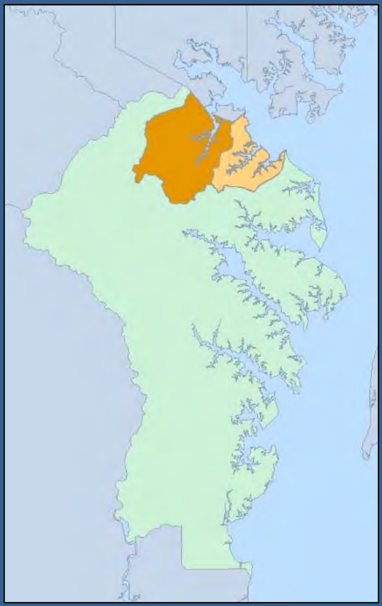


Baltimore Harbor and Curtis Creek/Bay Polychlorinated Biphenyls (PCB) TMDL Action Strategy

Final

Anne Arundel County, Maryland

July 2019

Anne Arundel County WATERSHED Protection & Restoration PROGRAM

Baltimore Harbor and Curtis Creek/Bay Polychlorinated Biphenyls (PCB) TMDL Action Strategy

July 2019

Prepared for:

Anne Arundel County
Department of Public Works
Watershed Protection and Restoration Program
2662 Riva Road, P.O. Box 6675
Annapolis, Maryland 21401

Prepared by:

Biohabitats, Inc.
2081 Clipper Park Road
Baltimore, Maryland 21211

Table of Contents

List of Tables

List of Figures

List of Acronyms

AACO	Anne Arundel County
BMP	Best Management Practice
BWI	Baltimore Washington International Airport
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulation
COMAR	Code of Maryland Regulations
Curtis Creek	Curtis Creek/Bay
DI	Deionized
DPW	Department of Public Works
DW	Dry Weather
EPA	U.S Environmental Protection Agency
g	Grams
IBI	Index of Biological Integrity
L	Liter
LA	Load Allocation
LDPE	Low Density Polyethylene
LRP	Land Restoration Program
MDE	Maryland Department of the Environment
mg	Milligrams
MS4	Municipal Separate Storm Sewer System
ng	Nanograms
NPDES	National Pollutant Discharge Elimination System
NRC	National Response Center
ODC	Other Direct Costs
PCBs	Polychlorinated Biphenyls
PDMS	Polydimethylsiloxane
POM	Polyoxymethylene
PRC	Performance Reference Compounds
QC	Quality Control
SW-WLA	Stormwater Waste Load Allocation
the County	Anne Arundel County
TMDL	Total Maximum Daily Load
TSCA	Toxic Substances Control Act
ug	Micrograms

VCP	Voluntary Cleanup Program
WLA	Waste Load Allocation
WPRP	Watershed Protection and Restoration Program
WQS	Water Quality Standard
WW	Wet Weather

1 Introduction and Background

Anne Arundel County's MS4 permit (11-DP-3316, MD0068306), issued by the Maryland Department of the Environment (MDE) in February of 2014, requires the development of Restoration Plans for each Total Maximum Daily Load (TMDL) with a Stormwater Wasteload Allocation (SW-WLA) approved by the EPA. In 2016, the Anne Arundel County Watershed Protection and Restoration Program (WPRP) developed a Restoration Plan to address local water quality impairments identified in the TMDL for Polychlorinated Biphenyls (PCBs) in Baltimore Harbor, Curtis Creek/Bay and Bear Creek Portions of Patapsco River Mesohaline Tidal Chesapeake Bay Segment (2012). The Restoration Plan was submitted to MDE in February 2017. Following MDE Recommendations for Addressing the PCB SW-WLA (MDE 2015), the Restoration Plan generally lays out efforts to conduct desktop screening and monitoring at select locations.

The purpose of this document is to layout a Targeted Action Strategy which builds upon the Restoration Plan by identifying a monitoring strategy to investigate and eventually address, elevated, site-specific sources of PCB pollution, if identified. Using a pilot catchment approach, the Targeted Action Strategy includes updated source tracking efforts, monitoring site selection, screening and monitoring strategies, options for handling PCB-contaminated sediments, and estimated costs and implementation schedule for monitoring. Monitoring goals include:

- Link tributary contamination to upland sources by using a mix of passive sampling and grab samples to track sources
- Verify desktop source tracking analysis approach by comparing desktop results to monitoring results for sites with significant potential for PCB contamination
- Provide specific direction for the next steps in the process of investigating watershed sources
- Inform a strategy that focuses future restoration efforts on targeting specific sites with likely PCB pollution.

1.1 PCBs Background

PCBs are a group of manmade chemicals comprised of 209 biologically and chemically stable congeners, which do not readily breakdown and bind strongly to sediment. PCBs are soluble in organic and hydrocarbon solvents and are slightly soluble in water. Of the 209 congeners, the most commonly used mixture of congeners is called Arochlor. PCBs were manufactured and widely used from 1929 to 1979 in caulk, paints, dyes, motor oil, and electrical equipment, such as transformers. PCBs were banned in 1979 due to their impacts on human health and the environment, however, they are still found in older vehicles and electronics, in the soils of industrial areas where PCBs were manufactured, and in older buildings where PCB laden caulk and paint were used (EPA, 2018).

2 Pilot Catchment Screening

To better understand and characterize PCB sources in the Baltimore Harbor Embayment and Curtis Creek, a pilot catchment was identified to target the development of a comprehensive monitoring strategy. The selection of the pilot catchment was based on the results of the desktop screening and field verification which are described in further detail below.

Desktop screening of potential pilot catchments was conducted prior to field verification to identify locations of potential PCB contamination and catchment characteristics. Baltimore

Harbor and Curtis Creek catchments are depicted in **Figure 1**. Based on a combination of MDE written guidance and comments and discussions with WPRP staff, catchments were screened for the following:

- Potential sources of PCB soil contamination via the following sources (tiers indicate whether source is more directly related to PCBs than others) (MDE, 2015):
    - Tier 1 Sites:
        - EPA PCB Transformer Registry Database
        - MDE Land Restoration Program (LRP) (sites where PCB soil contamination is confirmed)
        - National Response Center (NRC) Database
    - Tier 2 Sites:
        - MDE LRP (sites where hazardous contamination exists, but PCBs unconfirmed)
    - Tier 3 Sites:
        - Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA; also known as Superfund) Sites Database
    - Additional sites per MDE comments (MDE, 2017):
        - Industrial stormwater and surface dischargers associated with potential historical use or storage of PCB contaminating equipment and inadvertent production
        - PCB era buildings on public property
- Additional screening factors:
    - Catchment area
    - Catchment imperviousness
    - Structural Best Management Practices (BMPs) with potential for PCB soil contamination
        - Priority and Post-2011 BMPs
    - Presence of/access to tidal and non-tidal waters
    - Number of inlets

The results of the desktop screening are summarized in **Tables 1 and 2** below.

Table 1: Potential Sources of PCB Soil Contamination

Catchment Name	Catchment ID	Tier 1			Tier 2	Tier 3	Industrial Site Count	PCB Era Public Buildings	Total Sites with Potential PCB Soil Contamination
		PCB Transformer Count	LRP Site Count	NRC Count	LRP Site Count[1]	CERCLA Count			
Stony Creek	PT0	0	0	0	0	1	0	5	6
Unnamed Tributary	PT1	0	0	0	0	0	0	1	1
Cabin Branch 2	PT2	0	0	0	1	0	0	0	1
Cabin Branch	PT3	0	1	0	6	2	1	4	14
Swan Creek	PT4	0	1	0	0	0	0	0	1
Furnace Creek	PT5	0	0	1	2	0	1	4	8
Curtis Creek	PT6	0	0	0	4	1	1	0	8
Sawmill Creek 1	PT7	0	0	1	1	1	2	6	11
Marley Creek 1	PT8	0	0	0	2	1	0	3	6
Cox Creek	PT9	0	0	0	5	0	1	0	6
Patapsco Tidal	PTA	0	0	0	0	0	0	0	0
Rock Creek	PTB	0	0	0	1	1	0	2	4
Back Creek	PTC	0	0	0	1	0	1	1	3
Sawmill Creek 2	PTD	0	0	0	0	0	0	1	1
Marley Creek 2	PTE	0	0	0	0	0	0	1	1
Marley Creek 3	PTF	0	0	0	3	0	0	6	9
Marley Creek 4	PTG	0	0	0	1	0	0	4	5
Nabbs Creek	PTH	0	0	0	0	0	0	0	0
Patapsco Tidal	PTI	0	0	0	0	0	0	0	0
Patapsco Tidal	PTJ	0	0	0	0	0	0	0	0
Patapsco Tidal	PTK	0	0	0	0	0	0	0	0

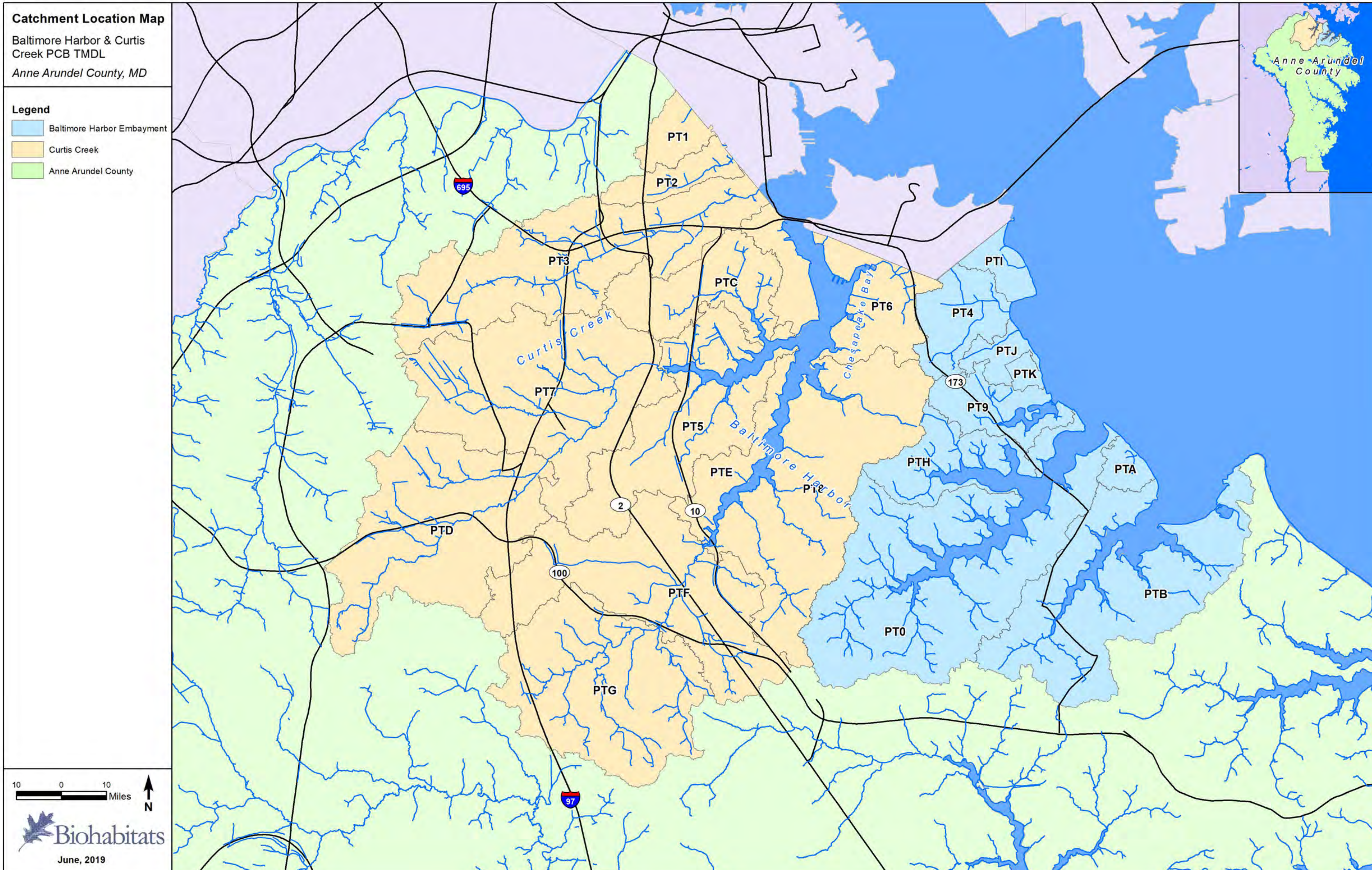
1: PCB presence unconfirmed

Table 2: Additional Desktop Screening Factors

Catchment ID	Total Area (ac)	Imperviousness (%)	Priority Structural BMPs Count[1]	Post 2011 BMP Count[2]	Inlets Count	Access to Tidal Waters	Access Rating[3]
PT0	3,367	24	7	13	571	Y	1
PT1	311	44	1	0	129	N	1
PT2	370	30	0	0	110	N	1
PT3	2,669	30	8	3	331	Y	1
PT4	652	17	3	0	20	Y	2

Catchment ID	Total Area (ac)	Imperviousness (%)	Priority Structural BMPs Count[1]	Post 2011 BMP Count[2]	Inlets Count	Access to Tidal Waters	Access Rating[3]
PT5	1,856	41	14	7	297	Y	1
PT6	1,178	32	11	6	11	Y	2
PT7	2,914	42	27	3	476	Y	2
PT8	2,767	17	1	10	156	Y	1
PT9	544	39	7	0	101	Y	3
PTA	181	38	0	0	59	Y	1
PTB	2,574	23	4	5	367	Y	1
PTC	1,045	44	18	1	189	Y	1
PTD	2,684	22	8	4	53	N	2
PTE	492	34	0	3	83	Y	1
PTF	2,517	41	15	6	513	Y	1
PTG	2,518	34	23	8	493	N	1
PTH	688	15	1	0	60	Y	1
PTI	242	13	0	0	0	N	3
PTJ	215	35	1	0	0	Y	5
PTK	85	32	0	0	0	Y	5

1: Priority level is based on land use type, drainage area within land use, and type of BMP (Anne Arundel County WPRP, 2016)
2: Included BMP types Bioretention, Extended Dry Detention, Dry Pond, and Extended detention wet
3: 1 = easy, 5 = difficult; based on best professional judgement, considering land use and property types


Catchment Location Map
Baltimore Harbor & Curtis Creek PCB TMDL
Anne Arundel County, MD
Legend
Baltimore Harbor Embayment
Curtis Creek
Anne Arundel County
10 0 10 Miles
N
Biohabitats
June, 2019
Anne Arundel County
Curtis Creek
Baltimore Harbor
Chesapeake Bay
PT1
PT2
PT3
PTC
PT6
PTI
PT4
PTJ
PTK
PT9
PT7
PT5
PTE
PTH
PTA
PTD
PTF
PTG
PT0
PTB
695
97
2
10
100
173

Catchments were narrowed down to a list of candidate catchments for field verification using the results of the desktop screening. Discussions with WPRP staff resulted in an initial list of potential pilot catchments. The list was narrowed down further once additional data, such as post-2011 BMPs, were considered. This process also identified potential catchment groupings to create more viable monitoring opportunities. Catchments considered candidates for field verification are identified in **Table 3**.

Table 3: Catchment Selection for Field Verification

Catchment ID	Candidate for Field Verification?	Rationale/ Notes
PT0	**Yes**	**Potentially group with adjacent PTH**
PT1	No	No tidal access
PT2	No	No significant sites of potential PCB contamination; no tidal access
PT3	No	Large non-MS4 area makes continuous sampling difficult
PT4	No	No tidal access via MS4 area
PT5	No	Few sites that may contain PCB contamination
PT6	No	Primarily consists of non-MS4 area
PT7	**Yes**	**Variety of areas/sources of interest**
PT8	No	Few sites that may contain PCB contamination
PT9	No	Limited stream network for receiving water monitoring
PTA	No	No significant sites of potential PCB contamination
PTB	No	Few sites that may contain PCB contamination
PTC	No	Limited stream network for receiving water monitoring
PTD	No	Large non-MS4 area makes continuous sampling difficult
PTE	No	Large non-MS4 area makes continuous sampling difficult
PTF	**Yes**	**Potentially group with PTG (directly upstream catchment)**
PTG	**Yes**	**Potentially group with PTF (directly downstream catchment); variety of areas/sources of interest**
PTH	**Yes**	**Potentially group with adjacent PT0**
PTI	No	Large non-MS4 area makes continuous sampling difficult; no significant sites of potential PCB contamination; no tidal access via MS4 area
PTJ	No	No significant sites of potential PCB contamination
PTK	No	No significant sites of potential PCB contamination

2.1 Pilot Catchment Selection: PT7

Based on the monitoring goals and the results of the desktop and field screening, Catchment PT7 is the selected catchment for the pilot monitoring strategy. There were several key factors included in the decision-making process for choosing a pilot catchment. These included good stream access, a mix of potential PCB hotspots, and the ability to use a trackback method (see Section 3.3, Monitoring Strategy Recommendations) within the stream network. The Catchment PT7 met all these criteria and additionally, there is currently a monitoring effort underway by Anne Arundel County to investigate the Index of Biotic Integrity throughout the Sawmill Creek watershed. Stream access is essential to monitoring, and through the Sawmill Creek monitoring effort, many locations are already identified as accessible. Additional sampling locations were identified via desktop review and field verified.

Catchment PT7 is located in the western portion of the Curtis Creek watershed in Anne Arundel County, MD. Catchment PT7 encompasses a portion of the Sawmill Creek subwatershed. The catchment covers 2,914 acres with 1,974 acres included in the MS4 permit. The western most portion of the catchment is occupied by Baltimore/Washington Thurgood Marshall International Airport (BWI), which is not part of Anne Arundel County's MS4 permit or subject to the PCB TMDL. There are also several Maryland state roadways in the catchment that are not part of the County's MS4 permit, including Interstate 97 and Route 100.

There are no confirmed PCB contaminated sites within Catchment PT7, however several sites were identified as having potential for PCB release. This includes a NRC site, a LRP site, a Comprehensive Environmental Response, CERCLA site, industrial sites, and PCB era public buildings. A summary of potential PCB sources is provided in **Table 4**.

BMPs were also analyzed and ranked by priority as locations where PCB-contaminated soils may have collected. Priority was based on land use type, drainage area, and type of BMP. BMPs after 2011 that are bioretention facilities, extended dry detention, dry pond, and extended detention types were also identified. An existing conditions map of Catchment PT7 is provided as **Figure 2**.

The existing index of biological integrity (IBI) Sawmill Creek monitoring sites will be used as sampling sites, when possible. Many of the existing sites are located above a confluence which lends well to the trackback method. There are 15 established sites, nine of which will be used in the proposed monitoring strategy.

Table 4: Potential PCB Sources in Catchment PT7

Potential PCB Source	Site Name	Status
Industrial Sites	Metal Recycling Center	Active
	EJ Enterprises	No longer in operation
Tier 2 LRP Site[1]	Carousel Cleaners	No longer in operation
Archived CERCLA Site	Alco-Gravure	No longer in operation
NRC Potential PCB Spill Site	106 Oak Ave; BGE Utility Pole Transformer in ROW	Isolated incident in 2001; Transformer down in road due to broken utility pole; BGE responded, contained, and cleaned up spill
PCB Era Public Buildings	George Cromwell Elem School	Undergoing renovations
	Ferndale Early Education Center	Renovated in 2003 and 2007
	Lindale Jr High School	Some renovations made in 1996
	North Glen Elementary School	Renovated in 2015
	Corkran Jr High School	Built in 1962; no known renovations to date
	Richard Henry Lee Elementary	Renovations underway

1: LRP sites where hazardous contamination is known to exist, but PCBs have not been confirmed

PT7 Existing Conditions

Baltimore Harbor & Curtis Creek PCB TMDL

Anne Arundel County, MD

Legend

- Sawmill Monitoring Sites
- Industrial Sites
- Tier 1 LRP Sites
- Tier 2 LRP Sites
- Archived CERCLA Sites
- NRC Potential PCB Spill Sites
- Priority BMPs
- Post 2011 BMPs
- Roads
- Streams
- PCB Era Public Buildings
- Non-MS4 Area
- MS4 Area

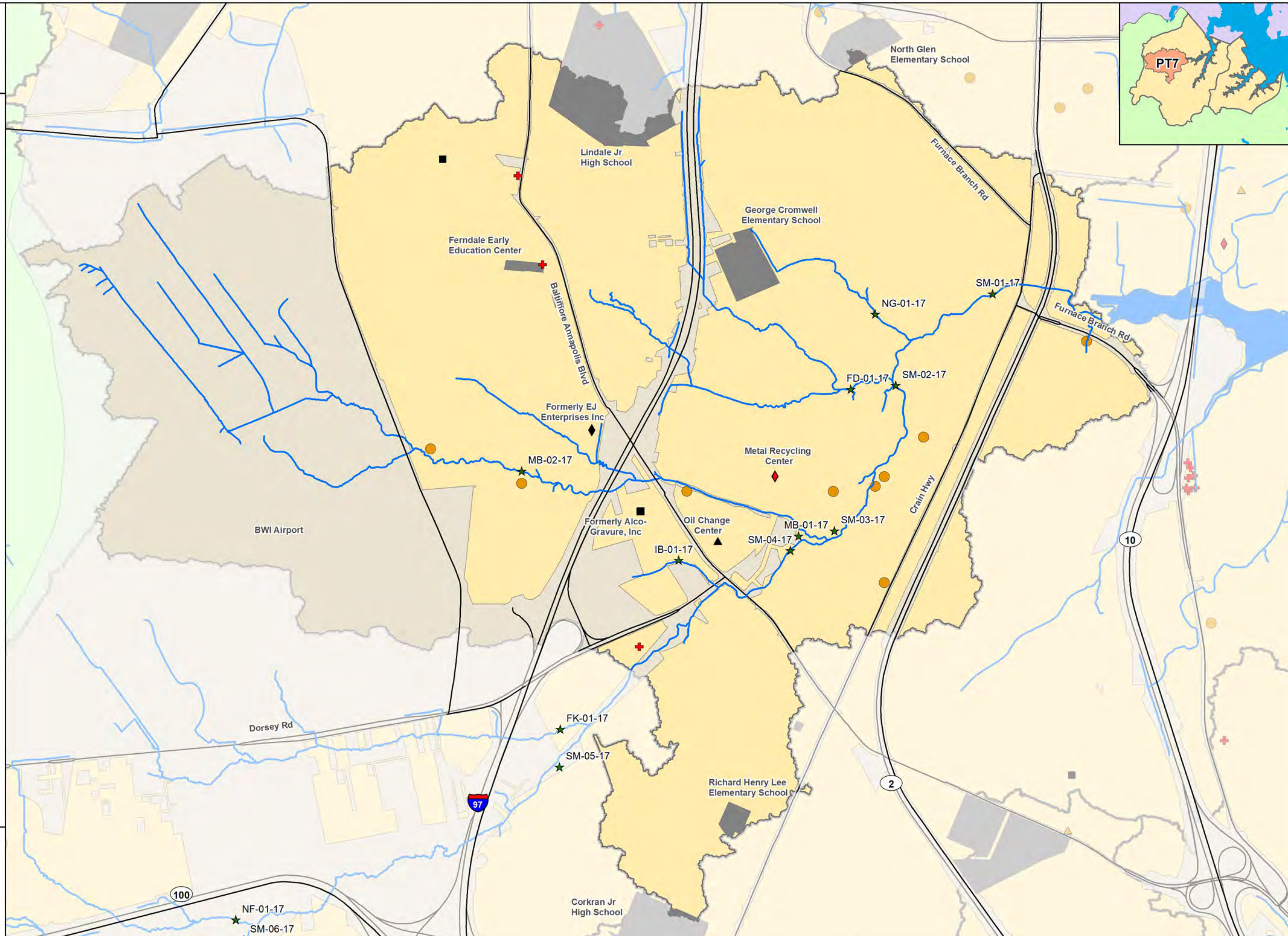
Symbols that appear black are no longer in business or active.

0 3 6 Miles

N

Biohabitats

June, 2019



3 Monitoring Strategy

3.1 Sampling Options

Several media types will be collected to create a comprehensive picture of potential PCB sources within Catchment PT7: sediment, stormwater runoff, and receiving water:

- Sediment – will be collected using grab samples. Surface sediment will be collected by grab samples in areas near potential hotspots that have no available stormwater collection point. Sediment samples will also be collected at receiving water and stormwater monitoring sites, where possible.
- Stormwater – will be sampled by grab samples in the stormwater collection system. Passive sampling is not an option at stormwater sites since continuous exposure over an extended period of time is needed to achieve PCB concentration equilibrium. In addition, a precipitation sample will be collected and analyzed for PCB levels.
- Receiving waters – passive samples will be collected to determine a PCB contribution baseload. Grab samples will be collected during dry and wet weather to supplement the understanding of PCBs in receiving water and potential contributions.

Sediment and stormwater grab samples will be taken during storm events that produce sufficient runoff. Sampling events will target storms >0.2" to ensure adequate runoff volume can be obtained for laboratory analysis. Additionally, grab sampling events will target storms where there is no precipitation for at least the preceding three days.

Passive sampling is a relatively new sampling method. Passive samplers will be submerged directly in the receiving water stream. These samplers adsorb PCBs in the stream over a period of time. Passive samples are recommended across all receiving water sites, where sufficient depth exists. After a period of two months, field crews will collect and send the samplers to the laboratory for analysis.

There are several steps to complete before and after deployment of passive samplers for receiving water sampling. The first step is to obtain a material for the sampling media. Three materials are commonly used: low density polyethylene (LDPE), Polyoxymethylene (POM), and Polydimethylsiloxane (PDMS). LDPE is the most readily available, has a low cost, and high durability. POM is more difficult to obtain, requires hand cutting to get into sheets, and is more fragile than LDPE. However, POM has a high accuracy for analysis. PDMS has the fastest equilibrium, but is very fragile, not well suited for water column deployment, and has a lower analytical accuracy when compared to LDPE or POM (USEPA, 2017). For the purposes of this study, LDPE is the recommended sampling media and is the media used by SiREM, the proposed passive sampler analysis lab.

The second step is to deploy the sampling material in a protective structure, which can be in a plastic frame, an aluminum frame, mesh envelope, or copper tubing, depending on the sampling and deployment media. For instance, if LDPE is chosen for the sampling media, an aluminum or copper mesh could be used for receiving water sampling, or an aluminum frame for submersion into receiving waters. Once the samplers are deployed, it takes 28 days minimum to obtain equilibrium (USEPA, 2012). To ensure equilibrium is achieved, passive samplers will be deployed for two months.

Additionally, this study will establish a precipitation (rainwater) collection site. The results from the precipitation site will help to identify baseline levels of PCBs in precipitation. This collection will occur in an open space such as a rooftop. Monitoring will occur a few times over the course of the monitoring study to capture potential variations in seasonality. The monitoring station will be identified with County staff and/or the local analysis laboratory (Test America) staff.

Quality assurance procedures for sampling are provided in **Appendix A.**

3.2 Laboratory Analysis

The sediment and water samples will be sent to an independent lab for analysis. There are two primary EPA Methods used to analyze PCB concentrations: EPA Methods 8082 and 1668A. EPA Method 8082 is less costly but has a higher detection limit compared to EPA Method 1668A, which costs more but has lower detection limits. In addition to the detection limits, EPA Method 1668A can detect 209 congeners, while EPA Method 8082A can detect either 19 of the congeners specific to the Aroclor formations or 28 congeners (EPA 8082A_con). The EPA Method 8082A minimum detection limit is 0.1 to 0.5 parts per billion compared to EPA Method 1668A's minimum detection limit of 0.3 to 0.8 parts per trillion. A summary of the methods is provided in **Table 5 – 7.**

For passive and grab samples, it is recommended to start Phase 1 and 2 passive, grab, and sediment monitoring of the trackback approach with EPA Method 1668A to identify specific congeners that may be associated with a source or industry and utilize low detection levels needed to distinguish background from potential sources. If the results are consistently higher than the EPA 8082A_con detection limit, then EPA Method 8082A_con may be considered for subsequent monitoring phases.

Precipitation samples should be analyzed at the laboratory using EPA Method 1668 to detect potentially low levels of PCBs.

Table 5: Summary of PCB Laboratory Analysis Methods

Lab	Method	Detection Limits	Cost	Notes
Test America	EPA 8082A	0.1 – 0.5 ppb	$70	Detects 19 congeners specific to the Aroclor formations
Test America	EPA 8082A_con	0.1 – 0.5 ppb	$180	Detects 28 congeners
SiREM Lab	EPA 1668A	0.3 – 0.8 ppt	$1200	Detects all 209 individual congeners; includes the cost of the sampler (preloaded with PRCs), the analytical, the calculations to convert the data to Cfree and reporting

Table 6: Grab Sample Preservation and Holding Times

Method	Matrix Sample	Collection Time	Container	Preservative	Prep/ Analysis Holding Time	Volume
EPA 1668A	Water	During Precipitation Event and Dry Weather	Amber glass; Teflon lined lid	Cool ≤6° C	1 yr/ 1 yr	2 L
	Sediment	During Dry Weather[1]	Amber glass; Teflon lined lid	Cool ≤6° C	1 yr/ 1 yr	10 g

1: Dry weather is considered 3 days without a rain event

Table 7: Passive Sample Preservation and Holding Times

Method[2]	Matrix Sample	Collection Time	Container	Preservative	Prep/Analysis Holding Time
EPA 8082A_con	Water	During Dry Weather[1]	Amber glass; Teflon lined lid	Cool ≤6° C	1 yr/ 1 yr
EPA 1668A	Water	During Dry Weather[1]	Amber glass; Teflon lined lid	Cool ≤6° C	1 yr/ 1 yr

1: Dry weather is considered 3 days without a rain event
2: While several methods can be used for grab samples, it is recommended that only methods that identify individual congeners (vs Aroclors) be used for passive samplers (USEPA, 2017)

3.3 Monitoring Strategy Recommendations

The recommended PCB monitoring strategy for Catchment PT7 is a trackback approach. The source analysis did not identify any confirmed sources of PCBs within Catchment PT7, so the trackback strategy is the suggested sampling approach as described in the draft, "Guidance for Using Trackdown Studies to Reduce PCB Loads" (Tetra Tech, 2016).

Under a trackback approach, monitoring is conducted in phases. The first phase starts at the lowest point(s) in the catchment and works upstream to determine the presence or absence of PCBs. If PCBs are present, then the next phase of monitoring focuses on narrowing down the sources to specific stream reaches or drainage areas. The definition of elevated PCB presence is discussed further under the subsection, Interpretation of Results.

Desktop and field efforts identified potential monitoring sites and phases to support a trackback strategy for Catchment PT7. Recommended sites and phases are described below and depicted in **Figures 3 and 4**. Depending on results, the County may want to adjust subsequent monitoring sites to better narrow down potential source areas.

Phase 1: This phase monitors sites at the most downstream portions of PT7 and establishes a precipitation site. The precipitation site will help establish aerial contribution to background PCB levels. These sites are summarized in **Table 8**.

Table 8: Phase 1 Monitoring Stations

Phase 1 Station ID[1]	Sample Type	Grab DW[2]	Grab WW[3]	Sediment	Passive	Notes
SM-01-17	Receiving water	X	X	X	X	Existing monitoring station; most downstream site in PT7
NG-01-17	Receiving water	X	X	X	X	Existing monitoring station
FD-01-17	Receiving water	X	X	X	X	Existing monitoring station
SM-02-17	Receiving water	X	X	X	X	Existing monitoring station
PT7-PPT-01	Precipitation		X			New rainwater site; location TBD

1: Monitoring sites that begin with "PT7" are new proposed monitoring sites
2: DW = dry weather
3: WW = wet weather

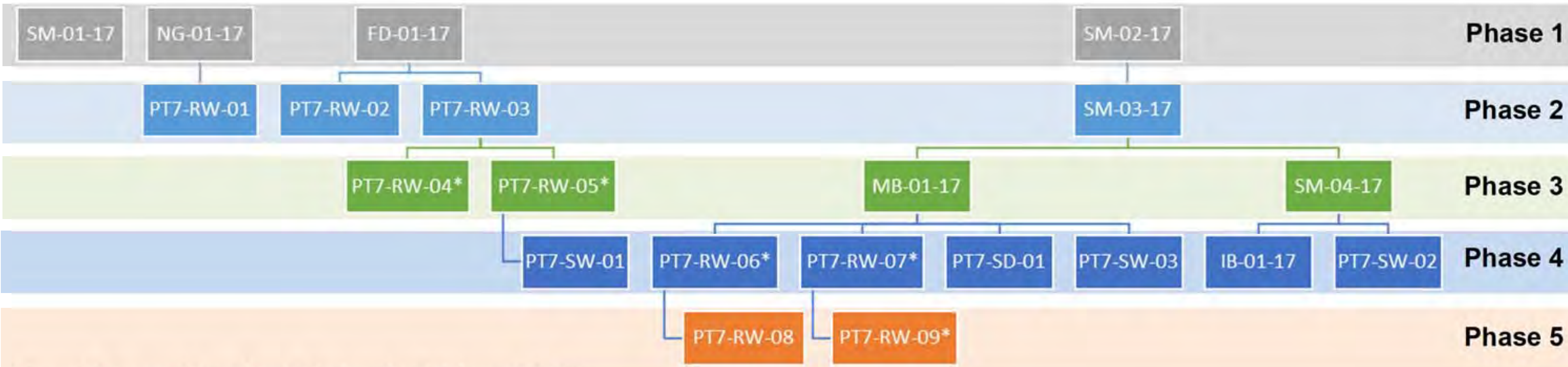
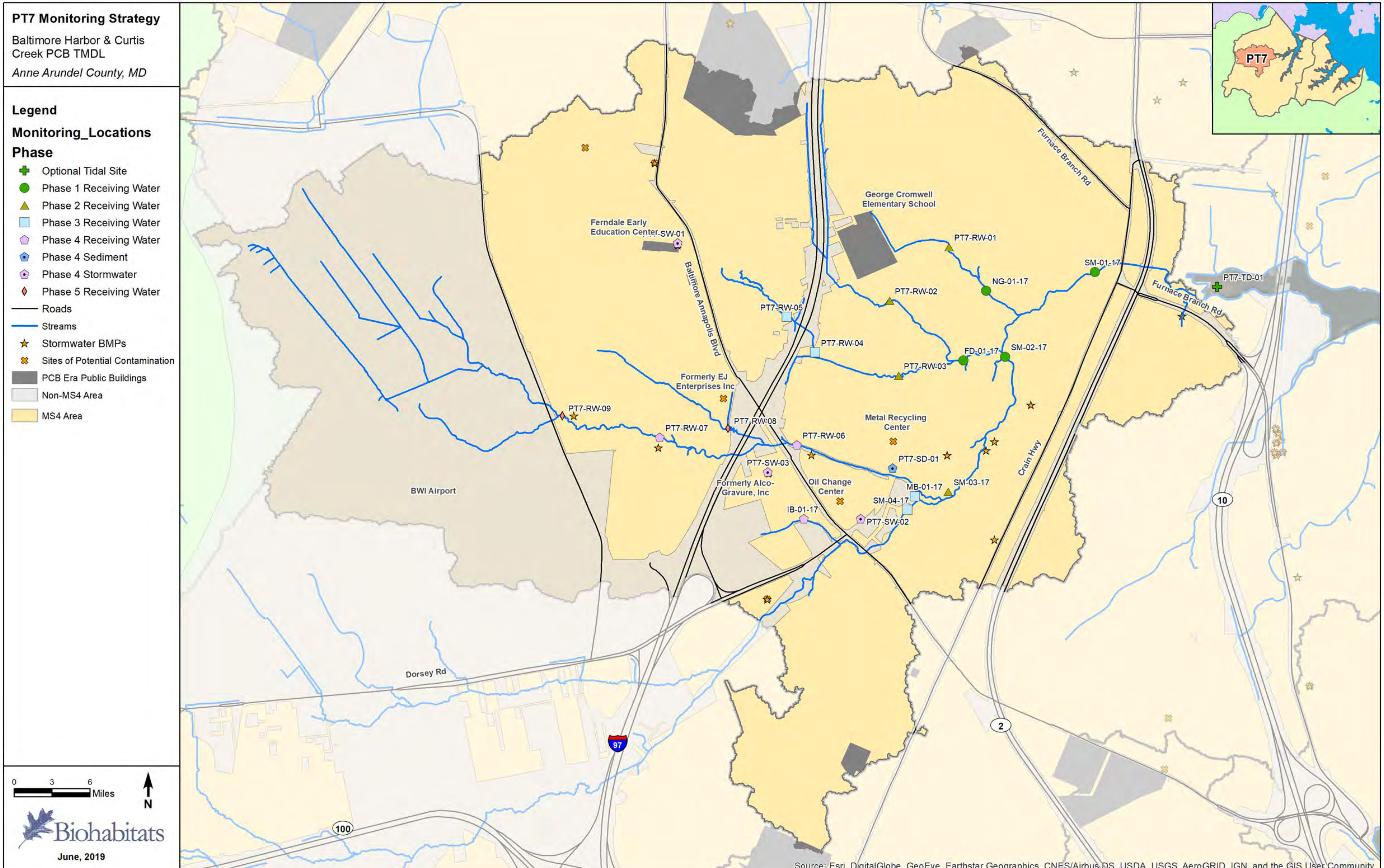


Figure 3: Proposed Trackback Strategy for Catchment PT7**

*Special Consideration Monitoring Site; recommend that County monitor these sites regardless of the trackback results to define the potential PCB contribution from non-MS4 areas

** Optional tidal monitoring site (PT7-TD-01) and precipitation site (PT7-PPT-01) not depicted in this figure



PT7 Monitoring Strategy
Baltimore Harbor & Curtis Creek PCB TMDL
Anne Arundel County, MD
Legend
Monitoring_Locations
Phase
Optional Tidal Site
Phase 1 Receiving Water
Phase 2 Receiving Water
Phase 3 Receiving Water
Phase 4 Receiving Water
Phase 4 Sediment
Phase 4 Stormwater
Phase 5 Receiving Water
Roads
Streams
Stormwater BMPs
Sites of Potential Contamination
PCB Era Public Buildings
Non-MS4 Area
MS4 Area
0 3 6 Miles
N
Biohabitats
June, 2019
PT7
George Cromwell Elementary School
Ferndale Early Education Center
PT7-SW-01
Baltimore Annapolis Blvd
Furnace Branch Rd
PT7-RW-01
NG-01-17
SM-01-17
PT7-TD-01
PT7-RW-02
PT7-RW-05
PT7-RW-04
FD-01-17
SM-02-17
PT7-RW-03
Formerly EJ Enterprises Inc
PT7-RW-09
PT7-RW-07
PT7-RW-08
PT7-RW-06
Metal Recycling Center
PT7-SD-01
PT7-SW-03
Formerly Alco-Gravure, Inc
Oil Change Center
MB-01-17
SM-03-17
SM-04-17
IB-01-17
PT7-SW-02
Crain Hwy
BWI Airport
Dorsey Rd
97
100
2
10
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Phase 2: Phase 2 sites will be monitored and compared against results from the Phase 1 monitoring to begin to understand potential sources and background levels of PCBs in receiving waters. Phase 2 sites are identified in **Table 9**.

Table 9: Phase 2 Potential Monitoring Sites

Phase 1 Station ID	Phase 2 Station ID[1]	Sample Type	Grab DW[3]	Grab WW[4]	Sediment	Passive	Notes
NG-01-17	PT7-RW-01	Receiving water	X	X	X	X	Downstream from George Cromwell Elementary School
FD-01-17	PT7-RW-02	Receiving water	X	X	X	X	Upstream of FD-01-17 on northern tributary
	PT7-RW-03	Receiving water	X	X	X	too shallow	Upstream of FD-01-17 on southern tributary
SM-02-17	SM-03-17	Receiving water	X	X	X	X	Upstream of SM-02-17
n/a	PT7-TD-01[2]	Receiving water	X	X	X	X	Optional site; monitoring may be conducted if Phase 1 and Phase 2 PCB levels are not elevated

1: Monitoring sites that begin with "PT7" are new proposed monitoring sites
2: Optional site; see notes
3: DW = dry weather
4: WW = wet weather

Phase 3: If PCBs are present at any of the Phase 2 sites, then sampling would continue at the corresponding upstream site(s) as identified in **Table 10**.

Table 10: Phase 3 Potential Monitoring Sites

Phase 2 Station ID[1]	Phase 3 Station ID[2]	Sample Type	Grab DW[4]	Grab WW[5]	Sediment	Passive	Notes
PT7-RW-03	PT7-RW-04[3]	Receiving water	X	X	X	X	Downstream of 97; also see Special Considerations
	PT7-RW-05[3]	Receiving water	X	X	X	X	Upstream of 97; also see Special Considerations
SM-03-17	MB-01-17	Receiving water	X	X	X	X	Existing monitoring station
	SM-04-17	Receiving water	X	X	X	X	Existing monitoring station

1: Do not anticipate monitoring Phase 2 sites in Phase 3. Phase 2 sites provided for reference to illustrate the hierarchy of the trackback strategy (also see Figure 3)
2: Monitoring sites that begin with "PT7" are new proposed monitoring sites
3: Special Consideration Monitoring Site; recommend that the County monitor these sites regardless of the trackback results to define the potential PCB contribution from non-MS4 areas
4: DW = dry weather
5: WW = wet weather

Phase 4: Phase 3 sites with PCBs present should proceed to subsequent Phase 4 sites (**Table 11**). In this Phase, several monitoring sites have reached the top of the stream network and therefore monitoring should focus on narrowing down specific sources of upland PCBs.

Table 11: Phase 4 Potential Monitoring Sites

Phase 3 Station ID[1]	Phase 4 Station ID[2]	Sample Type	Grab DW[4]	Grab WW[5]	Sediment	Passive	Notes
PT7-RW-05	PT7-SW-01	Stormwater		X	X	n/a	Runoff from portion of Ferndale Early Education Center
MB-01-17	PT7-RW-06[3]	Receiving water	X	X	X	X	Downstream of 97; also see Special Considerations
	PT7-RW-07[3]	Receiving water	X	X	X	X	Upstream of 97; also see Special Considerations
	PT7-SD-01	Sediment		n/a	X	n/a	Just outside Metal Recycling Center; stormwater monitoring not feasible due to lack of curb and gutter and safety/access concerns
	PT7-SW-03	Stormwater		X	X	n/a	Runoff from portion of Archived CERCLA site; monitoring potentially difficult here due to level of truck traffic
SM-04-17	IB-01-17	Receiving water	X	X	X	too shallow	Downstream of archived CERCLA site; existing monitoring station
	PT7-SW-02	Stormwater		X	X	n/a	Runoff from former Tier 2 LRP Site (Carousel Cleaners)

1: Do not anticipate monitoring Phase 3 sites in Phase 4. Phase 3 sites provided for reference to illustrate the hierarchy of the trackback strategy (also see Figure 3)
2: Monitoring sites that begin with "PT7" are new proposed monitoring sites
3: Special Consideration Monitoring Site; recommend that the County monitor these sites regardless of the trackback results to define the potential PCB contribution from non-MS4 areas
4: DW = dry weather
5: WW = wet weather

Phase 5: This last phase ends at the headwaters of PT7. Monitoring of the sites in **Table 12** will depend on the results of Phase 4. Additional monitoring may be warranted to further narrow down specific sources of PCBs within the catchment.

Table 12: Phase 5 Potential Monitoring Sites

Phase 4 Station ID[1]	Phase 5 Station ID[2]	Sample Type	Grab DW[4]	Grab WW[5]	Sediment	Passive	Notes
PT7-RW-06	PT7-RW-08	Receiving water	X	X	X	X	Downstream of former industrial site, EJ Enterprises
PT7-RW-07	PT7-RW-09[3]	Receiving water	X	X	X	X	Existing monitoring station

1: Do not anticipate monitoring Phase 4 sites in Phase 5. Phase 4 sites provided for reference to illustrate the hierarchy of the trackback strategy (also see Figure 3)
2: Monitoring sites that begin with "PT7" are new proposed monitoring sites
3: Special Consideration Monitoring Site; recommend that the County monitor these sites regardless of the trackback results to define the potential PCB contribution from non-MS4 areas
4: DW = dry weather
5: WW = wet weather

3.3.1 Special Considerations

Monitoring downstream of BWI and above and below Interstate 97 is recommended in order to define potential PCB contributions from non-MS4 areas. These sites are imbedded within the trackback strategy presented above, however they should be monitored regardless of the results from downstream sites. The monitoring station IDs for these sites are as follows:

- PT7-RW-04 and PT7-RW-05: above and below I-97
- PT7-RW-06 and PT7-RW-07: above and below I-97
- PT7-RW-09: below BWI

3.3.2 Interpretation of Results

Interpretation of monitoring results from each phase will inform and shape monitoring of subsequent phases as the County works to narrow down potential specific sources of PCBs. As PCBs are ubiquitous in the environment, identifying the right mechanisms for determining PCB presence is necessary to identify hotspots amongst the noise.

A combination of Phase 1 receiving water and precipitation monitoring results will be used to establish background levels of PCBs. Background levels combined with comparison against appropriate standards (summarized in **Tables 13 and 14**) will help to identify sites with elevated levels of PCBs. The results from the first two phases of monitoring will be used to calibrate elevated PCB levels for catchment PT7.

In addition to looking at concentrations of PCBs, the analysis of monitoring results will also look at the types of congeners identified at each stage. This will help to identify sources or changes and additions in sources as monitoring moves upstream.

Table 13: Applicable Maryland PCB Water Quality Standards (Source: MDE, 2012)

Type	PCB Water Quality Standard[1]
Human Health	0.64 ng/L (0.00064 ppb)
Freshwater Aquatic Life	14 ng/L (0.014 ppb)
Sediment	180 ng/g[2] (180 ppb)

1: ppb conversion provided for comparison with EPA method detection limits
2: Not an official WQS; corresponds to the Effect Range Median in accordance with methodology developed to assess toxic impairments in sediment

Table 14: Additional PCB Standards

Standard	PCB Level[1]
Water Column TMDL Endpoint	0.27 ng/L (0.00027 ppb)
Sediment TMDL Endpoint	3.1 ng/g (3.1 ppb)
Sediment Quality Guideline (SGQ) Threshold Effects Level (TEL)	21.6 ng/g (21.6 ppb)
Voluntary Cleanup Program Soils Standards Residential/ Non-Residential	3.20E-01 / 1.4E+00 mg/kg (320 / 1400 ppb)

1: ppb conversion provided for comparison with EPA method detection limits

4 Remediation

If a County-owned site is identified as a source of PCB contamination, the County will work with EPA and MDE to identify the appropriate actions to control and remediate the contamination. If the site is privately owned, the County will report the contamination to EPA. The Toxic Substances Control Act (TSCA) gives EPA the authority to regulate PCBs. Regulation under TSCA depends on a combination of contamination date and concentration of PCBs. Any soil or sediments containing PCBs ≥ 50 mg/kg are regulated for cleanup under TSCA. TSCA also regulates soil or sediments containing between 2 and 50 mg/kg that were spilled after 1978 from a source ≥ 50 mg/kg.

If EPA determines that a site is not regulated under TSCA and/or no action is required, the County will work with MDE Land and Materials Administration's Land Restoration Program (LMA-LRP). The Voluntary Cleanup Program (VCP) is the primary option to address PCB remediation at sites with no EPA oversight.

As part of the strategy to achieve PCB reductions, a sediment handling and disposal memorandum was developed and is provided in **Attachment B**. This memo provides additional detail on permitting and regulatory requirements for PCB remediation. Sediment disposal methods and locations, emerging technologies for remediating contaminated soils, and recommendations are also reviewed.

5 Implementation Schedule and Costs

A planning level cost estimate and schedule for implementation of the monitoring strategy are presented in **Tables 15 and 16**. These costs assume that monitoring will occur through all five phases of monitoring at all 23 sites, including the precipitation site. Costs will be reduced if monitoring all sites is deemed unnecessary. It is assumed that the precipitation site will be monitored three times throughout the monitoring study. Costs also include laboratory analysis and interpretation of results. Costs do not include any remediation or disposal actions.

Table 15: Monitoring Strategy Implementation Planning Level Cost Estimate

Task	Total Labor	Lab Costs	ODCs	TOTAL
Phase 1 and 2 Monitoring	**$30,600**	**$32,325**	**$1,352**	**$64,277**
Prepare for Sampling/ Finalize Sampling Analysis Plan	$8,020	$-		$8,020
Collect Samples (9 dry weather grab, 11 wet weather grab, 9 sediment grab, and 7 passive; count includes 2 QC/phase)	$14,780	$32,325	$1,352	$48,457
Analyze Data and Determine Subsequent Phase Sampling (incl conf call with County)	$7,800	$-		$7,800
Optional: Tidal Site Monitoring (1 dry grab, 1 wet grab, 1 passive)	*$3,370*	*$3,675*	*$476*	*$7,521*
Phase 3 Monitoring	**$12,890**	**$17,175**	**$576**	**$30,641**
Prepare for Sampling	$1,300	$-	$-	$1,300
Collect Samples (5 dry weather grab, 5 wet weather grab, 5 sediment grab, and 4 passive; count includes 2 QC/phase)	$7,470	$17,175	$576	$25,221
Analyze Data and Determine Subsequent Phase Sampling (incl conf call with County)	$4,120	$-	$-	$4,120
Phase 4 Monitoring	**$12,890**	**$17,250**	**$576**	**$30,716**
Prepare for Sampling	$1,300	$-	$-	$1,300
Collect Samples (4 dry weather grab, 7 wet weather grab, 7 sediment grab, and 2 passive; count includes 2 QC/phase)	$7,470	$17,250	$576	$25,296
Analyze Data and Determine Subsequent Phase Sampling (incl conf call with County)	$4,120	$-	$-	$4,120
Phase 5 Monitoring	**$12,890**	**$8,625**	**$576**	**$22,091**
Prepare for Sampling	$1,300	$-	$-	$1,300
Collect Samples (4 dry weather grab, 7 wet weather grab, 7 sediment grab, and 2 passive; count includes 2 QC/phase)	$7,470	$8,625	$576	$16,671

Task	Total Labor	Lab Costs	ODCs	TOTAL
Analyze Data; Determine Next Steps (incl conf call with County)	$4,120	$-	$-	$4,120
Summarize Results	**$15,840**	**$-**	**$75**	**$15,915**
Draft Memo of Results; meet with County to discuss	$11,500	$-	$75	$11,575
MDE Comment/Response	$1,520	$-	$-	$1,520
Final Memo	$2,820	$-	$-	$2,820
Total[1]	**$88,480**	**$79,050**	**$3,633**	**$171,163**

1: Includes cost of optional tidal site monitoring

Table 16: Monitoring Strategy Implementation Schedule

Task	Timeline
Prepare for Sampling/ Finalize Sampling Analysis Plan	Months 1 – 2
Collect and Analyze Phase 1 and 2 Samples	Months 3 – 5
Collect and Analyze Phase 3 Samples	Months 6 – 8
Collect and Analyze Phase 4 Samples	Months 8 – 10
Collect and Analyze Phase 5 Samples	Months 10 – 12
Compile Data and Determine Subsequent Phase Sampling (incl check-in after each Phase)	Months 3 – 12
Draft Memo of Results	Month 13
Final Memo	Month 14

6 References

"40 CFR Part 263 – Standards Applicable to Transporters of Hazardous Waste." Legal Information Institute. Accessed March 27, 2019. https://www.law.cornell.edu/cfr/text/40/part-263.

"40 CFR Part 761 – Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce and Use Prohibitions." Legal Information Institute. Accessed March 27, 2019. https://www.law.cornell.edu/cfr/text/40/part-761.

Aken, Benoit Van, Paola A. Correa, and Jerald L. Schnoor. "Phytoremediation of Polychlorinated Biphenyls: New Trends and Promises." Environmental Science & Technology. April 15, 2010. Accessed March 27, 2019. https://www.ncbi.nlm.nih.gov/pubmed/20384372.

Anne Arundel County Watershed Protection and Restoration Program. 2016. Baltimore Harbor and Curtis Creek/Bay Polychlorinated Biphenyls (PCB) TMDL Restoration Plan.

Cornelissen, Gerard, Paul C. M. Van Noort, and Harrie A. J. Govers. "Desorption Kinetics of Chlorobenzenes, Polycyclic Aromatic Hydrocarbons, and Polychlorinated Biphenyls: Sediment Extraction with Tenax® and Effects of Contact Time and Solute Hydrophobicity." Environmental Toxicology and Chemistry. October 26, 2009. Accessed March 27, 2019. https://setac.onlinelibrary.wiley.com/doi/full/10.1002/etc.5620160703.

Gomes, Helena I., Celia Dias-Ferreira, and Alexandra B. Ribeiro. "Overview of in Situ and Ex Situ Remediation Technologies for PCB-contaminated Soils and Sediments and Obstacles for Full-scale Application." The Science of the Total Environment. February 15, 2013. Accessed March 27, 2019. https://www.ncbi.nlm.nih.gov/pubmed/23334318.

Ghosh, Upal, Richard G. Luthy, Gerard Cornelissen, David Werner, and Charles A. Menzie. "In-situ Sorbent Amendments: A New Direction in Contaminated Sediment Management." Environmental Science & Technology. February 15, 2011. Accessed March 27, 2019. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3037809/.

MDE 2012. The Total Maximum Daily Loads of Polychlorinated Biphenyls in Baltimore Harbor, Curtis Creek/Bay, and Bear Creek Portions of Patapsco River Mesohaline Tidal Chesapeake Bay Segment, Maryland.

MDE 2015. Recommendations for Addressing the PCB SW-WLA. 2015. https://mde.maryland.gov/programs/Water/TMDL/DataCenter/Documents/MDE%20Recommendations%20for%20Addressing%20PCBs%207_30_12_3.pdf

MDE 2017. MDE Submitted Comments on the Baltimore Harbor, Curtis Creek/Bay, and Bear Creek PCB Restoration Plan.

MDE 2019. "Maryland's Voluntary Cleanup Program." Maryland Department of the Environment. Accessed March 27, 2019. https://mde.maryland.gov/programs/LAND/MarylandBrownfieldVCP/Pages/vcp_info.aspx.

Sizmur, Tom, Richard Quilliam, Aline Peregrina Puga, Eduardo Moreno-Jiminez, Luke, Beesley, and Jose L. Gomez-Eyles. "Application of Biochar for Soil Remediation." Semantics Scholar. 2015. Accessed March 27, 2019. https://pdfs.semanticscholar.org/4562/87932134556abd9c3e9b7206f37098d6fde3.pdf.

"Subtitle 13. Disposal of Controlled Hazardous Substances, Part 3., Title 26. Department of Environment, Code of Maryland Regulations." Code of Maryland Regulations. Accessed March 27, 2019. http://mdrules.elaws.us/comar/26_3_13.

Tetra Tech 2016. Draft Guidance for Using Trackdown Studies to Reduce PCB Loads.

U.S. EPA/SERDP/ESTCP. 2017. Laboratory, Field, and Analytical Procedures for Using Passive Sampling in the Evaluation of Contaminated Sediments: User's Manual. EPA/600/R-16/357. Office of Research and Development, Washington, DC 20460

U.S. EPA. 2012. Guidelines for using passive samplers to monitor organic contaminants at superfund sediment sites. OWSER Directive 9200.1-110 FS. Office of Research and Development, Washington, DC 20460

U.S. EPA. 2018."Learn about Polychlorinated Biphenyls (PCBs)." EPA. April 13, 2018. Accessed March 27, 2019. https://www.epa.gov/pcbs/learn-about-polychlorinated-biphenyls-pcbs.

U.S. EPA. 2018. "Summary of the Toxic Substances Control Act." EPA. September 19, 2018. Accessed March 27, 2019. https://www.epa.gov/laws-regulations/summary-toxic-substances-control-act.

U.S. EPA. 2019. "Technology Alternatives for the Remediation of PCB ..." EPA Clean Up Information. Accessed March 27, 2019. https://clu-in.org/download/contaminantfocus/pcb/PCB-EPA-600-S-13-079.pdf.

Appendix A: Quality Assurance Procedures for PCB Sampling

Determination of Roles and Responsibilities

Prior to the collection of samples, it will be necessary to determine the roles and responsibilities of each person involved in the project, including laboratory staff and transportation personnel. This will reduce the number of issues that could potentially arise with handling of samples and thus the quality of the data. Roles and responsibilities are outlined in **Table A-1.**

Table A-1: Sampling Roles and Responsibilities

Role	Responsibilities
Quality Assurance Personnel	Ensuring that duplicates/blanks have been collected, ensuring that chain of custody form is properly filled, ensuring corrective actions are taken if issues arise
Project Manager	Ensuring that personnel are operating in designated capacities, keeping project on track in terms of time and budget, making final decisions about sites, changes to plans etc.
Laboratory Personnel	Accepting samples from field crew, analyzing samples without cross contaminating, following lab QA/QC protocols, properly storing samples until fate is determined, delivering results to PI/PM, handing off samples to transportation personnel if necessary
Transportation Personnel	Accepting samples from laboratory and delivering hazardous wastes to appropriate disposal sites
Field Crew	Collecting samples; labeling sample containers with date, time, site identification and initials of collector(owner); and keeping samples secure until delivery to lab

Field Sampling Procedures

Ideally, field crews will be able to directly sample stormwater runoff or receiving water without the use of intermediate equipment. In this approach, the sample will be captured by holding a sample container with a gloved hand and collecting the sample directly from the stormwater runoff or receiving water. This approach will be used when the sample can be collected safely. In the event this is not possible, intermediate equipment, such as a sampling pole, will be used to collect the sample. If intermediate equipment is used, the field crew will practice the “clean hands, dirty hands” approach to minimize sample contamination. In this approach, one member is designated as “clean hands” and handles the sample bottles while the designated “dirty hands” handles all equipment. Sampling methods will be noted on field forms.

Chain of Custody

A chain of custody document will be kept to maintain the quality of the samples being collected. Each new owner must sign the document accepting responsibility for the samples and relinquishing the prior owner of any responsibility. A chain of custody form will include but is not limited to the following:

- Project name
- Sample collector’s name and signature
- Name of project manager or person who will receive data

- Analytical laboratory’s name and city
- Description of each sample including:
    - Unique identifier and matrix (solid, aqueous, etc.)
    - Date and time of collection
    - Type of analysis required
- Dated and timed signatures of persons involved in chain of possession

Collecting Quality Control Samples

Quality control samples are necessary to maintain the accuracy and validity of data. Between 5-10% of the sample set should be used for collecting quality control samples in the field. Quality control samples are described in **Table A-2** below.

Table A-2: Quality Control Samples

Quality Control Sample	Description
Field Duplicate	Field crews will collect another sample at the same place, time and manner
Lab Duplicate	Lab to process another sample from the same sample container
Field Blank	Field crews will fill a sample container with DI water in the field; to be transported and analyzed by the lab along with the other samples
Lab Blank	Lab to analyze a container of DI water from the lab along with the other samples

Corrective Actions

Once samples are collected and analyzed by a designated laboratory, a determination will need to be made about the fate of the samples that exceed PCB limitations. A similar determination will need to be made about remediation of the site where the sample originated. Potential issues and associated corrective actions are outlined in **Table A-3.**

Table A-3: Quality Control Corrective Actions

Quality Control Issue	Corrective Action
Samples contaminated in chain of custody	Investigate cause/new samples need to be collected
Samples exceed recommended amount of PCBs in sediment/water	Samples need to be disposed of at an approved site and transported by an approved transporter/ remediation of sites where samples were taken
Blanks test positive for PCBs	New samples need to be collected with better QC
Wide range of variation in duplicate results	Reanalyze first/new samples need to be collected with better QC

Appendix B: Sediment Handling and Disposal Memorandum

Biohabitats
The Stables Building
2081 Clipper Park Road
Baltimore, MD 21211
410.554.0156
www.biohabitats.com

MEMORANDUM

Date: April 23, 2019

To: Douglas Griffith, Anne Arundel County Department of Public Works

From: Tanaira Cullens, Biohabitats, Inc.

RE: Baltimore Harbor and Curtis Creek/Bay
Polychlorinated Biphenyls (PCB) TMDL Targeted Action Strategy

Subject: Sediment Handling and Disposal

Introduction

The Anne Arundel County Watershed Protection and Restoration Program (WPRP) developed a Restoration Plan to address local water quality impairments identified in the TMDL for Polychlorinated Biphenyls (PCBs) in Baltimore Harbor, Curtis Creek/Bay and Bear Creek Portions of Patapsco River Mesohaline Tidal Chesapeake Bay Segment (2012). The Restoration Plan generally identifies PCB sources and outlines targeted actions to reduce PCB loads.

As part of the strategy to achieve PCB reductions, the purpose of this memorandum is to provide background on the handling of sediments containing PCBs, particularly with regards to regulatory requirements, disposal methods and locations, and emerging technologies for remediating contaminated soils.

PCBs Background

PCBs are a group of manmade chemicals comprised of 209 biologically and chemically stable congeners, which do not readily breakdown and bind strongly to sediment. PCBs are soluble in organic and hydrocarbon solvents and are slightly soluble in water. Of the 209 congeners, the most commonly used mixture of congeners is called Arochlor. PCBs were manufactured and widely used from 1929 to 1979 in caulk, paints, dyes, motor oil, and electrical equipment, such as transformers. PCBs were banned in 1979 due to their impacts on human health and the environment, however, they are still found in older vehicles and electronics, in the soils of industrial areas where PCBs were manufactured, and in older buildings where PCB laden caulk and paint were used (EPA, 2018).

Permitting and Regulatory Requirements

There are several regulations that pertain to the transport, disposal, and clean-up of PCBs. The regulations most pertinent to Anne Arundel County's PCB Restoration Plan are summarized below and include:

- Toxic Substances Control Act (TSCA)
- Voluntary Cleanup Program (VCP)
- Code of Maryland Regulations (COMAR)

The Toxic Substances Control Act (TSCA) implemented in 1976 gives the EPA "authority to require reporting, record-keeping and testing requirements, and restrictions relating to chemical substances and/or mixtures" (EPA, 2018). Section 6(e) of the TSCA regulates PCBs, prohibits the import and export of PCBs, and involves the same compliance measures as the Code of Federal Regulations (CFR). In order to transport sediments potentially contaminated with PCBs, an EPA Transporter ID is required, otherwise it is illegal for layman to transport hazardous waste.

Collecting sediment and transporting it for analysis purposes does not require an EPA manifest, however, once sediment is determined to be contaminated and is ready for transport to a disposal facility, the generator of the PCBs is required to complete a manifest (40 CFR 761 and 40 CFR 263). "PCB-contaminated soil and sediments are regulated for cleanup and disposal under TSCA based on the date they were contaminated, the concentration of the source of PCBs, and the current PCB concentration. Any soil or sediments containing PCBs ≥ 50 mg/kg are regulated for cleanup and disposal as TSCA PCB remediation waste. Additionally, soil or sediments containing between 2 and 50 mg/kg that were spilled after 1978 from a source ≥ 50 mg/ kg or a source unauthorized for use, are regulated as PCB remediation waste" (EPA, 2019).

The Voluntary Cleanup Program (VCP) was established by the state legislature in 1997 and is administered by the Maryland Department of the Environment (MDE) Land and Materials Administration's Land Restoration Program (LMA-LRP) to provide State oversight for the voluntary cleanup of properties contaminated with hazardous substances. The goal of the program is to increase the number of sites cleaned by streamlining the cleanup process while ensuring compliance with existing environmental regulations" (MDE, 2019). Persons wishing to participate in the VCP complete an application that includes Phase I/Phase II environmental site assessment information, and informational sign stating the property is applying to VCP and an application fee. Properties with controlled hazardous substances (CHS) must develop a response action plan (RAP) stating the type of remediation that will be used and the schedule for addressing the issue along with a certified written statement that the property meets county and municipal zoning requirements. A "no further requirements determination" (NFRD) will be issued if the MDE deems there is "no unacceptable risk to exposed populations based on current conditions at the property." A certificate of completion (COC) will be issued once the RAP is approved and implementation of remediation is done on properties where CHS is above acceptable risk levels. Both NFRD and COC documents will have information about liability protections and limitations, conditions for reopeners, land use controls, and institutional controls for the property

The Code of Maryland Regulations (COMAR) 26.13.02 states that generation of less than 100 kg (220 lbs.) of hazardous waste per month is not subject to regulations in COMAR 26.13.03-26.13.07 and 26.13. 10, if the following regulations are adhered to:

- hazardous waste is removed and accumulated for the purpose of thermal destruction or is thermally destroyed in quantities greater than 100 kg
- the generator complies with COMAR 26.13.02
- waste is disposed or treated in an on-site facility or delivered to an off-site facility in the United States permitted by EPA, in interim status under 40 CFR 270 and 265 or COMAR 26.13.06 and 26.13.07, or permitted, licensed, or registered by the state of Maryland to manage municipal solid waste or nonmunicipal, nonhazardous waste disposal unit after January 1, 1998 and permitted to accept the waste

If hazardous waste is accumulated in quantities greater than 100 kg per month and will not be thermally destroyed, then all regulations apply.

Disposal

There are a variety of activities where the County may need to consider disposal of PCB contaminated sediment. These include:

- Catch basin cleanouts
- Street sweeping
- Stormwater BMP maintenance
- Restoration projects (BMP retrofits, stream restoration, living shorelines)
- County-owned contaminated site clean-up

Disposal of sediment from these activities may require several steps. The first step is to test sediments prior to disposal. An adequate number of samples should be obtained to be representative of site conditions (horizontal and vertical). If the results of the lab analysis indicate a high concentration of PCBs, then the County should work to identify and eliminate the source of the PCB contaminant by looking for potential sources within the drainage area.

Regardless of the source (e.g., contaminated site or stormwater pond), once excavated or dredged, PCB laden materials must be disposed of at an appropriate facility (**Table 1** and **Figure 1**). Sites A and B are either within or close to Anne Arundel County and accept hazardous materials but are not listed in the EPA's approved disposal sites. Both sites require the results of lab analyses before accepting any sediment. Costs associated with both sites will be based on lab results, sources of the PCBs, how contaminated the sediment is, and how much will be transported (to an approved facility). Neither site has specifications about acceptable level of PCB concentrations.

Table 1. Disposal Facilities

Site	Address	Contact
A. Clean Harbors Environmental	1910 Russell Street Baltimore, MD 21230	Chris Maciejewski maciejewskic@cleanharbors.com 301-343-6389
B. BWS Inc	7610 Energy Parkway Curtis Bay, MD 21226	Tim Pickering tpick@bwaste.com 410-627-7753

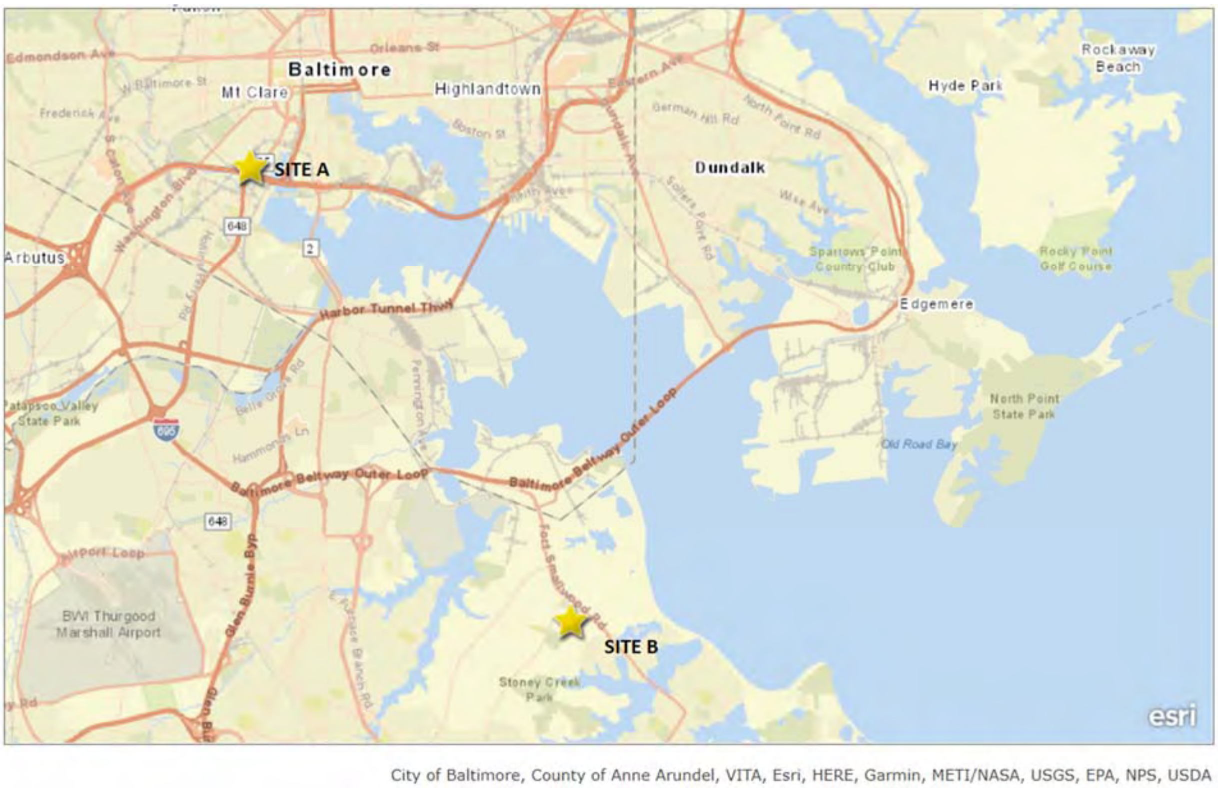


Figure 1. Locations of disposal facilities.

Emerging Technologies

Historically, PCBs were disposed of via incineration, hazardous waste landfilling, and capping. Incineration of PCBs volatilizes and combusts the waste material. While incineration rids the solid waste of the contaminant, gases produced still must be treated. Disposing of PCBs in landfills can cause issues with leakage into surface waters or groundwater if the landfill is not properly maintained. Both incineration and disposal via landfill require contaminated media to be dredged and transported from one location to another for treatment, which has the potential for spread of contaminants if not transported properly. Capping covers an area of contamination to prevent infiltration of contaminants into groundwater due to precipitation. While capping does not require transportation of contaminated media, if the cap is defective or becomes old, it may not prevent precipitation from entering the area of contamination.

Emerging technologies seek to treat contaminated areas in situ using natural forms of remediation. Several of these technologies are discussed below and include bioremediation, biochar remediation, and thermal desorption.

Bioremediation

Bioremediation is the use of biological agents such as bacteria, fungi, or green plants, to remove or neutralize contaminants in polluted soil or water. The results of bioremediation on PCBs vary because there are 209 distinct PCB congeners with a variable number of chlorines that range from one to ten (1 – 10 Cl). Bioremediation tends to be more effective in treating the less chlorinated congeners than the highly chlorinated ones.

Several plant species can be used for phytoremediation of sediments. One of the more widely studied plant species used for phytoremediation is switchgrass. When augmented with specific bacteria, some plant species, such as switchgrass, can significantly degrade PCBs in soils. Many studies about switchgrass as a bioremediation method include the introduction of genetically modified bacteria that can maintain a stable relationship with plants (without being one of the already naturally occurring organisms associated with the chosen plant community). Some phytoremediation studies, however, choose not to use genetically modified bacteria and instead use different plant species to activate the communities already present in the soils (Gomes, 2013).

According to Aken et al. there are a few constraints associated with phytoremediation including:

- Limited to use in shallow contamination of hydrophic compounds
- Plants lack ability to completely remediate PCBs
- Plants can accumulate toxic metabolites that can be released into the environment
- Limited effectiveness while plants are dormant
- Plants genetically modified for bioremediation may transfer genes to native or cultivated plants

<u>Biochar Remediation</u>

PCBs adsorb to biochars across congeners. Biochar works best in soils where there is low native organic carbon and black carbon content, otherwise it does not increase sorption by much. Sorption is increased with the presence of humic acids and metal cations and earthworms may also enhance the performance of biochar.

There are a few constraints associated with the use of biochar:

- application of biochar increases the pH of sediments
- sediments can be further contaminated if biochar is made from contaminated waste wood source material
- human health concerns that are not well understood regarding the breathing of small biochar particles though, these concerns decrease when biochar is used in a pellet form (Sizmur, 2015 and Cornelissen, 2009)

Activated carbon works best in areas where dredging is not possible or where there is sensitive habitat such as wetlands. It is meant to be used in situ and can be left for years without negative effects to the benthic community, according to Ghosh et al (2011). If dredging and disposal of sediment is preferred, then biochars can be used to minimize aqueous contaminants. Future research is still necessary to understand the effects of carbon on food webs and a project's carbon footprint (Ghosh, 2011).

<u>Thermal Desorption</u>

Thermal radiation treats contaminated sediment through indirect or direct heating of the medium and can be used in situ or ex situ. The units used to heat PCB laden materials are transportable and thus allows for treatment of multiple sites with few units. The two most common thermal desorption methods are the rotary dryer and the thermal screw. The thermal screw method, however, is considered more costly to use based on the amount of pretreatment necessary. Both systems require waste pretreatment and treatment of gases once PCBs are volatilized. After treatment disposal of the treated medium is required.

Ex situ thermal desorption works well with treating "organic contaminated (including PCBs) soil, sediment, sludge, and various filter cakes. Ex-situ thermal desorption is applicable to sites where the following conditions exist: the target matrix can be excavated or dredged readily for processing or the organic contaminants are amenable to desorption at kiln temperatures between 315°C (600°F) and 590°C (1,100°F)." If there is debris in the sediment, there must be separation or size reduction of the debris before it can be processed (EPA, 2019).

In situ thermal desorption "applies heat and vacuum to the soil. Heat is applied through thermal wells, which operate at temperatures as high as 900°C (1650°F). Heat is conducted from the wells into the soil, reaching treatment temperatures of 300°C (572°F) or greater. Desorbed and volatilized contaminants are collected and treated above ground using thermal oxidization and/or carbon cannisters" (EPA, 2019). Excavation and materials processing is not necessary with in situ treatments and is better when other infrastructure is present or when the soils are clay like.

Recommendations

The County may encounter a wide variety of situations where PCB contaminated sediment must be addressed. **Tables 2 and 3** summarize the recommended treatment options for specific site considerations, scenarios, and County-related activities such as street sweeping.

Table 2. Considerations for PCB Treatment Options

Considerations	Treatment Options					
	Incineration	**Hazardous Waste Landfilling**	**Capping**	**Bioremediation**	**Biochar**	**Thermal Desorption**
In Situ Treatment (e.g., sensitive downstream habitat/community)			X	X	X	X
Ex Situ Treatment	X	X				X
Light contamination		X		X	X	
Heavy contamination	X	X	X	X		X
Groundwater contamination concerns		X	X			
Low to no long-term maintenance	X	X			X	X
Highly chlorinated congeners	X	X	X			X
Immediate/near-term reuse of site	X	X				X

Table 3. Treatment Options for County Activities

County Activities	Treatment Options					
	Incineration	Hazardous Waste Landfilling	Capping	Bioremediation	Biochar	Thermal Desorption
Catch basin cleanouts	X	X				
Street sweeping	X	X				
Stormwater BMP maintenance	X	X		X		
Restoration projects	X	X		X	X	X
County-owned contaminated site clean-up	X	X	X	X	X	X

References

"40 CFR Part 263 – Standards Applicable to Transporters of Hazardous Waste." Legal Information Institute. Accessed March 27, 2019. https://www.law.cornell.edu/cfr/text/40/part-263.

"40 CFR Part 761 – Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce and Use Prohibitions." Legal Information Institute. Accessed March 27, 2019. https://www.law.cornell.edu/cfr/text/40/part-761.

Aken, Benoit Van, Paola A. Correa, and Jerald L. Schnoor. "Phytoremediation of Polychlorinated Biphenyls: New Trends and Promises." Environmental Science & Technology. April 15, 2010. Accessed March 27, 2019. https://www.ncbi.nlm.nih.gov/pubmed/20384372.

Cornelissen, Gerard, Paul C. M. Van Noort, and Harrie A. J. Govers. "Desorption Kinetics of Chlorobenzenes, Polycyclic Aromatic Hydrocarbons, and Polychlorinated Biphenyls: Sediment Extraction with Tenax® and Effects of Contact Time and Solute Hydrophobicity." Environmental Toxicology and Chemistry. October 26, 2009. Accessed March 27, 2019. https://setac.onlinelibrary.wiley.com/doi/full/10.1002/etc.5620160703.

Gomes, Helena I., Celia Dias-Ferreira, and Alexandra B. Ribeiro. "Overview of in Situ and Ex Situ Remediation Technologies for PCB-contaminated Soils and Sediments and Obstacles for Full-scale Application." The Science of the Total Environment. February 15, 2013. Accessed March 27, 2019. https://www.ncbi.nlm.nih.gov/pubmed/23334318.

Ghosh, Upal, Richard G. Luthy, Gerard Cornelissen, David Werner, and Charles A. Menzie. "In-situ Sorbent Amendments: A New Direction in Contaminated Sediment Management." Environmental Science & Technology. February 15, 2011. Accessed March 27, 2019. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3037809/.

"Learn about Polychlorinated Biphenyls (PCBs)." EPA. April 13, 2018. Accessed March 27, 2019. https://www.epa.gov/pcbs/learn-about-polychlorinated-biphenyls-pcbs.

"Maryland's Voluntary Cleanup Program." Maryland Department of the Environment. Accessed March 27, 2019. https://mde.maryland.gov/programs/LAND/MarylandBrownfieldVCP/Pages/vcp_info.aspx.

Sizmur, Tom, Richard Quilliam, Aline Peregrina Puga, Eduardo Moreno-Jiminez, Luke, Beesley, and Jose L. Gomez-Eyles. "Application of Biochar for Soil Remediation." Semantics Scholar. 2015. Accessed March 27, 2019. https://pdfs.semanticscholar.org/4562/87932134556abd9c3e9b7206f37098d6fde3.pdf.

"Subtitle 13. Disposal of Controlled Hazardous Substances, Part 3., Title 26. Department of Environment, Code of Maryland Regulations." Code of Maryland Regulations. Accessed March 27, 2019. http://mdrules.elaws.us/comar/26_3_13.

"Summary of the Toxic Substances Control Act." EPA. September 19, 2018. Accessed March 27, 2019. https://www.epa.gov/laws-regulations/summary-toxic-substances-control-act.

"Technology Alternatives for the Remediation of PCB ..." EPA Clean Up Information. Accessed March 27, 2019. https://clu-in.org/download/contaminantfocus/pcb/PCB-EPA-600-S-13-079.pdf.