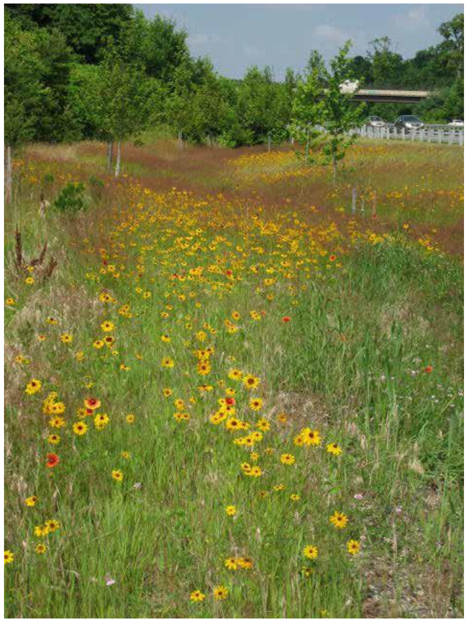
MARYLAND DEPARTMENT OF TRANSPORTATION

STATE HIGHWAY ADMINISTRATION

Gunpowder River and Bird River Subsegments of the Gunpowder River Oligohaline Segmentshed PCB TMDL Implementation Plan

PUBLIC REVIEW DRAFT September 1, 2017



MARYLAND DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

OPPORTUNITY FOR PUBLIC REVIEW AND COMMENT

DRAFT IMPLEMENTATION PLAN FOR THE TOTAL MAXIMUM DAILY LOAD (TMDL) OF POLYCHLORINATED BIPHENYL (PCB) IN THE GUNPOWDER RIVER AND BIRD RIVER SUBSEGMENTS OF THE GUNPOWDER RIVER OLIGOHALINE SEGMENTSHED, BALTIMORE COUNTY AND HARFORD COUNTY, MARYLAND

The Maryland Department of Transportation State Highway Administration (MDOT SHA) was issued a National Pollutant Discharge Elimination System Municipal Separate Storm Sewer System (MS4) Permit, (Permit No. 11-DP-3313), by the Maryland Department of the Environment (MDE) on October 9, 2015. This permit covers stormwater discharges from the storm drain system owned or operated by MDOT SHA within Anne Arundel, Baltimore, Carroll, Cecil, Charles, Frederick, Harford, Howard, Montgomery, Prince George's, and Washington Counties. The permit requires MDOT SHA to submit an implementation plan to MDE that addresses Environmental Protection Agency (EPA)-approved stormwater waste load allocations (WLAs) within one year of EPA approval.

EPA approved the ***Total Maximum Daily Load of Polychlorinated Biphenyls in the Gunpowder River and Bird River Subsegments of the Gunpowder River Oligohaline Segmentshed, Baltimore County and Harford County, Maryland*** on October 3, 2016. The MDOT SHA Office of Environmental Design (OED) is soliciting comments on its draft Implementation Plan to meet this WLA as required under the MS4 Permit. A 30-day public comment period will take place from September 1, 2017 to October 1, 2017. The draft Implementation Plan is available on MDOT SHA's website at http://www.roads.maryland.gov/Index.aspx?PageId=362.

Comments should be submitted to MDOT SHA **on or before October 1, 2017** by emailing to wpd@sha.state.md.us, faxing to (410) 209-5003, or mailing to:

Maryland Department of Transportation
State Highway Administration
Office of Environmental Design, C-303
707 N. Calvert Street
Baltimore, MD 21202

Please note that comments should include the name and address of the person submitting the comments. Responses to comments will not be provided directly, but material comments received during the comment period will be considered and the draft Implementation Plan will be revised as appropriate prior to submittal to MDE. A summary of comments received will be included in the MDOT SHA MS4 annual report submitted to MDE annually on October 9 and posted to this website: http://www.roads.maryland.gov/Index.aspx?pageid=336.

TABLE OF CONTENTS

PAGE INTENTIONALLY LEFT BLANK

GUNPOWDER AND BIRD RIVER SUBSEGMENTS OF THE GUNPOWDER RIVER OLIGOHALINE SEGMENTSHED PCB TMDL IMPLEMENTATION PLAN

A. WATER QUALITY STANDARDS AND DESIGNATED USES

TMDLs focus on offsetting the impacts of pollutants to waterway designated uses. The Federal Clean Water Act (CWA) established requirements for each State to develop programs to address water pollution including:

- Establishment of water quality standards (WQSs);
- Implementation of water quality monitoring programs;
- Identification and reporting of impaired waters; and
- Development of maximum allowable pollutant loads that when met and not exceeded will restore WQSs to impaired waters, called TMDL documents.

WQSs are based on the concept of designating and maintaining specifically defined uses for each waterbody. **Table 1** lists the designated uses for waterways in Maryland. TMDLs are based on these uses.

One means for the EPA to enforce these standards is through the NPDES program, which regulates discharges from point sources. MDE is the delegated authority to issue NPDES discharge permits within Maryland and to develop WQSs for Maryland including the water quality criteria that define the parameters to ensure designated uses are met.

Table 1: Designated Uses in Maryland

	Use Classes							
Designated Uses	**I**	**I-P**	**II**	**II-P**	**III**	**III-P**	**IV**	**IV-P**
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	✓	✓	✓	✓	✓	✓	✓	✓
Industrial Water Supply	✓	✓	✓	✓	✓	✓	✓	✓
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			✓	✓				
Seasonal Deep-Water Fish and Shellfish Use			✓	✓				
Seasonal Deep-Channel Refuge Use			✓	✓				
Growth and Propagation of Trout					✓	✓		
Capable of Supporting Adult Trout for a Put and Take Fishery							✓	✓
Public Water Supply		✓		✓		✓		✓

Source: http://www.mde.maryland.gov/programs/water/TMDL/WaterQualityStandards/Pages/wqs_designated_uses.aspx

MS4 Permit Requirements

The MDOT SHA MS4 Permit requires coordination with county MS4 jurisdictions concerning watershed assessments and development of a coordinated TMDL implementation plan for each watershed that MDOT SHA has a WLA. Requirements from the MDOT SHA MS4 Permit specific to watershed assessments and coordinated TMDL implementation plans include *Part IV.E.1.* and *Part IV.E.2.b., copied below.*

Watershed Assessments (Permit Part IV.E.1.)

SHA shall coordinate watershed assessments with surrounding jurisdictions, which shall include, but not be limited to the evaluation of available State and county watershed assessments, SHA data, visual watershed inspections targeting SHA rights-of-way and facilities, and approved stormwater WLAs to:

- *Determine current water quality conditions;*
- *Include the results of visual inspections targeting SHA rights-of-way and facilities conducted in areas identified as priority for restoration;*
- *Identify and rank water quality problems for restoration associated with SHA rights-of-way and facilities;*
- *Using the watershed assessments established under section a. above to achieve water quality goals by identifying all structural and nonstructural water quality improvement projects to be implemented; and*
- *Specify pollutant load reduction benchmarks and deadlines that demonstrate progress toward meeting all applicable stormwater WLAs.*

Coordinated TMDL Implementation Plans (Permit Part IV.E.2.b.)

Within one year of permit issuance, a coordinated TMDL implementation plan shall be submitted to MDE for approval that addresses all EPA approved stormwater WLAs (prior to the effective date of the permit) and requirements of Part VI.A., Chesapeake Bay Restoration by 2025 for SHA's storm sewer system. Both specific WLAs and aggregate WLAs which SHA is a part of shall be addressed in the TMDL implementation plans. Any subsequent stormwater WLAs for SHA's storm sewer system shall be addressed by the coordinated TMDL implementation plan within one year of EPA approval. Upon approval by MDE, this implementation plan will be enforceable under this permit. As part of the coordinated TMDL implementation plan, SHA shall:

- *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;*
- *Provide detailed cost estimates for individual projects, programs, controls, and plan implementation;*
- *Evaluate and track the implementation of the coordinated implementation plan through monitoring or modeling to document the progress toward meeting established benchmarks, deadlines, and stormwater WLAs; and*
- *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 SHA's watershed assessments.*

B. WATERSHED ASSESSMENT COORDINATION

According to the USGS (2016):

> *A watershed is an area of land where all water that falls on it and drains off it flows to a common outlet. A watershed is an area of land that drains all the streams and rainfall to a common outlet such as the outflow of a reservoir, mouth of a bay, or any point along a stream channel. The word watershed is sometimes used interchangeably with drainage basin or catchment. The watershed consists of surface water--lakes, streams, reservoirs, and wetlands--and all the underlying ground water. Larger watersheds contain many smaller watersheds. Watersheds are important because the streamflow and the water quality of a river are affected by things, human-induced or not, happening in the land area "above" the river-outflow point.*

The 8-digit scale is the most common management scale for watersheds across the state, and therefore is the scale at which most of Maryland's local TMDLs are developed. In some cases, a subwatershed has its own TMDL. See **Figure 1** for an illustration of an example 8-digit watershed in Maryland.

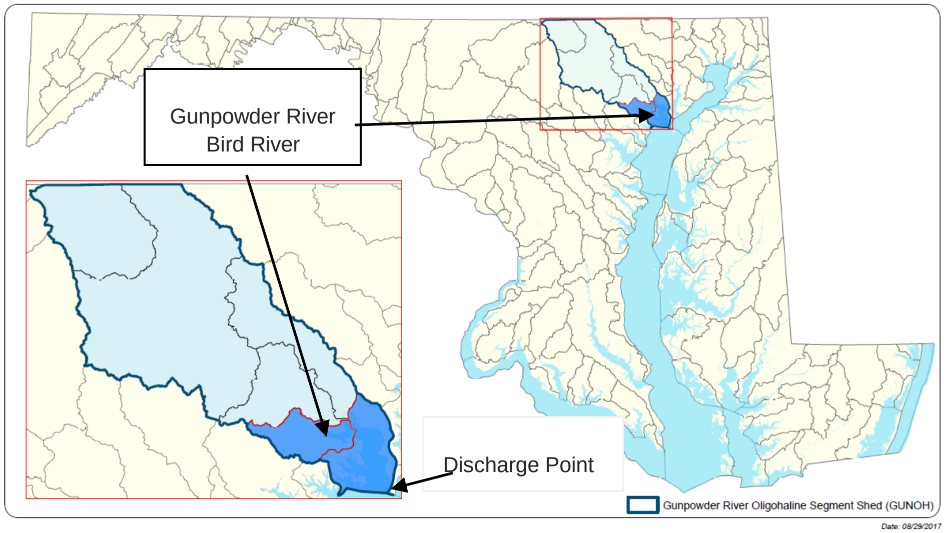


Figure 1: Maryland 8-digit Watershed Example

Segmentsheds are watersheds associated with tidal waters, which are referred to as segments. The Chesapeake Bay and its tidal tributaries are divided into 92 segments as shown in **Figure 2**. The Gunpowder River Oligohaline Segmentshed is designated GUNOH. This TMDL is a subsegment of the larger GUNOH segmentshed as shown in **Figure 1**. Gunpowder River and Bird River are 8-digit watersheds that make up that the larger GUNOH segmentshed along with several other 8-digit watersheds.

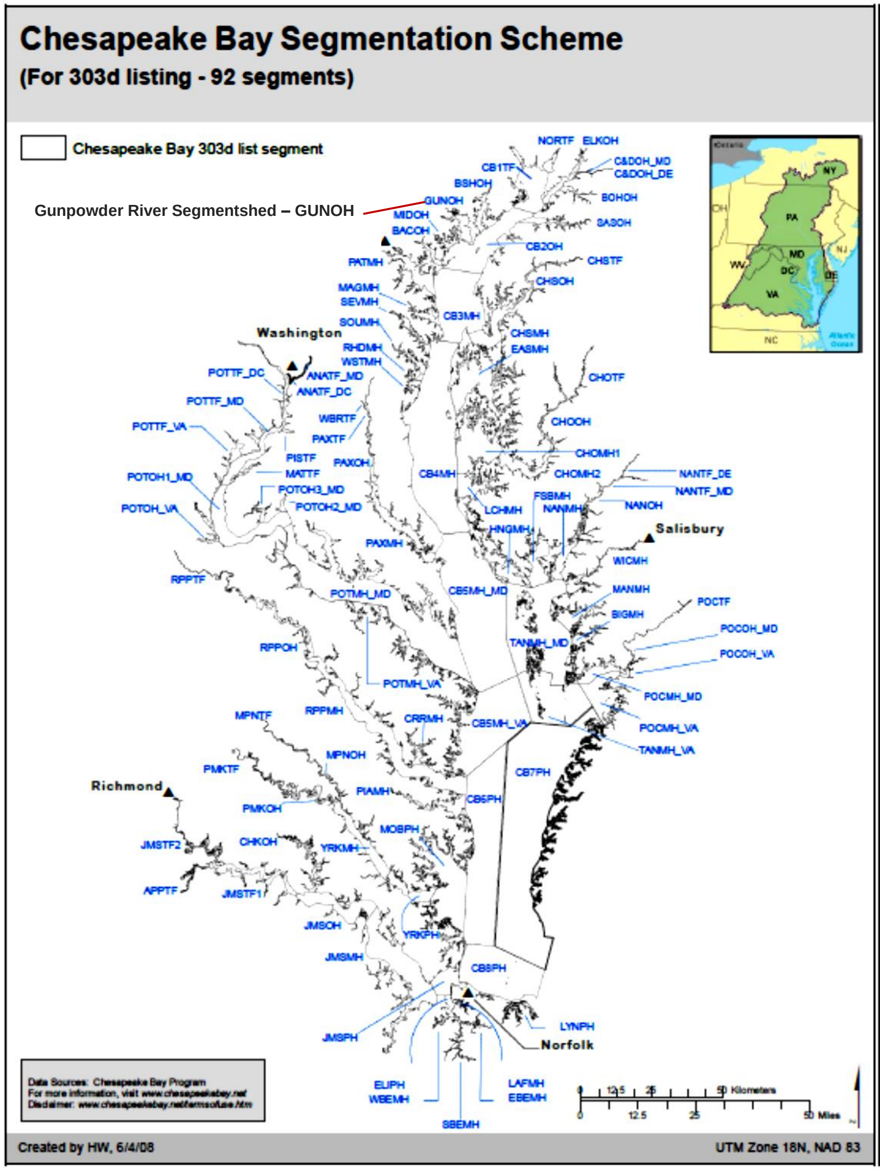


Figure 2: Chesapeake Bay 92 Segments

County Watershed Assessments

Each MS4 county is required to perform detailed assessments of local watersheds as a part of its MS4 permit requirements. These assessments determine current water quality conditions and include visual inspections; the identification and ranking of water quality problems for restoration; the prioritization and the ranking of structural and non-structural improvement projects; and the setting of pollutant reduction benchmarks and deadlines that demonstrate progress toward meeting applicable WQSs. MDOT SHA is not required to duplicate this effort, but is required to coordinate with the MS4 jurisdictions to obtain and review watershed assessments. Relying on assessments performed by other jurisdictions avoids redundant analysis and places the responsibility for developing the assessments with the jurisdictions that have close connection to local communities and watershed groups.

Watershed assessment evaluations conducted by MDOT SHA focus on issues that MDOT SHA can improve through practices targeting MDOT SHA right-of-way (ROW) or infrastructure. This information is used to determine priority areas for BMP implementation and to identify potential project sites or partnership project opportunities. Summaries of these evaluations are included in this Plan under **Section F**. MDOT SHA watershed assessment evaluations focus on the following:

- Impacts to MDOT SHA infrastructure such as failing outfalls and downstream channels;
- Older developed areas with little SWM and available opportunities to install retrofits;
- Degraded streams;
- Priority watershed issues such as improvements within a drinking water reservoir, special protection areas or Tier II catchments;
- Identification of areas most in need of restoration;

- Description of preferred structural and non-structural BMPs to use within the watershed;
- Potential project sites for BMPs; and
- In watersheds with PCB TMDLs, identifying locations of any known PCB sources.

In addition to using information from the county watershed assessments, MDOT SHA also undertakes other activities to identify potential project sites and prioritize BMP implementation including:

- On-going coordination meetings with each of the MS4 counties to discuss potential partnerships with the mutual goal of improving water quality;
- Perform visual watershed inspections as described below;
- Model MDOT SHA load reductions within the watershed based on MDOT SHA land uses and ROW; and
- Maximize existing impervious treatment within new roadway projects (practical design initiative).

C. VISUAL INSPECTIONS TARGETING MDOT SHA ROW

MDOT SHA has recently developed a process to methodically review each watershed for potential restoration projects within MDOT SHA ROW to meet the load reductions for current pollutant WLAs. Although these watersheds have previously been reviewed for all practice types, this new process adds a grid system to coordinate and track efforts of many teams systematically to ensure each watershed is thoroughly assessed. This method is used to search for new stormwater control structure sites and tree sites. The watershed review process includes two phases to visually inspect each watershed and identify all structural and non-structural water quality improvement projects to be implemented.

Desktop Evaluation

Phase one is a desktop evaluation of the watershed using available county watershed assessments and MDOT SHA data. MDOT SHA has created a grid system of 1.5 mile square cells to track the progress of the visual watershed inspections, allowing prioritized areas to be targeted first. With this grid system, many spatial data sets are reviewed to determine the most effective use of each potential restoration site. The sites are documented geographically and stored in GIS. Viable sites are prioritized and those located within watersheds with the most pollutant reduction needs move forward to the second phase, which is to perform field investigations. Data reviewed includes:

- Aerial imagery;
- Street view mapping;
- Environmental features delineations such as critical area boundary, wetlands buffers, floodplain limits;
- County data such as utilities, storm drain systems, contour and topographic mapping;
- MDOT SHA ROW boundaries;
- Current MDOT SHA stormwater control and restoration practice locations; and
- Drainage area boundaries.

Figure 7 illustrates the 1.5 mile grid system for the Gunpowder River and Bird River Tidal Subsegments.

Field Investigations

Phase two is a field investigation of each viable site resulting from the watershed desktop evaluation. MDOT SHA inspects and assesses each site in the field to identify and document existing site conditions, water quality problems, and constraints. This information is used to determine potential restoration BMP types as well as estimated restoration credit quantities.

MDOT SHA will continue to prioritize visual inspections in the highest need watersheds. **Figure 3** is an example field investigation summary map that documents observations from the field analysis. A standardized field inspection form is used.

D. BENCHMARKS AND DETAILED COSTS

Benchmarks and deadlines demonstrating progress toward meeting all applicable stormwater WLAs are provided in the segmentshed discussion in **Section F**. It contains generalized cost information that includes an overall estimated cost to implement the proposed practices. Detailed costs for specific construction projects are available on MDOT SHA's website (www.roads.maryland.gov) under the Contractors Information Center.

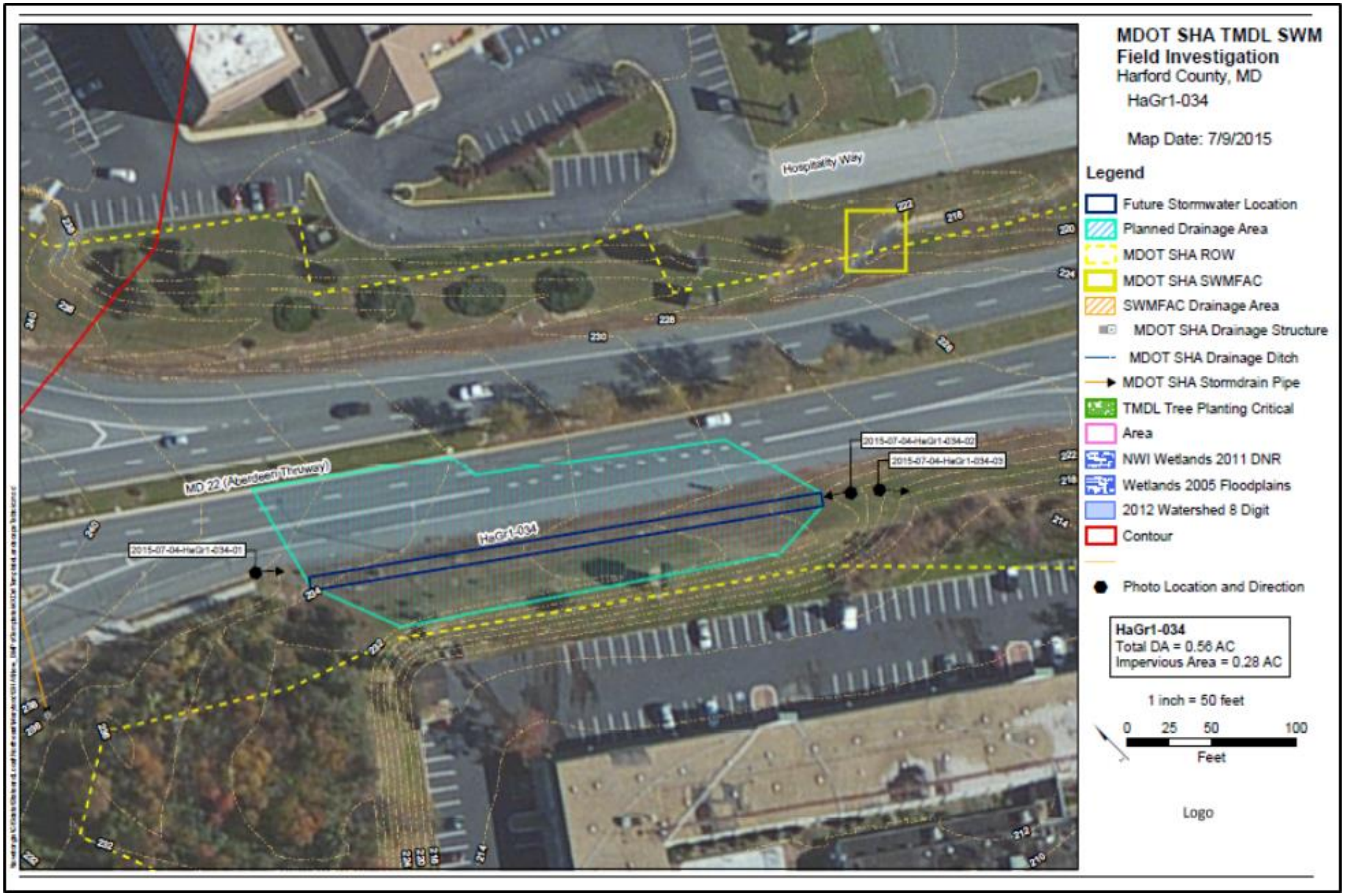


Figure 3: Example Field Investigation Summary Map

PAGE INTENTIONALLY LEFT BLANK

E. POLLUTION REDUCTION STRATEGIES

E.1. MDOT SHA TMDL Responsibilities

TMDLs define the maximum pollutant loading that can be discharged to a waterbody and still meet water quality criteria for maintaining designated uses. **Figure 4** illustrates the concept of maximum loading. The green area on the bar depicts the maximum load that maintains a healthy water environment for the pollutant under consideration. When this load is exceeded, the waterway is considered impaired as illustrated by the red portion of the bar. The example waterway needs restoration through implementation of practices to reduce the pollutant loading to or below the TMDL.

Generally, the formula for a TMDL is:

$$TMDL = \sum WLA + \sum LA + MOS$$

Where:

TMDL = total maximum daily load
WLA = wasteload allocation for point sources;
LA = load allocation for non-point sources; and
MOS = margin of safety.

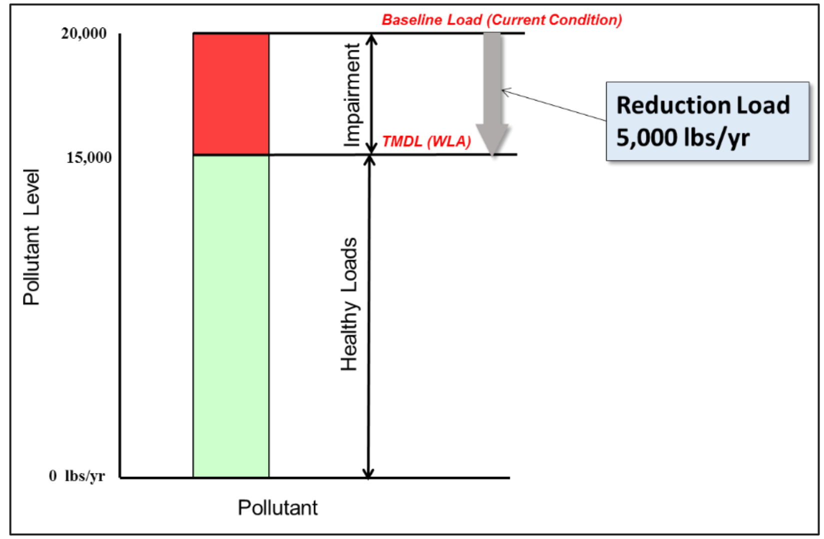


Figure 4: Example TMDL and Reduction Requirement

Pollutants for MDOT SHA Focus

Upon issuance of the MS4 Permit, MDOT SHA was named in TMDLs for five different pollutants within the MS4 coverage area including

- Bacteria,
- PCBs,
- Phosphorus,
- Sediment, and
- Trash.

The MDOT SHA MS4 Permit covers eleven Maryland counties that cross 84 8-digit watersheds representing larger rivers or streams. There are 43 EPA-approved TMDL documents that assign MDOT SHA to either an individual WLA or an aggregate WLA. Each watershed may be covered by one or more TMDL documents, so there is not a direct correlation between the number of TMDL documents and the number of watersheds affected.

Figure 5 shows a map of MDOT SHA TMDL responsibilities by watershed. **Table 2** on the following page summarizes MDOT SHA's PCB reduction requirement and projected progress in meeting the pollution reduction wasteload target within Gunpowder River Oligohaline segmentshed by the listed end date. There are instances where the projected modeled percent reduction does not equal the target percent reduction by the end date listed. In these cases, discussion is added to the reduction strategy **Section E** to analyze the conditions that preclude MDOT SHA from meeting the target reductions with currently available modeling methods, loading, reduction efficiencies, or practices.

Lists of proposed practices and costs to achieve the required reductions are included in **Section F**.

Modeling Parameters

MDE requires that pollutant modeling follow the guidance in MDE 2014a and if other methods are employed, they must be approved by MDE. MDOT SHA developed a restoration modeling protocol that describes the methods used for modeling pollutant load reductions for local TMDLs with MDOT SHA responsibility. This protocol was submitted to MDE as an appendix with the MDOT SHA MS4 2016 Annual Report. Once approved, this protocol will be available on the MDOT SHA website.

Different modeling methods are used depending upon the pollutants and current reduction practices in use. Brief descriptions of modeling methods are included in the following section, but the MDOT SHA restoration modeling protocol should be consulted for a more detailed explanation.

Aggregated Loads

WLAs may be assigned to each MS4 jurisdiction separately or as an aggregated WLA for all urban stormwater MS4 permittees that combines them into one required allocation and reduction target. The modeling approach developed by MDOT SHA uses MDOT SHA data (both impervious and pervious land as well as BMPs built before the TMDL baseline year, also know as baseline BMPs) to calculate baseline loads and calibrated reduction targets. Following this approach, disaggregation is done for each TMDL.

Available Reduction Practices

MDOT SHA reserves the right to implement new BMPs, activities, and other practices that are not currently available to achieve local TMDL load reduction requirements. In the future, expert panels may be convened to study the effectiveness of new or modified BMPs on pollutants. MDOT SHA will modify reduction strategies as necessary based on new, approved treatment guidance, and will include revised strategies in updates to this implementation plan.

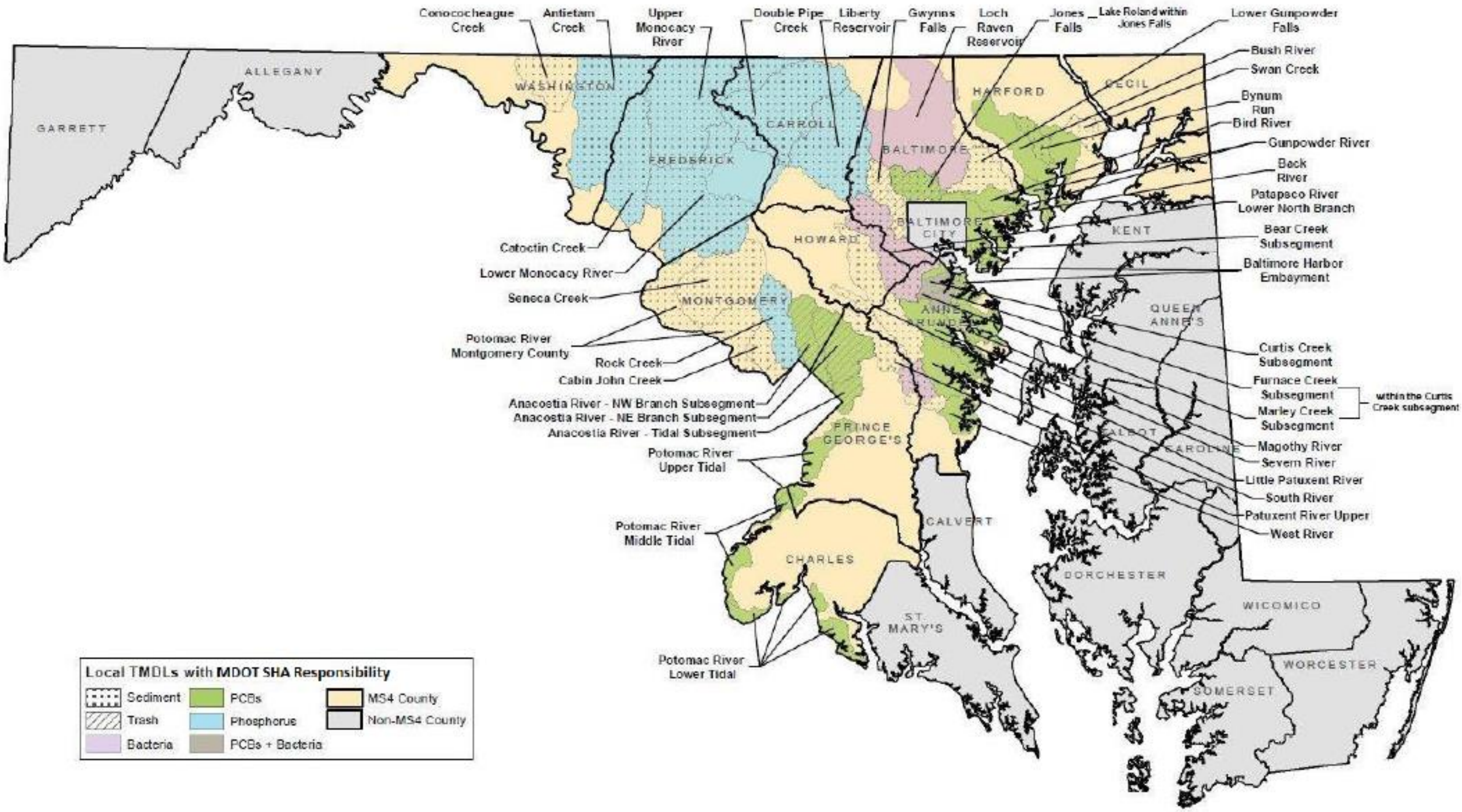


Figure 5: MDOT SHA TMDL Responsibilities in Local Watersheds

Table 2: MDOT SHA Gunpowder River Oligohaline Segmentshed PCB Modeling Results

Watershed Name	Watershed Number	County	Pollutant	EPA Approval Date	WLA Type	Baseline Year	Unit	MDOT SHA Baseline Load	MDOT SHA % Reduction Target	MDOT SHA Reduction Target	MDOT SHA WLA	Projected Reduction to be Achieved	Projected Reduction to be Achieved as a % of Baseline Load	Target Year
Gunpowder River	MD-GUNOH-02130801	BA, HA	PCBs	10/03/2016	Aggregate by County	2010	g/yr.	0.2	0%	-	-	-	-	-
Bird River	MD-GUNOH-02130803	BA	PCBs	10/03/2016	Aggregate by County	2010	g/yr.	1.31	70.0%	0.9	0.4	0.12	9.1%	2050

E.2 PCB Pollution Reduction Strategy

E.2.a. PCB TMDLs Affecting MDOT SHA

There are 14 EPA-approved PCB TMDLs with MDOT SHA responsibility that MDOT SHA has already addressed in previous implementation plans. The following is a list of TMDL documents for PCBs with MDOT SHA responsibility that are addressed with this plan:

- *Total Maximum Daily Load of Polychlorinated Biphenyls in the Gunpowder River and Bird River Subsegments of the Gunpowder River Oligohaline Segment, Baltimore County and Harford County, Maryland, approved by EPA October 3, 2016*

In the TMDL document (MDE, 2016c) there are separate reduction requirements for the Gunpowder River subsegment (02130801) and Bird River subsegment (02130803) of the Gunpowder River Oligohaline segmentshed. **Table 2** reflects the different reduction requirement for the subsegments at the 8-digit watershed scale. In **Table 2** the MDOT SHA reduction target for the Gunpowder River subsegment PCB TMDL is 0%, or 0 g/yr. Due to MDOT SHA having a 0 gram per year reduction requirement in the Gunpowder River subsegment of GUNOH segmentshed meeting this TMDL will rely on meeting the reduction requirement in the Bird River subsegment. For the Bird River subsegment the reduction target is 70%, or 0.9 g/yr. The Bird River subsegment can safely receive 0.4 grams of PCB by MDOT SHA on a yearly basis without being considered impaired. Currently, it is calculated that MDOT SHA is responsible for introducing 1.31 grams per year of PCBs into the segmentshed per the MDE TMDL document as a MS4 permittee by the Bird River subsegment. Thus, according to the definition of a the TMDL MDOT SHA has to reduce its load by 0.9 grams to meet its healthy load, WLA, of 0.4 grams per year. MDOT SHA's reduction target is found by multiplying the MDOT SHA baseline load by the MDOT SHA Reduction target percent. The MDOT SHA WLA is found by subtracting the MDOT SHA baseline load by the MDOT SHA target load. The projected reduction achieved is found by modeling the PCB load reduction that will be experienced by the construction of current and future BMPs in Bird River subsegment of the GUNOH segmentshed. These BMPs are either currently under construction or are planned to be constructed in the future. It is estimated that these future BMPs will reduce PBC loading by 0.1 gram to the GUNOH segmentshed. The reduction to be achieved expressed as a percent is found by dividing the projected reduction to be achieved by the MDOT SHA Baseline Load.

Three dates are shown: the EPA approval date, the baseline year set by MDE, and the Target Year. The baseline year published on the MDE Data Center will be used for MDOT SHA's implementation planning. This usually correlates to the time-period when monitoring data was collected for MDE's TMDL analysis. The Target Year is the year MDOT SHA proposes to meet the WLA.

E.2.b. PCB Sources

The objective to establish a TMDL for PCBs is to ensure that the designated use is protected in each of the impaired waterbodies. Monitoring to identify the impairment may have been performed in the water column, in sediments, or in fish tissue depending on whether the impairment was for water contact recreation or fish consumption.

PCBs do not occur naturally in the environment. Therefore, unless existing or historical anthropogenic sources are present, their natural background levels are expected to be zero. Although PCBs are no longer manufactured in the United States, they are still being released to the environment via accidental fires, leaks, or spills from PCB-containing equipment; potential leaks from hazardous waste sites that contain PCBs; illegal or improper dumping; and disposal of PCB-containing products into landfills not designed to handle hazardous waste. Once in the environment, PCBs do not readily break down and tend to cycle between various environmental media such as air, water, and soil.

Sources are not identified in detail, either by land use or other breakdowns. Two non-point sources are related to the waterbody itself: resuspension and diffusion from bottom sediments and tidal exchange with the Bay. Transport of PCBs from bottom sediments to the water column through resuspension and diffusion can be a source of PCBs; however, within the TMDLs it is considered internal loading and not assigned a baseline load or allocation. Tidal influences from the Bay or other tidewater can be either a source or sink. For the Magothy, Severn, South and West and Rhodes River TMDLs, the Bay tidal influence is the single major source of PCBs. Similarly, for Bird River, Bush River, and Gunpowder River, the tidal portions are a PCB source. Baltimore Harbor, Back River, and the Anacostia, on the other hand, export more PCBs to the Bay than they receive.

There are three diffuse watershed sources including atmospheric deposition, non-regulated watershed runoff, and NPDES regulated stormwater. Also, there are four discrete sources: contaminated sites, WWTP facilities, industrial process water and Dredged Material Containment Facilities (DMCF), which are described by name in the TMDL. **Table 3** shows which sources are described in the thirteen PCB TMDLs with MDOT SHA responsibility.

For PCBs, studies have shown the largest sources impacting stormwater are building demolition, building remodeling, and old industrial areas. The main pathways are runoff, wheel and foot tracking, and dust dispersion from industrial areas (San Francisco Estuary Institute [SFEI], 2010).

Table 3: PCB Sources in Each TMDL

Source	Contaminant	TMDL Watershed											
		Baltimore Harbor	Back River	Bird River	Bush River	Gunpowder River	Tidal Potomac/ Anacostia River	Non-Tidal Anacostia River	Lake Roland	Magothy River	Severn River	South River	West & Rhodes River
Non-Point Sources	Upstream Tributaries					✓	✓						
	Chesapeake Bay or Other Tidal Influence			✓	✓	✓				✓	✓	✓	✓
	Atmospheric Deposition	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓
	Non-regulated Watershed Runoff	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Contaminated Sites	✓	✓		✓		✓	✓	✓	✓			
Point Sources	Municipal WWTP and CSO	✓	✓		✓		✓	✓	✓		✓	✓	✓
	Industrial Process Water	✓			✓	✓							
	DMCF	✓											
	NPDES Regulated Stormwater	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Significance for MDOT SHA

MDOT SHA roadways pass through or are near areas that contain facilities or industries that may contribute PCBs to the environment. Two of the controllable sources in **Table 3** appear to fall under MDOT SHA's responsibility: contaminated sites and NPDES-regulated stormwater. MDOT SHA has conducted research on our industrial sites and to date has not discovered any legacy PCB contamination. Thus, MDOT SHA is left with stormwater as the only source to be addressed. MDOT SHA does not plan to complete a comprehensive investigation of all MDOT SHA's ROW, but a method is being researched to identify outfalls that have PCB discharging in stormwater to identify potential source drainage area. Once these areas are narrowed down, sources of PCBs can be tracked, documented, and methods to remediate developed.

E.2.c. MDOT SHA PCB Modeling Methods

MDOT SHA's modeling focuses on runoff loads and reductions from stormwater BMPs. The approach to modeling PCB reductions is based on the results of a literature review of PCB sources and treatment.

Two documents from the CBP discuss PCB sources, pathways, and treatment. (Schueler and Youngk, 2015) summarized research nationwide. They reported that PCB sampling in San Francisco Bay showed urban stormwater was the dominant pathway for PCBs to enter the Bay. The Chesapeake Bay *Toxic Contaminants Policy and*

Prevention Outcome (CBP, 2015) also concluded that stormwater was a significant pathway for both particulate and dissolved PCBs. Land use is also a factor.

Baseline Loading for PCBs

Loads discussed in the PCB TMDLs are based on monitoring the impaired waterbody. Watershed loads were estimated by deriving concentrations from the monitoring data and multiplying these by estimated flow rates to the impaired waterbody. Thus, the loads reported in the TMDL do not account for fate and transport from the watershed.

While PCBs can exist in stormwater in both dissolved and particulate forms, they are generally insoluble in water. Lighter compounds may dissolve and subsequently volatize to the air and heavier compounds bind to sediment. Schueler and Youngk (2015) discussed research indicating that a large portion of the PCB load was attached to sediment, including a sampling study in the Susquehanna River basin that showed 75 percent of PCB loads were associated with particulates. CBP (2015) concluded that contaminated soils were a predominant source of PCBs in stormwater. Both these reports and others (Gilbreath et al., 2012) found that runoff from older industrial areas tended to have a higher concentration of PCBs in runoff and in sediments.

Given the understanding that removal of contaminated sediment from stormwater can be an effective method of reducing the PCB loads, the modeling approach will be to focus on stormwater BMPs that treat sediment. The basis of the modeling will be Total Suspended Solids (TSS) loading rates based on MAST (2016) and reduction calculation based on MDE (2014a). This approach has also been documented by Interstate Commission on the Potomac River Basin (ICPRB) in the Tidal Potomac PCB TMDL.

To estimate the amount of PCBs in sediment from runoff, sampling data from bottom sediments reported in MDE's TMDL documents were used. Six of the thirteen TMDLs provide sufficient information on sediment concentrations to estimate an average value by watershed. No sediment data was reported in the TMDL for the Anacostia River Northeast and Northwest Branch. In lieu of this, data from the Tidal Potomac TMDL for Anacostia will be used.

For MDOT SHA modeling, baseline loads have been calculated in two steps: first, to model the untreated load, and next, to apply treatment as of the baseline year for each TMDL. Untreated baseline loads were modeled by multiplying MDOT SHA pervious and impervious acres by land-river segment using MDOT SHA spatial data with loading rates calculated at the land-river segment scale from a No-BMP scenario in MAST. Loading rates are described in further detail below. Load reductions from baseline BMPs were calculated from MDOT SHA database information, then applied to the untreated load to determine treated baseline load. All loads and load reductions for PCB TMDLs were first modeled in TSS EOS-lbs/yr. and then converted to TSS EOS-g/yr. and then multiplied by the average sediment PCB concentration from the TMDL document to calculate loads and load reductions in PCB g/yr.

PCB Pollutant Loading Rates by Land Use

Loading rates for TSS have been calculated at the most detailed level feasible: the land-river segments from the Chesapeake Bay model / MAST v5.3.2. Untreated loads and acres, per land-river segment, were derived from a No BMPs scenario in MAST at the Maryland statewide geographic scale using 2010 conditions. With the No-BMP scenario, loading rates for each MDOT SHA land use will stay constant for different baseline years, so these values will be valid for both the Bay TMDL and local TMDL analyses.

PCB Reduction Requirements

The model uses a percent reduction target for MDOT SHA published in the TMDL document. The percent reduction target is compared to the projected reduction to be achieved modeled from the implementation of restoration BMPs. This method assumes that like sediment, PCB is a conservative pollutant, and that loads exported from the watershed will approximate the loads in the waterbody, without significant loss or degradation in transport.

Reduction Modeling

The model is based on an Excel spreadsheet, using data derived from MAST and MDOT SHA's stormwater geodatabases. The modeling approach focuses on stormwater BMPs that treat sediment. BMP removal rates for structural and ESD stormwater controls (ESD/Runoff Reduction [RR] and Stormwater Treatment [ST] practices) and alternative BMPs (catch basin cleaning) have been implemented following MDE (2014a). For determining BMP efficiencies using MDE (2014a), the model uses the actual treatment and Pe for each BMP to calculate the sediment reduced for each ESD/RR BMP in the watershed.

The model determines sediment reductions achieved by each type of practice and then multiplies the sediment reductions by a PCB concentration to determine the PCB reduction. Sediment reduction computations vary depending upon the type of restoration practice planned: stormwater control structures or inlet cleaning. Steps for determining sediment reductions for stormwater controls include:

- Sediment loading within the drainage area is determined by identifying the MAST land-river segment containing the BMP and recording the loading rate for MDOT SHA pervious and impervious land use. (MAST, 2016);
- TSS removal rates from the database are stored with each BMP, based on its type;
- Load removal (lb/ac/yr) is calculated for pervious and impervious area by multiplying land use loading rate by TSS removal rate; and
- TSS removed (lb/yr) is calculated by multiplying load removal by pervious and impervious area within the BMP drainage area.

Steps for determining sediment reductions for catch basin cleaning include:

- GIS analysis of the area of MDOT SHA ROW within each shop boundary within each TMDL watershed;
- Fraction of ROW area in the TMDL watershed within each shop boundary;
- Lookup of dry weight of material collected from each shop;
- Calculation of material collected within the TMDL watershed by multiplying fraction of TMDL ROW by the total material collected; and
- Calculate TSS pounds removed using parameter from MDE Guidance (MDE, 2014a).

Computing PCB loads removed based on the sediment removal calculated in the previous steps includes:

- Add stormwater BMP and inlet cleaning pounds removed to find total sediment removed in each TMDL watershed and convert to grams;
- Multiply by PCB concentration factor of 80 ng/g (Schueler and Youngk, 2015) to find PCB load removed; and
- Multiply by 50% to account for inconsistency in BMP removal (results are in g/yr).

E.2.d. PCB Reduction Strategies

MDOT SHA will implement an evolving management process that relies on four main PCB reducing efforts. The first strategy will be source tracking and elimination. The second effort will be to track PCBs reduction achieved from ongoing impervious restoration efforts for MDOT SHA's MS4 permit. MDOT SHA will develop a monitoring and evaluation plan to study the effects of natural attenuation in our PCB TMDL watersheds. Lastly, partnering efforts to reduce PCB concentrations in the local watersheds will be explored with other jurisdictions where it is perceived to be mutually beneficial for both parties.

Stormwater BMP Reduction Modeling

As a byproduct of meeting the impervious surface restoration required under the existing MS4 permit, many of the BMPs used to reduce sediment will provide a secondary benefit in removing PCBs associated with sediments.

The modeling results in **Table 2** show that minimal reductions are achieved through stormwater BMPs in the watershed. Based on these results, MDOT SHA has concluded that source tracking and elimination may be a more effective way of achieving PCB load reductions.

Source Targeting and Elimination

According to MDE's main reports for PCB TMDLs, it's noted that an effective way to meet the WLA is to implement a PCB source targeting and elimination effort.

MDOT SHA will develop a protocol describing the process to implement steps that target a PCB source in the ROW. This protocol will also explain how MDOT SHA will evaluate feasibility of source elimination.

Monitoring and Evaluation Plan

MDOT SHA will continue to review MDE documentation of declining PCB concentrations in the local watersheds due to natural attenuation. This process will involve obtaining PCB concentration data directly from MDE and or other approved sources.

Partnering Efforts

MDOT SHA will implement partnering with other local jurisdictions to ensure that PCB WLAs are met. However, at this time it has not been determined what this effort will entail. There may be a possibility to work with another agency on a public education campaign or contribute effort or money to a PCB cleanup effort in a watershed in which there is an MDOT SHA responsibility. It is anticipated that an overall reduction of PCBs released in the watershed will have a positive load reduction on MDOT SHA's WLA reduction goals.

PAGE INTENTIONALLY LEFT BLANK

F. GUNPOWDER RIVER AND BIRD RIVER SUBSEGMENTS IMPLEMENTATION PLAN

F.1. Subsegments Description

As stated in **Section B**, the Chesapeake Bay and its tributaries are divided into 92 tidal water body segments, one of which is the Gunpowder River Oligohaline Segment. The Gunpowder River Oligohaline Segment includes both the Gunpowder River subsegment (hereinafter “Gunpowder River”) and the Bird River subsegment (hereinafter “Bird River”).

The Gunpowder River is a 6.8-mile-long (10.9 km) tidal inlet on the western side of the Chesapeake Bay in Baltimore and Harford Counties. The Gunpowder River is formed by the convergence of two freshwater tributaries: Gunpowder Falls (often referred to locally as "Big Gunpowder Falls") and Little Gunpowder Falls. Gunpowder River is surrounded by the Gunpowder River watershed (8-digit Basin Code: 02130801, excluding the Seneca Creek portion) in Harford County to the east and Baltimore County to the west. The total area of the Gunpowder River watershed is approximately 20 square miles. Major tributaries of the Gunpowder River watershed include Foster Branch and Emmord Branch.

The Bird River is located above the Baltimore County portion of the Gunpowder River watershed and is approximately 7 miles (11.3 km) in length. The Bird River watershed (8-digit Basin Code: 02130803) encompasses approximately 26 square miles solely within Baltimore County, Maryland. The Bird River flows east into the Gunpowder River; accordingly, both the Gunpowder River watershed and the Bird River watershed drain into the Gunpowder River. The Gunpowder River ultimately flows into the Chesapeake Bay. Major tributaries of the Bird River watershed include Whitemarsh Run, Honeygo Run, and Windlass Run.

There are 46 centerline miles of MDOT SHA roadway located within the Gunpowder River watershed; the associated ROW encompasses 530 acres, of which 246 acres are impervious.

There are 36 centerline miles of MDOT SHA roadway located within the Bird River watershed; the associated ROW encompasses 453 acres, of which 200 acres are impervious.

There are zero (0) MDOT SHA facilities located within the Gunpowder River and the Bird River watersheds (**Figure 6**).

F.2. MDOT SHA TMDLs in the Gunpowder River & Bird River Subsegments

MDOT SHA is included in the PCBs TMDL (MDE, 2016c) and has reduction requirements of 70 percent in the Bird River watershed and 0 percent in the Gunpowder River watershed, as shown in **Table 2**. Because MDOT SHA does not have a reduction requirement in the Gunpowder River watershed, **Section F.3.**, **Section F.4.**, and **Section F.5.** below only pertain to the Bird River watershed.

F.3. MDOT SHA Visual Inventory of ROW

The MS4 permit requires MDOT SHA to perform visual assessments. **Section C** describes the MDOT SHA visual assessment process. The implementation teams are currently evaluating grids in the segmentshed and will continue to do so until all are completed and accepted. The grid-tracking tool was developed to help teams efficiently search each watershed on a 1.5 x 1.5-square-mile system as shown in **Figure 7**. Planning efforts will continue and will be centered on areas with local TMDL needs that have been identified using the site search grid-tracking tool.

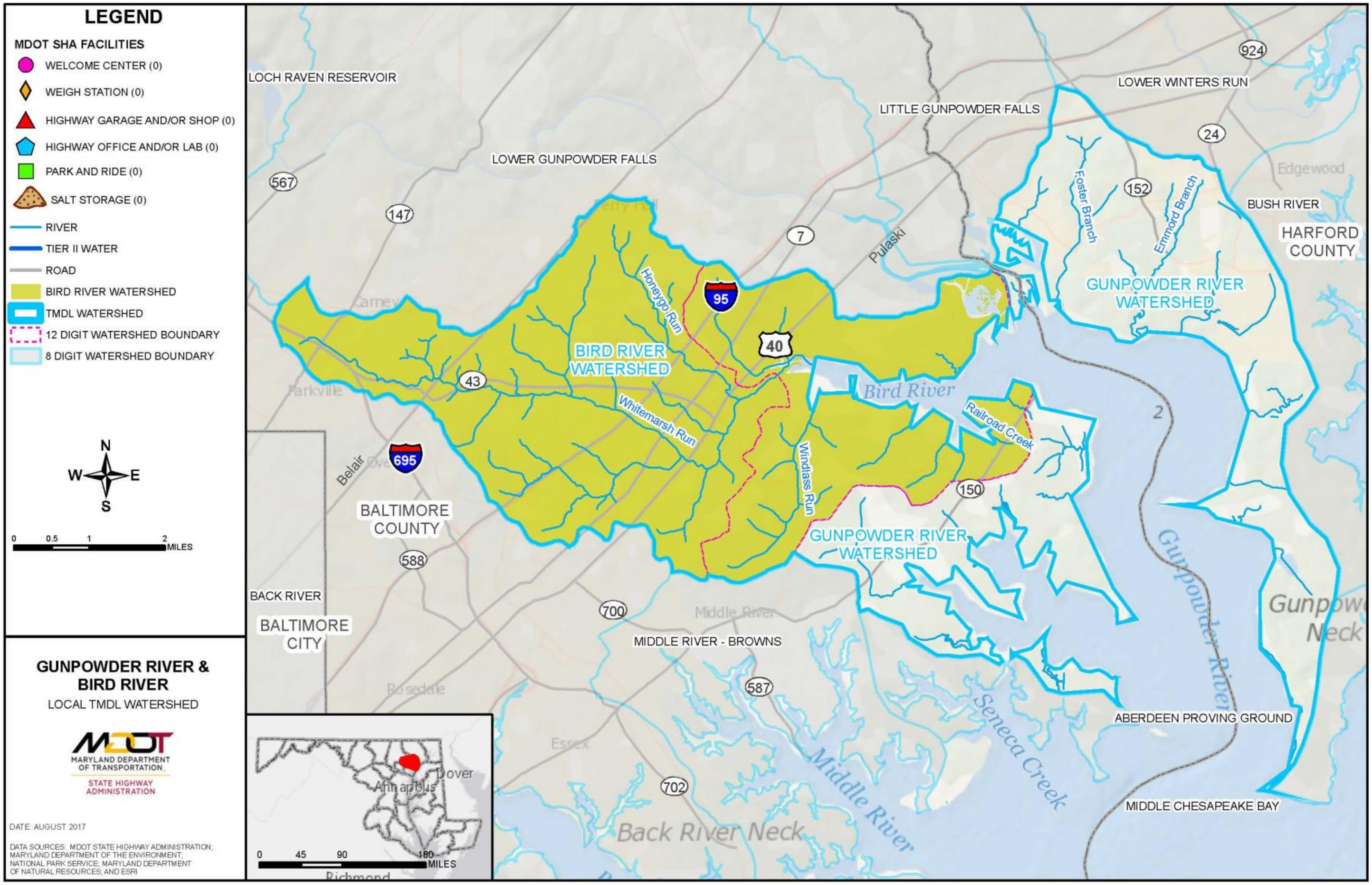


Figure 6: Gunpowder River & Bird River Subsegments of Gunpowder River Oligohaline Segmentshed

Many of the grids awaiting review have little potential for additional restoration due to minimal ROW along residential and wooded areas, which limits the ability to purchase ROW for the construction of a new BMP. Additionally, many MDOT SHA impervious areas within these grids are already treated by MDOT SHA BMPs. The current results of this ongoing grid search for the Bird River watershed are as follows:

24 Total Grids:

- 24 fully reviewed

The new stormwater site search resulted in a pool of potential sites comprised of the following:

- 47 locations identified as possible candidates for new stormwater BMPs;
- 42 facilities have been recommended for restoration after the completion of a preliminary desktop assessment; and
- 5 facilities remain on hold due to roadway construction projects.

The tree planting site search teams investigated 607 acres of MDOT SHA-owned pervious area. The ongoing site search resulted in a pool of potential sites comprised of the following:

- 20 acres of pervious area identified as potential for future restoration after the completion of a preliminary desktop assessment.

The stream restoration site search teams investigated 1,260 linear feet of stream channel for restoration opportunities. The site search resulted in the following:

- Zero (0) linear feet are recommended for future restoration potential.

Teams will continue to pursue the most viable and cost-effective BMPs that are currently within the existing pool of sites based on site feasibility.

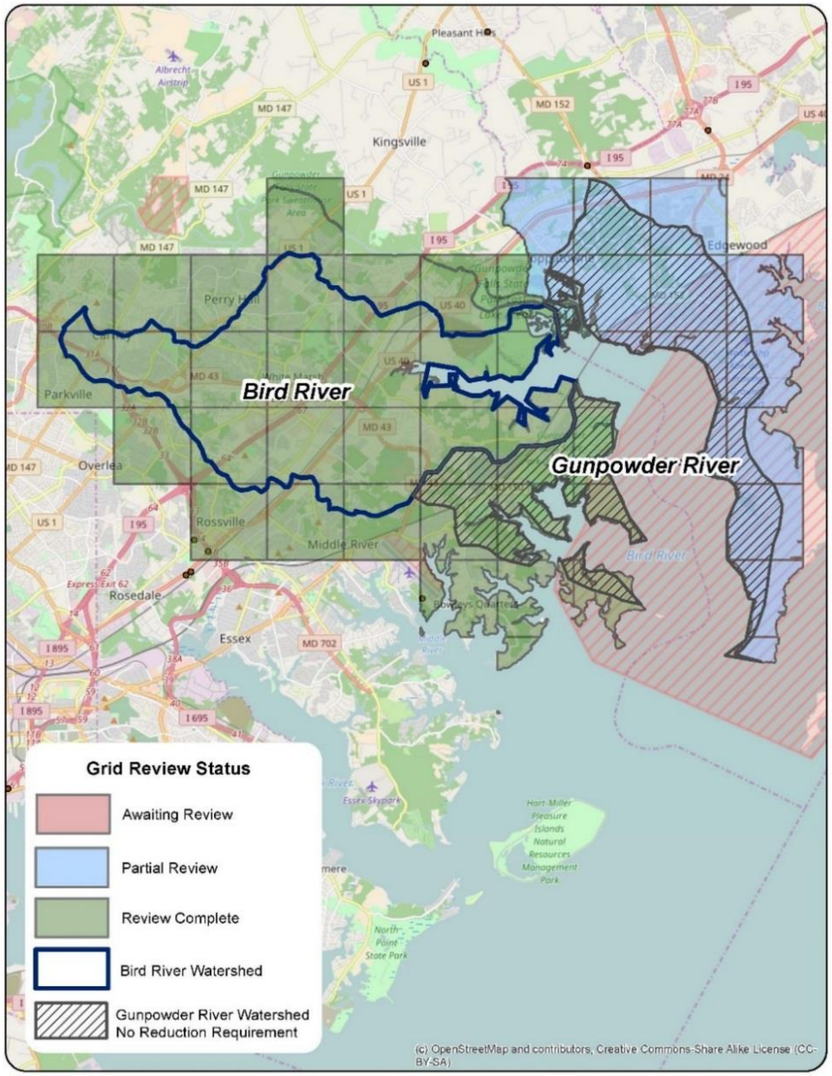


Figure 7: Gunpowder River & Bird River Subsegments Site Search Grids

F.4. Summary of County Assessment Review

The designated use of the waters of the Bird River (8-digit Basin Code: 02130803) is Use II – Support of Estuarine and Marine Aquatic Life and Shellfish Harvesting (MDE, 2016c). The Bird River is subject to the following impairments as noted on MDE's 303(d) List:

- PCB in Fish Tissue

The Baltimore County Department of Environmental Protection and Sustainability completed a Small Watershed Action Plan (SWAP) for the Bird River watershed (Versar, 2014). The Bird River SWAP provides guidance on the restoration of the Bird River watershed. It includes strategies and project prioritizations for watershed restoration and management for each of the 8 subwatersheds within the Bird River watershed, namely Whitemarsh Run, Whitemarsh Run (N. Fork), Whitemarsh Run (S. Fork), Honeygo Run, Windlass Run, Bird River-D, Bird River-B, and Railroad Creek_Bird River-A. Maryland Route 43 predominantly runs through the "Whitemarsh Run" subwatershed and separates the "Whitemarsh Run (N. Fork)" and "Whitemarsh Run (S. Fork)" subwatersheds: Whitemarsh Run (N. Fork) is located above MD Route 43 and Whitemarsh Run (S. Fork) is located below MD Route 43. "Bird-River-D" and "Bird River-B" surround Bird River: Bird River-D is predominately the drainage area directly above Bird River and Bird River-B is predominantly the drainage area directly below Bird River. The "Railroad Creek_Bird River-A" subwatershed surrounds Railroad Creek.

Land use/land cover within the Bird River watershed is predominantly urbanized (approximately 50 percent) and forested (approximately 29 percent). Impervious urban land cover comprises 3,058 acres (18.6 percent) of the watershed, and approximately 12 percent of the soils within the watershed are considered as high runoff potential.

The County estimates that impervious urban land use is responsible for contributing 28,269 lbs. of nitrogen, 4,260 lbs. of phosphorus, and 1,729,028 lbs. of sediment in the Bird River watershed each year. Stormwater runoff was identified as the primary contributor of nutrient (nitrogen and phosphorus) and sediment inputs to the Bird River watershed. Trash is another significant source of impairment; the Bird River SWAP states, "Trash is one of the most noticeable pollutants in the Bird River" (Versar, 2014, p. 2-3).

Restoration actions are needed throughout the entire Bird River watershed to meet environmental goals and requirements. However, using ranking criteria to prioritize the 8 subwatersheds within the Bird River watershed, Baltimore County supports a focused framework to identify which subwatersheds have the greatest need and potential for restoration.

The Bird River SWAP describes the ranking methodology used to prioritize the subwatersheds as follows: The subwatersheds were represented by an overall prioritization score on a scale of 48, based on a set of 12 criteria (listed below) each worth a maximum of four points. A total score of 0 means the subwatershed has the least significant impacts to water quality and a total score of 48 corresponds to a subwatershed with the greatest water quality improvement potential. The total prioritization score for each of the Bird River subwatersheds was determined using the following 12 ranking criteria:

- Phosphorus Loads;
- Nitrogen Loads;
- Impervious Surfaces;

- Neighborhood Restoration Opportunity/Pollution Source Indexes;
- Neighborhood Downspout Disconnection;
- Institutional Site Investigations;
- Pervious Area Assessments;
- Municipal Street Sweeping;
- Municipal Stormwater Conversions;
- Illicit Discharge Data;
- Stream Buffer Improvement; and
- Stream Restoration Potential.

The scoring resulted in the Whitemarsh Run and Honeygo Run subwatersheds being rated as "very high" and the Whitemarsh Run (N. Fork) and Whitemarsh Run (S. Fork) subwatersheds being rated as "high" in terms of restoration need and potential. **Table 4** shows the total score of each watershed and its corresponding ranking and prioritization for treatment category.

Table 4: County Identified Priority Areas for Treatment

Rank	Subwatershed	Total Score	Prioritization Category
1	Whitemarsh Run	41	Very High
2	Honeygo Run	31	Very High
3	Whitemarsh Run (N. Fork)	28	High
4	Whitemarsh Run (S. Fork)	28	High
5	Bird River-D	24	Medium
6	Railroad Creek_Bird River-A	17	Medium
7	Bird River-B	14	Low
8	Windlass Run	11	Low

Source: Versar (2014)

The subwatersheds were also ranked by protection priorities (**Table 5**). This was done to highlight the importance of protecting areas that are in good condition from any degradation that could occur. This ranking was established by reversing the subwatershed restoration prioritization as listed in **Table 4**. Therefore, Windlass Run and Bird River-B were listed as "very high," while Railroad Creek_Bird River-A and Bird River-D were listed as "high" in terms of protection priority.

Table 5: County Identified Priority Areas for Protection

Rank	Subwatershed	Total Score	Protection Category
1	Windlass Run	11	Very High
2	Bird River-B	14	Very High
3	Railroad Creek_Bird River-A	17	High
4	Bird River-D	24	High
5	Whitemarsh Run (N. Fork)	28	Medium
6	Whitemarsh Run (S. Fork)	28	Medium
7	Honeygo Run	31	Low
8	Whitemarsh Run	41	Low

Source: Versar (2014)

Table 6 presents Baltimore County-suggested BMPs to aid in meeting the restoration goals within the Bird River watershed. The recommended BMPs are separated out by applicable BMPs for developed and agricultural areas. Several other BMP suggestions such as citizen awareness activities are applicable to all areas of the watershed. The Bird River SWAP indicates that the Bird River-B and Windlass Run watersheds have the most agricultural land (cropland). The largest area of commercial and industrial land use is concentrated around the White Marsh Mall and The Avenue at White Marsh within the Whitemarsh Run watershed.

<table>
<tr><th colspan="2">Table 6: County Suggested BMPs for the Bird River Watershed</th></tr>
<tr><th>Developed Areas</th><th>All Areas</th></tr>
<tr><td>• Stormwater Management Upgrades
– conversions (ponds # 883 & # 1633 in the Whitemarsh Run, pond # 951 in Whitemarsh Run (N. Fork), and pond # 1166 in Whitemarsh Run (S. Fork) subwatersheds were recommended for conversion because water quality benefits could be significantly increased in these ponds with minimal effort)
– retrofits
• Stream Corridor Restoration
– stream restoration (data from stream corridor assessments indicates that a total of 6,924 linear feet of stream in the Bird River-D, Honeygo Run, and Whitemarsh Run subwatersheds are in need of restoration due to significant erosion and channel alteration)
– buffer restoration
– wetland creation
• Trash and Recycling
– single stream recycling
– household hazardous waste collection
– waterway trash boom
• Reforestation
• Street Sweeping
• Inlet Cleaning
• Illicit Discharge Detection and Elimination Program
• Waterway Dredging
• Land Development Review (including follow-up inspections post construction)</td>
<td rowspan="3">• Citizen Awareness Activities
– Stormwater Runoff
– Pet Waste/Bacteria Awareness
– Fertilizer Reduction
– Trash and Recycling (Compost Bins, Stewardship projects, Baltimore County's Reuse Directory, and the Re-source Newsletter)
– Environmental Awareness and Education

• Volunteer Restoration Programs
– Downspout Disconnection
– Bayscaping
– Tree Canopy Improvement
– Fertilizer Reduction/Education
– Stream Watch Program
– Open Space Trees

• Institutional Initiatives
– Parking Lot Retrofits
– Open Space Planting

• Land Preservation
– Maryland and County Rural Legacy Programs
– Maryland Environmental Trust and Local Land Trusts
– Maryland Agricultural Land Preservation Foundation
– Baltimore County Agricultural Land Preservation Program</td></tr>
<tr><th>Agricultural Areas</th></tr>
<tr><td>• Farm Conservation Plans
– Cover Crop
– Nutrient Management
– Integrated Pest Management
– Residue and Tillage Management
– Conservation Crop Rotation
– Stripcropping

• Nutrient Management Plans</td></tr>
<tr><td colspan="2">Source: Versar (2014)</td></tr>
</table>

The Bird River SWAP also established restoration strategies for each subwatershed as presented in **Table 7**. These strategies were based on the individual conditions and needs of each subwatershed.

Table 7: County Suggested BMPs for Subwatersheds within the Bird River Watershed

Subwatershed	**Recommended Actions**												
	Remove Impervious Cover	Stormwater Retrofit	Rain Barrels	Rain Gardens	Storm Drain Marking	Bayscaping	Tree Planting	Downspout Disconnection	Pet Waste Education	Trash Management	Stream Buffer Improvement	Parking Lot/Alley Retrofit	Street Sweeping
Whitemarsh Run (N. Fork)	X	X	X	X	X	X	X	X	X	X	X		
Honeygo Run			X	X	X	X	X	X			X		
Whitmarsh Run	X	X	X	X	X	X	X	X	X	X	X	X	X
Whitemarsh Run (S. Fork)		X	X	X	X	X	X	X		X	X	X	X
Bird River-D		X	X	X	X	X	X				X		
Railroad Creek-Bird River-A			X	X	X	X	X		X		X		
Bird River-B			X	X		X	X				X	X	
Windlass Run		X	X		X	X	X	X		X			
Source: Versar (2014)													

F.5. MDOT SHA Pollutant Reduction Strategies

Proposed practices to meet the PCB reductions in the Bird River watershed are shown in **Table 8**. Projected PCB reductions using these practices are described in **Section E** and shown in **Table 2**. Three timeframes are included in the table below:

- BMPs built before the TMDL baseline. In this case, the baseline is 2010;
- BMPs built after the baseline through fiscal year 2017; and
- BMPs built after fiscal year 2017 through 2050, the projected target date. MDOT SHA will accomplish the projected reduction to be achieved as a percent of the baseline load presented in **Table 2**. The reduction is not expected to meet MDE's 70% load reduction requirement. BMPs identified in this current plan will only achieve 9.1% of the reduction requirement. Through strategies discussed in section E.2.d. MDOT SHA will increase this expected reduction.

Estimated Capital Budget costs to design and construct practices within the Bird River watershed total $ 18,561,500. These projected costs are based on an average cost per impervious acre treated that is derived from cost history for a group of completed projects for each BMP category.

Figure 8 shows a map of MDOT SHA's restoration practices in the segmentshed and includes those that are under design or construction. Inlet cleaning is not reflected on this map.

Table 8: Bird River PCB BMP Implementation

BMP[1]	Unit	Baseline (Before 2010)	Restoration BMPs		Cost
			Progress (2010 – FY17)	Future (After FY17)	
New Stormwater	drainage area acres	97.1		16.2	$15,097,500
Retrofit	drainage area acres			64.6	$3,344,000
Inlet Cleaning[2]	tons			21.0	$120,000

[1] Tree planting, outfall stabilization, and stream restoration BMPs do not contribute to PCB load reductions; therefore, these practices are not included in this table.

[2] Inlet cleaning is an annual practice.

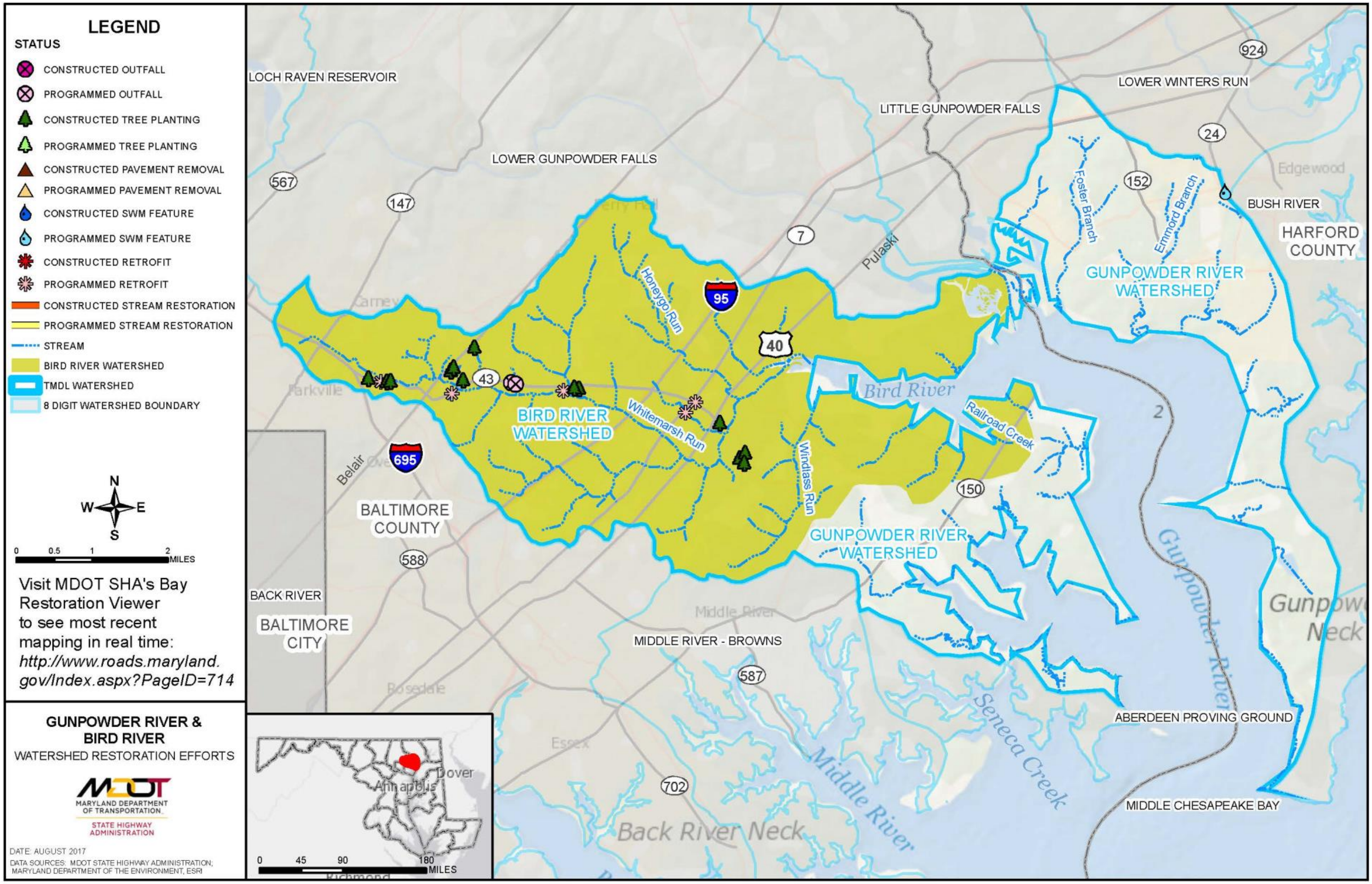


Figure 8: MDOT SHA Restoration Strategies within the Gunpowder River & Bird River Subsegments

PAGE INTENTIONALLY LEFT BLANK

ABBREVIATIONS

AA	Anne Arundel (County)
AA-DPW	Anne Arundel County, Department of Public Works
AAH	Adopt-A-Highway
AASHTO	American Association of State Highway and Transportation Officials
ac	Acre
AFB	Air Force Base
Alt	Alternative
AMT	Automated Modeling Tool
AMT, Inc.	A. Morton Thomas and Associates, Inc.
ATV	All-terrain vehicle
BA	Baltimore (County)
BARC	Beltsville Agriculture Research Center
Bay	Chesapeake Bay
BBO	Beaverdam Run, Baisman Run, and Oregon Branch Subwatersheds of the Loch Raven Reservoir Watershed
BC-DEPRM	Baltimore County, Department of Environmental Protection and Resource Management
BC-DEPS	Baltimore County, Department of Environmental Protection and Sustainability
BIBI	Benthic Index of Biotic Integrity
BMP	Best Management Practice
BOD	Biochemical Oxygen Demand
BSID	Biological Stressor Identification
BST	Bacterial Source Tracking
CAFO	Concentrated Animal Feeding Operation
CBP	Chesapeake Bay Program
CBWM	Chesapeake Bay Watershed Model
CC	Charles (County)
CC-BRM	Carroll County, Bureau of Resource Management
CC-DPGM	Charles County, Department of Planning & Growth
CCMS	Customer Care Management System
CFR	Code of Federal Regulations
CIP	Capital Improvement Project
CL	Carroll (County)
CRP	Community Reforestation Program
CSN	Chesapeake Stormwater Network
CSO	Combined Sewer Overflow
CTP	Consolidated Transportation Program
CWA	Clean Water Act
CWAPTW	Clean Water Action Plan Technical Workgroup
CWP	Center for Watershed Protection
DC	District of Columbia
DO	Dissolved Oxygen
DEL	Delivered Loads
DMCF	Dredged Material Containment Facilities
DNR	Maryland Department of Natural Resources
DRMO	Defense Reutilization and Marketing Office
ECD	Environmental Compliance Division (MDOT SHA)
E. coli	*Escherichia coli*
ED	Extended Detention
EMC	Event Mean Concentration
EMS	Environmental Management System
EOS	Edge of Stream

EPA	United States Environmental Protection Agency
EPD	Environmental Programs Division
ESC	Erosion and Sediment Control
ESD	Environmental Site Design
FC	Fecal Coliform
FC-DPW	Frederick County, Division of Public Works
FEMA	Federal Emergency Management Administration
FIB	Fecal Indicator Bacteria
FIBI	Fish Index of Biotic Integrity
FMD	Facility Maintenance Division (MDOT SHA)
FR	Frederick (County)
FY	Fiscal Year
GIS	Geographic Information System
GUNOH	Gunpowder River Oligohaline Segmentshed
HA	Harford (County)
HC-DPW	Harford County, Department of Public Works
HO	Howard (County)
HUC	Hydrologic Unit Code
HWG	Horsley Witten Group, Inc.
ICPRB	Interstate Commission on the Potomac River Basin
IDDE	Illicit Discharge Detection and Elimination
ISWBMPDB	International Stormwater BMP Database
LA	Load Allocations
lbs	Pounds (weight)
LF	Linear Feet
LN	Lower North
LNB	Lower North Branch
LRE	Loch Raven East subwatershed
LJF	Lower Jones Falls (Watershed)
LU	Land Use
MAA	Maryland Aviation Administration
MAST	Maryland Assessment Scenario Tool
MC-DEP	Montgomery County, Department of Environmental Protection
MD	Maryland
MDA	Maryland Department of Agriculture
MDE	Maryland Department of the Environment
MDOT	Maryland Department of Transportation
MDP	Maryland Department of Planning
MEP	Maximum Extent Practicable
MEPA	Maryland Environmental Policy Act
MGF	Middle Gwynns Falls (Watershed)
MO	Montgomery (County)
MOS	Margin of Safety
MPR	Maximum Practicable Reduction
MS4	Municipal Separate Storm Sewer System
NBOD	Nitrogenous Biochemical Oxygen Demand
NEPA	National Environmental Policy Act
NFHL	National Flood Hazard Layer
NJF	Northeastern Jones Falls (Watershed)
NPDES	National Pollutant Discharge Elimination System
NSQD	National Stormwater Quality Database
OC	Office of Communications (MDOT SHA)
OED	Office of Environmental Design
OOM	Office of Maintenance (MDOT SHA)
OP	Orthophosphate

OPPE	Office of Preliminary Planning and Engineering
PACD	Pennsylvania Association of Conservation Districts
PB	Parsons Brinckerhoff
PCB	Polychlorinated Biphenyl
P_E	Rainfall Target Used To Size ESD Practices
PERC	Perchloroethylene
PG	Prince George's (County)
PGC-DoE	Prince George's County, Department of the Environment
RBP	Rapid Bioassessment Protocol
RGP	Regional General Permit
ROW	Rights-Of-Way
Reqd	Required
RR	Runoff Reduction
RSPSC	Regenerative Step Pool System Conveyance
SAH	Sponsor-A-Highway
SB	Spring Branch subwatershed
SCA	Stream Corridor Assessment
SFEI	San Francisco Estuary Institute
SGW	Submerged Gravel Wetlands
SHA	State Highway Administration
SPR	State Planning and Research
SSO	Sanitary Sewer Overflow
ST	Stormwater Treatment
SW	Stormwater
SWAP	Small Watershed Action Plan
SWM	Stormwater Management
SWS	Subwatershed
SW-WLA	Stormwater Wasteload Allocation
TBD	To Be Determined
TBR	Tidal Back River (Watershed)
TBS	To Be Specified
TCWG	Toxic Contaminants Work Group
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
tPCB	Total Polychlorinated Biphenyl
TSS	Total Suspended Solids
TWGCB	Toxics Work Group Chesapeake Bay Partnership
UBR	Upper Back River (Watershed)
UGF	Upper Gwynns Falls (Watershed)
UJF	Upper Jones Falls (Watershed)
US	United States
USACE	United States Army Corps of Engineers
USDA-NRCS	United States Department of Agriculture, Natural Resources Conservation Service
USGS	United States Geological Survey
USWG	Urban Stormwater Work Group
WA	Washington (County)
WC-DPW	Washington County, Division of Public Works
WCSCD	Washington County Soil Conservation District
WIP	Watershed Implementation Plan
WLA	Wasteload Allocation
WPD	Water Programs Division
WQLS	Water Quality Limited Segment
WQSs	Water Quality Standards

WQv	Water Quality Volume
WQGIT	Water Quality Goal Implementation Team
WRAS	Watershed Restoration Action Strategy
WTM	Watershed Treatment Model
WTWG	Watershed Technical Work Group
WWTP	Waste Water Treatment Plant
yr	Year
12-SW	Maryland General Permit for Discharges from Stormwater Associated with Industrial Activities

REFERENCES

AMT, Inc. (A. Morton Thomas and Associates, Inc.). 2011. *Upper Gwynns Falls Small Watershed Action Plan* prepared for Baltimore County, Department of Environmental Protection and Sustainability. Retrieved from http://www.baltimorecountymd.gov/Agencies/environment/watersheds/gwynnsmain.html

AMT, Inc. and Biohabitats. 2003. *Watts Branch Watershed Restoration Study*, Task 1 Report, March 2003 prepared for Montgomery County Department of Environmental Protection. Retrieved from https://www.montgomerycountymd.gov/DEP/Resources/Files/ReportsandPublications/Water/Watershed%20studies/Lower%20Potomac%20Direct/Watts-Branch-stream-restoration-study-03.pdf

BC-DEPRM (Baltimore County, Department of Environmental Protection and Resource Management). 2008a. *Upper Back River Small Watershed Action Plan*. Retrieved from http://resources.baltimorecountymd.gov/Documents/Environment/Watersheds/swapupperbackrivervol1.pdf

BC-DEPRM. 2008b. *Spring Branch Subwatershed - Small Watershed Action Plan* (Addendum to the Water Quality Management Plan for Loch Raven Watershed). Retrieved from http://resources.baltimorecountymd.gov/Documents/Environment/Watersheds/swapspringbranchvol%201.pdf

BC-DEPS (Baltimore County, Department of Environmental Protection and Sustainability). 2012. *Northeastern Jones Falls Small Watershed Action Plan* (SWAP). Retrieved from http://resources.baltimorecountymd.gov/Documents/Environment/Watersheds/swapnejonesfallsvol1130605.pdf

BC-DEPS. 2015. *Liberty Reservoir Small Watershed Action Plan*. Vol. 1. Retrieved from http://resources.baltimorecountymd.gov/Documents/Environment/Watersheds/2016/libertyreservoir/libertyswapvol1complete.pdf

Biohabitats. 2012. *Rock Creek Implementation Plan* prepared for Montgomery County, Department of Environmental Protection. Retrieved from https://www.montgomerycountymd.gov/DEP/Resources/Files/ReportsandPublications/Water/Watershed%20studies/Rock-creek-watershed-implementation-plan-11.pdf

Caraco, D. 2013. *Watershed Treatment Model (WTM) 2013 User's Guide*. Center for Watershed Protection, Ellicott City, MD.

CBP (Chesapeake Bay Program). 2015. *Toxic Contaminants Policy and Prevention Outcome: Management Strategy.* 2015-2025. Vol 1. Retrieved from http://www.chesapeakebay.net/documents/22048/3e_toxics_policyprevention_6-25-15_ff_formatted.pdf

CC-BRM (Carroll County, Bureau of Resource Management). 2012. *Liberty Reservoir Watershed Stream Corridor Assessment*. Retrieved from http://ccgovernment.carr.org/ccg/resmgmt/doc/Liberty/Liberty%20SCA.pdf?x=1466803710079

Clary, J., Jones, J., Urbonas, B., Quigley, M., Strecker, E., & Wagner, T. 2008. Can Stormwater BMPs Remove Bacteria? New Findings from the International Stormwater BMP Database. *Stormwater Magazine,* May/June 2008. Retrieved from http://www.uwtrshd.com/assets/can-stormwater-bmps-remove-bacteria.pdf

Clemson Cooperative Extension. 2015. *Managing Waterfowl in Stormwater Ponds*. Retrieved from http://www.clemson.edu/extension/natural_resources/water/stormwater_ponds/problem_solving/nuisance_wildlife/waterfowl/

CWAPTW (Clean Water Action Plan Technical Workgroup). 1998. *Maryland Clean Water Action Plan: Final 1998 Report on Unified Watershed Assessment, Watershed Prioritization and Plans for Restoration Action Strategies*. Retrieved from http://msa.maryland.gov/megafile/msa/speccol/sc5300/sc5339/000113/000000/000385/unrestricted/20040775e.pdf

CWP (Center for Watershed Protection). 2003. *Bush River Watershed Management Plan* prepared for Harford County, Department of Public Works.

Retrieved from http://dnr.maryland.gov/waters/Documents/WRAS/br_strategy.pdf

CWP. 2008a. *Deriving Reliable Pollutant Removal Rates for Municipal Street Sweeping and Storm Drain Cleanout Programs in the Chesapeake Bay Basin,* CWP, Ellicott City, MD. Retrieved from https://www.epa.gov/sites/production/files/2015-11/documents/cbstreetsweeping.pdf

CWP. 2008b. *Lower Jones Falls Watershed Small Watershed Action Plan* (SWAP) prepared for Baltimore County, Department of Environment and Sustainability and the U.S. Environmental Protection Agency, Region III. Retrieved from http://resources.baltimorecountymd.gov/Documents/Environment/Watersheds/swaplowerjonesfalls.pdf

CWP. 2011. *Beaverdam Run, Baisman Run, and Oregon Branch SWAP* prepared for Baltimore County, Department of Environmental Protection and Sustainability. Retrieved from http://resources.baltimorecountymd.gov/Documents/Environment/Watersheds/swapareaivolume1.pdf

CWP. 2014. *Loch Raven East Small Watershed Action Plan: Final Report* prepared for Baltimore County, Department of Environmental Protection and Sustainability. Retrieved from http://resources.baltimorecountymd.gov/Documents/Environment/Watersheds/2014/lochraveneastswapvol1.pdf

CWP. 2015. *Upper Jones Falls SWAP* prepared for Baltimore County Department of Environmental Protection and Sustainability. Retrieved from http://resources.baltimorecountymd.gov/Documents/Environment/Watersheds/2015/AreaG/areagswapfulldoc1.pdf

DNR (Maryland Department of Natural Resources). 2002a. *Bush River Watershed Characterization*. Annapolis, MD. Retrieved from http://dnr.maryland.gov/waters/Documents/WRAS/br_char.pdf

DNR. 2002b. *Liberty Reservoir Watershed Characterization*. Retrieved from http://msa.maryland.gov/megafile/msa/speccol/sc5300/sc5339/000113/002000/002374/unrestricted/20063378e.pdf

DNR. 2004. *Upper Monocacy Stream Corridor Assessment*. Baltimore, MD: DNR, Watershed Assessment and Targeting Division, Watershed Services.
EPA (United States Environmental Protection Agency). 2010a. *Getting in Step: A Guide for Conducting Watershed Outreach Campaigns* (3rd ed.). (Publication No. EPA 841-B-10-002). Retrieved from https://cfpub.epa.gov/npstbx/files/getnstepguide.pdf

EPA. 2010b. *Chesapeake Bay Total Maximum Daily Load for Nitrogen, Phosphorus and Sediment*. US EPA, Chesapeake Bay Program Office, Annapolis, MD. December 29, 2010. Retrieved from https://www.epa.gov/chesapeake-bay-tmdl/chesapeake-bay-tmdl-document

EPA. 2016. Watershed Academy Web. Watershed Change Modules: Growth and Water Resources. Retrieved from https://cfpub.epa.gov/watertrain/

FC-DPW (Frederick County, Division of Public Works). 2004. *Lower Monocacy River Watershed Restoration Action Strategy*. Final Report. Retrieved from

FC-DPW. 2005. *Upper Monocacy River Watershed Restoration Action Strategy*. Retrieved from http://msa.maryland.gov/megafile/msa/speccol/sc5300/sc5339/000113/002000/002377/unrestricted/20063545e.pdf

Gilbreath, A., Yee, D., & McKee, L. 2012. *Concentrations and Loads of Trace Contaminants in a Small Urban Tributary, San Francisco Bay, California*. A Technical Report of the Sources Pathways and Loading Work Group of the Regional Monitoring Program for Water Quality: Contribution No. 650. San Francisco Estuary Institute, Richmond, California.

Hoos, A. B., Robinson, J. A., Aycock, R. A., Knight, R. R., & Woodside, M. D. 2000. *Sources, Instream Transport, and Trends of Nitrogen, Phosphorus, and Sediment in the Lower Tennessee River Basin, 1980-96*. U.S. Geological Survey, Water-Resources Investigations Report 99-4139. Nashville,

Tennessee.HWG (Horsley Witten Group, Inc). 2012a. *Muddy Branch and Watts Branch Subwatersheds Implementation Plan* prepared for the Montgomery County Department of Environmental Protection. Retrieved from https://www.montgomerycountymd.gov/DEP/Resources/Files/ReportsandPubl

ications/Water/Watershed%20studies/Muddy-Branch-Watts-Branch-Subwatersheds-Implementation-Plan-12.pdf
HWG. 2012b. *Great Seneca Subwatershed Implementation Plan* prepared for the Montgomery County Department of Environmental Protection. Retrieved from https://www.montgomerycountymd.gov/DEP/Resources/Files/ReportsandPublications/Water/Watershed%20studies/Great-Seneca-subwatershed-implementation-plan-12.pdf

KCI/CH2M Hill. 2011. *Patapsco Non-Tidal Watershed Assessment Comprehensive Summary Report* prepared for Anne Arundel County. August 2011 Final Report. Retrieved from http://dev.aacounty.org/departments/public-works/wprp/forms-and-publications/PNT_Report.pdf

Lazarick, L. 2013. 'Scoop the Poop Day in Maryland,' O'Malley declares, *MarylandReporter.com*, 27 August 2013. Retrieved from http://marylandreporter.com/2013/08/27/scoop-the-poop-day-in-maryland-omalley-declares/#

Leisenring, M., Clary, J., & Hobson, P. 2014. *International Stormwater Best Management Practices (BMP) Database Pollutant Category Statistical Summary Report: Solids, Bacteria, Nutrients, and Metals*. Retrieved from http://www.bmpdatabase.org/Docs/2014%20Water%20Quality%20Analysis%20Addendum/BMP%20Database%20Categorical_StatisticalSummaryReport_December2014.pdf

LimnoTech & Versar. 2012. *Patapsco Tidal and Bodkin Creek Watershed Assessment Comprehensive Summary Report* prepared for Anne Arundel County, Department of Public Works. Retrieved from http://dev.aacounty.org/departments/public-works/wprp/forms-and-publications/PTB_Summary_Report_Final_Main.pdf

LimnoTech & Versar. 2016. *Little Patuxent Watershed Assessment Comprehensive Summary Report* prepared for Anne Arundel County, Department of Public Works. Retrieved from http://www.aacounty.org/AACoOIT/WPRP/DRAFT%20Little_Patuxent_Summary_Report_20160219_with_Appendices-small.pdf

MAST (Maryland Assessment Scenario Tool). 2016. MASTSource_Data_3_31_2016.xlsx. http://www.mastonline.org/Documentation.aspx. Retrieved March 31, 2016.

MC-DEP (Montgomery County, Department of Environmental Protection). 1999. *Great Seneca Watershed Study*. Retrieved from https://www.montgomerycountymd.gov/DEP/Resources/Files/ReportsandPublications/Water/Watershed%20studies/Seneca%20Creek/Great-Seneca-Creek-watershed-study-99.pdf

MC-DEP. 2012. *Anacostia Watershed Implementation Plan*. Retrieved from www.montgomerycountymd.gov/DEP/Resources/Files/ReportsandPublications/Water/Watershed%20studies/Anacostia/AnacostiaRiverWIP_FINAL.pdf

MDE (Maryland Department of the Environment). 2006. *Prioritizing Sites for Wetland Restoration, Mitigation, and Preservation in Maryland*. Version: May 2006. Baltimore, MD: Maryland Department of the Environment, Wetlands and Waterways Program. Retrieved from http://www.mde.state.md.us/programs/Water/WetlandsandWaterways/AboutWetlands/Pages/Programs/WaterPrograms/Wetlands_Waterways/about_wetlands/priordownloads.aspx

MDE. 2008a. Revised Final *Total Maximum Daily Load of Sediment in the Antietam Creek Watershed, Washington County, Maryland*. Retrieved from http://mde.maryland.gov/programs/Water/TMDL/ApprovedFinalTMDLs/Pages/Programs/WaterPrograms/TMDL/approvedfinaltmdl/tmdl_final_antietam_creek_sediment.aspx

MDE. 2008b. Final *Total Maximum Daily Load of Sediment in the Conococheague Creek Watershed, Washington County, Maryland*. Retrieved from http://www.mde.state.md.us/programs/Water/TMDL/ApprovedFinalTMDLs/Pages/Programs/WaterPrograms/TMDL/approvedfinaltmdl/tmdl_final_conococheague_creek_sediment.aspx
MDE. 2008c. Final *Total Maximum Daily Loads of Phosphorus and Sediments for Triadelphia Reservoir (Brighton Dam) and Total Maximum Daily Loads of Phosphorus for the Rocky Gorge Reservoir, Howard, Montgomery, and Prince George's Counties, Maryland*. Retrieved from http://www.mde.state.md.us/programs/Water/TMDL/ApprovedFinalTMDLs/Pa

ges/Programs/WaterPrograms/TMDL/approvedfinaltmdl/tmdl_pax_res_p_sed.aspx

MDE. 2009a. *2000 Maryland Stormwater Design Manual Volumes I & II* (Effective October 2000, Revised May 2009). Retrieved from http://www.mde.state.md.us/programs/Water/StormwaterManagementProgram/MarylandStormwaterDesignManual/Pages/Programs/WaterPrograms/SedimentandStormwater/stormwater_design/index.aspx

MDE. 2009b. Final *Total Maximum Daily Loads of Fecal Bacteria for Loch Raven Reservoir Watershed in Baltimore, Carroll and Harford Counties, Maryland*. Retrieved from http://www.mde.state.md.us/programs/Water/TMDL/ApprovedFinalTMDLs/Pages/Programs/WaterPrograms/TMDL/approvedfinaltmdl/tmdl_final_loch_raven_reservoir_bacteria.aspx

MDE. 2009c. Final *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*. Retrieved from http://www.mde.state.md.us/programs/Water/TMDL/ApprovedFinalTMDLs/Pages/Programs/WaterPrograms/TMDL/approvedfinaltmdl/tmdl_final_patapsco_lnb_bacteria.aspx

MDE. 2009d. Revised Final *Total Maximum Daily Load of Sediment in the Catoctin Watershed, Frederick County, Maryland*. Retrieved from http://www.mde.state.md.us/programs/Water/TMDL/ApprovedFinalTMDLs/Pages/Programs/WaterPrograms/TMDL/approvedfinaltmdl/tmdl_final_catoctin_creek_sediment.aspx

MDE. 2009e. Final *Total Maximum Daily Load of Sediment in the Double Pipe Creek Watershed, Frederick and Carroll Counties, Maryland*. Retrieved from http://www.mde.state.md.us/programs/Water/TMDL/ApprovedFinalTMDLs/Pages/Programs/WaterPrograms/TMDL/approvedfinaltmdl/tmdl_final_doublepipecreek_sediment.aspx

MDE. 2009f. Final *Total Maximum Daily Load of Sediment in the Lower Monocacy River Watershed, Frederick, Carroll, and Montgomery Counties, Maryland*. Retrieved from http://www.mde.state.md.us/programs/Water/TMDL/ApprovedFinalTMDLs/Pages/Programs/WaterPrograms/TMDL/approvedfinaltmdl/tmdl_final_lower_monocacy_sediment.aspx

MDE. 2009g. Final *Total Maximum Daily Load of Sediment in the Upper Monocacy River Watershed, Frederick and Carroll Counties, Maryland*. Retrieved from http://www.mde.state.md.us/programs/Water/TMDL/ApprovedFinalTMDLs/Pages/Programs/WaterPrograms/TMDL/approvedfinaltmdl/tmdl_final_uppermonocacy_sediment.aspx

MDE. 2010a. *Total Maximum Daily Loads of Trash for the Anacostia River Watershed, Montgomery and Prince George's Counties, Maryland and the District of Columbia* Retrieved from: http://www.mde.state.md.us/programs/Water/TMDL/ApprovedFinalTMDLs/Documents/www.mde.state.md.us/assets/document/Anacostia_Trash_TMDL_081010_final.pdf

MDE. 2010b. Final *Total Maximum Daily Load of Sediment in the Gwynns Falls Watershed, Baltimore City and Baltimore County, Maryland*. Retrieved from http://www.mde.state.md.us/programs/Water/TMDL/ApprovedFinalTMDLs/Pages/Programs/WaterPrograms/TMDL/approvedfinaltmdl/tmdl_final_gwynns_falls_sediment.aspx

MDE. 2011a. Final *Total Maximum Daily Load of Polychlorinated Biphenyls in the Northeast and Northwest Branches of the Nontidal Anacostia River, Montgomery and Prince George's County, Maryland*. Retrieved from http://www.mde.state.md.us/programs/Water/TMDL/ApprovedFinalTMDLs/Pages/TMDL_Final_Nontidal_Anacostia_PCBs.aspx

MDE. 2011b. Final *Total Maximum Daily Loads of Bacteria for Impaired Recreational Areas in Marley Creek and Furnace Creek of Baltimore Harbor Basin in Anne Arundel County, Maryland*. Retrieved from http://www.mde.state.md.us/programs/Water/TMDL/ApprovedFinalTMDLs/Pages/TMDL_final_Marley.aspx

MDE. 2011c. Final *Total Maximum Daily Load of Sediment in the Bynum Run Watershed, Harford County, Maryland*. Retrieved from http://www.mde.state.md.us/programs/Water/TMDL/ApprovedFinalTMDLs/Pages/TMDL_Final_BynumRun_Sediment.aspx

MDE. 2011d. Final *Total Maximum Daily Load of Sediment in the Cabin John Creek Watershed, Montgomery County, Maryland*. Retrieved from http://www.mde.state.md.us/programs/Water/TMDL/ApprovedFinalTMDLs/Pages/TMDL_Final_CabinJohnCreek_Sediment.aspx

MDE. 2011e. Final *Total Maximum Daily Load of Sediment in the Jones Falls Watershed, Baltimore City and Baltimore County, Maryland*. Retrieved from http://www.mde.state.md.us/programs/Water/TMDL/ApprovedFinalTMDLs/Pages/TMDL_Final_Jones_Falls_Sediment.aspx

MDE. 2011f. Final *Total Maximum Daily Load of Sediment in the Little Patuxent River Watershed, Howard and Anne Arundel Counties, Maryland*. Retrieved from http://www.mde.state.md.us/programs/Water/TMDL/ApprovedFinalTMDLs/Pages/TMDL_Final_LittlePAX_Sediment.aspx

MDE. 2011g. Final *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*. Retrieved from http://www.mde.state.md.us/programs/Water/TMDL/ApprovedFinalTMDLs/Pages/TMDL_Final_PatapscoLNB_Sediment.aspx

MDE. 2011h. Final *Total Maximum Daily Loads of Fecal Bacteria for the Patuxent River Upper Basin in Anne Arundel and Prince George's Counties, Maryland*. Retrieved from http://www.mde.state.md.us/programs/Water/TMDL/ApprovedFinalTMDLs/Pages/TMDL_final_Patuxent_River_Upper_bacteria.aspx

MDE. 2011i. Final *Total Maximum Daily Load of Sediment in the Patuxent River Upper Watershed, Anne Arundel, Howard and Prince George's Counties, Maryland*. Retrieved from http://www.mde.state.md.us/programs/Water/TMDL/ApprovedFinalTMDLs/Pages/TMDL_Final_PaxUpper_Sediment.aspx

MDE. 2011j. Final *Total Maximum Daily Load of Sediment in the Rock Creek Watershed, Montgomery County, Maryland*. Retrieved from http://www.mde.state.md.us/programs/Water/TMDL/ApprovedFinalTMDLs/Pages/TMDL_final_Rock_Creek_sed.aspx

MDE. 2011k. Final *Total Maximum Daily Load of Sediment in the Seneca Creek Watershed, Montgomery County, Maryland*. Retrieved from http://www.mde.state.md.us/programs/Water/TMDL/ApprovedFinalTMDLs/Pages/TMDL_Final_Seneca_Creek_sed.aspx

MDE. 2012a. Final *Total Maximum Daily Load of Polychlorinated Biphenyls in Back River Oligohaline Tidal Chesapeake Bay Segment, Maryland*. Retrieved from http://www.mde.state.md.us/programs/Water/TMDL/ApprovedFinalTMDLs/Pages/TMDL_Final_BackRiver_PCBs.aspx

MDE. 2012b. Final *Total Maximum Daily Load of Polychlorinated Biphenyls in Baltimore Harbor, Curtis Creek/Bay, and Bear Creek Portions of Patapsco River Mesohaline Tidal Chesapeake Bay Segment, Maryland*. Retrieved from http://www.mde.state.md.us/programs/Water/TMDL/ApprovedFinalTMDLs/Pages/TMDL_Final_BaltHarbor_PCBs.aspx

MDE. 2012c. Final *Watershed Report for Biological Impairment of the Catoctin Creek Watershed in Frederick County, Maryland Biological Stressor Identification Analysis Results and Interpretation*. Retrieved from http://www.mde.state.md.us/programs/Water/TMDL/Documents/BSID_Reports/Catoctin_Creek_BSID_Report_final.pdf

MDE. 2012d. Final *Watershed Report for Biological Impairment of the Liberty Reservoir Watershed in Baltimore and Carroll Counties, Maryland, Biological Stressor Identification Analysis Results and Interpretation*. Retrieved from http://www.mde.state.md.us/programs/Water/TMDL/Documents/BSID_Reports/LibertyRes_BSID_25Jan2012_final.pdf

MDE. 2012e. Final *Total Maximum Daily Load of Sediment* in the Potomac River Montgomery County Watershed, Montgomery and Frederick Counties, Maryland. Retrieved from http://www.mde.state.md.us/programs/Water/TMDL/ApprovedFinalTMDLs/Pages/TMDL_Final_PotomacMOCnty_Sediment.aspx

MDE. 2013a. Final *Total Maximum Daily Load of Phosphorus in the Antietam Creek Watershed, Washington County, Maryland*. Retrieved from http://www.mde.state.md.us/programs/Water/TMDL/ApprovedFinalTMDLs/Pages/TMDL_final_Antietam_Creek_Nutrient.aspx

MDE. 2013b. Final *Total Maximum Daily Load of Phosphorus in the Catoctin Creek Watershed, Frederick County, Maryland*. Retrieved from http://www.mde.state.md.us/programs/Water/TMDL/ApprovedFinalTMDLs/Pages/TMDL_final_Catoctin_Creek_nutrient.aspx

MDE. 2013c. Final *Total Maximum Daily Load of Phosphorus in the Double Pipe Creek Watershed, Frederick and Carroll Counties, Maryland*. Retrieved from http://www.mde.state.md.us/programs/Water/TMDL/ApprovedFinalTMDLs/Pages/tmdl_final_double_pipe_creek_phosphorus.aspx

MDE. 2013d. Final *Total Maximum Daily Load of Phosphorus in the Lower Monocacy River Watershed, Frederick, Carroll, and Montgomery Counties, Maryland*. http://www.mde.state.md.us/programs/Water/TMDL/ApprovedFinalTMDLs/Pages/tmdl_final_lower_monocacy_river_phosphorus.aspx

MDE. 2013e. Final *Total Maximum Daily Load of Phosphorus in the Rock Creek Watershed, Montgomery County, Maryland*. Retrieved from http://www.mde.state.md.us/programs/Water/TMDL/ApprovedFinalTMDLs/Pages/TMDL_final_Rock_Creek_Nutrient.aspx

MDE. 2013f. Final *Total Maximum Daily Load of Phosphorus in the Upper Monocacy River Watershed, Frederick and Carroll Counties, Maryland*. Retrieved from http://www.mde.state.md.us/programs/Water/TMDL/ApprovedFinalTMDLs/Pages/tmdl_final_upper_monocacy_river_phosphorus.aspx

MDE. 2014a. *Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated: Guidance for National Pollutant Discharge Elimination System Stormwater Permits*. Retrieved from http://www.mde.state.md.us/programs/Water/StormwaterManagementProgram/Documents/NPDES%20MS4%20Guidance%20August%2018%202014.pdf

MDE. 2014b. *Guidance for Developing Stormwater Wasteload Allocation Implementation Plans for Nutrient, and Sediment Total Maximum Daily Loads*. Retrieved from http://www.mde.state.md.us/programs/Water/TMDL/DataCenter/Documents/Nutrient%20Sediment%20Implementation%20Plan%20Guidance_final_111814.pdf

MDE. 2014c. *Guidance for Developing a Stormwater Wasteload Allocation Implementation Plan for Bacteria Total Maximum Daily Loads*. Retrieved from http://www.mde.state.md.us/programs/Water/TMDL/DataCenter/Documents/Bacteria%20Implementation%20Plan%20Guidance_051414_clean.pdf

MDE. 2014d. *General Guidance for Developing a Stormwater Wasteload Allocation (SW-WLA) Implementation Plan*. Retrieved from http://www.mde.state.md.us/programs/Water/TMDL/DataCenter/Documents/General_Implementation_Plan_Guidance_clean.pdf

MDE. 2014e. Comment Response Document regarding the Final *Total Maximum Daily Load of Polychlorinated Biphenyls in Lake Roland of Jones Falls Watershed in Baltimore County and Baltimore City, Maryland*. Retrieved from http://mde.maryland.gov/programs/Water/TMDL/ApprovedFinalTMDLs/Pages/tmdl_final_lake_roland_pcb.aspx

MDE. 2014f. *Guidance for Developing Stormwater Wasteload Allocation Implementation Plans for Trash/Debris Total Maximum Daily Loads*. Retrieved from http://www.mde.state.md.us/programs/Water/TMDL/DataCenter/Documents/Trash%20Implementation%20Plan%20Guidance_052014.pdf

MDE. 2015a. *Maryland's Final 2014 Integrated Report of Surface Water Quality*. Retrieved from http://mde.maryland.gov/programs/Water/TMDL/Integrated303dReports/Pages/2014IR.aspx

MDE. 2015b. Final *Total Maximum Daily Load of Polychlorinated Biphenyls in the Magothy River Mesohaline Chesapeake Bay Tidal Segment, Anne Arundel County, Maryland*. Retrieved from http://www.mde.state.md.us/programs/Water/TMDL/ApprovedFinalTMDLs/Pages/tmdl_final_magothy_river_pcb.aspx

MDE. 2015c. Final *Total Maximum Daily Loads of Trash and Debris for Middle Branch and Northwest Branch Portions of Patapsco River Mesohaline Tidal Chesapeake Bay Segment, Baltimore City and County, Maryland*. Retrieved from http://www.mde.state.md.us/programs/Water/TMDL/ApprovedFinalTMDLs/Pages/TMDL_final_BaltimoreHarbor_trash.aspx

MDE. 2016a. Final *Total Maximum Daily Load of Polychlorinated Biphenyls in the Bush River Oligohaline Segment, Harford County, Maryland*. Retrieved from http://mde.maryland.gov/programs/water/TMDL/ApprovedFinalTMDLs/Pages/tmdl_final_bush_river_pcb.aspx

MDE. 2016b. Final *Total Maximum Daily Load of Polychlorinated Biphenyls in the Gunpowder River and Bird River Subsegments of the Gunpowder River Oligohaline Segment, Baltimore County and Harford County, Maryland*. Retrieved from http://mde.maryland.gov/programs/water/TMDL/ApprovedFinalTMDLs/Pages/tmdl_final_gunpowder_bird_pcb.aspx

MDE. 2016c. Final *Total Maximum Daily Load of Sediment in the Swan Creek Watershed, Harford County, Maryland*. Retrieved from http://mde.maryland.gov/programs/water/TMDL/ApprovedFinalTMDLs/Pages/TMDL_Final_SwanCreek_sediment.aspx

MDE. 2016d. Draft *Maryland Trading and Offset Policy and Guidance Manual Chesapeake Bay Watershed.* Retrieved from http://www.mde.state.md.us/programs/water/pages/wqtac.aspx

MDP (Maryland Department of Planning). 2010. Land Use/Land Cover. Retrieved from http://www.mdp.state.md.us/OurWork/landuse.shtml

PACD (Pennsylvania Association of Conservation Districts). 2009. *Stream Bank Fencing and Stream Crossings: We All Live Downstream*. Retrieved from http://pacd.org/webfresh/wp-content/uploads/2009/09/StreambankFencing1.pdf

PB (Parsons Brinckerhoff). 2010. *Tidal Back River Small Watershed Action Plan (SWAP)* prepared for Baltimore County, Department of Environmental Protection and Resource Management. Retrieved from http://resources.baltimorecountymd.gov/Documents/Environment/Watersheds/tbrswapvol1.pdf

PB. 2013. *Middle Gwynns Falls SWAP* prepared for Baltimore County, Department of Environmental Protection and Sustainability. Retrieved from http://resources.baltimorecountymd.gov/Documents/Environment/Watersheds/2013/swapmgfareacvol131113.pdf

PB. 2015. *Loch Raven North SWAP* prepared for Baltimore County, Department of Environmental Protection and Sustainability. Retrieved from http://resources.baltimorecountymd.gov/Documents/Environment/Watersheds/2016/lochravennorth/lrnswapvol1complete.pdf

PGC-DoE (Prince George's County, Department of the Environment). 2014. Draft *Implementation Plan for the Anacostia River Watershed Trash Total Maximum Daily Load in Prince George's County*, PGC-DoE, Largo, MD.

PGC-DoE. 2015. Restoration Plan for PCB-Impacted Water Bodies in Prince George's County. Retrieved from http://pgcdoe.net/pgcountyfactsheet/Areas/Factsheet/Documents/Plans/PCB%20Restoration%20Plan%2020151228-combined.pdf

Pitt, R., Maestre, A., & Morquecho, R. 2004. *The National Stormwater Quality Database (NSQD, version 1.1)* Retrieved from http://rpitt.eng.ua.edu/Research/ms4/Paper/Mainms4paper.html

S&S Planning and Design. 2012. *Tiber-Hudson and Plumtree Branch Stream Corridor Assessment* prepared for the Howard County Department of Public Works - Bureau of Environmental Services - Stormwater Management Division by S&S Planning and Design, LLC. Cumberland, MD. Retrieved from http://dnncquh0w.azurewebsites.net/LinkClick.aspx?fileticket=yHQ87JE3FGk%3d&portalid=0

SFEI (San Francisco Estuary Institute). 2010. *A BMP Tool Box for Reducing Polychlorinated Biphenyls (PCBs) and Mercury (Hg) in Municipal Stormwater*. Retrieved from http://www.nemallc.com/Resources/Documents/BMP%20Performance/pcb%20and%20hg%20bmp%20toolbox%202010.pdf

Schueler, T. 2000. Microbes in Urban Watersheds: Concentrations, Sources, & Pathways. *Watershed Protection Techniques, 3*(1), 554-565.

Schueler, T. 2011. *Nutrient Accounting Methods to Document Local Stormwater Reduction in the Chesapeake Bay Watershed*. CSN Technical Bulletin No. 9. Chesapeake Stormwater Network, Ellicott City, MD.

Schueler, T., & Youngk, A. 2015. *Potential Benefits of Nutrient and Sediment Practices to Reduce Toxic Contaminants in the Chesapeake Bay Watershed.*

Part 1: Removal of Urban Toxic Contaminants. Final Report. Chesapeake Stormwater Network, Ellicott City, MD.

Schueler, T. R. 1987. *Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs*. Washington, DC: Metropolitan Washington Council of Governments.

Tetra-Tech. 2009. An Assessment of Stormwater Management Retrofit and Stream Restoration Opportunities in Bennett Creek Watershed, Frederick County, Maryland

Tetra-Tech. 2014. Watershed Existing Condition Report for the Upper Patuxent River, Western Branch, and Rocky Gorge Reservoir Watershed prepared for the Prince George's County Department of the Environment. Retrieved from http://pgcdoe.net/pgcountyfactsheet/Areas/Factsheet/Documents/Reports/WECR_Patuxent_20141231.pdf

Tetra-Tech. 2015. *Restoration Plan for the Upper Patuxent River and Rocky Gorge Reservoir Watersheds in Prince George's County* prepared for the Prince George's County Department of Environment. Retrieved from http://pgcdoe.net/pgcountyfactsheet/Areas/Factsheet/Documents/Plans/Restoration%20Plan%20Upper%20Patuxent%2020151228-combined.pdf

WC-DPW (Washington County, Division of Public Works). 2014. 2013 NPDES MS4 Annual Report. Retrieved from https://www.washco-md.net/DEM/swm/pdfs/swm_2013_NPDES_AnnualReport.pdf

WCSCD (Washington County Soil Conservation District), Board of County Commissioners of Washington County, Antietam Creek Watershed Alliance, Canaan Valley Institute, & MDE. 2012. *Antietam Creek Watershed Restoration Plan.* Retrieved from http://www.mde.state.md.us/programs/Water/319NonPointSource/Pages/AntietamCreekWRP.aspx

USGS (United States Geological Survey). 2016. The USGS Water Science School: What is a watershed? Retrieved from http://water.usgs.gov/edu/watershed.html

URS. 2013. *Middle Great Seneca Creek Watershed Study* prepared for City of Gaithersburg. Retrieved from http://www.gaithersburgmd.gov/services/environmental-services

URS. 2014a. *Small Watershed Action Plan for Declaration Run and Riverside Watersheds* prepared for Harford County Department of Public Works. Retrieved from http://www.harfordcountymd.gov/ArchiveCenter/ViewFile/Item/332

URS. 2014b*. Muddy Branch Watershed Study* prepared for the City of Gaithersburg. Retrieved from http://www.gaithersburgmd.gov/services/environmental-services

URS. 2014c. *Lower Great Seneca Watershed Study* prepared for City of Gaithersburg. Retrieved from http://www.gaithersburgmd.gov/services/environmental-services

Vaughn, C. 2012. The Scoop on Poop: Pet Waste a Major Polluter of MD Waterways, *Capital News Service*, 25 October 2012. Retrieved from http://cnsmaryland.org/2012/10/25/the-scoop-on-poop-pet-waste-a-major-polluter-of-md-waterways/

Versar. 2011a. *Upper Potomac Direct Pre-Assessment Report* prepared for Montgomery County, Department of Environmental Protection. Retrieved from https://www.montgomerycountymd.gov/DEP/Resources/Files/ReportsandPublications/Water/Watershed%20studies/Upper-Potomac-Direct-Pre-Assessment-Report-11.pdf

Versar. 2011b. *Lower Potomac Direct Pre-Assessment Report* prepared for Montgomery County, Department of Environmental Protection. Retrieved from https://www.montgomerycountymd.gov/DEP/Resources/Files/ReportsandPublications/Water/Watershed%20studies/Lower-Potomac-Direct-Pre-Assessment-Report-11.pdf

Versar. 2011c. *Dry Seneca & Little Seneca Creek Pre-Assessment Report* prepared for Montgomery County Department of Environmental Protection. Retrieved from https://www.montgomerycountymd.gov/DEP/Resources/Files/ReportsandPublications/Water/Watershed%20studies/Seneca%20Creek/Dry-Seneca-Creek-and-Little-Seneca-Creek-watershed-pre-assessment-report-11.pdf

Versar. 2012a. *Cabin John Creek Implementation Plan* prepared for Montgomery County, Department of Environmental Protection. Retrieved from https://www.montgomerycountymd.gov/DEP/Resources/Files/ReportsandPublications/Water/Watershed%20studies/Cabin-John-Creek-implementation-Plan-12.pdf

Versar. 2012b. *Lower Patapsco River Small Watershed Action Plan*. Final Report. Vols. 1 and 2 prepared for the Baltimore County, Department of Environmental Protection and Sustainability. Retrieved from http://resources.baltimorecountymd.gov/Documents/Environment/Watersheds/lowerpatapscoswapvol1opt.pdf

Versar. 2014. *Bird River Small Watershed Action Plan*. Vols. 1 and 2 prepared for the Baltimore County, Department of Environmental Protection and Sustainability. Retrieved from http://www.baltimorecountymd.gov/Agencies/environment/watersheds/birdmain.html

Versar. 2015a. *Frederick County Stream Survey: 2014 Countywide Results* prepared for Frederick County, Office of Sustainability and Environmental Resources.

Versar. 2015b. *Little Patuxent River Watershed Assessment* prepared for the Howard County Department of Public Works.