brook Farm, Section*	4.839581	2002
Pine Brook Farm, Section*	0.030559	2002
Middle Run	8.582648	2002
Middle Run	0.098132	2002
Middle Run	0.106279	2002
Tuckers Branch	0.899804	2002
Pine Brook Farm, Section*	0.000292	2002
Pine Brook Farm, Section*	0.000058	2002
Pine Brook Farm, Section*	0.002605	2002
Pine Brook Farm, Section*	0.002605	2002
Middle Run	0.015489	2002
Middle Run	0.205668	2002
Tuckers Branch	10.289335	2004
Tuckers Branch	7.948689	2004
Pine Brook Farm II	5.742907	2004
Piney Run	6.616725	2004
Pine Brook Farm II	14.04952	2004
Gillis Falls	0.518025	2004
Gillis Falls	0.696524	2004
Pine Brook Farm II	0.000292	2004

Pine Brook Farm II	0.000058	2004
Whitetail Run Estates	0.137291	2005
Whitetail Run Estates	0.088453	2005
Whitetail Run Estates	0.626687	2005
Freedom Hills Farms	0.042157	2005
Tuckers Branch	12.665644	2005
Freedom Hills Farms	3.228446	2005
Piney Run	2.157508	2006
Kraft Heritage	0.067127	2006
Gillis Falls	2.869574	2006
Kraft Heritage	2.270669	2006
Piney Run	4.803649	2006
Kraft Heritage	0.000268	2006
Gillis Falls	0.443856	2006
Kraft Heritage	0.022345	2006
South Branch Patapsco Ri*	0.97809	2007
S. Carroll Gateway Ind P*	0.020584	2007
S. Carroll Gateway Ind P*	0.000453	2007
South Branch Patapsco Ri*	0.045509	2007
South Branch Patapsco Ri*	0.001967	2007
Symphony Hill	0.019238	2007
George Duke Subdivision	0.000033	2007
SES Americom	0.000131	2007
Symphony Hill	0.045064	2007
South Branch Patapsco Ri*	0.477789	2007
Symphony Hill	8.490547	2007
George Duke Subdivision	0.00799	2007

SES Americom	0.011223	2007
Symphony Hill	0.00248	2007
SES Americom	0.00248	2007
Symphony Hill	0.00034	2007
Symphony Hill	0.000048	2007
South Branch Patapsco Ri*	0.000167	2007
Symphony Hill	0.005617	2007
SES Americom	0.005617	2007
Symphony Hill	0.00027	2007
George Duke Subdivision	0.001437	2007
Symphony Hill	0.069233	2007
Symphony Hill	0.069233	2007
SES Americom	0.069233	2007
Symphony Hill	0.014183	2007
Symphony Hill	0.014183	2007
SES Americom	0.014183	2007
Raincliffe	0.022384	2008
South Branch Patapsco Ri*	0.146499	2008
Raincliffe	0.109735	2008
Piney Ridge Elementary	1.101836	2008
Shaw Glen, Section 2	0.011462	2008
Shaw Glen, Section 2	0.117303	2008
Raincliffe	0.001241	2008
South Branch Patapsco Ri*	0.151936	2008
Raincliffe	0.105191	2008
Harrison's Subdivision, *	0.494237	2008
Piney Ridge Elementary	0.013829	2008

George Duke Subdivision	0.372332	2009
George Duke Subdivision	0.345582	2009
George Duke Subdivision	4.124304	2009
George Duke Subdivision	3.448827	2009
Tuckers Branch	0.107031	2009
Talley's Hallowell, Lot *	0.054936	2009
George Duke Subdivision	0.133371	2009
George Duke Subdivision	0.001976	2009
George Duke Subdivision	0.019665	2009
George Duke Subdivision	0.007008	2009
George Duke Subdivision	0.001437	2009
George Duke Subdivision	0.133371	2009
Warfield Commerce & Cult*	0.001724	2010
Piney Run	0.258259	2010
Warfield Commerce & Cult*	0.574317	2010
GI-NA Farms Estates, Lot*	0.060278	2010
SES Americom	0.001134	2011
SES Americom	0.00888	2011
South Branch Patapsco Ri*	20.180166	2011
SES Americom	3.683354	2011
SES Americom	1.03121	2011
Mount Airy WWTP	0.587209	2011
Chimney Rock	1.151533	2011
Piney Ridge Village 8	0.010201	2011
Piney Run	0.003932	2011
Piney Run	0.001799	2011
Piney Ridge Village 8	0.504619	2011

Piney Ridge Village 8	0.080171	2011
Piney Run	14.691191	2011
Chimney Rock	0.078517	2011
SES Americom	0.000339	2011
South Branch Patapsco Ri*	0.026195	2011
SES Americom	0.003552	2011
SES Americom	0.011223	2011
Piney Ridge Village 8	0.00163	2011
Piney Ridge Village 8	0.00163	2011
SES Americom	0.133371	2011
SES Americom	0.133371	2011
SES Americom	0.001976	2011
SES Americom	0.00034	2011
SES Americom	0.019665	2011
SES Americom	0.007008	2011
SES Americom	0.014356	2011
SES Americom	0.014356	2011
SES Americom	0.000048	2011
SES Americom	0.00027	2011
SES Americom	0.069233	2011
SES Americom	0.014183	2011
South Branch Patapsco Ri*	7.671389	2012
Piney Run	0.880265	2012
Piney Run	2.115213	2012
Piney Run	0.29073	2012
Long Reach Farm	0.019762	2012
Long Reach Farm	0.004909	2012

Long Reach Farm	0.205621	2012
Piney Run	0.314396	2012
Long Reach Farm	0.248453	2012
Piney Run	2.189766	2012
Piney Run	0.372876	2012
Piney Run	0.290884	2012
Piney Run	0.000468	2012
Long Reach Farm	0.001715	2012
Long Reach Farm	0.001715	2012
Twin Arch Business Park	2.186463	2013
South Branch Patapsco	0.088527	2013
South Branch Patapsco	0.002408	2013
Twin Arch Business Park	0.513831	2013
Twin Arch Business Park	2.521146	2014
Twin Arch Business Park	1.436673	2014
Gillis Falls	5.798724	2014
Piney Run	1.136815	2015
Arrington Estates Parcel*	0.067942	2015
Piney Run	1.460983	2015
Piney Run	1.066132	2015
Brotman Property	0.04536	2015
Brotman Property	0.025479	2015
Brotman Property	0.006713	2015
Brotman Property	0.019761	2015
Brotman Property	0.131323	2015
Brotman Property	0.00829	2015
Brotman Property	0.028027	2015

Brotman Property	0.00002	2015
Brotman Property	0.005064	2015
Piney Run	0.934907	2015
Piney Run	0.03485	2015
Piney Run	0.491714	2015
Piney Run	0.90765	2015
Piney Run	0.000203	2015
Piney Run	0.000203	2015
Colonial Pipeline	13.240701	2019
Twin Arch Business Park	4.566503	2019
Cody's Crossing	2.692633	2019

Grass Buffer Protection Easements

Project Name	Acres	Implementation Year
Piney Run	0.407599	1995
Middle Run	1.982428	1996
Piney Run	0.211346	1997
South Branch Patapsco Ri*	1.002626	1997
Piney Run	14.697859	1997
Piney Run	0.818089	1997
Piney Run	0.33512	1999
Piney Run	2.518304	1999
South Branch Patapsco Ri*	1.656513	1999
Gillis Falls	18.154279	1999
Gillis Falls	1.815467	1999
Piney Run	1.786423	1999
Piney Run	0.818089	1999

Middle Run	2.790963	2001
Piney Run	1.202785	2001
Piney Run	0.327877	2001
South Branch Patapsco Ri*	0.06047	2001
Piney Run	0.575915	2001
Pine Brook Farm, Section*	5.488336	2002
Middle Run	3.291268	2002
Tuckers Branch	0.661302	2002
Middle Run	1.558596	2002
Piney Run	0.059753	2002
South Branch Patapsco Ri*	1.599781	2002
Middle Run	0.14382	2002
Pine Brook Farm, Section*	4.556554	2002
Middle Run	0.007228	2002
Piney Run	0.427115	2003
Piney Run	0.080537	2004
Pine Brook Farm II	0.958692	2004
Piney Run	0.200618	2004
Tuckers Branch	0.051204	2004
Tuckers Branch	0.362898	2004
Gillis Falls	0.963341	2004
Gillis Falls	0.126211	2004
Pine Brook Farm II	0.333209	2004
Whitetail Run Estates	0.00004	2005
Freedom Hills Farms	0.576129	2005
Tuckers Branch	3.69012	2005
Whitetail Run Estates	0.248671	2005

Whitetail Run Estates	0.019716	2005
Freedom Hills Farms	2.498322	2005
Gillis Falls	0.023764	2006
S. Carroll Gateway Ind P*	0.009401	2007
South Branch Patapsco Ri*	0.008542	2007
S. Carroll Gateway Ind P*	0.228586	2007
Piney Ridge Elementary	2.657464	2008
Raincliffe	0.066226	2008
Raincliffe	0.022997	2008
Raincliffe	0.250395	2008
Raincliffe	0.03268	2008
Raincliffe	0.038292	2008
Shaw Glen, Section 2	0.249229	2008
Shaw Glen, Section 2	1.225335	2008
Raincliffe	0.015574	2008
South Branch Patapsco Ri*	2.461916	2008
Piney Ridge Elementary	0.000818	2008
Piney Ridge Elementary	0.000785	2008
Raincliffe	0.255287	2008
Raincliffe	0.109487	2008
Raincliffe	1.949209	2008
Raincliffe	0.039045	2008
Raincliffe	0.36564	2008
Talley's Hallowell, Lot *	0.046277	2009
Tuckers Branch	0.383016	2009
Talley's Hallowell, Lot *	0.265025	2009
Warfield Commerce & Cult*	1.729928	2010

GI-NA Farms Estates, Lot*	0.204583	2010
Warfield Commerce & Cult*	4.813123	2010
Piney Run	1.948764	2010
Piney Ridge Village 8	0.011322	2011
Piney Ridge Village 8	0.104681	2011
Chimney Rock	1.81542	2011
Chimney Rock	17.445073	2011
Mount Airy WWTP	1.013647	2011
SES Americom	0.070891	2011
Piney Run	5.931667	2011
South Branch Patapsco Ri*	1.403404	2011
South Branch Patapsco Ri*	0.150587	2011
Piney Ridge Village 8	1.521398	2011
Piney Ridge Village 8	2.572473	2011
SES Americom	0.264327	2011
SES Americom	0.166024	2011
Piney Run	0.004224	2011
Piney Run	0.0673	2011
Piney Ridge Village 8	0.044391	2011
Piney Ridge Village 8	0.301637	2011
Piney Run	0.000016	2011
Piney Run	0.000016	2011
Piney Ridge Village 8	0.001698	2011
Piney Ridge Village 8	0.001698	2011
Piney Ridge Village 8	0.021758	2011
Piney Ridge Village 8	0.021758	2011
Long Reach Farm	1.52808	2012

Long Reach Farm	0.414818	2012
Long Reach Farm	1.531348	2012
Piney Run	1.987609	2012
Piney Run	1.06957	2012
Piney Run	1.446789	2012
Long Reach Farm	3.544568	2012
Long Reach Farm	0.004898	2012
Long Reach Farm	0.359786	2012
South Branch Patapsco Ri*	3.17226	2012
Piney Run	1.205462	2012
Piney Run	0.000125	2012
Long Reach Farm	0.002101	2012
Long Reach Farm	0.002101	2012
Long Reach Farm	0.000632	2012
Long Reach Farm	0.000632	2012
Twin Arch Business Park	0.906687	2013
Twin Arch Business Park	0.857872	2013
Twin Arch Business Park	0.154163	2013
South Branch Patapsco	0.003644	2013
South Branch Patapsco	1.615119	2013
Twin Arch Business Park	1.096177	2013
Arrington Estates Parcel*	0.003019	2015
Arrington Estates Parcel*	0.000182	2015
Piney Run	1.323136	2015
Piney Run	0.005942	2015
Piney Run	0.954976	2015
Piney Run	0.141169	2015

Piney Run	0.032681	2015
Arrington Estates Parcel*	0.025172	2015
Arrington Estates Parcel*	0.115895	2015
Charles Ray Acres Sec 2	1.504309	2017
Clnl. Pipl. Drsy. Junc.	0.862396	2018
Colonial Pipeline	0.939278	2019