Lower Monocacy River Watershed
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 Lower Monocacy River watershed within Carroll County, Maryland. 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. Annual 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

The Lower Monocacy River watershed (Figure 1) was placed on Maryland's 303(d) list of impaired waters for nutrients in 1996 and again for fecal bacteria in 2002. A Total Maximum Daily Load (TMDL) for bacteria was developed and approved in 2009 with a subsequent TMDL for phosphorus developed and approved in May of 2013 for the Lower Monocacy River watershed.

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). Additional stakeholders in this planning process include the Town of Mount Airy, and the Monocacy Scenic River Citizens Advisory Board.

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. In addition, restoration goals include the protection of source water for the Potomac River and ecologically sensitive and threatened species. 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 E.2).

1. Document Organization

Section I: Introduction; discusses the history of TMDL development within the Lower Monocacy River 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 BRM and identifies priority watersheds based on the assessment. The background section will also look at baseline and current land use within the Lower Monocacy River 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 BRM and discusses the various councils and the role they play in watershed restoration.

Section V: Restoration Implementation; describes the Best Management Practices (BMPs) and restoration projects that have been either completed or proposed to meet the local TMDL requirements for the Lower Monocacy River 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

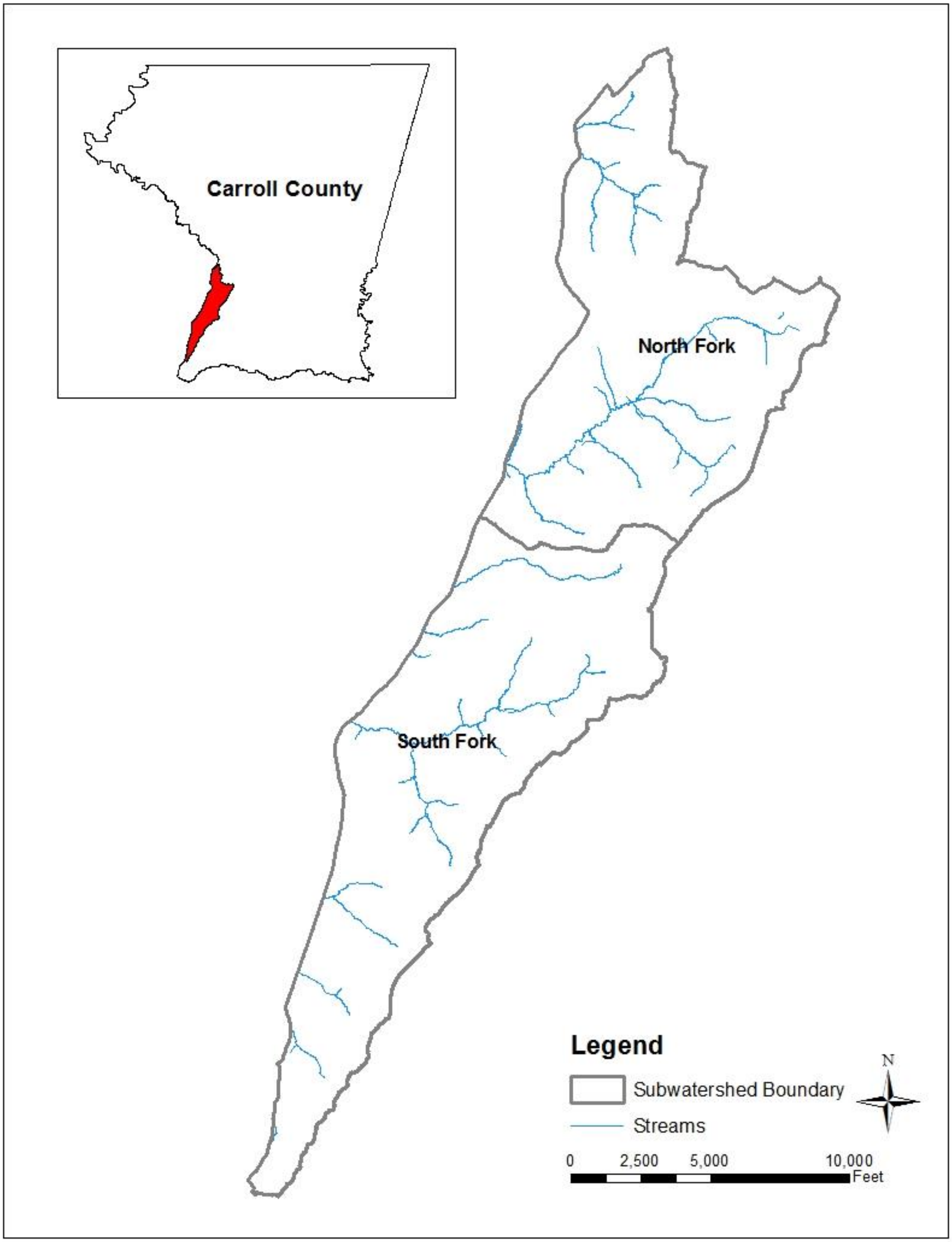

Figure 1: Lower Monocacy River Watershed and Subwatersheds Map

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

	Use Classes							
Designated Uses	**I**	**I-P**	**II**	**II-P**	**III**	**III-P**	**IV**	**IV-P**
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. Lower Monocacy River Water Quality Standards

The entire portion of the Lower Monocacy River watershed within Carroll County is designated as use IV-P, Water Contact Recreation, Protection of Aquatic Life, Recreational Trout Waters and Public Water Supply. The use IV-P waters are not capable of growing and propagating trout, but are capable of supporting adult trout for a put-and-take fishery.

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

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 (WQSs). 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, which are referred to as WLAs. Within the Lower Monocacy River watershed, these allocations are divided among counties and municipalities and then further divided by sources, including agricultural, wastewater, and stormwater. Due to the Memorandum of Agreement (MOA) between the County and each of the Municipalities, this restoration plan will concentrate on joint requirements for reducing TMDL loadings associated with the stormwater WLA.

a. Bacteria

The current estimated stormwater baseline load for bacteria within the Carroll County portion of Lower Monocacy Watershed as determined by the Maryland Department of Environment (MDE) TMDL Data Center is 116,000 billion MPN/year (MPN, or most probable number is a technique used to estimate microbial populations). The TMDL to meet the watersheds designated use was determined by MDE to be 1,856 billion MPN/year, which is a reduction of 114,144 billion MPN/year (98.4%) from the current estimated loading.

These maximum practicable reduction targets are based on the available literature and best professional judgment. There is much uncertainty with estimated reductions from BMPs. In certain watersheds, the goal of meeting water quality standards may require very high reductions that are not achievable with current technologies and management practices (MDE, 2009). Table 3 outlines the bacteria baseline and TMDL for the Carroll County portion of the Lower Monocacy Watershed.

Table 3: Lower Monocacy River 8-digit Watershed Bacteria TMDL

Lower Monocacy Watershed			Percent Reduction
Jurisdiction	Baseline	TMDL	
Carroll County	116,000	1,856	98.4%
Total	**116,000**	**1,856**	**98.4%**

b. Phosphorus

The current estimated stormwater baseline load for Carroll County as determined by the MDE TMDL Data Center is 1,155 lbs. /yr., the TMDL for the stormwater WLA was determined to be 806 lbs. /yr., which is a reduction of 349 lbs. /yr. (30%) from the current loading (MDE 2012) (Table 4).

Table 4: Lower Monocacy River 8-digit Watershed Phosphorus TMDL

Jurisdiction	Baseline (lbs./yr)	TMDL (lbs./yr)	Percent Reduction
Carroll County	1,155	806	30%
Total	**1,155**	**806**	**30%**

The TMDLs are based on average annual total phosphorus loads for the simulation period 1991-2000, which includes both wet and dry years, and thus takes into account a variety of hydrological conditions (MDE, 2012). Phosphorus remains as the only nutrient TMDL within the watershed and has been determined by MDE to be the limiting nutrient. If phosphorus is used up or removed, excess algal growth within the system will cease.

II. Background

A. Location and Subwatershed Map

The Monocacy River is a free-flowing stream that originates in Pennsylvania and flows 58 miles within Maryland where it finally empties into the Potomac River. The Upper Monocacy River drains into the Lower Monocacy River which eventually empties into the Middle Potomac River. The Lower Monocacy River watershed is located in the Potomac River Sub-basin, which lies within the Piedmont physiographic province. The Lower Monocacy River watershed is primarily within Frederick County, and small portions of Carroll and Montgomery Counties covering a total of approximately 194,790 acres. The watershed area within Carroll County covers 5,463 acres within two sub-watersheds. Figure 1 depicts the location of the Lower Monocacy River watershed and its subwatersheds.

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 Lower Monocacy River watershed, forest is the dominant land cover at about 36 percent of the total land, followed by agriculture which accounts for 34 percent, and residential, which accounts for about 25 percent of the total land cover. Mixed urban uses account for less than 3 percent of the total land cover which represents the relatively rural nature of the Lower Monocacy River 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 10% increase in low-density residential land cover since 2011, which has been incorporated into Table 5.

Table 5 shows the current land cover data for the Lower Monocacy River watershed, as well as the changes in land cover over time since 2001. The current land cover, as of 2011, within the Lower Monocacy River watershed can be found in Figure 2.

Table 5: Lower Monocacy River 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	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Low-Density Residential	896	16%	908	17%	906	17%	1,375	25%
Low-Density Mixed Urban	180	3%	192	4%	191	4%	125	2%
Medium-Density Mixed Urban	24	<1%	37	<1%	38	<1%	30	<1%
High-Density Mixed Urban	3	<1%	4.30	<1%	5	<1%	4	<1%
Barren Land	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Forest	2,004	37%	1,997	37%	1,999	37%	1,971	36%
Shrub/Scrub	51	<1%	50	<1%	49	<1%	27	<1%
Grassland	18	<1%	22	<1%	22	<1%	15	<1%
Pasture/Hay	820	15.0%	815	15%	815	15%	751	14%
Cropland	1,374	25%	1,346	25%	1,346	25%	1,087	20%
Wetland	79	1%	79	1%	75	1%	75	1%

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 Lower Monocacy River watershed is estimated to have 347 acres of total impervious within the catchment and accounts for approximately 6.3 percent of the total land area. The impervious surface area within Lower Monocacy River watershed, by subwatershed can be found in Table 6 and is shown in Figure 3.

Table 6: Lower Monocacy River Watershed Estimated Impervious Surface Area

DNR 12-digit Scale	Subwatershed	Acres	Impervious Acres	Percent Impervious
021403020238	North Fork	2,569.3	117.6	4.6
021403020235	South Fork	2,893.4	229.5	7.9
Lower Monocacy River Watershed		**5,462.7**	**347.1**	**6.3**

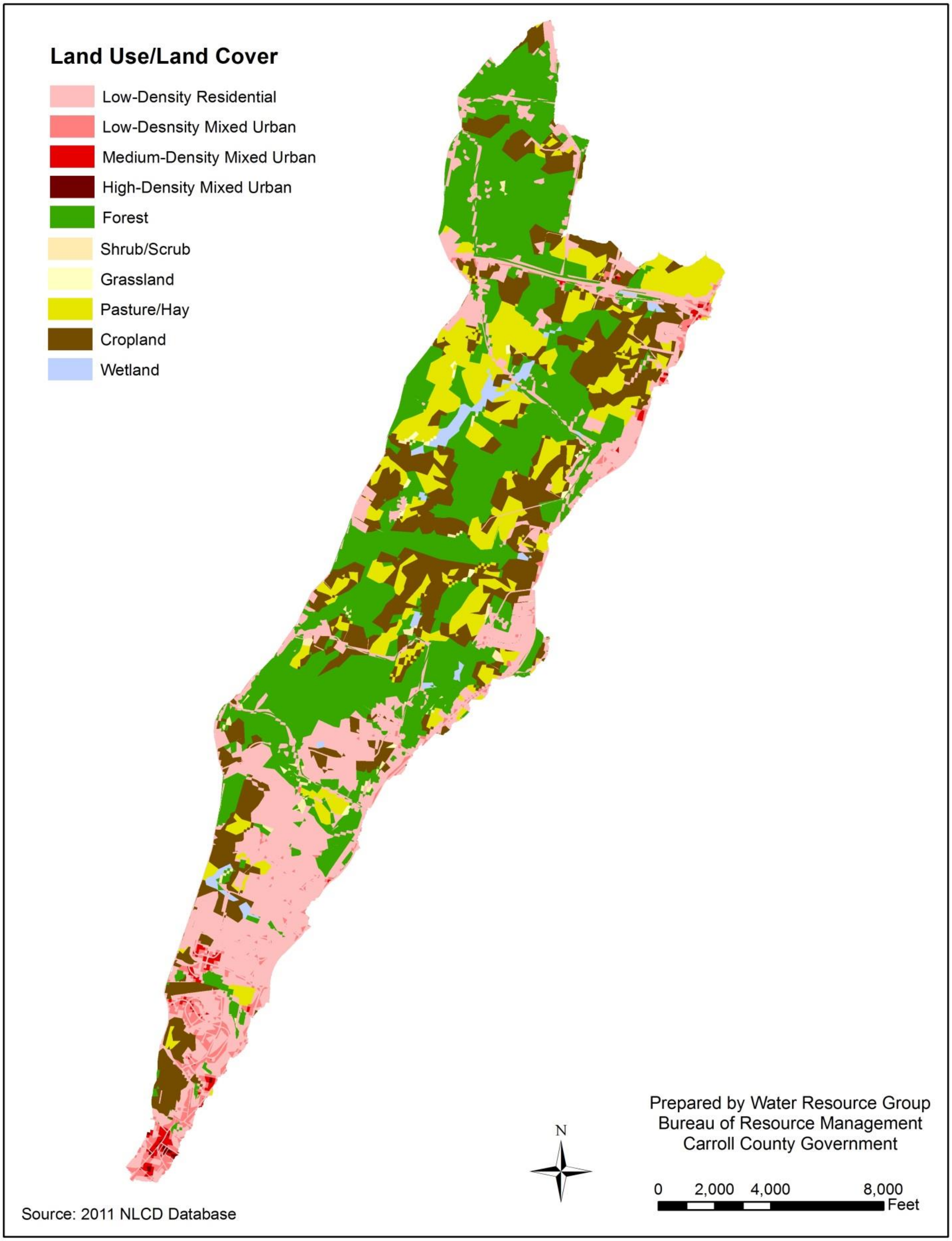

Figure 2: Lower Monocacy River Watershed Land Use/Land Cover from 2011

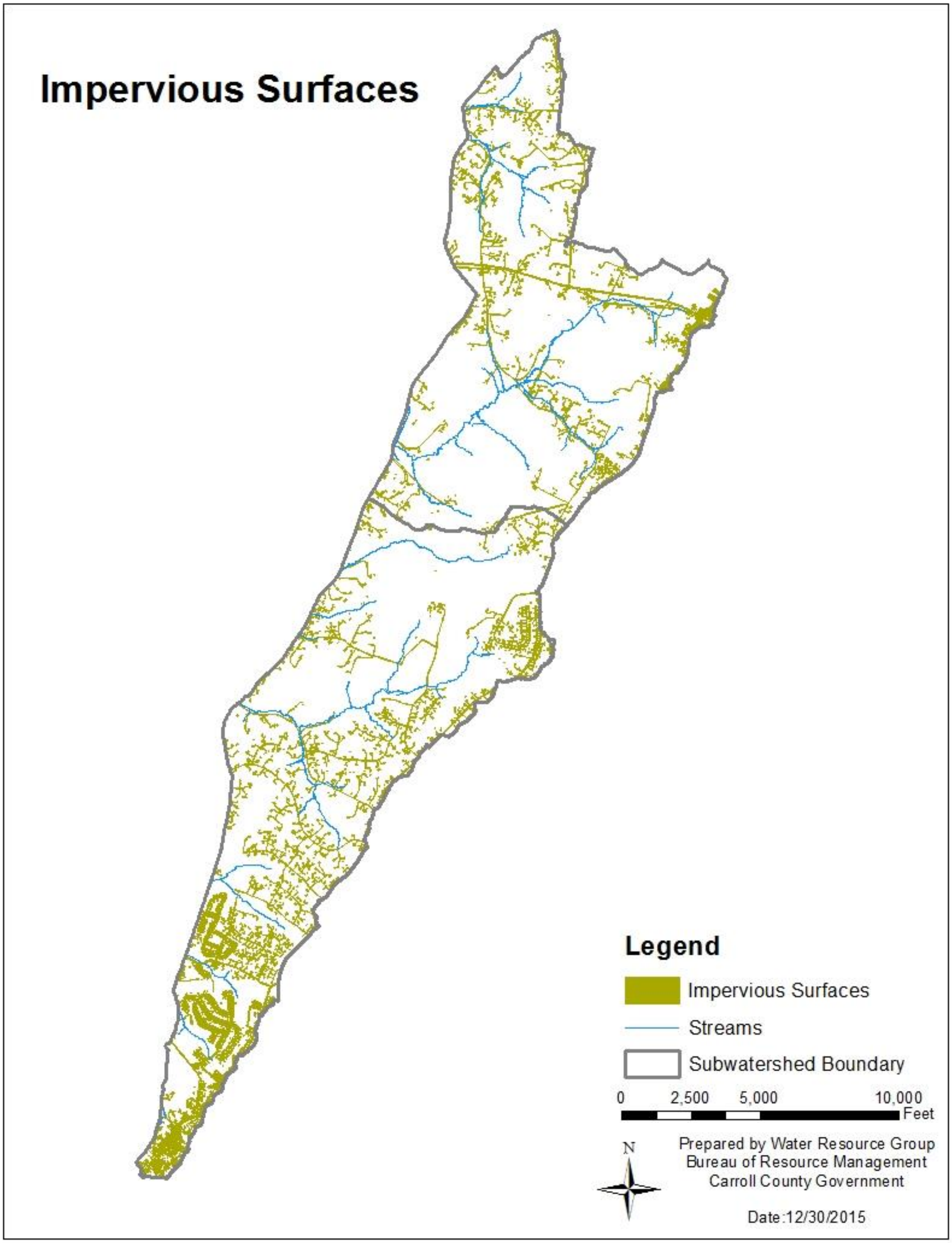

Figure 3: Lower Monocacy River Watershed Impervious Surface Area

C. Watershed Characterization

Following the Lower Monocacy River watershed stream corridor assessment (SCA, completed in 2014, a Watershed Characterization for the Lower Monocacy River 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 Lower Monocacy River watershed SCA will be used as the foundation for the watershed restoration and implementation plan. The Lower Monocacy River SCA and characterization documents can be found at:

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

http://ccgovernment.carr.org/ccg/resmgmt/LowerMonocacy/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 Lower Monocacy River watershed, there are no listed Tier II waters, though portions of the watershed are part of Tier II catchment basins.

b. Ecologically Sensitive Areas

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. There are approximately 24.5 acres of targeted ecological areas within the Lower Monocacy River watershed, as shown in Figure 4. Targeted ecological areas are a limited number of areas that rank exceptionally high for ecological criteria and that have a practical potential for preservation. 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.

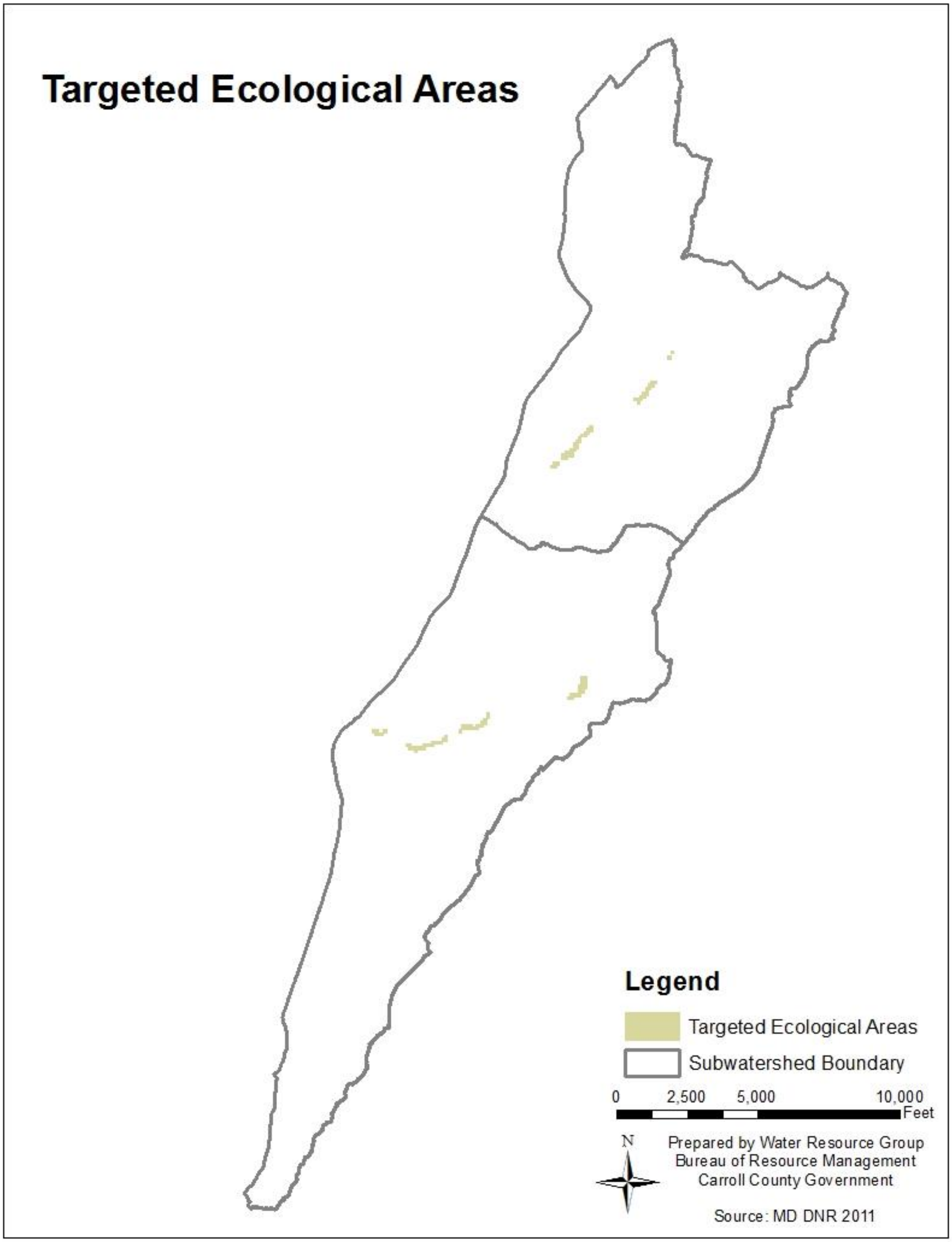

Figure 4: Lower Monocacy River Watershed Targeted Ecological Areas

2. Stream Corridor Assessment

A SCA of the Lower Monocacy River watershed was conducted during the winter of 2014 by Carroll County BRM staff. The Lower Monocacy River 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 Lower Monocacy River SCA is available at:

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

3. Priority Watersheds

During the SCA, field crews identified erosion problems along 3,767 linear feet of the corridor, 8.62% of the overall stream miles that were granted permission to assess. The highest percent of erosion based on the stream miles assessed was in South Fork, which partially originates within the corporate limits of the Town of Mount Airy. 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 feet 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 being treated and will focus on areas that will address significant downstream erosion that reduces nutrient and sediment loadings.

All of the proposed stormwater mitigation practices identified in *Section V.* of this report to address the stormwater WLA are focused in the South Fork subwatershed.

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
North Fork 021403020238	13.67	3.70	470	2.41%
South Fork 021403020235	10.37	4.58	3,297	13.63%
Total	**24.04**	**8.28**	**3,767**	**8.62%**

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 Lower Monocacy Watershed there are 244 parcels remaining with potential development on 2,078 acres for an estimated lot yield of 420 (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 5 shows the remaining parcels in Lower Monocacy 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.

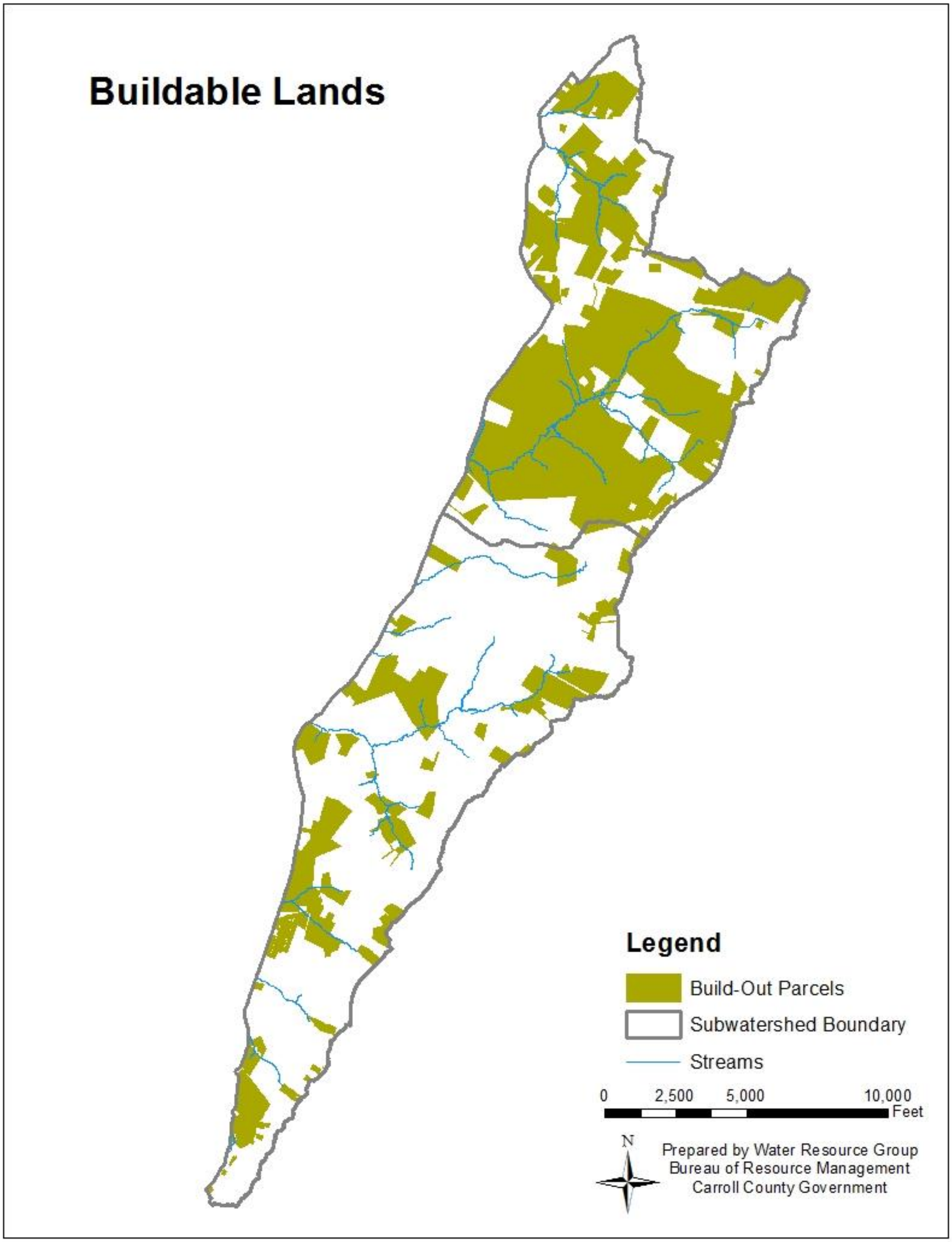

Figure 5: Lower Monocacy River Watershed Build Out Parcels

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 Lower Monocacy Watershed there are 0.68 acres of grass buffer and 0.98 acres of forest buffer protection easements. A list of the grass buffer and forest buffer protection easements within the Lower Monocacy Watershed can be found in Appendix B, and are shown in Figure 6. 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 Lower Monocacy River watershed lies just south of the Little Pipe Creek Rural Legacy area. The Lower Monocacy River watershed does not contain any rural legacy areas. The location of Lower Monocacy River watershed in relation to the Little Pipe Creek Rural Legacy area, and extent of growth area boundaries are shown in Figure 7.

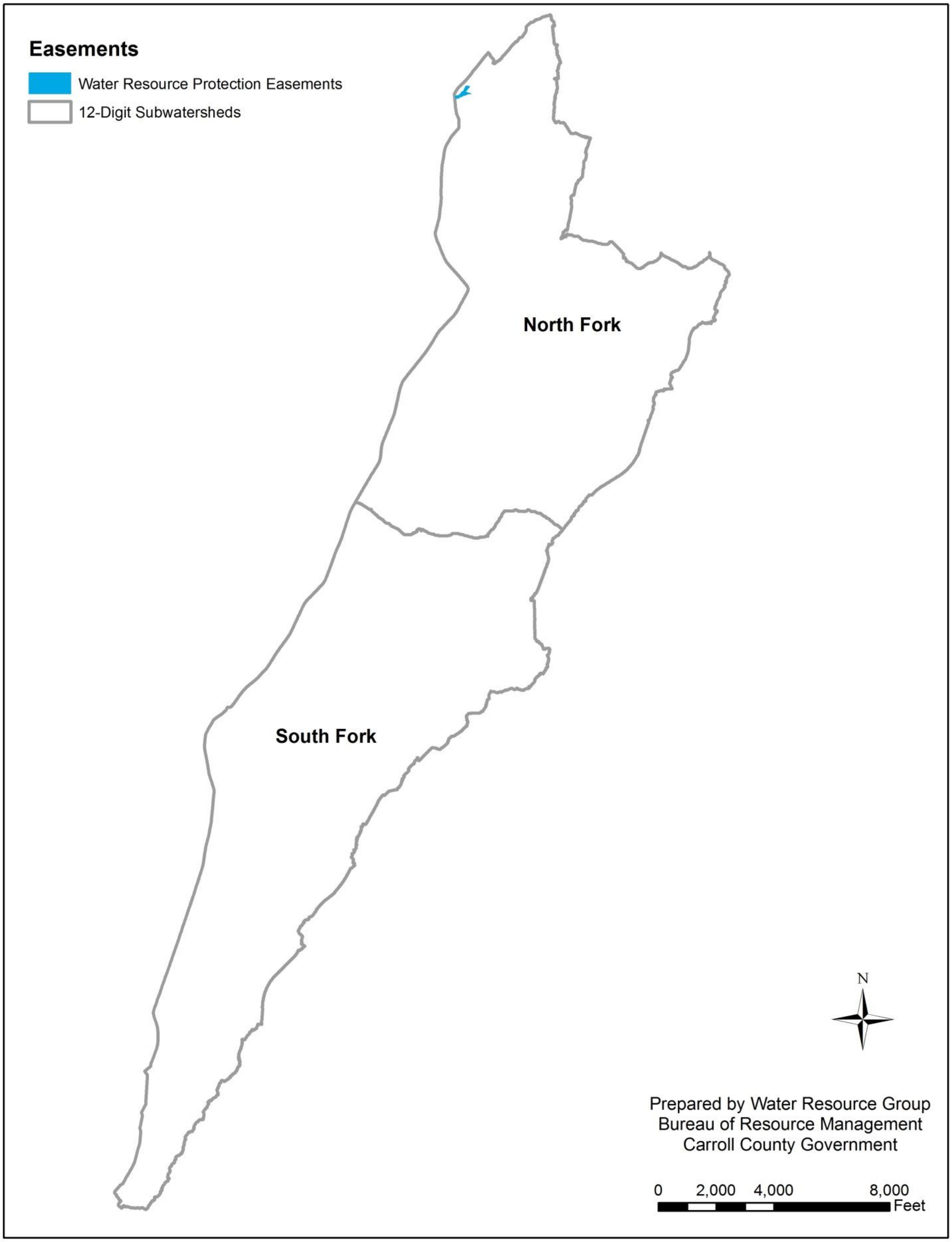

Figure 6: Water Resource Protection Easement Locations

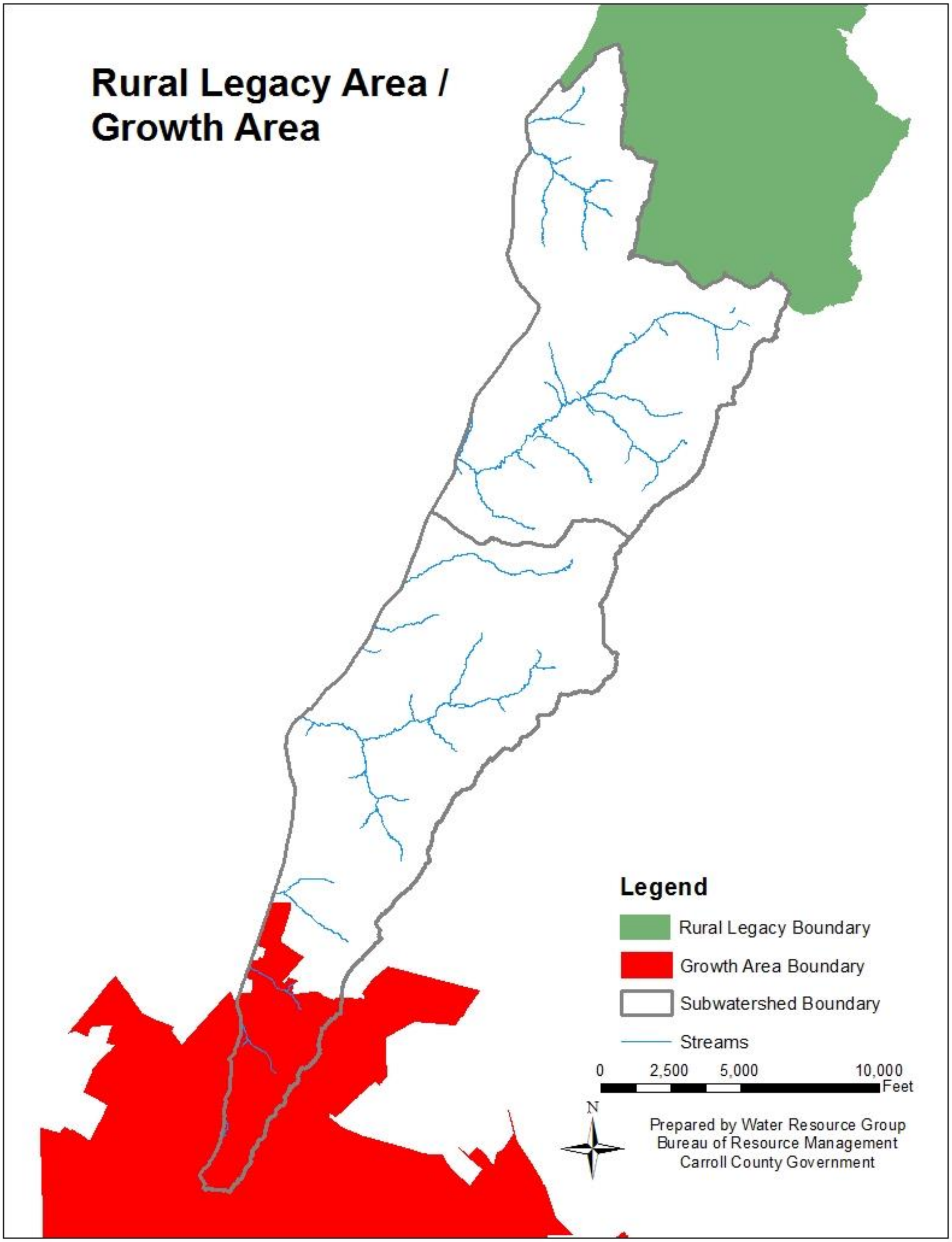

Figure 7: Little Pipe Creek Rural Legacy Area

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 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 issue 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; 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 are 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 has participated in that are either held within the Lower Monocacy River 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
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 Lower Monocacy River 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, 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 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.

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.), as properly designed and maintained stormwater ponds will help improve their performance (Clary et al. 2010; US EPA 2012). 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 Lower Monocacy River watershed TMDL's are listed in Table 9. The location of each facility can be found in Figure 8, the practice type and runoff depth treated for each facility can be found in Appendix B.

Table 9: Proposed Stormwater Management Projects

Project Name	Drainage Area	Impervious Area	Project Type	Subwatershed
Candice Estates	35	13	Planned	South Fork 021403020235
Windsong	135	16	Planned	South Fork 021403020235
Totals:	**170.0**	**29.0**		

B. Storm Drain Outfalls

During the Lower Monocacy River watershed SCA in winter 2014, erosion sites were documented and rated on severity. Stream Corridor Assessment identified erosion sites were analyzed in GIS to the location of existing SWM 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. There are no elementary schools in the Lower Monocacy River watershed that have planted rain gardens.

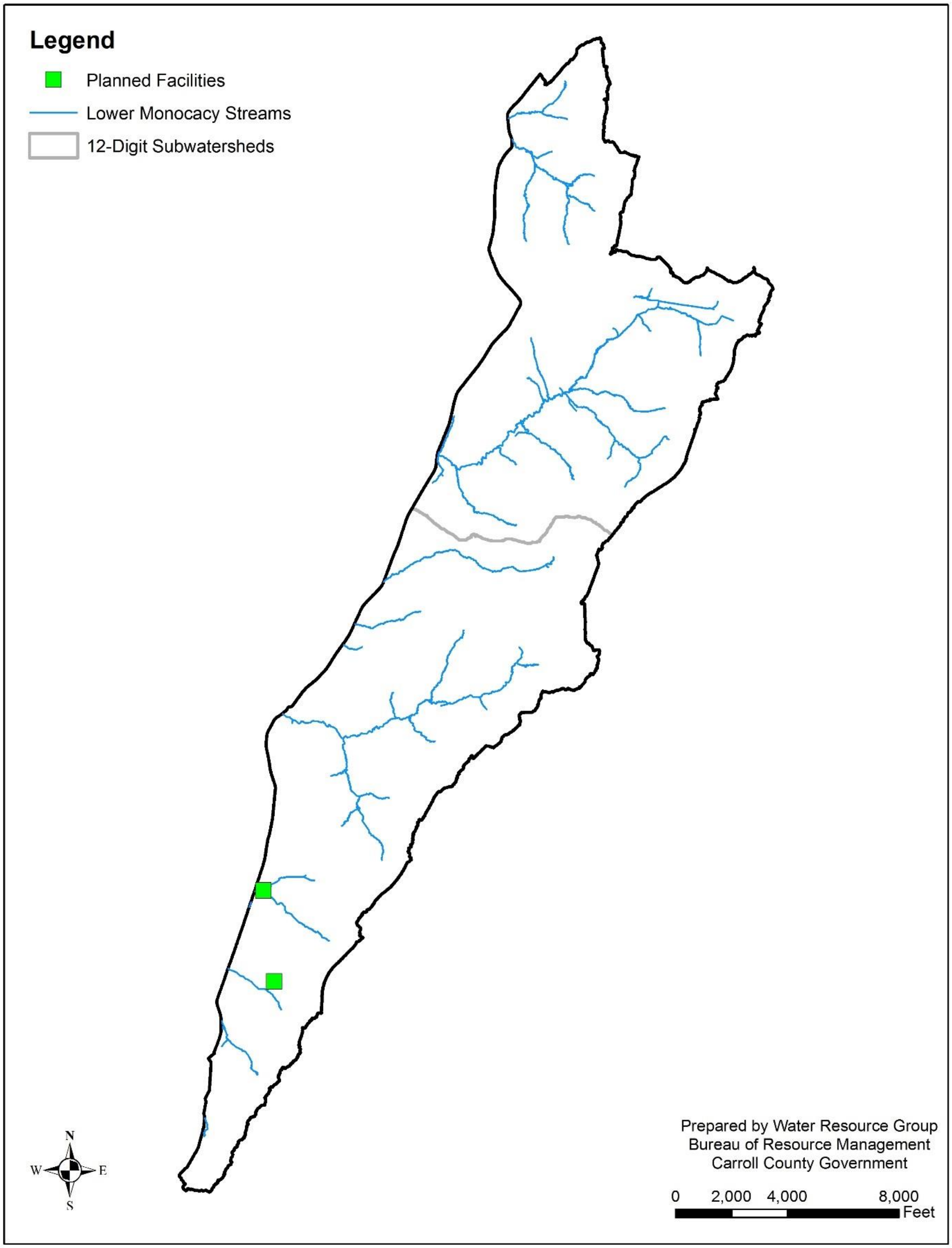

Figure 8: Stormwater Management Locations

D. Tree Planting and Reforestation

Stream buffers are vegetated areas along streams that reduce erosion, sedimentation and pollution of water (US EPA 2012a). Two tree planting initiatives were offered to landowners in the Lower Monocacy River watershed. These initiatives were 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

a. Neighborhood Green Program

The BRM assisted Frederick County to plant trees in the Linganore watershed, within the Lower Monocacy River watershed. Frederick County's Office of Sustainability & Environmental Resources received a grant from the National Fish & Wildlife Foundation to work with landowners to improve local water quality in the Linganore watershed through tree plantings. Participation in this stream buffer initiative was completely voluntary. The goal was to convert portions of mowed lawn to more natural areas with native trees and shrubs. Letters were mailed to landowners whose properties were identified as being part of the Linganore watershed. This letter provided education on the importance of stream buffers and offered grant-assisted buffer plantings at reduced cost to the homeowner. Eleven private properties participated in this initiative during 2013. The acreage planted for each location and the associated subwatershed can be found in Table 11. The approximate locations of the buffer plantings are shown in Figure 9.

b. Carroll County Stream Buffer Initiative

Following the completion of the winter 2014 SCA in the Lower Monocacy River watershed, the BRM began a stream buffer initiative. The winter 2014 Lower Monocacy River watershed SCA determined that over 80 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 during the SCA. This letter provided education on the importance of stream buffers and offered grant-assisted buffer plantings at no cost to the homeowner. One private property participated in this initiative during the Fall of 2014. The acreage planted for that location and the associated subwatershed can be found in Table 10. The approximate location of the buffer planting is included in Figure 9.

Table 10: Residential Buffer Plantings

	Acres Planted	Buffer Length	Buffer Width	Subwatershed	Date Planted
Planting 1	0.51	120	200	North Fork 021403020238	2013
Planting 2	0.58	170	140	South Fork 021403020235	2013
Planting 3	1.2	220	250	South Fork 021403020235	2014
Planting 4	5.8	730	300	South Fork 021403020235	2013
Planting 5	0.44	140	100	South Fork 021403020235	2013
Planting 6	0.43	230	50	South Fork 021403020235	2013
Planting 7	0.53	200	80	South Fork 021403020235	2013
Planting 8	1.44	300	200	South Fork 021403020235	2013
Planting 9	0.28	140	75	North Fork 021403020238	2013
Planting 10	0.61	160	140	South Fork 021403020235	2013
Planting 11	0.18	70	50	South Fork 021403020235	2013
Planting 12	0.22	100	95	South Fork 021403020235	Fall 2014

c. 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 monitored 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.

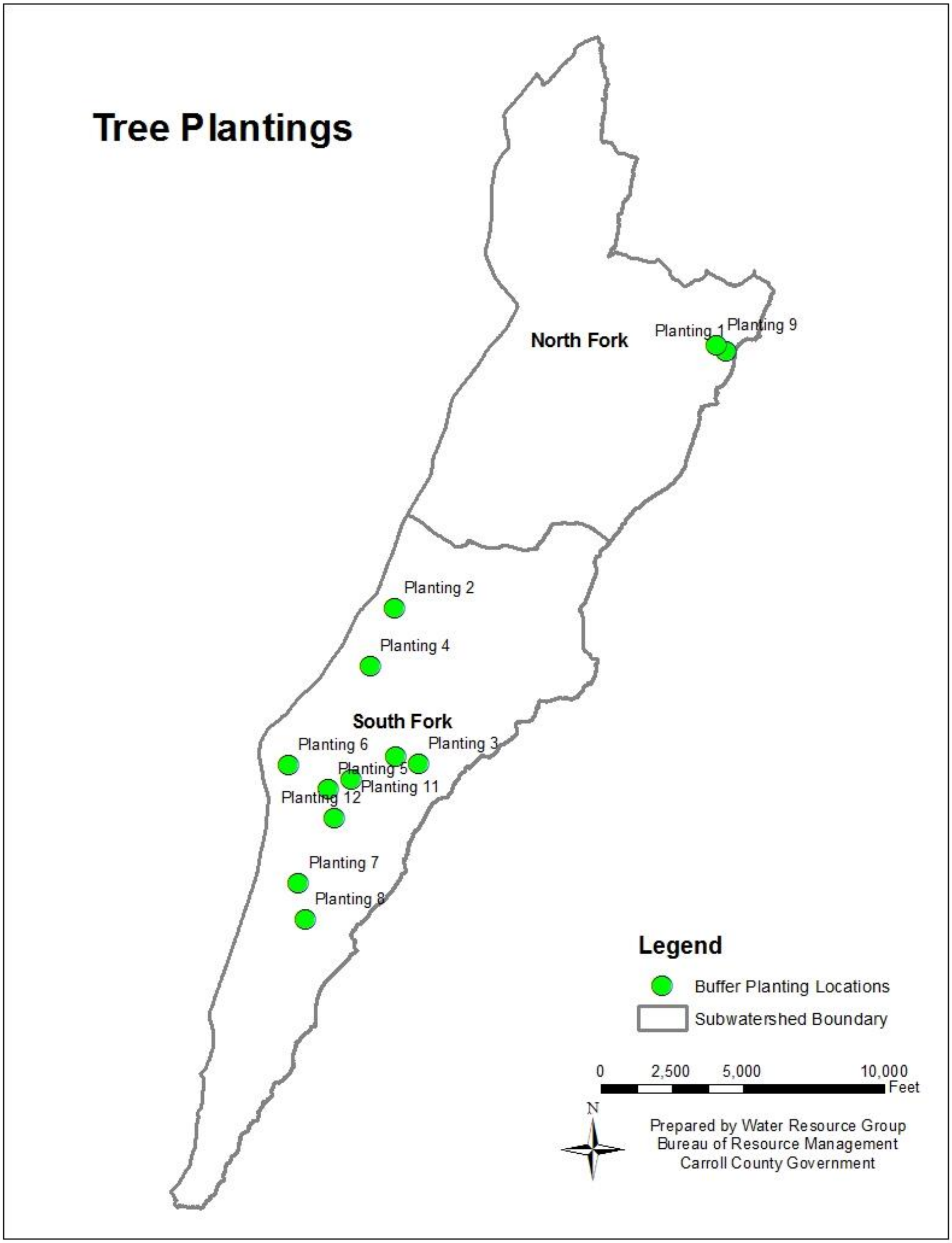

Figure 9: Buffer Planting Locations

E. 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 Lower Monocacy River watershed, and their associated reduction values are shown in Table 11.

Table 11: Road Maintenance Projects

Management Practice	Inlet Cleaning		
Town/City	Tons Removed	12-Digit Watershed	Date of Completion
Mount Airy	n/a		

F. 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 2007, five septic systems within the Lower Monocacy River watershed have been built utilizing BAT, and four have been repaired using BRF. Best available technology 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 Lower Monocacy River watershed are listed in Table 12.

Table 12: Septic Systems

Project Type	Subwatershed	Best Available Technology	Bay Restoration Funding	Completion Date
New Construction	021403020238	True	False	4/25/2014
New Construction	021403020235	True	False	2/24/2015
Repair	021403020238	True	True	11/16/2015
New Construction	021403020235	True	False	09/28/2015
Repair	021403020235	True	True	04/07/2015
Repair	021403020238	True	True	6/24/2016
Repair	021403020235	True	True	5/31/2016
New Construction	021403020238	True	False	1/13/2017
New Construction	021403020238	True	False	7/21/2016

G. Agricultural Best Management Practices

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 allow 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.

H. 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.

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 B provides the associated reduction values.

I. 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.

J. 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 C.

2. Restoration Progress: December 2019

Current restoration strategies outlined in this document are efforts initiated to meet Stormwater WLA TMDL requirements within the Lower Monocacy watershed. As described in Section I, phosphorus and bacteria 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, and an updated version due out for review in the Fall of 2019.

The local TMDL suggests an urban phosphorus load reduction of 30% from the 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. Lower Monocacy). 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 reduction of 30% of the baseline year. A baseline year of 2011 was used as a proxy for the 2009 baseline year in the TMDL, as land cover data from 2011 was the closest available for that time period. The modeled 2011 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 2009 TMDL baseline year can be counted toward load reductions necessary to meet the TMDL, even though 2011 was used as the baseline proxy year. For reference, the modeled baseline urban P load using the 2011 land cover was 180.66 lbs, which equates to a 30% reduction of 54.20 lbs (Table 13).

The projects completed as of December 2019 are providing 0.96 pounds of TP reduction, the planned projects within the current CIP will provide another 12.76 pounds of TP reduction. 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 Figure 10. 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 Lower Monocacy TMDL. At this point it is not feasible, and is fiscally not possible to identify or specify the exact projects, locations, or costs beyond the current CIP.

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

Table 13: Total Phosphorus Load Reduction in the Lower Monocacy Watershed (lbs/year) in Carroll County

Modeled Baseline Load (lbs)	% Required Reduction from TMDL	Required Load Reduction based on Modeled Baseline (lbs)	Reduction from Current BMPs (lbs)	Reduction from Restoration Plan Strategies (lbs)	Total % Reduction Achieved
180.66	30%	54.20	0.96	12.76	8%

Table 14: Comparison of Total Phosphorus delivered Load Reductions (lbs/year) by Restoration Strategies. This table includes both proposed and existing BMPs.

Status	Pond Retrofits (lbs)	Buffers (lbs)	Catch Basin/ Inlet Cleaning (lbs)	Water Resource Easements (lbs)
Completed		0.90	0.00	0.06
Planned	12.76			

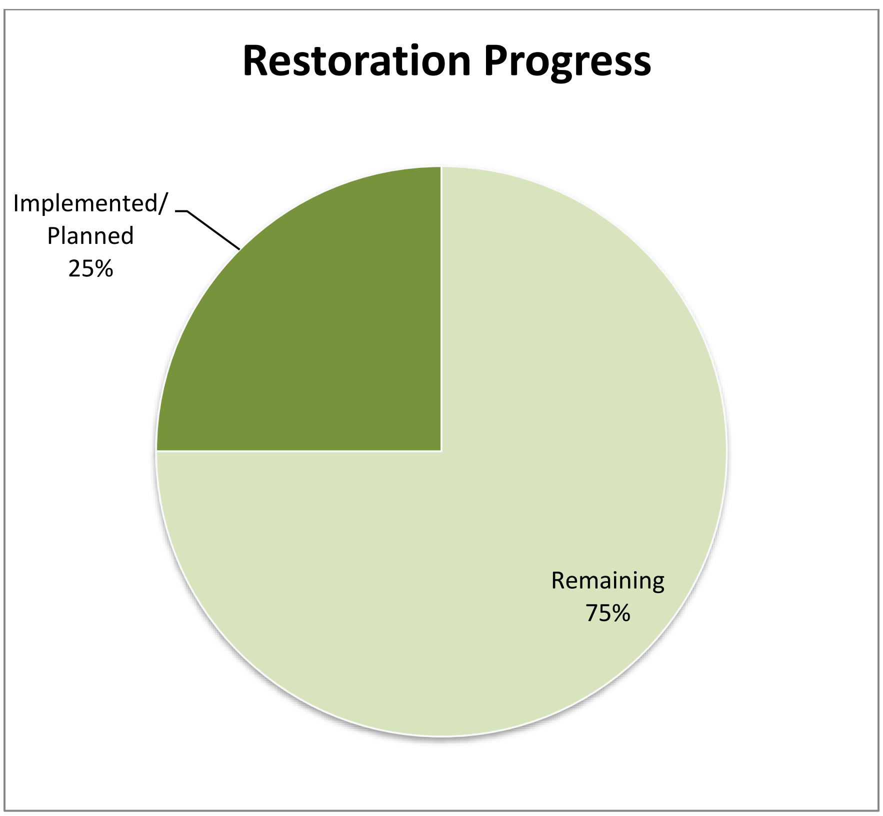

Figure 10: 2019 Restoration Progress Phosphorus

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.

a. Human Source Elimination

Elimination of human sources of bacteria within the Lower Monocacy 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.

Table 15 lists infrastructure related measures that have been implemented since the 2004 baseline year that would assist in reducing bacteria counts within the watershed.

Table 15: Waste Collection Infrastructure Upgrades

	County	Mount Airy
BAT Upgrades	**9**	**0***
Casings/Linings	n/a	TBD
Lateral line replacements	n/a	TBD
Pump Station upgrade	n/a	TBD

***upgrades occurred within corporate boundaries**

b. 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.

c. 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.

K. 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.

1. Retrofit Monitoring

The BRM has considered adding one location within the Lower Monocacy River watershed to our retrofit monitoring program. The Candice Estates site, shown in Figure 11 is located within the South Fork (0235) subwatershed.

Currently there are no stormwater controls to this location; a developer is in the planning phase for a project at this site that will consist of a surface sand filter. The Candice Estates location is primarily low-density residential, which encompasses 79% of the land cover. The drainage area to the monitoring site is approximately 39 acres, of which, 13 acres or 33% is impervious.

Bi-weekly monitoring at the Candice Estates site would consist of chemical grab samples with corresponding discharge measurements in order to calculate loadings. The chemical monitoring parameters, methods, and detection limits for the Candice Estates site can be found in Table 16. Additional monitoring at this location will include spring macro-invertebrate collection, which are based upon protocols set by Maryland's MBSS program (Stranko et al, 2014).

Table 16: 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. The County is currently exploring locations within the Lower Monocacy Watershed to include within the countywide bacteria trend monitoring program.

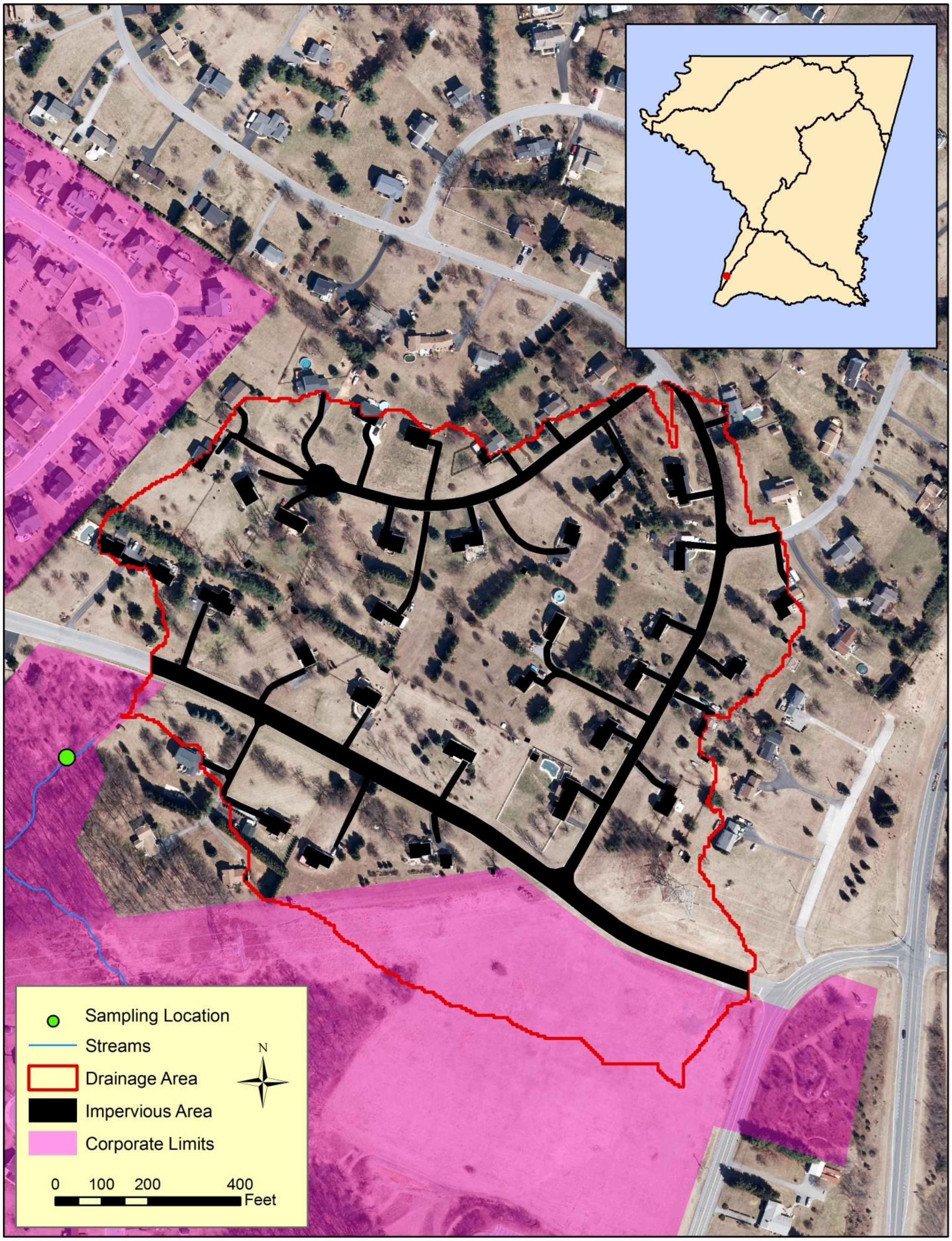

Figure 11: Candice Estates Monitoring Location

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 18). Best management practices and restoration projects that have been either completed or proposed to address local TMDL's within the Lower Monocacy River 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 17, and the tidal water designated use zones are shown in Figure 12.

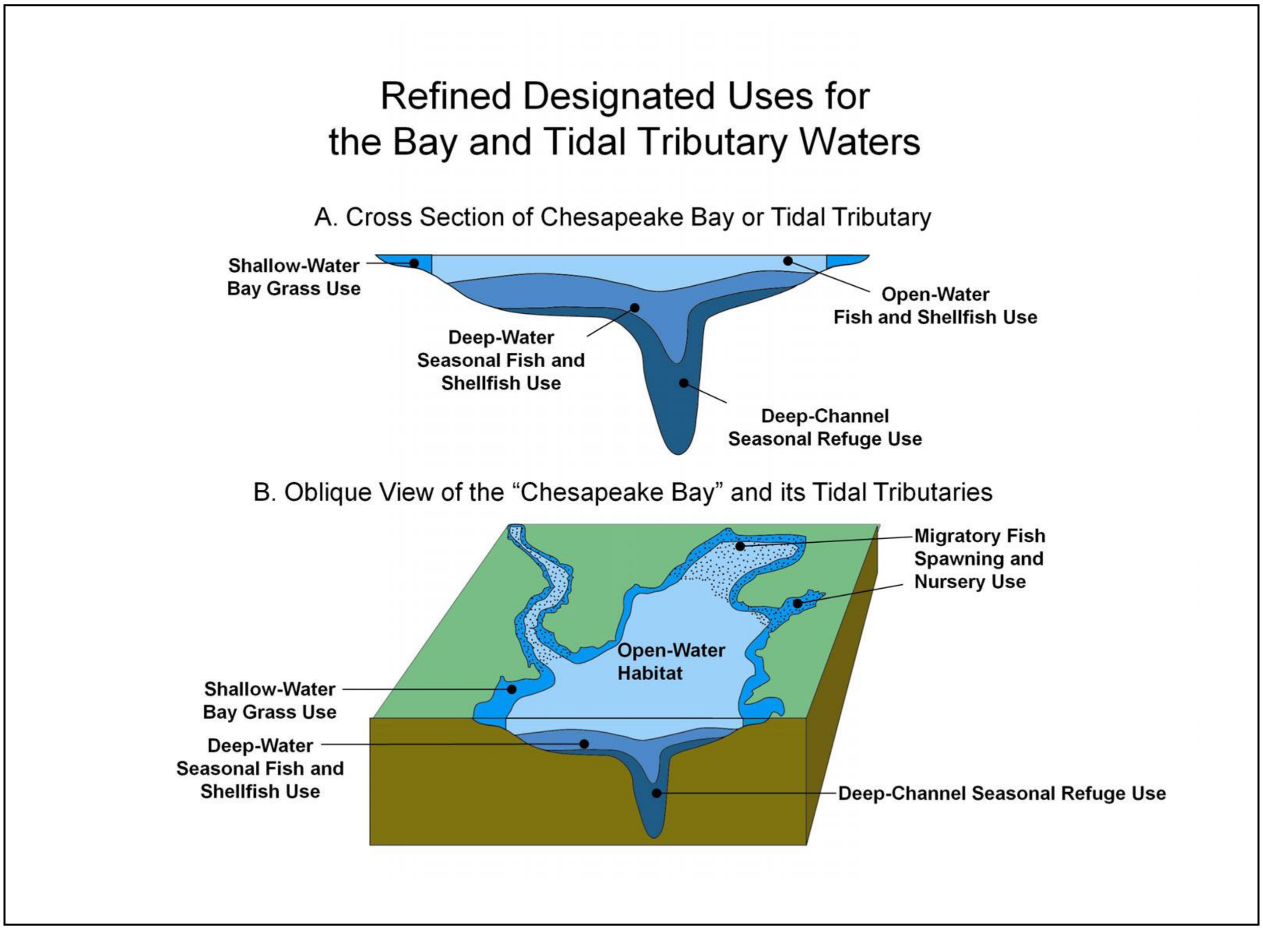

Figure 12: Chesapeake Bay Tidal Water Designated Use Zones (source: USEPA2003d)

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 17: 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 Lower Monocacy River watershed is located within the Potomac River Basin of the Chesapeake Bay. Within Maryland, the Potomac River Basin covers 1,539,973 acres across eight counties. Approximately 137,878 acres (9%) of the Potomac River Basin located in Maryland is within Carroll County, 4% of which is located in Lower Monocacy River watershed. The location of the Potomac River Basin segment is shown in Figure 13.

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 D) calculated using the 2014 MDE Guidance document so that they correspond to the Bay TMDL delivered load allocations and reductions shown in Table 18. 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 Potomac River Basin river segment within the Lower Monocacy River watershed are; 0.37 for nitrogen, 0.47 for phosphorus, and 0.65 for TSS. (MAST, 2016). Essentially, if one pound of nitrogen is discharged into a tributary within the Lower Monocacy River portion of the Potomac River Basin river segment, only 37% of that pound is reaching the Bay.

Table 19 shows the Chesapeake Bay TMDL for the Potomac 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 Lower Monocacy 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 Lower Monocacy Watershed show the restoration progress towards meeting the County's Bay TMDL reductions for the Potomac segment shed. The Lower Monocacy Watershed covers approximately 4% of the Potomac land-river segment within Carroll County.

Table 18: Carroll County[1] Bay TMDL Restoration Progress, including planned practices for the Lower Monocacy 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
10,100.99	22.07%	2,228.95	2.11	31.83	1.5%
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
110,661.46	9.25%	10,232.26	35.02	307.19	3.34%

[1]This table represents the combined County Phase I and Municipal Phase II loads and reductions for the Potomac land river segment of Carroll County. The BMP load reductions represent the combined reductions for County and Municipal projects in the Lower Monocacy watershed.

[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.

Table 19: Carroll County Potomac 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
Lower Monocacy Watershed	2.11	31.83	1.5%	35.02	307.19	3.34%
Upper Monocacy Watershed	69.73	57.11	5.69%	473.39	469.79	9.22%
Double Pipe Creek Watershed	152.95	266.16	18.80%	855.30	593.77	14.16%
Total	**224.79**	**355.10**	**25.99%**	**1,363.71**	**1,370.75**	**26.72%**

[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.

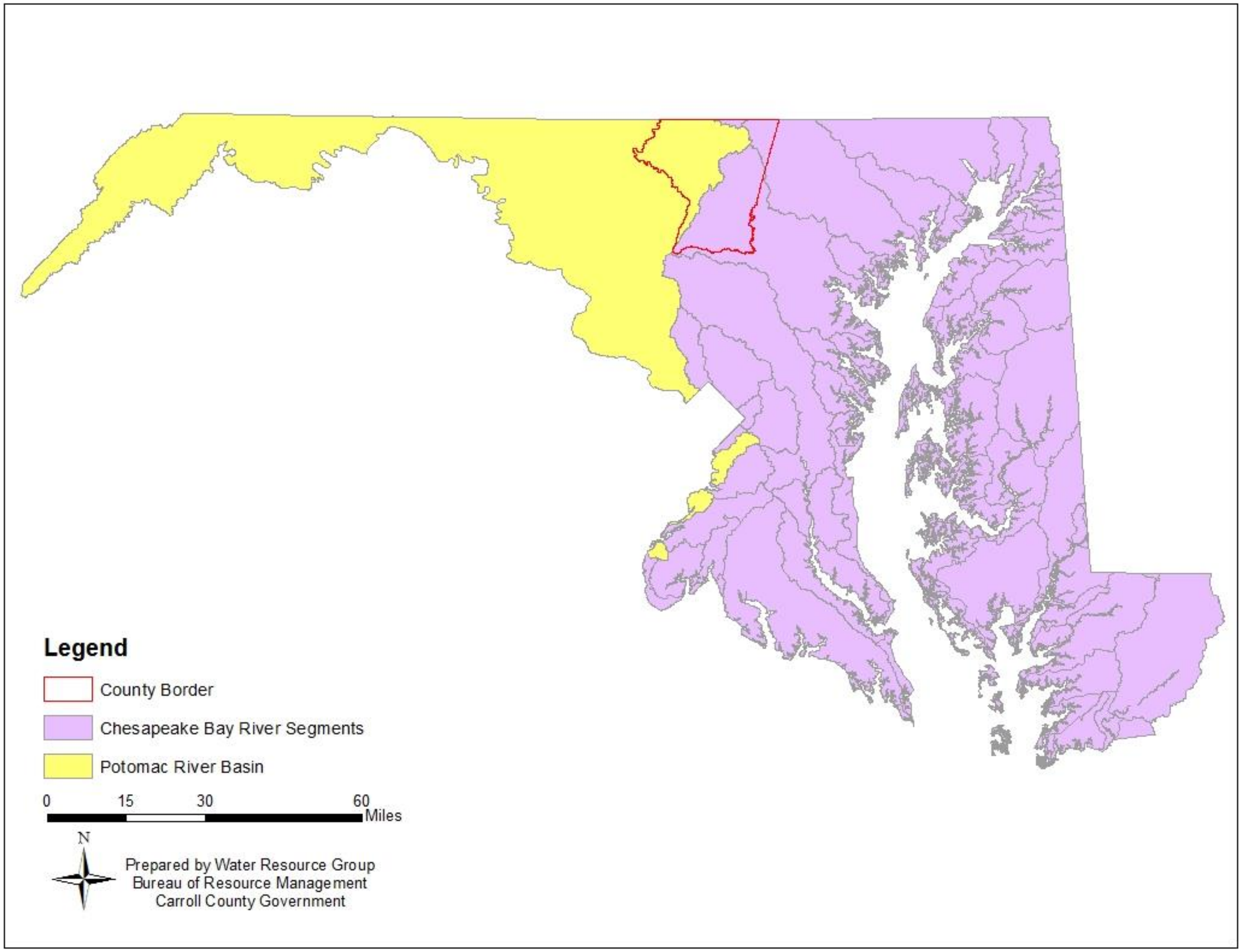

Figure 13: Chesapeake Bay River Segments

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 2% of the required reduction since the baseline year of 2009. Based on currently identified projects, the required reduction is expected to achieve 25% by 2025. The implementation from baseline through the current CIP is achieving approximately 1.56% reduction in the TMDL/year since the baseline.

If the County is able to achieve a 2.25% reduction rate per year until the phosphorus TMDL is fully implemented, the phosphorus TMDL in the Lower Monocacy Watershed would be achieved by 2058. 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 20 lists the anticipated benchmark for each nutrient TMDL within the Lower Monocacy 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 20: Nutrient TMDL Benchmarks

Nutrient	2019	2025	2058
Phosphorus	2%	25%	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 Lower Monocacy 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). (2009). Total Maximum Daily Load of Sediment in the Lower Monocacy River Watershed, Frederick, Carroll, and Montgomery Counties, Maryland.

Maryland Department of the Environment (MDE). (2009). Total Maximum Daily Loads of Fecal Bacteria for the Lower Monocacy River Basin in Carroll, Frederick, and Montgomery Counties, Maryland.

Maryland Department of the Environment (MDE). (2012). Significant Phosphorus Point Sources in the Lower Monocacy River Watershed Technical Memorandum

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.

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

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

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 (Completed)	County	2140302	Completed	$0	Completed
Buffer Plantings	County	2140302	Completed	$21,025	Completed
Roads: Street/Inlet Cleaning	Manchester	2140302	Annual	**	Annual
Water/floodplain Easement	County	2140302	Completed	N/A	Completed
SWM (Planned)	County	2140302	Planning/Design	$850,000	FY19-FY25
TBD	Watershed	2140302	Planning	$2,613,000	TBD

***Costs for proposed Stormwater facilities are based on current FY19-FY25 project costs, which may be subject to change.**

****Project Costs not reported.**

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

SWM Facilities (Pond Retrofits)

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)
Candice Estates	Retrofit	35	13	RR	2.50	3.7779%	68%	38.48	3.1532%	79%	5.70	1.7401%	85%	5.73
IDA Property	Facility	75.5	10.5	RR	2.50	2.6472%	68%	26.96	3.1375%	79%	5.67	3.4341%	85%	11.31
Windermere/Windsong	Facility	135	16	ST	1.00	2.4436%	35%	24.89	3.9094%	55%	7.06	5.0706%	70%	16.69
	Total:	**245.5**	**39.5**			**8.8687%**		**90.33**	**10.2001%**		**18.43**	**10.2447%**		**33.73**

Grass Buffer Easements--Efficiency factors from 2011 Guidance

Subdivision	Acres	Recorded Date	% 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 2009-Current	0.680	2009 -current	0.011%	30	0.11	0.014%	40	0.03	0.020%	55	0.07
		Total:	**0.011%**		**0.26**	**0.014%**		**0.03**	**0.020%**		**0.07**

Forest Buffer Easements--Efficiency factors from 2011 Guidance

Subdivision	Acres	Recorded Date	% 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 2009-Current	0.980	2009 -current	0.023%	45	0.23	0.021%	40	0.04	0.029%	55	0.10
		Total:	**0.023%**		**0.23**	**0.021%**		**0.04**	**0.029%**		**0.10**

Stream Buffer Plantings

Project	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)
Planting 1	0.51	0.017%	66	0.18	0.021%	77	0.04	0.016%	57	0.05
Planting 2	0.58	0.020%	66	0.20	0.024%	77	0.04	0.018%	57	0.06
Planting 3	1.2	0.041%	66	0.42	0.049%	77	0.09	0.037%	57	0.12
Planting 4	5.8	0.198%	66	2.02	0.235%	77	0.43	0.178%	57	0.58
Planting 5	0.44	0.015%	66	0.15	0.018%	77	0.03	0.013%	57	0.04
Planting 6	0.43	0.015%	66	0.15	0.017%	77	0.03	0.013%	57	0.04
Planting 7	0.53	0.018%	66	0.18	0.022%	77	0.04	0.016%	57	0.05
Planting 8	1.44	0.049%	66	0.50	0.058%	77	0.11	0.044%	57	0.15
Planting 9	0.28	0.010%	66	0.10	0.011%	77	0.02	0.009%	57	0.03
Planting 10	0.61	0.021%	66	0.21	0.025%	77	0.04	0.019%	57	0.06
Planting 11	0.18	0.006%	66	0.06	0.007%	77	0.01	0.006%	57	0.02
Planting 12	0.22	0.008%	66	0.08	0.009%	77	0.02	0.007%	57	0.02
Total:	**12.22**	**0.418%**		**4.25**	**0.496%**		**0.90**	**0.374%**		**1.23**

XIV. Appendix C: 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. This was not required in the Lower Monocacy watershed due to its small size.
- Digital Elevation Model: The County's DEM derived from Lidar data was clipped to the Carroll County portion of the Lower Monocacy 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 C-1) following guidance in Appendix G of the MapShed documentation (Evans and Corradini, 2015).

Table C-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 C-2, and were based on literature and professional judgement.

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

Parameter	Default	New Value	Units	Comments
Practice Factor (pasture/hay)**	0.61	0.25	NA	Little disturbance and heavy forage assumed.
Practice Factor (cropland)**	0.59	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 LD Mixed MD Mixed HD Mixed LD Residential	Imp. (Pervious) values 2.8 (0.8) 6.2 (0.8) 2.8 (0.8) 2.5 (1.3)	Imp. (Pervious) values 1.21 (0.19) 2.66 (0.30) 2.66 (0.30) 1.21 (0.19)	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.

* 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 area weighted using pasture/hay or cropland area of the subcatchments of this watershed.

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 C-3 for the Lower Monocacy 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 C-3 based on professional judgement.

Table C-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	0.53	0.10	353.83
MD Mixed	52	>=30 to <70	1.62	0.21	386.75
HD Mixed	87	>=70	1.66	0.21	389.73
LD Residential	15	>5 to <30	0.53	0.10	353.77

The baseline year for this TMDL is 2009, which means any retrofitted water quality BMPs installed since 2009 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 C-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 Lower Monocacy watershed, the load weighted average TN, TP, and TSS delivery ratios are 0.042, 0.041, and 0.093, 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.

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)

XV. Appendix D: 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)
Candice Estates	Retrofit	35	13	RR	2.50	15.3	198.9000	68%	134.6553	1.69	21.9700	79%	17.3150	0.44	5.7200	85%	4.8562
IDA Property	Facility	75.5	10.5	RR	2.50	15.3	160.6500	68%	108.7601	1.69	17.7450	79%	13.9852	0.44	4.6200	85%	3.9223
Windermere/ Windsong	Facility	135	16	ST	1.00	15.3	244.8000	35%	85.5576	1.69	27.0400	55%	14.8504	0.44	7.0400	70%	4.9210
	Total:	**245.5**	**39.5**				**604.35**		**328.97295**		**66.755**		**46.15050416**		**17.38**		**13.69942613**

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)
Candice Estates	Retrofit	35	22	RR	2.50	10.8	237.6000	68%	160.8552	0.43	9.4600	79%	7.4556	0.07	1.5400	85%	1.3074
IDA Property	Facility	75.5	65	RR	2.50	10.8	702.0000	68%	475.2540	0.43	27.9500	79%	22.0279	0.07	4.5500	85%	3.8629
Windermere/ Windsong	Facility	135	119	ST	1.00	10.8	1285.2000	35%	449.1774	0.43	51.1700	55%	28.1026	0.07	8.3300	70%	5.8227
	Total:	**245.5**	**206**				**2224.8**		**1085.2866**		**88.58**		**57.58608644**		**14.42**		**10.99296581**

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 2009-Current	0.680	2009 -current	11.7	7.9560	30	2.38680	0.68	0.4624	40	0.1850	0.18	0.1224	55
	0.680		**Total:**	**7.9560**		**2.38680**		**0.4624**		**0.1850**		**0.1224**	

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 2009-Current	0.980	2009 -current	11.7	11.4660	45	5.1597	0.68	0.6664	40	0.2666	0.18	0.1764	55
	0.980		**Total:**	**11.4660**		**5.15970**		**0.6664**		**0.2666**		**0.1764**	

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	0.51	10.8	5.5080	66	3.6353	0.43	0.2193	77	0.1689	0.07	0.0357	57	0.0203
Planting 2	0.58	10.8	6.2640	66	4.1342	0.43	0.2494	77	0.1920	0.07	0.0406	57	0.0231
Planting 3	1.2	10.8	12.9600	66	8.5536	0.43	0.5160	77	0.3973	0.07	0.0840	57	0.0479
Planting 4	5.8	10.8	62.6400	66	41.3424	0.43	2.4940	77	1.9204	0.07	0.4060	57	0.2314
Planting 5	0.44	10.8	4.7520	66	3.1363	0.43	0.1892	77	0.1457	0.07	0.0308	57	0.0176
Planting 6	0.43	10.8	4.6440	66	3.0650	0.43	0.1849	77	0.1424	0.07	0.0301	57	0.0172
Planting 7	0.53	10.8	5.7240	66	3.7778	0.43	0.2279	77	0.1755	0.07	0.0371	57	0.0211
Planting 8	1.44	10.8	15.5520	66	10.2643	0.43	0.6192	77	0.4768	0.07	0.1008	57	0.0575

Planting 9	0.28	10.8	3.0240	66	1.9958	0.43	0.1204	77	0.0927	0.07	0.0196	57	0.0112
Planting 10	0.61	10.8	6.5880	66	4.3481	0.43	0.2623	77	0.2020	0.07	0.0427	57	0.0243
Planting 11	0.18	10.8	1.9440	66	1.2830	0.43	0.0774	77	0.0596	0.07	0.0126	57	0.0072
Planting 12	0.22	10.8	2.3760	66	1.5682	0.43	0.0946	77	0.0728	0.07	0.0154	57	0.0088
Total:	**12.22**		**131.9760**		**87.1042**		**5.2546**		**4.0460**		**0.8554**		**0.4876**

XVI. Appendix E: Forest Buffer and Grass Buffer Easements

Forest Buffer Protection Easements

Project Name	Acres	Implementation Year
North Fork	0.787905	2012
North Fork	0.189594	2012

Grass Buffer Protection Easements

Project Name	Acres	Implementation Year
North Fork	0.681419	2012