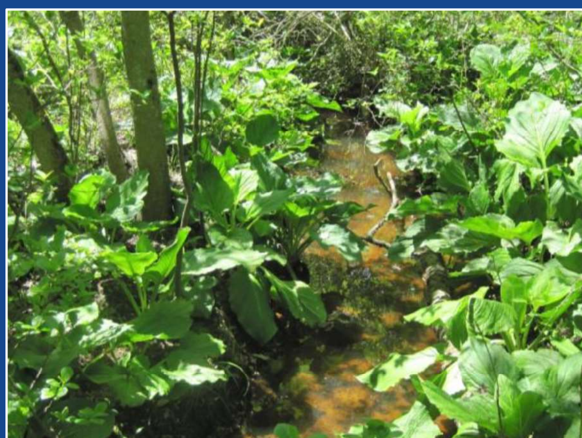

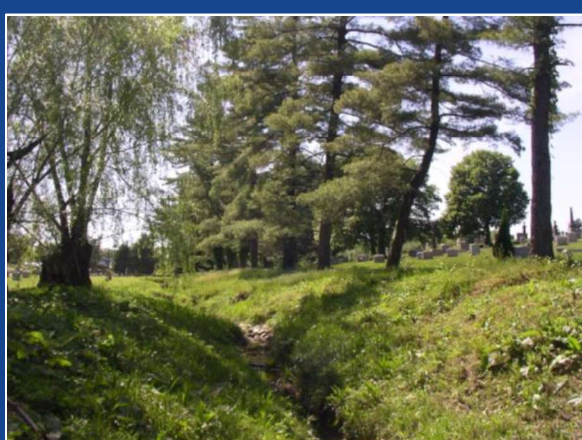

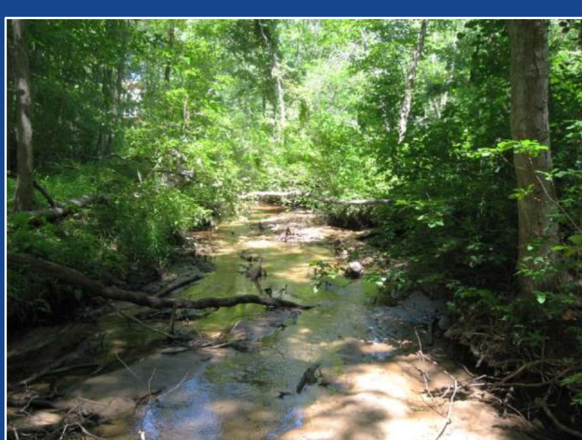

NON TIDAL BALTIMORE HARBOR WATERSHED

SEDIMENT TMDL IMPLEMENTATION PLAN

DECEMBER 2022

Anne Arundel County
Bureau of Watershed
Protection
& Restoration

NON TIDAL BALTIMORE HARBOR WATERSHED

SEDIMENT TMDL RESTORATION PLAN

DECEMBER 2022

DRAFT

PREPARED FOR

Anne Arundel County

Department of Public Works

Bureau of Watershed Protection and Restoration

2662 Riva Road, P.O. Box 6675

Annapolis, Maryland 21401

PREPARED BY

LimnoTech

1015 18th Street NW

Suite 900

Washington, DC 20003

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

List of Acronyms

AA	Anne Arundel
AAWSA	Anne Arundel Watershed Stewards Academy
AFG	Accounting For Growth
BIBI	Benthic Index of Biotic Integrity
BMP	Best Management Practice
BSID	Biological Stressor Identification
BWPR	Bureau of Watershed Protection and Restoration
CBP	Chesapeake Bay Program
CC	Chesapeake Conservancy
CIP	Capital Improvement Program
COMAR	Code of Maryland Regulations
CWA	Clean Water Act
DPW	Department of Public Works
EMC	Event Mean Concentration
EOS	Edge of Stream
EOT	Edge of Tide
EPA	Environmental Protection Agency
ESD	Environmentally Sensitive Design
FAP	Financial Assurance Plan
FIBI	Fish Index of Biotic Integrity
GIS	Geographic Information System
H&H	Hydrologic and Hydraulic
LA	Load Allocation
LULC	Land use / Land cover
MBSS	Maryland Biological Stream Survey
MDE	Maryland Department of the Environment
MDNR	Maryland Department of Natural Resources
MEP	Maximum Extent Practicable
MPHI	Maryland Physical Habitat Index
MS4	Municipal Separate Storm Sewer System
NGO	Non-governmental Organization
NLCD	National Land Cover Database
NPDES	National Pollutant Discharge Elimination System
NTU	Nephelometer Turbidity Units

PSU	Primary Sampling Unit
RBP	Rapid Bioassessment Protocol
ROW	Right of Way
SAT	Stream Assessment Tool
SPSC	Step Pool Storm Conveyance
STB	Stream and Bed Bank
SW-WLA	Stormwater Wasteload Allocation
TIPP	TMDL Implementation Progress and Planning
TMDL	Total Maximum Daily Load
TSS	Total Suspended Solids
USGS	United States Geological Survey
WIP	Watershed Implementation Plan
WLA	Waste Load Allocation
WMP6	Watershed Model Phase 6
WMT	Watershed Management Tool
WPRF	Watershed Protection and Restoration Fee’
WQA	Water Quality Analysis
WQIP	Water Quality Improvement Projects

1 Introduction

1.1 Background and Purpose

The Anne Arundel (AA) County Department of Public Works (DPW) Bureau of Watershed Protection and Restoration (BWPR) is developing implementation plans to address local water quality impairments where a Total Maximum Daily Load (TMDL) has been established by the Maryland Department of the Environment (MDE) and approved by the U.S. Environmental Protection Agency (EPA). A TMDL establishes a maximum load of a specific single pollutant or stressor that a waterbody can assimilate and still meet water quality standards for its designated use class.

Under the Federal Clean Water Act (CWA), the State of Maryland is required to assess and report on the quality of waters throughout the state. Where Maryland's water quality standards are not fully met, CWA Section 303(d) requires the state to list these water bodies as impaired waters. States are then required to develop a TMDL for pollutants of concern for the listed impaired waters. The Non Tidal Baltimore Harbor watershed is listed in Maryland's Integrated Report of Surface Water Quality (303(d) list and 305(b) Report) for sediment pollution. On January 27, 2022, EPA approved a sediment (total suspended solids, or TSS) TMDL for the Non Tidal Baltimore Harbor watershed in Baltimore City, Baltimore County, and Anne Arundel County (MDE, 2021d). This plan will address Anne Arundel County's responsibility for meeting its stormwater wasteload allocation (SW-WLA) included in the Non Tidal Baltimore Harbor watershed sediment TMDL.

The TMDL load targets, or allocations, are apportioned by source categories, which include non-point sources (termed load allocation or LA) and point sources (termed wasteload allocation or WLA). The WLA consists of loads originating from regulated process water or wastewater treatment and regulated stormwater. For the purposes of the TMDL and consistent with implementation of the National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) Discharge Permit, stormwater runoff from MS4 areas is considered a point source contribution.

Anne Arundel County's current MS4 permit (20-DP-3316, MD0068306, MDE 2021b) issued in its final form by MDE in November 2021, requires development of implementation plans for each SW-WLA approved by EPA prior to the effective date of the permit or within one year of EPA approval (permit Part IV.F.2). This plan will satisfy this permit requirement for the Anne Arundel County SW-WLAs in the Non Tidal Baltimore Harbor Watershed TMDL and will provide the load target, recommended management measures, load reduction estimates, schedule, programmed and proposed implementation, restoration, cost estimates and funding sources, and the tracking and monitoring approaches to meet the WLAs in the TMDL documents.

The Non Tidal Baltimore Harbor watershed extends over three jurisdictions (Baltimore City, Baltimore County, and Anne Arundel County) and includes multiple NPDES permittees. In Anne Arundel County, the area contributing to the Non Tidal Baltimore Harbor watershed consists of the Patapsco Tidal watershed. Anne Arundel County considers the Patapsco Tidal watershed to also include the Bodkin Creek watershed, as determined from watershed delineations using the County's digital elevation model. However, for the purposes of this sediment TMDL implementation plan, Maryland's 8-digit boundary, upon which the TMDL was based, was used. The 8-digit boundary includes the Patapsco Tidal portion and excludes the Bodkin Creek watershed.

For allocation purposes, MDE has assigned one MS4 SW-WLA to Anne Arundel County. As described above, the area contributing to the Non Tidal Baltimore Harbor watershed in Anne Arundel County consists of the Patapsco Tidal watershed. Therefore, Anne Arundel County will address its MS4 WLA for this TMDL through work in the Patapsco Tidal watershed. The assignment of the County's MS4 WLA from the Non Tidal Baltimore Harbor watershed TMDL to the County's Patapsco Tidal watershed is also consistent with the 8-digit watershed scale used in MDE's TMDL Implementation Progress and Planning (TIPP) tool (MDE, 2021a).

It is noted that TMDL implementation plans are an important first step towards achieving the SW-WLAs. The MS4 permit calls for an iterative and adaptive plan for implementation. If new methods of stormwater treatment are identified, or better approaches to source control are found, the implementation plans can be updated to take the changes into account. Similarly, if some elements of the plans are not as successful as expected, adaptations and improvements will be incorporated into future updates.

Anne Arundel County expects to meet its sediment SW-WLA for the Non Tidal Baltimore Harbor watershed by 2035. The strategies proposed in the plan will provide treatment to reduce current sediment loads from the MS4 stormwater sector.

1.2 TMDL Allocated and Planned Loads Summary

The Non Tidal Baltimore Harbor Watershed Implementation Plan (also called the Implementation Plan herein) only addresses loads allocated to Anne Arundel County's point source NPDES-regulated stormwater sediment as specified in the Final Technical Memorandum, Point Sources of Sediment in the Non Tidal Baltimore Harbor Watershed (MDE, 2021e). Additional SW-WLAs for the Non Tidal Baltimore Harbor Watershed TMDL assigned to other regulated entities (i.e., Baltimore City, Baltimore County, Maryland State Highway Administration, others) are not the responsibility of Anne Arundel County and are not addressed in this plan.

The Chesapeake Bay Program (CBP) Phase 5.3.2 (CBP P5.3.2) watershed model was used to calculate a 2009 baseline sediment load, and MDE refined the CBP P5.3.2 urban land-use data to determine the County's target SW-WLA under the Non Tidal Baltimore Harbor Watershed TMDL (Table 1-1) . A planning horizon of 2035 is used as the date to achieve these load reductions, and to assess progress.

Table 1-1: Non Tidal Baltimore Harbor Watershed Sediment TMDL Baseline Loads, WLA, and Required Reductions for Anne Arundel County

NPDES Regulated Stormwater Sector	Baseline Load (ton/yr)	WLA (ton/yr)	Reduction (%)
Non Tidal Baltimore Harbor Watershed, Anne Arundel County Phase I MS4	1660	697	58

The CBP P5.3.2 model used for the assignment of SW-WLAs for this TMDL has since been superseded by the CBP Watershed Model Phase 6 (WMP6) (CBP, 2017). In response to these model changes, MDE developed the TIPP tool, a spreadsheet-based pollutant load estimating tool that calculates pollutant loads and reductions using the same modeling approaches as the WMP6. The TIPP tool allows the original target reduction percentage (i.e., 58%) to be applied to the TIPP baseline loads, providing an updated SW-WLA and taking advantage of the model improvements and advances between CBP P5.3.2 and WMP6. For the purposes of this Implementation Plan, MDE's TIPP tool was used to model baseline, progress, planned, and proposed loads.

Based on MDE guidance, growth in the stormwater load since the TMDL baseline year was not accounted for in the development of this plan. Any increase in development (and accompanying increase in impervious surface) must include control of associated stormwater to the maximum extent practicable (MEP). Therefore, from a planning perspective, local TMDLs are considered met when the load reductions associated with 2009 baseline load, coupled with the planned implementation load reductions, exceed the load reduction required.

This section of the plan provides a concise summary of the loads and reductions at important timeline intervals, including the 2009 baseline, 2022 progress, interim programmed implementation, and 2035 final planning intervals (Table 1-2). These terms and dates are used throughout the plan and are explained in more detail in the following sections. They are presented here to assist the reader in understanding the definitions of each and how they were derived, and will be used to summarize the percent reduction required and percent reduction achieved through full implementation of this plan. Sediment loads and WLAs are presented as tons/year in the TMDL for the Non Tidal Baltimore Harbor watershed, but will be discussed as pounds/year (lbs/yr) in this Implementation Plan since TIPP provides the loads in terms of lbs/yr.

- **2009 Baseline Load**: These are the baseline level sediment loads from the 2009 conditions in the Patapsco Tidal River watershed. Baseline loads are estimated within the TIPP tool by subtracting the load reductions from Best Management Practices (BMPs) installed in or prior to 2009 from the 2009 baseline land-use loads. Baseline TSS loads, in conjunction with the percent load reduction prescribed by the TMDL (Table 1-2), are used to calculate the sediment SW-WLA.
- **2022 Progress Load and Reductions**: These are the progress loads and load reductions achieved from stormwater BMP implementation through the end of FY2022. The 2022 progress load reductions are calculated by estimating BMP implementation (post 2009 through end of FY2022) in TIPP. The 2022 progress load is then calculated by subtracting the 2022 progress load reductions from the 2009 baseline load.
- **Interim Programmed Implementation Load and Reductions**: These are the planned loads and reductions that will result from implementation of strategies and projects that are currently programmed (i.e., those projects for which design contracts have been issued and the design stage is 30% or greater). The programmed implementation loads are calculated by subtracting the programmed implementation load reductions from the 2009 baseline load.
- **2035 Planned Loads and Reductions**: These are the planned 2035 loads and reductions that will result from implementation of strategies, programmed implementation, and planned implementation (i.e., those projects for which a design contract has not been issued or are in a conceptual design stage) through 2035 and will meet the TMDL SW-WLAs. 2035 planned loads are calculated by subtracting the 2035 planned load reductions from the 2009 baseline load.

Table 1-2: Summary of the TIPP Loads and Reductions at Important Timeline Intervals

	Patapsco Tidal River Watershed Sediment (lbs/year)
2009 Baseline Load	21,673,357
2010-2022 Progress Load Reductions	1,843,172
2022 Progress Load	19,830,185
Interim Programmed Implementation Load Reductions	7,876,949
Interim Programmed Implementation Planned Load	11,953,236
2035 Planned Load Reductions	2,868,130
2035 Planned Load	9,085,106
Required Reduction by 2035 (percent)	58
Planned Progress Reduction by 2035 (percent)	58.1

1.3 Implementation Plan Elements and Structure

This plan is developed within the context of on-going watershed management planning, implementation, restoration, and resource protection being conducted by Anne Arundel County. The County initiated comprehensive watershed assessment and management plans in 2000 and has completed plans for all of its 12 major watersheds. A comprehensive watershed assessment for the watersheds of the Patapsco Tidal River segment was completed in August of 2012. The County also prepared a Phase II Watershed Implementation Plan (WIP) for nitrogen, phosphorus and sediment in 2012 in response to requirements set forth in the Chesapeake Bay TMDL. Information synthesized and incorporated into this Implementation Plan for the Non Tidal Baltimore Harbor watershed draws upon these sources, with updates and additions where necessary, to meet the specific goals of the TMDL. The TMDL analyses and reports developed by MDE were also used to develop this plan. These primary sources include:

- *Patapsco Tidal and Bodkin Creek Watershed Assessment Comprehensive Summary Report* (Anne Arundel County, 2012b) (hereafter referred to as the "*Patapsco Tidal Watershed Assessment Report"*)
- *Chesapeake Bay TMDL, Phase II Watershed Implementation Plan, Final* (Anne Arundel County, 2012a)
- *Total Maximum Daily Load of Sediment in the Baltimore Harbor Watershed, Baltimore City, Baltimore County, and Anne Arundel County, Maryland* (including supplemental technical memoranda and decision letters) (MDE, 2021d)
- *Technical Memorandum: Point Sources of Sediment in the Non Tidal Baltimore Harbor Watershed* (MDE, 2021e)

MDE has prepared several guidance documents to assist municipalities with preparation of TMDL implementation plans. This plan is developed following the guidance detailed in the following documents, with modifications as necessary:

- *Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated; Guidance for National Pollutant Discharge Elimination System Stormwater Permits* (MDE, 2020)
- *TMDL Implementation Progress and Planning Tool (TIPP*) (MDE, 2021a)
- *General Guidance for Local Total Maximum Daily Load Stormwater Wasteload Allocation Watershed Implementation Plans* (MDE, 2021f)

The Non Tidal Baltimore Harbor Watershed Implementation Plan has been prepared in accordance with the EPA's nine essential elements for watershed planning. These elements, commonly called the "a through I criteria" are important for the creation of thorough, robust, and meaningful watershed plans and incorporation of these elements into the plan is of particular importance in receiving funding for implementation. EPA has clearly stated that to ensure that Section 319-(the EPA Nonpoint Source Management Program[1]) funded projects make progress towards restoring waters impaired by nonpoint source pollution, watershed-based plans that are developed or implemented with Section 319 funds to address 303(d)-listed waters must include at least the nine elements. While the sediment Implementation Plan described herein is focused on Anne Arundel County MS4 point sources, EPA recommends including these nine elements in all watershed plans because they provide a quantitative framework for the planning process that leads to water quality improvements and restoration to attain water quality standards.

The Non Tidal Baltimore Harbor Watershed Implementation Plan is organized based on these nine elements. A modification to the order has been incorporated into this plan such that element c., a description of the management measures, is included in the plan as Section 4, before element b., the expected load reductions, which is included in the plan as Section 5. This modified approach makes the plan easier to follow. The planning elements (summarized below in the order presented by EPA) are:

a. An identification of the causes and sources that will need to be controlled to achieve the load reductions estimated in the plan and to achieve any other watershed goals identified in the plan, as discussed in element (b) immediately below. (Section 3 of this Implementation Plan)
b. An estimate of the load reductions expected for the management measures described under element I below, recognizing the natural variability and the difficulty in precisely predicting the performance of management measures over time. (Section 5 of this Implementation Plan)
c. A description of the management measures that will need to be implemented to achieve the load reductions estimated under element (b) above, as well as to achieve other watershed goals identified in the plan, and an identification of the critical areas in which those measures will be needed to implement this plan. (Section 4 of this Implementation Plan)
d. An estimate of the amount of technical and financial assistance needed, associated costs, and/or the sources and authorities that will be relied upon, to implement this plan. (Section 6 of this Implementation Plan)
e. An information/education component used to enhance public understanding of the project and encourage their early and continued participation in selecting, designing, and implementing the recommended management measures. (Section 7 of this Implementation Plan)

[1] https://www.epa.gov/nps/319-grant-program-states-and-territories

f. A schedule for implementing the management measures identified in this plan that is reasonably expeditious. (Section 8 of this Implementation Plan)
g. A description of interim programmed implementation for determining whether management measures or other control actions are being implemented. (Section 8 of this Implementation Plan)
h. A set of criteria that can be used to determine whether loading reductions are being achieved over time and substantial progress is being made towards attaining water quality standards and, if not, the criteria for determining whether the plan needs to be revised. (Section 9 of this Implementation Plan)
i. A monitoring component to evaluate the effectiveness of the implementation efforts over time, measured against the criteria established under element (h) immediately above. (Section 10 of this Implementation Plan)

The implementation planning efforts described in this document provide a blueprint for the implementation of restoration projects that will result in meeting Anne Arundel County's sediment SW-WLA, and contribute to meeting water quality standards. Successful implementation of the plan will lead to improvements in local watershed conditions and aquatic health.

2 Watershed Characteristics

As described in Chapter 1 above, the area in Anne Arundel County contributing to the Non Tidal Baltimore Harbor watershed consists of the Patapsco Tidal River watershed. Therefore, Anne Arundel County will address its MS4 WLA for this TMDL through work in the Patapsco Tidal River watershed. The following sections describe the watershed characteristics for the Patapsco Tidal River watershed.

2.1 Watershed Delineation

The Patapsco Tidal River watershed is located in the northeastern part of Anne Arundel County, Maryland, as shown in Figure 2.1, and is one of the 12 major watersheds in the County. The watershed is approximately 30,846 acres (48.2 mi^2)[2] and contains approximately 135 miles of streams, 50 miles of which are perennial streams. It is also part of the larger Chesapeake Bay watershed. Six Patapsco Tidal River subwatersheds are excluded from this implementation plan because they do not align with the Non Tidal Baltimore Harbor TMDL watershed delineation, shown in Figure 2.2. The area of the Patapsco Tidal River watershed included in this implementation plan is 29,868 acres (46.7 mi^2). Approximately 131 miles of streams, including all 50 miles of perennial streams, are in this portion of the Patapsco Tidal River watershed.

[2] Per the *Anne Arundel Countywide TMDL Stormwater Implementation Plan: FY 22 Annual Progress Report* (Anne Arundel County, 2022), which is based on a watershed boundary set by MDE and consists of only MS4 area, the watershed is 30,357 ac (47.4 mi^2). However, the watershed area used in this Implementation Plan is based the *Patapsco Tidal and Bodkin Creek Watershed Assessment Comprehensive Summary Report* (Anne Arundel County, 2012b).

Figure 2-1: Location of the Patapsco Tidal River Watershed Within Anne Arundel County

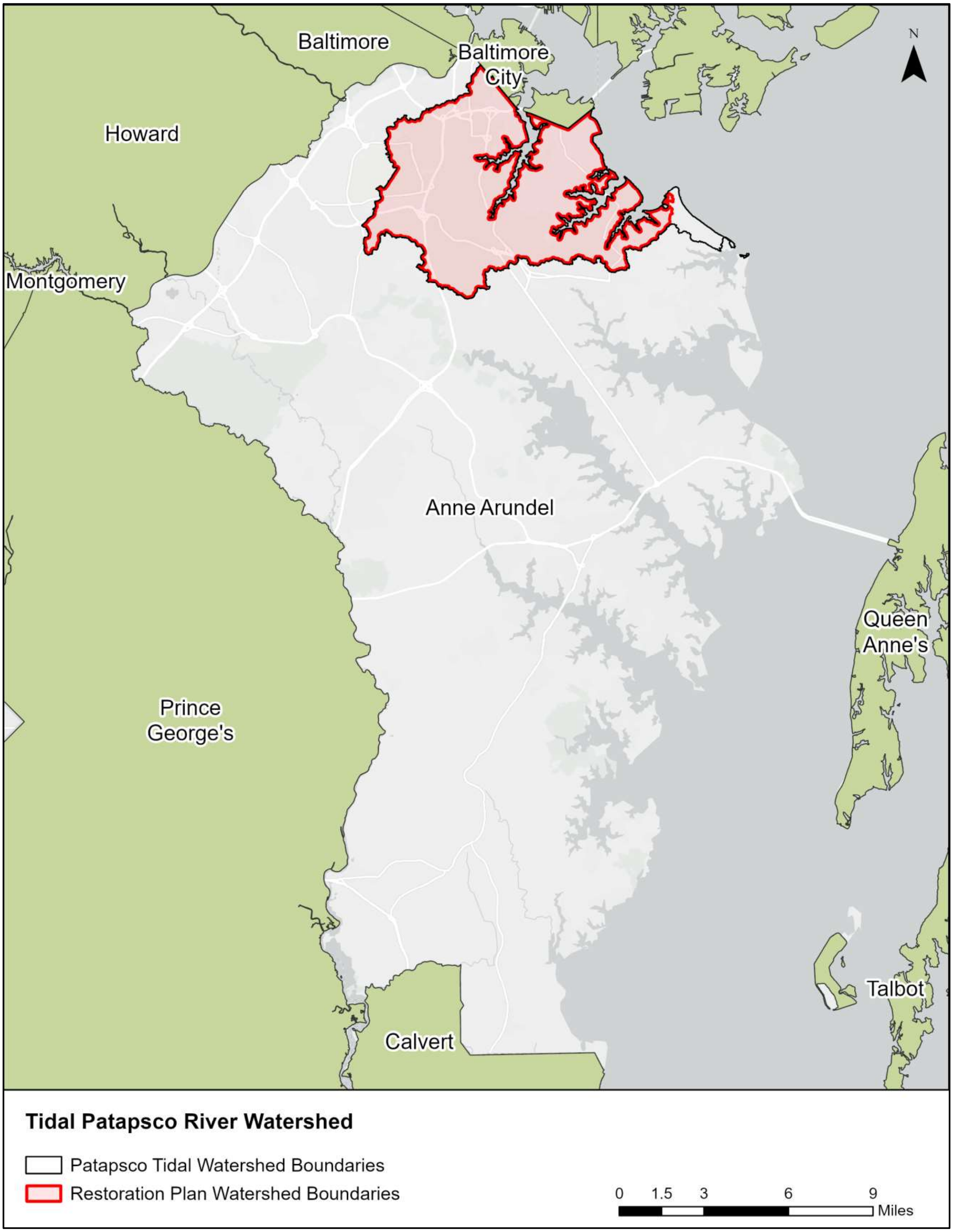
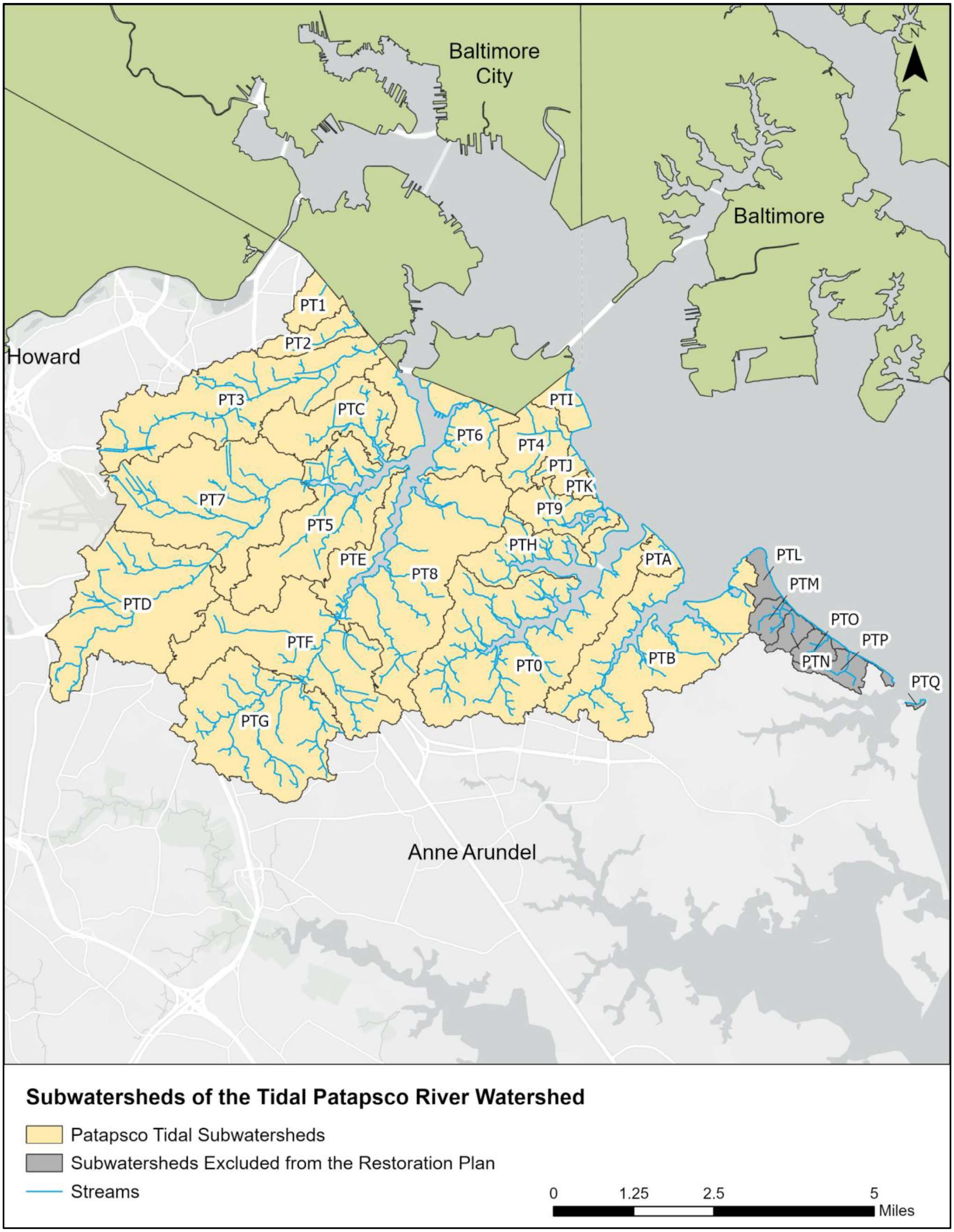


Figure 2-2 shows the subwatershed delineations for the watershed.

Figure 2-2: Subwatersheds of the Patapsco Tidal River Watershed



2.2 Patapsco Tidal River Subwatersheds

The following information was taken from the *Patapsco Tidal and Bodkin Creek Watershed Assessment Comprehensive Summary Report* (Anne Arundel County, 2012b). The *Patapsco Tidal and Bodkin Creek Watershed Assessment Comprehensive Summary Report* divides the Patapsco Tidal River watershed into 27 subwatersheds, which were used as the planning units. Note that six subwatersheds that are included in the *Patapsco Tidal and Bodkin Creek Watershed Assessment Comprehensive Summary Report* (Anne Arundel County, 2012b) have not been included in the tables and figures included in this Implementation Plan because they are not part of the watershed defined in the TMDL. Table 2-1 shows the area and length of stream for each subwatershed.

Table 2-1: Patapsco Tidal River Subwatershed Area and Stream Length

Subwatershed Code	Subwatershed Name	Drainage Area (acres)	Drainage Area (square miles)	Total Stream Length[1] (miles)
PT0	Stony Creek	3,367	5.3	14.6
PT1	Unnamed Tributary	312	0.5	0
PT2	Cabin Branch II	370	0.6	2.0
PT3	Cabin Branch	2,667	4.2	16.7
PT4	Swan Creek	652	1.0	3.3
PT5	Furnace Creek	1,856	2.9	7.0
PT6	Curtis Creek	1,179	1.8	3.2
PT7	Sawmill Creek I	2,914	4.6	13.9
PT8	Marley Creek I	2,767	4.3	8.2
PT9	Cox Creek	544	0.9	2.1
PTA	Patapsco Tidal	181	0.3	0.6
PTB	Rock Creek	2,574	4.0	7.5
PTC	Back Creek	1,045	1.6	4.8
PTD	Sawmill Creek II	2,684	4.2	13.3
PTE	Marley Creek II	492	0.8	0.6
PTF	Marley Creek III	2,517	3.9	11.4
PTG	Marley Creek IV	2,517	3.9	16.5
PTH	Nabbs Creek	688	1.1	4.1
PTI	Patapsco Tidal	242	0.4	0.5
PTJ	Patapsco Tidal	215	0.3	0.8
PTK	Patapsco Tidal	85	0.1	0
	Patapsco Tidal River Watershed Total	29,868	46.7	131.1

[1]Stream miles includes ephemeral, intermittent channels as well as perennial stream reaches

2.3 Land Use/Land Cover

Land use and land cover (LULC) have a significant impact on water quality and stream habitat condition. Undeveloped, forested areas slow the flow of stormwater and allow for infiltration. Vegetation and soil remove some of the nutrients and pollutants found in stormwater, improving the water quality as the stormwater infiltrates. Developed areas with high levels of impervious surface do not slow or filter stormwater. Thus, developed areas result in increased flow levels and decreased water quality, both of which degrade the stream habitats through erosion and pollution, respectively. Agricultural land can also impair streams with nutrients and bacteria if not managed properly.

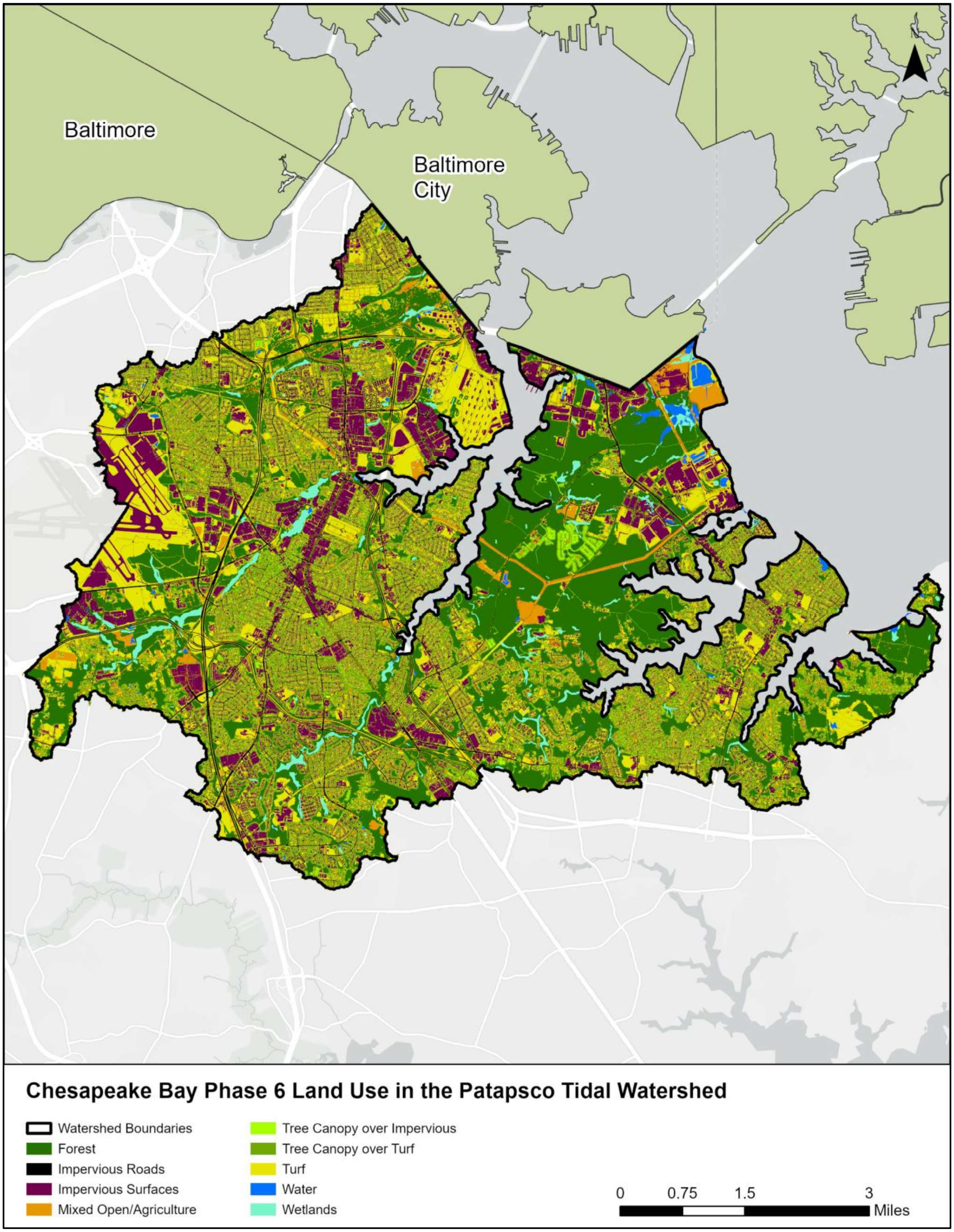
2.3.1 Existing Land Use/Land Cover

As shown in Table 2-2, the Patapsco Tidal River watershed is mainly developed, containing mostly turf (39.1%) and impervious surfaces (30.3%). Turf includes all LULC categories that include turf, tree canopy over turf, and fractional turf land use categories. Impervious surfaces include all impervious LULC categories including roads, surfaces, and structures, as well as tree canopy over roads, surfaces, and structures. Forest makes up 24% of the land use in the Patapsco Tidal River watershed. Figure 2-3 shows the LULC of the watershed. These data were obtained from the CBP Phase 6 Land Use data set published by the United States Geological Survey (USGS, 2018).

Table 2-2: Patapsco Tidal River Watershed Land Use/Land Cover

Land Use/Land Cover	Patapsco Tidal River Watershed (Acres)	Percent of Patapsco Tidal River Watershed
Forest	7,182	24.0%
Turf	6,950	23.3%
Impervious Surfaces	5,680	19.0%
Tree Canopy over Turf	4,727	15.8%
Impervious Roads	2,096	7.0%
Tree Canopy over Impervious	1,274	4.3%
Mixed Open/Agriculture	1,059	3.5%
Wetlands	539	1.8%
Water	362	1.2%
TOTAL	29,869[2]	100%
[2]Total acres may differ from Table 2-1 due to rounding		

Figure 2-3: CBP Phase 6 Land Use in the Patapsco Tidal River Watershed



2.3.2 Impervious Surfaces

Impervious surfaces accelerate and concentrate stormwater runoff, causing significant potential for degradation when the runoff reaches the streams. Stormwater runoff also washes off pollutants accumulated on impervious surfaces, leading to degraded water quality in streams. Areas with lower levels of impervious surfaces tend to correspond with better stream health. Impervious cover is an important factor to consider when determining pollutant loads and other characteristics of stormwater runoff.

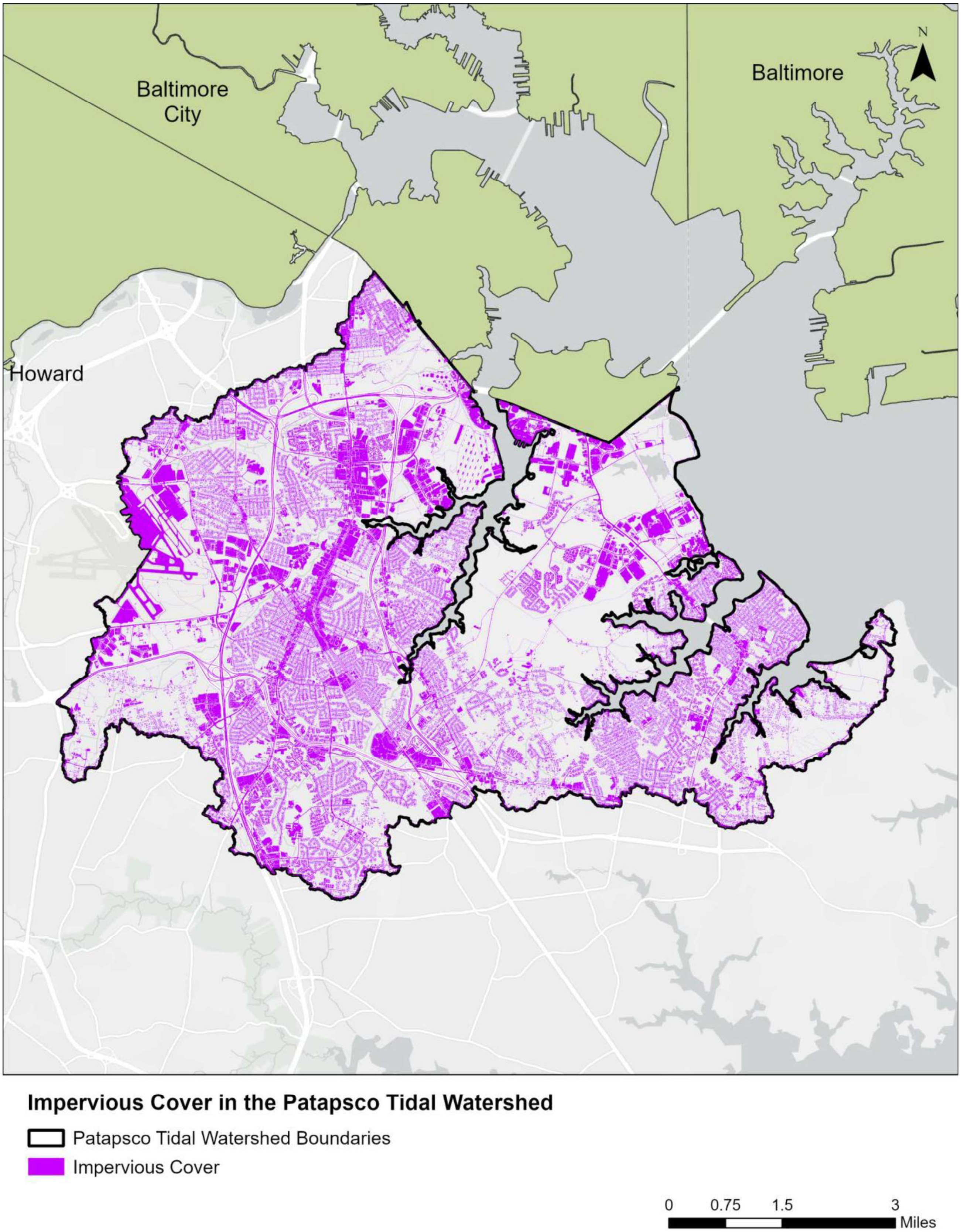
Impervious surfaces make up approximately 30.9% of the Patapsco Tidal River watershed, with the percent impervious in a given subwatershed ranging from 4.1% to as high as 45.3% impervious cover, as shown in Table 2-3. Figure 2-4 shows the impervious cover within the watershed.

Table 2-3: Patapsco Tidal River Watershed Percent Impervious Area by Subwatershed[3]

Subwatershed Code	Subwatershed Name	Percent Impervious
PT0	Stony Creek	24.9%
PT1	Unnamed Tributary	45.3%
PT2	Cabin Branch II	30.2%
PT3	Cabin Branch	30.8%
PT4	Swan Creek	14.7%
PT5	Furnace Creek	38.1%
PT6	Curtis Creek	32.8%
PT7	Sawmill Creek I	42.9%
PT8	Marley Creek I	19.9%
PT9	Cox Creek	39.7%
PTA	Patapsco Tidal	38.7%
PTB	Rock Creek	23.7%
PTC	Back Creek	43.5%
PTD	Sawmill Creek II	22.3%
PTE	Marley Creek II	35.0%
PTF	Marley Creek III	41.3%
PTG	Marley Creek IV	35.1%
PTH	Nabbs Creek	21.2%
PTI	Patapsco Tidal	4.1%
PTJ	Patapsco Tidal	37.8%
PTK	Patapsco Tidal	30.7%
	Patapsco Tidal River Watershed Total	**30.9%**

[3] Anne Arundel County, Impervious Surfaces, 2022.

Figure 2-4: Impervious Cover in the Patapsco Tidal River Watershed



As further explained below in Section 4, County-owned impervious areas, and in particular buildings and parking lots, represent opportunities for targeted BMP implementation to control stormwater runoff. A Geographic Information System (GIS) analysis was conducted to identify these impervious surfaces, utilizing GIS data on County-wide impervious surfaces (Figure 2-4), and public parcels. Any surfaces that were already treated by existing BMPs were left out of the impervious surface analysis, as were small buildings (smaller than 2,000 sf) and parking lots (smaller than 1/16th of an acre). These thresholds were set in order to limit potential implementation to areas where retrofit projects would be most practical and cost-effective. A summary of the remaining impervious surfaces are summarized below in Table 2-4.

Table 2-4: Area of County-Owned Buildings and Parking Lots for Potential BMP Implementation in the Patapsco Tidal River Watershed

Buildings	Total Untreated Area (sq.ft.)	Number of Buildings
2,000-4,000 sf	92,056	29
4,000-6,000 sf	55,822	12
>6,000 sf	1,302,495	33
TOTAL	**1,450,33**	**74**
Parking Lots	**Total Untreated Area (ac)**	**Number of Parking Lots**
1/16-1/8 acre	2.2	25
1/8-1/4 acre	4.7	2
¼-1/2 acre	5.1	14
>1/2 acre	28.3	21
TOTAL	**40.3**	**84**
Parking Lots & Driveways	**Total Untreated Area (ac)**	**Number of Parking Lots**
1/16-1/8 acre	3.4	39
1/8-1/4 acre	6.0	32
¼-1/2 acre	5.4	15
>1/2 acre	29.0	22
TOTAL	**43.8**	**108**

2.4 Water Quality

2.4.1 Use Designations

According to water quality standards established by MDE in the Code of Maryland Regulations (COMAR) 26.08.02.08[4], the Non Tidal Baltimore Harbor watershed is classified as a Class I water. Class I waters are generally designated to support "water contact recreation and protection of non tidal warm water aquatic life." The more detailed designated uses of Class I waters are shown below in Table 2-5.

Table 2-5: Designated Uses in Non Tidal Baltimore Harbor Watershed and its Tributaries

Category/Sub -category	Designated Use	Non Tidal Baltimore Harbor Watershed
Class I	Water Contact Recreation, and Protection of Nontidal Warmwater Aquatic Life	Yes

[4] http://www.dsd.state.md.us/comar/comarhtml/26/26.08.02.08.htm

Category/Sub -category	Designated Use	Non Tidal Baltimore Harbor Watershed
Class I subcategory	Growth and propagation of fish (not trout), other aquatic life and wildlife	Yes
Class I subcategory	Water contact sports	Yes
Class I subcategory	Leisure activities involving direct contact with surface water	Yes
Class I subcategory	Fishing	Yes
Class I subcategory	Agricultural water supply	Yes
Class I subcategory	Industrial water supply	Yes

2.4.2 303(d) Impairments

According to Maryland's final 2018 303(d) list of impaired waters, the Non Tidal Baltimore Harbor watershed is impaired by chloride, sulfates, TSS, habitat alteration, and lack of riparian buffer. The water quality impairment of the Non Tidal Baltimore Harbor watershed is caused, in part, by an elevated sediment load beyond a level that the watershed can sustain, thereby causing sediment-related impacts to aquatic life. The sediment impairment was listed in 2014. The sediment/TSS listing is Category 5, which indicates that the waterbody is impaired and a TMDL or water quality analysis (WQA) is needed. Other Category 5 listings include chloride and sulfates. Habitat alteration and lack of riparian buffer are listed in Category 4c, which indicates the cause of the impairment is pollution and not a pollutant. Impairments are summarized below in Table 2-6.

Table 2-6: 303(d) Impairments in the Non Tidal Baltimore Harbor Watershed

Watershed	Basin Code	Non tidal/ Tidal	Designated Use Class	Designated Use Class Sub-category[1]	Year Listed	Identified Pollutant	Listing Category
Baltimore Harbor	02130903	Non tidal	Class I	Aquatic Life and Wildlife	2014	Chloride	5
Baltimore Harbor	02130903	Non tidal	Class I	Aquatic Life and Wildlife	2014	Sulfates	5
Baltimore Harbor	02130903	Non tidal	Class I	Aquatic Life and Wildlife	2014	TSS	5
Baltimore Harbor	02130903	Non tidal	Class I	Aquatic Life and Wildlife	2014	Habitat Alteration	4c
Baltimore Harbor	02130903	Non tidal	Class I	Aquatic Life and Wildlife	2014	Lack of Riparian Buffer	4c

[1]While the TMDL refers to the impairment of the "Aquatic Life and Wildlife" subcategory of the Class I use, the full name of this subcategory is "Growth and propagation of fish (not trout), other aquatic life and wildlife."

2.4.3 TMDLs

TMDLs are pollutant limits established for waterbodies on Maryland's 303(d) list to help achieve the waterbody's designated use. In order to establish the TMDL, the State estimates the maximum allowable pollutant load that the waterbody can receive and still meet water quality standards. TMDLs are required by the CWA for waters listed in Category 5. The *Total Maximum Daily Load of Sediment in the Baltimore Harbor Watershed, Baltimore City, Baltimore County, and Anne Arundel County, Maryland* (MDE, 2021d) was approved on January 27, 2022. The TMDL targets for the Anne Arundel County MS4 were obtained from the TMDL document titled *Final Technical Memorandum, Point Sources of Sediment in the Non Tidal Baltimore Harbor Watershed* (MDE, 2021e). The watershed loads in the TMDL were modeled using the CBP Phase 5.3.2 (CBP P5.3.2) watershed model 2009 Progress Scenario edge-of-stream (EOS) sediment loads. The TMDL baseline loads, SW-WLAs, and required sediment load percent reduction are summarized in Table 2-7 below. Note that baseline year for the TMDL is 2009. For the County's portion of the Non Tidal Baltimore Harbor Watershed, the County's MS4 regulated area requires a 58% reduction in sediment load.

Table 2-7: Non Tidal Baltimore Harbor Watershed Sediment TMDL WLA for Anne Arundel County

NPDES Regulated Stormwater Sector	Baseline Load (ton/yr)	SW-WLA (ton/yr)	Reduction (%)
Non Tidal Baltimore Harbor Watershed, Anne Arundel County Phase I MS4	1660	697	58

Of the information presented in the TMDL, only the percent reduction will be used in this implementation plan. The baseline loads and SW-WLA target were recalculated using TIPP, as further explained in Section 4.1.

2.4.4 NPDES

Under Section 402(p) of the CWA, the EPA's NPDES permit program is required to include MS4 discharges. Since 2002, NPDES permits have included WLA requirements, including those for MS4 discharges. Anne Arundel County holds a Phase 1 Large Jurisdiction MS4 NPDES permit issued by MDE (20-DP-3316, MD0068306; MDE2021b). The County's first permit was issued in 1993. The current fifth generation permit was issued on November 5, 2021.

Part IV.F.2 of the current permit requires the County to develop an implementation plan for any EPA approved local TMDL with a SW-WLA allocation. The implementation plan must be completed within a year of the TMDL approval date. EPA approved the Sediment TMDL for the Non Tidal Baltimore Harbor Watershed on January 27, 2022, thus requiring the submittal of an implementation plan by January 27, 2023.

The implementation plan must address the following requirements, as outlined in the County's MS4 permit:

- Include the final date for meeting applicable SW-WLAs and a detailed schedule for implementing all structural and non-structural water quality improvement projects, enhanced stormwater management programs, and alternative stormwater control initiatives necessary for meeting applicable SW-WLAs;

- Provide detailed cost estimates for individual projects, programs, controls, and plan implementation;
- Evaluate and track implementation of implementation plans through monitoring or modeling to document the progress toward meeting established benchmarks, deadlines, and SW-WLAs; and
- Develop an ongoing iterative process that continuously implements structural and non-structural restoration projects, program enhancements, new and additional programs, and alternative BMPs where EPA approved TMDL SW-WLAs are not being met according to the benchmarks and deadlines established a part of the County's watershed assessments.

The permit also requires public outreach and involvement in the development of the implementation plan and the rest of the TMDL process (permit Part IV.F.4).

The permit requires an MS4 Annual Report assessing the NPDES stormwater program based on the fiscal year. The MS4 Annual Report must include the identification of water quality improvements and documentation of attainment and/or progress toward attainment of schedules, benchmarks, deadlines, and applicable stormwater WLAs developed under EPA established or approved TMDLs, as well as the identification of any proposed changes to the County's program when stormwater WLAs are not being met (permit Part V.A.1.e-f). In addition, as part of its Countywide Stormwater TMDL Implementation Plan, the County must summarize annual progress toward meeting approved TMDL WLAs. Components of the progress reporting include a summary of all completed BMPs, programmatic initiatives, alternative control practices, or other actions implemented for each TMDL stormwater WLA; an analysis and table summary of the net pollutant reductions achieved annually and cumulatively for each TMDL stormwater WLA; and an updated list of proposed BMPs, programmatic initiatives, and alternative control practices, as necessary, to demonstrate adequate progress toward meeting the Department's approved benchmarks and final stormwater WLA implementation dates (permit Part IV.F.2.a-c).

The County's permit also requires restoration of impervious surface area to the MEP, including a specific requirement to restore 2,998 impervious acres (permit Part IV.E.3). Strategies in this Implementation Plan will contribute to additional treatment of impervious surfaces, but accounting for the contribution of this plan to the County's overall impervious treatment requirement is not included in this report.

2.4.5 Monitoring

The County has many on-going monitoring programs to assess and track water quality progress within the watershed. These are more fully explained in Section 10.

3 Causes and Sources of Impairments

3.1 Impairments

Elevated levels of sediment currently impair the Non Tidal Baltimore Harbor watershed, as evident through the 303(d) listings and local TMDL requirement. Sediment is the loose sand, clay, silt and other soil particles that settle at the bottom of a body of water. Sediment from both upland and in-stream sources can impact in-stream habitat by covering and filling gravelly and rocky substrate, which is a preferred substrate habitat for some aquatic organisms (fish and benthic communities) and is necessary for some fish species for spawning. Finer clays, silts and sands associated with sediment are more mobile and transient and provide less livable space for more sensitive benthic macroinvertebrate species by filling the interstitial spaces between larger substrate particles in the channel bottom. Increases in sediment loads in channels that cannot adequately transport the load can lead to deposition and aggrading streams. These factors often negatively impact channel flow, causing additional erosion and increases in flooding, particularly if road crossing capacity is limited by sediment accumulation. Suspended sediment in the water column may limit light penetration and prohibit healthy propagation of algae and submerged aquatic vegetation. Suspended sediments can cause gill abrasion in fish and can limit clarity, which impacts aquatic species that rely on sight for feeding. Section 10 discusses the ongoing monitoring that helps assess progress towards reducing the sediment impairments.

3.2 Sources

Sediment can come from soil erosion or from the decomposition of plants and animals. Wind, water and ice help carry these particles to rivers, lakes and streams. While natural erosion produces nearly 30 percent of the total sediment in the United States, accelerated erosion from human use of land accounts for the remaining 70 percent[5]. For Anne Arundel County's MS4 jurisdictional area, sediment sources are predominantly tied to the MS4 land use sources and stream erosion.

The loading rates used in the modeling for the Implementation Plan are from MDE's TIPP tool are shown in Table 3-1 below. The TIPP tool's loading rates are aggregated at the 8-digit watershed and Chesapeake Bay Segment scale by county. The loading rates include Stream Bed and Bank (STB) loads, which were determined by a variation of the method used to determine STB load in the 2020 MS4 Accounting Guidance (MDE, 2020) document. The TIPP tool includes a range of land use types, but for the Patapsco Tidal River watershed modeling, only the aggregate impervious and turf load sources were used, as shown in the Table 3-1.

[5] https://cfpub.epa.gov/npstbx/files/ksmo_sediment.pdf

Table 3-1: Percent Impervious and Turf Area in the MS4 Portion of Patapsco Tidal River Watershed and Corresponding Loading Rate[6]

Load Source	Amount (acres)	Percent of Total Area	Loading Rate
MS4 Aggregate Impervious	4,986	35%	2905
MS4 Tree Canopy over Aggregate Impervious	1,064	7%	2702
MS4 Tree Canopy over Turf	3,591	25%	701
MS4 Turf	4,739	33%	744

3.2.1 Urban Stormwater Runoff

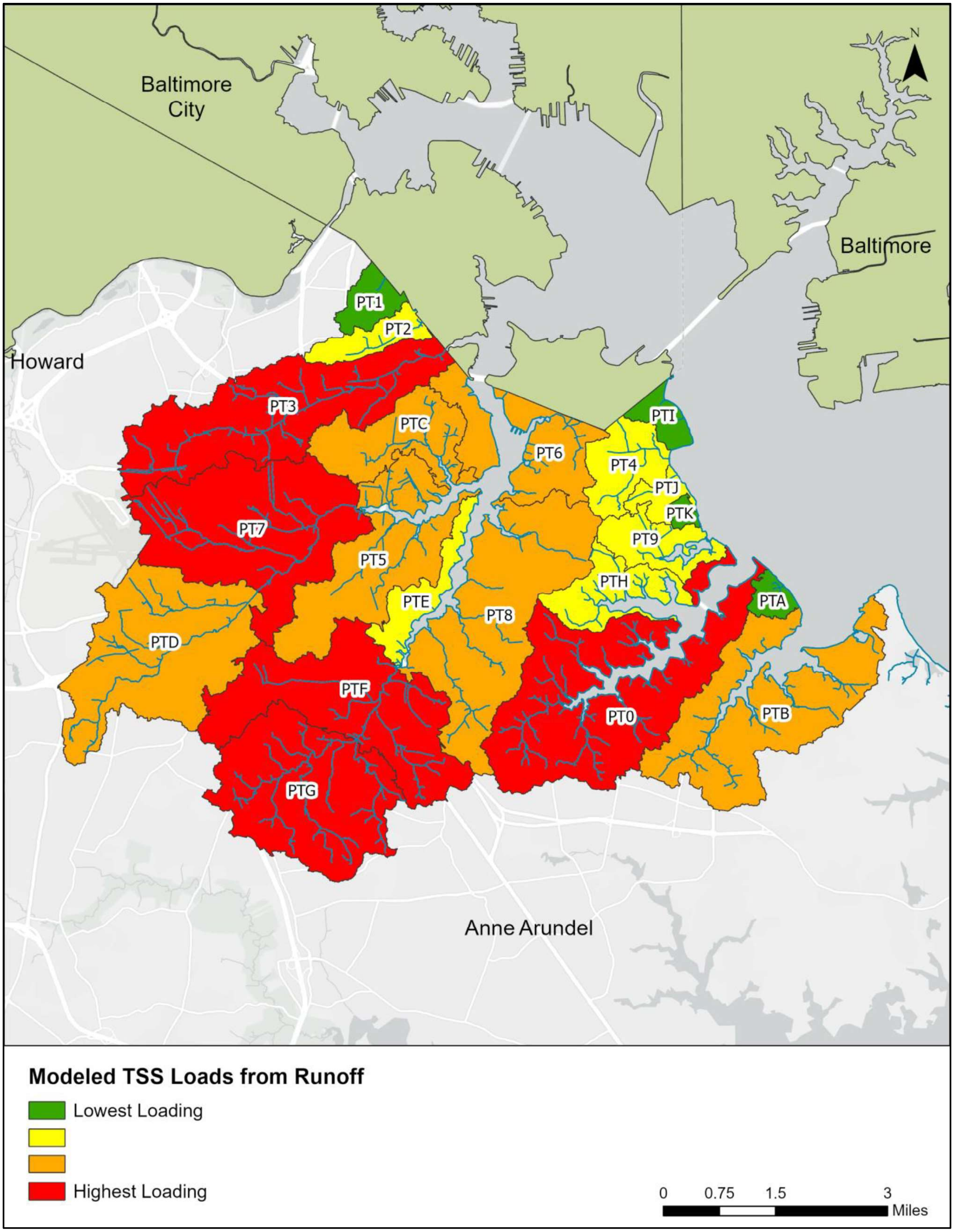
The sediment load contribution of urban stormwater and urban nonpoint sources was analyzed in the *Patapsco Tidal and Bodkin Creek Watershed Assessment Comprehensive Summary Report* (Anne Arundel County, 2012b) (as described above, Anne Arundel County's portion of the larger Non Tidal Baltimore Harbor watershed is the Patapsco Tidal River watershed). Figure 3-1 presents the modeled annual total suspended solids runoff load as the relative quantity of sediment contributed from each subwatershed (i.e., lowest to highest) in the Patapsco Tidal River watershed. This modeling scenario represents current actual land use conditions and accounts for pollutant load reductions from existing public and privately owned BMPs, all implementation and restoration projects performed as part of the County's Capital Improvement Program (CIP), and disconnected impervious surfaces. The water quality model used for the assessment was based on EPA's Simple Method (Schueler, 1987) and PLOAD models (EPA, 2001) using event mean concentrations (EMCs) for each LULC type. The results presented here are the sediment associated with runoff, and do not reflect in-stream sources. Model results indicate that runoff from the following LULC categories contribute the most overall sediment: row crops, pasture and hay, transportation, and airports. These LULC categories also have the highest sediment loading rates. While residential land has a lower sediment loading rate, it makes up a significant portion of the watershed (approximately 43%) and is therefore also a significant contributor to loads.

Subwatersheds contributing the highest amount of existing sediment loads include PT0, PT3, PT7, PTF, PTG, and to a lesser extent, subwatersheds PT5, PT6, PT8, PTB, PTC, and PTD.

Management measures targeted in subwatersheds with high existing sediment loads, and with high contributions from the MS4 land use sectors, will be the priority of this Implementation Plan to ensure required reductions are achieved and maintained.

[6] Note that Table 3-1 shows only results from the MS4 area, whereas Table 2-2 shows results from the entire watershed. Therefore, the total areas will be different between the two tables.

Figure 3-1: Modeled Existing Watershed Sediment Loads for the Patapsco Tidal River by Subwatershed from the 2012 Watershed Characterization Report



3.2.2 In-stream Sources

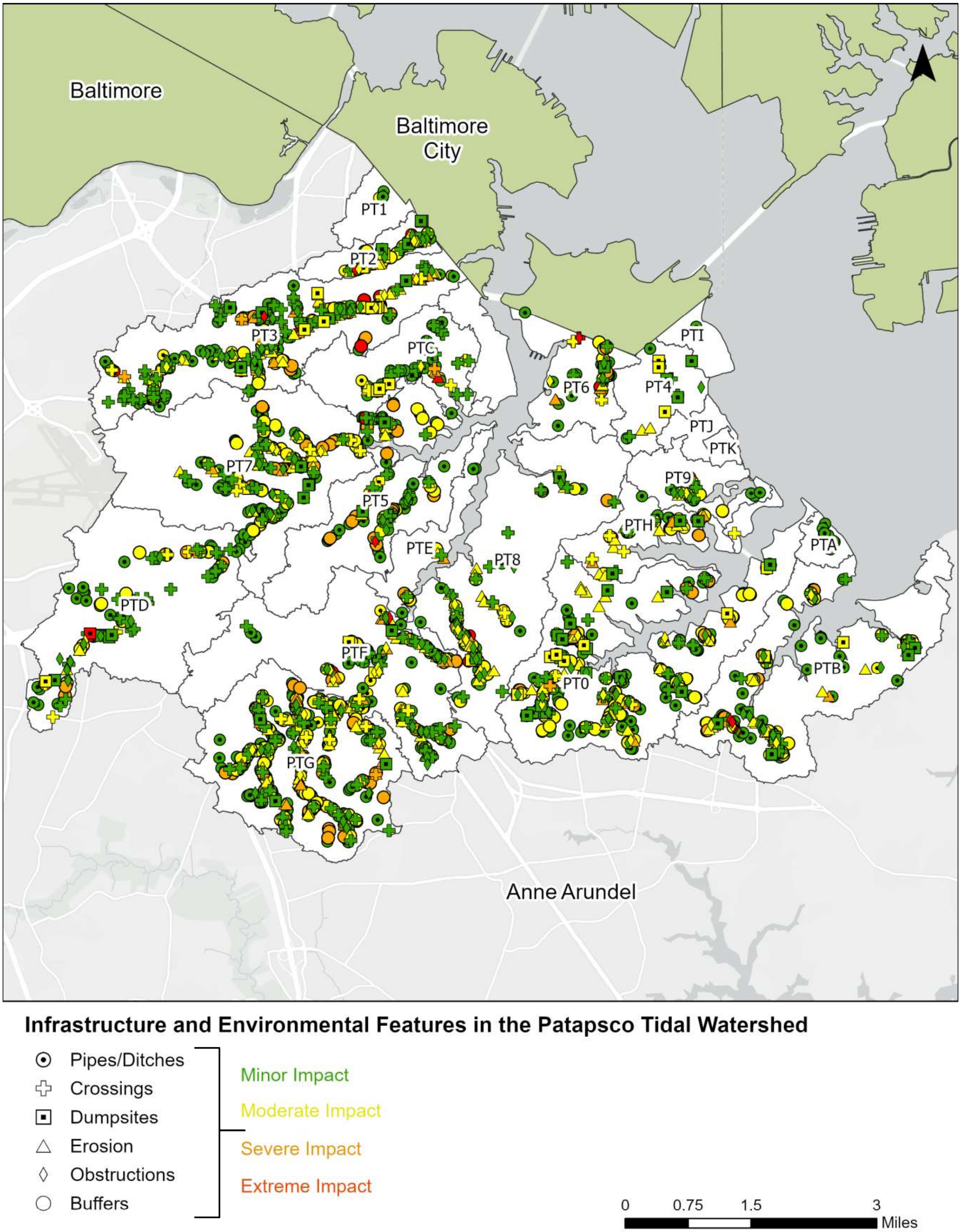
Although channel bed and bank erosion occurs naturally as streams work to maintain a state of dynamic equilibrium, excessive erosion can occur due to increased stream discharge and velocity. Increased stream discharge is often associated with development and agricultural activities that increase runoff and encroach on riparian buffers within the watershed. Channel erosion can deliver excessive pollutants such as sediment and phosphorus downstream, where water quality can be impacted and important habitat for fish spawning and benthic invertebrates can be degraded. Excessive erosion can also threaten the stability of nearby built infrastructure. The Biological Stressor Identification Analysis (BSID) included in the *Watershed Report for Biological Impairment of the Baltimore Harbor Watershed* (MDE, 2014b) determined that biological communities in this watershed are likely degraded due to inorganics (i.e., chloride and sulfates); sediment and in-stream habitat related stressors; anthropogenic channelization of stream segments; and anthropogenic alterations of riparian buffer zones. With respect to sediment and in-stream habitat related stressors, the report notes that these stressors often result from altered hydrology and increased runoff from impervious areas, specifically from channel erosion and subsequent elevated suspended sediment transport through the watershed. Thus, suspended sediment was identified as a probable cause and confirmed the Category 5 listing for TSS as an impairing substance in this watershed.

Approximately 135 miles of streams were assessed and characterized for the Patapsco Tidal River watershed, as described in the *Patapsco Tidal and Bodkin Creek Watershed Assessment Comprehensive Summary Report* (Anne Arundel County, 2012b). Approximately 131 of these miles are in the subwatersheds included in this Plan (Table 2-1). Data collected included stream classifications, physical habitat condition assessment, inventory of infrastructure and environmental features, habitat scores, channel geomorphology, road crossing flood potential, bioassessments, and aquatic resource indicators. Within each perennial reach, channel erosion was assessed and scored based on severity. A score of five was considered Moderate impact, a score of seven was considered Severe, and a score of 10 was considered an Extreme condition. A total of 1,051 erosion locations in the subwatersheds included in this Plan were cataloged with erosion severity rated as moderate, severe, or extreme (Figure 3-2). Erosion impacts were attributed mostly to development in the watersheds. The information on location of erosion and other collected data such as length of erosion are used to assess potential stream restoration projects.

An assessment of channel geomorphology utilizing Rosgen Level I geomorphic classifications (Rosgen, 1996) was also developed for each single-threaded, perennial reach throughout the watershed as part of the *Patapsco Tidal and Bodkin Creek Watershed Assessment Comprehensive Summary Report* (Anne Arundel County, 2012b). An assessment of channel geomorphology is useful to better understand the stability of a stream and its associated behaviors, including channel entrenchment. The Rosgen classification system has four levels. The Level I classification is a geomorphic characterization that groups streams as Types A through G based on aspects of channel geometry, including water surface slope, entrenchment, width/depth ratio, and sinuosity.

The majority of the assessed perennial stream miles in the Patapsco Tidal River watershed were Type B (34.7 percent) or Type C (22.7 percent) channels. Type B channels are typically characterized as predominantly stable, moderate gradient channel, with low sinuosity and low erosion rate. Type C channels exhibit a well-developed floodplain, higher sinuosity, and susceptibility to de-stabilization when flow regimes are altered. Type G channels, which make up 20.0 percent of the assessed stream miles, are unstable, incised “gully” channels with high erosion rates. Type F channels made up 15.4 percent of assessed stream miles, and are generally entrenched, meandering streams, often with high width/depth ratios, and very high bank erosion and lateral extension rates. The remaining 7.2 percent of stream miles were of other types. Because they represent such a small percentage of stream miles, these streams are not discussed further here, but they are discussed in more detail in the *Patapsco Tidal and Bodkin Creek Watershed Assessment Comprehensive Summary Report* (Anne Arundel County, 2012b).

Figure 3-2: Watershed Infrastructure and Environmental Features Including Stream Erosion Inventory (Anne Arundel County, 2012b)



4 Management Measures

This section describes the modeling approach and types of BMPs and management measures being implemented in the watershed to reduce sediment loads. Load reductions that result from these measures are discussed in Section 5.

4.1 Modeling Approach

BMPs provide reductions for nitrogen, phosphorus, sediments, and other pollutants. The sediment pollutant loads for the Patapsco Tidal River watershed were determined using the TIPP Tool [Version 8/16/21] developed by MDE. The TIPP tool functions as a calculator to estimate pollutant loads and evaluate current progress and implementation scenarios, ensuring sufficient restoration and management practices are planned to meet the load reduction target.

The loads provided in the TIPP Tool are available at two different scales: EOS and Edge-of-Tide (EOT). EOS refers to loads that reach the edge of a small stream, while EOT refers to loads that reach the edge of the tidal portion of the Bay. EOS loads are more appropriate for watershed implementation plans and were used for all modeling analyses. The TIPP tool calculates EOS loads using the methods and BMP efficiencies recommended by the expert panels approved by CBP.

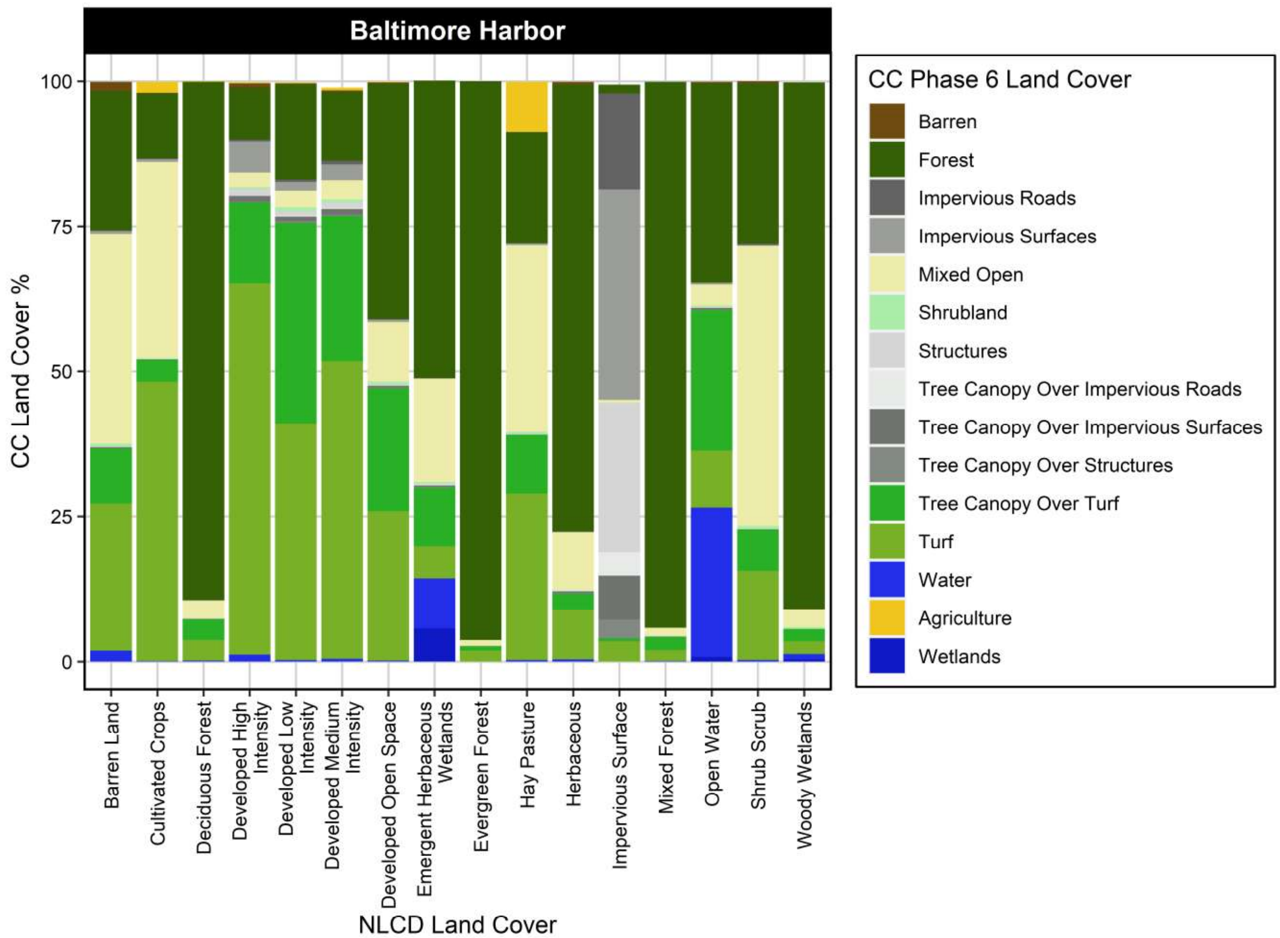
National Land Cover Database (NLCD) data was used as the 2013/2014 Chesapeake Conservancy (CC) land cover data, which was provided with the TIPP tool by MDE, does not reflect the baseline year land use conditions for the Patapsco Tidal River Watershed. MS4 regulated landcover increased between the baseline years and 2013/2014, and therefore, relying on 2013/2014 landcover would inflate baseline year loads. The backcasting method developed by Baltimore County, and approved by MDE, resolves this issue. The backcasting method was applied to NLCD data and makes it consistent with the Phase 6 Chesapeake Bay Watershed Model land cover classes.

Backcasting was achieved via a python script and compares MDE-modified 2013/2014 CC land cover data to 2013 NLCD land cover data. Before backcasting, several steps were taken to pre-process the NLCD and CC data. Firstly, MDE's classification of 'Mixed Open/Agriculture' was disaggregated into 'Mixed Open' and 'Agriculture'. This was achieved by reclassifying 'Mixed Open/Agriculture' to 'Agriculture' where the land cover classification intersected with a parcel with an agricultural assessment. All other occurrences of 'Mixed Open/Agriculture' that did not intersect with a parcel with an agricultural assessment were reclassified as 'Mixed Open'.

As NLCD land cover data does not have an 'Impervious' land cover category, but rather is classified as different intensities of 'Developed', all NLDC land cover data were reclassified as 'Impervious' if it intersected with the County's impervious land cover dataset. The 2007 County impervious data were used for backcasting, as it was the earliest impervious dataset closest to the 2009 baseline year. Finally, NLCD data were clipped to the extent of the County MS4-regulated area, removing State, Federal, and any other land that does not fall under the County's jurisdiction.

Backcasting was conducted for the Patapsco Tidal River watershed separately, rather than county-wide. Using both the 2013/2014 NLCD and CC land cover data, for each NLCD land cover category, the percentage of different CC land cover classes within each NLCD land cover class were summarized. The NLCD land cover acreages were then multiplied by the percentages of CC land covers presented in Figure 4-1, transforming the NLCD land cover to CC land cover classes compatible with the TIPP spreadsheet tool. Figure 4-1 serves as the key with which to 'translate' NLCD data prior to 2014 and make data consistent with the Phase 6 Chesapeake Bay Watershed Model land cover classes.

Figure 4-1: Unique NLCD-CC Translations for the Patapsco Tidal River Watershed.



To run the TIPP tool, basic project information such as watershed, baseline year, and required reduction were first entered. The tool allows users to provide their own specific land use information or use aggregate impervious data. The County used the aggregate impervious data approach, which is an option within TIPP that allows the tool to pull from MDE's reclassified land cover dataset. For each watershed, backcasted Aggregate Impervious and Turf acres were entered into the TIPP Tool to determine the baseline load. Land cover including Tree Canopy over Turf and Tree Canopy over Aggregate Impervious were added as land cover conversions from Turf. In these cases, Tree Canopy over Turf and Tree Canopy over Aggregate Impervious acres were added to the baseline Turf acres. Baseline conditions were established by entering BMPs in place by fiscal year 2009. Current Progress was evaluated separately by specifying BMP information for practices implemented through the current fiscal year (2022).

When exploring future implementation, two scenarios were established. The first one was a milestone scenario for Interim Programmed Implementation, which includes BMPs currently under a design contract that have reached the 30% design stage. The second scenario was for Planned Implementation, which includes projects that are proposed but not currently under a design contract or have a conceptual design.

4.2 Best Management Practices

Many stormwater BMPs can be implemented for both water quantity and water quality purposes; however, the effectiveness of sediment removal can vary between practices. The County has the technical expertise, operational capacity, and system resources in place to site, design, construct, and maintain these practices. These practices are consistent with Maryland's Stormwater Design Manual, and are described below:

- **Infiltration** — A depression or trench to form a shallow basin where sediment is trapped and stormwater infiltrates into the soil. No underdrains are associated with infiltration basins and trenches, because by definition these systems provide complete infiltration. Design specifications require infiltration basins and trenches to be built in good soil; they are not constructed on poor soils, such as C and D soil types. Yearly inspections to determine if the basin or trench is still infiltrating runoff are planned.
- **Bioretention** — An excavated pit backfilled with engineered media, topsoil, mulch, and vegetation. These are planting areas installed in shallow basins in which the stormwater runoff is temporarily ponded and then treated by filtering through the bed components, and through biological and biochemical reactions within the soil matrix and around the root zones of the plants.
- **Dry Detention Ponds** – Depressions or basins created by excavation or berm construction that temporarily store runoff and release it slowly via surface flow. These devices are designed to improve quality of stormwater using features such as swirl concentrators, grit chambers, oil barriers, baffles, micropools, and absorbent pads to remove sediments, nutrients, metals, organic chemicals, or oil and grease from urban runoff.
- **Wet ponds or wetlands** — A water impoundment structure that intercepts stormwater runoff and then releases it at a specified flow rate. These structures retain a permanent pool and usually have retention times sufficient to allow settlement of some portion of the intercepted sediments and attached pollutants. There is little or no vegetation within the pooled area nor are outfalls directed through vegetated areas prior to open water release. Nitrogen reduction is minimal, but phosphorus and sediment are reduced.
- **Filtering Practices** - Practices that capture and temporarily store runoff and pass it through a filter bed of either sand or an organic media. There are various sand filter designs, such as above ground, below ground, perimeter, etc. An organic media filter uses another medium besides sand to enhance pollutant removal for many compounds due to the increased cation exchange capacity achieved by increasing the organic matter.
- **Swales** – Channels that provide conveyance, water quality treatment, and flow attenuation of stormwater runoff. Swales provide pollutant removal through vegetative filtering, sedimentation, biological uptake, and infiltration into the underlying soil media. Types of swale practices include dry

swales, grass swales, wet swales, and bio-swales. Implementation of each is dependent upon site soils, topography, and drainage characteristics.

- **Dry Well** – Excavated pit or structural chamber filled with gravel or stone that provides temporary storage of stormwater runoff from rooftops. The storage area may be constructed as a shallow trench or a deep well. Rooftop runoff is directed to these storage areas and infiltrates into the surrounding soils prior to the next storm event. The pollutant removal capability of dry wells is directly proportional to the amount of runoff that is stored and allowed to infiltrate.
- **Rain Garden** – Shallow, excavated landscape feature or a saucer-shaped depression that temporarily holds runoff for a short period of time. Rain gardens typically consist of an absorbent-planted soil bed, a mulch layer, and planting materials such as shrubs, grasses, and flowers. An overflow conveyance system is included for bypass of larger storms. These types of practices typically capture runoff from downspouts, roof drains, pipes, swales, or curb openings. The captured runoff temporarily ponds and slowly filters into the soil over 24 to 48 hours.
- **Infiltration Berms** – A mound of earth composed of soil and stone that is placed along the contour of a relatively gentle slope. This practice may be constructed by excavating upslope material to create a depression and storage area above a berm or earth dike. Stormwater runoff flowing downslope to the depressed area filters through the berm in order to maintain sheetflow. Infiltration berms should be used in conjunction with practices that require sheetflow (e.g., sheetflow to buffers) or in a series on steeper slopes to prevent flow concentration.
- **Disconnection of Rooftop Runoff** – Involves directing flow from downspouts onto vegetated areas where it can soak into or filter over the ground. This disconnects the rooftop from the storm drain system and reduces both runoff volume and pollutants delivered to receiving waters. To function well, rooftop disconnection is dependent on several site conditions (e.g., flow path length, soils, slopes).
- **Disconnection of Non-Rooftop Runoff** – Involves directing flow from impervious surfaces onto vegetated areas where it can soak into or filter over the ground. This disconnects these surfaces from the storm drain system, reducing both runoff volume and pollutants delivered to receiving waters. Non-rooftop disconnection is commonly applied to smaller or narrower impervious areas like driveways, open section roads, and small parking lots and is dependent on several site conditions (e.g., permeable flow path length, soils, slopes, compaction) to function well.
- **Sheetflow to Conservation Areas** – Stormwater runoff is effectively treated when flow from developed land is directed to adjacent natural areas where it can soak into or filter over the ground. To function well, this practice is dependent on several site conditions (e.g., buffer size, contributing flow path length, slopes, compaction).
- **Stream Restoration** - Stream restoration is a set of techniques and methods that restores the natural hydrology and landscape of a stream by engineering the stream to reduce stream bank erosion, reconnecting the stream bed to the floodplain, minimizing down-cutting of stream bed, and restoring the aquatic ecosystems.

In addition to the structural BMPs listed above, the County also implements non-structural management measures that are conducted throughout a given year and repeated annually, including:

- **Inlet Cleaning** - Storm drain cleanout practice ranks among the oldest practices used by communities for a variety of purposes to provide a clean and healthy environment, and more recently to comply with their NPDES stormwater permits. Sediment reduction credit is based on the mass of material collected (MDE, 2020).
- **Street sweeping** - This practice uses mechanical or vacuum-assisted sweeper trucks to remove the buildup of pollutants that have been deposited along streets or curbs. The amount of nutrient and sediment reduction associated with this program is dependent on the stream sweeping technology and the frequency of sweeping.

4.3 Offsetting Sediment Loads from Future Growth

Anne Arundel County's new General Development Plan, *Plan2040* (Anne Arundel County, 2021), establishes the following vision for the County's natural environment into the future: *Resilient, Environmentally-Sound, and Sustainable Communities – Planning and land use decisions affecting development and redevelopment will enhance neighborhoods while protecting the natural environment and increasing community resilience to climate change. We will support the diverse communities in the County from rural lands, to waterfront communities, to suburban neighborhoods, to town centers. Collective efforts to reduce stormwater runoff, and restore forests, rivers, and shorelines will contribute to a healthier environment. The County will strive to reduce greenhouse gas emissions through conservation and renewable energy production.*

The land and water conservation framework within Anne Arundel County consists of multiple programs, plans and regulatory measures in place at the Federal, State, and County levels for protection of natural resources. Collectively they accomplish much in terms of natural resource preservation, land conservation, and water quality improvements.

In Volume 2 of Plan2040, in the section describing "Planning for the Built Environment," the County describes trends and lays out its policies for land use and development. Plan2040 addresses land use needs Countywide and specifically where future growth and development should be concentrated, where land should be preserved and how established neighborhoods can be preserved. The Plan revises the County's adopted 2009 Development Policy Areas and

- Creates an intentional and strategic approach to direct the County's future development in areas where redevelopment and revitalization opportunities exist;
- Creates vibrant, mixed-use, transit oriented, walkable communities;
- Capitalizes on existing and planned infrastructure investments;
- Preserves natural, rural and agricultural resources; and
- Protects existing neighborhoods and the peninsula areas from additional impacts of development is to create development policy areas

A Land Use Market Analysis completed in 2019 revealed that over 90% of the County's land area is classified as developed, in large part due to large-lot residential development in the southern and central parts of the County. Approximately 13,736 acres of developable land (land zoned for development without environmental constraints) remains in the County. About one-fourth of this land is in the southern part of the County, where growth potential is limited by low-density zoning and development policies.

According to the latest adopted forecasts by the Baltimore Metropolitan Council, the population of the County is projected to grow by approximately 50,000 people (29,000 households) by 2040. Countywide employment is projected to grow by more than 68,000 jobs by 2040. Based on the development capacity analysis, there is sufficient buildable land under current zoning to support that growth. Plan2040 establishes a framework for where and how growth occurs. Low-density, suburban growth patterns will strain availability of undeveloped land and costs for development and maintenance of public infrastructure and services. Given the commitment to environmental, rural and agricultural preservation, redevelopment and revitalization of existing developed areas will be the key to the County's sustainability. The requirements of environmental regulation, adequate public facilities ordinance, limitations on upzoning based on consistency with the adopted land use plan, along with real estate economics and development incentives are likely to direct much of that future growth to redevelopment within Targeted Growth Areas with less subdivision of forest and farmland than has occurred in recent decades. Based on these considerations, the County developed an updated Planned Land Use Map for inclusion in Plan2040. Changes from the 2009 land use map included changes in land use categories; minor consistency changes; planned land use change application requests; and "comprehensive land use changes" that are designed to achieve the goals of either reflecting better alignment with the parcel boundary that is not considered a minor change; or changing an existing nonconforming use expected to continue within the planning horizon to the appropriate planned land use designation.

Overall, growth and development is expected to occur throughout Anne Arundel County, and depending on when and where this growth occurs, pollutant loading from urban stormwater sources may also increase. *Plan2040* will direct and, in association with programmatic and regulatory measures, manage future growth in a way that will minimize increases in sediment loading from new development in the Patapsco Tidal River watershed. In addition, Maryland's baseline programs, including the 1991 Forest Conservation Act, the 1997 Priority Funding Areas Act, the 2007 Stormwater Management Act, the 2009 Smart, Green & Growing Planning Legislation, the 2010 Sustainable Communities Act, the 2011 Best Available Technology Regulation, and the 2012 Sustainable Growth & Agricultural Preservation Act, effectively mitigate the majority of the impacts from new development. Any additional loads will be offset through Maryland's alignment for growth policies and procedures as articulated through Chesapeake Bay milestone achievement. The overriding goal of no net growth in loads is reflected in these policies, programs, and implementation as part of the net WLA accounting as stipulated in Part VI of the NPDES-MS4 permit.

It is anticipated that new development will make use of Environmentally Sensitive Design (ESD) stormwater treatment according to MDE's Stormwater Regulations. Further, Maryland's 2007 Stormwater Management Act went into effect in October of 2007, with resulting changes to COMAR and the 2000 Maryland Stormwater Design Manual in May of 2009. The most significant changes relative to watershed planning are in regard to implementation of ESD. The 2007 Act defines ESD as "using small-scale stormwater management practices, nonstructural techniques, and better site planning to mimic natural hydrologic runoff characteristics and minimize the impact of land development on water resources." As such, Anne Arundel County has updated Articles 16 and 17 of the County Code to incorporate the requirements for ESD. Anne Arundel County finalized the *Anne Arundel County Stormwater Management Practices and Procedures Manual* (Anne Arundel County, 2010, revised 2017) to incorporate criteria specific to the County that are not addressed within the Maryland Design Manual. Additionally, a comprehensive review and update to the County's Manual was completed in 2017 and approved by MDE. The update included a new "Temporary

Stormwater Management" policy that requires management of the 1-year storm for all construction projects that require grading permits.

Anticipated Accounting for Growth (AFG) policies will address the residual load (TN: 50 percent, TP: 40 percent, TSS: 10 percent, and bacteria: 30 percent) that is potentially uncontrolled by development-based stormwater controls. As required by the State's Phase III Watershed Implementation Plan (Bay Implementation Plan) Maryland is developing an AFG policy that will address the expected increase in the State's pollution load from increases in population growth and new development. While not currently a fully formed policy, the State's plan, as of the *Final Report of the Workgroup on Accounting for Growth in Maryland* (Maryland Department of Agriculture and others, 2013), focuses on two elements: 1) the strategic allotment of nutrients loads to large wastewater treatment plants, upgraded to the best available technology; and 2) the requirement that all other new loads must be offset by securing pollution credits.

5 Expected Load Reductions

5.1 2009 Baseline Load

SW-WLAs in the sediment TMDL were developed using the CBP Watershed Model Phase 5.3.2 (CBP WM P5.3.2) watershed model. The TIPP tool used for TMDL planning in this Implementation Plan uses the Chesapeake Bay Phase 6 CAST-2017d Watershed Model No Action (No BMP) scenario loading rates to generate loads based on user inputs of land use and existing BMPs. The required reduction percent assigned to the Anne Arundel County Phase I MS4 source from the TMDL document was then applied to the new baseline load calculated in TIPP to calculate the required sediment reduction expressed as a load. The required sediment reduction load was then subtracted from the new baseline load to calculate the target TMDL SW-WLA. The sediment load requirements for the Patapsco Tidal River watershed are shown in Table 5-1.

Table 5-1: Anne Arundel County Sediment SW-WLA Reduction Required for the Patapsco Tidal River Watershed

2009 Baseline Load (lbs/yr)	Required Reduction (%)	Required Reductions (lbs/yr)	TMDL SW-WLA (lbs/yr)
21,673,357	58%	12,570,547	9,102,810

5.2 2022 Progress Load (Current Implementation)

BMP data used in the TIPP modeling was taken from the County's BMP inventory, which is also submitted to MDE as part of the County's MS4 annual report. Source reduction practices implemented after 2009 were incorporated into the calculations to determine the current (2022) loads (i.e., the 2022 Progress Load). Stream restoration, street sweeping, storm drain cleaning, land use conversion, and stormwater management BMPs were completed in the Patapsco Tidal River Watershed have been completed in the watershed since 2009 as shown in Table 5-2.

Table 5-2: Current BMP Implementation through 2022 for the Patapsco Tidal River Watershed

Type	Baseline Year	FY22 Progress	Total	Units Treated
Stream Restoration	0	5,765	5,765	ft
Street Sweeping	0	60	60	Lane Miles
Storm Drain Cleaning	0	252,066	252,066	lbs
Land Use Conversion	0	3	3	Acres
SW Management BMPs	1,784	438	2,222	Acres

The total load reduction in pounds for these source reduction practices are shown in Table 5-3. Urban BMPs constructed as part of development or re-development after 2009 were not included in the 2022 Progress scenario because they were required to be implemented to offset the increase in impervious area caused by development or re-development, and therefore should not be counted for additional sediment load reduction credit for the TMDL.

Table 5-3: Baseline Loads and Current Load Reductions in the Patapsco Tidal River Watershed

Load Source		EOS Sediment Load (lbs)
TIPP Baseline Loads	MS4 Aggregate Impervious	14,485,135
	MS4 Tree Canopy over Aggregate Impervious	2,875,709
	MS4 Tree Canopy over Turf	2,517,125
	MS4 Turf	3,525,723
	Baseline BMPs Load Reduction	(1,730,335)
2009 Baseline Load		**21,673,357**
TIPP Current Load Reductions	Inlet Cleaning	113,430
	Street Sweeping	25,393
	Land Use Conversions	468
	Stormwater Management BMPs	420,737
	Stream Restoration	1,283,144
2022 Progress Load		**19,830,185**

As shown in Table 5-4, the Patapsco Tidal River watershed has currently achieved a sediment reduction of 8.5 percent compared to its 58 percent target reduction.

Table 5-4: 2022 Progress Reductions Achieved in the Patapsco Tidal River Watershed

Results and TMDL WLA	Loads and Percent Reduction
2009 Baseline Load (lbs)	21,673,357
2022 Progress Load (lbs)	19,830,185
Percent Reduction	8.5%
Target TMDL WLA Reduction	58.0%

5.3 Milestone and Planned Implementation

As shown in the previous section, Anne Arundel County must achieve further load reductions to meet its TMDL requirements in these watersheds. The Patapsco Tidal River watershed is located within a more developed portion of Anne Arundel County. As previously described in Section 2.3.1, a vast majority of the land cover is turf (39.1%) (including turf and tree canopy over turf) and impervious surfaces (30.3%) (including roads, surfaces, and structures, as well as tree canopy over roads, surfaces, and structures), which provides great opportunity to achieve additional sediment load reductions from managing stormwater runoff from impervious surfaces. Approximately 24% of the watershed consists of forest.

Milestone and Planned BMP implementation for the Patapsco Tidal River watershed is shown in Table 5-5. Milestone and Planned implementation projects include stormwater management BMPs and stream restoration.

Table 5-5: Milestone and Planned BMP Implementation through 2035 for Patapsco Tidal River Watershed

	Load Source	Amount	Unit	EOS Sediment Load (lbs)
Baseline (2009) Load Total				**21,673,357**
Current (2022) Load Total				**19,830,185**
Milestone and Planned Source Reductions	Stream Restoration	41,875	ft	9,910,710
	Stormwater Management BMPs	660	acres	834,368
Total Milestone and Planned Source Reductions				**10,745,078**
2035 Planned Load (2022 Progress Load – sum of milestone and planned source reductions)				**9,085,106**
Total Sediment Reduction	Percent Reduction Achieved	58.1%		
	Target TMDL WLA Reduction	58%		
	Remaining Reduction Required	0		

Feasibility studies of the planned strategies may reveal that some existing structures identified for retrofitting or enhancement may not be feasible candidates for future projects and may be eliminated from consideration. The County will take an adaptive management approach and will reevaluate treatment needs as feasibility studies progress. The County will continue to track the overall effectiveness of the various BMP strategies and will adapt the suite of solutions based on the results. In addition, new technologies are continuously evaluated to determine if the new technologies allow more efficient or effective pollution control.

Section 8 describes the implementation schedule, Section 9 discusses how progress will be measured, and Section 10 describes the ongoing monitoring efforts that will help evaluate the effectiveness of the implementation on improving water quality.

6 Technical and Financial Assistance Needs

6.1 Technical Needs

Technical assistance to meet the reductions and goals of a TMDL takes on many forms, including MDE assistance to local governments, state and local partner assistance to both MDE and municipalities, and technical consultants contracted to provide support across a wide variety of service areas related to BMP planning and implementation. MDE has provided technical assistance to local governments (and will continue to do so in the future) through training, outreach and tools, providing recommendations on ordinance improvements, technical review and assistance for implementation of BMPs at the local level, and identification of potential financial resources for implementation (MDE, 2014b and MDE, 2021f).

Anne Arundel County DPW contracts with consultants through several contract vehicles, including open-end task-based assignments and full delivery contracts, to provide a variety of technical services. These services, provided by planners, engineers, environmental scientists and GIS specialists, include watershed assessment and management, stream monitoring, stormwater planning and design, stream restoration design, outfall enhancement, and environmental permitting, among others. The County itself has complementary staff in DPW and other County departments to manage contracts, provide review and approval of planning and design work, conduct assessments, and develop and administer planning and progress tracking tools.

Anne Arundel County has many partners that provide outreach to homeowners and communities in the form of technical assistance, education, and funding for implementation of BMPs within local communities. The Watershed Stewards Academy, further discussed in Section 7, routinely engages and informs the public on reducing pollution sources and employing stormwater/rainscaping retrofits to reduce stormwater impacts.

Continued technical assistance for public participation and education and for monitoring is necessary to fully implement and track progress towards meeting the goals of the local TMDL. These elements are discussed in Sections 7 and 10 of this plan.

6.2 Financial Needs

The total projected cost to implement the County's CIP projects described in this Implementation Plan for the Patapsco Tidal River watershed is approximately $134M. Table 6-1 includes a summary of funding needs per BMP type. Project costs are inclusive of all project elements and include design, obtaining land right of way (ROW), construction, and County overhead and administrative costs. The costs are presented based on implementation planning periods out to FY2035. The total cost of the suite of BMPs necessary to meet the TMDL is shown for the Milestone 1 and planned 2035 timeframes in

Table 6-2.

Table 6-1: Patapsco Tidal River Watershed Planned Projects Cost Estimate

Load Source	Amount[1]	Unit	Cost/Unit	Total Cost[1]
Stormwater Management BMPs (new)	232.9	acres	$165,500	$38,546,350
Stormwater Management BMPs (retrofit)	427.1	acres	$106,000	$45,270,620
Stream Restoration	41,875	linear feet	$1,200	$50,250,000
			Total	**$134,066,970**
1. Numbers shown in this table have been rounded.				

Table 6-2: Planned Projects Cost Estimate Through 2035

Watershed	Milestone 1	2035	Total
Patapsco Tidal River Watershed	$93,858,470	$40,208,500	$134,066,970

Several sources were used to calculate the cost estimates for each BMP type. Implementation cost of completed projects in the County's geodatabase were used to calculate average costs for inlet cleaning, street sweeping, and other types of projects the County will do to address its load reduction requirements. King and Hagan (2011) was also consulted for reference.

6.3 Funding Sources

A major source of funding for the implementation of local stormwater management plans through stormwater management practices and stream and wetland restoration activities is the County's Watershed Protection and Restoration Fee. To comply with requirements of the Phase I NPDES MS4 permit, and to support restoration efforts towards reducing pollutant loads required for both the Chesapeake Bay TMDL and local TMDLs throughout Maryland, the State Legislature passed a law in 2012 (House Bill 987) mandating that Maryland's 10 largest jurisdictions (those with Phase I MS4 permits), including Anne Arundel County, develop a Watershed Protection and Restoration Program and establish a Stormwater Remediation Fee. To comply with the State legislation, Anne Arundel County passed legislation in 2013, Bill 2-13.

In 2015, the Maryland Legislature passed Senate Bill 863 (Watershed Protection and Restoration Programs – Revisions) which repealed House Bill 987. Senate Bill 863 removed the *requirement* that jurisdictions adopt the Stormwater Remediation Fee but did still allow for the jurisdictions to adopt and collect the fee. As a replacement of the stormwater remediation fee requirement, jurisdictions are now to develop financial assurance plans (FAP), due initially on July 1, 2016, and subsequently every two years, that describe how stormwater runoff will be treated and paid for over the next five years to meet TMDL and impervious surface treatment requirements. Anne Arundel County's initial FAP was adopted by County Council on July 5, 2016. The most recent update to the County's FAP was adopted by the County Council on October 3, 2022 (Resolution #37-22).

The County's Stormwater Remediation Fee, which is termed the 'Watershed Protection and Restoration Fee' (WPRF) is assessed to Anne Arundel County property owners based on the type of property and the amount of impervious surface on their property and is included as a separate line item on the owner's real property tax bill. The fee is structured to provide sufficient funding for projects to meet the pollutant load reduction required by the Chesapeake Bay TMDL and EPA-approved individual TMDLs with a SW-WLA, and to meet the impervious surface management requirements, as well as other stormwater obligations set forth in the County's NPDES MS4 Permit. More information on the rate structure can be found at https://www.aacounty.org/departments/public-works/wprp/wprf-rate-information/index.html along with information on the WPRF Credit Program and Appeal Program.

Prior to adoption of the Watershed Protection and Restoration Fee and, as stated in the Anne Arundel County Phase II WIP (Anne Arundel County, 2012a), the County's funding capacity to implement urban stormwater restoration/retrofit projects was limited by the County's CIP budget for environmental restoration and water quality improvement projects.

To supplement the WPRF, Anne Arundel County actively pursues grant funding from Federal, State and non-governmental organizations (NGOs) to leverage funding for its restoration projects. The County has also developed a Grant Program to provide funding to local NGOs to facilitate implementation of restoration projects that further the County's ability to meet its regulatory requirements. Anne Arundel County, along with the Chesapeake Bay Trust, fund and administer a County-specific set of grants for restoration practices. They include funding in three categories: Community Planting, Forestry and Forested Land Protection, and Watershed Restoration.

7 Public Participation / Education

7.1 County Outreach Efforts

Anne Arundel County gave numerous public presentations throughout the development of the County's Phase II WIP (Anne Arundel County, 2012a) in order to disseminate information on the Chesapeake Bay TMDL, WIP process, and strategies for meeting the County's assigned pollutant load reductions. In addition to providing a level of understanding to the public, the County uses the presentations as an opportunity to receive input and comment on restoration efforts. As described in the Phase II WIP, Anne Arundel County has a variety of organizations interested in water quality, including Anne Arundel County Commercial Owners; Anne Arundel Watershed Stewards Academy (AAWSA); Anne Arundel County Chamber of Commerce, Environmental Committee; Leadership Anne Arundel; and Chesapeake Environmental Protection Association.

In order to implement an effective strategy to meet water quality standards and achieve pollutant load reduction, an effort to engage a very broad audience of landowners was a necessity. AAWSA, a non-profit 501(c)(3) environmental organization, was formed through Anne Arundel County Department of Public Works and the County Board of Education's Arlington Echo Outdoor Education Center. AAWSA's mission is to identify, train, and support citizens to become Master Watershed Stewards who take action with their neighbors to restore local waterways in Anne Arundel County. This program is a unique way to integrate education as a vital element in the AAWSA's role in preservation, conservation and advocacy. Since 2009, 325 Watershed Stewards have been trained in Anne Arundel County – of whom about 230 remain active today. These 230 Watershed Stewards represent over 100 residential communities and over 30 houses of worship. Annually, an average of 25 Watershed Stewards complete the Certification Program and continue to engage communities including neighborhoods, congregations, libraries, schools and businesses. Stewards also serve institutional communities such as schools, parks and libraries. In FY2022, AAWSA and 27 Steward Candidates engaged over 450 community volunteers in capstone projects, resulting in over 4,000 hours of volunteer time. Nineteen Rainscaping projects resulted in 2,691 perennials and 338 trees and shrubs planted, as well as 16,590 square feet of invasive species removed. Additional work under a separate capstone project included planting a total of 425 native perennials, 23 native shrubs, and five native trees over multiple residential properties in an ethnically diverse, underserved neighborhood.

The AAWSA has extensive resources through the Consortium of Support Professionals, which is composed of over 80 governmental, non-profit and business professionals who provide technical assistance to Master Watershed Stewards. Consortium members are experts in their field of conservation, ecology, government laws, landscape architecture, low impact design, water quality monitoring, and watershed assessment, and provide consulting on design and development of watershed restoration projects. The AAWSA is also supported by staff that provides day-to-day guidance to Master Watershed Stewards, connecting Stewards to Anne Arundel County resources, coordinating Stewards certification, post certification professional development, and networking opportunities for Stewards and Consortium of Support Professionals.

The AAWSA has an interactive website (www.aawsa.org) that provides guidance to common water quality problems including information on the following:

- Reduce Your Pollution
    - Practice Bay-Friendly Lawn Care
    - Maintain and Upgrade your Septic System
    - Pick Up Pet Waste
    - Choose Non-Toxic Household Products
    - Maintain your Car and Boat
    - Reduce your Energy Use
- Capture Stormwater
    - Install a Rain Barrel or Cistern
    - Build a Rain Garden
    - Choose to Have Conservation Landscapes
    - Plant Native Trees
    - Direct Water with Swales and Berms
    - Use Permeable Pavers and Pavement
- Clean Up!
    - Invasive Species Removal
    - Dump Site Cleanup
- Conserve and Preserve
    - Land Preservation

Moving forward, the County will focus these programs and others like them on the Patapsco Tidal River watershed.

In addition to the AAWSA, the following organizations have been identified for possible partnerships and education and outreach for the Patapsco Tidal River watershed:

- Alliance for the Chesapeake Bay
- Alliance for Sustainable Communities
- Anne Arundel Community College
- Arundel Rivers Federation
- Audubon Naturalist Society of the Central Atlantic States
- Audubon Society
- Audubon Society of Central Maryland
- Baywise Master Gardeners
- Blue Water Baltimore
- Center for Watershed Protection
- Chesapeake Audubon Society

- Chesapeake Bay Foundation
- Chesapeake Bay Program
- Chesapeake Bay Trust
- Chesapeake Ecology Center
- Maryland Home Builders Assoc.
- Master Gardeners
- Nature Conservancy
- Patapsco River Alliance
- Sierra Club – Maryland Chapter
- Smithsonian Environmental Research Center
- Students for the Environment
- University of Maryland
- University of Maryland Extension
- Volunteer Center for Anne Arundel County

Eligible private property owners in Anne Arundel County also have the opportunity to reduce their stormwater fees by up to 50 percent for proactive and sustainable uses of stormwater runoff controls. The BWPR Credit Program Policy and Guidance document for Anne Arundel County provides the Department of Public Works the framework and procedures needed to administer the program.

In addition, the BWPR established the WPRF Stormwater Remediation Fee Credit Agreement to provide credit to single-family property owners that have installed small-scale (e.g., under 5,000 sq.ft. land disturbance) stormwater BMPs on their property. Further information and applications for these credit programs is available on the BWPR webpage.

BWPR has developed a comprehensive web-based informational program including a dedicated webpage, Facebook page and Twitter account to provide information to the public. The webpage, www.aarivers.org, offers valuable information on Anne Arundel County watersheds, including an interactive clickable map that displays geographically referenced environmental, utility and land use data in addition to restoration project locations, descriptions, and drainage areas. This outreach platform is also used to notify the public of the opportunity to review and comment on this and other TMDL Implementation Plans.

7.2 Public Comment Period

Part IV.F.4 of the County's NPDES MS4 permit outlines requirements for public involvement in the development of TMDL Implementation Plans. The County fulfills these requirements by providing notice in *The Capital Gazette* newspaper, which serves all of Anne Arundel County, detailing how the public may obtain information on the plan and provide comments. The County makes the reports available for review on the BWPR website at www.aarivers.org and makes copies of the implementation plans available at the County office to parties upon request. The County will provide for a minimum 30-day comment period following submittal of the draft Plan to MDE and will incorporate public comments into the final version of the Plan. The final document will include documentation of the public review period notices and the public comments and responses.

8 Implementation Schedule

This section presents the target loads, load reductions expected to be achieved through interim programmed implementation, and activities required to achieve load reduction targets based on a planning horizon of 2035 for achieving the target load reductions.

8.1 Loading Allocations and Targets

Progress loads for 2022 and final load requirements for 2035 in the Patapsco Tidal River watershed are shown in Table 8-1. As discussed in Section 5, some progress has already been made towards reaching the target TMDL WLA. However, large load differences remain between current progress and the 2035 allocated load. Significant load reduction efforts are still needed to achieve the final goal.

Table 8-1: Patapsco Tidal River Watershed Planning and Target Loads

Load	Patapsco Tidal River Watershed Sediment Load (lbs/yr)
2009 Baseline Load	21,673,357
2022 Progress Load	19,830,185
2035 TMDL Allocated Load	9,085,106
Percent Reduction between 2009 Baseline and 2035 Loads	58%

8.2 Planned Progress

To meet the final SW-WLAs, implementation of programs and BMPs must keep pace and meet planned implementation targets. Table 8-2 outlines the expected progress that will allow the County to stay on track with the sediment reduction goals in the Patapsco Tidal River watershed, based on scheduled interim programmed and planned implementation and restoration projects.

Table 8-2: Planned Progress from 2022 to 2035 for the Patapsco Tidal River Watershed

Progress Year	Period Load Reduction (lbs)	Period End Load (lbs)	Total Percent Reduction from 2009 Baseline Load
Milestone 1	7,876,949	11,953,236	44.9%
2035	2,868,130	9,085,106	58.1%

Feasibility studies of the planned strategies may reveal that some existing structures identified for retrofitting or enhancement may not be feasible candidates for future projects and may be eliminated from consideration. The County will take an adaptive management approach and will reevaluate treatment needs as feasibility studies progress. The County will continue to track the overall effectiveness of the various BMP strategies and will adapt a suite of solutions based on those results. In addition, new technologies are continuously evaluated to determine if they allow more efficient or effective pollution control.

8.3 Implementation Priorities

To meet the load reduction milestones outlined in the previous sections, implementation will be planned based on prioritization analyses presented in the *Patapsco Tidal and Bodkin Creek Watershed Assessment* (Anne Arundel County, 2012b). Subwatersheds in Patapsco Tidal River watershed were prioritized for restoration/retrofit project selection potential using three separate prioritization models. The models integrated historical environmental data, current stream assessment monitoring data, drainage area characteristics, and watershed modeling results into indicators of watershed condition and need. The indicators are combined into the three models:

- Stream Reach Restoration
- Subwatershed Restoration
- Subwatershed Preservation

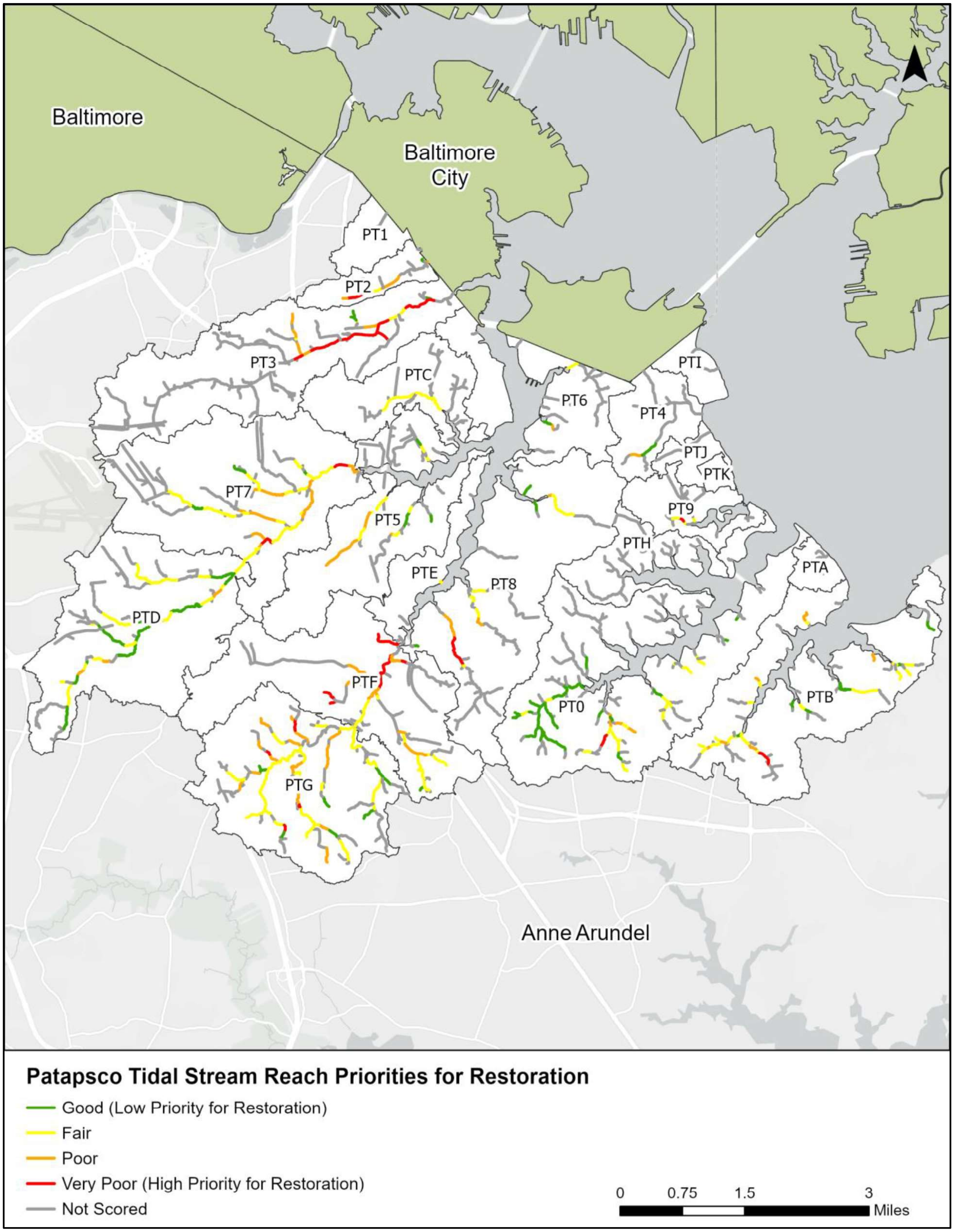
The models were designed to operate at three management scales: the individual stream reach scale; the parcel scale; and the subwatershed scale. Additionally, the models differentiated between identification of restoration opportunities for the degraded portions of the watershed (reach and subwatershed scale), and identification of preservation opportunities for high quality sensitive areas that could be subject to additional stressors in future scenarios (subwatershed and parcel scale). For the purpose of this Implementation Plan, prioritization results for stream reach restoration and subwatershed restoration are presented below to address in-stream sources and urban stormwater runoff, respectively.

8.3.1 Stream Reach Restoration

The stream restoration prioritization uses a suite of indicators that are weighted and then combined into a final relative rating for each perennial reach as identified in the Physical Habitat Condition Assessment in the *Patapsco Tidal and Bodkin Creek Watershed Assessment* (Anne Arundel County, 2012b). The suite of stream restoration indicators were grouped into five categories, including indicators to rate stream habitat, stream morphology, land cover, infrastructure, and hydrology and hydraulics.

In the Patapsco Tidal River watershed, 338 perennial reaches were assessed using these indicators. Of these, a total of 35 reaches were rated as “High” priority for restoration, 76 reaches were rated as “Medium High,” 149 reaches were rated as “Medium,” and 78 were rated as “Low.” A map of the stream reach prioritization was generated using data from the *Patapsco Tidal and Bodkin Creek Watershed Assessment Report* (Anne Arundel County, 2012b), and was included in Figure 8-1.

Figure 8-1: Patapsco Tidal River Stream Reach Priorities for Restoration (Anne Arundel County, 2012b)



8.3.2 Subwatershed Restoration

Similar to the stream restoration assessment, the subwatershed assessment in the *Patapsco Tidal and Bodkin Creek Watershed Assessment* (Anne Arundel County, 2012b) used a collection of restoration indicators that were weighted and combined to assign a single rating to each subwatershed. Restoration indicators fell into one of seven categories: stream ecology; 303(d) list; septics; BMPs; Hydrologic & Hydraulic (H&H) modeling; water quality; and landscape.

In the Patapsco Tidal River watershed, six of the 21 subwatersheds included in this Implementation Plan were rated as a "High" priority for restoration. Eight subwatersheds were assessed to be "Medium High" on the prioritization scale for restoration needs, and six subwatersheds were assessed to be "Medium" priority. Finally, one subwatershed was assessed to be "Low" priority. A map of the subwatershed restoration prioritization was included in the *Patapsco Tidal and Bodkin Creek Watershed Assessment* (Anne Arundel County, 2012b) and is included as Figure 8-2. Tables 8-3 and 8-4 below show the prioritization of subwatersheds in a tabular format.

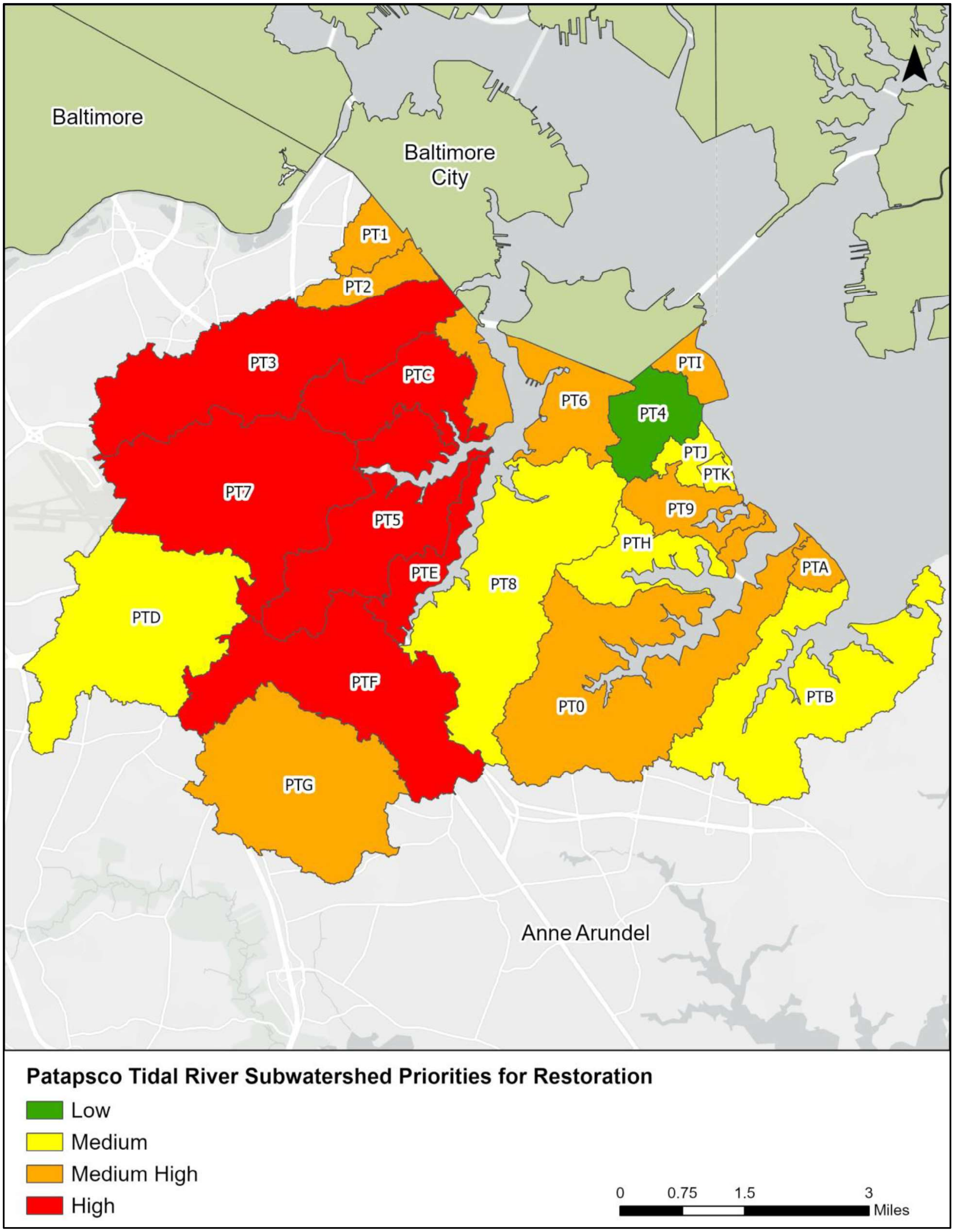
Table 8-3: Patapsco Tidal River Subwatershed Priority for Restoration

Subwatershed Code	Subwatershed Name	Priority for Restoration
PT3	Cabin Branch	High
PT5	Furnace Creek	High
PT7	Sawmill Creek I	High
PTC	Back Creek	High
PTE	Marley Creek II	High
PTF	Marley Creek III	High
PT0	Stony Creek	Medium High
PT1	Unnamed Tributary	Medium High
PT2	Cabin Branch II	Medium High
PT6	Curtis Creek	Medium High
PT9	Cox Creek	Medium High
PTA	Patapsco Tidal	Medium High
PTG	Marley Creek IV	Medium High
PTI	Patapsco Tidal	Medium High
PT8	Marley Creek I	Medium
PTB	Rock Creek	Medium
PTD	Sawmill Creek II	Medium
PTH	Nabbs Creek	Medium
PTJ	Patapsco Tidal	Medium
PTK	Patapsco Tidal	Medium
PT4	Swan Creek	Low

Table 8-4: Subwatershed Restoration Assessment Results

Rating	Number of Subwatersheds	Percent of Subwatersheds
High	6	28.6%
Medium High	8	38.1%
Medium	6	28.6%
Low	1	4.8%
Total	**21**	**100%**

Figure 8-2: Patapsco Tidal River Subwatershed Priorities for Restoration (Anne Arundel County, 2012b)



8.3.3 Subwatershed Preservation

The subwatershed preservation assessment in the *Patapsco Tidal and Bodkin Creek Watershed Assessment* (Anne Arundel County, 2012b) used a collection of preservation indicators that were weighted and combined into a single rating for each subwatershed for consideration for preservation activities. Preservation indicators fell into one of five categories: stream ecology; future departure of water quality conditions; soils; landscape; and aquatic living resources.

In the Patapsco Tidal River watershed, six subwatersheds were rated to be “High” priority for preservation, six subwatersheds were rated “Medium High,” seven subwatersheds were rated “Medium,” and two were rated “Low” priority for preservation.

A map of the subwatershed preservation prioritization was included in the *Patapsco Tidal and Bodkin Creek Watershed* Assessment Report, and is as Figure 8-3. Tables 8-5 and 8-6 below show the prioritization of subwatersheds for preservation in a tabular format.

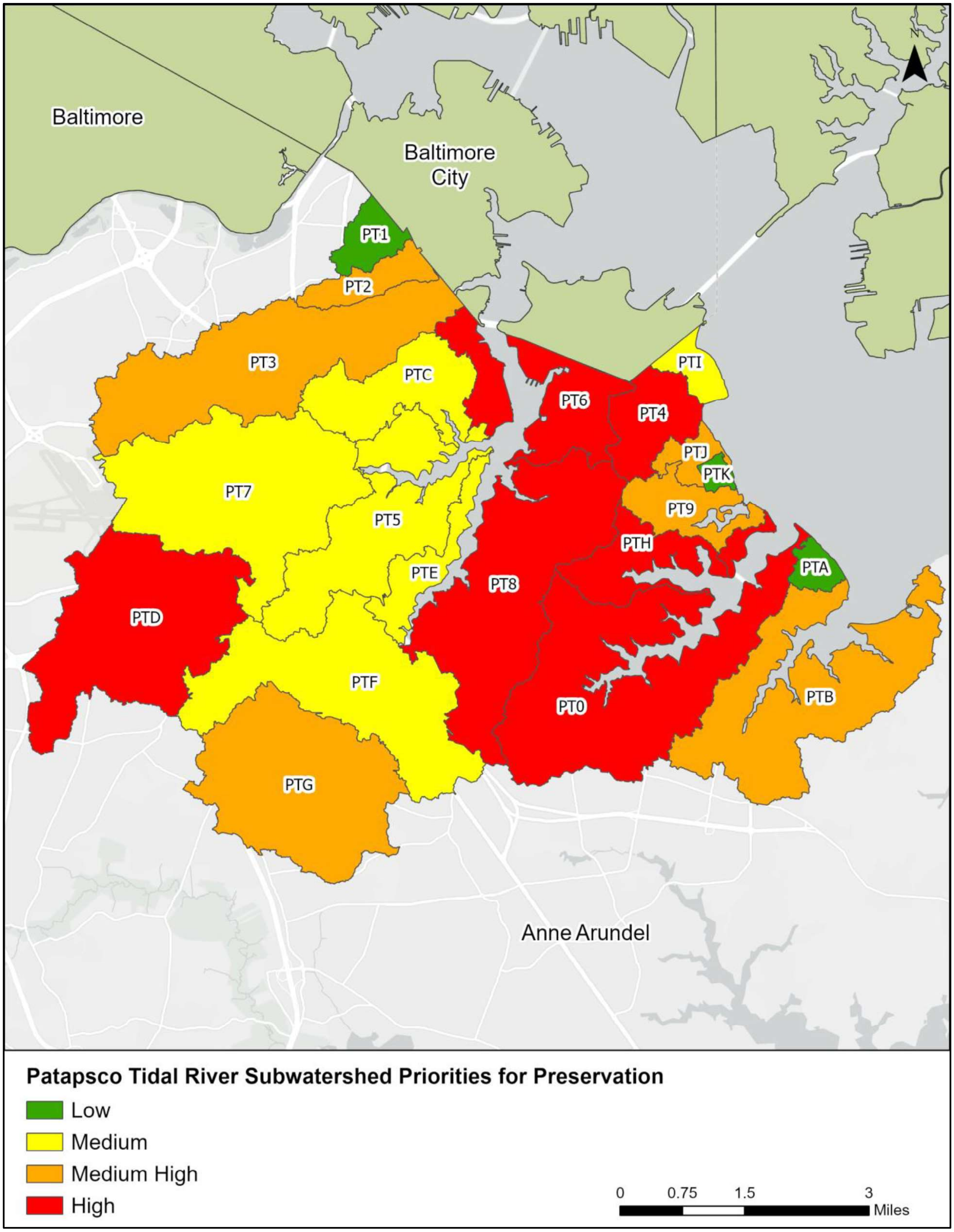
Table 8-5 Patapsco Tidal River Subwatershed Priority for Preservation

Subwatershed Code	Subwatershed Name	Priority for Preservation
PT0	Stony Creek	High
PT4	Swan Creek	High
PT6	Curtis Creek	High
PT8	Marley Creek I	High
PTD	Sawmill Creek II	High
PTH	Nabbs Creek	High
PT2	Cabin Branch II	Medium High
PT3	Cabin Branch	Medium High
PT9	Cox Creek	Medium High
PTB	Rock Creek	Medium High
PTG	Marley Creek IV	Medium High
PTJ	Patapsco Tidal	Medium High
PT1	Unnamed Tributary	Medium
PT5	Furnace Creek	Medium
PT7	Sawmill Creek I	Medium
PTC	Back Creek	Medium
PTE	Marley Creek II	Medium
PTF	Marley Creek III	Medium
PTI	Patapsco Tidal	Medium
PTA	Patapsco Tidal	Low
PTK	Patapsco Tidal	Low

Table 8-6: Patapsco Tidal River Subwatershed Preservation Assessment Results

Rating	Number of Subwatersheds	Percent of Subwatersheds
High	6	28.6%
Medium High	6	28.6%
Medium	7	33.3%
Low	2	9.5%
Total	**21**	**100%**

Figure 8-3: Patapsco Tidal River Subwatershed Priorities for Preservation (Anne Arundel County, 2012b)



8.4 Implementation Strategy

Anne Arundel County's FY22 six-year CIP budget includes BWPR class projects to continue implementing restoration projects identified in the County's Phase II WIP and applicable individual TMDLs for achieving SW-WLAs. Funding for this class of projects averages approximately $27M annually. Projects in the BWPR class are identified and prioritized through a planning level assessment.

The MS4 permit calls for an iterative and adaptive plan for implementation. As BWPR projects are funded, more detailed feasibility and constructability assessments are conducted. These assessments may result in adaptations and updates to the Implementation Plan if projects previously thought to be feasible are in fact not feasible. The assessment may also result in the identification of additional and/or new opportunities. As these feasibility assessments are completed, the County incorporates these findings into its modeling, re-assesses anticipated load reductions, and adapts it implementation program and CIP accordingly. Additionally, the County will reassess and modify its restoration strategy as BMP technologies and efficiencies change, programs mature, credit trading is enacted, and new regulations are put into place.

9 Load Reduction Evaluation Criteria

Adaptive management is a critical component of achieving the SW-WLAs required in the Patapsco Tidal River watershed to address the Baltimore Harbor Sediment TMDL. As presented in Section 8 of this plan, the County has developed an expected Milestone 1 implementation and load reduction goal based on interim programmed implementation. Evaluation of progress achieved by Milestone 1 can serve as a vehicle for assessing incremental progress toward the load reduction targets.

Progress will be measured through three approaches: tracking implementation of management measures; estimating load reductions through modeling; and tracking overall program success through long term monitoring. Planning targets will be re-evaluated against progress and revised to ensure that Anne Arundel County is on track to meet established goals. Progress assessments are completed annually and reported to MDE with the County's MS4 Annual Report.

9.1 Tracking Implementation of Management Measures

Implementation will be measured by determining whether the targets for implementation shown in Table 8-2 are maintained according to the milestone schedule. Anne Arundel County manages a comprehensive system for adding and tracking projects and accounting for new programs. New BMPs constructed through new development and redevelopment projects are entered into the County's BMP database and NPDES MS4 geodatabase as they come on-line. BWPR is responsible for implementing and tracking Water Quality Improvement Projects (WQIP; i.e., restoration and retrofit projects and programs). Additional internal County groups including Bureau of Highway Road Operation Division, which is responsible for maintenance efforts (i.e., street sweeping and inlet cleaning), report back to BWPR. The County is also capturing and tracking projects implemented by the AAWSA through the BWPR-Chesapeake Bay Trust Restoration Grant Program.

9.1.1 Annual NPDES MS4 Reporting

As a requirement of the NPDES permit described in Part V.A, on or before December 31 of each year, the County must submit a progress report demonstrating implementation of the NPDES stormwater program based on the fiscal year. If the County's MS4 Annual Report does not demonstrate compliance with their permit and show progress toward meeting SW-WLAs, the County must implement BMP and program modifications within 12 months. The MS4 Annual Report includes the following (items in bold font directly relate to elements of the load reduction evaluation criteria):

a. The status of implementing the components of the stormwater management program that are established as permit conditions including:

i. Permit Administration;

ii. Legal Authority;

iii. Source Identification;

iv. **Stormwater Management**;

v. Erosion and Sediment Control;

vi. Illicit Discharge Detection and Elimination;

vii. Property Management and Maintenance;

viii. Public Education;

ix. **Stormwater Restoration**;

x. **Countywide Stormwater TMDL Implementation Plan**;

xi. Assessment of Controls; and

xii. Program Funding

b. A narrative summary describing the results and analyses of data, including monitoring data that is accumulated throughout the reporting year

c. Expenditures for the reporting period and the proposed budget for the upcoming year

d. A summary describing the number and nature of enforcement actions, inspections, and public education programs

e. The identification of water quality improvements and documentation of attainment and/or progress toward attainment of benchmarks and applicable WLAs developed under EPA approved TMDLs; and,

f. The identification of proposed changes to the County's program when WLAs are not being met

All annual reporting is required to be made using MDE's MS4 Geodatabase format. Elements of the database, following MDE's current schema (Version 1.2 Draft Updates, November 2021), include feature classes and associated tables that store and report the County's restoration projects to MDE. MDE and the CBP use the data for larger scale Chesapeake Bay modeling and TMDL compliance tracking. The relevant database features include:

- AltBMPLine - stream restoration, shoreline restoration, outfalls
- AltBMPPoint – septic system practices (pump-out, upgrades, connections)
- AltBMPPoly – tree planting, street sweeping, inlet cleaning, impervious removal
- RestBMP – stormwater BMPs (SPSC, bioretention, wet ponds etc.)

9.1.2 TMDL Annual Assessment Reports

Anne Arundel County produces A Countywide TMDL Stormwater Implementation Plan to assess and report progress for each County TMDL that has a completed and final implementation plan in place. The reports include implementation and load reduction summaries for the projects and programs completed in the current reporting year, and also compiled for the full restoration period from the baseline through the current reporting year. Comparisons are made to the planned implementation targets to determine if the County is on track. Costs of program implementation are reported. For sediment TMDLs, a section is dedicated to reporting County water quality and biomonitoring results from the Countywide Biomonitoring Program and from any relevant targeted restoration monitoring sites. The Countywide TMDL Stormwater Implementation Plan is submitted to MDE with the County's MS4 Annual Report.

9.1.3 Financial Assurance Plan Reporting

The County's FAP outlines the County's financial ability to meet its local and Chesapeake Bay TMDL obligations and is another mechanism of reporting to MDE. The FAP demonstrates the County's ability to fund projects that will reduce pollutants of concern and make measurable progress towards improving water quality. Anne Arundel County's first FAP was submitted to MDE in July of 2016, and submitted an updated version was adopted by the County Council on October 3, 2022 (Resolution #37-22) and will be submitted as an appendix to the County's FY2022 Annual NPDES MS4 Report. A copy of the 2022 Financial Assurance Plan can be found at: https://www.aacounty.org/departments/public-works/wprp/financial-assurance-plan/index.html.

9.2 Estimating Load Reductions

The County performs modeling annually to evaluate load reductions and progress towards meeting SW-WLA goals. The load reductions are reported in the County's "Countywide TMDL Stormwater Implementation Plan as described above and in the County's MS4 Annual Report. Modeled baseline and current loads are reported in the NPDES geodatabase in the "LocalStormwaterWatershedAssessment" table. The annual assessment of progress assessment contribute to ongoing re-evaluation of management plans, and adapting responses accordingly as technologies and efficiencies change, programs mature, credit trading is enacted, and regulations are put in place. The County will model load reductions for the Patapsco Tidal River watershed using TIPP to maintain consistency with the model framework used to develop the Implementation Plan and initial progress loads.

9.3 Tracking Overall Program Success through Monitoring

Overall program success will be evaluated using trends identified through the long term monitoring program described below in Section 10. TMDL compliance status will be evaluated to determine if the Implementation Plan needs to be updated. If it is found during the evaluation of BMP implementation and load reductions that the milestone targets are no longer being met, a revision of the plan may be necessary.

9.4 Best Management Practices Inspection and Maintenance

Anne Arundel County has established policies and procedures in place for stormwater management facility inspection, maintenance and enforcement.

9.4.1 Background

Both the State and County stormwater management codes require maintenance inspections be performed on all stormwater management practices during the first year of operation and every three years thereafter. The first year of operation inspections are performed by the Department of Inspections and Permits' Environmental Control Inspectors before Certificates of Completion are issued for the grading permits under which the practices were constructed. The three-year maintenance inspections are the responsibility of the BWPR inspection staff.

9.4.2 Phase 1 Inspection and Enforcement

Phase I Inspection and Enforcement reflects the first time a stormwater management practice receives a three-year maintenance inspection and maintenance is required. Using the proper Maintenance Inspection Checklists, the Inspector performs the required three-year maintenance inspection, indicating on the Checklist boxes if maintenances is required, not required, or the item is non-applicable. The information on the completed Checklist will serve to comply with the inspection requirements of COMAR 26.17.02.11 and is used to complete a Phase I Correction Notice that is mailed to the current listed property owner on record with SDAT. The Phase 1 Correction Notices are prepared using the I&P standard computerized inspection report. They include a detailed description of the maintenance required and the compliance date by which the required maintenance is to be completed. Phase 1 Correction Notices contain the proper contact information for the Inspector that performed the inspection. The Urban BMP geodatabase is updated to document when a three-year Maintenance Inspection is performed. For monthly reporting purposes, all re-inspections are recorded as inspections and not as new facilities inspected or as new correction notices issued. Depending on the degree of maintenance required, a Compliance Schedule (or extended maintenance timeline) may be appropriate. All proposed Compliance Schedules must be authorized by the BWPR Supervisor. Phase 1 enforcement allows for (2) sequential 30-day correction periods to complete required work if compliance has not been achieved by the initial inspection specified due date.

9.4.3 Phase 2 Inspection and Enforcement

Phase 2 Enforcement reflects situations where Phase 1 Enforcement was not successful in obtaining compliance. Phase 2 Enforcement consists of a formal Phase 2 Violation Notice of Non-Compliance in the form of a certified letter to the property owner or responsible party. The Phase 2 Violation Notice of Non-Compliance is prepared by the BWPR Inspector using the appropriated form letter, reviewed by the BWPR Supervisor or Code Compliance Administrator as appropriate, and signed by the BWPR Supervisor. The Phase 2 Notice establishes final compliance date(s) for the completion of the required maintenance. The final compliance date(s) may reflect agreed-upon Compliance Schedules as authorized by the BWPR Supervisor.

9.4.4 Phase 3 Inspection and Enforcement

Phase 3 Enforcement reflects situations where Phase 2 Enforcement was not successful in obtaining compliance. Phase 3 enforcement consists of a legal referral to the Office of Law for the enforcement of the Private Inspection and Maintenance Agreement recorded against the deed for the property in question. The referral file is prepared by the Inspector, signed off by the BWPR Supervisor and Code Compliance Administrator using the inspection documents and records associated with the violation.

10 Monitoring

Official monitoring for Integrated Report assessments and impairment status is the responsibility of the State; however, the County has many on-going monitoring programs that supplement the State's efforts.

To determine the specific parameters to be monitored for tracking progress, one must understand the approach used for the initial listing. In 2002, the State began listing biological impairments on the Integrated Report, at the 8-digit scale, based on a percentage of stream miles degraded and whether they differ significantly from a reference condition watershed (<10 percent stream miles degraded). The biological listing is based on Benthic and Fish Indices of Biotic Integrity (BIBI/FIBI) results from wadeable streams from assessments conducted by the Maryland Department of Natural Resources (MDNR) Maryland Biological Stream Survey (MBSS). The Baltimore Harbor watershed was listed for biological community impairment in 2002.

MDE then utilized its BSID process to identify the probable or most likely causes of poor biological conditions. The Baltimore Harbor's BSID document, *Watershed Report for Biological Impairment of the Baltimore Harbor Watershed in Baltimore City, Baltimore, and Anne Arundel Counties, Maryland Biological Stressor Identification Analysis Results and Interpretation* (MDE, 2014a) was developed in 2014. For sediment specifically, the BSID identified that 'altered hydrology and increased runoff from urban and impervious surfaces have resulted in channel erosion, scouring, and transport of suspended sediments in the watershed, which are in turn the probable causes of impacts to biological communities.' Overall, the results indicated that inorganics (i.e., chloride and sulfates), sediment and in-stream habitat related stressors, anthropogenic channelization of stream segments, and anthropogenic alterations of riparian buffer zones as the primary stressors causing impacts to biological communities.

Based on the results of the BSID, MDE replaced the biological impairment listing with a listing TSS in 2012. The 2014 IR also includes chloride, sulfate, habitat alterations, and lack of riparian buffer as impairments of the Harbor's aquatic life and wildlife use. The 2014, 2016 and 2018 final Integrated Reports list 'Fish and Benthic IBIs' as the indicator, and 'Urban Runoff/Storm Sewers" as the source. It is noted that the *Decision Methodology for Solids for the April 2002 Water Quality Inventory* (MDE, 2012) makes a specific distinction between two different - although related - 'sediment' impairment types in free flowing streams:

1. **TSS**: The first type is an impact to water clarity with impairment due to TSS using turbidity measured in Nephelometric Turbidity Units (NTUs). Although numeric criteria have not been established in Maryland for TSS, MDE uses a threshold for turbidity (a measurement of water clarity) of a maximum of 150 NTUs and maximum monthly average of 50 NTU as stated in Maryland COMAR regulations (26.08.02.03-3). Turbidity also may not exceed levels detrimental to aquatic life in Class I designated waters.
2. **Sedimentation / siltation**: The second type is an impact related to erosional and depositional impacts in wadeable streams. The measures used are biocriteria and the criteria for Class I

streams (the protection of aquatic life and growth and propagation of fish [other than trout] and other aquatic life).

Since two types of sediment impairments are identified in the IRs, monitoring of both water clarity and sedimentation should be incorporated into monitoring programs to track changes in the watershed condition over time. The BWPR has several on-going monitoring programs that target measures of water clarity and sedimentation. These programs are described below.

10.1 Countywide Biological Monitoring

In 2004, a Countywide Biological Monitoring and Assessment Program for Anne Arundel County was developed to assess the biological condition of the County's streams at multiple scales (i.e., site specific, primary sampling unit (PSU), and countywide). Under Round 1 and 2 of the Countywide Biological Monitoring and Assessment program, biology (i.e., benthic macroinvertebrates) and stream habitat, as well as geomorphological and water quality parameters, were assessed at approximately 240 sites throughout the entire County over a five-year period using a probabilistic, rotating-basin design. Round 1 of the County's Biological Monitoring and Assessment Program occurred between 2004 and 2008, and Round 2 took place between 2009 and 2013. Round 3, which began in 2017 and was completed in 2021, added fish sampling and water quality grab samples, and expanded the number of sites to 400 over the five-year period.

The biological monitoring program's stated goals are applicable at three scales; Countywide, Watershed wide, and Stream-specific, and include the following components:

- Status: describe the overall stream condition
- Trends: how has the overall stream condition changed over time
- Problem identification/prioritization: identify the impaired and most degraded streams
- Stressor-response relationships: identify anthropogenic stressors and their biological response
- Evaluation of environmental management activities: monitor the success of implemented programs and restoration/retrofit projects

Ten sampling sites were sampled in each PSU in Round 1 and Round 2 sampling, while eight sites were sampled in Round 3. All Rounds follow procedures and protocols developed for the MBSS for the biological sampling. Habitat evaluations have included both MBSS's Physical Habitat Index (MPHI) and the EPA's Rapid Bioassessment Protocol (RBP) metrics. In-situ water quality measures are also collected at each site, along with a geomorphic evaluation utilizing cross-sections, particle substrate analysis using pebble counts, and measures of channel slope. As stated previously, fish sample and a water chemistry grab sample were added to the assessment activities for Round 3.

Following these procedures, the County is collecting several parameters related to water clarity and sediment deposition at each site.

- Water Quality Measures and Observations
    - Turbidity (measured), observations of general water clarity and color

    - Water chemistry sample (Round 3 only)
- Biological Measures
    - Benthic macroinvertebrates (benthic index of biotic integrity - BIBI)
    - Fish (fish index if biotic integrity – FIBI—Round 3 only)

The Countywide Biological Monitoring PSU corresponding to the Patapsco Tidal River watershed is the Marley Creek PSU. Marley Creek was monitored in 2006 during Round 1; in 2009 during Round 2; and in 2018 during Round 3.

10.2 Restoration Monitoring

To evaluate management activities, the County uses assessment methods similar to the countywide program (biological monitoring, water chemistry sampling, physical habitat, geomorphic evaluation) to assess baseline and post-restoration conditions for select stream, wetland and stormwater restoration and retrofit sites. In addition, these techniques are utilized to meet several NPDES MS4 permit monitoring requirements, particularly related to Assessment of Controls and Watershed Restoration Assessment.

10.3 Watershed Assessments Monitoring

In 2000, Anne Arundel County initiated a series of systematic and comprehensive watershed assessments and management plans for restoration and protection across the County. The plans are developed within a regulatory context that includes NPDES MS4 requirements, local TMDLs and Watershed Implementation Plans for the Chesapeake Bay TMDL, Maryland Stormwater Regulations and the Water Resources Element of the County's General Development Plan.

Biological monitoring is a component of the characterization and prioritization process within the watershed management plans. The biological monitoring data is primarily utilized in the County's Watershed Management Tool (WMT) and Stream Assessment Tool (SAT), which were developed and maintained by the BWPR. Within this program, sampling sites are selected using a targeted approach with the goal of having at least one, and sometimes two, sites located within each subwatershed planning unit in order to examine the relationships between land use and ecological conditions downstream. Monitoring components include benthic macroinvertebrate community sampling, *in situ* water chemistry measurements, and instream and riparian physical habitat condition assessments. Water quality grab sampling and detailed geomorphic assessments have been included for some watershed studies, but not as routine monitoring components.

Biological monitoring in the Patapsco tidal watershed was completed in 2006 and 2008. A full description of the results of this monitoring is too lengthy to describe in this report, but can be found at https://www.aacounty.org/departments/public-works/wprp/forms-and-publications/PTB_Summary_Report_Final_Main.pdf. This monitoring program is noted herein because the associated BIBI and PHI data can be used as additional baseline data points to track changes over time. The County continues to reevaluate its monitoring programs as the state of the science progresses, as the understanding of water quality and ecological interactions are improved, and as regulatory programs are added or modified.

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Appendix A: Public Comments

The *Non Tidal Baltimore Harbor Watershed Sediment TMDL Draft Implementation Plan, Anne Arundel County, Maryland* will be posted on the County's web page and advertised for public comment in *The Capital Gazette* newspaper for a 30-day public comment period.

Comments received and Anne Arundel County's response to those comments, will be and addressed and included in this appendix. Also included will be the Notice of Public Comment and *The Capital Gazette* newspaper posting.