# OTHER WEST CHESAPEAKE WATERSHED

## SEDIMENT TMDL RESTORATION PLAN

JANUARY | 2019

**PREPARED FOR**

Anne Arundel County, Maryland

Department of Public Works

Watershed Protection and Restoration Program

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## List of Acronyms

| | |
|---|---|
| AAWSA | Anne Arundel Watershed Stewards Academy |
| AFG | Accounting for Growth |
| AHB | Advocates for Herring Bay |
| BIBI | Benthic Index of Biotic Integrity |
| BMP | Best Management Practice |
| BSID | Biological Stressor Identification |
| CAST | Chesapeake Assessment Scenario Tool |
| CBP | Chesapeake Bay Program |
| CIP | Capital Improvement Program |
| CWA | Clean Water Act |
| DPW | Department of Public Works |
| EMC | Event Mean Concentration |
| EOS | Edge of Stream |
| EOT | Edge of Tide |
| EPA | United States 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 |
| MPHI | Maryland Physical Habitat Index |
| MS4 | Municipal Separate Storm Sewer System |
| NGO | Non-governmental Organization |
| NPDES | National Pollutant Discharge Elimination System |
| NTU | Nephelometer Turbidity Units |
| OSDS | On-site Disposal Systems |
| PSU | Primary Sampling Unit |
| RBP | Rapid Bioassessment Protocol |
| ROW | Right of Way |
| SAT | Stream Assessment Tool |
| SPSC | Step Pool Storm Conveyance |
| SW to MEP | Stormwater to the Maximum Extent Practicable |
| TMDL | Total Maximum Daily Load |
| TSS | Total Suspended Solids |
| WIP | Watershed Implementation Plan |
| WLA | Waste Load Allocation |
| WM P6 | Watershed Model Phase 6 |
| WMT | Watershed Management Tool |
| WPRP | Watershed Protection and Restoration Program |
| WQIP | Water Quality Improvement Projects |

# Executive Summary

This restoration plan addresses the total suspended solids (TSS; sediment) TMDL for the Other West Chesapeake watershed in Anne Arundel County, Maryland, which was approved by the Environmental Protection Agency (EPA) on February 9, 2018. The Anne Arundel County portion of the Other West Chesapeake watershed is also known as Herring Bay, and both names will be used in this plan.

Sediment, both from upland and in-stream sources, can degrade in-stream habitat for aquatic organisms by covering and filling gravelly and rocky substrate with finer clays, silts, and sands. 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. Suspended sediment in the water column may limit light penetration and prohibit healthy propagation of algae and submerged aquatic vegetation.

The majority of sediment loads in the Other West Chesapeake watershed originate from urban stormwater and agricultural runoff and in-stream sources related to channel erosion. The most significant contributing land use categories related to urban and agricultural stormwater in terms of loading rates include row crops, pasture and hay, transportation, and commercial and industrial areas. Residential development, while a lower loading rate, makes up a large portion of the watershed (23.4%) and is therefore also a significant contributor. 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 velocities. Increased velocities can be associated with development activities that increase imperviousness and agricultural activities that encroach on riparian buffers within the watershed.

The Other West Chesapeake watershed TMDL requires a 33.0% reduction of sediment loads from 2009 baseline levels to achieve the target stormwater waste load allocation (SW-WLA) for Anne Arundel County National Pollutant Discharge Elimination System (NPDES) regulated stormwater. A planning horizon of 2030 is used as the date to achieve these load reductions.

The Chesapeake Assessment Scenario Tool (CAST) Chesapeake Bay Program Watershed Model Phase 6 (CBP WM P6) model was used to model baseline, progress, and planned loads. Using CAST, the sediment loads are translated from the values derived by the Bay model version 5.3.2 that was used in the development of the TMDL and calibrated to the Phase 6 model, making them compatible with current methods following MDE recommendations. The 2009 Phase 6 calibrated baseline load was determined to be 3,895,399 lbs/year. Applying the 33% required reduction results in a reduction goal of 1,285,482 lbs.

A suite of possible best management practice (BMP) types was developed that, if implemented, would achieve the required load reduction. BMPs include stormwater BMPs, such as bioretention, bioswale, infiltration, SPSC, shoreline management, and wet ponds; land use change BMPs, such as impervious surface reduction and tree planting; and programmatic annual practices, such as inlet cleaning and street sweeping. The total projected cost to implement the projects described in this plan for the Other West Chesapeake watershed is approximately $7,743,835.

Progress will be measured through 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.

# 1 Introduction

## 1.1 Background and Purpose

The Anne Arundel County Department of Public Works (DPW) Watershed Protection and Restoration Program (WPRP) is developing restoration plans to address local water quality impairments for which 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, 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 Other West Chesapeake watershed has a listing in Maryland's Integrated Report of Surface Water Quality [303(d) list and 305(b) Report] for sediment pollution. An approved total suspended solids (TSS; sediment) TMDL for the Other West Chesapeake watershed from urban stormwater sources was approved by the EPA on February 9, 2018. This TMDL applies to Calvert County as well. This plan will specifically address the Other West Chesapeake sediment TMDL under the responsibility of Anne Arundel County. The Anne Arundel County portion of the Other West Chesapeake watershed is also called the Herring Bay watershed, and both names will be used in this Plan.

Responsibility for Other West Chesapeake sediment reduction is divided among the contributing jurisdictions. The TMDL loading targets, or allocations, are also divided among the pollution source categories, which in this case includes non-point sources (termed load allocation or LA) and point sources (termed waste load allocation or WLA). The WLA consists of loads attributable to regulated process water or wastewater treatment, and to 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 Discharge Permit (MS4), stormwater runoff from MS4 areas is considered a point source contribution.

Anne Arundel County's current MS4 permit (11-DP-3316, MD0068306) issued in its final form by the MDE in February of 2014 requires development of restoration plans for each stormwater WLA approved by EPA prior to the effective date of the permit (permit section IV.E.2.b). This plan satisfies this permit requirement and provides the loading target, recommended management measures, load reduction estimates, schedule, milestones, cost estimates and funding sources, and the tracking and monitoring approaches to meet the stormwater WLA (SW-WLA).

It is noted that TMDL restoration plans are an important first step. 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 plans can be extended and 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 in future updates.

**This plan demonstrates that Anne Arundel County will meet its sediment SW-WLA for the Other West Chesapeake watershed by 2030. The strategies proposed will provide treatment to reduce current sediment loads from the urban stormwater sector.**

## 1.2 TMDL Allocated and Planned Loads Summary

The following Restoration Plan only addresses loads allocated to Anne Arundel County NPDES regulated stormwater point source sediment. Additional SW-WLAs for the Other West Chesapeake watershed TMDL assigned to Calvert County, Maryland State Highway Administration, and other NPDES regulated stormwater are not the responsibility of Anne Arundel County and will not be addressed in this plan.

The Other West Chesapeake watershed TMDL requires a 33.0% reduction of sediment loads from 2009 baseline levels to achieve the target SW-WLA for Anne Arundel County NPDES regulated stormwater. A planning horizon of 2030 will be used as the date to achieve these load reductions with 2021, 2023, and 2025 proposed as interim milestones to assess progress.

The Chesapeake Assessment Scenario Tool (CAST) Chesapeake Bay Program Watershed Model Phase 6 (CBP WM P6) model was used to model baseline, progress, and planned loads. CAST, created by the Chesapeake Bay Program, is a web-based pollutant load estimating tool that calculates pollutant loads and reductions calibrated to the Chesapeake Bay Program Partnership Watershed Phase 6 Model. The 2009 baseline load was determined to be 3,895,399 lbs/year. The 33% required reduction results in a reduction of 1,285,482 lbs. Details of the modeling and load calculations are included in sections 4 and 5.

Based on MDE guidance, growth in the stormwater load since the TMDL baseline year was not accounted for in the development of this plan. Local TMDLs are considered met, from a planning perspective, when the load reductions associated with 2009 restoration progress coupled with the planned restoration load reductions exceed the load reduction required.

This section of the plan, including Table 1, provides a concise summary of the loads and reductions at important timeline intervals including the 2009 baseline, 2018 progress, 2025 interim milestone and 2030 final planning intervals. These terms and dates are used throughout the plan and explained in more detail in the following sections. They are presented here to assist the reader in understanding the definitions of each, how they were derived, and to provide an overall summary demonstrating the percent reduction required and percent reduction achieved through full implementation of this plan. Sediment loads and wasteload allocations are presented as tons/year in the *Total Maximum Daily Load of Sediment in the Other West Chesapeake Watershed, Anne Arundel and Calvert Counties, Maryland* document but will be discussed as lbs/year in this restoration plan, with the exception of Figure 6-9.

- **2009 Baseline Loads**: Baseline levels (i.e., land use loads with baseline BMPs) from 2009 conditions in the Other West Chesapeake watershed were calculated using the MDE 2009 Progress BMPs in Chesapeake Assessment Scenario Tool (CAST) Chesapeake Bay Program Watershed Model Phase 6 (CBP WM P6) model. Baseline loads were used to calculate the stormwater allocated sediment loads, or SW-WLA.
- **2018 Progress Loads and Reductions**: Progress loads and load reductions achieved from stormwater best management practice (BMP) implementation through 2018. The 2018 Progress Load Reductions are calculated from the 2009 Baseline Loads by the following calculations: 2009 Baseline Load – 2018 Progress Load.
- **2025 Interim Milestone Goal Loads and Planned Loads and Reductions**: Planned 2025 loads and reductions will result from implementation of strategies through 2025. The 2025 Planned Load Reductions are calculated from the 2009 Baseline Loads by the following calculation: 2009 Baseline Load – 2025 Planned Load.

- **2030 Allocated Load**: Allocated loads are calculated from the 2009 baseline levels, calibrated to CBP WM P6 as noted above, using the following calculation: 2009 Baseline Load – (2009 Baseline Load x 0.33).
- **2030 Planned Loads and Planned Reductions**: Loads and reductions that will result from implementation of this plan. The 2030 Planned Load Reductions are calculated from the 2009 Baseline Load by the following calculation: 2009 Baseline Load – 2030 Planned Load.

**Table 1: Other West Chesapeake Local TMDL Allocated and Planned Loads**

| | Sediment (tons/year) | Sediment (lbs/year) |
|---|---|---|
| 2009 Baseline Loads | 1,948 | 3,895,399 |
| 2018 Progress Loads | 1,877 | 3,754,604 |
| 2018 Progress Reductions | 70 | 140,795 |
| 2025 Planned Loads | 1,539 | 3,078,518 |
| 2025 Planned Reductions | 408 | 816,882 |
| 2030 TMDL Allocated Loads | 1,305 | 2,609,917 |
| 2030 Planned Loads | 1,270 | 2,540,150 |
| 2030 Planned Reductions | 678 | 1,355,249 |
| Required Percent Reduction | 33.0% | 33.0% |
| Planned Percent Reduction Achieved | 34.8% | 34.8% |

## 1.3 Restoration Plan Elements and Structure

This plan is developed within the context of on-going watershed management planning, 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 the 12 major watersheds. A comprehensive watershed assessment for the Herring Bay watershed was completed in 2018. The County also prepared a Phase II Watershed Implementation Plan (WIP) in 2012 in response to requirements set forth in the Chesapeake Bay TMDL for nitrogen, phosphorus and sediment. Information synthesized and incorporated into this plan for the Other West Chesapeake watershed draws upon these sources with updates and additions where necessary to meet the specific goals of the SW-WLA. The TMDL analyses and reports developed by MDE are also referenced. These primary sources include:

- Herring Bay, Middle Patuxent, and Lower Patuxent Watershed Assessment Comprehensive Summary Report (Anne Arundel County, 2018)
- Chesapeake Bay TMDL, Phase II Watershed Implementation Plan, Final (Anne Arundel County, 2012)
- Total Maximum Daily Load of Sediment in the Other West Chesapeake Watershed, Anne Arundel and Calvert Counties, Maryland (MDE, 2018b)

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

- General Guidance for Developing a Stormwater Wasteload Allocation (SW-WLA) Implementation Plan (MDE, October 2014 (b))
- Guidance for Developing Stormwater Wasteload Allocation Implementation Plans for Nutrient and Sediment Total Maximum Daily Loads (MDE, November 2014 (c))
- Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated (MDE, August 2014 (a))

The Other West Chesapeake 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 is of particular importance when seeking implementation funding. The EPA has clearly stated that to ensure that Section 319 (the EPA Nonpoint Source Management Program) 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.

The Other West Chesapeake watershed restoration plan is organized based on these elements. A modification to the order has been incorporated such that element c., a description of the management measures, is included before element b., the expected load reductions. We feel this modified approach is easier to follow. The letters (a. through i.) are included in the headers of the plan's major sections to indicate to the reader the elements included in that section. The planning elements 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 item (b) immediately below. (Section 3)

b. An estimate of the load reductions expected for the management measures described under paragraph (c) below, recognizing the natural variability and the difficulty in precisely predicting the performance of management measures over time. (Section 5)

c. A description of the management measures that will need to be implemented to achieve the load reductions estimated under paragraph (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)

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)

e. An information/education component that will be 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)

f. A schedule for implementing the management measures identified in this plan that is reasonably expeditious. (Section 8)

g. A description of interim, measurable milestones for determining whether management measures or other control actions are being implemented. (Section 8)

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)

i. A monitoring component to evaluate the effectiveness of the implementation efforts over time, measured against the criteria established under item (h) immediately above. (Section 10)

The outcomes of the planning effort are to provide guidance for the strategic implementation of watershed protection and restoration efforts that will advance progress toward meeting Anne Arundel County's local TMDLs pollutant loading allocations, and ultimately meeting water quality standards. Successful implementation of the plan will lead to improvements in local watershed conditions and aquatic health.

# 2 Watershed Characteristics

## 2.1 Watershed Delineation

The Other West Chesapeake watershed is one of 12 major watersheds in Anne Arundel County, Maryland, and is situated in the southeastern portion of the County (Figure 1). The watershed shares political boundaries with Calvert County. The Other West Chesapeake watershed drains directly to the east into Herring Bay, which leads to the Chesapeake Bay. Communities within the Other West Chesapeake watershed include Deale, Shadyside, Rose Haven, and Fairhaven.

## 2.2 Other West Chesapeake

The Anne Arundel County portion of the Other West Chesapeake watershed is approximately 14,662 acres (22.9 square miles) in area and contains approximately 100 total miles of streams. The watershed includes several named streams, including, among others, Tracys Creek, Deep Creek, Rockhold Creek, Parker Creek, Carrs Creek, and Red Lyon Creek. The streams are distributed among 21 subwatersheds, as shown below in Table 2 and in Figure 2. These subwatersheds were used as planning units for the watershed assessment and management plan completed for this watershed by the County in 2018 (Anne Arundel County, 2018). Although the average subwatershed size is 698 acres, the subwatersheds range in size from 118 in HBR to 2,401 in HB2. The channel length in each subwatershed also varies similarly.

**Table 2: Other West Chesapeake Watershed Drainage Area and Stream Miles**

| Subwatershed Code | Subwatershed Name | Drainage Area (Acres) | Drainage Area (Square Miles) | Stream Miles |
|---|---|---|---|---|
| HB0 | Rockhold Creek | 1,963.74 | 3.07 | 9.3 |
| HB1 | Tracys Creek I | 1,803.47 | 2.82 | 17.2 |
| HB2 | Tracys Creek II | 2,400.97 | 3.75 | 23.6 |
| HB3 | Jack Creek | 228.84 | 0.36 | 0.6 |
| HB7 | Cedarhurst | 492.89 | 0.77 | 1.9 |
| HB8 | Deep Creek | 832.81 | 1.30 | 2.3 |
| HB9 | Deep Cove Creek | 1,002.27 | 1.57 | 6.6 |
| HBB | Chesapeake Bay | 156.72 | 0.24 | 0.1 |
| HBC | Broadwater Creek | 452.22 | 0.71 | 0.6 |
| HBD | Carrs Creek | 269.01 | 0.42 | 0.0 |
| HBF | Parker Creek | 447.60 | 0.70 | 1.9 |
| HBL | Trotts Branch | 1,372.24 | 2.14 | 12.1 |
| HBM | Herring Bay | 183.41 | 0.29 | 0.3 |
| HBO | Unnamed Tributary | 335.55 | 0.52 | 2.2 |

| Subwatershed Code | Subwatershed Name | Drainage Area (Acres) | Drainage Area (Square Miles) | Stream Miles |
|---|---|---|---|---|
| HBP | Herring Bay II | 118.87 | 0.19 | 0.0 |
| HBQ | Unnamed Tributary II | 1,544.99 | 2.41 | 15.5 |
| HBR | Herring Bay III | 117.59 | 0.18 | 0.6 |
| HBS | Unnamed Tributary III | 317.02 | 0.50 | 3.3 |
| HBT | Red Lyon Creek | 249.98 | 0.39 | 2.0 |
| HBU | Herrington Harbor | 128.67 | 0.20 | 0.0 |
| HBV | Chesapeake Bay II | 243.83 | 0.38 | 0.0 |
| **Other West Chesapeake Total** | | **14,662.69** | **22.91** | **100.0** |

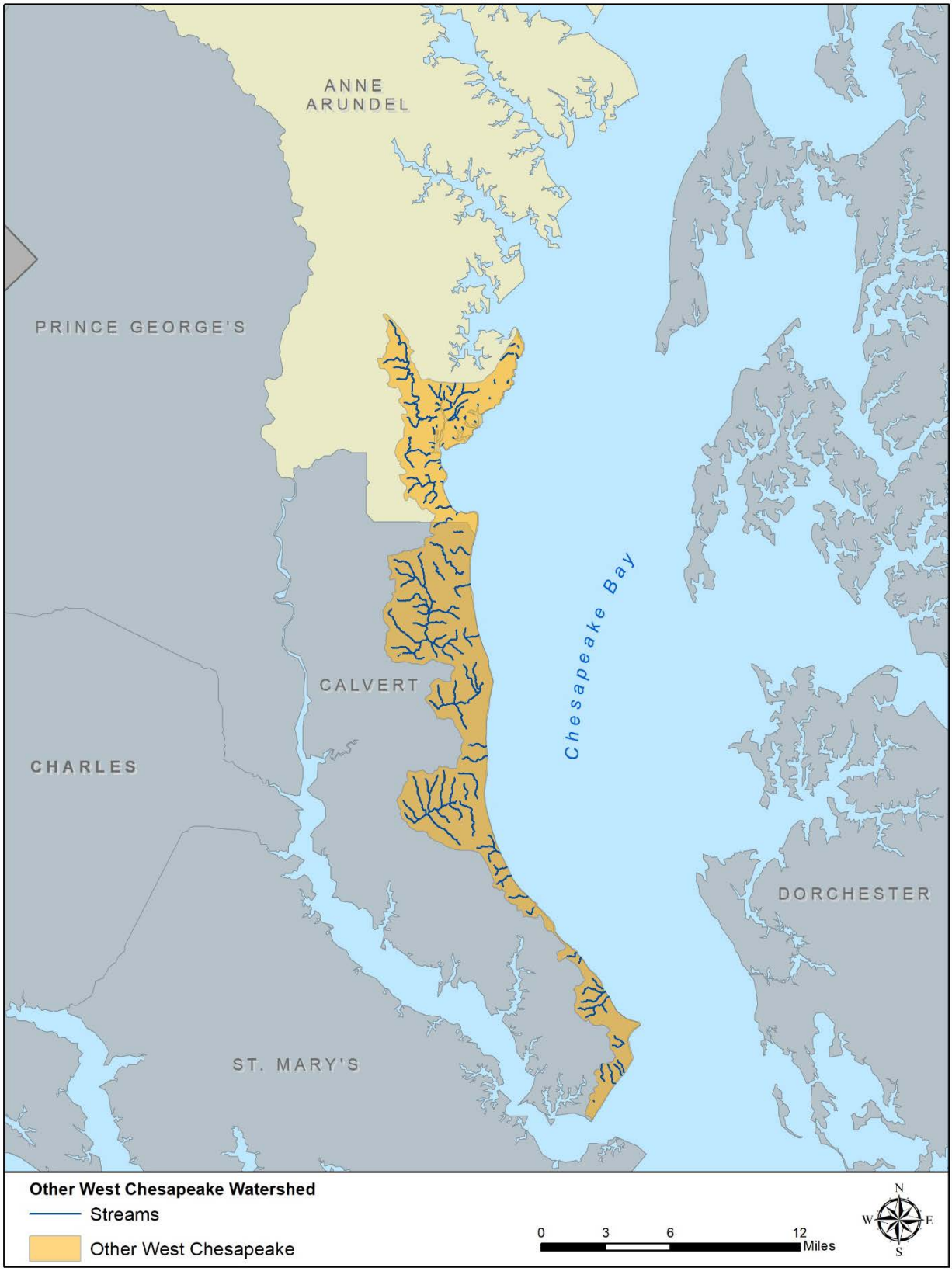
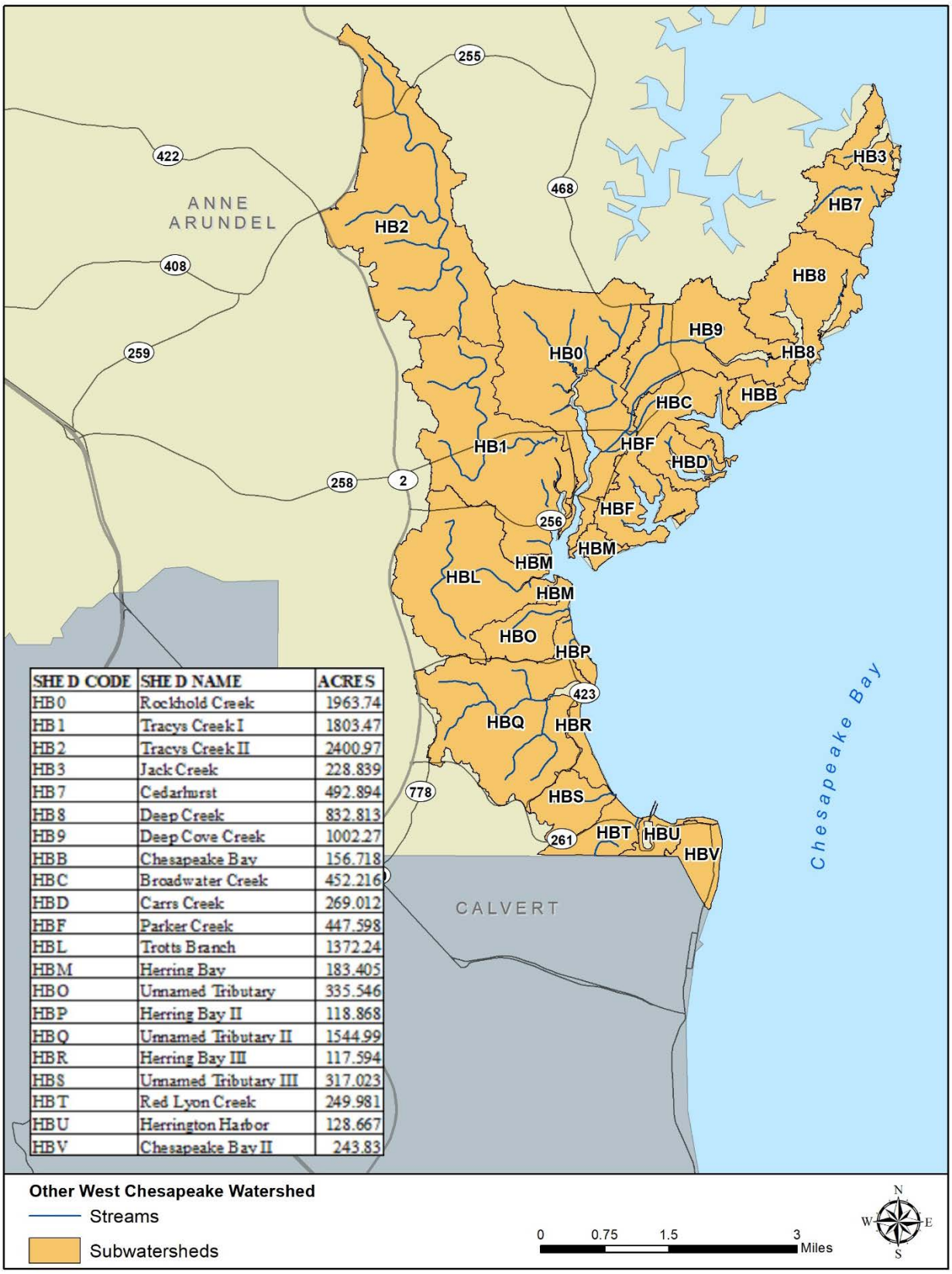



**Figure 1: Other West Chesapeake Watershed**




| SHED CODE | SHED NAME | ACRES |
|---|---|---|
| HB0 | Rockhold Creek | 1963.74 |
| HB1 | Tracys Creek I | 1803.47 |
| HB2 | Tracys Creek II | 2400.97 |
| HB3 | Jack Creek | 228.839 |
| HB7 | Cedarhurst | 492.894 |
| HB8 | Deep Creek | 832.813 |
| HB9 | Deep Cove Creek | 1002.27 |
| HBB | Chesapeake Bay | 156.718 |
| HBC | Broadwater Creek | 452.216 |
| HBD | Carrs Creek | 269.012 |
| HBF | Parker Creek | 447.598 |
| HBL | Trotts Branch | 1372.24 |
| HBM | Herring Bay | 183.405 |
| HBO | Unnamed Tributary | 335.546 |
| HBP | Herring Bay II | 118.868 |
| HBQ | Unnamed Tributary II | 1544.99 |
| HBR | Herring Bay III | 117.594 |
| HBS | Unnamed Tributary III | 317.023 |
| HBT | Red Lyon Creek | 249.981 |
| HBU | Herrington Harbor | 128.667 |
| HBV | Chesapeake Bay II | 243.83 |

**Figure 2: Other West Chesapeake Subwatershed Location**

## 2.3 Land Use/Land Cover

The type and density of various land uses can have a dramatic effect on water quality and stream habitat. Forested areas slow stormwater flow and allow water to gradually seep into soils and drain into streams. Vegetation and soils bind nutrients and pollutants found within stormwater—improving water quality as it infiltrates the ground. Developed areas, with a high percentage of impervious surfaces (buildings, paved roads, parking lots, etc.), do not reduce either the volume or flow of stormwater—increasing the amount of pollutants entering streams. Increased stormflow affects stream habitat negatively by increasing bank erosion and decreasing instream and riparian habitat. Agricultural land, if managed incorrectly, can also impair streams with increases in nutrients and bacteria.

See Figure 3 for aerial imagery of the Other West Chesapeake watershed. Land use / land cover (LULC) data from the Anne Arundel County Office of Information Technology (2014) is presented in Figure 4. Data presented in the figures below were used to characterize the watershed and show potential pollution sources. These LULC data were not used in the calculations of loads and load reduction, which were based instead on the land-river segment scale from the Chesapeake Bay Program Partnership Watershed Model Phase 6 (N24003WL0_4771_0000 and N24003WL0_4772_0000).

### 2.3.1 Existing Land Use/Land Cover

According to 2014 LULC data (Table 3), the largest category in the Other West Chesapeake is forested land, or mixed woods (41.1%) followed by 2-acre residential (13.0%). Developed land accounts for 30.0% of the watershed and largely consists of residential (23.4%) and commercial (2.1%).

**Table 3: 2014 Land Use / Land Cover**

| Land Use / Land Cover | Acres | Percent of Watershed |
|---|---|---|
| Airport | 6.5 | 0.0% |
| Commercial | 313.3 | 2.1% |
| Forested Wetland | 1,379.2 | 9.4% |
| Industrial | 24.9 | 0.2% |
| Open Space | 521.6 | 3.6% |
| Open Wetland | 619.6 | 4.2% |
| Pasture/Hay | 566.8 | 3.9% |
| Residential 1/2-acre | 257.8 | 1.8% |
| Residential 1/4-acre | 343.4 | 2.3% |
| Residential 1/8-acre | 628.8 | 4.3% |
| Residential 1-acre | 292.9 | 2.0% |
| Residential 2-acre | 1,903.4 | 13.0% |
| Row Crops | 910.3 | 6.2% |
| Transportation | 308.9 | 2.1% |
| Utility | 321.9 | 2.2% |
| Water | 136.3 | 0.9% |
| Woods-Coniferous | 100.4 | 0.7% |
| Woods-Mixed | 6,025.8 | 41.1% |
| **Total** | **14,662.0** | **100.0%** |

### 2.3.2 Impervious Surfaces

Impervious surfaces concentrate stormwater runoff, accelerating flow rates and directing stormwater to the receiving stream. This accelerated, concentrated runoff can cause stream erosion and habitat degradation. Runoff from impervious surfaces picks up and washes off pollutants and is usually more polluted than runoff generated from pervious areas. In general, undeveloped watersheds with small amounts of impervious cover are more likely to have better water quality in local streams than urbanized watersheds with greater amounts of impervious cover. Impervious cover is a primary factor when determining pollutant characteristics and loadings in stormwater runoff.

The degree of imperviousness in a watershed also affects aquatic life. There is a strong relationship between watershed impervious cover and the decline of a suite of stream indicators. As imperviousness increases the potential stream quality decreases with most research suggesting that stream quality begins to decline at or around 10 percent imperviousness (Schueler, 1994; CWP, 2003). However, there is considerable variability in the response of stream indicators to impervious cover observed from 5 to 20 percent imperviousness due to historical effects, watershed management, riparian width and vegetative protection, co-occurrence of stressors, and natural biological variation. Because of this variability, one cannot conclude that streams draining low impervious cover will automatically have good habitat conditions and a high quality aquatic life.

Impervious surfaces make up 6.5% of the overall Other West Chesapeake drainage (Table 4 and Figure 5; impervious surfaces data obtained from Anne Arundel County Office of Information Technology - 2014). Impervious surface is highest in areas surrounding Deale, Rose Haven, and other communities located along the Herring Bay shoreline.

**Table 4: Other West Chesapeake Watershed Percent Impervious Cover**

| Subwatershed Code | Subwatershed Name | % Impervious Cover |
|---|---|---|
| HB0 | Rockhold Creek | 6.6% |
| HB1 | Tracys Creek I | 6.3% |
| HB2 | Tracys Creek II | 3.7% |
| HB3 | Jack Creek | 9.5% |
| HB7 | Cedarhurst | 12.2% |
| HB8 | Deep Creek | 5.5% |
| HB9 | Deep Cove Creek | 6.7% |
| HBB | Chesapeake Bay | 23.7% |
| HBC | Broadwater Creek | 13.7% |
| HBD | Carrs Creek | 8.9% |
| HBF | Parker Creek | 16.6% |
| HBL | Trotts Branch | 2.9% |
| HBM | Herring Bay | 19.7% |
| HBO | Unnamed Tributary | 4.5% |
| HBP | Herring Bay II | 12.7% |
| HBQ | Unnamed Tributary II | 2.4% |
| HBR | Herring Bay III | 7.3% |

| Subwatershed Code | Subwatershed Name | % Impervious Cover |
|---|---|---|
| HBS | Unnamed Tributary III | 1.3% |
| HBT | Red Lyon Creek | 5.1% |
| HBU | Herrington Harbor | 29.5% |
| HBV | Chesapeake Bay II | 9.1% |
| **Other West Chesapeake Total** | | **6.5%** |


**Figure 3: Other West Chesapeake Watershed Aerial Imagery (2017)**

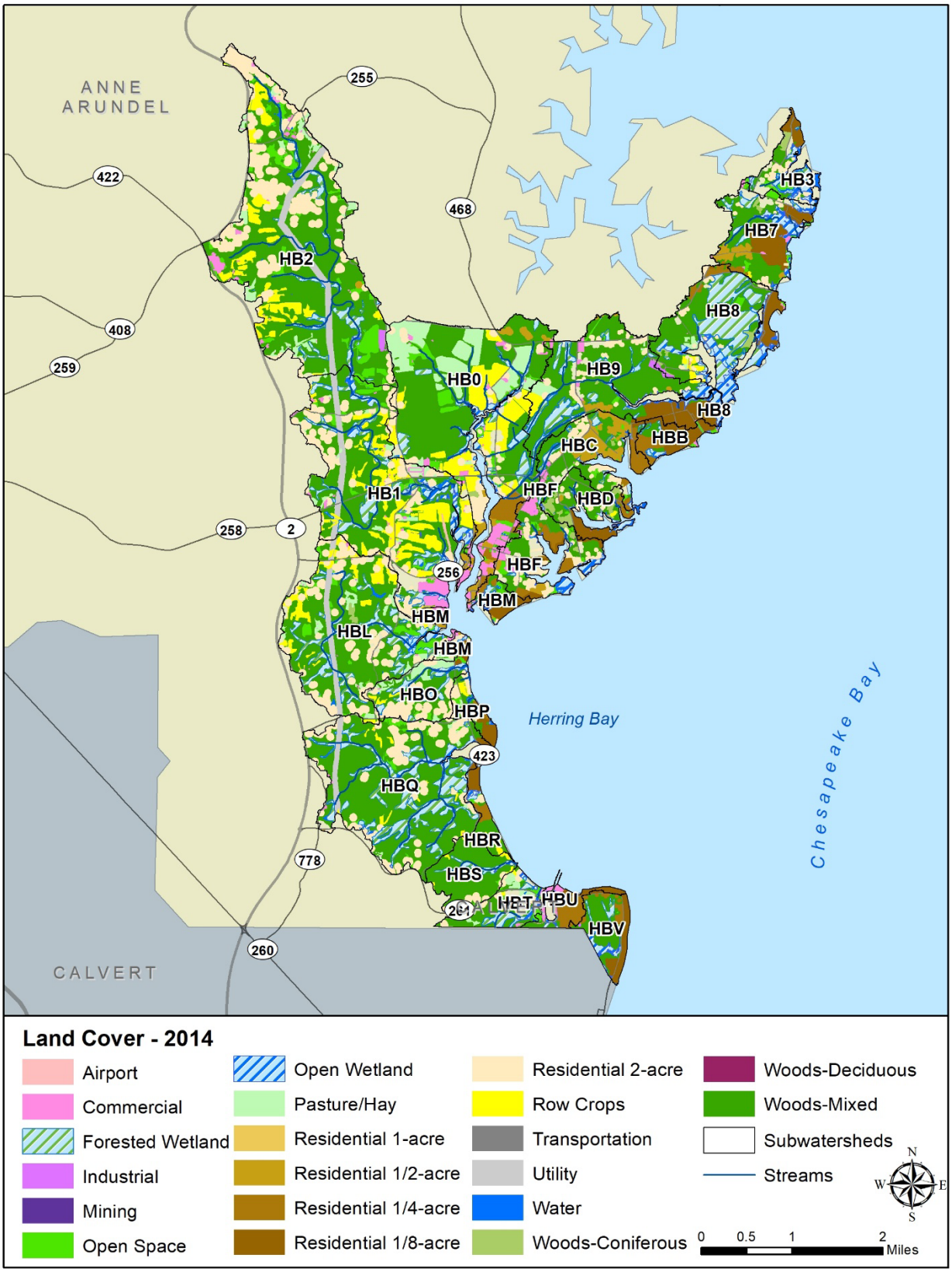



**Figure 4: Other West Chesapeake Watershed Land Cover (2014)**

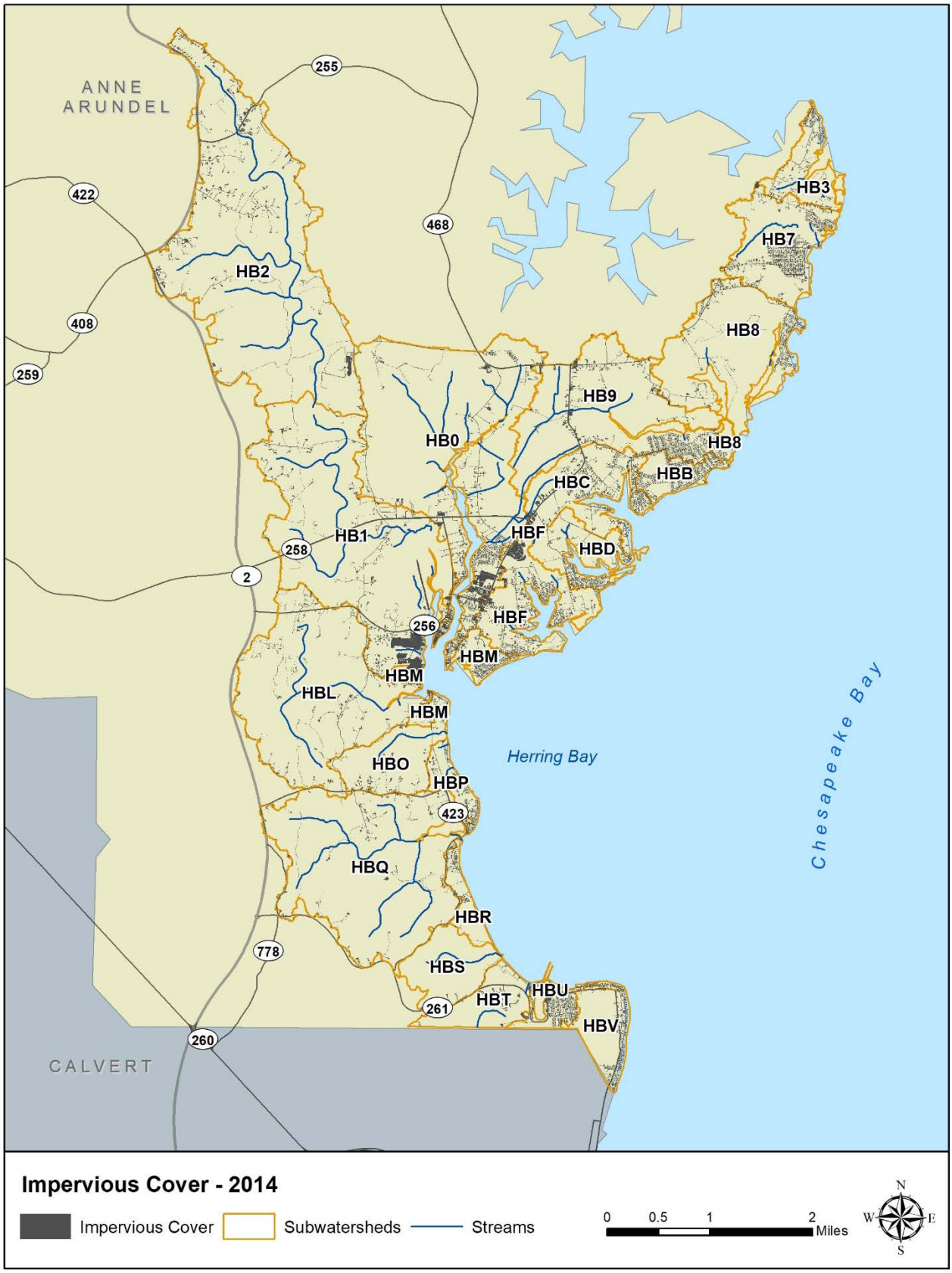



**Figure 5. Other West Chesapeake Watershed Impervious Cover (2014)**

## 2.4 Water Quality

### 2.4.1 Use Designations

According to water quality standards established by MDE in the Code of Maryland Regulations (COMAR) 26.08.02.03-.03 - Water Quality, the Other West Chesapeake watershed contains both Use I and II waters. Use Class I has the following designated uses: growth and propagation of fish (not trout), other aquatic life and wildlife; water contact sports; leisure activities involving direct contact with surface water; fishing; agricultural water supply; and industrial water supply. Use Class II refers to tidal waters and contains all of the designated uses of Use Class I with the addition of: propagation and harvesting of shellfish; seasonal migratory fish spawning and nursery use; seasonal shallow-water submerged aquatic vegetation use; open-water fish and shellfish use; and seasonal deep-channel refuge use.

In general, tidal portions of Other West Chesapeake streams are designated Use II, while non-tidal waters are designated Use I (Table 5).

**Table 5: Use Designations of the Other West Chesapeake Watershed**

| Designated Uses | Use I | Use II |
|---|---|---|
| Growth and propagation of fish (not trout), other aquatic life and wildlife | X | X |
| Water contact sports | X | X |
| Leisure activities involving direct contact with surface water | X | X |
| Fishing | X | X |
| Agricultural water supply | X | X |
| Industrial water supply | X | X |
| Propagation and harvesting of shellfish | - | X |
| Seasonal migratory fish spawning and nursery use | - | X |
| Seasonal shallow-water submerged aquatic vegetation use | - | X |
| Open-water fish and shellfish use | - | X |
| Seasonal deep-water fish and shellfish use | - | X |
| Seasonal deep-channel refuge use | - | X |
| Growth and propagation of trout | - | - |
| Capable of supporting adult trout for a put and take fishery | - | - |
| Public water supply | - | - |

Source: https://mde.maryland.gov/programs/Water/TMDL/WaterQualityStandards/Pages/wqs_designated_uses.aspx

### 2.4.2 303(d) Impairments

According to Maryland's final 2016 and draft 2018 303(d) list of impaired waters (MDE, 2017; MDE, 2018a), several segments within the Other West Chesapeake watershed are listed for water quality impairments.

The Other West Chesapeake watershed contains eight Category 4a listings, which include those waters that are not meeting their use designation but for which a TMDL has been developed to address the impairments. Tracy and Rockhold Creeks are listed for fecal coliform with the source identified as waste from pets.

Category 5 waters for the Other West Chesapeake, which include those waters that are not meeting their use designation and require a TMDL, include the entire watershed for "cause unknown" and 1st through 4th order streams for Total Suspended Solids (TSS).

### 2.4.3 TMDLs

Total Maximum Daily Loads (TMDLs) are established for waterbodies on Maryland's 303(d) integrated list of impaired waterbodies to set pollutant limits to achieve attainment of the designated use. For each combination of waterbody and pollutant, the State must estimate the maximum allowable pollutant load, or TMDL, that the waterbody can receive and still meet water quality standards. TMDLs are required by the Clean Water Act.

Category 4a of the 303(d) list describes impaired waters with a TMDL or other reduction measure in place. Category 5 lists impaired waters in need of a TMDL. The non-tidal Other West Chesapeake Bay watershed was originally listed as impaired by sediment and requiring a TMDL (Category 5) in MDE's 2014 Integrated Report. A TMDL for sediment in the Other West Chesapeake watershed for Anne Arundel and Calvert Counties was approved by EPA on February 9, 2018. The West Chesapeake Bay watershed also has a TMDL for fecal coliform for Tracy and Rockhold Creeks (approved 2006). This Restoration Plan focuses on implementing strategies to address the sediment TMDL which requires a 33% reduction of Anne Arundel County NPDES regulated stormwater point source sediment.

In addition to local TMDLs in the Other West Chesapeake, the County also has responsibilities for the WLAs allocated from the *Chesapeake Bay Total Maximum Daily Loads for Nitrogen, Phosphorus, and Sediment* (USEPA, 2010). The Bay TMDL is a result of requirements under the CWA to meet water quality standards that put a renewed emphasis and focus on the Chesapeake Bay. The County's NPDES MS4 permit requires treatment of 20% of the County's untreated impervious surfaces as the method for meeting the Bay TMDL goals. The local sediment TMDL for the Other West Chesapeake is more geographically specific than the Bay-wide allocated loads assigned in the Bay TMDL. However, all load reductions achieved from implementation efforts described in this plan will help support the County's impervious surface and Bay TMDL efforts.

### 2.4.4 NPDES

Section 402(p) of the Clean Water Act required the EPA to add Municipal Separate Storm Sewer System (MS4) discharges to the NPDES permit program. In 2002, EPA directed permit writers to include WLA requirements in NPDES permits, including those for MS4 discharges. Anne Arundel County holds a Phase I – Large Jurisdiction (greater than 250,000 population) MS4 permit (11-DP-3316, MD0068306) issued by the MDE. The County's first generation permit was issued in 1993. The current fourth generation permit was issued in February of 2014 and expires February of 2019.

***TMDL Permit Requirements***

The objective of this plan is to meet the County's MS4 NPDES permit requirement to develop restoration plans for local TMDLs per permit condition IV.E.2.b. Plans must be developed within one year of EPA approval of TMDL WLAs. The Other West Chesapeake Sediment TMDL was approved February 9, 2018, therefore the restoration plan must be complete by February 9, 2019.

The permit states the County must submit "…a restoration plan for each stormwater Waste Load Allocation (WLA) approved by EPA prior to the effective date of the permit." For each WLA, the County is required to:

PART IV. Standard Permit Conditions
E. Restoration Plans and Total Maximum Daily Loads
2. Restoration Plans
b. Within one year of permit issuance, Anne Arundel County shall submit to MDE for approval a restoration plan for each stormwater WLA approved by EPA prior to the effective date of the permit. The County shall submit restoration plans for subsequent TMDL WLAs within one year of EPA approval. Upon approval by MDE, these restoration plans will be enforceable under this permit. As part of the restoration plans, Anne Arundel County shall:

i. Include the final date for meeting applicable WLAs and a detailed schedule for implementing all structural and nonstructural water quality improvement projects, enhanced stormwater management programs, and alternative stormwater control initiatives necessary for meeting applicable WLAs;
ii. Provide detailed cost estimates for individual projects, programs, controls, and plan implementation;
iii. Evaluate and track the implementation of restoration plans through monitoring or modeling to document the progress toward meeting established benchmarks, deadlines, and stormwater WLAs; and
iv. Develop an ongoing, iterative process that continuously implements structural and nonstructural restoration projects, program enhancements, new and additional programs, and alternative best management practices (BMPs) where EPA approved TMDL stormwater WLAs are not being met according to the benchmarks and deadlines established as part of the County's watershed assessments.

Further, the permit requires continual outreach to the public regarding the development of its watershed assessments and restoration plans and requires public participation in the TMDL process (permit section IV.E.3.a-d).

The permit requires an annual progress report presenting the assessment of the NPDES stormwater program based on the fiscal year. A TMDL assessment report to include complete descriptions of the analytical methodology used to evaluate the effectiveness of the County's restoration plans and how these plans are working to achieve compliance with EPA approved TMDLs is a component of the annual report. The assessment will include: estimated net change in pollutant load reductions from water quality improvement projects; a comparison of the net change to targets, deadlines, and applicable WLAs; cost data for completed projects; cost estimates for planned projects; and a description of a plan for implementing additional actions if targets, deadlines, and WLAs are not being met (permit section IV.E.4.a-e).

***Impervious Surface Permit Requirements***

The County's permit requires implementation of restoration efforts for 20% of the County's impervious surface area that has not already been restored to the maximum extent practicable (MEP) (permit section (IV.E.2.a). Though projects and strategies outlined in this plan will certainly add treatment of impervious surfaces, accounting for impervious treatment is not included in this report.

# 3 Causes and Sources of Impairment (a)

## 3.1 Impairments

Elevated levels of sediment currently impair the Other West Chesapeake watershed as evident through the 303(d) listings and local TMDL requirement. Sediment, both from 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 community) and necessary for some fish species for spawning. Finer clays, silts and sands associated with sediment as a pollutant are more mobile and transient and provide less liveable 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.

## 3.2 Sources

The majority of sediment loads in the Other West Chesapeake watershed originate from urban and agricultural stormwater runoff and in-stream sources related to channel erosion.

### 3.2.1 Stormwater Runoff

The contribution of urban stormwater to sediment loading was analyzed in the Herring Bay, Middle Patuxent, and Lower Patuxent Watershed Assessment (Anne Arundel County, 2018). Figure 6 presents the annual total suspended solids runoff load as the relative quantity of sediment contributed from each subwatershed (i.e., lowest to highest). The water quality model used for the assessment was based on EPA's Simple Method (Schueler, 1987) and PLOAD models (USEPA, 2001) using event mean concentrations (EMCs) for each LULC type. The results presented here are only the sediment associated with runoff, and do not reflect in-stream sources. The most significant contributing urban and agricultural LULC categories with the highest loading rates include row crops, pasture and hay, transportation, and commercial and industrial areas. Residential development, while a lower loading rate, makes up a large portion of the watershed (23.4%) and is therefore also a significant contributor.

Subwatersheds contributing the lowest amount of existing sediment loads include HB3, HB7, HBB, HBC, HBD, HBF, HBM, HBO, HBP, HBR, HBS, HBT, HBU, and HBV. Subwatersheds contributing the highest amount of existing sediment loads include HB0, HB1, and HB2 and to a lesser extent, subwatersheds HBL and HB8. Management measures targeted in subwatersheds with high existing sediment loads will be the priority of this restoration plan to ensure required reductions are achieved and maintained.

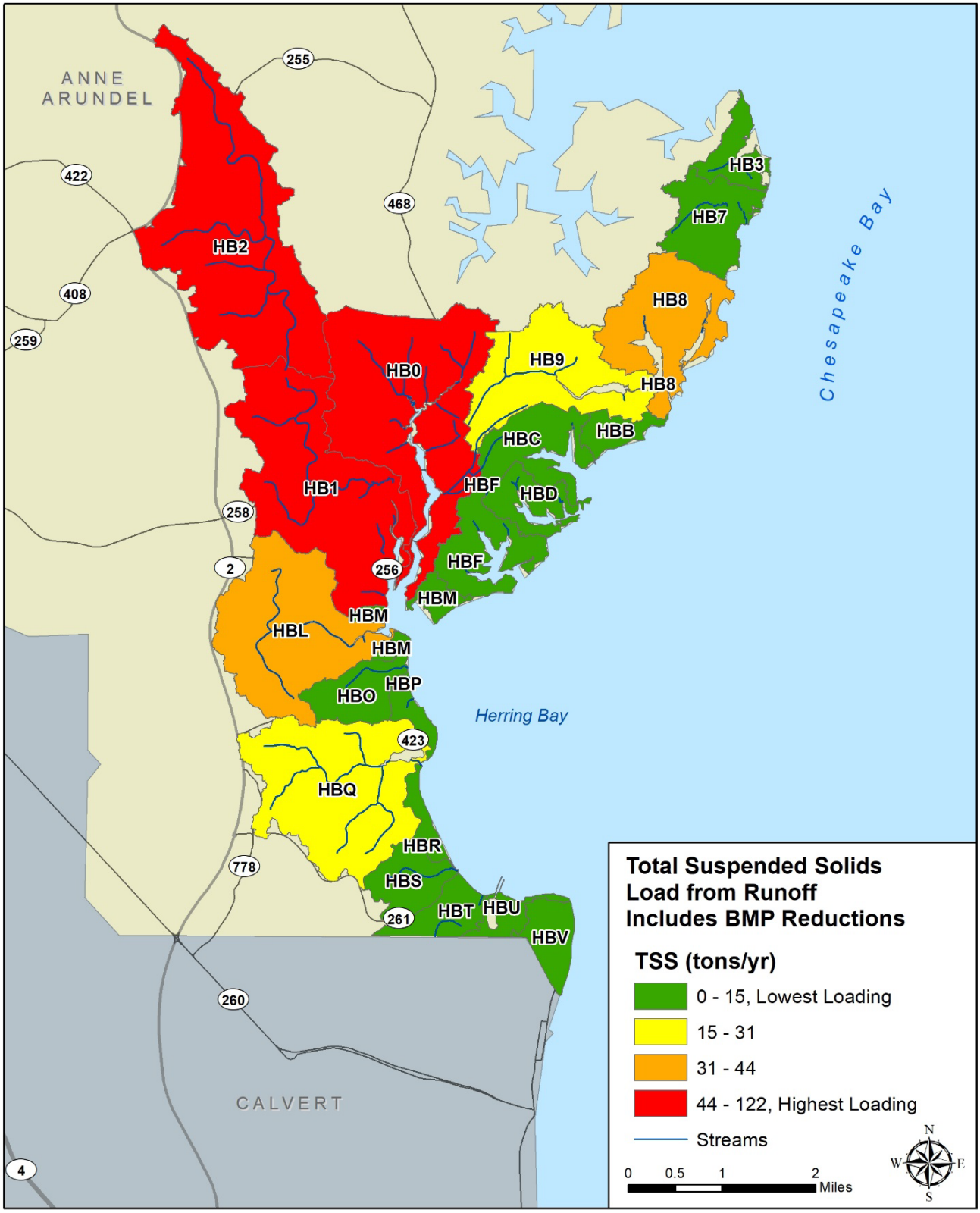



**Figure 6: Total Suspended Solids Load from Runoff Based on Existing Conditions – tons per year. Includes BMP Reductions (Anne Arundel County, 2018)**

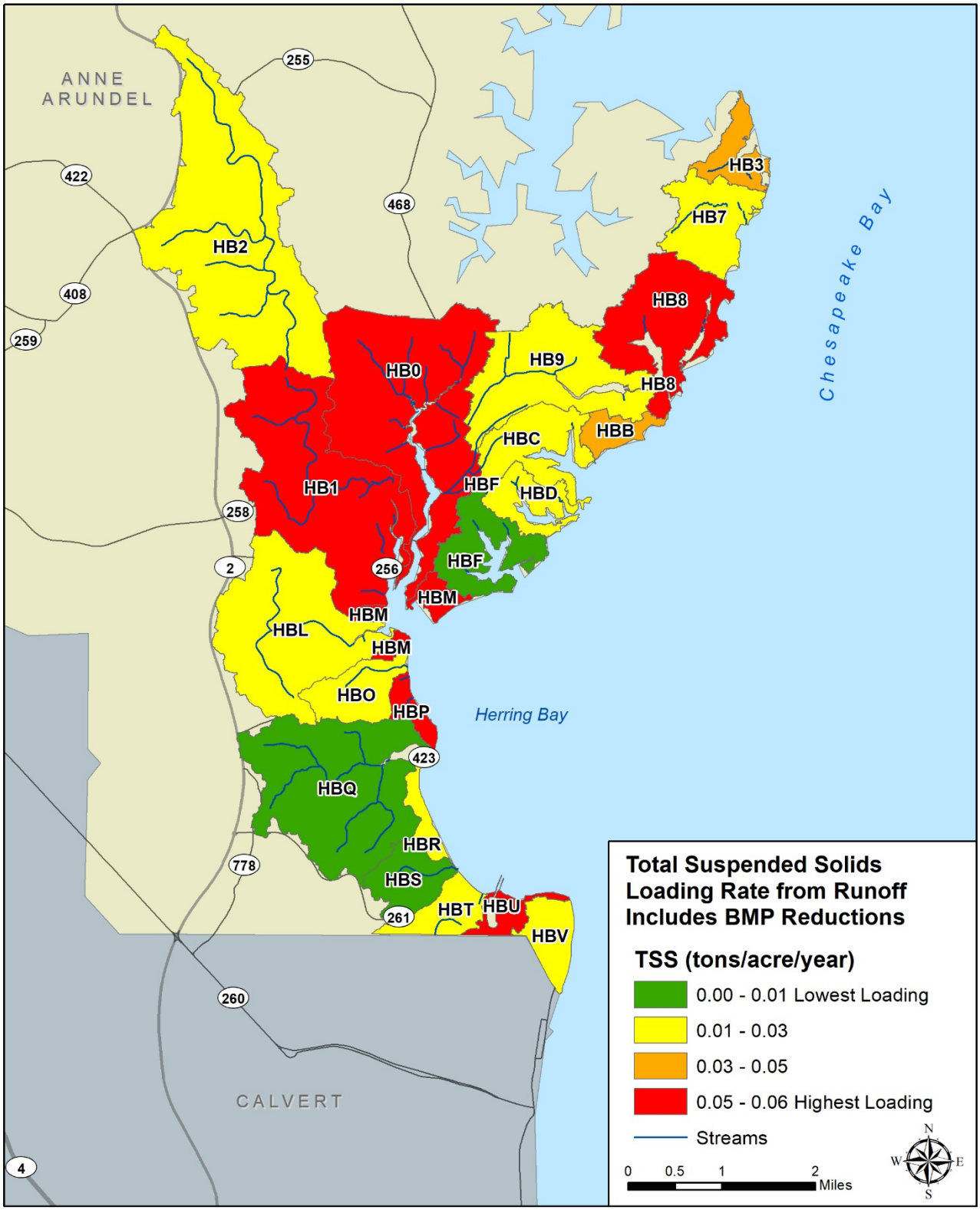



**Figure 7. Total Suspended Solids Loading Rates from Runoff Based on Existing Conditions – tons per acre per year. Includes BMP Reductions (Anne Arundel County, 2018)**

### 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 smothered. Excessive erosion can also threaten the stability of nearby built infrastructure. The Biological Stressor Identification Analysis (BSID; MDE, 2014d for the West Chesapeake Bay watershed has determined that biological communities in this watershed are likely degraded due to sediment and in-stream habitat related stressors, as well as water quality. These stressors often result from altered hydrology and increased runoff from impervious area, 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 total suspended sediment as an impairing substance in this watershed.

Approximately 43 miles of streams were assessed and characterized for the Herring Bay Watershed Assessment (Anne Arundel County, 2018). Collected data 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 5 was considered Moderate impact, a score of 7 was considered Severe, and a score of 10 was considered an Extreme condition. A total of 92 erosion locations impacting approximately 18,345 linear feet of stream reaches were cataloged in the Herring Bay watershed with erosion severity rated as moderate or severe (Table 6 and Table 7). Over three quarters of the erosion sites (77.2%) were located in Tracys Creek (HB2), Trotts Branch (HBL), and an unnamed tributary (HBQ). In addition to stream erosion, a total of 98 headcuts were inventoried, with an average height of 3.5 feet, but reaching as high as 12 feet tall.

**Table 6: Erosion Inventory and Severity per Subwatershed (Anne Arundel County, 2018)**

| Subwatershed and stream miles assessed | | Number of Erosion Impacts by Impact Score | | Total |
|---|---|---|---|---|
| | | Moderate | Severe | |
| HB0 | 6.3 | 7 | 0 | 7 |
| HB1 | 5.9 | 5 | 3 | 8 |
| HB2 | 10.8 | 23 | 9 | 32 |
| HBC | 0.4 | 1 | 0 | 1 |
| HBL | 5.2 | 14 | 5 | 19 |
| HBQ | 6.7 | 12 | 8 | 20 |
| HBS | 2.3 | 2 | 0 | 2 |
| HBT | 1.5 | 2 | 1 | 3 |
| **Total** | | **66** | **26** | **92** |

Gray =<5 sites | Green = 5-10 sites | Yellow = 11-20 sites | Orange = 21-50 sites

**Table 7: Linear Feet of Erosion per Subwatershed (Anne Arundel County, 2018)**

| Subwatershed | Erosion Impacts and Linear Feet | | Total Linear Feet |
|---|---|---|---|
| | Moderate | Severe | |
| HB0 | 2,619 | 0 | 2,619 |
| HB1 | 695 | 693 | 1388 |
| HB2 | 5,884 | 3,266 | 9,150 |
| HBC | 150 | 0 | 150 |
| HBL | 1,423 | 1,053 | 2,476 |
| HBQ | 1,088 | 1,133 | 2,221 |
| HBS | 78 | 0 | 78 |
| HBT | 183 | 80 | 263 |
| **Total** | **12,120** | **6,225** | **18,345** |

An assessment of channel geomorphology utilizing Rosgen Level I geomorphic classifications (Rosgen, 1996) was also administered for each single-threaded, perennial reach throughout the watershed as part of the Herring Bay Watershed Assessment (Anne Arundel County, 2018). 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.

Majority of the assessed perennial stream miles in the Herring Bay watershed were Type C (38.2%) or Type E (37.6%) channels. Type C channels exhibit a well-developed floodplain, higher sinuosity, and susceptibility to de-stabilization when flow regimes are altered. Type E channels are generally stable, low gradient, meandering streams with low width/depth ratios. Type G channels consisted of 16.3% of assessed stream miles, and are unstable, incised "gully" channels with high erosion rates. The remaining 7.8% of stream miles were Type A, B, DA, or F.

## 3.3 Anticipated Growth

Future urban sector growth and the anticipated increase in urban loads that may result are expected to be controlled by two elements: stormwater management to the MEP that is required with new development, and anticipated "Accounting for Growth" policies. This restoration plan is developed to treat the reduction required from the initial baseline year load, calibrated to the current Bay model. Based on coordination with MDE, TMDL restoration planning should focus on the untreated and undertreated areas associated with the urban footprint at the time of the TMDL baseline. Future load and loads potentially added to the urban sector since the baseline year to present, are not accounted for here as they are addressed under other programs.

### 3.3.1 Estimates of Future Growth

As stated in the MDE guidance document General Guidance for Developing a Stormwater Wasteload Allocation (SW-WLA) Implementation Plan, Section 1.h. (MDE, 2014b):

*New urban areas that have been developed since TMDL allocations were set imply loads beyond the original SW-WLA (i.e., additional urban footprint within a watershed). This can confound the process of accounting for load reductions to meet the allocations. MDE is working to develop methods to deal with*

*this issue. However, MDE is also recommending that within the SW-WLA implementation plans, local jurisdictions estimate this potential new urban load as the next step in a longer-term process to address the issue.*

The Anne Arundel County General Development Plan was finalized April 2009 and was adopted in October 2009 (Bill No. 64-09; Anne Arundel County, 2009). The next update of the plan is due by 2019. Anne Arundel County is considered one of the fastest growing counties in the region with 14.6% population growth (427,239 to 489,656 persons) over 1990-2000 compared to 6.9% growth in the Baltimore region and 10.8% growth throughout the State of Maryland (Anne Arundel County, 2009). The population in Anne Arundel County is projected to increase to 564,925 persons by 2025, which is an increase of 15.4% from 2000 data and to 579,137 persons by 2035, an increase of 18.3% from 2000 data.

There are no major cities or towns located in the Other West Chesapeake watershed. The primary developed areas located in Other West Chesapeake watershed are residential properties along the shoreline and roadways including Bay Front Road and Deale Churchton Road. With the majority of the watershed as forested land, additional residential properties may develop as growth occurs throughout the County. Anne Arundel County continues to utilize strategies such as promoting low impact development and implementing stormwater BMPs for water quality treatment. However, increased urban stormwater related loads will inevitably occur as growth continues.

Figure 8 and Figure 9 depict sediment loading by subwatershed based on a future conditions modeling scenario with the implementation of projects funded in the County's Capital Improvement Program (CIP) as recommended in the Herring Bay Watershed Assessment (Anne Arundel County, 2018) and discussed further in Section 4: Management Measures. In general, future sediment loading is projected to be highest in the Rockhold Creek (HB0), Tracys Creek (HB1), Deep Creek (HB8), Chesapeake Bay (HBB), Herring Bay (HBM), and Herrington Harbor (HBU) subwatersheds.

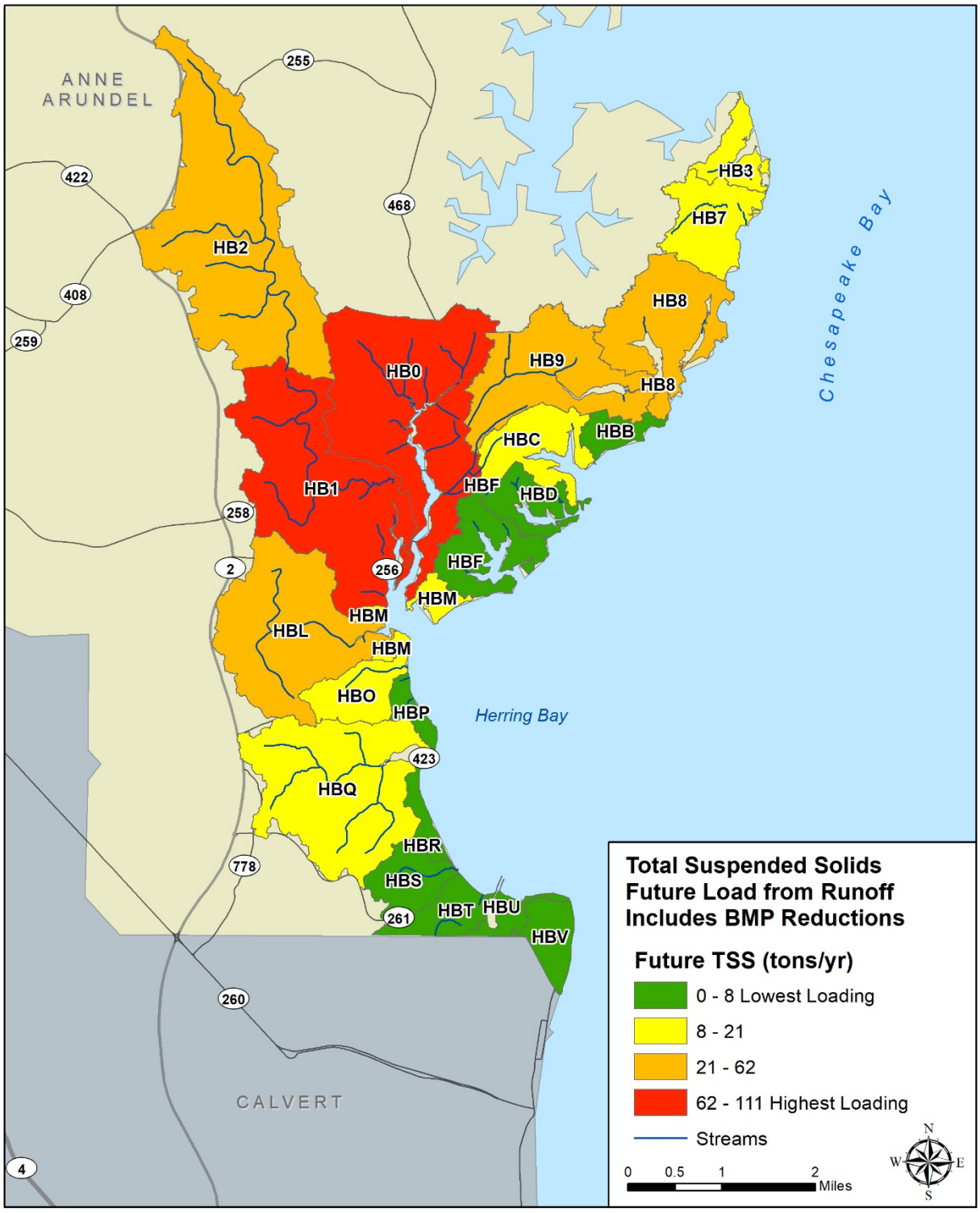



**Figure 8: Total Suspended Solids Loads from Runoff Based on Future Conditions – tons/year - Includes BMP Reductions (Anne Arundel County, 2018)**

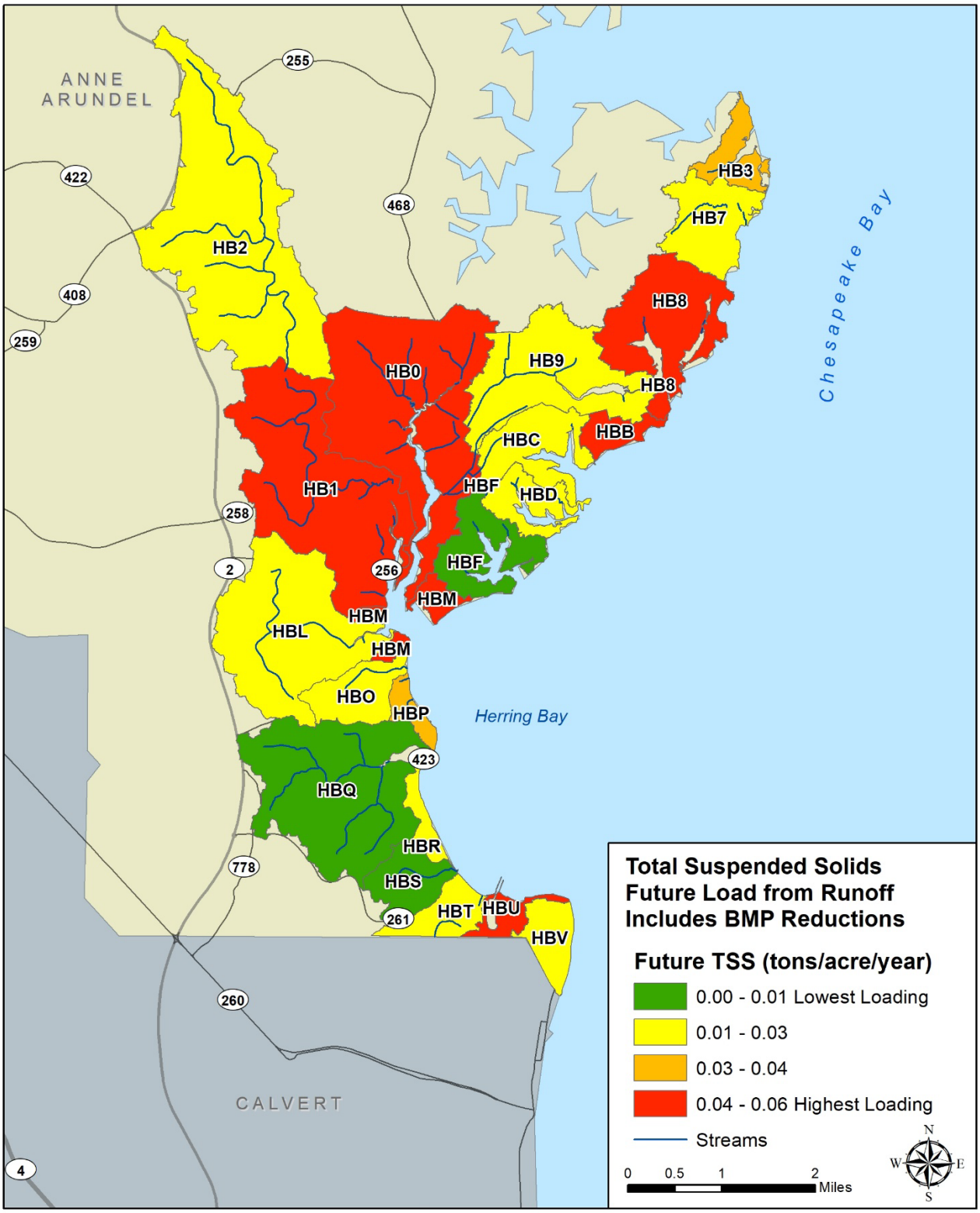



**Figure 9. Total Suspended Solids Loading Rates from Runoff Based on Future Conditions – tons/acre/year - Includes BMP Reductions (Anne Arundel County, 2018)**

### 3.3.2 Offsetting Sediment Loads from Future Growth

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. It is anticipated that new development will make use of environmentally sensitive design (ESD) stormwater treatment according to MDE's Stormwater Regulations.

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* to incorporate criteria specific to the County that are not addressed within the Maryland Design Manual (Anne Arundel County, 2010). 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" policies will address the residual load (TN: 50%, TP: 40%, TSS: 10%, and bacteria: 30%) that is potentially uncontrolled by development-based stormwater controls. As required by the State's Watershed Implementation Plan (Bay Restoration Plan) Maryland is developing an Accounting for Growth (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* (August 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.

# 4 Management Measures (c)

Best management practices (BMPs) are either already implemented or are planned for implementation to achieve and maintain the Other West Chesapeake local TMDL sediment load reductions. This section to describes the types of BMPs and management measures being implemented in the watershed. Load reductions that result from these measures are discussed in the following section, Section 5: Expected Load Reductions.

## 4.1 Modeling Approach

Pollutant load modeling for the Other West Chesapeake watershed was determined using Chesapeake Assessment Scenario Tool (CAST), which calculates pollutant loads and reductions calibrated to the Chesapeake Bay Program Partnership Watershed Model (CBP WM Phase 6). CAST, created by the Chesapeake Bay Program, is a web-based pollutant load estimating tool that streamlines environmental planning. Using CAST, the sediment loads are translated from the values derived by the Bay model version 5.3.2 that was used in the development of the TMDL and calibrated to the Phase 6 model, making them compatible with current methods following MDE recommendations. The 2009 Phase 6 calibrated baseline

load was determined to be 3,895,399 lbs/year. Applying the 33% required reduction results in a reduction goal of 1,285,482 lbs.

Each BMP provides a reduction for nitrogen, phosphorus, and sediment, along with other pollutants. Users select a specific geographical area and then add BMPs to apply to that area. CAST builds the scenario and calculates estimates of nitrogen, phosphorus, and sediment loads. Local TMDL baseline loads were calculated in CAST by modeling MDE 2009 Progress BMPs on top of baseline land use background loads. This ensures that the same set of baseline BMPs are used throughout future progress and planned scenarios.

The Phase 6 Bay model includes the 'stream bed and banks' as a unique load source to account for loads generated within the watershed stream systems. The load source is equivalent to all of the streams in the watershed including those in non-developed land uses including agricultural areas. To calculate the amount of baseline stream bed and bank load allocated to the urban MS4 stormwater sector, the load was disaggregated from the total based on the proportion of total MS4 load source areas in CAST within the Other West Chesapeake watershed. The proportion of MS4 area to the total area is 21.6% as of 2009, the baseline year, therefore 21.6% of the stream bed and bank load were included in the County's SW-WLA baseline.

CAST estimates of load reductions for point and nonpoint sources include: agriculture, urban, forest, and septic loading. Load reductions are not tied to any single BMP, but rather to a suite of BMPs working in concert to treat the loads. CAST calculates reductions from all BMPs as a group, much like a treatment train. Reductions are processed in order, with land use change BMPs first, load reduction BMPs next, and BMPs with individual effectiveness values at the end. The overall amount of load reduction can vary depending on which BMPs are implemented.

Pollutant load reductions from maintenance efforts (e.g., street sweeping and inlet cleaning) are calculated outside of CAST. As discussed in the following section 4.2: Best Management Practices, inlet cleaning and street sweeping will be practiced in the Other West Chesapeake watershed. Sediment reduction credit for vacuum-assisted street sweeping and inlet cleaning is calculated following methods described in MDE (2014a) based on the mass of material removed.

CAST provides loads at two different scales: edge of a small stream (EOS) and delivered to the tidal portion of the Chesapeake Bay (EOT). Delivered loads show reductions based on in-stream processes, such as nutrient uptake by algae or other aquatic life. Local TMDLs are generally modeled at the EOS with a focus on upland and freshwater instream sources without accounting for downstream processes and delivery to tidal and Chesapeake Bay segments. This TMDL plan focuses on reducing loads from upland and headwater sources, therefore EOS estimates are more appropriate and were used for all of the modeling analyses.

This section presents the level of BMP implementation. Section 9 presents information on how progress toward load reductions will be evaluated and management plans adapted on an on-going basis.

## 4.2 Best Management Practices

Many stormwater BMPs address both water quantity and quality, however, some BMPs are more effective at reducing sediment than others. The stormwater practices listed below keep the focus on "green technology" to reduce the impacts of stormwater runoff from impervious surfaces. These BMPs

were selected specifically for three reasons: 1) effectiveness for water quality improvement, 2) willingness among the public to adopt, and 3) implementable in multiple facility types without limitations by zoning or other controls.

These practices are consistent with those currently being implemented by Anne Arundel County DPW as water quality improvement projects. The County has the technical expertise, operational capacity, and system resources in place to site, design, construct and maintain these practices.

The recommended practices are also consistent with those proposed in the County's Phase II WIP for the Chesapeake Bay TMDL and in the County's comprehensive watershed planning efforts. Exceptions to this are dry ponds which include dry detention ponds and dry extended detention ponds. These practices are no longer considered for future implementation; however, there are many existing facilities that are still actively treating runoff throughout the County so they are described here as well. The practices include:

- **Bioretention** — An excavated pit backfilled with engineered media, topsoil, mulch, and vegetation. These are planting areas installed in shallow basins in which the storm water 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. Rain gardens may be engineered to perform as a bioretention.
- **Bioswales** —An open channel conveyance that functions similarly to bioretention. Unlike other open channel designs, there is additional treatment through filter media and infiltration into the soil.
- **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.
- **Dry Extended Detention Ponds** - Depressions created by excavation or berm construction that temporarily store runoff and release it slowly via surface flow or groundwater infiltration following storms. They are similar in construction and function to dry detention basins, except that the duration of detention of stormwater is designed to be longer, allowing additional wet sedimentation to improve treatment effectiveness.
- **Impervious Surface Reduction** - Reducing impervious surfaces to promote infiltration and percolation of runoff storm water. Disconnection of rooftop and non-rooftop runoff, rainwater harvesting (e.g., rain barrels), and sheetflow to conservation areas are examples of impervious surface reduction.
- **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. Dry wells, infiltration basins, infiltration trenches, and landscaped infiltration are all examples of this practice type.
- **Outfall Enhancement with Step Pool Storm Conveyance (SPSC)** – The SPSC is designed to stabilize outfalls and provide water quality treatment through pool, subsurface flow, and vegetative uptake. All County SPSCs are completed at the end of outfalls, prior to discharging to a perennial

stream. The retrofits promote infiltration and reduce stormwater velocities. This strategy is modeled in CAST as bioswales.

- **Shoreline Stabilization –** Shoreline management practices prevent and/or reduce tidal sediment loads to the Bay and can include living shorelines, revetments and/or breakwater systems and bulkheads and seawalls.
- **Stream Restoration -** Stream restoration is used to restore the stream ecosystem by restoring the natural hydrology and landscape of a stream, help improve habitat and water quality conditions in degraded streams.
- **Stormwater Retrofits –** Anne Arundel County plans to construct a variety of retrofits throughout the County. Stormwater retrofits may include converting dry ponds, dry extended detention ponds, or wet extended detention ponds into wet pond structures, wetlands, infiltration basins, or decommissioning the pond entirely to install SPSC (step pool storm conveyance).
- **Urban Filtering** - 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. These systems require yearly inspection and maintenance to receive pollutant reduction credit.
- **Tree Plantings** - Tree planting can occur on pervious areas and/or in riparian buffers, and involves planting trees at a rate that would produce a forest-like condition over time. The intent of the planting is to eventually convert the area to forest. If the trees are planted as part of the urban landscape, with no intention to covert the area to forest, then this would not count as urban tree planting
- **Vegetated Open Channels** - Open channels are practices that convey stormwater runoff and provide treatment as the water is conveyed, includes bioswales. Runoff passes through either vegetation in the channel, subsoil matrix, and/or is infiltrated into the underlying soils.
- **Wet ponds or wetlands** — A water impoundment structure that intercepts stormwater runoff 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. Until 2002 in Maryland, these practices were generally designed to meet water quantity, not water quality objectives. 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.

The measured effectiveness for each of these practices may be found in Table 8.

**Table 8: Typical Sediment Reduction from Stormwater BMPs**

| BMP | Sediment Reduction |
|---|---|
| Bioretention A/B soils, no underdrain | 90% |
| Bioretention C/D soils | 55% |
| Bioswales | 80% |
| Dry Detention Ponds | 10% |
| Dry Extended Detention Ponds | 60% |
| Impervious Surface Reduction* | - |
| Infiltration | 95% |
| SPSC** | 80% |

| BMP | Sediment Reduction |
|---|---|
| Shoreline Stabilization | 164 lbs/linear ft |
| Stream Restoration | 248 lbs/linear ft |
| Urban Filtering | 80% |
| Tree Plantings | 50% |
| Vegetated Open Channels A/B soils | 70% |
| Wet Ponds or Wetlands | 60% |

Sources: Chesapeake Assessment Scenario Tool (CAST) documentation
* Calculated as a land use change to a lower loading land use
**Outfall enhancement with SPSC modeled as bioswales in CAST

Along with the structural BMPs listed above, treatment will also be provided through non-structural measures. These are treatments that rely on programs that continue throughout the year and are repeated annually. The County maintains an extensive database of street sweeping and inlet cleaning locations, along with pounds removed for each area swept or vacuumed. Figure 10 shows street sweeping and inlet cleaning routes in Other West Chesapeake watershed.

- **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, at the rate of 420 lb TSS per ton of wet material (MDE, 2014a).
- **Street sweeping** — Starting Fiscal Year 2015, Anne Arundel County has enhanced their street sweeping program which now includes sweeping curb-miles and parking lots within the Other West Chesapeake (Anne Arundel County DPW, 2015). This enhanced program targets impaired watersheds and curbed streets that contribute trash/litter, sediment, and other pollutants. For full credit by MDE, street sweeping should occur twice a month or 26 times a year on urban streets. This frequent sweeping of the same street will reduce nitrogen and phosphorus as well as sediment. Under the enhanced street sweeping program Anne Arundel County is sweeping arterial, collector, and local streets within the Other West Chesapeake watershed on a bi-weekly basis (26 times a year). Sediment reduction credit is based on the mass of material collected, at the rate of 420 lb TSS per ton of wet material (MDE, 2014a).

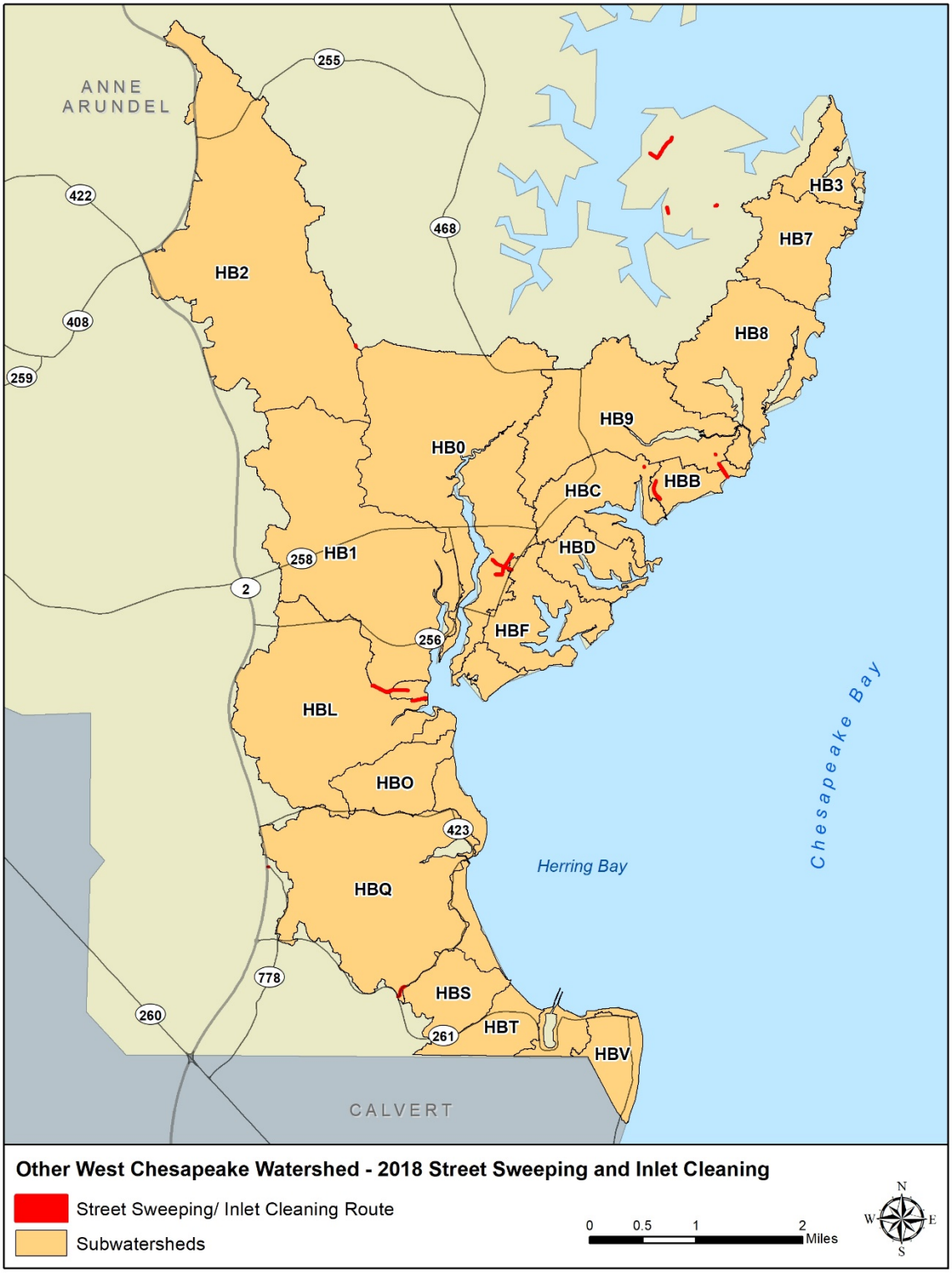



**Figure 10: Street Sweeping and Inlet Cleaning Routes in Other West Chesapeake Watershed**

# 5 Expected Load Reductions (b)

WLAs in the sediment TMDL were developed using the Chesapeake Bay Program Watershed Model Phase 5.3.2 (CBP WM P5.3.2) watershed model. Currently, CAST is using a computational framework that is compatible with an updated version of the model: CBP WM P6. Because the TMDL was developed under an older version of the model, the TMDL WLA needed to be translated into a CAST-compatible target load. In order to do this, the 2009 baseline sediment load was re-calculated in CAST by modeling MDE 2009 Progress BMPs in Other West Chesapeake on top of baseline impervious and pervious Anne Arundel County Phase I MS4 acres. Stream bed and bank loads in CAST were disaggregated to the County's MS4 load sources to derive the stream loads allocated to the County's urban stormwater sector. The required reduction percent assigned to the Anne Arundel County Phase I MS4 source (33%) in the local TMDL was then applied to the new baseline load to calculate required sediment reduction. The required sediment reduction was then subtracted from the new baseline load to calculate the CAST-compatible target TMDL WLA. Sediment loads required for the Other West Chesapeake Anne Arundel County Phase I MS4 source are shown in Table 9.

**Table 9: Sediment Loads Required for the Other West Chesapeake Local TMDL Anne Arundel County Phase I MS4 Source**

| 2009 Baseline Load (lbs/yr) | Required Reduction % | Required Reductions (lbs/yr) | TMDL Load Allocation (lbs/yr) |
|---|---|---|---|
| 3,895,399 | 33.0% | 1,285,482 | 2,609,917 |

## 5.1 2018 Progress – Actual Implementation

Anne Arundel County maintains an extensive geodatabase of stormwater urban BMP facilities and water quality improvement projects (WQIP). Approximately 29 acres of County Phase I MS4 land has been treated by restoration BMPs through 2018 in addition to 1,216 linear feet of shoreline management and the implementation of other non-structural restoration BMPs (source: WPRP urban BMP and WQIP database, 2018). Current BMP implementation through FY2018 in the Other West Chesapeake is shown in Table 10. A list of completed projects is included in Appendix A.

**Table 10: Current BMP Implementation through 2018 for Other West Chesapeake**

| BMP | Unit | 2009 – 2018 Restoration |
|---|---|---|
| Bioretention | acre | 0.0 |
| Bioswale | acre | 0.0 |
| Dry Ponds | acre | 0.0 |
| Extended Detention Dry Ponds | acre | 0.0 |
| Filtering Practices | acre | 0.0 |
| Impervious Surface Reduction | acre | 0.0 |
| Infiltration | acre | 0.0 |
| Inlet Cleaning* | lbs removed | 916 |
| Permeable Pavement | acre | 0.0 |

| BMP | Unit | 2009 – 2018 Restoration |
|---|---|---|
| Shoreline Management | linear feet | 1,216.3 |
| Street Sweeping* | lbs removed | 777 |
| Vegetated Open Channels | acre | 0.0 |
| Wet Ponds or Wetlands | acre | 28.8 |

Source: WPRP urban BMP and WQIP database
*Street Sweeping and Inlet Cleaning are annual practices. Pounds of material removed reported here is the yearly average of FY17 and FY18.

2018 Progress results are shown in Table 11.

**Table 11: 2018 Progress Reductions Achieved**

| Baseline Load and TMDL WLA | TSS-EOS lbs/yr |
|---|---|
| 2009 Baseline Scenario Load | 3,895,399 |
| Required Percent Reduction | 33.0% |
| Required Reduction | 1,285,482 |
| Local TMDL WLA | 2,609,917 |
| **2018 Progress Results** | **TSS-EOS lbs/yr** |
| 2018 Progress Scenario Load | 3,754,604 |
| 2018 Progress Reduction Achieved | 140,795 |
| 2018 Percent Reduction Achieved | 3.6% |

## 5.2 Planned Implementation

Table 12 compares implementation of existing restoration BMPs with planned levels of implementation. This increase in implementation is expected to achieve the loads required in the local TMDL by 2030. Table 13 presents the Planned reduction results. A list of completed and programmed projects is included in Appendix A.

The County's geodatabase lists one planned project in the Other West Chesapeake watershed: Jack Creek Park shoreline stabilization, which includes 1,600 linear feet of shoreline stabilization.

Due to the limited number and extent of currently planned projects, a suite of possible BMPs types was examined to help achieve the required load reduction (Table 12). The Herring Bay Watershed Assessment (Anne Arundel County, 2018) identified priority stream reaches for restoration, as well as prioritized parcels for potential impervious surface removal and tree planting projects. The high priority sites identified in the watershed assessment were selected as potential projects for planning purposes. Planned tree planting sites were assumed to be located within riparian buffers and modeled as such. Riparian sites should be prioritized over upland sites, however all tree planting sites should be considered and credited accordingly.

Inlet cleaning and street sweeping practices are recommended to continue at the current rate within the watershed.

Acreage treated by additional stormwater BMP practices such as bioretention, bioswale, infiltration, SPSC, and wet pond were estimated as necessary to achieve the required load reduction. BMP types with the highest sediment removal efficiencies were prioritized (Table 8).

Figure 11 shows baseline and progress loads (green bars) and planned loads (yellow bars) compared to milestone goal loads (red bars and red line). This comparison shows that the baseline load will be treated to the required TMDL allocated load with current and future BMP implementation.

**Table 12: Restoration BMP Implementation - Current 2018 and Planned 2030 Implementation Levels for the Other West Chesapeake**

| BMP | Units | 2009 - 2018 Restoration | 2019 – 2030 Planned Restoration | Total Restoration |
|---|---|---|---|---|
| Bioretention | acre | 0 | 30 | 30 |
| Bioswale | acre | 0 | 30 | 30 |
| Impervious Surface Reduction | acre | 0 | 5 | 5 |
| Infiltration | acre | 0 | 30 | 30 |
| Inlet Cleaning* | lbs removed | 916 | 916 | 916 |
| SPSC | acre | 0 | 30 | 30 |
| Shoreline Management | linear feet | 1,216 | 800 | 2,016 |
| Street Sweeping* | lbs removed | 777 | 777 | 777 |
| Tree Planting | acre | 0 | 50 | 50 |
| Urban Stream Restoration | linear feet | 0 | 2,000 | 2,000 |
| Wet Ponds or Wetlands | acre | 29 | 30 | 59 |

*Street Sweeping and Inlet Cleaning are annual practices. Pounds of material removed reported here is the yearly average of FY17 and FY18. A similar rate of future implementation is anticipated.

**Table 13: 2030 Planned Reductions**

| Baseline Load and TMDL WLA | TSS-EOS lbs/yr |
|---|---|
| 2009 Baseline Scenario Load | 3,895,399 |
| Required Percent Reduction | 33.0% |
| Required Reduction | 1,285,482 |
| Local TMDL WLA | 2,609,917 |
| **2030 Planned Results** | **TSS-EOS lbs/yr** |
| 2030 Planned Load[1] | 2,540,150 |
| 2030 Planned Reduction Achieved | 1,355,249 |
| 2030 Percent Reduction Achieved | 34.8% |

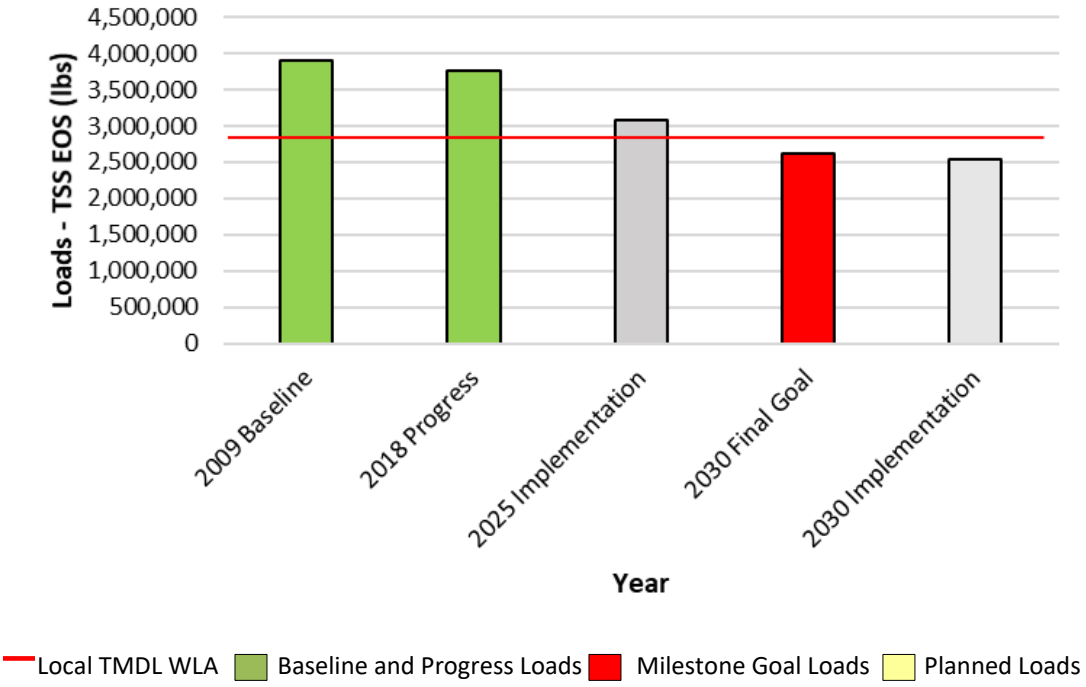



**Figure 11: Progress and Planned Reductions in the Other West Chesapeake Watershed**

# 6 Technical and Financial Assistance Needs (d)

***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 and will provide technical assistance to local governments through training, outreach and tools, including 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).

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 geographic information system (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 best management practices

within local communities. The Watershed Stewards Academy, further discussed in Section 7: Public Participation/Education, routinely engages and informs the public on reducing pollution sources and employing stormwater/rainscaping retrofits to reduce their impacts.

Technical assistance for Public Participation and Education and for Monitoring will also be 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.

***Financial Needs***

The total projected cost to implement the County's CIP projects described in this plan for the Other West Chesapeake watershed is approximately $7,743,835. Table 14 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/administrative costs. The costs are presented based on restoration planning periods out to FY2030. The total cost of the suite of BMPs necessary to meet the TMDL was calculated and then divided proportionally across the milestone periods.

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 cost of stream and shoreline restoration, wet pond, SPSC, and infiltration projects. King and Hagan (2011) was referenced to calculate tree planting, bioswale, and impervious surface reduction due to the lack of data in the County's database.

Non-structural BMP costs for inlet cleaning and street sweeping are based on implementation cost records in the County's geodatabase. Operating costs do not include the purchase and maintenance of street sweeping equipment. Annual costs for street sweeping and inlet cleaning reflect continuation of the current rate of implementation of these practices. The annual costs were extrapolated out for the number of years in each planning period in the table below.

**Table 14: Other West Chesapeake Cost Over Milestone Periods**

| Project type | FY2020+ FY2021 Planned | FY2022+ FY2023 Planned | FY2024+ FY2025 Planned | FY2026- FY2030 Planned | Total Cost |
|---|---|---|---|---|---|
| Bioretention | $99,750 | $99,750 | $99,750 | $299,250 | $598,500 |
| Bioswale | $88,000 | $88,000 | $88,000 | $264,000 | $528,000 |
| Impervious Surface Reduction | $121,875 | $121,875 | $121,875 | $365,625 | $731,250 |
| Infiltration | $112,586 | $112,586 | $112,586 | $337,758 | $675,516 |
| Inlet Cleaning | $8,470 | $8,470 | $8,470 | $21,174 | $46,584 |
| SPSC | $165,740 | $165,740 | $165,740 | $497,220 | $994,440 |
| Shoreline Management | $193,333 | $193,333 | $193,333 | $580,000 | $1,160,000 |
| Street Sweeping | $596 | $596 | $596 | $1,489 | $3,276 |
| Tree Planting | $91,667 | $91,667 | $91,667 | $275,000 | $550,000 |
| Urban Stream Restoration | $307,667 | $307,667 | $307,667 | $923,000 | $1,846,000 |
| Wet Ponds or Wetlands | $101,712 | $101,712 | $101,712 | $305,135 | $610,269 |
| | | | | **Grand Total** | **$7,743,835** |

## 6.1 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 forthcoming 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 (Stormwater Management – Watershed Protection and Restoration Program). 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, 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 financial assurance plan was adopted by County Council on July 5, 2016. The most recent update to the County's financial assurance plan will be submitted with their annual NPDES report in February 2019.

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, 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, 2012), 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 (e)

## 7.1 County Outreach Efforts

Anne Arundel County gave numerous public presentations throughout the development of the County's Phase II WIP 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. Anne Arundel County has a variety of organizations interested in water quality, including Severn River Association; South River Federation; 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 (Anne Arundel County, 2012).

More recently, the County held two public meetings associated with the development of the Herring Bay, Middle Patuxent, and Lower Patuxent Watershed Assessment. The first public meeting was held prior to initiation of fieldwork on September 27, 2016 and presented the goals and methods of the study. The second meeting was held on April 24, 2018 and included presentations of the results of the completed study element. Both meetings solicited feedback from the public. Questions and answer sessions followed each of the presentations. The County solicited public review and comment of the draft watershed assessment report through the April 24, 2018 public meeting and a 30-day public review period, which ran from May 26 through June 26, 2018. The documents for review were available on the County's website. The final Herring Bay, Middle Patuxent and Lower Patuxent Watershed Assessment Report is posted on the County's website at: https://www.aacounty.org/departments/public-works/wprp/watershed-assessment-and-planning/watershed-studies.

The Advocates for Herring Bay (AHB) is a local group of citizens working to preserve the Herring Bay watershed and foster collaboration among the community. They monitor water quality, identify and work to protect habitats, conduct community cleanup and invasive removal, and advocate for policies to protect Herring Bay. The County engaged with AHB during preparation of the watershed assessment and specifically at the public meetings. Anne Arundel County is actively working with AHB on land protection and preservation strategies in the watershed.

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. The Anne Arundel Watershed Stewards Academy (AAWSA), a pre-eminent 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 (Anne Arundel County, 2012). 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 its role in preservation, conservation and advocacy. There are currently more than 200 certified Master Watershed Stewards throughout Anne Arundel County and adjacent areas.

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

These programs and others like them could be more focused on the Other West Chesapeake watershed.

In addition to the AAWSA, the following organizations have been identified for possible partnerships and education and outreach for the Other West Chesapeake:

- Master Gardeners
- Audubon Society
- Students for the Environment
- Maryland civic associations and service clubs:
  - Maryland Home Builders Assoc.
  - Audubon Naturalist Society of the Central Atlantic States
  - Audubon Society of Central Maryland
  - Blue Water Baltimore
  - Chesapeake Audubon Society
  - Chesapeake Bay Program
  - Chesapeake Bay Foundation
  - Chesapeake Bay Trust
  - Chesapeake Ecology Center
  - Center for Watershed Protection
  - Alliance for the Chesapeake Bay
  - Alliance for Sustainable Communities

- Baywise Master Gardeners
- Sierra Club – Maryland Chapter
- Magothy River Association
- Patuxent Riverkeeper
- West/Rhode Riverkeeper
- Nature Conservancy
- Smithsonian Environmental Research Center
- Anne Arundel Community College
- University of Maryland
- University of Maryland Extension
- Volunteer Center for Anne Arundel County

WPRP 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 display 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 restoration plans.

## 7.2 Public Comment Period

Part 4.E.3 of the County's NPDES MS4 permit outlines requirements for public involvement in the development of TMDL restoration plans. The County fulfills these requirements by providing notice in *The Capital* and *Maryland Gazette* newspapers, which serve 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 WPRP website at www.aarivers.org and makes copies of the restoration plan 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 and Milestones (f & g)

This section presents the target loads and the activities required to achieve those targets based on 2021, 2023, and 2025 interim and 2030 final loads and implementation targets.

## 8.1 Loading Allocations and Milestone Targets

Planning loads for 2025 and final planning loads for 2030 for the Other West Chesapeake watershed are presented in Table 15 below. As mentioned in Section 5: Expected Load Reductions (b) (see Tables 10 and 11), progress is already underway with the implementation of strategies throughout the watershed. The 2030 Planned Load is less than the TMDL Allocated load.

**Table 15: Other West Chesapeake Planning and Target Loads (EOS)**

| Load | Sediment Load (lbs/year) |
|---|---|
| 2009 Baseline Load | 3,895,399 |
| 2018 Progress Load | 3,754,604 |
| 2021 Progress Load | 3,529,242 |
| 2023 Progress Load | 3,303,880 |
| 2025 Planned Load | 3,078,518 |
| 2030 Planned Load | 2,540,150 |
| 2030 TMDL Allocated Load | 2,609,917 |
| Percent Reduction between 2009 Baseline and 2030 Loads | 34.8% |

## 8.2 Implementation Milestones

To meet the loading allocations and milestones outlined in the previous section, implementation of programs and BMPs must keep pace and meet planned implementation targets. Table 16 details the implementation for each tracked BMP with the associated unit of measure. The 2018 data reflects existing BMPs while the 2025 and 2030 values reflect the planned implementation for those years. A list of completed and programmed projects is included in Appendix A.

The 2030 planned management strategies incorporate CIP stormwater retrofits, stream restoration, shoreline management, and outfall enhancement projects, as well as street sweeping and inlet cleaning annual practices. 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.

**Table 16: Other West Chesapeake Planning Milestones for Implementation**

| BMP | Unit | FY2018 Restora-tion | FY2020+ FY2021 Planned | FY2022+ FY2023 Planned | FY2024+ FY2025 Planned | FY2026-FY2030 Planned | Total Implemen-tation |
|---|---|---|---|---|---|---|---|
| Bioretention | acre | 0 | 5 | 5 | 5 | 15 | 30 |
| Bioswale | acre | 0 | 5 | 5 | 5 | 15 | 30 |
| Impervious Surface Reduction | acre | 0 | 1 | 1 | 1 | 2 | 5 |
| Infiltration | acre | 0 | 5 | 5 | 5 | 15 | 30 |
| Inlet Cleaning* | lbs removed | 916 | 916 | 916 | 916 | 916 | n/a |
| SPSC | acre | 0 | 5 | 5 | 5 | 15 | 30 |
| Shoreline Management | linear feet | 1,216 | 133 | 133 | 134 | 400 | 800 |
| Street Sweeping* | lbs removed | 777 | 777 | 777 | 777 | 777 | n/a |
| Tree Planting | acre | 0 | 8 | 8 | 9 | 25 | 50 |
| Urban Stream Restoration | linear feet | 0 | 333 | 333 | 334 | 1000 | 2,000 |
| Wet Ponds or Wetlands | acre | 29 | 5 | 5 | 5 | 15 | 30 |

*Street Sweeping and Inlet Cleaning are annual practices. Pounds of material removed reported here are representative of only one year within each milestone period.

## 8.3 Implementation Priorities

To meet the loading allocations and milestones outlined in the previous sections, implementation will be planned based on prioritization analyses presented in the Herring Bay Watershed Assessment (Anne Arundel County, 2018). Herring Bay subwatersheds 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 (GIS data), 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, parcel scale, and 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 (subwatershed and parcel scale) for high quality sensitive areas that could be subject to additional stressors in future scenarios. For the purpose of this Restoration 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.

The suite of stream restoration indicators used in the Herring Bay watershed, along with the indicator weight is presented in Table 17.

**Table 17: Stream Restoration Assessment Indicators (Anne Arundel County, 2018)**

| Category | Indicator | Weight |
|---|---|---|
| Stream Habitat | Maryland Physical Habitat Index (MPHI) score | 31.6% |
| Stream Morphology | Rosgen Level I classifications | 5.3% |
| Land Cover | Percent Imperviousness | 5.3% |
| Infrastructure | Riparian Buffer impacts | 5.3% |
| | Channel erosion impacts | 10.5% |
| | Head cut impacts | 5.3% |
| | Dump site impacts | 5.3% |
| | Other infrastructure impacts (pipes, ditches, crossings, and obstructions) | 15.8% |
| Hydrology and Hydraulics | Road Crossing flooding potential | 15.8% |

A total of 124 reaches were processed in the stream restoration model. Thirteen reaches were rated as "High" priorities for restoration, 37 reaches were rated as "Medium High". The remaining 74 reaches were rated as "Medium" or "Low" (44 and 30, respectively; Table 18 and Figure 12). The Tracys Creek subwatershed (HB2) ranked as a very high priority overall, as six of the thirteen "High" reaches and 43% of "Medium High" reaches are located in Tracys Creek. The Trotts Branch (HBL) and Unnamed Tributary (HBQ) subwatersheds had a combined total of 14 reaches (38%) rated in the "Medium High" category.

**Table 18: Stream Restoration Assessment Results (Anne Arundel County, 2018)**

| | Number of Reaches with Priority Rating | | | |
|---|---|---|---|---|
| Subwatershed | High | Medium High | Medium | Low |
| HB0 | 2 | 1 | 1 | 1 |
| HB1 | 0 | 3 | 8 | 2 |
| HB2 | 6 | 16 | 12 | 9 |
| HBF | 2 | 3 | 1 | 0 |
| HBL | 1 | 8 | 8 | 9 |
| HBQ | 2 | 6 | 10 | 5 |
| HBR | 0 | 0 | 1 | 0 |
| HBS | 0 | 0 | 1 | 3 |
| HBT | 0 | 0 | 2 | 1 |
| **Total** | **13** | **37** | **44** | **30** |

### 8.3.2 Subwatershed Restoration

Similar to the stream restoration assessment, the subwatershed assessment used a collection of restoration indicators to assign a rating to each subwatershed. The indicators were weighted and combined into a single restoration rating for each subwatershed. Restoration indicators fell into one of six categories: stream ecology, TMDL impairments, On-site Disposal Systems (OSDS), BMPs, Hydrologic and Hydraulic (H&H) Modeling, Water Quality, and Landscape. Each category contains one to four different indicators. Table 19 provides a summary of the categories, indicators, and relative weighting assigned by the County.

**Table 19: Subwatershed Priority Rating Indicators for Restoration (Anne Arundel County, 2018)**

| Category | Indicator | Weight |
|---|---|---|
| Stream Ecology | Final habitat score | 8.1% |
| | Bioassessment score | 8.1% |
| 303(d) List | Number of TMDL impairments | 8.1% |
| Septics | Total nitrogen load from septics (lbs) | 2.0% |
| BMPs | Impervious area treated by BMPs (%) | 6.4% |
| H&H (Land and Soils only) | Peak flow from 1-year storm (cfs/acre) | 4.4% |
| | Peak flow from 2-year storm (cfs/acre) | 4.4% |
| | Runoff volume from 1-year storm (inches/acre) | 5.6% |
| | Runoff volume from 2-year storm (inches/acre) | 5.6% |
| Water Quality (land only) Landscape | Nitrogen load from runoff (lbs/acre/yr) | 6.7% |
| | Phosphorus load from runoff (lbs/acre/yr) | 6.7% |
| | Impervious cover (%) | 9.3% |
| Landscape Stream Ecology | Forest within the 100 ft stream buffer (%) | 10.1% |
| | % of existing wetlands to potential wetlands | 9.3% |
| | Acres of developable critical area | 5.2% |
| | Final habitat score | 8.1% |

The final ratings range from “Lowest Priority for Restoration” to “Highest Priority for Restoration” where “Lowest Priority” indicates that a subwatershed is a low priority for restoration and therefore in good condition whereas “Highest Priority” indicates that a subwatershed should be a priority for restoration. Subwatersheds HB0, HB7, HBB, HBC, HBF, HBM, and HBU were rated the highest priority for restoration. Five watersheds, HB2, HBL, HBQ, HBR, and HBS, were rated the lowest priorities for restoration (Figure 13). It is also important to focus restoration efforts in subwatershed that ranked highest for existing TSS loads from runoff, which include subwatersheds HB0, HB1, and HB2 (Figure 6 and Figure 7).

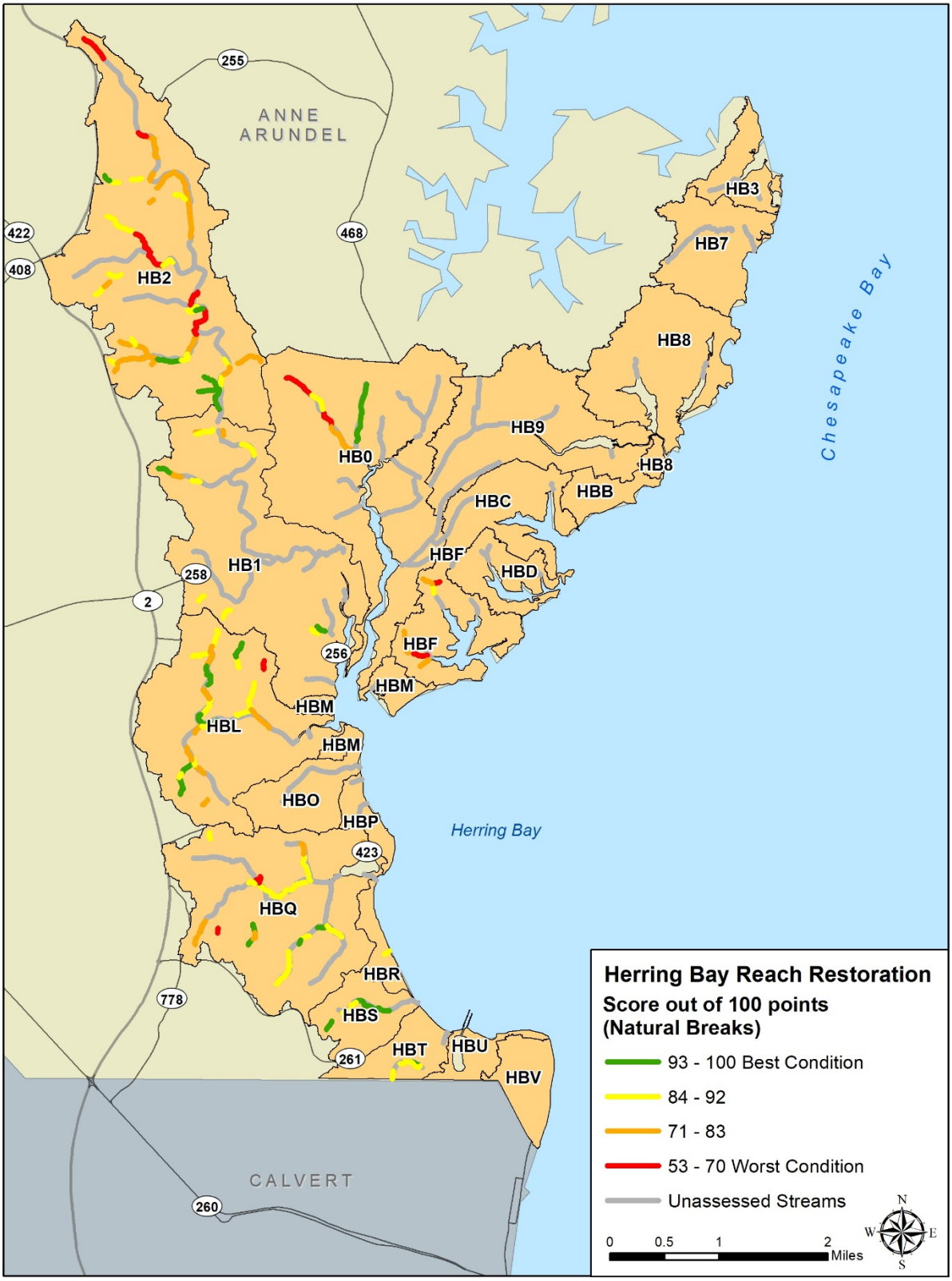



**Figure 12: Stream Restoration Assessment Results (Anne Arundel County, 2018)**

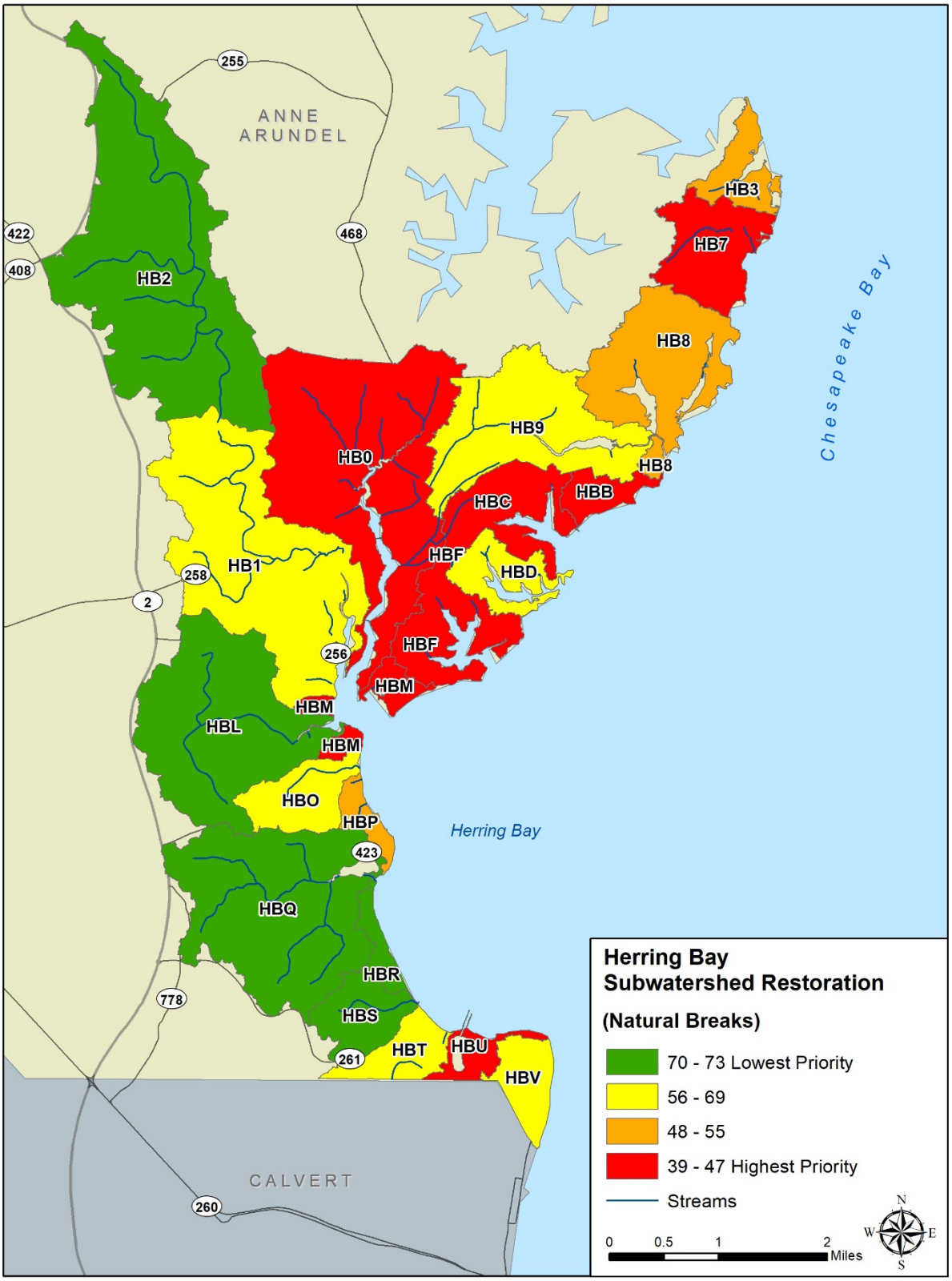



**Figure 13: Subwatershed Restoration Assessment Results (Anne Arundel County, 2018)**

# 9 Load Reduction Evaluation Criteria (h)

Adaptive management is a critical component of achieving the WLAs required by the Other West Chesapeake TMDL. As presented in section 8 of this plan the County has established implementation and load reduction targets at specific intervals between current progress and the 2030 end date to provide interim planning targets and to serve as a vehicle for assessing progress toward the load reduction targets. The interim milestone dates are 2021, 2023, and 2025.

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 annual report.

## 9.1 Tracking Implementation of Management Measures

Implementation will be measured by determining whether the targets for implementation shown in Table 16 are maintained according to the milestone schedule presented. 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. WPRP 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, who are responsible for maintenance efforts (i.e., street sweeping and inlet cleaning), report back to WPRP. The County is also capturing and tracking projects implemented by the AAWSA through the WPRP-Chesapeake Bay Trust Restoration Grant Program.

***Two-Year Milestone Reporting***

As a part of the federal Chesapeake Bay Accountability Framework, the County is required to report two-year milestones, representing near-term commitments and progress to MDE, towards achieving load reduction goals for the Bay TMDL. These efforts will also support local TMDL planning and tracking at the County level.

Milestones were previously reported in two forms: Programmatic and BMP Implementation. Programmatic milestones identify the anticipated establishment or enhancement of the institutional means that support and enable implementation. Examples of Programmatic milestones include projected funding, enhancement of existing programs and resources, and the establishment of new programs and studies. The milestone period for Programmatic covers two calendar years – for example, the period for 2018 -2019 is from January 1, 2018 through December 31, 2019. Following the development of MDE's NPDES MS4 geodatabase as a reporting vehicle for BMP Implementation, 2-Year BMP Implementation milestone reports are no longer required to be submitted.

***Annual NPDES Reporting***

As a requirement of the NPDES permit described in Section 2.4.4, the County must submit on or before the anniversary date of the current permit a progress report demonstrating implementation of the NPDES stormwater program based on the fiscal year. If the County's annual report does not demonstrate compliance with their permit and show progress toward meeting WLAs, the County must implement BMP and program modifications within 12 months.

The 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. Source Identification
   **ii. Stormwater Management**
   iii. Erosion and Sediment Control
   iv. Illicit Discharge Detection and Elimination
   v. Litter and Floatables
   vi. Property Management and Maintenance
   vii. Public Education
   viii. Watershed Assessment
   **ix. Restoration Plans**
   **x. TMDL Compliance**
   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**

g. The County is required to complete a database containing the following information:
   i. Storm drain system mapping
   **ii. Urban BMP locations**
   iii. Impervious surfaces
   **iv. Water quality improvement project locations**
   **v. Monitoring site locations**
   **vi. Chemical monitoring results**
   **vii. Pollutant load reductions**
   **viii. Biological and habitat monitoring**
   ix. Illicit discharge detection and elimination activities
   x. Erosion and sediment control, and **stormwater program information**
   xi. Grading permit information
   xii. Fiscal analyses – cost of NPDES related implementation

Elements of the database, following MDE's, current schema (version 1.2, May 2017) include feature classes and associated tables that store and report to MDE the County's restoration projects. MDE and the Bay Program use the data for larger scale 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.)

***Annual Assessment Report***

Anne Arundel County produces an annual progress assessment report for each County TMDL that has a completed and final 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 levels 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 annual progress assessment reports are submitted to MDE with the County's annual NPDES report in February of each year.

***Financial Assurance Plan Reporting***

The County's Financial Assurance Plan (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 which will reduce pollutants of concern and make measureable progress towards improving water quality. Anne Arundel County's first FAP was submitted to MDE in July of 2016, and an updated version will be submitted in February of 2019.

## 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 'Annual Assessment Reports' as described above and in the County's NPDES annual report. Modeled baseline and current loads are reported in the NPDES geodatabase following MDE's schema in the 'LocalStormwaterWatershedAssessment' table. The progress assessments contribute to constant 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 Other West Chesapeake using CAST to maintain consistency with the model framework used to develop the 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: Monitoring. TMDL compliance status will be evaluated to determine if the Restoration 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.

**Background**

Both the State and County SWM Codes require maintenance inspections be performed on all SWM practices during the first year of operation and every 3 years thereafter. The first year of operation inspections are performed by the Environmental Control Inspectors before Certificates of Completion is issued for the grading permits under which the practices were constructed. The 3-year maintenance inspections are the responsibility of the WPRP inspection staff.

**Phase 1 Inspection and Enforcement**

Phase 1 reflects the first time a SWM practice receives a 3-year maintenance inspection and maintenance is required. Using the proper Maintenance Inspection Checklists the Inspector performs the required 3-year maintenance inspection indicating on the Checklist boxes if maintenance 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 be used to complete a Phase 1 Correction Notice issued in the field or mailed to the property owner. The Phase 1 Correction Notices are prepared using the I&P standard computerized inspection report software, contain a detailed description of the maintenance required and the compliance date by which the required maintenance is to be completed. If necessary Phase 1 Correction Notices can be completed by hand using the standard Environmental Programs Inspection Report Form. Phase 1 Correction Notices contain the proper contact information, are written in a clear and concise fashion with no speculation, editorial comments or superfluous information. The Urban BMP geodatabase is updated to document when a 3-year Maintenance Inspection is performed. For monthly reporting purposes, all re-inspections are recorded as inspections and not as facilities inspected or as new correction notices issued. Depending on the degree of maintenance required, a Compliance Schedule may be appropriate. All proposed Compliance Schedules must be authorized by the WPRP Supervisor.

**Phase 2 Inspection and Enforcement**

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

**Phase 3 Inspection and Enforcement**

Phase 3 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 is prepared by the Environmental Code Administrator using the records associated with the violation.

# 10 Monitoring (i)

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. The Other West Chesapeake was originally listed for sediments in 1996 as a suspended sediment 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% 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 Other West Chesapeake watershed was listed for biological community impairment in 2002.

MDE then utilized its Biological Stressor Identification (BSID) process to identify the probable or most likely causes of poor biological conditions. For sediment specifically, the BSID identified 'altered habitat, and increased runoff from residential and historical agricultural landscapes have resulted in changes to stream geomorphology and subsequent elevated suspended sediment in the watershed'. Overall, the results indicated flow/sediment and in-stream habitat related stressors 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 for total suspended solids (TSS). The 2014 final and 2018 draft integrated reports lists 'Habitat Evaluation' as the indicator, and 'Anthropogenic Land Use Changes' as the source. It is noted that the *Decision Methodology for Solids for the April 2002 Water Quality Inventory (updated in February of 2012)*[1], 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 Nephelometer 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 Use 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 Use I streams (the protection of aquatic life and growth and propagation of fish (other than trout) and other aquatic life).

With these two sediment impairments in mind the Other West Chesapeake, which is listed as impaired for TSS, would seem to be a water clarity issue; however the methodology used for listing (biological and habitat measures related sediment deposition) seems to point to an in-stream sediment deposition problem. In all likelihood both types of impairment, water clarity and sedimentation, are factors and both should be incorporated into monitoring programs to track changes in the watershed condition over time.

[1] http://www.mde.state.md.us/programs/Water/TMDL/Integrated303dReports/Documents/Assessment_Methodologies/AM_Solids_2012.pdf

Anne Arundel County's Watershed Protection and Restoration Program (WPRP) has several on-going monitoring programs that target measures of water clarity and sedimentation. These programs are described here.

***Countywide Biological Monitoring***

In 2004, a Countywide Biological Monitoring and Assessment Program for Anne Arundel County, Maryland 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 5-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 will be completed in 2021, added fish sampling, water quality grab samples, and expanded the number of sites to 400 over the 5-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

The Other West Chesapeake watershed is made up of one PSU – Herring Bay. Ten sampling sites were sampled in each PSU in each round of sampling. Methodologies follow those used by MBSS for the biological sampling and 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.

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
- Biological Measures
    - Benthic macroinvertebrates (benthic index of biotic integrity - BIBI)
    - Fish (fish index of biotic integrity - FIBI)
- Habitat Measures
    - General: bar formation and substrate, presence/absence of substrate type
    - PHI: epibenthic substrate, instream habitat
    - RBP: epifaunal substrate / available cover, pool substrate characterization, sediment deposition, channel alteration

- Geomorphic Measures
    - Particle size analysis using modified Wolman pebble counts at 10 transects proportioned by channel bed features

Results summarized at the PSU scale with mean BIBI and habitat ratings (PHI and RBP) are presented in Table 20. The Herring Bay PSU will be sampled for Round 3 in Year 5, 2021.

**Table 20: Countywide Biological Monitoring Results for Herring Bay**

| PSU Name | Round | PSU Code | Year Sampled | Drainage Area (acres) | BIBI Rating | PHI Rating | RBP Rating |
|---|---|---|---|---|---|---|---|
| Herring Bay | 1 | 15 | 2005 | 14,595 | P | D | PS |
| Herring Bay | 2 | 15 | 2010 | 14,595 | F | PD | PS |

BIBI Ratings: G = Good, F = Fair, P = Poor, VP = Very Poor
PHI Ratings: MD = Minimally Degraded, PD = Partially Degraded, D = Degraded, SD = Severely Degraded
RBP Ratings: C = Comparable, S = Supporting, PS = Partially Supporting, NS = Non-Supporting

***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.

***Watershed Assessment***

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 management plans. The biological monitoring data is primarily utilized in the County's Watershed Management Tool (WMT) and Stream Assessment Tool (SAT), which was developed and maintained by the WPRP. 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.

The WAP program's stated goals include:

- Characterize subwatersheds;
- Prioritize subwatersheds for preservation and restoration; and
- Inform stressor-response relationships for planning and modeling.

Biological monitoring in support of the Herring Bay, Middle Patuxent, and Lower Patuxent watershed assessment was completed in 2013 and 2016 with the Herring Bay sites completed in 2013. 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: Other West Chesapeake Project List

| Project ID | Project Name | BMP Type | Impervious (acres) | Drainage Area (acres) | Length (linear feet) | TSS Reduction (lbs/year) | TP Reduction (lbs/year) | TN Reduction (lbs/year) | Built Date | Implementation Cost* |
|---|---|---|---|---|---|---|---|---|---|---|
| **Completed Projects** | | | | | | | | | | |
| AA17ALN000031 | 5187 Chesapeake Avenue Living Shoreline | Shoreline Stabilization | | | 94.00 | 12,878 | 6.39 | 7.05 | 1/1/2014 | |
| AA17ALN000024 | 1107 Bay Front Ave Living Shoreline | Shoreline Stabilization | | | 120.00 | 16,440 | 8.16 | 9.00 | 1/1/2016 | |
| AA17ALN000050 | 5905 Deale Beach Rd Living Shoreline | Shoreline Stabilization | | | 382.34 | 52,380 | 26.00 | 28.68 | 1/1/2016 | |
| AA17ALN000038 | 751 Parkers Creek Rd Living Shoreline | Shoreline Stabilization | | | 140.00 | 19,180 | 9.52 | 10.50 | 1/1/2016 | |
| AA17ALN000045 | 511 Deale Rd Rock Revetment | Shoreline Stabilization | | | 480.00 | 65,760 | 32.64 | 36.00 | 1/1/2017 | |
| AA18RST000034 | TriState Marine Stormwater Retrofit System | Pocket Wetland | 14.55 | 28.81 | | 10,808 | 17.63 | 137.51 | 4/9/2018 | $ 164,010 |
| **Planned Projects** | | | | | | | | | | |
| AA18ALN000003 | Jack Creek Park Shoreline | Shoreline Stabilization | | | 1,600.00 | 1,206,856 | 6.82 | 112.02 | | $ 4,511,312 |

*Projects with missing costs were not County funded, implementation cost not available.

# Appendix B: Public Comment Period Documentation

Documentation of the 30-day Public Comment period will be included here, as well as documentation of responses to comments received.