Prince George's County
DEPARTMENT OF THE
ENVIRONMENT

November 30, 2024

2024 Nutrient and Sediment Stormwater Wasteload Allocation (SW-WLA) Watershed Implementation Plan (WIP) for the **Anacostia River Watershed** in Prince George's County, Maryland

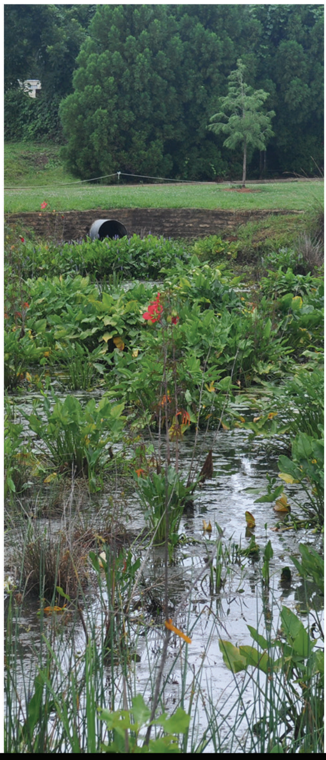
Prepared for: Prince George's County Department of the Environment, 1801 McCormick Drive, Suite 500, Largo, Maryland 20774
Prepared by: Tetra Tech, 10306 Eaton Place, Suite 340, Fairfax, VA 22030









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ABBREVIATIONS AND ACRONYMS

ALT	Alternative BMP practices
AR	Anacostia River
A-StoRM	Advancing Stormwater Resiliency in Maryland
BIBI	Benthic Index of Biotic Integrity
BMP	best management practice
BOD	biochemical oxygen demand
BSID	Biological Stressor Identification
CFR	Code of Federal Regulations
CIP	Capital Improvement Program
COMAR	Code of Maryland Regulations
CWA	Clean Water Act
CWP	Clean Water Partnership
DC DOEE	District of Columbia Department of Energy and Environment
DO	dissolved oxygen
DoE	[Prince George's County, MD] Department of the Environment
DPIE	[Prince George's County, MD] Department of Permitting, Inspection, and Enforcement
DPW&T	[Prince George's County, MD] Department of Public Works and Transportation
EPA	U.S. Environmental Protection Agency
ESD	environmental site design
°F	degrees Fahrenheit
FAP	Financial Assurance Plan
FIBI	Fish Index Biotic Integrity
FY	fiscal year
GRTS	Generalized Random Tessellation Stratified
HOA	homeowner association
HSG	hydrologic soil group
IBI	Index of Biotic Integrity
IDDE	illicit discharge detection and elimination
IDF	intensity-duration-frequency
LA	load allocation
lb	pound
MARISA	Mid-Atlantic Regional Integrated Sciences and Assessments
MBSS	Maryland Biological Stream Survey
MD DNR	Maryland Department of Natural Resources
MDE	Maryland Department of the Environment
MDP	Maryland Department of Planning
MEP	maximum extent practicable
mg/L	milligrams per liter

MGS	Maryland Geological Survey
M-NCPPC	Maryland-National Capital Park and Planning Commission
MOS	margin of safety
MS4	municipal separate storm sewer system
NEB	Northeast Branch
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NWB	Northwest Branch
NWS	National Weather Service
O&M	operation and maintenance
PCB	polychlorinated biphenyl
ROW	right-of-way
RR	runoff reduction
SCA	stream corridor assessment
ST	stormwater treatment
SW-WLA	stormwater wasteload allocation
SWM	stormwater management
SWMM	Stormwater Management Model
TIPP	TMDL Implementation Progress and Planning
TMDL	total maximum daily load
TN	total nitrogen
TP	total phosphorus
TP40	Technical Paper Number 40
TSS	total suspended solids
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
WIP	Watershed Implementation Plan
WLA	wasteload allocation
WSSC	Washington Suburban Sanitary Commission
XSa	cross sectional area
XS	cross-section

Executive Summary

On December 2, 2022, the Maryland Department of the Environment (MDE) issued Prince George's County (the County) its fifth-generation permit (Permit Number: 20-DP-3314 MD0068284) for its National Pollutant Discharge Elimination System (NPDES) municipal separate storm sewer system (MS4), which is a series of stormwater sewers owned by a municipal entity (e.g., the County) that discharges the conveyed stormwater runoff into a water body (e.g., Anacostia River). The permit covers the period of December 2, 2022, through December 1, 2027. The MS4 permits are generally issued in 5-year cycles enabling regulators and permit holders to adjust permit objectives and expectations.

The 2022 MS4 permit requires that the County develop local restoration plans to address each U.S. Environmental Protection Agency (EPA)-approved total maximum daily load (TMDL) with a stormwater wasteload allocation (SW-WLA). A TMDL can be seen as a *pollution diet* in that it is the maximum amount of a pollutant that a water body can assimilate and still meet water quality standards and designated uses.

This SW-WLA Watershed Implementation Plan (WIP) covers the SW-WLA assigned to the County's MS4 for nutrient and sediment impairments in the Anacostia River watershed (Figure ES-1). A WIP is a strategy for managing the natural resources within a geographically defined watershed. For the County's Department of the Environment (DoE), this means managing urban stormwater (i.e., runoff originating from rainstorms) to restore and protect the County's water bodies. Stormwater management is most effective when viewed in the watershed context—watersheds are land areas and their network of streams that convey stormwater runoff downstream to a single point.

Along with the 2022 MS4 permit, MDE released multiple guidance documents on addressing TMDLs. This WIP contains updates based on the latest MDE guidance and is an update to a previous restoration plan for nutrients, sediment, and bacteria that was submitted to MDE in 2015 (Tetra Tech 2015). It uses new information, including loading rates derived from the Bay Model 6, provided by MDE to counties in the TMDL Implementation Progress and Planning (TIPP) tool. This WIP follows the following MDE guidance documents:

- *Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated: Guidance for National Pollutant Discharge Elimination System Stormwater Permits* (November 2021)
- *General Guidance for Local TMDL (Total Maximum Daily Load) Stormwater Wasteload Allocation (SW-WLA) Watershed Implementation Plans (WIPs)* (February 2022)
- *Guidance for Developing Local Nutrient and Sediment TMDL (Total Maximum Daily Load) Stormwater Wasteload Allocation (SW-WLA) Watershed Implementation Plans (WIPs)* (March 2022)
- *TMDL Implementation Progress and Planning (TIPP) Tool* (Original version: June 2021, Most recent version: April 2022)

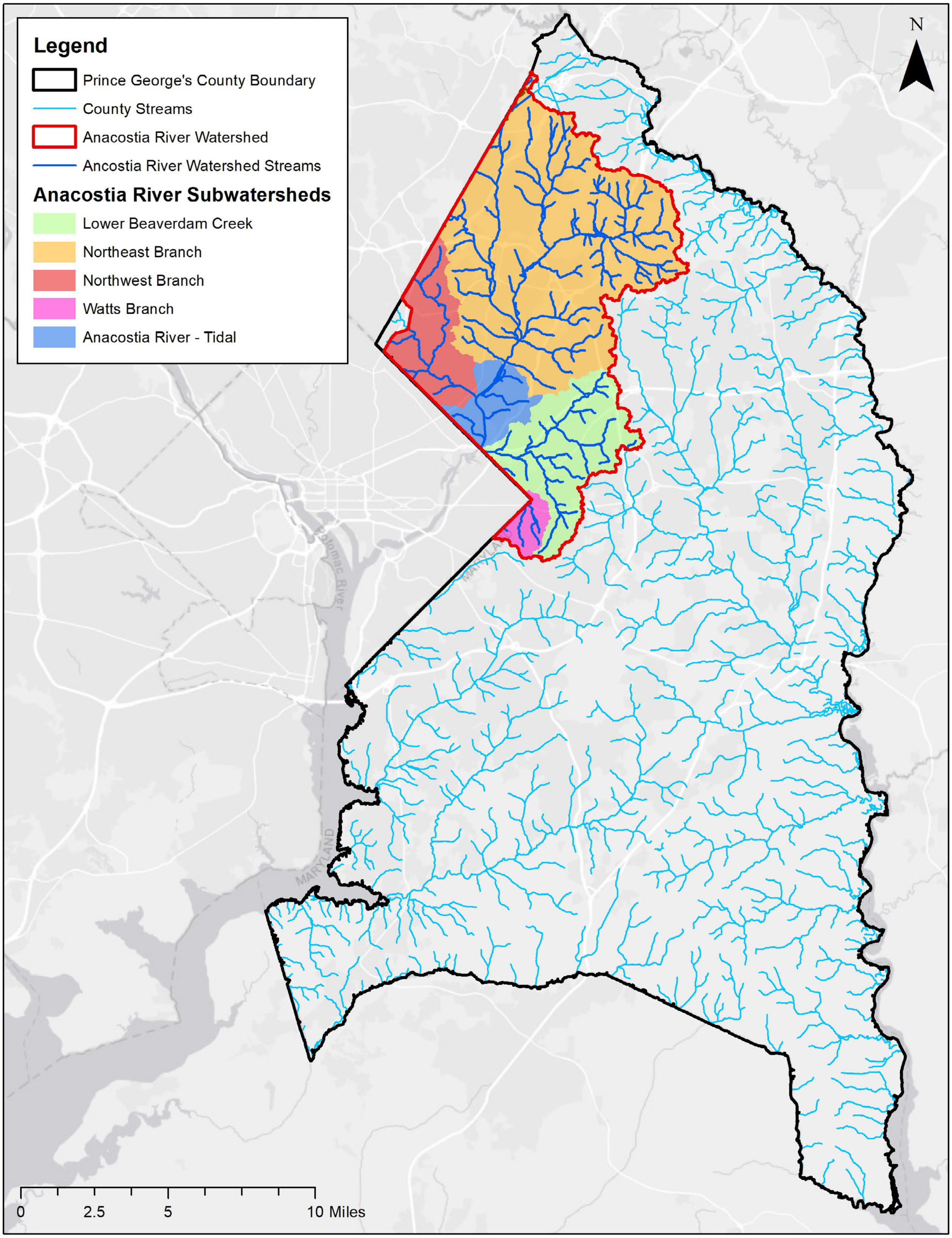
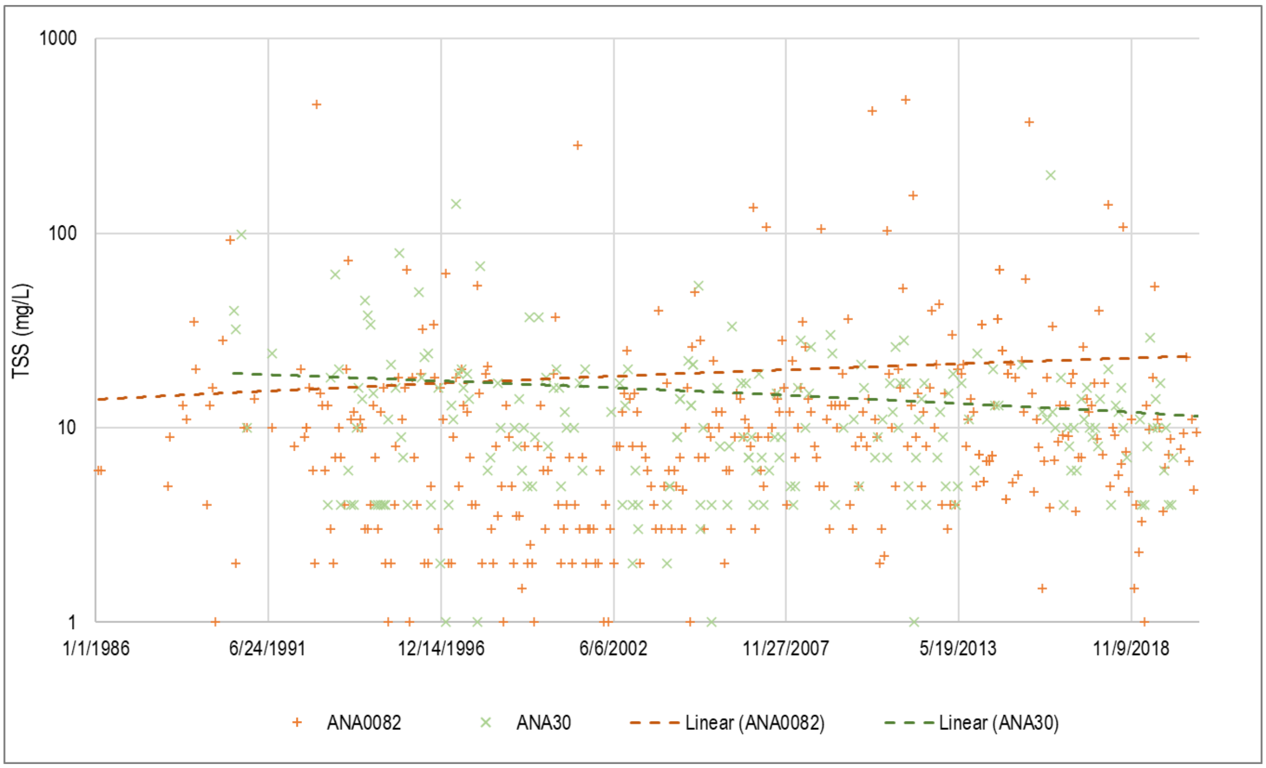


Figure ES-1. Prince George's County's portion of the Anacostia River Watershed.

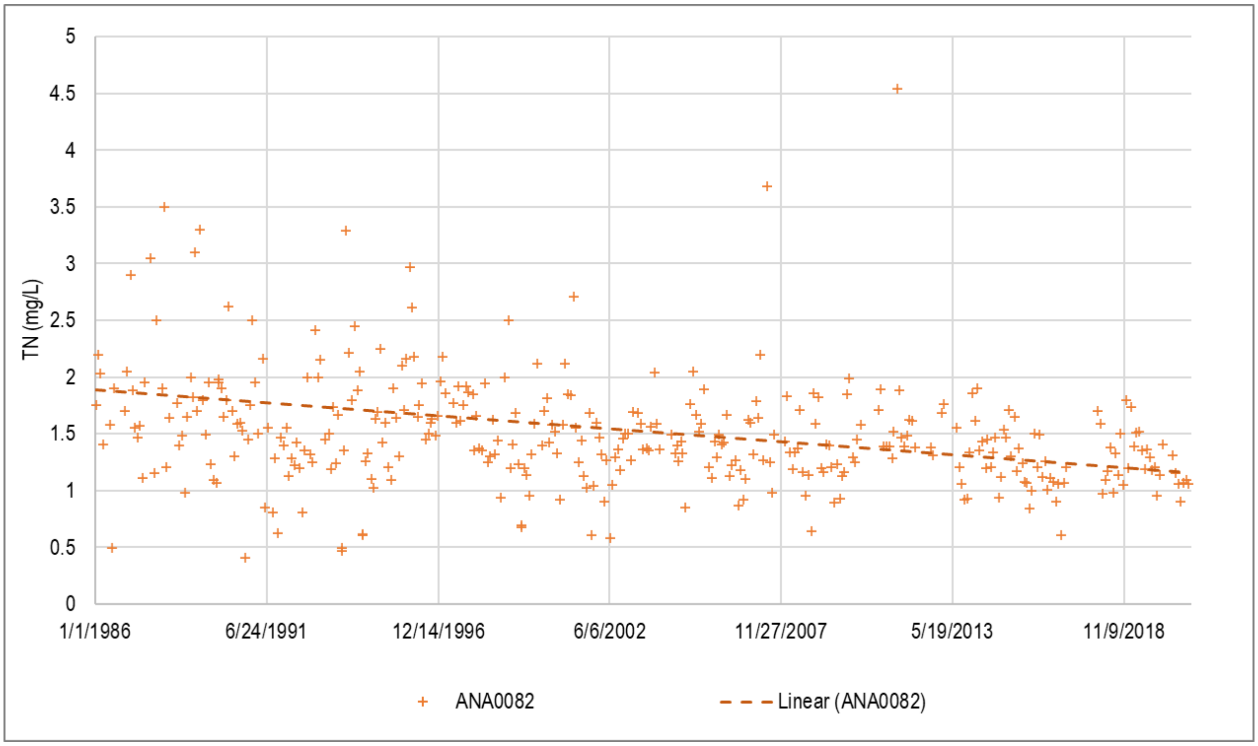
Long-term Water Quality Data

There is a long history of nutrient and sediment data (1986-–2022) at two locations in the Prince George's County portion of the Anacostia River watershed. Figure ES-2 through Figure ES-6 present an overview of nutrient and sediment trends from the locations with the most data. (Refer to Section 3.1 for a location map, summary tables, and additional information on these and other locations.) The nutrient TMDL was established in 2008 and the sediment in 2007. The plots show a downward trend in nutrient concentrations, which might be attributed to various watershed factors (see Section 2 for the watershed characterization) or work by the Washington Suburban Sanitary Commission (WWSC) on repairing leaking sewer lines. Many of the data points are scattered with a few stations showing slight downward trends in nutrients and sediment. There are other water quality stations in the watershed, but without a long period of record. Data from these stations are further summarized in Section 3.1 of this document.



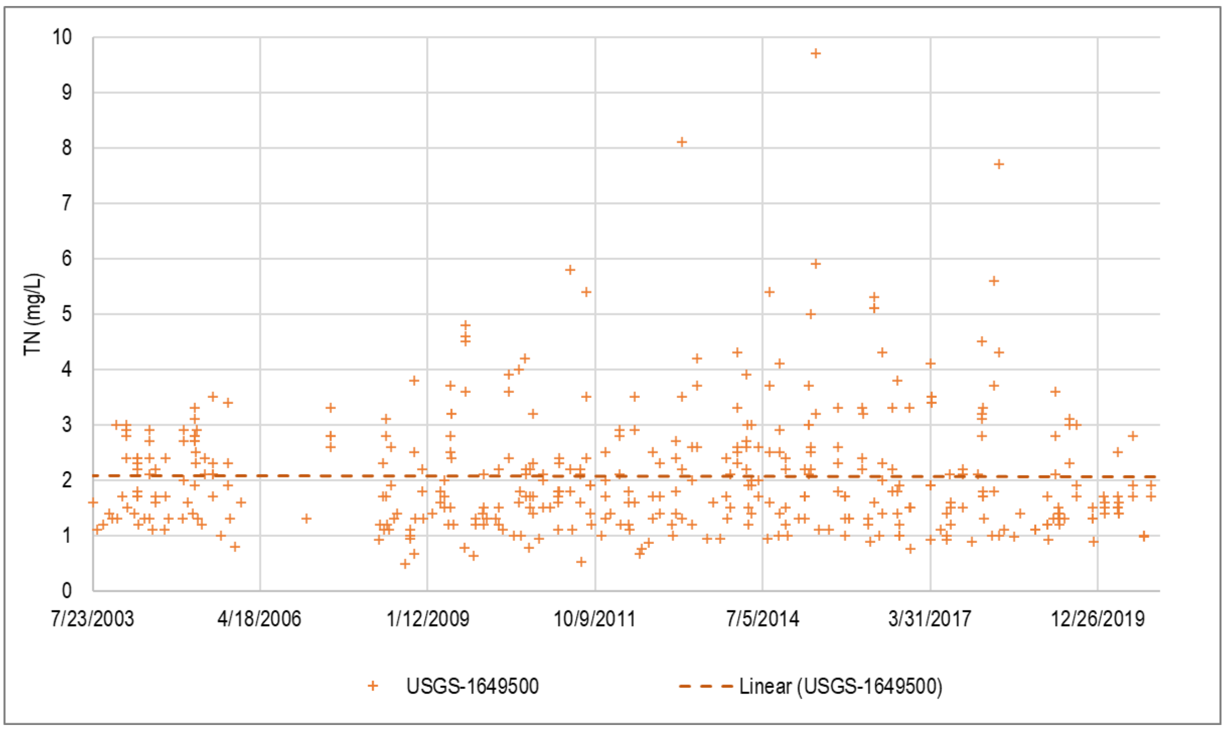
Source: NWQMC 2023.

Figure ES-2. Plot of TSS concentration over time at monitoring stations ANA0082 and ANA30.



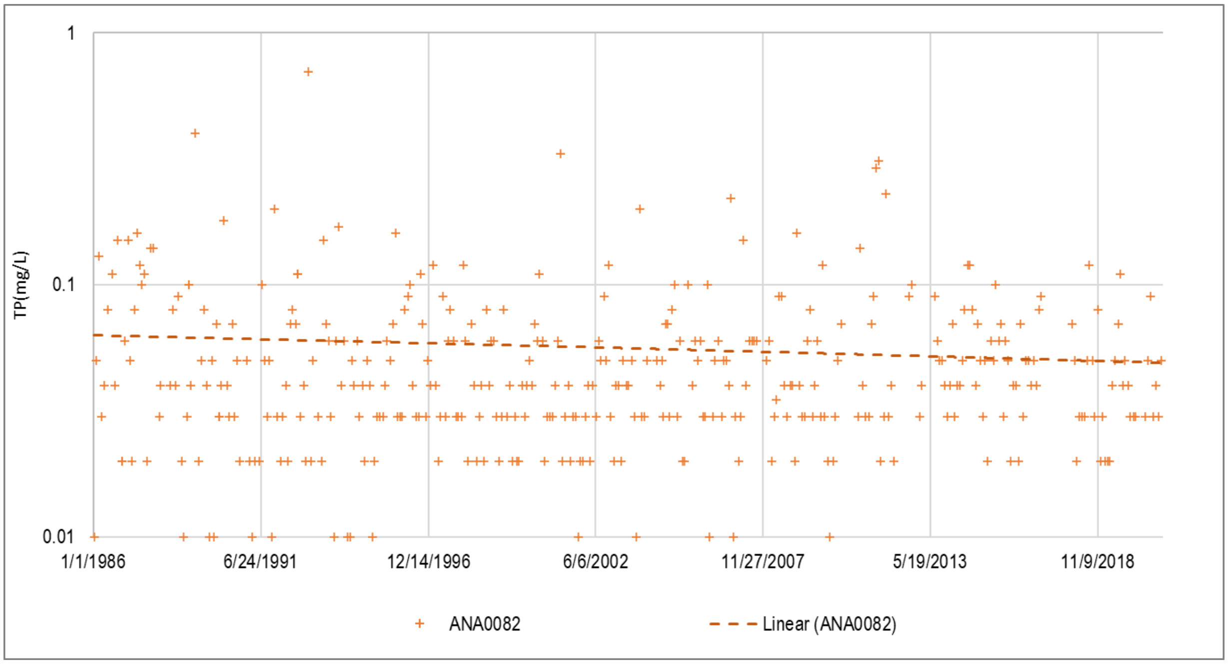
Source: NWQMC 2023.

Figure ES-3. Plot of TN concentration over time at monitoring station ANA0082.



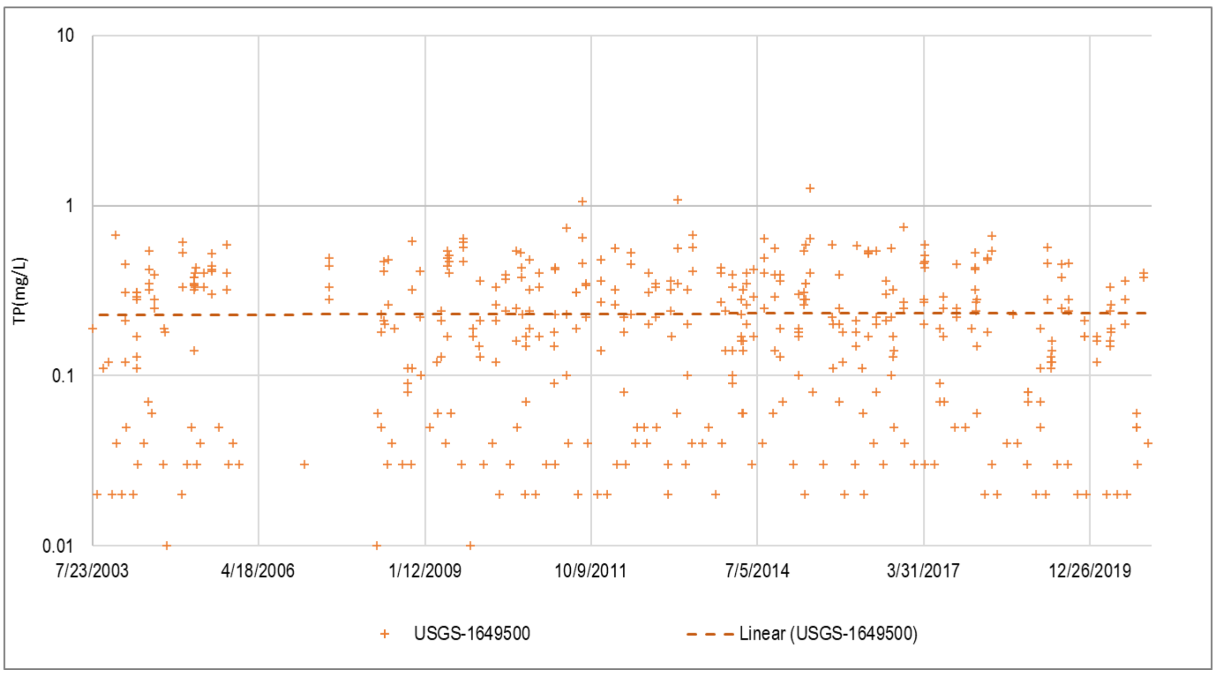
Source: NWQMC 2023.

Figure ES-4. Plot of TN concentration over time at monitoring station USGS01649500.



Source: NWQMC 2023.

Figure ES-5. Plot of TP concentration over time at monitoring station ANA0082.



Source: NWQMC 2023.

Figure ES-6. Plot of TP concentration over time at monitoring station USGS-1649500.

TMDL Load Reduction Goals

Tables ES-1, ES-2, and ES-3 summarize the load reductions for the Prince George's County portion of the Anacostia River watershed. The tables present the baseline load at the time of the TMDL, progress loads as of July 2023, and projected future loads. (For full descriptions of load reduction terminology, please see Section 5 of this document.) Figure ES-7 presents the cumulative reductions by restoration activity since the TMDL was developed, which are represented in the tables as the difference between the baseline load and the progress load.

MDE has not mandated an end date for the local TMDL WIPs; however, the County understands the public prefers an expedited restoration process and shares that sense of urgency. The County and its watershed partners are committed to finding site opportunities and expediting the planning, design, and construction phases for management activities to the maximum extent practicable (MEP). Implementation milestones in these tables follow a proposed 2 percent restoration rate of untreated impervious surfaces having a 95-year time span to accomplish the reductions needed.

The Anacostia River nutrient and sediment TMDLs required 80 percent or more reductions for nutrients (nitrogen and phosphorus) and sediment. Load allocations provided might not be accurate due to changes in the watershed since the TMDLs were developed in 2007 (sediment) and 2008 (nutrients), such as extensive sanitary sewer repairs and changes to fertilizer and turf management. The County has requested MDE to revise the 2007 and 2008 TMDLs to reflect current conditions to obtain more attainable load reduction targets. For local TMDL compliance, load reduction estimates are based on MDE's 2021 *Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated: Guidance for National Pollutant Discharge Elimination System Stormwater Permits* (MDE 2021a). The guidance lists available best management practices (BMPs) and practices and the associated load reduction efficiencies for WIP load reduction calculations. Assuming a runoff reduction BMP treats a rainfall depth of 2 inches, the maximum nitrogen reduction is 66.8 percent, 78.2 percent for phosphorus, and 83.9 percent for sediment. The current load reduction targets could take $6 billion over 100 years to meet the target. Current estimates show that most, if not all, land area in the County's MS4 will need to be treated with BMPs, in addition to stream restoration and tree planting to meet TMDL goals.

Furthermore, MDE's recommended use of BMPs have inefficiencies as per MDE's *Accounting for Wasteload Allocations and Impervious Acres Treated*, bringing the cost higher.

The County identifies specific BMP opportunities over a 6-year planning horizon, which becomes part of the approved annual county stormwater capital improvement program (CIP) budget. The milestones in Tables ES-1, ES-2, and ES-3 were developed through the CIP and represent future CIP and programmatic restoration initiatives. These opportunities are included in the County's biannual Financial Assurance Plan (FAP) and summarized in the County's annual MS4 progress report. Planning, design, and construction activities follow a rigorous internal evaluation, including budget, CIP progress tracking, and necessary adjustments to implementation schedules due to unforeseen conditions. The result of this process is adjusted annually. Any BMPs installed by the County to address local TMDLs will also help meet Chesapeake Bay load reduction goals.

Tables ES-1, ES-2, and ES-3 present the required reductions, current restoration progress (from restoration BMPs installed from the date of the TMDL to June 30, 2023), planned BMP reductions for BMPs in the County's BMP database of upcoming projects, and BMPs identified in this WIP to meet the restoration gap (load reductions from current and planned BMPs from the required reduction).

Table ES-1. Summary of WIP load reductions in the Anacostia Creek watershed for meeting only TSS reductions.

Measure or Practice	TN (lbs/yr)	% of Baseline Load	TP (lbs/yr)	% of Baseline Load	TSS (lbs/yr)	% of Baseline Load
Information from Table 5-5						
Required Reductions	***179,779***	***81%***	***22,370***	***81%***	***62,491,797***	***85%***
Current Restoration BMP Reductions (through June 30, 2023)	13,197	6%	3,178	12%	8,227,010	11%
Planned Restoration BMP Reductions (Identified in County BMP database)	2,050	1%	502	2%	1,874,219	3%
Remaining Restoration Gap to meet TMDL	164,532	74%	18,691	68%	52,390,568	71%
BMPs identified in this WIP to Meet Restoration Gap						
Stream Restoration / Outfall Stabilization	13,862	6%	12,568	46%	45,836,658	62%
Tree Planting	232	0%	180	1%	280,764	0%
Wet Ponds	5,991	3%	1,310	5%	3,694,372	5%
RR Practices	6,527	3%	1,033	4%	2,565,364	3%
Impervious to Turf	19	0%	-1	0%	13,433	0%
Total WIP	**26,631**	12%	**15,091**	55%	**52,390,591**	71%
Total Restoration Activities						
Current BMPs, Planned BMPs, and WIP BMPs	**41,878**	19%	**18,770**	68%	**62,491,820**	85%

Notes:
lbs/yr = pounds per year.
See Section 5.1 for a discussion of the terminology in this table.

Table ES-2. Summary of WIP load reductions in the Anacostia Creek watershed for meeting TP (and TSS) reductions.

Measure or Practice	TN (lbs/yr)	% of Baseline Load	TP (lbs/yr)	% of Baseline Load	TSS (lbs/yr)	% of Baseline Load
Information from Table 5-5						
Required Reductions	***179,779***	***81%***	***22,370***	***81%***	***62,491,797***	***85%***
Current Restoration BMP Reductions (through June 30, 2023)	13,197	6%	3,178	12%	8,227,010	11%
Planned Restoration BMP Reductions (Identified in County BMP database)	2,050	1%	502	2%	1,874,219	3%
Remaining Restoration Gap to meet TMDL	164,532	74%	18,691	68%	52,390,568	71%
BMPs identified in this WIP to Meet Restoration Gap						

Measure or Practice	TN (lbs/yr)	% of Baseline Load	TP (lbs/yr)	% of Baseline Load	TSS (lbs/yr)	% of Baseline Load
Stream Restoration / Outfall Stabilization	10,969	5%	9,945	36%	36,271,447	49%
Tree Planting	116	0%	90	0%	140,381	0%
Wet Ponds	37,210	17%	8,139	30%	22,946,578	31%
RR Practices	3,264	1%	517	2%	1,282,734	2%
Impervious to Turf	0	0%	0	0%	0	0%
Total WIP	**51,559**	23%	**18,691**	68%	**60,641,141**	82%
Total Restoration Activities						
Current BMPs, Planned BMPs, and WIP BMPs	**66,806**	30%	**22,370**	81%	**70,742,370**	96%

Notes:
lbs/yr = pounds per year.
See Section 5.1 for a discussion of the terminology in this table.

Table ES-3. Summary of WIP load reductions in the Anacostia Creek watershed for meeting TN (and TP and TSS) reductions.

Measure or Practice	TN (lbs/yr)	% of Baseline Load	TP (lbs/yr)	% of Baseline Load	TSS (lbs/yr)	% of Baseline Load
Information from Table 5-5						
Required Reductions	***179,779***	***81%***	***22,370***	***81%***	***62,491,797***	***85%***
Current Restoration BMP Reductions (through June 30, 2023)	13,197	6%	3,178	12%	8,227,010	11%
Planned Restoration BMP Reductions (Identified in County BMP database)	2,050	1%	502	2%	1,874,219	3%
Remaining Restoration Gap to meet TMDL	164,532	74%	18,691	68%	52,390,568	71%
BMPs identified in this WIP to Meet Restoration Gap						
Stream Restoration / Outfall Stabilization	2,443	1%	2,215	8%	8,076,967	11%
Tree Planting	174	0%	135	0%	210,572	0%
Wet Ponds	148,842	67%	32,556	118%	91,786,317	125%
RR Practices	13,055	6%	2,066	8%	5,130,940	7%
Impervious to Turf	19	0%	-1	0%	13,400	0%
Total WIP	**164,532**	74%	**36,971**	134%	**105,218,196**	143%
Total Restoration Activities						
Current BMPs, Planned BMPs, and WIP BMPs	**179,779**	81%	**40,650**	148%	**115,319,425**	157%

Notes:
lbs/yr = pounds per year.
See Section 5.1 for a discussion of the terminology in this table.

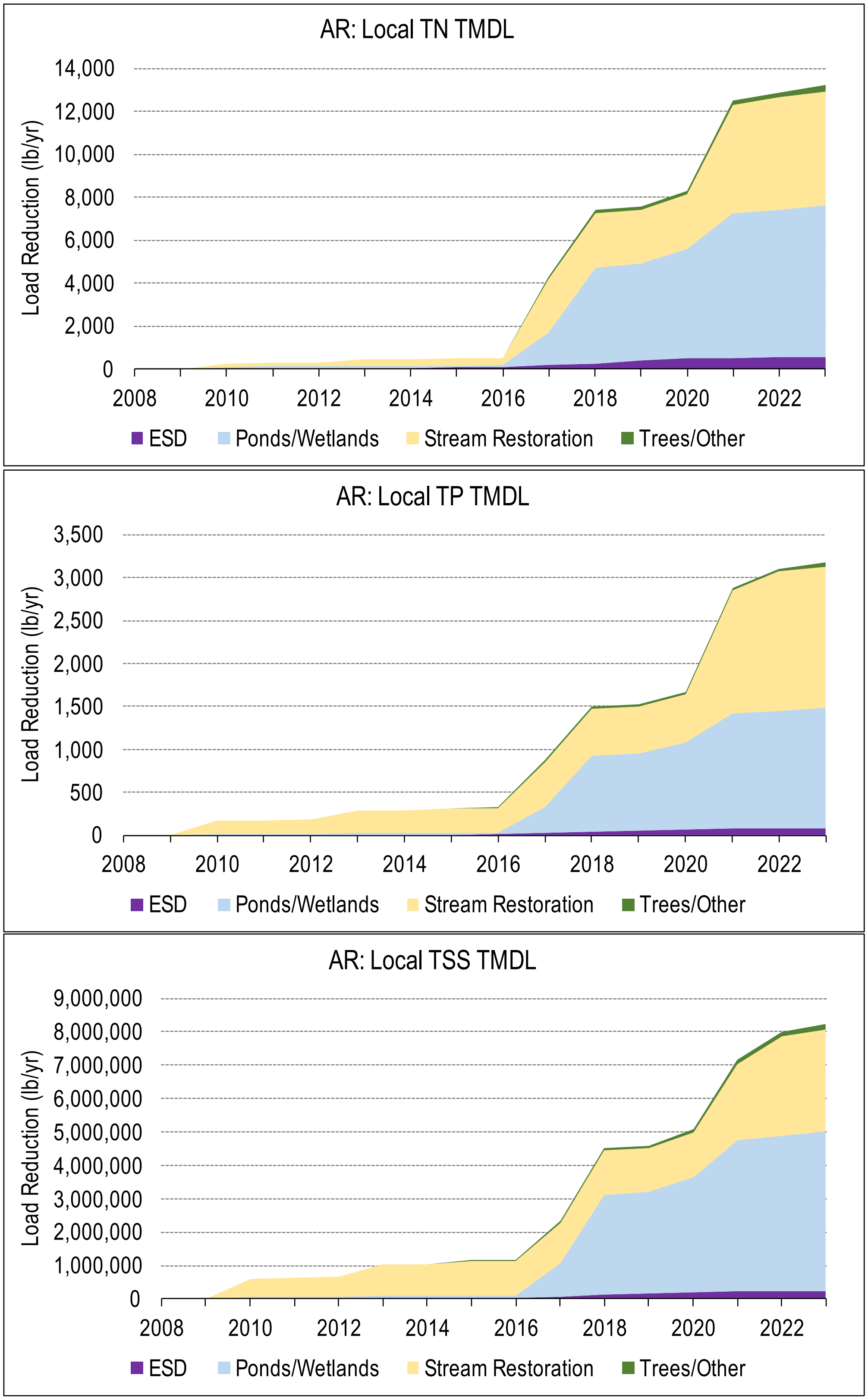


Figure ES-7. Cumulative Load Reductions from Existing and Planned Restoration Activities.

WATERSHED IMPLEMENTATION PLAN DOCUMENT ORGANIZATION

This document is organized into the following sections, which help the reader understand the TMDL, the watershed, and existing or planned restoration activities. Sections 4 through 7 build on information from the prior sections:

- **Section 1 – Introduction:** Contains information for readers new to TMDLs and WIPs and includes information on previous studies, water quality standards, designated uses, and impaired waters.
- **Section 2 – Watershed Characterization:** Contains information on watershed hydrology, climate/precipitation, topography soil, land use, land cover including impervious area, and land ownership. Focuses on watershed information to aid in planning and designing restoration projects.
- **Section 3 – Watershed and Water Quality Conditions:** Contains information on past water quality data, along with biological data, geomorphic data, stream erosion estimates, and potential pollutant sources. Provides Capital Improvement Project (CIP) designers with background to plan restoration projects.
- **Section 4 – Current Stormwater Management Activities:** Provides non-technical readers insight and information on current BMPs in the watershed. Provides the foundation for the discussion of the load reduction targets and current progress in Section 5. Written in a general form for an audience of readers who do not have a background in stormwater management.
- **Section 5 – Load Reduction Targets and Current Progress:** Provides the WIP's overall load calculation methodology and terminology, so that the non-technical readers understand the discussions in Section 6 and Section 7. Contains baseline, progress, and target loads.
- **Section 6 – Load Reduction Strategy:** Provides the overall WIP methodology and restoration scenarios for achieving load reductions. Includes information on BMP identification and selection along with implementation budgeting.
- **Section 7 – WIP Restoration Activities**: Analyzes the future BMPs necessary to meet the TMDL reductions. Includes budget and timeline.
- **Section 8 –Tracking Progress, Monitoring Stream Health, and Conducting Adaptive Management:** Contains information on County restoration progress tracking and reporting, along with information on County monitoring programs. Discusses the County's adaptive management approach to the WIP.
- **Appendix A – Current Stormwater Management Programs:** Overview of existing County stormwater management programs for readers unfamiliar with the programs.
- **Appendix B – BMP Removal Efficiencies:** Contains the BMP efficiencies used in load reduction calculations.
- **Appendix C – BMP Identification and Selection:** Overview of the methodology for identifying and siting BMPs for readers unfamiliar with County protocols.
- **Appendix D – Funding:** Overview of County funding mechanisms for readers unfamiliar with them.

- **Appendix E – Public Outreach and Involvement:** Provides residents and businesses ways that they can stay informed about and aid in the watershed restoration process.
- **Appendix F – Geomorphic Cross Section Assessment:** Provides result summary tables and plots of 2020 cross section analysis in the watershed.
- **Appendix G – Proposed WIP Cumulative Number of Impervious Areas and Load Reductions:** Overview of estimated load reductions and costs per year to meet TMDL load reductions.

MDE WIP COMPLIANCE CHECKLIST

MDE's *General Guidance for Local TMDL (Total Maximum Daily Load) Stormwater Wasteload Allocation (SW-WLA) Watershed Implementation Plans (WIPs)* (MDE 2022a) listed seven items that must be included in SW-WLA WIPs. This table lists these seven primary elements and suggested sub-elements. Each item has a link to the relevant section in this WIP.

Elements and Sub-elements from MDE Guidance	Section/Page
1. What is being adaptively managed, e.g., a resource, a pollutant, a program, and/or individual implementation projects?	1.2.1 / 1-9
2. Why is adaptive management being used?	8.3 / 8-4
2.1. Is there an aspect of the water resource management process that is specialized?	8.3 / 8-4
2.2. Does the jurisdiction expect to have to modify the project or program as a result of an issue?	8.3 / 8-4
3a. What are the stepwise goals and objectives that consider both jurisdictional resources and the goals and objectives of the SW-WLA and TMDL?	1.1.2 / 1-2 7 / 7-1
3b. What are the costs associated with proposed management strategies?	6.3/ 7.3 / 7-10
3.1. What is the budget?	D.1 / D-1
3.2. Who has responsibility?	8.1 / 8-2
3.3. Who is legally liable?	1 / xix
4. Who is the primary audience of the plan, and why?	1.1.3 / 1-4
5. What information is available and how is that information used to inform WIP development?	2 / 2-1 3 / 3-1 4.2 / 4-2
5.1. Is information from permit required watershed assessments being addressed in detail by section in the TMDL implementation plan?	0 / 2-1 3 / 3-1
5.2. Have other documents/studies been published that contribute to understanding the watershed as a multi-faceted system and the natural resources it supports?	1.1.4 / 1-5
5.3. Do other watershed plans exist in the watershed; either generated by a government, utility, or nongovernmental entity? Provide this information and details about other monitoring programs, so data can be shared on a regularly scheduled basis.	1.1.4 / 1-5 3 / 3-1
5.4. Has the jurisdiction modeled pollutant sources and expected load reductions from potential, planned actions, where applicable?	5 / 5-1 7.2.2 / 7-5
5.5. Is monitoring data being used to inform actions?	8.2 / 8-2 C.2.3 / C-5
6. How does the watershed function for the public in terms of its beneficial uses?	1.2.1 / 1-9
6.1. How are stakeholders considered in the planning document	1.1.3 / 1-4 E / E-1
7. What are the proposed planning horizons and how will they be justified?	7.4 / 7-12
7.1. Identify indicators and determine if they are currently meeting goals.	8 / 8-1
7.2. Is the proposed planning horizon the point at which improvement is expected? 7.3. Or is the planning horizon simply based on model accounting?	7.4 / 7-12
7.5. Who does what if milestones for horizons are not met on time?	8.1 / 8-2 8.3 / 8-4

1 INTRODUCTION

On December 2, 2022, the Maryland Department of the Environment (MDE) issued Prince George's County (the County) its fifth generation permit (Permit Number: 20-DP-3314 MD0068284) for its National Pollutant Discharge Elimination System (NPDES) municipal separate storm sewer system (MS4), which is a series of stormwater sewers owned by a municipal entity (e.g., the County) that discharges the conveyed stormwater runoff into a water body (e.g., Anacostia River). The permit covers the period of December 2, 2022, through December 1, 2027. The MS4 permits are generally issued in 5-year cycles, enabling regulators and permit holders to adjust permit objectives and expectations that could require adjustments to this plan.

The County's 2022 MS4 permit requires that the County develop local restoration plans to address each U.S. Environmental Protection Agency (EPA)-approved total maximum daily load (TMDL) with a stormwater wasteload allocation (SW-WLA). A TMDL can be seen as a *pollution diet* in that it is the maximum amount of a pollutant that a water body can assimilate and still meet water quality standards and designated uses.

This SW-WLA Watershed Implementation Plan (WIP) is the portion of the TMDL that is allocated to permitted dischargers such as wastewater treatment plants or MS4s. This SW-WLA Watershed Implementation Plan (WIP) covers the SW-WLA assigned to the County's MS4 for nutrient (nitrogen and phosphorus) and sediment impairments in the Anacostia watershed. The Anacostia River watershed covers portions of Montgomery and Prince George's Counties in Maryland and the District of Columbia. All maps and data in this document only reflect the Prince George's County portion of the watershed, unless specifically stated otherwise.

The 2014 and 2022 MS4 permits stipulate that the County must develop additional restoration plans within one (1) year of the EPA approval of a new TMDL. This WIP covers the Anacostia River nutrient and sediment TMDLs, which were approved by EPA in April 2008 (nutrients) and June 2007 (sediment). This WIP is an update of a previous restoration plan for nutrients, sediment, and bacteria that was submitted to MDE in 2015 as part of the 2014 MS4 permit compliance (Tetra Tech 2015). This WIP uses new information, including loading rates derived from the Bay Model 6, provided by MDE to counties in the TMDL Implementation Progress and Planning (TIPP) tool. This plan was developed in a similar way as previous plans, following guidance provided by MDE's *Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated: Guidance for National Pollutant Discharge Elimination System Stormwater Permits* (MDE 2021a).

1.1 Purpose of Report and Watershed Restoration

1.1.1 What is a TMDL?

Section 303(d) of the Clean Water Act (CWA) and EPA's Water Quality Planning and Management Regulations (codified in Title 40 of the *Code of Federal Regulations* Part 130) require states to develop TMDLs for impaired water bodies. TMDLs provide the scientific basis for a state to establish water quality-based controls to reduce pollution from both point and nonpoint sources to restore and maintain the quality of the state's water resources (USEPA 1991).

A TMDL is a *pollution diet* that establishes the amount of a pollutant a water body can assimilate without exceeding its water quality standard for that pollutant and is represented as a mass per unit of time (e.g., pounds per day). The mass per unit of time is called the *load*. For instance, a TMDL could stipulate that a maximum load of 1,000 pounds of sediment per day could be discharged into an entire stream before the stream experiences any detrimental effects. The pollution diet for a given pollutant and water body is composed of the sum of individual waste load allocations (WLAs) for point sources and LAs for nonpoint sources and natural background levels. The WLA is the portion of the TMDL that is allocated to permitted dischargers such as wastewater treatment plants or MS4s. In addition, the TMDL must include an implicit or explicit margin of safety (MOS) to account for the uncertainty in the relationship between pollutant loads and the quality of the receiving water body. The following equation illustrates TMDL components:

$$TMDL = \Sigma\ WLAs + \Sigma\ LAs + MOS$$

The County's MS4 permit requires the County to develop local WIPs to address each EPA-approved TMDL with stormwater WLAs.

Figure 1-1 shows a generalized TMDL schematic. A TMDL identifies the maximum amount of pollutant load that the water body can receive and still meet applicable water quality criteria. The bar on the left represents the *baseline* pollutant load that exists in a water body before a TMDL is developed. The elevated load causes the water body to exceed water quality criteria associated with the water body's officially designated uses. The bar on the right represents the amount the pollutant load will need to be reduced for the water body to meet water quality criteria. Another way to convey the required load reduction is by identifying the percent reduction needed.

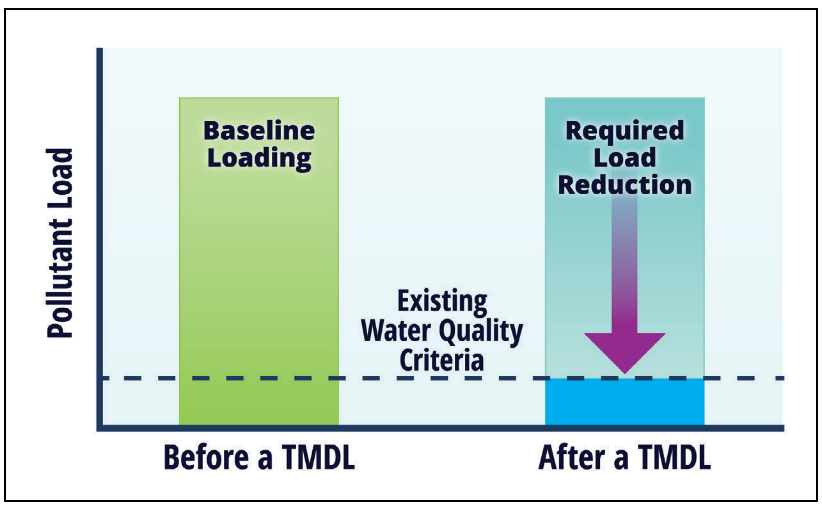


Figure 1-1. Conceptual schematic of a typical pollution diet, or TMDL.

1.1.2 What is a SW-WLA Watershed Implementation Plan?

A WIP is a strategy for managing natural resources in a geographically defined watershed. For the County's Department of the Environment (DoE), this means managing urban stormwater (i.e., runoff originating from rainstorms) to restore and protect the County's water bodies. Stormwater management is most effective when viewed in the watershed context—watersheds are land areas and their network of streams that convey stormwater runoff to a common body of water. Successful stormwater management consists of structural practices (e.g., vegetated roadway swales) and public outreach (e.g., pet waste campaigns and education) at both the public and private levels. Stormwater management must be implemented per the County's State-approved stormwater regulations and ordinances. These guidelines use changes and their stormwater runoff management requirements. The State provides the County with prescribed methods for restoration for addressing various types of impairments through its accounting for SW-WLA guidance (MDE 2021a), which contains recommended BMP practices and their associated pollutant load removal efficiencies. In preparation for this WIP, the County must follow MDE recommendations as prescribed in the guidance. The WIP development process will address changes that are needed to the County's priorities to comply with water quality regulations, to improve the health of the streams in the County, and to create value for neighborhoods in the County's watersheds.

The overall goals of restoration planning are to:

- Protect, restore, and enhance habitat in the watershed.
- Restore watershed functions, including hydrology, water quality, and habitat, using a balanced approach that minimizes negative impacts.
- Support compliance with regional, state, and federal regulatory requirements.
- Increase awareness and stewardship within the watershed, including encouraging policymakers to develop policies that support a healthy watershed.
- Support environmental justice initiatives to help underserved and overburdened communities.
- Provide the understanding that these implementation plans will carry over several years and be based on adaptive management.

This document represents the first stage in achieving these goals. This plan focuses on watershed-based planning, not site-level planning. The restoration planning process seeks to:

- Identify the causes and sources of pollution.
- Estimate pollutant load reductions.
- Describe management options and identify critical areas.
- Estimate the technical and financial assistance needed.
- Develop an education component.
- Develop a project schedule.
- Describe interim, measurable milestones.
- Identify indicators to measure progress.
- Develop a monitoring component.

WIP progress is tracked and reported to MDE via annual NPDES reports, which include a geodatabase with updated restoration information and geographic features representing BMP locations. The County prepares a financial assurance plan that provides information on the County's financial capacity to fund projects two years in advance. That plan also includes lists of completed projects and future planned projects. This is discussed in Section 8.

1.1.3 Stakeholders

Overall success of the WIP will depend on the concerted effort of the County and many regional agencies, municipalities, community leaders, and local landowners. Each watershed partner has an important role to play in the restoration process. The proposed management actions will require significant time and resources from all those entities. Technical assistance and other in-kind support from the watershed partners and the public will be important in implementing the plan, especially when addressing obstacles, including permitting challenges, technological limitations, and a lack of available sites where best management practices (BMPs) sites can be implemented.

The intended audience of the WIP includes a wide range of interest groups including local watershed groups, individual citizens (landowners), developers (new and re-development), DoE restoration program planning staff (e.g., DoE Capital Improvement Project [CIP] Section, Clean Water Partnership), DPW&T CIP planning staff, and nongovernment organizations (e.g., Low Impact Development Center, Chesapeake Bay Trust).

This WIP was developed to aid County decision makers and watershed planners in the watershed restoration process. DoE staff use the WIP for BMP project planning and design. It also serves to inform the public and stakeholders on the restoration strategies that the County is taking for impaired waterbodies. The County routinely engages watershed groups countywide. There are watershed groups already formed that can participate as stakeholders during the development of these plans, which are available online for comments and collaboration. Information on how the public and stakeholders can contribute to the restoration process is provided in Appendix E. For instance, watershed groups can search various County sources for information using the County websites, focusing on issues affecting the watershed (e.g., littering, illegal dumping, illicit discharges, erosion control). They can participate in volunteer clean ups or address community stormwater BMPs needs that also treat water quality..

Developers also are stakeholders in watershed health. They are required to treat stormwater from their properties during construction using erosion and sediment control practices to prevent sediment from entering the MS4 and waterways. Developers are also required to implement post-construction BMPs to offset increased impervious areas, and they are responsible for operation and maintenance (O&M) activities to keep the practices functioning properly. This and other WIPs are available to the County Department of Permitting, Inspections, and Enforcement (DPIE) to ensure developers follow BMP recommendations and practices.

When approved, all County restoration plans and WIPs are made available via a County website, along with the materials from public meetings, for anyone who wishes to participate in making improvements to the watershed.[1] The County's annual MS4 reports are also posted on the County website for stakeholders to review.[2]

[1] https://www.princegeorgescountymd.gov/293/NPDES-MS4-Permit. Accessed May 2023.
[2] https://www.princegeorgescountymd.gov/departments-offices/environment/stormwater-management/clean-water-program/npdes-ms4-permit. Accessed December 2023.

1.1.4 Previous Studies

Over the years, the County and other agencies have conducted studies and developed plans in the County, including for the Anacostia River watershed. This section details the more recent studies.

The Anacostia Watershed Forest Management and Protection Strategy prepared by the Metropolitan Washington Council of Governments (MWCOG) Department of Environmental Programs in June 2005 (MWCOG 2005) provides strategies to protect and expand forest cover throughout the Anacostia River watershed. The document evaluates various types of forest cover (e.g., riparian buffer, upland, street trees) and presents strategies to increase and protect each type of forest cover.

In 2005 the Maryland Department of Natural Resources produced a series of reports on the Anacostia River watershed. These reports include:

- *Report on Nutrient Synoptic Surveys in the Anacostia River Watershed, Prince George's County, Maryland, April 2004 as part of a Watershed Restoration Action Strategy* (MD DNR 2005b). Looks at data collected during 2004 in the watershed at multiple stations. The report found that nutrients did not appear to be a significant problem at that time; however, there were issues with low dissolved oxygen (DO) concentrations.
- *Anacostia River Stream Corridor Survey* (MD DNR 2005c). Assessed the conditions of the stream channels by looking at several factors such as inadequate stream buffers, channel alterations, trash dumping, exposed pipes, and erosion.
- *Characterization of the Anacostia River Watershed in Prince George's County* (MD DNR 2005a). Early watershed characterization that covers several similar topics as this WIP.

A series of reports in 2009 and 2010 was developed for and by the Anacostia Watershed Restoration Partnership for 15 major subwatersheds in the Anacostia River watershed in Montgomery County, Prince George's County, and the District. Each subwatershed has a subwatershed action plan, baseline condition report, and project inventory. The subwatershed action plans and project inventory reports looked at the existing impervious areas and BMPs, and then evaluated and suggested potential projects in each subwatershed. Table 1-1 presents a summary of selected proposed restoration activities from the subwatershed action plans. For a complete list of practices, see the individual plans. The plans call for more than $1 billion in restoration activities for treating 6,500 acres of impervious land and 11,500 acres of total land area. The Anacostia Watershed Restoration Partnership estimated that implementing the plans' activities would achieve the following reductions: 81,800 pounds per year (lb/year) of nitrogen, 9,300 lb/year of phosphorus, and 2,300 tons/year total suspended solids (TSS). The most recommended practice was implementing bioretention systems.

Table 1-1. Summary of selected proposed restoration activities in the Anacostia Watershed Restoration Partnership's subwatershed action plans.

Restoration Practice	Number of Practices	Number on Private Land	Percent on Private Land	Restoration Practice	Number of Practices	Number on Private Land	Percent on Private Land
Bioretention	1,501	612	41%	Rain garden	383	60	16%
Bioswale	202	62	31%	Reforestation	18	0	0%

Restoration Practice	Number of Practices	Number on Private Land	Percent on Private Land
Downspout disconnection	516	105	20%
Dry pond	58	19	33%
Education and outreach	14	1	7%
Extended detention pond	2	1	50%
Filter	647	275	43%
Green roof	480	86	18%
Infiltration practices	7	2	29%
Permeable pavement	244	25	10%
Pond modification	2	1	50%
Rain barrel	201	16	8%
Riparian buffer	29	8	28%
Sand filter	3	1	33%
Signs	8	0	0%
Stream restoration	168	44	26%
Street sweeping	79	0	0%
Wet pond	112	36	32%
Wetland	88	30	34%
Wetland creation	2	0	0%
Wetland restoration	37	9	24%

Source: USACE 2010.

In 2010, the Maryland-National Capital Park and Planning Commission (M-NCPPC) developed its Water Resources Functional Master Plan (M-NCPPC 2010). The document amended the County's 2002 General Plan. The update summarized estimated existing and future nutrient loadings and looked at the County's water and sewer services capacity relative to planned growth through 2030.

The state of Maryland published its Chesapeake Bay Phase I WIP in December 2010 for major basins, including the Anacostia River. A primary goal was to identify target pollutant load reductions that need to be achieved by various sources and geographic areas within the state. In 2011, the County developed a countywide Chesapeake Bay WIP in response to the 2010 Chesapeake Bay Nutrient and Sediment TMDL (PGC DER 2012). The Chesapeake Bay WIP was finalized in 2012 and laid out a plan for BMP implementation and other restoration activities through two target years: 2017 and 2025. In addition to urban stormwater runoff, the Chesapeake Bay WIP covered agricultural practices and upgrades to wastewater systems (i.e., municipal wastewater treatment plants and on-site wastewater systems). MDE also published a Phase II WIP in October 2012, which contained detailed plans for meeting the TMDL at a local level. The plans identified the target loads for each individual jurisdiction (i.e., counties and the city of Baltimore) within the area. The MDE Phase II WIP included the Prince George's County Phase II WIP.

In 2014, the County developed restoration plans to serve as blueprints for improving water quality and meeting pollutant reduction goals called for in approved local TMDLs. One of these plans was for bacteria, nutrients, and sediment in the Anacostia River watershed (Tetra Tech 2015). That plan describes the pollutants and sources of those pollutants specific to each body of water, the land uses and natural features in the watershed, a method for determining the amount of pollutant reductions that need to be achieved, and targeted pollutant reduction strategies for each watershed. The strategies include both programmatic initiatives (e.g., tree planting, street sweeping) as well as on-the-ground, pollution-reducing BMPs. The plans included implementing programmatic (e.g., street sweeping, litter control) and on-the-ground BMPs to address impairments in the watershed.

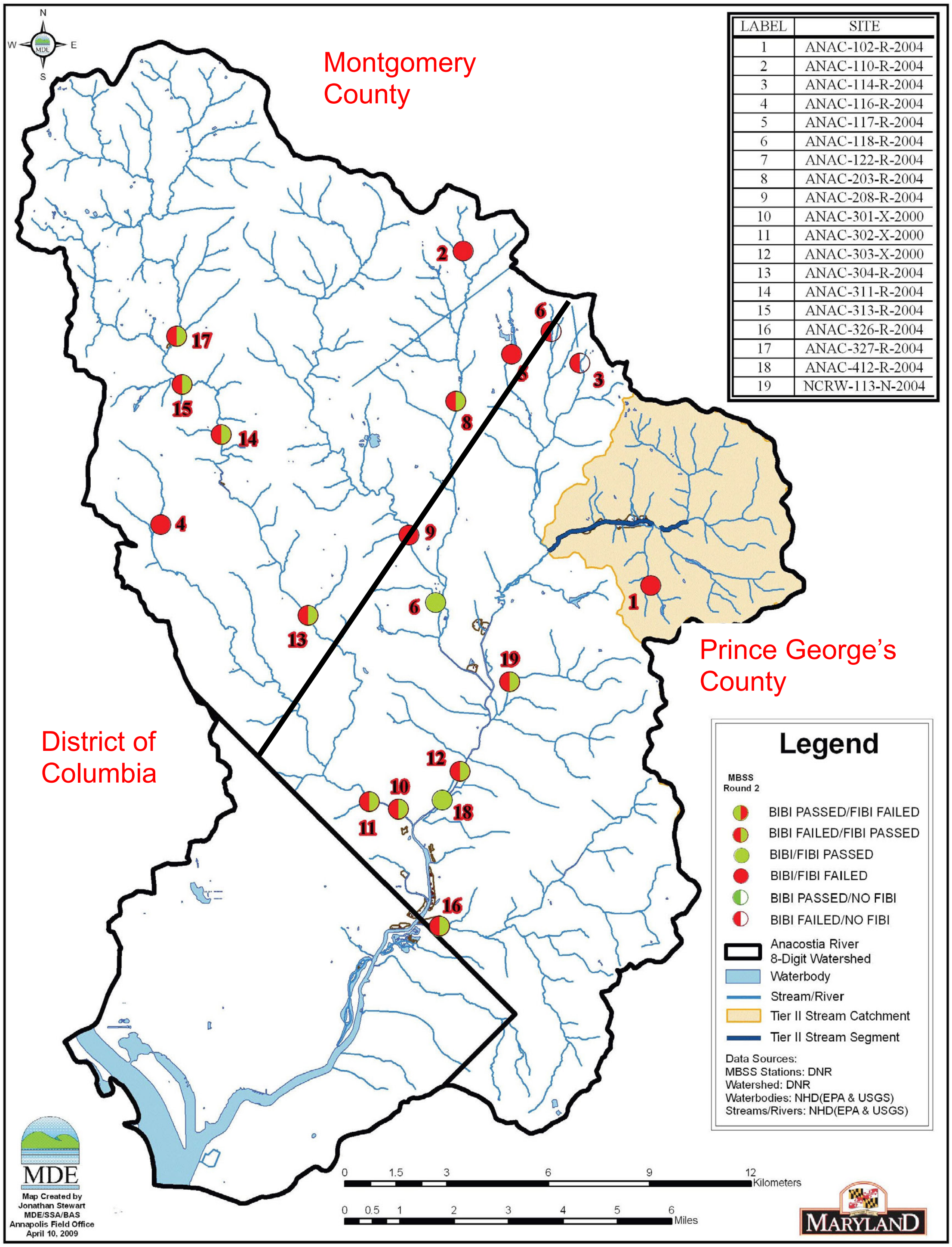
This WIP builds on the 2015 restoration plan with new information, such as land use. The 2015 plan used Maryland Department of Planning 2010 land use. This updated plan uses land cover data provided by MDE representing 2015. This new land cover data is the same as used in the recent Chesapeake Bay model and the land cover categories match the updated land-cover loading rates and BMP efficiencies from MDE's 2021 wasteload allocation guidance (MDE 2021a). In early 2022, MDE released its *General Guidance for Local TMDL (Total Maximum Daily Load) Stormwater Wasteload Allocation (SW-WLA) Watershed Implementation Plans (WIPs)* (MDE 2022b). This document lays out the required elements of a WIP, along with additional data. This plan follows MDE guidance.

In 2024, the County finalized its countywide plans for addressing bacteria and polychlorinated biphenyls (PCBs). Both plans follow recent MDE guidance. The bacteria strategy covers the bacteria TMDLs in Anacostia River, Piscataway Creek, and a portion of the Upper Patuxent River watersheds (Tetra Tech 2024a). The PCB strategy covers the bacteria TMDLs in Anacostia River, Mattawoman Creek, Piscataway Creek, Patuxent River, and Potomac River watersheds (Tetra Tech 2024b). Also, in 2024, the County reviewed and analyzed data on chlorides in the County (Tetra Tech 2024c). This analysis was in response to new MDE permit requirements in the County's 2022 MS4 permit. The County has five watersheds (Anacostia, Mattawoman, Piscataway, Upper Potomac Tidal, and Upper Patuxent) on Maryland's list of impaired waters due to chloride, however, not all have established TMDLs. The County Department of Public Works and Transportation (DPW&T) will be developing the overall salt/de-icer management plan for the County to meet the permit requirement by December 2025.

1.2 Anacostia River Water Quality Impairments

This section summarizes the various water quality problems identified in the Anacostia River watershed. MDE used its Biological Stressor Identification (BSID) data to support its impairment decisions (MDE 2022a). The Watershed Report for Biological Impairment (MDE 2022a) indicated that long-term monitoring data collected in the watershed showed significant negative deviations from reference biological conditions, indicating impacts to biological communities that impair the watershed's ability to support aquatic life and wildlife (support of aquatic life and wildlife must be achieved to meet water quality standards). These 303(d) listings for impairment use a biological assessment methodology, the BSID method, which examines the Benthic Index of Biotic Integrity (BIBI) and the Fish Index of Biotic Integrity (FIBI). In addition to the Index of Biotic Integrity (IBI) data, the TMDL development process also examined physical habitat assessments in the context of epifaunal substrate (surfaces on which aquatic organisms may live), and other in-stream habitat considerations, finding correlated results of these measures with sediment influence in the watershed. The BSID identified that the biological communities were likely degraded due to sediment-related stressors.

MDE (MDE 2022a) estimates that 89 percent of the Anacostia River watershed stations having benthic and/or fish IBIs significantly lower than 3.0 (i.e., poor to very poor). These data were collected during Maryland Biological Stream Survey (MBSS) round 1 (1995–1997) and round 2 (2000–2004) monitoring activities, which include 37 sites. Monitoring round 2 included the 19 monitoring stations that comprise the principal dataset used for this TMDL; 17 of those stations exhibited benthic and/or fish IBIs significantly lower than 3.0 (i.e., poor to very poor). The results from these datasets are presented in Figure 1-2. The low scoring IBIs can be attributed to the watershed having undergone full development with no stormwater management controls, predating the first stormwater management (SWM) ordinance in 1985. The hydrologic watershed balance was disrupted and created a domino effect to the biology and fish.



Source: Adopted from MDE 2022.

Figure 1-2. MBSS results from MDE 2022 for entire Anacostia River watershed, including portions in Montgomery County and the District of Columbia.

1.2.1 Designated Uses

MDE has classified waterbodies in the state based on the waterbody's existing conditions and the potential uses for the waterbody. Additional information on designated uses is found in the *Code of Maryland Regulations* (COMAR) Sections 26.08.02.02[3] and 26.08.02.02-1[4]

Figure 1-3 presents the designated uses in the watershed, which are also listed below:

- Use Class I: Water Contact Recreation, and Protection of Nontidal Warmwater Aquatic Life
- Use Class II: Support of Estuarine and Marine Aquatic Life and Shellfish Harvesting
- Use Class III: Nontidal Cold Water
- Use Class IV: Recreational Trout Waters

The Class I designation includes waters that are suitable for:

a) water contact sports;
b) play and leisure time activities where individuals may come in direct contact with the surface water;
c) fishing;
d) the growth and propagation of fish (other than trout), other aquatic life, and wildlife;
e) agricultural water supply; and
f) industrial water supply.

The Class II designation includes waters in support of estuarine and marine aquatic life and shellfish harvesting. This class designation includes all applicable uses identified for Class I in addition to:

a) All tidally influenced waters of the Chesapeake Bay and tributaries, the Coastal Bays, and the Atlantic Ocean to the 3-nautical-mile boundary;
b) Tidally influenced waters that are or have the potential for:
    (i). Shellfish propagation and storage, or harvest for marketing purposes;
    (ii). Actual or potential areas for the harvesting of oysters, soft-shell clams, hard-shell clams, and brackish water clams.

The Class III designation includes all uses identified for Class I and waters that have the potential for or are suitable for the growth and propagation of self-sustaining trout populations and other coldwater obligate species.

The Class IV designation includes all uses identified for Class I in cold or warm waters that have the potential for or are:

a) Capable of holding or supporting adult trout for put-and-take fishing;
b) Managed as a special fishery by periodic stocking and seasonal catching.

[3] http://mdrules.elaws.us/comar/26.08.02.02
[4] http://mdrules.elaws.us/comar/26.08.02.02-1

Maryland has also designated Tier II high-quality waters, which are waterbodies with existing water quality that is significantly better than water quality standards. Per federal regulations (Title 40 of the *Code of Federal Regulations* Section 131.12 [40 CFR 131.12]), these waters must be maintained at their high-quality level.

The Anacostia River has two stream segments that have been designated as Tier II waters on the Beaverdam Creek tributary (Figure 1-3). The downstream segment is 2.19 miles and the upstream is 0.58 miles. The Beaverdam Creek super catchment is approximately 9,000 acres.

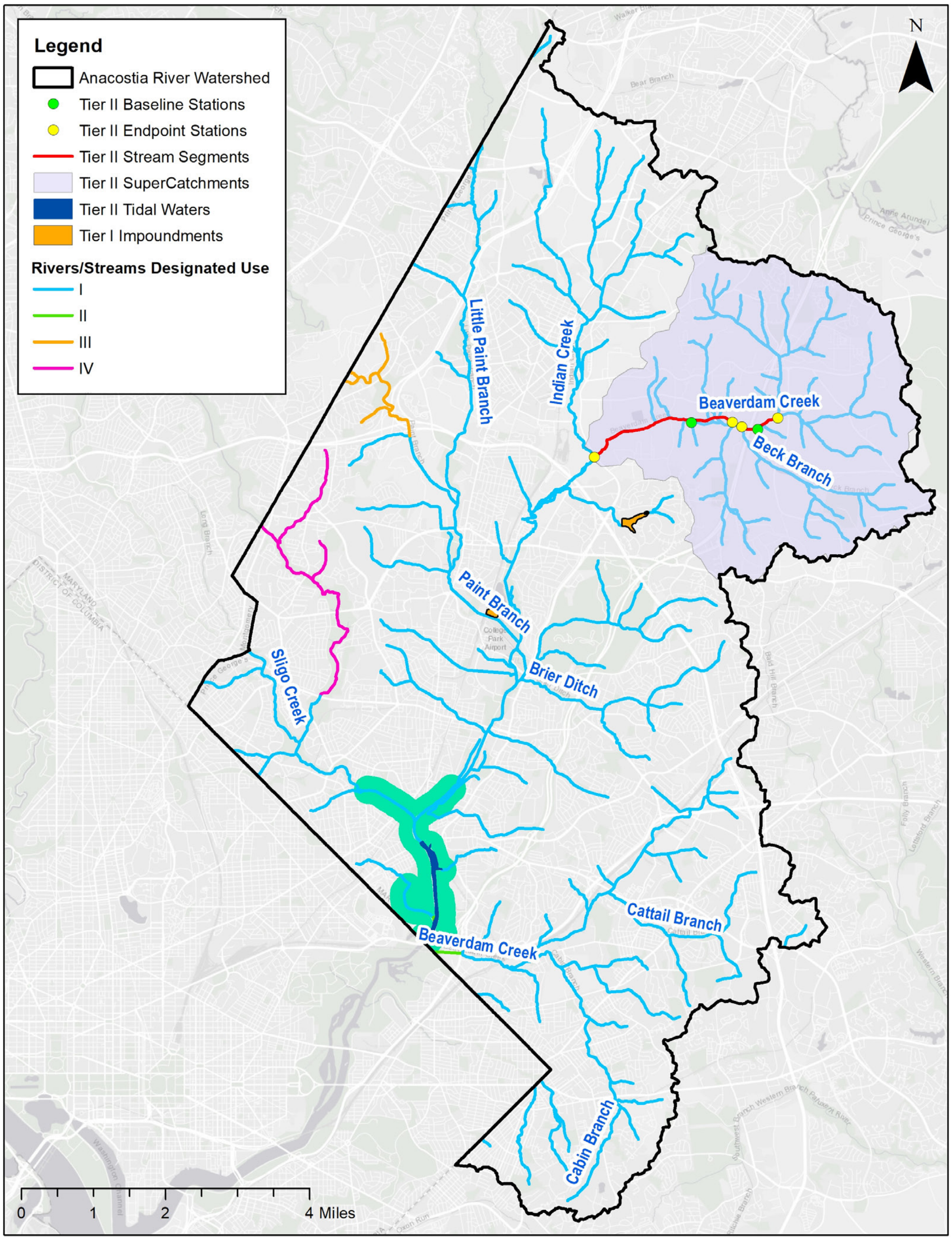


Figure 1-3. Designated uses and Tier II waters in the Anacostia River watershed.

1.2.2 Impairment Listings

Anacostia River and its tributaries are included on the MDE 303(d) list of impaired waters for several pollutants. Table 1-2 lists these pollutants, their listing year, if a TMDL was developed, and the resulting percent reductions. The Anacostia River watershed flows from Montgomery County (35 percent) of watershed) into Prince George's County (48 percent), and then into the District of Columbia (17 percent). For each TMDL, MDE provided Montgomery County with its own percent reductions prior to the river flowing into Prince George's County. Similarly, U.S. EPA provided the District of Columbia with its own TMDL reductions that they need to meet.

Table 1-2. List of impaired waters in the Anacostia River watershed in Prince George's County.

Pollutant	Year	Finalized TMDL? (Year)	TMDL Percent Reduction for MS4	Included in this WIP?
Nutrients (nitrogen, phosphorus), biochemical oxygen demand (BOD)	1996	Yes (2008)	Biochemical oxygen demand: 58% Total nitrogen (TN): 81% Total phosphorus (TP): 81.2%	Yes
Sediment, total suspended solids	1996	Yes (2007)	85%	Yes
Nutrients (nitrogen, phosphorus) and Sediment, as part of Chesapeake Bay TMDL	2012	Yes (2010)	Watts/Lower Beaverdam TN: 26.2% TP: 41.2% NEB/NWB/Tidal TN: 18.1% TP: 39.3%	No. See PGC DER 2012.
Trash and debris	2008	Yes (2010)	100%	No. See EA 2015.
Fecal coliform bacteria (enterococci)	nontidal waters (2002); tidal waters (2004)	Yes (2006)	NEB / NWB: 80.3% Tidal: 99.3%	No. See Tetra Tech 2024a.
Polychlorinated biphenyls (PCBs)	Toxics (2002); Fish tissue (2006)	Yes (2007)	NEB: 98.64% NWB: 98.1%	No. See Tetra Tech 2024b.
Heptachlor Epoxide	2002; 2015	No. Required (high priority).	n/a[a]	n/a
Perfluorooctane Sulfonate (PFOS) In Fish Tissue	2024	No. Required (high priority).	n/a	n/a
Salt (chlorides)[b]	2012	No[c]	n/a	n/a
Habitat Alternations/(Lack of) Riparian Buffer[d]	2012	n/a	n/a	n/a

Source: MDE 2024.
Notes:
n/a = not applicable.
[a] Draft TMDL has not been finalized.
[b] Replaces biological integrity biological listing.
[c] High priority to be addressed through pollution control requirements. Low priority for TMDL development.
[d] Impaired, but not due to water quality. Stream channelization due to urban development and lack of riparian buffer is stressor affecting biological integrity. Replaces biological integrity biological listing.

MDE developed TMDLs to address impairments caused by the exceedance of water quality standards for fecal coliform bacteria (*Enterococcus*), PCBs, biochemical oxygen demand (BOD), total nitrogen, total phosphorus, sediment, and trash. This WIP addresses the nutrient and sediment impairments. The Anacostia River watershed has a local TMDL for BOD, which is related to nutrient levels in waterbodies. Because MDE will not develop BOD loading rates or BMP efficiencies, they have stated that if a permittee meets its nutrient reduction goal, the BOD reduction for that watershed will be met. Therefore, BOD loads are not presented in this document for the Anacostia River watershed. Other documents address the bacteria, PCB, and trash impairments (Tetra Tech 2024a, Tetra Tech 2024b, EA 2015). In addition, EPA developed an overall TMDL for the Chesapeake Bay watershed for nitrogen, phosphorus, and sediment (USEPA 2010). MDE suggests that the Chesapeake Bay TMDL sediment reductions will be met by achieving nutrient reductions, therefore, does not provide a percent load reduction needed for sediment. The County has developed a Watershed Implementation Plan (WIP) in response to the Chesapeake Bay TMDL (PGC DER 2012).

1.2.3 Water Quality Standards

Maryland's General Water Quality Criteria states that "the waters of this State may not be polluted by…any material, including floating debris, oil, grease, scum, sludge and other floating materials attributable to sewage, industrial waste, or other waste in amounts sufficient to be unsightly; produce taste or odor; change the existing color to produce objectionable color for aesthetic purposes; create a nuisance; or interfere directly or indirectly with designated uses" [COMAR 26.08.02.03B(2)].

The nutrient TMDL was developed in response to low DO and high chlorophyll *a.* Because DO cannot be expressed as a mass load (a requirements for TMDLs), DO TMDLs are usually expressed using total nitrogen and total phosphorus as surrogates for DO. These parameters are selected because of their effect on DO concentrations in waterbodies and the need to identify measurable loadings from the watershed. An essential part of TMDL development is establishing a link between predicted loads (i.e., total nitrogen, total phosphorus) and the numeric indicators (i.e., DO standards) that are chosen as a measure of attainment.

Maryland does not have numeric criteria for nitrogen or phosphorus, so other parameters, such as DO, are used in the TMDL process. Table 1-3 summarizes the Maryland DO criteria applicable to the nutrients TMDL.

Table 1-3. Maryland dissolved oxygen water quality criteria

Designated Use	Period Applicable	DO Criteria
MD Use I-P	Year-round	≥ 5 mg/L (instantaneous)
MD Use II: Migratory Fish Spawning and Nursery Subcategory	2/1–5/31	≥ 5.0 mg/L (instantaneous) ≥ 6.0 mg/L (7-day average)
MD Use II: Open Water Fish and Shellfish Subcategory	6/1–1/31	≥ 3.2 mg/L (instantaneous) ≥ 4.0 mg/L (7-day average) ≥ 5.5 mg/L (30-day average applicable all year) ≥ 4.3 mg/L (instantaneous for water temperature > 29 °C for protection of Shortnose Sturgeon)

Designated Use	Period Applicable	DO Criteria
MD Use III	Year-round	≥ 5 mg/L (instantaneous) ≥ 6 mg/L (1-day average)
MD Use IV	Year-round	≥ 5 mg/L (instantaneous)

Note: DO = dissolved oxygen; mg/L= milligrams per liter.

The sediment TMDL is in response to turbary (i.e., Secchi depth measurements) criteria. Because turbidity cannot be expressed as a mass load, the turbidity TMDLs are expressed using TSS as a surrogate for turbidity to establish a loading, as mass per unit time. During TMDL development, the historical water quality data are typically analyzed for relationships between turbidity and TSS.

The Maryland sediment water quality criterion is narrative for nontidal portions of the watershed. For tidal portions, the criterion is based on an average Secchi disk depth of equal to or greater than 0.4 meters for the period from April 1 through October 31 of each year [COMAR 26/26.08.02.03-3]. Secchi depth is a measure of the clarity of water. The criterion is meant to protect submerged aquatic vegetation in the tidal portions of the watershed. This plan focuses on addressing the sediment TMDL for the nontidal portions of the watershed in Prince George's County. For sediment impairments, such as the one discussed in this plan, the water quality standard is based on biological and physical habitat measures relating to the IBI.

1.2.4 TMDL Pollutants

TMDLs for nutrients and sediment were developed by MDE to address water quality impairments. Below are brief descriptions of the TMDL pollutants.

Nitrogen

Nitrogen at levels higher than 10 mg/L can lead to a condition called methemoglobinemia (or "blue baby" syndrome) in infants and at levels higher than 100 mg/L can lead to taste problems and physiological distress (Straub 1989). However, a more common effect of excess nitrogen and its constituent parameters is that it plays an important role in eutrophication of water bodies. *Eutrophication* is the over-enrichment of aquatic systems by excessive inputs of nutrients; it is associated with an overabundance of aquatic plant growth including phytoplankton, periphyton, and macrophytes. Nitrogen acts as a fertilizer for aquatic plant communities, leading to explosive plant growth followed by die-off and depletion of DO levels as the dead plant matter decays. Maryland does not specify numeric standards for nitrogen species; however, many TMDLs identify as endpoints, the levels of nitrogen associated with maintaining DO levels to support aquatic life.

Phosphorous

Like nitrogen, excessive loading of phosphorus into surface water bodies can lead to eutrophication by fueling aquatic plant growth. Phosphorus in fresh and marine waters exists in organic and inorganic forms. The most readily available form for plants is soluble inorganic phosphorus ($H_2PO_4^-$, HPO_4^{2-}, and PO_4^{3}), also commonly referred to as soluble reactive phosphorus. Phosphorus is also able to sorb to sediment particles and is carried into water bodies by upland and streambank erosional processes. Maryland does not have numeric criteria for phosphorus.

Total Suspended Solids

TSS are small soil particles, including particles that make up sediment, that are carried in water and capable of being captured by a filter. Stream channel erosion is a major source of TSS and tends to worsen because of land development if stormwater runoff is not effectively controlled.

TSS concentrations in streams tend to increase with the amount of impervious surface in a watershed. As the impervious surfaces send runoff more quickly to local streams, the higher velocities and volumes of water in typically incised stream channels tend to increase rates of erosion. Channel erosion moves soil particles into the water from both the stream banks and the stream bed. Much of the resulting suspended sediment that is generated during a stormwater runoff event could settle out in deposits as the water slows between events. But those sediments can be resuspended and transported downstream with increased stream flow velocity.

In addition to the erosive effects, excessive settling of sediment on the stream bed and into the gravel blocks the flow of fresh, oxygenated water into the substrate. This situation leads to the destruction of fish spawning beds, a loss of aquatic habitat, and an increase in the mortality rate of macroinvertebrates from damaged or clogged gills and loss of food sources. Suspended sediment blocks light transmission, which limits the growth and survival of submerged aquatic vegetation. Sediment and sediment deposits in tidal reaches can also contribute to the demise of aquatic life there.

2 WATERSHED CHARACTERIZATION

The Anacostia River watershed lies across the northwestern portions of the County, as well as portions of Montgomery County and the District (Figure 2-1). In Maryland, it includes the municipalities of Berwyn Heights, Bladensburg, Brentwood, Capital Heights, Cheverly, College Park, Colmar Manor, Cottage City, Edmonston, Fairmount Heights, Glenarden, Greenbelt, Hyattsville, Landover Hills, Mount Rainier, New Carrollton, North Brentwood, Riverdale Park, Seat Pleasant, and University Park. The watershed also contains a large area of federal land (Beltsville Agricultural Research Center and Greenbelt Park) and state-owned land (University of Maryland).

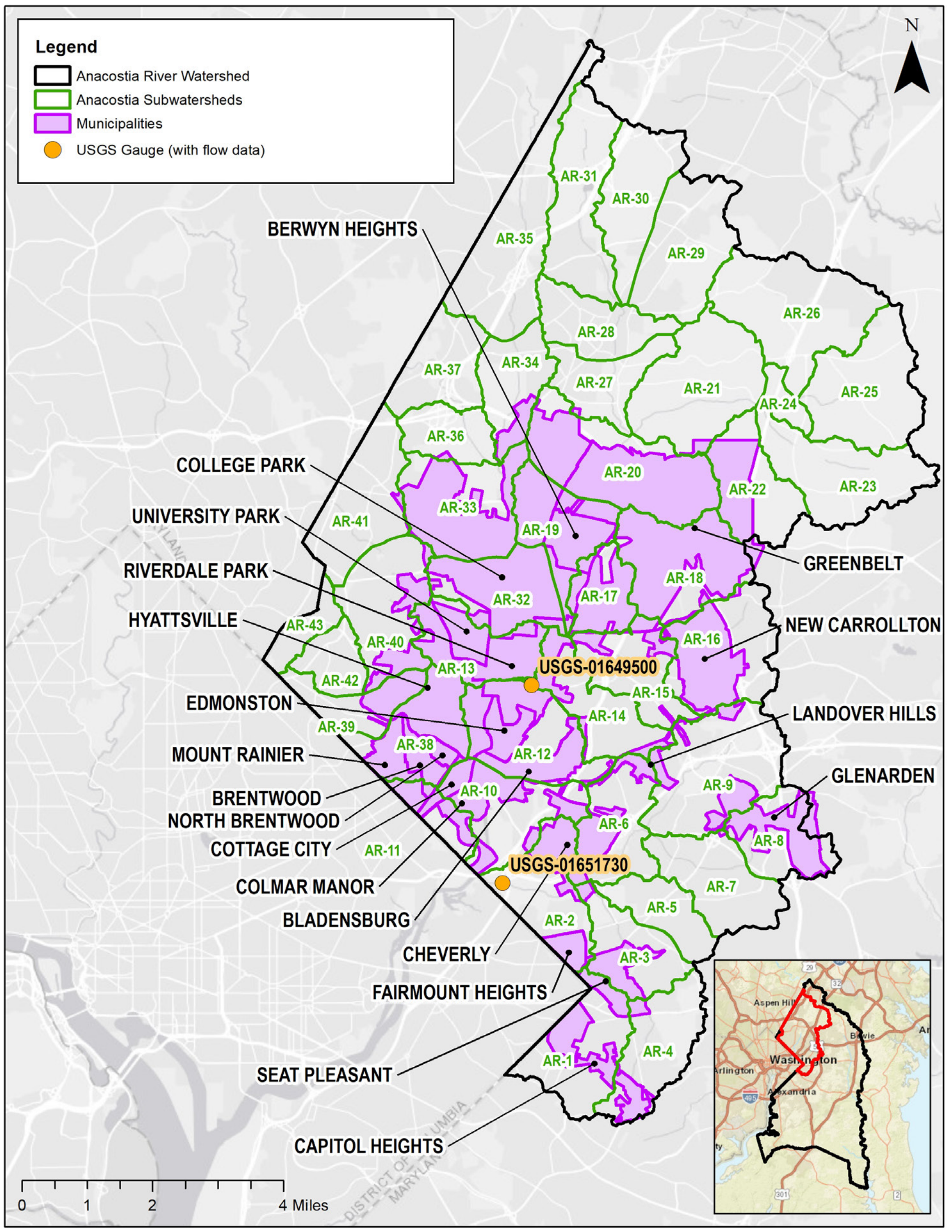


Figure 2-1. Location of the Anacostia River watershed.

The watershed has been inhabited for more than 4,000 years, but European colonization began in the 1700s. Historically a predominately forested watershed, agriculture dominated through the late 1800s, after which time urbanization began to replace agricultural land uses. The County portion of the watershed has a broad mix of land uses, ranging from undeveloped forestland and agriculture to high-density development. The population of the Anacostia River watershed is more than 800,000 persons. The western portions of the watershed are the most densely populated with more than 24,000 people per square mile.

2.1 Physical and Natural Features

2.1.1 Hydrology

The mainstem of the Anacostia River is 8.4 miles long, beginning at the confluence of the Northwest Branch (NWB) and the Northeast Branch (NEB) and ending at the Potomac River in the District. The Anacostia River watershed spans both Maryland and the District. The non-tidal reaches are predominantly in Prince George's and Montgomery counties in Maryland. The lower, tidal portions are mostly in the District; however, a portion of the tidal mainstem extends into the County. The watershed is 176 square miles, 145 of which are in Maryland. In Maryland, the Anacostia River is classified as a *Wild and Scenic River*. The major drainages in the County include NEB, NWB, Lower Beaverdam Creek, Watts Branch, and the tidal drainage.

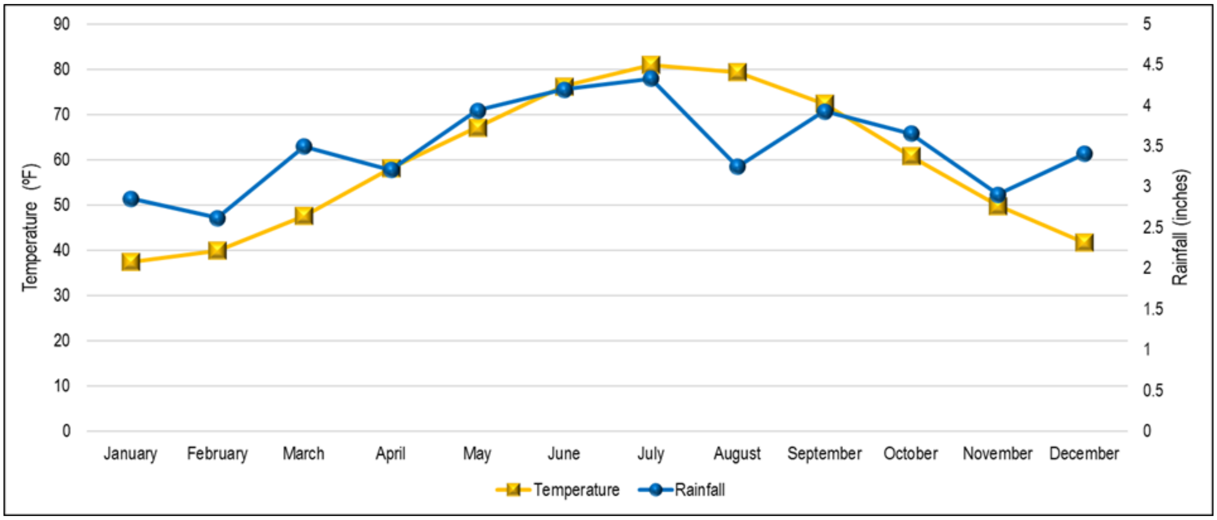
The Anacostia River watershed comprises 15 subwatersheds: NWB, Sligo Creek, Paint Branch, Little Paint Branch, Indian Creek, Upper Beaverdam Creek, Still Creek, Brier Ditch, NEB, Lower Beaverdam Creek, Watts Branch, Fort Dupont Tributary, Pope Branch, Hickey Run, and the tidal river. Except for Hickey Run, Fort Dupont Tributary, and Pope Branch, all the subwatersheds have a portion in the County (Figure 2-1). Most of the land in the watershed is drained by MS4 outfalls. In the Maryland portion of the watershed, 9,500 acres drain directly to the Anacostia River and tributaries, and the remaining 82,600 acres are drained via MS4 outfalls. The County has 44,000 acres of MS4 drainage (MDE and DDOE 2010). The tributary system of the Anacostia River is described as *flashy*, meaning there is a quick rise in stream level because of rainfall (MWCOG 2010).

The County has broken down the main watershed into small subwatersheds (e.g., 500–1,000 acres) to help address restoration at a smaller scale. These smaller subwatersheds are identified as AR-1 through AR-43 in Figure 2-1. The smaller watersheds are not considered watershed management areas. Implementation strategies are presented in later sections for the entire watershed, as individual project opportunities are unknown at the time of WIP development.

There are three USGS stream gages in the watershed with flow data (see Section 3.1). USGS-01651730 is on Beaverdam Creek near Cheverly, USGS-1649500 is on the NEB of the Anacostia River at Riverdale and USGS-1651000 is on the NWB of the Anacostia River near Hyattsville. Flow data provides general historical trends that can help the County understand hydrologic response in the watershed. The gages are not collecting data specific to the impairments; however, they are helpful as a big picture of watershed conditions. USGS 01651730 currently provides gage height and discharge data but has served as a sampling point for USGS to evaluate the presence of nutrients and sediments (see Section 3.1).

2.1.2 Climate/Precipitation

The climate of the Anacostia River watershed is characterized as temperate. The National Weather Service (NWS) Forecast Office reports a 30-year average annual precipitation of 41.82 inches (NWS 2023). On average, winter is the driest season, with 8.89 inches of precipitation, and summer is the wettest season, with 11.78 inches (NWS 2023). The average annual temperature is 59.3 degrees Fahrenheit (°F), with the January normal low at 30.1 °F and the July normal high at 89.6 °F (NWS 2022). The normal monthly precipitation and temperature for Washington D.C. are presented in Figure 2-2 . Average monthly temperatures range from approximately 38 °F in January to a peak of 81 °F in July.



Sources: NWS 2022, 2023.

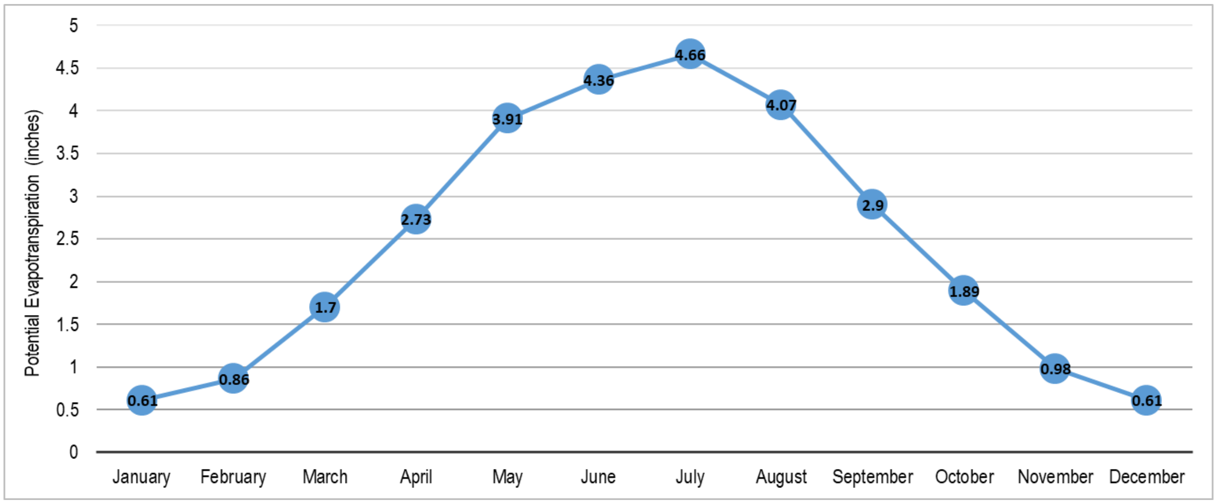
Figure 2-2. Average monthly temperature and precipitation.

Evapotranspiration accounts for water that evaporates from the land surface (including water bodies) and is lost through plant transpiration. Evapotranspiration varies throughout the year because of climate but is greatest in the summer. Figure 2-3 presents the potential evapotranspiration, which is described by the National Oceanic and Atmospheric Administration (NOAA) as "the maximum amount of water that would be evapotranspired if enough water were available (from precipitation and soil moisture)" (NOAA n.d.). That amount is affected by solar radiation, air temperature, vapor pressure, and wind speed. Expected rates of evapotranspiration constitute a design consideration for certain BMPs, particularly those that have permanent water (e.g., wet ponds) or rely on moisture-rich soils (e.g., wetlands).

The County is reviewing the potential effects of climate change on watershed implementation.[5] Climate change is the result of rising temperatures due to elevated levels of heat-trapping greenhouse gases such as carbon dioxide in the atmosphere. Rising temperatures are expected to increase and shift energy distribution in the atmosphere, which could lead to increased evaporation, increased humidity, higher average rainfall, and greater occurrences of heavy rainstorms in some regions and droughts in others (USEPA 2016). Though average annual precipitation in Maryland has increased by approximately 5 percent in the past century,

[5] Prince George's County has created an overall County *Climate Actin Plan*. For additional information, please see https://www.princegeorgescountymd.gov/departments-offices/environment/sustainability/climate-change.

precipitation from extremely heavy events has increased in the eastern United States by more than 25 percent since 1958 (USEPA 2016). Average precipitation is expected to increase during winter and spring, which will cause snow to melt earlier and intensify flooding during these seasons. The higher rates of evaporation will also likely result in drier soil during the summer and fall.



Source: NRCC 2014.

Figure 2-3. Average monthly potential evapotranspiration in inches (1981–2010).

The Mid-Atlantic Regional Integrated Sciences and Assessments (MARISA) program maintains a website that helps illustrate the impact of climate change on precipitation under future climate conditions (MARISA 2022). The website provides updated intensity-duration-frequency (IDF) curves by county. These curves describe the relationship between rainfall intensity, rainfall duration, and frequency of the interval (e.g., 5-year rainfall). IDF curves are used for forecasting floods and designing stormwater conveyance and treatment practices. Precipitation frequency is the amount of rainfall at a location for a specified duration that has the probability of occurring. For instance, if a location has an 8.5 inch precipitation frequency for a 100-year, 24-hour storm, it means that for a rainfall event that lasts 24 hours, there would be a one in a hundred (1 percent) chance that 8.5 inches would be exceed in a 24-hour period.

Initial precipitation frequency estimates were developed in 1961 by the U.S. Weather Bureau in Technical Paper Number 40 (TP40). These numbers were revised in 2006 by NOAA and are referred to as Atlas 14. Recently, the MARISA team and the Chesapeake Bay Program looked at future predictions for precipitation frequencies. Table 2-1 presents the precipitation frequencies for Beltsville, MD from TP40, Atlas 14, and MARISA.

Table 2-1. Precipitation (inches) frequency 24-hour estimates for Beltsville, MD.

24 Hour Duration	TP 40	Atlas 14	MARISA Atlas 14 Projected 2020–2070	MARISA Atlas 14 Projected 2050–2100
2-Year	3.3	3.2	3.46	3.68
10-Year	5.3	4.92	5.31	5.71
100-Year	7.4	8.49	9.42	10.1

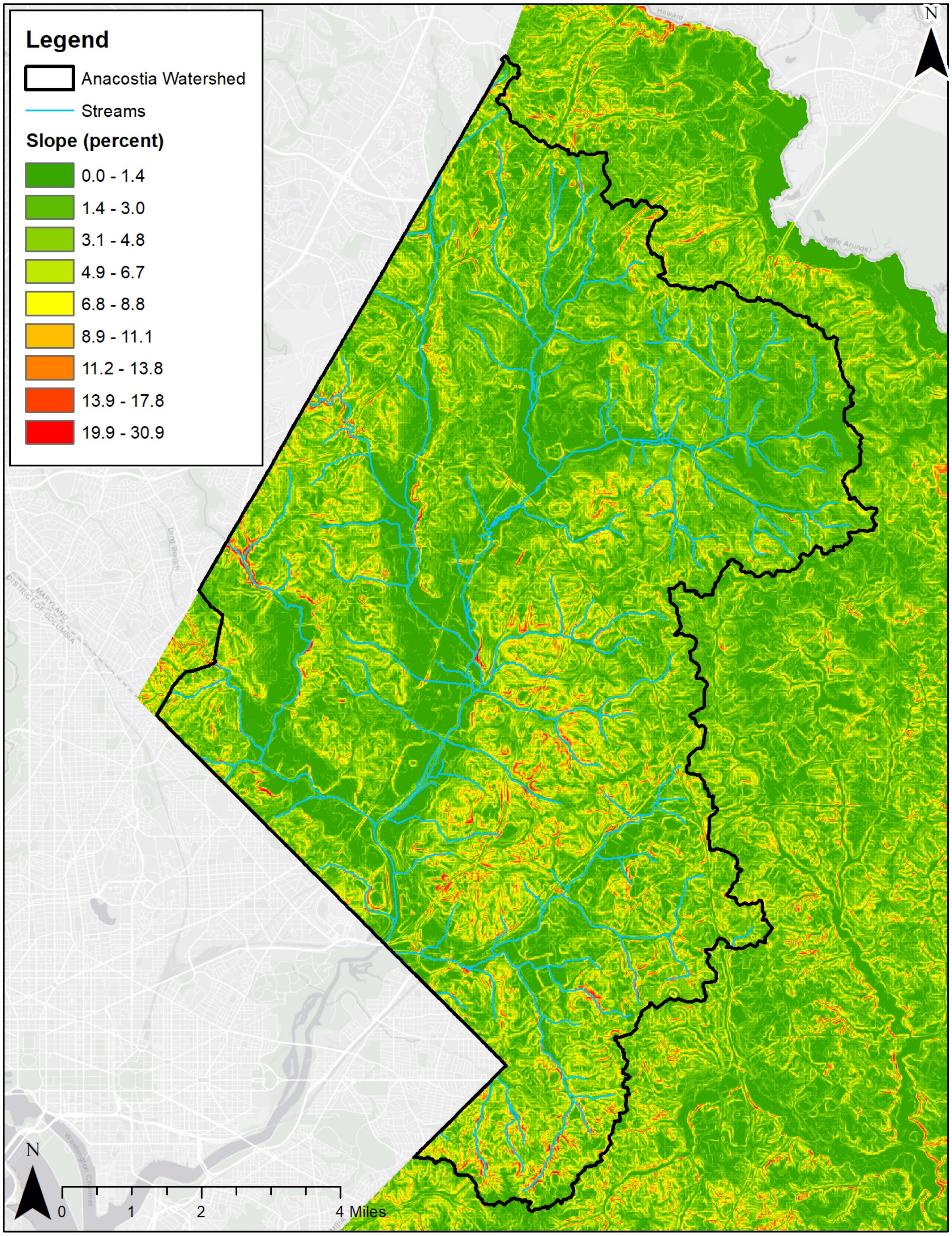
Sources : NOAA 2006, Miro et.al. 2021.

2.1.3 Topography/Elevation

According to the Maryland Geological Survey (MGS), the Fall Line between the Atlantic Coastal Plain and the Piedmont approximates the boundary between Prince George's and Montgomery counties. Most of the County portion of the watershed is in the coastal plain, which is underlain by unconsolidated sediments, including gravel, sand, silt, and clay (MGS 2014). The coastal plain is characterized by gentle slopes, meandering streams, and lower relief.

Figure 2-4 displays land surface slopes across the Anacostia River watershed. This method of mapping identifies the steepest areas of the watershed, which could indicate the variability of speed in overland runoff and suggest places that are more susceptible to higher rates of erosion and increased sediment in the stream. This can help to characterize some of the sediment-influencing capacity of that flow, especially when combined with other relevant information, such as soils data.

The watershed is relatively flat with elevations typically only between sea level and 200 feet. The highest elevations in the watershed are in the northern portion, with the lowest portions following the mainstems of NEB, NWB, and Beaverdam Creek. The greatest slopes encountered in the Anacostia River watershed are found near the transition from the primary mainstem floodplains in the initial stream valley wall; therefore, stream flows will experience greater velocities in these areas.



Source: M-NCPPC 2014.

Figure 2-4. Land slopes across the Anacostia River watershed.

2.1.4 Soils

The U.S. Department of Agriculture (USDA) Natural Resources Conservation Service has defined four hydrologic soil groups (HSGs), providing a means for grouping soils by similar infiltration and runoff characteristics during periods of prolonged wetting. Poorly drained clay soils (group D) have the lowest infiltration rates, resulting in the highest amount of runoff, while well-drained sandy soils (group A) have high infiltration rates, with little runoff. This is important in determining the types of restoration activities that can be implemented. For example, infiltration practices require group A or B soils and will not be effective in Group D soils. Table 2-2 summarizes soil make-up in the watershed by HSG.

Figure 2-5 presents the USDA hydrologic soil group data. For some areas, the USDA data were null; therefore, the information was filled in with State Soil Geographic Database (STATSGO) data. Most of the watershed is underlain by hydrologic group D soils. Hydrologic soil group B is the least represented in the watershed.

Soils in the watershed are frequently also classified as "urban land complex" or "udorthent" soils. These are soils that have been altered by disturbance because of land development activities. Soils affected by urbanization can have a higher density because of compaction during construction activities and might be more poorly drained. Natural pervious land covers on Group B soils have very little runoff compared to that from disturbed soils.

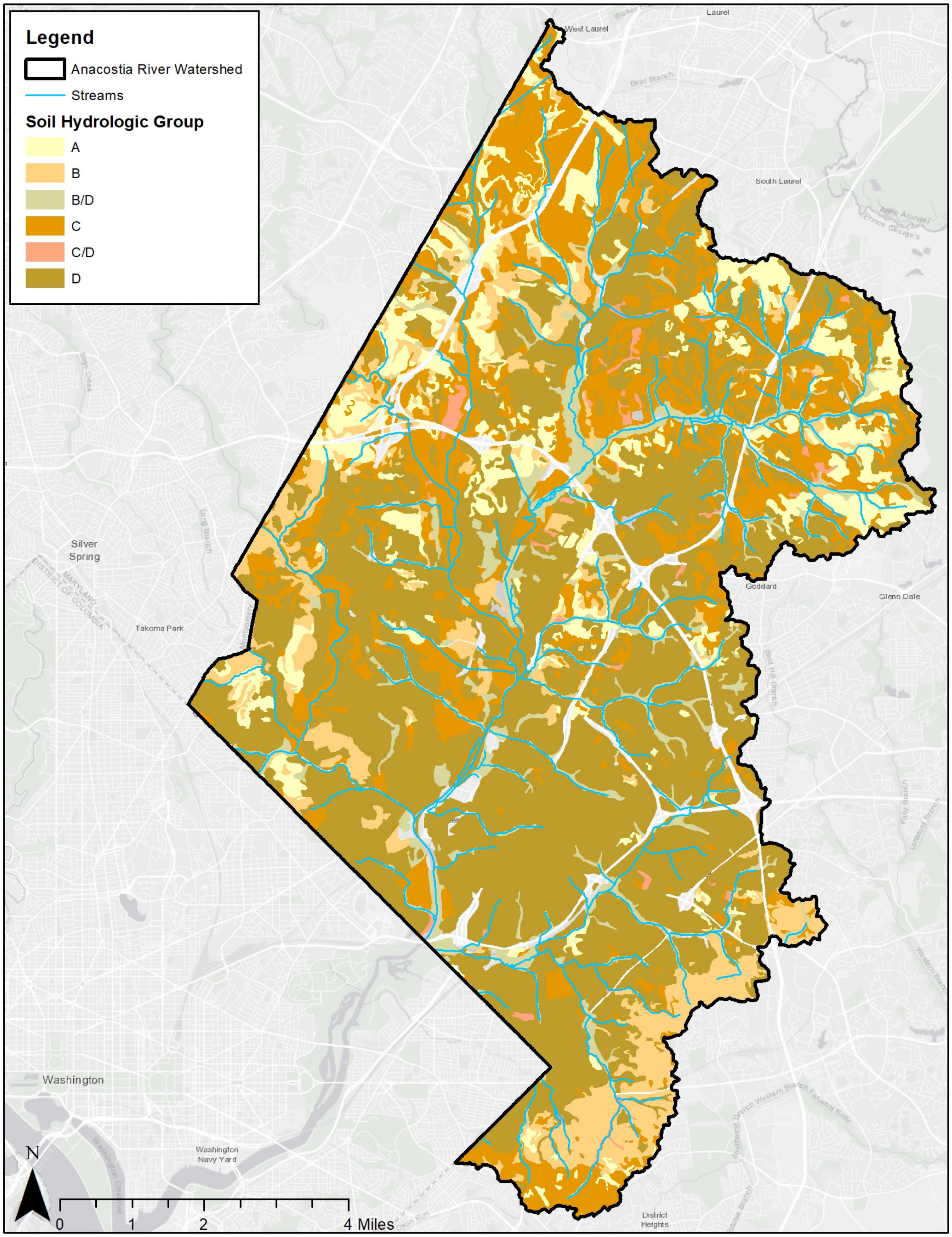
Soils of the NWB tributary are predominantly in the Manor-Glenelg-Chester soil series, which are Piedmont soils. These soils are fine-loamy, mixed mesic Typic Hapludults and are very deep and well-drained (SCS 1995).

NEB tributary soils are mostly in the Sunnyside-Christiana-Muirkirk soil series, which is a Coastal Plain soil. The Sunnyside soils are mostly red, deep, and well-drained. The Christiana-Muirkirk soils are also red and deep but are less permeable than the Sunnyside soils (SCS 1967). Below the confluence of the NEB and NWB, the soils are primarily in the Sunnyside-Christiana-Muirkirk soil series and the Beltsville-Croom-Sassafras soil series (STATSGO). The Beltsville-Croom-Sassafras series is gently sloping to steep and dominantly gravelly (SCS 1967).

Table 2-2. Summary of soils in Anacostia River watershed.

Soil Type	A	B	B/D	C	C/D	D
Acres	5,040	4,958	3,932	11,190	427	26,342
% Total	9.7%	9.6%	7.6%	21.6%	0.8%	50.8%

Note: Soil types B/D and C/D behave as B or C soils respectively, during dry weather and soil type D during wet weather.



Source: USDA 2003.

Figure 2-5. Hydrologic soil groups in the Anacostia River watershed.

2.2 Land Use and Land Cover

Land use and land cover are key watershed characteristics that influence the type and amount of pollution entering the County's water bodies. Land use is how the land is being used (e.g., residential neighborhood). Land cover is what is covering the land (e.g., turf, impervious surface).

Over time, land use and land cover changes have caused stream health to be degraded and certain streams to be classified as impaired. Some natural changes have occurred over centuries, others were the result of farming, new development, and construction of roads. The County has many older neighborhoods inside the Beltway, close to the border with Washington DC, which were developed without stormwater quality controls. The areas outside the Beltway continue to be developed and are moving from agricultural land and forests to developed land, which is the leading cause of impairments. In 2014, the County Planning Department created *Plan 2035*, which contains the County's future development plans.[6] One of the policy goals of Plan 2035 is to reduce stormwater runoff.

2.2.1 Land Use Distribution

Land use information for the watershed was obtained from the Maryland Department of Planning (MDP) 2010 land use update (MDP 2010). Land uses are made of many different land covers, such as roads, roofs, turf, and tree canopy. The proportion of land covers in each land use control the hydrologic and pollutant loading response of such uses. Table 2- summarizes the land use distribution in the Anacostia River watershed. Figure 2-6 shows the land uses in the watershed.

The urban area in the watershed is largely residential land (37 percent), with the majority being low-density residential (24 percent). There are also significant areas of forested land (25 percent), institutional land (such as schools, government buildings, churches) (9 percent), and commercial/industrial land (12 percent).

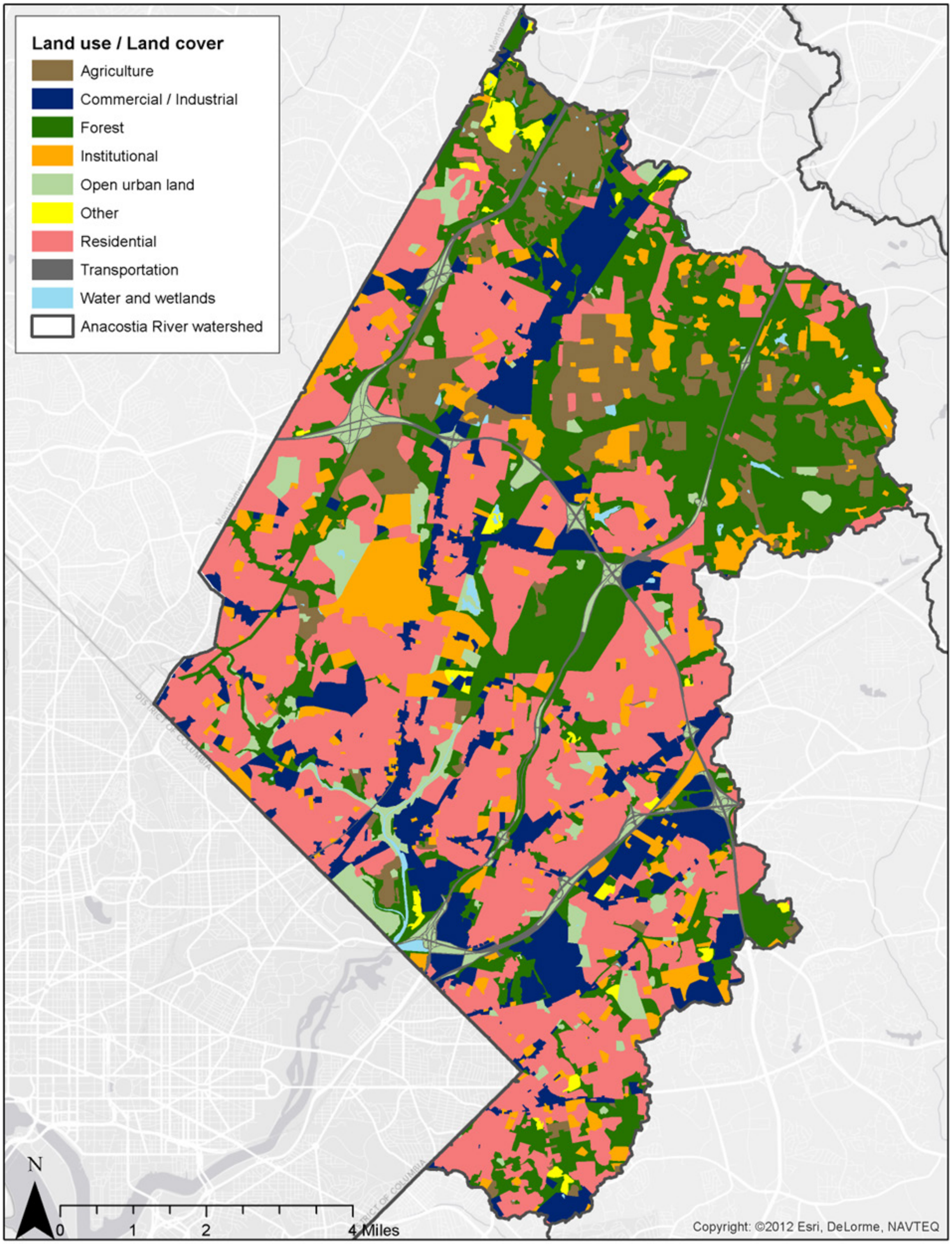
Table 2-3. Anacostia River watershed land use.

Land Use	Acres	Percent of Total	Percent of Land Use Grouping
Agriculture	**4,520**	**8.33%**	**100.0%**
Agricultural building	0	0.00%	0.0%
Cropland	3,135	5.78%	69.4%
Feeding operations	0	0.00%	0.0%
Large lot subdivision (agriculture)	48	0.09%	1.1%
Orchards/vineyards/horticulture	0	0.00%	0.0%
Pasture	1,307	2.41%	28.9%
Row and garden crops	29	0.05%	0.6%

[6] https://www.mncppcapps.org/planning/publications/BookDetail.cfm?item_id=279&Category_id=1

Land Use	Acres	Percent of Total	Percent of Land Use Grouping
Forest	**13,721**	**25.30%**	**100.00%**
Brush	388	0.72%	2.8%
Deciduous forest	6,301	11.62%	45.9%
Evergreen forest	886	1.63%	6.5%
Large lot subdivision (forest)	88	0.16%	0.6%
Mixed forest	6,057	11.17%	44.1%
Other	**559**	**1.03%**	**100.0%**
Bare ground	350	0.64%	62.6%
Beaches	0	0.00%	0.0%
Extractive	209	0.39%	37.4%
Urban	**35,139**	**64.79%**	**100.0%**
Commercial	3,143	5.80%	8.9%
High-density residential	5,696	10.50%	16.2%
Industrial	3,315	6.11%	9.4%
Institutional	4,904	9.04%	14.0%
Low-density residential	1,173	2.16%	3.3%
Medium-density residential	13,151	24.25%	37.4%
Open urban land	2,588	4.77%	7.4%
Transportation	1,170	2.16%	3.3%
Water and Wetlands	**296**	**0.55%**	**100.0%**
Water	267	0.49%	90.2%
Wetlands	29	0.05%	9.8%
Total	**54,235**	**100%**	

Source: MDP 2010.



Source: MDP 2010.

Figure 2-6. Land use in the Anacostia River watershed.

2.2.2 Land Cover Distribution

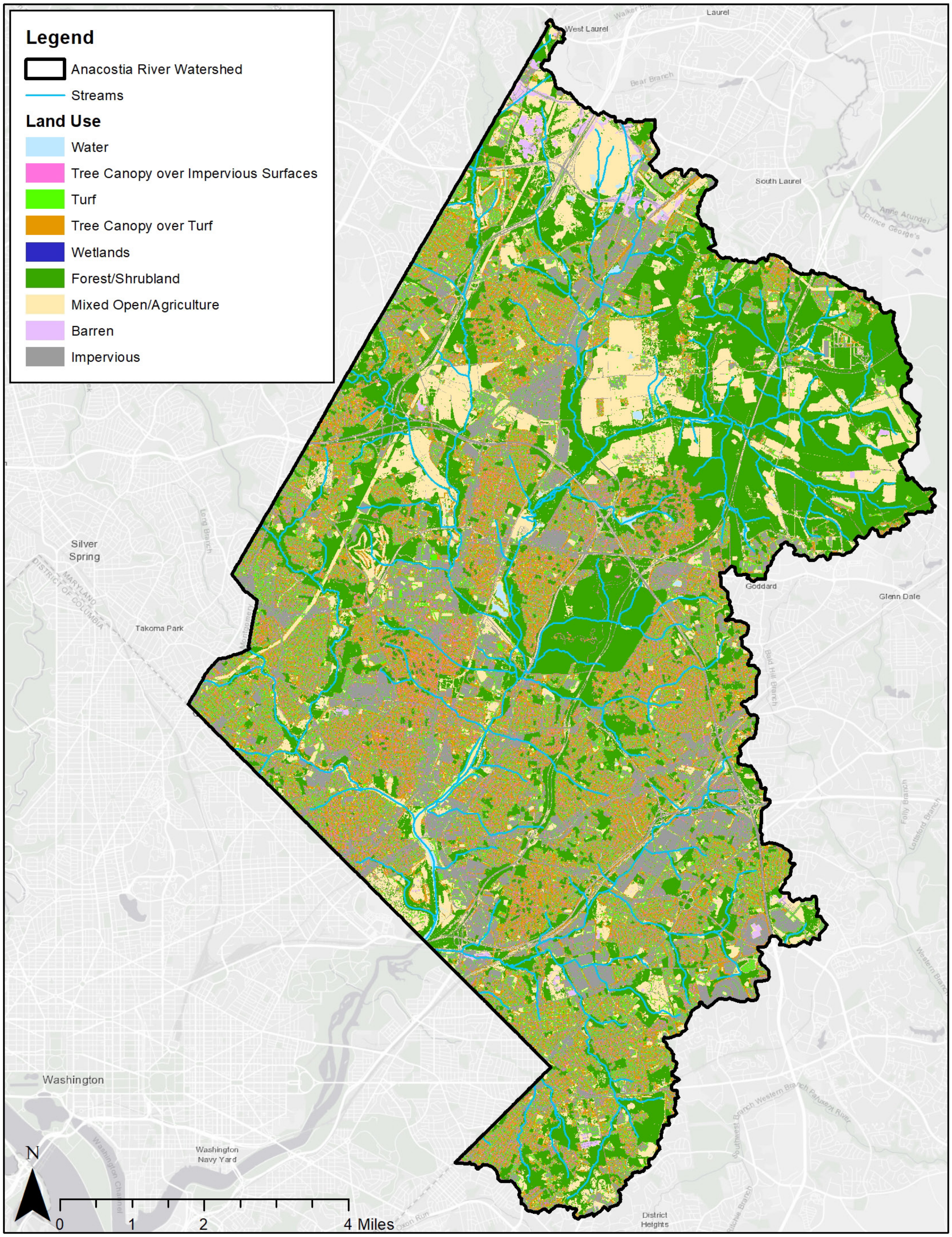
Land cover differs from land use in that it describes what covers the land instead of how it is used. Land cover information was obtained from MDE (2021b) and matches the land cover data in the Chesapeake Bay model. Table 2-4 summarizes the land cover distribution in the Anacostia River watershed. Figure 2-7 shows a map of land cover in the watershed.

Overall, half the land cover in the watershed is urban. The largest areas of urban land cover are impervious (23 percent) followed by tree canopy over turf (14.6 percent). There are also significant areas of mixed open/agriculture land cover (15 percent), which is considered outside the MS4 area.

Table 2-4. Anacostia River watershed land cover.

Land Cover Category	Area (acres)	% Total
Barren	358	0.66%
Forest/Shrubland	16,894	31.06%
Impervious	12,541	23.06%
Mixed open / Agriculture	8,300	15.26%
Tree Canopy over Impervious Surfaces	2,534	4.66%
Tree Canopy over Turf	7,928	14.58%
Turf	5,564	10.23%
Water	265	0.49%
Total	**54,383**	**100.00%**

Source: MDE 2021b.



Source: MDE 2021b.

Figure 2-7. Land cover in the Anacostia River watershed.

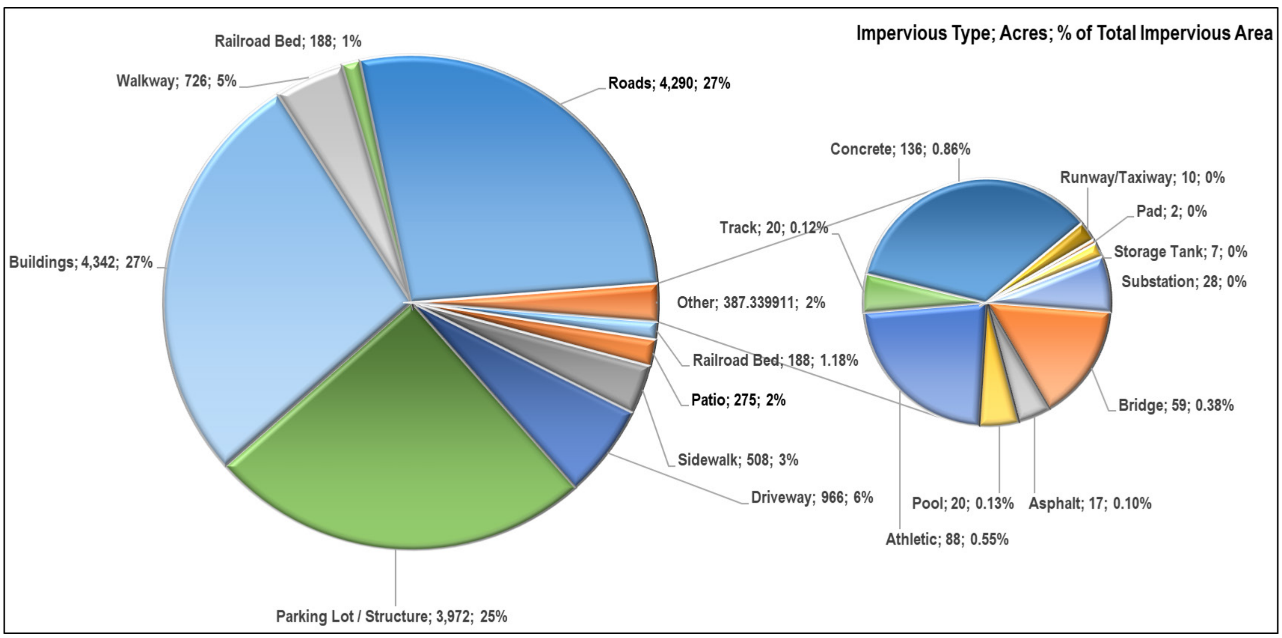
2.2.3 Impervious Area

Impervious area is the land surface covered with a solid material or compacted to the point at which water cannot infiltrate into underlying soils (e.g., parking lots, roads, houses, patios, swimming pools, compacted gravel areas). Consequently, impervious areas resulting from land development affect both the amount and the quality of runoff.

Compared to naturally vegetated areas, impervious areas generally decrease the amount of water infiltrating into groundwater and increase the amount of water flowing to the stream channels in the watershed. This increased surface flow not only carries greater amounts of sediment and other pollutants but also increases the velocity of the streams, which worsens erosion. More erosion increases the amount of sediment carried by the water, which can be detrimental to the appearance of a stream and its ecological health.

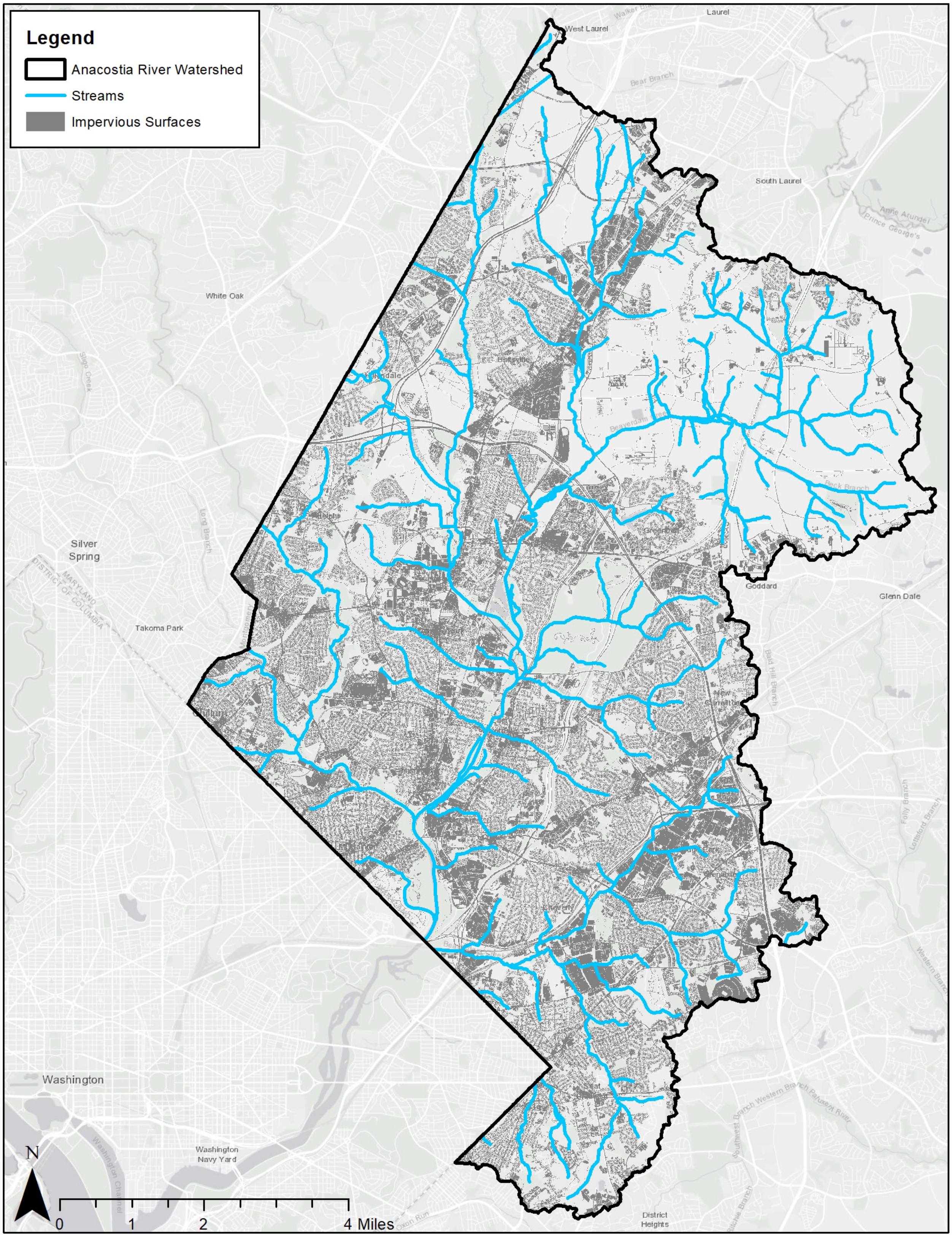
Figure 2-8 shows the percent of each type of impervious area (e.g., roads) in the watershed. Roads and buildings each accounted for 27 percent of the watershed, followed by parking lots (25 percent).

Figure 2-9 shows the impervious land cover throughout the watershed area, which is available from the Prince George's County GIS Open Data Portal (M-NCPPC 2022). Greater proportions of impervious land cover may be seen in more developed areas on smaller scales, especially in the form of roadways, parking facilities, and buildings.



Source: M-NCPPC 2022.

Figure 2-8. Anacostia River watershed percent of impervious area by source.

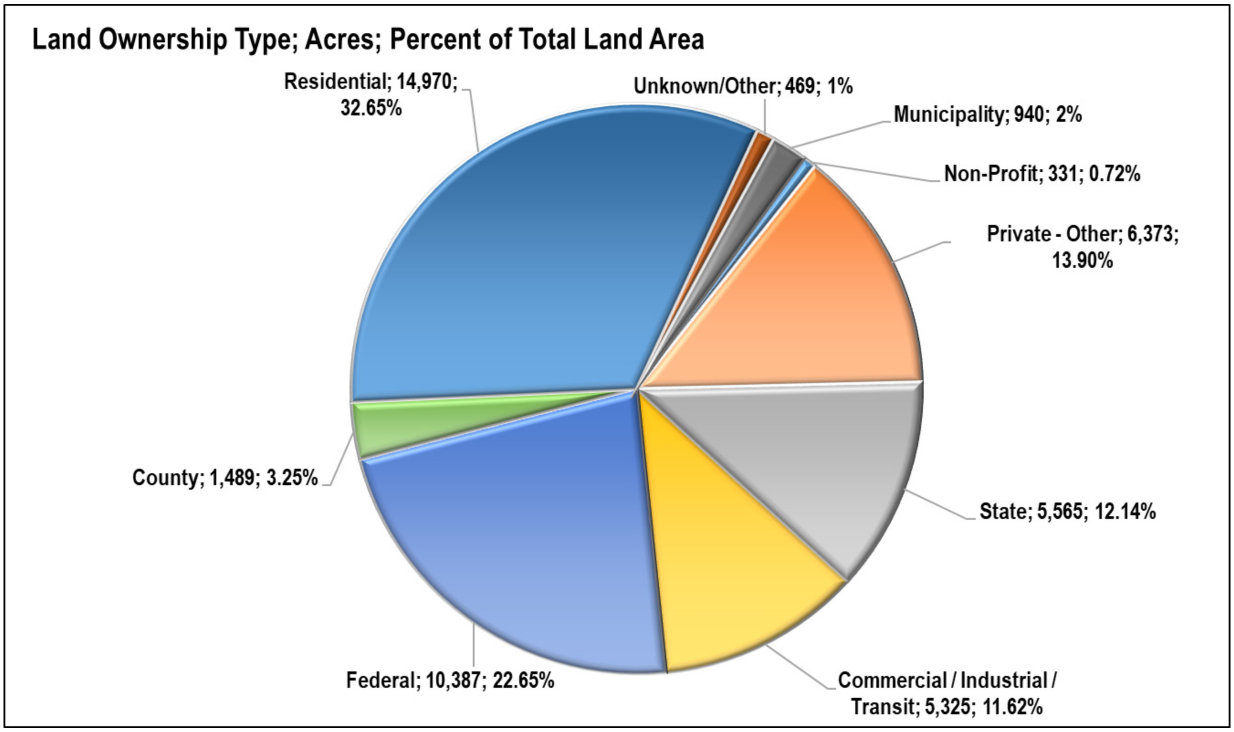


Source: M-NCPPC 2022.

Figure 2-9. Impervious cover in Anacostia River watershed.

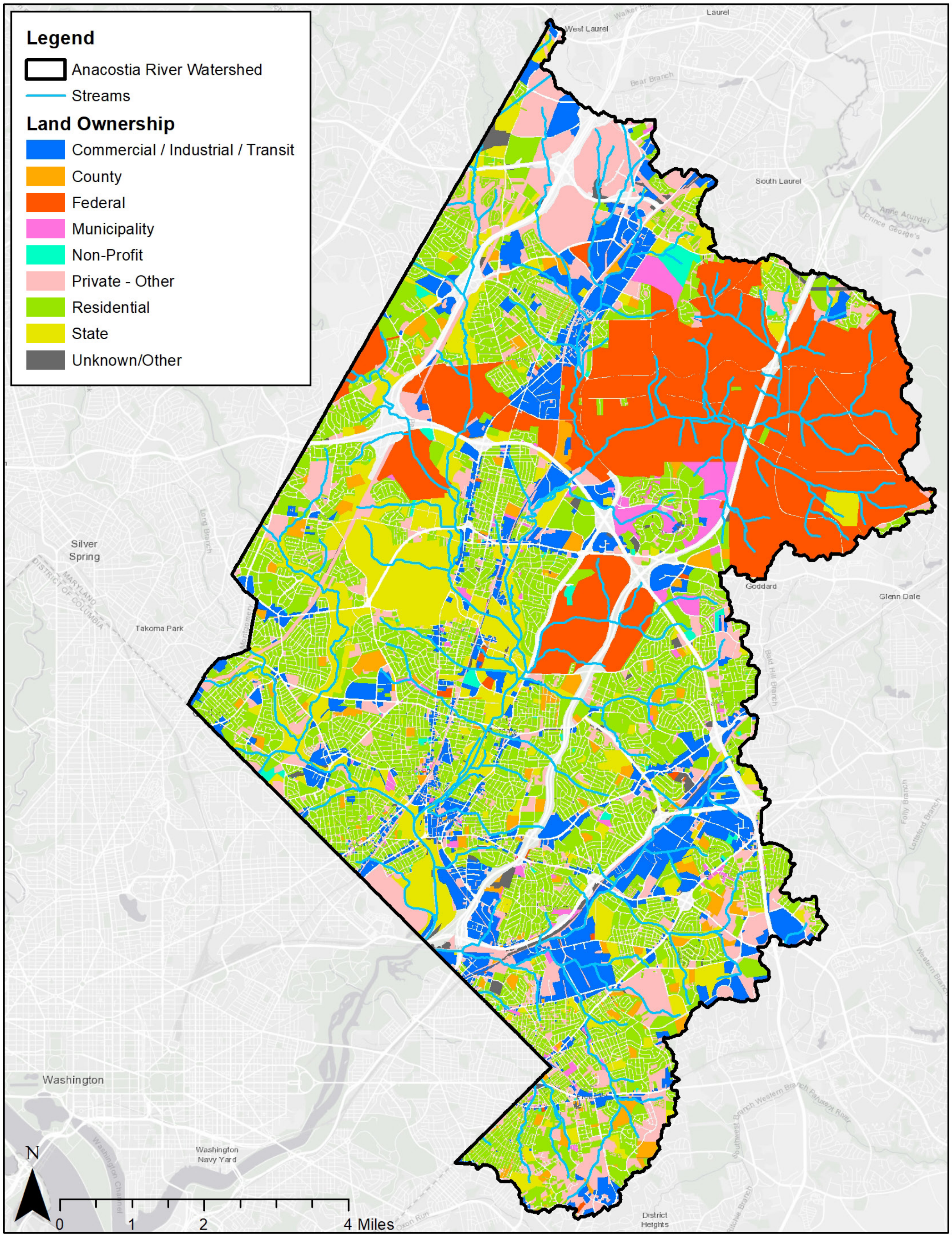
2.3 Land Ownership

Overall, the watershed is primarily privately owned residential land (Figure 2-10, Figure 2-11). The majority (32 percent) of land is owned by residents, with 22 percent owned by federal entities, and 14 percent owned by private (other). A closer examination of land ownership will come into play during specific restoration planning, as it can sometimes be a simpler solution to implement BMPs on County, or otherwise publicly-owned, lands. While roadways are usually considered public right-of-way, Figure 2-11 was created using parcel information available from the Prince George's County GIS Open Data Portal (M-NCPPC 2022), which does not include roadway information, so roadways show on the map as white lines.



Source: M-NCPPC 2022.

Figure 2-10. Land ownership percent by source.



Source: M-NCPPC 2022.

Figure 2-11. Land ownership in the Anacostia River watershed.

2.4 Population and Growth

Table 2- presents the recent U.S. Census population estimates for Prince George's County. These numbers are not available by watershed level but there is a continuing upward trend in population. Figure 2-12 presents the population density of the watershed, by U.S. census block. There are lower density populations from the headwaters to Beaverdam Creek, with higher density populations inside the Beltway.

Table 2-5. Prince George's County population (1980–2020).

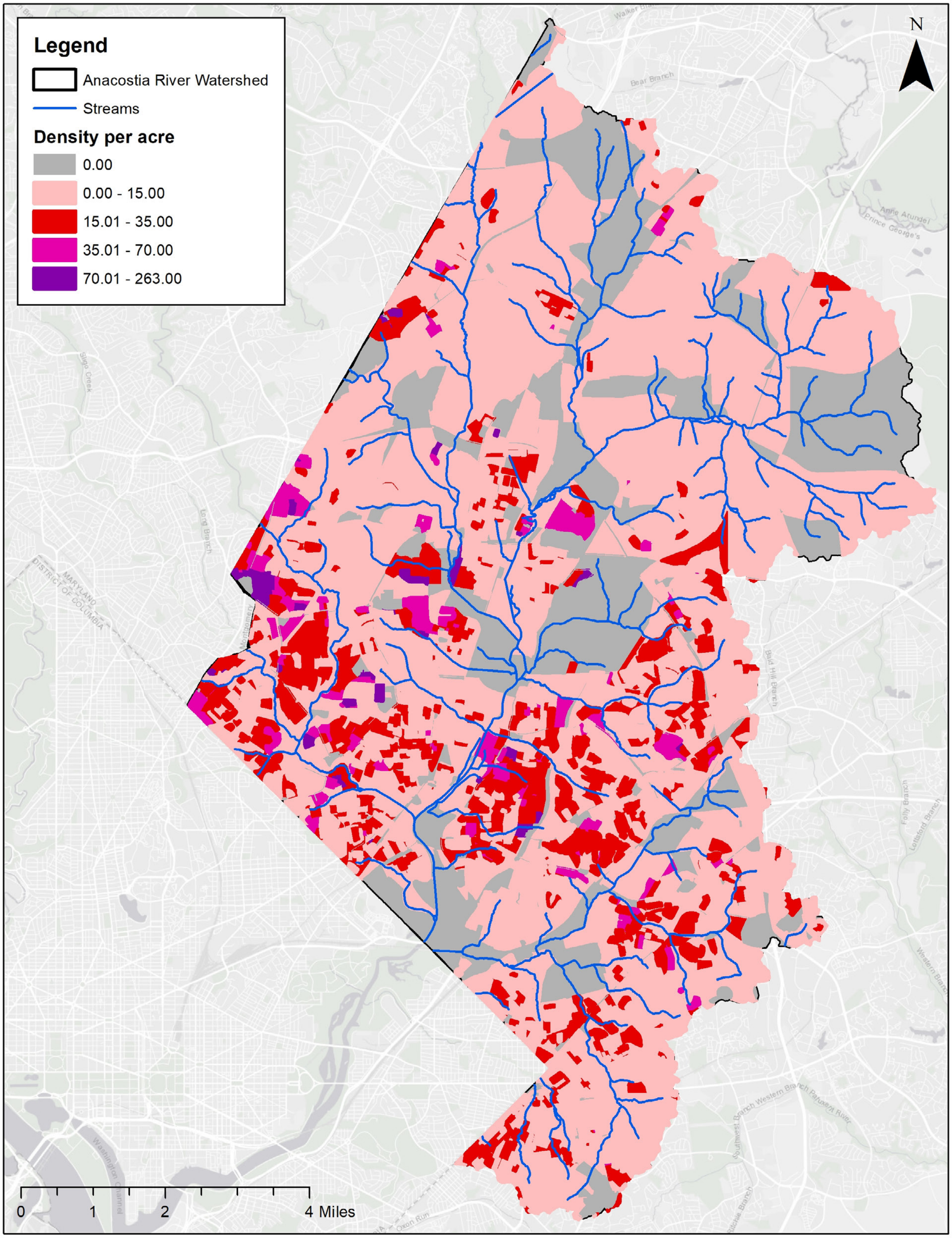
1980	1990	2000	2010	2020
665,071	729,268	801,515	863,420	967,201

Source: Wikipedia 2023.

In 2010, the Prince George's County Planning Department developed the County's *Water Resources Functional Master Plan*, which amended the 2002 *General Plan* (M-NCPPC 2010). The plan contains information on the County's water and sewer service capacity for planned growth through 2030. It included a methodology to calculate nutrient loadings from existing and future conditions. The plan discusses County agency responsibilities regarding stormwater, key issues, and overarching policies and strategies.

MDE maintains an *Environmental Justice Screening Tool*.[7] The tool contains demographic and socioeconomic data by U.S. Census tracks, which can cross watershed boundaries. The tool also identifies underserved communities (based on income level, ethnicity, and English proficiency) and overburdened communities (based on factors such as air quality, cancer risk, certain health statistics, and proximity to hazardous or toxic waste, landfills, and power plants). The final environmental justice score is a combination of pollution burden exposure, pollution burden environmental effects, sensitive populations, and socioeconomic/demographic indicators.

[7] https://mde.maryland.gov/Environmental_Justice/Pages/EJ-Screening-Tool.aspx



Source: U.S. Census 2023.

Figure 2-12 Population density by census block in the Anacostia River watershed.

3 Watershed and Water Quality Conditions

3.1 Water Quality Data

Water quality data were analyzed to assess the degree to which water quality might be getting better or worse. Graphs later in this section present a record of TSS, TN, and TP concentrations over different periods of record. Figure 3-1 presents the locations of the water quality monitoring stations in the Anacostia River watershed.

Water quality data were obtained from the following sources:

- EPA's STORET (STOrage and RETrieval) Data Warehouse.
- Federal Water Quality Portal (www.waterqualitydata.us/). (This service, which is sponsored by EPA, USGS, and the National Water Quality Monitoring Council, collects data from more than 400 federal, state, local, and tribal agencies.)

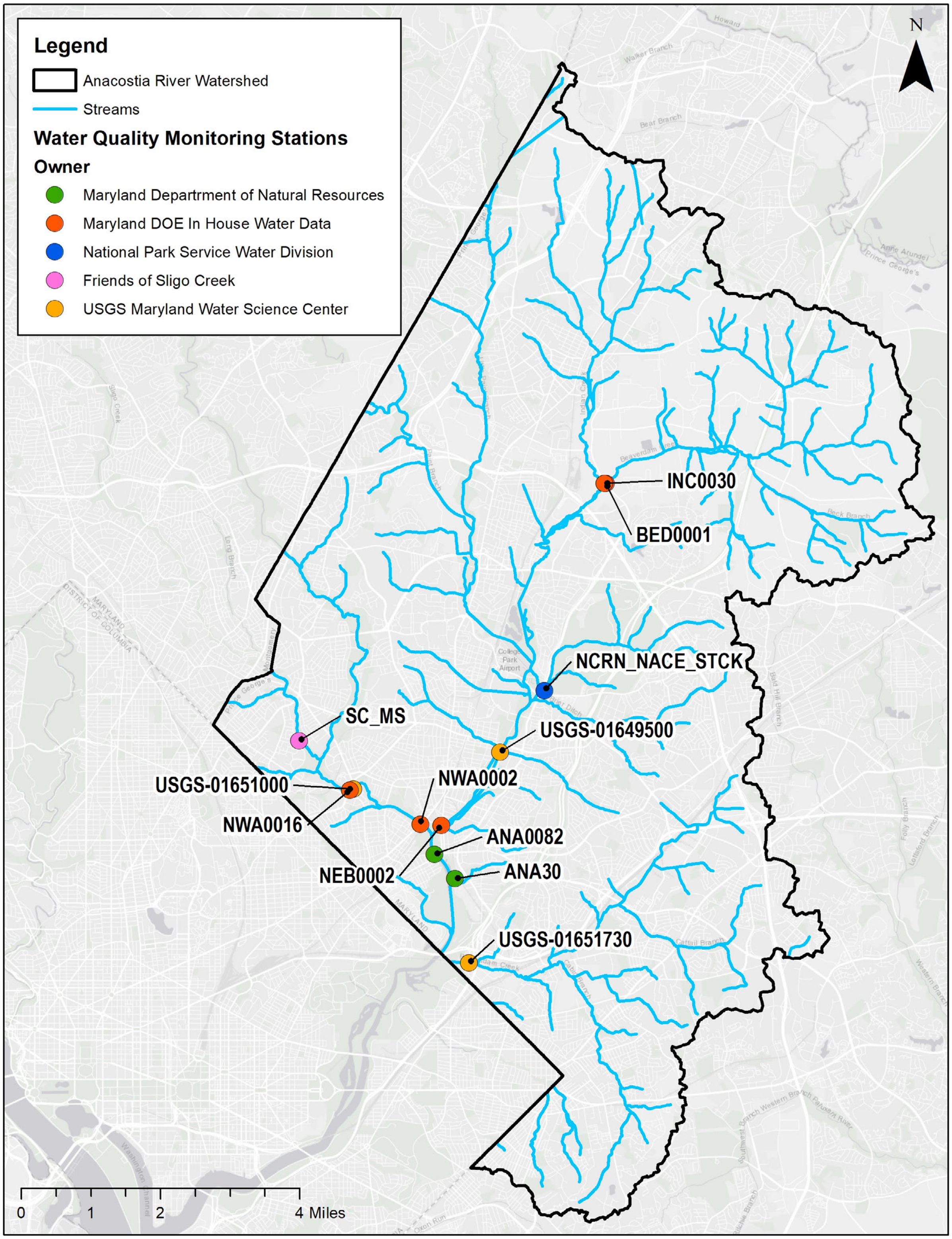
3.1.1 Total Suspended Solids

Time series of TSS data from these monitoring stations for the periods in Table 3-1 are shown in Figure 3-2, Figure 3-3, and Figure 3-4 for the Anacostia River watershed. This section only discusses stations with recent water quality data after 2000 and at least 50 data points.

Eight monitoring stations with recent data are in the Anacostia River watershed, and two of those monitoring stations have comprehensive datasets ranging from 1990 to 2020 (Table 3-1 and Figure 3-2). Monitoring stations ANA0082 and ANA30 represent the most complete datasets in the watershed, with a respective 433 and 245 records (Table 3-1 and Figure 3-2). Both are in the tidal zone in the lower watershed. TSS concentrations at ANA0082 have a slightly positive slope (+0.0007) and the concentrations at ANA30 have a slightly negative slope (-0.0007). The trend line slopes are small and not significant. The coefficient of determination (R^2 value) for both are under 0.02, indicating there is no significant trend of concentration versus time.

Monitoring stations USGS-1649500 and USGS-1651000 have comprehensive datasets ranging from 1960 to 2020. However, a data gap from 1975 to 2000 existed, with most data points distributed after 2002 (Figure 3-3).

The other monitoring stations in the Anacostia River watershed have significantly fewer data records (between 1 and 165) for analysis (Table 3-1). The limited sample sizes of those stations and shorter period of record contribute to uncertainty because the extreme values could influence the slopes of the trendlines for those data. Stations with more than 50 data points since 2000 are plotted in Figure 3-3 and Figure 3-4.



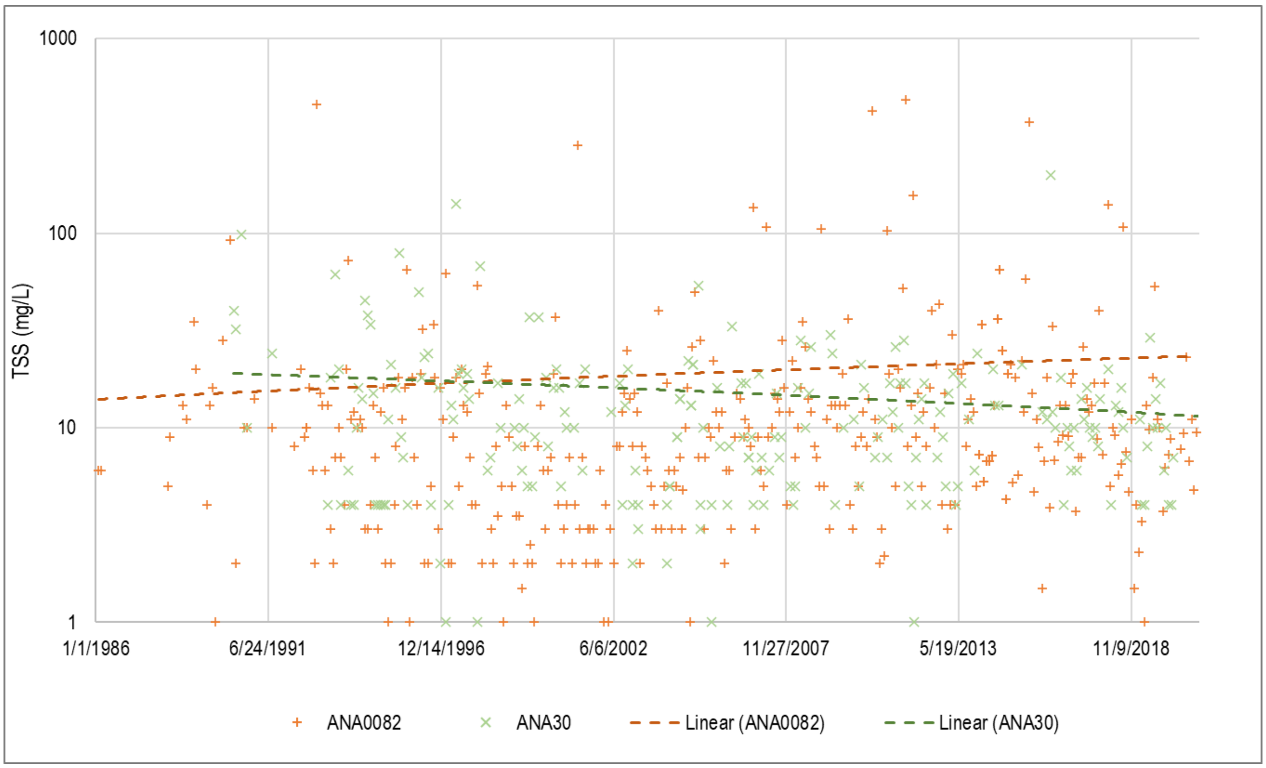
Source: NWQMC 2022.

Figure 3-1. Locations of water quality monitoring stations in the Anacostia River watershed.

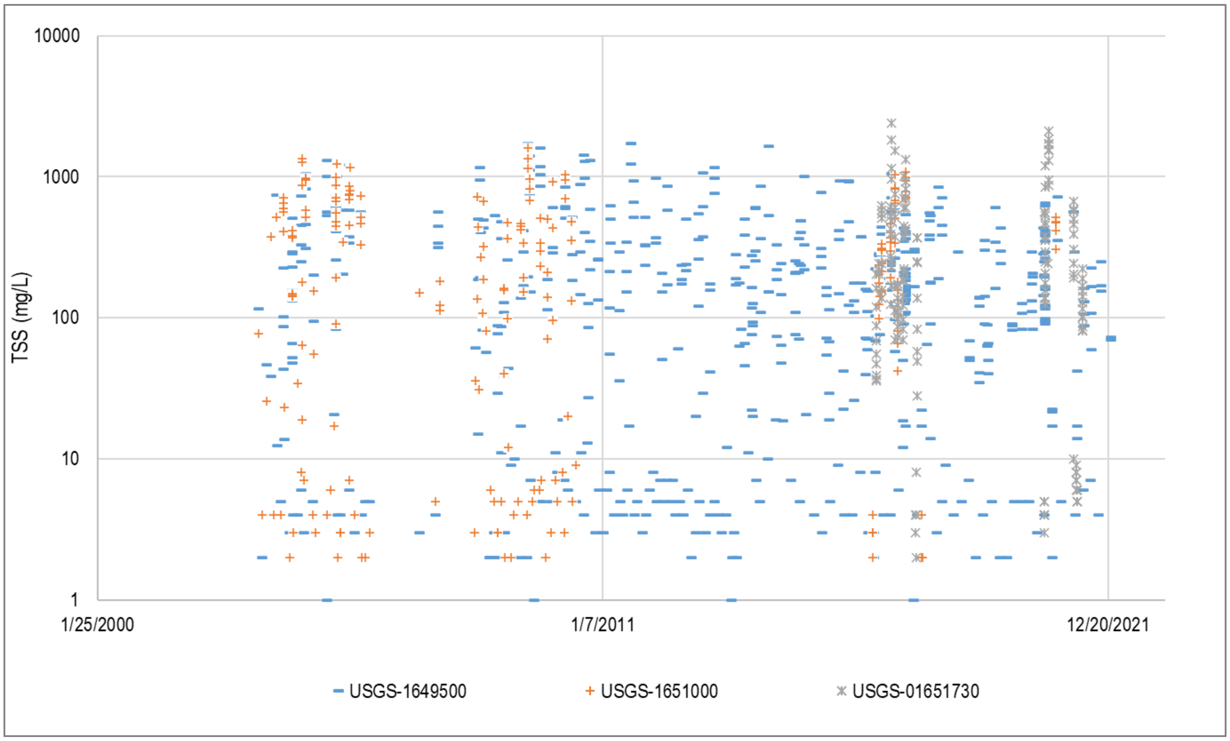
Table 3-1. Summary of TSS data in the Anacostia River watershed.

Station ID	Station Name	Owner	Start Date	End Date	Number of Records	Min. Value (mg/L)	Mean Value (mg/L)	Max. Value (mg/L)
ANA0082	Anacostia River	MDE	01/07/86	12/02/20	433	1.00	18.35	486
DOEE-ANA30	Anacostia River	DC DOEE	04/03/90	11/09/21	245	0	15.46	199
NWA0016	NWB	EPA	01/06/03	09/23/19	165	1.00	132.17	3,197
USGS01651730	Beaverdam Creek near Cheverly, MD	USGS	12/06/16	05/29/21	154	2.00	374.39	2,390
USGS1649500	NEB Anacostia River at Riverdale, MD	USGS	01/03/59	01/09/22	626	1.00	277.11	5,270
USGS1651000	NWB Anacostia River Near Hyattsville, MD	USGS	01/03/60	10/29/20	239	0	533.59	8,270

Source: NWQMC 2023.
Note:
mg/L = milligrams per liter.

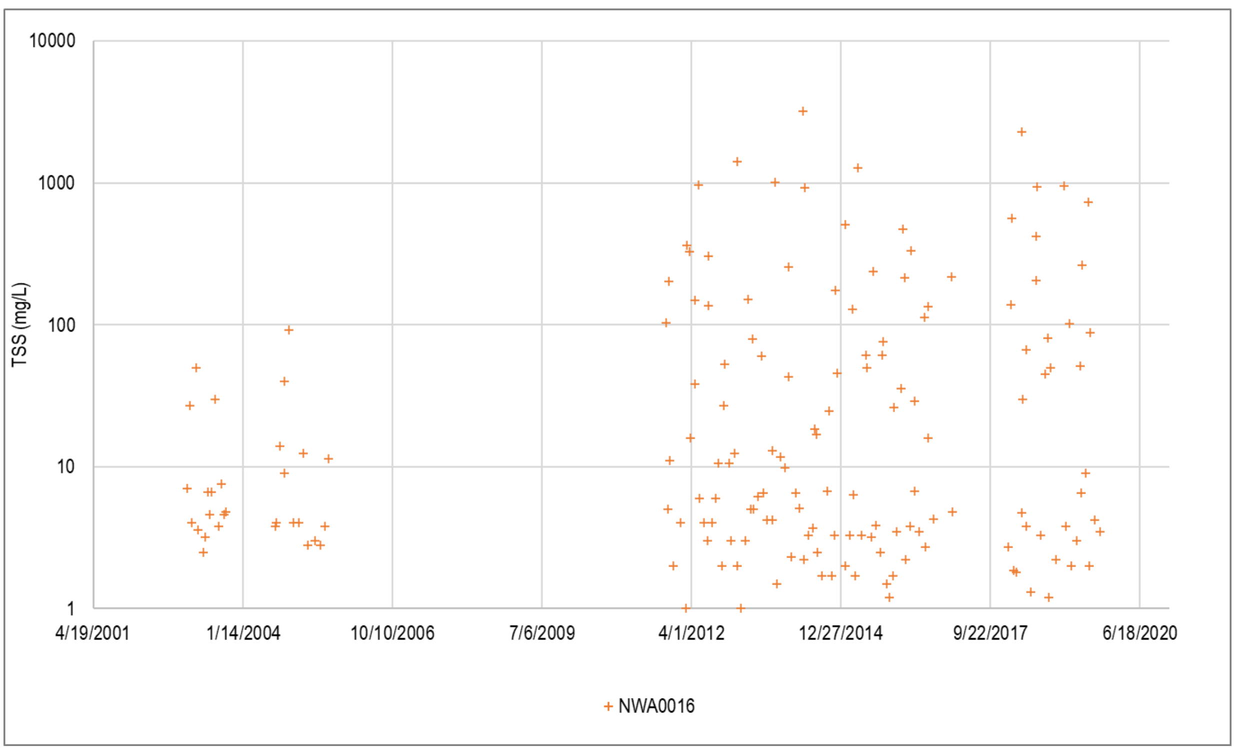


Source: NWQMC 2023.
Figure 3-2. Plot of TSS concentration over time at monitoring stations ANA0082 and ANA30.



Source: NWQMC 2023.

Figure 3-3. Plot of TSS concentration over time at USGS-1649500, USGS-1651000 and USGS-01651730 monitoring stations.



Source: NWQMC 2023.

Figure 3-4. Plot of TSS concentration over time at NWA0016 monitoring station.

3.1.2 Total Nitrogen

Time series of TN data from these monitoring stations for the periods in Table 3-2 are shown in Figure 3-5, Figure 3-6, and Figure 3-7 for the Anacostia River watershed. This section only discusses stations with recent water quality data after 2000 and at least 50 data points.

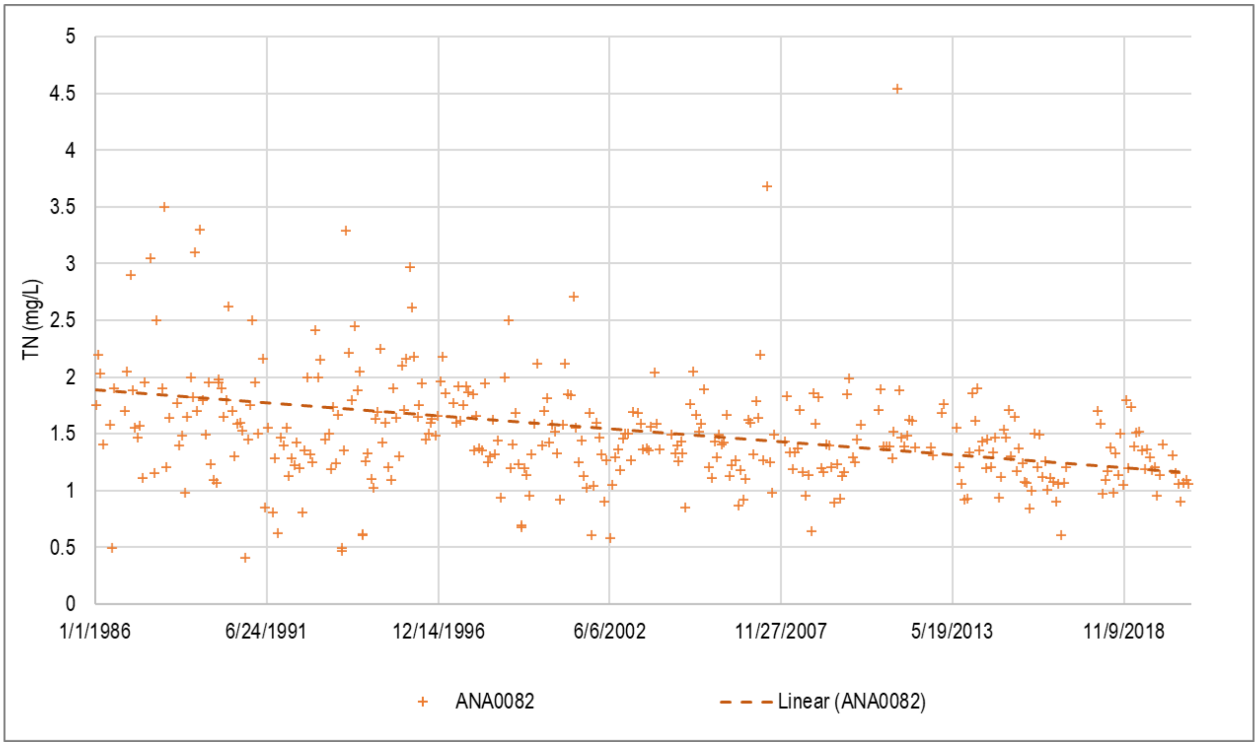
Nine monitoring stations with recent data are in the Anacostia River watershed. One of those monitoring stations has a comprehensive dataset ranging from 1986 to 2020 (ANA0082, Table 3-2 and Figure 3-5). Monitoring station USGS1649500 (NEB Anacostia River) represents the most complete datasets in the watershed, with 439 records (Table 3-2 and Figure 3-6). Both ANA0082 and USGS1649500 are in the lower portion of the watershed. TN concentrations at ANA0082 have a negligible negative slope (-6E-05), and the concentrations at USGS1649500 have a relatively steady slope. The trend line slopes are small and not significant. The R^2 value for ANA0082 is a bit larger (0.09), indicating there is no significant trend of concentration versus time.

The other monitoring stations in the Anacostia River watershed have fewer data records (less than 200) for analysis (Table 3-2). The limited sample sizes of those stations and shorter period of record contribute to uncertainty because the extreme values could influence the slopes of the trendlines for those data. Stations with more than 50 data points since 2000 are plotted in Figure 3-7.

Table 3-2. Summary of TN data in the Anacostia River watershed.

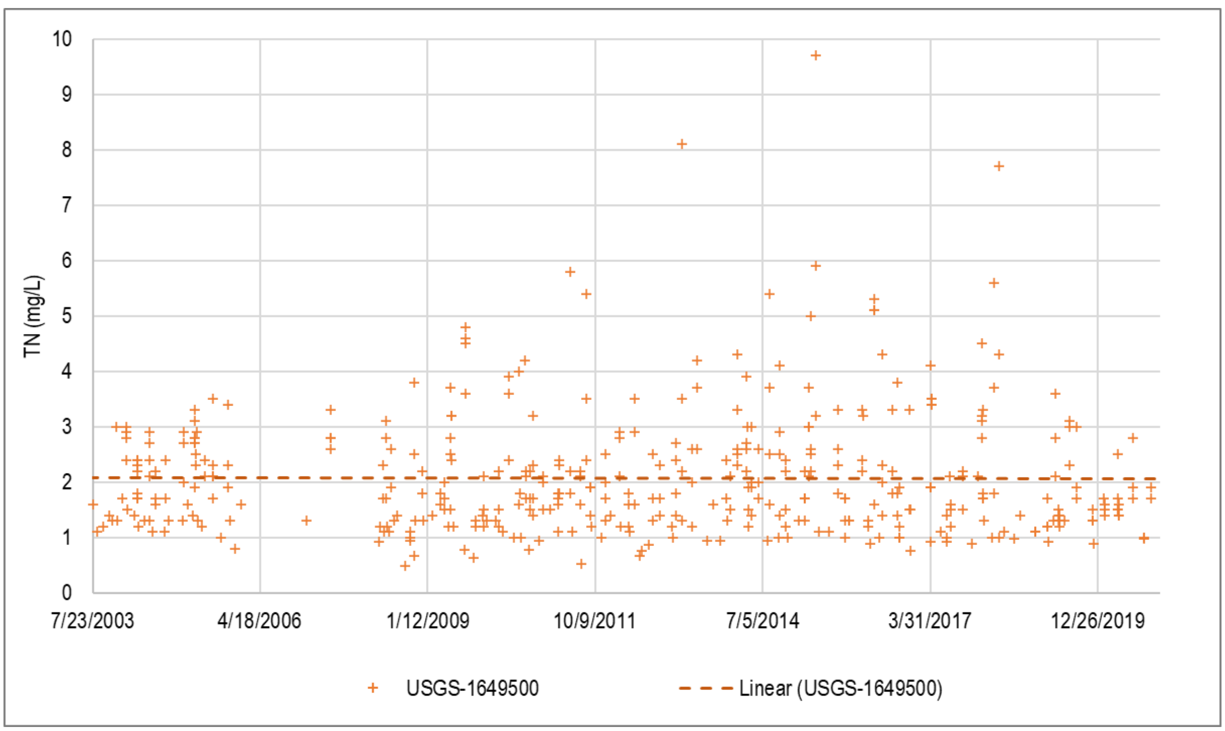
Station ID	Station Name	Owner	Start Date	End Date	Number of Records	Min. Value (mg/L)	Mean Value (mg/L)	Max. Value (mg/L)
ANA0082	Anacostia River	MDE	01/07/86	12/02/20	372	0.41	1.54	7.25
NEB0002	NWB	MDE	10/07/02	12/15/08	52	0.51	1.30	1.93
NWA0002	NWB	MDE	10/07/02	12/15/08	53	0.74	1.54	2.58
NWA0016	NWB	MDE	08/18/04	09/23/19	151	0.61	1.54	3.6
SC_MS	Main Stem	Friends of Sligo Creek	09/04/04	09/11/10	176	0.14	0.97	2.36
USGS1649500	NEB Anacostia River at Riverdale, MD	USGS	07/23/03	03/17/22	438	0.48	2.07	9.7
USGS1651000	NWB Anacostia River Near Hyattsville, MD	USGS	07/23/03	06/09/10	127	0.82	2.40	5.9

Source: NWQMC 2023.
Note:
mg/L = milligrams per liter.



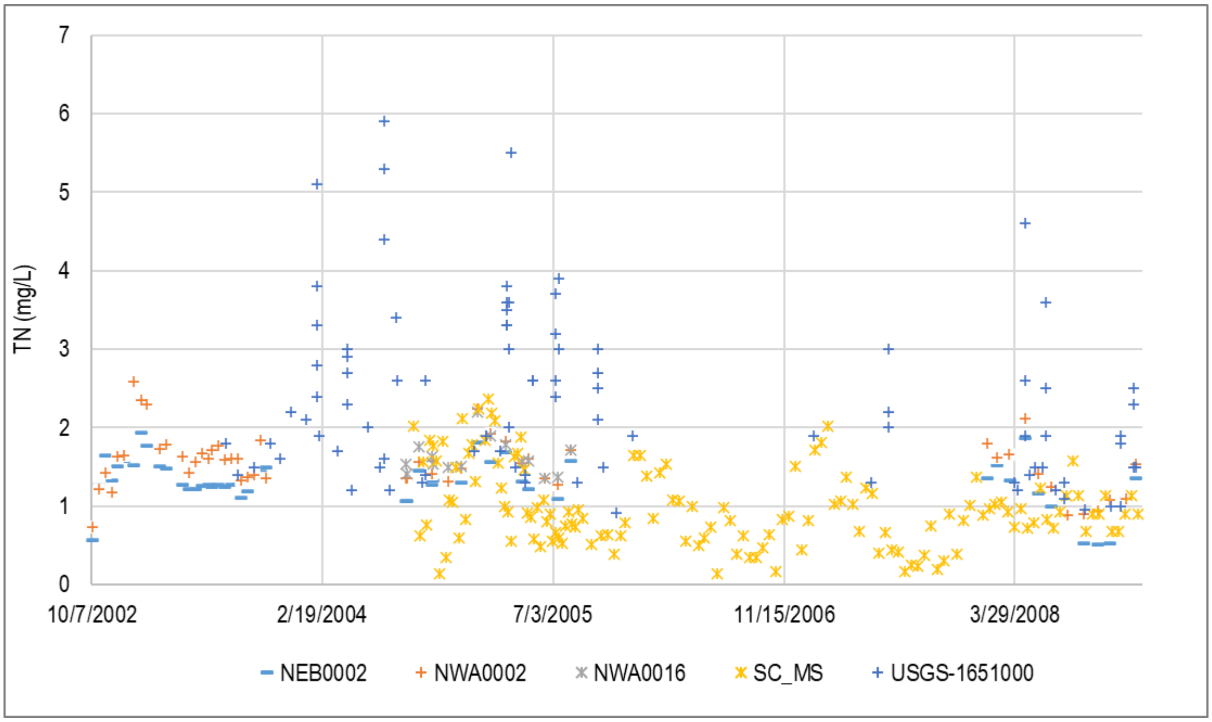
Source: NWQMC 2023.

Figure 3-5. Plot of TN concentration over time at monitoring station ANA0082.



Source: NWQMC 2023.

Figure 3-6. Plot of TN concentration over time at monitoring station USGS01649500.



Source: NWQMC 2023.

Figure 3-7. Plot of TN concentration over time at monitoring stations NEB0002, NWA0002, NWA0016, SC_MS and USGS-1651000.

3.1.3 Total Phosphorous

Time series of TP data from these monitoring stations for the periods in Table 3-3 are shown in Figure 3-8, Figure 3-9, Figure 3-10, and Figure 3-11 for the Anacostia River watershed. This section only discusses stations with recent water quality data after 2000 and at least 50 data points.

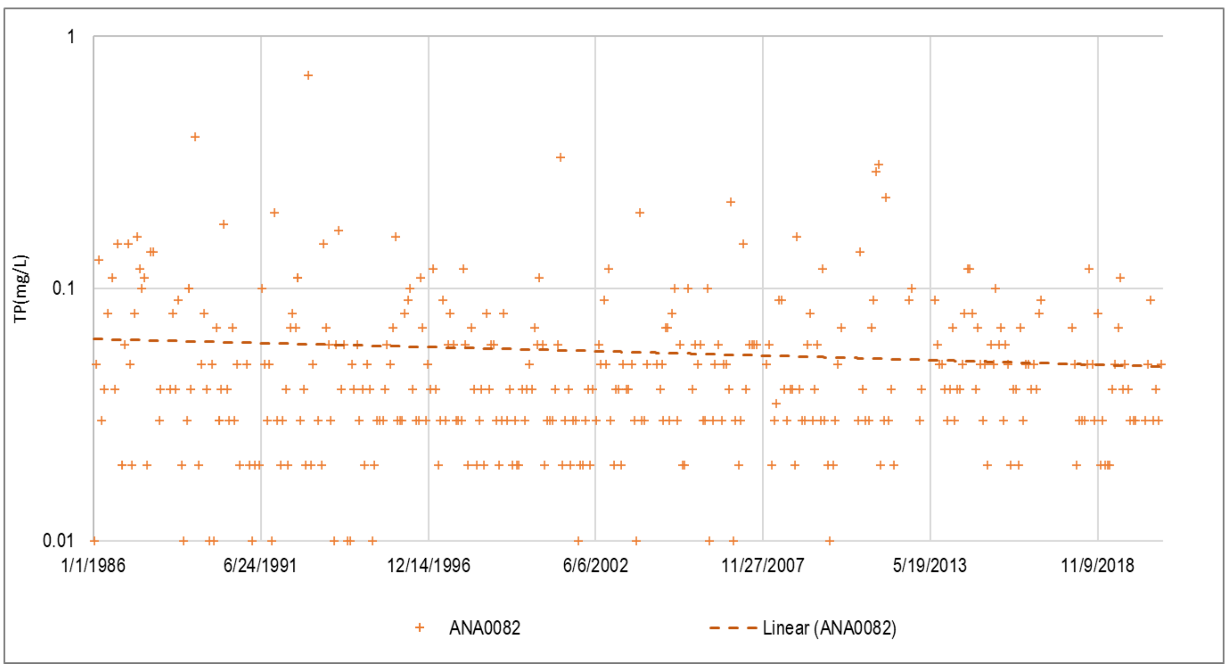
Ten monitoring stations with recent data are in the Anacostia River watershed. One of those monitoring stations has significantly comprehensive datasets ranging from 1986 to 2020 (ANA0082 with 376 records, Table 3-3 and Figure 3-8). Monitoring station USGS1649500 (NEB Anacostia River) represents one of the most complete datasets in the watershed, with 477 records from 2003 to 2022 (Table 3-3 and Figure 3-9). Both ANA0082 and USGS1649500 are in the lower portion of the watershed. TN concentrations at ANA0082 have a negligible negative slope (-1E-06) and the concentrations at USGS1649500 have a relatively steady slope. The trend line slopes are small and not significant. The coefficient of determination (R^2 value) for both are under 0.02, indicating there is no significant trend of concentration versus time.

The other monitoring stations in the Anacostia River watershed have fewer data records (less than 200) for analysis (Table 3-3). Among those stations, NCRN_NACE_STCK has higher TP concentration data (Table 3-3, Figure 3-10). The limited sample sizes of those stations and shorter period of record contribute to uncertainty because the extreme values could influence the slopes of the trendlines for those data. Stations with more than 50 data points since 2000 are plotted in Figure 3-10 and Figure 3-11.

Table 3-3. Summary of TP data in the Anacostia River watershed.

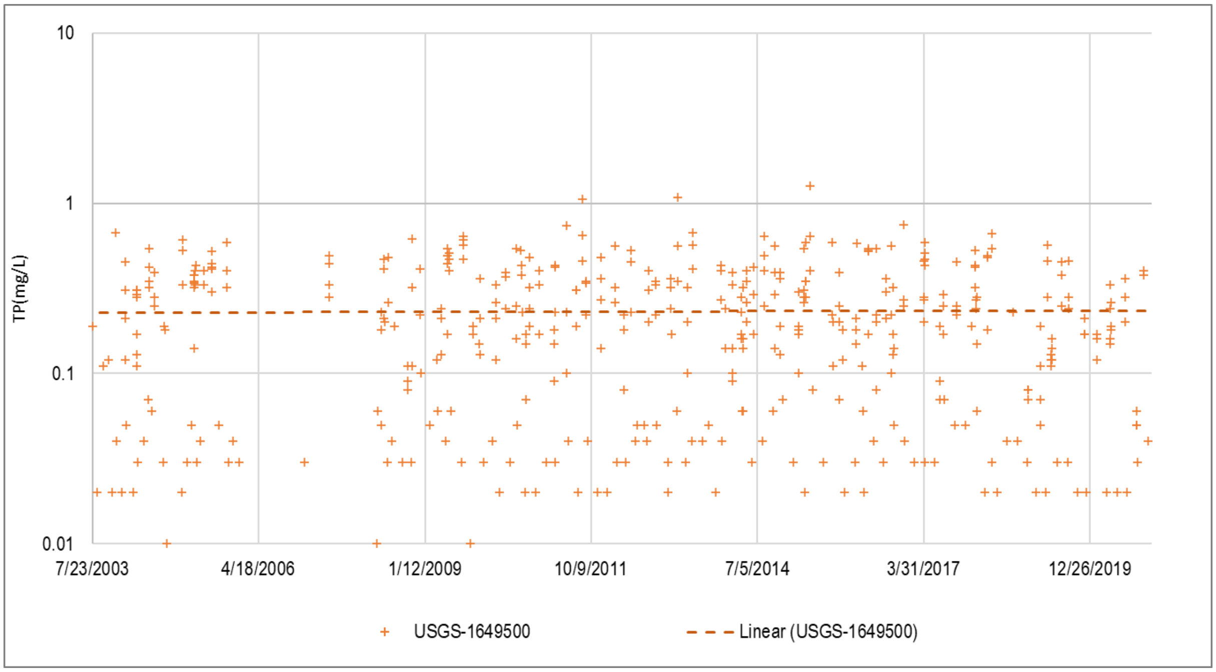
Station ID	Station Name	Owner	Start Date	End Date	Number of Records	Min. Value (mg/L)	Mean Value (mg/L)	Max. Value (mg/L)
ANA0082	Anacostia River	MDE	01/07/86	12/02/20	376	0.01	0.06	0.7
NEB0002	NWB	MDE	10/07/02	12/15/08	52	0.01	0.04	0.22
NWA0002	NWB	MDE	10/07/02	12/15/08	53	0.01	0.04	0.26
NWA0016	NWB	MDE	08/18/04	09/23/19	150	0.01	0.11	0.76
SC_MS	Main Stem	Friends of Sligo Creek	09/04/04	07/05/08	120	0	0.02	0.12
NCRN_NACE_STCK	Still Creek	NPS-WRD	03/30/06	06/26/18	69	0.0083	0.34	6.26
USGS1649500	NEB Anacostia River at Riverdale, MD	USGS	10/23/69	04/07/22	477	0.01	0.23	1.27
USGS1651000	NWB Anacostia River Near Hyattsville, MD	USGS	10/23/69	06/09/10	138	0.003	0.29	0.93

Source: NWQMC 2023.
Note:
mg/L = milligrams per liter.



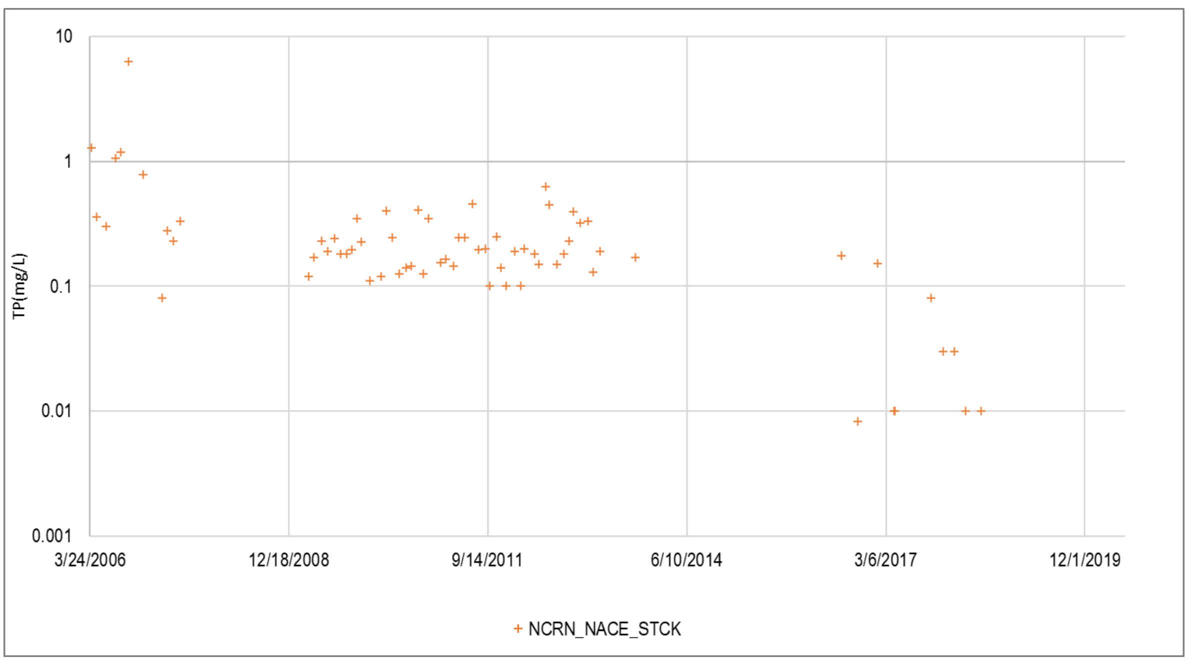
Source: NWQMC 2023.

Figure 3-8. Plot of TP concentration over time at monitoring station ANA0082.



Source: NWQMC 2023.

Figure 3-9. Plot of TP concentration over time at monitoring station USGS-1649500.



Source: NWQMC 2023.

Figure 3-10. Plot of TP concentration over time at monitoring station NCRN_NACE_STCK.

Source: NWQMC 2023.

Figure 3-11. Plot of TP concentration over time at monitoring stations NEB0002, NWA0002, NWA0016, SC_MS and USGS-1651000.

3.2 Biological Assessment

Analyses of biological monitoring program data provide insights into the status and trends of ecological conditions in a stream and watershed. Watershed planners can use the biological monitoring data to identify problems; document relationships among stressor sources, stressors, and response indicators; and evaluate environmental management activities, including restoration. Especially with a TMDL for sediment specific to first- through fourth-order streams, biological monitoring data is central to targeting potential restoration to the areas of the watershed with the greatest need because biological responses are closely related to upland land use changes. Lack of or insufficient stormwater management controls will cause stream scour, incision, sediments, and other geomorphic changes affecting the benthic macroinvertebrate communities. The County's biological monitoring collects annual stream samples of those communities and a report is submitted to MDE. Past bioassessment data can be compared to future bioassessment data to determine trends.

3.2.1 Assessment Methodology

DoE began implementing its countywide, watershed-scale biological monitoring and assessment program in 1996. To date, the department has collected 292 stream samples in the Anacostia River watershed, including 165 in the NEB, 29 in the NWB and 98 in the Downstream Anacostia, through four rounds of data gathering. The primary measure of stream health is the BIBI (Southerland et al. 2007). Because different stream conditions support different types of "benthic"—or bottom-dwelling—organisms, analyzing the benthic organisms collected along a stream reach can provide a good indication of the health of that reach.

Field sampling and data analysis protocols employed by the County for the program are comparable to those used in the Maryland Department of Natural Resources' (MD DNR's)

MBSS. Streams assessed are wadeable and generally first- through third-order according to the Strahler Stream Order system (Strahler 1957). Stream order designation is based on the National Hydrography Dataset map scale of 1:100,000. The numbers of streams sampled in each watershed are proportional to the size of the watershed and are allocated among first- to third-order streams, with a larger number of sites on smaller first-order streams. Samples and data collected at each location include benthic macroinvertebrates, visual-based physical habitat quality, substrate particle size distribution, and field chemistry (DO, conductivity, pH, and water temperature).

For the County's biological monitoring assessment, a 100-meter reach was sampled at each selected site. At a laboratory, technicians identified these biological samples each to a target taxonomic level, usually genus. The numbers of the different kinds of organisms found were used to calculate the BIBI numeric value or score. Based on that score, the biological integrity was rated as Good, Fair, Poor, or Very Poor. Stream reaches rated as Poor or Very Poor are considered degraded. All biological data is supplied to MDE and MD DNR annually for tracking progress and inclusion on MDE's Integrated report.

3.2.2 Biological Assessment Results

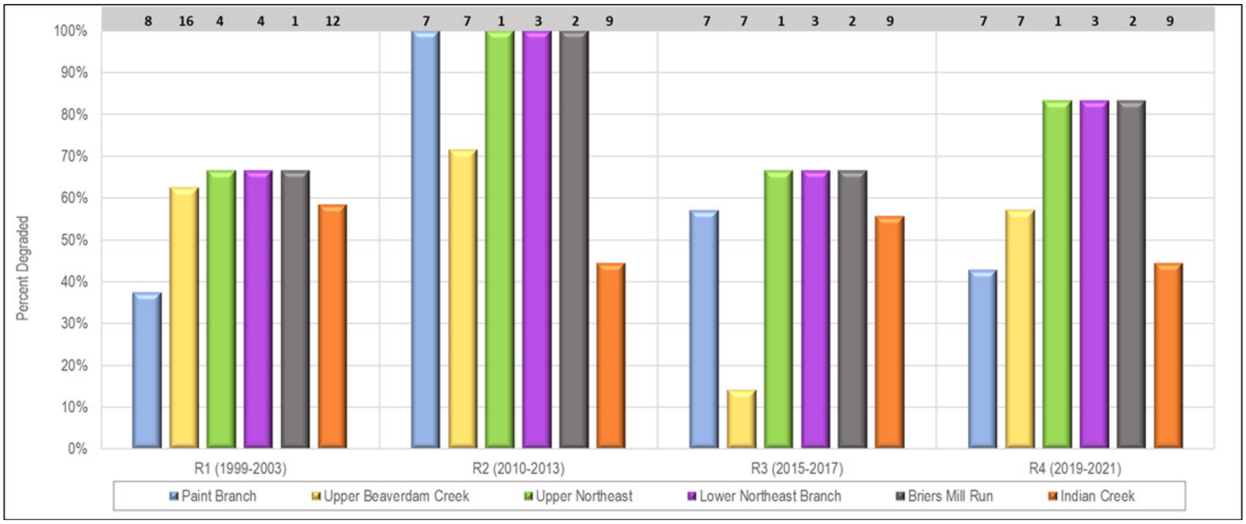
This section evaluates the results in three ways: (1) plot of percent of degradation by assessment round and major basin, (2) plot of number of sites per basin and round per narrative rating, and (3) a map of monitoring locations and their narrative ratings.

The percent of sites identified as degraded were plotted by sampling round for the NEB, NWB, and the areas downstream of their confluence. The specific stream reaches (sites) sampled in a basin are different each year. They are randomly selected to be more representative of stream and basinwide conditions. This is why there are differences from one round to the next, reflecting expected environmental variability. The biological data reveal that the NEB watershed had moderate level of degradation during assessment round 1 and round 3, while having a high level of degradation during assessment round 2 and round 4 (Figure 3-12). Levels of degradation in the NWB watershed through the four assessment rounds range largely throughout the sampling rounds, with round 2 as the most degraded (Figure 3-13). The downstream watershed had extremely high level of degradation during rounds 1, 3, and 4 for Upper Anacostia and Lower Anacostia River, while the level of degradation showed a decrease for Lower Beaverdam Creek from rounds 1 to 3 (Figure 3-14).

Figure 3-15 shows the biological assessment narrative ratings by major subbasin for rounds 1 to 4. A significant number of sites in the NEB watershed were rated as Fair, Poor or Very Poor, with only a few being rated as Good in round 1. Later sampling rounds revealed a decreased frequency of sites that are degraded. The data in both NWB and Downstream Anacostia were more frequently degraded, with most sites being rated as Poor and none being rated as Good. The results in Downstream Anacostia could be reflective of the higher amounts of impervious cover in the watershed, especially throughout the headwaters of the stream network that exhibit greater amounts of urban land use.

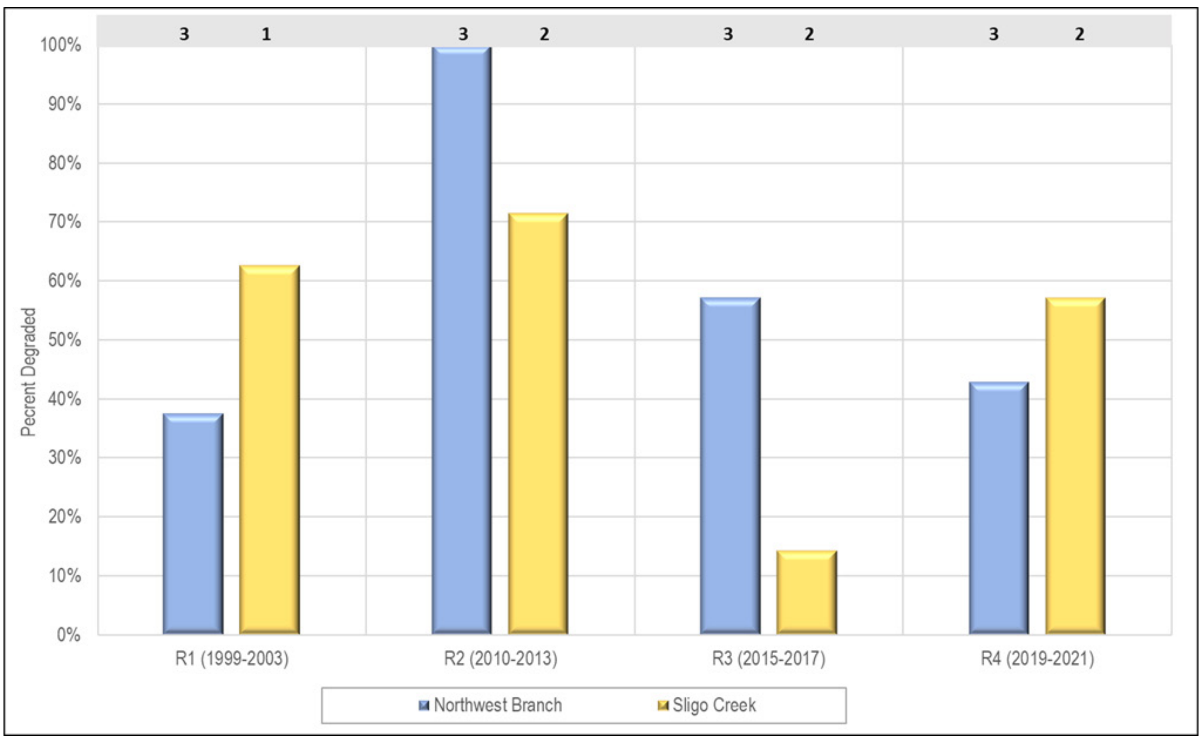
The geographic distribution of the narrative results of the biological assessments can be seen in Figure 3-16, where the NEB (northeastern portion of the watershed) has more areas rated as

Good to Very Good while Downstream (southern portion of the watershed) has more areas rated as Poor.



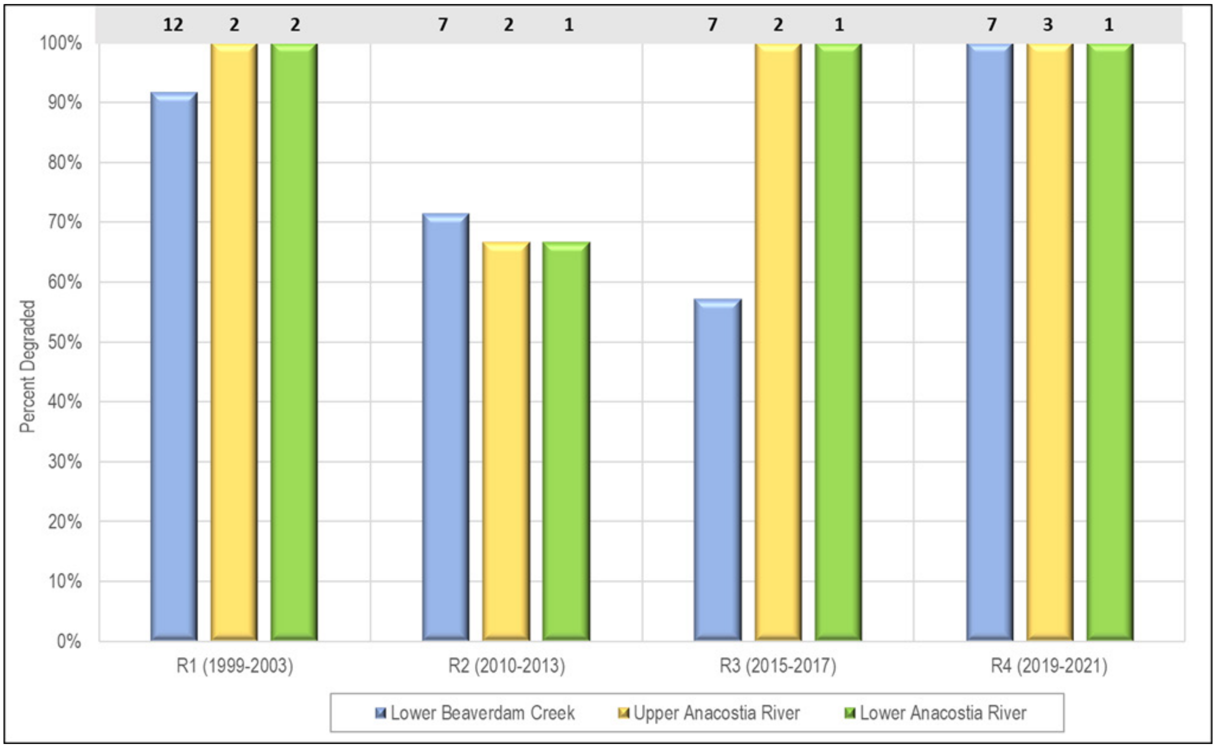
Note: The gray bar across the top shows the number of site locations sampled in each basin for the assessment round.

Figure 3-12. NEB percent degraded by assessment round.



Note: The gray bar across the top shows the number of site locations sampled in each basin for the assessment round.

Figure 3-13. NWB percent degraded by assessment round.



Note: The gray bar across the top shows the number of site locations sampled in each basin for the assessment round.

Figure 3-14. Downstream percent degraded by assessment round.

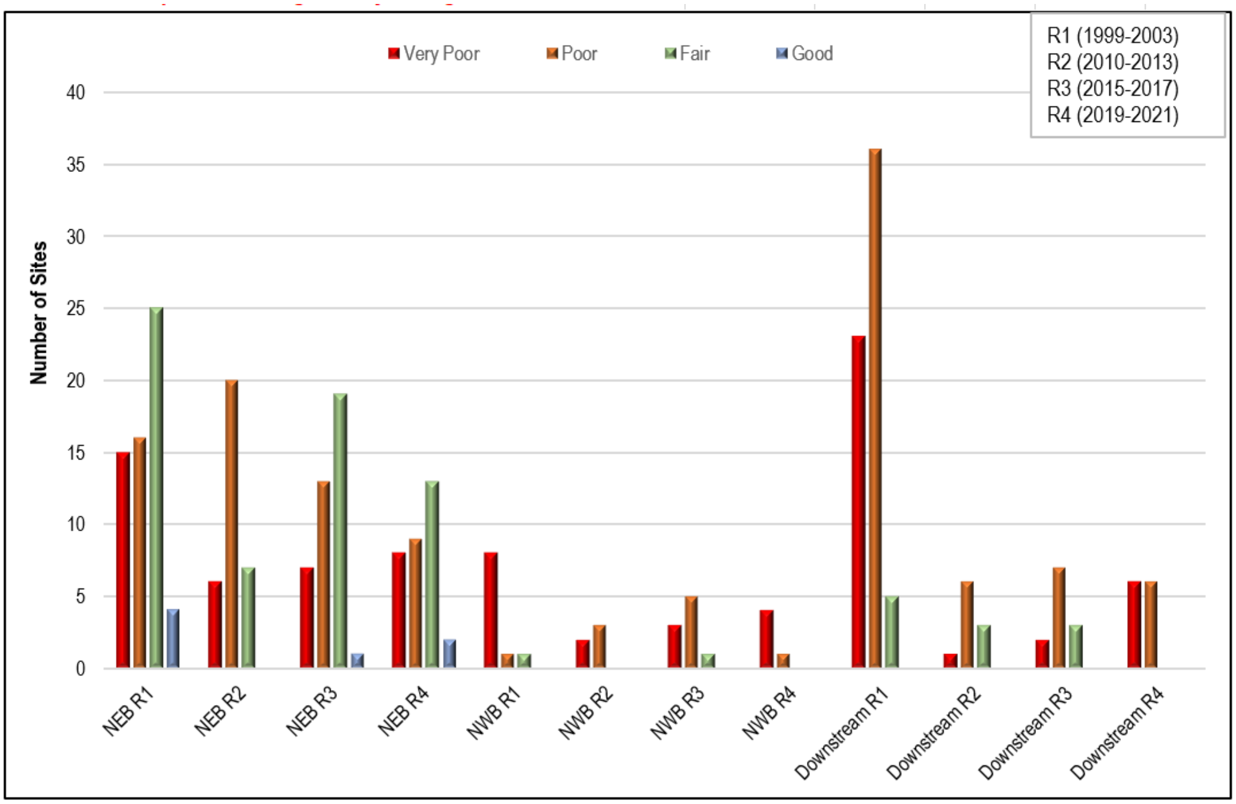


Figure 3-15. NEB, NWB, and Downstream IBI narrative results by assessment round.

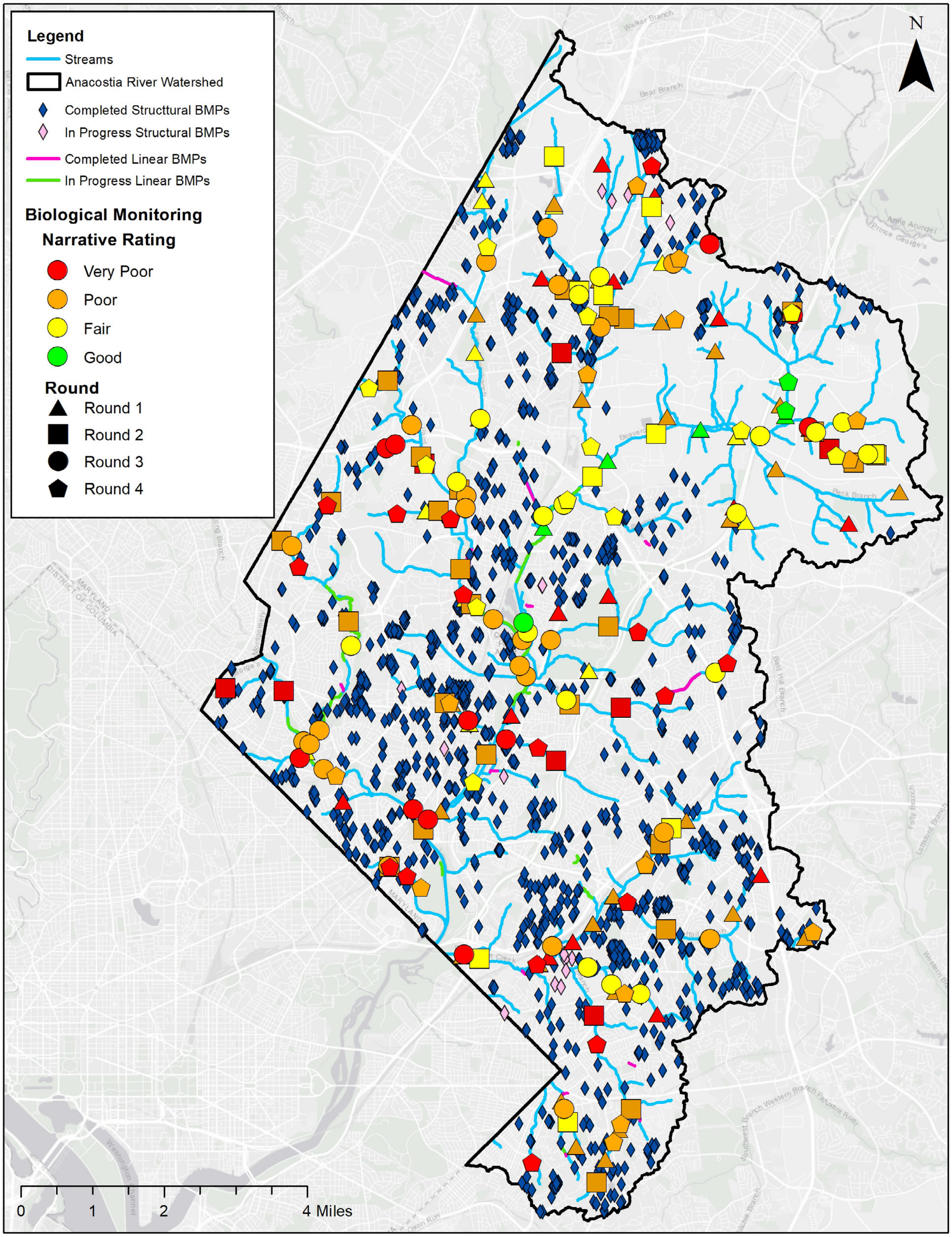


Figure 3-16. Biological assessment narrative ratings by monitoring location.

3.3 Geomorphic Cross Section Assessment

During round 1 and part of round 2 of the countywide biological assessments, DoE assessed fluvial geomorphic conditions (primarily Rosgen Level II classification) to document and characterize channel stability. Rosgen Level II is a quantitative morphological assessment of the stream reach, which provides greater detail from data collected in the field for the implementation into land management/design decisions as part of the analysis for alternatives of proposed repairs. Rosgen Level II will help determine if the stream channel is stable and describes channel aggradation/degradation. These are directly related to the MBSS physical habitat determination as required by DNR. Restoration opportunities can be derived from the collected field data, including assessments of the channel cross-section, longitudinal profile, and plan-form pattern. Often, restoration engineers use geomorphic assessment entrenchment ratios as indicators for excess discharges from upland sources, requiring further evaluation of effective stormwater management controls. If a stream segment needs repair or stabilization due to damage or infringement (soil loss), the geomorphic assessments contain cross-section measurements, entrenchment ratio, width:depth ratio, dominant substrate, slope, stream bed features, sinuosity, and meander, which will aid in restoration design.

Physical habitat is widely understood to be the principal environmental factor controlling stream biological condition, as well as a reflection of the complex interplay among surface water flows, topography/gradient, soils, vegetation, and surrounding land cover characteristics. Thus, when a stream is exposed to altered patterns of flow and the resulting accelerated erosion, the relative stability of stream channel morphology is compromised and is (A) directly related to the quality of the habitat supporting the survival and reproduction of aquatic life, such as benthic macroinvertebrates and fish, and (B) an indicator of sources of unmanaged storm flow that cause the instability, thus supplying information for siting and potentially designing control measures. The County reassessed 80 cross-section sites with historic monumented cross section data randomly selected throughout the County for the 2020 re-surveying effort (Tetra Tech 2022). The historic cross-section locations were co-located with stations monitored over the first several years of countywide biological monitoring. The original, and subsequent, biological stations are chosen at random sampling sites with GRTS (Generalized Random Tessellation Stratified), adopting a sampling approach stratifying by at least the Maryland 8-digit watershed and adopting a 1:24,000 scale map, enhancing the temporal and spatial resolution of the data and its usefulness in data analysis. Of the 78 re-assessed sites, there were 39 sites assessed in this manner in the Anacostia River watershed (Figure 3-17).

3.3.1 Assessment Methodology

Permanent monuments were established as the point of reference for taking channel cross-sectional (XS) measurements, which also allowed several other components of channel form to be measured and documented. Following a time interval ranging from approximately 12–20 years, 78 reaches were visited to re-survey; comparisons of results allowed calculation of changes in XS area (square meters) and the amounts of sediment lost (erosion) or gained (sedimentation). In addition to XS, we also collected modified Wolman 100-particle pebble counts and other data needed for the Rosgen level II classification of each reach. Data were downloaded, organized, and processed to characterize changes in land use and land cover contributing to conditions potentially affecting rates and magnitudes of erosion. The County calculated changes in XS area over the 15- to 21-year intervals and used a conversion factor developed by a mid-Atlantic expert panel for the two nontidal physiographic provinces in which the County lies: the Coastal Plain Lowland Non-Tidal and the Coastal Plain Dissected Uplands Non-Tidal. The conversion factor was used to calculate annual sediment yield (tons) from changes in XS area due to erosion and deposition. Additional analyses of the results will include site-specific bulk density values, which will provide a more accurate estimate of sediment yield. Sites were ranked to isolate those with the greatest geomorphic activity, specifically each of the 10 undergoing the most erosion (sediment loss) and deposition (sediment gain).

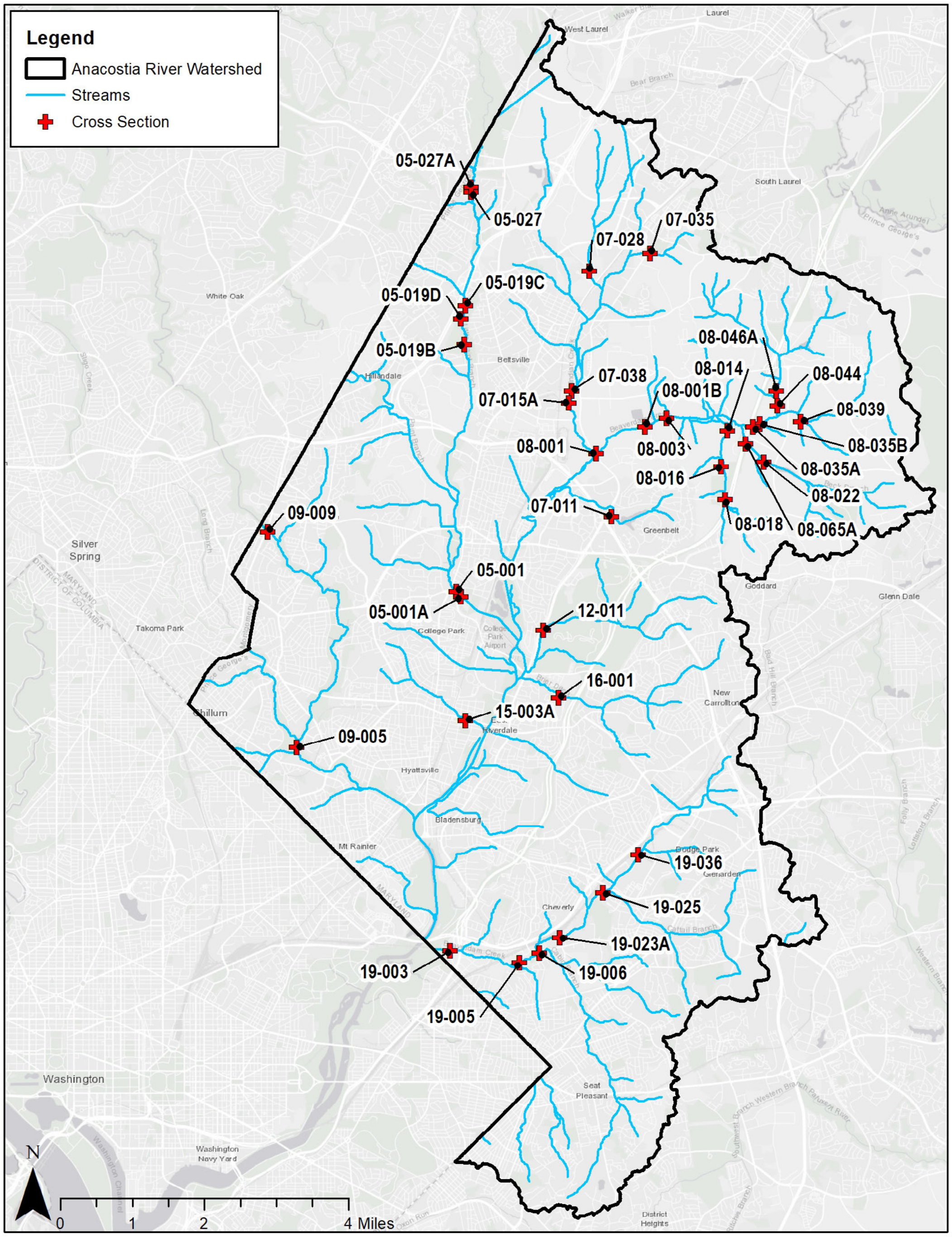


Figure 3-17. Cross-section measurement locations in Anacostia River watershed.

3.3.2 Geomorphic Assessment Results

Appendix F-1F presents geomorphic assessment results for several locations from the 2001 and 2020 assessment years. The data presented is from the field geomorphic field observations and measurements, and the subsequent geomorphic calculations. Sediment yield is calculated using changes in full stream channel cross-sectional area (XSa) and by converting the volume (freight tons) of sediment lost (degradation) or gained (aggradation) into annual changes. Detailed assessment results are shown in Appendix F. This suggests there is erosion upstream, and the resulting sediment is being deposited in the study reaches.

Comparison of fluvial geomorphic conditions using the Rosgen classification system organizes several pieces of data and information to help interpret relative stream channel stability, including entrenchment, width:depth ratio, sinuosity, slope, and substrate characteristics. We compared stream classification from the original field geomorphic characterization to those taken in 2020. Elevated channel instability is generally associated with F- and G-type channels, and relative geomorphic stability is generally associated with E-, C-, and B-type channels. Results from current and historical data showed that three reaches were classified as having experienced little to no change in relative stability, with the final station going from an unstable channel to a stable channel.

Due to the number of cross sections, changes in cross sections at the 39 stations are presented in Appendix F. While only a few cross sections were relatively stable, most cross sections significantly changed through channel migration and incision.

3.4 Known Stream Erosion Issues

The MD DNR conducted stream corridor assessments (SCAs) of all County watersheds in the 2000s. These assessments included field site visits and stream walks to determine the conditions of the streams. Each site was given an identification number and photographed. Stream bank erosion and head cutting were investigated during the analysis. Stream reaches were rated on the severity of erosion, correctability, and access to the stream. This WIP assumes that if a stream had erosion issues in the 2000s, it is likely to have them still today if no corrective actions have been taken.

Only a few SCAs showed severe or very severe in-stream erosion concerns (Figure 3-18). The greatest concentration of stream reaches identified as being of at least moderate concern was in the southern half of the Anacostia River watershed, These SCAs identified 52,593 linear feet of stream—rated as severe or very severe—for potential restoration. These will be part of the restoration strategy presented in Section 7 of this WIP.

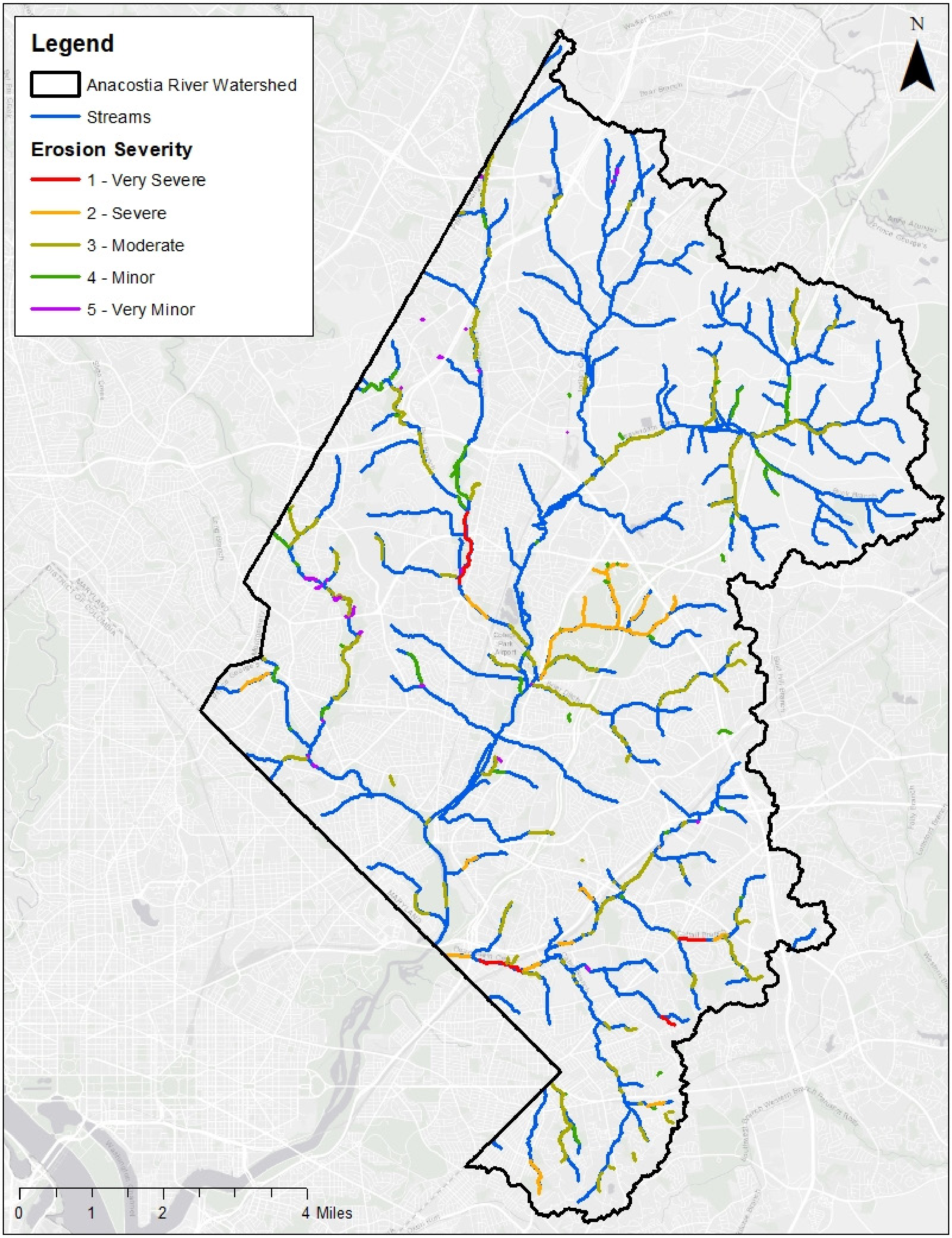


Figure 3-18. Locations of SCA-identified erosion (with severity) in the Anacostia River watershed.

3.5 Other Potential Pollutant Sources

Identifying the sources of pollutants of concern is valuable in developing appropriate strategies to reduce the amount of those pollutants entering the environment. This section provides an assessment of the potential point and nonpoint pollutant sources in the watershed. Point sources discharge effluent through distinct points that are regulated through permits from the NPDES program. Nonpoint sources are not covered by this permitting program. They are diffuse sources that typically cannot be identified as entering a water body through a discrete conveyance at one location. Nonpoint sources can originate from land activities that contribute pollutants to surface water from rainfall runoff. Types of nonpoint source pollution include wildlife, atmospheric deposition, onsite wastewater disposal systems (septic tanks), and agricultural practices.

3.5.1 NPDES-Permitted Point Sources

Under 40 CFR 122.2, a point source is described as a discernible, confined, and discrete conveyance from which pollutants may be discharged to surface waters. The NPDES program, established under CWA Sections 318, 402, and 405, requires permits for the discharge of pollutants from point sources, including urban stormwater systems known as MS4s. The County is an MS4-permitted discharger.

Stormwater discharges are generated by runoff during precipitation events from urban land and impervious areas, such as paved streets, parking lots, and rooftops. These discharges often contain high concentrations of pollutants that can eventually enter nearby water bodies.

Under the NPDES stormwater program, operators of large, medium, and regulated small MS4s must obtain authorization from MDE to discharge pollutants. The Stormwater Phase I Rule requires all medium and large MS4s operators to obtain NPDES permits and develop stormwater management programs (55 Federal Register [FR] 47990, November 16, 1990). Medium and large MS4s are defined by the size of the population in the MS4 service area, not including the population served by combined sewer systems. A medium MS4 serves a population of between 100,000 and 249,999. A large MS4 serves a population of 250,000 or more. The Stormwater Phase II Rule applies to operators of regulated small MS4s serving a population of less than 100,000 not already covered by Phase I; however, the Phase II Rule is more flexible and allows greater variability of regulated entities than does the Phase I Rule (64 FR 68722, December 8, 1999).

Regulated small MS4s include those lying within the boundaries of urbanized areas, as defined by the U.S. Census Bureau, and those designated by the NPDES permitting authority. The NPDES permitting authority can designate a small MS4 as requiring regulation under any of the following circumstances: the MS4's discharges do or can negatively affect water quality, the population served exceeds 10,000, the population density is at least 1,000 people per square mile, or the contribution of pollutant loadings to a physically interconnected MS4 is evident. The Phase II MS4 in the Anacostia River watershed is mostly present in the western half of the watershed.

Table 3-4 lists the federal, state, and other entities in the Anacostia River watershed that possess an MS4 permit. These entities should have their own stormwater or sediment load goals and are not included in Prince George's County restoration calculations. Figure 3-19 shows the locations of other regulatory MS4s in the watershed. The map shows where there are federal and state lands from which the County is not responsible for stormwater. Other MS4 entities cover 27 percent of the watershed.

Table 3-4. MS4 permitted federal, state, and other entities in the Anacostia River watershed.

Agency	Installation/Facility	Acres [a]
Maryland Army National Guard	Multiple properties	7.85
Maryland Department of Transportation Motor Vehicle Administration	Multiple properties	N/A [b]
Maryland State Highway Administration	Multiple (outside Phase I jurisdictions)	2.22
Maryland Transit Administration	Multiple properties	N/A [b]
Maryland Transportation Authority	Multiple properties	N/A [b]
National Aeronautics and Space Administration	Goddard Space Flight Center	N/A [b]
U.S. Department of Agriculture	Beltsville Agricultural Research Center	N/A [b]
U.S. Department of the Army	Adelphi Laboratory Center	N/A [b]
U.S. Department of the Army, Reserves	Multiple properties	N/A [b]
U.S. Department of Agriculture APHIS-PPQ	National Plant Germplasm and Biotechnology Laboratory	N/A [b]
University of Maryland	College Park campus	1,011.9
Washington Metropolitan Area Transit Authority	Multiple Metrorail stations	491.38
Washington Suburban Sanitary Commission	Multiple properties	143.22
United States of America	Multiple properties (research institutions, Croom Manor Federal Housing, military installations,	12,945.88
United States Postal Service	Multiple properties	18.65

Notes:

[a] Acres were determined using the County's property parcel boundaries.

[b] Property information for this permittee was not found.

Information on other permitted facilities was available from MDE's website and EPA's Integrated Compliance Information System. There are 195 privately owned permitted facilities in the watershed. Of these, more than half of which are listed as discharging stormwater. Other facilities are permitted for discharging from construction sites, mining facilities, dewatering activities, refuse sites, and swimming pools. The County is not responsible for these facilities meeting their WLAs.

Wastewater facilities might include publicly owned treatment works providing wastewater treatment and disinfection for sanitary sewer systems or industrial facilities providing treatment of process waters. In the Anacostia River watershed, two federal facilities (USDA Eastside Wastewater Treatment Plant and USDA Westside Wastewater Treatment Plant) are permitted to discharge treated sanitary wastewater into the watershed. The Washington Suburban Sanitary Commission (WSSC) recently addressed problems that cause sanitary sewer overflows and leaks through their Sewer Repair, Replacement and Rehabilitation Program.

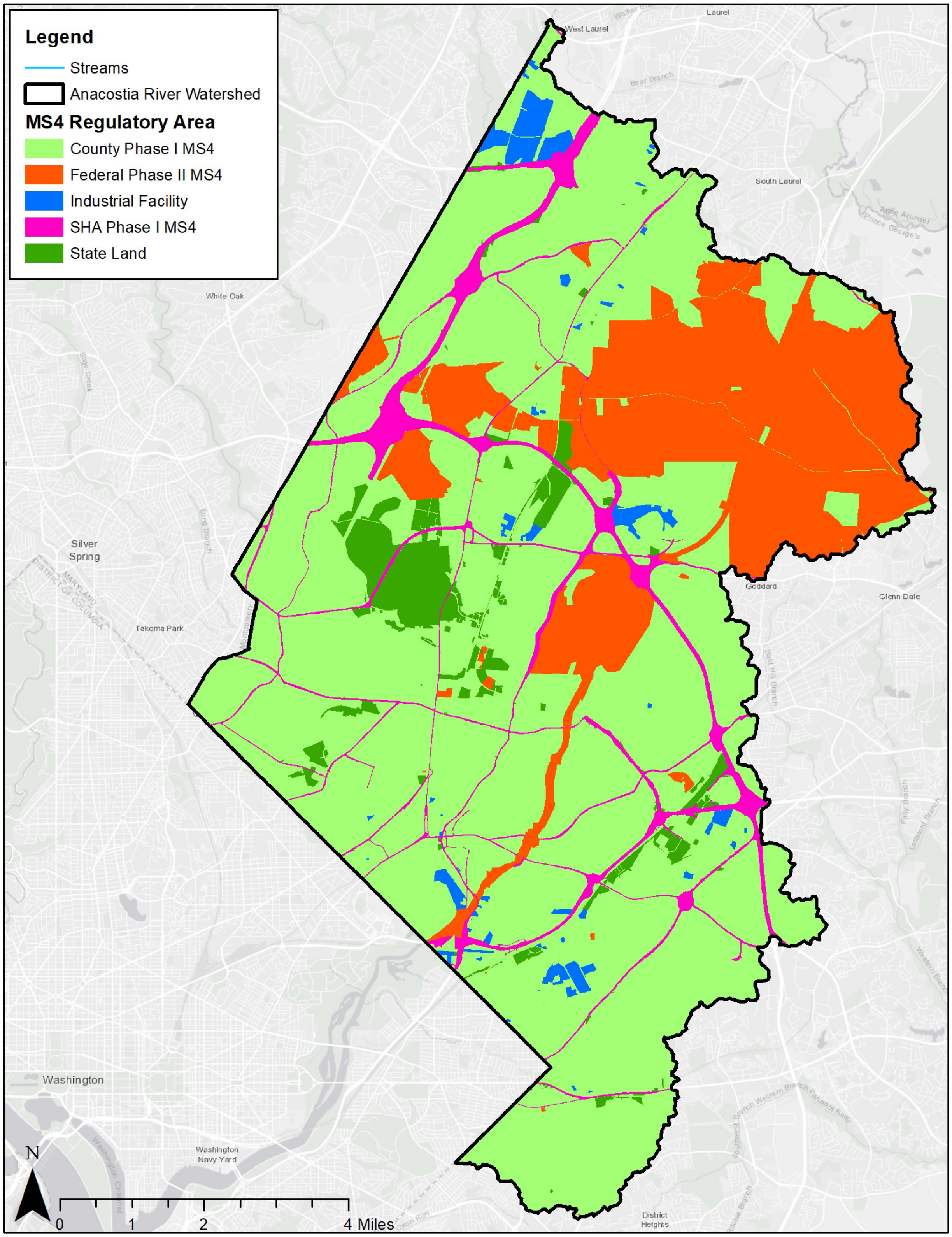


Figure 3-19. MS4-regulated areas in the Anacostia River watershed.

3.5.2 Nonpoint and Other Sources

Potential nonpoint sources vary greatly, including agriculture-related activities, atmospheric deposition, on-site treatment systems, and wildlife.

Nonpoint sources of pollution from agricultural activities include the runoff of fertilizers and exposed soils from crop fields, and waste from animal operations. The Maryland Department of Agriculture regulates agricultural activities, which are outside of the jurisdiction of DoE. Consequently, the Anacostia River watershed WIP does not include restoration activities for agricultural practices.

Streams and rivers can be vulnerable to wildlife impacts. Wild animals with direct access to streams, such as deer, raccoons, other small mammals, and avian species, can potentially increase erosion. For example, deer populations can clear low vegetation, including regenerative forest growth, which poses potential vulnerabilities to sediment load reduction efforts. Deer and other animals also create paths to the stream's edge, exposing base sediment and potentially causing stream bank erosion at the site of their access to the stream.

4 Current Stormwater Management Activities

When precipitation falls in the County, the resulting runoff flows off roofs, lawns, driveways, and roads into a network of stormwater sewers that discharge directly to area streams. The stormwater flow picks up pollutants such as sediments and transports them into the waterways of the County. High volumes of water flowing to the stream channel during storm events cause erosion of the land and the channel itself. Many areas of the County were developed before stormwater regulations and practices were adopted in the 1970s and early 1980s. Many of these older developments did not have adequate stormwater controls for water quality at the time of their construction; since then, the County has accelerated a restoration program to address stormwater and water quality restoration.

The State adopted a statewide stormwater law and new regulations in 1983, and the County enacted a SWM ordinance in 1985. Since 2000, following new state regulations, developers of new and redevelopment projects in the County are required to provide water quality treatment for this urban runoff using a wide range of stormwater practices. During the initial years of stormwater regulation, those practices were somewhat crude and straightforward, but they have been continuously improved. Today, *environmental site design* (ESD)—the approach to SWM required by MDE—is based on the use of landscape-based practices, such as rain gardens and bioswales, and is considered an ecologically sustainable approach to SWM. The County is currently installing those types of BMPs. This section describes current SWM programs and the BMPs installed in the County.

The County has implemented a wide range of programmatic SWM initiatives over the years to address existing water quality concerns. They are grouped into three categories: stormwater-specific programs, tree planting and landscape revitalization programs, and public education programs. This section describes each grouping (and its respective individual initiatives), including the contributions the programs make to water quality protection and improvement.

4.1 Stormwater Programs

Many of the County's stormwater-related programmatic initiatives target more than one issue area. For example, in addition to promoting the adoption of on-the-ground BMPs, the Alternative Compliance Program promotes stormwater education via environmentally focused sermons at places of worship. Appendix A provides full descriptions of the programs that directly or indirectly support water quality improvement and are administered by various departments within the County government or its partners. These programs include:

- Stormwater-specific programs
    - Stormwater Management Program
    - Clean Water Partnership (CWP)
    - Alternative Compliance Program
    - Rain Check Rebate and Grant Program
    - Stormwater Stewardship Grant Program
    - Countywide Green/Complete Streets Program

  - Erosion and sediment control
  - Street sweeping
  - Storm drain maintenance: inlet, storm drain, and channel cleaning
  - Storm drain stenciling
  - Illicit Connection and Enforcement Program
- Tree planting and landscape revitalization programs
  - Volunteer Tree Planting
  - Tree ReLeaf Grant Program
  - Neighborhood Design Center
  - Arbor Day Every Day
  - Tree planting demonstrations
- Public education programs
  - Interactive displays and speakers for community meetings
  - Stormwater Audit Program
  - Master Gardeners
  - Flood Awareness Month

4.2 Existing Stormwater BMPs

The County has been installing BMPs since 1985, with the inception of the first SWM ordinance. BMPs were applied to control peak discharges and infiltration where possible. In 2000, the County's new SWM ordinance instituted the requirement for improving water quality from runoff. This later requirement introduced the new ESD concept, by combining BMP strategies to treat runoff at the source.

Since the Chesapeake Bay TMDL was developed in 2010, the County has implemented SWM BMPs to control and reduce the pollutant load. This section describes the type and distribution of BMPs the County has installed in the watershed and evaluates the load reductions from the BMPs.

BMPs are measures used to control and reduce sources of pollution. They can be structural or nonstructural and are used to address both urban and agricultural sources of pollution. Structural practices include the placement of retention ponds, porous pavement, tree planting, stream restoration, and bioretention systems. Nonstructural BMPs include institutional, educational, or pollution prevention activities that, when implemented, work to reduce pollutant loadings. Examples of nonstructural BMPs include implementing strategic disconnection of impervious areas in a municipality, street sweeping, homeowner and landowner education campaigns, and nutrient management. Different BMP types remove pollutants at varying levels of efficiency. Ponds tend to have lower efficiencies but can treat large areas, while bioretention systems and infiltration practices tend to have higher efficiencies but can treat only smaller areas.

The two main reasons for installing BMPs are: (1) new development and (2) watershed restoration. Developer BMPs are installed as new development is constructed to negate the effects of excess runoff and pollution. As part of their construction permit, developers are required to install these BMPs. These do not get credited toward the TMDL load reduction targets. Even with developer BMPs installed, a waterbody might not meet water quality criteria due to development prior to stormwater regulations. In these circumstances, additional water quality treatment is needed. BMPs for watershed restoration are installed to improve the water quality of streams and, if installed after the date of the TMDL, can be credited towards meeting the TMDL.

The Anacostia River watershed has limited BMP coverage. The County actively updates a BMP geodatabase with new information as it becomes available. The BMPs were installed to support restoration activities or as offsets for new development. Table 4-1 lists the number of each type of restoration BMPs per watershed and categorizes them as a part of the baseline period (prior to 2015), progress, and planned BMPs. Table 4-2 shows similar information for developer BMPs. In Table 4-2, the baseline BMPs are considered part of the baseline calculations (prior to 2015), and the other column lists developer BMPs after the baseline period. These developer BMPs do not count towards TMDL restoration progress. Figure 4-1 shows the locations of the developer and restoration BMPs as of August 2022. While bioretention systems, infiltration trenches, and dry wells make up the majority of BMPs, wet ponds treat more watershed area.

Table 4-1. Restoration BMPs in the Anacostia River watershed as of August 2022.

BMP Type	Baseline		Progress		Planned		Total	
	#	Acres Treated[a]	#	Acres Treated[a]	#	Acres Treated[a]	#	Acres Treated[a]
Bioretention	7	2.87	23	11.42	0	0.00	30	14.29
Bio-Swale	1	0.32	2	0.93	0	0.00	3	1.25
Disconnection of Non-Rooftop Runoff	0	0.00	32	0.22	0	0.00	32	0.22
Dry Swale	1	1.30	6	0.43	2	0.53	9	2.26
Extended Detention - Wetland	1	11.73	0	0.00	0	0.00	1	11.73
Extended Detention Structure, Wet	4	60.50	5	131.80	0	0.00	9	192.30
Impervious Surface Elimination (to pervious)	0	0.00	78	5.24	0	0.00	78	5.24
Infiltration Basin	1	1.78	0	0.00	0	0.00	1	1.78
Infiltration Trench	2	4.60	0	0.00	0	0.00	2	4.60
Landscape Infiltration	0	0.00	1	0.03	0	0.00	1	0.03
Micro-Bioretention	0	0.00	92	28.81	0	0.00	92	28.81
Oil Grit Separator	0	0.00	1	0.92	0	0.00	1	0.92
Outfall Stabilization	0	0.00	4	437.26	1	50.00	5	487.26
Permeable Pavements	0	0.00	43	1.14	0	0.00	43	1.14
Planting Trees or Forestation on Previous Urban	0	0.00	0	0.00	1	0.50	1	0.50
Pocket Wetland	2	32.69	0	0.00	0	0.00	2	32.69
Rain Gardens	0	0.00	5	0.08	0	0.00	5	0.08
Rainwater Harvesting	0	0.00	153	2.16	0	0.00	153	2.16
Retention Pond (Wet Pond)	3	86.26	19	875.63	2	313.58	24	1,275.47
Sand Filter	1	0.90	16	16.14	0	0.00	17	17.04
Shallow Marsh	1	3.43	0	0.00	0	0.00	1	3.43

BMP Type	Baseline		Progress		Planned		Total	
	#	Acres Treated[a]	#	Acres Treated[a]	#	Acres Treated[a]	#	Acres Treated[a]
Step Pool Storm Conveyance	0	0.00	4	14.11	0	0.00	4	14.11
Stream Restoration	2	2,288.03	17	13,889.71	3	2,356.00	22	18,533.74
Street Trees	0	0.00	13,750	137.50	0	0.00	13,750	137.50
Submerged Gravel Wetlands	0	0.00	8	3.91	1	0.02	9	3.93
Underground Filter	0	0.00	4	3.39	0	0.00	4	3.39
Urban Tree Canopy	0	0	63	0.63	0	0.00	63	0.63
Total	**26**	**2,494.41**	**14,326**	**15,561.46**	**10**	**2,720.63**	**14,362**	**20,776.50**

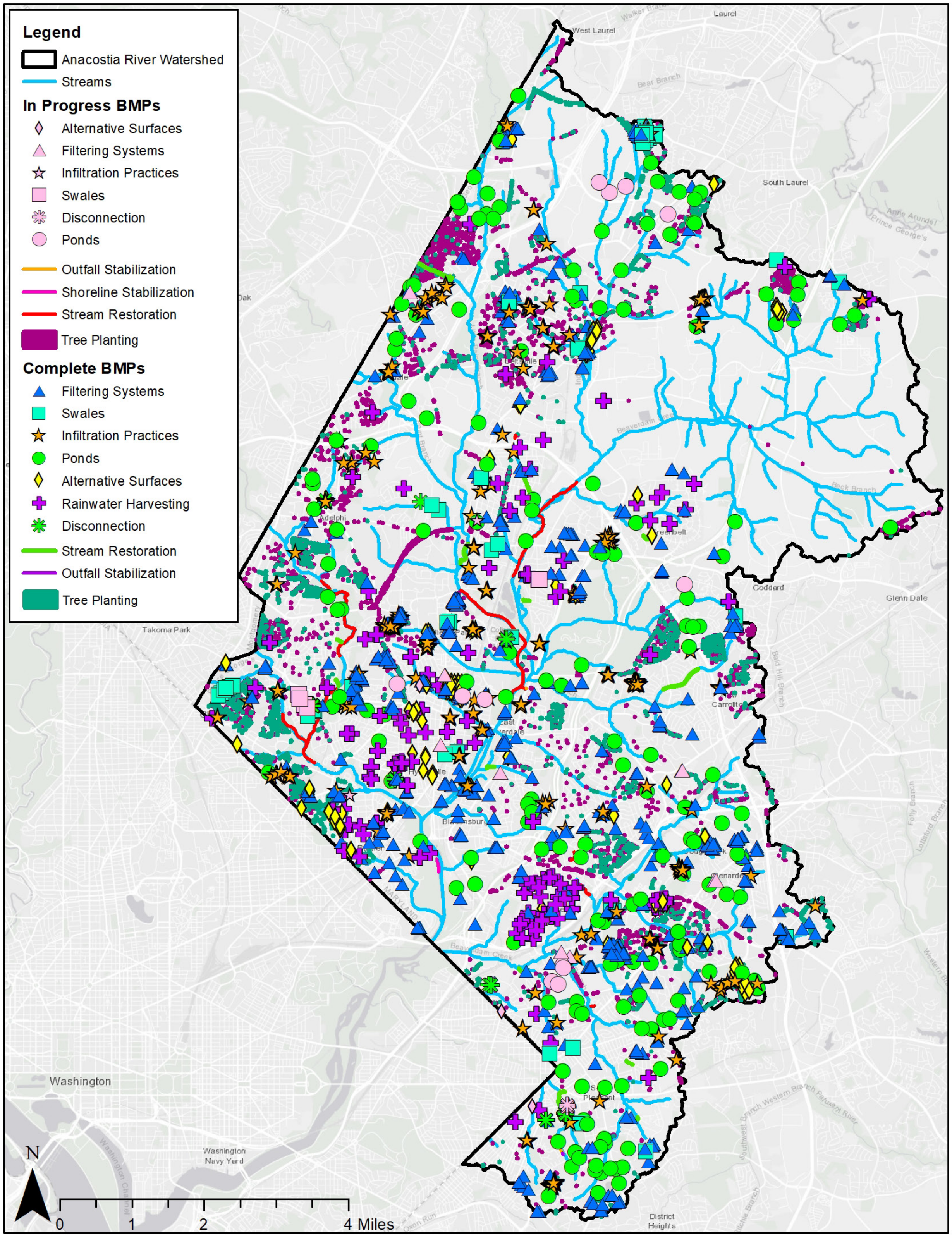
Source: DoE 2023.
Note:
[a] Stream restoration, shoreline stabilization, and outfall stabilization totals are provided in linear feet.

Table 4-2. Developer BMPs in the Anacostia River watershed as of August 2022.

BMP Type	Developer Baseline		Developer	
	#	Acres Treated	#	Acres Treated
Bioretention	81	67.11	59	14.42
Bio-Swale	0	0.00	20	0.80
Detention Structure (Dry Pond)	13	46.39	0	0.00
Disconnection of Non-Rooftop Runoff	1	0.03	5	0.00
Disconnection of Rooftop Runoff	4	0.16	2	0.02
Dry Swale	0	0.00	6	1.88
Dry Well	108	1.93	141	0.62
Enhanced Filters	0	0.00	1	1.07
Extended Detention - Wetland	1	14.32	0	0.00
Extended Detention Structure, Dry	18	121.33	0	0.00
Extended Detention Structure, Wet	25	187.85	7	28.07
Flood Management Area	18	62.27	7	7.10
Grass Swale	5	3.17	15	0.52
Green Roof - Extensive	0	0.00	3	0.01
Green Roof - Intensive	1	0.23	2	0.00
Infiltration Basin	2	6.44	1	1.78
Infiltration Berms	0	0.00	2	0.24
Infiltration Trench	70	87.70	16	9.67
Micro-Bioretention	2	0.66	386	35.18
Oil Grit Separator	45	40.29	13	8.73
Permeable Pavements	13	28.38	95	3.28
Rain Gardens	0	0.00	15	0.26
Rainwater Harvesting	0	0.00	3	0.00
Reinforced Turf	0	0.00	2	0.24
Retention Pond (Wet Pond)	53	258.98	7	41.70
Sand Filter	1	0.40	17	12.62

	Developer Baseline		Developer	
BMP Type	**#**	**Acres Treated**	**#**	**Acres Treated**
Shallow Marsh	1	70.88	0	0.00
Sheetflow to Conservation Areas	0	0.00	1	0.00
Submerged Gravel Wetlands	0	0.00	10	5.29
Underground Filter	18	34.48	9	6.24
Total	**480**	**1,033.00**	**845**	**179.74**

Source: DoE 2023.



Source: DoE 2023.

Figure 4-1. Developer and restoration BMPs in the Anacostia River watershed.

5 Load Reduction Targets and Current Progress

This section discusses the calculation of load reduction targets for the watershed, reductions that have resulted from current BMPs, and reductions remaining to be met through this WIP. The calculations rely on TMDL information, land cover information, and existing BMP information. This WIP will look at local nutrient and sediment TMDL reductions for the Anacostia River watershed.

5.1 Load Reduction Terminology

The amount of sediment load still required to be reduced after accounting for load reductions from current practices is called the *load reduction gap*. Figure 5-1 illustrates that concept.

The following load reduction terms are used in text, tables, and plots in the Executive Summary and throughout the remainder of this document:

- **No-action load:** This load is the pollutant load directly from the land surface without the influence of any BMPs.
- **Baseline load:** This load is the pollutant load from the land surface at the time the TMDL was developed. It includes reductions from restoration BMPs installed prior to the TMDL and developer BMPs installed prior to the date of the land use.
- **Target load:** This is the load that is met once load reductions specified in the Chesapeake Bay TMDL are met. This is determined using the baseline load and required percent reduction from the TMDL Data Center (MDE 2019b).
- **Required load reduction:** This is the load that will need to be reduced through restoration BMPs. This load is the difference between the baseline load and the target load.
- **Permit load:** The load at the beginning of the 2014 MS4 permit term (December 2014).
- **Progress load:** The County has already installed BMPs in the watersheds. This is the current load accounting for these BMPs and is the difference between baseline loads and the loads treated by restoration BMPs after the date of the TMDL.
- **Milestone load:** The load is based on all BMPs planned to be installed by the end of fiscal year (FY) 2025 (Milestone 1) and FY 2027 (Milestone 2).
- **Planned load:** The load reduction is based on BMPs identified during the development of this WIP.
- **Load reduction to date:** This is the load reduced by currently installed BMPs or the difference between the baseline and current loads.
- **% of target:** This is the percent of the required load reduction removed by installed BMPs.
- **Progress load reduction gap:** This is the required load reduction remaining (i.e., gap) once the load reduction to date is subtracted from the required load reduction.
- **Load removed from BMPs in planning/design:** This value is the load reduction from the implementation of BMPs for watershed restoration not yet constructed but already being planned and designed.

- **Final load gap:** This is the required load reduction that remains (i.e., gap) once the load reductions from current BMPs and restoration BMPs in design and planning are subtracted. This is the load reduction this plan addresses.

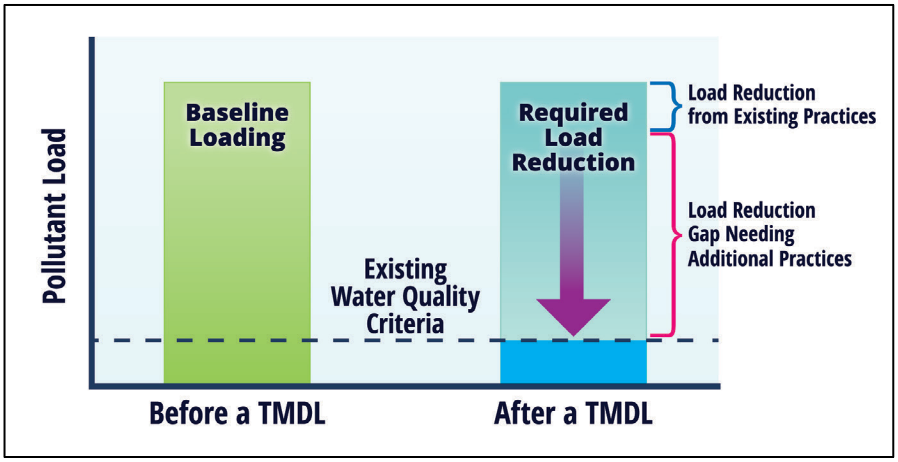


Figure 5-1. Schematic for typical pollution diet (TMDL) showing existing load reduction credits.

5.2 Load Calculation Methodology

Prior to the development of this WIP, the County had consulted and collaborated with MDE on the load calculation approach and methodology. The County used the load calculation methodology from MDE's *TMDL Implementation Progress and Planning (TIPP) Tool* (MDE 2022c). "MDE requires the use of TIPP to ensure consistency among load reduction calculation methods" for "meeting Phase I MS4 permit implementation planning and reporting requirements" for applicable TMDLs (MDE 2022b). The loads calculated in this WIP incorporate recent land use data, land use loading rates, and restoration data for the portions of the Anacostia River watershed in the County's MS4 area. The loadings will not match the loads in the local Anacostia River watershed TMDL because of the different data used in the TMDL.

The County uses a Microsoft Access database in its load calculation process that uses the data and methodology of MDE's April 2022 TIPP Tool (MDE 2022d). Still, the County's process breaks down the loadings into smaller subwatersheds for planning purposes. For example, the County's tool follows the MDE spreadsheet tool in only including impervious areas and turf in its baseline load calculations. Like the MDE tool, the County's load calculations did not include loads generated from agriculture, wetlands, forested areas, or mixed open land areas, which are considered outside the County's MS4 area. Similarly, loads from state and federal lands were not used in this WIP. In developing its loads, the County used the land cover-specific loading rates for TSS provided by MDE in its TIPP Tool (MDE 2022c), which is in Microsoft Excel (Table 5-1). The MDE rates were derived from the latest Chesapeake Bay model data, which include loading contributions from stream bed and bank erosion. After developing the Access tool, the County compared the results from the Mattawoman Creek, Piscataway Creek, and Anacostia River watersheds. The largest percent difference for any watershed/analyte pair is 0.12 percent difference. Differences are attributed to slight rounding differences and that the TIPP Tool uses the BMP rating curves for rainfall treated values greater than 2.6, as opposed to using the numeric tables. Based on these results, the County is confident that the Access Tool can replicate the TIPP Tool results.

Table 5-1. TIPP land cover/use loading rates for Anacostia River watershed.

TIPP Land Cover/Use	MS4 Land	TN (lb/ac/yr)	TP (lb/ac/yr)	TSS (lb/ac/yr)
Aggregate impervious	Yes	12.73	1.36	5,499
Barren	No	8.19	1.58	3,552
Forest	No	1.16	0.09	222
Impervious Roads	Yes	15.92	1.88	7,070
Impervious Surfaces	Yes	11.39	1.14	4,465
Mixed Open/Agriculture	No	4.61	0.95	1,466
Shrubland	No	1.16	0.09	222
Structures	Yes	11.39	1.14	4,465
Tree Canopy over Aggregate Impervious	Yes	11.65	1.21	5,114
Tree Canopy over Impervious Roads	Yes	14.57	1.67	6,575
Tree Canopy over Impervious Surfaces	Yes	10.42	1.02	4,153
Tree Canopy over Structures	Yes	10.42	1.02	4,153
Tree Canopy over Turf	Yes	5.76	0.97	1,381
Turf	Yes	7.56	1.27	1,466
Wetlands	No	2.31	0.32	747

Source: MDE 2022c.

5.3 BMP Pollutant Load Reduction Calculation

The primary purpose of implementing BMPs is to remove stormwater pollutants (e.g., sediment) near their source and prevent pollutant loads from entering and degrading water bodies. Different types of BMPs remove pollutants with differing degrees of effectiveness or pollutant removal efficiency. Estimating pollutant reductions achieved through implementing BMPs is a two-step process: (1) determine the varying removal efficiencies of the BMPs being considered and (2) calculate the load reduction.

The information available for most BMPs included drainage area (i.e., total land area flowing to a specific BMP [e.g., a bioretention system]). Load reductions for the existing BMPs were calculated using the documented pollutant removal rates (Appendix B) in conjunction with BMP drainage area land cover and the land-cover-specific pollutant loading rate. MDE's *Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated* (MDE 2021a) incorporates recent Chesapeake Bay Program recommendations for sediment load reduction removal efficiencies associated with BMP implementation. This information is incorporated into their TIPP Tool (MDE 2022d). By using those removal efficiencies in its reduction calculations, the County is consistent with regional efforts to meet the Chesapeake Bay TMDL. See Appendix B for additional information on BMP effectiveness. That calculation provided the loading attributed to the BMP drainage area, which was then multiplied by the BMP pollutant removal efficiency to determine the amount of load reduction attributed to a specific BMP.

The County implemented restoration BMPs prior to the TMDL. The load reductions from these BMPs are reflected in the baseline loadings. Besides restoration BMPs, developers also install BMPs to offset the increased pollutant loads from new developments. Because those BMPs are installed to offset new loadings and not to remove existing loadings, they are not counted towards watershed restoration. Partial credits can be counted towards restoration from redevelopment BMPs if the BMPs meet specific requirements.

All BMPs (restoration, retrofit, and developer) installed up to and including 2014 (date of land use) were used to calculate the baseline loads along with restoration BMPs installed up to 2019 (date of TMDL). Load reductions from completed restoration BMPs since 2019 are considered as progress load reductions.

Table 5-2, Table 5-3, and Table 5-4 list load reductions of TN, TP, and TSS by BMP type for the baseline period and for those counted towards TMDL progress. They also include load reductions from specific BMPs that are already in the planning, design, or construction phase. These tables include restoration BMPs that were implemented under one of the programs discussed in Appendix A.

Table 5-2. Baseline, progress, and planned TN load reductions by BMP types.

BMP Type	Baseline TN Reduction (lbs/yr)	Progress TN Reduction (lbs/yr)	Planned TN Reduction (lbs/yr)	Total TN Reduction (lbs/yr)
Bioretention	21	108	0	129
Bio-Swale	5	14	0	19
Disconnection of Non-Rooftop Runoff	0	0	0	0
Dry Swale	20	5	5	30
Extended Detention - Wetland	66	0	0	66
Extended Detention Structure, Wet	347	813	0	1160
Impervious Surface Elimination (to pervious)	0	20	0	20
Infiltration Basin	6	0	0	6
Infiltration Trench	15	0	0	15
Landscape Infiltration	0	0	0	0
Micro-Bioretention	0	334	0	334
Oil Grit Separator	0	3	0	3
Outfall Stabilization	0	33	4	37
Permeable Pavements	0	16	0	16
Planting Trees or Forestation on Previous Urban	0	0	3	3
Pocket Wetland	209	0	0	209
Rain Gardens	0	2	0	2
Rainwater Harvesting	0	10	0	10
Retention Pond (Wet Pond)	449	6,256	1,876	8,581
Sand Filter	6	100	0	106
Shallow Marsh	11	0	0	11
Step Pool Storm Conveyance	0	0	0	0
Stream Restoration	172	5,266	160	5,598
Street Trees	0	149	0	149
Submerged Gravel Wetlands	0	43	2	45

BMP Type	Baseline TN Reduction (lbs/yr)	Progress TN Reduction (lbs/yr)	Planned TN Reduction (lbs/yr)	Total TN Reduction (lbs/yr)
Underground Filter	0	24	0	24
Urban Tree Canopy	0	1	0	1
Total	**1,327**	**13,198**	**2,050**	**16,574**

Source: DoE 2023.
Note: lbs/yr = pounds per year.

Table 5-3. Baseline, progress, and planned TP load reductions by BMP types.

BMP Type	Baseline TP Reduction (lbs/yr)	Progress TP Reduction (lbs/yr)	Planned TP Reduction (lbs/yr)	Total TP Reduction (lbs/yr)
Bioretention	3	15	0	18
Bio-Swale	1	2	0	3
Disconnection of Non-Rooftop Runoff	0	0	0	0
Dry Swale	3	1	1	5
Extended Detention - Wetland	14	0	0	14
Extended Detention Structure, Wet	72	158	0	230
Impervious Surface Elimination (to pervious)	0	0	0	0
Infiltration Basin	1	0	0	1
Infiltration Trench	3	0	0	3
Landscape Infiltration	0	0	0	0
Micro-Bioretention	0	50	0	50
Oil Grit Separator	0	1	0	1
Outfall Stabilization	0	30	3	33
Permeable Pavements	0	2	0	2
Planting Trees or Forestation on Previous Urban	0	0	1	1
Pocket Wetland	45	0	0	45
Rain Gardens	0	0	0	0
Rainwater Harvesting	0	1	0	1
Retention Pond (Wet Pond)	91	1248	351	1690
Sand Filter	1	19	0	20
Shallow Marsh	2	0	0	2
Step Pool Storm Conveyance	0	0	0	0
Stream Restoration	156	1618	145	1919
Street Trees	0	21	0	21
Submerged Gravel Wetlands	0	6	0	6
Underground Filter	0	5	0	5
Urban Tree Canopy	0	0	0	0
Total	**391**	**3176**	**501**	**4067**

Source: DoE 2023.
Note: lbs/yr = pounds per year.

Table 5-4. Baseline, progress, and planned TSS load reductions by BMP types.

BMP Type	Baseline TSS Reduction (lbs/yr)	Progress TSS Reduction (lbs/yr)	Planned TSS Reduction (lbs/yr)	Total TSS Reduction (lbs/yr)
Bioretention	9,179	47,803	0	56,982
Bio-Swale	2,056	5,100	0	7,156
Disconnection of Non-Rooftop Runoff	0	0	0	0
Dry Swale	7,227	2,480	2,157	11,865
Extended Detention - Wetland	42,672	0	0	42,672
Extended Detention Structure, Wet	221,108	549,464	0	770,572
Impervious Surface Elimination (to pervious)	0	15,717	0	15,717
Infiltration Basin	4,586	0	0	4,586
Infiltration Trench	11,307	0	0	11,307
Landscape Infiltration	0	107	0	107
Micro-Bioretention	0	135,971	0	135,971
Oil Grit Separator	0	2,323	0	2,323
Outfall Stabilization	0	108,439	12,400	120,839
Permeable Pavements	0	5,925	0	5,925
Planting Trees or Forestation on Previous Urban	0	0	622	622
Pocket Wetland	128,717	0	0	128,717
Rain Gardens	0	532	0	532
Rainwater Harvesting	0	4,629	0	4,629
Retention Pond (Wet Pond)	293,906	4,233,881	1,329,318	5,857,105
Sand Filter	3,364	66,018	0	69,382
Shallow Marsh	8,281	0	0	8,281
Step Pool Storm Conveyance	0	0	0	0
Stream Restoration	567,430	2,962,668	529,232	4,059,330
Street Trees	0	52,926		52,926
Submerged Gravel Wetlands	0	17,351	490	17,841
Underground Filter	0	15,621	0	15,621
Urban Tree Canopy	0	54	0	54
Total	**1,299,834**	**8,227,009**	**1,874,219**	**11,401,062**

Source: DoE 2023.
Note: lbs/yr = pounds per year.

5.4 Baseline, Progress, and Target Load Calculation

Table 5-5 presents County MS4 baseline loads for the Anacostia River watershed. Those baseline loads do not include loads attributed to the town of Bowie or federal or state land because the County MS4 permit does not cover these areas. The loads in Table 5-5 account for all BMPs installed through 2022. The methodology for calculating the baseline loads followed MDE's TIPP Tool (MDE 2022d). Table 5-5 also presents the percent reduction reported in the TMDL, which was applied to the calculated baseline load to determine the implementation load reduction target. The TMDL percent reduction values were obtained directly from the MDE TMDL Data Center (MDE 2019b). That target, and the amount by which the loads need to be reduced, are also presented. Table 5-6 presents the sediment loads for different scenarios (e.g., progress, milestones).

As shown in Table 5-5, the load reductions from existing restoration activities are insufficient to meet the targeted reductions. With the BMPs either previously implemented or planned, a reduction gap still exists in the Anacostia River watershed. Additional practices will need to be planned to close the gap in its pollutant reduction requirements to meet the TMDLs. These are discussed in Section 7.

Table 5-5. Sediment load and targets for the Anacostia River watershed.

Measure	TN	TP	TSS
No-action load	228,334	28,892	78,013,386
Baseline reductions	6,384	1,342	4,493,624
Baseline load	221,949	27,549	73,519,762
Reduction required %	81%	81.2%	85%
Target load	42,170	5,179	11,027,964
Required reduction	179,779	22,370	62,491,797
Progress reductions	13,197	3,178	8,227,010
Progress load	208,753	24,372	65,292,752
Current load reduction gap	166,582	19,192	54,264,788
Planned reductions	2,050	502	1,874,219
Planned load	206,702	23,870	63,418,533
Restoration gap (Remaining load reduction to meet target. See Section 7.2.)	**164,532**	**18,691**	**52,390,568**

Notes:
lbs/yr = pounds per year; ton/yr = tons per year.
See Section 5.1 for a discussion of the terminology in this table.

6 LOAD REDUCTION STRATEGY

The County has constructed BMPs countywide, including in the Anacostia River watershed. The restoration activities in the Anacostia River watershed will require a sustained level of effort annually to reach the reduction targets outlined in the TMDL. Consequently, the County has developed a strategy with five components to achieve the goals of the plan:

- Use MDE-developed land use loading rates and accepted BMP pollutant load reduction efficiencies to evaluate the ability of existing practices and programmatic initiatives to meet the local TMDL SW-WLAs.
- Quantify future BMPs necessary to meet the SW-WLAs.
- Develop cost estimates associated with implementing the BMPs and initiatives.
- Develop timelines associated with the deployment of BMP practices and initiatives to determine if the timelines required by the TMDL program can be achieved.
- Identify the financial and technical resources required to implement the BMPs and initiatives and develop achievable timelines that can meet TMDL program requirements with the greatest efficiency.

The County's strategy for developing a WIP includes evaluating the capacity of existing BMPs and restoration activities and identifying future activities necessary to meet the SW-WLAs. The methodology emphasizes the use of adaptive management as outlined in Section 8.3 and a simplified project identification and implementation framework to achieve greater cost efficiency while not sacrificing the resiliency of the WIP.

In a simplified framework, once the existing BMPs have been accounted for and the load reduction gap has been calculated, the County will attempt to identify potential future BMPs that could be implemented to close the remaining gap. Generally, the County's implementation of those BMPs would be prioritized by the cost-effectiveness for meeting water quality goals. Seeking out cost-effective opportunities that deliver the greatest pollutant load reduction will ensure that the most beneficial practices that are easiest to accomplish are not overlooked during the implementation process.

The overall load calculation process will follow these general steps:

1) Calculate the *no action* load using the MDE land use and land use loading rates.
2) Determine baseline load, which accounts for existing BMPs.
    a) Calculate the load reductions from developer BMPs implemented prior to the date of the land cover data (2014).
    b) Calculate the load reduction from restoration BMPs implemented prior to the date of the TMDL (2019).
    c) Subtract these amounts from the no action load to obtain the baseline load.
3) Apply the TMDL percent reduction to the baseline load to obtain the target load.
4) Calculate the total reduction required.

5) Calculate the load reductions from restoration BMPs installed since the date of TMDL (2019) to determine the current restoration progress.
6) Determine the remaining load reduction gap.
7) Calculate the load reductions from BMPs that are currently in the planning, design, or construction phase.
8) Determine the remaining load reduction gap.
9) Determine the amount of BMPs needed to fill in the load restoration gap.

6.1 Programmatic Initiatives

The County analyzed current stormwater programs (discussed in Section 4 and Appendix A). The existing programmatic activities are expected to continue and will be supplemented with additional practices, to support the programmatic strategies for this WIP as they are identified and/or developed.

6.2 BMP Identification and Selection

The MDE 2000 *Stormwater Design Manual* provides guidance for designing several types of structural BMPs, including wet ponds, wetlands, filtering practices, infiltration practices, and swales (MDE 2009). MDE also describes nonstructural BMPs that include programmatic, educational, and pollution prevention practices that work to reduce pollutant loadings. Examples of nonstructural BMPs include diverting stormwater from impervious to pervious areas, street sweeping, and public education campaigns (MDE 2009). Additionally, the County will use MDE's *Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated: Guidance for National Pollutant Discharge Elimination System Stormwater Permits* in planning future BMPs (MDE 2021a).

The County has implemented and will continue to implement runoff reduction (RR) practices, stormwater treatment (ST) practices, nonstructural stormwater treatment practices, and MDE-approved alternative BMP practices to meet its programmatic goals and responsibilities, including MS4 permit compliance, TMDL WLAs, and flood mitigation. Appendix A has additional information on specific practices.

The County does not own many sites that are suitable for BMP implementation. The County could seek partnerships with other organizations (e.g., nonprofit organizations, businesses) to gain access to private lands and conduct restoration activities on them. For example, a shopping center owner could partner with the County to gain assistance with installing BMPs. (For more information, please see Appendix section *E.2. Public Involvement to Support Implementation Activities*.) This assistance may range from technical assistance to partnering to install a BMP that treats the shopping center parking area and the County right-of-way (ROW). Nonprofit organizations can participate with the County through the raincheck rebate and stewardship grant programs (see Appendix A.1). These programs are in place to help property owners work with the County in restoring their own properties. Examples of projects include tree planting, reforestation, impervious surface removal, and nonstructural BMPs. Without forming partnerships and being granted access to private land, the County will be limited to installing BMPs only on properties to which it has direct access, such as ROWs or County government-owned land. Appendix C has additional information on BMP site selection.

BMP types and locations are not explicitly specified in this WIP, giving the County flexibility to identify specific locations for BMPs and to work with partners on implementing them (e.g., installing BMPs on institutional land). The County also will have the flexibility to select suitable BMPs based on costs, land availability, feasibility, pollutant removal efficiencies, and other factors.

6.3 Implementation Budgeting

This section provides projected estimated budgets for the probable expenditures and staff resources that might be anticipated over the implementation period. Given the iterative and adaptive nature of the WIP and the potential for modified proposed activities, the estimated budget in this plan should be considered preliminary for the year estimated; in later years, it should be revisited as the implementation period moves forward and new data becomes available.

6.3.1 Programmatic Initiatives Estimating

Generally, the costs of programmatic initiatives for nonstructural BMPs (e.g., public education, tree planting, downspout disconnection) are more challenging to determine than costs for structural BMPs (e.g., ponds, stream restoration, RR/ST practices). Some programmatic initiatives are included in current County practices; thus, the County has already accounted for those costs. For instance, the ReLeaf Grant Program is one of the County's active tree planting programs with an existing budget. Costs for programs that result in structural BMP implementation, such as the Clean Water Partnership (CWP), are included in the BMP analysis; the only additional cost to the County is staff time for administering and coordinating the program as part of regular duties. Nonstructural BMPs are funded through DoE's operating budget, whereas structural BMPs are funded through the CIP budget. Appendix D has information on the County's funding sources.

6.3.2 BMP Implementation Estimating

Table 6-1 presents data on BMP unit cost per impervious acre treated, including costs for operation and maintenance (O&M). These unit costs were developed in *Cost Analysis of Stormwater and Agricultural Practices for Reducing Nitrogen and Phosphorus Runoff in Maryland* (UMCES 2019). The costs in Table 6-1 were converted to January 2020 dollars using the RSMeans historical cost indexes (Gordian 2020). Table 6-1 shows simple annual unit costs and annualized costs with and without land purchase costs. Simple costs were determined using the median implementation cost divided by the BMP lifespan and adding annual O&M costs. The annualized costs assumed a 5 percent annualization rate applied to the median implementation cost. Then, annual O&M costs were added. Simple annual costs without land costs were used in this plan and do not account for inflation over the course of this plan.

Table 6-1. Typical BMP unit costs by stormwater BMP by impervious acre treated.

Stormwater Practices	Type of Practice	Life-span	Median Implement-ation Cost ($/imp acre per year)[a]	Annual O&M ($/imp acre per year)[a]	Simple Annual ($/imp acre per year)[a]		Annualized ($/imp acre per year)[a]	
					No Land Costs	With Land Costs	No Land Costs	With Land Costs
Bioretention	RR	20	$211,110	$24,278	$34,833	$35,018	$41,217	$41,402
Micro-bioretention	RR	20	$311,121	$35,779	$51,334	$51,519	$60,744	$60,867
Rain gardens	RR	20	$147,635	$16,978	$24,360	$24,544	$28,825	$29,010
Bio-swale	RR	20	$59,994	$6,899	$9,899	$10,022	$11,714	$11,837
Grass swale	RR	20	$250,054	$28,756	$41,259	$41,382	$48,821	$48,944
Dry swale	RR	20	$203,772	$23,434	$33,623	$33,746	$39,785	$39,908
Micro-pool extended detention pond	pond	30	$75,894	$8,727	$11,257	$11,340	$13,665	$13,788
Multiple pond system	pond	30	$163,087	$18,755	$24,191	$24,274	$29,364	$29,487
Extended detention structure, wet	pond	30	$28,816	$3,314	$4,274	$4,357	$5,189	$5,312
Retention pond (wet pond)	pond	30	$53,782	$6,185	$7,977	$8,060	$9,683	$9,806
Extended detention - wetland	stormwater	30	$78,413	$9,018	$11,631	$11,714	$14,118	$14,241
Wet pond - wetland	stormwater	30	$58,082	$6,679	$8,616	$8,697	$10,458	$10,581
Shallow marsh	stormwater	30	$36,842	$4,237	$5,465	$5,547	$6,633	$6,756
Impervious surface elimination (to pervious)	alternative	20	$911,948	$0	$45,598	$48,672	$73,177	$76,252
Infiltration basin	stormwater	20	$68,653	$9,199	$12,633	$12,940	$14,709	$15,016
Infiltration trench	stormwater	20	$121,571	$16,291	$22,370	$22,677	$26,046	$26,353
Permeable pavements	RR	20	$389,890	$52,246	$71,740	$71,740	$83,531	$83,531
Organic filter (peat filter)	stormwater	20	$219,834	$25,281	$36,272	$36,580	$42,921	$43,229
Submerged gravel wetlands	RR	30	$161,582	$18,582	$23,968	$24,050	$29,093	$29,216
Sand filter	stormwater	20	$18,759	$2,158	$3,096	$3,403	$3,663	$3,970
Underground filter	stormwater	20	$112,979	$12,993	$18,642	$18,950	$22,059	$22,366
Regenerative step pool conveyance	RR	20	$75,236	$6,169	$9,931	$9,931	$12,207	$12,207
Outfall stabilization	alternative	20	$207,941	$17,051	$27,449	$27,449	$33,737	$33,737
Stream restoration	alternative	20	$61,047	$5,005	$8,059	$8,059	$9,905	$9,905
Planting trees or forestation or pervious urban	alternative	20	$35,385	$0	$1,769	$9,860	$2,840	$10,930
Wet pond average	pond	30	--	--	$11,925	$12,008	$14,475	$14,598
Runoff reduction average	RR	20	--	--	$33,439	$33,550	$39,549	$39,658

Source: UMCES 2019.
Notes: $/imp acre = dollars per impervious acre, RR = runoff reduction.
[a] Costs inflated to January 2020 dollars.

7 WIP RESTORATION ACTIVITIES

The County is in its 5th generation NPDES permit and has been constructing BMPs as part of SWM controls and restoration requirement countywide, including in the Anacostia River watershed. Existing and planned BMPs meet 81 percent reductions for TN, 81.2 percent for TP, and 85 percent reduction for TSS of the TSS target goal in the Anacostia River watershed. This section describes the County's proposed changes intended to strengthen the implementation process it uses to improve water quality and, thereby, meet the goals and objectives of this WIP. It includes specific planned actions, cost estimates, and a proposed schedule, as well as describes the financial and technical resources available to support and implement the plan. This section also describes how the County will involve the public throughout the plan's implementation, including keeping residents informed and encouraging them to participate directly in the implementation actions. The WIP creates the overall blueprint and timeline for restoration activities in the Anacostia River watershed.

7.1 Programmatic Initiatives

The County's existing programmatic practices (Section 4 and Appendix A) are expected to remain in place. They will be supplemented with additional practices discussed in this section to make up the programmatic strategies for this WIP.

Estimating potential load reductions resulting from programmatic initiatives is challenging because some of the initiatives require public participation and changes in long-standing behaviors. Some of the programmatic initiatives will result in BMPs being installed. The acreage that will be treated through those programs has yet to be estimated. The BMPs that are installed as those programs are implemented will be credited towards the identified load reduction targets and load reduction gap discussed in Section 5.3.

Programmatic activities are generally not measured for load reductions unless they were designed specifically for a surrogate benefit. One of the County's measurable programmatic activities includes inlet cleaning. (See Appendix A for a list of County programs.) Although the cumulative effects of programmatic activities will help reduce loads entering local water bodies in different ways, thus improving their health, their impacts cannot be calculated and are not included as part of this WIP. Those activities do, however, form an important part of this plan. Most of them serve to educate the public on how they can help improve water quality. The improvements in water quality resulting from the activities will be reflected through adaptive management, through which the County will assess cumulative improvements in the water quality and health of water bodies under the WIP.

7.2 Structural BMPs

This section assesses different treatment options, including stream restoration. It also explores outfall stabilization, tree planting, new wet ponds, and RR practices (e.g., grass swales, bioretention systems) that treat stormwater runoff from both pervious and impervious land. The combination of pervious and impervious land is used in calculating the load reduction potential of new wet ponds and RR practices. RR practices are typically smaller and treat smaller areas than wet ponds. (Based on the County's BMP database, RR practices treat an average of 0.5 acres and wet ponds an average of 40 acres.) Wet ponds are typically regional facilities that remove sediments and other pollutants by treating runoff from large drainage areas, but they have lower removal efficiencies. Only the impervious area is assessed for costing because the available cost data are provided per impervious acre treated rather than for the total land area treated (Section 6.3.2).

As recommended by MDE's accounting for SW-WLA guidance (MDE 2021a) the County will consider the following practices; however, the County can choose practices based on available resources and priorities. Please refer to Appendix C for additional information on the types of BMPs in this WIP:

- Stream restoration
- Outfall stabilization
- Tree planting (forest planning, tree canopy, riparian buffers)
- Impervious to pervious (turf)
- Wet ponds (treating 3-inch rainfall)
- RR practices (treating 3-inch rainfall)

7.2.1 BMP Determination – Desktop Excel Analysis

The County could use many different combinations of BMPs to meet the load reductions for these TMDLs. However, the cost and lack of available space for implementation would make many of them unfeasible. The results of a cost-effectiveness analysis of various scenarios with different combinations of BMPs will assist the County in selecting a strategy that can work together most effectively to meet the load reduction targets at the lowest cost.

Given the large geographical area in the watershed for potential restoration, including factors such as land use/land cover types, soil classes, and existing developments without SWM controls, Microsoft Excel Solver Add-in was used to determine the most cost-effective scenarios to meet the load reductions for this WIP. Solver processes a set of conditions to meet the County's objective: *the lowest cost*. The main condition was meeting the load reduction target in every scenario. Other conditions set a range of implementation for RR practices, outfall stabilization, stream restoration, tree planting, and new wet ponds. For example, a scenario could limit RR practices to treat runoff to 100 acres of land, while another scenario allows for treatment of up to 250 acres. The amount of stream restoration and outfall stabilization was determined using information on known stream erosion issues from the MD DNR SCA (Section 3.4). Solver then determined the best value in that range for that scenario. In Solver, forest planting accounts for 10 percent of the total tree acres planted, with street trees 40 percent, urban tree canopy 45 percent, and riparian buffers at 5 percent. The total acres for forest planting and riparian buffers need to be greater than 0.5 acres each per their BMP definition.

Multiple scenarios were analyzed using Solver. Anacostia River watershed requires large reductions for TN, TP, and TSS. While reducing TSS loadings is relatively easy, it is not as easy to reduce TN loadings through BMPs. Thus, achieving TN load reduction targets require a significantly more BMPs. Table 7-1 provides the median Solver results for meeting only the TSS load reductions, meeting the TP (and TSS) reductions, and then meeting the TN reductions, which will also meet the TP and TSS load reductions.

The scenario closest to the median cost (shown in Table 7-1) was selected for the WIP to provide the County with several options. The scenario that has been selected for presentation with this plan serves as a starting point for the County to make future decisions. The actual combination of BMPs implemented to meet the TMDL can change over time as adaptive management principles are applied to this plan.

Table 7-2, Table 7-3, and Table 7-4 present comparisons of the ten most cost-effective scenarios for load reduction. The low-cost scenarios maximized the amount of stream restoration, tree planting, and wet ponds. These practices have a lower cost per impervious acre treated than RR practices:

- The costs for meeting only the TSS load reductions ranged from $1.17 billion to $1.87 billion, with a median of $1.31 billion (Table 7-2).
- The costs for meeting TP (and TSS) load reductions ranged from $1.76 billion to $2.93 billion, with a median of $2.11 billion (Table 7-3).
- The costs for meeting TN (and TP and TSS) load reductions ranged from $5.61 billion to $6.45 billion, with a median of $5.73 billion (Table 7-4).

Table 7-1. Results of cost optimization to meet TMDL.

Variable (unit)	Value	Constraints
Meeting only TSS reductions		
Stream restoration (linear feet)	154,525	100–300% of MD DNR SCA known erosion issues (section 3.4)
Outfall stabilization (outfalls)	303	100–300% of MD DNR SCA outfall
Tree planting (acres planted)	100	0–100 acres
Impervious to turf (acres)	5.0	0–5 acre
New wet ponds (acres treated)	1,610	0–10,000 acres
RR practices (acres treated)	1,000.0	0-1,000 acres
Cost (January 2020 $M)	$1,310.1	Lowest cost for the constraints listed above.
Meeting TP (and TSS) reductions		
Stream restoration (linear feet)	115,956	100–300% of MD DNR SCA known erosion issues (section 3.4)
Outfall stabilization (outfalls)	303	100–300% of MD DNR SCA outfall
Tree planting (acres planted)	50	0–50 acres
Impervious to turf (acres)	0.0	0–5 acre
New wet ponds (acres treated)	10,000	0–10,000 acres
RR practices (acres treated)	500	0-500 acres
Cost (January 2020 $M)	$2,111.5	Lowest cost for the constraints listed above.
Meeting TN (and TP and TSS) reductions		
Stream restoration (linear feet)	32,568	0–300% of MD DNR SCA known erosion issues (section 3.4)
Outfall stabilization (outfalls)	0	0–200% of MD DNR SCA outfall
Tree planting (acres planted)	75	0–75 acres

Variable (unit)	Value	Constraints
Meeting only TSS reductions		
Impervious to turf (acres)	5.0	0–5 acre
New wet ponds (acres treated)	40,000	0–40,000 acres
RR practices (acres treated)	2,000	0-2,000 acres
Cost (January 2020 $M)	$5,725.1	Lowest cost for the constraints listed above.

Note: $M = in millions of dollars.

Table 7-2. Top 10 cost optimization scenarios for meeting only TSS reductions.

Practice (unit)	Top Five Low-Cost Scenarios				
	1 (Lowest)	2	3	4	5
Stream restoration (linear feet)	157,077	157,777	157,573	150,686	154,525
Outfall stabilization (outfalls)	303	303	303	303	303
Tree planting (acres planted)	75.0	80.0	75.0	75.0	100.0
Impervious to Turf (acres)	0.0	0.0	0.0	0.0	5.0
New wet ponds (acres treated)	2,379	1,873	1,878	3,179	1,610
RR practices (acres treated)	98.5	477.7	498.5	0.0	1000.0
Total cost ($M)	$1,170.0	$1,209.4	$1,214.7	$1,224.8	$1,310.1
Practice (unit)	**Cost Scenarios 6–10**				
	6	**7**	**8**	**9**	**10**
Stream restoration (linear feet)	131,476	138,480	105,169	101,101	100,104
Outfall stabilization (outfalls)	303	0	303	303	303
Tree planting (acres planted)	66.2	100.0	99.9	59.8	99.8
Impervious to Turf (acres)	0.0	5.0	8.4	0.0	0.0
New wet ponds (acres treated)	4,920	6,619	7,500	8,000	7,499
RR practices (acres treated)	310	1,000	500	499	999
Total cost ($M)	$1,466.2	$1,561.8	$1,768.5	$1,809.5	$1,877.6

Note: $M = in millions of dollars.

Table 7-3. Top 10 cost optimization scenarios for meeting TP (and TSS) reductions.

Practice (unit)	Top Five Low-Cost Scenarios				
	1 (Lowest)	2	3	4	5
Stream restoration (linear feet)	157,242	122,942	122,400	122,718	115,956
Outfall stabilization (outfalls)	303	303	455	455	303
Tree planting (acres planted)	10.0	75.0	150.0	10.0	50.0
Impervious to Turf (acres)	0.0	0.0	0.0	0.0	0.0
New wet ponds (acres treated)	7,274	9,996	7,654	7,984	10,000
RR practices (acres treated)	0	0	749.9	712.3	500.0
Total cost ($M)	$1,763.5	$2,000.9	$2,071.4	$2,099.4	$2,111.5
Practice (unit)	**Cost Scenarios 6–10**				
	6	**7**	**8**	**9**	**10**
Stream restoration (linear feet)	92,624	99,934	85,089	78,153	97,637
Outfall stabilization (outfalls)	0	303	0	0	0

Practice (unit)	Cost Scenarios 6–10				
	6	7	8	9	10
Tree planting (acres planted)	10.0	50.0	100.0	75	50.0
Impervious to Turf (acres)	0.0	3.0	0.0	0	0.0
New wet ponds (acres treated)	15,000	10,705	15,000	15,000	5,621
RR practices (acres treated)	161	999	500	1,000	7,150
Total cost ($M)	$2,246.5	$2,285.4	$2,316.0	$2,426.10	$2,937.9

Note: $M = in millions of dollars.

Table 7-4. Top 10 cost optimization scenarios for meeting TN (and TP and TSS) reductions.

Practice (unit)	Top Five Low-Cost Scenarios				
	1 (Lowest)	2	3	4	5
Stream restoration (linear feet)	0	0	31,797	29,997	32,568
Outfall stabilization (outfalls)	0	0	0	0	0
Tree planting (acres planted)	50.0	10.0	100.0	150.0	75.0
Impervious to Turf (acres)	0.0	0.0	5.0	10.0	5.0
New wet ponds (acres treated)	44,123	44,254	40,000	40,000	40,000
RR practices (acres treated)	35.7	0	2000.0	2000.0	2000.0
Total cost ($M)	$5,614.1	$5,619.9	$5,723.5	$5,724.0	$5,725.1
Practice (unit)	**Cost Scenarios 6–10**				
	6	**7**	**8**	**9**	**10**
Stream restoration (linear feet)	323,128	0	52,593	52,593	743,904
Outfall stabilization (outfalls)	0	303	303	303	303
Tree planting (acres planted)	100.0	149.3	10.0	50.0	150.0
Impervious to Turf (acres)	10.0	5.6	0.0	0.0	10.0
New wet ponds (acres treated)	35,000	40,000	39,790	38,177	25,000
RR practices (acres treated)	1,500	1,999	1,568	2,473	2,000
Total cost ($M)	$5,898.8	$5,955.8	$5,973.4	$6,011.6	$6,453.3

Note: $M = in millions of dollars.

7.2.2 Load Reductions

Table 7-5 through 7-10 restate the load calculations from earlier in the document (Table 5-5) along with new reductions for the different restoration activities relevant to this plan (BMPs and programmatic initiatives) for each load reduction scenario described above. The most significant reductions will be obtained through stream restoration and implementing new wet ponds.

Table 7-5. WIP load reductions in the Anacostia River watershed for meeting only TSS reductions.

Measure or Practice	TN (lbs/yr)	% of Baseline Load	TP (lbs/yr)	% of Baseline Load	TSS (lbs/yr)	% of Baseline Load
Information from Table 5-5						
Baseline Load	221,949	100%	27,549	100%	73,519,762	100%
Target Load	42,170	19%	5,179	19%	11,027,964	15%

Measure or Practice	TN (lbs/yr)	% of Baseline Load	TP (lbs/yr)	% of Baseline Load	TSS (lbs/yr)	% of Baseline Load
Required Reduction	***179,779***	***81%***	***22,370***	***81%***	***62,491,797***	***85%***
Current Restoration BMP Reductions (through June 30, 2023)	13,197	6%	3,178	12%	8,227,010	11%
Progress Load	208,753	94%	24,372	88%	65,292,752	89%
Current Load Reduction Gap	166,582	75%	19,192	70%	54,264,788	74%
Planned Restoration BMP Reductions (Identified in County BMP database)	2,050	1%	502	2%	1,874,219	3%
Planned Load	206,702	93%	23,870	87%	63,418,533	86%
Remaining Restoration Gap to meet TMDL	*164,532*	*74%*	*18,691*	*68%*	*52,390,568*	*71%*
BMPs identified in this WIP to Meet Restoration Gap						
Stream Restoration / Outfall Stabilization	13,862	6%	12,568	46%	45,836,658	62%
Tree Planting	232	0%	180	1%	280,764	0%
Wet Ponds	5,991	3%	1,310	5%	3,694,372	5%
RR Practices	6,527	3%	1,033	4%	2,565,364	3%
Impervious to Turf	19	0%	-1	0%	13,433	0%
Total WIP	**26,631**	12%	**15,091**	55%	**52,390,591**	71%
Total Restoration Activities						
Current BMPs, Planned BMPs, and WIP BMPs	**41,878**	19%	**18,770**	68%	**62,491,820**	85%

Notes:
lbs/yr = pounds per year.
See Section 5.1 for a discussion of the terminology in this table.

Table 7-6. WIP load reductions in the Anacostia River watershed for meeting TP (and TSS) reductions.

Measure or Practice	TN (lbs/yr)	% of Baseline Load	TP (lbs/yr)	% of Baseline Load	TSS (lbs/yr)	% of Baseline Load
Information from Table 5-5						
Baseline Load	221,949	100%	27,549	100%	73,519,762	100%
Target Load	42,170	19%	5,179	19%	11,027,964	15%
Required Reduction	***179,779***	***81%***	***22,370***	***81%***	***62,491,797***	***85%***
Current Restoration BMP Reductions (through June 30, 2023)	13,197	6%	3,178	12%	8,227,010	11%
Progress Load	208,753	94%	24,372	88%	65,292,752	89%
Current Load Reduction Gap	166,582	75%	19,192	70%	54,264,788	74%

Measure or Practice	TN (lbs/yr)	% of Baseline Load	TP (lbs/yr)	% of Baseline Load	TSS (lbs/yr)	% of Baseline Load
Planned Restoration BMP Reductions (Identified in County BMP database)	2,050	1%	502	2%	1,874,219	3%
Planned Load	206,702	93%	23,870	87%	63,418,533	86%
Remaining Restoration Gap to meet TMDL	*164,532*	*74%*	*18,691*	*68%*	*52,390,568*	*71%*
BMPs identified in this WIP to Meet Restoration Gap						
Stream Restoration / Outfall Stabilization	10,969	5%	9,945	36%	36,271,447	49%
Tree Planting	116	0%	90	0%	140,381	0%
Wet Ponds	37,210	17%	8,139	30%	22,946,578	31%
RR Practices	3,264	1%	517	2%	1,282,734	2%
Impervious to Turf	0	0%	0	0%	0	0%
Total WIP	**51,559**	23%	**18,691**	68%	**60,641,141**	82%
Total Restoration Activities						
Current BMPs, Planned BMPs, and WIP BMPs	**66,806**	30%	**22,370**	81%	**70,742,370**	96%

Notes:
lbs/yr = pounds per year.
See Section 5.1 for a discussion of the terminology in this table.

Table 7-7. WIP load reductions in the Anacostia River watershed for meeting TN (and TP and TSS) reductions.

Measure or Practice	TN (lbs/yr)	% of Baseline Load	TP (lbs/yr)	% of Baseline Load	TSS (lbs/yr)	% of Baseline Load
Information from Table 5-5						
Baseline Load	221,949	100%	27,549	100%	73,519,762	100%
Target Load	42,170	19%	5,179	19%	11,027,964	15%
Required Reduction	***179,779***	***81%***	***22,370***	***81%***	***62,491,797***	***85%***
Current Restoration BMP Reductions (through June 30, 2023)	13,197	6%	3,178	12%	8,227,010	11%
Progress Load	208,753	94%	24,372	88%	65,292,752	89%
Current Load Reduction Gap	166,582	75%	19,192	70%	54,264,788	74%
Planned Restoration BMP Reductions (Identified in County BMP database)	2,050	1%	502	2%	1,874,219	3%
Planned Load	206,702	93%	23,870	87%	63,418,533	86%
Remaining Restoration Gap to meet TMDL	*164,532*	*74%*	*18,691*	*68%*	*52,390,568*	*71%*

Measure or Practice	TN (lbs/yr)	% of Baseline Load	TP (lbs/yr)	% of Baseline Load	TSS (lbs/yr)	% of Baseline Load
BMPs identified in this WIP to Meet Restoration Gap						
Stream Restoration / Outfall Stabilization	2,443	1%	2,215	8%	8,076,967	11%
Tree Planting	174	0%	135	0%	210,572	0%
Wet Ponds	148,842	67%	32,556	118%	91,786,317	125%
RR Practices	13,055	6%	2,066	8%	5,130,940	7%
Impervious to Turf	19	0%	-1	0%	13,400	0%
Total WIP	**164,532**	74%	**36,971**	134%	**105,218,196**	143%
Total Restoration Activities						
Current BMPs, Planned BMPs, and WIP BMPs	**179,779**	81%	**40,650**	148%	**115,319,425**	157%

Notes:
lbs/yr = pounds per year.
See Section 5.1 for a discussion of the terminology in this table.

Table 7-8. Summary of WIP load reductions in the Anacostia Creek watershed for meeting only TSS reductions, as presented in the TIPP Tool.

Load Category	TN	TP	TSS	Units
Baseline *– Estimated load at time of TMDL*				
Impairment Baseline Load	221,949	27,549	73,519,762	lbs/yr
Target Reduction %	81.0%	81.2%	85.0%	%
Target Load	42,170	5,179	11,027,964	lbs/yr
Total Reduction Required	179,779	22,370	62,491,797	lbs/yr
Permit *– Estimated load at beginning of 2014 permit (includes BMP reductions since TMDL development)*				
Total Permit Load	214,046	25,880	67,847,422	lbs/yr
% of Total Reduction Required	4.4%	7.5%	9.1%	%
Progress *– Estimated load as of July 2023 (includes BMP reductions since TMDL development)*				
Total Progress Load	208,753	24,372	65,292,752	lbs/yr
% of Total Reduction Required	7.3%	14.2%	13.2%	%
Implementation (Milestone 1) *– Estimated load with Planned BMPs through 2025 (includes BMP reductions since TMDL development)*				
Total Load after Implementation	207,727	24,121	64,355,642	lbs/yr
% of Total Reduction Required	7.9%	15.3%	14.7%	%
Implementation (Milestone 1 + Milestone 2) *– Estimated load with Planned BMPs through 2027 (includes BMP reductions since TMDL development)*				
Total Load after Implementation	206,702	23,870	63,418,533	lbs/yr
% of Total Reduction Required	8.5%	16.4%	16.2%	%
Implementation (Milestone 1 + Milestone 2 + Planned) *– Estimated load with Planned BMPs through 2027 and BMPs identified in this WIP (includes BMP reductions since TMDL development)*				
Total Load after Implementation	180,072	8,779	11,027,941	lbs/yr

Load Category	TN	TP	TSS	Units
% of Total Reduction Required	23.3%	83.9%	100.0%	%

Notes:
lbs/yr = pounds per year.
See Section 5.1 for a discussion of the terminology in this table.

Table 7-9. Summary of WIP load reductions in the Anacostia Creek watershed for meeting TP (and TSS) reductions, as presented in the TIPP Tool.

Load Category	TN	TP	TSS	Units
Baseline *– Estimated load at time of TMDL*				
Impairment Baseline Load	221,949	27,549	73,519,762	lbs/yr
Target Reduction %	81.0%	81.2%	85.0%	%
Target Load	42,170	5,179	11,027,964	lbs/yr
Total Reduction Required	179,779	22,370	62,491,797	lbs/yr
Permit *– Estimated load at beginning of 2014 permit (includes BMP reductions since TMDL development)*				
Total Permit Load	214,046	25,880	67,847,422	lbs/yr
% of Total Reduction Required	4.4%	7.5%	9.1%	%
Progress *– Estimated load as of July 2023 (includes BMP reductions since TMDL development)*				
Total Progress Load	208,753	24,372	65,292,752	lbs/yr
% of Total Reduction Required	7.3%	14.2%	13.2%	%
Implementation (Milestone 1) *– Estimated load with Planned BMPs through 2025 (includes BMP reductions since TMDL development)*				
Total Load after Implementation	207,727	24,121	64,355,642	lbs/yr
% of Total Reduction Required	7.9%	15.3%	14.7%	%
Implementation (Milestone 1 + Milestone 2) *– Estimated load with Planned BMPs through 2027 (includes BMP reductions since TMDL development)*				
Total Load after Implementation	206,702	23,870	63,418,533	lbs/yr
% of Total Reduction Required	8.5%	16.4%	16.2%	%
Implementation (Milestone 1 + Milestone 2 + Planned) *– Estimated load with Planned BMPs through 2027 and BMPs identified in this WIP (includes BMP reductions since TMDL development)*				
Total Load after Implementation	155,143	5,179	2,777,392	lbs/yr
% of Total Reduction Required	37.2%	100.0%	113.2%	%

Notes:
lbs/yr = pounds per year.
See Section 5.1 for a discussion of the terminology in this table.

Table 7-10. Summary of WIP load reductions in the Anacostia Creek watershed for meeting TN (and TP and TSS) reductions, as presented in the TIPP Tool.

Load Category	TN	TP	TSS	Units
Baseline *– Estimated load at time of TMDL*				
Impairment Baseline Load	221,949	27,549	73,519,762	lbs/yr
Target Reduction %	81.0%	81.2%	85.0%	%
Target Load	42,170	5,179	11,027,964	lbs/yr
Total Reduction Required	179,779	22,370	62,491,797	lbs/yr

Load Category	TN	TP	TSS	Units
***Permit** – Estimated load at beginning of 2014 permit (includes BMP reductions since TMDL development*				
Total Permit Load	214,046	25,880	67,847,422	lbs/yr
% of Total Reduction Required	4.4%	7.5%	9.1%	%
***Progress** – Estimated load as of July 2023 (includes BMP reductions since TMDL development)*				
Total Progress Load	208,753	24,372	65,292,752	lbs/yr
% of Total Reduction Required	7.3%	14.2%	13.2%	%
***Implementation (Milestone 1)** – Estimated load with Planned BMPs through 2025 (includes BMP reductions since TMDL development)*				
Total Load after Implementation	207,727	24,121	64,355,642	lbs/yr
% of Total Reduction Required	7.9%	15.3%	14.7%	%
***Implementation (Milestone 1 + Milestone 2)** – Estimated load with Planned BMPs through 2027 (includes BMP reductions since TMDL development)*				
Total Load after Implementation	206,702	23,870	63,418,533	lbs/yr
% of Total Reduction Required	8.5%	16.4%	16.2%	%
***Implementation (Milestone 1 + Milestone 2 + Planned)** – Estimated load with Planned BMPs through 2027 and BMPs identified in this WIP (includes BMP reductions since TMDL development)*				
Total Load after Implementation	42,170	0	0	lbs/yr
% of Total Reduction Required	100.0%	123.2%	117.6%	%

Notes:
lbs/yr = pounds per year.
See Section 5.1 for a discussion of the terminology in this table.

7.3 Restoration Budget

The planning level costs per restoration activity are shown in Table 7-11, Table 7-12, and Table 7-13, along with the estimated load reductions and cost per pound of sediment reduced for scenario #5. The overall cost for this plan is $1.3 billion meeting TSS load reductions, $2.1 billion meeting TP (and TSS) reductions, and $5.7 billion for meeting TN load reductions. These costs include the O&M of each new BMP over the lifespan of the BMP. The total cost does not include the O&M costs for existing BMPs, replacements of BMPs that have exceeded their lifespan, or aging stormwater infrastructure. Based on County experience, O&M costs account for 5 to 10 percent of the total construction cost. Appendix D has information on the County's funding sources. These estimates are based on MDE's TMDL allocation that are more than 15 years old. For the control of nutrients in urbanized areas, MDE also recommends using certain BMP types, which are also subject to low removal efficiencies. Additionally, there could have been introduction of nutrients to the watershed from the sanitary wastewater sewer lines. These repairs were completed in 2020, which is 12 years after MDE's determination of nutrient allocations. The County believes the percent reductions are high, which in turn can drive the cost estimates to unaffordable levels. The County is open to work with MDE to evaluate further nutrients in the Anacostia River watershed.

The BMP unit costs from Table 6-1 were used to determine the restoration plan budget. Because this plan does not specify exact RR types, the average of the RR practices was used to determine the budget for the RR practices in Table 7-11, Table 7-12, and Table 7-13. The most cost-effective strategy is planting trees, while impervious surface removal is the least cost-effective.

Stream restoration and outfall stabilization are also relatively cost-effective, followed by creating new wet ponds and ESD practices.

The median cost scenario serves as a starting point for the County to make future decisions. The actual combination of BMPs implemented to meet the TMDL can change over time as adaptive management principles are applied to this plan.

Table 7-11. Total BMP proposed implementation costs and cost efficiency by restoration for meeting only TSS reductions.

Practice	Budget	TN		TP		TSS			
		TN (lbs/yr)	$/lb/yr	TP (lbs/yr)	$/lb/yr	TSS (lbs/yr)	$/lb/yr	Impervious Credit	$/Imp Acre
Stream restoration / outfall stabilization	$830,792,479	13,862	$2,997	12,568	$3,305	45,836,658	$0.91	3,696.50	$224,751
Tree planting	$3,537,451	232	$763	180	$984	280,764	$0.63	47.10	$75,105
Impervious to Turf	$4,559,413	19.13	$11,920	-0.64	$0	13,433.45	$16.97	3.55	$1,284,445
Wet pond	$204,440,603	5,991	$1,138	1,310	$5,201	3,694,372	$1.84	571.47	$357,748
ESD practices	$266,794,722	6,527	$1,936	1,033	$12,233	2,565,364	$4.93	377.94	$705,925
Total Restoration Plan	**$1,310,124,667**	**26,631**	**$2,311**	**15,091**	**$4,078**	**52,390,591**	**$1.17**	**4,696.56**	**$278,954**

Notes:
lbs/yr = pounds per year; $/lb = dollars per pound; $/imp acre = dollars per impervious acre.
Costs in January 2020 dollars.

Table 7-12. Total BMP proposed implementation costs and cost efficiency by restoration strategy for meeting TP (and TSS) reductions

Practice	Budget	TN		TP		TSS			
		TN (lbs/yr)	$/lb/yr	TP (lbs/yr)	$/lb/yr	TSS (lbs/yr)	$/lb/yr	Impervious Credit	$/Imp Acre
Stream restoration / outfall stabilization	$706,463,736	10,969	$3,220	9,945	$3,552	36,271,447	$0.97	2,925.12	$241,516
Tree planting	$1,768,719	116	$763	90	$984	140,381	$0.63	23.55	$75,105
Impervious to Turf	$0	0.00	$0	0.00	$0	0.00	$0	0.00	$0
Wet pond	$1,269,826,831	37,210	$1,138	8,139	$5,201	22,946,578	$1.84	3,549.50	$357,748
ESD practices	$133,402,788	3,264	$1,936	517	$12,233	1,282,734	$4.93	188.98	$705,925
Total Restoration Plan	**$2,111,462,074**	**51,559**	**$1,617**	**18,691**	**$4,462**	**60,641,141**	**$1.38**	**6,687.15**	**$315,749**

Notes:
lbs/yr = pounds per year; $/lb = dollars per pound; $/imp acre = dollars per impervious acre.
Costs in January 2020 dollars.

Table 7-13. Total BMP proposed implementation costs and cost efficiency by restoration strategy for meeting TN (and TP and TSS) reductions.

Practice	Budget	TN		TP		TSS			
		TN (lbs/yr)	$/lb/yr	TP (lbs/yr)	$/lb/yr	TSS (lbs/yr)	$/lb/yr	Impervious Credit	$/Imp Acre
Stream restoration / outfall stabilization	$104,984,533	2,443	$2,149	2,215	$2,370	8,076,967	$0.65	651.37	$161,175
Tree planting	$2,653,070	174	$763	135	$984	210,572	$0.63	35.32	$75,105
Impervious to Turf	$4,548,099	19.08	$11,920	-0.63	$0	13,400.12	$17	3.54	$1,284,445
Wet pond	$5,079,307,625	148,842	$1,138	32,556	$5,201	91,786,317	$1.84	14,198.02	$357,748
ESD practices	$533,611,487	13,055	$1,936	2,066	$12,233	5,130,940	$4.93	755.90	$705,925
Total Restoration Plan	**$5,725,104,814**	**164,532**	**$1,196**	**36,971**	**$5,320**	**105,218,196**	**$1.87**	**15,644.16**	**$365,958**

Notes:
lbs/yr = pounds per year; $/lb = dollars per pound; $/imp acre = dollars per impervious acre.
Costs in January 2020 dollars.

7.4 Implementation Schedule

This section provides the planning-level implementation schedule for the BMP and programmatic strategy necessary to meet TMDL compliance milestones. There is no mandated end date for the local TMDL WIPs; however, the County understands the public prefers an expedited restoration process and shares that sense of urgency. The County and its watershed partners are committed to finding site opportunities and expediting the planning, design, and construction phases for management activity to the maximum extent practicable. The County identifies specific BMP opportunities over a 6-year planning horizon, which becomes part of the approved annual county budget. These opportunities are included in the County's biannual Financial Assurance Plan (FAP) and summarized in the County's annual MS4 progress report. Planning, design, and construction activities follow a rigorous internal evaluation, including budget, CIP progress tracking, and necessary adjustments to implementation schedules due to unforeseen conditions. The result of this process is adjusted annually. Any BMPs installed by the County to address local TMDLs will help meet Chesapeake Bay load reduction goals.

Implementing the restoration activities in the proposed schedule will depend largely on future available funding and program capacity. The County has additional local nutrient and sediment TMDL WIPs in Piscataway Creek, Mattawoman Creek, Rocky Gorge Reservoir, Lower Patuxent River, Middle Patuxent River, and the Upper Patuxent River watersheds and will need to allocate available funding and resources across those priority watersheds. These are competing funding priorities in addition to reducing bacteria and PCBs for several local TMDLs through monitoring, source trackdown, and elimination.

DoE estimates that it can retrofit an average of 2 percent of its untreated impervious area per year (as per anticipated new NPDES permit conditions) over the course of WIP implementation. This estimate is backed up by MDE in its Phase III Chesapeake Bay WIP (MDE 2019a). Using that implementation average as a guide, we can determine the time needed to implement this

WIP fully. There are 8,186 acres of untreated impervious area (for both existing and currently planned restoration BMPs) in the Anacostia River watershed. Meeting the TMDL will require treating up to 15,644 impervious acres based on the restoration scenario to meet TN (Table 7-13).

This WIP is anticipated to take until 2120 to fully implement the TN required reductions, including treating the identified impervious acres with BMPs and all programmatic activities. (It is anticipated to take until FY2065 to meet the TP reductions and 2053 for the TSS reductions.) This end date considers the 2 percent implementation estimate, other competing priority WIPs, source identification, available BMP technologies, and ease of implementation, in addition to the County's need to pay more towards its restoration debt service during the implementation phase of this WIP. This is the date that implementation will be expected to be completed; however, complete improvements in stream health (e.g., benthic macroinvertebrates) are expected to lag until the aquatic organisms repopulate the streams. In addition, the County already has several BMPs in the planning or design phase for the watershed, including stream restoration, outfall stabilization, street trees, reforestation, forest conservation, and a wet pond conversion.

The projected end date was developed using estimates of the number of acres of impervious area that could be treated each year. During that period, the County will be implementing several other watershed WIPs, creating competing priorities that could limit the pace at which restoration is accomplished in the Anacostia River watershed. Faster implementation would require additional funding, staffing, and industry resources (e.g., bioretention soils, plants) sooner. The County is working with its watershed protection restoration program to increase the County's TMDL reduction rates. The County continues to research and evaluate innovative practices to help increase BMP efficiencies while lowering costs. Additional staff at the local level and close coordination with the state would be needed to review and approve BMP plans and permits in a timely manner to avoid slowed implementation. Throughout the implementation of this WIP, implementation uncertainties could emerge that will require adjustments to the plan.

Appendix G presents the estimated average annual number of impervious acres treated and the estimated load reductions by year from BMP implementation based on a steady implementation rate. There will be fluctuations in the annual load reductions due to the types of BMPs used and the land uses they treat but the County will aim to meet or exceed the annual goals. In addition, the County reserves the right to focus on specific areas of the County for restoration and not implement in certain watersheds in a given year. Appendix G also presents the overall target milestone timeline for this restoration effort. The County will continuously monitor this schedule to assess ways to increase the rate of implementation and to ensure practices are implemented as planned. Progress on this WIP will be monitored annually in the County's MS4 annual report based on its 5-year permit milestones.

Restoration activities on the scale of this plan are difficult to estimate to the exact acres treated per year. WIPs are planning guides for the estimated level of effort that could be needed to meet reduction goals. The number of impervious acres to be treated every year will vary depending on funding, program capacity, and availability of sites. It is always the County's goal to exceed those estimates to speed up the restoration process. The County realizes that some efforts might be more successful than others and reserves the right to prioritize specific watersheds with higher load reduction requirements. For that reason, this WIP offers an adaptive management (Section

8.3) component to ensure issues are identified and addressed early. The County expects to reevaluate this plan every five years based on program capacity, funding, priority watersheds, staffing, and industry resources.

8 TRACKING PROGRESS, MONITORING STREAM HEALTH, AND CONDUCTING ADAPTIVE MANAGEMENT

The County is required by its MS4 permit to:

> …[e]valuate and track the implementation of WIPs through monitoring or modeling to document the progress toward meeting established benchmarks, deadlines, and stormwater WLAs.

The County will fulfill this requirement by producing its annual MS4 report, annual countywide implementation plan, and environmental monitoring. The County intends to track its implementation of this WIP and evaluate how well its efforts improve the conditions in the County's surface waters and adjust its restoration activities accordingly. The County will use the data from tracking and monitoring efforts to inform its adaptive management of this WIP.

At the end of each 5-year NPDES permit term, the County will assess the effectiveness of the strategies and their impact on the TMDL goals and recommend adjustments to the plan for MDE review. This could include changing implementation strategies that may not yield results and redirecting funding to strategies that are demonstrated to be more effective.

The overall adaptive management approach for this WIP is provided in Figure 8-1. The approach follows a cyclic process of planning, implementing, monitoring, evaluating, and adjusting. Each of these has its own list of tasks. For example, implementation includes BMP installation, public education and outreach, and BMP O&M.

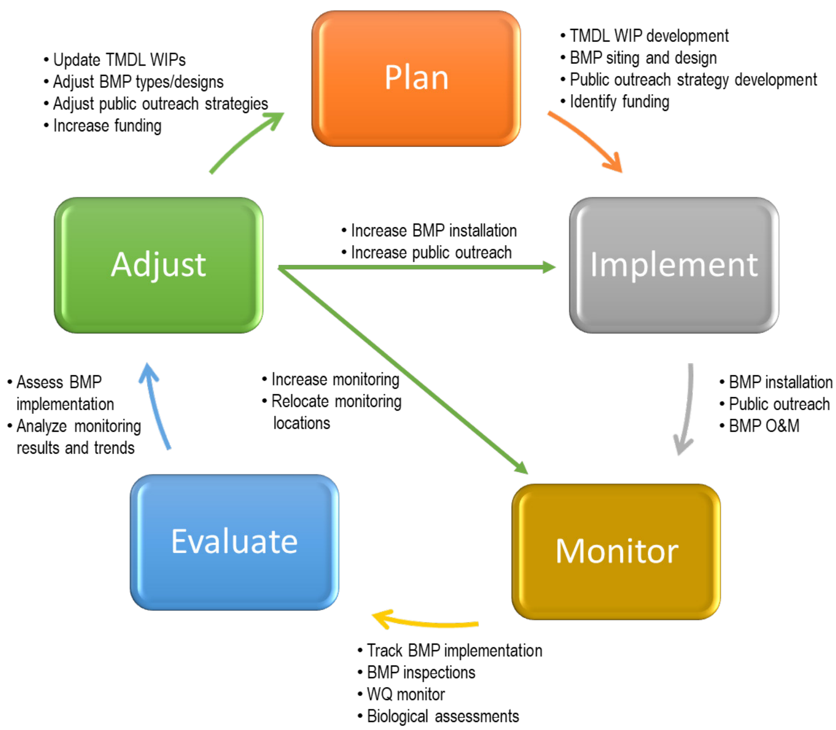


Figure 8-1. Generalized adaptive management approach.

8.1 Progress Tracking

The County's MS4 permit sets implementation goals for the permit term in terms of impervious acres treated over the 5-year permit term. To assess compliance with its permit, the County has a process to track and report impervious acres treated and pollutant load reductions. The County also reports the calculated load reductions using MDE's TIPP tool methodology, as per MDE's *Guidance for Developing Local Nutrient and Sediment TMDL (Total Maximum Daily Load) Stormwater Wasteload Allocation (SW-WLA) Watershed Implementation Plans (WIPs)* (MDE2022b), while also conducting watershed assessment monitoring. The County's annual MS4 report is the main mechanism for tracking permit activities and reporting them to MDE. While DoE is responsible for its submittal, it is a collaborative effort between the DPW&T and DPIE. The completed annual report and appendices are posted on DoE's stormwater management website.[8]

As specified in the County's permit, the annual report includes information about the County's BMP implementation, illicit discharge detection and elimination (IDDE), trash and litter control measures, public outreach and education initiatives, watershed assessments, and funding. It is the chief vehicle for tracking and reporting BMP implementation and programmatic initiatives. The annual report provides the following information:

- Estimated pollutant load reductions resulting from all completed structural and nonstructural water quality improvement projects and enhanced stormwater management programs. Load reductions will be calculated according to TIPP Tool methodology and data.
- Comparison of achieved load reductions to required load reductions by year to determine the degree to which the County is meeting its restoration goals (annual and total) or needs to adjust its programs to be more effective.

The annual report is accompanied by supplemental data about BMPs (including alternative practices such as stream restoration, septic system upgrades, and tree planting), funding, and water quality. Stormwater BMP data are provided in a georeferenced database. The database provides descriptive details for each BMP, including BMP type, project location, drainage area delineation, equivalent acres of impervious surface treated, maintenance records, year installed, and estimated load reductions. County staff update the database continuously with new and planned projects, which provides an indication if restoration is progressing as planned and allows for adjustments in future BMP implementation.

8.2 Monitoring Stream Health

The purpose of monitoring the conditions in the watershed is to determine the degree to which implementation of the WIP is resulting in the intended improvements. Past monitoring data (water quality, biological, geomorphic) can be compared to future monitoring data to show changes that can affect future restoration activities. This information is useful for project and BMP type selection, as it can provide insight into activities related to land use changes.

DoE recognizes that effective environmental monitoring requires a long-term commitment to routine and consistent sampling, measurement, analysis, and reporting. Although some of the

[8] https://www.princegeorgescountymd.gov/293/NPDES-MS4-Permit. Accessed June 2022.

monitoring requirements for assessing progress toward meeting TMDLs originate with MDE, others reflect the County's interest in providing additional meaningful information to policymakers and the public.

The County will continue evaluating options for its monitoring activities in consultation with MDE. Regardless of which monitoring activities are undertaken by the County, it will remain MDE's responsibility to perform the official monitoring for the state's Integrated Report assessments and impairment. MDE gathers monitoring data for every watershed in the state on a 5-year cycle.

8.2.1 Biological Monitoring

Biological indicators will continue to be used to document and report ecological conditions throughout the County. Other types of monitoring will contribute to understanding whether restoration activities are leading to the elimination, reduction, or otherwise more effective management of pollutants within the County. To ensure that the compiled data sets are accurate, monitoring is performed in accordance with a quality plan with standard operating procedures for sample collection. The County uses biological conditions as indicators of restoration activities. The data will be used to show overall changes in the watershed.

The biological condition of the County's streams is rated using MD DNR's BIBI, which is calculated based on the number of different kinds of organisms (benthic macroinvertebrates) found in samples taken along a stream section or reach. Because the types of organisms found reflect the cumulative influence of a variety of environmental factors, a low BIBI value alone is unlikely to point definitively to a pollutant or other stressor that should be reduced to improve the condition of the stream. Rather, the usefulness of the BIBI in the context of a stream restoration effort is that a sufficiently long record of BIBI values can be expected to reveal the overall effect of a broad restoration program aimed at eliminating, reducing, or otherwise managing known and potentially unknown stressors and their sources.

The County has been implementing biological monitoring since 1999. Sampling at each stream location encompassed benthic macroinvertebrate populations, physical habitat quality, and in situ water quality (pH, conductivity, temperature, and DO). Site locations were selected for each round using a stratified random process, where all wadeable, nontidal streams were stratified by subwatershed and stream order. Stream order designations (generally, first- through fourth-order) were based on the Strahler system of 1:100,000 map scale (Strahler 1957). Distribution of sample locations was more heavily weighted to smaller first- and second-order streams. The County started sampling round 5 in 2023 and it will run until 2025. For each subwatershed, the County will obtain a value for percent biological degradation from round 3, noting the intensity of impairment and any known or most probable sources of pollution or other stressors. It will then compare the percent degradation with the values found in round 5 to determine the direction and magnitude of changes.

The County will focus its efforts on areas of rapid BMP implementation through the CWP. Additional and more detailed analyses of conditions and data in individual subwatersheds can help associate stream biological health with the implementation of BMPs (and programmatic initiatives) so the County can adjust its restoration strategy, if needed.

The approach presented here assumes the continuation of routine, countywide monitoring of biological conditions for wadeable streams in round 5 and beyond, with potentially additional effort being applied to data analyses related to physical habitat characteristics, altered hydrology, and water chemistry. This not only provides insight into those stressors most likely causing biological degradation, but it also aids in identifying sources of stressors where additional restoration efforts would be beneficial.

8.2.2 Geomorphic Monitoring

The County is planning for future characterization and monitoring of fluvial geomorphic activity. This will focus on additional locations, as well as enhancing the calculation accuracy of (A) sediment yield and (B) nutrients (i.e., nitrogen, phosphorus). These enhancements will contribute to the DoE stream restoration crediting. The number and frequency of geomorphic surveys will increase, depending on budget constraints, to have a greater and more even coverage of the County and a frequency that will allow the County to be more immediately responsive to incremental changes in erosion rates as well as catastrophic bank failures. Initial thoughts on increased frequency are that monumented XS might be revisited every 3–5 years and could be done in a rotating basin design. The biomonitoring sites are selected using a stratified random approach but for channel erosion measures, it is likely more meaningful to have time-series data from fixed locations.

8.2.3 Water Quality Monitoring

Water quality monitoring is conducted to assess a set of upstream restoration practices. The 2022 MDE guidance for developing local TMDL nutrient and sediment WIPs includes suggested monitoring. Currently, the County does not have the resources to conduct watershed restoration and water quality monitoring at multiple locations. The County will consider targeted monitoring for TMDL compliance at the previous monitoring location as the County nears its load reduction goals. The County is enrolled in the pooled monitoring for BMP effectiveness, as part of its NPDES MS4 permit requirements. Future monitoring will not be conducted at any individual BMP sites to assess their effectiveness in reducing pollutant loads. Pollutant removal efficiencies have already been established for the proposed BMP types, so only new and innovative BMPs will need to be individually monitored to assess their load-reduction capabilities.

8.3 Adaptive Management Approach

This WIP was developed using the best information available at the time the plan was developed. As implementation progresses, adaptive management allows for adjustments to restoration activities as new information becomes available from the state or different stakeholders, opportunities to increase effectiveness and reduce costs emerge. The County will use new information as it becomes available to assess the effectiveness of its restoration program and adjust as needed.

To address the nutrient and sediment load reduction targets, MDE issued Prince George's County a permit that focused on treating untreated impervious surfaces. The County NPDES permit requires restoration to be reported as equivalent impervious acres as the main measurement of progress. The County will evaluate and analyze TMDL plans for necessary updates on a 5-year cycle, coinciding with the NPDES permit cycle. Depending on the impairment type, WIP adjustments could increase or decrease the timeline for milestones based on County regulatory priorities and community needs. WIP revisions will include new documented data, updated science, and modeling tools.

It will be important for the County, MDE, and watershed partners to work together to ensure successful ongoing implementation. Close coordination is especially valuable for adaptive management because of the possibility of unanticipated circumstances arising during WIP implementation. For example, the installed BMPs might remove significantly more or less than the amount of pollution expected. A natural disaster could affect the plan's implementation. And if BMPs are being implemented at a slower rate than is called for in the WIP, the adaptive management process will need to include a look at the causes of the lag in implementation and either address those causes or otherwise propose additional activities to compensate for the lag. Additional factors include the following.

- County factors: Budgets, restoration opportunities, and community buy-in on certain types of projects addressing environmental justice concerns.
- MDE factors: Approval of new technologies, models, tools, and science, which are continuously being developed and evolving.

Implementation lags can be caused by a lack of available land, delays in obtaining the necessary permits for constructing BMPs, being denied permission to build a BMP on private land, and lapses in funding. The County has a process to prevent many issues through initial project discussions and planning. Some implementation issues are not preventable (e.g., weather). In these cases, the County will work to develop contingency plans to keep watershed restoration on or ahead of schedule through adaptive management.

In addition, new BMP technologies are being researched that will help lower costs, decrease BMP footprints, and increase removal efficiencies. MDE and the Chesapeake Bay Program will need to approve the technologies and assign them removal efficiencies in a timely manner. In addition to having new BMP technologies approved, the County looks to MDE to continue issuing grant funding for stormwater restoration activities and to help perform water quality monitoring in high-priority County watersheds.

The County will evaluate the progress of this WIP implementation during its next permit cycle following this adaptive management approach. The evaluation will use an updated BMP inventory, new BMP technologies, experience with the new programmatic initiatives, and more recent water quality data. The evaluation could provide the County with the opportunity to remove practices from consideration that are expensive and show no water quality improvement. For this WIP, adaptive management will involve ongoing biological monitoring, evaluating applied strategies, assessing progress, and incorporating any useful new knowledge into further restoration activities.

Several aspects of this WIP support the use of adaptive management:

- Large portions of the County's inner Beltway development predate stormwater management regulation first established in the regulations in 1985 where greater than 85 percent of development already occurred. This makes watershed restoration challenging and costly, where the watershed needs to address upland BMPs to be installed, while also addressing stream erosion through armoring banks, thereby protecting impacted properties from further erosion. Adaptive management will be important to help these challenges so that this plan can undergo adjustments in the future.

- The County has a stormwater management ordinance that requires developers to install BMPs to offset the increased impervious area due to new construction.
- The County will use adaptive management to determine the most appropriate restoration practices at the best locations. This means that the County will look across land uses to determine where restoration projects will be most cost-effective in achieving pollutant load reductions. The County reserves the right to use alternative restoration activities if the opportunity arises and the alternative practices will produce greater load reductions or a similar load reduction at a lower cost.
- Part of the adaptive management strategy is to help reduce long-term costs while increasing load reduction. The County recognizes that future BMP-related research could result in new, more efficient pollution reduction technologies becoming available. These advances could decrease cost, decrease the footprints of the BMPs, or increase load reduction efficiencies. Some of the advances could come from proprietary technologies, which the County will evaluate based on their cost and performance.
- Using biological monitoring results, DoE can adjust implementation priorities and target areas of poor stream health. The biological assessment results will be interpreted at multiple spatial scales as Degraded/Not Degraded (for specific stream sites) and percent degradation (for sets of sites within subwatersheds and the watershed as a whole). The County will use these results as the principal indicator of stressor-reduction effectiveness. A lack of positive response will be taken as evidence that additional or more intensive stormwater management is necessary to achieve ecologically meaningful pollutant reductions.

In the future, climate change will play a role in watershed restoration and BMP implementation. The County is becoming more aware of the potential effects of climate change and its impact on BMPs. The EPA conducted a modeling study investigating the resilience of BMPs with the potential for more extreme precipitation events due to climate change (USEPA 2018). The study's results (*Improving the Resilience of Best Management Practices in a Changing Environment: Urban Stormwater Modeling Studies*) found that BMPs designed for current conditions will most likely fail to treat and reduce runoff from the larger and more intense storm events projected in future conditions. This failure could cause stormwater to overflow BMPs; thus, the BMPs would not treat all the runoff and would not reduce runoff volume reaching the County's water bodies. This could result in downstream channel erosion and flooding impacts. BMPs built with current design standards will require a larger temporary storage volume or reconfigured outlet structures to reduce the likelihood of flooding and channel erosion.

MDE is working to address flooding issues. In June 2021, the Stormwater Management Law was signed. This requires the MDE to perform several actions to help address flooding issues in the state. MDE is to collect and report the most recent precipitation data, investigate flooding events since 2000, and update the state's stormwater quantity management standards for flood control. MDE has started working with municipalities and will adopt new regulations in 2023. MDE is also creating a stormwater management climate change action plan with their *Advancing Stormwater Resiliency in Maryland (A-StoRM)* program. Climate change challenges will be handled through adaptive management and future assessments of WIP implementation.

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APPENDIX A: CURRENT STORMWATER MANAGEMENT PROGRAMS

A.1 Stormwater Specific Programs

As required under NPDES regulations, the County must operate an overall stormwater program that addresses six minimum control measures—public education and outreach, public participation/involvement, IDDE, construction site runoff control, post-construction runoff control, and pollution prevention/good housekeeping. To meet that requirement, the County administers various programs and initiatives, many of which have goals to help achieve pollution reductions in response to TMDL requirements. Stormwater-specific program initiatives are designed to reduce flow volumes and pollutant loads reaching surface waters by facilitating the implementation of practices to retain and infiltrate runoff. Stormwater-specific programs include the following:

- ***Stormwater Management Program (Capital Improvement Program [CIP] SWM Program).*** The SWM Program is responsible for performing detailed assessments of impairments to address stormwater management and existing water quality. It also is responsible for preparing design plans for and overseeing the construction of regional stormwater management facilities and water quality control projects. Those activities contribute to annual load reductions through improved planning and assessment and implementation of BMPs that reduce pollutant loading.
- ***Clean Water Partnership* (*CWP*).** The County recently initiated this program, which is a community-based public-private partnership, to assist in addressing the restoration requirements of the Chesapeake Bay WIP program. The CWP program initially focused on ROW runoff management in older communities, which are primarily inside the Capital Beltway. The program is expected to be responsible for providing water quality treatment for impervious land.
- ***Alternative Compliance Program.*** The Alternative Compliance Program, administered by DoE, allows tax-exempt religious and nonprofit organizations to receive reductions in their CWA Fee if they adopt stormwater management practices. The organizations have three options and can use any combination to receive the credits. The options are to (1) provide easements so the County can install BMPs on their property; (2) agree to take part in outreach and education encouraging others to participate in the Rain Check Rebate and Grant Program and create an environmental team for trash pickups, tree planting, recycling, planting rain gardens, and so forth; and (3) agree to use good housekeeping techniques to keep their lots clean and to use lawn management companies certified in the proper use of fertilizers.

- ***Rain Check Rebate and Grant Program.*** The Rain Check Rebate and Grant Program, administered by the DoE, allows property owners to receive rebates for installing County-approved stormwater management practices. It was established in 2012 through County Bill CB-40-2012 and implemented in 2013. The County will reimburse homeowners, businesses, and nonprofit entities (including housing cooperatives and places of worship) for some of the costs of installing practices covered by the program. Installing practices at the individual property level helps reduce the volume of stormwater runoff entering the storm drain system as well as the amount of pollutants in the runoff. In addition, property owners implementing these techniques through the program will reduce their CWA Fee if they maintain the practice for three years. Currently, rebates are capped at $6,000 for residential properties and $20,000 for nonprofit groups and residential, commercial, industrial, and institutional properties and nonprofit groups.

- ***Stormwater Stewardship Grant Program.*** Through the County's Stormwater Stewardship Grant Program, the Chesapeake Bay Trust currently funds requests for the construction of water quality improvement projects. The Trust also funds citizen engagement and behavior change projects implemented by various nonprofit groups, including homeowner associations (HOAs). Nonprofit organizations, municipalities, watershed organizations, education institutions, community associations, faith-based organizations, and civic groups can be awarded $50,000 to $150,000 for water quality projects and $50,000 to $100,000 for tree planting projects. Projects must complete on-the-ground restoration that will improve water quality and watershed health (reduction in loads of nutrients or sediment) or significantly engage members of the public in stormwater issues by promoting awareness and behavioral change.
- ***Countywide Green/Complete Streets Program.*** DPW&T initiated a countywide Green/Complete Streets Program in 2013 as a strategy for addressing mounting MS4 and TMDL treatment requirements. The program identifies opportunities to incorporate stormwater control measures, environmental enhancements, and community amenities into DPW&T's capital improvement projects. The types of projects that can contribute to pollutant load reductions include ESD practices, tree shading, alternative pavements, and landscape covers.
- ***Erosion and Sediment Control.*** MDE has assigned the responsibility for conducting erosion and sediment control enforcement to the County. For new developments, this responsibility is assigned to DPIE. It involves conducting site inspections and providing Responsible Personnel Certification courses, which educate construction site operators to conscientiously manage disturbed land areas commonly found at construction sites. These

control measures prevent excess sediment entering County water bodies from active construction sites.

- ***Street Sweeping.*** The County conducts street sweeping operations on select arterial, collector, and industrial roadways. Residential subdivisions are swept on a request-only basis. Street sweeping can reduce the amount of debris, including sediment, that reaches waterways.
- ***Litter Control.*** The County maintains an aggressive litter control and collection program along County-maintained roadways. The litter service schedule is based on historical collection data; therefore, the most highly littered roadways are serviced as often as 24 times per year.
- ***Storm Drain Maintenance: Inlet, Storm Drain, and Channel Cleaning.*** These are systematic water quality-based storm drain programs that provide routine inspections and cleanouts of targeted infrastructure with high sediment and trash accumulation rates. Municipal inspections of the storm drain system can be used to identify priority areas. DPW&T inspects and cleans major channels on a 3-year cycle. Additionally, the County performs storm drain vacuuming that removes sediments from the storm drain system.
- ***Storm Drain Stenciling.*** The Storm Drain Stenciling Program continues to raise community awareness and alert community members to the connection between storm drains and the Chesapeake Bay. The County uses Chesapeake Bay Trust funding to purchase the paint, tools, and stencils used by the volunteers to stencil the "Don't Dump—Chesapeake Bay Drainage" message. It is difficult to estimate the load reduction from storm drain stenciling; however, it is expected to help reduce pollutant loads to local water bodies.

- ***Illicit Connection and Enforcement Program.*** DoE conducts field screening and outfall sampling to detect and eliminate nonpermitted discharges from the County's MS4.

A.2 Tree Planting and Landscape Revitalization Programs

Significant hydrologic and water quality benefits accrue when localities convert urban land to forest. Tree planting typically occurs piecemeal across the urban landscape, whereas reforestation usually occurs on a much larger scale. In either case, to claim pollutant reduction credits from those plantings, a survival rate of 100 or more trees per acre is necessary, with at least 50 percent of the trees being 2 inches or more in diameter at 4.5 feet above ground level (MDE 2021a).

The pollutant load reduction credit for planting trees is based on the load difference when the land cover is converted from urban to forest. To qualify for the alternative credits for Reforestation on Pervious Urban Land, the County will need to demonstrate compliance with the credits criteria.

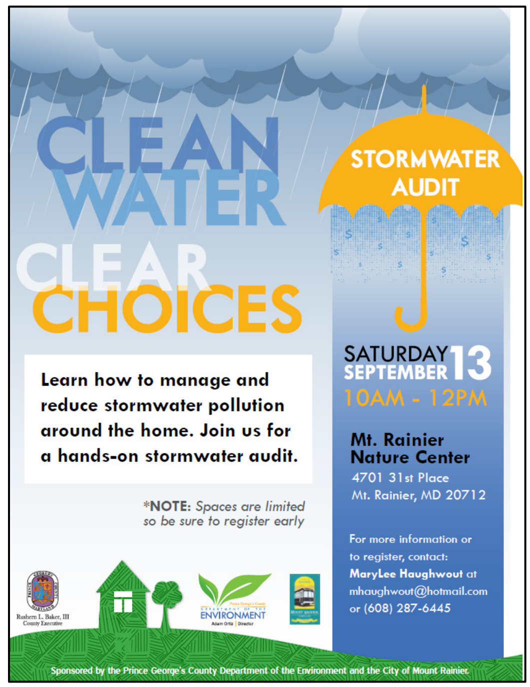
- ***Volunteer Tree Planting.*** DPW&T oversees volunteer tree planting in October of every year. Trees are planted by organizations (e.g., HOAs) in public spaces (e.g., parks and institutional areas). Approximately 2,000–2,500 trees are planted under the program every year.
- ***Tree ReLeaf Grant Program.*** DoE's Tree ReLeaf Grant Program is funded by fees-in-lieu; therefore, it only supports planting projects on public property. The program funds neighborhood, civic, and community/homeowner organizations; schools; libraries; and municipalities for tree and shrub planting projects in public spaces or common areas. The goals of the program include increasing the native tree canopy to improve air and water quality, conserve energy, and reduce stormwater runoff. Organizations can receive up to $5,000 under the program, and municipalities are eligible for grants up to $10,000.
- ***Neighborhood Design Center.*** The Neighborhood Design Center, a local nonprofit in Riverdale, is an important partner in many County initiatives. They furnish pro bono design and planning services to a wide variety of individuals, organizations, and low-to-moderate-income communities. Their goal is to involve the entire community in developing and implementing initiatives and projects designed to revitalize neighborhoods. The Neighborhood Design Center develops plans for parks, gardens, and community plantings, including wetland and rain gardens, reforestation projects, and median and shade tree plantings. Collectively, these efforts have increased the County's green space, reduced stormwater runoff, and improved water quality through the creation of natural systems to cleanse stormwater runoff.
- ***Arbor Day Every Day***. Arbor Day Every Day provides free trees to schools to plant and maintain on school grounds. This program educates students on the everyday importance of native trees, empowers them to enhance their community, and provides funds for planting projects.
- ***Tree Planting Demonstrations.*** The Sustainable Initiatives Division recently began a tree planting demonstration program to increase tree canopy and promote tree care.

A.3 Public Education Programs

DoE seeks every opportunity to promote environmental awareness, green initiatives, and community involvement to protect natural resources and promote clean and healthy communities. The County also integrates water quality outreach as a vital component of watershed restoration projects. At public outreach events, DoE staff provide handouts, answer questions, make presentations, promote programs, and display posters and real-world examples of stormwater pollution prevention materials (e.g., sample rain barrels and samples of permeable pavement). The County also has published a series of brochures to raise stormwater pollution awareness and educate the residential, business, and industrial sectors on their roles in preventing stormwater pollution. Topics include stormwater BMPs such as rain gardens, cisterns, and pavement removal.

Following are details about other County-administered outreach and education efforts that have the potential to reduce stormwater pollution through BMP implementation:

- ***Interactive Displays and Speakers for Community Meetings.*** County staff support multiple outreach events to provide presentations, displays, and handouts; answer questions; and promote environmental stewardship. At these events, County staff provide information on the importance of trees and tree planting, stormwater pollution prevention, lawn care, Bayscaping (replacing turf with plants native to the Chesapeake Bay region), and trash prevention and cleanup.
- ***Stormwater Audit Program.*** DoE conducts stormwater audits on residential properties. During the audits, County staff walk a property with the homeowner and make suggestions on the most appropriate types and potential locations for stormwater BMPs.



- ***Master Gardeners.*** Master Gardeners are volunteer educators who provide horticultural education services to individuals, groups/ institutions, and communities. The program's mission is to educate Maryland residents about safe, effective, and sustainable horticultural practices that build healthy gardens, landscapes, and communities. The program has the potential to aid the overall reduction of fertilizer and pesticide use as well as promote increases in stormwater practices such as installing rain gardens and using rain barrels.
- ***Flood Management.*** During June, DoE works to raise awareness of flood risks and what County residents can do to protect their homes, families, and personal belongings if flooding occurs. DoE incorporates messages encouraging residents to implement flood-prevention stormwater practices (e.g., BMPs), such as using permeable pavers and rain gardens to help prevent costly property damage caused by backyard flooding.

APPENDIX B: BMP REMOVAL EFFICACIES

MDE's *Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated* (MDE 2021a) incorporates recent Chesapeake Bay Program recommendations for sediment load reduction removal efficiencies associated with implementing BMPs. This information is incorporated into their TIPP Tool (MDE 2022d). By using those removal efficiencies in its reduction calculations, the County is consistent with regional efforts to meet the Chesapeake Bay TMDL.

Pollutant removal efficiencies were calculated by runoff depth treated and are provided in Table B-1. MDE (2021a) separates BMPs into three broad classes—runoff reduction (RR), stormwater treatment (ST), and alternative BMP practices (ALT). RR practices reduce pollutants through infiltration interception by vegetation and adsorption by soil (e.g., bioswales and permeable pavement). ST practices reduce pollutants through filtration or settling (e.g., sand filters and wet ponds). RR practices have a higher level of pollutant removal than ST practices because of their removal mechanisms. ALT practices are restoration activities such as stream restoration. For RR and ST practices, the removal efficiency increases as more runoff volume is treated. The table also illustrates that RR practices consistently reduce pollutant loads at a higher efficiency than structural practices at all treatment volumes. The RR curves should be used in locations where RR practices are used or other acceptable RR practices predominate. Otherwise, the ST practice curves should be used. If a BMP did not have a reported runoff depth treated, it was assumed to be 0.5 inches.

Table B-1. Pollutant removal rates for runoff reduction and structural practices.

Runoff Depth Treated (inches)	Total Nitrogen		Total Phosphorus		TSS	
	Runoff Reduction (%)	Structural Practices (%)	Runoff Reduction (%)	Structural Practices (%)	Runoff Reduction (%)	Structural Practices (%)
0.00	0%	0%	0%	0%	0%	0%
0.25	32%	19%	38%	29%	40%	37%
0.50	44%	26%	52%	41%	56%	52%
0.75	52%	30%	60%	47%	64%	60%
1.00	57%	33%	66%	52%	70%	66%
1.25	60%	35%	70%	55%	76%	71%
1.50	64%	37%	74%	58%	80%	74%
1.75	66%	39%	77%	61%	83%	77%
2.00	69%	40%	80%	63%	86%	80%
2.25	71%	41%	82%	65%	88%	83%
2.50	72%	42%	85%	66%	90%	85%

Source: MDE 2021a.

Typical RR practices include:

- Bioretention
- Bioswale

- Dry swale
- Dry well
- Enhanced filter
- Grass swale
- Green roof
- Landscape infiltration
- Micro-bioretention
- Permeable pavements
- Rain gardens
- Rainwater harvesting
- Reinforced turf
- Wet swale

Typical ST practices include:

- Extended detention–wetland
- Extended detention structure, wet
- Micro-pool extended detention pond
- Pocket pond
- Pocket wetland
- Retention pond (wet pond)
- Infiltration basin
- Infiltration trench
- Sand filter
- Shallow marsh
- Submerged gravel wetlands
- Underground filter

Table B-2 presents the pollutant reduction efficiency of several ALT practices, including stream restoration (for which the load reduction efficiencies are only for planning purposes). Once the stream restoration projects are installed, the County will use the approved protocols—based on design and field measurements—to determine their actual load reductions.

Table B-2. Pollutant removal efficiencies of selected alternative BMPs.

BMP Type	Units	TSS Removal
Stream restoration (planning only)	lb/ft/yr	248
Outfall stabilization (planning only)	lb/ft/yr	248
Shoreline management (planning only)	lb/ft/yr	328
Impervious surface reduction (imp. to turf)[a]	lb/ac/yr	3,590
Forest planting (turf to forest)[a]	lb/ac/yr	1,409
Street trees (imp. to tree canopy over imp.)[a]	lb/ac/yr	529
Urban tree canopy planting (turf to tree canopy over turf)[a]	lb/ac/yr	101
Riparian forest planting (turf to forest) [a]	lb/ac/yr	2,342

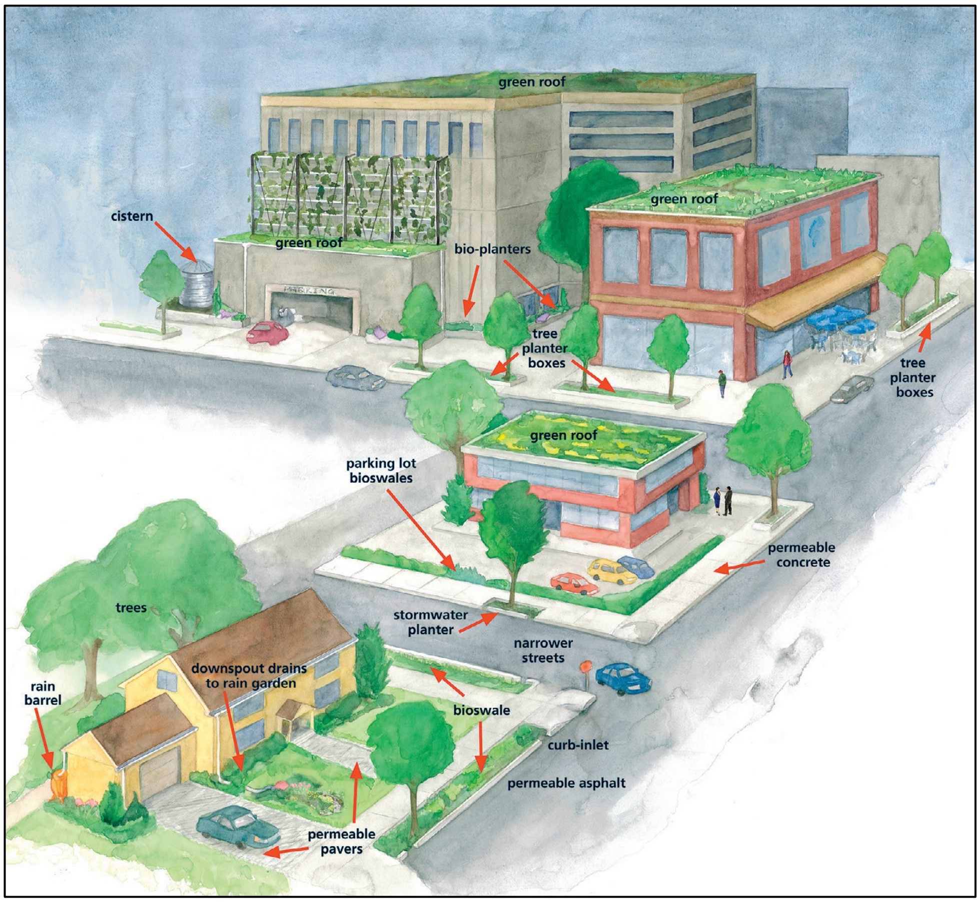
Source: MDE 2021a.
Notes:
lb/ac/yr = pound per acre per year; lb/ft/yr = pound per foot per year.
[a] Varies by major watershed based on land use loading rates.

Appendix C: BMP Identification and Selection

C.1 BMP Identification and Selection

The MDE 2000 *Stormwater Design Manual* provides guidance for designing several types of structural BMPs, which include wet ponds, wetlands, filtering practices, infiltration practices, and swales (MDE 2009). MDE also describes nonstructural BMPs that include programmatic, educational, and pollution prevention practices that work to reduce pollutant loadings. Examples of nonstructural BMPs include diverting stormwater from impervious to pervious areas, street sweeping, and homeowner and landowner education campaigns (MDE 2009). Additionally, the County will use the MDE's *Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated: Guidance for National Pollutant Discharge Elimination System Stormwater Permits* (MDE 2021a).

Figure C-1 presents conceptual art of an urban area with a variety of practices. It includes some practices not specifically mentioned in the plan, but that could be incorporated into the County's overall strategy.



Credit: EPA Office of Wetlands, Oceans and Watersheds.

Figure C-1. Conceptual urban area with ESD practices.

C.1.1 Urban Stream Restoration

Urban impacts on streams typically include bank and channel erosion, stream health degradation, and loss of natural habitat. Multiple techniques for restoring a stream can be used to mimic the natural state of the stream, provide stability to the channel bed and banks, and improve stream health and habitat in nontidal areas. Various kinds of in-stream structures can be used to restore the main channel by providing stable flow steering and energy dissipation as well as creating pools where natural habitats can develop. In addition to in-stream structures, the increase in riparian vegetation can help to stabilize stream banks, further reducing in-stream erosion in high-velocity areas. The County recently completed a major stream restoration project (7.7 miles) in the upper reaches of the Tinkers Creek subwatershed. This project removed 2,000 tons of sediment. The County is planning another 2.7 miles of stream restoration and outfall stabilization in the watershed, with an estimated sediment removal of over 1,500 tons.

C.1.2 Outfall Stabilization

Storm drainage systems in the County terminate at outfall structures that usually discharge to surface drainage features such as channels or streams. The outfall structures are often the initial source of stream erosion and degradation because they are the delivery point for the increased runoff from impervious areas. As the stream channel erodes and downcuts, it often undercuts the outfall structure, resulting in outlet failure. Outfall stabilization typically involves repairing localized areas of erosion below a storm drainpipe and addressing structural and functional problems associated with exposed infrastructure. Because the failing outfalls actively contribute to stream erosion and sediment generation, they present many restoration opportunities. Many outfalls have been in place for 50 years, and the County should inspect and prioritize old and failing previously installed outfalls to prevent sediment releases in the watershed. As part of their regular maintenance, the DPW&T storm drain division inspects and evaluates outfalls to determine their condition for potential improvements and repairs.

C.1.3 Structural Practices

The County will consider opportunities to implement BMPs on all types of land uses, wherever there is a need to provide treatment to currently untreated impervious surfaces. Some BMPs are better suited to certain land uses than others, and this section discusses examples of those land uses and their primary corresponding but nonexclusive BMPs. The County will also look for BMPs upstream from the ongoing stream restoration project to help reduce flow and future erosion in the restored stream.

C.1.3.1 Rights-of-Way

The County owns and maintains ROWs, which are public space along streets and roadways. They contribute to the impervious runoff impact and represent a high-priority area for restoration and will be a major focus of the County watershed restoration efforts. If opportunities to implement BMPs in ROW areas present themselves, possible retrofits for different types of ROW are available (Table C-1).

Table C-1. Potential BMP types per urban road ROW grouping.

Potential BMP	Urban Open Section with No Sidewalk	Urban Closed Section with Curb and Gutter but No Sidewalk	Urban Closed Section with Curb, Gutter, and Sidewalk	Suburban Open Section with No Curb, Gutter, or Sidewalk	Suburban Closed Section with Curb, Gutter, and Sidewalk
Permeable pavement or sidewalks	X	X	X	X	X
Curbside filter systems		X	X		X
Curb extension with bioretention or bioswale		X	X		X
Curb cuts to underground storage/infiltration or detention device		X	X		X

Potential BMP	Urban Open Section with No Sidewalk	Urban Closed Section with Curb and Gutter but No Sidewalk	Urban Closed Section with Curb, Gutter, and Sidewalk	Suburban Open Section with No Curb, Gutter, or Sidewalk	Suburban Closed Section with Curb, Gutter, and Sidewalk
Grass swales and bioswales				X	
Green street (bioretention or bioswales) to convert an ROW				X	X
Infiltration trenches with underdrains				X	

C.1.3.2 Institutional Land Use

Existing institutional land uses also offer opportunities for BMP retrofits. The land uses include County and nonprofit organization properties such as schools, libraries, places of worship, parks, government buildings, fire and police stations, and hospitals. The County has implemented the Alternative Compliance Program, administered by DoE, which allows nonprofit organization property owners to reduce their CWA Fee by installing approved stormwater management practices. Most of the properties have substantial areas of impervious cover, including rooftops, driveways, and parking areas, that offer opportunities for cost-effective retrofits. A BMP retrofit matrix can be applied to these sites based on impervious cover type (Table C-2). The retrofit matrix will help in the selection process and identify practical and feasible practices that offer the highest pollutant removal at the lowest cost.

Table C-2. Typical impervious area BMP retrofit matrix for institutional property.

BMP Description	Impervious Cover Elements				
	Roofs	Driveways	Parking	Sidewalks	Other[a]
RR practices					
Permeable pavements		X	X	X	X
Rainwater harvesting	X				
Submerged gravel wetlands			X		
Landscape infiltration	X	X	X		X
Dry wells	X				
Bioretention / rain gardens / swales		X	X		X
Enhanced filters	X	X	X	X	X
ST practices					
Wet ponds/wetlands			X		X
Infiltration practices[b]			X		X
Filtering practices		X	X	X	X
Tree planting and reforestation					
Impervious urban to pervious		X	X		X
Planting trees on impervious urban		X	X		X
Other					
Disconnection of rooftop runoff	X				

BMP Description	Impervious Cover Elements				
	Roofs	Driveways	Parking	Sidewalks	Other[a]
Disconnection of non-rooftop runoff		X	X	X	X
Sheet flow to conservation areas		X	X		

Notes:
[a] Includes miscellaneous other impervious surfaces (e.g., basketball courts, tennis courts, patios).
[b] Considered ST unless designed according to Section VI of MDE 2021a.

C.1.3.3 Commercial/Industrial Land Use

Much like institutional properties, commercial and industrial properties are characterized by large areas of impervious cover, including roofs, driveways, parking lots, and other paved areas. From a technical standpoint, the opportunities for implementing a variety of BMPs in those areas are similar to the opportunities in institutional areas (Table C-2). However, most of the commercial and industrial facilities are privately owned. Consequently, the County has limited influence on the use of BMPs in those areas except along the public roads that serve them. The Rain Check Program currently offers financial incentives for property owners to implement approved stormwater management practices. Property owners can benefit through rebates, grants, or a reduction in a portion of their CWA Fee.

C.1.3.4 Residential Land Use

Residential areas comprise roughly 31 percent of the watershed and have varying amounts of impervious cover, such as roofs, driveways, walkways, and patios. Many of the practices in Table C-2 can be used on residential land. The most common practices for individual homeowners are permeable pavement, rooftop disconnection, rainwater harvesting (e.g., rain barrels), landscape infiltration, rain gardens, and planting trees. For row houses, the most common practices are likely permeable pavement (on sidewalks leading to houses and alleyways), rooftop disconnection, rainwater harvesting (e.g., rain barrels), and rain gardens. Apartment and condominium communities could install any of the practices listed in Table C-2.

It is difficult to implement BMPs on residential properties, however, because they are privately owned. As with commercial and industrial property owners, the Rain Check Program offers financial incentives for residential property owners to implement approved stormwater management practices. Additionally, the County could explore opportunities to provide further education and awareness outreach on residential BMPs to help property owners learn about their benefits.

C.2 Prioritizing BMP Locations

The location of a BMP or other restoration practice significantly impacts how successful the restoration will be. For instance, a lawn care campaign will have little effect in areas with few homeowners to implement the strategy. In identifying the best locations for BMPs, the County will consider sites where the most significant water quality benefits will be realized for available funding, and the BMPs can be installed in a desirable time frame with minimal disruption. Three main considerations for prioritizing BMP locations are land ownership and site access, location in the stream watershed, and locations of known issues and existing treatment.

C.2.1 Land Ownership and Site Access

DoE and CWP are actively installing BMPs countywide. The most suitable locations to install BMP practices are municipally owned land such as town halls, police stations, public schools, libraries, and the ROWs or easements along roads and stormwater outfalls. For example, the County has site access to stormwater outfalls (usually available as flood easements), which allows the County to proceed without the delays that would sometimes result from negotiating with private landowners—this accelerates implementation and reduces the resources spent on interacting with landowners.

In some instances, the County is granted permission from a property owner to install a BMP on their property. For example, the County's Alternative Compliance Program provides incentives to faith-based and other nonprofit organizations to allow the County to install BMPs on their properties. The organizations are granted credit toward their CWA Fee. The aesthetics of a restoration project are often preferred to the condition of the site before the BMP was installed. Attractive examples of watershed restoration efforts can be used in an outreach effort to encourage property owners to grant access to their own properties. A public education campaign highlighting those examples can build public support for implementing BMPs on private properties.

C.2.2 Location in the Watershed

Another factor to consider in BMP placement is how close the location is to the stream headwaters. Improvements to water quality and stream stability in stream headwaters will provide benefits along the entire length of the stream. Restoring downstream reaches first, on the other hand, will later expose the restored reaches to sediment from upstream, increasing the risk that the restored channel will fail because of the fresh sediment deposits. Water quality improvement projects that address excess sediment from stream erosion are most appropriately placed in smaller headwater (first- and second-order) subwatersheds. Adding BMPs to headwaters above stream restoration projects will help protect the stream reaches that have been restored. Restoring conditions in the headwaters makes it easier to detect and attribute the water quality improvements to each restoration project because the complexity of factors that could be affecting water quality tends to decrease with drainage area.

C.2.3 Locations of Known Issues and Existing Treatment

A third key consideration in determining where to place BMPs includes identifying known areas of erosion and poor biological health and locating treatment practices that are in place but still need to be adequately implemented. Figure 3-7 shows the biological narrative ratings for the watershed. The contributing drainage areas to locations that were rated as Poor or Very Poor should be targeted for upland restoration. Appendix F presents the results of geomorphic assessments in the watershed. This information can be used in combination with the information from Figure 3-13, which presents the known stream and outfall erosion areas. These locations can be targeted for stream restoration, outfall stabilization, and upland measures to reduce the amount of flow (and sediment) entering the stream.

APPENDIX D: FUNDING

D.1 Budget Funding

Funding refers to sources of revenue used to pay for annual operating expenditures, including maintenance and administrative costs; pay for management activities directly out of current revenues; and repay debt issued to finance capital improvements projects.

D.1.1 Sources of Funding

The County has relied mainly on stormwater bonds, general obligation bonds, federal and state grants, and the State Revolving Fund to pay for the stormwater CIP, including watershed restoration projects. The County's Stormwater Enterprise Fund pays for debt service on the bond sales and agency operating costs.

In 2013, the County enacted a CWA Fee that provides a dedicated revenue source for addressing stormwater runoff and improving water quality for regulatory mandates such as the Chesapeake Bay WIP, TMDL WIPs, and the NPDES MS4 permit (independent of the ad valorem tax and General Fund). The CWA Fee is based on a property's assessed impervious surface coverage and provides a mechanism to equitably allocate the fee based on a property's stormwater contribution. Thus, each property contributes a fair and equitable share toward the overall cost of improving water quality and mitigating the impact of stormwater runoff. The fee collects roughly $14 million of dedicated funding annually. Depending on the rate of restoration activities completed by the CWP and County CIP efforts, the County might reevaluate funding options in the future.

Most stormwater restoration funds are from the CWA Fee, stormwater ad valorem tax, and CIP budget. Federal, state, or other grants are expected to provide a minor but essential contribution to funding. The ad valorem tax is based on property assessment, which will vary annually, and supports the DPIE's development process and DPW&Ts long-term stormwater management maintenance program. The County has successfully obtained various grants in the past and expects that trend to continue. The County will continue to pursue grant opportunities available for restoration projects. In addition to grants, federal and state loans (e.g., State Revolving Fund) might be an option for helping to fund part of the TMDL restoration process. In addition, the County encourages government entities (e.g., municipalities) and private organizations (e.g., watershed groups and nonprofits) to identify and apply for grant opportunities.

The County expects current Stormwater Enterprise Fund sources and funding levels to remain consistent with the County's biannual FAP, expected to reoccur over the life of this WIP. The countywide dollars for restoration average no more than $70 million per year for all stormwater restoration. The available funding will need to compete across multiple local WIPs, including the Chesapeake Bay WIP; however, many of the activities in the WIP can be counted toward local WIPs. As part of its NDPES permit requirements, the County updates and submits its 2-year FAP to MDE for review. The FAP includes planned restoration projects of 5-year periods and the funding commitment for the next two fiscal years. The most recent plan approved by County Resolution is for FY 2021 and FY 2022. The County has created a new FAP for FY 2022 and FY 2023, which will be approved in spring 2023.

D.1.2 Budget for Restoration Activities

The stormwater CIP contains project construction budget projections for the next six years for the entire county. For countywide watershed or water quality restoration projects, the County primarily relies on two CIP projects: the CWP Project and NPDES MS4 Permit Compliance and Restoration. Other stormwater CIP projects include funding appropriation for restoration activities.

Table D-1 provides a list of countywide stormwater CIP projects included in the County's FAP that include aspects of watershed restoration, a portion of which are available for projects in the Anacostia River watershed. The projects generally fund new watershed restoration activities or rehabilitation of existing assets to improve water quality. Specific watershed restoration projects or locations are not listed. However, the County maintains a project list that is used to determine the proposed funding. Once this WIP is completed, the County will start incorporating proposed restoration scenarios subject to funding availability.

The County's stormwater CIP budget has, in the past, appropriated up to $50 million per year for countywide watershed or water quality restoration activities. For current funding capacities, the County typically prioritizes programs and shifts funding between watersheds. By doing so, the County can prioritize and shift year-to-year load reduction goals between watersheds; however, the County aims to achieve the targeted completion dates.

Table D-1. FY 2023 to FY 2028 FAP budget for countywide stormwater management projects.

CIP ID	Project Name	Project Class	Total FY23–FY28 Budget ($000)
5.54.0016	Bear Branch Subwatershed	Rehabilitation	$7,439
5.54.0018	Clean Water Partnership NPDES/MS4	Rehabilitation	$99,961
5.54.0019	MS4/NDPES Compliance & Restoration	Rehabilitation	$115,351
5.54.0006	Participation Program Countywide	New construction	$3,000
5.66.0002	Stormwater Management Countywide Restoration	Rehabilitation	$47,138
5.66.0004	Stormwater Structure Restoration and Construction	New construction	$45,500

Source: Prince George's County 2022.
Note: $000 = Dollars in thousands.

APPENDIX E: PUBLIC OUTREACH AND INVOLVEMENT

The County recognizes that involving the public in planning and implementing restoration is important to the success of its stormwater management efforts. It welcomes any ideas citizens have to improve the restoration process, recognizing that the people who live and work in the watersheds are most familiar with them. They can act as the eyes and ears of the County on a day-to-day basis to identify water quality issues, pollutant spills, or potential BMP opportunities. Residents can stay informed on the County's progress through the annual MS4 report to MDE, which is posted on the County's website and contains information on BMP implementation, public outreach events, and other County programs that can help meet TMDL goals. In addition, the County welcomes public input on restoration activities and potential BMP types or locations.

Besides staying informed, homeowners, nonprofit organizations, and business associations can play a more active role in the restoration process. Residents can take a pledge to clean up after their pets and practice environmentally friendly lawn care. In addition, the public can participate in the Rain Check Rebate and Tree ReLEAF Grant Programs and nonprofits can participate in the Alternative Compliance Program. Private landowners and nonprofit organizations can aid in restoring the watersheds by installing BMPs (e.g., rain barrels, rain gardens, permeable pavement) on their properties to help minimize their impact on the overall pollution loading to the County's water bodies. Installing BMPs on private property reduces the owner's CWA Fee. Although those practices might seem insignificant, the overall load reductions can be significant if enough private landowners get involved. Organizations such as HOAs, neighborhood associations, and business organizations can also help by promoting the programmatic initiatives outlined in this WIP.

DoE has initiated a wide range of initiatives to inform County residents about the impacts their daily activities have on the health of their watershed and local water bodies. During FY 2019, the County hosted more than 500 events to promote environmental awareness, green initiatives, and community involvement in reducing the amount of pollution entering the County's waterways, during which nearly 33,000 members of the public participated (DoE 2019). DoE's outreach and educational programs encourage volunteerism and environmental stewardship among community organizations, businesses, and citizens. Under DoE's Sustainability Division, the Natural Resource Protection & Stewardship Programs Section (Programs Section) is the lead office managing and administering most of the education and outreach initiatives described in this section.

Current outreach programs are discussed in Appendix A. Beyond those targeted efforts, the County will work with watershed partners to ensure the public is informed of implementation progress and that active public involvement is pursued throughout the process.

E.1 Outreach to Support Implementation Activities

The County's outreach efforts continue to specifically target TMDL pollutants and pollutant-generating behaviors. Over the past several years, the Programs Section has sponsored the following activities and projects to target TMDL pollutants and encourage the adoption of pollutant-reducing behaviors:

- ***Inventory of Environmental Outreach Programs in and around Prince George's County***. The Programs Section inventoried existing local programs (e.g., nonprofits and educational institutions) that are working toward shared goals of environmental stewardship or stormwater pollution reduction and already have ongoing or planned outreach efforts in and around the County. This was done to identify potential outside partners and overlapping programs/efforts. The Programs Section researched which programs and materials have been successful and are available to share and cross-market to target audiences.
- ***Audience Research Analysis: A Review of Target Audience Characteristics in Prince George's County for a Stormwater Outreach Strategy.*** The County is made up of a diverse population in terms of age, race, culture, language, education, and income. As a result, the Programs Section analyzed U.S. Census data and secondary research to gain an understanding of the potential target audiences and their specific characteristics as well as possible barriers to environmental messages (e.g., lack of homeownership, native language, age, household economics). This analysis helped determine the best way to reach diverse groups and identify different messaging and methods that would resonate with target audiences.
- ***Priority Watersheds Analysis***. The County has nine major watersheds, each with different water quality concerns. The Programs Section identified location-specific outreach needs based on water quality priorities and areas where the County should target its outreach efforts. Coupled with the Audience Research Analysis, this analysis recommended target locations and audiences for developing topic-specific outreach campaigns (e.g., pet waste and lawn care).
- ***Prince George's County Stormwater Outreach and Engagement Strategies***. The Programs Section developed seven individual campaign strategies: pet waste disposal, increasing the tree canopy, stormwater management and implementation, antilittering, lawn stewardship, household hazardous waste, and residential car care. Each campaign included goals, target audiences, priority locations, key messages, delivery techniques (e.g., events, materials, trainings, social media, developing and promoting programs), metrics, potential partnerships, and priority neighborhoods. The campaigns also included slogans and messages on what citizens should be doing (e.g., using fertilizer only if soil tests dictate a need) and not be doing (e.g., spilling fertilizer on driveways). The Programs Section is using these outreach and engagement strategies to plan and implement programs, events, and other efforts to encourage residents to adopt pollutant-reducing behaviors.
- ***Enhancing and Growing Partnerships***. The County's numerous partnerships with groups such as Master Gardeners, Chesapeake Bay Trust, and the University of Maryland Environmental Finance Center continue to be fostered and supported so that outreach efforts piggybacking on the efforts undertaken by those groups can continue to grow. In addition, new partnerships with groups such as landscapers, nursery suppliers, HOAs, and local boy scout or girl scout groups help broaden stormwater outreach and reach citizens who have not been reached in the past.

Although the results of outreach and involvement efforts are difficult to quantify in terms of pollutant reductions, these activities make a difference by slowly changing the mindsets and behaviors of County residents over time.

E.2 Public Involvement to Support Implementation Activities

Community organizations and citizen groups can participate in restoration activities by getting involved in local nonprofit groups with which the County is currently partnering. This section lists ways County residents and organizations can stay informed and help promote pollutant-reducing behaviors. These activities will also reduce the demand on the County's resources and staff's limited time.

- **Learn about County programs that promote tree plantings, cleanup events, and community awareness**. The Programs Section manages numerous programs in which citizens can get involved and promote pollutant-reducing behaviors. Residents can either organize or participate in volunteer efforts by working with their civic associations or schools or one-on-one with property owners. The public can visit the Community Outreach web page at https://www.princegeorgescountymd.gov/departments-offices/environment/sustainability/community-outreach for more information on the Programs Section programs and how to contact the County. Appendix A for details about the County's tree planting and landscape revitalization programs. Other volunteer programs included:
  - **Volunteer Neighborhood Cleanup Program** provides interested communities with technical assistance and materials such as trash bags, gloves, and roll-off containers (depending on availability). The public can visit the website at https://www.princegeorgescountymd.gov/464/Volunteer-Neighborhood-Cleanup-Program.
  - **Volunteer Storm Drain Stenciling Program** helps spread the word to prevent water pollution by stenciling/inlet marking the storm drains in neighborhoods with "Don't Dump – Chesapeake Bay Drainage." Stenciling serves as a visual reminder to neighbors that anything dumped in the storm drain contaminates the Chesapeake Bay. The Programs Section provides the supplies and helps design a storm drain stenciling/inlet marking project that can be accomplished with any size team or age group at https://www.princegeorgescountymd.gov/how-do-i/sign/drain-stenciling-program.
- **Apply for grants to implement projects through the Chesapeake Bay Trust**, which manages the Rain Check Rebate and Stormwater Stewardship programs as well as the Litter Reduction and Citizen Engagement Mini Grant. See Appendix A for details on the Rain Check Rebate and Stormwater Stewardship programs. The public can find more information about the grants at https://cbtrust.org/grants/.
  - **Litter Reduction and Citizen Engagement Mini Grants** support efforts that engage and educate residents, students, and businesses on ways to make their communities cleaner and greener. Up to $2,500 can be awarded to HOAs and nonprofits to develop and implement projects such as community cleanups, "Adopt-a-Stream" projects to remove litter from a local stream, and storm drain stenciling.
- **Stay informed**. The County provides numerous ways for residents to stay informed about community events, trainings, emergencies, and County news:
  - **Monitor the County's social media accounts** to become aware of trainings and community events that promote environmental education and include opportunities to provide feedback to the County. See the County's accounts at Facebook (PGC

Department of the Environment), Twitter (PGC Environment @PGCsprout), and Instagram (pgcsprout).

  - **Monitor the County's website** to view information about upcoming events, meetings, recent news, and details about the County's programs at https://www.princegeorgescountymd.gov/.
  - **Sign up to receive "Alert Prince George's"** to receive emergency alerts, notifications, and updates to registered devices. Example notifications include traffic conditions, government closures, public safety incidents, and severe weather. More information is available at http://www.princegeorgescountymd.gov/794/Alert-Prince-Georges.

- **View the Clean Water Map,** an interactive tool to help the community stay informed about the health of County waters and know where restoration efforts are taking place. Residents can view BMPs, BMP drainage areas, and locations of activities such as Rain Check Rebates and Stormwater Stewardship Grants at https://princegeorges.maps.arcgis.com/apps/webappviewer/index.html?id=dc168a43d3554905b4e4d6e61799025f.
- **Provide feedback**. The County heard through numerous outreach and engagement events that several citizens and watershed groups want to provide information and feedback about on-the-ground support for BMP implementation projects, programmatic initiatives, and other outreach efforts to support implementation. Ways to provide this feedback include:
  - **Attend a public involvement meeting.** The County holds public outreach and involvement meetings as part of restoration planning efforts and other programs. At these meetings, residents can suggest specific locations for biological or water quality monitoring activities to be carried out based on surrounding land uses/ changes, historical water quality problems, or public desires. The County also welcomes suggestions on potential BMP types or locations so that the County can help communities identify and install the best BMPs for specific areas.
  - **Use County Click 3-1-1.** A call center (available weekdays from 7 a.m. to 7 p.m.) and website application (download CountyClick311Mobile) allow County residents to request services or report problems. This tool could be used to report on visual inspections of installed BMPs and is available at www.countyclick311.com.
- **Help foster partnerships.** Residents and civic and environmental groups can work directly with an organization or commercial business with a significant amount of untreated impervious surface, such as large parking lots or a large building footprint. The groups can help obtain a commitment from the business to participate in the Rain Check Rebate Program or Alternative Compliance Program, or they can install stormwater BMPs on the property. Group members can offer technical assistance and volunteer labor hours to support installation and/or maintenance. The participating civic or environmental group should discuss the selected location and BMP type with the County before working with the property owner. Groups can also work with established organizations such as the Alice Ferguson Foundation (https://fergusonfoundation.org/) to participate in cleanup events or provide volunteer hours.
- **Become educated through partner trainings and events**. Numerous organizations in Prince George's County always need volunteers. They also provide meaningful education

programs in which participants learn about the issues through hands-on educational experiences. Those organizations include:

- **Watershed Stewards Academy** equips and supports community leaders to recognize and address local pollution problems in their nearby streams and rivers. They provide community leaders with the tools and resources they need to bring solutions to those problems, restoring their local waterways and the communities they affect. More information is available at http://extension.umd.edu/programs/environment-natural-resources/program-areas/watershed-protection-and-restoration-program/watershed-stewards-academy/.
- **Alice Ferguson Foundation** has training and outreach events to unite students, educators, park rangers, communities, regional organizations, and government agencies throughout the Washington, DC, metropolitan area to promote the environmental sustainability of the Potomac River watershed. More information is available at https://fergusonfoundation.org/.
- **Anacostia Watershed Society** has numerous educational programs, river restoration programs, and community events. More information is available at https://www.anacostiaws.org/.

APPENDIX F: GEOMORPHIC CROSS SECTION ASSESSMENT

F.1 Geomorphic Assessment Results

Table F-1. Results of geomorphic assessments for site 05-001 and 05-001A on Paint Branch

Site ID	05-001		05-001A	
Year	2001	2020	2004	2020
Entrenchment ratio	2.8	1.5	3.8	1.5
Width:depth ratio	23	31.7	17.5	22.5
Sinuosity	1.04	1.04	1.03	1.03
Slope	0.16	0.16	0.42	0.42
Median substrate particle size (D50)	23.4	17.6	22.9	28
Rosgen classification	C4	F4	C4	F4
Bankfull XSa (ft^2)	225.2	276.5	160	209.5
Bankfull XSa difference (ft^2)	51.3		49.5	
Full XSa (ft^2)	225.2	460.6	313.6	433.7
Full XSa difference (ft^2)	235.4		120.1	
Sed. yield (tons/year)	0.77		0.47	

Note:
ft^2 = square feet; XSa = Stream channel cross-sectional area.

Table F-2. Results of geomorphic assessments for site 05-019B, 05-019C, 05-019D, 05-027 and 05-027A on Little Paint Br.

Site ID	**05-019B**		**05-019C**			**05-019D**		**05-027**		**05-027A**	
Year	**2001**	**2020**	**2001**	**2004**	**2020**	**2004**	**2020**	**2001**	**2020**	**2004**	**2020**
Entrenchment ratio	2.9	2.8	1.7	2.7	1.7	2.9	3.2	5.3	4.2	5.9	4
Width:depth ratio	16	15	24.7	25.6	10.5	14.2	43.4	11.6	14.4	10.2	15.9
Sinuosity	1.06	1.06	1.1	1.1	1.1	1.11	1.11	1.1	1.1	1.1	1.1
Slope	0.7	0.7	0.44	0.44	0.44	0.61	0.61	0.31	0.31	0.4	0.4
Median substrate particle size (D50)	12.7	25.1	43.1	52.3	35.8	20.6	21.8	9.14	28	16	29.7
Rosgen classification	C4	C4	B4	C4	G4c	C4	C4	E4	C4	E4	C4
Bankfull XSa (ft^2)	73	87.8	115.8	121.8	88.6	84.6	87.4	68	87.8	62.8	88.3
Bankfull Xsa difference (ft^2)		14.8		6	-27.6		2.8		19.8		25.5
Full XSa (ft^2)	138	304.2	257.4	121.8	141.1	116.6	139.3	84.2	171.9	96.7	245.6
Full XSa difference (ft^2)		144.1		-135.6	-116.3		22.7		87.7		148.9
Sed. yield (tons/yr.)		0.47		-2.83	-0.38		0.09		0.29		0.58

Note:
ft^2 = square feet; XSa = Stream channel cross-sectional area.

Table F-3. Results of geomorphic assessments for site 07-011, 07-015A, 07-028, 07-035 and 07-038 on Indian Creek.

Site ID	07-011		07-015A		07-028		07-035			07-038	
Year	2005	2020	2004	2020	2003	2020	2003	2004	2020	2003	2020
Entrenchment ratio	5.2	2.3	2.9	3.6	2.7	3.1	1.9	3.5	1.7	3.2	2.2
Width:depth ratio	10.5	11.2	17	14.9	6.3	11	9.5	9.1	12.1	13.3	52
Sinuosity	1.04	1.04	1.08	1.08	1.05	1.05	1.12	1.12	1.12	1.11	1.11
Slope	0.34	0.34	0.32	0.32	1.3	1.3	0.3	0.3	0.3	0.41	0.41
Median substrate particle size (D50)	0.97	0.3	1.83	0.25	0.0625	23.5	0.203	0.104	0.5	0.75	8.7
Rosgen classification	E5	E5	C5	C5	E6	E4	G5c	E5	B5c	C5	C4
Bankfull XSa (ft^2)	35.1	21.3	68.8	50.9	5.7	23.9	14.2	14.6	15	17.9	39.3
Bankfull Xsa difference (ft^2)		-13.8		-17.9		18.2		0.4	0.8		21.4
Full XSa (ft^2)	43.9	44.7	84.5	53.1	5.7	29.5	23.4	20.7	39.1	17.9	39.3
Full XSa difference (ft^2)		0.08		-31.4		23.8		-2.7	15.7		21.4
Sed. yield (tons/yr.)		0		-0.12		0.09		-0.17	0.06		0.08

Note:
ft^2 = square feet; XSa = Stream channel cross-sectional area.

Table F-4. Results of geomorphic assessments for site 08-001, 08-001B, 08-003, 08-014 and 08-016 on Upper Beaverdam Creek.

Site ID	08-001		08-001B		08-003		08-014			08-016	
Year	**2000**	**2020**	**2004**	**2020**	**2004**	**2020**	**2000**	**2004**	**2020**	**2004**	**2020**
Entrenchment ratio	4.8	7.1	6.8	3.4	3.4	1.2	5.12	1.6	5.2	1.4	4.5
Width:depth ratio	8.7	13.5	4.9	14.9	39.7	29	13.2	14.5	11.1	14.6	5.4
Sinuosity	1.01	1.01	1.01	1.01	1.1	1.1	1.1	1.1	1.1	1.06	1.06
Slope	1	1	1	1	2	2	0.2	0.2	0.2	0.5	0.5
Median substrate particle size (D50)	0.2	1.5	0.714	1.864	0.0625	0.125	0.173	0.148	0.327	0.27	0.0625
Rosgen classification	E5	C5	E5	C5	C6	F5b	C5	B5c	E5	F5	E6
Bankfull XSa (ft²)	49.4	58.9	44.9	57.8	27.6	30.8	29.1	40.3	32.8	19.4	90.4
Bankfull Xsa difference (ft²)		9.5		12.9		3.2		11.2	3.7		71
Full XSa (ft²)	74.2	80.7	78.9	121.6	72	167	76.1	141.5	60	49.7	90.4
Full XSa difference (ft²)		6.5		42.7		95		65.4	-16.1		40.7
Sed. yield (tons/yr.)		0.02		0.17		0.37		1.02	-0.05		0.16

Note:
ft² = square feet; XSa = Stream channel cross-sectional area.

Table F-5. Results of geomorphic assessments for site 08-018, 08-035A, 08-035B, 08-039, 08-044 and 08-046A on Upper Beaverdam Creek.

Site ID	08-018		08-035A		08-035B		08-039		08-044		08-046A	
Year	2000	2020	2000	2020	2004	2020	2000	2020	2000	2020	2004	2020
Entrenchment ratio	1.4	1.2	4.7	3.3	3.6	3.3	2.8	2.5	1.3	2.4	4.6	5.5
Width:depth ratio	13.4	10.2	11.2	19.2	6.8	16.7	28.7	13.6	10.6	10.6	13.7	6.3
Sinuosity	1.08	1.08	1.21	1.21	1.16	1.16	1.2	1.2	1.2	1.2	1.2	1.2
Slope	1.4	1.4	0.4	0.4	0.2	0.2	1.1	1.1	1.5	1.5	0.2	0.2
Median substrate particle size (D50)	0.104	0.0625	0.388	1.086	0.347	1.179	0.092	0.512	0.273	8	0.367	1.3
Rosgen classification	F5	G6c	E5	C5	E5	C5	C6	C5	G5c	E4	C5	E5
Bankfull XSa (ft^2)	11.2	21.3	40.1	47.1	40.6	54.2	10.9	11.7	16.5	27	35.1	52
Bankfull Xsa difference (ft^2)	10.1		7		13.6		0.8		10.5		16.9	
Full XSa (ft^2)	40.7	64.6	67.3	73.6	80.2	54.2	11.4	14.3	44.9	66.1	64.7	58.9
Full XSa difference (ft^2)	23.9		6.3		-26		2.9		21.2		-5.8	
Sed. yield (tons/yr.)	0.07		0.02		-0.1		0.01		0.07		-0.02	

Note:
ft^2 = square feet; XSa = Stream channel cross-sectional area.

Table F-6. Results of geomorphic assessments for site 08-022 and 08-065A on Beck Branch.

Site ID	08-022		08-065A	
Year	2000	2020	2004	2020
Entrenchment ratio	3.1	3.7	1.4	1.1
Width:depth ratio	8.9	7.5	34.3	9.4
Sinuosity	1.01	1.01	1.12	1.12
Slope	0.3	0.3	0.2	0.2
Median substrate particle size (D50)	0.206	0.121	0.381	0.198
Rosgen classification	E5	E5	F5	G5c
Bankfull XSa (ft^2)	12.8	13.7	25.8	19.8
Bankfull Xsa difference (ft^2)	0.9		-6	
Full XSa (ft^2)	12.8	27.3	89.7	45.4
Full XSa difference (ft^2)	14.5		-44.3	
Sed. yield (tons/yr.)	0.05		-0.17	

Note:
ft^2 = square feet; XSa = Stream channel cross-sectional area.

Table F-7. Results of geomorphic assessments for site 09-005 and 09-009 on NWB.

Site ID	09-005		09-009	
Year	2004	2020	2004	2020
Entrenchment ratio	1.3	1.6	1.4	1.6
Width:depth ratio	15.8	24.1	13.6	8.8
Sinuosity	1.04	1.04	1.12	1.12
Slope	0.5	0.5	0.4	0.4
Median substrate particle size (D50)	36.85	69	38.86	75.8
Rosgen classification	B4c	B3c	F4	G3c
Bankfull XSa (ft^2)	143.4	169.5	191.3	254.3
Bankfull Xsa difference (ft^2)	26.1		63	
Full XSa (ft^2)	406.4	738.6	406.4	509.7
Full XSa difference (ft^2)	332.2		103.3	
Sed. yield (tons/yr.)	1.3		0.4	

Note:
ft^2 = square feet; XSa = Stream channel cross-sectional area.

Table F-8. Results of geomorphic assessments for site 12-011 and 15-003A on NEB.

Site ID	12-011		15-003A		
Year	2004	2020	1999	2004	2020
Entrenchment ratio	1.1	1.2	4.7	1.3	1.6
Width:depth ratio	20.7	22.2	8.5	10.5	8.9
Sinuosity	1.01	1.01	1	1	1
Slope	0.4	0.4	0.4	0.4	0.4
Median substrate particle size (D50)	28.44	9.2	N/A	CTC	CTC
Rosgen classification	F4	F4	G4c	G4c	G4c
Bankfull XSa (ft^2)	72.8	69.5	52.1	55.1	60.2
Bankfull Xsa difference (ft^2)	-3.3		3		8.1
Full XSa (ft^2)	192.9	218.9	75	148.9	207.8
Full XSa difference (ft^2)	26		73.9		132.8
Sed. yield (tons/yr.)	0.1		0.92		0.4

Note:
ft^2 = square feet; XSa = Stream channel cross-sectional area.

Table F-9. Results of geomorphic assessments for site 16-001 on Brier Mill Run.

Site ID	16-001		
Year	2004	2010	2020
Entrenchment ratio	1	1.1	3.9
Width:depth ratio	37.2	30.6	22
Sinuosity	1.44	1.44	1.44
Slope	2	2	2
Median substrate particle size (D50)	CTC	18.5	26.3
Rosgen classification	F4b	F4b	C4
Bankfull XSa (ft^2)	58.7	58.9	118.4
Bankfull Xsa difference (ft^2)	0.2		59.7
Full XSa (ft^2)	270.5	284	231.3
Full XSa difference (ft^2)	13.5		-39.2
Sed. yield (tons/yr.)	0.14		-0.15

Note:
ft^2 = square feet; XSa = Stream channel cross-sectional area.

Table F-10. Results of geomorphic assessments for site 19-003, 19-005, 19-006, 19-023A, 19-025 and 19-036 on Lower Beaverdam Creek.

Site ID	**19-003**			**19-005**		**19-006**		**19-023A**		**19-025**		**19-036**	
Year	**2000**	**2005**	**2020**	**2002**	**2020**	**2002**	**2020**	**2001**	**2020**	**2002**	**2020**	**2002**	**2020**
Entrenchment ratio	3.6	3.6	3.6	2.8	1.3	3.8	1.4	1.2	1.1	3.6	1	6.1	1.1
Width:depth ratio	11.4	11.4	11.7	3	23	2.3	14.9	13.1	15.3	2.4	15.9	2.1	10.2
Sinuosity	1.01	1.01	1.01	1.14	1.14	1	1	1.11	1.11	1.03	1.03	1.08	1.08
Slope	0.05	0.05	0.05	0.2	0.2	0.9	0.9	0.33	0.33	0.29	0.29	1.1	1.1
Median substrate particle size (D50)	9.8	8	5.3	0.03	11.4	3.3	14.3	0.102	1	0.198	1.5	0.108	1
Rosgen classification	E4	E4	E4	E5	F4	E4	F4	F5	F5	E5	F5	E5	G5c
Bankfull XSa (ft^2)	270	268.3	265	107.8	177.9	75.5	99.6	62.2	107.6	94.9	119.8	36	40.2
Bankfull Xsa difference (ft^2)		-1.7	-5		70.1		24.1		45.4		24.9		4.2
Full XSa (ft^2)	293.5	287.8	444.4	107.8	301.9	75.5	308.8	284.2	427.4	301.2	409.4	115.7	135.5
Full XSa difference (ft^2)		-5.7	150.9		194.1		233.3		134.2		108.2		19.8
Sed. yield (tons/yr.)		-0.07	0.47		0.67		0.81		0.44		0.38		0.07

Note:
ft^2 = square feet; XSa = Stream channel cross-sectional area.

F.2 Change in Cross Sections

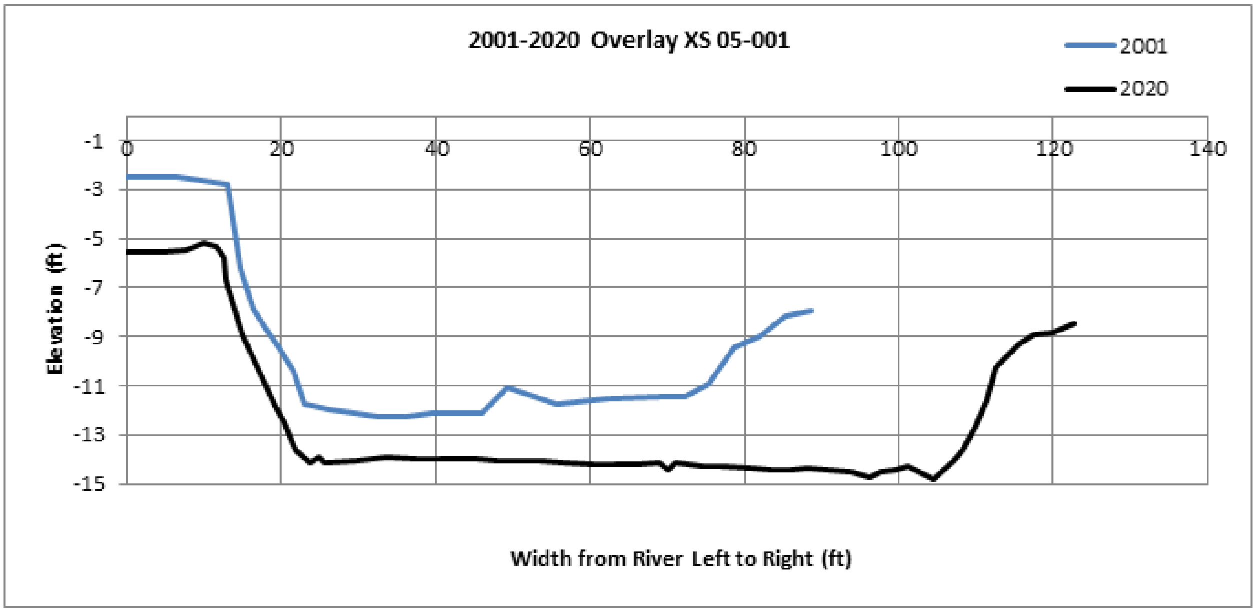


Figure F-1. Change in cross-sections for 05-001 between 2001 and 2020.

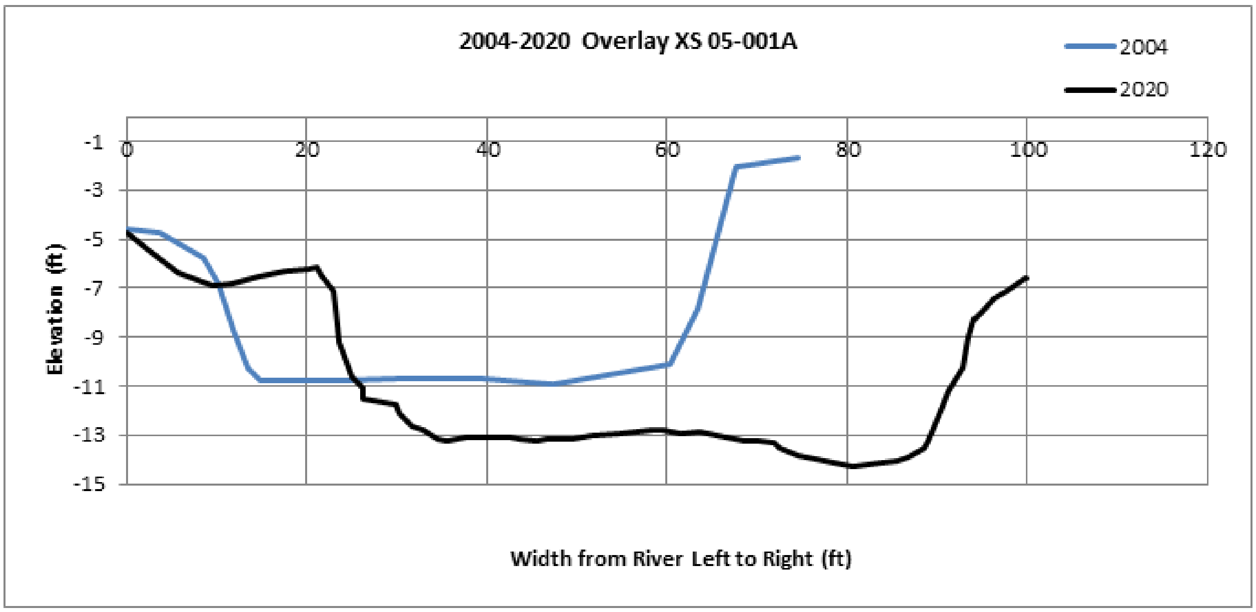


Figure F-2. Change in cross-sections for 05-001A between 2004 and 2020.

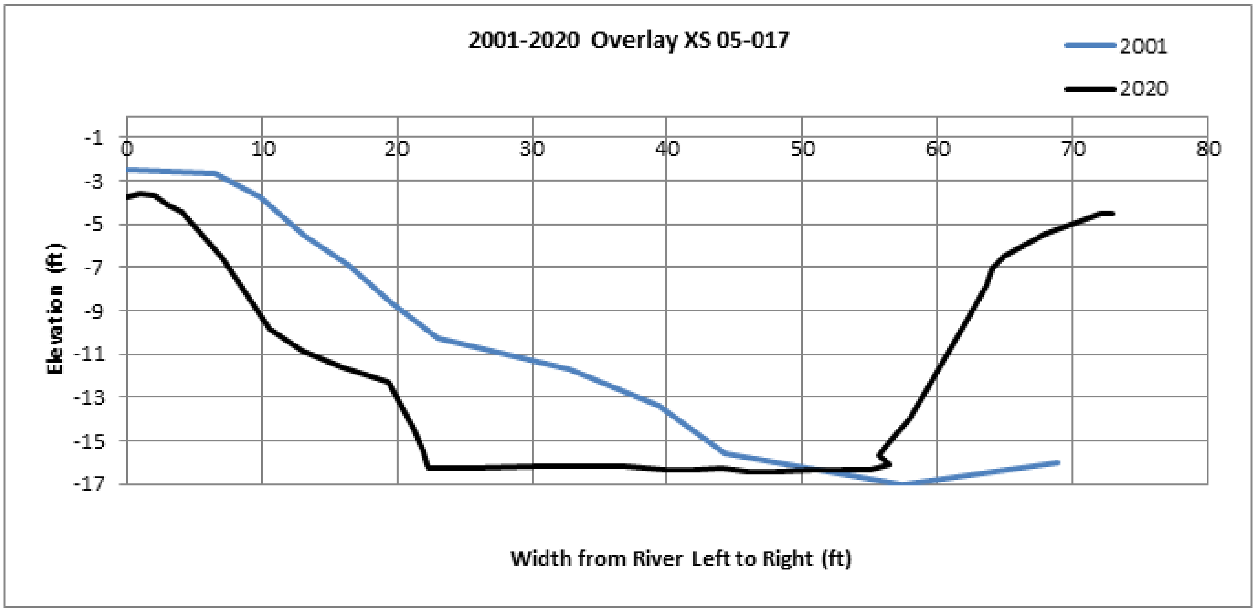


Figure F-3. Change in cross-sections for 05-017 between 2001 and 2020.

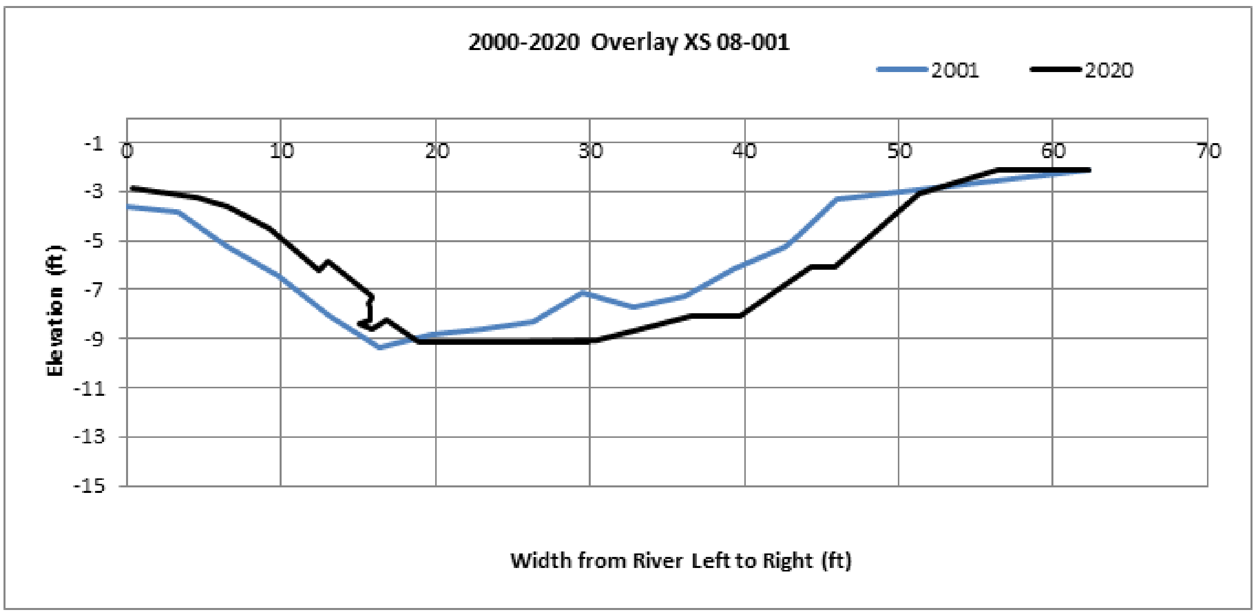


Figure F-4. Change in cross-sections for 08-001 between 2000 and 2020.

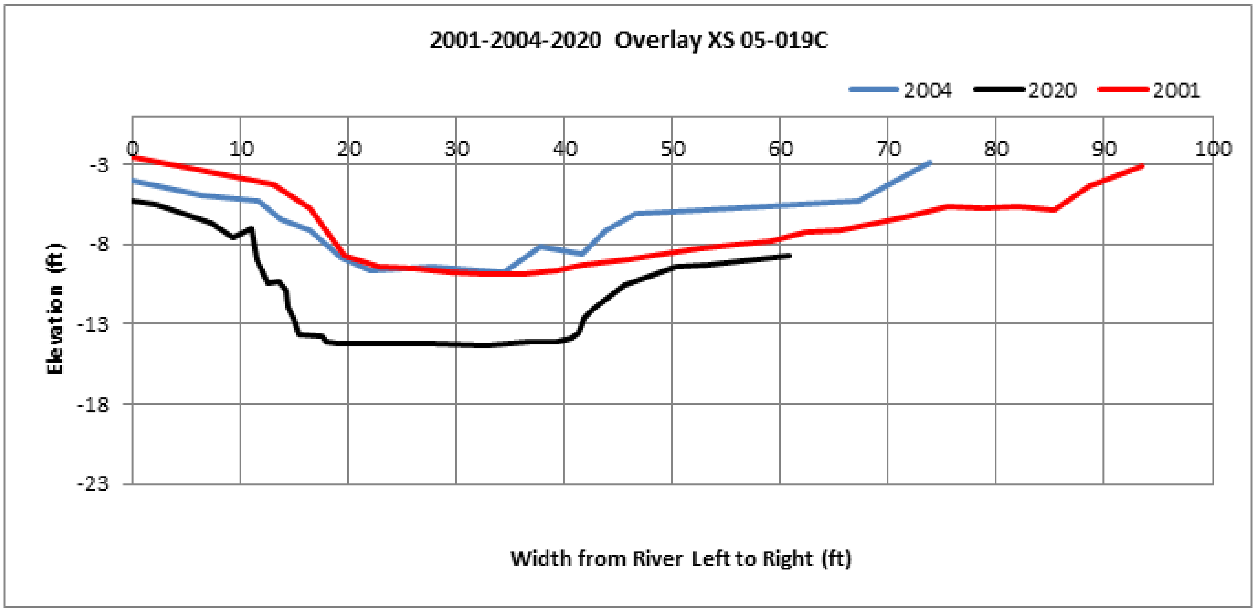


Figure F-5. Change in cross-sections for 05-019C between 2001, 2004 and 2020.

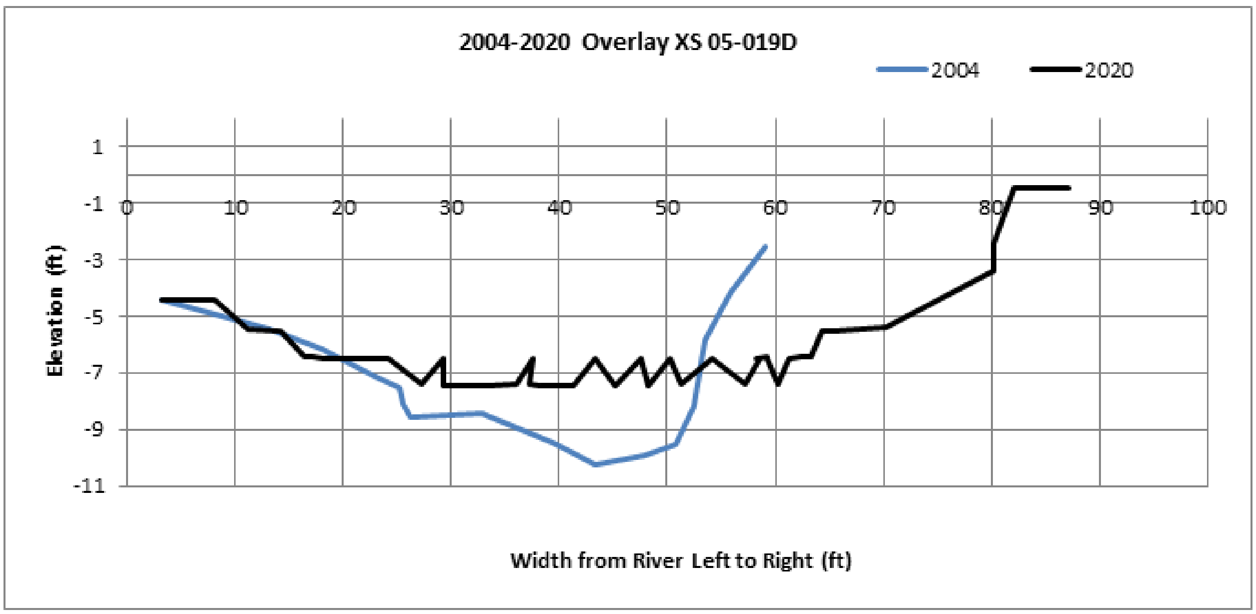


Figure F-6. Change in cross-sections for 05-019D between 2004 and 2020.

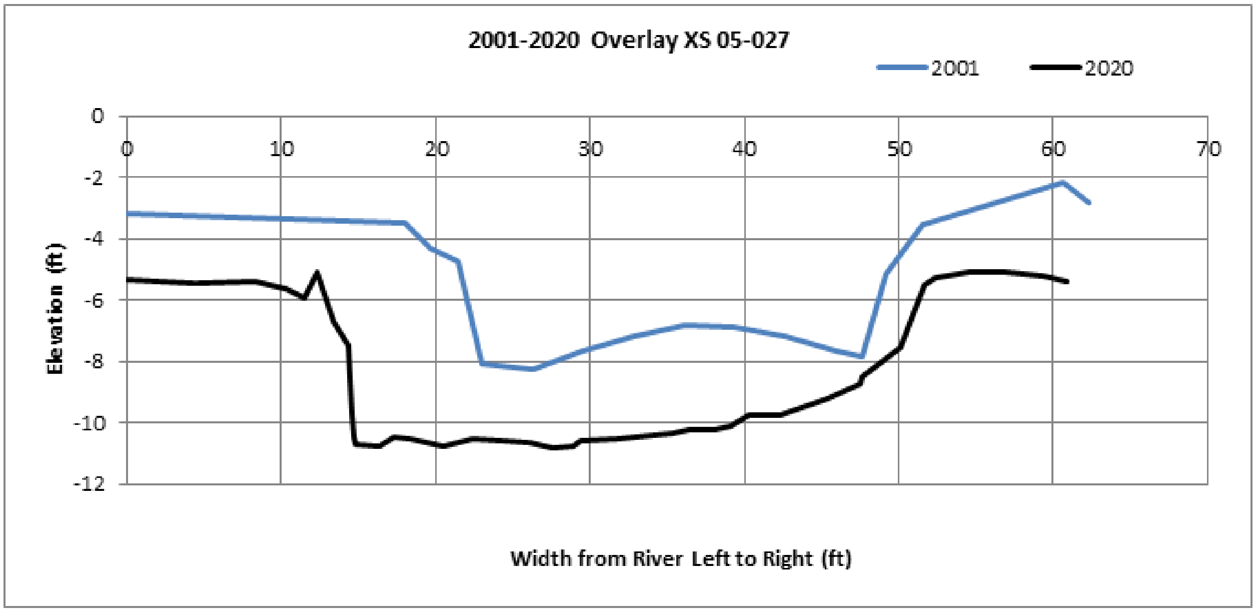


Figure F-7. Change in cross-sections for 05-027 between 2001 and 2020.

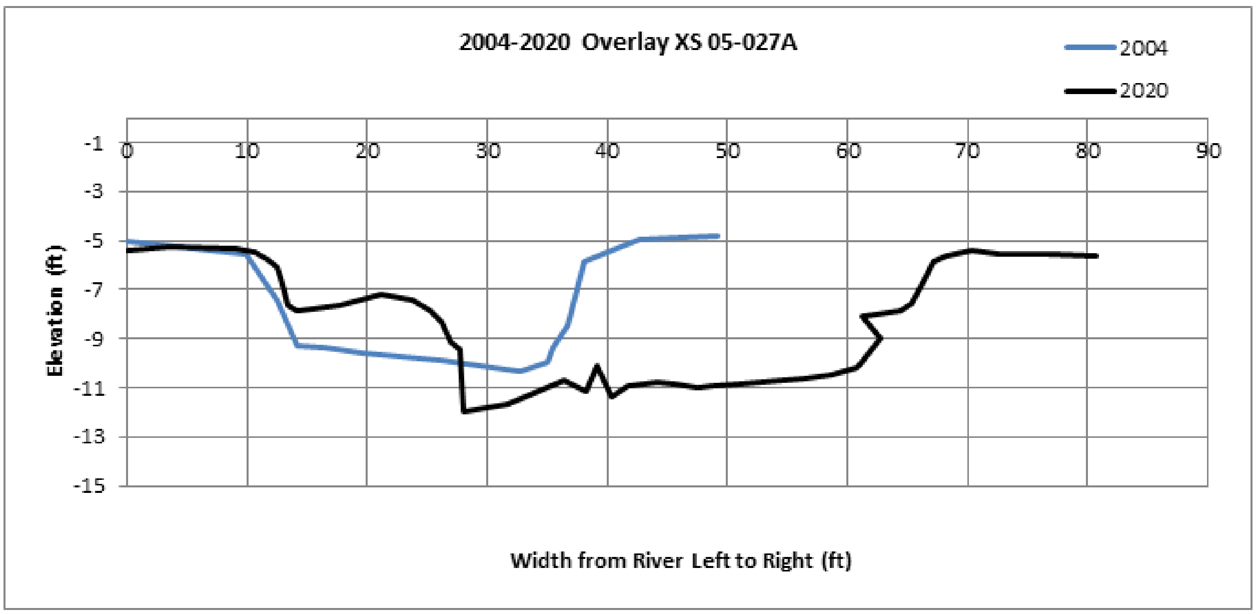


Figure F-8. Change in cross-sections for 05-027 between 2004 and 2020.

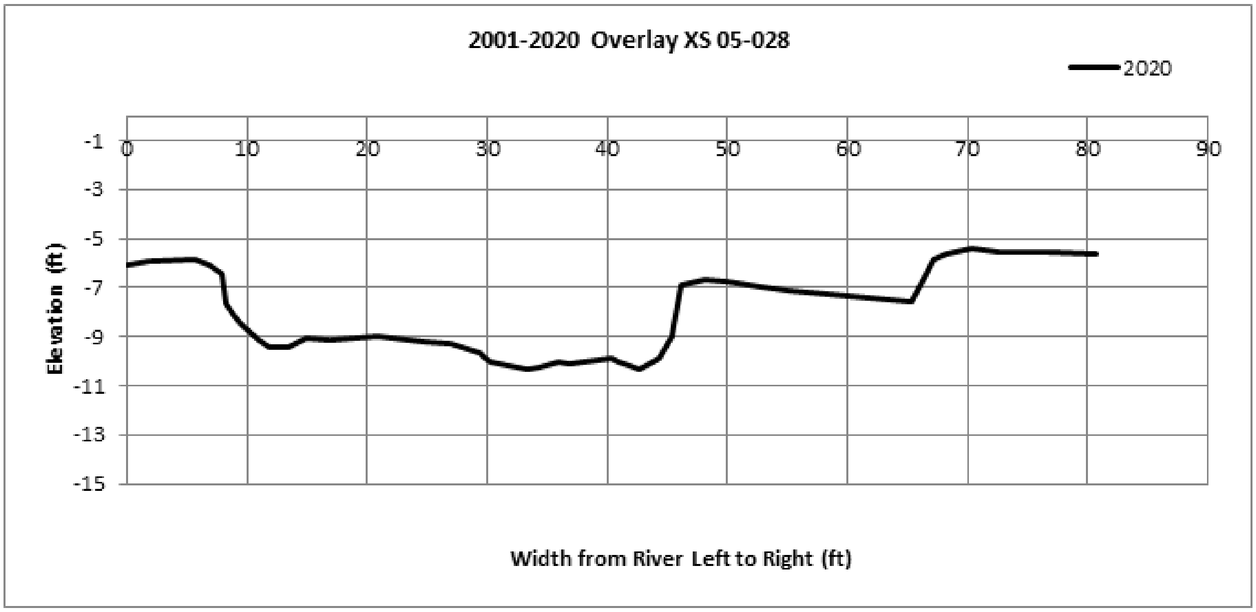


Figure F-9. Change in cross-sections for 05-028 between 2001 and 2020.

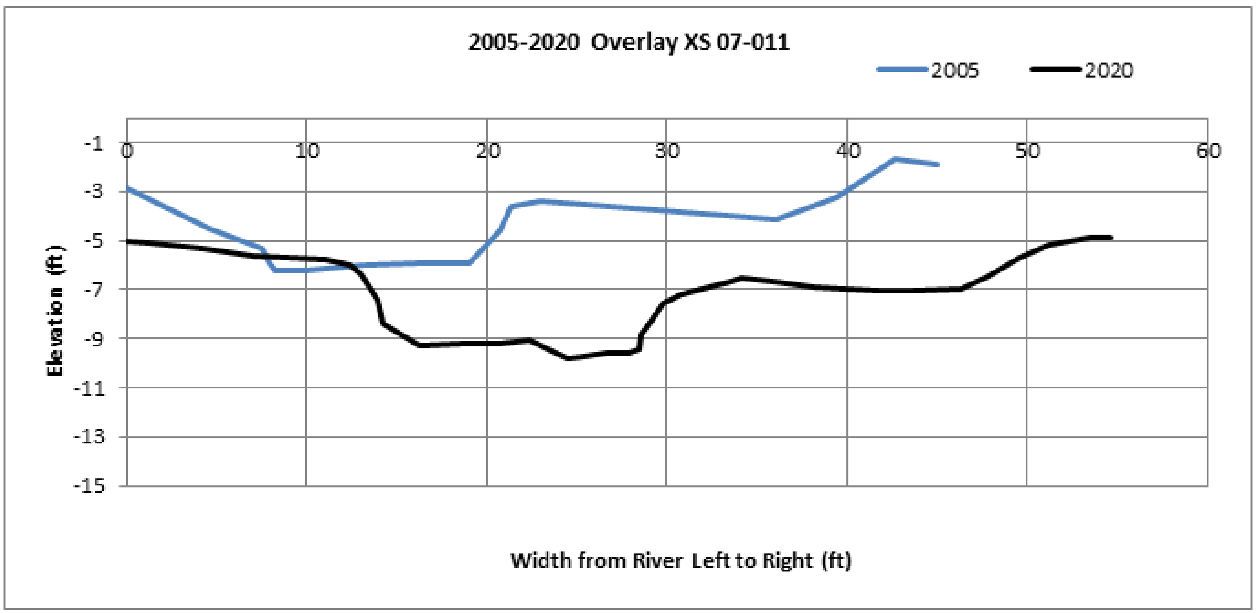


Figure F-10. Change in cross-sections for 07-011 between 2005 and 2020.

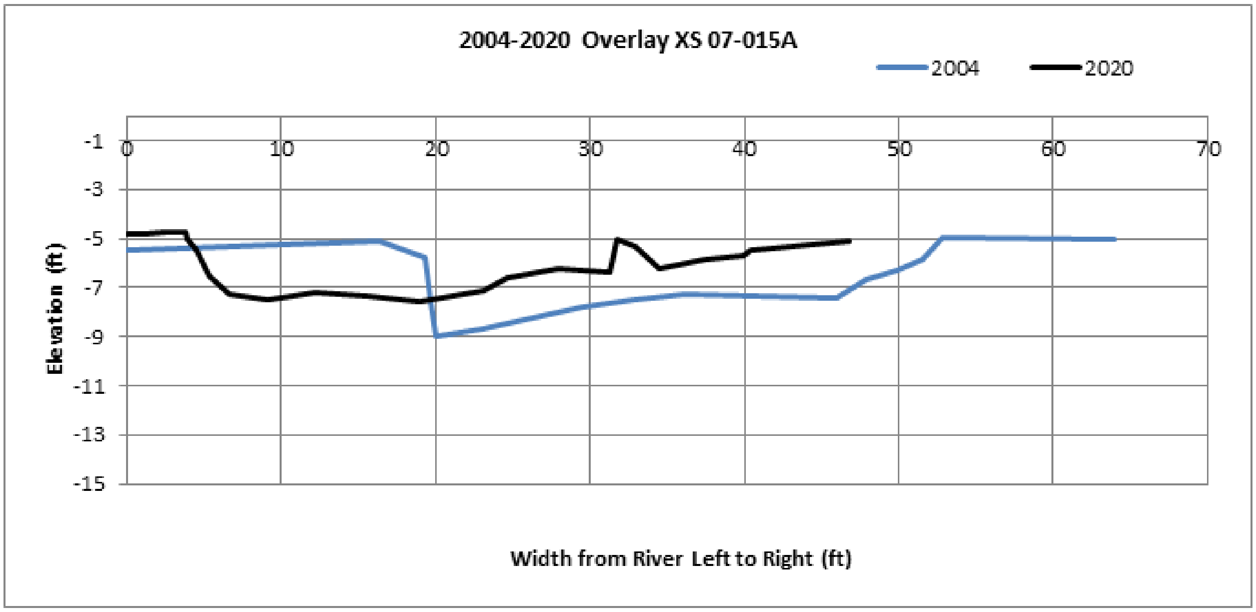


Figure F-11. Change in cross-sections for 07-015A between 2004 and 2020.

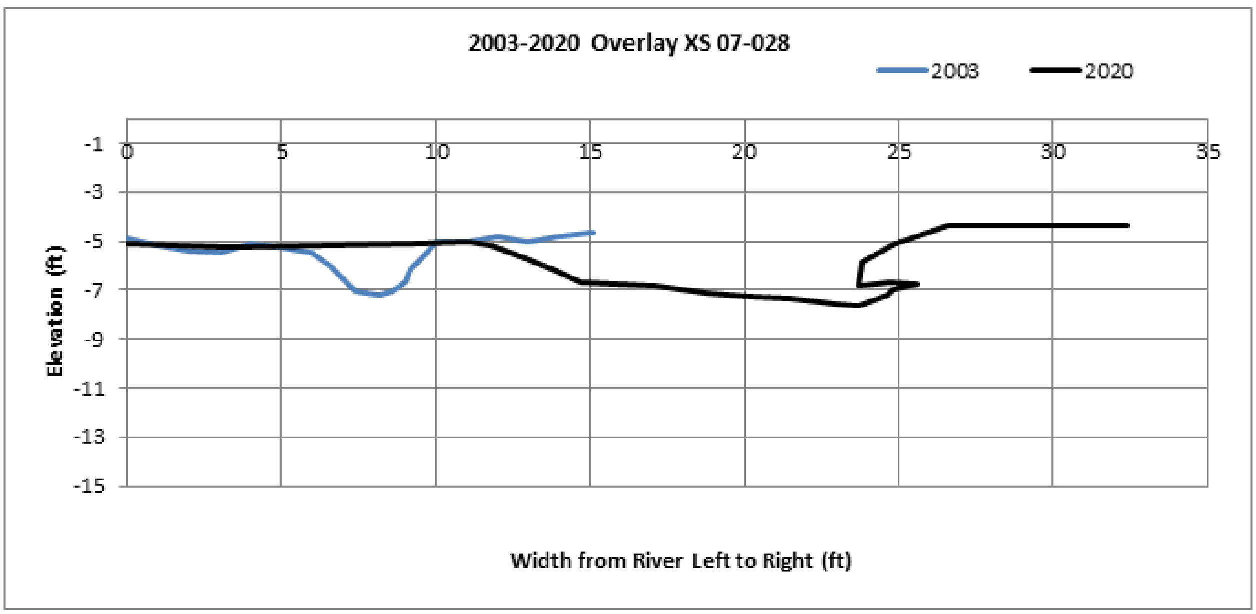


Figure F-12. Change in cross-sections for 07-028 between 2003 and 2020.

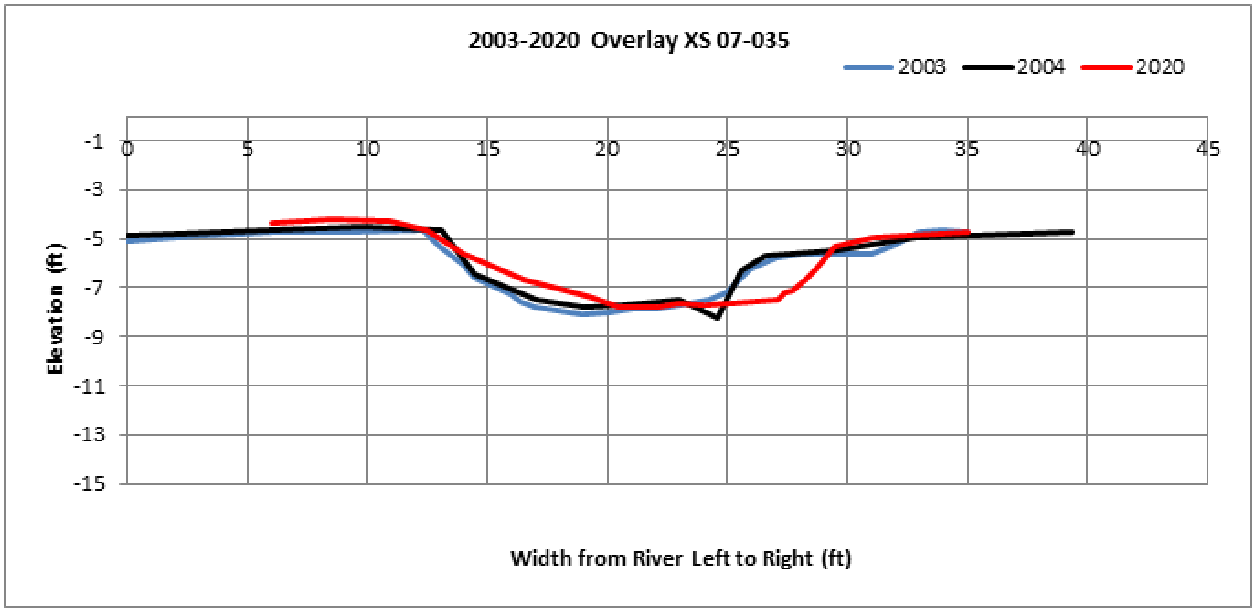


Figure F-13. Change in cross-sections for 07-035 between 2003 and 2020.

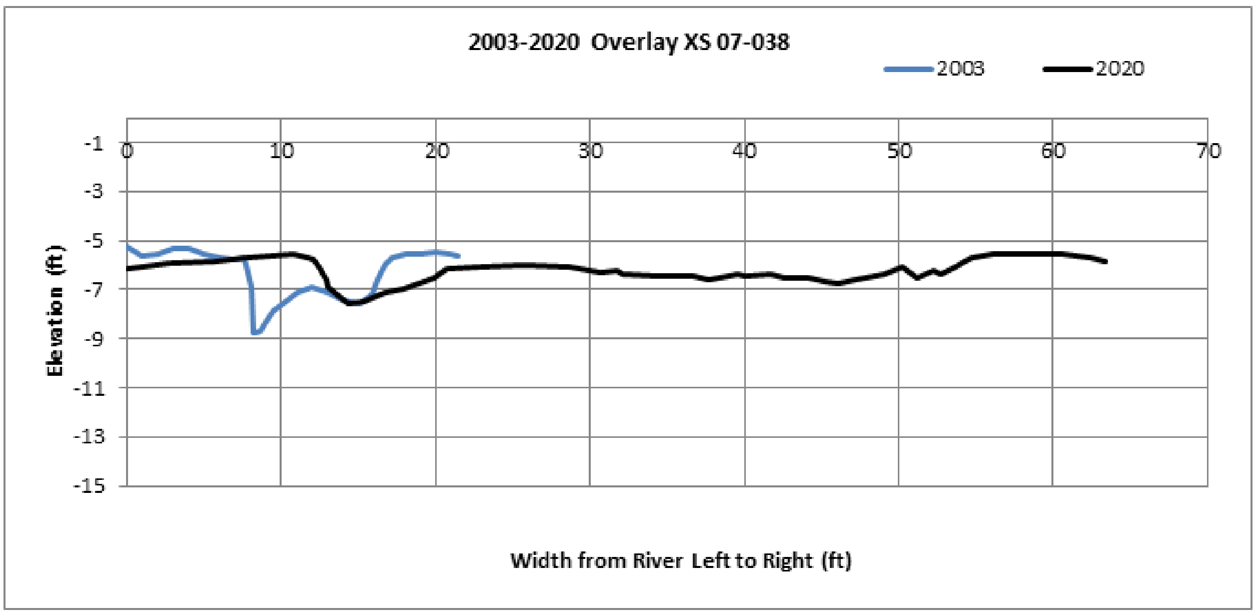


Figure F-14. Change in cross-sections for 07-038 between 2003 and 2020.

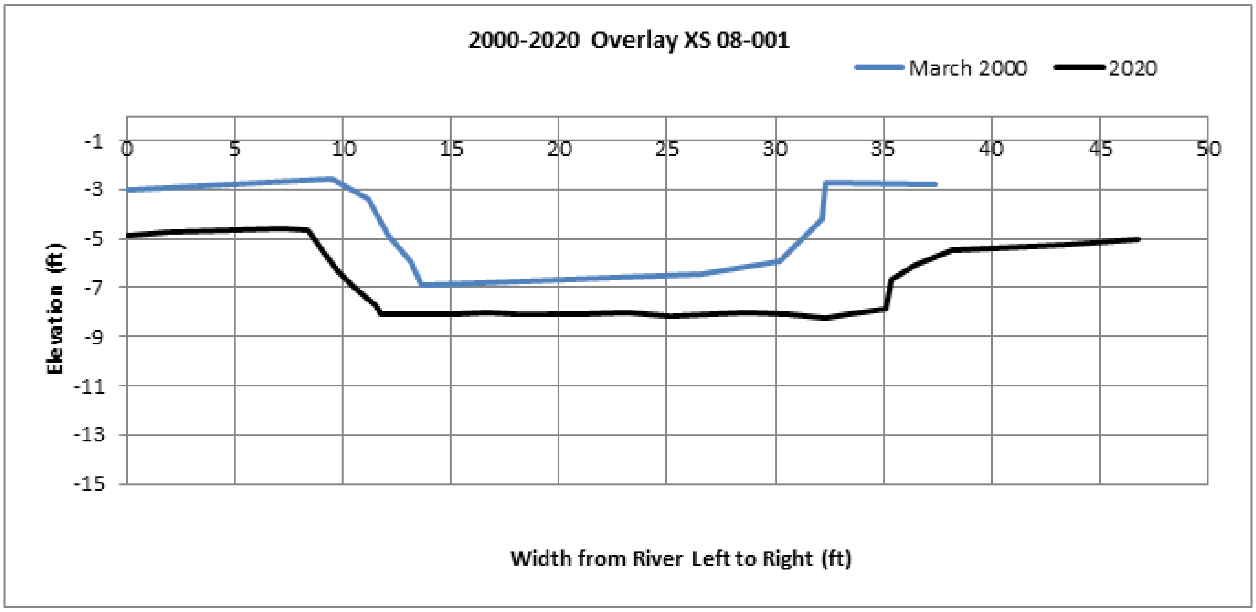


Figure F-15. Change in cross-sections for 08-001 between 2000 and 2020.

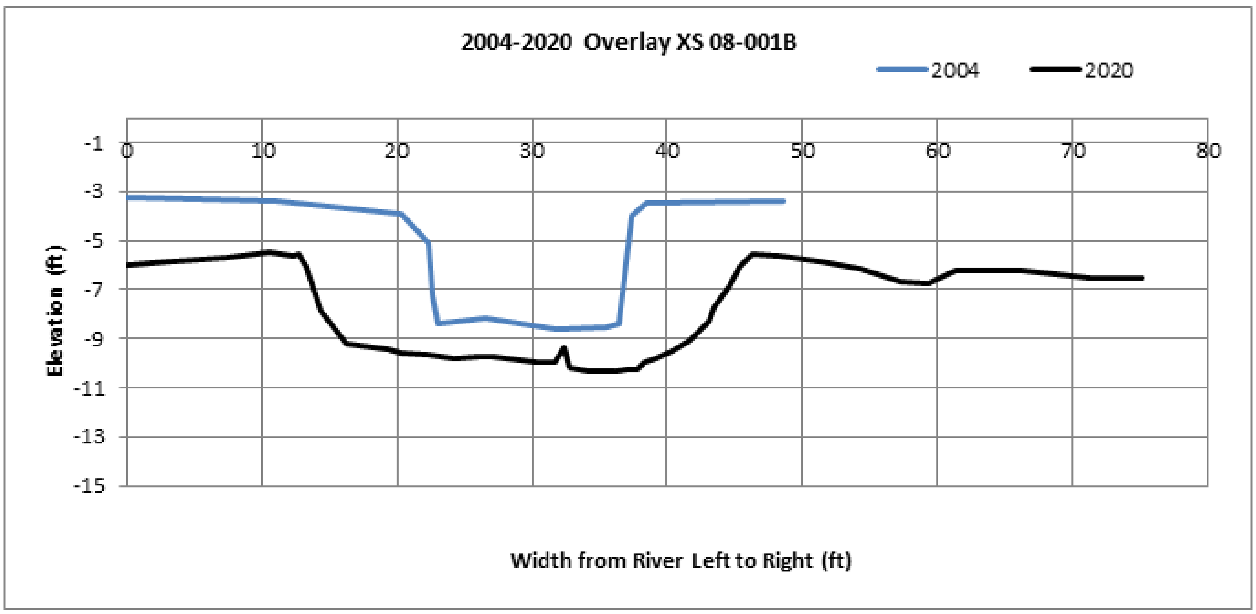


Figure F-16. Change in cross-sections for 08-001B between 2004 and 2020.

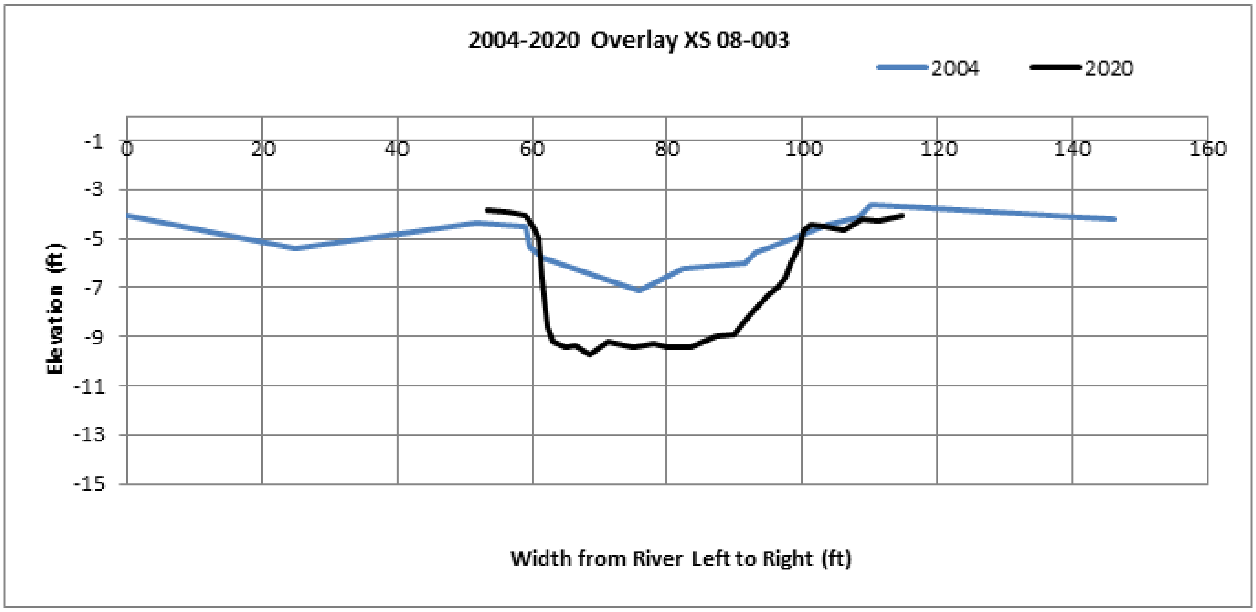


Figure F-17. Change in cross-sections for 08-003 between 2004 and 2020.

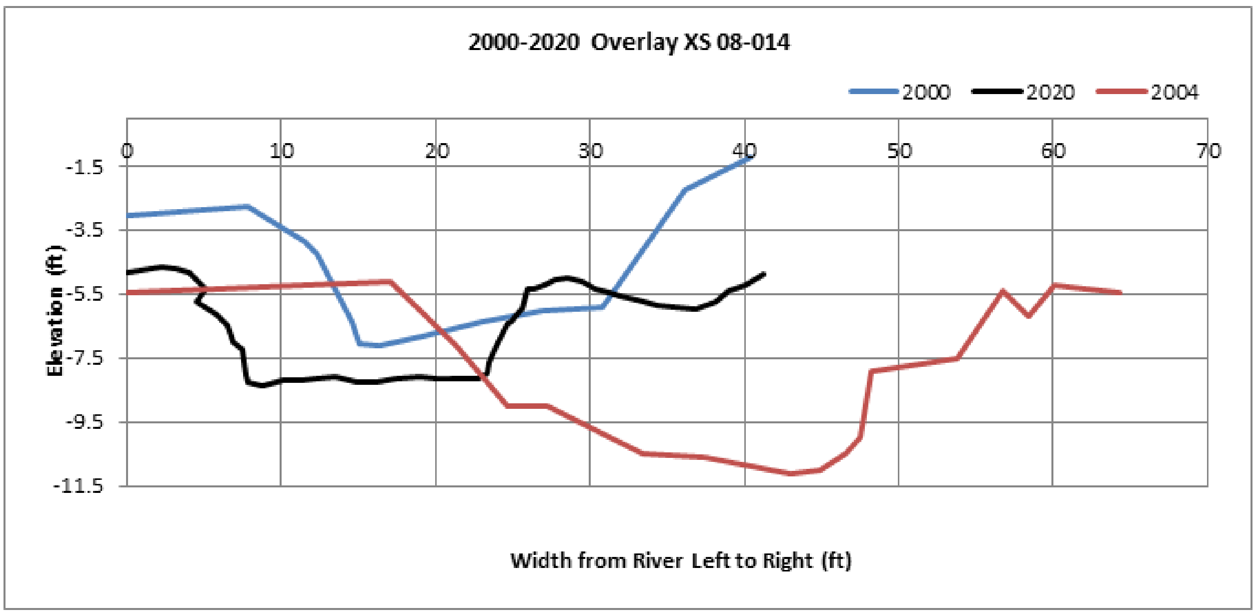


Figure F-18. Change in cross-sections for 08-014 between 2000 and 2020.

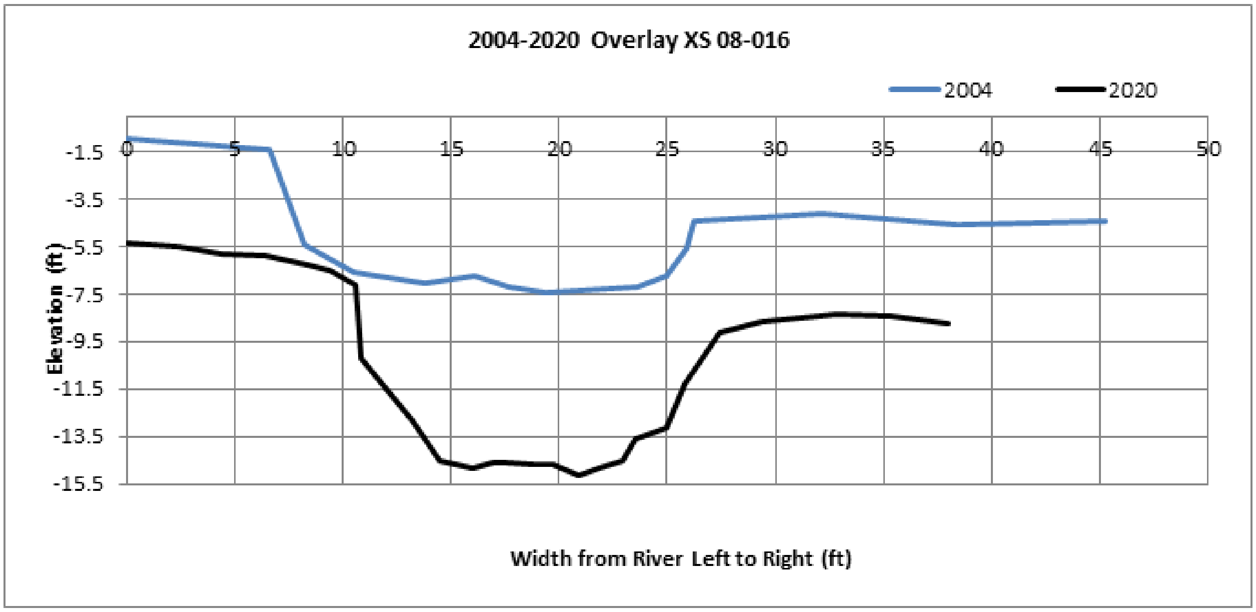


Figure F-19. Change in cross-sections for 08-016 between 2004 and 2020.

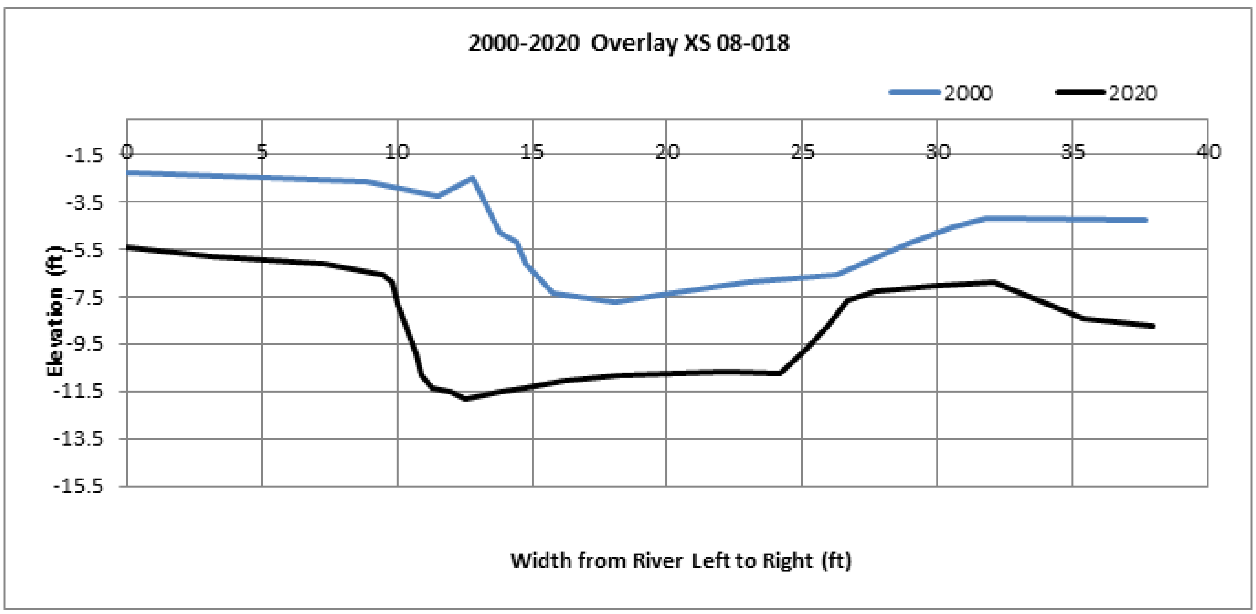


Figure F-20. Change in cross-sections for 08-018 between 2000 and 2020.

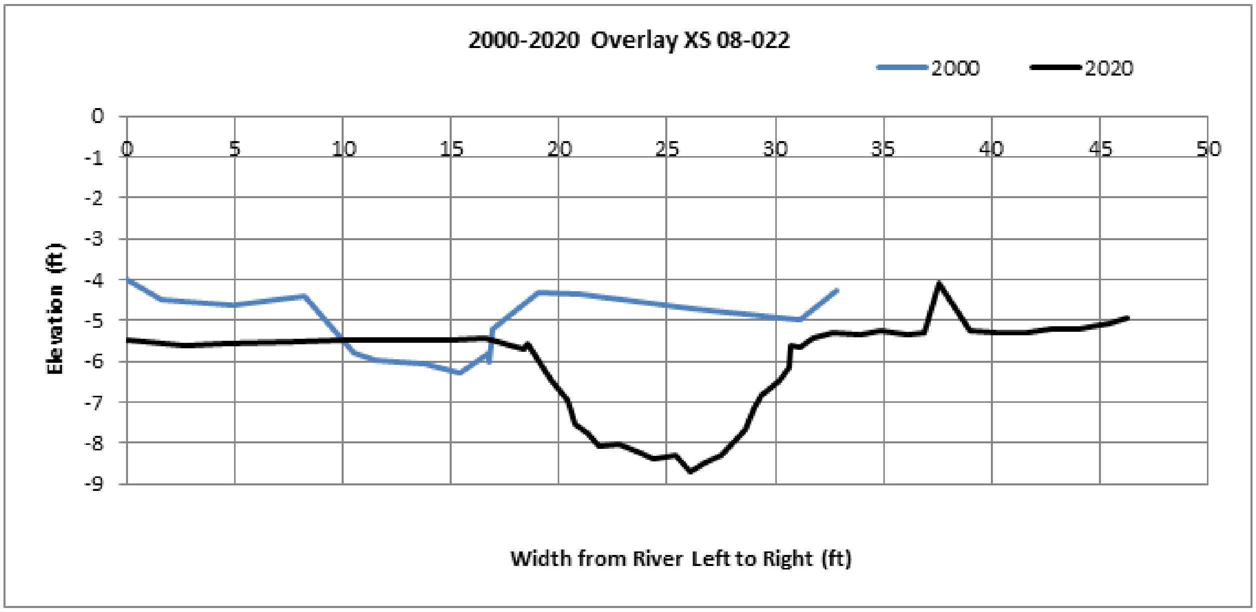


Figure F-21. Change in cross-sections for 08-022 between 2000 and 2020.

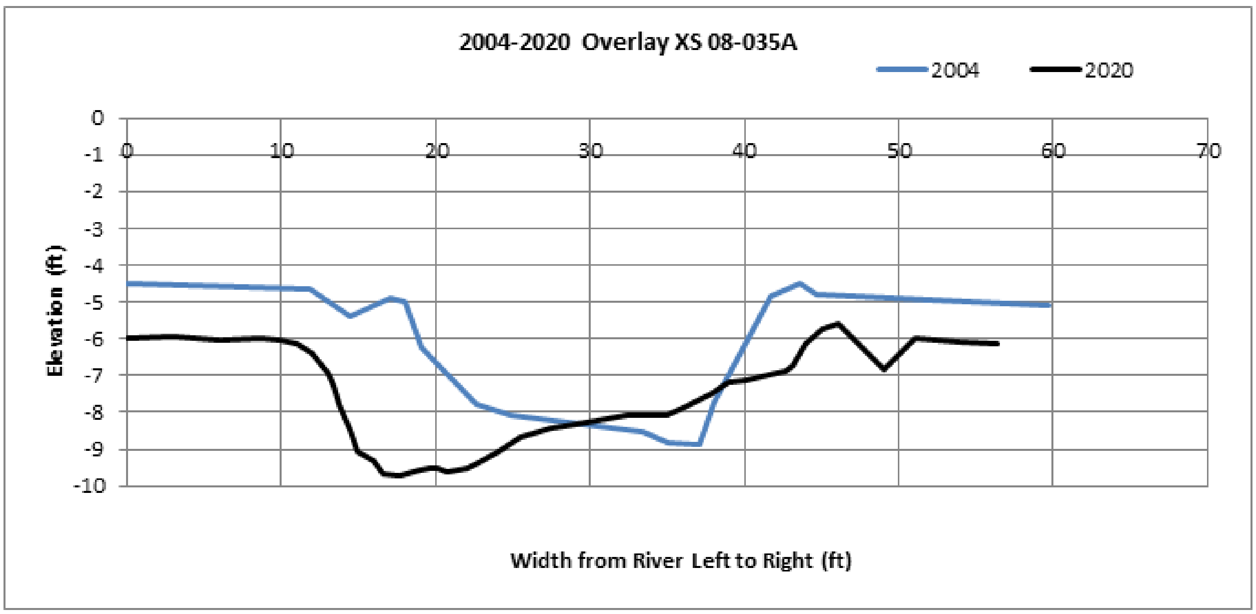


Figure F-22. Change in cross-sections for 08-035A between 2004 and 2020.

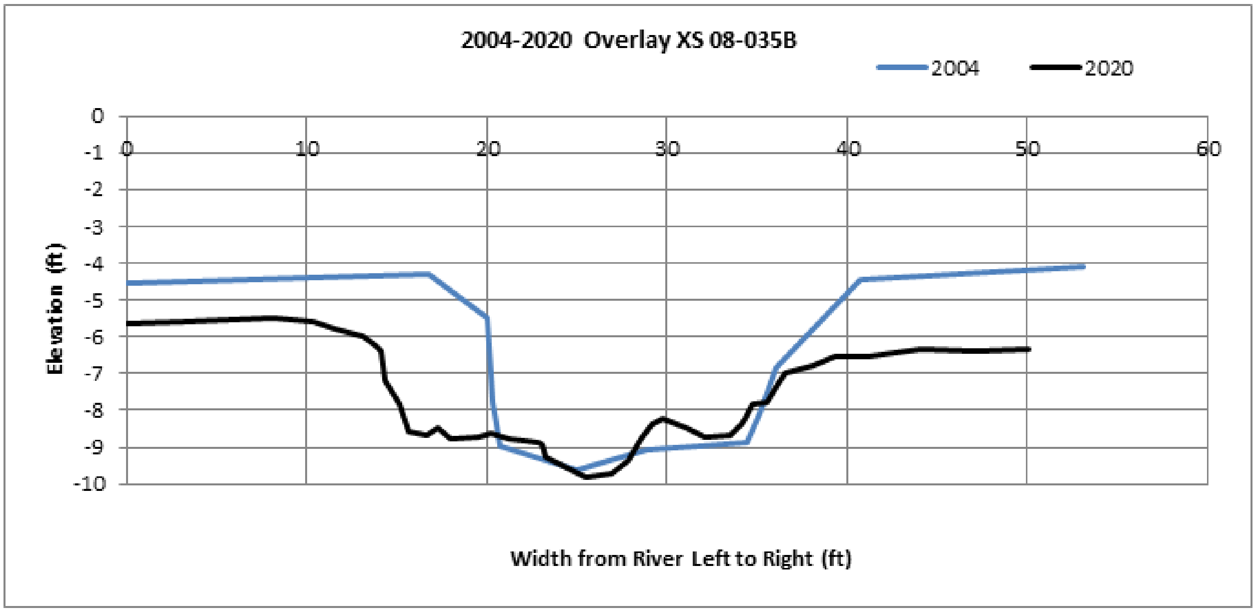


Figure F-23. Change in cross-sections for 08-035B between 2004 and 2020.

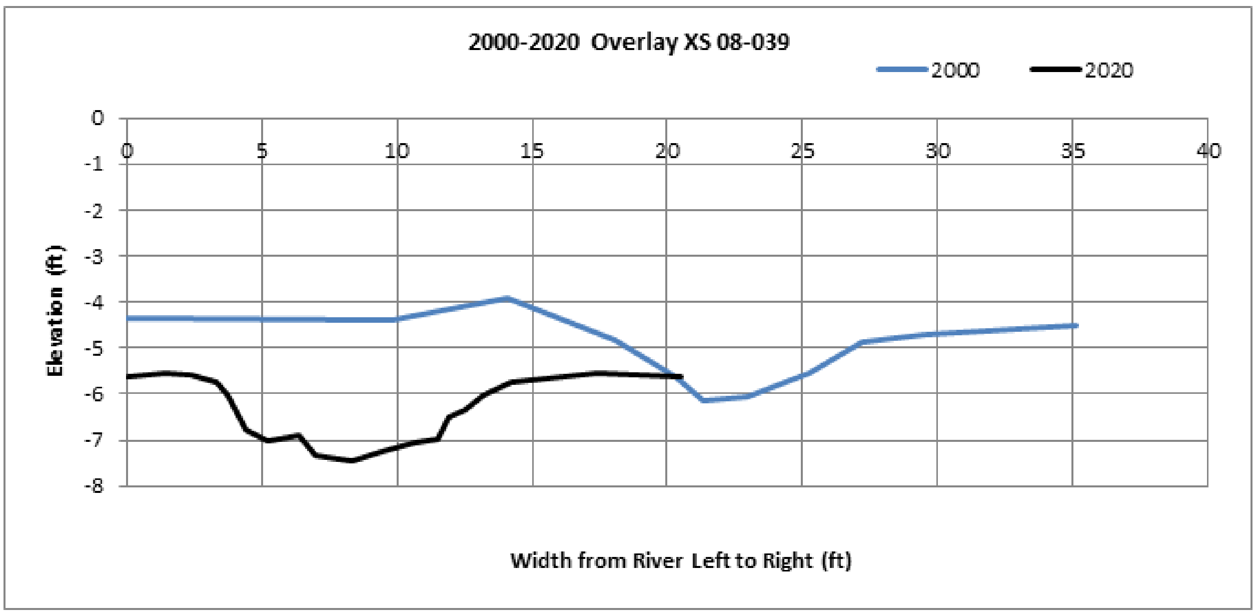


Figure F-24. Change in cross-sections for 08-039 between 2000 and 2020.

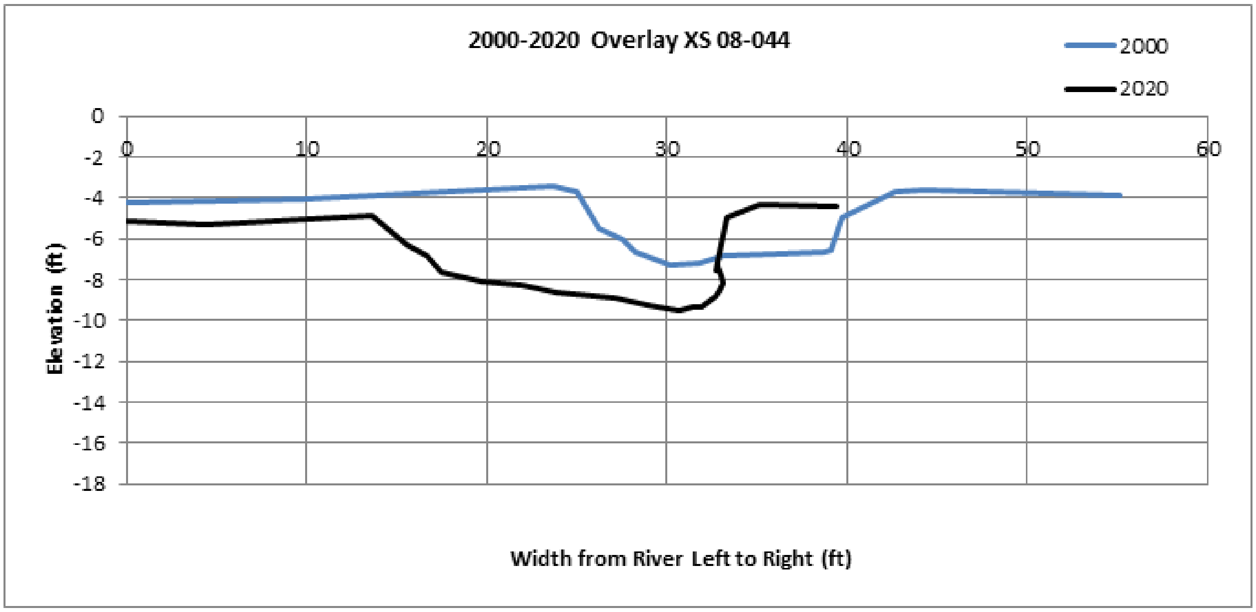


Figure F-25. Change in cross-sections for 08-044 between 2000 and 2020.

Figure F-26. Change in cross-sections for 08-046 between 2004 and 2020.

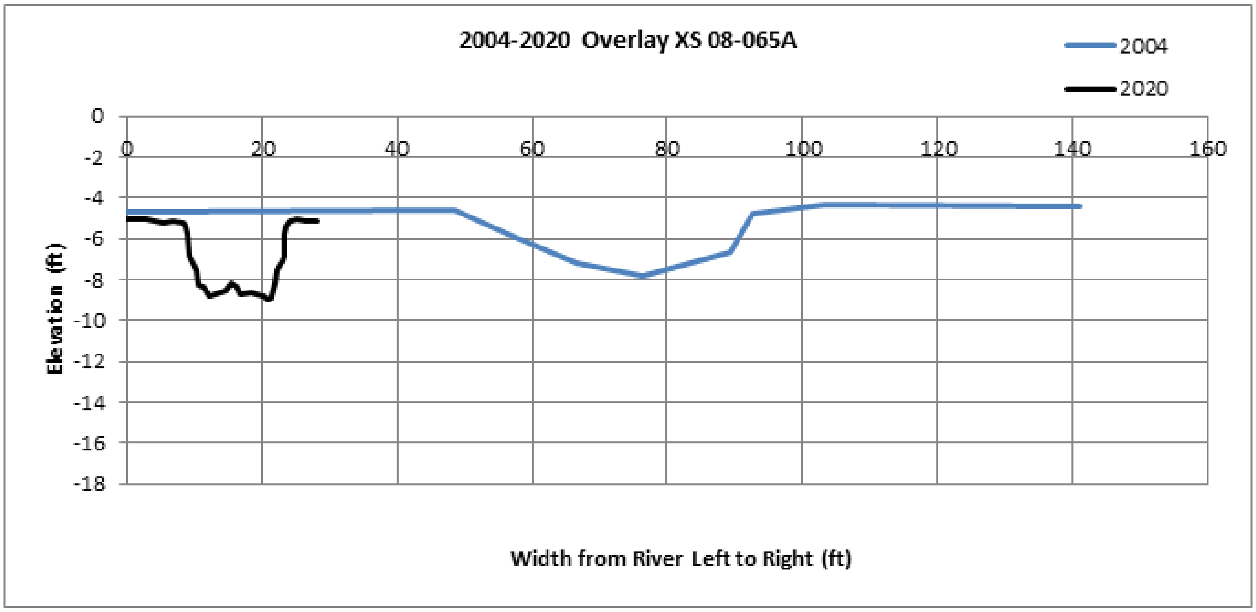


Figure F-27. Change in cross-sections for 08-065A between 2004 and 2020.

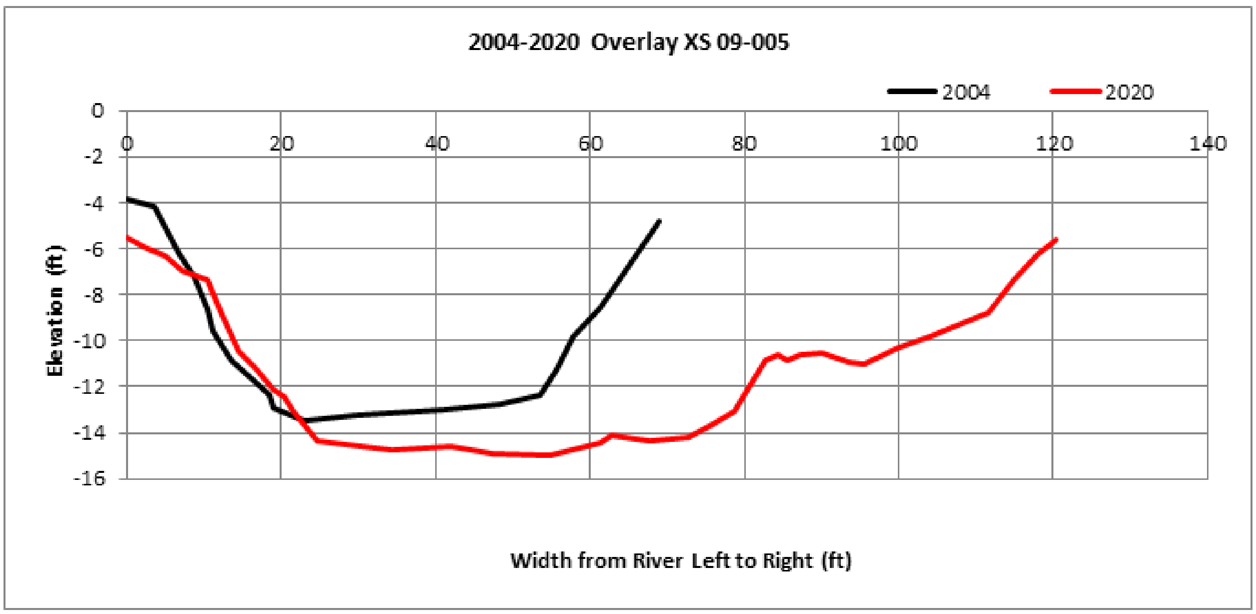


Figure F-28. Change in cross-sections for 09-005 between 2004 and 2020.

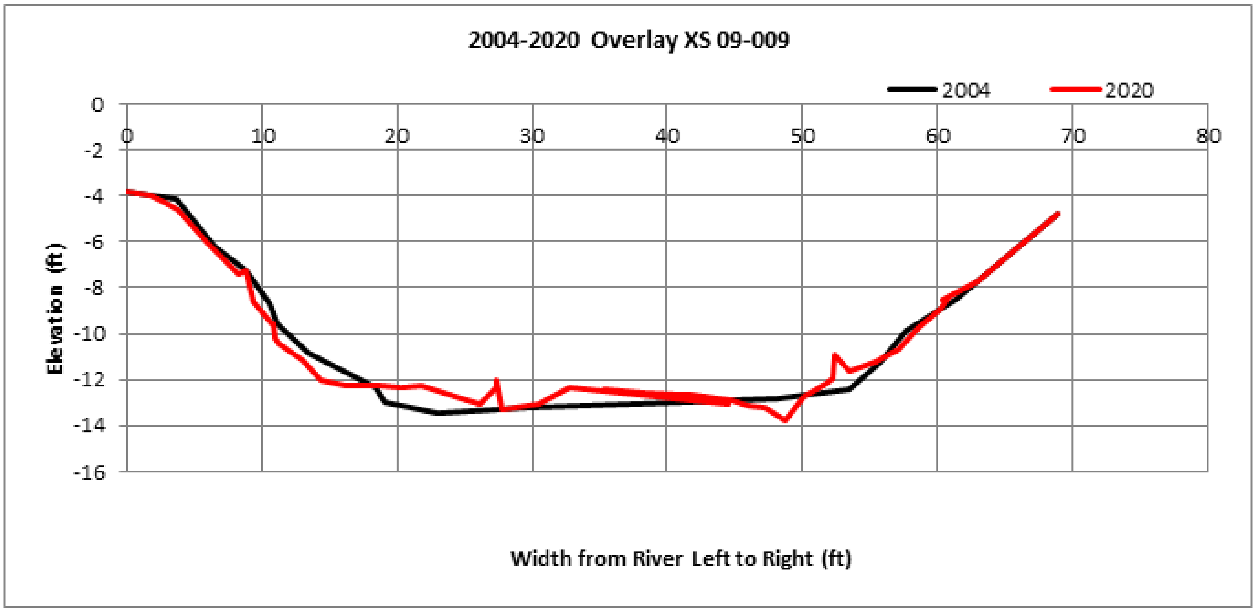


Figure F-29. Change in cross-sections for 09-009 between 2004 and 2020.

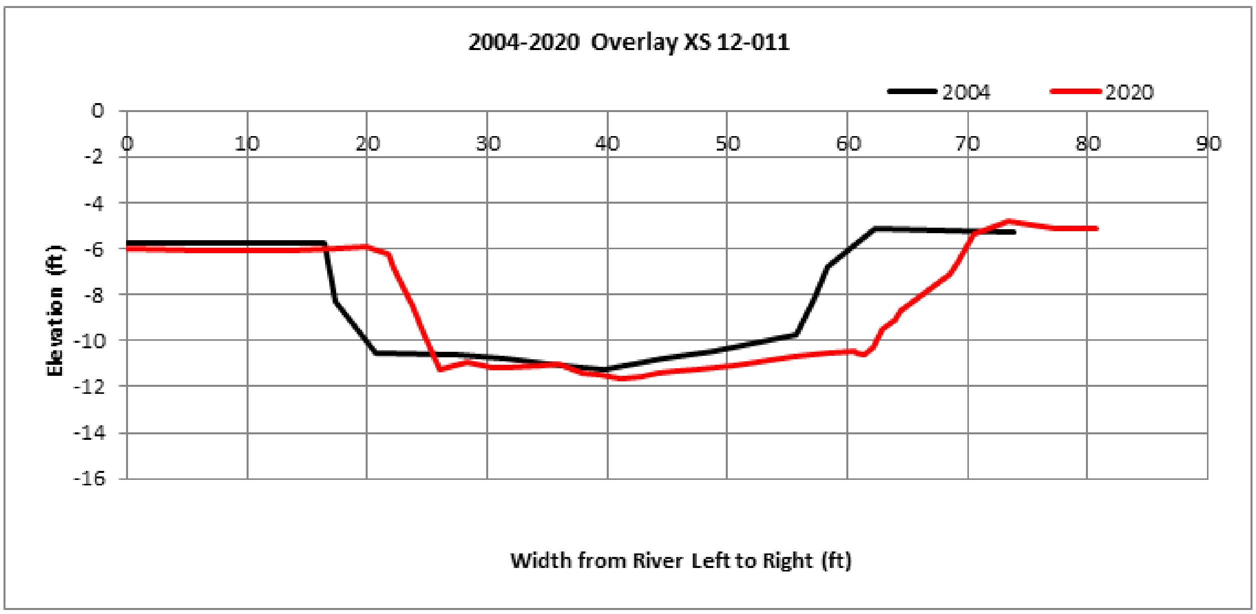


Figure F-30. Change in cross-sections for 12-011 between 2004 and 2020.

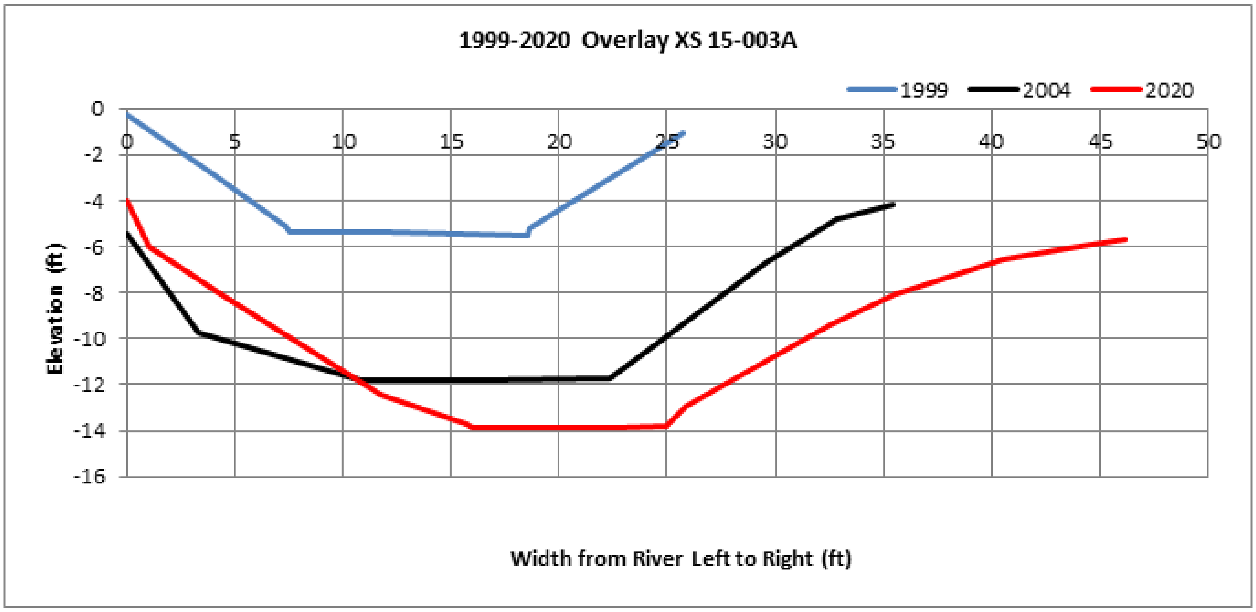


Figure F-31. Change in cross-sections for 15-003A between 1999 and 2020.

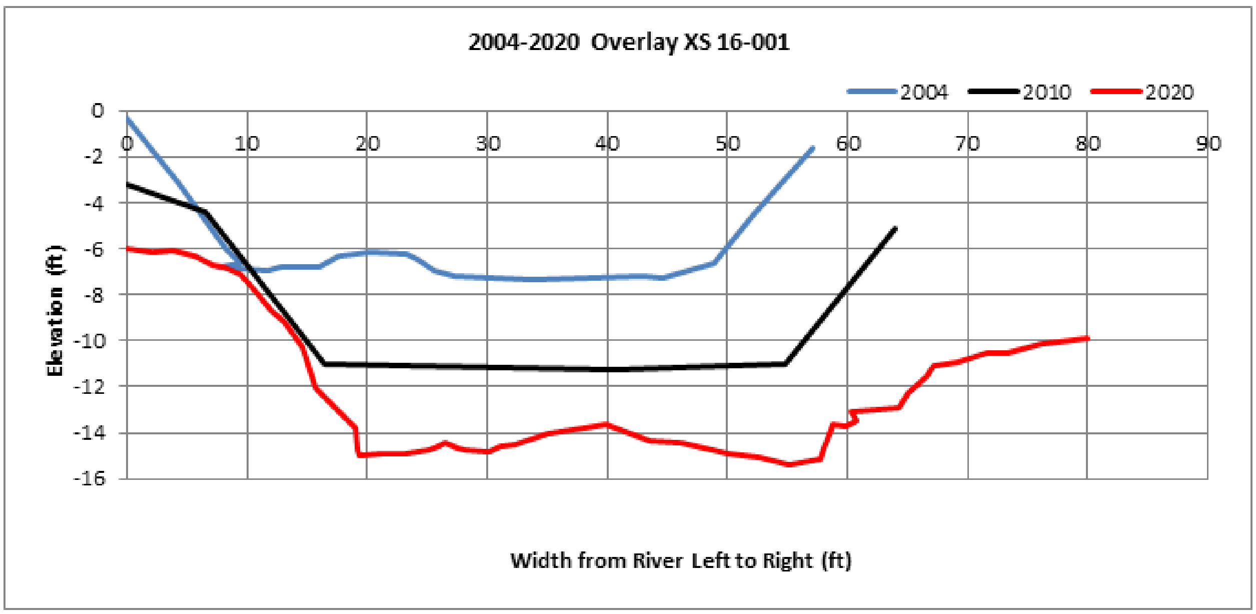


Figure F-32. Change in cross-sections for 16-001 between 2004 and 2020.

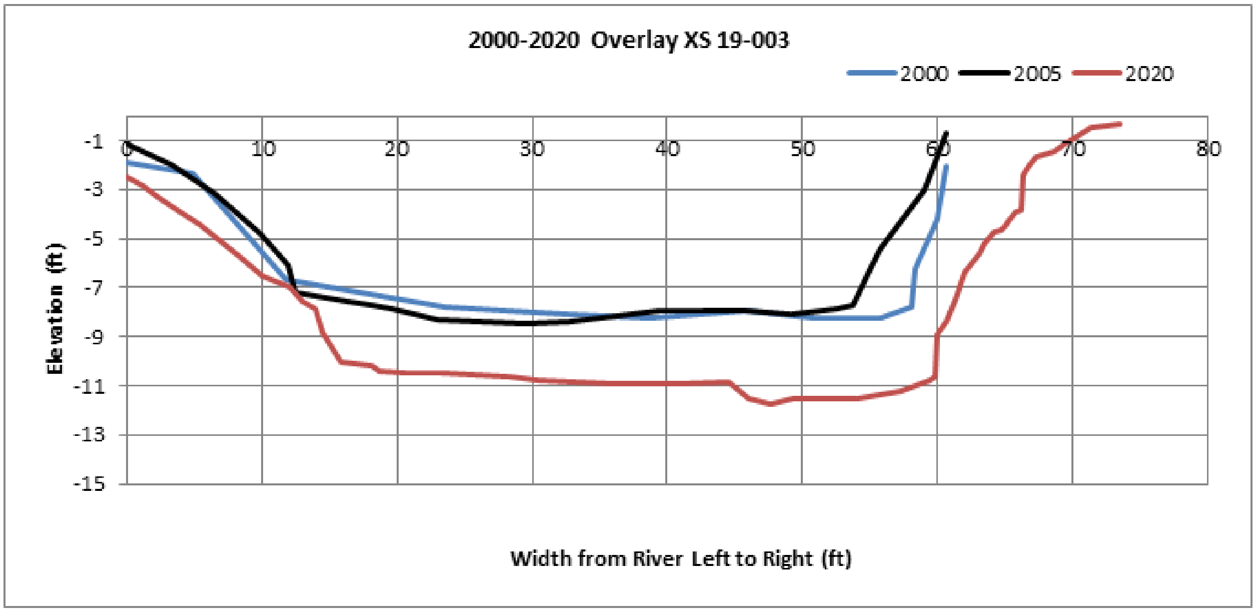


Figure F-33. Change in cross-sections for 19-003 between 2000 and 2020.

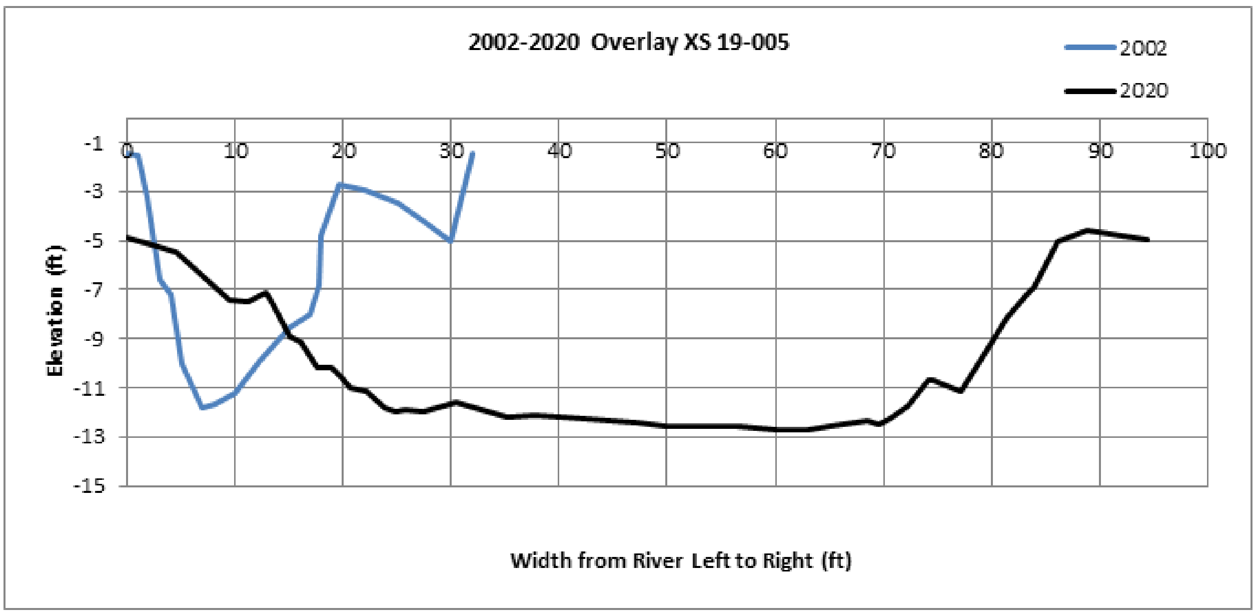


Figure F-34. Change in cross-sections for 19-005 between 2002 and 2020.

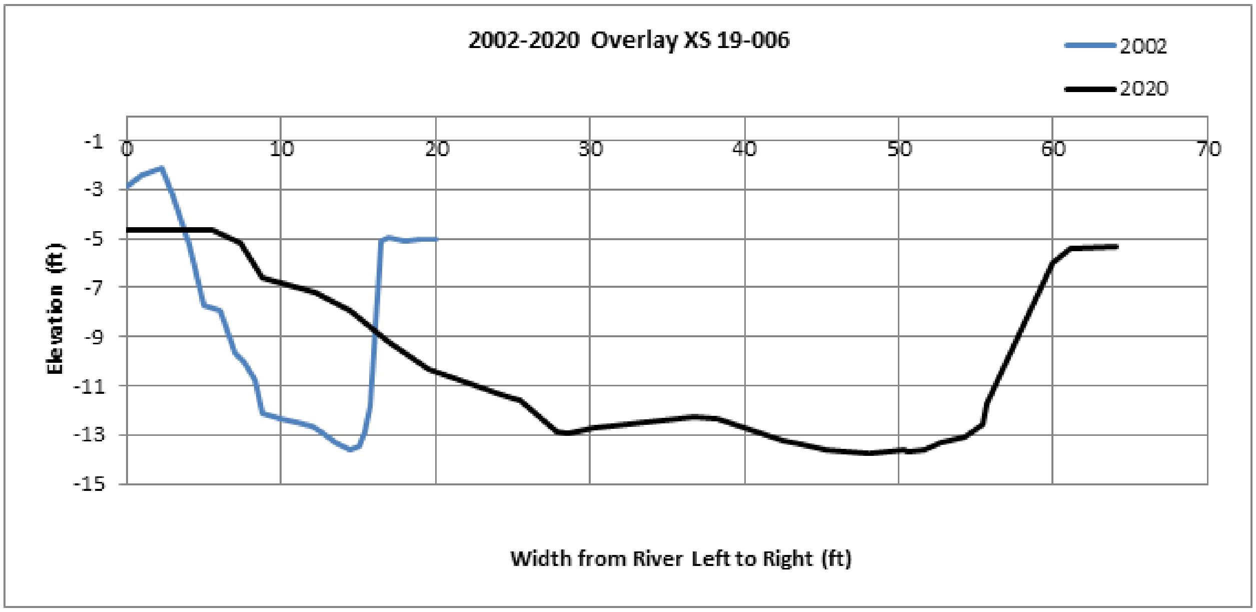


Figure F-35. Change in cross-sections for 19-006 between 2002 and 2020.

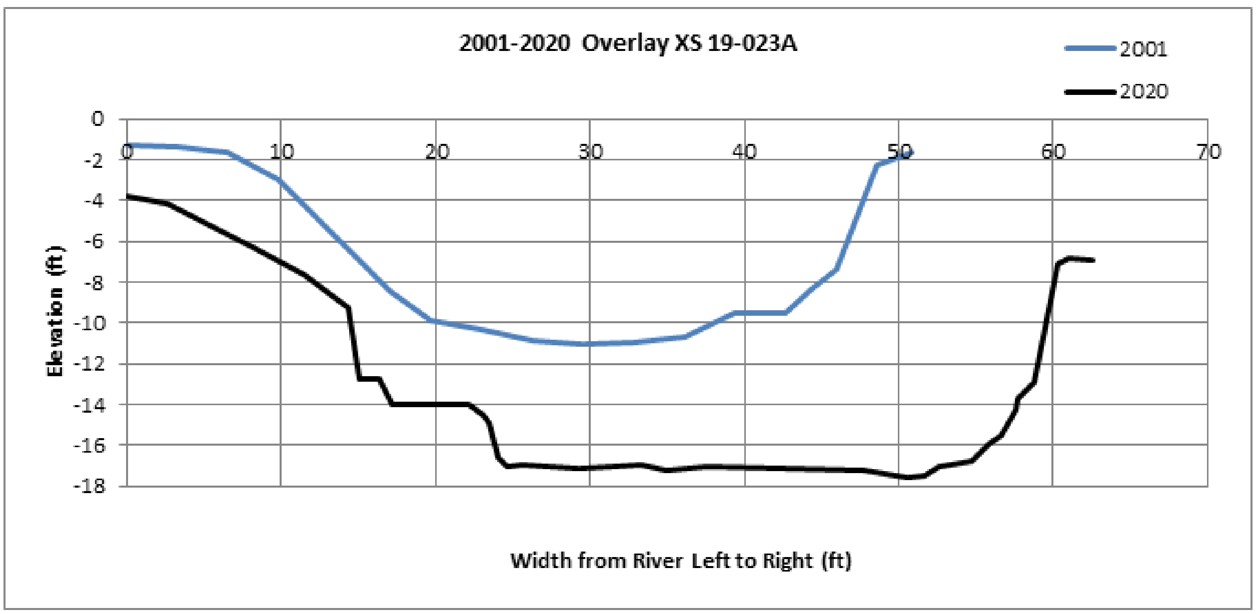


Figure F-36. Change in cross-sections for 19-023A between 2001 and 2020.

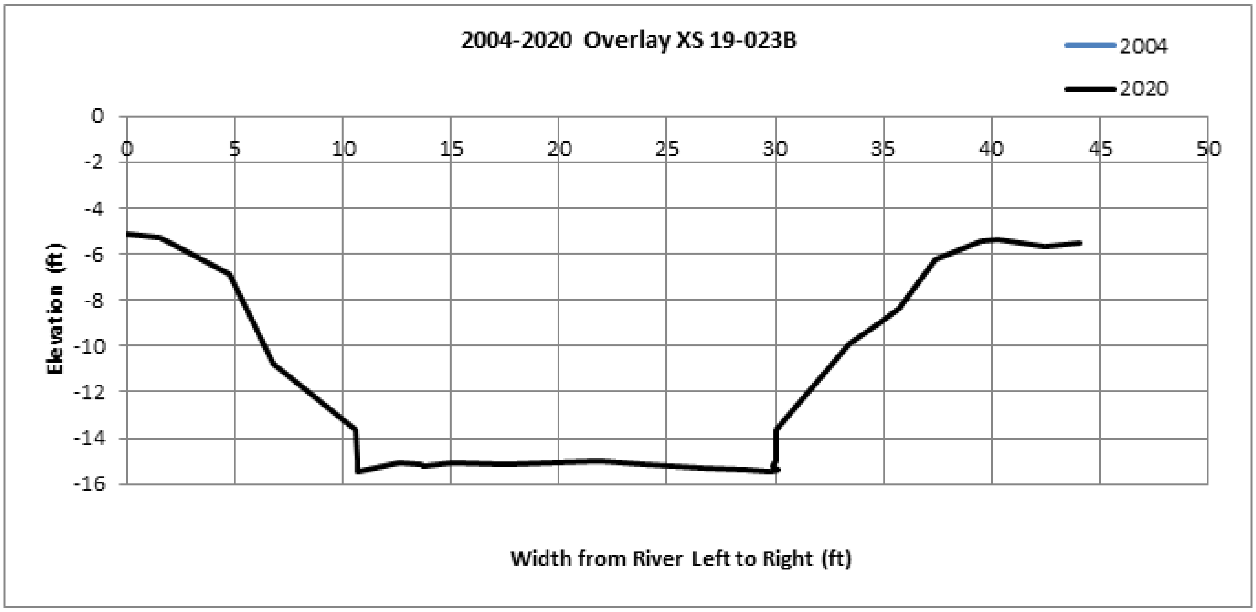


Figure F-37. Change in cross-sections for 19-023B between 2004 and 2020.

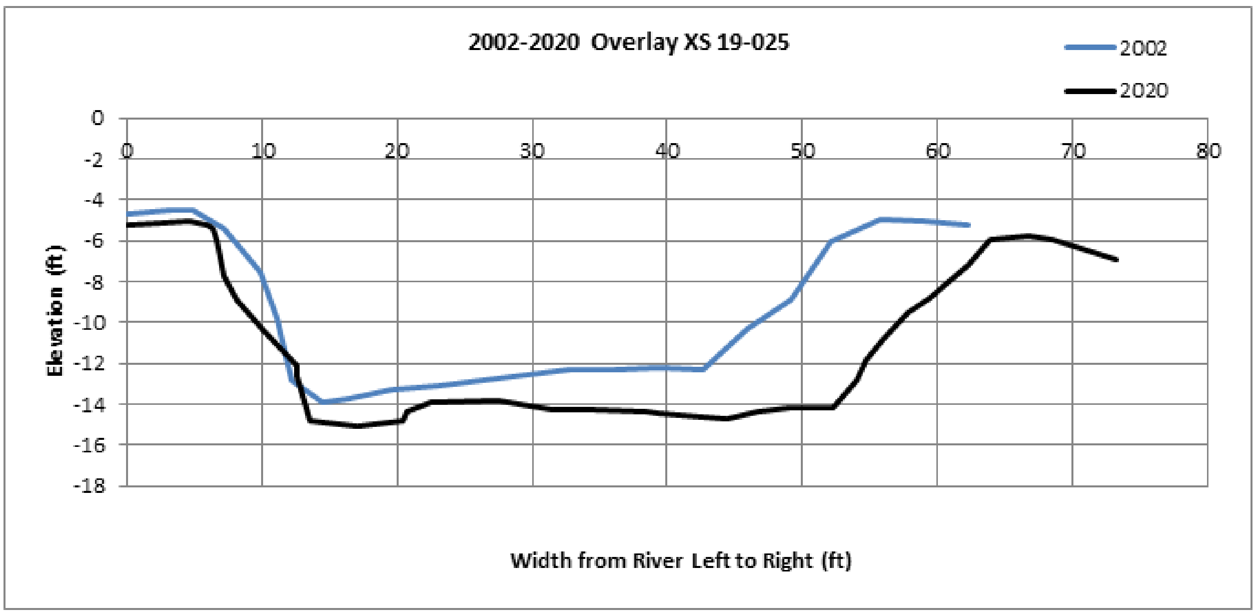


Figure F-38. Change in cross-sections for 19-025 between 2002 and 2020.

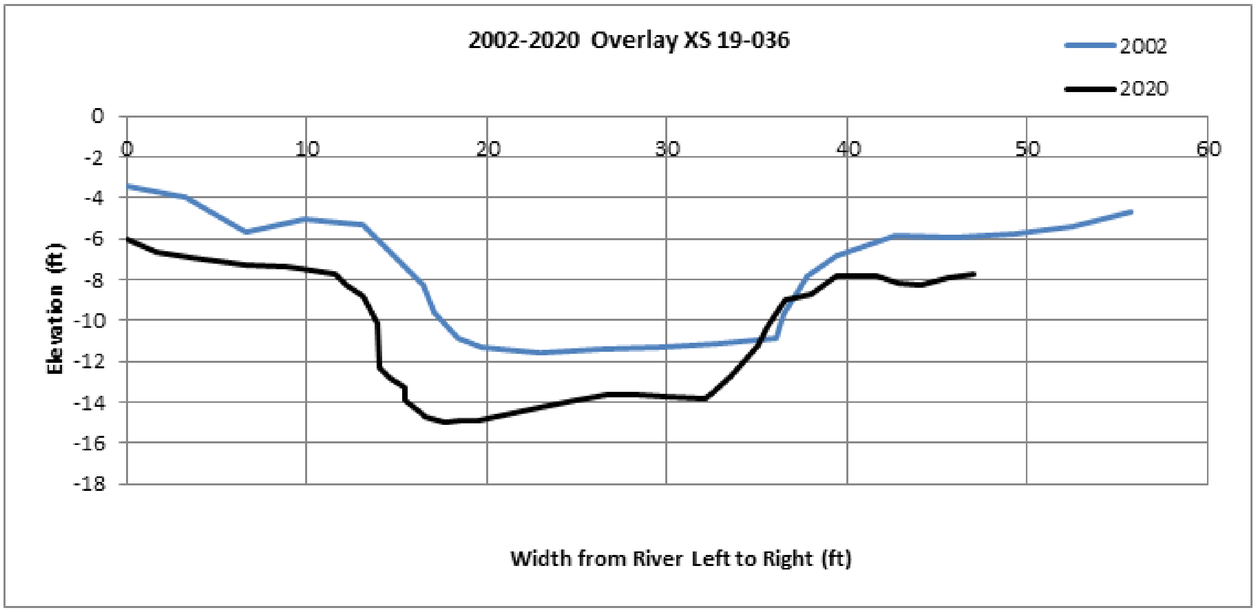


Figure F-39. Change in cross-sections for 19-036 between 2002 and 2020.

APPENDIX G: PROPOSED WIP CUMULATIVE NUMBER OF IMPERVIOUS AREAS AND LOAD REDUCTIONS

Table G-1. Proposed WIP cumulative number of impervious area (acres) and load reductions based on steady implementation rate for meeting TSS reductions.

Fiscal Year	Impervious Acres Treated	Estimated Cumulative Budget (Based on unit costs in Table 6-1.)	TN (lb/year)	TP (lb/year)	TSS (lb/year)
2025	163.71	$45,667,751	928	526	1,826,208
2026	327.42	$91,335,502	1,857	1,052	3,652,417
2027	491.13	$137,003,253	2,785	1,578	5,478,625
2028	654.84	$182,671,004	3,713	2,104	7,304,833
2029	818.55	$228,338,755	4,641	2,630	9,131,041
2030	982.26	$274,006,506	5,570	3,156	10,957,250
2031	1,145.97	$319,674,257	6,498	3,682	12,783,458
2032	1,309.68	$365,342,008	7,426	4,208	14,609,666
2033	1,473.39	$411,009,759	8,355	4,734	16,435,874
2034	1,637.11	$456,677,510	9,283	5,260	18,262,083
2035	1,800.82	$502,345,261	10,211	5,786	20,088,291
2036	1,964.53	$548,013,012	11,139	6,312	21,914,499
2037	2,128.24	$593,680,763	12,068	6,838	23,740,707
2038	2,291.95	$639,348,514	12,996	7,364	25,566,916
2039	2,455.66	$685,016,265	13,924	7,890	27,393,124
2040	2,619.37	$730,684,016	14,853	8,416	29,219,332
2041	2,783.08	$776,351,767	15,781	8,942	31,045,540
2042	2,946.79	$822,019,518	16,709	9,468	32,871,749
2043	3,110.50	$867,687,269	17,637	9,994	34,697,957
2044	3,274.21	$913,355,020	18,566	10,520	36,524,165
2045	3,437.92	$959,022,771	19,494	11,046	38,350,373
2046	3,601.63	$1,004,690,522	20,422	11,572	40,176,582
2047	3,765.34	$1,050,358,273	21,351	12,099	42,002,790
2048	3,929.05	$1,096,026,024	22,279	12,625	43,828,998
2049	4,092.76	$1,141,693,775	23,207	13,151	45,655,206
2050	4,256.47	$1,187,361,526	24,135	13,677	47,481,415
2051	4,420.18	$1,233,029,277	25,064	14,203	49,307,623
2052	4,583.89	$1,278,697,028	25,992	14,729	51,133,831
2053	4,696.56	$1,310,124,667	26,631	15,091	52,390,591

Table G-2. Proposed WIP cumulative number of impervious area (acres) and load reductions based on steady implementation rate for meeting TP reductions.

Fiscal Year	Impervious Acres Treated	Estimated Cumulative Budget (Based on unit costs in Table 6-1.)	TN (lb/year)	TP (lb/year)	TSS (lb/year)
2025	163.71	$51,691,480	1,262	458	1,484,578
2026	327.42	$103,382,959	2,524	915	2,969,156
2027	491.13	$155,074,439	3,787	1,373	4,453,734
2028	654.84	$206,765,918	5,049	1,830	5,938,312
2029	818.55	$258,457,398	6,311	2,288	7,422,890
2030	982.26	$310,148,877	7,573	2,745	8,907,468
2031	1,145.97	$361,840,357	8,836	3,203	10,392,046
2032	1,309.68	$413,531,836	10,098	3,661	11,876,625
2033	1,473.39	$465,223,316	11,360	4,118	13,361,203
2034	1,637.11	$516,914,795	12,622	4,576	14,845,781
2035	1,800.82	$568,606,275	13,885	5,033	16,330,359
2036	1,964.53	$620,297,754	15,147	5,491	17,814,937
2037	2,128.24	$671,989,234	16,409	5,948	19,299,515
2038	2,291.95	$723,680,713	17,671	6,406	20,784,093
2039	2,455.66	$775,372,193	18,934	6,864	22,268,671
2040	2,619.37	$827,063,672	20,196	7,321	23,753,249
2041	2,783.08	$878,755,152	21,458	7,779	25,237,827
2042	2,946.79	$930,446,631	22,720	8,236	26,722,405
2043	3,110.50	$982,138,111	23,983	8,694	28,206,983
2044	3,274.21	$1,033,829,590	25,245	9,152	29,691,561
2045	3,437.92	$1,085,521,070	26,507	9,609	31,176,139
2046	3,601.63	$1,137,212,549	27,769	10,067	32,660,718
2047	3,765.34	$1,188,904,029	29,031	10,524	34,145,296
2048	3,929.05	$1,240,595,508	30,294	10,982	35,629,874
2049	4,092.76	$1,292,286,988	31,556	11,439	37,114,452
2050	4,256.47	$1,343,978,467	32,818	11,897	38,599,030
2051	4,420.18	$1,395,669,947	34,080	12,355	40,083,608
2052	4,583.89	$1,447,361,426	35,343	12,812	41,568,186
2053	4,747.60	$1,499,052,906	36,605	13,270	43,052,764
2054	4,911.32	$1,550,744,385	37,867	13,727	44,537,342
2055	5,075.03	$1,602,435,865	39,129	14,185	46,021,920
2056	5,238.74	$1,654,127,344	40,392	14,642	47,506,498
2057	5,402.45	$1,705,818,824	41,654	15,100	48,991,076
2058	5,566.16	$1,757,510,303	42,916	15,558	50,475,654
2059	5,729.87	$1,809,201,783	44,178	16,015	51,960,232
2060	5,893.58	$1,860,893,262	45,441	16,473	53,444,810

Fiscal Year	Impervious Acres Treated	Estimated Cumulative Budget (Based on unit costs in Table 6-1.)	TN (lb/year)	TP (lb/year)	TSS (lb/year)
2061	6,057.29	$1,912,584,742	46,703	16,930	54,929,389
2062	6,221.00	$1,964,276,221	47,965	17,388	56,413,967
2063	6,384.71	$2,015,967,701	49,227	17,845	57,898,545
2064	6,548.42	$2,067,659,180	50,490	18,303	59,383,123
2065	6,687.15	$2,111,462,074	51,559	18,691	60,641,141

Table G-3. Proposed WIP cumulative number of impervious area (acres) and load reductions based on steady implementation rate for meeting TN reductions.

Fiscal Year	Impervious Acres Treated	Estimated Cumulative Budget (Based on unit costs in Table 6-1.)	TN (lb/year)	TP (lb/year)	TSS (lb/year)
2025	163.71	$59,911,173	1,722	387	1,101,071
2026	327.42	$119,822,346	3,444	774	2,202,142
2027	491.13	$179,733,519	5,165	1,161	3,303,212
2028	654.84	$239,644,692	6,887	1,548	4,404,283
2029	818.55	$299,555,864	8,609	1,934	5,505,354
2030	982.26	$359,467,037	10,331	2,321	6,606,425
2031	1,145.97	$419,378,210	12,052	2,708	7,707,495
2032	1,309.68	$479,289,383	13,774	3,095	8,808,566
2033	1,473.39	$539,200,556	15,496	3,482	9,909,637
2034	1,637.11	$599,111,729	17,218	3,869	11,010,708
2035	1,800.82	$659,022,902	18,939	4,256	12,111,778
2036	1,964.53	$718,934,075	20,661	4,643	13,212,849
2037	2,128.24	$778,845,247	22,383	5,030	14,313,920
2038	2,291.95	$838,756,420	24,105	5,416	15,414,991
2039	2,455.66	$898,667,593	25,827	5,803	16,516,062
2040	2,619.37	$958,578,766	27,548	6,190	17,617,132
2041	2,783.08	$1,018,489,939	29,270	6,577	18,718,203
2042	2,946.79	$1,078,401,112	30,992	6,964	19,819,274
2043	3,110.50	$1,138,312,285	32,714	7,351	20,920,345
2044	3,274.21	$1,198,223,458	34,435	7,738	22,021,415
2045	3,437.92	$1,258,134,631	36,157	8,125	23,122,486
2046	3,601.63	$1,318,045,803	37,879	8,512	24,223,557
2047	3,765.34	$1,377,956,976	39,601	8,898	25,324,628
2048	3,929.05	$1,437,868,149	41,322	9,285	26,425,698
2049	4,092.76	$1,497,779,322	43,044	9,672	27,526,769
2050	4,256.47	$1,557,690,495	44,766	10,059	28,627,840
2051	4,420.18	$1,617,601,668	46,488	10,446	29,728,911

Fiscal Year	Impervious Acres Treated	Estimated Cumulative Budget (Based on unit costs in Table 6-1.)	TN (lb/year)	TP (lb/year)	TSS (lb/year)
2052	4,583.89	$1,677,512,841	48,210	10,833	30,829,981
2053	4,747.60	$1,737,424,014	49,931	11,220	31,931,052
2054	4,911.32	$1,797,335,186	51,653	11,607	33,032,123
2055	5,075.03	$1,857,246,359	53,375	11,994	34,133,194
2056	5,238.74	$1,917,157,532	55,097	12,380	35,234,265
2057	5,402.45	$1,977,068,705	56,818	12,767	36,335,335
2058	5,566.16	$2,036,979,878	58,540	13,154	37,436,406
2059	5,729.87	$2,096,891,051	60,262	13,541	38,537,477
2060	5,893.58	$2,156,802,224	61,984	13,928	39,638,548
2061	6,057.29	$2,216,713,397	63,705	14,315	40,739,618
2062	6,221.00	$2,276,624,569	65,427	14,702	41,840,689
2063	6,384.71	$2,336,535,742	67,149	15,089	42,941,760
2064	6,548.42	$2,396,446,915	68,871	15,476	44,042,831
2065	6,712.13	$2,456,358,088	70,593	15,862	45,143,901
2066	6,875.84	$2,516,269,261	72,314	16,249	46,244,972
2067	7,039.55	$2,576,180,434	74,036	16,636	47,346,043
2068	7,203.26	$2,636,091,607	75,758	17,023	48,447,114
2069	7,366.97	$2,696,002,780	77,480	17,410	49,548,185
2070	7,530.68	$2,755,913,953	79,201	17,797	50,649,255
2071	7,694.39	$2,815,825,125	80,923	18,184	51,750,326
2072	7,858.10	$2,875,736,298	82,645	18,571	52,851,397
2073	8,021.81	$2,935,647,471	84,367	18,957	53,952,468
2074	8,185.53	$2,995,558,644	86,088	19,344	55,053,538
2075	8,349.24	$3,055,469,817	87,810	19,731	56,154,609
2076	8,512.95	$3,115,380,990	89,532	20,118	57,255,680
2077	8,676.66	$3,175,292,163	91,254	20,505	58,356,751
2078	8,840.37	$3,235,203,336	92,976	20,892	59,457,821
2079	9,004.08	$3,295,114,508	94,697	21,279	60,558,892
2080	9,167.79	$3,355,025,681	96,419	21,666	61,659,963
2081	9,331.50	$3,414,936,854	98,141	22,053	62,761,034
2082	9,495.21	$3,474,848,027	99,863	22,439	63,862,104
2083	9,658.92	$3,534,759,200	101,584	22,826	64,963,175
2084	9,822.63	$3,594,670,373	103,306	23,213	66,064,246
2085	9,986.34	$3,654,581,546	105,028	23,600	67,165,317
2086	10,150.05	$3,714,492,719	106,750	23,987	68,266,388
2087	10,313.76	$3,774,403,892	108,471	24,374	69,367,458
2088	10,477.47	$3,834,315,064	110,193	24,761	70,468,529
2089	10,641.18	$3,894,226,237	111,915	25,148	71,569,600

Fiscal Year	Impervious Acres Treated	Estimated Cumulative Budget (Based on unit costs in Table 6-1.)	TN (lb/year)	TP (lb/year)	TSS (lb/year)
2090	10,804.89	$3,954,137,410	113,637	25,535	72,670,671
2091	10,968.60	$4,014,048,583	115,359	25,921	73,771,741
2092	11,132.31	$4,073,959,756	117,080	26,308	74,872,812
2093	11,296.03	$4,133,870,929	118,802	26,695	75,973,883
2094	11,459.74	$4,193,782,102	120,524	27,082	77,074,954
2095	11,623.45	$4,253,693,275	122,246	27,469	78,176,024
2096	11,787.16	$4,313,604,447	123,967	27,856	79,277,095
2097	11,950.87	$4,373,515,620	125,689	28,243	80,378,166
2098	12,114.58	$4,433,426,793	127,411	28,630	81,479,237
2099	12,278.29	$4,493,337,966	129,133	29,017	82,580,308
2100	12,442.00	$4,553,249,139	130,854	29,403	83,681,378
2101	12,605.71	$4,613,160,312	132,576	29,790	84,782,449
2102	12,769.42	$4,673,071,485	134,298	30,177	85,883,520
2103	12,933.13	$4,732,982,658	136,020	30,564	86,984,591
2104	13,096.84	$4,792,893,831	137,742	30,951	88,085,661
2105	13,260.55	$4,852,805,003	139,463	31,338	89,186,732
2106	13,424.26	$4,912,716,176	141,185	31,725	90,287,803
2107	13,587.97	$4,972,627,349	142,907	32,112	91,388,874
2108	13,751.68	$5,032,538,522	144,629	32,499	92,489,944
2109	13,915.39	$5,092,449,695	146,350	32,885	93,591,015
2110	14,079.10	$5,152,360,868	148,072	33,272	94,692,086
2111	14,242.81	$5,212,272,041	149,794	33,659	95,793,157
2112	14,406.52	$5,272,183,214	151,516	34,046	96,894,227
2113	14,570.24	$5,332,094,386	153,237	34,433	97,995,298
2114	14,733.95	$5,392,005,559	154,959	34,820	99,096,369
2115	14,897.66	$5,451,916,732	156,681	35,207	100,197,440
2116	15,061.37	$5,511,827,905	158,403	35,594	101,298,511
2117	15,225.08	$5,571,739,078	160,125	35,981	102,399,581
2118	15,388.79	$5,631,650,251	161,846	36,367	103,500,652
2119	15,552.50	$5,691,561,424	163,568	36,754	104,601,723
2120	15,644.16	$5,725,104,814	164,532	36,971	105,218,196