BALTIMORE HARBOR WATERSHED

2017 NUTRIENT TMDL ANNUAL ASSESSMENT REPORT

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Prepared For

Anne Arundel County
Watershed Protection and Restoration Program
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List of Acronyms

BayFAST	Chesapeake Bay Facility Assessment Scenario Tool
BMP	Best Management Practices
BSID	Biological Stressor Identification
CBP	Chesapeake Bay Program
CIP	Capital Improvement Program
EOS	Edge of Stream
MDE	Maryland Department of the Environment
MS4	Municipal Separate Storm Sewer System
NPDES	National Pollutant Discharge Elimination System
SPSC	Step Pool Storm Conveyance
SW to MEP	Stormwater to the Maximum Extent Practicable
SW-WLA	Stormwater Wasteload Allocation
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosporus
TSS	Total Suspended Solids
EPA	United States Environmental Protection Agency
WLA	Wasteload Allocation
WPRP	Watershed Protection and Restoration and Program

1 Introduction

1.1 Background

The Anne Arundel County Department of Public Works (DPW) Watershed Protection and Restoration Program (WPRP) has developed and is currently implementing, 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) (MDE, 2006). 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.

There are currently four final approved TMDLs within the Patapsco River Mesohaline Stream Segment, hereafter referred to as the Baltimore Harbor Watershed, for which Anne Arundel County has jurisdiction; a total suspended solids (TSS; sediment) TMDL for the Patapsco River Lower North Branch approved in 2001, an *Escherichia coli* TMDL for the Patapsco River Lower North Branch approved in 2009, a nitrogen TMDL approved in 2007, and a phosphorus TMDL approved in 2007. These TMDLs apply to several jurisdictions including Baltimore City, Baltimore, Carroll, Howard, and Anne Arundel Counties. Anne Arundel County WPRP developed a TMDL restoration plan dealing with both nitrogen and phosphorus (referred to in this document collectively as the nutrient TMDL), drafted in 2015 and finalized in November of 2016 (Anne Arundel County, 2016) after review and comment from MDE and the general public. The plan specifically addresses the Baltimore Harbor Watershed nutrient TMDL under the responsibility of Anne Arundel County. The sedimentation/siltation and *E. coli* TMDLs are being addressed by Anne Arundel County in separate plans.

Responsibility for Baltimore Harbor Watershed nutrient reduction is divided among the contributing jurisdictions, listed above. 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 required 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), and requires an annual TMDL assessment report to document progress with implementation, pollutant load reductions, and program costs (permit section (IV.E.4). The *Baltimore Harbor Watershed Nutrient TMDL Restoration Plan* (the plan) (Anne Arundel County, 2016) satisfied the permit planning requirement and this *2017 Baltimore Harbor Nutrient TMDL Annual Assessment Report* satisfies the progress documentation requirement.

1.2 Watershed Description

The Baltimore Harbor Watershed consists of two of 12 major watersheds in Anne Arundel County, Maryland, and is situated in the northern portion of the County (Figure 1). The watershed shares political boundaries with Baltimore City, Baltimore, Carroll, and Howard Counties. The Baltimore Harbor Watershed is a part of the Chesapeake Bay watershed with the Baltimore Harbor joining the Chesapeake Bay at North Point near Fort Howard and Rock Point near Fort Smallwood.

Figure 1: Watershed Location Map

The Baltimore Harbor watershed in Anne Arundel County is approximately 45,134 acres (70.5 square miles) in area and contains approximately 202 total miles of stream reaches. The watershed includes several named streams including Back Creek, Cabin Branch, Cox Creek, Curtis Creek, Deep Run, Furnace Creek, Holly Creek, Marley Creek, Nabbs Creek, Patapsco River Lower North Branch Mainstem, Piney Run, Rock Creek, Sawmill Creek, Stoney Run, Swan Creek, and the mainstem of the tidal Patapsco River.

Communities within the Baltimore Harbor watershed include Hanover, Linthicum Heights and Severn. Baltimore Washington International Airport is also located in the western portion of the watershed (Figure 1).

1.3 TMDL Allocation and Planned Loads Summary

This section describes the derivation of the TMDL reduction targets. WLAs in the nutrient TMDL were developed using the Chesapeake Bay Program Phase 5 (CBP P5) watershed model. In development of the Baltimore Harbor Watershed Plan in 2015-2016, BayFAST was used in the modeling. See section 1.5 below for more details on the modeling specifics. BayFAST, during plan development, was compatible with an updated version of the model: CBP P5.3.2. Because the TMDL was developed under an older version of the model, the TMDL WLA needed to be translated into a BayFAST-compatible target load. In order to do this, the 1995 baseline nutrient load was re-calculated in BayFAST by modeling baseline BMPs in Baltimore Harbor Watershed on top of baseline impervious and pervious Anne Arundel County Phase I MS4 acres.

The required reduction percent assigned to the Anne Arundel County Phase I MS4 source (15.0%) in the local TMDL regulation was then applied to the new baseline load to calculate required nutrient reduction. The required nutrient reduction was then subtracted from the new baseline load to calculate the BayFAST-compatible target TMDL WLA. Nutrient loads required for the Baltimore Harbor Watershed Anne Arundel County Phase I MS4 source are shown in Table 1.

Table 1: Nutrient Loads Required for the Baltimore Harbor Watershed Local TMDL

1995 Baseline Load (lbs/yr)		Required Reduction %		Required Reductions (lbs/yr)		TMDL Load Allocation (lbs/yr)	
TN	TP	TN	TP	TN	TP	TN	TP
161,514	13,941	15.0%	15.0%	24,227	2,091	137,287	11,850

Since development of the final plan in late 2016, Phase 6 of the Bay model has been developed and is currently being deployed out to BayFAST. For the purposes of this annual progress report the version of BayFAST built on Bay model version P5.3.2 has been maintained. Future progress modeling may be revised to reflect Phase 6 updates.

1.4 Planned Reductions

This section includes a summary of the reductions that were presented in the 2016 Baltimore Harbor Watershed Plan. Table 2, provides a concise summary of the loads and reductions at important timeline intervals including the 1995 baseline, 2015 progress, 2017 milestone, 2020 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.

- **1995 Baseline Loads**: Baseline levels (i.e., land use loads with baseline BMPs) from 1995 conditions in the Baltimore Harbor Watershed using the Chesapeake Bay Facility Assessment Scenario Tool (BayFAST) Chesapeake Bay Program Phase 5.3.2 (CBP P5.3.2) model. Baseline loads were used to calculate the stormwater allocated nutrient loads, or SW-WLA.
- **2015 Progress Loads and Reductions**: Progress loads and load reductions achieved from stormwater best management practice (BMP) implementation through 2015. The 2015 Progress Loads are calculated from the 1995 Baseline Loads by the following calculations: 1995 Baseline – 2015 Progress Reduction.
- **2017 Interim Milestone Goal Planned Loads and Reductions**: Planned 2017 loads and reductions will result from implementation of strategies through 2017. The 2017 Planned Loads are calculated from the 1995 Baseline Loads by the following calculation: 1995 Baseline – 2017 Planned Reduction.
- **2020 Interim Milestone Goal Planned Loads and Reductions**: Planned 2020 loads and reductions will result from implementation of strategies through 2020. The 2020 Planned Loads are calculated from the 1995 Baseline Loads by the following calculation: 1995 Baseline – 2020 Planned.
- **2025 Interim Milestone Goal Planned Loads and Reductions**: Planned 2025 loads and reductions will result from implementation of strategies through 2025. The 2025 Planned Loads are calculated from the 1995 Baseline Loads by the following calculation: 1995 Baseline – 2025 Planned.
- **2030 Allocated Load**: Allocated loads are calculated from the 1995 baseline levels, calibrated to CBP P5.3.2 as noted above, using the following calculation: 1995 Baseline – (1995 Baseline x 0.15).
- **2030 Planned Loads and Planned Reductions**: Loads and reductions that will result from implementation of this plan. The 2030 Planned Loads are calculated from the 1995 Baseline Loads by the following calculation: 1995 – 2030 Planned Reduction.

Table 2: Baltimore Harbor Watershed Local TMDL Allocated and Planned Loads

	Nitrogen (lbs/year)	Phosphorus (lbs/year)
1995 Baseline Loads	161,514	13,941
FY2015 Progress Loads	160,130	13,658
FY2015 Progress Reductions	1,384	283
FY2017 Planned Loads*	156,718	12,842
FY2017 Planned Reductions	4,796	1,099
FY2020 Planned Loads*	148,308	8,356
FY2020 Planned Reductions	13,206	5,585
FY2025 Planned Loads*	141,157	7,908
FY2025 Planned Reductions	20,357	6,033
TMDL Allocated Loads	137,287	11,850
FY2030 Planned Loads*	134,195	7,460
FY2030 Planned Reductions	27,319	6,481

	Nitrogen (lbs/year)	Phosphorus (lbs/year)
Required Percent Reduction	15.00%	15.00%
Planned Percent Reduction Achieved	16.91%	46.49%

*2017, 2020, 2025 and 2030 planned loads are calculated by subtracting planned restoration nutrient reductions from the 1995 Baseline Load. It is assumed that all new development will be treated with SW to the MEP implementation to achieve 50% nitrogen removal and 60% phosphorus removal and Accounting for Growth policies will address the remaining 50% and 40%, respectively.

1.5 Modeling Methods

1.5.1 Overview

Each BMP provides a reduction for nitrogen, phosphorus, and sediment, along with other pollutants. The pollutant load for the Baltimore Harbor Watershed was determined using BayFAST, which calculates pollutant loads and reductions calibrated to the Chesapeake Bay Program Partnership Watershed Model. BayFAST, created by Devereux Environmental Consulting for MDE, is a web-based pollutant load estimating tool that streamlines environmental planning. BayFAST allows users to specify, delineate facility boundaries (e.g., watershed, parcel, drainage area), and alter land use information within the delineated boundary depending on the model year. Local TMDL baseline loads were calibrated in BayFAST by modeling BMPs installed prior to the TMDL baseline year 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.

BayFAST 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. Both BayFAST and the Chesapeake Bay Program Partnership Watershed Model calculate 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 the load reduction can vary depending on which BMPs are implemented.

Pollutant load reductions achieved by annual based maintenance efforts (e.g., street sweeping and inlet cleaning) are calculated outside of BayFAST. Nutrient reduction credit for vacuum-assisted street sweeping and inlet cleaning is calculated following methods described in MDE (2014) based on the mass of material removed.

Both the Chesapeake Bay Program Partnership Watershed Model and BayFAST provide loads at two different scales: Edge-of-Stream (EOS) and Delivered (DEL). Delivered loads show reductions based on in-stream processes, such as nutrient uptake by algae or other aquatic life. This TMDL plan focuses on reducing load on the land, so EOS estimates are more appropriate and were used for all the modeling analysis.

1.5.2 Practice Level

This section briefly describes each practice and includes a summary of the typical nutrient reductions achieved with each type.

1.5.2.1 Modeled in BayFAST

- **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. BayFAST modeling includes hydrodynamic structures in this category. 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 BayFAST as bioswales.
- **Outfall Stabilization** – Restoration of outfalls using design approaches including rip-rap, riffle run sequences, step-pools and other grade and bank stabilization measures. These stabilization practices are modeled as stream restoration.
- **Permeable Pavement -** Pavement or pavers that reduce runoff volume and treat water quality through both infiltration and filtration mechanisms. Water filters through open voids in the pavement surface to a washed gravel subsurface storage reservoir, where it is then slowly infiltrated into the underlying soils or exits via an underdrain.
- **Urban Stream Restoration -** Stream restoration in urban areas is used to restore the urban 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.
- **Urban Tree Plantings** - Urban tree planting is planting trees on urban pervious areas at a rate that would produce a forest-like condition over time. The intent of the planting is to eventually convert the urban 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.1711

The measured effectiveness for each of these practices are found in Table 3.

Table 3: Typical Nutrient Reduction from Stormwater BMPs

BMP	Nitrogen Reduction	Phosphorus Reduction
Bioretention A/B soils	70%	75%
Bioretention C/D soils	25%	45%
Bioswales	70%	75%
Dry Detention Ponds	5%	10%
Dry Extended Detention Ponds	20%	20%
Impervious Surface Reduction[1]	-	-
Infiltration	85%	85%
Outfall Enhancement with SPSC[2]	70%	75%
Outfall Stabilization	0.075 lbs/linear ft	0.068 lbs/linear ft
Permeable Pavement	75%	80%
Rain Gardens	70%	75%
Stormwater Retrofits	25%	35%
Stream Restoration[3]	0.075 lbs/linear ft	0.068 lbs/linear ft
Urban Filtering	80%	85%
Urban Tree Plantings[1]	-	-
Vegetated Open Channels	45%	45%
Wet Ponds or Wetlands	20%	45%

Sources: Simpson and Weammert, 2009; and BayFAST documentation
[1] Calculated as a land use change to a lower loading land use
[2] Outfall enhancement with SPSC modeled as bioswales in BayFAST
[3] Outfall stabilization and stream restoration listed with revised interim rate; specific stream restoration projects now use Bay Program Protocols however streams and outfalls for this assessment are modeled in BayFAST.

1.5.2.2 Modeled using MDE Guidance

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. Both are calculated using MDE's accounting guidance (MDE, 2014).

- **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. Nutrient reduction credit is based on the mass of material collected, at the rate of 3.5 lbs TN and 1.4 lbs TP per ton of wet material (MDE, 2014). Data for the mass removed was reported from the County's Bureau of Highways.
- **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 Baltimore Harbor Watershed (Anne Arundel County DPW, 2015; Figure 2). This enhanced program targets impaired watersheds and curbed streets that contribute trash/litter, sediment, and other pollutants. Load reductions for this assessment are calculated using the material collected, at the rate of 3.5 lbs TN and 1.4 lbs TP per ton of wet material (MDE, 2014). The total mass of material collected by the street sweeping program each year is distributed proportionately across all of the roadway segments swept and then summed at the watershed scale. Note that currently the TN and TP reductions included in the County's MS4 NPDES geodatabase are calculated using the lane miles swept method and reduction rates from the Bay Program expert panel report (CBP, 2016).
- **Shoreline Stabilization** – Anne Arundel County implemented two shoreline stabilization projects in the Baltimore Harbor Watershed. Currently, BayFAST does not provide nitrogen or phosphorus reduction for these types of projects. These projects were modeled outside of BayFAST using load reductions at the rate of 0.075 lbs TN per linear foot and 1.4 lbs TP per linear foot (MDE, 2014).

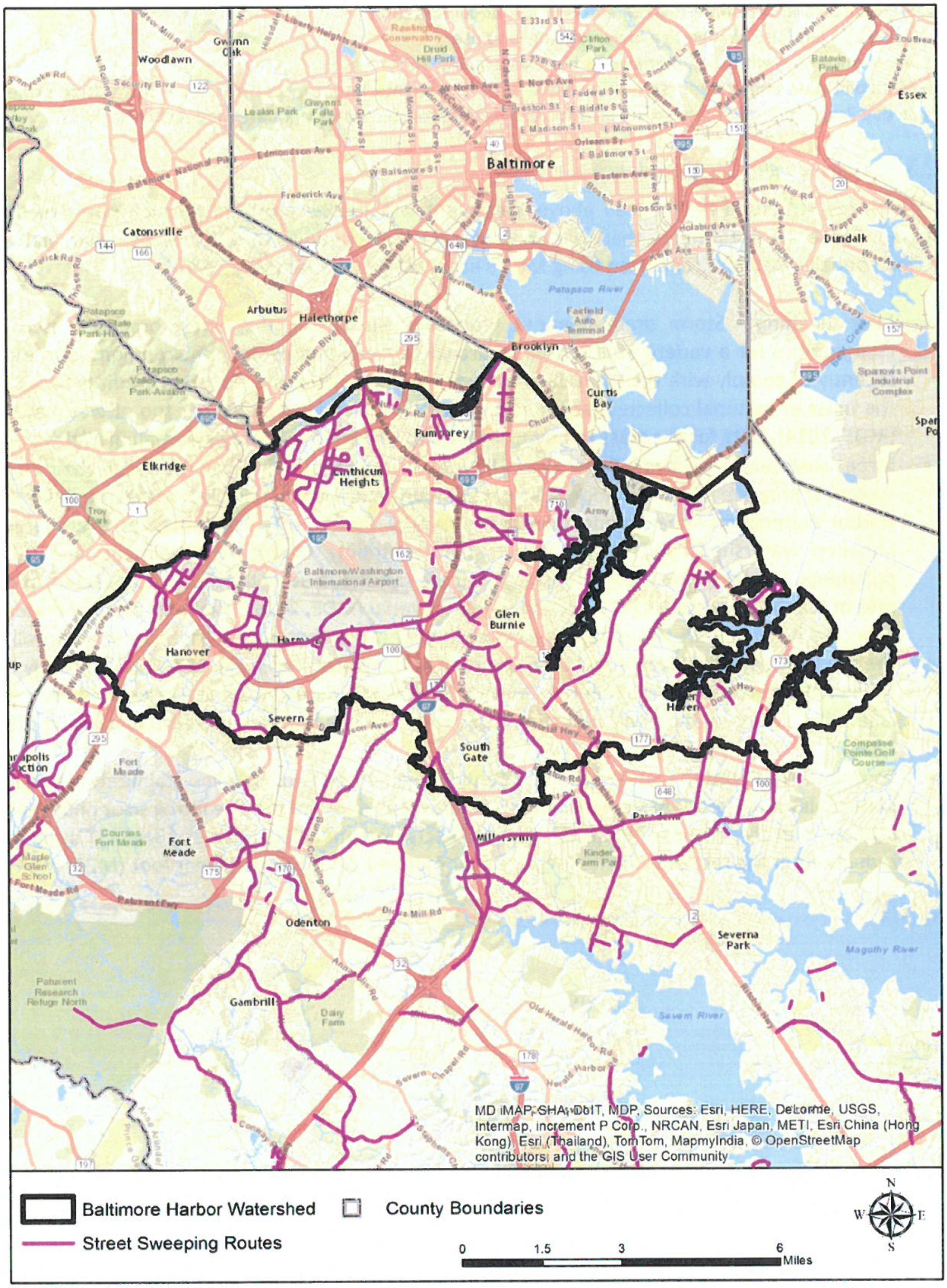

Figure 2: Street Sweeping Routes in Baltimore Harbor Watershed, Anne Arundel County, Maryland

2 2017 Progress Summary

The following section summarizes the County's implementation efforts, the resulting load reductions achieved, and the costs of program implementation.

2.1 Implementation Results

Implementation up through the end of fiscal year 2017 is detailed in Table 4. Information on completed projects and programs is gleaned primarily from the County's MS4 geodatabase. All 2016-2017 implementation is included in the database. Additional pre-2016 restoration projects were pulled from the County's geodatabase of stormwater urban BMP facilities and water quality improvement projects (WQIP). The County is actively updating the MS4 NPDES geodatabase to include older pre-2014 projects.

Bioswale
One bioswale project was completed in the watershed in 2017 (Northrup Grumman property).

Infiltration
Three infiltration retrofits were completed in the watershed in 2017.

Permeable Pavement
Five permeable pavement projects were completed in 2017 (Northrup Grumman property).

Rain gardens
Four rain garden projects were completed in the watershed in 2017 which totaled 1.00 acres of treatment (Northrup Grumman and Empowering Believers Church properties).

Shoreline Stabilization
Two shoreline stabilization projects were completed in 2017, including a living shoreline at Stahl Point Road, and a revetment project at Atlanta Road.

Step Pool Stormwater Conveyance
One SPSC project was completed in the watershed in 2017 (Juneberry Way).

Wet Ponds
One wet pond retrofit was completed in the watershed in 2017 (Tulip Oak Court).

Outfall Stabilization
Three outfall projects were completed in 2017, totaling 160ft.

Inlet Cleaning
A total of 118 inlets were cleaned using storm drain vacuuming.

Street Sweeping
Based on the County's enhanced street sweeping program, 96.1 curb miles are swept in the watershed annually. The total mass of material collected by the street sweeping program in fiscal year 2017 (599.92 tons) was distributed proportionately across all of the roadway segments swept and then summed at the watershed scale.

The total cost of the practices and programs implemented in FY2017 is $ 2,290,269.

Table 4: Current BMP Implementation through FY2017

BMP	Unit	1995 Baseline	1996 - 2015 Restoration[1]	2016 Restoration[1]	2017 Restoration[1]	2017 Progress[2]	2017 Restoration Cost[3]
Structural Permanent Practices							
Bioretention	acre	0	0	0	0	0	
Bioswale	acre	0	0	0	0.6	0.6	
Dry Ponds	acre	1,143.6	37.1	0	0	37.1	
Extended Detention Dry Ponds	acre	284.7	44.7	0	0	44.7	
Impervious Surface Reduction	acre	3.0	0.1	0	0	0.1	
Infiltration	acre	235.8	3.8	0	46.6	50.4	$ 941,471
Outfall Enhancement with SPSC	acre	0	100.2	46.9	5.4	152.5	$ 310,117
Outfall Stabilization	linear feet	0	0	30	160	190	$ 150,538
Permeable Pavement	acre	9.3	0	0	5.8	5.8	
Rain Gardens	acre	0	0	0	1.0	1.0	$ 43,080
Shoreline Stabilization	linear feet	0	0	0	608	608	
Urban Stream Restoration	linear feet	0	500	650	0	1,150	
Wet Ponds or Wetlands	acre	645.2	164.2	34.0	35.8	234.0	$ 455,727
Annual Practices							
Inlet Cleaning	inlets/yr	0.0	729	0	118	118	$ 205,272
Street Sweeping[4]	lbs /yr	0.0	NA	NA	505,073	505,073	$ 184,064
Total Cost							$ 2,290,269

Source: WPRP urban BMP, WQIP and MDE MS4 FY17 geodatabase

[1] Restoration completed in each specific period, i.e. 1996-2015, 2016 and 2017.

[2] Total cumulative restoration accounting for the full 1995-2017 period.

[3] Cost of projects and programs for the 2017 period only. Only costs using County funds are included.

[4] Value listed here is the lbs of material removed, not specifically the fine TSS sediment

2.2 Load Reduction Results

The implementation summarized in Table 4 above resulted in the load reductions presented here in Table 5. Reductions in the 2017 were substantially higher than those reported in the previous 2016 period largely due to restoration implementation coupled with better accounting of street sweeping mass reduction values in 2017.

Of the 2,763 lbs of nitrogen progress reduction achieved through FY2017, 884 lbs (32.0% of the total reduction) are being removed by street sweeping, and 281 lbs (10.2%) is accounted for by inlet cleaning. Of the 764 lbs of phosphorus progress reduction achieved through FY2017, 354 lbs (46.3% of the total reduction) are being removed by street sweeping, and 112 lbs (14.7%) is accounted for by inlet cleaning. The remainder is being reduced by the suite of restoration projects.

Table 5: 2017 Progress Reductions Achieved

Baseline Load and TMDL WLA	**TN-EOS lbs/yr**	**TP-EOS lbs/yr**
1995 Baseline Scenario Load	161,514	13,941
Required Percent Reduction	15.0%	15.0%
Required Reduction	24,227	2,091
Local TMDL WLA	137,287	11,850
2015 Results	**TN-EOS lbs/yr**	**TP-EOS lbs/yr**
1995-2015 Load Reduction	1,384	283
1995-2015 Load Reduction Percent	0.86%	2.03%
Progress Scenario Load	160,130	13,658
Progress Reduction Achieved	1,384	283
Percent Reduction Achieved	0.9%	2.0%
2016 Results	**TN-EOS lbs/yr**	**TP-EOS lbs/yr**
2016 Load Reduction	282	89
2016 Load Reduction Percent	0.1%	0.7%
Progress Scenario Load	159,848	13,569
Progress Reduction Achieved	1,666	372
Percent Reduction Achieved	1.0%	2.7%
2017 Results	**TN-EOS lbs/yr**	**TP-EOS lbs/yr**
2017 Load Reduction	1,097	392
2017 Load Reduction Percent	0.7%	2.8%
Progress Scenario Load	158,705	13,136
Progress Reduction Achieved	2809	805
Percent Reduction Achieved	1.7%	5.8%

3 2017 Progress Comparison

This section describes the current progress of both implementation and load reductions with comparison to the planned totals and the progress that was expected by 2017.

3.1 Implementation

Table 6 compares implementation of existing restoration BMPs up through fiscal year 2017 (2017 Progress) with the total planned levels of implementation that were derived in the initial plan (Anne Arundel County, 2016). Several of the strategies were completed fully in the initial 2006-2015 period (dry ponds, extended detention dry ponds, impervious surface reduction) and street sweeping is continuing at the prescribed rate.

Implementation of BMP retrofits to wet ponds/wetlands and infiltration is on-going. Implementation of bioretention, SPSC outfall enhancement, and stream restoration projects are also on-going. Several BMP types were not initially planned for in the 2016 plan but were implemented in the watershed. Those project types include bioswales, outfall stabilization, permeable pavement, rain gardens, and shoreline stabilization.

Estimates of inlet cleaning in the development of the plan were based on the total number of inlets cleaned Countywide with estimates based on the numbers of inlets in each watershed and assumptions of the average sediment yield from each inlet cleaned. The plan then called for a level of treatment consistent with the progress rate of 729 inlets per year. The actual number cleaned in the current reporting period is 118, however the mass of sediment extracted from those inlets greatly exceeded the initial average estimates therefore a significant drop in loads reduced by that practice did not occur.

Table 6: Restoration BMP Implementation - Current 2017 and Planned 2030 Implementation Levels

BMP	Units	Total Planned Restoration	2017 Progress	Percent Complete
Bioretention	acre	29.1	0	0%
Bioswale	acre	0	0.6	n/a
Dry Ponds	acre	37.1	37.1	100%
Extended Detention Dry Ponds	acre	44.7	44.7	100%
Impervious Surface Reduction	acre	0.1	0.1	100%
Infiltration	acre	86.2	50.4	58%
Outfall Enhancement with SPSC	acre	3,043.3	152.5	5%
Outfall Stabilization	linear feet	0	190	n/a
Permeable Pavement	acre	0	5.8	n/a
Rain Gardens	acre	0	1.0	n/a
Shoreline Stabilization	linear feet	0	608	n/a
Urban Stream Restoration	linear feet	79,171.0	1,150	1%
Wet Ponds or Wetlands	acre	913.7	234.0	26%
Annual Practices				
Inlet Cleaning	inlets/yr	729	118	16%
Street Sweeping	curb-miles	96.1	96.1	100%

To track progress, the 2017 implementation milestone first reported in the 2016 plan was compared against the 2017 progress reported here in this assessment. Table 7 presents the strategies that were planned for the 2017 milestone period, which includes 2016 and 2017 with a comparison to the practices that were completed for that period.

Multiple BMP conversion projects (to both infiltration and wet ponds) were completed in the period along with four outfall stabilization projects, two stream restoration projects, and one SPSC project. The list of implemented projects includes several that were not initially planned for; one bioswale project, four outfall stabilization projects, two shoreline stabilization projects, and several permeable pavement and rain garden projects implemented by NGOs. Street sweeping continues at the prescribed rate and with better supporting information on measured quantities of material removed is now yielding very good results. Inlet cleaning appears to be lower than planned, but measured mass removed from inlets shows a much larger removal of material than was initially planned for in the restoration plan.

Table 7: Implementation Milestones Comparison

BMP	Unit	FY2016-FY2017 Planned	FY2016-FY2017 Actual	Percent Complete
Bioretention	acre	29.1	0	0%
Bioswale	acre	0	0.6	n/a
Dry Ponds	acre	0	0	n/a
Extended Detention Dry Ponds	acre	0	0	n/a
Impervious Surface Reduction	acre	0	0	n/a
Infiltration	acre	82.4	46.6	57%
Outfall Enhancement with SPSC	acre	155.7	52.3	34%
Outfall Stabilization	linear feet	0	190	n/a
Permeable Pavement	acre	0	5.8	n/a
Rain Gardens	Acre	0	1.0	n/a
Shoreline Stabilization	linear feet	0	608	n/a
Urban Stream Restoration	linear feet	6,000.0	1,150	19%
Wet Ponds or Wetlands	acre	694.4	269.8	39%
Annual Practices				
Inlet Cleaning	no. of inlets/yr	729	118	16%
Street Sweeping (roads)[1]	curb-miles	96.1	96.1	100%

3.2 Load Reductions

This section compares the required and planned nutrient load reductions against the progress made through fiscal year 2017. Values given in Table 8 include the load reductions for each period (generally the milestone years) and the resulting load. Both the planned results and the actual results are shown for the 2015, 2016, 2017, 2020, 2025, and 2030 periods. All values shown (reductions, loads, percent reduction) are the cumulative values, not the year over year changes.

Overall the results indicate that on a TMDL allocated goal of 15.0%, the County has achieved a 1.7% reduction for nitrogen and 5.8% for phosphorus, which translates to 11.3% progress towards the reduction goal for nitrogen and 38.6% for phosphorus. The 2016 plan (Anne Arundel County, 2016) anticipated 3.0% reduction for nitrogen and 7.9% reduction for phosphorus by 2017, indicating that progress is slightly behind the planned 2017 milestone.

The County's initial estimate and plan were based on a 2030 end date for meeting the nutrient TMDL. Although the progress as of FY2017 is slightly behind schedule, the program is on track to meet the phosphorus end date ahead of schedule with completion of planned restoration projects and continued street sweeping and inlet cleaning as prescribed. The County currently has 29 restoration projects that are in planning and design phases that are scheduled to be complete by FY2020. These projects include stream restoration, bioretention, wet ponds and wetlands, infiltration basins and trenches, and rain gardens and barrels.

Estimates of phosphorus reduction from planned projects show an additional reduction of 608 lbs over the next three years which represents an additional 4.2% reduction, added to the 5.8% achieved through FY2017 will result in a total reduction progress of 10.1%. Using the rate of implementation from the last two years of 3.8%, the County should meet the required phosphorus reduction by 2024. It is noted that the 46.5% reduction outlined in the restoration plan is based on the assumption that all of the recommended strategies would be completed, which is not often the case due to feasibility, site constraints etc.

Estimates of nitrogen reduction from planned projects show an additional reduction of 5,021 lbs over the next three years which represents an additional 3.1% reduction, added to the 1.7% achieved through FY2017 will result in a total reduction progress of 4.8%. Projecting the rate of planned implementation for nitrogen reduction out into the future, the County will meet the nitrogen reduction in 2030.

Table 8: Planning and Target Nutrient Load Comparison (lbs/year)

Milestone Year	Planned Load Reduction		Planned Load		Planned % Reduction From Baseline		Actual Load Reduction		Actual Load		Actual % Reduction from Baseline	
	TN	TP	TN	TP	TN	TP	TN	TP	TN	TP	TN	TP
1995 Baseline	-	-	-	-	-	-	-	-	161,514	13,941	-	-
2015 Progress	-	-	-	-	-	-	1,384	283	160,130	13,658	0.9%	2.0%
2016 Progress	-	-	-	-	-	-	1,666	372	159,848	13,569	1.0%	2.7%
2017 Planned and Progress	4,796	1,099	156,718	12,842	3.0%	7.9%	2,809	805	158,705	13,136	1.7%	5.8%
2020 Planned	13,206	5,585	148,308	8,356	8.2%	40.1%	-	-	-	-	-	-
2025 Planned	20,357	6,033	141,157	7,908	12.6%	43.3%	-	-	-	-	-	-
2030 Allocated	24,227	2,091	137,287	11,850	15.0%	15.0%	-	-	-	-	-	-
2030 Planned	27,319	6,481	134,195	7,460	16.9%	46.5%	-	-	-	-	-	-

4 Monitoring

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

Anne Arundel County's Watershed Protection and Restoration Program (WPRP) has several on-going monitoring programs that target measures of watershed condition and relative nutrient levels. These programs are described here.

4.1 Countywide Biological Monitoring

Biological monitoring and assessment provide a direct measure of the ecological health of a stream. Stream organisms are continuous monitors of both short- and long-term water quality and other environmental factors and provide direct indicators of the quality of a stream. Advantages of using benthic macroinvertebrates include their generally restricted mobility and often multi-year life cycles, allowing them to integrate the effects of both chemical and physical perturbations over time. When hydrologic regimes of streams are altered, the physical nature of the habitat changes due to accelerated erosion and deposition of channel soils and other materials. This changes the capacity of a stream to support a healthy biota. Changes in the quality of the water resource are reflected as changes in the structural and functional attributes of the macroinvertebrate assemblage. Biological monitoring and assessment results can be used to detect impairment of the biological community and to assess the severity of impacts from both point source (PS) and nonpoint source (NPS) pollution. When coupled with information on chemical and physical stressors, these types of exposure and effect data can be used to improve water quality assessments. Over the past several decades, biological monitoring and assessment of aquatic communities along with characterization of their chemical and physical habitats have increased with application of these data to watershed management policies and practices.

Historically, many municipalities have been hampered in their ability to recommend and implement pollution control and remediation efforts because the chemical, physical, and biological condition of most of their water resources have not been adequately characterized. To expand its monitoring program, Anne Arundel County developed a stream monitoring program consisting of chemical, physical, and biological assessment techniques to document and track changes in the condition of stream resources County-wide. Problems resulting from chemical contamination and physical habitat alteration are reflected by changes in the aquatic biota. Therefore, inclusion of a biological monitoring component is providing Anne Arundel County with the relevant indicators for assessing the condition of, and managing, its water resources.

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 the Countywide Biological Monitoring and Assessment program, biology (i.e., benthic macroinvertebrates) and stream habitat, as well as geomorphological and water quality parameters, are assessed at approximately 240 sites throughout the entire County over a 5-year period using a probabilistic, rotating-basin design.

Round One of the County's Biological Monitoring and Assessment Program occurred between 2004 and 2008, and Round Two took place between 2009 and 2013. During 2017, Round 3 monitoring was initiated and fish sampling and additional water quality parameters were added. Field data collection was completed and analysis is currently underway. Annual reports and Round summary reports are available for review at: http://www.aacounty.org/departments/public-works/wprp/ecological-assessment-and-evaluation/biological-monitoring/biological-monitoring-reports/index.html

The primary goals of the program are to assess the current status of biological stream resources, establish a baseline for comparison with current and future assessments, and to relate them to specific programmatic activities. The County currently uses a combination of chemical sampling, geomorphic assessment, storm water sampling, and biological sampling to assist in its environmental management decision-making process. This combination of monitoring greatly assists the County in assessing progress toward achieving Stormwater Wasteload allocations set forth in TMDLs. 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 Baltimore Harbor watershed is made up of five PSUs; Piney Run, Stony Run, Lower Patapsco, Sawmill Creek, and Marley Creek. Ten sampling sites were sampled in each of these PSUs in each round of sampling. Methodologies follow those used by MBSS for the biological sampling (benthic macroinvertebrates only) and habitat evaluations have included both MBSS's Physical Habitat Index (PHI) 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.

In addition to collecting the parameters described above, the County may added water quality sampling at each site to the Round Three monitoring initiative. These parameters, which include the analysis of nutrient levels, are listed below:

- Total Nitrogen (TN)
- Ammonia (NH_3)
- Ammonium (NH_4)
- Nitrate (NO_3)
- Nitrite (NO_2)
- Total Phosphorus (TP)
- Phosphate (PO_4)
- Dissolved organic carbon (DOC)
- Total organic carbon (TOC)
- Copper
- Lead
- Zinc
- Chloride

Results summarized at the PSU scale with mean BIBI and habitat ratings (PHI and RBP) are presented in Table 9.

Table 9: Countywide Biological Monitoring Results for Baltimore Harbor Watershed

PSU Name	Round	PSU Code	Year Sampled	Drainage Area (acres)	BIBI Rating	PHI Rating	RBP Rating
Piney Run	1	1	2007	4,868	P	D	PS
Piney Run	2	1	2009	4,868	P	PD	PS
Stony Run	1	2	2007	6,203	P	D	PS
Stony Run	2	2	2010	6,203	P	PD	S
Lower Patapsco	1	3	2004	4,040	P	PD	PS
Lower Patapsco	2	3	2012	4,040	P	PD	NS
Sawmill Creek	1	4	2008	11,044	VP	D	PS
Sawmill Creek	2	4	2010	11,044	P	D	PS
Marley Creek	1	5	2006	19,425	P	D	PS
Marley Creek	2	5	2009	19,425	VP	D	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

4.2 Targeted Restoration Monitoring Program

In addition to the Countywide Program, the County implements a targeted biological monitoring program. This program utilizes the same techniques and procedures as use in the Countywide Program, but the sites are not randomly selected. There are two general approaches to site selection in the targeted work. First, the County samples a collection of long term sites every year, the number of which has varied over the years. Currently, there are 11 sites in the program, 10 of which are past stream restoration reaches that the County tracks to see how the stream insect community changes over time while one site is a minimally disturbed stream reach that is used as a reference reach. Most of the sites in this group have only been monitored post-restoration. The latest summary report can be found here: http://www.aacounty.org/departments/public-works/wprp/ecological-assessment-and evaluation/2016%20Targeted%20Site%20Summary%20Report_Final.pdf

The other group of sites, varying in number from year to year, is established on reaches planned for future restoration work. The intent is to create a baseline of biological conditions to justify project implementation by providing permitting agencies evidence that biological and habitat impairments exist within a reach of interest.

5 Conclusion

This Baltimore Harbor Watershed TMDL Annual Assessment report documents the progress achieved through the end of fiscal year 2017. The assessment includes a report on the project and program implementation completed in the current report year and cumulatively through FY2017. The report summarizes the modeled and calculated pollutant load reductions and loads achieved through the implemented programs. Further the report compares the implementation levels and load reductions against the overall goals, specifically the TMDL WLA, and the planned milestone targets as outline in the 2016 plan (Anne Arundel County, 2016).

Anne Arundel County spent $2.3 million dollars in FY2017 in capital and operational costs. With those funds the County is completing restoration projects and implementing programmatic practices including inlet cleaning and street sweeping. Load reductions are at 1.7% for nitrogen and 5.8% for phosphorus on a total goal of 15.0% reduction for each. The County currently has 29 restoration projects that are in planning and design phases that are scheduled to be complete by FY2020. These projects include stream restoration, bioretention, wet ponds and wetlands, infiltration basins and trenches, and rain gardens and barrels. With completion of these projects and through continuation of currently existing operations programs, the County plans to meet the WLA and load reduction with additional project implementation before the 2030 date set in the County's plan.

Biological stream monitoring data thus far with two rounds completed indicates a watershed that is in poor biological health. The Baltimore Harbor watersheds (PSUs 1, 2, 3, 4, 5) are scheduled to be monitored again in the County's rotating framework between 2018 and 2020 which will provide a check on overall biological conditions.

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