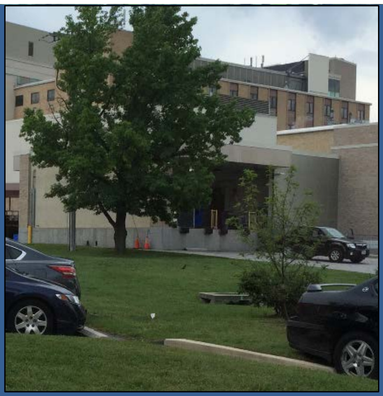

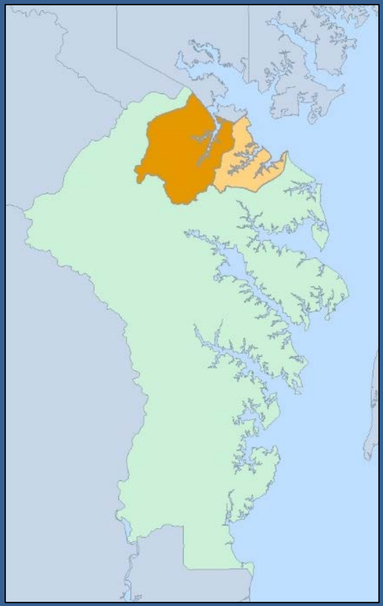

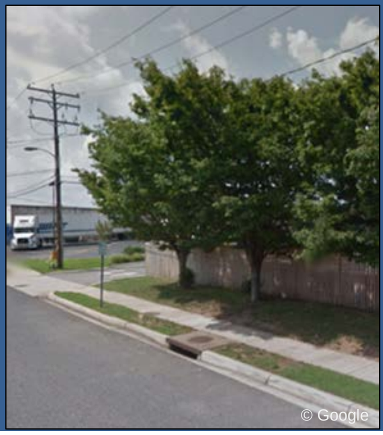

Baltimore Harbor and Curtis Creek/Bay Polychlorinated Biphenyls (PCB) TMDL Restoration Plan

Final Draft

Anne Arundel County, Maryland

Submitted to MDE February 2016

Anne Arundel County WATERSHED Protection & Restoration PROGRAM

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Prepared for:

Anne Arundel County Watershed Protection & Restoration Program

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List of Acronyms

AACO	Anne Arundel County
BMP	Best Management Practice
CBP	Chesapeake Bay Program
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COMAR	Code of Maryland Regulations
Curtis Creek	Curtis Creek/Bay
CWP	Center for Watershed Protection
DNR	Maryland Department of Natural Resources
DPW	Department of Public Works
EMC	Event mean concentration
EPA	U.S Environmental Protection Agency
ERM	Effects Range Median
g	grams
GSA	General Services Administration
HSG	Hydrologic Soil Group
L	Liter
LA	Load Allocation
LRP	Land Restoration Program
MBSS	Maryland Biological Stream Survey
MDE	Maryland Department of the Environment
mg	Milligrams
MS4	Municipal Separate Storm Sewer System
ng	Nanograms
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NRC	National Response Center
PCBs	Polychlorinated biphenyls
SW-WLA	Stormwater Waste Load Allocation
the County	Anne Arundel County
TMDL	Total maximum daily load
TRI	Toxic Release Inventory
TSCA	Toxic Substances Control Act
TSS	Total Suspended Solids
ug	micrograms

USCG	United States Coast Guard
VCP	Voluntary Cleanup Program
WIP	Watershed Implementation Plan
WLA	Waste Load Allocation
WPRF	Watershed Protection and Restoration Fee/Fund
WQS	Water quality standard
WTM	Watershed Treatment Model
yd^3	Cubic yard

1 Introduction

1.1 Background and Purpose of Restoration Planning

In 2012, the U.S. Environmental Protection Agency (EPA) Region III approved Maryland Department of the Environment's (MDE) Total Maximum Daily Load (TMDL) for Polychlorinated Biphenyls (PCBs) for the Baltimore Harbor, Curtis Creek/Bay, and Bear Creek portions of the Patapsco River Mesohaline Tidal Chesapeake Bay Segment (MDE 2012). This report will be referred to as the Baltimore Harbor PCB TMDL. Among other objectives, the Baltimore Harbor PCB TMDL established PCB waste load allocations (WLAs) for PCB sources to achieve reductions needed to meet water quality standards (WQSs).

An aggregate stormwater WLA (SW-WLA) was assigned to regulated stormwater from National Pollutant Discharge Elimination System (NPDES) permit holders in Anne Arundel County for portions of the Baltimore Harbor Embayment and Curtis Creek/Bay subwatersheds within Anne Arundel County. Anne Arundel County (the County) is an NPDES Phase I Municipal Separate Storm Sewer System (MS4) permit holder. As part of the 4th generation MS4 permit, effective February 2014, Anne Arundel County is required to develop restoration plans for each SW-WLA approved by EPA prior to the effective date of the permit. This restoration plan addresses the WLAs as established in the Baltimore Harbor PCB TMDL applicable to the Anne Arundel County MS4 permit (MD0068306).

The purpose of this PCB TMDL restoration plan is to develop a strategy to achieve the reductions required to meet the PCB SW-WLA. In doing so, the County will be doing its part to reduce PCB pollution in the Patapsco River Mesohaline Tidal Chesapeake Bay. The restoration plan supplements broader watershed restoration actions underway for the MS4 permit by outlining targeted actions intended to specifically reduce PCB loads. Through source targeting, modeling, and proposed monitoring, the restoration plan provides a blueprint that will guide the County's efforts to efficiently reduce PCB pollution.

1.2 Impaired Water Bodies and TMDL Allocated and Planned Loads Summary

The Baltimore Harbor PCB TMDL addressed three PCB impairments in water bodies as listed in Table 1.

Table 1: PCB Impairments addressed in Baltimore Harbor PCB TMDL

Water Bodies	Impairment
Baltimore Harbor Embayment	PCBs in Fish Tissue
Curtis Creek	PCBs in Fish Tissue and Sediment
Bear Creek	PCBs in Fish Tissue and Sediment

These water bodies and corresponding subwatershed areas are shown in Figure 1, excerpted from the Baltimore Harbor PCB TMDL. The portions of the Curtis Creek/Bay (Curtis Creek) and Baltimore Harbor Embayment – Direct Drainage located within Anne Arundel County are the focus of this restoration plan (MDE 2012) and are shown in Figure 2. Throughout the report, the Curtis Creek subwatershed within Anne Arundel County will be referred to as Curtis Creek AACO. Similarly, the Baltimore Harbor Embayment – Direct Drainage subwatershed within Anne Arundel County will be referred to as Baltimore Harbor AACO.

Tributary drainages to the Baltimore Harbor were only assigned a load allocation (LA) in the Baltimore Harbor PCB TMDL. With no specific SW-WLA assigned to NPDES holders within

Anne Arundel County for tributary drainage, this area is not addressed in the restoration plan. However, efforts underway as part of MS4 watershed restoration and the Patapsco River Lower North Branch Sediment TMDL Restoration Plan are anticipated to have a positive impact on reducing PCBs within the Anne Arundel County portion the Patapsco River tributary drainage.

The WLAs for Anne Arundel County NPDES regulated stormwater are shown in Table 2. Since the WLAs are an aggregate, the regulated stormwater to be addressed by the County MS4 permit within each subwatershed is only a portion of the aggregate WLAs shown. Additionally, the Baltimore Harbor PCB TMDL defined the Baltimore Harbor Embayment as inclusive of both Bear Creek and Curtis Creek subwatershed in the WLAs. To prevent double counting as each subwatershed is modeled independently, Table 2 lists the NPDES regulated stormwater WLA to Anne Arundel County for Baltimore Harbor Embayment and Curtis Creek separately. Note the disaggregated WLA is provided in Section 4.3

Table 2: Anne Arundel County NPDES regulated stormwater PCB WLA by Subwatershed

Subwatershed	**NPDES regulated stormwater PCB WLA (grams (g)/year)**
Baltimore Harbor AACO	43.84
Curtis Creek AACO	23.13

While PCB transport modeling was used in the development of the Baltimore Harbor PCB TMDL, there are no watershed planning modeling tools available that directly model PCBs. Watershed planning tools commonly used in Maryland thus far have focused on modeling total phosphorus, total nitrogen, and total suspended solids (TSS) for which reduction efficiencies for Best Management Practices (BMPs) both structural and non-structural have been developed. PCB concentrations are known to correlate with TSS as PCBs adsorb to particles. As such, this restoration plan takes a similar approach as that used by Prince George's County in the development of their *Restoration Plan for PCB-Impacted Water Bodies in Prince George's County* (Tetra Tech 2014) in which PCB loads and reductions were modeled by using TSS as a surrogate for PCBs and relating TSS to PCBs using regression equations developed for the Tidal Potomac and Anacostia River PCB TMDL (Haywood and Buchanan 2007). While the regressions were originally developed for the Tidal Potomac and Anacostia River, regional proximity and similarity in PCB sources suggest it is a reasonable approach to apply the regressions to Anne Arundel County modeling efforts.

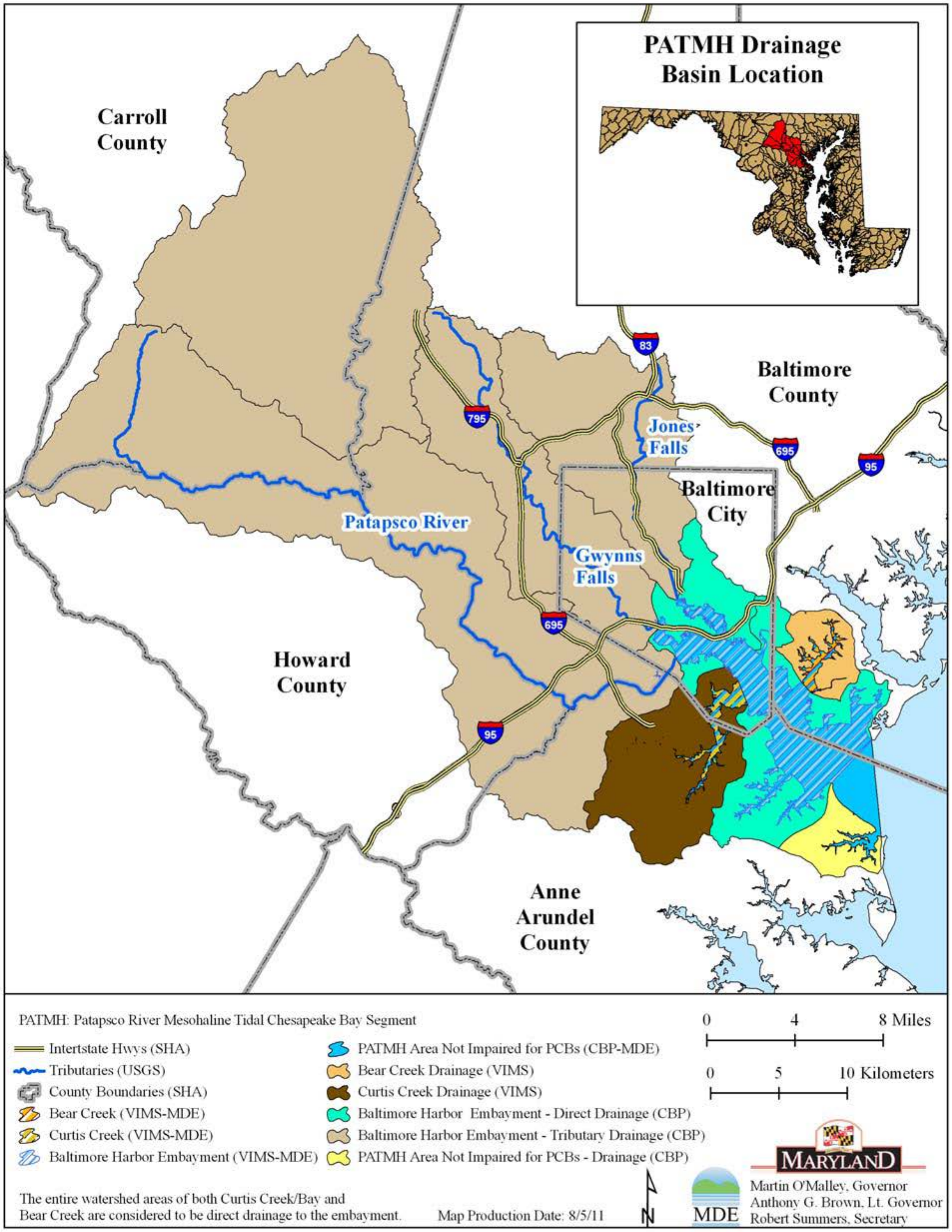

Figure 1: Impaired Waterbodies and Corresponding Watersheds (Baltimore Harbor PCB TMDL Figure 1)

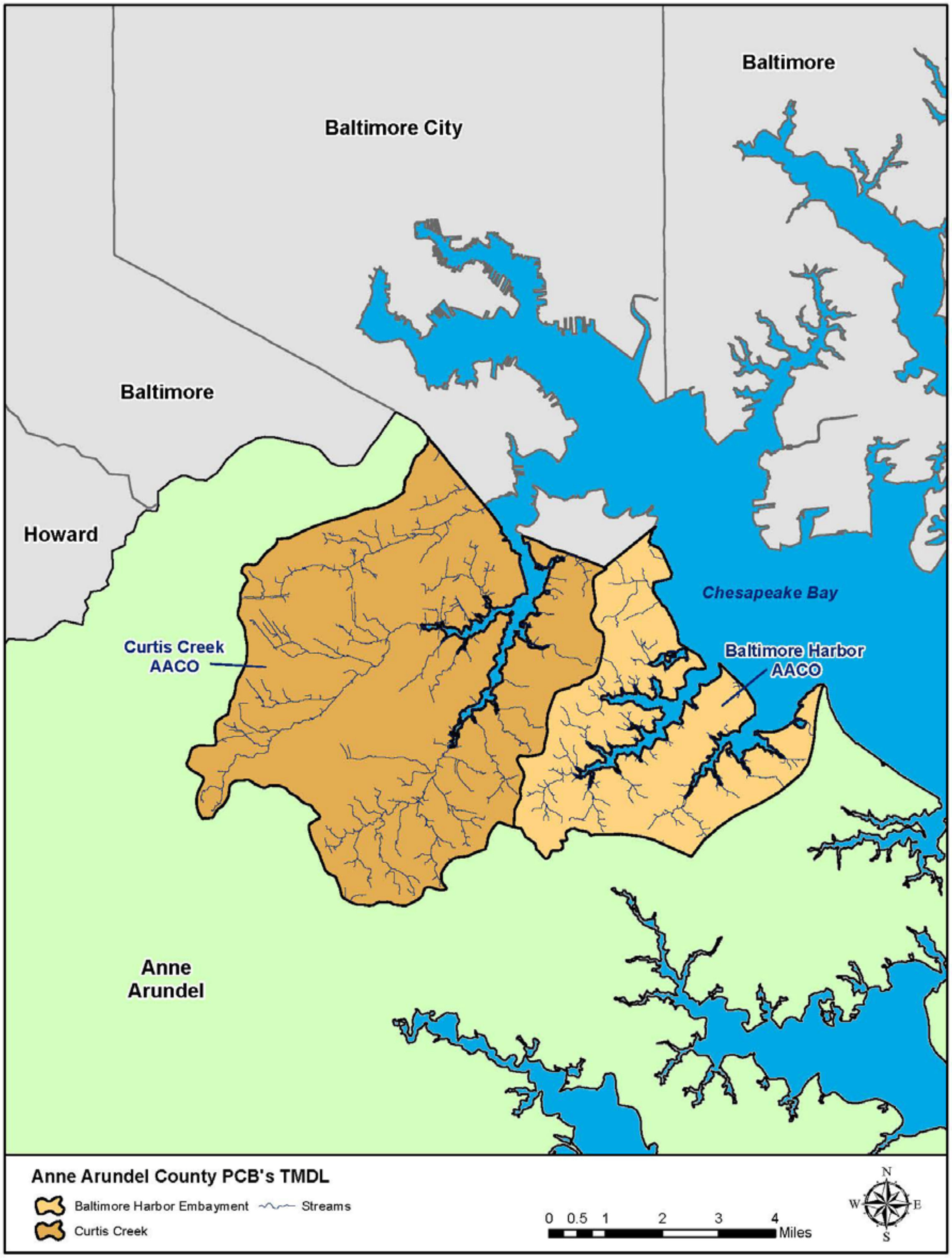

Figure 2: Portions of the Curtis Creek and Baltimore Harbor Embayment – Direct Drainage located within Anne Arundel County Addressed in Restoration Plan

1.2.1 Water Quality Standards

Water quality standards (WQSs) for the state of Maryland relating to PCBs are described in detail in Section 2.2 of the Baltimore Harbor PCB TMDL report. WQSs are set to protect surface waters for uses such as recreation, fishing and protection of aquatic life as well as special uses designated by use category. The water quality standard designation of use categories for the water bodies addressed in this report are described in Section 2.4. The Baltimore Harbor PCB TMDL and associated WLAs were developed to meet PCB WQSs as shown in Table 3. The designated impairments listed in Section 1.2 were a result of failing to meet one or more of the PCB WQSs.

Table 3: Summary of Maryland PCB WQSs

Type	Water Quality Standard
Human Health (associated with consumption of PCB contaminated fish), Water Column tPCB Criterion	0.64 nanograms/liter (ng/L)
Saltwater Aquatic Life, Water Column tPCB Criterion	30 ng/L
Freshwater Aquatic Life, Water Column tPCB Criterion	14 ng/L
Sediment, Sediment tPCB concentration in the presence of toxicity and degraded benthic community	180ng/g*
***** Not an official WQS, corresponds to the Effects Range Median (ERM) in accordance with methodology developed to assess toxic impairments in sediment.	

1.2.2 Problem Identification

Polychlorinated biphenyls (PCBs) are a man-made class of synthetic organic compounds. PCBs are a concern because they are a probable carcinogen, are able to bioaccumulate, and are persistent in the environment. PCBs in the environment primarily pose health risks for aquatic species as well as humans consuming PCB contaminated fish.

PCBs were produced in the United States starting in1929 and by 1979 the manufacturing, processing, distribution, and use of PCBs was banned under the Toxic Substances Control Act (TSCA) (Oregon DEQ 2012). PCBs are thermally and chemically stable and were therefore widely used in coolants, lubricants, heat transfer fluids, flame retardants, hydraulic fluids, and dielectric fluids in commercial and industrial applications (MDE 2015b).

The stability of PCBs means they do not readily breakdown and therefore, while banned in 1979, PCBs are still found throughout the environment (MDE 2015b). PCBs bind strongly to sediment because they are non-polar and only slightly soluble. As such, PCBs continue to enter surface waters via contaminated sediment in surface runoff. In addition, volatilized PCBs are transported near and far distances through the air and then redeposited to land or surface waters (Oregon DEQ 2012).

The WLAs set by the Baltimore Harbor PCB TMDL establish required load reductions of PCBs entering the already impaired water bodies. Reducing PCB loads from Anne Arundel County MS4 regulated stormwater to the Baltimore Harbor Embayment and Curtis Creek is an important step in addressing PCB contamination.

1.2.3 Previous Studies

Previous studies and data collection in the watersheds addressed in this restoration plan include:

Patapsco Tidal and Bodkin Creek Watershed Assessment Comprehensive Summary Report, August 2012 (Anne Arundel 2012)

The watershed assessment was completed as part of the 3rd generation MS4 permit watershed restoration requirements. The assessment identifies impaired streams, models baseline and restoration reduction of pollutant loads, and develops a watershed implementation plan outlining planned BMP strategies. The watershed assessment provides excellent background information on the watershed and is used in calibrating the modeling efforts of this plan.

Previous studies and data collection contributing to the development of the Baltimore Harbor PCB TMDL are summarized in Section 2.2 and Appendix K of the Baltimore Harbor PCB TMDL report.

1.3 Restoration Plan Overview

The following guidance documents were used in the development of this restoration plan:

- MDE's Final General Guidance for Developing Stormwater Wasteload Allocations (SW-WLA) Implementation Plan, October 2014 (MDE 2015c)
- MDE's Recommendations for Addressing the PCB SW-WLA, 2015 (MDE 2015d)
- MDE's Guidance for Using the Maryland Assessment Scenario Tool to Develop Wasteload Allocation Implementation Plans for Local Nitrogen, Phosphorus, and Sediment TMDLs, June 2014
- MDE's Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated, August 2014

Several documents served as primary sources of information supporting the modeling and strategies developed. These documents are:

- MDE Total Maximum Daily Load (TMDL) for polychlorinated biphenyls (PCBs) for the Baltimore Harbor, Curtis Creek/Bay, and Bear Creek portions of the Patapsco River Mesohaline Tidal Chesapeake Bay Segment, October 2012 (MDE 2012)
- Anne Arundel County Patapsco Tidal and Bodkin Creek Watershed Assessment Comprehensive Summary Report, August 2012 (Anne Arundel County 2012)
- Restoration Plan for PCB-Impacted Water Bodies in Prince George's County, December 2014 (Tetra Tech 2014)

This restoration plan is organized into six sections that follow the progression of the restoration plan development. Following the introduction, the plan provides important context with a basic characterization of the PCB-impacted watersheds (Section 2). Section 3 builds on the watershed characterization by identifying causes of PCB-impairment and pollutant sources and presents the results of source tracking efforts and plans for reduction accounting intended to inform and guide the programmatic initiatives of the restoration plan. Section 4 documents and provides the results of the watershed treatment model (WTM) and outlines the proposed strategy for meeting the PCB TMDL. With the proposed strategy developed, Section 5 presents the estimated load reductions achieved by implementation of the proposed strategy and includes associated costs. The final section addresses the implementation schedule and the public outreach and involvement component.

2 Watershed Characterization

2.1 Watershed Delineations and Hydrology

Curtis Creek AACO and Baltimore Harbor AACO subwatersheds are specific subwatersheds within the Patapsco River Mesohaline Chesapeake Bay Segment and the Baltimore Harbor 8-Digit watershed (02130903). Both Curtis Creek AACO and Baltimore Harbor AACO subwatersheds are located on the southwest shore of the Baltimore Harbor and share political boundaries with Baltimore City to the north.

The Curtis Creek/Bay watershed is approximately 23,539 acres (36.8 square miles). Within Anne Arundel County, the Curtis Creek AACO is 21,524 acres (33.6 square miles). Curtis Creek AACO contains approximately 98.1 miles of streams (Table 4). The subwatershed includes several named streams including Back Creek, Cabin Branch, Curtis Creek, Furnace Creek, Marley Creek, and Sawmill Creek. To reach the Chesapeake Bay, the subwatershed flows to Furnace and Marley Creeks, to Curtis Creek to Curtis Creek Bay to Patapsco River finally to the Chesapeake Bay.

The Baltimore Harbor Embayment – Direct Drainage watershed is approximately 53,995 acres (84.4 square miles). Within Anne Arundel County, the Baltimore Harbor AACO is approximately 8,756 acres (13.7 square miles). Baltimore Harbor AACO subwatershed contains approximately 33.1 miles of streams (Table 4). The subwatershed includes several named streams including Brookfield Branch, Cox Creek, Nabbs Creek, Stony Creek, Swan Creek, and Rock Creek. To reach the Chesapeake Bay, the subwatershed flows to Stony Creek and Rock Creek both flowing to Patapsco River and finally to the Chesapeake Bay. The data source used for streams was the Anne Arundel County 2011 Streams GIS file.

Table 4: Subwatershed Drainage Area and Stream Miles

Subwatershed Name	Drainage Area (Acres)	Drainage Area (Square Miles)	Stream Miles
Curtis Creek AACO	21,524	33.6	98.1
Baltimore Harbor AACO	8,756	13.7	33.1

2.2 Geology and Soils

Curtis Creek AACO and Baltimore Harbor AACO subwatersheds are both located within the Atlantic Coastal Plan Province and Glen Burnie Rolling Upland District characteristic of flat to gently rolling uplands underlain by unconsolidated sediments including quarzitic sands, gravels, silts and clays (MGS 2008).

<u>Curtis Creek AACO</u>

The dominant soil map units within Curtis Creek AACO include Patapsco-Fort Mott-Urban land complex, 0 to 5 percent slopes (PgB), Urban land (Uz), and Patapsco-Evesboro-Fort Mott complex, 0 to 5 percent slopes (PeB) at 19.8, 10.5, and 8.3 percent of total Curtis Creek AACO subwatershed, respectively. PgB and PeB soil map units are well to excessively drained soils formed in sandy eolian deposits over loamy fluviomarine deposits. Both soil map units are mapped on summits of broad interstream divides. Uz soil map unit is characterized as areas covered with impervious cover (i.e. pavement, driveways, and buildings). Based on the soil survey mapping, the majority of the subwatershed has low slopes ranging from 0 to 5 percent. It is also important to note that a large portion of the soil map units contain an urban land component indicating there are areas throughout the subwatershed covered by impervious surfaces.

Each soil map unit, with the exception of Water (W), is assigned a hydrologic soil group (HSG) based on the estimate of runoff potential. Table 5 presents the HSGs within Curtis Creek AACO. Almost half of the subwatershed, approximately 49.3%, is classified as Group A or as soils having high infiltration and low runoff potential. The remainder of the subwatershed is dominated by Group C and D at 22.0% and 18.8%, respectively. Group C soils have a slow infiltration rate while Group D have a very slow infiltration rate and high runoff potential. The dominate HSGs are directly related to the dominate soil map units. PgB and PeB are well to excessively drained sandy soils and are classified as Group A, while Uz and soil map units with urban land components have impervious surfaces present that would increase runoff and are therefore classified as Group C and/or D.

Table 5: Curtis Creek AACO Hydrologic Soil Groups

Hydrologic Soil Group	Acres	Percent of Total (%)
A	10617.7	49.3
A/D	27.8	0.1
B	664.3	3.1
B/D	1395.1	6.5
C	4728.7	22.0
D	4037.8	18.8
Not Applicable*	52.9	0.2
	Total	**100.0**
*Applies to Water (W) map units.		

<u>Baltimore Harbor AACO</u>

Similar to Curtis Creek AACO, the dominant soil map units within Baltimore Harbor AACO include Patapsco-Fort Mott-Urban land complex, 0 to 5 percent slopes (PgB), Russerr-Christiana-Hambrock complex, 0 to 5 percent slopes (RhB), Patapsco-Evesboro-Fort Mott complex, 0 to 5 percent slopes (PeB), and Udorthents, loamy, 0 to 5 percent slopes (UoB) at 22.4, 11.5, 8.4, and 8.1 percent of total Baltimore Harbor AACO subwatershed, respectively. PgB and PeB soil map units are mapped on summits of broad interstream divides and are well to excessively drained soils formed in sandy eolian deposits over loamy fluviomarine deposits. Similarly, RhB soil map unit is a moderately well to well-drained soil formed in loamy to clayey fluviomarine deposits on summits and footslopes of broad interstream divides. UoB soil map unit is a well-drained soil that has formed in soils manipulated by anthropogenic activities. Based on the soil survey mapping, the majority of the subwatershed has low slopes ranging from 0 to 5 percent. Like Curtis Creek AACO, Baltimore Harbor AACO also has soil map units that contain an urban land components and thus impervious cover (i.e. pavement, driveways, and buildings), but to a lesser extent.

The HSGs within Baltimore Harbor AACO are presented in Table 6. More than half of the subwatershed, approximately 61.8%, is classified as Group A or a soils having high infiltration and low runoff potential. Group C dominated the remainder of the subwatershed at 24.7%. Group C soils have a slow infiltration rate and moderately high runoff potential. The dominate HSGs are directly related to the dominate soil map units. PgB and PeB are well to excessively drained sandy soils and are classified as Group A, while RhB, UoB, and soil map units with urban land components have finer textured soil and impervious surfaces and are classified as Group C and/or D.

Table 6: Baltimore Harbor AACO Hydrologic Soil Groups

Hydrologic Soil Group	Acres	Percent of Total (%)
A	5411.5	61.8
A/D	176.5	2.0
B	141.5	1.6
B/D	355.8	4.1
C	2160.0	24.7
D	381.6	4.4
Not Applicable	125.4	1.4
	Total	**100.0**
*Applies to Water (W) map units.		

As previously described, soil type affects infiltration and runoff potential. As such, soil classification by hydrologic soil group is an input parameter to the WTM. Soils designated as A/D or B/D are included in group D in the WTM to be conservative.

2.3 Existing Land Use and Land Cover

Water quality is affected by the type and density of the various land uses within a watershed. Vegetated areas (i.e. woods and open space) slow stormwater flow allowing water to gradually infiltrate into the soil. As the stormwater infiltrates into the soil, nutrients and pollutants are filtered out improving water quality. In contrast, developed areas (i.e. residential, commercial, industrial, etc.) do not reduce runoff or nutrients and sediment in the stormwater due to the high percentages of impervious surfaces that prevent infiltration. Since PCBs bind to sediment, developed areas that act as sources of sediment may also be sources of PCBs. In addition, watersheds and smaller areas within a watershed with a higher concentration of commercial and industrial land use are of particular interest regarding PCB pollution since PCBs were primarily used in commercial and industrial applications. Land use presented in Table 7 was used to characterize the subwatersheds and show potential pollution sources.

2.3.1 Land Use / Land Cover Distribution

According to County 2011 land use data for Curtis Creek AACO and Baltimore Harbor AACO (Table 7), the dominant categories in both subwatersheds is woods (23.2 and 29.0% respectively) followed closely by residential 1/8-acre (22.6 and 27.6% respectively).

In Curtis Creek AACO, developed land accounts for 63.8% of the subwatershed and largely consists of residential (39.1%) and commercial (9.5%). Similarly in Baltimore Harbor AACO, developed land accounts for 62.0% of the subwatershed and largely consists of residential (47.0%) and industrial (7.3%). Land use distribution across the subwatershed is shown in Figure 3. Land use is a direct input to the WTM.

Table 7: 2011 Land Use / Land Cover for Curtis Creek AACO and Baltimore Harbor AACO

Land Use	Curtis Creek AACO		Baltimore Harbor	
	Acres	Percent of Subwatershed (%)	Acres	Percent of Subwatershed (%)
Airport	552.0	2.6	0.0	0.0001
Commercial	2053.5	9.5	319.8	3.7
Industrial	1188.6	5.5	641.7	7.3
Open Space	2603.0	12.1	546.7	6.2
Open Wetland	6.4	0.03	34.0	0.4
Pasture/Hay	2.2	0.01	0.0	0.0
Residential 1-acre	230.6	1.1	426.2	4.9
Residential 1/2-acre	495.7	2.3	539.7	6.2
Residential 1/4-acre	2450.2	11.4	454.1	5.2
Residential 1/8-acre	4864.7	22.6	2413.1	27.6
Residential 2-acre	378.6	1.8	280.0	3.2
Row Crops	76.7	0.4	0.0	0.0
Transportation	1352.1	6.3	279.6	3.2
Utility	176.5	0.8	72.7	0.8
Water	89.2	0.4	206.1	2.4
Woods	5004.3	23.2	2539.2	29.0
	Total	**100.0**	**Total**	**100.0**

2.3.1 Impervious Surfaces

Impervious surfaces make up 31.1% of Curtis Creek AACO and 23.0% of Baltimore Harbor AACO land areas as presented in Table 8. Roads/highways (8.9%), buildings (7.9%), and parking lots (7.4%) are the dominant impervious cover types within Curtis Creek AACO. In Baltimore Harbor AACO, the dominant impervious cover types include buildings (7.3%), road/highways (6.2%), driveways (3.2%) and parking lots (3.0%). The impervious cover types are reflective of the dominant land uses (i.e. residential, commercial and industrial) identified within each subwatershed. The data source used for impervious cover was the Anne Arundel County 2011 Countywide Impervious GIS file. Distribution of impervious surfaces is illustrated in Figure 4. Imperviousness associated with different land uses is also used in the WTM.

Table 8: Impervious Cover in Curtis Creek AACO and Baltimore Harbor AACO

Impervious Cover Type	Curtis Creek AACO (Drainage Area = 21,524 acres)		Baltimore Harbor (Drainage Area = 8,756 acres)	
	Acres	Percent of Subwatershed (%)	Acres	Percent of Subwatershed (%)
Athletic courts	23.0	0.1	4.5	0.1
Building	1695.9	7.9	641.8	7.3
Driveways	529.4	2.5	278.2	3.2
Other paved areas	439.2	2.0	101.7	1.2
Parking lots	1598.3	7.4	266.1	3.0
Patios/Decks	124.6	0.6	80.0	0.9
Piers	0.7	0.003	3.4	0.04
Rails	29.4	0.1	1.3	0.01
Roads/Highways	1919.3	8.9	541.5	6.2
Sidewalks	287.1	1.3	74.5	0.9
Swimming pools	42.0	0.2	21.0	0.2
Impervious Cover Totals	**6688.9**	**31.1**	**2013.8**	**23.0**

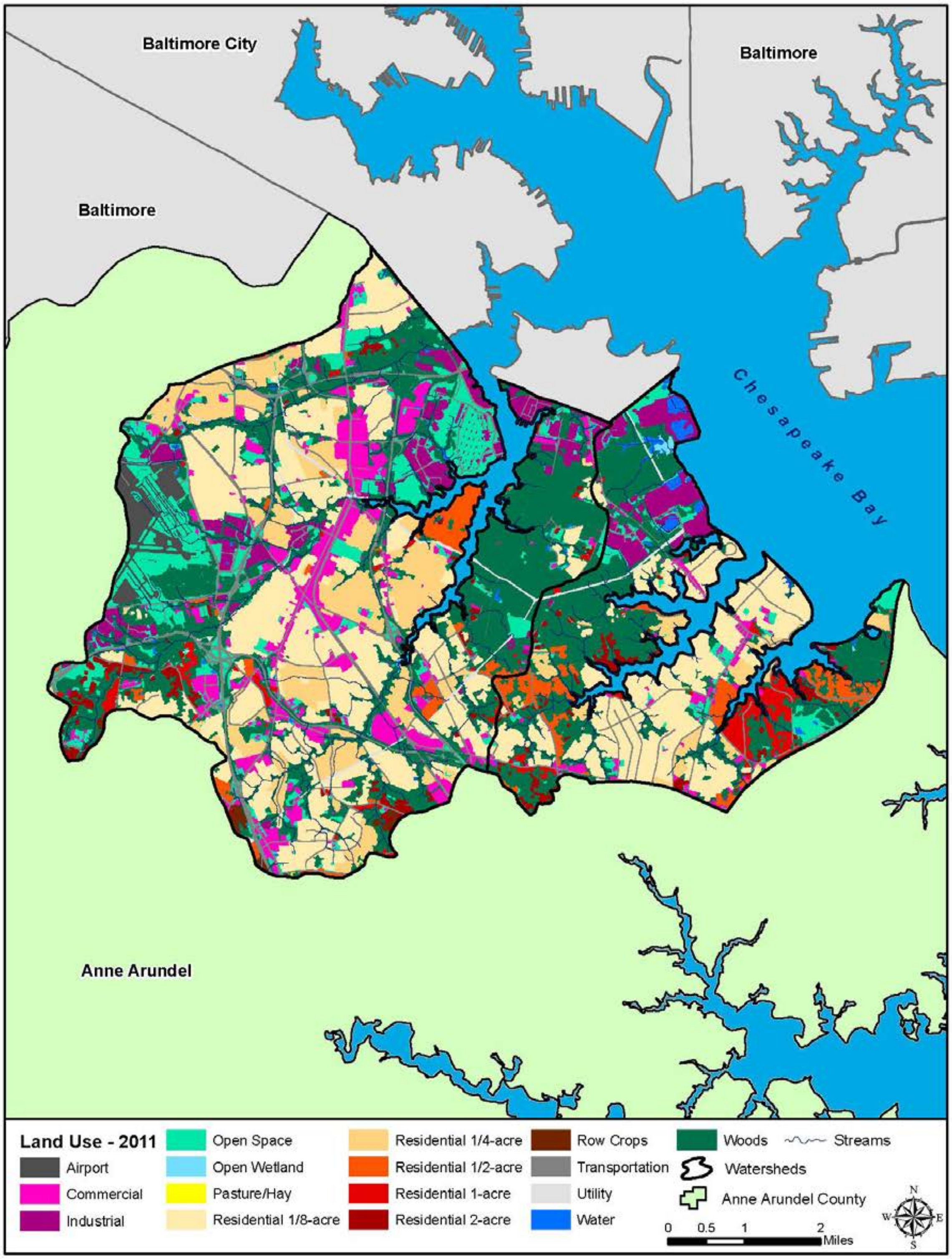

Figure 3: 2011 Land Use/Land Cover for Curtis Creek AACO and Baltimore Harbor AACO Subwatersheds

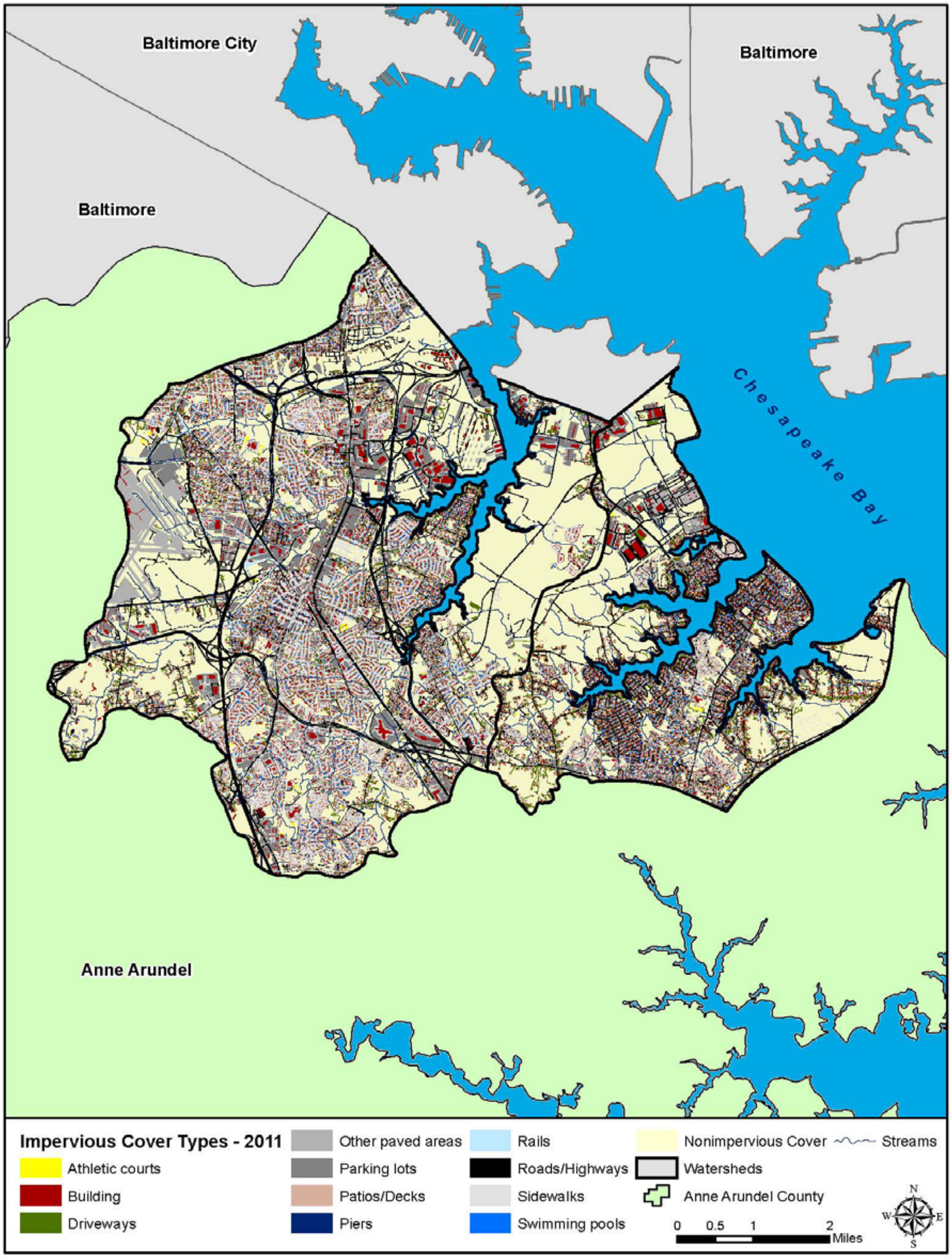

Figure 4: 2011 Impervious Curtis Creek AACO and Baltimore Harbor AACO Subwatersheds

2.4 Watershed Health and Water Quality

In 1993, Maryland Department of Natural Resources (DNR) created the Maryland Biological Stream Survey (MBSS) to characterize the health of Maryland's freshwater streams. Stream sites are selected through a random statistical design and physical, chemical, and biological (fish and macroinvertebrates) data is collected at each selected site. The collected data is combined into an overall rating (i.e. good, fair, or poor) enabling Anne Arundel County and DNR to estimate stream health in medium to large watersheds. Curtis Creek AACO and Baltimore Harbor AACO subwatersheds are comprised of the following DNR 12-digit watersheds: 021309031010, 021309031008, 021309031009, and 021309031006 (DNR 2014a). The current health of each DNR 12-digit watershed is ranked as poor (DNR 2014b).

According to Code of Maryland Regulations (COMAR) Section 26.08.02.08 – Stream Segment Designations, stream segments within Curtis Creek AACO and Baltimore Harbor AACO are classified as Use I waters (MDE 2014a). Use I waters are designated to support water contact recreation and protection of non-tidal warm water aquatic life. Table 9 shows the individual uses for Use I.

Table 9: Designated Uses pertaining to Use I Waters

Designated Uses	Stream Segments within Curtis Creek AACO & Baltimore Harbor AACO
Growth and propagation of fish (not trout), other aquatic life and wildlife	X
Water contact sports	X
Leisure activities involving direct contact with surface water	X
Fishing	X
Agricultural water supply	X
Industrial water supply	X
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.state.md.us/programs/Water/TMDL/Water%20Quality%20Standards/Pages/programs/waterprograms/tmdl/wqstandards/wqs_designated_uses.aspx	

According to Maryland's final 303(d) list of impaired waters provided in the Final 2014 Integrated Report of Surface Water Quality (MDE 2014b), two basins in which Curtis Creek AACO and Baltimore Harbor AACO are located, are listed for PCB water quality impairments. Both water bodies are listed as Category 4a indicating each are still impaired but have a TMDL developed to address the impairment.

Curtis Creek AACO and Baltimore Harbor AACO subwatersheds are also listed as impaired for other water quality parameters including chlordane, sediment, nutrients, metals, biological, and bacteria. Approved TMDLs pertaining to both Curtis Creek AACO and Baltimore Harbor AACO exist for sediment and nutrients (nitrogen and phosphorus). An approved chlordane TMDL applies to the Baltimore Harbor AACO, and an approved bacteria TMDL for enterococci applies to Furnace Creek and Marley Creek both located within the Curtis Creek AACO subwatershed.

2.5 MS4 Area

The above sections of the watershed characterization include all of the area within the Curtis Creek AACO and Baltimore Harbor AACO subwatersheds to provide a complete context. However, as mentioned in Section 1.2, the Anne Arundel County MS4 permit is one of several NPDES permits active within the Curtis Creek AACO and Baltimore Harbor AACO subwatersheds. Other permit holders include Maryland State Highway Administration (SHA), federal facilities, and individual facilities.

The jurisdictional areas within the Curtis Creek AACO and Baltimore Harbor AACO subwatersheds to which the Anne Arundel County MS4 permit applies is shown in Figure 5. Anne Arundel County MS4 area covers 79% and 95% of the total area of Curtis Creek AACO and Baltimore Harbor AACO subwatersheds respectively. Detailed areas are provided in Table 10 in Section 3.2. This plan addresses PCB load reductions for the areas within the County MS4 area only. Load reductions from areas outside of the County MS4 area and from sources within the MS4 area specifically identified and addressed in the Baltimore Harbor PCB TMDL are the responsibility of other entities.

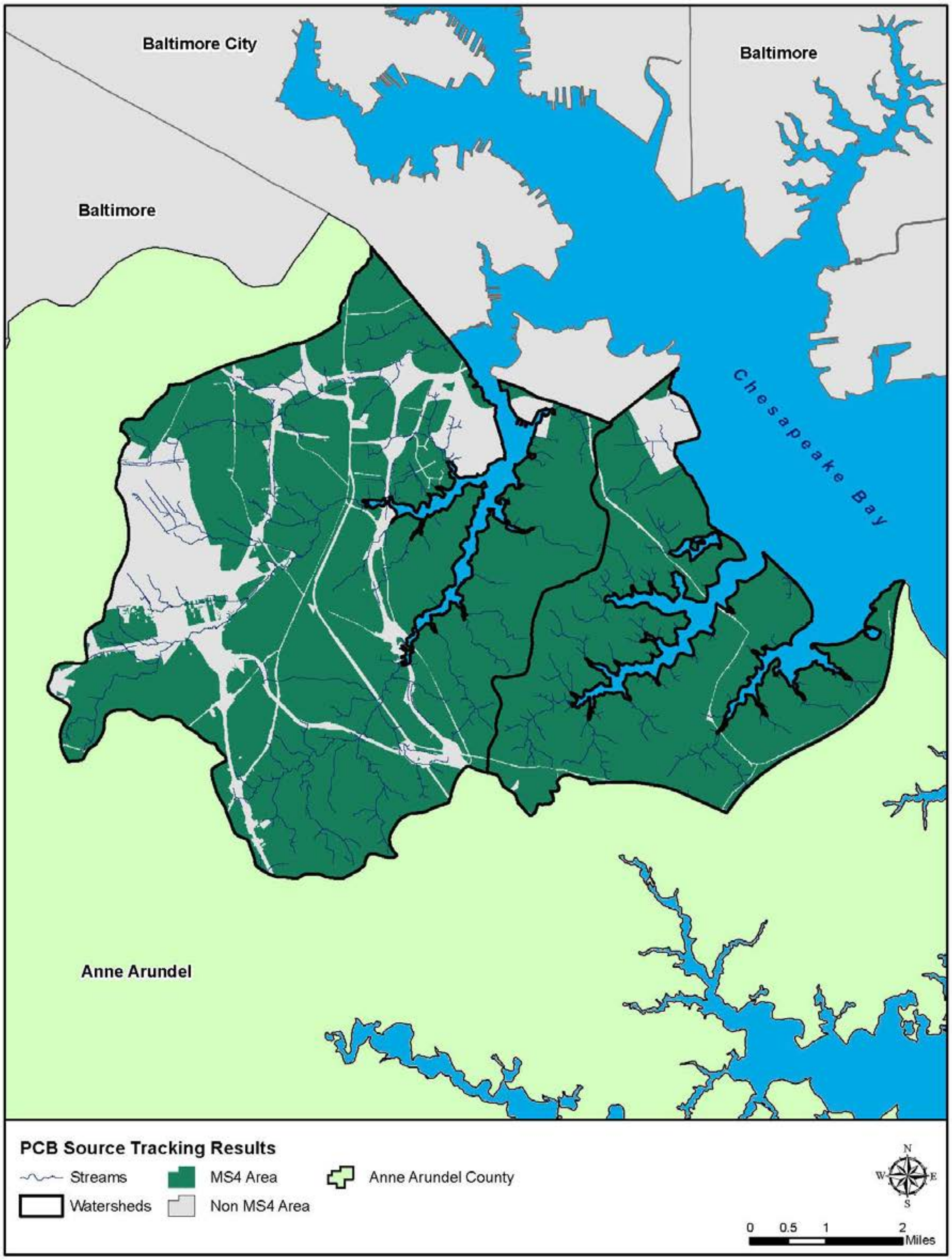

Figure 5: Anne Arundel County MS4 Jurisdictional Area

3 Causes and Sources of Impairment

3.1 Causes of Impairments

The 303(d) listings described in Section 2.5 and local TMDL requirements confirm that elevated levels of PCBs currently impair the Curtis Creek AACO and Baltimore Harbor AACO subwatersheds. PCBs are non-naturally occurring, therefore their presence anywhere in the environment signifies a release. Initially released at discrete locations, or hot spots, PCBs then disperse through volatilization into the atmosphere or adsorption to sediment that is then transported away from the release area.

From both hot spots and areas with disperse contamination, PCBs attached to sediment are transported by stormwater runoff into the network of streams which flow to Curtis Creek and Baltimore Harbor depositing PCBs in the waterbodies. The sediment can remain suspended in the water column or settle to the bottom depending on particle size. Over time, small amounts of PCBs are released from the sediment to the water (Oregon DEQ 2012). PCBs in sediment and the water column are consumed by bottom-dwelling organisms that concentrate PCBs in their tissue and are then eaten by small fish. As predator species consume small fish, PCBs continue to bioaccumulate leading to elevated levels in fish tissue qualifying as an impairment (MDE 2015b). Deposition of PCBs from the atmosphere directly to water surfaces, as well as surrounding watershed surfaces, also contributes to elevated levels of PCBs (MDE 2012).

3.2 Pollutant Sources

Prior to regulation under TSCA in 1979, PCBs were released to land and aquatic environments, either accidentally or intentionally, through sewers, smokestacks, stormwater runoff, spills, and, more rarely, direct application for the purpose of dust reduction or in agricultural pesticides. Used primarily in commercial and industrial applications, PCB-containing products were burned, application of coatings and materials containing PCBs allowed for vaporization, PCB-containing fluids were directly released into sewers and streams, and equipment containing PCBs was improperly disposed of in non-secure landfills sites and municipal disposal facilities (Oregon DEQ 2012). These unregulated, historic practices have led to “legacy” PCBs in the form of both hot spots and disperse contamination. Current sources of “new” PCBs introduced to the environment are limited and include illegal or outdated landfills or scrap yards and spills or explosions of pre-1979 electrical and other equipment containing PCBs (Oregon DEQ 2012).

Since introduction of “new” PCBs into the environment is limited and can be addressed as situations and the need arise, this restoration plan focuses on addressing “legacy” PCB contamination sources within the County MS4 areas of the Curtis Creek AACO and Baltimore Harbor AACO subwatersheds that are not otherwise addressed in the Baltimore Harbor PCB TMDL report. Other PCB pollutant sources identified and addressed in the Baltimore Harbor PCB TMDL include industrial process water, effluent from waste water treatment plants, specific contaminated sites, atmospheric deposition, and non-regulated stormwater run-off. These sources as well as the other NPDES-permitted facilities within the Curtis Creek AACO and Baltimore Harbor AACO subwatersheds are intentionally omitted from and not addressed in this plan as the County is not responsible for load reductions from these sources.

For dispersed contamination, areas considered as potential pollutant sources include all urban areas within the County MS4 area. Within the broader category of urban areas, areas with commercial and industrial land use have even greater potential to be a PCB pollutant source due to the use of PCBs in commercial and industrial applications. The potential PCB pollutant source areas in acres of urban, commercial, and industrial land use within the County MS4 area are shown in Table 10 for the Curtis Creek AACO and Baltimore Harbor AACO watersheds. Table 10 also provides total MS4 and total subwatershed areas for context.

Table 10: Potential PCB pollutant source areas with the County MS4 Area

	MS4 Areas within Curtis Creek AACO	MS4 Areas within Baltimore Harbor AACO
Urban Land Use (acres)	13,137	5,503
Commercial (acres)	1936	314
Industrial (acres)	914	487
MS4 area (acres)	17,022	8,278
Subwatershed area (acres)	21,524	8,754

For hot spot contamination, pollutant sources are locations where PCB releases have occurred in the past and where elevated concentrations of PCB persist in the area. Hot spot sources are of particular concern as they continue to slowly disperse PCBs. The process of identifying potential hot spot sources is addressed in the following Section 3.3.

Existing BMPs such as stormwater ponds that trap stormwater runoff and sediment from urban, and especially commercial and industrial, areas may build up PCBs overtime. In this way, BMPs can serve the beneficial purpose of re-concentrating dispersed contamination. If contaminated BMP materials are removed and properly disposed, PCBs loads can be effectively reduced. However, if an unusually large storm event washes out the sediment collected in the BMP, the BMP could re-release PCBs further downstream. Finding and removing PCBs from existing BMPs is discussed more in Sections 3.3.2 and 4.4.3.

3.3 Pollutant Source Tracking

Since PCBs are transported by sediment, addressing dispersed contamination involves addressing sediment loading. Reducing sediment loading reduces the PCB load to the degree that the sediment is contaminated. For dispersed contamination, this is best achieved through BMPs as discussed in Section 4.4 with load reductions estimated through a more general regression relating TSS and PCBs concentrations. Addressing hot spots, however, offers a unique opportunity to significantly reduce PCB loads by removing material with an elevated and known PCB concentration. To address hot spot sources, first locations with significant potential for PCB contamination need to be identified. This step is called source tracking or source targeting. Next, sites are screened and/or monitored to determine if PCBs are present and at what concentration. If PCBs are detected and PCB containing materials are removed, the PCB load reduction is calculated to reflect the known removal of PCBs and can be counted as progress towards meeting the PCB TMDL.

The guidance document titled MDE Recommendations for Addressing the PCB SW-WLA (MDE 2015d) provides recommendations for source targeting, monitoring, and accounting for load reductions. Incorporating the provided guidance, a source tracking desktop analysis was performed for the Curtis Creek AACO and Baltimore Harbor AACO subwatersheds. The source tracking desktop analysis identified both specific site locations as well as prioritized structural BMPs with significant potential for PCB soil contamination. MDE recommendations for monitoring and accounting for load reductions are discussed in Section 4.4.3.

3.3.1 Locations with Significant Potential for PCB Soil Contamination

MDE recommendations suggest a desktop analysis to review existing State and County records to identify locations with significant potential for PCB soil contamination. Following this recommendation, records from seven sources were reviewed:

- EPA PCB Transformer Registry Database
- PCB Activities Database
- Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA also known as Superfund) Sites Database
- Toxic Release Inventory (TRI) Database
- MDE Land Restoration Program (LRP)
- National Response Center (NRC) Database
- MDE Historic Landfill Initiatives (HLI) Report

The goal of the analysis was to identify sites with the potential for PCB release from the records located in the MS4 area within the Curtis Creek AACO and Baltimore Harbor AACO subwatersheds. Once identified, the sites were classified as Tier 1, Tier 2, or Tier 3 based on the source of the record as some sources are more directly related to PCBs than others.

The results of the review are summarized for each source and the combined results presented in Table 11. The location of the identified sites are shown in Figure 6.

<u>EPA PCB Transformer Registry Database</u>

Searching the EPA Transformer Registry Database resulted in 30 records for Maryland. Most records were located outside of the study subwatersheds. However, two records, both with the same address, were located in the Baltimore Harbor AACO subwatershed. The records indicated that in 2010, 16 transformers were located at the site and that in 2011, the number of transformers on the site was down to zero. Since this database source documents sites where known PCB-containing transformers are or were located, this site is classified as Tier 1.

<u>PCB Activities Database</u>

Searching the PCB Activities Database reports resulted in 63 entries for Maryland. While most records were located outside of the study subwatersheds, one entry was located in the Curtis Creek AACO subwatershed. However, this entry corresponded to the Curtis Bay United States Coast Guard (USCG) Yard, a federal facility, which is an area that is excluded from the County MS4 area. Therefore, no identified sites were from this source are included in the results.

<u>CERCLA (Superfund) Sites Database</u>

The CERCLA database search identified 10 active sites within Anne Arundel County with two located in the Curtis Creek AACO subwatershed. However, the sites (one the Curtis Bay USCG Yard, and the other the General Services Administration (GSA) Curtis Bay Depot) are both federal facilities and located outside of the County MS4 area. In addition, 29 archived sites were found within Anne Arundel County with seven located in the study subwatersheds and MS4 area. Therefore, seven identified sites from this source are included in the results and are classified as Tier 3 as they are not PCB specific sites and have received the designation of “Archived” indicating the sites are of no further interest for cleanup under CERCLA.

<u>TRI Database</u>

The TRI database search identified nine records of PCB releases for Maryland. However, zero records were located within the study subwatersheds. Therefore, no identified sites from this source are included in the results.

<u>NRC Database</u>

The NRC database of reported spills and accidents was searched via the Right to Know search engine. The search resulted in 30 unique report records for Anne Arundel County in which PCBs were suspected to be involved. Most reports involved a downed and/or leaking transformer for which PCB content was unknown. There were two records with locations within the study subwatersheds and MS4 area that are included in the results. Since these records were specific to potential PCB releases, they are classified as Tier 1.

<u>MDE LRP</u>

The MDE LRP focuses on cleaning up uncontrolled hazardous waste sites throughout Maryland (MDE 2008). The GIS shapefile provided through the LRP website contains the locations of various National Priorities List (NPL) sites, other contaminated sites not on the NPL, brownfield sites, and Voluntary Cleanup Program (VCP) sites. This listing also includes landfills currently designated as hazardous waste sites. The data was reviewed and 41 sites were found within the study subwatershed with 29 sites within the MS4 area, excluding CERCLA sites already identified through the CERCLA database and contaminated sites specifically addressed in the Baltimore Harbor PCB TMDL. Of the 29 sites, two were designated as having PCBs in soil at the site. The two sites with PCBs in soil were classified as Tier 1 since PCB contamination is known to be present, the remaining sites were classified as Tier 2 since hazardous contamination is known to exist, but PCBs have not been confirmed.

<u>MDE Historic Landfill Initiatives Report</u>

Prior to the1950s, landfills and open burning dumps were mostly unregulated. Since PCBs were in use starting in 1929, landfill and dump sites, especially those receiving industrial waste could be potential PCB sources. While the MDE LRP included landfill sites currently designated as hazardous waste sites, additional review of the MDE 2009 the Maryland Historic Landfill Initiative (HLI) report was carried out to determine if any additional historic landfills may have been located within the study subwatersheds.

This report listed numerous historic landfill and dump sites within Anne Arundel County. However, the specific location of many of the sites is not known. Historic landfill and dump sites with known locations within the watershed, but not listed in the LRP database, included the Johnson and Speake Dump and the Garrett Dump. However, these two historic sites were associated with larger landfills already identified in the LRP, Solley Road Landfill and Snow Hill Lane Landfill respectively. While the HLI report did not provide any new locations, it confirmed the inclusion of Solley Road Landfill and Snow Hill Lane Landfill as possible source locations. The B&O Railroad Landfill, also located within the study subwatersheds and MS4 area, was excluded from the results as the site was addressed specifically in the Baltimore Harbor PCB TMDL as a PCB contaminated site that was assigned a LA.

Table 11: Combined Results of Source Tracking Desktop Analysis

Tier	Source	Site Name/Identification	Address/Location	City
1	EPA PCB Transformer Database	Baltimore Gas & Electric Company - Generating Station (H.A. Wagner/Brandon Shores)	1000 Brandon Shores Road	Baltimore
1	NRC Database	Indicent ID 1029996 - Call Received 11/8/2012 7:15 AM	110 Carroll Rd	Glen Burnie
1	NRC Database	Indicent ID 556425 - Call Received 2/12/2001 8:56 AM	106 Oak Rd	Glen Burnie
1	MDE LRP	Tanyard Cove	Northwest end of Tanyard Cove Road	Glen Burnie
1	MDE LRP	Snow Hill Lane Site Phase III	(Parcel 46); Abutting Snow Hill Lane Phase II	Brooklyn
2	MDE LRP	Drumco Drum Dump	1500 Arundel Boulevard	Baltimore
2	MDE LRP	Nova-Kote Inc.	7615 Energy Parkway	Baltimore
2	MDE LRP	Snow Hill Lane Site Phase I	Abutting Snow Hill Lane	Brooklyn
2	MDE LRP	Snow Hill Lane Site Phase IV	Parcel 60, northeast of interchange of Route 2 and I-695	Brooklyn
2	MDE LRP	Snow Hill Lane Site	Snow Hill Lane and Cedar Hill Lane	Brooklyn
2	MDE LRP	Diamond Shamrock Corp. - Chemetals Division (Erachem Comilog, Inc.)	711 Pittman Road; 610 Pittman Road	Curtis Bay
2	MDE LRP	Arundel Plaza (Sears, PoFolks Restaurant, Sears Automotive)	6650 Governor Ritchie Highway	Glen Burnie
2	MDE LRP	Baymeadow Property (Martin Marietta; Gould Electronics)	6711 Baymeadow Road	Glen Burnie
2	MDE LRP	Marley Neck Property	Marley Neck Road and Marley Neck Boulevard	Glen Burnie
2	MDE LRP	Patriot's Plaza (Former Ida's Dry Cleaning)	8039 Ritchie Highway	Pasadena
2	MDE LRP	Southgate Marketplace	337 Hospital Drive	Glen Burnie
2	MDE LRP	Former Reichold Site (NL Chemicals, NL Industries Baltimore, Textron Inc)	6401 Chemical Road	Baltimore
2	MDE LRP	Snow Hill Lane Site Phase II	East of Cedar Hill Lane and north of I-695	Brooklyn
2	MDE LRP	Snow Hill Lane Site Phase V	Aspen Street And Pennington Avenue	Brooklyn
2	MDE LRP	Parcel 247	1600 Aspen Street	Baltimore
2	MDE LRP	Harundale Well Field (Harundale Plaza/ Mall; Lord Baltimore Cleaners)	7700 Ritchie Highway	Glen Burnie
2	MDE LRP	Cherry Hill/Pittman Road/Waldorf Trailer/Cherry Pit Drum Site B (Pittman Location)	701 Pittman Road	Baltimore
2	MDE LRP	Cromwell Fields Shopping Center (Carousel Cleaners)	7389 Baltimore-Annapolis Boulevard (Intersection with Dorsey Road)	Glen Burnie
2	MDE LRP	Fila U.S.A., Inc. - Brandon Woods Business Park	7630 Gambrills Cove Road	Baltimore
2	MDE LRP	Anne Arundel County Landfill	100 Dover Road	Glen Burnie
2	MDE LRP	Brandon Woods Business Park; Commerce Corporation	7603 Energy Parkway	Baltimore

Tier	Source	Site Name/Identification	Address/Location	City
2	MDE LRP	Energy Parkway	7621 Energy Parkway	Baltimore
2	MDE LRP	7246 Mockingbird Circle	7246 Mockingbird Circle	Glen Burnie
2	MDE LRP	Praxair, Inc. (Union Carbide Plant)	7350 Carbide Road	Baltimore
2	MDE LRP	Auto Emporium (Auto Clinic)	7595 Baltimore and Annapolis Blvd.	Glen Burnie
2	MDE LRP	Rock Creek Village Shopping Center	8531-8541 Fort Smallwood Road	Pasadena
2	MDE LRP	Brandon Woods II	7629 Gambrills Cove Road	Curtis Bay
3	CERCLA Database	Alco-Gravure Inc. (Quebecor Printing, Inc.; Maxwell Communication)	7364 Baltimore Annapolis Boulevard	Glen Burnie
3	CERCLA Database	Joy Reclamation Company (Phelps Co.)	402 Arundel Corporation Road	Glen Burnie
3	CERCLA Database	Fresh Pond	Forest Glen Drive, 0.25 miles north of Mountain Road	Pasadena
3	CERCLA Database	Browning Ferris Industries - Solley Road Landfill - BFI	7890 Solley Road	Glen Burnie
3	CERCLA Database	Fort Smallwood - Control Nike BA-43	Old Nike Missile Site Road (off Fort Smallwood Road)	Pasadena
3	CERCLA Database	MCS Baltimore Site	605 Pittman Road	Baltimore
3	CERCLA Database	Kanasco Ltd. (Consolidated Pharmeceutical)	6110 Robinwood Road	Glen Burnie

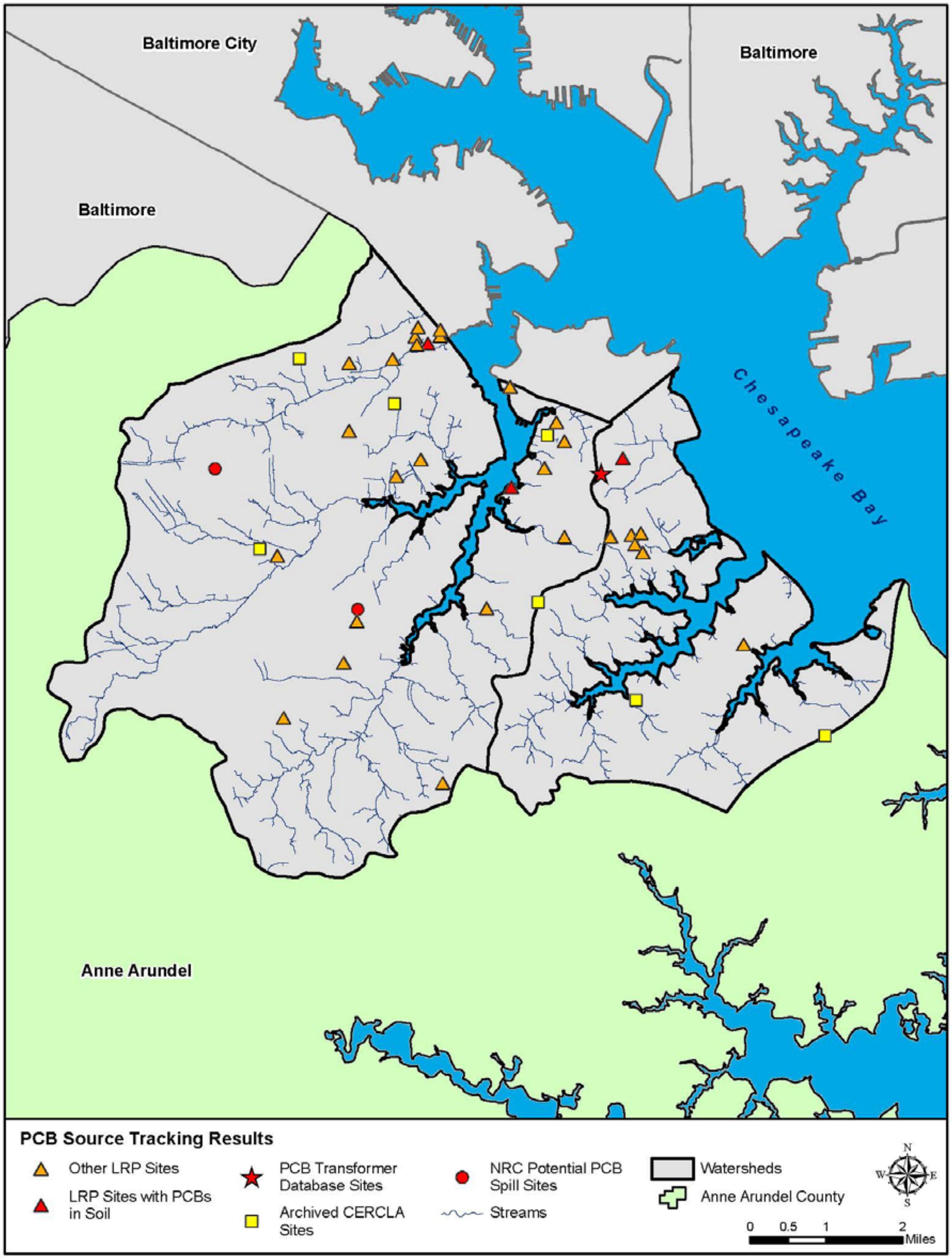

Figure 6: Location Results of PCB Source Tracking Desktop Analysis

3.3.2 Structural BMPs with Potential for PCB Soil Contamination

The MDE PCB SW-WLA recommendations for source tracking also notes structural stormwater BMPs, specifically stormwater ponds, as locations with significant potential PCB soil contamination thus potential sources of PCBs. Additional source tracking desktop analysis identified and prioritized BMPs with potential for PCB soil contamination.

Two separate analyses and prioritizations were carried out. The first analysis looked at land use and prioritized BMPs located within and/or with drainage areas containing commercial, industrial or utility land uses. The second analysis looked at the location of BMPs and BMP drainage areas in proximity to sites identified as having significant potential for PCB contamination. The analyses were carried out using Excel and ArcGIS utilizing BMP data (Urban BMP 2014 County GIS), land use data (2011 County GIS), and source tracking results data. The analysis is briefly described for each approach and the resulting lists of prioritized BMPs are presented. Note that a summary of the type and distribution of existing BMPs by group within each subwatershed MS4 area is described in Section 4.2.

<u>Land Use</u>

The desktop analysis looked first at 474 BMPs without polygon delineated drainage areas and determined that 89 were located within commercial, industrial or utility land use areas within the MS4 area in both subwatersheds combined. Since BMPs with a larger drainage area have greater potential to collect PCBs and in order to narrow the list of possible BMPs, a minimum drainage area of 2 acres was set. BMPs with drainage areas less than 2 acres within the land use categories of interest were excluded, leaving 17 BMPs. All 17 BMPs are included in the results with the priority to spatially delineate their drainage areas. Once spatially delineated, the next step would be to prioritize these alongside the BMPs with polygon delineated drainage areas for future monitoring and maintenance.

Next the desktop analysis looked at 1387 BMPs with polygon delineated drainage areas and found that 415 BMPs had drainage areas intersecting commercial, industrial or utility land use areas within the MS4 area in both subwatersheds combined. Since BMPs with a larger drainage area have greater potential to collect PCBs and in order to narrow the list of possible BMPs, a minimum drainage area of 2 acres was set. BMPs with drainage areas less than 2 acres within the land uses of interest were excluded. Additionally, BMPs with a build date after 1/1/2005, 10 years from the approximate date of this restoration plan, were excluded as the newer BMPs will have had less time to accumulate sediment than older BMPs. This left 66 BMPs included in the priority list (11 in Baltimore Harbor AACO, and 55 in Curtis Creek AACO).

BMPs were prioritized into four categories with 1 being highest priority and 4 being lowest priority based on land use type, drainage area within land use, and type of BMP. Dry detention ponds, extended dry detention ponds and wet ponds were prioritized as 1 or 2 based on the drainage area. If the drainage area was greater than 3 acres of industrial or greater than 5 acres of commercial or utility the BMP received priority 1, all others received priority 2. Other BMPs, primarily infiltration practices, received priority 3 or 4 based on the same land use area criteria. The results are shown in Table 12 and Table 13 for Curtis Creek AACO and Baltimore Harbor AACO respectively. BMPs are organized and listed first by type, then priority, then land use (industrial, utility, and commercial), and finally drainage area in land use. The BMP Storm_ID corresponds to the unique BMP identifier in the County BMP geodatabase. The location of the prioritized BMPs with accompanying drainage areas are shown in Figure 7.

Table 12: Curtis Creek – Land Use BMP Prioritization Results

Type of BMP	BMP Storm_ID	Land Use	Total Drainage Area (acres)	Drainage Area in Land Use (acres)	Build Date	Priority
Detention Dry	190	Industrial	29.8	20.4	12/17/2002	1
	63	Industrial	22.3	16.1	1/1/1980	
	1398	Industrial	4.5	3.3	1/1/1991	
	2137	Commercial	21.8	16.2	7/3/1997	
	13201	Commercial	21.9	4.0	4/8/1997	2
	1924	Commercial	2.6	2.5	11/1/1999	
	1224	Commercial	75.0	2.3	7/1/1993	
	132	Commercial	19.0	2.3	2/10/1985	
	795	Commercial	42.0	2.0	9/8/1989	
	9769	Commercial	4	Unknown	11/19/2008	Spatially Delineate DA
	9770	Commercial	4	Unknown	11/19/2008	
	8991	Commercial	2.65	Unknown	7/15/2009	
Extended Detention Dry	2586	Industrial	24.3	13.7	2/9/2000	1
	6158	Industrial	12.3	11.5	7/23/2002	
	1747	Industrial	29.7	8.7	2/8/1999	
	6159	Industrial	8.1	7.1	7/23/2002	
	1746	Industrial	5.6	4.8	6/18/2002	
	1745	Industrial	5.8	4.6	6/18/2002	
	298	Commercial	29.0	6.9	9/14/1995	
	1687	Commercial	6.1	5.3	11/20/1991	
	6332	Commercial	9.7	4.6	12/11/2003	2
	6489	Commercial	16.9	4.3	2/24/2004	
	1689	Commercial	4.3	3.7	6/2/2000	
Wet Ponds	4309	Industrial	15.0	12.4	11/25/1998	1
	1078	Industrial	7.0	6.2	12/11/1991	
	322	Commercial	56.8	45.8	10/9/1991	
	3956	Commercial	272.5	37.9	10/9/2000	
	187	Commercial	29.1	15.2	6/22/1988	
	296	Commercial	24.0	14.5	7/1/1993	
	1366	Commercial	19.3	10.6	11/5/1992	
	715	Commercial	9.7	7.5	9/23/1987	
	167	Commercial	7.4	7.3	7/24/1996	
	4796	Commercial	25.8	6.7	10/14/1999	
	169	Commercial	5.1	4.9	6/24/1988	2
	3925	Commercial	23.2	4.3	9/18/1998	
	4020	Industrial	8.95	Unknown	10/15/2007	Spatially Delineate DA
Infiltration	1915	Industrial	8.6	7.3	4/28/1990	3
	559	Industrial	6.6	6.6	5/17/1993	
	1819	Industrial	7.0	6.5	8/9/1995	
	1077	Industrial	4.5	4.4	12/11/1991	
	1425	Industrial	10.7	4.3	11/2/1995	
	1076	Industrial	4.2	4.1	12/11/1991	
	3413	Industrial	3.7	3.7	8/9/1995	
	4604	Industrial	3.8	3.7	3/8/2003	
	454	Industrial	3.3	3.2	3/20/1993	
	182	Commercial	32.8	19.4	4/8/1986	
	1607	Commercial	18.3	14.8	6/20/2001	

Type of BMP	BMP Storm_ID	Land Use	Total Drainage Area (acres)	Drainage Area in Land Use (acres)	Build Date	Priority
	5315	Commercial	19.5	10.0	1/3/2000	
	1858	Commercial	9.6	8.2	2/4/2004	
	3339	Commercial	7.5	7.5	11/4/1992	
	6696	Commercial	6.3	6.3	8/11/2004	
	2661	Commercial	5.8	5.8	11/4/1992	
	2341	Commercial	5.4	5.4	11/20/1991	
	5833	Commercial	5.0	5.0	8/11/2004	
	3031	Industrial	2.6	2.5	2/15/1993	4
	2221	Industrial	2.8	2.5	11/9/1994	
	2834	Commercial	6.3	4.3	10/14/1992	
	513	Commercial	4.5	3.9	4/26/1995	
	369	Commercial	3.0	2.9	4/21/1995	
	1810	Industrial	7.9	Unknown	11/2/1995	Spatially Delineate DA
	896	Industrial	7.75	Unknown	1/2/2001	
Filtration	9474	Industrial	2.4	Unknown	12/1/2008	Spatially Delineate DA
	9475	Industrial	2.4	Unknown	12/1/2008	
	9476	Industrial	2.4	Unknown	12/1/2008	
	7902	Commercial	7.09	Unknown	8/12/2006	
	7898	Commercial	6.17	Unknown	8/12/2006	
	7899	Commercial	5.45	Unknown	8/12/2006	
	10450	Commercial	5.3	Unknown	1/9/2010	
	8102	Commercial	2	Unknown	7/10/2011	
ESD	9768	Commercial	7	Unknown	11/19/2008	Spatially Delineate DA
Wetlands	6514	Commercial	2	Unknown	7/1/2009	Spatially Delineate DA

Table 13: Baltimore Harbor – Land Use BMP Prioritization Results

Type of BMP	BMP Storm_ID	Land Use	Total Drainage Area (acres)	Drainage Area in Land Use (acres)	Build Date	Priority
Detention Dry	4451	Commercial	22.3	4.9	6/1/2000	1
	4177	Commercial	12.8	8.3	5/18/2001	
	872	Commercial	41.6	9.3	7/1/1993	
	6139	Industrial	41.6	Unknown	1/26/2009	Spatially Delineate DA
Extended Detention Dry	2880	Industrial	25.2	21.0	4/4/2002	1
	4798	Industrial	6	3.6	1/12/2001	
	1692	Utility	14.6	4.9	7/16/1997	
	1875	Commercial	6.8	3.5	10/1/1990	2
	1097	Commercial	3.5	2.8	10/10/1995	
Wet Ponds	498	Industrial	141.9	94.2	12/17/1997	1
	4326	Industrial	4.6	2.8	8/17/2001	2
Infiltration	1812	Commercial	14.3	4.7	11/2/1995	4

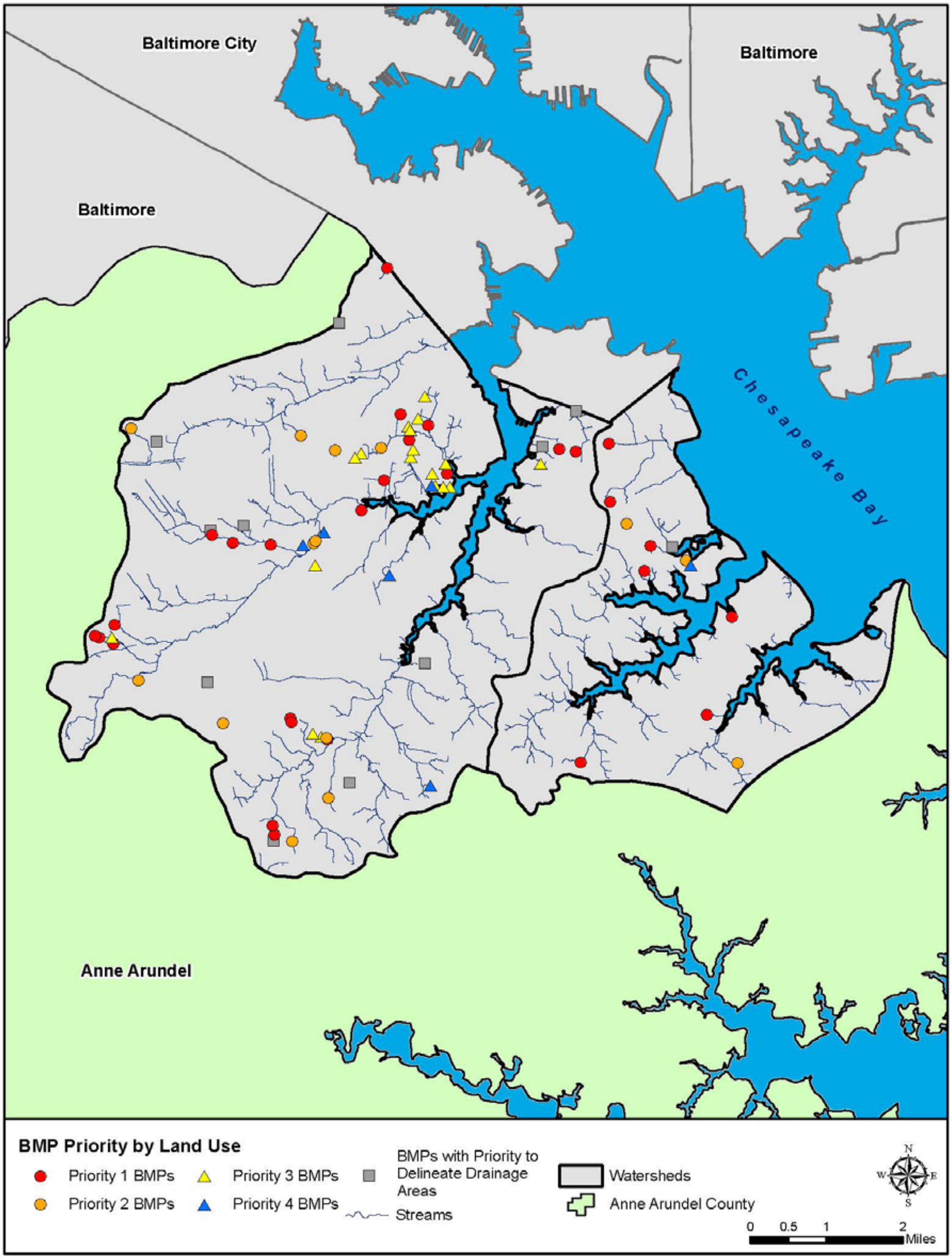

Figure 7: BMP Land Use Prioritization Results

Proximity to Sites Identified Through Source Tracking

This desktop analysis first looked at BMPs with polygon delineated drainage areas. Four BMPs were identified as having a drainage area containing one or more of the source tracking identified sites. The BMPs and source tracking sites are provided in Table 14. Three of the four BMPs were also identified as priority sites through the land use analysis. These BMPs are denoted with an asterisk. Notably, there were no BMPs whose polygon delineated drainage areas contained a source tracking Tier 1 site.

Table 14: BMPs with Polygon Delineated Drainage Areas Containing Source Tracking Sites

Source Tracking Site	Source Tracking Site Source	Source Tracking Tier	BMP Storm_ID	BMP Type
Praxair, Inc.	MDE LRP	2	1425*	Infiltration
Southgate Marketplace	MDE LRP	2	4796*	Wet Pond
5 Sites: Nova-Kote, Inc. Fila U.S.A, Inc. Brandon Woods Business Park Energy Parkway Brandon Woods II	MDE LRP	2	498*	Wet Pond
Fort Smallwood - Control Nike BA-43	CERCLA Database	3	4958	Wet Pond
*BMPs also identified as priority through land use analysis.				

For the BMPs without polygon delineated drainage areas, analysis involved identifying BMPs within a designated search radius from the source tracking site. For each source tracking site source, the search radius started at 500 feet and expanded to up to 0.75 miles or until a sufficiently large number of BMPs were located. Similar to land use analysis, the priority action for these BMPs would be to spatially delineate the drainage areas associated with the BMPs. If the delineated drainage areas encompass a source tracking site, the BMP should be given priority in targeted monitoring and maintenance actions. Table 15 provides the Storm_IDs for BMPs within the designated search radius proximity to source tracking sites. Results are organized by source tracking site source.

Table 15: BMPs without Polygon Delineated Drainage Areas in Proximity to Source Tracking Sites

Source Tracking Site Source	Source Tracking Tier	Search Radius	BMP Storm_ID
NRC Database Sites	1	0.25 miles	10611, 9992, 13411, 2723 (plus additional BMPs at same location)
EPA PCB Transformer Database Site	1	0.75 miles	2185, 4526, 4249
MD LRP – PCBs in Soil Sites	1	0.75 miles	9387, 6728, 1810, 8669, 10125, 10735, 7497, 7815, 7807, 7022, 6313, 7964
MDE LRP Sites	2	750 feet	2847, 11221, 6757, 5986, 9992, 8838, 8839, 532, 8723
CERCLA Database Sites	3	0.25 miles	1810, 5861, 6644, 7546, 9994, 11884, 11885, 2847, 1178, 2362, 8669

Next steps planned to address PCB source contamination from identified potential sites and prioritized structural BMPs are addressed in Section 4.4.3 that describes the County's restoration plan strategy for targeted PCB actions.

4 Management Activities and Strategy Development

4.1 Modeling Approach

To aid in planning restoration efforts to achieve the PCB TMDL reductions, a watershed treatment model was developed to estimate how conditions will improve in response to various treatment options. The basis of the modeling approach was the Custom 2013 version of the Center for Watershed Protection (CWP) Watershed Treatment Model (WTM). The WTM is a spreadsheet based model that uses the Simple Method to estimate stormwater runoff pollutant loads (CWP 2013). The Custom 2013 version is designed to model total nitrogen, total phosphorus, TSS, and bacteria. The Custom 2013 version was adapted to estimate PCB loads utilizing the process for modeling TSS.

Since the TMDL baseline loading and required reductions are subwatershed specific, separate WTMs were developed for each subwatershed. The WTM process involved developing several versions of the model representing important time steps such as a baseline version representing loads at the start of 2011 (approximating the date of Baltimore Harbor PCB TMDL), a progress version representing loads at the start of 2015 (approximating date of restoration plan), and future versions representing loads at specific points in the future incorporating various planned treatment options.

Input data to the WTM included land use (2011 County GIS), soil (2015 National Resource Conservation Service GIS), and percent impervious (2011 County GIS) for the MS4 area only. Event mean concentrations (EMCs) used to estimate pollutant concentration in stormwater runoff and removal rates for BMPs were set to match the values used in the watershed model developed for the Patapsco Tidal and Bodkin Creek Watershed Assessment. BMP data (Urban BMP 2014 County GIS) was incorporated at the appropriate step based on the build date of the BMP.

The first step in adjusting the WTMs to estimate PCB loads was to set up the models to accurately estimate TSS. The results of the initial TSS setups were compared to the TSS loads presented in the Patapsco Tidal and Bodkin Creek Watershed Assessment and were found to be similar. This confirmed an acceptable initial model setup. The next step in adjusting the model from calculating TSS loads to calculating PCB loads was to convert the EMCs to represent PCB runoff concentrations. This was achieved by using the regression equations developed for the Tidal Potomac and Anacostia River PCB TMDL (Haywood and Buchanan 2007) which relate the concentration of TSS to a concentration of PCBs. The EMCs were converted using the regression best applicable to the land use type. Non-urban land uses (forest, open wetland, pasture/hay, row crops, and open water) were assigned an EMC of 0 since historic use of PCBs suggest non-urban land use types are unlikely to contribute significant PCB pollution. Further explanation of the conversion of EMCs from TSS to PCBs including regression equations is provided in Appendix A. The removal rates remained unchanged as Chesapeake Stormwater Network's December 2015 publication "Potential Benefits of Nutrient and Sediment Practices to Reduce Toxic Contaminants in the Chesapeake Bay Watershed" suggests that PCB removal rates will be comparable to suspended sediment removal rates for most urban BMPs

The EMC conversion resulted in PCB baseline loading estimates that were within the correct order of magnitude, but outside of reasonable variation from the Baltimore Harbor PCB TMDL baseline estimate. This initial difference was not unexpected as the Baltimore Harbor PCB

TMDL baseline estimates were calculated using time-series to predict the subwatershed load from measured PCB concentrations and flow rates at specific monitoring stations whereas the WTM estimates are based on Simple Method calculation of pollutant loads. To calibrate the model to correct for this difference, a subwatershed specific multiplier was applied to the EMCs. The multiplier was selected such that the results in WTM 2011 baseline loads were similar to but did not exceed the Baltimore Harbor PCB TMDL baseline load for each subwatershed. The EMCs with applicable multiplier were compared with the range of research documented EMCs (Gilbreath et al. 2012) and were found to be within the range. In general, research on PCB loads in stormwater documented in Gilbreath et al. (2012) suggest EMCs for PCBs can be quite variable and that urban or percent impervious might not be the strongest predictors of PCB yield in an unmonitored watershed. However, until further research is complete and better models based on other factors such as older industrial landscape or presence of specific historic industries are developed, the approach described above provides a functioning method in which the multiplier accounts for differences in the subwatersheds that influence PCB loads as calculated in the Baltimore Harbor PCB TMDL that are not otherwise accounted for in the WTM. Table 16 documents the TSS EMC, the regression applied, the converted PCB EMC, and the PCB EMC with the subwatershed multiplier used in the WTM models.

Table 16: Conversion of TSS EMCs to PCB EMCs

	TSS EMC (mg/L)	Regression	PCB EMC (ng/L)*	PCB EMC with Curtis Creek AACO multiplier 0.7 (ng/L)*	PCB EMC with Baltimore Harbor AACO multiplier 3.6 (ng/L)*
Residential 1-acre	43	Near DC	2.39	1.68	8.63
Residential 1/2-acre	43	Near DC	2.39	1.68	8.63
Residential 1/4-acre	43	Near DC	2.39	1.68	8.63
Residential 1/8-acre	43	Near DC	2.39	1.68	8.63
Residential 2-acre	43	Near DC	2.39	1.68	8.63
Commercial	43	DC Urban	35.72	25.21	128.61
Airport	99	Near DC	3.66	2.56	13.16
Transportation	99	Near DC	3.66	2.56	13.16
Utility	34	DC Urban	28.44	19.91	102.41
Open Space	34	Near DC	2.12	1.49	7.66
Industrial	77	DC Urban	62.87	44.01	226.34
* PCB EMCs are expressed in ng/L for ease of comparison, however, the values are entered into the WTM as mg/L.					

The 2011 PCB Baseline WTM included BMPs with a build date through the end of 2010. The next step, modeling progress to 2015, added BMPs with a build date between the start of 2011 through the end of 2014. Existing BMPs are discussed in greater detail in Section 4.2. BMP data continued to be adjusted for each iteration of the WTM representing estimates from planned restoration efforts both structural as well as programmatic. The results of the 2011 baseline and 2015 progress are detailed in Section 4.3 along with the calculation of the disaggregated subwatershed-specific baseline loads and WLAs from the Baltimore Harbor PCB TMDL.

4.2 Existing Practices

Anne Arundel County maintains a geodatabase of structural BMPs throughout the county (Urban BMP 2014 County GIS). Within the combined MS4 area of the subwatersheds, the geodatabase contains 1861 BMPs with delineated drainage areas (1387 delineated with accompanying polygons) that were reported to MDE in 2014 and were included in the WTM analysis.

BMPs were organized into eight categories in accordance with MDE BMP codes using the same grouping as the Patapsco Tidal and Bodkin Creek Watershed Assessment (Table 3.4, Section 3.1.2). The total number of BMPs, total drainage area, and impervious area for each of the categories is shown in Table 17 and Table 18 for Curtis Creek AACO and Baltimore Harbor AACO, respectively with grouping of pre-2011 BMPs and post-2011 BMPs used in the 2011 baseline and 2015 progress iterations of the WTM. In Table 17 and Table 18, ESD stands for Environmental Site Design and represents small scale stormwater management practices such as green roofs, rain barrels, and rain gardens, and Alternative - FPU stands for forestation on pervious urban and represents BMPs coded as "plantings" in the geodatabase. Each BMP group has a specified percent removal efficiency (removal rate) for TSS from the Patapsco Tidal and Bodkin Creek Watershed Assessment which is included in the WTM. The removal efficiencies are shown in Table 19.

Table 17: Curtis Creek AACO BMPs

BMP Groups	Total BMP Count	Total Drainage Area	Total Impervious Area
Pre-2011			
Detention Dry	62	757.4	269.3
Extended Detention Dry	54	461.8	152.9
Filtration	104	215.8	75.0
Infiltration	598	579.0	304.0
Wet Ponds	48	931.6	416.5
Wetlands	9	39.3	6.2
ESD	18	10.0	5.6
Alternative - FPU	14	1.3	0.1
Totals	**907**	**2996.1**	**1229.5**
Post-2011			
Detention Dry	4	5.9	1.6
Extended Detention Dry	3	9.1	3.8
Filtration	36	45.1	12.6
Infiltration	56	48.1	14.8
Wet Ponds	4	43.4	3.8
Wetlands	-	-	-
ESD	37	6.6	2.8
Alternative - FPU	3	0.2	0.0
Totals	**143**	**158.4**	**39.5**

Table 18: Baltimore Harbor AACO BMPs

BMP Groups	Total BMP Count	Total Drainage Area	Total Impervious Area
Pre-2011			
Detention Dry	36	344.5	122.4
Extended Detention Dry	31	165.8	62.0
Filtration	61	218.2	23.9
Infiltration	455	222.7	79.7
Wet Ponds	16	310.6	103.8
Wetlands	5	12.2	5.8
ESD	33	16.7	2.7
Alternative - FPU	66	3.6	0.9
Totals	**703**	**1294.3**	**401.0**
Post-2011			
Detention Dry	-	-	-
Extended Detention Dry	-	-	-
Filtration	19	11.9	4.8
Infiltration	30	11.1	8.2
Wet Ponds	2	2.2	0.04
Wetlands	-	-	-
ESD	50	10.2	1.9
Alternative - FPU	7	0.3	0.1
Totals	**108**	**35.7**	**15.1**

Note for BMPs with polygon delineated drainage areas, the geodatabase contained values for both the total drainage area and impervious area which were used in the BMP analysis. For BMPs without a polygon delineated drainage, the geodatabase contained only a value for the total drainage area. The impervious area for these remaining 474 BMPs was estimated by determining the land use on which the BMP was located and multiplying the total drainage area by the subwatershed specific average percent impervious for the particular land use. Additionally, the WTM requires setting three discount factors that take into account reduction of BMP effectiveness due to imperfect capture, design standards, and maintenance. These discount factors were set to 0.9, 0.8 and 0.6 respectively based on descriptions provided in the WTM 2013 Documentation (CWP 2013).

Table 19: BMP Category Removal Rates

BMP Category	Percent Removal Efficiency TSS (unchanged for PCBs)
Detention Dry	10
Extended Detention Dry	60
Filtration	80
Infiltration	95
Wet Ponds	60
Wetlands	60
ESD	90
Alternative - FPU	57

In addition to existing structural BMPs, the County also routinely carries out street sweeping, inlet cleaning, and public outreach as part of its broader watershed restoration efforts. While these programmatic practices also serve to reduce pollutant loads, street sweeping and inlet cleaning were not incorporated in the 2011 baseline or 2015 progress WTM versions because subwatershed specific data is unavailable for these time periods. However, street sweeping and inlet cleaning are included in the future scenarios incorporating planned actions at the subwatershed level.

4.3 PCB WLA Disaggregation, 2011 Baseline, and Progress through 2015

The Baltimore Harbor PCB TMDL presented the WLAs as aggregate values for all NPDES holders within the subwatershed. To determine the WLA applicable to the Anne Arundel County MS4 NPDES permit for each subwatershed, the WLAs needs to be disaggregated. MDE provides guidance for disaggregating TMDL WLAs as part of their TMDL Stormwater Toolkit (MDE 2015). Following the process outlined in the toolkit for each subwatershed, the acres of urban land use within the MS4 area were divided by the total number of urban acres in the subwatershed. This fraction represented the portion of the WLA applicable to the MS4 permit. Urban land use was calculated using the 2006 USGS-CBP Land-Cover shapefile available from the TMDL Stormwater Toolkit website. The results of the disaggregation documenting the County MS4 specific baseline load, WLA, and required load reductions are shown in Table 20.

Table 20: Calculation of MS4 Specific Baseline Load, WLA, and required Load Reductions

	Curtis Creek AACO	Baltimore Harbor AACO
A. Total Subwatershed Urban (acres)	17102	5810
B. MS4 Subwatershed Urban (acres)	13138	5540
C. Fraction of MS4 urban over Total Urban (B/A)	**0.768**	**0.947**
D. NPDES Aggregate Baseline Load (g/year)	357.68	493.06
E. MS4 only Baseline Load (C*D) (g/year)	**274.77**	**467.09**
F. NPDES Aggregate TMDL WLA (g/year)	23.13	43.84
G. MS4 TMDL WLA (C*F) (g/year)	**17.77**	**41.53**
H. MS4 Load Reduction (E-G) (g/year)	**257**	**425.56**
I. MS4 Load Reduction (H/E) (%)	**93.5**	**91.1***
* This percent reduction is slightly less than what is shown in the Baltimore Harbor PCB TMDL due to subtracting out the Curtis Creek area to prevent double counting.		

4.3.1 WTM Baseline Load 2011 Modeling Results

The WTM 2011 baseline load results for each subwatershed are shown in Table 21. The results are compared with the TMDL baseline and in both cases the WTM slightly underestimates the TMDL baseline. While very similar with percent differences of less than 5%, but given that differences still exist between the TMDL baseline and the WTM baseline, the goal WLA for each subwatershed is calculated relative to the WTM baseline based on the required percent reduction. This WTM based goal WLA will be used throughout the remainder of this restoration plan to compare progress and effects of planned restoration efforts.

Table 21: WTM Baseline Load 2011 Results

	Curtis Creek AACO	Baltimore Harbor AACO
A. WTM 2011 Baseline PCB load (g/year)	262.89	454.55
B. TMDL MS4 Baseline PCB load (g/year)	274.77	467.09
C. Percent difference between TMDL baseline and WTM baseline ((A-B)/B*100)	-4.3%	-2.7%
D. Required percent reduction from Table 20 Line I	93.5%	91.1%
E. Goal WLA based on WTM 2011 Baseline PCB Load ((1-D)*A) (g/year)	**17.09**	**40.45**

4.3.2 WTM Progress Load 2015 Modeling Results

The WTM 2015 progress load results for each subwatershed are shown in Table 22. The 2015 progress results estimate the reductions in PCB loading from the structural BMPs added between the time of the baseline (start of 2011) and the start of 2015. This progress load documents the County's approximately current status towards achieving the WLA. This value is the approximate current status as the County BMP geodatabase documents BMPs completed through the end of 2014, BMPs added in 2015 are not yet included in the geodatabase and therefore were not included in the model.

Table 22: WTM Progress Load 2015 Results

	Curtis Creek AACO	Baltimore Harbor AACO
A. WTM 2015 Progress PCB load (g/year)	**262.09**	**453.33**
B. WTM 2011 Baseline PCB load (g/year)	262.89	454.55
C. Reduction (B-A) (g/year)	**0.8**	**1.22**
D. WLA based on WTM 2011 Baseline PCB Load (g/year)	17.09	40.45
E. Remaining Reduction (A-D) (g/year)	**245.00**	**412.88**
Additional drainage acres controlled by newly constructed BMPs	158.4	35.7
Additional impervious acres controlled by newly constructed BMPs	39.5	15.1

The 2015 progress added 143 and 108 BMPs in the Curtis Creek AACO and Baltimore Harbor AACO subwatershed respectively. However, these BMPs respectively only controlled for 39.5 and 15.1 acres of impervious cover. As a result, the PCB load reduction was very small, 0.8 for Curtis Creek AACO and 1.22 Baltimore Harbor. In order to achieve significant reduction in the PCB loads as required by the Baltimore Harbor PCB TMDL, substantially more impervious cover will need to be controlled with BMPs in the future and/or restoration efforts will need to specifically target potential PCB sources.

4.4 Restoration Plan Activities

The WTM results for the 2015 Progress Load indicate significant PCB load reductions are still required in order to meet the PCB WLAs for Curtis Creek AACO and Baltimore Harbor AACO subwatersheds, 245.0 g/year and 412.9 g/year respectively.

This restoration plan includes three primary strategies for reducing PCB loads including structural BMPs, non-structural BMPs, and targeted PCB actions. A description and estimate of the projected reductions are provided for each strategy. Load reductions are projected in 2-year time steps through 2025 to be consistent with the timeframe and planning efforts for meeting the Chesapeake Bay TMDL. Time steps modeled include 2017, 2019, 2021, and 2025. Current budget data past 2021 is not refined enough to model the 2023 time step.

For the structural BMPs and non-structural BMPs, the strategy first looks at anticipated load reductions from projects already planned and budgeted through the Anne Arundel County Watershed Protection and Restoration Program. These projects within the Curtis Creek AACO and Baltimore Harbor AACO were developed to meet the Chesapeake Bay TMDL WLAs for total nitrogen and total phosphorus and will also serve to reduce PCB loads. Recommendations for any additional structural or non-structural BMPs are discussed in light of the relative load reductions anticipated, as well as cost-effectiveness.

4.4.1 Restoration Plan Structural BMPs and Projected Reductions

The structural BMP strategy includes stormwater pond retrofits and new structural BMPs. Stormwater pond retrofits are one of the Core Tier I Watershed Implementation Plan (WIP) strategies outlined in the Patapsco Tidal and Bodkin Creek Watershed Assessment and numerous projects are underway to retrofit stormwater ponds in both subwatersheds. The other core WIP strategies of stream restoration and outfall retrofits are not included in this restoration plan strategy as it is less likely that the reduced sediment loads from these types of projects have come in contact with PCBs. New structural BMPs would include BMPs constructed to control currently uncontrolled impervious areas.

The structural BMP strategy first looks at reductions from already planned and budgeted stormwater pond retrofits. The planned stormwater pond retrofits (also referred to as simply pond retrofits) are documented in the Patapsco Tidal and Bodkin Creek Watershed Assessment. Data analysis was based on the County GIS source data layers “PondRetrofits”, “PondRetrofitsDA”, and “Urban_BMP_2014_DA” as well as the approved FY14, FY15, and FY16 budgets for Watershed Protection and Restoration Program.

From the County GIS data, 68 and 26 pond retrofits were identified within Curtis Creek AACO and Baltimore Harbor AACO, respectively. This includes both private and publically owned ponds. The drainage area and impervious cover within each drainage area was estimated for each pond. For 87 of the 94 ponds that could be joined to the polygon delineated BMP drainage areas from the Urban_BMP_2014_DA layer, the joined layer data provided the drainage area and impervious estimates. For the 7 remaining ponds that did not join, the drainage areas were estimated from the PondRetrofitsDA layer data and impervious was calculated by multiplying the drainage area by the average percent impervious for the land use type where the pond was located.

Each pond retrofit was then assigned to a model time step based on the original retrofit construction date estimated in the watershed assessment and refined using the FY14, FY15, and FY16 budgets that provide updates on project and funding status. It was assumed that for a given pond type, the retrofit would result in shifting to the BMP type with the next highest removal efficiency. For example, dry ponds (10% removal efficiency) would shift to wet ponds or dry ponds with extended detention (60% removal efficiency) and wet ponds or dry ponds with extended detention would shift to filtration (80% removal efficiency). The drainage area and impervious area were summed for the same retrofit types within a specific time step. The retrofits by time step are shown in Table 23 for Curtis Creek AACO and Table 24 for Baltimore Harbor AACO.

Table 23: Summary of stormwater pond retrofits by time step for Curtis Creek AACO

Time Step	Number of Ponds	Existing BMP/Pond Type (% removal efficiency)	Assumed Retrofit BMP Type (% removal efficiency)	Sum of Drainage Areas (acres)	Sum of Impervious Area (acres)
2017 (2015-2017)	22	Dry Ponds (10%)	Wet Ponds (60%)	839.5	396.1
	1	Dry Extended Detention (60%)	Filtration (80%)	12.3	8.2
	9	Wet Ponds (60%)	Filtration (80%)	256.2	144.9
	4	Wetlands (60%)	Filtration (80%)	47.2	14.5
2019 (2017-2019)	6	Dry Ponds (10%)	Wet Ponds (60%)	208.6	56.5
	5	Dry Extended Detention (60%)	Filtration (80%)	77.0	25.3
	6	Wet Ponds (60%)	Filtration (80%)	410.1	174.1
2021 (2019-2021)	1	Dry Ponds (10%)	Wet Ponds (60%)	10.1	5.1
	2	Dry Extended Detention (60%)	Filtration (80%)	39.6	9.3
	1	Wet Ponds (60%)	Filtration (80%)	23.2	9.6
2025 (2021-2025)	6	Dry Ponds (10%)	Wet Ponds (60%)	63.7	23.3
	3	Dry Extended Detention (60%)	Filtration (80%)	64.0	7.3
	2	Wet Ponds (60%)	Filtration (80%)	39.5	10.5
Totals	**68**			**2091.0**	**884.9**

Table 24: Summary of stormwater pond retrofits by time step for Baltimore Harbor AACO

Time Step	Number of Ponds	Existing BMP/Pond Type (% removal efficiency)	Assumed Retrofit BMP Type (% removal efficiency)	Sum of Drainage Areas (acres)	Sum of Impervious Area (acres)
2017 (2015-2017)	5	Dry Ponds (10%)	Wet Ponds (60%)	54.7	20.6
2019 (2017-2019)	5	Dry Ponds (10%)	Wet Ponds (60%)	67.5	25.0
	3	Wet Ponds (60%)	Filtration (80%)	175.6	80.0
	1	Wetlands (60%)	Filtration (80%)	6.53	2.67
2021 (2019-2021)	No retrofits assigned to this time step.				
2025 (2021-2025)	6	Dry Ponds (10%)	Wet Ponds (60%)	106.7	24.4
	3	Dry Extended Detention (60%)	Filtration (80%)	55.1	22.5
	3	Wet Ponds (60%)	Filtration (80%)	106.0	14.5
Totals	**26**			**572.1**	**189.7**

Incorporating the time-step pond retrofit data into the Progress Load 2015 WTM resulted in the incremental projected PCB load reductions shown in Table 25. The total estimated PCB load reduction from pond retrofits through 2025 is 13.78 g/year for Curtis Creek AACO and 13.5 g/year for Baltimore Harbor ACCO. Table 26 summarizes the progress towards meeting the PCB WLAs by 2025 from pond retrofits and the required reductions remaining.

Based on the preliminary costs provided in the watershed assessment, the estimated cost for the above 94 retrofits likely falls within the range of $20M-$30M. Combining reductions from subwatersheds for a total of 26.28 g/year, the cost per gram of PCB load reduction from pond retrofits is within the range of $750K – $1.1M.

Table 25: Anticipated Incremental Reductions by Time Step for Pond Retrofits

	Incremental PCB Load Reduction from Time Step (g/year)	
Time Step	**Curtis Creek AACO**	**Baltimore Harbor AACO**
2017	8.79	1.76
2019	3.81	6.24
2021	0.37	0
2025	0.81	5.5
Total	**13.78**	**13.5**

Table 26: Progress towards meeting WLAs by 2025 from Pond Retrofits

	Curtis Creek AACO (g/year)	**Baltimore Harbor AACO (g/year)**
WTM 2015 Progress Load	262.09	453.33
WTM 2025 Progress Load with Pond Retrofits	248.31	439.83
PCB WLAs	17.09	40.45
Required Reduction Remaining	231.22	399.38

As shown in Table 26 the anticipated reductions from stormwater pond retrofits are not sufficient to meet the PCB WLAs. New BMPs were not part of the WIP strategies and as such none are currently planned for the subwatersheds.

Planned Strategy: The County will continue to implement the planned stormwater retrofits and will update the progress loads and projected reductions as projects are completed and/or implementation schedules shift. The County has the option to complete additional pond retrofits and/or implement new BMPs to address existing uncontrolled impervious. These efforts would continue to reduce loads and the County will investigate the feasibility and potential beneficial impact of implementing additional pond retrofits or new BMPs on an individual basis and as situations present themselves. However, comparing the cost of the planned retrofits to the estimated reductions on a cost-effectiveness basis, the County will not actively pursue untargeted additional pond retrofits and new BMPs projects solely for the purpose of PCB load reduction because the load reductions from these efforts would continue to make only incrementally small improvements. Instead, the County plans to focus additional PCB TMDL specific reduction efforts on targeted PCB actions. Yet if additional pond retrofits or new BMPs are implemented as part of other efforts within the subwatersheds, the PCB load reductions from such projects would be calculated and incorporated into future WTM updates.

4.4.2 Restoration Plan Non-Structural BMPs and Projected Reductions

The non-structural BMP or programmatic strategies includes street sweeping and inlet cleaning. Street sweeping and inlet cleaning are two Core Tier II WIP strategies outlined in the Patapsco Tidal and Bodkin Creek Watershed Assessment. The County Department of Public Works (DPW) through the Bureau of Highways currently carries out an impressive program of street sweeping and inlet cleaning that reduces trash and stormwater pollution throughout the County with program details documented in the MS4 Annual Reports. Estimates of pollution reduction from roads swept and inlets cleaned can be counted towards meeting TMDL WLAs.

The non-structural BMP strategy first looks at reductions from already planned street sweeping and inlet cleaning as documented in the Patapsco Tidal and Bodkin Creek Watershed Assessment. Data analysis was based on the County GIS source data layers "StreetSweeping" and "ClosedSectionRd_Inlets".

To calculate PCB load reductions from street sweeping using the WTM, the area of street swept was calculated for non-residential land uses within the MS4 area in each subwatershed. Since the County is currently not routinely sweeping residential streets, residential streets were not included. Road areas in the land use category of woods were also omitted since woods are not likely sources of PCBs. Planned frequency of sweeping is monthly using a regenerative air sweeper. The technique discount factor was assumed to be 0.75 based on descriptions provided in the WTM 2013 Documentation (CWP 2013).

To calculate PCB load reductions from inlet cleaning using the WTM, impervious area captured was estimated for inlets identified for cleaning within the MS4 area. Drainage areas to inlets have not been delineated, and therefore an assumption was made that each inlet captures a 0.25 acre drainage area. This assumption was based on the maximum drainage area to various inlet types as noted in SHA Field Guide for Erosion and Sediment Control (SHA 2013). Impervious area was estimated by multiplying the assumed drainage area by the average impervious for the land use type where the inlet is located. All inlets except for those located on the land use category woods were included. The inlets are cleaned annually. To be consistent with the WTM input option of semi-annual cleaning the total impervious captured was divided by two when entered into the WTM. The disposal discount was set to 1.0 based on descriptions provided in the WTM 2013 Documentation (CWP 2013).

A summary of the area of road to be swept, number of inlets to be cleaned and impervious area captured by inlets annually is provided by subwatershed in Table 27

Table 27: Planned Street Sweeping and Inlet Cleaning Summary

	Curtis Creek AACO	**Baltimore Harbor AACO**
Area of road swept monthly (acres)	165.1	59.6
Number of inlets to be cleaned	1221	804
Impervious area captured by inlets (acres)	81.7	117.1

Since street sweeping and inlet cleaning numbers represent one year of activity, the area inputs were multiplied by the number of years represented in each time step. Removal efficiencies were kept as the default WTM values.

The anticipated incremental PCB load reductions from non-structural practices are shown by time step in Table 28. The total estimated PCB load reduction from non-structural BMPs through 2025 is 12.95 g/year for Curtis Creek AACO and 26.79 g/year for Baltimore Harbor ACCO.

Continued progress towards meeting the PCB WLAs by 2025 and required reduction remaining are summarized in Table 29 with total reductions from non-structural BMPs subtracted from the WTM 2025 progress load with pond retrofits.

The Bureau of Highways provided an estimate of operational unit costs for both street sweeping and inlet cleaning to be approximately $120 per street mile swept (includes both sides of the street) and approximately $25 per inlet if cleaned by hand and $70 per inlet if cleaned mechanically. This estimate does not include acquisition cost of the street sweeper. Based on the number of miles of street sweeping and number of inlets to be cleaned, the cost for 10 years of the non-structural BMPs program is estimated to be between approximately $2.0M and $2.9M, with 10 years of street sweeping costing $1.5M and 10 years of inlet cleaning costing between $0.5M and $1.4M depending on whether inlets are cleaned by hand or mechanically. This estimate assumes the combined area of road swept monthly in acres is equivalent to 108 miles based on GIS analysis. Combining reductions from subwatersheds for a total of 39.74 g/year, the cost per gram of PCB load reduction from non-structural BMPs is estimated to be between approximately $52K and $73K. While much more cost-effective than the pond retrofits, the cost of reducing PCB loads via non-structural BMPs is still very high.

Table 28: Anticipated Incremental Reductions by Time Step for Non-Structural BMPs

	Incremental PCB Load Reduction from Time Step (g/year)			
	Curtis Creek AACO		**Baltimore Harbor AACO**	
Time Step	**Street Sweeping**	**Inlet Cleaning**	**Street Sweeping**	**Inlet Cleaning**
2017	2.49	0.10	4.60	0.76
2019	2.49	0.10	4.60	0.76
2021	2.49	0.10	4.60	0.76
2025	4.98	0.20	9.20	1.51
Total	**12.45**	**0.50**	**23**	**3.79**

Table 29: Progress towards meeting WLAs by 2025 from Pond Retrofits and Non-Structural BMPs

	Curtis Creek AACO (g/year)	**Baltimore Harbor AACO (g/year)**
WTM 2025 Progress Load with Pond Retrofits	248.31	439.83
WTM 2025 Progress Load with Pond Retrofits and Non-Structural BMPs	235.36	413.04
PCB WLAs	17.09	40.45
Required Reduction Remaining	218.27	372.59

The WTM results indicate PCB load reductions from planned street sweeping and inlet cleaning combined with reductions from pond retrofits will not be sufficient to meet the PCB WLAs.

<u>Planned Strategy:</u> The County will continue to implement and track the street sweeping and inlet cleaning as planned for in the Patapsco Tidal and Bodkin Creek Watershed Assessment. In addition, the County has a 2016-2017 milestone for the Chesapeake Bay TMDL to increase street sweeping frequency to bi-monthly. Future PCB load reduction accounting will incorporate this frequency increase as it is implemented. Based on the minimal PCB reductions gained from already planned street sweeping and inlet cleaning, the County does not propose expanding these non-targeted programs for the purpose of PCB load reductions. Instead, the County will focus additional PCB TMDL efforts on targeted PCB actions. However, if street sweeping and/or inlet cleaning efforts are further expanded as a result of other initiatives, additional PCB load reductions will be calculated and incorporated into future WTM updates.

4.4.3 Targeted PCB Actions and Projected Reductions

After implementing the structural and non-structural strategies through the 2025 time step, the required reductions remaining to meet the PCB WLAs are still significant for both Curtis Creek AACO and Baltimore Harbor AACO at 218.27 and 372.59 g/year respectively. This remaining reduction is not surprising as these strategies are comprised of the restoration efforts developed for the Patapsco Tidal and Bodkin Creek Watershed Assessment to achieve the Chesapeake Bay nutrient TMDLs which call for lesser percent reductions than the PCB TMDL. In addition, the very low PCB EMCs used in the WTM represent more diffuse PCB pollution and result in restoration project and programmatic efforts having a lesser impact on reducing pollutant loads than would be observed if more concentrated PCB pollution was addressed.

Rather than investing additional efforts in the structural and non-structural strategies that result in small reductions because it must be assumed that they address only diffuse PCB pollution, the County proposes to focus additional PCB TMDL specific efforts on the targeted PCB actions strategy. Targeted PCB actions look to address elevated, site-specific, and quantified levels of PCB pollution and will be relied upon to achieve the remaining reductions required to meet the PCB WLAs.

The targeted PCB actions strategy builds on the source tracking results and includes screening and monitoring, addressing PCB contaminated materials, and accounting for load reductions.

Screening and Monitoring

The source tracking desktop analysis completed as part of this restoration plan first identified sites within the subwatershed MS4 areas that have significant potential for PCB soil contamination and then prioritized BMPs with potential for PCB soil contamination based on land use and proximity to the identified sites. According to the MDE Recommendations for Addressing the PCB SW-WLA (MDE 2015d) guidance document, the next step is to monitor for PCBs at selected locations. MDE recommends the County apply best professional judgement to determine which sites should be monitored. Based on the potential of BMPs to accumulate PCBs in sediment and ease of access for monitoring, the County plans to first pursue structural BMPs and then look to specific identified sites as warranted.

MDE recommends that monitoring samples should be analyzed by EPA method 1668 for total PCBs. The analytical method EPA 1668 provides a breakdown according to PCB congeners, specific chemical compounds in the PCB category, and can be costly at $600-$700 per sample analysis (Biohabitats 2016). Many analytical laboratories offer discounts if multiple samples are processed.

Prior to monitoring at the level recommended by MDE, the County may choose to first screen locations for total PCBs using analytical EPA method 8082. This method is less sensitive than EPA 1668, but the cost for analysis is much less at $80 per sample, again with discounts offered for multiple samples (Biohabitats 2016). With the lower cost screening analysis, the County would be able to screen more BMPs and then advance to monitor select BMPs using the more rigorous recommended analytical method. This approach would maximize the County's ability to identify BMPs with elevated PCB levels.

MDE suggests collecting and testing one sediment sample in an area where fine sediments have accumulated before maintenance and sediment removal (MDE 2015d). The method for collecting sediment samples from BMPs should follow the guidance provided in EPA's 2001 "Methods for Collection, Storage, and Manipulation of Sediments for Chemical and Toxicological

Analyses; Technical Manual" (EPA 2001). Sampling container and equipment used, volume of sediment collected, and sample storage, hold times, and temperatures should be in accordance with the requirements of the intended analytical method.

Screening and monitoring is an important step because minimal data is available regarding accumulated PCB concentrations in BMP sediments. Published research on the topic is limited to stormwater ponds in Arizona (Parker et al 2000). However, Parker et al (2000) found that PCBs were detected in all 24 stormwater control basins sampled. The concentrations detected were considerably variable with the maximum concentration more removed from the median values than for other pollutants such as metals. Given the ubiquity of PCB contamination in BMP sediment and the variability in detected concentrations, the proposed sequence of screening and then monitoring is the most efficient and cost-effective approach to locating elevated PCB concentrations within the subwatersheds.

Addressing PCB Contaminated Sediment

MDE recommendations indicate that based on monitoring results, the County should then decide whether remediation steps will be taken. For all BMPs in which PCBs are found above the detection limit, but below required mitigation levels, the County will document and justify its decision on whether remediation steps will be taken (MDE 2015d). In the absence of specific MDE mitigation levels for PCBs in BMPs, the County will use the MDE VCP cleanup standards for comparison of screening and monitoring results.

In the case of BMPs, the most common option for addressing PCB contaminated sediment is removal through excavation or dredging and disposal of the contaminated sediment at an appropriate facility. With removal of sediment, the County is then able to account for the PCB load reduction. Other options include capping, as well as employing cutting-edge techniques for in-situ remediation using PCB degrading bacteria or fungi. In order to account for PCB load reductions from non-removal options, the County would need to document and validate PCB load reductions for MDE approval. The County plans to stay abreast of technological developments in remediating PCBs and plans to consider incorporating new methods that prove to be cost-effective and feasible as they become available.

Cost of disposal and available disposal options for PCB contaminated sediment would depend on the concentration of PCBs. As part of the targeted PCB actions strategy, the County plans to investigate acceptable disposal options such as the County landfill or commercial waste handling facilities, acceptable relocation methods, as well as any permitting requirements for addressing PCB contaminated sediment. Based on estimated disposal cost, the County plans to develop an approach for addressing PCB contaminated sediment that most cost-effectively maximizes PCB load reductions.

Generally the party responsible for the contamination pays for cleanup. As such, the County plans to make every effort to identify the party responsible for the release and hold the party liable. Additional source tracking, working in the upstream direction from the BMP, may be required and may involve desktop analysis and/or field verification. The County and/or responsible party may pursue working through the MDE VCP on site cleanup if a specific source of PCBs is located. A BMP with elevated sediment PCB concentrations would not be considered a source, but may lead to locating a hot spot source contributing to continued environmental release of PCBs within the BMP drainage area.

Accounting for PCB Load Reductions

MDE provides specific recommendations for accounting for load reductions when PCB contaminated sediment is removed and properly disposed of at encapsulated or contained facility. The County may take credit for removal of PCB contamination equal to the product of the sediment PCB concentration and the volume of sediment removed (MDE 2015d).

Planned Strategy: The County will develop a plan for carrying out targeted PCB actions. The proposed elements of the plan include:

- Number of BMPs to be screened annually.
- Criteria for selecting a BMP for more rigorous MDE recommended monitoring.
- Identification of specific disposal facilities for contaminated sediment along with the criteria for facility acceptance and unit cost for disposal.
- Decision framework for determining which BMPs will be remediated as screening and monitoring results become available and a timeframe for completion.

This plan will form the basis for a budget request to fund the proposed activities. The County also plans to work to integrate PCB screening, monitoring, and contaminated sediment removal efforts with the ongoing BMP maintenance program run through the Bureau of Highways that services County-maintained BMPs with mowing, inspection, and general maintenance. In addition, the County plans to investigate the potential for incorporating PCB screening, monitoring, and contaminated sediment removal efforts with ongoing stormwater retrofit projects. In this case, there would be potential for the pond retrofit projects to reduce PCB loads through improved removal efficiency as well as a site-specific and quantified PCB load reduction from contaminated sediment removal.

Projected Reduction

Based on the planned strategies, this restoration plan projects that the targeted PCB actions will achieve the remaining required reductions to meet the WLA. Screening and monitoring is required to identify the specific BMPs to be targeted for PCB contaminated sediment removal. As such, it is not possible to estimate the reductions from specific removal actions that will be carried out in the future. Instead, based on some simplifying assumptions regarding PCB concentrations in sediment, an estimated range of required remediation effort is calculated for each subwatershed.

The required remediation effort range is then evaluated for feasibility based on the number of existing BMPs and total drainage areas, specifically looking at prioritized BMPs. The efforts required to carry out the targeted PCB actions strategy are then reasonably distributed across the time steps to roughly approximate the anticipated PCB load reductions by time step.

PCB concentrations in stormwater detention basin sediments sampled in Parker et al (2000), ranged from 1-2000 ug/kg with a median value of 6 ug/kg and mean value of 21 ug/kg, excluding the outlier of 2000 ug/kg. Another PCB concentration of interest is the residential clean up standard for MDE VCP of 320 ug/kg for total PCBs. Assuming a sediment density of 1.5 US tons per cubic yard (yd^3), the estimated removal effort for the targeted PCB actions to meet the WLA is shown in Table 30 for Curtis Creek AACO and Table 31 for Baltimore Harbor AACO. In addition to volume for removal, the tables also present an estimate of the surface area of BMPs that would need to be remediated based on an assumed removal depth of 1ft.

Table 30: Estimated Removal Effort for Targeted PCB Actions to Meet Curtis Creek AACO PCB WLA Based on a Range of PCB Concentrations

	PCB concentrations of interest to demonstrate range of efforts.		
Concentration of PBC in Sediment (ug/kg)	6	21	320
Estimated volume of sediment needing to be remediated (yd^3)	27,000	7,600	500
Area to be remediated (acres)*	16.6	4.7	0.3
*Assuming 1ft depth of contaminated sediment removed.			

Table 31: Estimated Removal Effort for Targeted PCB Actions to Meet Baltimore Harbor AACO PCB WLA Based on a Range of PCB Concentrations

	PCB concentrations of interest to demonstrate range of efforts.		
Concentration of PBC in Sediment (ug/kg)	6	21	320
Estimated volume of sediment needing to be remediated (yd^3)	46,000	13,000	900
Area to be remediated (acres)*	28.3	8.1	0.5
*Assuming 1ft depth of contaminated sediment removed.			

The higher the PCB concentration in the sediment, the smaller the total volume of sediment that will need to be remediated. As such, finding BMPs with more elevated PCB concentrations will be important to cost-effectively reducing PCB loads.

There are 36 and 11 priority 1 and 2 BMPs identified in Section 3.3.2 which include dry ponds, dry ponds with extended dry detention, and wet ponds in Curtis Creek AACO and Baltimore Harbor AACO, respectively. These priority BMPs drain 905 acres in Curtis Creek AACO and 320 acres in Baltimore Harbor AACO. Assuming the surface area of BMPs available for remediation is 2% of the total drainage area, there are 18.1 acres of priority BMPs in Curtis Creek AACO and 6.4 acres of priority BMPs in Baltimore Harbor AACO. Even at a PCB concentration of 6 ug/kg, there is sufficient area of BMPs available to be remediated in Curtis Creek AACO to meet the PCB WLA.

For Baltimore Harbor AACO, at a PCB concentration of 6 ug/kg, there is insufficient area available to meet the WLA. When expanding the BMPs considered to include all dry ponds, dry ponds with extended dry detention, and wet ponds within Baltimore Harbor AACO, the available area increases to 16.4 acres. This is sufficient for a PCB concentration of 21 ug/kg, but still short of what is needed at lower PCB concentrations. Meeting the Baltimore Harbor AACO PCB WLA through the targeted PCB actions will depend on the identification of BMPs within the subwatershed with higher PCB levels.

Based on the estimated range of removal efforts required and the available BMP area, it is feasible and anticipated that the targeted PCB actions will reduce PCB loads to achieve the WLAs. However, the PCB load reduction potential ultimately depends on the level of PCBs that have accumulated in the BMPs in each subwatershed. If the screening and monitoring efforts fail to locate ponds with elevated PCB levels, the County will re-evaluate the planned strategies and make adjustment as necessary to ensure the WLAs can and will be met. Moreover, the planned strategies rely heavily on the targeted PCB actions under the reasonable assumption that removing more concentrated PCBs will be more cost-effective than addressing more diffuse pollution. If after initial implementation of the targeted PCB actions plan, the County anticipates or finds the targeted PCB action reductions to be less cost-effective than the structural BMPs or non-structural BMPs, the County will re-evaluate the planned strategies and make adjustments as necessary.

A rough estimate for PCB load reductions by time step from the targeted PCB actions strategy is shown in Table 32 which also includes explanation of actions that would likely take place during the time step. These estimates will be revised as needed as the targeted PCB actions strategy is implemented. Progress towards meeting the WLA by 2025 through implementation of the targeted PCB actions in addition to the pond retrofits and non-structural BMPs are summarized Table 33.

Table 32: Anticipated Incremental Reductions by Time Step for Non-Structural BMPs

	Incremental PCB Load Reduction from Time Step (g/year)		**Actions likely taking place during time step.**
Time Step	**Curtis Creek AACO**	**Baltimore Harbor AACO**	
2017	0	0	Targeted PCB Actions Plan development and beginning screening and monitoring process.
2019	54.57	93.15	Finalize Targeted PCB Actions Plan. Continued screening and monitoring and beginning remediation of selected BMPs accounting for 1/4 of required reduction remaining.
2021	109.14	186.30	Screening and monitoring complete. Concerted efforts in remediation of selected BMPs accounting for 1/2 of required reduction remaining.
2025	54.57	93.15	Complete remediation of selected BMPs accounting for 1/4 of required reduction remaining
Total	**218.27**	**372.60**	

Table 33: Progress towards meeting WLAs by 2025 from Pond Retrofits Non-Structural BMPs, and Targeted PCB Actions

	Curtis Creek AACO (g/year)	**Baltimore Harbor AACO (g/year)**
WTM 2025 Progress Load with Pond Retrofits and Non-Structural BMPs	235.36	413.04
Progress Load with Pond Retrofits and Non-Structural BMPs and Targeted PCB Actions	17.09	40.45
PCB WLAs	17.09	40.45
Required Reduction Remaining	0	0

5 Expected Load Reductions and Cost Estimates

5.1 Summary of Estimated Load Reductions

Sections 4.4.1 through 4.4.3 calculated the load reductions from the planned restoration strategies for structural BMPs, non-structural BMPs, and targeted PCB actions. The incremental reductions are summarized in Table 34 and Table 35 for Curtis Creek AACO and Baltimore Harbor AACO respectively. Figure 8 and Figure 9 illustrate the cumulative reduction as well as the percent reductions achieved at each time step relative to the required percent reduction.

Table 34: Summary of Incremental PCB Reductions for Curtis Creek AACO

	Completed	Planned Strategies				
Time Step	PCB load reduction from BMPs added between 2011 and 2015 (g/year)	PCB load reduction from Structural BMPs (g/year)	PCB load reduction from Non-Structural BMPs (combining street sweeping and inlet cleaning) (g/year)	PCB load reduction from Targeted PCB Actions (g/year)	Total PCB load reduction for time step (g/year)	Percent of overall reduction required from 2011 Baseline (245.8 g/year)
2015 Progress	0.8	-	-	-	0.8	0.3%
2017	-	8.79	2.59	0	11.4	4.6%
2019	-	3.81	2.59	54.57	61.0	24.8%
2021	-	0.37	2.59	109.14	112.1	45.6%
2025	-	0.81	5.18	54.57	60.6	24.7%
Total	0.8	13.78	12.95	218.27	245.8	100%

Table 35: Summary of Incremental PCB Reductions for Baltimore Harbor AACO

	Completed	Planned Strategies				
Time Step	PCB load reduction from BMPs added between 2011 and 2015 (g/year)	PCB load reduction from Structural BMPs (g/year)	PCB load reduction from Non-Structural BMPs (combining street sweeping and inlet cleaning) (g/year)	PCB load reduction from Targeted PCB Actions (g/year)	Total PCB load reduction for time step (g/year)	Percent of overall reduction required from baseline (414.1 g/year)
2015 Progress	1.22	-	-	-	1.2	0.3%
2017	-	1.76	5.36	0	7.1	1.7%
2019	-	6.24	5.36	93.15	104.8	25.3%
2021	-	0	5.36	186.30	191.7	46.3%
2025	-	5.5	10.71	93.15	109.4	26.4%
Total		13.5	26.79	372.60	414.1	100%

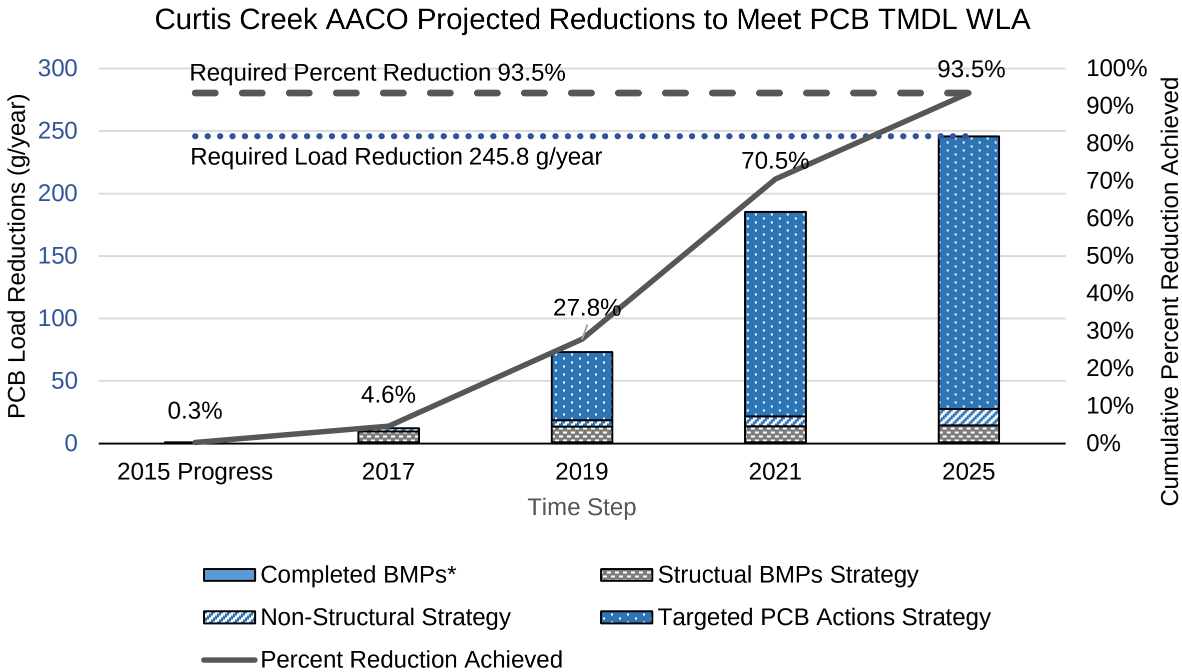

Figure 8: Graphical Illustration of Projected PCB TMDL Progress for Curtis Creek AACO

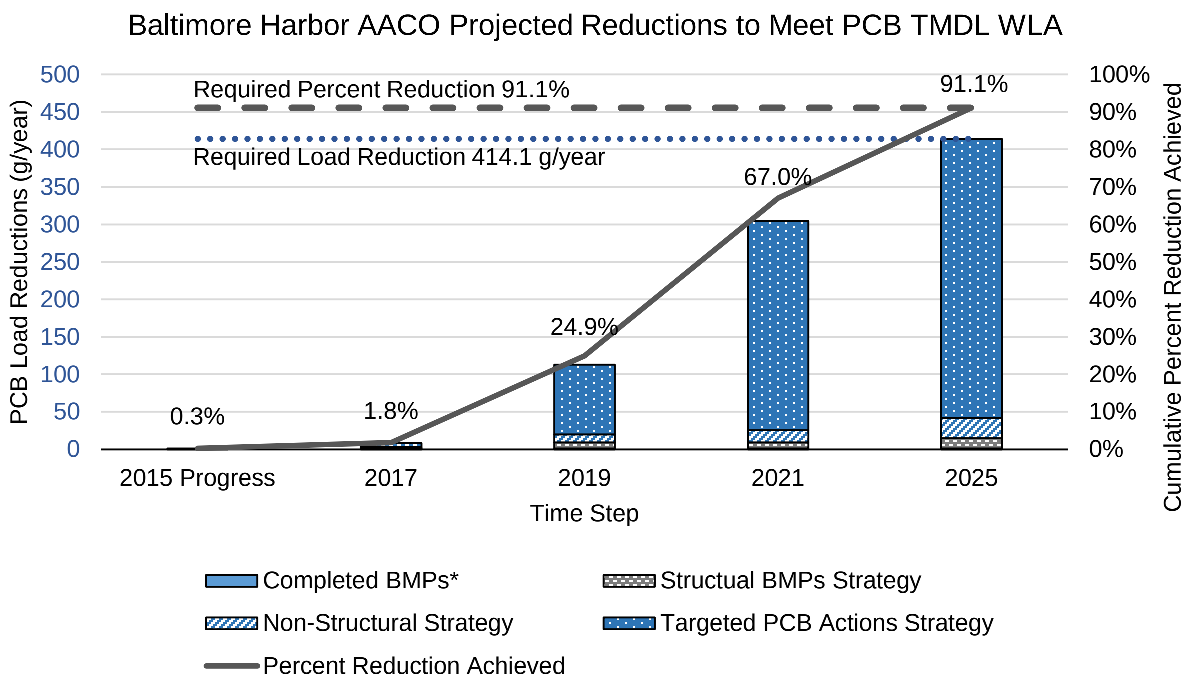

Figure 9: Graphical Illustration of Projected PCB TMDL Progress for Baltimore Harbor AACO

*Reductions from Completed BMPs for both subwatersheds are small compared to the restoration plan strategy reductions and therefore are not as visible on the figures. Completed BMPs account for the 0.3% reduction at the 2015 Progress Time Step for both subwatersheds.

The most significant PCB load reductions are anticipated from the targeted PCB actions strategy with structural and non-structural BMP strategies contributing relatively small reductions. Based on the projected implementation, the most significant percent reduction is anticipated at the 2021 time step representing efforts from 2019-2021. These trends apply to both subwatersheds.

5.2 Cost Estimates

The overall cost estimate for meeting the PCB WLAs is calculated as the sum of the individual cost estimates for each of the three strategies.

Structural BMP Strategy

The costs associated with the structural BMP strategy are based on the preliminary costs presented in the Patapsco Tidal and Bodkin Creek Watershed Assessment. The watershed assessment estimates $22.4M for pond retrofits. This point estimate is broadened to a range of $20M-$30M to develop an upper and lower estimate for the structural BMP strategy.

- **Total of $20M-30M for structural BMP strategy**

Non-structural BMP Strategy

The costs associated with the non-structural BMP strategy were estimated based on operational cost estimates provided by the Bureau of Highways. The unit cost estimates are as follows:

- Approximately $120 per mile of street swept (includes both sides of the street)
- Approximately $25 per inlet cleaned by hand and $70 per inlet cleaned mechanically

This estimate does not include acquisition cost of the street sweeper. The implementation time frame through 2025 represents approximately 10 years of program implementation. Multiplying the miles of road swept annually (108 miles per month x 12 months) and inlets cleaned annually (2025) by 10 years results in a total of 12,960 miles of street swept and 20,250 inlets cleaned. This assumes the combined area of road swept monthly in acres is equivalent to 108 miles based on GIS analysis. The estimated cost for implementing the non-structural BMP strategy through 2025 is:

- $1.5M for street sweeping
- $0.5M to $1.4M for inlet cleaning
- **Total of $2.0M-$2.9M for non-structural BMP strategy**

Targeted PCB Actions

The costs associated with the targeted PCB actions strategy depend heavily on the screening and monitoring plan to be developed as well as the costs for remediation that are contingent on the concentrations of PCBs detected. To develop a cost estimate, fixed costs and variable costs are considered separately. All costs described are rough order of magnitude estimates for the purpose of this restoration plan and are subject to significant revision in the future.

The fixed costs associated with the strategy would include development and ongoing updating of the strategy plan and program administration and documentation. Given a 10-year program horizon, fixed costs are roughly estimated to be between $600K and $1.4M, assuming plan development and updating costs within $100K-$400K and program administration and documentation costs within $500K-$1M.

The variable costs associated with the strategy would include screening and monitoring efforts along with remediation efforts. Screening and monitoring costs would involve labor to collect the samples and laboratory analytical cost. This assumes coordination and interpretation of results are covered by program administration fixed costs. An upper bound on the screening and monitoring costs is estimated to be $620K. This assumes $800 per BMP in analytical costs, $1600 per BMP in labor costs with screening and monitoring carried out at all 260 BMPs with the subwatershed MS4 area that are dry ponds, dry ponds with extended dry detention, and wet ponds.

Remediation costs would involve project planning and authorization, construction, disposal, and close-out. This assumes higher-level coordination and documentation are covered by program administration fixed costs. Since these costs are highly dependent on the magnitude of the required remediation, an estimate is not developed. Rather, a metric for cost-effectiveness is proposed by which to evaluate potential targeted PCB actions.

Potential targeted PCB actions should be considered for implementation if they are at least as cost-effective as the next best alternative. The alternatives for PCB reductions include the structural BMPs and non-structural BMPs strategies. Of the two alternatives, the most cost-effective PCB reduction comes from the non-structural BMPs strategy at between $52K and $73K per gram of PCB removed. This range for cost per gram of PCB reduction should be metric against which potential targeted PCB actions are evaluated. It should be noted however, that PCB reductions from the non-structural BMPs strategy may eventually be limited by miles of street and number of inlets present within the subwatersheds. Thus, in addition to cost, feasibility of the next best alternative should also be considered when evaluating potential targeted PCB actions.

<u>Overall Cost Estimate to Achieve the PCB TMDL WLAs</u>

The overall cost estimate as the sum of the individual strategy costs are represented by the equation below:

$$\begin{Bmatrix}\textbf{\textit{Structural BMP Strategy}}\\ \$20M-\$30M\end{Bmatrix}$$

$$+\begin{Bmatrix}\textbf{\textit{Non}}-\textbf{\textit{Structural BMPs Strategy}}\\ \$2.0M-\$2.9M\end{Bmatrix}$$

$$+\begin{Bmatrix}\textbf{\textit{Targeted PCB Actions Strategy}}\\ (\$0.6M-\$1.4M)+0.6M+(Remediation\ Costs)\end{Bmatrix}$$

- **Overall cost estimate range: $23.2M to $34.9M + (Remediation Costs)**

In the unlikely event that targeted PCB actions are less cost-effective than the alternatives, or there is insufficient contaminated sediment to remove, the remaining required reductions, would have to be achieved through the non-structural and structural BMPs strategies at a cost of between $52K-$73K and $1.1M per gram of PCB reduction.

6 Implementation Schedule and Milestones

6.1 Implementation Schedule and Milestones

Similar to estimated costs, the overall implementation schedule is a combination of the schedules for implementing each of three restoration plan strategies as presented in Sections 4.4.1-4.4.3.

Funding is allocated for 71 of 94 structural BMP stormwater pond retrofits. Projected completion dates were used in assigning each project to a time step. However, actual completion dates may vary due to project delays or other complications. This may cause the reductions to shift to later time steps. Additionally, the 23 projects not already allocated funding as of FY2016 budget were assigned to the 2025 time step. Some of these projects may extend beyond 2025 for completion or may be ultimately eliminated due to infeasibility, high costs, or other reasons.

The Non-Structural BMPs strategy assumes a constant implementation effort for street sweeping and inlet cleaning over ten years based on routes and inlets identified in the Patapsco Tidal and Bodkin Creek Watershed Assessment. Actual implementation may vary due to unpredicted mechanical issues or funding changes. Also initial estimated load reductions could be revised if additional information becomes available that enables refining the conservative assumption of drainage area caught by each inlet. In general, implementation of the Non-Structural BMPs strategy should result in a fairly consistent annual reduction through 2025 and beyond as the County DPW's street sweeping and inlet cleaning program is anticipated to continue into the foreseeable future.

The Targeted PCB Actions strategy implementation schedule assumes availability of funding and timely review and acceptance of this restoration plan to initiate targeted PCB action plan development. Once the plan is developed, it is anticipated the screening and monitoring can be completed within several years. Implementation of remediation will be dependent on the availability of funding and actual time required to carry out remediation which is likely to vary by project. The schedule proposed in 4.4.3 assumes funding will be available to cover remediation efforts that will conclude by 2025 and reduce PCB loads to meet the WLA. There are numerous assumptions and unknowns at this point which may cause the remediation activities to extend beyond the 2025 time frame proposed.

The Baltimore Harbor PCB TMDL does not establish specific milestones or a timeframe in which the TMDL WLAs must be met. In accordance with the MS4 permit reporting requirements (Part V. A.e), the County plans to provide an annual update on progress towards attaining the PCB TMDL WLA, implementation status of the PCB TMDL restoration plan, and will make adjustments to the planned strategies as needed. The County plans to carry out a more comprehensive assessment of the effectiveness of this restoration plan in 2025, the timeframe for meeting the Chesapeake Bay TMDL, and complete additional modeling or make adjustments to the plan as needed to achieve any reductions remaining to meet the WLA. The County also plans to maintain communication with other jurisdictions working towards achieving PCB TMDL WLAs to share knowledge and information to further improve and accelerate the implementation.

The County proposes two-year PCB load goal milestones through 2025 as shown in Table 36. The milestones loads are based on reductions from Structural BMPs and Non-Structural BMPs strategies only. Numerical reductions from targeted PCB actions are currently omitted from the since the proposed implementation schedule hinges on too many uncertainties to comfortably include in the reductions in the milestones. However, completion of specific activities are noted along with the milestone loads to ensure the Targeted PCB Actions strategy is implemented.

Table 36: PCB TMDL WLA Goal Milestones

Milestone	Curtis Creek AACO – Goal PCB Load g/year	Baltimore Harbor AACO – Goal PCB Load g/year	Targeted PCB Actions – Activities
2017	233.62	405.78	Targeted PCB Actions Plan Initiated
2019	227.22	394.18	Targeted PCB Actions Plan Complete
2021	224.26	388.82	Screening and Monitoring Complete
2023*	221.67	383.46	
2025	218.27	372.60	
* Milestone loads at 2023 only include reductions only from Non-Structural BMPs strategy.			

6.2 Potential Funding Sources and Technical Needs

Cost estimates for each of three restoration plan strategies are presented in Section 5.2 and represent the financial needs of the County to meet the WLAs. In addition to providing specific dollar value estimates where possible, Section 5.2 also identified actions for which actual costs must be estimated in the future once additional information is gathered.

Watershed restoration efforts are primarily funded through the Watershed Protection and Restoration Fee/Fund (WPRF). Additional information regarding the WPRF can be found in the County's Annual MS4 Reports. The WPRF has provided funding for the 71 structural BMP stormwater pond retrofits already budgeted. A portion of the street sweeping and inlet cleaning is also funded through the WPRF in addition to the general DPW budget allocation. The WPRF will be relied upon as the primary funding source for carrying out the targeted PCB actions strategy. Additional funding sources for the targeted PCB actions strategy may also include any identifiable responsible parties. Outside of the WPRF, the County may seek financial support for PCB TMDL related activities through actively pursuing grant funding from federal, states, and non-governmental agencies.

Technical needs to meet the PCB TMDL WLAs depend on the specific activities required by each strategy. According to MDE guidance document, Final General Guidance for Developing Stormwater Wasteload Allocations (SW-WLA) Implementation Plan, MDE offers technical assistance to local governments through training, outreach and tools, and technical review and assistance of implementation of BMPs at the local level (MDE 2015c). In addition, the County has several contract vehicles available to contract with consultants to provide a variety of technical services. County DPW staff actively manage consultant contracts, review and approve plans and designs, carry out assessment, and track progress among many other tasks. Through contracting consultants, the County's staff has access to the additional technical support provided by planners, engineers, environment scientists and GIS specials.

6.3 Public Outreach and Involvement

The County supports a robust public outreach and involvement program as part of its Watershed Protection and Restoration Program. Specifics of the County's MS4 public outreach efforts are documented in the County's MS4 Annual Reports available on the County's website. Citizen education through public outreach and involvement reduces stormwater pollution by encouraging improved behavioral habits and providing support for small scale projects. This restoration plan does not account for PCB load reductions from public outreach and involvement activities.

Requirements for public involvement in the development of TMDL restoration plans are outlined in Part 4.E.3 of the County's MS4 permit. The County will fulfill these requirements by providing notice in a local newspaper outlining how the public may obtain information on the development of this restoration plan and opportunities for comment. The County will have a procedure for providing copies of this restoration plan to parties upon request. The County will allow for a minimum 30-day comment period before finalizing this restoration plan and will include a summary in the next annual report of how the County addressed or will address any material comment received from the public.

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Appendix A: Conversion of Event Mean Concentrations from TSS to PCBs

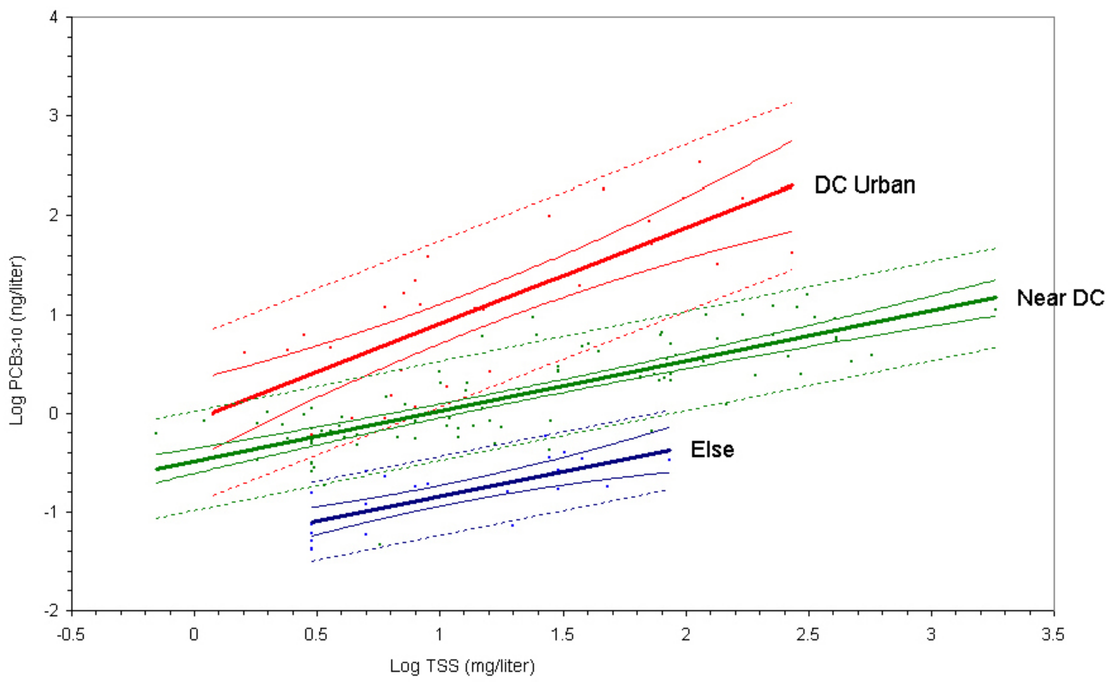
Event mean concentrations (EMCs) are important input components of the Watershed Treatment Model (WTM) that represent pollutant loading and are used in total load and load reduction calculations. Since limited data is available regarding PCB concentrations in urban stormwater runoff there are no available default values to use for PCB EMCs. As such, PCB EMCs were estimated by converting TSS EMCs. This conversion was based on the relationship between concentrations of TSS and PCBs documented in Appendix A of the Tidal Potomac and Anacostia River PCB TMDL (Haywood and Buchanan 2007) calculating PCB external loads for the Potomac PCB model.

The Tidal Potomac and Anacostia River PCB TMDL developed three regressions, one for each watershed-based zone including DC Urban, Near DC, and Else. The regressions relate concentration of TSS (mg/L) with the concentration of PCB3+ (ng/L), a subset of total PCBs, according to the following equations.

Zone	Regression Equation	Correlation Coefficient (r^2) and number of samples (n)
DC Urban	$[PCB3+] = 0.855\ [TSS]^{0.9702}$	0.61 (n=30)
Near DC	$[PCB3+] = 0.3290\ [TSS]^{0.5059}$	0.63 (n=94)
Else	$[PCB3+] = 0.0458\ [TSS]^{0.5008}$	0.52 (n=25)

Figure A-7 excerpted from Appendix A of the Tidal Potomac and Anacostia River PCB TMDL and shown below illustrates the regression equations and underlying data. DC Urban has the steepest regression, followed by Near DC, and Else resulting in significantly different [PCB3+] estimates when inputting the same TSS concentration into all three regressions.

Figure A-7. The TSS:PCB3+ regressions with their underlying data. Symbols: DC Urban, red squares and thick line; Near DC, green diamonds and thick line; Else, dark blue triangles and thick line; thin solid lines, 90th% confidence interval around the slopes; dashed lines, 90th% confidence intervals around the individual estimates of PCB3+ (prediction interval). See text for details. Note the scale is log-log.



The TSS EMCs converted using the above equations were those provided in the Patapsco Tidal and Bodkin Creek Watershed Assessment that have been compiled from literature sources or calculated directly from export coefficients used by the Chesapeake Bay Program (CBP) and are conservatively set to be equal to or greater than the values used by the CBP (Anne Arundel County 2012).

The regression used for each EMC was based on the land use type. Land uses where PCBs were historically used were assigned the DC Urban regression and all other land uses were assigned the Near DC regression.

The table below summarizes the land use, original TSS EMC, regression used, resulting EMC in terms on PCB3+ and the resulting EMC in terms of total PCBs. Values in terms of [PCB3+] are translated to total PCBs by dividing by 0.92. (See Appendix B of the Tidal Potomac and Anacostia River PCB TMDL for additional explanation regarding relationship between PCB3+ and total PCBs.) Note, unless otherwise specified, the term PCBs refers to total PCBs.

Land Use	**TSS EMC (mg/L)**	**Regression**	**PCB3+ EMC (ng/L)**	**PCB EMC (ng/L)***
Residential 1-acre	43	Near DC	2.21	2.39
Residential 1/2-acre	43	Near DC	2.21	2.39
Residential 1/4-acre	43	Near DC	2.21	2.39
Residential 1/8-acre	43	Near DC	2.21	2.39
Residential 2-acre	43	Near DC	2.21	2.39
Commercial	43	DC Urban	32.87	35.72
Airport	99	Near DC	3.36	3.66
Transportation	99	Near DC	3.36	3.66
Utility	34	DC Urban	26.17	28.44
Open Space	34	Near DC	1.96	2.12
Industrial	77	DC Urban	57.84	62.87
* PCB EMCs are expressed in ng/L for ease of comparison, however, the values are entered into the WTM as mg/L.				

Following the conversion of the TSS EMCs to PCB EMCs as detailed above, the values were further adjusted using a multiplier to calibrate the WTM as described in Section 4.1.