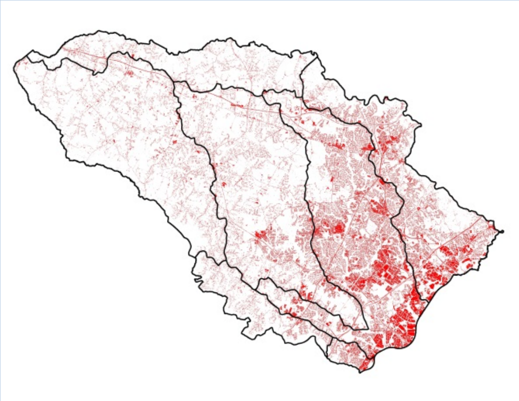
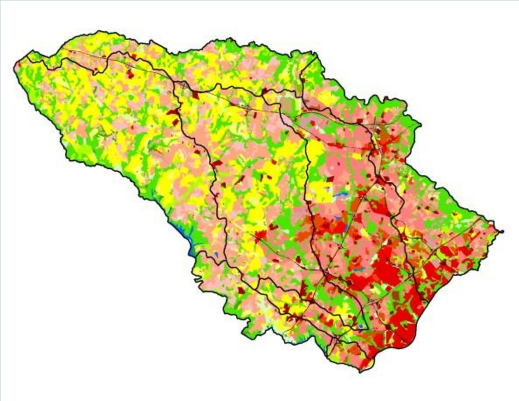
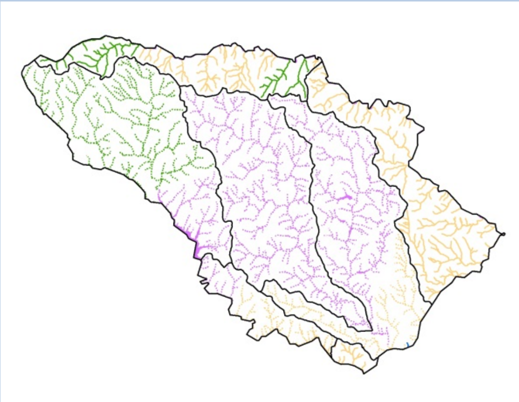
COUNTYWIDE IMPLEMENTATION STRATEGY

TMDL AND IMPERVIOUS SURFACE RESTORATION PLAN







HOWARD COUNTY, MARYLAND

DECEMBER 2015

COUNTYWIDE IMPLEMENTATION STRATEGY

DECEMBER 2015

PREPARED FOR

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Acknowledgements

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List of Acronyms

AFG	Accounting for Growth
BACI	Before-After Control-Impact
BayFAST	Bay Facility Assessment Scenario Tool
BMP	Best Management Practices
BSID	Biological Stressor Identification Studies
CA	Columbia Association
CBP	Chesapeake Bay Program
CIP	Capital Improvement Plan
CIS	Countywide Implementation Strategy
CWA	Clean Water Act
DEL	Delivered
DRP	Department of Recreation and Parks
EOS	Edge of Stream
EPA	U.S. Environmental Protection Agency
ESD	Environmental Site Design
LULC	Land use / Land cover
MAST	Maryland Assessment Scenario Tool
MBSS	Maryland Biological Stream Survey
MDE	Maryland Department of the Environment
MDP	Maryland Department of Planning
MEP	Maximum Extent Practicable
MS4	Municipal Separate Storm Sewer System
NOAA	National Oceanographic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
PSU	Primary Sampling Unit
SHA	State Highway Administration
SPSC	Step Pool Storm Conveyance
SSO	Sanitary Sewer Overflow
SWMD	Stormwater Management Division
SW to MEP	Stormwater to the Maximum Extent Practicable
SW-WLA	Stormwater Wasteload Allocation
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
TSS	Total Suspended Solids
USGS	United States Geological Survey
WIP	Watershed Implementation Plan
WLA	Wasteload Allocation
WQA	Water Quality Assessment
WWTP	Wastewater treatment plant
WSSC	Washington Sanitary Sewer Commission

Executive Summary

On December 18, 2014, Howard County received a new National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) Discharge Permit (11-DP-3318, MD0068322) from the Maryland Department of the Environment (MDE) that includes requirements for watershed restoration activities, specifically preparation of a restoration plan within the first year of the permit term (Section IV.E.2). To address this requirement, Howard County has developed this Countywide Implementation Strategy (CIS) that:

- Demonstrates ways to meet the Total Maximum Daily Load (TMDL) Stormwater Wasteload Allocations (SW-WLAs) approved by U.S. Environmental Protection Agency (EPA)
- Illustrates a strategy to provide additional stormwater runoff management for impervious acres equal to 20% of the impervious area for which runoff is not currently managed to the Maximum Extent Practicable (MEP)
- Educates and involves residents, businesses, and stakeholders in achieving measurable water quality improvements
- Establishes a reporting framework for annual reporting under the County's MS4 permit
- Provides an evaluation and adaptive management process for developing actions to be taken if permit requirements are not met
- Identifies the funding needed to implement the CIS

In addition to these requirements, the County must develop watershed assessments for each watershed in the County before the end of the permit term in December 2019. The County has completed two of eight major watershed assessments with the completion of the Little Patuxent and Middle Patuxent watersheds in December 2015. The County's remaining watersheds will be assessed in 2016. These assessments, which provide visual characterization, identification of water quality issues and prioritized solutions, are the foundation on which this CIS has been and will be developed.

As required by the permit, the CIS includes a schedule of activities, provides dates for meeting the SW-WLAs, presents cost estimates for projects and programs, describes the County's monitoring and progress evaluation frameworks, including adaptive management, and includes public participation elements.

Impervious Surface Restoration

As a requirement of PART IV.E.2.a of the County's NPDES MS4 permit, the County must conduct an impervious area assessment to define the restoration efforts required under the permit and restore 20% of countywide baseline untreated impervious acres by 2019, the end of the current permit term. The CIS includes the County's impervious accounting to determine the levels of treated, untreated and partially treated impervious surface under County MS4 jurisdiction and presents the County's impervious surface baseline and 20% restoration goal. The total County MS4 Impervious Area, or the area under Howard County jurisdiction, is 18,202.8 acres. The difference between this value and the total impervious area of 20,574.5 is impervious surfaces under other ownership (state lands) and portions regulated by other NPDES permits (MSHA and industrial sites). The impervious baseline treated area is 7,981.1 acres and the untreated area is 10,221.6 acres. Applying the 20% factor to the untreated area yields a 20% restoration target of 2,044.3 acres.

Howard County implemented its stormwater utility fee, termed the "Watershed Protection Fee" on July 1, 2013. Using the fees collected, the County has been making concerted efforts to plan, design, implement and monitor restoration projects implemented specifically towards meeting the current NPDES MS4 permit's 20% restoration goal. Therefore restoration projects implemented following July 1, 2013are considered restoration, while restoration projects implemented before July 1, 2013are credited to the baseline. **The results indicate that the County has completed 157.4 impervious acres of restoration to apply to its 20% goal, leaving 1,886.9 acres of impervious restoration to be completed by the end of the permit term in December, 2019**.

The CIS, with a full accounting of current progress and the projects and programs recommended and planned, would result in a total restoration of 2,116.4 acres, or 20.7% of the untreated baseline.

Local TMDLs

As a requirement of section PART IV.E.2.b of the County's NPDES MS4 permit, the County must develop restoration plans by December 2015 for each SW-WLA approved by EPA prior to the effective date of the permit. There are currently eight final approved TMDLs within Howard County with either an individual or aggregate SW-WLA (ES Table 1). Several County TMDL watersheds fall within neighboring counties; however, SW-WLAs assigned to jurisdictions outside of Howard County's Phase I MS4, which may also include, Phase II jurisdictions, Maryland State Highway Administration, and other NPDES regulated stormwater are not the responsibility of Howard County and are not addressed in the CIS.

The following describes TMDLs that are not addressed in the CIS:

- Centennial Lake sediment and phosphorus TMDLs (approved April 2002) do not have SW-WLAs assigned to the Howard County MS4 source sector
- Lower segment of the Patuxent River Upper bacteria TMDL (approved August 2011) does not have a SW-WLA assigned to the Howard County MS4 source sector
- Triadelphia Reservoir sediment TMDL (approved November 2008), which does have a SW-WLA for Howard County Phase I MS4, requires a 0% reduction in baseline sediment loads with the assumption that meeting the phosphorus TMDL will result in the necessary sediment reductions (MDE, 2008).
- Patuxent River Upper (Cash Lake) mercury TMDL (approved March 2011), which is listed in Attachment B of the County's current permit, is located wholly within Prince George's County, therefore Howard County is not responsible for this TMDL
- South Branch Patapsco does not have a local TMDL, but it is included in the analysis since it, with the Patapsco River Lower North Branch, makes up the Baltimore Harbor watershed.
- The Middle Patuxent watershed does not have a TMDL.

The CIS presents disaggregated and calibrated baseline loads for each SW-WLA to calculate the load reduction required from the baseline value. Based on MDE guidance, growth in the stormwater load since the TMDL baseline year was not accounted for in the analysis. Local TMDLs are considered met, from a planning perspective, when the load reductions associated with 2015 restoration progress coupled with the planned restoration load reductions included in the CIS exceed the load reduction required. Some TMDLs are estimated to be exceeded by a wide margin because removals per pollutant type are not achieved at the same rate. TN removal rates are relatively low compared to TP and TSS on a per project basis. This impacts watersheds with multiple TMDLs and also nested watersheds as in Baltimore Harbor.

ES Table 1. Howard County Local TMDL Summary

Watershed Name	Watershed Number	WLA Type	Pollutant	Baseline Year	MDE Published Reduction	CIS Planned Reduction
Patapsco River Lower North Branch	02130906	Individual	Sediment	2005	10.0%	48%
		Aggregate	Bacteria	2005	13.4%	18.0%
Baltimore Harbor (Patapsco R LN Br + S Br Patapsco)	02130906	Aggregate	Nitrogen	1995	15.0%	15.3%
	02130908					
	02130906	Aggregate	Phosphorus	1995	15.0%	82.3%
	02130908					
Patuxent River Upper	02131104	Individual	Sediment	2005	11.40%	34.1%
Little Patuxent River	02131105	Individual	Sediment	2005	48.10%	48.5%
Rocky Gorge Reservoir	02131107	Aggregate	Phosphorus	2000	15%	23.3%
Triadelphia Reservoir (Brighton Dam)	02131108	Aggregate	Phosphorus	2000	15%	19.7%
		Aggregate	Sediment	2000	0%	--

Chesapeake Bay TMDL

The Chesapeake Bay TMDL, established by the EPA (EPA, 2010), sets pollution limits for nitrogen, phosphorus, and sediment in the Chesapeake Bay Watershed. While not a requirement in the County's NPDES MS4 permit, strategies provided in this plan to meet local TMDL reduction targets and impervious restoration treatment are modeled against the Bay TMDL goals in order to calculate progress. The County's MS4 permit requires compliance with the Chesapeake Bay TMDL for the stormwater sector through the use of the 20% impervious surface restoration strategy rather than through the use of calculating and tracking nutrient reductions; however the Bay TMDL nutrient reductions have been tabulated in the CIS for general comparison.

Management Measures

Management measures to reduce pollutant loads and restore impervious surfaces include structural stormwater Best Management Practices (BMPs), alternate practices, and also non-structural County based and homeowner-implemented programs. The major project types accounted for in the CIS towards the reduction goals are presented in ES Table 2. These include projects currently identified in the County's FY2016 and FY2017 Capital Improvement Plan (CIP) list, potential project sites identified with concept plans developed in the 2015 watershed assessments in the Little and Middle Patuxent, and potential project sites to be identified in 2016 with assessment of the County's remaining watersheds. They are listed here with the proposed level of implementation.

ES Table 2. CIS Planned Strategies

BMP	Number of Projects Planned Countywide	Accounting Unit	Countywide Total
Stormwater BMP Conversion	45	Drainage area acres	727.0
New Stormwater BMP	34	Drainage area acres	166.1
Outfall Stabilization	17	Linear feet	2,584.9
Outfall Enhancement (SPSC)	91	Linear feet	14,910.8
Stream Restoration	103	Linear feet	190,494.3
Urban Tree Planting	59	Acres planted	307.8
Rain Barrels	100 / year added	Per units implemented	300
Septic System Pump-Outs	3,000 / year added	Per unit (annual practice)	9,000
Septic System Upgrades	30 / year added	Per unit	90

Note: rain barrel and septic totals are shown only for the three year period between FY16 and FY19 to coincide with the 2019 impervious restoration schedule end-date

Cost and Schedule

The cost of implementing the CIS to meet the stated goals has been estimated. It is important to note that the costs represent planning level estimates for use in high level forecast budgeting with many assumptions made. The cost estimates provided in the CIS will likely adjust as the County progresses with implementation of its program.

The total projected cost to implement the County's CIP projects described in this plan is $ 222,290,000 over the entire period between FY2016 through FY2027. Estimates of the planned projects and associated cost per year are shown in ES Table 3. Because the schedule requires the 20% restoration to be complete by 2019, there is a rapid increase in funding needed from current expenditures planned for FY2016 to the peak annual expenses anticipated for FY2017 through FY2020. Additional costs associated with the rain barrel and septic programs have been formulated and will add another $915,000 to the total cost between FY2016 and FY2019.

ES Table 3. Fiscal Year Schedule of Project Implementation and Cost

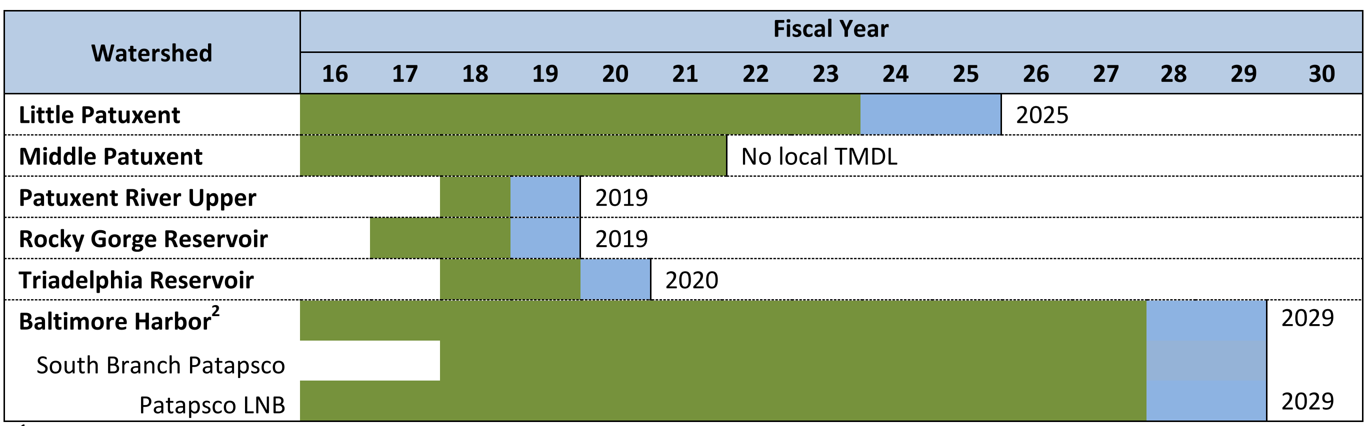
Fiscal Year	Number of Planned Projects to Meet the 20% Restoration Requirement[1]	Total Cost to Meet the 20% Restoration Requirement[1]	Number of Additional Planned Projects to Complete the TMDL Goals[2]	Total Additional Cost to Complete the TMDL Goals[2]
2016	20	$ 8,515,487		
2017	38	$ 27,555,179		
2018	40	$ 32,091,365		
2019	42	$ 32,328,247		
2020	43	$ 32,110,558		
2021			20	$ 13,894,277
2022			22	$ 13,706,835
2023			21	$ 12,879,189
2024			23	$ 12,467,750
2025			29	$ 12,287,148
2026			30	$ 12,287,148
2027			21	$ 12,166,869
Total	183	$ 132,600,836	166	$ 89,689,216

[1] Values for FY2016 through FY2020 meet the 20% restoration requirement and also provide a portion of the nutrient and sediment load reductions required toward meeting the local and Bay TMDL goals.

[2] Values for FY2021 through FY2027 provide the additional nutrient and sediment load reductions required toward meeting the local and Bay TMDL goals. The grand total cost of the complete project implementation plan is $ 222,290,052.

Implementation of the CIS at the required pace and with necessary funding is projected to meet the impervious surface restoration goal by December of 2019 and will meet the local TMDL-required reductions by the end dates indicated in the following figure, ES Figure 1.

ES Figure 1. Implementation Schedule with End Dates Indicated[1]



[1] Primary project completion period is shown in green, additional implementation contingent period for each TMDL are in blue.

[2] Baltimore Harbor TMDL includes the South Branch Patapsco and Patapsco Lower North Branch watersheds. There is no local TMDL specifically for the South Branch Patapsco.

Adaptive Management

The CIS is an important first step; however, the MS4 permit calls for an iterative and adaptive plan for implementation. The County will monitor implementation progress on a regular basis and will report progress, load reductions achieved, and impervious surface reductions to MDE with the NPDES annual report and at required milestone intervals. The County will review the CIS annually and make plan adaptations based on the results. 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 these 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. Plans may also change if pollutant removal crediting methods are modified in the future.

It is also possible that The Maryland Nutrient Trading Policy Statement released by MDE on October 23, 2015 could affect the proposed work effort and costs noted in the CIS. Additionally, ongoing or future legal challenges to the County's MS4 permit or to the TMDLs could affect the County's permit requirements, the amount of restoration and nutrient reductions required, and related project implementation.

The County has applied a disconnection methodology to account for disconnected impervious surfaces. Currently the County is accounting for these disconnections as baseline treatment; however the County is investigating use of the treatment as restoration and may present data and rationale to MDE at a later date with proposed revisions to the baseline and restoration accounting, which would reduce the County's overall restoration requirement.

1 Introduction

1.1 Background and Purpose

Howard County continues to implement significant controls on stormwater discharges under its National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) discharge permit and other Clean Water Act (CWA) requirements. In addition, the County has programs supporting watershed restoration and environmental sustainability that include (1) protection of water resources, (2) public outreach, (3) new investment in stormwater management, and (4) preparation of this countywide implementation strategy.

On December 18, 2014, Howard County received a new National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) Discharge Permit (11-DP-3318, MD0068322) from the Maryland Department of the Environment (MDE) that includes requirements for watershed restoration activities, specifically preparation of a restoration plan within the first year of the permit term (Section IV.E.2). To address this requirement, Howard County has developed this Countywide Implementation Strategy (CIS) that:

- Demonstrates ways to meet the Total Maximum Daily Load (TMDL) Stormwater Wasteload Allocations (SW-WLAs) approved by U.S. Environmental Protection Agency
- Illustrates a strategy to provide additional stormwater runoff management on impervious acres equal to 20% of the impervious area for which runoff is not currently managed to the Maximum Extent Practicable (MEP)
- Educates and involves residents, businesses, and stakeholders in achieving measurable water quality improvements
- Establishes a reporting framework for annual reporting under the County's MS4 permit
- Provides an evaluation and adaptive management process for developing actions to be taken if permit requirements are not met
- Identifies the funding needed to implement the CIS

It is noted that the CIS is an important first step; however, 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. Plans may also change if pollutant removal crediting methods are modified in the future.

1.1.1 Howard County MS4 Permit

Section 402(p) of the Clean Water Act required the EPA to add 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. Howard County is one of five medium jurisdictions in Maryland that is regulated by a NPDES MS4 Discharge Permit (Section 402(p) of the Water Quality Act of 1987 and NPDES Permit Application Regulations for Storm Water Discharges of November 16, 1990). Howard County's first permit went into effect on April 17, 1995 and the County received its fourth permit on December 18, 2014 (11-DP-3318, MD0068322). This fourth permit includes the following new requirements related to Restoration Plans, impervious surface treatment, and TMDLs among others.

Permit Requirements

One objective of this plan is to meet the County's MS4 NPDES permit requirement to restore 20% of the County's impervious surface area that has not already been restored to the MEP per permit section PART IV.E.2.a. Another objective is to develop restoration plans for local TMDLs, specifically each stormwater Waste Load Allocation (WLA) approved by EPA, prior to the effective date of the permit, per permit section PART IV.E.2.b. Plans must be developed within the first year of permit issuance. Howard County's final permit was issued on December 18, 2014 therefore the restoration plans must be complete by December 17, 2015.

The following specific permit sections and language apply:

PART IV. Standard Permit Conditions
E. Restoration Plans and Total Maximum Daily Loads
2. Restoration Plans

a. Within one year of permit issuance, Howard County shall submit an impervious surface area assessment consistent with the methods described in the MDE document "Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated, Guidance for National Pollutant Discharge Elimination System Stormwater Permits" (MDE, June 2011 or subsequent versions). Upon approval by MDE, this impervious surface area assessment shall serve as the baseline for the restoration efforts required in this permit.

By the end of this permit term, Howard County shall commence and complete the implementation of restoration efforts for twenty percent of the County's impervious surface area consistent with the methodology described in the MDE document cited in PART IV.E.2.a. that has not already been restored to the MEP. Equivalent acres restored of impervious surfaces, through new retrofits or the retrofit of pre-2002 structural BMPs [Best Management Practices], shall be based upon the treatment of the WQv criteria and associated list of practices defined in the 2000 Maryland Stormwater Design Manual. For alternate BMPs, the basis for calculation of equivalent impervious acres restored is based upon the pollutant loads from forested cover.

b. Within one year of permit issuance, Howard 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, Howard 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 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 PART 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 including 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 includes: 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 PART IV.E.4.a-e).

In addition to the standard permit conditions described above, the County is also required to address additional programmatic conditions specific to the Chesapeake Bay TMDL as outlined below:

PART VI. Special Programmatic Conditions
A. Chesapeake Bay Restoration by 2025

A Chesapeake Bay TMDL has been developed by the EPA for the six Bay States (Delaware, Maryland, New York, Pennsylvania, Virginia, and West Virginia) and the District of Columbia. The TMDL describes the level of effort that will be necessary for meeting water quality criteria and restoring Chesapeake Bay. This permit is requiring compliance with the Chesapeake Bay TMDL through the use of a strategy that calls for the restoration of twenty percent of previously developed impervious land with little or no controls within this five year permit term as described in Maryland’s Watershed Implementation Plan. The TMDL is an aggregate of nonpoint sources or the load allocation (LA), and point sources or WLA, and a margin of safety. The State is required to issue NPDES permits to point source discharges that are consistent with the assumptions of any applicable TMDL, including those approved subsequent to permit issuance.

Urban stormwater is defined in the CWA as a point source discharge and will subsequently be a part of Maryland’s WLA. The NPDES stormwater permits can play a significant role in regulating pollutants from Maryland’s urban sector and in the development of Chesapeake Bay Watershed Implementation Plans. Therefore, Maryland’s NPDES stormwater permits issued to Howard County and other municipalities will require coordination with MDE’s Watershed Implementation Plan and be used as the regulatory backbone for controlling urban pollutants toward meeting the Chesapeake Bay TMDL by 2025.

The strategies and plans included in this CIS establish the steps that Howard County is taking to fulfill its new MS4 permit requirements.

1.1.2 MS4 Permit Coverage

MDE considers the MS4 Permit for Howard County to be the entire county with the exception of lands which have their own NPDES stormwater permits (Figure 1) including federal lands, state highway lands, and other state lands. NPDES regulated industrial facilities are also excluded from the County's permit coverage. MDE notes that the inclusion of private and non-urban land in the MS4 permit is based on the rationale that stormwater management for private property in Maryland is locally administered for plan approval, inspection, and enforcement, and that these facilities are inherently a part of a locality's storm drain system. The County's SW-WLA responsibilities are only for those areas included in the MS4 area.

It is important to note that the vast majority of lands in the MS4 area are privately owned residential units (as shown in Table 5 of Section 2.2.1 Land Use/Land Cover). Approximately one-half of these residential units are single family detached units with the remainder evenly split between single family attached (townhouses) and apartments. An increase of about one-third in residential units is projected by 2030 (Howard County, 2012a). It is imperative that this CIS address advocacy of best management practices (BMPs) on private residential properties to meet impervious cover treatment and TMDL pollutant load reduction targets. The cooperation of all private property owners will be an important factor in the County meeting these targets.

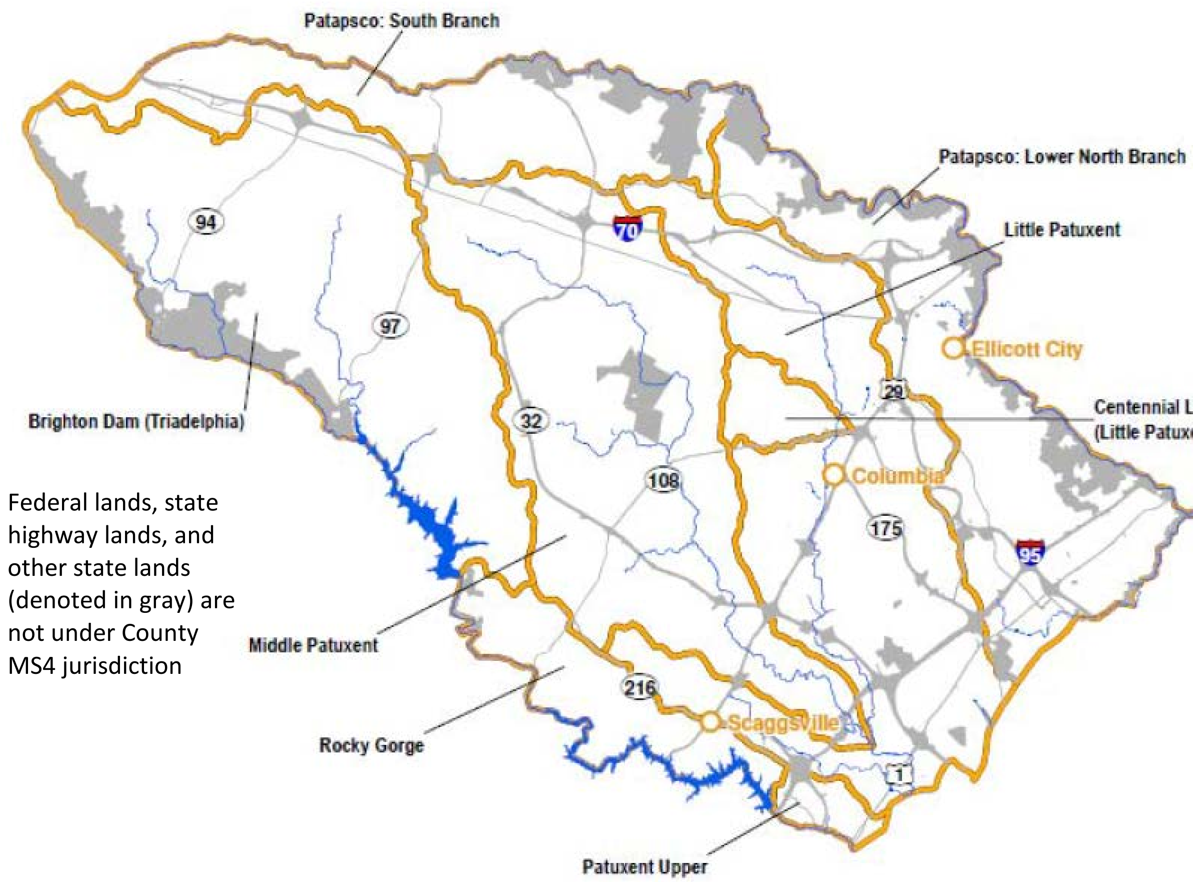


Figure 1. County Watershed and MS4 Permit Area

1.2 TMDL Allocations and Impervious Restoration Targets

1.2.1 Local TMDLs

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) of the CWA requires the state to list these water bodies as impaired waters. States are then required to estimate the maximum allowable pollutant load, or TMDL, that the listed water body can receive and still meet water quality standards.

Howard County has several watersheds where an EPA-approved quantitative assessment study (the TMDL) has established pollutant loading limits for waterbodies. These loading limits represent a maximum amount of a pollutant that the water body can receive and still meet water quality standards, and an allocation of that load among the various sources of that pollutant (e.g., point sources or nonpoint sources). Pollutant loads from point and nonpoint sources must be reduced by implementing a variety of control measures. Responsibility for TMDL reductions is divided among various contributing jurisdictions within the area draining to the water body. 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 NPDES MS4 permit, stormwater runoff from MS4 areas is considered a point source contribution.

As a requirement of section PART IV.E.2.b of the NPDES MS4 Discharge Permit issued by MDE to Howard County, the County must develop restoration plans for each SW-WLA approved by EPA prior to the effective date of the permit. This applies to all current local TMDLs as well as any new TMDLs approved by EPA. Such new TMDLs could be developed for any watersheds in the County that have listed water quality impairments as shown in Table 1. Several County TMDL watersheds fall within neighboring counties; however, SW-WLAs assigned to jurisdictions outside of Howard County's Phase I MS4, which may also include, Phase II jurisdictions, Maryland State Highway Administration, and other NPDES regulated stormwater are not the responsibility of Howard County and are not addressed in the CIS.

The following describes TMDLs that are not addressed in the CIS:

- Centennial Lake sediment and phosphorus TMDLs (approved April 2002) do not have SW-WLAs assigned to the Howard County MS4 source sector
- Lower segment of the Patuxent River Upper bacteria TMDL (approved August 2011) does not have a SW-WLA assigned to the Howard County MS4 source sector
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- South Branch Patapsco does not have a local TMDL, but it is included in the analysis since it, with the Patapsco River Lower North Branch, makes up the Baltimore Harbor watershed.
- The Middle Patuxent watershed does not have a TMDL.

The following statuses shown in Table 1 correspond to the following categories used by MDE to describe water quality impairment listings (MDE, 2015a):

- WQA – Category 2; waters meeting the standards for which they have been assessed based on a completed Water Quality Assessment (WQA)
- Insufficient data – Category 3; waters that have insufficient data or information to determine whether any water quality standard is being attained
- TMDL developed – Category 4a; waters that are still impaired by have a TMDL developed that establishes pollutant loading limits designed to bring the water body back into compliance.
- Impaired – Category 5; water bodies that may require a TMDL

Table 1. MDE Water Quality Impairment Listings and Status for Howard County (as of October 2015)

Impairment	Applicable Segment	Status	Approval Date
PCB in fish Tissue	Patapsco LNB	Insufficient data	
Chlorides	Patapsco LNB	Impaired	
Sulfates	Patapsco LNB	Impaired	
Heavy Metals	Patapsco LNB	WQA	January 2005
Phosphorus	Patapsco LNB	WQA	September 2009
Escherichia coli	**Patapsco LNB**	**TMDL developed**	**December 2009**
Sediment	**Patapsco LNB**	**TMDL developed**	**September 2009**
Escherichia coli	S Branch Patapsco	Insufficient data	
Biological	S Branch Patapsco	Impaired	
Nitrogen/Phosphorus	**Baltimore Harbor**	**TMDL developed**	**December 2007**
Chlorides	Little Patuxent	Impaired	
Escherichia coli	Little Patuxent	Insufficient data	
Phosphorus	Little Patuxent	WQA	March 2010
Cadmium	Little Patuxent	WQA	July 2009
Sediment	**Little Patuxent**	**TMDL developed**	**September 2011**
Sediment	Little Patuxent-Centennial	TMDL completed	April 2002
Phosphorus	Little Patuxent-Centennial	TMDL completed	April 2002
Sediment	Middle Patuxent	WQA	December 2010
Zinc	Middle Patuxent	WQA	July 2009
Nitrogen/Phosphorus	Middle Patuxent	WQA	February 2007
Nitrogen/Phosphorus	Patuxent R. Upper	WQA	February 2007
Escherichia coli	Patuxent R. Upper - lower segment	TMDL completed	August 2011
Escherichia coli	Patuxent R. Upper - upper segment	Insufficient data	
Sediment	**Patuxent R. Upper**	**TMDL developed**	**September 2011**
Biological	Patuxent R. Upper	Impaired	
Phosphorus	**Patuxent R. Upper – Brighton**	**TMDL developed**	**November 2008**
Sediment	**Patuxent R. Upper – Brighton**	**TMDL developed**	**November 2008**
Biological	Patuxent R. Upper – Rocky Gorge	Impaired	
Mercury	Patuxent R. Upper – Rocky Gorge	Impaired	
Phosphorus	**Patuxent R. Upper – Rocky Gorge**	**TMDL developed**	**November 2008**

Final approved TMDLs within Howard County with either an individual or aggregate SW-WLA, shown in bold text
Source: Maryland's Final 2014 Integrated Report of Surface Water Quality (MDE, 2015a)

There are currently eight final approved TMDLs within Howard County with either an individual or aggregate SW-WLA, shown in bold text in Table 1 above and also shown in Figure 2. Although there are sediment and phosphorus TMDLs completed for Centennial Lake (approved April 2002) and a bacteria TMDL completed for the lower segment of the Patuxent River Upper (approved August 2011), they do not have SW-WLAs assigned to the Howard County MS4 source sector and are therefore not included in the CIS.

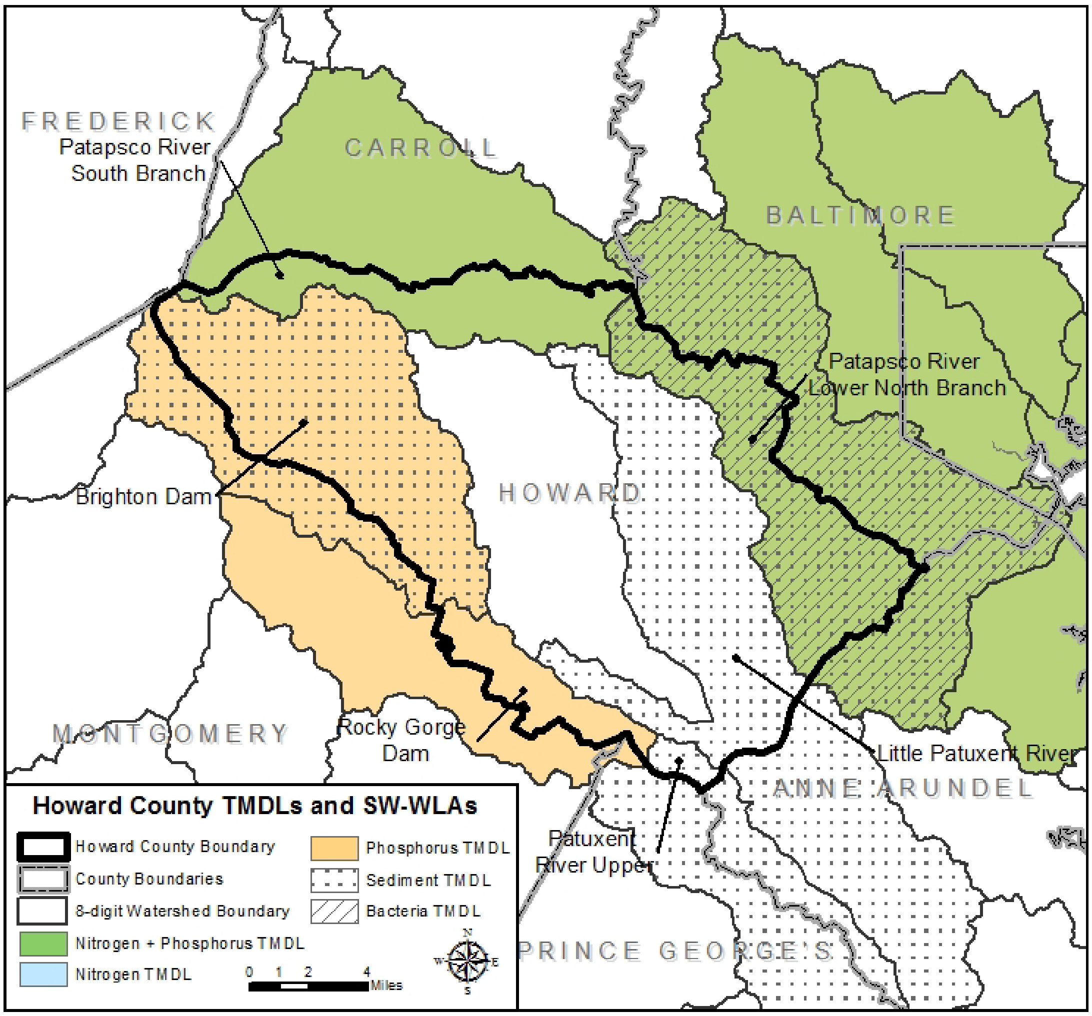


Figure 2. Howard County Local TMDLs with SW-WLAs

This CIS only addresses loads allocated to Howard County NPDES regulated stormwater point source. Howard County local TMDLs with SW-WLAs assigned to the County MS4 are listed in Table 2. It is important to note that the Triadelphia Reservoir (Brighton Dam) sediment TMDL requires 0% reduction with the assumption that meeting the phosphorus TMDL will result in the necessary sediment reductions (MDE, 2008). Therefore, the Triadelphia Reservoir sediment local TMDL is not addressed further in the CIS. Additional SW-WLAs assigned to Maryland State Highway Administration and other NPDES regulated stormwater are not the responsibility of Howard County and will not be addressed in this plan.

All nutrient (i.e., total nitrogen [TN] or total phosphorus [TP]) and total suspended solids (TSS), or sediment, local TMDL SW-WLAs are for edge of stream annual loads (EOS-lbs/yr). An EOS load is the amount of a pollutant load that is transported from a source to the nearest stream annually.

Reduction Target Derivation

In order to derive the County MS4-specific SW-WLA load reduction targets, MDE's published baseline values for each TMDL need to be *disaggregated* and *calibrated* before the percent reduction is applied to calculate the load reduction required. There two procedures are described here in summary form, and in more detail in the attached Technical Appendix, followed by a more detailed description of how the methods were applied to the various watersheds.

Disaggregation

Some SW-WLAs are developed by MDE as an aggregate load including load contributions from multiple jurisdictions. Aggregate values must be first disaggregated to determine the portion of the load that each jurisdiction is responsible for. To date, Howard County has six aggregate SW-WLAs and three individual SW-WLAs (refer to the Technical Appendix for the full listing). There are two methods used in the CIS for disaggregating loads; the first method uses the proportion of County urban land to total urban land in the watershed to partition out the County's baseline load, and the second method uses the BayFAST (Bay Facility Assessment Scenario Tool) model to calculate the baseline load.

Calibration

Howard County's TMDLs were developed by MDE at different periods in time using a variety of models. In order to use current models such as MAST (Maryland Assessment Scenario Tool), which is based on the current version of the Chesapeake Bay Model (v5.3.2), for analysis of load reductions, the baseline load needs to be translated or "calibrated" from the model used to develop the TMDL to the current model. According to the MDE guidance document *Guidance for Using the Maryland Assessment Scenario Tool to Develop Stormwater Wasteload Allocation Implementation Plans for Local Nitrogen, Phosphorus, and Sediment TMDLs* (MDE, 2014b), Section I, baseline nutrient and sediment loads and SW-WLAs must be calibrated to the model used to calculate load reductions:

Because all of Maryland's approved local nutrient and sediment TMDLs were developed using watershed models other than MAST [Maryland Assessment Scenario Tool], the baseline and target loads from these TMDLs need to be translated into MAST loadings. This adjustment is required to account for potential differences between models. This is a two-step process that involves 1) creating a MAST scenario that replicates the baseline year of the TMDL, and 2) applying the load reduction percentage from the TMDL to the MAST loading for the baseline year.

Bacteria Baseline Loads and SW-WLAs

Bacteria load reductions are not modeled using BayFAST or MAST, therefore aggregate bacteria SW-WLAs were disaggregated but did not require calibration. The aggregate SW-WLA for the bacteria TMDL in Patapsco Lower North Branch was disaggregated following steps outlined in MDE's TMDL Stormwater Toolkit (MDE, 2015b). In order to determine Howard County's portion of the load, the aggregate SW-WLA must be disaggregated based on the percentage of Howard County's MS4 regulated urban land area within the TMDL watershed. The proportion of Howard County MS4 urban land area to total urban land area, including other jurisdictions, within the 8-digit watershed boundaries (8-digit watershed boundaries shown in Figure 2) was calculated. Urban land use categories from Maryland Department of Planning 2010 land use data (MDP, 2010) were used to define each jurisdiction's urban area. The percentage of Howard County MS4 urban land area was then applied to the aggregate SW-WLA published in the local TMDL document. Local TMDLs with individual SW-WLAs require a specified percent reduction of pollutant loads from baseline levels to achieve the target SW-WLA and no disaggregation is necessary. A table displaying Howard County local TMDLs with SW-WLAs disaggregated is included in the Technical Appendix.

The load reduction calculated from disaggregating the bacteria SW-WLA following MDE Guidance stated above is the target for the Patapsco River Lower North Branch bacteria local TMDL. This value is presented in bold in Table 2.

Disaggregating and Calibrating Nutrient and Sediment Baseline Loads and SW-WLAs

Local TMDL baseline loads for nutrients and sediments were disaggregated and calibrated in BayFAST (Bay Facility Assessment Scenario Tool). BayFAST allows users to specify the watershed and jurisdiction to model; therefore the results include only Howard County MS4 baseline loads and do not include other municipalities. The results then represent the disaggregated portion of the baseline load.

The baseline model includes County BMPs installed prior to the TMDL baseline year on top of baseline land use background loads. BayFAST functions similarly to (MAST); which is described further in Section 3.2: Modeling Approach of this plan, however BayFAST allows users to delineate facility boundaries (e.g., watershed, parcel, drainage area) and alter land use information within the delineated boundary depending on the model year. A table displaying Howard County nutrient and sediment local TMDLs with baseline loads and SW-WLAs calibrated to BayFAST is included in the Technical Appendix. The general calibration procedure is as follows:

1. For each local TMDL, a facility boundary for the 8-digit TMDL watershed within Howard County borders was delineated within BayFAST.
2. All default land use acreages were deleted and regulated pervious and impervious acres were replaced with MAST Local Base County Phase I MS4 urban pervious and impervious acres using the Compare Scenario tool in MAST for the respective baseline year for each local TMDL. This approach inherently disaggregates County MS4 loads from the rest of the NPDES regulated area within the watershed.
3. County BMPs installed prior to the TMDL baseline year were then added to the model.
4. The reduction percentage published in the TMDL document was then applied to the calibrated baseline loads modeled in BayFAST to calculate a calibrated reduction in EOS-lbs/yr.
5. A calibrated SW-WLA was calculated by subtracting the calibrated reduction from the BayFAST baseline load.

Calibrated load reductions calculated based on TMDL percent reductions and baseline loads modeled in BayFAST using Howard County Phase I MS4 baseline pervious and impervious land use and baseline treatment are the target reductions used in the CIS for nutrient and sediment local TMDLs. These values are presented in bold in Table 2.

More detailed comparison of the results of the disaggregation and calibration process per watershed is included in the Technical Appendix.

Table 2. Disaggregated and Calibrated Local TMDL SW-WLAs and Load Reductions

Watershed Name	Watershed Number	Baseline Year	Pollutant	Unit	Reduction %[1]	Baseline Loads[2]	Load Reductions[3]	WLA[4]
Patapsco River Lower North Branch	02130906	2005	Sediment	EOS-lbs/yr	10%	6,123,442	**612,344**	5,511,098
		2003	Bacteria	Billion MPN/yr	13.4%	60,283	**8,078**	52,205
Baltimore Harbor (Patapsco R LN Br + S Br Patapsco)	02130906	1995	Nitrogen	EOS-lbs/yr	15%	81,058	**16,059**	91,000
	02130908					26,001		
	02130906	1995	Phosphorus	EOS-lbs/yr	15%	5,530	**982**	5,564
	02130908					1,016		
Patuxent River Upper	02131104	2005	Sediment	EOS-lbs/yr	11.40%	145,902	**16,633**	129,269
Little Patuxent River	02131105	2005	Sediment	EOS-lbs/yr	48.10%	10,346,821	**4,976,821**	5,370,000
Rocky Gorge Reservoir	02131107	2000	Phosphorus	EOS-lbs/yr	15%	861	**129**	732
Triadelphia Reservoir (Brighton Dam)[5]	02131108	2000	Phosphorus	EOS-lbs/yr	15%	2,654	**398**	2,256
		2000	Sediment	EOS-lbs/yr	0%	1,844,103	**0**	1,844,103

Target load reductions used in the CIS shown in bold text.

1) Published Reduction % from the MDE TMDL Data Center SW-WLAs for County Storm Sewer Systems in Howard County

2) Nutrient and Sediment Local TMDLs: Baseline loads modeled in BayFAST using County BMPs installed prior to the TMDL baseline year on top of baseline land use background load. Additional load reductions from Howard County lakes installed prior to the baseline year and rooftop/non-rooftop disconnects were included outside of BayFAST. Bacteria Local TMDL: Disaggregated baseline loads calculated by subtracting the disaggregated load reduction from the disaggregated SW-WLA

3) Nutrient and Sediment Local TMDLs: Calibrated reductions calculated by applying the MDE published percent reduction to the BayFAST calibrated baseline loads. Bacteria Local TMDL: Disaggregated load reductions were calculated from the disaggregate WLA and reduction % using the following equation: (Disaggregated WLA / (1 - Reduction %)) - Disaggregated WLA

4) Nutrient and Sediment Local TMDLs: Calibrated WLAs calculated by subtracting the calibrated reduction from the BayFAST calibrated baseline load. Bacteria Local TMDL: Disaggregated WLAs were calculated by multiplying MDE published aggregate WLAs by the percentage of Howard County MS4 land within the urban NPDES land area of the 8-digit watershed.

5) The Triadelphia Reservoir (Brighton Dam) sediment TMDL requires 0% reduction with the assumption that meeting the phosphorus TMDL will result in the necessary sediment reductions (MDE, 2008). Therefore, the Triadelphia Reservoir sediment local TMDL is not addressed further in the CIS.

6) See the Technical Appendix for more detailed information on the disaggregation of aggregate SW-WLAs and calibration of nutrient and sediment SW-WLAs.

1.2.2 Chesapeake Bay TMDL

The Chesapeake Bay TMDL, established by the EPA (EPA, 2010), sets pollution limits for nitrogen, phosphorus, and sediment in the Chesapeake Bay Watershed. Total limits set in the Bay TMDL for the states of Delaware, Maryland, New York, Pennsylvania, Virginia, West Virginia, and the District of Columbia are “185.9 million pounds of nitrogen, 12.5 million pounds of phosphorus and 6.45 billion pounds of sediment per year—a 25 percent reduction in nitrogen, 24 percent reduction in phosphorus and 20 percent reduction in sediment” (EPA, 2010). The TMDL also sets “rigorous accountability measures” for state compliance.

The County’s MS4 permit is requiring compliance with the Chesapeake Bay TMDL through the use of the 20% impervious surface treatment strategy, as described in greater detail in the following section. While not a requirement in the County’s MS4 permit, the strategies provided in this plan to meet local TMDL reduction targets have been modeled in order to calculate potential progress toward meeting the Bay TMDL nutrient and sediment reduction goals.

Table 3 provides a concise summary of Howard County’s portions of target edge of stream (EOS) and delivered (DEL) reductions towards the Chesapeake Bay TMDL and 2010 baseline and 2025 allocated loads. 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 through full implementation of this plan. Planned loads and percent reduction achieved through this plan are discussed in Section 4: Expected Load Reductions and Impervious Treatment.

- **TN, TP, TSS:** Total Nitrogen, Total Phosphorus, Total Suspended Sediment. As specified in the Bay TMDL, if the phosphorus target is met, the sediment target will be met.
- **EOS lbs/yr and DEL lbs/yr:** An EOS load is the amount of a pollutant load that is transported from a source to the nearest stream annually while a DEL load is the amount of a pollutant load that is transported to the tidal waters of the Chesapeake Bay annually. DEL loads are generally less than EOS loads due to losses during transport from streams to the Bay.
- **Calibrated 2010 Baseline Load**: Baseline levels (i.e., land use loads with baseline BMPs) from 2010 conditions in the Howard County MS4 source sector using the Maryland Assessment Scenario Tool (MAST) Chesapeake Bay Program Phase 5.3.2 (CBP P5.3.2) model. Baseline loads were used to calibrate the Bay TMDL nitrogen and phosphorus SW-WLAs.
- **Target Percent Reduction**: Percent reductions assigned to Howard County Phase I MS4 stormwater sector (http://wlat.mde.state.md.us/ByMS4.aspx). If TP target is met, TSS target will be met.
- **Calibrated Target Reduction:** Target reduction calibrated to MAST CBP v.5.3.2 by multiplying the reduction percent published by the 2010 baseline load. If TP target is met, TSS target will be met.
- **Calibrated TMDL WLA**: Allocated loads are calculated from the 2010 baseline levels, calibrated to CBP P5.3.2 as noted above, using the following calculation: 2010 Baseline – (2010 Baseline x Target Percent Reduction); or, 2010 Baseline x (1 – Target Percent Reduction).

Table 3. Howard County Chesapeake Bay TMDL Baseline and Target Loads

Baseline and Target	TN-EOS lbs/yr	TN-DEL lbs/yr	TP-EOS lbs/yr	TP-DEL lbs/yr	TSS-EOS lbs/yr	TSS-DEL lbs/yr
Calibrated 2010 Baseline Load	566,350	319,997	27,609	14,300	26,344,338	20,262,457
Target Percent Reduction	11.98%	12.00%	20.72%	19.74%	-	-
Calibrated Target Reduction	67,849	38,400	5,721	2,823	-	-
Calibrated Bay TMDL WLA	498,501	281,597	21,889	11,477	-	-

1.2.3 Impervious Restoration

As a requirement of section PART IV.E.2.a of the NPDES MS4 Discharge Permit issued by MDE to Howard County, the County must conduct an impervious area assessment to define the restoration efforts required under the permit to restore 20% of remaining Countywide baseline impervious acres not already restored to the MEP. The restoration is required to be complete by 2019, the end of the current permit term.

The first step in this process is to determine the County's MS4 area of jurisdiction and the baseline impervious surface area that is treated, untreated, and partially treated. The County's GIS planimetric impervious layer was used as the basis for the analysis. The most recent and most complete impervious layer is the 2013 version. Using this layer in combination with treatment from existing BMPs, the amount of untreated impervious surfaces was obtained and the 20% then applied. Existing BMPs include structural stormwater BMPs and other treatment including rooftop and non-rooftop impervious surface disconnects, septic system upgrades, rain barrels, and Howard County lakes.

Impervious restoration conducted prior to the implementation of the County's stormwater utility fee, termed the 'Watershed Protection Fee' on July 1, 2013 is considered baseline treatment. All County impervious restoration occurring following the fee is considered restoration credit. As of July 1, 2013 the County was using the fee to fund concerted efforts to plan, design, implement and monitor restoration projects implemented specifically towards meeting the 20% NPDES permit restoration goal; therefore the projects implemented following that date are considered restoration. Section 4 of this report describes the impervious restoration credit achieved.

Impervious accounting methodology is provided here with results at the watershed and County scale presented in Table 4. Although there are no required restoration targets at the watershed scale, the calculations were made at that level to assist in planning and targeting restoration practices to areas with the greatest need. The following steps were used to derive the baseline values and 20% treatment target:

- Define County Jurisdiction – Impervious areas under public ownership other than County ownership and impervious areas regulated under other NPDES permits (Phase I, Phase II or Industrial) were removed as they are not under County jurisdiction. These include state lands, Maryland State Highway Administration (MSHA), and several industrial sites with NPDES permits.
- Baseline 2002 - Maryland's stormwater design regulations as of 2002 required new development to treat 100% of the WQv, or a 1.0-inch storm event. Therefore development with BMPs implemented after 2002 are considered to be fully treated and do not require restoration.

For the purposes of this baseline analysis then, all structural BMPs implemented after 2002 and before July 1, 2013 were considered to be treating 100% of the WQv such that the impervious surface associated with those BMPs could be effectively subtracted from the total. The result represents the impervious surface total as of 2002 with either no, or partial treatment.

- Impervious Treatment (Structural) – Existing structural stormwater BMPs are accounted for in the analysis by calculating the impervious area treated for each BMP following MDE's August 2014 impervious accounting guidance (MDE, 2014c). Impervious area treated is a function of the amount of impervious surface located in its drainage area and the water quality volume treated as a measure of the precipitation event treated. In this manner, BMPs treating the full water quality volume associated with the 1.0-inch rainfall event are considered 100% treated and the full value of impervious acres located in the drainage area are given treatment credit. Values less than 1.0-inch are credited as a function of the rainfall event treated multiplied by the impervious acres. Values more than 1.0 inch are credited following adjustor curve relationships from MDE's guidance, which increases credit by 0.1 acres for every 0.4 inches treated above 1.0 inch (MDE, 2014c).
- Restoration Timing - The breakpoint in time used to distinguish between restoration projects applied to "baseline" credit versus restoration projects applied to "restoration" credit is July 1, 2013. This date represents the County's implementation of its Watershed Protection Fee.
- Other Treatment – Other methods of existing impervious treatment were accounted for including Rooftop and Non-Rooftop Impervious Surface Disconnects, septic system upgrades, rain barrels, and Howard County lakes. These practices, in place before July 1, 2013 were subtracted from the baseline. Detailed descriptions of these practices and their accounting are included in Section 3, Management Measures.
- The result of the calculations Countywide yields the impervious acres that are fully treated, partially treated, and not treated.
- Untreated Impervious Area – Following from the impervious treatment analysis, the total acres of treatment were subtracted from the County's total MS4 impervious area and the result is the acres of untreated or partially untreated impervious area.
- 20% Target – A 20% factor was applied to the County's total untreated impervious acres to determine the restoration target.

Howard County's impervious baseline accounting is presented in Table 4 and Figure 3. Countywide, the total County MS4 Impervious Area, or the area under Howard County jurisdiction, is 18,202.8 acres. The difference between this value and the total impervious area of 20,574.5 is impervious area under other ownership (state lands) and areas regulated by other NPDES permits (MSHA and industrial sites). Existing treatment is broken down by era between new development, redevelopment, and restoration for informational purposes only.

The impervious baseline treated area is 7,981.1 acres and the untreated area is 10,221.6 acres. Applying the 20% factor to the untreated area yields a 20% restoration target of 2,044.3 acres.

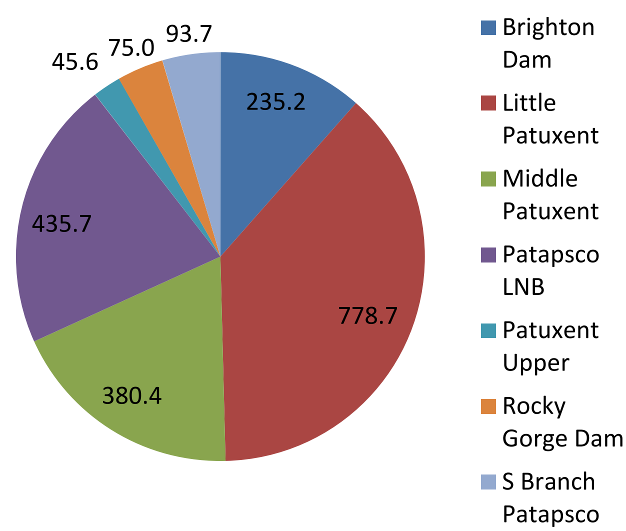


Figure 3. Impervious acre reductions per watershed

Table 4. Impervious Accounting Results per Watershed

	Brighton Dam	Little Patuxent River	Middle Patuxent River	Patapsco River L N Br	Patuxent River Upper	Rocky Gorge Dam	South Branch Patapsco	Countywide
Impervious Baseline and Target (Impervious Credit Acres)								
Total Impervious Area	**1,830.1**	**9,139.7**	**3,410.9**	**4,424.8**	**439.7**	**584.8**	**744.3**	**20,574.5**
County MS4 Impervious Area	**1,691.1**	**8,124.7**	**2,990.6**	**3,854.5**	**381.0**	**530.9**	**629.9**	**18,202.8**
Pre-1985 Stormwater BMPs	2.4	112.4	34.2	15.1	0.0	0.4	0.0	164.4
New Development	*2.4*	*38.2*	*8.0*	*5.4*	*0.0*	*0.4*	*0.0*	*54.2*
Redevelopment	*0.0*	*74.3*	*26.2*	*9.7*	*0.0*	*0.0*	*0.0*	*110.2*
Restoration	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
1985 - 2002 Stormwater BMPs	50.7	743.1	222.9	465.8	67.0	20.6	7.6	1,577.6
New Development	*18.6*	*520.8*	*179.6*	*386.5*	*66.2*	*19.6*	*6.2*	*1,197.5*
Redevelopment	*23.8*	*208.4*	*23.5*	*65.7*	*0.8*	*0.6*	*0.0*	*322.8*
Restoration	*8.3*	*13.8*	*19.8*	*13.6*	*0.0*	*0.4*	*1.3*	*57.3*
2002 - 2013 Stormwater BMPs	230.0	1,613.3	572.7	909.6	72.7	79.5	56.6	3,534.2
New Development	*87.8*	*1,080.9*	*332.8*	*703.8*	*71.7*	*66.0*	*13.0*	*2,356.0*
Redevelopment	*20.0*	*289.8*	*53.0*	*139.0*	*0.1*	*1.1*	*5.0*	*508.0*
Restoration before 7/1/2013	*122.1*	*242.5*	*186.9*	*66.8*	*1.0*	*12.3*	*38.6*	*670.2*
Howard County Lakes	0.0	1,450.2	24.6	152.2	0.0	0.0	0.0	1,627.0
Rooftop Disconnect	55.7	163.5	64.7	44.7	5.5	12.9	20.7	367.5
Non-Rooftop Disconnect	176.2	147.8	168.5	88.6	7.8	42.7	75.7	707.3
Rain Barrels	0.1	0.5	0.1	0.2	0.0	0.0	0.0	0.9
Septic Upgrades	0.0	0.5	0.8	0.0	0.0	0.0	0.8	2.1
Impervious Baseline Treated	**515.0**	**4,231.2**	**1,088.4**	**1,676.1**	**153.1**	**156.0**	**161.3**	**7,981.1**
Impervious Baseline Untreated	**1,176.1**	**3,893.5**	**1,902.2**	**2,178.3**	**227.9**	**374.9**	**468.6**	**10,221.6**
20% Restoration Target	**235.2**	**778.7**	**380.4**	**435.7**	**45.6**	**75.0**	**93.7**	**2,044.3**

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 Howard County. While watershed assessments have been completed for nearly the entire County, shown in the bulleted list below, additional planning to include detailed inventories of projects that can be undertaken to treat impervious surface and control nutrients and sediment in stormwater runoff is needed to meet the restoration targets of the current NPDES permit.

Information synthesized and incorporated into this plan draws upon the sources listed below with updates and additions where necessary to meet the specific goals of the SW-WLAs and impervious restoration goals. The TMDL analyses and reports developed by MDE are also referenced. These primary sources include:

- General watershed restoration assessments and strategies (WRASs) and stream corridor assessments (SCAs) for:
    - Little Patuxent (Howard County, 2002; MDNR, 2001)
    - Middle Patuxent (MDNR, 2002)
    - Lower Patapsco and Deep Run (Howard County 2006; MDNR, 2005)
    - Patuxent reservoirs (WSSC, 2012)

- Specific watershed plans with restoration projects:
    - Deep Run and Tiber-Hudson (U.S. Army Corps of Engineers, Baltimore District, 1999)
    - Cherry Creek (Howard County, 2002)
    - Centennial Lake and Wilde Lake in Little Patuxent (CWP and Tetra Tech, 2005)
    - Sucker Branch and Rockburn Branch in Lower Patapsco (CWP and Tetra Tech, 2006)
    - Downtown Columbia (Howard County, 2010)
    - Lake Elkhorn in Little Patuxent (Versar, Inc., 2009)
    - Upper Little Patuxent (KCI Technologies, Inc., 2009)
    - Tiber-Hudson Subwatershed Restoration Action Plan (CWP, 2013)
    - Little Patuxent (KCI Technologies, Inc., 2015; Versar, Inc., 2015)
    - Middle Patuxent (Versar, Inc., 2015; McCormick Taylor, 2015; BioHabitats, 2015)

- TMDL Documents:
    - Total Maximum Daily Loads of Nitrogen and Phosphorus for the Baltimore Harbor in Anne Arundel, Baltimore, Carroll and Howard Counties and Baltimore City, Maryland (MDE, 2006)
    - Total Maximum Daily Loads of Phosphorus and Sediments for Triadelphia Reservoir (Brighton Dam) and Total Maximum Daily Loads of Phosphorus for Rocky Gorge Reservoir, Howard, Montgomery, and Prince George's Counties, Maryland (MDE, 2008)
    - Total Maximum Daily Loads of Fecal Bacteria for the Patapsco River Lower North Branch Basin in Anne Arundel, Baltimore, Carroll, and Howard Counties, and Baltimore City, Maryland (MDE, 2009a)
    - Total Maximum Daily Load of Sediment in the Little Patuxent River Watershed, Howard and Anne Arundel Counties, Maryland (MDE, 2011a)
    - Total Maximum Daily Load of Sediment in the Patapsco River Lower North Branch Watershed, Baltimore City and Baltimore, Howard, Carroll and Anne Arundel Counties, Maryland (MDE, 2011b)

- Total Maximum Daily Load of Sediment in the Patuxent River Upper Watershed, Anne Arundel, Howard and Prince George's Counties, Maryland (MDE, 2011c)

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)
- Guidance for Using the Maryland Assessment Scenario Tool to Develop Stormwater Wasteload Allocation Implementation Plans for Local Nitrogen, Phosphorus, and Sediment TMDLs (MDE, June 2014)
- Guidance for Developing Stormwater Wasteload Allocation Implementation Plans for Nutrient and Sediment Total Maximum Daily Loads (MDE, November 2014)
- Guidance for Developing a Stormwater Wasteload Allocation Implementation Plan for Bacteria Total Maximum Daily Loads (MDE, May 2014)
- Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated (MDE, August 2014)

The CIS 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 CIS 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 2)

b. An estimate of the load reductions and impervious treatment 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 4)

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 3)

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 5)

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 6)

f. A schedule for implementing the management measures identified in this plan that is reasonably expeditious. (Section 7)

g. A description of interim, measurable milestones for determining whether management measures or other control actions are being implemented. (Section 7)

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 8)

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 9)

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 Howard County's local TMDLs pollutant loading allocations and impervious restoration requirement. Successful implementation of the plan will lead to improvements in local watershed conditions and aquatic health.

2 Causes and Sources of Impairment

2.1 Impairments

Sources of water quality impairments vary across the landscape. The most common impairments in the urban environment are nutrients (nitrogen and phosphorus), sediment, bacteria, and impairment to the biological condition of streams. Impairments can have different implications for management. Impairments that cause a water body to not meet its designated use require the responsible jurisdiction to address the impairment to enable that water body to meet its designated use once again. The mechanism for this in Maryland is through the development and implementation of TMDLs.

2.1.1 Water Quality

Use Designations

Use classes for Maryland streams are defined in the Code of Maryland Regulations (COMAR) 26.08.02.02. For each use class there are several designated uses. 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 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. Use Class II refers to tidal waters, none of which are located within Howard County. Use Class III contains all of the designated uses of Use Class I with the addition of the growth and propagation of trout. Use Class IV contains all of the designated uses of Use Class I and is also capable of supporting adult trout for a put-and-take fishery. Use classes with the '-P' suffix contain all of the designated uses of the use class with the addition of public water supply. Therefore, Use Class III-P has the designated uses of Use Class I with the addition of growth and propagation of trout, and public water supply.

The spatial extent for stream and impoundment use classes is defined in COMAR 26.08.02.08. A map of stream and impoundment use class for Howard County is presented in Figure 4. Use Class I streams within Howard County are defined as: Patuxent River and tributaries not designated Use Class I-P, III, III-P, Iv, or IV-P; Patapsco River Lower North Branch not designated Use Class IV; and Patapsco River South Branch not designated Use Class III or Use Class IV. Use Class I-P streams within Howard County are Little Patuxent River and all tributaries Upstream of Old Forge Bridge except those designated as Use Class IV-P, and Patuxent River and all tributaries upstream of Rocky Gorge Dam except those designated as Use Class III-P or Use Class IV-P. There are no Use Class II streams in Howard County. Use Class III streams in Howard County are Patapsco River South Branch and all tributaries upstream of the confluence with Gillis Falls, unnamed tributary to South Branch Patapsco River at Henryton, and unnamed tributary to South Branch Patapsco River at Marriottsville. Use Class III-P streams in Howard County include Patuxent River and all tributaries upstream of Triadelphia Reservoir. Use Class IV streams in Howard County include Patapsco River Lower North Branch mainstem, and South Branch Patapsco River mainstem downstream of the confluence with Gillis Falls. Use Class IV-P streams in Howard County include Little Patuxent and Middle Patuxent Rivers and all tributaries upstream of U.S. Route 1, and Patuxent River and all tributaries between Rocky Gorge Reservoir and Triadelphia Reservoir including those flowing into Triadelphia Reservoir. All impoundments in Howard County (Centennial Lake, Lake Elkhorn, Lake Kittamaqundi, Triadelphia Reservoir, and Wilde Lake) are listed at Use Class IV-P with the exception of Rocky Gorge Reservoir which is Use Class I-P.

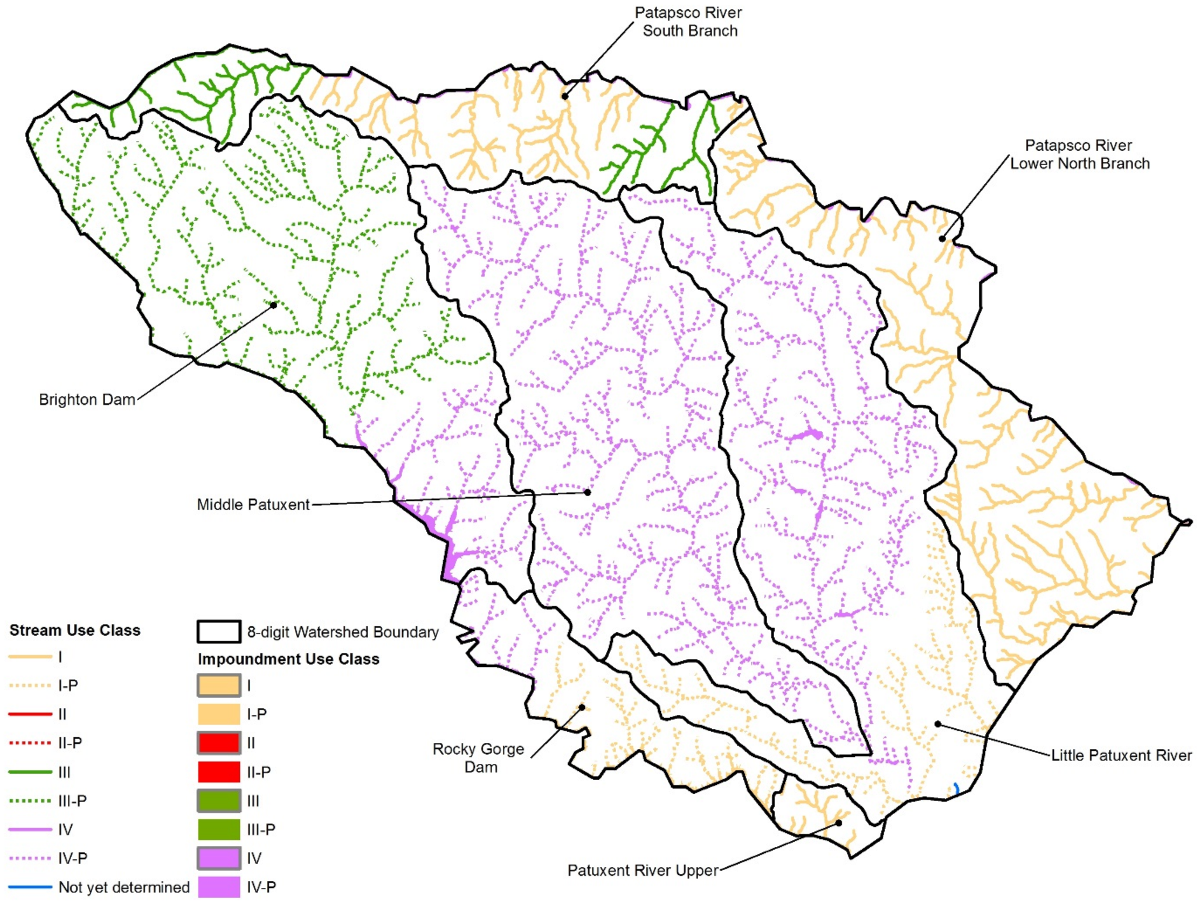


Figure 4. Howard County Stream and Impoundment Designated Use Classes

303(d) Impairments

According to Maryland's final 2014 list of impaired waters (MDE, 2015a), several segments within Howard County are listed for water quality impairments as previously discussed in Section 1.1.2 and shown in Table 1. Howard County contains ten Category 4a stream segments which include those waters that are not meeting their use designation but for which a TMDL has been developed to address impairments. Category 4a waters include five watersheds listed for sediment, three watersheds listed for phosphorus, and two watersheds listed for bacteria. Category 5 waters, which include those waters that are not meeting their use designation and require a TMDL, include three watersheds listed for an unknown pollutant (i.e., cause unknown), two watersheds listed for chlorides, one watershed listed for sulfates, and a final watershed listed for mercury in fish tissue.

2.1.2 Biological Impairments

The condition of Howard County's watersheds, as indicated by Benthic Index of Biotic Integrity (BIBI) scores, is shown in the following map of County stream monitoring results (Figure 5). While stream conditions vary across the county, degradation is more common where the urban area is more dense or older. This reflects, in part, the history of urban and suburban development prior to effective stormwater management regulations. Stream condition is generally better in the more rural parts of the county, but stream degradation still occurs in these areas as a likely result of large lot development and legacy agricultural impacts. By reducing the adverse effects of stormwater runoff throughout the county, this CIS should improve the condition of County streams and watersheds over time.

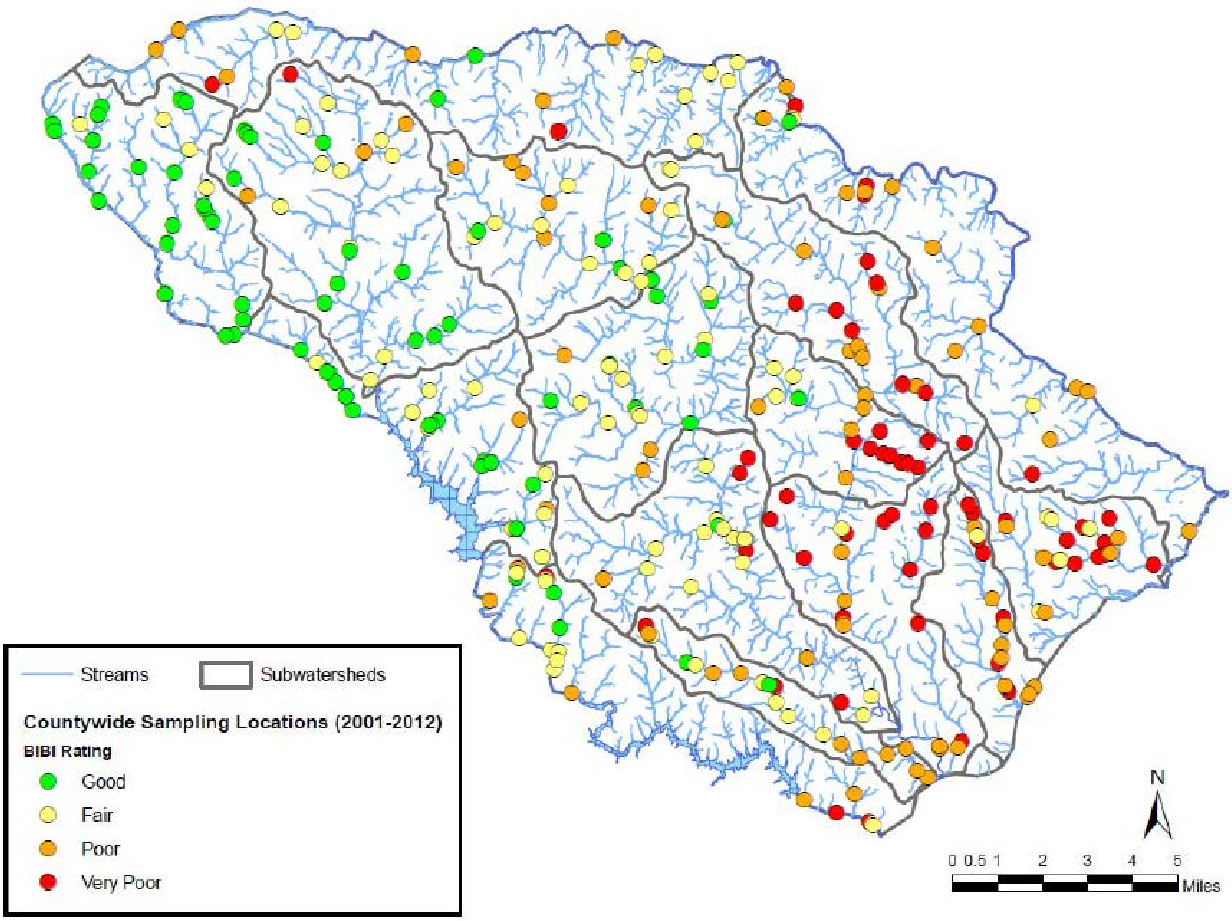


Figure 5. Condition of Howard County streams as indicated by sampling of benthic macroinvertebrate communities at random locations (2001 - 2012)

Recent countywide bioassessment results are available for 2013 and 2014. 2013 sampling took place in the Little Patuxent watershed, comprised of Upper Little Patuxent, Middle Little Patuxent, and Lower Little Patuxent subwatersheds. During 2014, sampling was conducted in the Upper Middle Patuxent, Middle Middle Patuxent, and Lower Middle Patuxent subwatersheds which combined make up the Middle Patuxent watershed.

Results from 2013 sampling (Rogers et al., 2013) indicate that stream biological condition in the Little Patuxent watershed is poor, with the mean BIBI score of the three subwatersheds ranging from 'Poor' to 'Very Poor'. Stream habitat mean scores for all three subwatersheds were in the 'Partially Supporting' or 'Not Supporting' category for the RBP habitat assessment and 'Degraded' for the Maryland PHI habitat assessment. *In situ* water quality results were within COMAR standards excepting two sites, both in the Upper Little Patuxent subwatershed, which had pH values below the codified threshold value of 6.5.

2014 sampling (Rogers et al., 2014) results indicate that all three subwatersheds had mean BIBI scores in the 'Fair' category. Stream habitat mean scores for all three subwatersheds were in the 'Partially Supporting' category for the RBP habitat assessment and 'Degraded' or 'Partially Degraded' for the Maryland PHI habitat assessment. *In situ* water quality results were within COMAR standards excepting two sites, one in the Upper Middle Patuxent and one in the Middle Middle Patuxent subwatersheds, which had pH values below the codified threshold value of 6.5.

2.2 Sources

Approved TMDLs exist for three pollutants in Howard County: nutrients, both nitrogen and phosphorus; sediment; and bacteria.

Nutrients are a pollutant of concern as an overabundance can cause algal blooms. Nitrogen is the limiting nutrient in the Chesapeake Bay, with high levels of nitrogen leading to algal blooms which cause decreased water clarity and light attenuation in the bay, as well as rob the bay of dissolved oxygen as algal blooms die and decompose at the bottom of the water column. Phosphorus is the limiting nutrient in freshwater systems and can lead to algal blooms in lakes and reservoirs with the same impacts as algal blooms in the Chesapeake Bay but also can have an impact on drinking water if the bloom occurs in a reservoir that is used as a water source for municipal drinking water. Both Rocky Gorge and Triadelphia Reservoirs are part of the Washington Suburban Sanitary Commission's (WSSC) drinking water system. Sources of nutrients include agricultural runoff, urban stormwater, municipal wastewater treatment plants, phosphorus bound to sediments supplied to the system, and discharge from upstream impoundments.

Another pollutant of concern is sediments. Sediments consist of particles of weathered rock or soils which make it into streams and are carried downstream to end up in the Chesapeake Bay. Fine sediments in suspension can cloud the water, blocking out light needed for aquatic vegetation to grow, and can accumulate on the bottom of streams, lakes, and the Bay smothering aquatic invertebrates, underwater grasses, and shellfish. Sediments can also help transport nutrients as much of the phosphorus which travels downstream is bound to sediments. Sources of sediments include erosion of poorly buffered agricultural land, instream erosion of stream banks and the stream bed, urban stormwater, shoreline erosion, and as a natural process of rivers and streams.

Bacteria are another pollutant of concern. Bacteria in the water can create a human health hazard and require water contact restrictions in streams, rivers, lakes, and the bay. Bacteria come from multiple sources, which can be classified as either human, domestic pets, livestock, or wildlife. The most common sources of human-specific bacteria are sanitary sewer overflows (SSO), leaking sewer infrastructure, illicit connections, or failed septic systems. Bacteria can originate from pet waste that is not disposed of properly. Livestock are another source of bacteria, especially agricultural feeding operations. Finally, bacteria can come from wildlife living in the watershed, in both urban and forested areas.

Nutrients

Approved TMDLs for nutrients exist for three watersheds in Howard County. Those watersheds are Baltimore Harbor (both nitrogen and phosphorus), Rocky Gorge Reservoir (phosphorus), and Triadelphia Reservoir (phosphorus).

The two largest sources of nitrogen to the Baltimore Harbor as identified in the Baltimore Harbor Nutrient TMDL (MDE, 2006) are municipal and industrial point sources (71%), and urban stormwater (12%). The two largest sources of phosphorus to the Baltimore Harbor from the Baltimore Harbor Nutrient TMDL (MDE, 2006) are municipal and industrial point sources (58%), and urban stormwater (29%). As of 2006, there were two municipal wastewater treatment plants (WWTP) in the watershed (Patapsco WWTP, and Cox Creek WWTP) as well as five industrial wastewater treatment plants.

The Rocky Gorge Reservoir TMDL document identifies the two largest sources of phosphorus as Triadelphia (34%) and cropland (24%).

The two largest sources of phosphorus to Triadelphia Reservoir are cropland (50%) and scour (28%). Scour is sediment delivered to the reservoir that was eroded from stream banks or from the stream bed.

Sediment

Approved TMDLs for sediment exist for four watersheds in Howard County. Those watersheds are Little Patuxent River, Patapsco River Lower North Branch, Patuxent River Upper, and Triadelphia Reservoir.

The sediment TMDL document for Little Patuxent River lists the largest sources of sediment as urban land (67.9%) and cropland (14.4%; MDE, 2011a). The Biological Stressor Identification analysis (BSID) completed by MDE for the Little Patuxent River found that biological impairment is due in part to sediment/flow related stressors; that increased runoff from impervious sources in the urban environment has altered the hydrology and resulted in increased sediment from instream erosion, adversely affecting the instream biological communities.

The sediment TMDL document for Patapsco River Lower North Branch lists the largest sources of sediment as urban land (68.4%) and cropland (16.9%; MDE, 2011b). The BSID analysis completed by MDE for the Patapsco River Lower North Branch found that biological impairment is due in part to sediment/flow related stressors; that increased runoff from impervious sources in the urban environment has altered the hydrology and resulted in increased sediment from instream erosion, adversely affecting the instream biological communities.

The sediment TMDL document for Patuxent River Upper Watershed lists the largest sources of sediment as urban land (42.0%) and cropland (41.0%) (MDE, 2011c). The Biological Stressor Identification analysis (BSID) completed by MDE for the Patuxent River Upper Watershed found that biological impairment is likely due to sediment/flow related stressors; that increased runoff from impervious sources in the urban environment has altered the hydrology and resulted in increased sediment from instream erosion, adversely affecting the instream biological communities.

The TMDL for sediment in Triadelphia Reservoir identified cropland (54%) and scour (38%) as the two largest sources of sediment in that watershed (MDE, 2008). The scour source accounts for instream erosion as the source of sediment input to the reservoir.

Bacteria

Only one watershed in Howard County has an approved TMDL for bacteria: the Patapsco River Lower North Branch. The TMDL (MDE, 2009a) was prepared using monitoring data from five stations on the mainstem of the river, and calculated WLAs and reductions relative to the monitored instream loads. As such, the TMDL addresses delivered loads rather than watershed loads at the source.

Bacteria sources were identified using bacteria source tracking (BST) analysis. The results categorized the probable sources as livestock (38%), human (30%), domestic pets (26%) and wildlife (6%). Sources were not disaggregated in the TMDL to the County level; however, using Maryland Department of Planning land use/land cover data, it is possible to make some conclusions. Agricultural land only accounts for 7% of the land area and there are no animal feeding operations in Howard County's portion of the watershed, so livestock loads are not likely to be a major source. The human sources are more probable in a developed area with older sewer infrastructure or failing septic systems. Forest and wetland areas make up almost one-third of the watershed, so it is likely that wildlife could be a larger source in the County's part of the watershed.

The sources are significant in relation to permit conditions. The TMDL only included domestic pets and urban wildlife as contributors to the SW-WLA subject to the permit. However, there are two other potential human sources which could discharge through the MS4: leaking sewers and illicit connections. Rural wildlife, livestock, SSOs, and failed septic systems are nonpoint sources that generally enter the receiving waters directly and not through a storm drain outfall.

2.2.1 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 nutrients and bacteria.

Land use / land cover (LULC) data from Maryland Department of Planning (MDP, 2010) is presented in Figure 6. Data presented in the figure and tables below were used to characterize the County 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.

Existing Land Use/Land Cover

According to 2010 LULC data (Table 5), the largest category in Howard County is urban, or developed, land (50.3%) followed by forested land (26.1%) and agriculture (22.3%). Developed land largely consists of residential (low-density 17.7%, medium-density 10.1%), and large lot subdivisions (large lot agriculture 4.6%, large lot forest 3.9%). Residential areas as a total make up 39.2% of the watershed.

Land use / land cover data are summarized by watershed in Table 6. The watershed in Howard County with the largest percentage of urban land is Little Patuxent River (68.9%) followed by Patuxent River Upper (63.2%) and Patapsco River Lower North Branch (57.7%). The watershed with the least amount of urban land is Brighton Dam (34.5%), followed by South Branch Patapsco River (35.8%), Rocky Gorge Dam (47.1%), and Middle Patuxent River (48.7%). Patapsco River Lower North Branch (34.4%) and Rocky Gorge Dam (34.1%) are the watersheds with the largest portion of forested land. Brighton Dam (37.5%) and South Branch Patapsco River (36.1%) are the watersheds with the largest amount of agricultural lands.

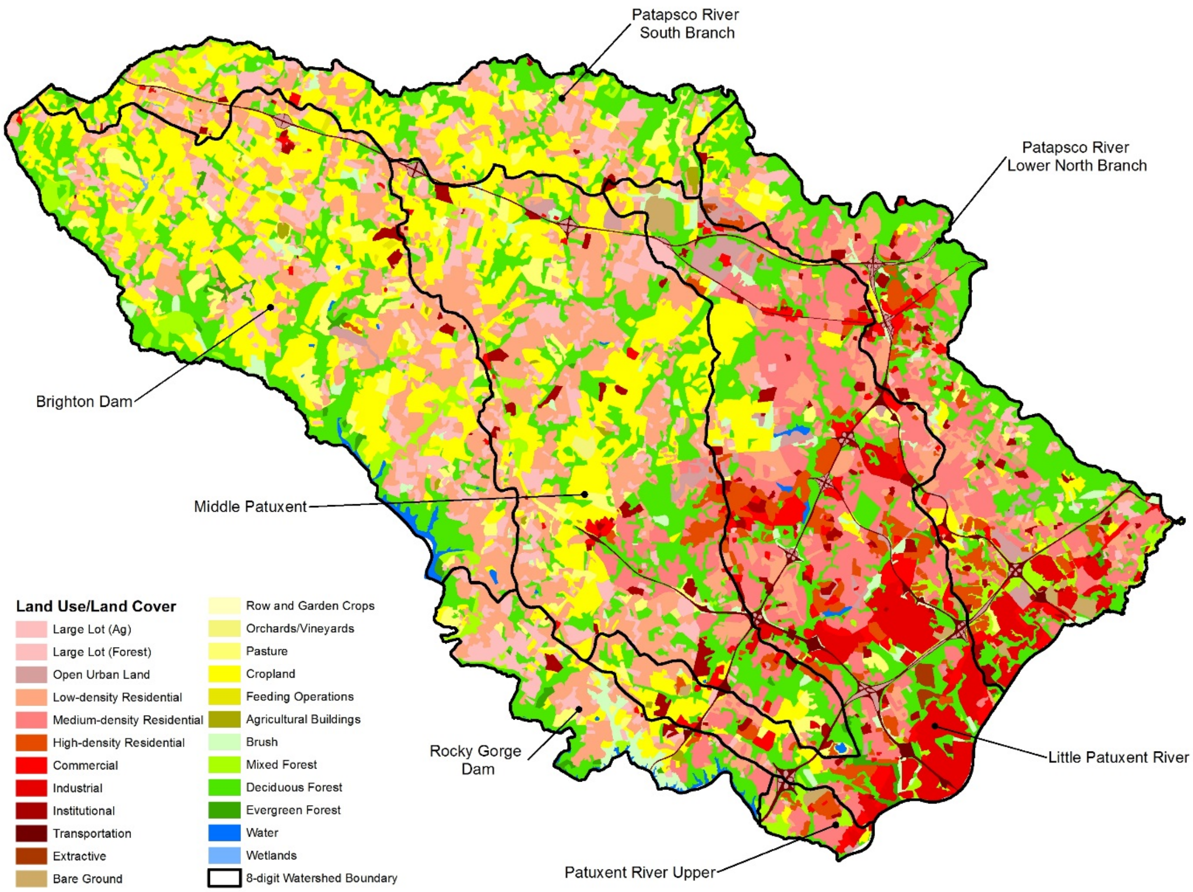


Figure 6. Countywide Land Use/Land Cover (MDP, 2010)

Table 5. Countywide Land Use/Land Cover (MDP, 2010)

Land Use / Land Cover		Acres	Percent
Urban		**81,575.6**	**50.3**
	Large lot subdivision (agriculture)	7,437.0	4.6
	Large lot subdivision (forest)	6,394.9	3.9
	Low-density residential	28,644.9	17.7
	Medium-density residential	16,285.4	10.1
	High-density residential	4,829.4	3.0
	Open urban land	2,978.5	1.8
	Commercial	4,070.1	2.5
	Industrial	5,077.6	3.1
	Institutional	3,269.1	2.0
	Extractive	224.3	0.1
	Transportation	2,364.2	1.5
Agriculture		**36,174.7**	**22.3**
	Cropland	30,051.9	18.5
	Pasture	5,331.6	3.3
	Orchards/vineyards/horticulture	337.7	0.2
	Row and garden crops	57.6	0.0
	Feeding operations	126.9	0.1
	Agricultural building	269.1	0.2
Forest		**42,231.7**	**26.1**
	Deciduous forest	34,139.0	21.1
	Evergreen forest	906.8	0.6
	Mixed forest	4,148.1	2.6
	Brush	3,037.8	1.9
Water		**1,003.6**	**0.6**
Other		**1,049.9**	**0.6**
	Wetlands	29.5	0.0
	Bare ground	1,020.4	0.6
Total		**162,035.5**	**100.0**

Table 6. Land Use/Land Cover (MDP, 2010) and Impervious Cover (2013) by Watershed

Watershed	Urban		Agriculture		Forest		Water		Other		Imperviousness	
	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent
Brighton Dam	12,730.2	34.5	13,864.0	37.5	9,815.9	26.6	488.9	1.3	23.5	0.1	1,830.1	5.0
Little Patuxent River	26,178.5	68.9	3,382.6	8.9	7,774.8	20.5	140.9	0.4	541.5	1.4	9,139.7	24.0
Middle Patuxent River	18,067.5	48.7	10,305.0	27.8	8,595.2	23.2	42.3	0.1	63.4	0.2	3,410.9	9.2
Patapsco River Lower North Branch	13,988.1	57.7	1,593.7	6.6	8,340.0	34.4	0.0	0.0	310.2	1.3	4,424.8	18.3
Patuxent River Upper	1,090.9	63.2	70.7	4.1	478.3	27.7	0.0	0.0	86.0	5.0	439.7	25.5
Rocky Gorge Dam	3,771.0	47.1	1,167.5	14.6	2,729.4	34.1	328.0	4.1	10.6	0.1	584.8	7.3
South Branch Patapsco River	5,749.5	35.8	5,791.1	36.1	4,498.2	28.0	3.6	0.0	14.8	0.1	744.3	4.6

2.2.2 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.

Figure 7 shows the distribution of impervious cover within the County using the County's 2013 planimetric impervious surface spatial data. Table 6 presents a summary of the countywide impervious cover totals by watershed; Table 7 presents a summary of impervious cover totals by each NPDES source sector by watershed; and Table 8 shows the breakdown of impervious cover into individual impervious surface types (e.g., buildings and roads).

The total impervious surface acreage for Howard County is 20,574.5 acres, or 12.7% of the county. Little Patuxent River is the watershed with the most impervious acres at 9,139.7, or 24.0% of total watershed area, while Upper Patuxent River has the largest percentage of imperviousness at 25.5%, or 439.7 acres out of a total 1,725.9 acres (Table 6). The watershed with the lowest impervious percentage is South Branch Patapsco at 4.6%. Table 7 presents percent impervious cover by watershed and NPDES source sector. The majority of the County's impervious cover is within the County MS4 Phase I source sector (89%) with some impervious cover owned by Maryland State Highway Administration (10%), other State-owned property (1%), and some regulated industrial facilities (0.4%).

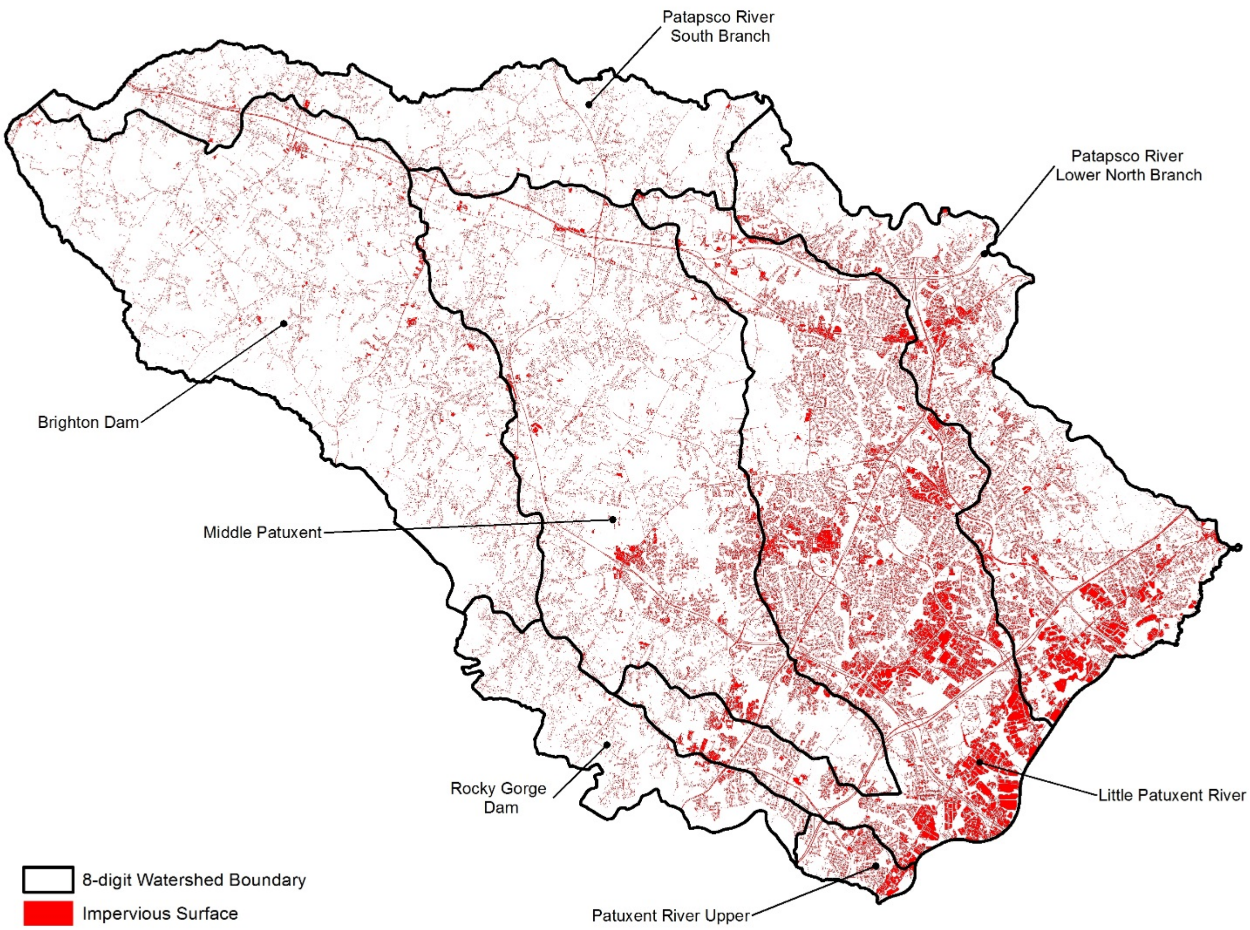


Figure 7. Distribution of impervious cover within Howard County (as of 2014)

Table 7. Percent Impervious Cover by Watershed and NDPES Source Sector

Watershed Name	Total Impervious Acres	City Phase I MS4	County Phase I MS4	County Phase II MS4	Federal Property	Municipal Phase II MS4	Regulated Industrial Facility	SHA Phase I/II MS4	State Property
Brighton Dam	1,830.1	0%	92%	0%	0%	0%	0%	7%	1%
Little Patuxent River	9,139.7	0%	90%	0%	0%	0%	0%	9%	1%
Middle Patuxent River	3,410.9	0%	88%	0%	0%	0%	0%	12%	0%
Patapsco Lower North Branch	4,424.8	0%	87%	0%	0%	0%	1%	10%	2%
Patuxent River Upper	439.7	0%	87%	0%	0%	0%	0%	13%	0%
Rocky Gorge Dam	584.8	0%	91%	0%	0%	0%	0%	9%	0%
South Branch Patapsco	744.3	0%	85%	0%	0%	0%	0%	14%	2%
Countywide Total	**20,574.5**	**0%**	**89%**	**0%**	**0%**	**0%**	**0.4%**	**10%**	**1%**

Table 8. Area and Percent of each Impervious Type within the MS4 for Howard County

Type Impervious	Total Impervious Acres	Percent of Total Impervious in County
Bridge Decks	12.6	0.1%
Buildings	6,003.1	32.8%
Driveway Paved	2,952.4	16.2%
Driveway Unpaved	572.9	3.1%
Parking Lots Paved	3,857.5	21.1%
Parking Lots Unpaved	412.8	2.3%
Roads Paved	4,129.3	22.6%
Roads Unpaved	41.4	0.2%
Sidewalks Major	65.8	0.4%
Sidewalks Minor	29.8	0.2%
Trails and Pathways	199.1	1.1%
Total	18,276.7	100.0%

2.3 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 CIS 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 loads 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. MDE has requested in restoration plan development guidance (MDE, 2014d) that jurisdictions begin estimating potential additional loads, therefore estimates are included in section 2.3.2.

2.3.1 Offsetting Loads from Future Growth

Growth and development is expected to occur throughout Howard 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 Environmental Site 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.”

The following section discusses projected land use loads with the application of stormwater BMPs to the maximum extent practicable (SW to the MEP). TMDL modeling efforts to estimate future loads include the application of SW to the MEP to represent ESD treatment for new development in the watershed. SW to the MEP will control 50%, 60%, 90%, and 70% of nitrogen, phosphorus, sediment and bacteria loads, respectively, for new development.

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.

2.3.2 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, 2014d):

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.

To estimate increases in loads over time, an analysis was completed using a combination of MAST modeled loads and projected loading estimates in addition to estimates based on recent growth patterns. The estimates were completed at the Countywide scale (i.e., sum of all watersheds) and for local TMDL watersheds. The average percent change in County Phase I MS4 urban land use acres (impervious and pervious acres) was calculated as the average percent change observed between MAST land use acres from 2010 through 2015. There was a 1.7% Countywide increase in County Phase I MS4 urban land use acres observed between 2010 and 2015 (Table 9) while average percent change ranged from 1.1% (Patuxent River Upper) to 2.9% (Rocky Gorge Reservoir) for land use acres in local TMDL watersheds (Table 12).

The pace of growth in loads is consistent with growth projections outlined in Howard County's Water Resources Element (WRE) (Howard County, 2010). The WRE is built upon General Plan 2000, a 20-year plan; however, the growth projections of the WRE extend beyond 2020 to the year 2030. The WRE anticipates the same general pace of growth between 2020 and 2030 as in the original 20-year plan between 2000 and 2020. The WRE also acknowledges that the pace may slow as developable land becomes more scarce in the out years approaching 2030. The time period used to assess current growth in loads is 2010 to 2015, which should then be representative of growth for the CIS planning period out to 2025.

Projected TN, TP, and TSS EOS and DEL loads were calculated by applying the average percent change observed between MAST loading results for County Phase I MS4 urban land (impervious and pervious acres) from 2010 through 2015 to loads of the previous year by watershed and Countywide. Since bacteria loading is not available in MAST, the average percent change in bacteria loads in the Patapsco River Lower North Branch was derived using the 2005 MS4 disaggregated baseline load and estimated 2015 loads, which was calculated by applying a bacteria loading rate to 2015 MAST County Phase I MS4 urban land. The average percent change in bacteria loads was then applied to the loads of the previous year.

Howard County average percent change in County Phase I MS4 background pollutant loads are shown in Table 10 which ranges from 1.4% to 1.7%. Average percent change in County Phase I MS4 background loads for watersheds with listed local TMDL pollutants are shown in Table 12 with ranges from 1.1% (Little Patuxent River) to 2.7% (Rocky Gorge Reservoir). In this manner, a 1.7% annual increase in TSS-EOS Countywide loads and a 2.7% annual increase in TP-EOS loads in Rocky Gorge Reservoir would be expected from 2015 to 2025 if development were to occur at the same rate and be implemented without BMPs. Because new development will implement BMPs under Maryland's stormwater regulations, the resultant loading increases were reduced by 50% for TN, 60% for TP, and 90% for TSS based on the MAST removal rates for nutrients and sediment treated by stormwater treatment to the maximum extent practicable (SW to the MEP). Bacteria loading increases were reduced by 70% based on a conservative average reduction rate for bacterial removal by structural BMPs. Projected loading with application of SW to the MEP was incorporated in both Bay and local TMDL modeling and is shown in

Table 11 and Table 12. These additional loads are cumulative since 2015; for example, 2017 additional land use loads consists of additional loads for 2016 growth and 2017 growth.

Table 9. Howard County Average Percent Change in County Phase I MS4 Urban Land Use Acres

County Phase I MS4 Urban Land Use Acres	
2010	63,289
2015	68,683
Average % Change	1.7%

Table 10. Howard County Average Percent Change in County Phase I MS4 Background Pollutant Loads

No BMP County Phase I MS4 Urban Land Use Loads	TN EOS-lbs/yr	TN DEL-lbs/yr	TP EOS-lbs/yr	TP DEL-lbs/yr	TSS EOS-lbs/yr	TSS DEL-lbs/yr
2010	656,081	379,207	36,726	19,835	38,960,095	31,474,608
2015	712,312	406,667	39,682	21,272	42,038,356	33,746,443
Average % Change	1.7%	1.4%	1.6%	1.4%	1.6%	1.4%

Table 11. Additional Estimated Future Loads for Howard County Bay TMDL

Additional Land Use Loads - With SW to MEP	TN EOS-lbs/yr	TN DEL-lbs/yr	TP EOS-lbs/yr	TP DEL-lbs/yr	TSS EOS-lbs/yr	TSS DEL-lbs/yr
2017 Estimate	12,210	5,890	511	247	132,859	97,433
2019 Estimate	24,420	11,780	1,022	493	265,718	194,865
2025 Estimate	61,050	29,449	2,555	1,233	664,295	487,163

Additional loads are cumulative since 2015

Table 12. Nutrient, Sediment, and Bacteria Local TMDLs – Estimated Future Increases in Land Use and Pollutant Loads

County Phase I MS4 Urban Land Use Acres	Baltimore Harbor		Little Patuxent River	Patapsco River Lower North Branch		Patuxent River Upper	Rocky Gorge Reservoir	Triadelphia Reservoir (Brighton Dam)
2010	15,255		24,893	12,918		1,146	2,057	7,624
2015	16,507		26,336	13,870		1,207	2,352	8,709
Average % Change	1.6%		1.2%	1.5%		1.1%	2.9%	2.8%
No BMP County Phase I MS4 Urban Land Use Loads	**TN EOS-lbs/yr**	**TP EOS-lbs/yr**	**TSS EOS-lbs/yr**	**TSS EOS-lbs/yr**	**Bacteria MPN/100 mL/yr**	**TSS EOS-lbs/yr**	**TP EOS-lbs/yr**	**TP EOS-lbs/yr**
2010*	131,274	8,666	16,117,115	9,051,056	60,282	286,799	1,061	3,721
2015	142,760	9,352	17,015,519	9,728,170	70,457	302,996	1,204	4,205
Average % Change	1.7%	1.6%	1.1%	1.5%	1.4%	1.1%	2.7%	2.6%
Additional Land Use Loads - With SW to MEP	**TN EOS-lbs/yr**	**TP EOS-lbs/yr**	**TSS EOS-lbs/yr**	**TSS EOS-lbs/yr**	**Bacteria MPN/100 mL/yr**	**TSS EOS-lbs/yr**	**TP EOS-lbs/yr**	**TP EOS-lbs/yr**
2017 Estimate	2,498	118	37,939	29,111	610	684	26	87
2019 Estimate	4,997	237	75,879	58,222	1,220	1,369	52	175
2025 Estimate	12,491	592	189,697	145,554	3,051	3,422	131	437

*2005 MS4 baseline disaggregated load used to calculate bacteria load growth.

3 Management Measures

Best management practices (BMPs) are either already implemented or are planned for implementation to achieve and maintain the local TMDL load reductions and impervious surface treatment. This section serves to describe the watershed planning process, types of BMPs, and management measures being implemented throughout the County. Load reductions and impervious treatment that result from these measures (Criterion b) are discussed in the following section, Section 4: Expected Load Reductions and Impervious Treatment.

3.1 County Planning Process

The following sections describe Howard County's current watershed-based planning process which includes watershed assessment and implementation.

3.1.1 Watershed Assessment - 2015

Howard County initiated its current watershed assessment approach in the Spring of 2015 with assessments in the Middle Patuxent and Little Patuxent watersheds. Howard County's Stormwater Management Division utilized four teams of consultant contractors to assess the watersheds that were divided into four study area planning units – Northern Middle Patuxent, Southern Middle Patuxent, Northern Little Patuxent, and Southern Little Patuxent. Thus, approximately half of the County's watersheds now have current watershed assessments completed to support TMDL and NPDES assessment and planning requirements (Versar 2015a, Versar 2015b). Table 13 lists the watershed groupings used in the assessment.

Table 13. 2015 Completed Watershed Assessment Areas

Study Area	Included County Watersheds
Northern Middle Patuxent (NMP)	Upper Middle Patuxent Dorsey Run
Southern Middle Patuxent (SMP)	Lower Middle Patuxent Hammond Branch (part of Lower Little Patuxent)
Northern Little Patuxent (NLP)	Upper Little Patuxent Centennial Lake (part of Middle Little Patuxent)
Southern Little Patuxent (SLP)	Middle Little Patuxent (except for Centennial Lake) Lower Little Patuxent

The primary goal of the assessments was to identify impacted, untreated and degraded areas in need of treatment and restoration. A desktop analysis was first conducted to identify those areas that had the highest potential for both impairment and restoration. The evaluation included land use, previous stream assessment results, impervious surface data, stormdrain network mapping, existing citizen erosion and/or drainage complaints, and location and type of existing BMPs. The types of assessments were categorized into several groups based on the type of facility / landform to be assessed and the resulting type of project. The numbers of the various assessments are included here in Table 14. A total of 693 sites were assigned to the consultant teams, where stream miles walked were considered one site for accounting purposes.

Several sites (86) were also identified from the previous watershed studies listed in Section 1.3. These sites were added to the list but were more limited in scope to include a desktop assessment, with field visits when needed, to update the assessment information for these previously documented sites. The total, combining the field and desktop assessments, was 779 sites.

Table 14. Watershed Assessment Numbers of Sites Assessed per Project Type

Impairment / Project Type	NMP	SMP	NLP	SLP	Total
Convert Existing BMPs	55	21	11	73	160
Opportunities for new BMPs for untreated impervious areas	50	29	52	76	207
Potential stream restoration (stream miles)	21	18	24	15	78
Potential Tree planting sites	15	11	16	4	46
Outfall Stabilization	34	36	37	95	202
SubTotal Field Assessment Sites [1]	***175***	***115***	***140***	***263***	***693***
Desktop Assessment	9	15	32	30	86
Total Sites (miles) Assessed [1]	***184***	***130***	***172***	***293***	***779***

[1] Each stream mile counted as one 'site' for accounting purposes

Once the field assessment was complete, the results from each site were evaluated and prioritized with narrative ratings of "high", "medium" and "low" priorities for further development of concept plans to identify the specific issue and a potential solution for each site. The concept plans describe the site conditions, land ownership, benefits expected from completion of the project including calculation of pollutant removal and impervious treatment credits, and any perceived constraints to project implementation including access, tree removal, and conflicts with existing infrastructure or utilities. A planning level cost estimate was derived for each project which included construction, design, survey, permitting and contingency.

The result of the assessment is a prioritized list of 148 high and medium priority projects with completed concept plans that are ready to move into the next phases of implementation. A summary of the projects by type is included in Table 15.

Table 15. Watershed Assessment 2015 Summary of Potential Project Sites from Little and Middle Patuxent

Project Category and Type	Number of Project Sites	Treated Area (ac)	Project Length (ft)
BMP Conversion	**20**	**310.6**	
Extended Detention Structure, Wet	1	4.7	
Micropool Extended Detention Pond	3	46.8	
Retention Pond (Wet Pond)	5	90.0	
Sand Filter	4	34.3	
Shallow Marsh	1	9.0	
Shallow Wetland	2	80.8	
Submerged Gravel Wetlands	3	32.4	

Project Category and Type	Number of Project Sites	Treated Area (ac)	Project Length (ft)
Swale	1	12.6	
New BMP	**10**	**46.1**	
Bioretention	2	6.9	
Perimeter (Sand) Filter	2	4.0	
Retention Pond (Wet Pond)	4	25.4	
Underground Filter	2	9.9	
Outfall	**26**	**171.3**	**4,485.3**
Outfall Stabilization	19	31.5	3,335.7
Step Pool Storm Conveyance	7	139.8	1,149.6
Stream Restoration	**60**		**120,651.1**
Stream Restoration	60		120,651.1
Tree Planting	**32**	**175.3**	
Planting Trees or Forestation on Pervious Urban	32	175.3	
Grand Total	**148**	**703.4**	**125,136.4**

Because there is currently no SW-WLA for Middle Patuxent, and no TMDL anticipated in the near future, it is proposed to limit the implementation of those projects proposed for the Middle Patuxent to half of the projects initially identified. Therefore there are currently 31 projects proposed out of the original 62 identified. Little Patuxent has 86 projects identified from the 2015 watershed assessments. To meet the reductions required by the Little Patuxent sediment TMDL an additional 31 projects will be needed. Concepts for these projects will be derived from the list of high and medium potential sites that were identified in the 2015 assessment. These projects are listed in Table 16.

Table 16. Little and Middle Patuxent Concept Project Types

BMP Type	Little Patuxent	Little Patuxent (pending in 2016)	Middle Patuxent	Total
BMP Conversion	12	5	4	21
New BMP	10	5	0	15
Outfall Stabilization	13	0	3	16
Outfall - SPSC	5	5	1	11
Stream Restoration	32	11	14	57
Tree Planting	14	5	9	28
Totals	**86**	**31**	**31**	**148**

3.1.2 Watershed Assessment – 2016

In 2016, Howard County is planning to complete watershed assessments similar to those completed in 2015 for the Middle and Little Patuxent, for the remaining County watersheds including South Branch Patapsco, Patapsco Lower North Branch, Upper Patuxent River, Rocky Gorge Reservoir and Triadelphia Reservoir (Brighton Dam). It is anticipated that the total number of projects identified will be roughly similar to the projects identified in 2015. For planning purposes, a goal of 160 high and medium priority projects was used and is divided among the watersheds to reach the local TMDL goals specific to each watershed (Table 17). Following analysis of the estimated load reductions that would result from these projects, it was determined that potentially many more projects would be needed, specifically to meet the Patapsco LNB bacteria reductions. As a result a total of 177 high and medium priority projects may be required, 17 more than originally planned. See Section 4 for the load reductions and impervious credits estimated with completion of these projects. It is noted that the number and type of projects are only estimates used for general planning, modeling pollutant reduction, and estimating impervious surface restoration. The final numbers of sites per category are likely to change and be refined in each phase of completion from the watershed assessment phase, through the concept planning phase, and into specific project implementation phases including the design, permitting, and construction.

Table 17. Estimated Number of Projects from 2016 Watershed Assessment Divided by Watershed

BMP Type	Baltimore Harbor		Patuxent R Upper	Rocky Gorge Reservoir	Triadelphia Reservoir (Brighton Dam)	Total
	S Branch Patapsco	Patapsco R LN Branch				
BMP Conversion	0	17	0	0	0	17
New BMP	0	17	0	0	0	17
Outfall Stabilization	0	0	0	0	0	0
Outfall - SPSC	10	67	0	0	0	77
Stream Restoration	5	25	1	1	3	35
Tree Planting	10	21	0	0	0	31
Totals	**25**	**147**	**1**	**1**	**3**	**177**

3.1.3 Project Implementation

Howard County has an implementation process in place through two on-going high-capacity on-call contracts. The first is the Stormwater and Watershed Management Evaluation, Design services contract. The County has three engineering firms on this on-call contract to complete the assessment, design and engineering, permitting, construction phase and monitoring elements of structural stormwater BMP and retrofit projects including all of the project types identified in the current round of watershed assessments. The County has an associated on-call contract for construction, which includes six construction firms. Projects are completed by assigning a firm from each contract to a project site.

3.2 Modeling Approach

A combination of models was used for baseline, progress, and planned pollutant load modeling for Bay and local TMDLs. They are described below. Each BMP provides impervious surface restoration as well as a reduction for nitrogen, phosphorus, and sediment, along with other pollutants.

Section 3.3 presents the suite of practices the County uses for current implementation and/or plans to use to address local TMDL and impervious restoration permit requirements. Section 8 presents information on how progress toward load reductions will be evaluated and how management plans will be adapted on an on-going basis.

MAST and BayFAST

The pollutant loads (i.e., nitrogen, phosphorus, and sediment) for the Bay TMDL baseline and progress scenarios in addition to local TMDL progress scenarios were determined using MAST, which calculates pollutant loads and reductions calibrated to the Chesapeake Bay Program Partnership Watershed Model. MAST, created by Devereux Environmental Consulting for MDE, is a web-based pollutant load estimating tool that streamlines environmental planning. Users specify a geographic area (e.g., County, watershed) and then select BMPs to apply on that area. MAST builds the scenario and provides estimates of pollutant load reductions and allows users to understand which BMPs provide the greatest load reduction benefit and the extent to which these BMPs can be implemented. Based on the scenario outputs, users can refine their BMP choices in their planning. MAST facilitates an iterative process to determine if TMDL allocations are met. Scenarios may be compared to each other, to TMDL allocations, or to the amount of pollutants reduced by current BMP implementation.

MAST 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 MAST and the 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 load reduction can vary depending on which BMPs are implemented.

The baseline pollutant loads for nutrient and sediment local TMDLs were determined using BayFAST (Bay Facility Assessment Scenario Tool). BayFAST functions similarly to MAST but allows users to 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. Local TMDL baseline scenario loads are provided in MAST; however, the functionality to edit baseline BMPs in the scenarios is not available.

Both the Watershed Model and MAST/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. Local TMDL plans focus on reducing load on the land, so EOS estimates are more appropriate and were used for nutrient and sediment modeling analysis.

Removal Rate Curve Equations

Pollutant load reductions for planned projects were calculated using revised removal rate curve equations for runoff reduction (RR) and stormwater treatment (ST) practices prepared by Chesapeake Stormwater Network (Schueler and Lane, 2015). Reductions are calculated based on rainfall treatment, whether noted in project concepts or as an assumption of 1-inch treatment, and removal efficiencies per RR and ST practice (Table 18).

Table 18. Runoff Reduction and Stormwater Treatment Practices Removal Rate Reductions

Practice	Rainfall Treatment	Nitrogen Reduction	Phosphorus Reduction	Sediment Reduction
Runoff Reduction (RR)	1”	60%	70%	75%
Stormwater Treatment (ST)	1”	35%	55%	70%

Bacteria Modeling

Bacteria loads were modeled with a spreadsheet analysis. Because of the high variability in loading, sources which are difficult to identify or quantify, unknown processes of die-off or growth, and lack of data, more sophisticated approaches were not judged to provide a significantly better estimate of loads or reductions to justify the additional effort.

The TMDL did not provide sufficient information to break out the source categories for the Howard County portion of the watershed. As a result, a single loading factor was derived for the regulated urban land by dividing the disaggregated baseline load by the regulated land area. This factor was used to estimate loading to BMPs. It represents the human, domestic pets, and urban wildlife sources that contribute to the SW-Baseline loads.

Two types of treatment were modeled. The first was load reductions for non-structural measures that can help reduce bacteria loads, such as the Howard County Department of Recreation and Parks Bark Rangers program. Calculations for load reduction measures were made using algorithms and default parameters from the Watershed Treatment Model (Caraco, 2001).

The second type of treatment modeled was conventional structural stormwater management. For these facilities, removal rates were derived from the International Stormwater BMP Database, supplemented with other sources. No bacteria removal rates were found for some of the approved BMPs, including rooftop disconnection, permeable pavement, stream restoration, outfall stabilization, tree planting, or vegetated open channels. These types of practices are not credited for bacteria treatment.

3.3 Best Management Practices

Many stormwater BMPs address both water quantity and quality, however, some BMPs are more effective at reducing particular pollutants 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 Howard County 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 Watershed Implementation Plan (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. MAST 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 credited as 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. The retrofits promote infiltration and reduce stormwater velocities. This strategy is modeled in MAST as SW to the MEP. Bacteria reductions for this practice are modeled as a sand filter.

- **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.
- **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 –** Howard 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.

Along with the standard set of structural BMPs listed above, treatment will also be provided through alternative and non-structural measures including the following strategies that are performed through the programs listed below:

Impervious Surface Disconnects

Howard County has developed a process to account for existing disconnections of impervious surfaces from both rooftop and non-rooftop sources. The County's method involves GIS analysis and field verification of a percentage of credited sites and follows the disconnection methods outlined in the Maryland Stormwater Design Manual. The methodology for rooftop disconnects has been reviewed and approved by MDE. Approval for the non-rooftop disconnect methods is pending.

Currently the County is accounting for these disconnections as baseline treatment; however the County is investigating use of the treatment as restoration and may present data and rationale to MDE at a later date with proposed revisions to the baseline and restoration accounting, which would reduce the County's overall restoration requirement.

Rooftop Runoff disconnection treats runoff of residential downspouts by directing the water to pervious areas with relatively low slope. This slows the water and allows it to be infiltrated into the soil. The main functions of this method are to reduce runoff velocity, decrease erosion, and therefore reduce the amount of pollutants reaching local waterways. Some residential areas built previous to 2000 meet the criteria for the rooftop runoff disconnection credit.

Non-rooftop disconnection credit is given for practices that disconnect surface impervious cover runoff by directing it to pervious areas where it is either infiltrated into the soil or filtered (by overland flow). Sites that are graded to promote overland vegetative filtering may receive a non-rooftop disconnection credit.

Specific details of the methods can be found in Technical Memoranda entitled *Howard County Rooftop Disconnection Analysis,* (McCormick Taylor, 2015a), and *Howard County Non-rooftop Disconnection Analysis*, (McCormick Taylor, 2015b). A summary of the criteria and included here.

According to Chapter 5 of the *Maryland Stormwater Design Manual*, to receive credit for disconnection, the follow criteria must be met:

Rooftop Runoff Disconnection Credit Criteria

- In residential development applications, disconnections will only be credited for lot sizes greater than 6,000 square feet.
- The length of the "disconnection" shall be 75 feet or greater.
- Dry wells, french drains, rain gardens, or other similar storage devices may be utilized to compensate for areas with disconnection lengths less than 75 feet.
- The entire vegetative "disconnection" shall be on an average slope of 5% or less.
- Rooftop cannot be within a designated hotspot.
- Disconnection shall cause no basement seepage.
- The contributing area of rooftop to each disconnected discharge shall be 500 square feet or less.
- The disconnection must drain continuously through a vegetated channel, swale, or through a filter strip to the property line or BMP.
- For those rooftops draining directly to a buffer, only the rooftop disconnection credit or the buffer credit may be used, not both.

Non-Rooftop Runoff Disconnection Credit Criteria

- Runoff cannot come from a designated hotspot.
- The maximum contributing impervious flow path length shall be 75 feet.
- The disconnection shall drain continuously through a vegetated channel, swale, or filter strip to the property line or BMP.
- The length of the "disconnection" must be equal to or greater than the contributing length.
- The entire vegetative "disconnection" shall be on an average slope of 5% or less.
- The surface impervious area to any one discharge location cannot exceed 1,000 sq. ft.
- Disconnections are encouraged on relatively permeable soils (HSG's A and B).
- If the site cannot meet the required disconnect length, a spreading device, such as a french drain, rain garden, gravel trench or other storage device may be needed for compensation.
- For those areas draining directly to a buffer, only the non-rooftop disconnection credit or the stream buffer credit can be used, not both.

Impervious surfaces located within existing stormwater BMP drainage areas were removed from the analysis so as to not double count the impervious treatment credited.

Street Sweeping

Street sweeping is an operational program that the County has managed since 1996 to reduce pollutant loads. According to MDE's guidance document (2014a), mechanical street sweeping at a rate of 2 times per month reduces the load on the swept area by TN 4% / TP 4% / TSS 10%. 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.

Forthcoming crediting guidance from the Chesapeake Bay Program (CBP, 2015) indicates that some credit can be obtained for sweeping at a frequency of at least 10 times per year for mechanical street sweeping; however, the credits are very low at 0.1% for TSS and 0% for TN and TP. Even mechanical sweeping at twice a week (100 times per year) is low in removal rates with 0.7% for TSS and 0% for TN and TP. Use of sweepers with Advanced Sweeping Technology (AST) yields much better removal according to the guidance, at up to TN 4% / TP 10% / TSS 21% for 100 times per year. AST is defined as sweepers classified as either Regenerative-Air Sweepers (RAS) or Vacuum Assisted Sweepers (VAS).

Currently, the County uses mechanical broom sweepers (MBS) to sweep roads with curbs and gutters four times each year. Road length listed per watershed is shown Section 4.1. The frequency and technology used would not receive any credit under either of the guidance and crediting methods mentioned above. The County will research its current sweeping methods including routes, technology, frequency and cost and potentially seek ways to improve the performance of the technique to obtain credit in the future.

Septic Systems

Septic system maintenance (pump-outs), upgrades and waste water treatment plant connections are methods to reduce impacts from septic systems, especially for nitrogen as septic systems can be a major contributor of nitrogen. Credits for TN, TP and TSS for septic system maintenance are not given for the urban stormwater sector. Pollution removal credits to the County for septic maintenance would fall under the waste water sector and are therefore not accounted for in the CIS which focuses on the stormwater sector.

Credit for impervious surface restoration, however, is available for three septic system activities. Septic pump-outs, that are part of a regular septic system maintenance program, provide 0.03 equivalent acres of restoration when a system is maintained and verified annually. Septic upgrades to install enhanced septic denitrification technologies result in a permanent credit of 0.26 equivalent acres for each upgrade completed. Additionally, 0.39 equivalent acres would be credited for each septic system connected to a WWTP.

Howard County maintains data on the number of septic upgrades on an annual basis, completed largely through the Bay Restoration Fund (BRF) grant program. In total 162 upgrades were completed between FY11 and October of FY16. Replacement or upgrades of failed septic systems are also an alternative for reducing bacteria in a watershed, although, it addresses the LA and not the WLA of a TMDL. Each upgrade reduces bacteria loads by approximately 2 billion MPN/100mL/yr.

Howard County is investigating implementation of a Septic Pump-Out rebate program to encourage and help document the number of septic pump-outs completed per year. Pump-outs are credited for impervious surface treatment at a rate of 0.03 equivalent acres for every unit participating. The practice is considered an annual credit that needs to be maintained with regular annual pump-out. Septics programs are discussed further in Sections 4, 5, and 7.

Forest Conservation/Reforestation Program

This program began in 1996 and provides developers, who do not have the room to do their forest conservation "on-site", the option to pay a fee-in-lieu to the County. A portion of this fee is passed on to the Department of Recreation & Parks, Natural Resources Division to perform the mitigation. The Department, which manages over 8,000 acres, determines where the trees are most needed. The County's first priority is planting and enhancing riparian forest buffers.

Stream ReLeaf

The Stream ReLeaf Program was initiated by the Howard County Stormwater Management Division (Department of Public Works) in 2003 as part of the implementation of the Little Patuxent River Watershed Restoration Action Strategy. The Program has grown and expanded in scope significantly over the years, and is now managed by the Natural Resources Division of the Department of Recreation and Parks.

Stream ReLeaf is a program designed to enhance riparian (stream) buffers by providing free native trees and shrubs to homeowners. The homeowner commits to planting the trees and shrubs on their property and the County delivers the requested plants. Requirements for the program are as follows: the area that the homeowner is willing to plant must be within 75 feet of a stream (rights of ways are not eligible); and the homeowner must commit to planting at least 12 trees.

The Bark Ranger Program

In the summer of 2013, the Park Rangers of Howard County Recreation and Parks implemented a new program to address loads from domestic animals. “Bark Ranger” encourages patrons to clean up after their pets, more specifically dogs, and to use a leash while visiting Howard County parks. Dog feces not picked up is unsightly, negatively impacts ground and surface water, and attracts rodents. Currently the program has 1,400 participants signed up for the program.

Nutrients, sediment, and bacteria can be modeled as a load reduction BMP using parameters for the amount of feces picked up and the pollutant fraction per pound. Forecasts of program expansion can be estimated with data from surveys that estimate the number of dogs in a watershed, describe the impact of types of outreach, and proportion of dog owners willing to change their behavior.

Canada Goose Management Program

Dealing with high population levels of resident Canada geese, mallards and illegally released domestic waterfowl is an ongoing problem on Recreation and Parks lands. The County currently treats goose nests at Centennial Lake and Font Hill under a federal permit that allows eggs to be coated with vegetable oil to prevent hatching. In addition to nest treatment, the Department continues to address this issue through an integrated approach that includes public education, habitat modification, behavior modification, and population reduction.

Deer Population Management in Howard County Parks

Managed deer hunts take place on prescheduled dates from October until February and are a response to continuing damage to trees, shrubs and groundcover in the parks from deer browsing. Without management, the current trends will continue causing degradation of forest shrubs and ground cover layers. Long-term forest health will also be impacted since replacement of mature canopy trees would be reduced or eliminated through destruction of seedling stock. These impacts have been documented on these properties, and are well confirmed in scientific literature.

Load reductions from deer management can be estimated similarly to methods used for domestic pets. Using literature data on the annual amount of deer droppings and pollutant fractions, the load reduction per deer can be calculated.

County Lakes

Howard County has many lakes that are providing water quality volume reduction and pollution attenuation and treatment and therefore should be credited for impervious surface restoration and pollutant load reduction. All lakes included in the analysis were developed prior the impervious baseline cutoff (July 1, 2013), prior to the Bay TMDL baseline (2010), and prior to the local TMDL baseline for the watershed in which they are located; therefore all lakes were accounted for as baseline treatment, both for impervious baseline calculation and for development of calibrated TMDL baseline values.

Lakes were modeled as 'Wet Ponds / Wetlands' as described above and following MDEs accounting guidance for stormwater treatment (ST) practices (MDE, 2014a) with treatment factors presented in Table 20 and Table 21 below. To account for lake treatment, the design plans for each lake were researched to define the WQv (acre feet) provided by each facility. Current impervious surface values were calculated for each lake's drainage area to determine the WQv required. The ratio of WQv provided to WQv required represents the runoff depth treated (inches). Impervious treatment was then calculated as the runoff depth treated times the impervious area, with allowances for extra credit as defined by MDE (2014a); however impervious area already treated by other nested stormwater BMPs was subtracted to avoid double counting of treatment. Lakes included in the baseline credit accounting are listed in Table 19. Results are included in section 4 below.

Table 19. County Lakes used in Credit Accounting

Lake	Watershed	Built Date
Centennial Lake	Little Patuxent River	11/15/1999
Lake Elkhorn	Little Patuxent River	1/1/1986
Lake Kittamaqundi	Little Patuxent River	8/2/1989
Wilde Lake	Little Patuxent River	7/18/1993
Lang Beach (Jackson Pond)	Little Patuxent River	10/20/2008
Shadow Lane	Middle Patuxent River	11/19/1984
Montgomery Meadows	Patapsco River LNB	7/14/1992
Waverly Woods	Patapsco River LNB	4/20/2001

Rain Barrel Program

Howard County continues to provide residents with free barrels through the County's Rain Barrel Program. Predrilled rain barrels are available free of charge to residents who attend seminars at the Alpha Ridge landfill. Residents purchase the hardware needed and Master Gardeners provide free instruction on how to assemble the rain barrels. A total of 586 rain barrels have been given away within the past four years. Pollutant reduction for existing rain barrels are modeled as an ESD micro scale practice using the impervious surface reduction BMP type in MAST. Credit for future planned implementation is given for pollutant reduction using land use loading rates with treatment percentages following removal curves in MDE guidance (MDE, 2014c). Impervious surface treatment is based on the square feet and inches of rainfall treated per rain barrel, with a 0.75 factor applied relating rain barrels to impervious surface treatment (Goulet and Schueler, 2014).

Rain Gardens

For the past two years, the County has provided funding for the READY (Restoring the Environment and Developing Youth) program. Led by the Alliance for the Chesapeake Bay, People Acting Together in Howard (PATH), Parks and People Foundation, and the University of Maryland Extension Service, the READY Program teaches young adults about environmental issues, trains them to build water quality projects, asks them to give presentations throughout the community, and has them install local projects. This program uses college students and community associations to create rain gardens and other stormwater enhancements at churches, schools and open space areas. The County assists by excavating areas where the rain gardens are to be installed for an eight-week period during the summer. This practice is modeled as bioretention in MAST.

The measured effectiveness and impervious equivalency for each of these practices may be found in Table 20 and Table 21.

Table 20. Typical Pollutant Reductions from Structural and Non-Structural BMPs

BMP	Nitrogen	Phosphorus	Sediment	Bacteria
Bioretention A/B soils	70%	75%	80%	70%
Bioretention C/D soils	25%	45%	55%	70%
Bioswales	70%	75%	80%	-5%
Dry Detention Ponds	5%	10%	10%	66%
Dry Extended Detention Ponds	20%	20%	60%	60%
Impervious Surface Reduction*	-	-	-	-
Infiltration w/ sand, veg.	85%	85%	95%	90%
Infiltration w/o sand, veg.	80%	85%	95%	90%
Outfall Enhancement with SPSC**	50%	60%	90%	70%
Permeable Pavement w/ sand, veg.	80%	80%	85%	-
Permeable Pavement w/o sand, veg.	75%	80%	85%	-
Septic Systems (pumping, upgrades, connections)	0%	0%	0%	1.9 billion MPN/ 100mL each
Stream Restoration	0.08 lbs/ linear ft	0.07 lbs/ linear ft	44.88 lbs/ linear ft	-
Street Sweeping	0%	0%	0%	-
Urban Filtering	40%	60%	80%	60%
Urban Tree Plantings*	-	-	-	-
Vegetated Open Channels	45%	45%	70%	-
Wet Ponds or Wetlands	20%	45%	60%	95%

Sources: MDE, 2014c; Maryland Assessment Scenario Tool (MAST) documentation; International Stormwater BMP Database, Watershed Treatment Model

* Calculated as a land use change to a lower loading land use

**Outfall enhancement with SPSC modeled as SW to the MEP in MAST for nutrients and sediment and as sand filters for bacteria

Table 21. Impervious Acre Equivalent for Structural and Non-Structural BMPs

BMP	Treatment Unit	Impervious Acre Equivalent*
Bioretention A/B soils	WQv (provided)/WQv (required)	1.00
Bioretention C/D soils	WQv (provided)/WQv (required)	1.00
Bioswales	WQv (provided)/WQv (required)	1.00
Dry Detention Ponds	WQv (provided)/WQv (required)	0.00
Dry Extended Detention Ponds	WQv (provided)/WQv (required)	0.00
Impervious Surface Reduction	Per acre disconnected or removed	0.75
Infiltration	WQv (provided)/WQv (required)	1.00
Outfall Stabilization	WQv (provided)/WQv (required)	0.01
Permeable Pavement	WQv (provided)/WQv (required)	0.75
Rain barrel	WQv (provided)/WQv (required)	0.75
Septic pump-outs	Per unit (annual practice)	0.03
Septic Upgrades (denitrification)	Per unit	0.26
Step Pool Storm Conveyance (SPSC)	WQv (provided)/WQv (required)	1.00
Stream Restoration	Linear foot	0.01
Street Sweeping	Dry ton removed	0.00
Urban Filtering	WQv (provided)/WQv (required)	1.00
Urban Tree Plantings	Acres planted	0.38
Vegetated Open Channels	WQv (provided)/WQv (required)	1.00
Wet Ponds or Wetlands	WQv (provided)/WQv (required)	1.00

Source: MDE, 2014c

*Assuming full 1-inch rainfall treatment, full WQv is provided. Acres of impervious in BMP drainage area is multiplied by the equivalent acres to determine credited acres

4 Expected Load Reductions and Impervious Treatment

4.1 2015 Progress – Actual Implementation

Howard County maintains an extensive geodatabase of urban stormwater BMP facilities and water quality improvement projects. Current BMP implementation through November 2015 is shown in Table 22. The treatment provided through current BMP implementation towards the County's local TMDL, impervious treatment, and Bay TMDL goals are shown in the sections below.

4.1.1 Local TMDLs

2015 Progress results are shown in Table 23 with modeling terminology defined below. This modeling terminology is also used in Table 24, which presents Chesapeake Bay TMDL 2015 Progress results.

- **Calibrated Baseline Loads**: Baseline levels (i.e., land use loads with baseline BMPs) from baseline year conditions in the Howard County MS4 source sector for each SW-WLA calibrated to BayFAST CBP v.5.3.2. Baseline years vary by local TMDL (as presented in Table 23). Patapsco River Lower North Branch bacteria baseline disaggregated according to County MS4 urban land area within the watershed.
- **Target Percent Reductions**: Percent reductions assigned to Howard County Phase I MS4 stormwater sector (http://wlat.mde.state.md.us/ByMS4.aspx).
- **Calibrated Target Reductions:** Target reduction calibrated to BayFAST CBP v.5.3.2 by multiplying the reduction percent published by the calibrated baseline load. Patapsco River Lower North Branch bacteria load reduction disaggregated according to County MS4 urban land area within the watershed.
- **Calibrated TMDL WLA**: Allocated loads are calculated from the baseline levels, calibrated to CBP P5.3.2 as noted above, using the following calculation: Baseline – (Baseline x Target Percent Reduction); or, Baseline x (1 – Target Percent Reduction). Patapsco River Lower North Branch bacteria WLA disaggregated according to County MS4 urban land area within the watershed.
- **Restoration Reduction**: Load reductions from restoration BMPs with a built date after the baseline to 2015.
- **Restoration Reduction Percent**: The percent difference of the baseline load and the restoration reduction.
- **Reduction Remaining for Treatment**: The difference between the calibrated TMDL target reduction and restoration reduction.
- **Reduction Percent Remaining**: The difference between the Target Percent Reduction and Restoration Reduction Percent. This is the percent reduction left to be treated.

Progress as of 2015 is mixed across the watersheds. Very good progress has been made in the Little Patuxent and Patapsco River Lower North Branch watersheds with 697,379 lbs and 99,887 lbs of sediment being treated by County restoration projects through 2015, respectively. However, with a target percent reduction of 48.1%, there is still 41.4% reduction percent remaining for Little Patuxent. Sixty-two percent of the Patapsco River Lower North Branch bacteria and half of the Rocky Gorge Reservoir phosphorus reduction targets were treated by County restoration projects through 2015.

Table 22. Current BMP Implementation through 2015

BMP	Unit	Brighton Dam	Little Patuxent River	Middle Patuxent River	Patapsco River L N Branch	Patuxent River Upper	Rocky Gorge Dam	South Branch Patapsco	County-wide
Bioretention	DA acres	83.6	193.9	265.2	203.7	60.0	18.5	3.2	828.1
Bioswale	DA acres	29.9	160.6	145.2	132.3	10.0	15.0	5.0	498.0
Dry Detention Ponds	DA acres	141.3	3,693.7	1,251.5	1,833.7	230.5	128.8	46.8	7,326.4
Extended Dry Detention Ponds	DA acres	175.8	1,216.9	581.0	1,132.2	187.8	82.4	57.5	3,433.6
Impervious Surface Reduction	DA acres	2.3	2.8	0.8	7.7	0.0	0.0	0.0	13.6
Infiltration w/ sand, veg.	DA acres	28.6	148.0	61.8	138.6	1.3	0.0	0.0	378.3
Infiltration w/o sand, veg.	DA acres	144.1	343.9	190.1	418.9	32.2	20.7	33.2	1,183.1
Lakes	DA acres	0.0	6,986.1	378.5	696.4	0.0	0.0	0.0	8,061.0
Non-Rooftop Disconnect	Impervious acres	186.6	159.7	179.6	95.0	8.4	45.3	79.8	754.4
Outfall Enhancement w/ SPSC	DA acres	0.0	7.1	10.0	0.0	0.0	0.0	0.0	17.0
Permeable Pavement w/ sand, veg.	DA acres	0.2	0.0	0.0	0.2	0.0	0.0	0.0	0.3
Permeable Pavement w/o sand, veg.	DA acres	0.4	1.8	1.7	2.7	0.0	0.9	0.0	7.4
Rain Barrels	No. of barrels	5,192.0	35,376.0	10,912.0	15,576.0	1,320.0	1,848.0	2,024.0	72,248.0
Rooftop Disconnect	Impervious acres	55.7	163.5	64.7	44.7	5.5	12.9	20.7	367.5
Septic Upgrades	No. of units	37	24	50	10	0	8	7	136
Stream Restoration	Linear feet	0.0	16,576.9	487.6	1,757.1	100.0	890.0	0.0	19,811.5
Street Sweeping	Miles swept quarterly	11.8	383.6	120.2	299.8	24.7	29.5	7.4	877.0
Urban Filtering	DA acres	12.8	188.1	80.1	219.7	15.2	3.4	3.8	523.0
Urban Tree Plantings	Acres planted	399.4	140.8	322.1	123.5	0.0	13.8	114.5	1,114.1
Vegetated Open Channels	DA acres	0.0	1.3	12.7	0.0	0.0	0.0	0.0	13.9
Wet Ponds or Wetlands	DA acres	926.3	4,819.1	2,940.4	2,421.0	311.4	305.6	125.3	11,849.0

Table 23. Local TMDL 2015 Progress Reductions Achieved

	Baltimore Harbor		Little Patuxent River	Patapsco River Lower North Branch		Patuxent River Upper	Rocky Gorge Reservoir	Triadelphia Reservoir (Brighton Dam)
	TN-EOS lbs	TP-EOS lbs	TSS-EOS lbs	TSS-EOS lbs	Bacteria MPN/100 mL/yr	TSS-EOS lbs	TP-EOS lbs	TP-EOS lbs
Baseline Loads and Target Reductions								
TMDL Baseline Year	1995	1995	2005	2005	2005	2005	2000	2000
Calibrated Baseline Load	107,059	6,546	10,346,821	6,123,442	60,282	145,902	861	2,654
Target Percent Reduction	15.0%	15.0%	48.1%	10.0%	13.4%	11.4%	15.0%	15.0%
Calibrated Target Reduction	16,059	982	4,976,821	612,344	8,078	16,633	129	398
Calibrated TMDL WLA	91,000	5,564	5,370,000	5,511,098	52,204	129,269	732	2,256
2015 Progress Reductions								
Restoration Reduction (from baseline to 2015)	2,324	205	697,379	99,887	4,975	4,477	64	112
Restoration Reduction Percent	2.2%	3.1%	6.7%	1.6%	8.3%	3.1%	7.4%	4.2%
Reduction Remaining for Treatment	13,735	777	4,279,442	512,457	3,103	12,156	65	286
Reduction Percent Remaining	12.8%	11.9%	41.4%	8.4%	5.1%	8.3%	7.6%	10.8%

4.1.2 Chesapeake Bay TMDL

2015 Progress results are shown in Table 24. As mentioned in previous plan sections, Howard County is meeting its Bay TMDL responsibilities through the 20% impervious surface restoration; therefore the Bay TMDL targets and reductions shown here are for informational purposes only.

Table 24. Bay TMDL 2015 Progress Reductions Achieved

	TN-EOS lbs/yr	TN-DEL lbs/yr	TP-EOS lbs/yr	TP-DEL lbs/yr	TSS-EOS lbs/yr	TSS-DEL lbs/yr
Baseline Loads and Target Reductions						
Calibrated 2010 Baseline Load	566,350	319,997	27,609	14,300	26,344,338	20,262,457
Target Percent Reduction	11.98%	12.00%	20.72%	19.74%	-	-
Calibrated Target Reduction	67,849	38,400	5,721	2,823	-	-
Calibrated Bay TMDL WLA	498,501	281,597	21,889	11,477	-	-
2015 Progress Reductions						
Restoration Reductions (from baseline to 2015)	4,950	2,115	1,353	893	843,467	808,062
Restoration Reduction Percent	0.87%	0.66%	4.90%	6.24%	3.20%	3.99%
Reduction Remaining for Treatment	62,898	36,285	4,368	1,930	-	-
Reduction Percent Remaining	11.11%	11.34%	15.82%	13.50%	-	-

4.1.3 Impervious Restoration

2015 Progress results are shown in Table 25. The table builds on the impervious accounting information included in Table 4 in previous sections, but adds the restoration progress completed between July 1, 2013 and November 2015. Results are provided at the watershed level for informational purposes only and to aid in planning and targeting future restoration efforts, the 20% requirement is to be met at the County scale, not at the watershed scale. **The results indicate that the County has 157.4 impervious acres of restoration to apply to its 20% goal, leaving 1,886.9 acres of impervious restoration to be completed by the end of the permit term in December, 2019.**

Table 25. Impervious Restoration 2015 Progress per Watershed

	Brighton Dam	Little Patuxent River	Middle Patuxent River	Patapsco River L N Branch	Patuxent River Upper	Rocky Gorge Dam	South Branch Patapsco	Countywide
Impervious Baseline and Target (Impervious Credit Acres)								
County MS4 Impervious Area	**1,691.1**	**8,124.7**	**2,990.6**	**3,854.5**	**381.0**	**530.9**	**629.9**	**18,202.8**
Impervious Baseline Treated	**515.0**	**4,231.2**	**1,088.4**	**1,676.1**	**153.1**	**156.0**	**161.3**	**7,981.1**
Impervious Baseline Untreated	**1,176.1**	**3,893.5**	**1,902.2**	**2,178.3**	**227.9**	**374.9**	**468.6**	**10,221.6**
20% Restoration Target	**235.2**	**778.7**	**380.4**	**435.7**	**45.6**	**75.0**	**93.7**	**2,044.3**
Impervious Restoration and 2015 Progress (Impervious Credit Acres)								
Restoration BMPs after 7/1/13	21.7	66.1	14.1	9.2	0.0	1.5	4.4	117.0
Rain Barrels	0.01	0.15	0.06	0.05	0.01	0.01	0.00	0.3
Septic Upgrades after 7/1/13	13.5	5.7	14.0	2.6	0.0	2.1	2.1	40.0
Total Impervious Restoration	**35.2**	**72.0**	**28.2**	**11.8**	**0.0**	**3.6**	**6.5**	**157.4**
% Impervious Treated	**3.0%**	**1.8%**	**1.5%**	**0.5%**	**0.0%**	**1.0%**	**1.4%**	**1.5%**
Remaining Impervious Restoration to be Complete by December 17, 2019								**1,886.9**

4.2 Planned Implementation

A large majority of the planned projects and programs include structural practices to be implemented by Howard County DPW. In addition several non-structural programs are included.

Structural Practices

Table 26 displays planned levels of implementation including FY16 planned projects, project concepts developed in 2015 as a result of watershed assessments in both Little and Middle Patuxent Rivers, and pending 2016 concepts assumed from future watershed assessments. The number of projects and provided treatment were estimated for pending 2016 concepts using concepts developed from the 2015 watershed assessments. Using the distribution of number of projects for each BMP type (i.e., BMP conversion, new BMP, outfall stabilization, outfall stabilization with SPSC, stream restoration, and tree planting), the average amount of treatment provided in drainage area or linear feet was calculated. Average impervious credit and TN, TP, and TSS reductions were calculated from the average amount of treatment per project. 2016 projects were distributed based on local TMDL requirements and progress achieved from current BMP implementation.

This increase in treatment through implementation of planned practices will achieve the load reductions required in the local TMDLs as listed in Table 2. In addition, planned implementation will fulfill the impervious restoration requirement stated in the MS4 permit.

A majority of the planned management strategies incorporate stream restoration, tree planting, and outfall stabilization with SPSC with the incorporation of some BMP retrofits and new BMPs. 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 they provide more efficient or effective pollution control.

Non-Structural Homeowner Practices

In addition to these structural BMPs, two primary homeowner programs are emphasized for rain barrels and septic systems. Treatment credits for these programs are included for impervious surfaces in Table 29. Rain barrels are planned to be installed at a rate of 100 per year, a slightly conservative estimate based on an average rain barrel installation rate of approximately 135 per year over the last six years from 2010 to 2015.

Septic upgrades to denitrification systems are also planned at a rate of 30 per year which is again a conservative rate based on an average rate of approximately 50 per year over the last three years. Howard County is investigating implementation of a Septic Pump-Out rebate program to both encourage and help document the number of septic pump-outs completed per year. The County estimates that with 50% participation among the approximately 18,000 septic systems located County-wide, that a significant reduction in pollutants, and an equivalent credit for impervious surface treatment will be achieved. Assuming a 3-year program beginning in FY2017 with approximately 3,000 new participants each year, final participation of 9,000 units at 0.03 equivalent acres would provide 270 acres of credit towards the impervious restoration goal. Estimates of cost and schedule are provided in Sections 5 and 7.

Table 26. BMP Implementation - Planned Levels for Howard County

		BMP Conversion (ac)	New BMP (ac)	Outfall Stabilization (lf)	Outfall Enhancement w/ SPSC (lf)	Stream Restoration (lf)	Urban Tree Plantings (ac)	Total Number of Projects
Brighton Dam								
FY 16/17 Planned Projects	# of Projects	0	0	0	0	0	0	**0**
	Area or Length Treated	0.0	0.0	0.0	0.0	0.0	0.0	
2015 Concepts	# of Projects	0	0	0	0	0	0	**0**
	Area or Length Treated	0.0	0.0	0.0	0.0	0.0	0.0	
2016 Concepts (Pending)	# of Projects	0	0	0	0.0	3	0	**3**
	Area or Length Treated	0.0	0.0	0.0	0.0	6,032.6	0.0	
Total	# of Projects	0	0	0	0	3	0	**3**
	Area or Length Treated	0.0	0.0	0.0	0.0	6,032.6	0.0	
Little Patuxent River								
FY 16/17 Planned Projects	# of Projects	2	0	0	0	5	0	**7**
	Area or Length Treated	18.9	0.0	0.0	0.0	2,250.0	0.0	
2015 Concepts	# of Projects	12	10	13	5	32	14	**86**
	Area or Length Treated	200.3	46.1	1,808.6	738.4	62,028.0	45.9	
2016 Concepts (Pending)	# of Projects	5	5	0	5	11	5	**31**
	Area or Length Treated	77.7	23.1	0.0	821.1	22,119.4	27.4	
Total	# of Projects	19	15	13	10	48	19	**124**
	Area or Length Treated	296.9	69.2	1,808.6	1,559.6	86,397.3	73.2	
Middle Patuxent River								
FY 16/17 Planned Projects	# of Projects	2	1	1	2	3	0	**9**
	Area or Length Treated	27.5	16.0	12.8	300.0	1,900.0	0.0	
2015 Concepts	# of Projects	4	0	3	1	14	9	**31**
	Area or Length Treated	55.1	0.0	763.5	205.6	29,311.6	64.7	
2016 Concepts (Pending)	# of Projects	0	0	0	0	0	0	**0**
	Area or Length Treated	0.0	0.0	0.0	0.0	0.0	0.0	
Total	# of Projects	6	1	4	3	17	9	**40**
	Area or Length Treated	82.6	16.0	776.3	505.6	31,211.6	64.7	

		BMP Conversion (ac)	New BMP (ac)	Outfall Stabilization (lf)	Outfall Enhancement w/ SPSC (lf)	Stream Restoration (lf)	Urban Tree Plantings (ac)	Total Number of Projects
Patapsco River Lower North Branch								
FY 16/17 Planned Projects	# of Projects	2	1	0	1	3	0	**7**
	Area or Length Treated	74.5	2.5	0.0	200.0	3,511.0	0.0	
2015 Concepts	# of Projects	0	0	0	0	0	0	**0**
	Area or Length Treated	0.0	0.0	0.0	0.0	0.0	0.0	
2016 Concepts (Pending)	# of Projects	17	17	0	67	25	21	**147**
	Area or Length Treated	264.0	78.4	0.0	11,003.3	50,271.3	115.0	
Total	# of Projects	19	18	0	68	28	21	**154**
	Area or Length Treated	338.5	80.9	0.0	11,203.3	53,782.3	115.0	
Patuxent River Upper								
FY 16/17 Planned Projects	# of Projects	0	0	0	0	0	0	**0**
	Area or Length Treated	0.0	0.0	0.0	0.0	0.0	0.0	
2015 Concepts	# of Projects	0	0	0	0	0	0	**0**
	Area or Length Treated	0.0	0.0	0.0	0.0	0.0	0.0	
2016 Concepts (Pending)	# of Projects	0	0	0	0	1	0	**1**
	Area or Length Treated	0.0	0.0	0.0	0.0	1,005.4	0.0	
Total	# of Projects	0	0	0	0	1	0	**1**
	Area or Length Treated	0.0	0.0	0.0	0.0	1,005.4	0.0	
Rocky Gorge Dam								
FY 16/17 Planned Projects	# of Projects	1	0	0	0	0	0	**1**
	Area or Length Treated	8.9	0.0	0.0	0.0	0.0	0.0	
87+60 2015 Concepts	# of Projects	0	0	0	0	0	0	**0**
	Area or Length Treated	0.0	0.0	0.0	0.0	0.0	0.0	
2016 Concepts (Pending)	# of Projects	0	0	0	0	1	0	**1**
	Area or Length Treated	0.0	0.0	0.0	0.0	2,010.9	0.0	
Total	# of Projects	1	0	0	0	1	0	**2**
	Area or Length Treated	8.9	0.0	0.0	0.0	2,010.9	0.0	

		BMP Conversion (ac)	New BMP (ac)	Outfall Stabilization (lf)	Outfall Enhancement w/ SPSC (lf)	Stream Restoration (lf)	Urban Tree Plantings (ac)	Total Number of Projects
South Branch Patapsco								
FY 16/17 Planned Projects	# of Projects	0	0	0	0	0	0	**0**
	Area or Length Treated	0.0	0.0	0.0	0.0	0.0	0.0	
2015 Concepts	# of Projects	0	0	0	0	0	0	**0**
	Area or Length Treated	0.0	0.0	0.0	0.0	0.0	0.0	
2016 Concepts (Pending)	# of Projects	0	0	0	10	5	10	**25**
	Area or Length Treated	0.0	0.0	0.0	1,642.3	10,054.3	54.8	
Total	# of Projects	0	0	0	10	5	10	**25**
	Area or Length Treated	0.0	0.0	0.0	1,642.3	10,054.3	54.8	
Countywide								
FY 16/17 Planned Projects	# of Projects	7	2	1	3	11	0	**24**
	Area or Length Treated	129.8	18.5	12.8	500.0	7,661.0	0.0	
2015 Concepts	# of Projects	16	10	16	6	46	23	**117**
	Area or Length Treated	255.5	46.1	2,572.2	944.0	91,339.5	110.6	
2016 Concepts (Pending)	# of Projects	17	17	0	77	35	31	**177**
	Area or Length Treated	341.7	101.5	0.0	13,466.7	91,493.8	197.2	
Total	# of Projects	45	34	17	91	103	59	**349**
	Area or Length Treated	727.0	166.1	2,584.9	14,910.8	190,494.3	307.8	

4.2.1 Local TMDLs

Table 27 displays local TMDL loads with current and planned BMP practices. Planned accounting and modeling terminology is described below. This terminology is also used in Table 28, which presents Chesapeake Bay TMDL Planned results.

- **Planned Reductions**: The sum of loads treated by FY16 planned projects, project concepts developed in 2015 as a result of watershed assessments in both Little and Middle Patuxent Rivers (sub row FY16 Planned Projects and 2015 Concepts), and pending 2016 concepts from future watershed assessments (sub row 2016 Concepts (Pending)).
- **Additional Bacteria Concepts (Pending)**: These are projects that were needed for full completion of the Patapsco LNB watershed bacteria reduction. These are itemized separately as they may be identified and planned following the 2016 watershed assessment.
- **Reduction (Progress + Planned)**: The sum of loads treated from restoration BMPs with a built date after the baseline to 2015 (i.e., 2015 Progress Reductions) and Planned Reductions.
- **Reduction Percent (Progress + Planned)**: The percent difference of the baseline load and the Reduction (Progress + Planned).
- **Reduction Remaining for Treatment**: The difference between the calibrated TMDL WLA target reduction and the Reduction (Progress + Planned). A negative number means the target reduction is exceeded by the plan.

Table 27 below represents the progress that would be made once planned reductions from projects in Table 26 above are implemented. With this level of implementation the local TMDLs in the Patuxent River Upper, Rocky Gorge Reservoir, and Brighton Dam (Triadelphia Reservoir), Baltimore Harbor, and Patapsco LNB would be met (see Figure 8). Some TMDLs are far exceeded because removals per pollutant type are not achieved at the same rate. TN removal rates are relatively low compared to TP and TSS on a per project basis. Therefore the number of projects needed to meet the Baltimore Harbor TN reduction goal resulted in overachieving on the TP reduction, and the TSS reduction in the Patapsco River LNB which is nested in the Baltimore Harbor watershed.

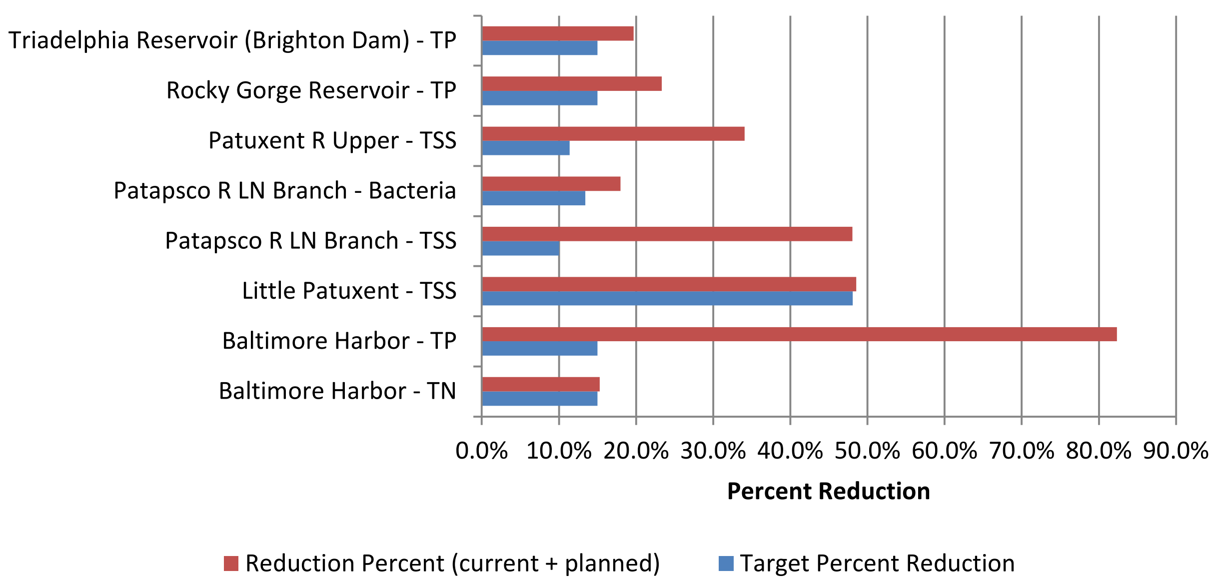


Figure 8. Percent reduction required and planned per watershed

Table 27. Local TMDL Reductions with Planned Implementation

	Baltimore Harbor		Little Patuxent	Patapsco R LN Branch		Patuxent R Upper	Rocky Gorge Reservoir	Triadelphia Reservoir (Brighton Dam)
	TN-EOS lbs/yr	TP-EOS lbs/yr	TSS-EOS lbs/yr	TSS-EOS lbs/yr	Bacteria MPN/100 mL/yr	TSS-EOS lbs/yr	TP-EOS lbs/yr	TP-EOS lbs/yr
Baseline Loads and Target Reductions								
TMDL Baseline Year	1995	1995	2005	2005	2005	2005	2000	2000
Calibrated Baseline Load	107,059	6,546	10,346,821	6,123,442	60,282	145,902	861	2,654
Target Percent Reduction	15.0%	15.0%	48.1%	10.0%	13.4%	11.4%	15.0%	15.0%
Calibrated Target Reduction	16,059	982	4,976,821	612,344	8,078	16,633	129	398
Calibrated TMDL WLA	91,000	5,564	5,370,000	5,511,098	52,204	129,269	732	2,256
2015 Progress Reductions								
Restoration Reductions (from baseline to 2015)	2,324	205	697,379	99,887	4,975	4,477	64	112
Planned Reductions								
Planned Reductions	14,020	5,184	4,325,445	2,841,452	5,862	45,244	137	410
2016 Concepts (Pending)	*13,526*	*4,913*	*1,124,634*	*2,633,671*	*5,513*	*45,244*	*137*	*410*
FY16/17 Planned + 2015 Concepts	*494*	*271*	*3,200,810*	*207,781*	*349*	*0*	*0*	*0*
Restoration Reduction Percent	13.1%	79.2%	41.8%	46.4%	9.7%	31.0%	15.9%	15.5%
Totals								
Reduction (Progress+Planned)	16,344	5,389	5,022,824	2,941,339	10,837	49,721	201	522
Reduction Percent (Progress + Planned)	15.3%	82.3%	48.5%	48.0%	18.0%	34.1%	23.3%	19.7%
Reduction Remaining for Treatment	-285	-4,407	-46,003	-2,328,995	-2,759	-33,088	-72	-124

4.2.2 Chesapeake Bay TMDL

Table 28 represents the progress towards the Bay TMDL reduction targets that would be made by 2025 once planned reductions from projects in Table 26 are implemented. Howard County's stormwater sector is required by its MS4 NPDES permit to meet the Bay TMDL requirements by completion of the 20% impervious surface restoration; however the Bay TMDL nutrient reductions have been tabulated here for general comparison. While the 20% goal is required by 2019, the Bay TMDL timeline is 2025, therefore it was determined that providing the reductions with implementation through 2025 would be most useful.

With implementation of the projects and programs in the CIS the Bay TN reductions would not be met, but the TP reductions would be met. Based on accepted Bay TMDL accounting protocol, TSS is assumed to be met as the TP goal is met because the two parameters are closely related. Howard County's local TMDLs are largely TP and TSS, with only one TN TMDL. As described above, BMPs generally reduce TP and TSS at a higher rate than TN, therefore the local TMDLs required fewer BMPs to meet the TP and TSS goals than it would have if more TN TMDLs were in place. Additionally, projects types were emphasized based on their TP and TSS removal rates over their TN rates.

Table 28. Bay TMDL Reductions with Planned Implementation

	TN-EOS lbs/yr	TN-DEL lbs/yr	TP-EOS lbs/yr	TP-DEL lbs/yr	TSS-EOS lbs/yr	TSS-DEL lbs/yr
Baseline and Targets						
Calibrated 2010 Baseline Load	566,350	319,997	27,609	14,300	26,344,338	20,262,457
Target Percent Reduction	11.98%	12.00%	20.72%	19.74%	-	-
Calibrated Target Reduction	67,849	38,400	5,721	2,823	-	-
Calibrated Bay TMDL WLA	498,501	281,597	21,889	11,477	-	-
2015 Progress Reductions						
Restoration Reductions (from baseline to 2015)	4,950	2,115	1,353	893	843,467	808,062
Planned Reductions (2016 – 2025)						
Planned Reductions	32,333	20,956	18,048	11,338	12,759,062	11,695,030
2016 Concepts (Pending)	*18,314*	*10,589*	*8,962*	*4,723*	*6,475,206*	*5,060,663*
FY16/17 Planned + 2015 Concepts	*14,018*	*10,367*	*9,086*	*6,615*	*6,283,856*	*6,634,367*
Planned Reduction Percent	5.7%	6.5%	65.4%	79.3%	48.4%	57.7%
Total Reductions						
Reduction (Progress + Planned)	37,283	23,071	19,400	12,231	13,602,529	12,503,092
Reduction Percent (Progress + Planned)	6.58%	7.21%	70.27%	85.53%	51.63%	61.71%
Reduction Remaining for Treatment	30,566	15,328	-13,680	-9,408	-	-
Reduction Percent Remaining	5.4%	4.8%	-49.5%	-65.8%	-	-

4.2.3 Impervious Restoration by 2019

Impervious surface restoration for 20% of the baseline untreated impervious surface acres by the end of 2019 is required. Implementation of the practices described above and included in Table 26 will achieve restoration equivalent to 1,959.0 acres by 2019. This value, together with existing progress of 157.4 acres will result in a total restoration of 2,116.4 acres, or 20.7% of the untreated baseline. A full accounting of the planned restoration per watershed and Countywide is included in Table 29 below. It is noted that the restoration goal is a Countywide goal, but progress is monitored at the watershed scale for planning purposes. Figure 9 presents both the 2015 progress and 2016-2019 planned impervious restoration for each watershed.

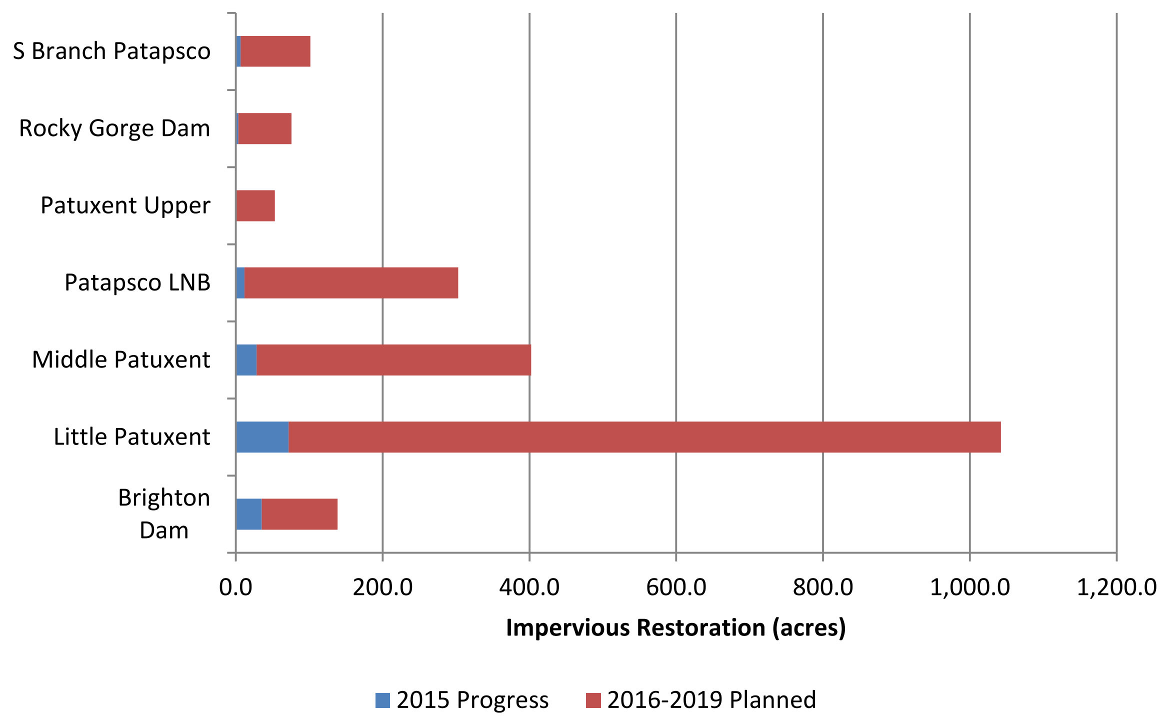


Figure 9. Total Impervious Restoration Progress and Planned per Watershed

Table 29. Impervious Restoration by 2019

	Brighton Dam	Little Patuxent River	Middle Patuxent River	Patapsco River L N Br	Patuxent River upper	Rocky Gorge Dam	S Branch Patapsco	Countywide
Impervious Baseline and Target (Impervious Credit Acres)								
County MS4 Impervious Area	**1,691.1**	**8,124.7**	**2,990.6**	**3,854.5**	**381.0**	**530.9**	**629.9**	**18,202.8**
Impervious Baseline Treated	**515.0**	**4,231.2**	**1,088.4**	**1,676.1**	**153.1**	**156.0**	**161.3**	**7,981.1**
Impervious Baseline Untreated	**1,176.1**	**3,893.5**	**1,902.2**	**2,178.3**	**227.9**	**374.9**	**468.6**	**10,221.6**
20% Restoration Target	**235.2**	**778.7**	**380.4**	**435.7**	**45.6**	**75.0**	**93.7**	**2,044.3**
2015 Progress Impervious Restoration (Impervious Credit Acres)								
2015 Total Progress Restoration	**35.2**	**72.0**	**28.2**	**11.8**	**0.0**	**3.6**	**6.5**	**157.4**
% Impervious Treated	**3.0%**	**1.8%**	**1.5%**	**0.5%**	**0.0%**	**1.0%**	**1.4%**	**1.5%**
Planned Impervious Restoration (2016-2019) (Impervious Credit Acres)								
Total Restoration BMPs	60.3	926.8	330.9	247.9	10.1	29.0	51.6	1,656.6
2016 Concepts (Pending)	*60.3*	*106.2*		*201.1*	*10.1*	*20.1*	*51.6*	*449.5*
FY16/FY17 Planned + 2015 Concepts		*820.6*	*330.9*	*46.8*		*8.9*		*1,207.1*
Rain Barrels	0.04	0.30	0.09	0.13	0.01	0.02	0.61	1.2
Septic Pump-outs	38.6	38.6	38.6	38.6	38.6	38.6	38.6	270.0
Septic Upgrades	4.5	4.5	4.5	4.5	4.5	4.5	4.5	31.2
Total Planned Impervious Restoration	**103.4**	**970.2**	**374.0**	**291.0**	**53.1**	**72.1**	**95.3**	**1,959.0**
% Impervious Treated	**8.8%**	**24.9%**	**19.7%**	**13.4%**	**23.3%**	**19.2%**	**20.3%**	**19.2%**
Total Impervious Restoration to 2019 (Impervious Credit Acres)								
2015 Progress	**35.2**	**72.0**	**28.2**	**11.8**	**0.0**	**3.6**	**6.5**	**157.4**
2016-2019 Planned	**103.4**	**970.2**	**374.0**	**291.0**	**53.1**	**72.1**	**95.3**	**1,959.0**
Total Impervious Restoration	**138.6**	**1,042.1**	**402.2**	**302.9**	**53.1**	**75.7**	**101.8**	**2,116.4**
% Impervious Treated	**11.8%**	**26.8%**	**21.1%**	**13.9%**	**23.3%**	**20.2%**	**21.7%**	**20.7%**

5 Technical and Financial Assistance Needs

This section details the technical and financial factors required for successful implementation of the planned recommendations.

5.1 Technical Requirements

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).

A streamlined environmental review and permitting process for County MS4 restoration projects related to NPDES MS4 impervious restoration and TMDL treatment projects is currently in planning stages with MDE. The Maryland Association of Counties (MACO) and the Metropolitan Washington Council of Governments are spearheading the effort and discussions with MDE. MDE has recognized the impact of the TMDL and restoration programs on localities and has acknowledged that County projects will require expeditious review to ensure that restoration goals are met. It is the County's hope that County projects meeting certain criteria will not require mitigation, will allow for alternatives analysis to be waived if the project is part of a larger plan, and will provide flexibility for site access for repairs without a new permit. At the federal level, the recent Regional General Permit for Chesapeake Bay TMDL Activities, effective July 1, 2015 should serve to streamline the permitting process as it related to US Army Corps of Engineers review and approval. Together these permitting factors, if implemented as they are intended should allow for faster and more efficient implementation of projects.

Howard County also emphasizes the on-going process by MDE and the Chesapeake Bay Program, specifically in the Water Quality Goal Implementation Team and the related Urban Stormwater Workgroup, Watershed Technical Workgroup, and the Best Management Practices (BMP) Verification Committee to provide for sound BMP reduction rates and credit accounting and to continue to facilitate review and approval of BMPs not currently credited.

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 6 and 9 of this plan.

5.2 Financial Needs

The cost of implementing the CIS to meet the stated goals has been estimated. It is important to note that the costs represent planning level estimates for use in high level forecast budgeting with many assumptions made. The cost estimates provided here focus on the capital costs associated with implementing the projects described in previous sections. The following presents the methods used to derive the cost estimates per project type with summaries of costs for full implementation at the watershed and County scale.

5.2.1 Project Cost Estimates – Watershed Assessment

Cost estimates used in development of the CIS for structural projects were derived during the 2015 watershed assessments completed for the Little and Middle Patuxent watersheds. Estimates were made during the Concept Plan development stage for each project selected for a concept. Costs were created for each project individually based on an itemized planning level cost estimate. Line item costs were derived with County and consultant input based on many years of project implementation in Howard County and were used consistently among the contractors developing the concept plans. Cost estimates included each of the following items:

- Construction Costs – listed per item needed (e.g. excavation, structures, rip-rap, sand fill, risers, trees) listed with unit costs, quantity needed (cubic yards, linear feet, each, lump sum), and extended cost and totaled for a total Construction Cost.
- Engineering and Management – including engineering, design, site topographic and property survey, required state and federal permitting and environmental clearance, geotechnical evaluations, and construction management and oversight all summed for a total Design Cost.
- Contingency – due to the many unknown site factors at the early concept stage, a 30% contingency was added to the total construction and design cost.
- Total Project Cost – includes the total of the Construction, Design, and Contingency items.

Costs not included are pre- and post-construction monitoring and life cycle costs for inspection and maintenance. These will be estimated in later planning stages. Cost estimate templates varied between project types to include the items specific to that type. Project types include: stormwater BMP conversions, new stormwater BMPs, stream restoration, outfall stabilization, outfall stabilization with step-pool stormwater conveyance (SPSC) and tree planting.

5.2.2 CIS Cost Estimate

Cost estimates developed for the 2015 concept plans described above were used to extrapolate to the yet to be determined projects that will be identified in the upcoming 2016 watershed assessments. For each project type, average costs were derived on a "per project" basis from the 2015 data. These results are included in Table 30. The estimated average cost for each project type was used in conjunction with the average acres to derive the cost of additional projects needed to meet the pollutant reduction and impervious goals. For example the average cost for a BMP conversion is $384,927 for an average project drainage area of 15.5 acres. As the number of BMP conversion projects planned was developed, the credits were factored by the average drainage area, and the cost was factored using the average cost. The costs per project unit (per acre for stormwater BMP, per linear foot for streams and outfalls, and per acres planted) are also presented.

Table 30. Average Cost Per Project Type

BMP Type	Number of Projects	Unit	Calculation	Amount	Estimated Cost	Cost per Unit (acres or lf)
BMP Conversion	20	DA acres	total	310.6	$7,698,544	$24,785
			average	15.5	$384,927	
New BMP	10	DA acres	total	46.1	$5,364,620	$116,294
			average	4.6	$536,462	
Outfall Stabilization	19	Linear Feet	total	3,335.7	$4,636,721	$1,390
			average	175.6	$244,038	
Outfall - SPSC	7	Linear Feet	total	1,149.6	$1,740,216	$1,514
			average	164.2	$248,602	
Stream Restoration	60	Linear feet	total	120,651.1	$93,265,443	$773
			average	2,010.9	$1,554,424	
Tree Planting	32	Acres Planted	total	175.3	$7,596,008	$43,334
			average	5.5	$237,375	

To aid in the planning process, costs per project type per impervious acre treated and per pound of pollutant removed were developed from the same 2015 watershed assessment concept plan cost estimate data (Table 31). In this manner, planners can determine which projects would be expected to perform the best on a $/lb or $/impervious acre basis and then use those projects to develop more efficient and cost effective plans. Outfall stabilization projects do not currently receive pollutant removal credit; therefore this project type is not expected to be recommended in future assessments. The strategy will likely still be used when an SPSC is not feasible or when a site specifically needs a more basic structural solution in response to infrastructure protection or citizen complaint needs.

Table 31. Project Cost per Removal and Credit

BMP Type	Cost Per Removal / Credit				
	Impervious Credit ($/ac)	TN ($/lb)	TP ($/lb)	TSS ($/lb)	Bacteria[2] ($/MPN/100ml)
BMP Conversion	$64,439	$5,851	$53,057	$38	$13,940
New BMP	$160,281	$21,923	$150,269	$123	$32,703
Outfall Stabilization	$148,947	NA	NA	NA	NA
Outfall - SPSC	$49,048	$3,012	$32,527	$24	$3,496
Stream Restoration	$77,303	$10,307	$11,368	$17	NA
Tree Planting	$114,003	$6,613	$192,304	$239	NA
Project Suite[1]	$80,595	$9,752	$14,190	$21	NA

[1] Total cost per credit for the Little and Middle Patuxent Project Suite
[2] Bacteria data calculated from 2016 planned data, no bacteria TMDL in the Little of Middle Patuxent watersheds

Bacteria calculations were also made to help address the Patapsco LNB bacteria TMDL. A total project suite value was derived for TN, TP and TSS based on the 2015 watershed assessment projects. Overall, SPSC projects provided the best credit per dollar spent and were therefore planned in several watersheds to address the challenging TN and bacteria reductions.

Other practices included in the cost estimation include the homeowner related practices that the County supports financially including rain barrels and plans in development for a septic pump-out rebate program. The planning level and in the case of the septic program, preliminary cost of these measures is included in Table 32.

Howard County continues to provide residents with free rain barrels through the County's Rain Barrel Program. Predrilled rain barrels are available free of charge to residents who attend seminars at the Alpha Ridge landfill. Residents purchase the hardware needed and the Master Gardeners provide free instruction on how to assemble the rain barrels. A total of 586 rain barrels have been given away within the past four years. For this analysis, the costs to the County of the rain barrels are estimated at $50 each with a total of $5,000 per year. It is anticipated that this program will continue for an extended period, however the yearly costs are only shown through FY19.

Howard County is investigating implementation of a Septic Pump-Out rebate program to both encourage and help document the number of septic pump-outs completed per year. The County estimates that with 50% participation within the approximately 18,000 septic systems located County-wide, that a significant reduction in pollutants, and an equivalent credit for impervious surface treatment will be achieved. Assuming a 3-year program beginning in FY2017 with approximately 3,000 new participants each year, final participation of 9,000 units at 0.03 equivalent acres would provide 270 acres of credit towards the impervious restoration goal with a total cost of $900,000 through FY19 and a cost per impervious acre of $3,333.

Table 32. Supplemental Practices Cost Estimate

Program	FY17	FY18	FY19	Cumulative / Total Credit
Septic Pump-Outs				
Units participating	3,000	6,000	9,000	9,000
Cost	$150,000	$300,000	$450,000	$900,000
Impervious Credit	90	180	270	270
Rain Barrels				
New Units participating / year	100	100	100	300
Cost	$5,000	$5,000	$5,000	$15,000

5.2.3 Cost Summary

The total projected cost to implement the County's Capital Improvement Plan (CIP) projects described in this plan is $ 222,290,052. The estimates per year and per watershed are shown in Figure 10 and Table 33. Because the schedule requires the 20% restoration to be complete by 2019 there is a rapid increase in funding needed from current expenditures planned for FY2016 to the peak annual expenses anticipated for FY2017 through FY2020 anticipated to be near $32 million. Costs are generally placed in the fiscal year in which the construction costs are expected to be incurred and when the project will be largely complete. For example projects completed in the Triadelphia Reservoir (Brighton Dam) will be identified in FY2016, designed in FY2017 and then constructed in FY2018 and FY2019.

For the purposes of this CIS, the costs of these projects focuses on the specific implementation costs associated with engineering, permitting, and construction. County operational costs such as additional County staff to manage the work, additional inspections, maintenance, etc., have not been included. These costs will be developed and factored into future County budgeting.

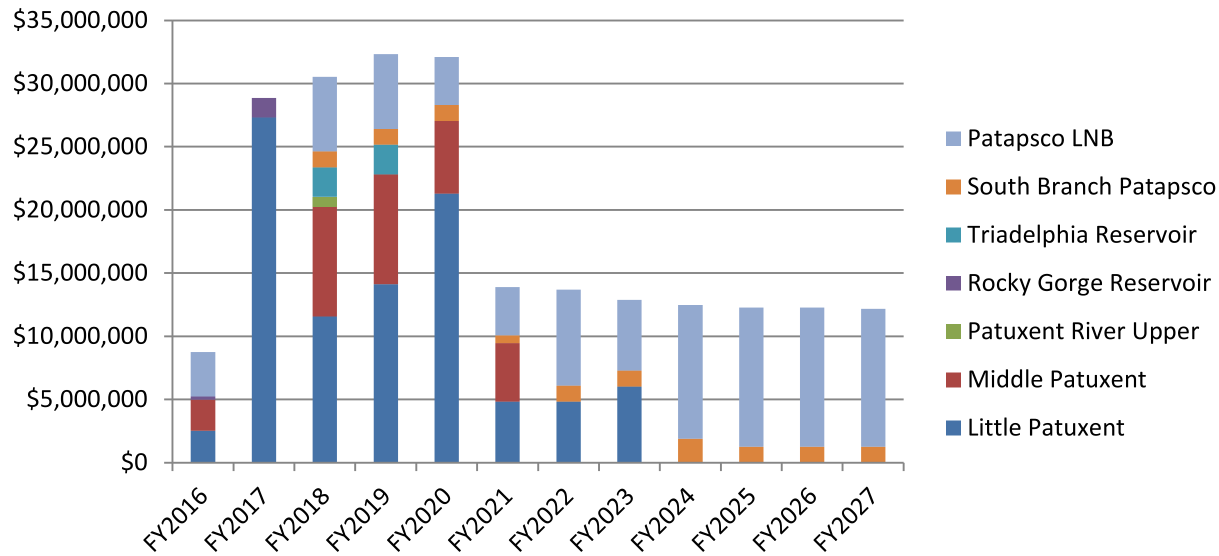


Figure 10. Cost per Fiscal Year per Watershed

It is also possible that The Maryland Nutrient Trading Policy Statement released by MDE on October 23, 2015 could affect the proposed work effort and costs noted in the CIS. Additionally, ongoing or future legal challenges to the County's MS4 permit or to the TMDLs could affect the County's permit requirements, the amount of restoration and nutrient reductions required, and related project implementation.

Table 33. Cost Summary Per Year Structural Restoration BMPs

						Baltimore Harbor		
Fiscal Year	Little Patuxent	Middle Patuxent	Patuxent River Upper	Rocky Gorge Reservoir	Triadelphia Reservoir	South Branch Patapsco	Patapsco LNB	Total
2016	$ 2,536,484	$ 2,443,236					$ 3,535,768	$ 8,515,487
2017	$ 27,305,179			$ 250,000				$ 27,555,179
2018	$ 11,558,331	$ 8,693,734	$ 777,212	$ 1,554,424	$ 2,331,636	$ 1,263,190	$ 5,912,839	$ 32,091,365
2019	$ 14,126,849	$ 8,693,734			$ 2,331,636	$ 1,263,190	$ 5,912,839	$ 32,328,247
2020	$ 21,290,014	$ 5,749,082				$ 1,263,190	$ 3,808,273	$ 32,110,558
2021	$ 4,827,100	$ 4,627,310				$ 631,595	$ 3,808,273	$ 13,894,277
2022	$ 4,827,100					$ 1,263,190	$ 7,616,545	$ 13,706,835
2023	$ 6,033,875					$ 1,263,190	$ 5,582,125	$ 12,879,189
2024						$ 1,894,784	$ 10,572,965	$ 12,467,750
2025						$ 1,263,190	$ 11,023,958	$ 12,287,148
2026						$ 1,263,190	$ 11,023,958	$ 12,287,148
2027						$ 1,263,190	$ 10,903,680	$ 12,166,869
2028								
2029								
Total	$ 92,504,931	$ 30,207,095	$ 777,212	$ 1,804,424	$ 4,663,272	$ 12,631,896	$ 79,701,223	$ 222,290,052

6 Public Participation / Education

Howard County's MS4 permit requires a significant increase in effective public outreach and community stewardship. Such public involvement is necessary for the CIS to achieve its restoration goals. The following describes the public involvement strategy being used to gather input for the CIS and a summary of education and outreach programs.

6.1 CIS and Watershed Assessment Public Participation

Development of the 2015 watershed assessments and preparation of the CIS are done with public input gathered through a combination of public review and comment periods and through a series of public meetings. The draft watershed assessment reports for the Little Patuxent and Middle Patuxent watersheds and this draft CIS were posted on the County's stormwater management division website in December 2015 for a 30-day public review and comment period. Comments received will be taken into consideration and modifications to the assessments and CIS will be made where appropriate.

A series of public meetings were held in the summer of 2015 and in early to mid-December to disseminate information on the County's watershed planning and restoration program and to specifically introduce the goals, methods and results of the assessments and CIS.

Four meetings were held from June 17 to June 30, 2015 at locations in each of the four planning areas. The meetings focused on the preliminary watershed assessment results.

- Southern Middle Patuxent Watershed – June 17, 2015 @ Robinson Nature Center
- Northern Little Patuxent Watershed – June 22, 2015 @ Dunloggin Middle School
- Southern Little Patuxent Watershed – June 24, 2015 @ Hammond High School
- Northern Middle Patuxent Watershed – June 30, 2015 @ Folly Quarter Middle School

Four meetings were held from December 2 to December 10, 2015 at locations in each of the four planning areas. The meetings included the final assessment results and introduced the CIS.

- Northern Middle Patuxent – Dec. 2, 2015 @ Gary J. Arthur Community Center
- Southern Little Patuxent – Dec. 3, 2015 @ North Laurel Community Center
- Southern Middle Patuxent – Dec. 9, 2015 @ Robinson Nature Center
- Northern Little Patuxent – Dec. 10, 2015 @ Howard Community College

The meetings included presentations of the planning documents and opportunities for questions. Maps and copies of the planning documents were present for participants to review in person. County staff and consultants who completed the field assessment and concept plan development were present to answer questions and to describe assessment results from any specific location that a property owner or interested individual might be concerned about.

6.2 Program Summary

Public education and outreach occurs throughout the County and is conducted by various agencies. Current programs include information about stormwater runoff, stormwater infrastructure maintenance, water conservation, trash reduction and recycling, lawn care management, and programs that provide a mechanism for reporting suspected illicit discharges and spills. New to the MS4 permit is the requirement to develop and implement, within one year, a public education and outreach program to reduce littering and increase recycling, which includes:

- Educating the public on the importance of reducing, reusing, and recycling
- Disseminating information by using signs, articles, and other media outlets
- Promoting educational programs in schools, businesses, community associations, etc.

The County is required to evaluate annually and report on the effectiveness of the education programs (e.g., in terms of personnel and financial resources). The following programs are good examples of the programs currently being implemented throughout the County. Refer to the County's NPDES Annual Report (Howard County, 2014 and 2015) for a complete list of all programs currently being implemented.

6.2.1 Stormwater Management Division (SWMD) Education Programs

School Outreach

The SWMD continues to provide workshops to the schools and businesses in Howard County. Schools participate in County-sponsored programs and workshops designed to increase their awareness of water quality issues.

Other Educational Outreach Initiatives

The SWMD as well as Department of Recreation and Parks (DRP) staff speak at the Howard County Legacy Leadership Institute for the Environment (HoLLIE), Master Gardener training events, and are part of the Howard County Watershed Forum. The result of the forum was the first Howard County Watershed Steward Academy class in 2012 and annual classes since 2012. The result of all of these efforts is to create a more educated County citizen who will contribute to the improvement of water quality in Howard County and in the Chesapeake Bay.

6.2.2 Recycling Division Programs

The County's Recycling Division distributes recycling and waste reduction literature to households and businesses and provides outreach materials through local libraries, public buildings, events, and the County's website: www.HowardCountyRecycles.org. The County's recycling rate more than doubles the State's mandated annual rate of 20 percent. The County has also instituted apartment and special event based recycling programs.

Outreach to Business Communities

The Business Recycling Program has been providing technical support to the Howard County Chamber of Commerce business collection co-op.

Outreach to Students and Schools

The County is maintaining its presence in schools that has been established over the past four years. The County's Recycling Coordinators distribute school recycling information through school programs, brochures, and lunchroom recycling posters. The County also administers programs ranging from individual classroom talks and short lunchroom presentations to school-wide assemblies for students as young as 2 years old.

6.2.3 Department of Recreation and Parks (DRP) Programs

Stream and Pond Cleanup Program

Since 1996, the Department has actively recruited volunteers and tracked their efforts removing trash and other debris from Howard County's waterways. To date, the County has had 2,376 people spend 5,161 hours cleaning the County’s waterways.

Howard County GreenFest

For six years, the County has hosted an annual Green Fest which features many exhibits and vendors dealing with tree plantings, energy efficient home improvements, rain barrels, gardening and composting, document shredding, Goodwill donations, Nike Reuse-a-Shoe collection, Bikes for the World collection, as well as live bird and reptile displays. Other features include the County’s recycling program and community tree planting programs as well as many community groups focused on environmental awareness. SWMD attends to promote water quality and illicit discharge reduction.

Robinson Nature Center

The Robinson Nature Center, in operation since September 2011, serves as a model of innovative water conservation methods and officially received its LEED Platinum certification by the USGBC in 2012. Using the building as a teaching tool, the Robinson Nature Center educates the public about green technologies, sustainability, environmental stewardship and techniques that can help reduce stormwater runoff, as well as reducing water and energy consumption. In addition to using the building’s features, including porous pavement, bioretention, native landscaping, and a green roof, to educate the public, Robinson Nature Center offers informal and formal educational opportunities that help educate the public about Howard County’s connection to the Chesapeake Bay and about the LEED certification program. Robinson Nature Center partners with local and regional groups to promote programs that recycle organic materials for uses consistent with mitigating stormwater runoff and sediment discharge. Robinson also offers professional development opportunities to teachers that allow them to bring water conservation and stewardship issues back to the classroom.

7 Implementation Schedule and Milestones

This section presents the estimated timeline required to achieve the impervious treatment and load reduction targets. The end-date for treating an additional 20% of impervious cover is the end of the 5-year cycle of the new MS4 permit, December 2019. The timeline for meeting the nitrogen and phosphorus reduction targets in the Chesapeake Bay TMDL is 2025 with 70% progress by 2017 per the Phase II Watershed Implementation Plan (WIP). The County's NPDES permit however requires that the County's stormwater portion of the Bay TMDL will be met through the 20% impervious treatment goal, therefore the County's stormwater sector is focused on the 20% target and is not specifically scheduling its urban MS4 sector to the 2017 and 2025 milestone dates.

The number of projects to be implemented per year and per watershed are presented in Figure 11 and Table 34. The program peaks in years FY2020 with approximately 44 projects to be implemented each year before dropping in FY2021 to an average of approximately 20-30 projects per year.

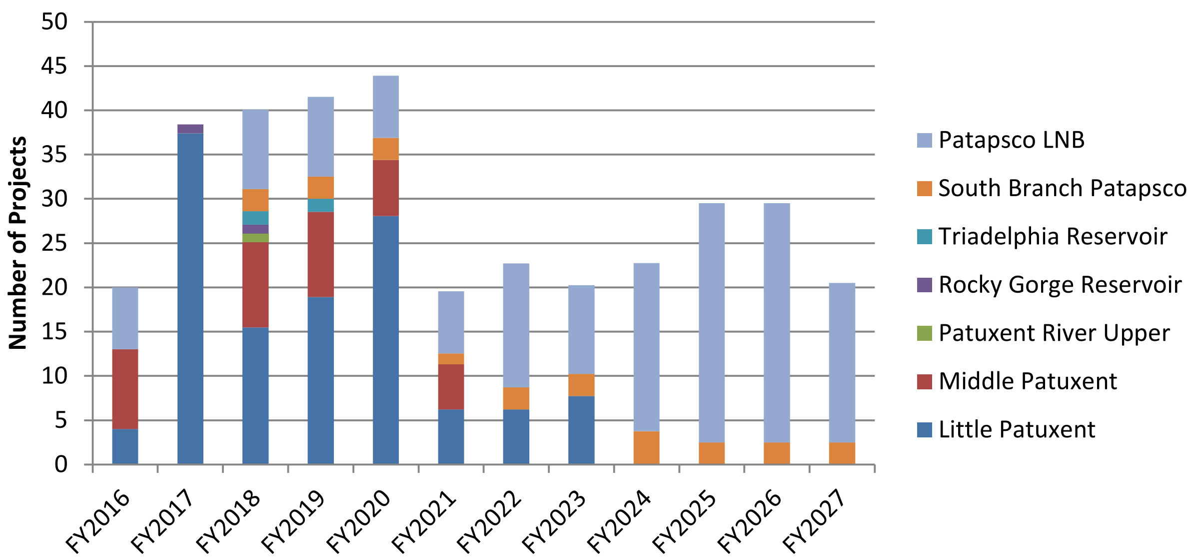


Figure 11. Project Implementation by Fiscal Year and Watershed

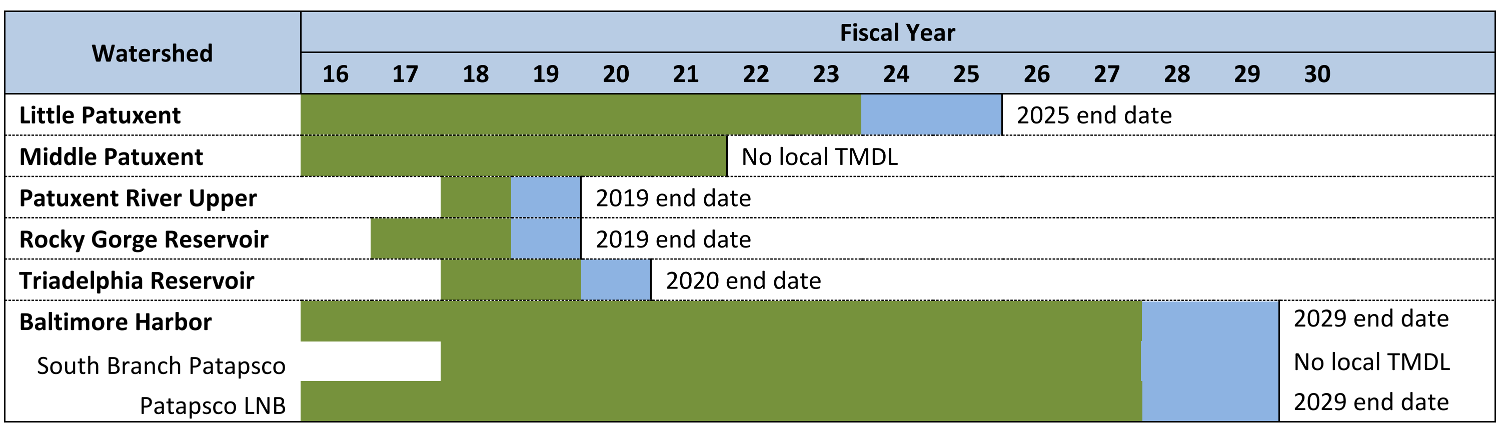
The schedule is developed such that the year a project is anticipated to be constructed and completed is the year it is indicated on the schedule in Table 34. Project completion will be preceded by approximately two-years of site specific assessment, design and permitting. Some projects, stream restoration for example, will likely be followed by a set number of years of monitoring.

Projects slated for the FY16 and FY17 time periods include projects already in development and on County CIP lists. They also include some projects identified in the 2015 watershed assessments. A focus is on the Little Patuxent between FY16 and FY20 since a large percentage of untreated County impervious is located in the watershed, and many projects are already identified with concept plans developed and ready to move into design stages. Little and Middle Patuxent projects are generally slated first since concepts have been developed. Watershed assessments to be completed by the fall of 2016 will identify the list of potential projects for the remainder of County watersheds; therefore these projects are generally scheduled for later stages of the program.

Table 34. Project Implementation List Per Year and Watershed

Fiscal Year	Little Patuxent	Middle Patuxent	Patuxent River Upper	Rocky Gorge Reservoir	Triadelphia Reservoir	Baltimore Harbor		Total
						South Branch Patapsco	Patapsco LNB	
2016	4	9					7	20
2017	37			1				38
2018	15	10	1	1	1.5	3	9	40
2019	19	10			1.5	2	9	42
2020	28	6				2	7	43
2021	7	5				1	7	20
2022	6					2	14	22
2023	8					3	10	21
2024						4	19	23
2025						2	27	29
2026						3	27	30
2027						3	18	21
Total	124	40	1	2	3	25	154	349

Figure 12. Implementation Schedule



Primary project completion period is shown in green. Additional implementation contingent period in blue. Baltimore Harbor TMDL includes the South Branch Patapsco and Patapsco Lower North Branch watersheds.

Figure 12 above indicates the general planning level schedule for project implementation. The County's 20% impervious restoration target is slated to be met by December of 2019. Local TMDL SW-WLA completion is indicated on the same figure with 'end dates' noted for each local TMDL. Smaller reductions have been given a 1-year additional implementation contingent period to allow for unexpected program elements. Larger, more challenging local TMDLs in the Little Patuxent (sediment), Patapsco River LNB (sediment and bacteria) and the Baltimore Harbor (nitrogen and phosphorus) are given a 2-year additional implementation contingent period. No local TMDLs are currently in place for the Middle Patuxent or South Branch Patapsco.

8 Load Reduction Evaluation Criteria

Adaptive management is a critical component of achieving and maintaining the local TMDLs, Bay TMDL, and this restoration plan. The milestones proposed in Section 7 will be used to reevaluate against progress and will be revised, if necessary, to ensure that Howard County continues to maintain TMDL requirements. Progress evaluation 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.

8.1 Tracking Implementation of Management Measures

Implementation will be measured by determining whether the targets for implementation shown in previous sections are maintained according to the schedule presented. Howard County is developing an NPDES Geodatabase that will manage a comprehensive system for adding and tracking projects and accounting for new programs. Development of the database has been initiated and it is expected to be operational in 2016.

Feasibility studies of the planned strategies may reveal that some existing structures or sites identified for retrofitting or enhancement may not be feasible candidates for future projects and may be eliminated from consideration. Since many restoration projects will need to be done on private property, lack of approval by private property owners may also impact the number and types of projects that can be accomplished. 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.

Two-Year Milestone Reporting

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

Milestones are 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 2014 - 2015 is from January 1, 2014 through December 31, 2015. BMP Implementation milestones are a quantitative account of various types of restoration activities (e.g., structural BMPs, stream restoration, maintenance efforts), which have geo-located coordinates. The period for BMP implementation milestones differs from the Programmatic milestones period and covers two state fiscal years – for example, the period for 2014 – 2015 is from July 1, 2013 through June 30, 2015. Planned BMP Implementation milestones reported to MDE include the action (e.g., BMP type), proposed restoration over the 2-year milestone period (e.g., area treated, length restored), actual rate of implementation over 1 year, and percent progress.

The Programmatic and BMP Implementation milestone submittal and reporting process follows an iterative approach and includes three separate submittals to MDE. The first is an initial milestone submittal to MDE by January 31st of the first milestone calendar year (e.g., 2014), followed by an interim milestone progress report submittal by January 31st of the second milestone calendar year (e.g., 2015), and concluding with a final milestone progress submittal by January 31st of the start of the subsequent milestone period (e.g., 2016).

Annual NPDES Reporting

As a requirement of the NPDES permit, the County must submit annually a progress report demonstrating the 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:

- 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
- **A narrative summary describing the results and analyses of data, including monitoring data that is accumulated throughout the reporting year**
- Expenditures for the reporting period and the proposed budget for the upcoming year
- A summary describing the number and nature of enforcement actions, inspections, and public education programs
- **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,**
- **The identification of any proposed changes to the County's program when WLAs are not being met**
- Attachment A – 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

8.2 Estimating Load Reductions

Progress assessments are scheduled by the Chesapeake Bay Program for 2017 and 2021. Multiple lines of evidence including: several models, monitoring data, and the most recent science on BMP effectiveness and water quality response will be evaluated in the assessments. The milestones and progress assessments will contribute to regular reassessment of management plans, and adaptation of 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 in MAST at the interim (2016, 2018) and milestone (2015, 2017, 2019) years, which equates to about once a year at minimum.

8.3 Tracking Overall Program Success through Monitoring

Overall program success will be evaluated using trends identified through a long term monitoring program such as that described below in Section 9: Monitoring. TMDL compliance status will be evaluated to determine if the CIS 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.

8.4 Best Management Practices Inspection and Maintenance

Implementing the 2000 Maryland Stormwater Design Manual and providing applicable feedback to MDE on programmatic problems is a condition of the current NPDES permit, MDE has updated the Design Manual per the requirements set forth by the Stormwater Management Act of 2007. The County is now implementing the current version of the Design Manual, including the 2009 revision for ESD, and providing feedback on that version as necessary.

The County performs preventative maintenance inspections of all County, Board of Education, and private SWM facilities on a triennial basis. In addition, there are also individual residential ESD BMPs (e.g., rain gardens, rain barrels, etc.), which are being inspected triennially. The 2009 ESD revision has led to a large influx of facilities needing to be inspected.

Inspectors follow the requirements outlined in the County's Storm Water Management Facility Inspection and Maintenance Procedures (Howard County, 2012b). The general procedure for the inspection of privately maintained facilities is to use the owner information in the BMP database developed by the County to give prior notification to the BMP owners of the County's intent to inspect their facility; perform the inspection; provide the owner a complete record of the results of the inspection, including deficiencies that need to be repaired; then follow up with the owner to ensure the necessary repairs are made within a reasonable time frame. The County has developed an extensive component to the BMP database to allow tracking of the inspection and maintenance process in detail for each BMP inspected.

9 Monitoring

Official monitoring for impairment status is the responsibility of the State; however the County utilizes a variety of monitoring programs to ensure progress towards its NPDES responsibilities and TMDL progress.

The new MS4 permit emphasizes the need to monitor progress toward meeting permit requirements and apply adaptive management as necessary. Specifically, the County is expected to implement a back-up plan for additional restoration if required pollutant reductions are not met. The additional BMPs available beyond the projects and programs presented in the CIS (i.e., BMPs above the TMDL target) provide this back-up inventory of projects that could be implemented if necessary. In each watershed assessment, BMPs in excess of the minimum number needed to meet restoration requirements may be developed to provide this back-up plan.

The approach for tracking progress toward meeting regulatory and programmatic targets should include a combination of the County's NPDES geodatabase, updated progress models using MAST, and monitoring of the reductions in stressors and improvements in stream conditions that result from project implementation.

Physical monitoring reflects the realities of monitoring restoration (Southerland, 2012), wherein (1) monitoring the design, construction, and maintenance of BMPs or other restoration projects is relatively easy; while (2) monitoring the performance of these projects, in terms of reducing stressors, is more difficult (owing to technical and cost factors); and, (3) in terms of stream condition, is often much harder (owing to confounding factors and time lags). Most problematic is monitoring to capture water quality improvements associated with programmatic restoration measures, such as increased outreach, enhanced enforcement, or adopting new legislation or regulation. Documenting improvements associated with these types of approaches are better addressed as part of public outreach and stewardship.

The 2010 Chesapeake and Coastal Bays Trust Fund Water Quality Monitoring Strategy (Trust Fund Evaluation Workgroup, 2010) recognizes that intensive monitoring of BMP performance, while effective, is not practical on a large scale. The Strategy recommends that sampling of larger receiving waters be done only when a 30% reduction in nutrient or sediment loads from one or more BMPs are expected; otherwise, monitoring should be done as close to the implementation site as possible. The Strategy concludes that these monitoring challenges underscore the need for an adaptive management approach that draws upon existing sampling networks and institutional partnerships and recognizes issues related to the local budget and funding cycle. As one of the major recipients of Trust Fund monies, Howard County is already advanced in conducting monitoring under this Strategy.

An approach for Howard County to augment its tracking of restoration project implementation could be:

- Stream condition monitoring on a time scale where improvements are likely to occur (including biological community metrics beyond narratives of excellent, good, fair, and poor)
- BMP performance monitoring on the spatial scale where changes in stressors are expected to be measurable

Stream condition changes are unlikely to be detected over short time periods and, therefore, would only be evaluated after 5-10 years. Reductions in stressors from effective BMPs may be measurable over periods of 1-5 years, but are unlikely to be detected over large spatial scales in less than 10 years.

The County has a history of both extensive monitoring to address stream condition and intensive monitoring to address BMP performance. It is not practical to expand the intensive monitoring effort commensurate with the many-fold increase in project implementation. Therefore, the County may evaluate its combined, existing monitoring effort and, if necessary, consider reallocation and augmentation to most efficiently track progress toward meeting the targets of the MS4 Permit.

Where appropriate, monitoring by the State or others (including volunteer citizens) may contribute to providing a more complete picture of restoration progress (e.g., toward Chesapeake Bay TMDL targets). As described above, it is important not to encourage unrealistic expectations for observing stream condition improvements over large geographic scales or over short time periods.

9.1 Current Howard County Monitoring

The County currently conducts monitoring in the following three areas:

- **Countywide stream resource monitoring**. Although not required by its MS4 permit, the County has conducted biological monitoring since 2001. The Howard County Biological Monitoring and Assessment Program has been sampling about 150 stream sites every five years (generally 10 sites in each of three watersheds each year). Monitoring includes benthic macroinvertebrate sampling, in-situ water quality monitoring, physical habitat assessment, and a basic geomorphic assessment at each site. In the first two five-year rounds, sites were selected randomly within watersheds or primary sampling units (PSUs); in the third round that began in 2011, two sites are re-sampled from the first round and two sites are re-sampled from the second round, while the remaining six sites are selected at random. This partial replacement methodology is optimal for both status assessment and trend detection. This countywide monitoring provides an excellent baseline for ecological stream conditions that should improve with the implementation of restoration projects.

  Stormwater Design Manual monitoring. After MDE finalized the Maryland 2000 Stormwater Management Design Manual, and as a requirement of the County's MS4 Permit at the time, Howard County undertook physical stream monitoring in the Hammond Branch watershed to determine the effectiveness of stormwater management practices being applied to new development for stream channel protection. After ten years of monitoring in the Hammond Branch Tributary Watershed, the County provided adequate data and requested and was given permission by MDE to discontinue monitoring at this location and initiate monitoring in another developing watershed.

  In 2011, Howard County (in conjunction with MDE) replaced monitoring at the Hammond Branch site with monitoring of an unnamed tributary to Red Hill Branch, a tributary of the Upper Little Patuxent (hereafter called Rumsey Run). Given the evolution of stormwater regulations following Maryland's Stormwater Management Act of 2007, the monitoring at Rumsey Run is designed to differentiate between the effects of Environmental Site Design treatment of runoff ("green stormwater infrastructure") and the effects of no or traditional stormwater treatment ("gray stormwater infrastructure") on stream channel stability. Monitoring includes the survey of approximately 4,000 linear feet of stream channel, cross-sectional surveys, and pebble counts. In addition, four maximum-level gauges are monitored within Rumsey Run to support hydraulics and hydrology modeling. Continuous flow monitoring at outfalls representative of different stormwater infrastructures was added in 2013.

- **Discharge characterization and restoration monitoring**. Previously, Howard County intensively monitored the water chemistry, biology, and stream physical condition on the Font Hill Tributary to the Little Patuxent River, to meet the discharge characterization requirements of their MS4 Permit. After completion of a watershed plan for the Centennial Lake and Wilde Lake watersheds in 2005, this monitoring was moved to these two watersheds, but discontinued in the Centennial Lake watershed in 2009. The monitoring effort was shifted to the Red Hill Branch subwatershed of the Upper Little Patuxent watershed after the watershed plan was completed.

  Monitoring in the Wilde Lake watershed includes biological, geomorphic, and water quality assessments. Synoptic (one-time) chemical, physical, and biological sampling is conducted throughout the watershed to determine if the restoration efforts outlined in the Centennial and Wilde Lake Watershed Restoration Plan are reducing pollutant loading and increasing the health of the lake and streams. Biological monitoring began in 2006 and is conducted at five sites per year. It includes the collection and analysis of the benthic macroinvertebrate community, assessment of the physical habitat, and instream water quality sampling. Geomorphic assessment also began in 2006 and includes the annual survey of four channel cross-sections, particle size analysis, and longitudinal profile of three reaches. The County also maintains and operates an automated sampler to evaluate stormwater quality at a site located on the main channel draining to Wilde Lake. The sampling station includes a probe for continuous instream water quality monitoring, continuous flow monitoring, and a refrigerated unit for collection of stormwater samples. Continuous flow measurements are used to estimate annual and seasonal pollutant loads and for the calibration of watershed assessment models.

  Monitoring in the Red Hill Branch subwatershed includes biological, geomorphic, and water quality evaluations to assess the effectiveness of restoration efforts identified in the Upper Little Patuxent Watershed Management Plan. Monitoring was initiated in late 2009 with geomorphic assessments, and in early spring of 2010 with biological assessments, continuous discharge, baseflow and stormflow water quality, and sediment sampling. Biological monitoring includes the collection and analysis of the macroinvertebrate community, physical habitat assessments, and measurements of in-situ water chemistry. Biological assessments include annual sampling at three sites located at the downstream end of the major drainage areas within the Red Hill Branch subwatershed, as well as a fourth control site located in an adjacent watershed. Beginning in 2011, the Maryland Biological Stream Survey is supplementing this monitoring with annual fish assessments during the summer. Geomorphic assessments are conducted at two locations within Red Hill Branch and at a third control site in an adjacent watershed; these include the annual survey of channel cross sections, particle size analysis, and a longitudinal profile of three reaches. Other monitoring techniques include assessments of bed and bank stability through bank pin and scour chain measurements and channel facies mapping, as well as bulk bar sieve samples.

  Howard County also conducts baseflow and stormflow water quality monitoring at five stations associated with three restoration projects in the Red Hill Branch watershed. The Bramhope study area consists of two sites, one upstream and one downstream of a stream restoration project. The Salterforth study area consists of two sites, one upstream and one downstream of a dry extended detention basin retrofit. The third study area is located within Meadowbrook Park near the downstream extent of the subwatershed and consists of a single monitoring station to monitor changes in water quality resulting from the combined restoration treatments throughout the subwatershed. An automated sampler includes a probe for continuous instream water quality monitoring, continuous flow monitoring, and a refrigerated unit for collection of stormwater samples. Continuous discharge, baseflow, and stormflow water quality are monitored to determine the pollutant loading and removal rates. Innovative techniques to assess bedload and suspended sediment during storm flows include pit trap and siphon samplers. DNR is also conducting flow monitoring upstream and downstream of the Bramhope stream restoration project to enable calculation of pollutant loads. Pre-restoration monitoring began in 2010; post-restoration and retrofit monitoring for both Bramhope and Salterforth began in 2012.

Howard County is also conducting restoration monitoring at Dorsey Hall in the Red Hill Branch and Plumtree Branch subwatersheds and for restoration projects located in and around Turf Valley in the upper portions of the Little Patuxent watershed. Dorsey monitoring includes base and stormflow water chemistry, sediment, geomorphological assessment, biological sampling, habitat assessment and continuous discharge. Turf Valley monitoring is limited to biological, physical habitat, and in situ water quality evaluations.

There is additional water quality and flow monitoring being conducted at USGS stream gages in Howard County (Figure 13), as follows:

- **Water quality and flow monitoring at USGS gages**. In 2012, the U.S. Geological Survey (USGS) operated ten 10 stream gages within Howard County watersheds in coordination with Howard County, Columbia Association (CA), State Highway Administration (SHA), Washington Sanitary Sewer Commission (WSSC), Maryland Geological Survey, American Rivers, and National Oceanographic and Atmospheric Administration (NOAA). Three of the stations are on the Patapsco River to document the effects of dam removal and may be terminated at some point. The Little Patuxent stations above Wilde Lake and Lake Elkhorn are new and do not have stream discharge ratings developed, yet. The full list of USGS gages is given below with data at http://waterdata.usgs.gov/md/nwis/current/?type=flow.
    - USGS 01591400 CATTAIL CREEK NEAR GLENWOOD, MD (starting 1944, funded by WSSC)
    - USGS 01591610 PATUXENT RIVER BELOW BRIGHTON DAM NEAR BRIGHTON, MD (starting 1983, funded by WSSC)
    - USGS 01592500 PATUXENT RIV NEAR LAUREL, MD (starting 1944, funded by WSSC)
    - USGS 01593370 L PAX RIV TRIB ABOVE WILDE LAKE AT COLUMBIA, MD (starting Oct 2012, funded by CA)
    - USGS 01593450 L PAX RIV TRIB ABOVE LAKE ELKHORN NR GUILFORD, MD (starting Oct 2012, funded by CA)
    - USGS 01593500 LITTLE PATUXENT RIVER AT GUILFORD, MD (starting 1932, funded by SHA)
    - USGS 01594000 LITTLE PATUXENT RIVER AT SAVAGE, MD (starting 1939, funded by Howard County Bureau of Utilities)

- o USGS 01589000 PATAPSCO RIVER AT HOLLOFIELD, MD (May 1944 to January 1992, March 1994 to September 1995, January 2000 to September 2004, April 2010 to current year; funded by Maryland Geological Survey)
- o USGS 01589025 PATAPSCO RIVER NEAR CATONSVILLE, MD (starting Oct. 2010, funded by American Rivers and NOAA)
- o USGS 01589035 PATAPSCO RIVER NEAR ELKRIDGE, MD (starting Oct. 2010, funded by American Rivers and NOAA)

These gages help the County monitor (1) pollutant loadings being carried across jurisdictions, (2) changes associated with stream restoration and stormwater retrofits, and (3) effects of development in upstream watersheds. This supports other monitoring by providing information on both upstream contributing and downstream cumulative conditions.

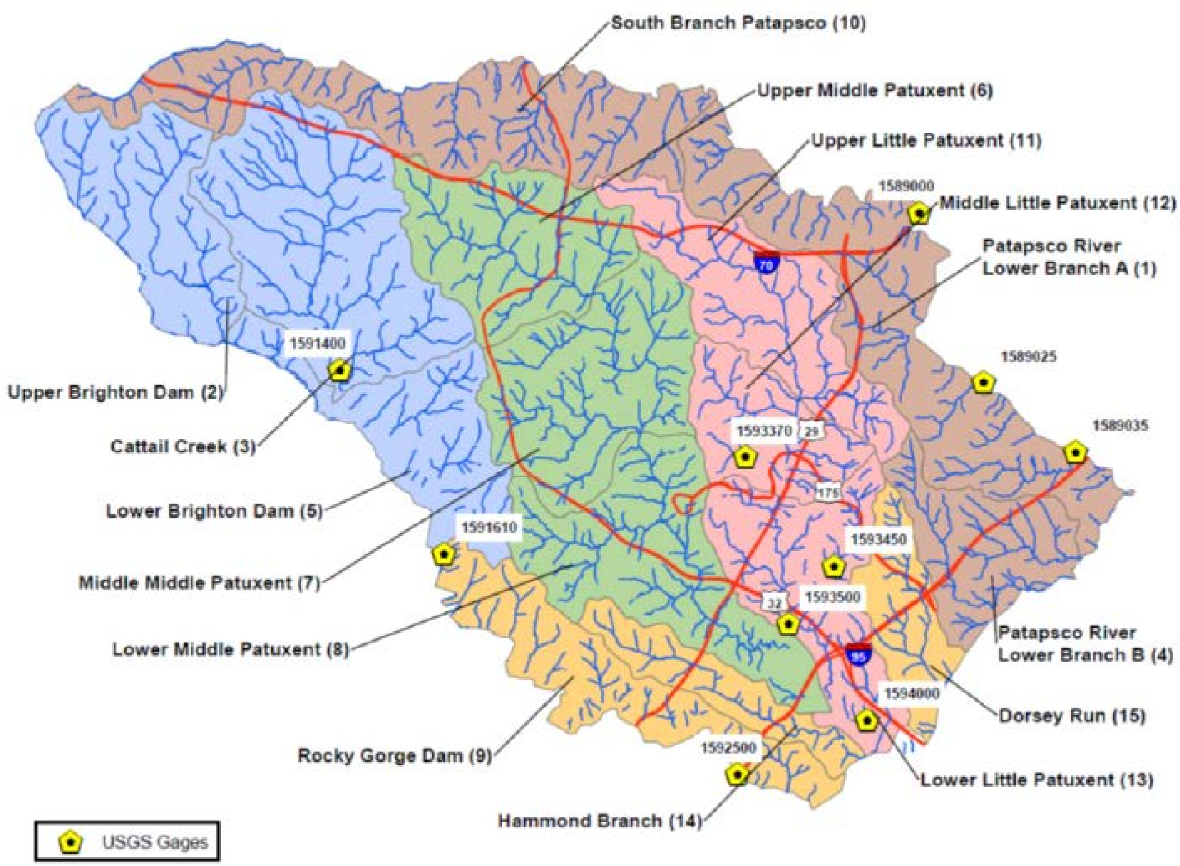


Figure 13. Locations of the 10 USGS stream gages operating within Howard County watersheds during 2012.

9.2 Recommended Monitoring to Track Implementation Progress

Applying the adaptive management approach, the County will consider whether to reallocate and augment its current monitoring program, including the possibility of incorporating the following two components:

1. **Stream resource sampling** of stream benthic macroinvertebrates, water quality, and physical habitat should continue using the partial-replacement design instituted in 2012. Under this

design, four of the 10 sites sampled in each watershed would be repeats of sites sampled in Round 1 (2001-2005) and Round 2 (2006-2010), while the remaining six sites would be new random sites. To provide the best trend detection for changes in each watershed resulting from restoration efforts, these four sites per watershed should remain fixed in perpetuity. For the purposes of monitoring improvements to Howard County watersheds resulting from implementation of the new MS4 Permit and Chesapeake Bay WIP, years 2000-2010 can be viewed as baseline stream conditions. Each watershed and site could be evaluated after each 5-year sampling with comparisons to the random and sentinel (fixed, annual) site Maryland Biological Stream Survey (MBSS) monitoring conducted by the State, to control for weather or other confounding factors. Where possible, the results from fish and salamander sampling conducted by the MBSS could be incorporated into the trend evaluations.

Indicators of significant changes in the composite stream condition scores based on indices of biotic integrity or more sensitive community-based analyses), are the ultimate measure of restoration success. Select measures of changes in both biological communities and physical habitat will be evaluated to detect more immediate changes related to reductions in specific stressors. For a headwaters site, the selected monitoring parameters would directly represent the project goals and anticipated environmental benefits to measure success. For example, the Maryland Biological Stressor Identification Process (MDE, 2009b; Southerland et al., 2007) has identified the following variables as significantly correlated with sediment (flow/sediment) and nutrient (energy) stressors to be addressed with restoration projects:

- <u>Flow/Sediment effects</u>: Benthic Tolerant Species, bank stability index, embeddedness, epifaunal substrate condition, instream habitat condition

- <u>Energy effects</u>: Hilsenhoff Biotic Index, shading, dissolved oxygen, dissolved organic carbon, total nitrogen, ammonia-NH3, total phosphorus

Each of these metric scores or other measures of community change could be evaluated, in addition to the composite stream condition scores, to potentially track improvements resulting from reductions in sediment and nutrients, respectively. The biological metrics—Benthic Tolerant Species and Hilsenhoff Biotic Index—alone may prove to be useful indicators. Additional biological metrics taken from the literature (e.g., specific intolerant taxa) will also be considered.

2. **<u>Intensive restoration performance monitoring</u>** of flow and pollutant transport in representative subwatersheds may be extrapolated countywide. This monitoring may use statistically robust, before-after-control-impact (BACI) designs where the maximum number of restoration projects will be implemented. GIS data describing the interplay of land use and stream network would be collected from these subwatersheds and benchmarked to the monitoring results, so that the performance could be extrapolated to similar areas throughout the County. Creating representative subwatershed restorations for each combination of land use type and stormwater solution is critical to this approach.

   Currently, Howard County is conducting BMP performance monitoring in two subwatersheds and the Columbia Association may institute similar monitoring in a third subwatershed as follows:

a. Wilde Lake watershed contains an older residential community near the center of Columbia and predates stormwater controls. Monitoring since 2006 occurs along several reaches within the subwatershed and encompasses three stream restorations, two SWM retrofits, and two bioretentions. A new USGS gage was installed in October 2011 at a downstream point in this subwatershed.

b. Red Hill Branch watershed has a mixed-age community outside of Columbia and variable stormwater controls. Monitoring since 2009 includes BACI designs for a stream restoration and a stormwater retrofit. The Rumsey Run geomorphic assessment of newer infiltration BMPs drains to the most downstream monitoring station in Red Hill Branch. A volunteer rain garden program has also been initiated within the subwatershed.

c. Lake Elkhorn watershed is not currently monitored, but a new USGS gage was installed in October 2011 at a downstream point in this subwatershed. Eighteen restoration projects, ranging from stream restoration to SWM retrofits to bioretentions, are planned for Lake Elkhorn watershed, some of which already have been completed.

   Each of these monitoring efforts will contribute to extrapolation of restoration performance results countywide. As new restoration projects are constructed, they could be clustered in at least two other subwatersheds with different characteristics to improve the extrapolations to other land uses.

The most important aspect of these restoration performance monitoring efforts is the inclusion of a statistically rigorous design with proper controls (spatially, using upstream and downstream sites or paired watersheds; and temporally, with monitoring before and after a restoration event). It will be important to use sampling methods with the least variability and clearest signal. Currently, the Trust Fund program is developing standard geomorphic and water quality methods that are being informed by the monitoring done in Howard County. It is possible that the lessons of intensive monitoring in Red Hill Branch will identify redundant methods that can be eliminated from future monitoring.

It is also possible that emerging technologies will allow continuous recording of water chemistry that was previously unaffordable. For example, optical dissolved oxygen probes do not need regular calibration and can be installed in streams to provide information on diurnal changes. Unexplained low dissolved oxygen conditions may reflect high algal or microbial levels related to nutrient enrichment. Initially, the County could sample a small number of sites associated with restoration efforts, moving the equipment periodically to increase coverage.

Lastly, Howard County may use the continuous flow monitoring of USGS gages for current and future monitoring within the county. Co-locating water quality monitoring with these gages or using them as an indicator of cumulative flows from comparable subwatersheds would increase the value of monitoring data, especially for calculating pollutant loads. Fortunately, USGS gages have recently been installed in the Wilde Lake and Lake Elkhorn subwatersheds. Since all three current monitoring efforts are in the Little Patuxent watershed, extrapolation watershed-wide can make use of the downstream USGS gage at Savage. The USGS gage on Cattail Creek offers an opportunity to monitor clustered restoration projects in western Howard County.

In summary, Howard County monitoring efforts to document stream changes associated with restoration efforts may incorporate the following framework and methods.

- Continue to use sentinel (fixed) sites for trend monitoring of stream conditions
- Use existing monitoring networks (such as the countywide and Maryland Department of Natural Resources Maryland Biological Stream Surveys (MDNR MBSS) stream resource monitoring) to provide baselines and adjust for confounding effects such as precipitation and unusual weather
- Leverage the intensive monitoring of restoration performance in subwatersheds such as Wilde Lake, Red Hill
- When needed, identify the best additional sites to conduct restoration monitoring in subwatersheds with different land uses such as commercial and high-density developments
- Use statistically robust before-after-control-impact (BACI) designs, latest affordable sampling methods, and co-location with USGS gages to optimize the power to detect changes associated with restoration efforts

The type of monitoring described above would be compliant with current NPDES permit conditions and would seek to draw conclusions to specific management questions to assist the County in making informed decisions. To that end, the County will attempt to balance cost, availability of resources, private property owner approvals, and other factors to determine the final monitoring strategies implemented.

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Technical Appendix: Disaggregation and Calibration of Howard County Local TMDL SW-WLAs

Disaggregation of Aggregate WLAs

Some SW-WLAs are developed by MDE as an aggregate load including load contributions from multiple jurisdictions. In order to determine Howard County's portion of the load, the aggregate SW-WLA must be disaggregated based on the percentage of Howard County's MS4 regulated urban land area within the TMDL watershed. To date, Howard County is responsible for six aggregate SW-WLAs and three individual SW-WLAs. Aggregate WLAs were disaggregated following steps outlined in MDE's TMDL Stormwater Toolkit (MDE, 2015b). The proportion of Howard County MS4 urban land area to total urban land area, including other jurisdictions, within the 8-digit watershed boundaries was calculated. Urban land use categories from Maryland Department of Planning 2010 land use data (MDP, 2010) were used to define each jurisdiction's urban area. The percentage of Howard County MS4 urban land area was then applied to the aggregate SW-WLA published in the local TMDL document. Local TMDLs with individual SW-WLAs require a specified percent reduction of pollutant loads from baseline levels to achieve the target SW-WLA and no disaggregation is necessary. Table 1 displays Howard County local TMDLs with aggregate SW-WLAs disaggregated.

The load reduction calculated from disaggregating the bacteria SW-WLA following MDE Guidance stated above is the target for the Patapsco River Lower North Branch bacteria local TMDL. This value is presented in bold in the Calculated Disaggregated County MS4 Reduction column of Table 1.

Calibrating Nutrient and Sediment Baseline Loads and WLAs

According to the MDE guidance document *Guidance for Using the Maryland Assessment Scenario Tool to Develop Stormwater Wasteload Allocation Implementation Plans for Local Nitrogen, Phosphorus, and Sediment TMDLs* (MDE, 2014b), Section I, baseline loads and WLAs must be calibrated to the model used to calculate load reductions:

Because all of Maryland's approved local nutrient and sediment TMDLs were developed using watershed models other than MAST [Maryland Assessment Scenario Tool], the baseline and target loads from these TMDLs need to be translated into MAST loadings. This adjustment is required to account for potential differences between models. This is a two-step process that involves 1) creating a MAST scenario that replicates the baseline year of the TMDL, and 2) applying the load reduction percentage from the TMDL to the MAST loading for the baseline year.

Local TMDL baseline loads for nutrients and sediments were calibrated in BayFAST (Bay Facility Assessment Scenario Tool) by modeling County BMPs installed prior to the TMDL baseline year on top of baseline land use background loads. BayFAST functions similarly to Maryland Assessment Scenario Tool (MAST); which is described further in Section 3.2: Modeling Approach of this plan, however BayFAST allows users to delineate facility boundaries (e.g., watershed, parcel, drainage area) and alter land use information within the delineated boundary depending on the model year. The general calibration procedure is as follows:

1. For each local TMDL, a facility boundary for the 8-digit TMDL watershed within Howard County borders was delineated within BayFAST.
2. All default land use acreages were deleted and regulated pervious and impervious acres were replaced with MAST Local Base County Phase I MS4 urban pervious and impervious acres using the Compare Scenario tool in MAST for the respective baseline year for each local TMDL. This approach inherently disaggregates County MS4 loads from the rest of the NPDES regulated area within the watershed.
3. County BMPs installed prior to the TMDL baseline year were then added to the model.

4. The reduction percentage published in the TMDL document was then applied to the calibrated baseline loads modeled in BayFAST to calculate a calibrated reduction in EOS-lbs/yr.
5. A calibrated WLA was calculated by subtracting the calibrated reduction from the BayFAST baseline load.

Aggregate nutrient and sediment SW-WLAs are inherently disaggregated through this approach. Therefore, disaggregated loads calculated using the proportion of Howard County MS4 urban land (as described in the Disaggregation of Aggregate SW-WLAs section above) were not used in the CIS. Additionally, because bacteria load reductions are not modeled using BayFAST or MAST, aggregate bacteria SW-WLAs were disaggregated but not calibrated.

Calibrated load reductions calculated based on TMDL percent reductions and baseline loads modeled in BayFAST using Howard County Phase I MS4 baseline pervious and impervious land use and baseline treatment are the target reductions used in the CIS for nutrient and sediment local TMDLs. These values are presented in bold in Table 2.

Table 1. Howard County Local TMDLs with SW-WLAs. Aggregate SW-WLAs Disaggregated Following MDE Guidance

Watershed Name	Watershed Number 8-digit	WLA Type	Baseline Model[1]	Pollutant	Units	MDE Published WLA[2]	MDE Published Reduction %[2]	Watershed Howard County MS4 Urban Land Area (ac)[3]	Watershed Total Urban NPDES Land Area (ac)[4]	% of County MS4 Land Area[5]	Calculated Disag-gregated County MS4 WLA[6]	Calculated Disag-gregated County MS4 Reduction[7]	Calculated Disag-gregated County MS4 Baseline Load
Patapsco River Lower North Branch	02130906	Individual	CBP WM P5	Sediment	tons/yr	2,634.30	10%	-	-	-	-	-	-
		Aggregate	N/A	Bacteria	billion MPN/yr	143,218.0	13.4%	12,520.91	34,349.82	36.5%	52,204.6	**8,077.9**	60,282.5
Baltimore Harbor (Patapsco R LN Br + S Br Patapsco)	02130906 02130908	Aggregate	HSPF, CH3D, CE-QUAL_ICM, sediment flux	Nitrogen	lbs/yr	79,659.0	15%	18,099.87	53,483.69	33.8%	26,958.1	4,757.3	31,715.4
	02130906 02130908	Aggregate		Phosphorus	lbs/yr	8,622.0	15%	18,099.87	53,483.69	33.8%	2,917.8	514.9	3,432.8
Patuxent River Upper	02131104	Individual	CBP WM P5.2	Sediment	tons/yr	579.8	11.4%	-	-	-	-	-	-
Little Patuxent River	02131105	Individual	CBP WM P5.2	Sediment	tons/yr	3,609.3	48.1%	-	-	-	-	-	-
Rocky Gorge Reservoir	02131107	Aggregate	CE-QUAL-W2	Phosphorus	lbs/yr	1,512.0	15%	3,457.01	14,734.75	23.5%	354.7	62.6	417.3
Triadelphia Reservoir (Brighton Dam)	02131108	Aggregate	CE-QUAL-W2	Phosphorus	lbs/yr	4,672.0	15%	12,467.78	14,707.93	84.8%	3,960.4	698.9	4,659.3
		Aggregate	CE-QUAL-W2	Sediment	tons/yr	354.0	0%				300.1	0.0	300.1

Target load reductions used in the CIS shown in bold text.
SW-WLA disaggregation method: MDE TMDL Stormwater Toolkit (http://www.mde.state.md.us/programs/Water/TMDL/DataCenter/Pages/TMDLStormwaterToolkit.aspx)

1) Baseline model used to create the TMDL. Chesapeake Bay Program Watershed Model Phase (CBP WM P); Hydrological Simulation Program Fortran (HSPF); Curvilinear Hydrodynamic in Three Dimensions (CH3D); Corps of Engineers-Water Quality-Integrated Compartment Model (CE-QUAL-ICM), Corps of Engineers-Water Quality-and Hydrodynamic model in 2D (CE-QUAL-W2)
2) Published WLA and Reduction % from the MDE TMDL Data Center SW WLAs for County Storm Sewer Systems in Howard County
3) MDP 2010 LULC urban land area within Howard County NPDES MS4 Phase I/II source sector in watershed.
4) MDP 2010 LULC urban land area within total NPDES source sectors in watershed.
5) The percent of County MS4 land area was calculated by dividing the total County MS4 urban land area with the total urban NPDES source sector land area of the 8-digit watershed area (MDP, 2010).
6) Disaggregated WLAs were calculated by multiplying MDE published aggregate WLAs by the percentage of County MS4 land within the urban NPDES land area of the 8-digit watershed.
7) Disaggregated reductions were calculated from the disaggregate WLA and reduction % using the following equation: (Disaggregated WLA / (1 - Reduction %)) - Disaggregated WLA

Table 2. Disaggregated and Calibrated Nutrient and Sediment Local TMDL SW-WLAs and Load Reductions

Watershed Name	Watershed Number	Baseline Year	Pollutant	MDE Published Reduction %[1]	Baseline Acres (MAST Local TMDL Base Year)[2] County Phase I MS4 Impervious	Baseline Acres (MAST Local TMDL Base Year)[2] County Phase I MS4 Pervious	Baseline Loads EOS-lbs/yr[3]	Reduction EOS-lbs/yr[4]	WLA EOS-lbs/yr[5]
Patapsco River Lower North Branch	02130906	2005	Sediment	10%	3,049	8,461	6,123,442	**612,344**	5,511,098
Baltimore Harbor (Patapsco R LN Br + S Br Patapsco)	02130906	1995	Nitrogen	15%	2,773	7,776	81,058	**16,059**	91,000
	02130908				371	1,816	26,001		
	02130906	1995	Phosphorus	15%	2,773	7,776	5,530	**982**	5,564
	02130908				371	1,816	1,016		
Patuxent River Upper	02131104	2005	Sediment	11.40%	247	942	145,902	**16,633**	129,269
Little Patuxent River	02131105	2005	Sediment	48.10%	6,189	18,189	10,346,821	**4,976,821**	5,370,000
Rocky Gorge Reservoir	02131107	2000	Phosphorus	15%	291	1,517	861	**129**	732
Triadelphia Reservoir (Brighton Dam)[6]	02131108	2000	Phosphorus	15%	869	4,859	2,654	**398**	2,256
		2000	Sediment	0%			1,844,103	**0**	1,844,103

Target load reductions used in the CIS shown in bold text.

1) Published Reduction % from the MDE TMDL Data Center SW WLAs for County Storm Sewer Systems in Howard County
2) County Phase I MS4 urban impervious and pervious acres for the TMDL baseline year. A query was run using the MAST Compare Scenario tool based on local TMDL watershed split by County and Local Base year. Local TMDL base data prior to 2000 is unavailable in MAST; therefore, 2000 County Phase I MS4 urban impervious and pervious acres were used in the Baltimore Harbor baseline model (baseline year = 1995).
3) Baseline loads modeled in BayFAST using County BMPs installed prior to the TMDL baseline year on top of baseline land use background loads. Modeled 10/22/2015. Additional load reductions from Howard County lakes installed prior to the baseline year and rooftop/non-rooftop disconnects were included outside of BayFAST.
4) Calibrated reductions calculated by applying the MDE published percent reduction to the BayFAST calibrated baseline loads.
5) Calibrated WLAs calculated by subtracting the calibrated reduction from the BayFAST calibrated baseline load.
6) The Triadelphia Reservoir (Brighton Dam) sediment TMDL requires 0% reduction with the assumption that meeting the phosphorus TMDL will result in the necessary sediment reductions (MDE, 2008). Therefore, the Triadelphia Reservoir sediment local TMDL is not addressed further in the CIS.

Comparison of Published, Disaggregated, and Calibrated SW-WLAs

- Baltimore Harbor – Nitrogen and Phosphorus: The Baltimore Harbor nutrient TMDL requires a 15% reduction of 1995 baseline nitrogen and phosphorus loads and includes Patapsco River Lower North Branch and South Branch Patapsco watersheds. This local TMDL has aggregate SW-WLAs for the NPDES stormwater sector for nitrogen and phosphorus – 79,659 TN EOS-lbs/yr and 8,622 TP EOS-lbs/yr as published in the TMDL document (MDE, 2006). Disaggregated nutrient SW-WLAs (26,958 TN EOS-lbs/yr and 2,918 TP EOS-lbs/yr) are much lower than nutrient SW-WLAs calibrated to BayFAST (91,000 TN EOS-lbs/yr and 5,564 TP EOS-lbs/yr) due to differences in the baseline model used to calculate the original aggregate WLA. Models included the following: a watershed model Hydrological Simulation Program Fortran (HSPF), a hydrodynamic model (Curvilinear Hydrodynamic in Three Dimensions (CH3D), a water quality model (Corps of Engineers-Water Quality-Integrated Compartment Model (CE-QUAL-ICM), and a sediment flux model. When calibrating nitrogen and phosphorus baseline loads using BayFAST (CBP WM P5.3.2), 1995 baseline land use information (i.e., Howard County Phase I MS4 impervious and pervious acres) was unavailable and 2000 land use information was used in the model. The differences between models and 1995/2000 land use background loads may have increased the calibrated SW-WLAs when compared to the disaggregated SW-WLAs resulting from the disaggregation of the original aggregate SW-WLA.

- Little Patuxent River – Sediment: The Little Patuxent River sediment TMDL requires a 48.1% reduction of 2005 baseline loads. This local TMDL has an individual SW-WLA assigned to the Howard County MS4 Phase I urban sector of 7,218,600 EOS-lbs/yr (3,609 tons/yr) as published in the TMDL document (MDE, 2011a). There is a 26% difference in the SW-WLA calibrated in BayFAST (5,370,000 EOS-lbs/yr) likely due to changes between the baseline model (CBP WM P5.2) and the current model (CBP WM P5.3.2).

- Patapsco River Lower North Branch – Sediment: The Patapsco River Lower North Branch sediment TMDL requires a 10% reduction of 2005 baseline loads. This local TMDL has an individual SW-WLA assigned to the Howard County MS4 Phase I urban sector of 5,268,600 EOS-lbs/yr (2,634.4 tons/yr) as published in the TMDL document (MDE, 2011b). There is a 5% difference in the SW-WLA calibrated to BayFAST (5,511,098 EOS-lbs/yr) likely due to slight differences between the baseline model (CBP WM P5) and the current model (CBP WM P5.3.2).

- Patapsco River Lower North Branch – Bacteria: The Patapsco River Lower North Branch bacteria TMDL requires a 13.4% reduction of 2003 baseline loads. This local TMDL has an aggregate SW-WLA of 143,218 billion MPN/yr for the NPDES stormwater sector within the watershed as published in the TMDL document (MDE, 2009a). Bacteria SW-WLA disaggregated to the Howard County MS4 Phase I urban sector resulted in a WLA of 52,025 billion MPN/yr. This disaggregated WLA accounts for 36.5% of the aggregate WLA, which is the percentage of Howard County's NDPES MS4 urban land area within the total NPDES urban land area of the watershed.

- Patuxent River Upper – Sediment: The Patuxent River Upper sediment TMDL requires an 11.4% reduction of 2005 baseline loads. This local TMDL has an individual SW-WLA assigned to the Howard County MS4 Phase I urban sector of 1,159,600 EOS-lbs/yr (579.8 tons/yr) as published in the TMDL document (MDE, 2011c). However, the calibrated SW-WLA modeled in BayFAST resulted in a load approximately ten times less than the published individual SW-WLA (129,269 EOS-lbs/yr). In addition to differences between the baseline model (CBP WM P5.2) and the current model (CBP WM P5.3.2), differences in Howard County Phase I MS4 urban land area may also be attributing to the difference in WLA. As discussed in the section above, *Calibrating Nutrient and Sediment Baseline Loads and WLAs*, MAST Local Base land use for Howard County Phase I MS4 urban impervious and pervious acres were used to calibrate TMDL baseline loads. MAST shows 247 impervious acres and 942 pervious acres for 2005 Upper Patuxent Howard County Phase I MS4; therefore, a SW-WLA of 129,269 EOS-lbs/yr (calibrated SW-WLA) is much more reasonable for this area than a SW-WLA of 1,159,000 EOS-lbs/yr (published individual SW-WLA).

- Rocky Gorge Reservoir – Phosphorus: The Rocky Gorge Reservoir phosphorus TMDL requires a 15% reduction of 2000 baseline loads. This local TMDL has an aggregate SW-WLA for the NPDES stormwater sector of 1,512 EOS-lbs/yr as published in the TMDL document (MDE, 2008). Sediment SW-WLA disaggregated to the Howard County MS4 Phase I urban sector resulted in a WLA of 354.7 EOS-lbs/yr. This disaggregated WLA accounts for 23.5% of the aggregate WLA, which is the percentage of Howard County's NDPES MS4 urban land area within the total NPDES urban land area of the watershed. There is a 106% difference in the SW-WLA calibrated to BayFAST (732.0 EOS-lbs/yr) when compared to the disaggregated SW-WLA likely due to differences between the baseline model used to calculate the aggregated SW-WLA (CE-QUAL-W2) and the current model (CBP WM P5.3.2).

- Triadelphia Reservoir (Brighton Dam) – Phosphorus and Sediment: The Triadelphia Reservoir TMDL requires a 15% reduction of 2000 baseline phosphorus loads. Sediment is also listed in this TMDL; however, the Howard County MS4 Phase I urban sector requires a 0% reduction in baseline sediment loads and will not be addressed further in the CIS. An aggregate phosphorus SW-WLA for the NPDES stormwater sector of 4,672 EOS-lbs/yr is published in the TMDL document (MDE, 2008). Phosphorus SW-WLA disaggregated to the Howard County MS4 Phase I urban sector resulted in a WLA of 3,960 EOS-lbs/yr. This disaggregated WLA accounts for 84.8% of the aggregate WLA, which is the percentage of Howard County's NPDES MS4 urban land area within the total NPDES urban land area of the watershed. There is a 43% difference in the SW-WLA calibrated to BayFAST (2,256 EOS-lbs/yr) when compared to the disaggregated SW-WLA likely due to differences between the baseline model used to calculate the aggregated SW-WLA (CE-QUAL-W2) and the current model (CBP WM P5.3.2).