Total Maximum Daily Loads of Polychlorinated Biphenyls in Northeast River Embayment, Cecil County, Maryland

PUBLIC REVIEW DRAFT

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Table of Contents

Table of Contents i
List of Figures ii
List of Tables ii
List of Abbreviations iii
EXECUTIVE SUMMARY v
1. INTRODUCTION 1
2. SETTING AND WATER QUALITY DESCRIPTION 3
2.1. General Setting 3
2.2. Water Quality Characterization and Impairment 6
2.3. Source Assessment 9
3. TARGETED WATER COLUMN AND SEDIMENT GOALS 17
4. TOTAL MAXIMUM DAILY LOADS AND LOAD ALLOCATION 18
4.1. Overview 18
4.2. Analysis Framework 18
4.3. Critical Condition and Seasonality 19
4.4. TMDL Allocations 20
4.5. Margin of Safety 22
4.6. Summary of Total Maximum Daily Loads 22
5. ASSURANCE OF IMPLEMENTATION 23
REFERENCES 24
Appendix A. List of Individual tPCB Measurements A1
Appendix B. Derivation of Adj-tBAF and Adj-SediBAF B1
Appendix C. Tidal Prism Model C1
Appendix D. Tidal Prism Model Calculation for Northeast River D1
Appendix E. Calculation of 95% CIs E1
Appendix F. Calculation of Fraction of Different PCB Forms F1
Appendix G. Technical Approach Used to Generate Maximum Daily Loads G1
Appendix H. MDE Permit Information H1
Appendix I. Contaminated Site Load Calculation Methodology I1
Appendix J. Derivation of the Boundary PCB Concentration J1
Appendix K. List of Analyzed PCB Congeners K1
Appendix L. WWTP Load Evaluation L1

List of Figures

FIGURE 1: LAND USE DISTRIBUTION IN THE NORTHEAST RIVER WATERSHED 3
FIGURE 2: LOCATION MAP OF THE NORTHEAST RIVER WATERSHED AND EMBAYMENT 4
FIGURE 3: LAND USE IN THE NORTHEAST RIVER WATERSHED 5
FIGURE 4: PCB MONITORING STATIONS IN NORTHEAST RIVER WATERSHED 8
FIGURE 5: LOCATIONS OF THE CONTAMINATED SITES IN THE NORTHEAST RIVER WATERSHED 13
FIGURE 6: LOCATIONS OF THE TWO WWTPS IN THE NORTHEAST RIVER WATERSHED 15
FIGURE 7: CHANGE OF SEDIMENT TPCB CONCENTRATION WITH TIME 19
FIGURE 8: CHANGE OF WATER COLUMN TPCB CONCENTRATION WITH TIME 19
FIGURE 9: SEASONAL VARIATIONS OF WATER COLUMN TPCB CONCENTRATIONS IN NORTHEAST RIVER EMBAYMENT (2003, 2006) 20

List of Tables

TABLE 1: LAND USE DISTRIBUTION IN THE NORTHEAST RIVER WATERSHED 3
TABLE 2: FISH TISSUE TPCB CONCENTRATIONS IN THE NORTHEAST RIVER EMBAYMENT (2002) 6
TABLE 3: WATER QUALITY MONITORING STATIONS AND AVERAGE TPCB CONCENTRATIONS IN THE NORTHEAST RIVER EMBAYMENT, WATERSHED, AND BAY BOUNDARY (2003, 2006) 9
TABLE 4: BREAKDOWN OF THE TOTAL WATERSHED TPCB BASELINE LOADS (G/YEAR) 12
TABLE 5: CONTAMINATED SITE BASELINE LOADS 13
TABLE 6: WWTP BASELINE PCB LOADINGS 14
TABLE 7: SUMMARY OF TPCB TOTAL BASELINE LOADS 16
TABLE 8: NORTHEAST RIVER TPCB BASELINE LOADS, TMDL, REQUIRED REDUCTIONS, AND MDL 22

List of Abbreviations

Adj-SediBAF	Sediment Bioaccumulation Factor
Adj-tBAF	Adjusted Total Bioaccumulation Factor
BCF	Bioconcentration Factor
BSAF	Biota-sediment accumulation factor
CFR	Code of Federal Regulations
CI	Confidence Interval
COMAR	Code of Maryland Regulations
CSF	Cancer Slope Factor
CV	Coefficient of Variation
CWA	Clean Water Act
DOC	Dissolved Organic Carbon
DRBC	Delaware River Basin Commission
ERRP	Environmental Restoration and Redevelopment Program
ft	Feet
g	Gram
km	Kilometer
Kow	PCB Octanol-Water Partition Coefficient
L/kg	Liters/kilogram
LA	Load Allocation
Lbs/lb	Pounds per pound
m	Meter
MDE	Maryland Department of the Environment
MDL	Maximum Daily Load
mg/kg-day	Milligrams/kilogram-day, ppm-day
MGD	Million gallons per day
MOS	Margin of Safety
MS4	Municipal Separate Storm Sewer Systems

ng/g	Nanograms per gram, ppb
ng/kg	Nanograms per kilogram, ppt
ng/L	Nanograms per liter, ppt
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
PA	Pennsylvania
PCB	Polychlorinated Biphenyl
POC	Particulate Organic Carbon
POPs	persistent organic pollutants
ppb	Parts per billion
ppm	Parts per million
ppt	Parts per trillion
QEA	Quantitative Environmental Analysis, LLC
RUSLE2	Revised Universal Soil Loss Equation Version II
TMDL	Total Maximum Daily Load
tPCB	Total PCB
TSD	Technical Support Document
µg/day	Micrograms/day
UMCES	University of Maryland Center for Environmental Science
US EPA	U. S. Environmental Protection Agency
USGS	United States Geological Survey
WAS	Waste Management Administration
WLA	Waste Load Allocation
WQA	Water Quality Analysis
WQLS	Water Quality Limited Segment
WQS	Water Quality Standard
WWTP	Waste Water Treatment Plant
yr	Year

EXECUTIVE SUMMARY

Section 303(d) of the federal Clean Water Act (CWA) and the U.S. Environmental Protection Agency's (US EPA) implementing regulations direct each State to identify and list waters, known as water quality limited segments (WQLSs), in which current required controls of a specified substance are inadequate to achieve water quality standards (WQSs). For each WQLS, the State is to either establish a Total Maximum Daily Load (TMDL) of the specified substance that the waterbody can receive without violating WQSs, or demonstrate that WQSs are being met (CFR 2007).

The Maryland surface water use designation states that all surface waters of Maryland shall be protected for water contact recreation, fishing, and protection of aquatic life and wildlife (COMAR 2007a). The specific designated use of the Northeast River Tidal Fresh (also referred to as the Northeast River embayment) is Use II – Support of Estuarine and Marine Aquatic Life and Shellfish Harvesting (COMAR 2007b). The Maryland Department of the Environment (MDE) has identified the tidal fresh waters of the Northeast River (basin number 02130608) on the State's 303(d) List as impaired by lead (1996), nutrients (1996), zinc (1996), and polychlorinated biphenyls (PCBs) in fish tissue (2002) (MDE 2008). This document, upon US EPA approval, establishes a total PCB (tPCB) TMDL for the Northeast River embayment. Data solicitation for PCB related information was conducted by MDE, and all readily available data from the past five years have been considered. Nitrogen and phosphorus TMDLs and a Water Quality Analysis (WQA) for zinc in the Northeast River were approved by the US EPA in 2005. A WQA for lead in the Northeast River was submitted to US EPA in July of 2008.

The objective of the tPCB TMDL established in this document is to ensure that the "fish consumption" designated use in the Northeast River embayment is protected. This objective was achieved with the use of a tidal prism model and the tPCB fish tissue listing threshold of 39 nanogram/gram (ng/g, ppb) – wet weight (MDE 2008, 72-74). The tidal prism model incorporates the influences of freshwater discharge, tidal flushing, and exchanges between the water column and bottom sediments, thereby representing the dynamic transport within the Northeast River embayment. The tidal prism model was used to:

1. Estimate and predict PCB transport and fate based on the measured tPCB concentrations in the water column and sediment of the Northeast River embayment.
2. Simulate the long-term tPCB concentrations in the water column and bottom sediments.
3. Given the estimated rate of decline in the Chesapeake Bay boundary concentrations, estimate the time needed for the PCB concentrations to meet the site specific water column and sediment targets of 0.18 nanograms/liter (ng/L) and 4.3 ng/g, respectively, which were derived from the established 39 ng/g tPCB fish tissue listing threshold.

As part of this analysis, point and non-point PCB sources have been identified throughout the Northeast River watershed. Two nonpoint sources, resuspension and diffusion from the bottom sediments and tidal flushing from the Chesapeake Bay, were determined to be the major sources of tPCBs to the Northeast River embayment. PCB loads are transported from the Chesapeake Bay into the embayment during flood tides and tend to accumulate in the bottom sediments. Other nonpoint sources include atmospheric deposition to the embayment, and runoff from contaminated sites and other watershed sources. Point sources include wastewater treatment

plants (WWTPs) and National Pollutant Discharge Elimination System (NPDES) regulated stormwater.

The Total Baseline (i.e., 2003) Load of tPCBs to the Northeast River embayment is 8,274 g/year. It can be further subdivided into a Nonpoint Source Baseline Load and Point Source Baseline Load. The tPCB TMDL for the Northeast River embayment is 1,072 g/year with a reduction of 87.0% from the Total Baseline Load (see Table ES- 1). This TMDL when implemented will ensure that the PCB loads are at a level expected to support the "fish consumption" designated use in the Northeast River embayment.

Table ES- 1: Summary of Baseline and Allowable Annual Loads of tPCB and the Required Load Reduction

Source	Baseline (g/year)	Baseline (%)	TMDL (g/year)	Load Reduction (%)
Chesapeake Bay (Tidal Influence)	5,847.6	70.67	480.5	91.8
Bottom Sediment (Resuspension and Diffusion)	2,248.0	27.17	306.8	86.4
Direct Atmospheric Deposition (to the Surface of the Embayment)	54.4	0.66	54.4	0.0
Maryland Watershed Nonpoint Sources *	83.4	1.01	83.4	0.0
Contaminated Sites *	0.2	0.00	0.2	0.0
Pennsylvania Upstream	13.4	0.16	13.4	0.0
Nonpoint Sources/Load Allocations	***8247.0***	**99.67**	***938.7***	***88.6***
WWTP *△	1.1	0.01	1.1	0.0
NPDES Regulated Stormwater *	25.4	0.31	25.4	0.0
Point Sources/Waste Load Allocations*	***26.5***	**0.32**	***26.5***	***0.0***
Margin of Safety	**-**	**-**	***107.2***	**-**
Total	**8,274**	**100**	**1,072**	**87.0**

Notes: * These sources were characterized only for the Maryland portion of the watershed.
△ WWTP loads were considered to be *de minimis* and at this point will not be subject to the traditional waste load allocation requirements.

All TMDLs need to be presented as a sum of waste load allocations (WLAs) for the identified point sources, load allocations (LAs) for nonpoint source loads generated within the assessment unit, and where applicable, natural background, tributary, and adjacent segment loads. NPDES regulated stormwater was the only permitted point source assigned a WLA. The WWTP loads were considered to be *de minimis* (see Appendix L for details); given no appreciable environmental benefit of reducing these loadings, at this point, they will not be subject to the traditional waste load allocation requirements.

Furthermore, all TMDLs must include a margin of safety (MOS) to account for uncertainty in the relationship between pollutant loads and water quality as well as the scientific and technical understanding of water quality in natural systems (CFR 2007). An explicit MOS of 10% or 107.2 grams/year (g/year) was incorporated into the analysis to account for such uncertainty. The State reserves the right to revise these allocations provided the revisions are consistent with achieving WQSs.

The TMDL presented in this document is protective of human health at all times and in this way implicitly accounts for seasonal variations as well as critical conditions. Since PCB levels in fish become elevated due to long-term exposure, rather than temporary spikes in water column concentration, it has been determined that the selection of an average tPCB water column concentrations as the baseline conditions adequately considers the impact of seasonal variations and critical conditions on the "fish consumption" designated use in the Northeast River embayment. Furthermore, the water column tPCB target used to develop this TMDL is lower than the current human health criterion for consumption and is more protective than the freshwater and saltwater chronic aquatic life criteria concentrations necessary to protect fish and wildlife.

Resuspension and diffusion from the bottom sediments and tidal flushing from the Chesapeake Bay have been identified as the two major sources of tPCBs to the Northeast River embayment. It has been further estimated that on average tPCB concentrations in the Upper Chesapeake Bay are decreasing at a rate of 6.5% per year. Given this rate of decline in the boundary concentrations, the tPCB levels in the Northeast River embayment are expected to decline over time. Discovering and remediating any existing PCB land sources throughout the upper Chesapeake Bay watershed via future TMDL development and implementation efforts will further help to meet water quality goals in the Northeast River embayment.

Once US EPA has approved this TMDL, MDE will begin an iterative process of implementation, focusing first on those sources with the largest impact on water quality and giving consideration to the relative cost and ease of implementation. MDE's fish consumption program will continue to monitor tPCB levels in fish tissue. This information will be used to evaluate the PCB impairment in the Northeast River embayment on an ongoing basis.

1. INTRODUCTION

Section 303(d) of the federal Clean Water Act (CWA) and the U.S. Environmental Protection Agency's (US EPA) implementing regulations direct each State to identify and list waters, known as water quality limited segments (WQLSs), in which current required controls of a specified substance are inadequate to achieve water quality standards (WQSs). For each WQLS, the State is to either establish a Total Maximum Daily Load (TMDL) of the specified substance that the waterbody can receive without violating WQSs, or demonstrate that WQSs are being met (CFR 2007).

TMDLs are established to determine the pollutant load reductions needed to achieve and maintain WQSs. A WQS is the combination of a designated use for a particular body of water and the water quality criteria designed to protect that use. Designated uses include activities such as swimming, drinking water supply, fish and shellfish propagation and harvest, etc. Water quality criteria can be either narrative statements or numeric values designed to protect the designated uses. Criteria may differ among waters with different designated uses.

The Maryland surface water use designation states that all surface waters of Maryland shall be protected for water contact recreation, fishing, and protection of aquatic life and wildlife (COMAR 2007a). The specific designated use of the Northeast River Tidal Fresh (also referred to as the Northeast River embayment) is Use II – Support of Estuarine and Marine Aquatic Life and Shellfish Harvesting (COMAR 2007b). The Maryland Department of the Environment (MDE) has identified the tidal fresh waters of the Northeast River (basin number 02130608) on the State's 303(d) List as impaired by lead (1996), nutrients (1996), zinc (1996), and polychlorinated biphenyls (PCBs) in fish tissue (2002) (MDE 2008). This document, upon US EPA approval, establishes a total PCB (tPCB) TMDL for the Northeast River embayment. A data solicitation for PCB related information was conducted by MDE, and all readily available data from the past five years have been considered. Nitrogen and phosphorus TMDLs and a Water Quality Analysis (WQA) for zinc in the Northeast River were approved by the US EPA in 2005. A WQA for lead in the Northeast River was submitted to US EPA in July of 2008.

PCBs are a class of man-made compounds that were manufactured and used for a variety of industrial applications. They consist of 209 related chemical compounds (congeners) that were manufactured and sold as mixtures under various trade names (QEA, 1999). Each of the 209 possible PCB compounds consists of two phenyl groups and one or more chlorine atoms. The congeners differ in the number and position of the chlorine atoms along the phenyl group. From the 1940s to the 1970s, they were extensively used as heat transfer fluids, flame retardants, hydraulic fluids, and dielectric fluids because of their dielectric and flame resistant properties. They have been identified as a pollutant of concern due to the following:

1. They are bioaccumulative and can cause both acute and chronic toxic effects.
2. They have carcinogenic properties.
3. They are persistent organic pollutants (POPs) that do not readily breakdown in the environment.

In the late 1970s, concerns regarding potential human health effects led the United States government to take action to cease PCB production, restrict PCB use, and regulate the storage and

disposal of PCBs. Despite these actions, PCBs are still being released into the environment through fires or leaks from old PCB containing equipment, accidental spills, burning of PCB containing oils, leaks from hazardous waste sites, etc. As PCBs tend to bioaccumulate in aquatic organisms including fish tissue, people who ingest fish may become exposed to PCBs. In fact, elevated levels of PCBs in edible parts of fish tissue are one of the leading causes of fish consumption advisories in the United States.

The Northeast River embayment was first identified as impaired by PCBs on the 2002 303(d) List based on fish tissue PCB concentration data from MDE's monitoring program that exceeded the tPCB fish tissue listing threshold of 39 nanogram/gram (ng/g, ppb) – wet weight (MDE 2008, 72-74). Besides identifying waterbodies on the 303(d) List of impaired waters, MDE also issues statewide and site specific fish consumption advisories (ranging from 0 to 4 meals per month) and recommendations (ranging from 4 to 8 meals per month). Current fish consumption advisories within the Northeast River embayment suggest limiting the consumption of the following fish species: American Eel, Brown Bullhead, Channel Catfish, Common Carp, and White Perch.

2. SETTING AND WATER QUALITY DESCRIPTION

2.1. General Setting

The Northeast River watershed is located within Cecil County in the extreme reaches of the Maryland portion of the upper Chesapeake Bay watershed with the northern most portion of the watershed extending through Pennsylvania (Figure 2). The tidal fresh portion of the watershed extends as far north as the Town of North East. The depth of the tidal range at the United States National Oceanic and Atmospheric Administration (NOAA) tidal station in Charlestown is 1.9 feet (0.58 meters (m)). The depths of the river range from about 6 inches (0.15 m) in the headwaters to greater than 13 feet (4.0 m) in the main channel and from 6 to 7 feet (1.8-2.1 m) at the mouth of the river (MDE 2005a).

Table 1: Land Use Distribution in the Northeast River Watershed

Land Use	Area (km^2)	Percent of Total
Water	16.5	8.0
Urban	40.8	20.3
Barren	2.3	1.1
Forest	69.2	34.5
Agriculture	67.3	33.8
Natural grass	0.4	0.2
Wetland	3.9	2.0
Total	**200**	**100**

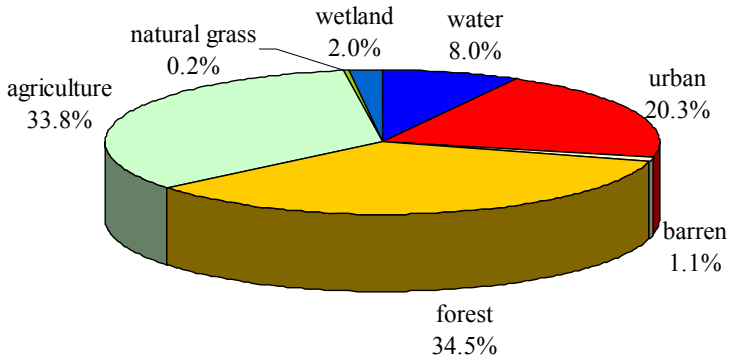

Figure 1: Land Use Distribution in the Northeast River Watershed

The entire Northeast River watershed stretches over approximately 77 square miles (200 km^2). The tidal fresh portion of the river is approximately 5.9 miles (9.5 kilometers (km)) in length. The watershed is predominately rural in nature consisting of 34.5% forest and 33.8% agricultural land (see Figure 1, Figure 3, and Table 1). Limited commercial fishing is conducted in the tidal fresh zone. Recreational fishing and general water contact recreation are enjoyed throughout most of the year (MDE 2005a).

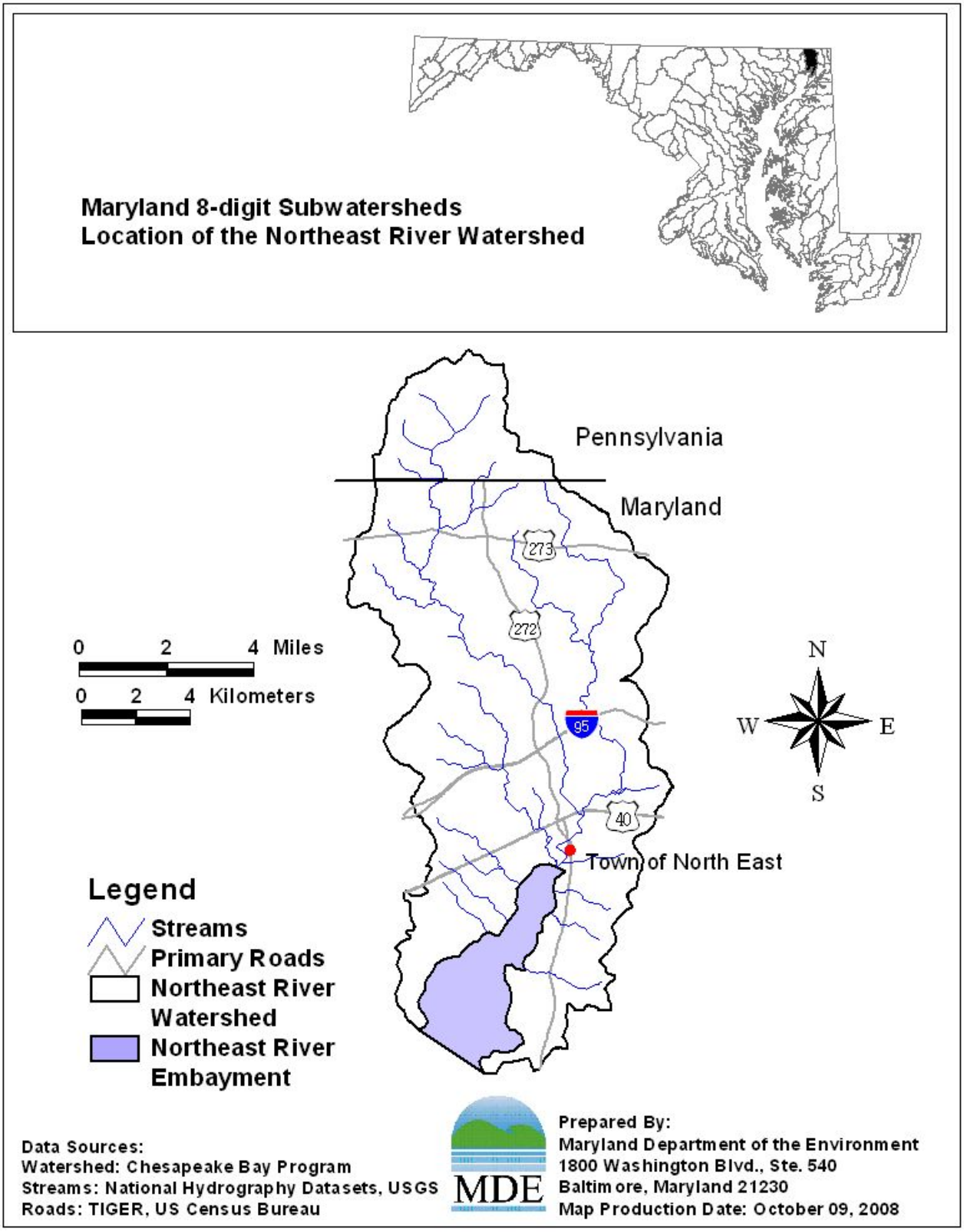

Figure 2: Location Map of the Northeast River Watershed and Embayment

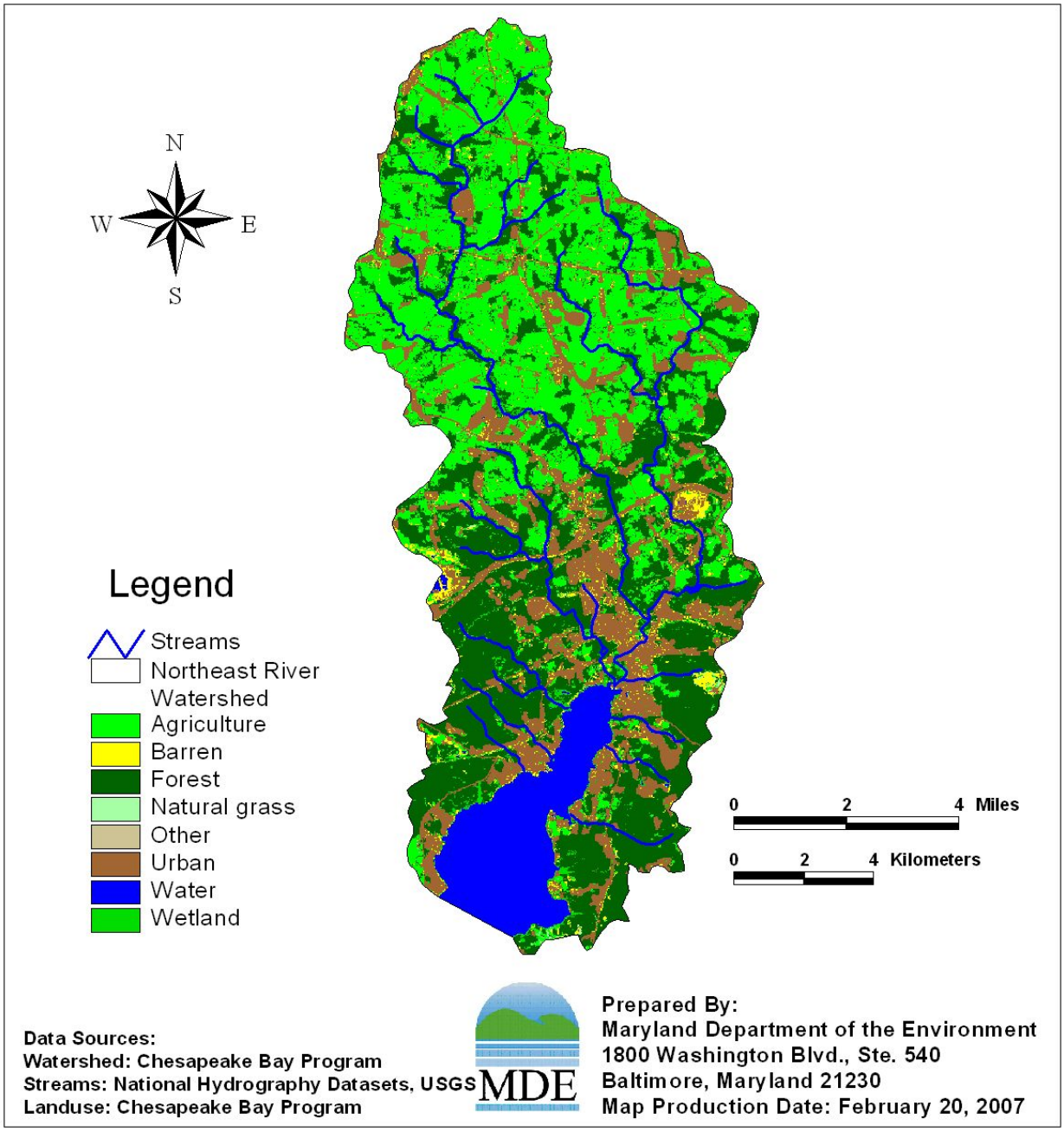

Figure 3: Land Use in the Northeast River Watershed

2.2. Water Quality Characterization and Impairment

The Maryland surface water use designation states that all surface waters of Maryland shall be protected for water contact recreation, fishing, and protection of aquatic life and wildlife (COMAR 2007a). The specific designated use of the Northeast River Tidal Fresh is Use II – Support of Estuarine and Marine Aquatic Life and Shellfish Harvesting (COMAR 2007b). The State of Maryland adopted three separate ambient water quality/water column criteria: human health criterion for protection of human health associated with consumption of PCB contaminated fish, as well as freshwater and salt water chronic criteria for protection of aquatic life. The Maryland tPCB human health criterion is set at 0.64 nanograms/liter (ng/L, ppt) (COMAR 2007c, US EPA 2006). This criterion is based on a cancer slope factor (CSF) of 2 milligrams/kilogram-day (mg/kg-day), bioconcentration factor (BCF) of 31,200 liters/kilogram (L/kg), risk level of 10^{-5}, lifetime risk level and exposure duration of 70 years, and fish intake of 17.5 grams/day (g/day). A cancer risk level provides an estimate of the additional incidence of cancer that may be expected in an exposed population. A risk level of 10^{-5} indicates a probability of one additional case of cancer for every 100,000 people exposed. The Maryland aquatic life freshwater chronic tPCB criterion is 14 ng/L, and the saltwater chronic tPCB criterion is 30 ng/L (COMAR 2007c; US EPA 2006). A PCB sediment criterion has not been established within Maryland water quality standards.

In addition to the above described criteria, fish tissue monitoring can serve as an indicator of PCB water quality conditions. The Maryland fish tissue monitoring data is used to issue fish consumption advisories/recommendations and determine whether Maryland waterbodies are meeting their primary designated uses. Currently Maryland applies 39 ng/g as the tPCB fish tissue 303(d) listing threshold (MDE 2008, 72-74). MDE has collected fish tissue samples in the Northeast River embayment on 09/03/2002 (Table 2). The average concentration for each of the indicator fish species, except Black Crappie, exceeds the PCB listing threshold, indicating a PCB impairment in the Northeast River embayment.

Table 2: Fish Tissue tPCB Concentrations in the Northeast River Embayment (2002)

Species Name	Mean Lipid Content (%)	tPCBs* (ng/g – wet weight)	Number of Individual Fish in a Composite	Exceed MD Criterion
Black Crappie	1.84	27.79	1	No
Brown Bullhead Catfish	1.12	143.08	5	Yes
American Eel	10.37	150.58	5	Yes
Channel Catfish	4.64	217.42	5	Yes
White Perch (1)	2.41	244.24	5	Yes
White Perch (2)	1.65	275.25	5	Yes

Note: *Actual values (i.e., not lipid normalized).

In 2003, sampling surveys were conducted by MDE to measure sediment and water column PCB concentrations throughout the embayment. Water column samples were also collected at three locations in the Northeast River nontidal watershed (NER 8, NER9, and NER10). In 2006, additional

samples were taken at two tidal stations: XKI2616 (inside of the embayment) and XKI1309 (outside of the embayment). While none of the total average water column tPCB concentrations exceed the 30 ng/L aquatic life saltwater chronic criterion, all of them exceeded the 0.64 ng/L human health criterion (see Table 3). Figure 4 displays the locations of the Northeast River monitoring stations. Detailed tPCB results for each measurement are presented in Appendix A.

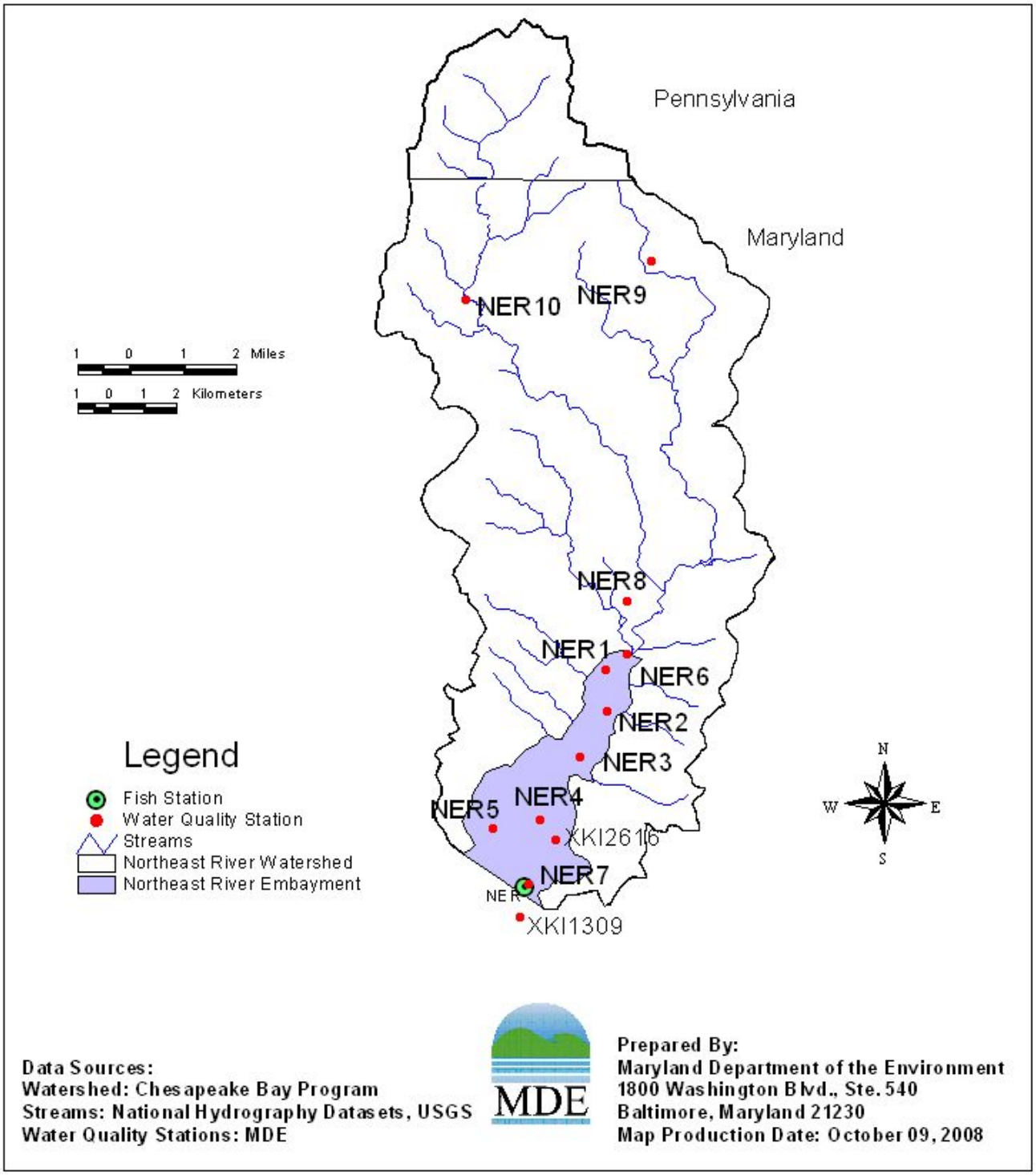

Figure 4: PCB Monitoring Stations in Northeast River Watershed

Table 3: Water Quality Monitoring Stations and Average tPCB Concentrations in the Northeast River Embayment, Watershed, and Bay Boundary (2003, 2006)

Station Name	Collection Year	Latitude	Longitude	Average Water Column Concentration (ng/L)			Sediment Concentration (ng/g dry weight)
				Dissolved	Particulate	Total	
NER1	2003	39.5891	-75.9570	0.60	1.40	2.00	11.04
NER2	2003	39.5778	-75.9564	0.17	0.98	1.15	31.97
NER3	2003	39.5654	-75.9656	0.56	1.94	2.50	50.04
NER4	2003	39.5485	-75.9792	0.88	1.14	2.01	59.14
NER5	2003	39.5460	-75.9958	0.38	0.64	1.02	24.66
NER6	2003	39.5934	-75.9496	0.72	0.26	0.99	5.90
NER7	2003	39.5308	-75.9832	0.36	0.84	1.20	42.53
NER8	2003	39.6076	-75.9499	0.60	0.50	1.10	NA
NER9	2003	39.6999	-75.9426	0.64	0.44	1.08	NA
NER10	2003	39.6889	-76.0074	0.66	0.35	1.00	NA
XKI2616*	2006	39.5428	-75.9738	0.06	1.64	1.70	27.54
XKI1309*	2006	39.5218	-75.9862	0.10	1.13	1.23	38.37

Note: * Based on Ko and Baker (2004), it is estimated that on average tPCB concentrations in the Upper Chesapeake Bay are decreasing at a rate of 6.5% per year (p.10). For purpose of this analysis 2006 data will be adjusted to the expected 2003 concentrations.

PCB analytical services were provided by the University of Maryland Center for Environmental Science (UMCES). PCB congeners were identified and quantified by high resolution gas chromatography with electron capture detection. UMCES uses a slightly modified version of the PCB congener specific method described in Ashley and Baker (1999), in which the identities and concentrations of each congener in a mixed Aroclor standard (25:18:18 mixture of Aroclors 1232, 1248, and 1262) are determined based on their chromatographic retention times relative to the internal standards (PCB 30 and PCB 204). Based on this method, 86 chromatographic peaks can be quantified (see Appendix K). Some of the peaks contain one PCB congener, while many are comprised of two or more co-eluting congeners. The PCB analysis presented in this document is based on tPCB concentrations that are calculated as the sum of the detected PCB congeners/congener groups representing most common congeners that were historically used in the Aroclor commercial mixtures.

2.3. Source Assessment

PCBs do not occur naturally in the environment. Therefore, unless existing or historical anthropogenic sources are present, their natural background levels are expected to be zero. This section provides a detailed description of the existing nonpoint and point sources that have been identified as contributing PCB loads to the Northeast River embayment.

2.3.1. Nonpoint Sources

Nonpoint sources do not have a single discharge point, but rather can occur over a part of or the entire length of a waterbody. For the purpose of this TMDL, the following nonpoint sources have been identified: the Chesapeake Bay tidal influence, resuspension and diffusion from bottom

sediments, watershed runoff (mainly including runoff associated with atmospheric deposition to the watershed and the two PCB contaminated sites), and direct atmospheric deposition to the embayment.

Chesapeake Bay (Tidal Influence)

Based on the tPCB concentration measured at the mouth of Northeast River and the relatively high quantity of water flowing from the Bay to the embayment during the flood tides, the tPCB Chesapeake Bay Baseline Load of 5847.6 g/year is the major source of tPCBs to the Northeast River embayment (see Appendix C and Appendix D).

The Susquehanna River is the major source of flow and PCBs to the Upper Chesapeake Bay (Ko and Baker 2004). In order to determine the temporal changes in PCB loads of the Susquehanna River to the Upper Chesapeake Bay, Ko and Baker (2004) measured tPCB concentration downstream of the Susquehanna River and compared it with the results reported by Foster et al. (2000) and Godfrey et al. (1995). According to this analysis, flow normalized tPCB loadings decreased from 37 kg/m^3/year in 1992 to 24 kg/m^3/year in 1998. Based on these results, it is estimated that on average tPCB concentrations in the Upper Chesapeake Bay are decreasing at a rate of 6.5% per year (Appendix J). This rate was used to adjust additional data collected in 2006 to expected 2003 (i.e., baseline) concentrations and was applied in the model to account for the expected temporal changes in the Chesapeake Bay boundary concentrations (Equation 1).

$$\text{Concentration}_{2003} = \frac{\text{Concentration}_{2006}}{(1 - 0.065)^{\text{time}}} \qquad \text{(Equation 1)}$$

Bottom Sediments (Resuspension and Diffusion)

Because PCBs tend to bind to sediments, a large portion of the PCBs introduced into the embayment from various sources will quickly end up in the bottom sediments. This accumulation of PCBs can subsequently become a significant source of PCBs to the water column in the embayment through resuspension and diffusion from bottom sediments. Based on the measured tPCB concentrations in the water column and bottom sediments, the tPCB Bottom Sediment Baseline Load of 2,248.0 g/year is the second largest source of tPCBs to the Northeast River embayment (see Appendix C and Appendix D).

Atmospheric Deposition

Based on previous research conducted in the Chesapeake Bay area, a relatively small portion of the tPCB load to the Northeast River embayment can be attributed to atmospheric deposition although a net loss of tPCB occurs due to volatilization (Totten et al, 2006). The observed annual atmospheric tPCB loading to the entire surface of the Chesapeake Bay is approximately 38 ± 7 kg/year (Leister and Baker 1994). Based on the Chesapeake Bay surface area of 1.15×10^{10} m^2 and Northeast River embayment surface area of 1.647×10^7 m^2, the estimated direct tPCB atmospheric deposition to the surface of the Northeast River embayment is:

$$\frac{38}{(1.15\times10^{10})}\times(1.647\times10^{7})\approx \textbf{54.4 g/year} \qquad \text{(Calculation 1)}$$

Using the same data, the atmospheric loading to the entire land surface of the watershed (1.839×10^{8} m^2) is:

$$\frac{38}{(1.15\times10^{10})}\times(1.839\times10^{8})\approx \textbf{607.7 g/year} \qquad \text{(Calculation 2)}$$

However, according to Totten et al. (2006) not all of the atmospheric deposition to the terrestrial part of the watershed is expected to be delivered to the embayment. Considering the PCB pass-through efficiency estimated by Totten et al. for the Delaware River watershed is about 1%, the atmospheric PCB loading to the Northeast River embayment from the watershed is approximately 6.1 g/year. Compared to other sources (Table 7), atmospheric deposition constitutes a relatively small portion of the tPCB load delivered to the Northeast River embayment.

Watershed Runoff

The Total Watershed tPCB Baseline Load of the Northeast River was estimated by multiplying the mean water column tPCB concentration (1.06 ng/L) of stations NER8, NER9, and NER10, and the total flow of the watershed.

Using the 20-year monthly mean flow at the USGS station located at Northeast Creek (USGS01496000) and ratio of the Northeast River watershed area to the USGS station drainage area, the total flow was estimated as 3.66 m^3/s (129.4 cfs). This total flow was distributed between Pennsylvania (0.40 m^3/s) and Maryland (3.26 m^3/s) portions of the watershed according to their respective watershed areas and used to calculate the tPCB watershed baseline loads (Calculation 3).

PA Load = 0.40 m^3/s × 1.06 ng/L × 1,000 L/m^3 × 10^{-9} g/ng × 60 minutes/hour × 60 seconds/minute × 24 hours/day × 365 days/year = **13.4 g/year**

(Calculation 3)

MD Load = 3.26 m^3/s × 1.06 ng/L × 1,000 L/m^3 × 10^{-9} g/ng × 60 minutes/hour × 60 seconds/minute × 24 hours/day × 365 days/year = **109.0 g/year**

While the Upstream Pennsylvania Baseline Load is presented as a single upstream load, the Maryland Watershed Baseline Load is further subdivided into:

- Point Source Loads: National Pollutant Discharge Elimination System (NPDES) Regulated Stormwater Baseline Load,
- Nonpoint Source Loads: Maryland Watershed Nonpoint Source Baseline Load and Contaminated Site Baseline Load (see Table 4).

Table 4: Breakdown of the Total Watershed tPCB Baseline Loads (g/year)

Source	Baseline (g/year)
Maryland Watershed Nonpoint Sources	83.4
NPDES Regulated Stormwater	25.4
Contaminated Sites	0.2
Maryland Watershed Baseline Loads	*109.0*
Pennsylvania Upstream Baseline Loads	*13.4*
Total Watershed Baseline Load	**122.4**

About 6.1 g/year of the Northeast River Total Watershed tPCB Baseline Load is attributed to atmospheric deposition. The remaining load is due to unidentified sources of PCB contamination from the historical uses and releases. However, when compared with the Chesapeake Bay and Bottom Sediment loads, the watershed load is insignificant and even its complete elimination would not result in noticeable decrease in the PCB water column concentrations in the Northeast River embayment.

Contaminated Sites

Six contaminated sites have been identified in the Northeast River watershed based on information gathered from US EPA's Superfund Database (US EPA 2007) and MDE's Environmental Restoration and Redevelopment Program (ERRP) (MDE 2007a) (see Figure 5 and Table 5).

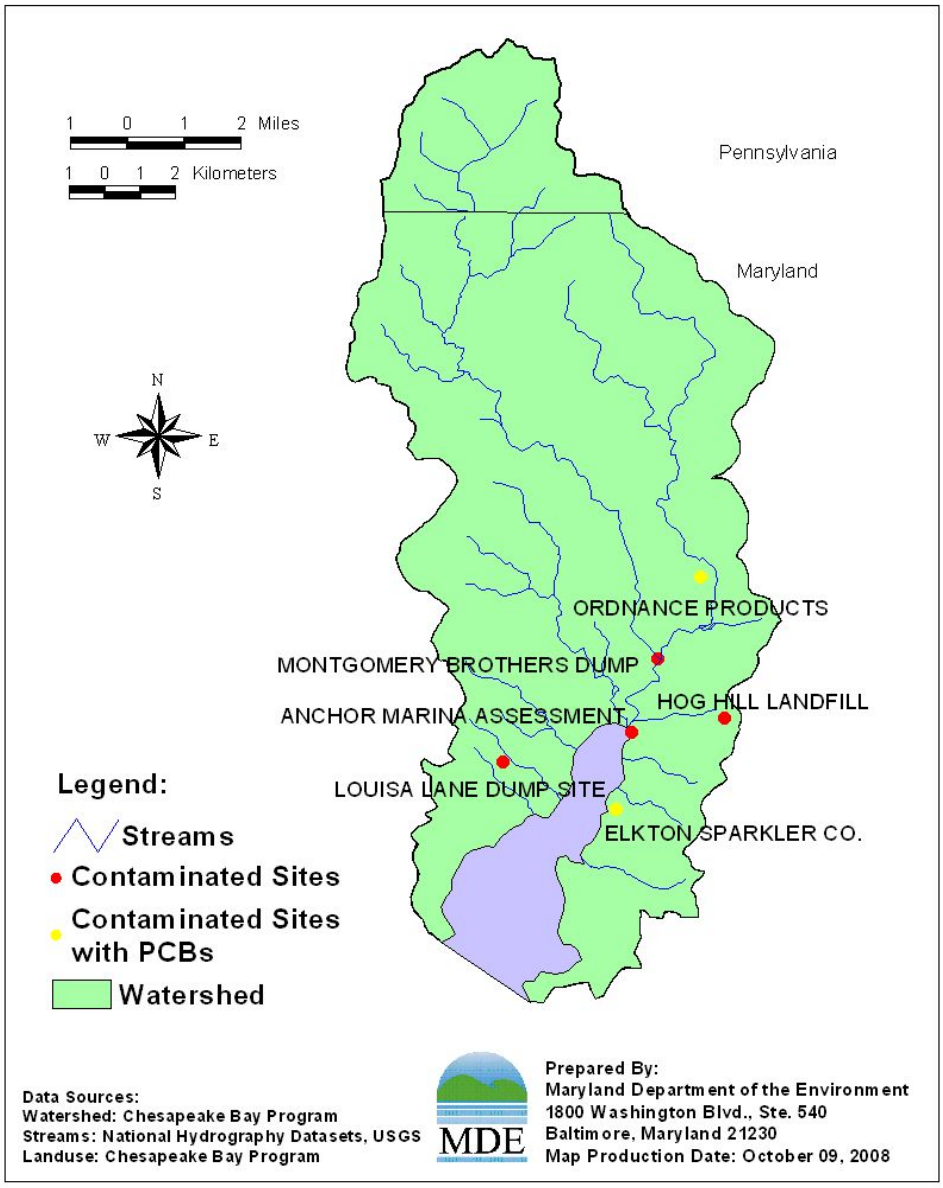

Figure 5: Locations of the Contaminated Sites in the Northeast River Watershed

Table 5: Contaminated Site Baseline Loads

Site Name	USEPA Site Number	MD ID	PCBs Detected	Baseline Load (g/year)
Anchor Marina Assessment	MD0001093533	MD-474	No	N/A
Hog Hill Landfill	MDD985407774	MD-440	No	N/A
Louisa Lane Dump Site	MDD981941503	MD-259	No	N/A
Montgomery Brothers Dump	MDD980705214	MD-137	No	N/A
Elkton Sparkler Co.	MDN000306101	—	Yes	7.19×10^{-4}
Ordnance Products	MDD982364341	MD-268	Yes	0.16

PCBs were detected at the following two sites: Ordnance Products and the Elkton Sparkler Co., which are located within the urban land use of the watershed. Based on soil properties, topography, and land cover at the sites, the amount of soil lost per year was estimated for each of the sites using the Revised Universal Soil Loss Equation Version II (RUSLE2). The methodology is presented in Appendix I. This annual erosion factor was subsequently combined with the observed PCB soil concentrations to estimate the tPCB loading. The total baseline tPCB loadings for Ordnance products and the Elkton Sparkler Co. are 0.16 g/year and 7.19×10^{-4} g/year, respectively. At less than 0.01 % of the Total Baseline Load, the tPCB loadings from these sites are considered to be insignificant.

2.3.2. Point Sources

The Department applies US EPA's requirement that "stormwater discharges that are regulated under Phase I or Phase II of the NPDES storm water program are point sources that must be included in the WLA portion of a TMDL" (US EPA 2002). Other point sources in the Northeast River watershed include loads from wastewater treatment facilities. While loads from wastewater treatment facilities have been estimated, they have been considered *de minimis* (see Appendix L) and at this point will not be subject to the traditional waste load allocation requirements. This section provides detailed explanation about how loads from these sources have been estimated.

Waste Water Treatment Plants

There are two waste water treatment plants (WWTPs) located in the watershed: Northeast River Advanced WWTP (MD0052027) and Morning Cheer WWTP (MD0052299) (Figure 6). Both of them discharge directly to the Northeast River embayment. The Northeast River Advanced WWTP was monitored for the discharge of PCBs for the purposes of this analysis. As no PCB data for Morning Cheer WWTP have been identified, the tPCB concentration for this facility was estimated as the median tPCB concentration of 31 samples from 13 WWTPs monitored by MDE in the Chesapeake Bay watershed. The baseline PCB loadings were based on the permit design flow for each of the WWTP and the appropriate PCB concentrations. Thus, the estimated tPCB loadings for the Northeast River Advanced WWTP and Morning Cheer WWTP are 1.03 and 0.03 g/year, respectively (Table 6).

Table 6: WWTP Baseline PCB Loadings

WWTP	tPCB Concentration (ng/L)	Design Flow (MGD)	Mean Flow (MGD)	Baseline Loading (g/year)
Northeast River Advanced WWTP	0.374	2	0.654	1.03
Morning Cheer	0.906	0.025	0.018	0.03

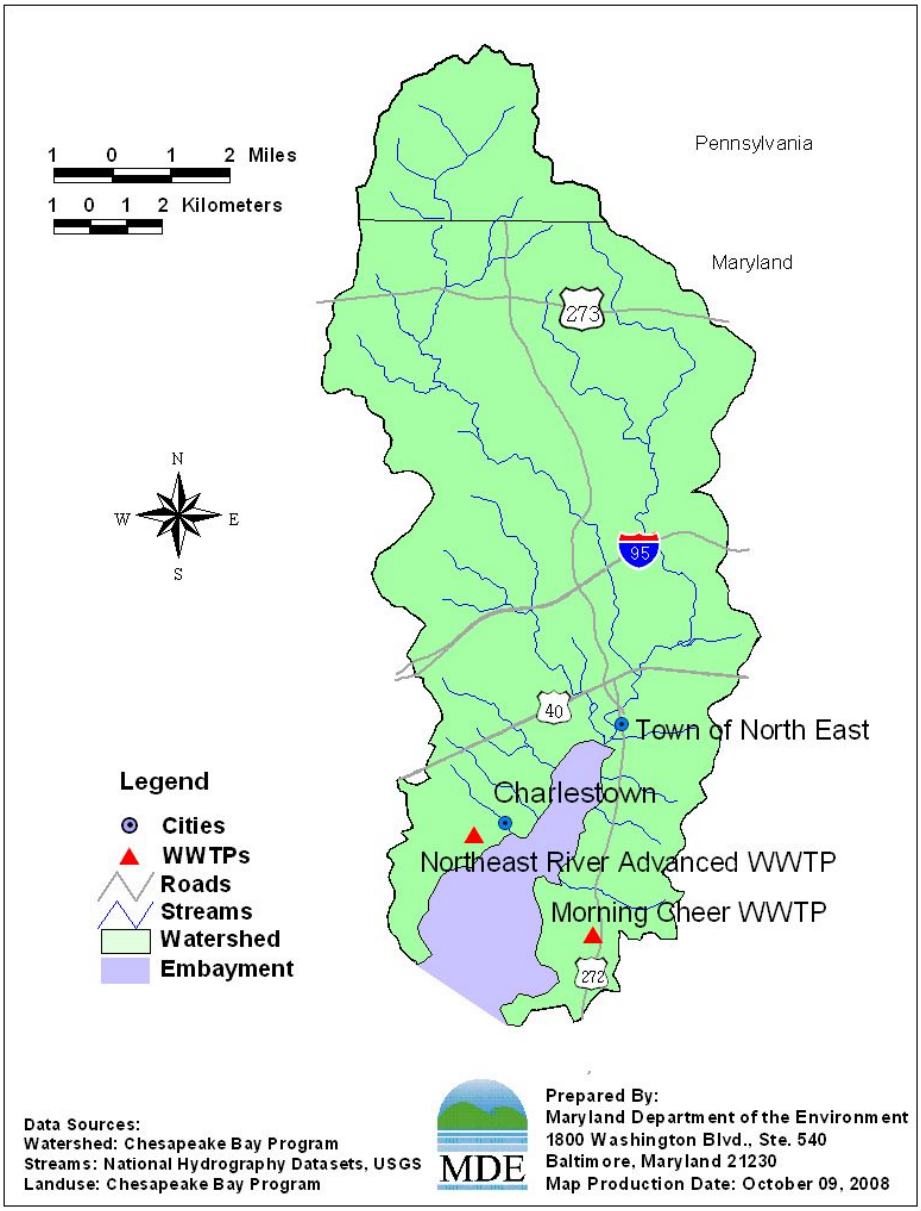

Figure 6: Locations of the Two WWTPs in the Northeast River Watershed

NPDES Regulated Stormwater

Although PCBs are no longer manufactured in the United States, they are still being released to the environment via accidental fires, leaks, or spills from older PCB-containing equipment; potential leaks from hazardous waste sites that contain PCBs; illegal or improper dumping; and disposal of PCB-containing products (e.g., transformers, old fluorescent lighting fixtures, electrical devices or appliances containing PCB capacitors, old microscope oil, and old hydraulic oil) into landfills not designed to handle hazardous waste. Once in the environment, PCBs do not readily break down and tend to cycle between various environmental media such as air, water, and soil.

A list of all the NPDES regulated stormwater permits within the Northeast River watershed that could potentially convey tPCB loads to the Northeast River embayment has been compiled (Appendix H). The types of permits identified include general industrial stormwater and general municipal separate storm sewer systems (MS4s). The tPCB baseline load of 25.6 g/year was estimated by multiplying the urban land use percentage of the total watershed area in Maryland (23.53%) and the Total Maryland Watershed Baseline Load (109.0 g/year). As the two PCB contaminated sites are located within the urban land use area, their respective loads (0.2 g/year) were subtracted from the total and presented separately, resulting in a NPDES Regulated Stormwater Baseline Load of 25.4 g/year.

2.3.3. Summary

In summary, tidal flushing from the Chesapeake Bay and resuspension and diffusion from the bottom sediments are the two major PCB sources to the Northeast River embayment. The remaining nonpoint sources (i.e., watershed runoff, contaminated sites runoff, and atmospheric deposition to the embayment) and point sources (i.e, WWTPs and NPDES regulated stormwater) comprise a relatively small portion of the tPCB Total Baseline Load. Table 7 summarizes the estimated loadings from various sources.

Table 7: Summary of tPCB Total Baseline Loads

Source	Baseline (g/year)	Baseline (%)
Chesapeake Bay (Tidal Influence)	5,847.6	70.67
Bottom Sediment (Resuspension and Diffusion)	2,248.0	27.17
Direct Atmospheric Deposition (to the Surface of the Embayment)	54.4	0.66
Maryland Watershed Nonpoint Sources*	83.4	1.01
Contaminated Sites*	0.2	0.00
Pennsylvania Upstream	13.4	0.16
Nonpoint Sources	***8,247.0***	**99.67**
WWTP*	1.1	0.01
NPDES Regulated Stormwater*	25.4	0.31
Point Sources*	***26.5***	**0.32**
Total	**8,274**	**100**

Note: * These sources were characterized only for the Maryland portion of the watershed.

3. TARGETED WATER COLUMN AND SEDIMENT GOALS

The overall objective of the tPCB TMDL established in this document is to ensure that the "fish consumption" designated use in the Northeast River embayment is protected. As described in Section 2.2, MDE evaluates whether a waterbody meets WQSs with the use of either the tPCB fish tissue listing threshold (39 ng/g) or the PCB water quality/water column criterion (0.64 ng/L). In order to determine which one of these targets is a more environmentally protective endpoint, the tPCB fish tissue listing threshold was converted to a corresponding tPCB water column concentration (see Equation 2 and Calculation 4). This was done with the use of the adjusted total Bioaccumulation Factor (Adj-tBAF) of 211,633 L/kg following the method applied within the Potomac River PCB TMDLs (see Appendix B for the derivation of the Adj-tBAF) (MDE 2007b).

$$\text{Water Concentration} = \text{Fish Tissue Concentration} / \text{Adj-tBAF} \times \text{Unit Conversion} \qquad \text{(Equation 2)}$$

Substituting 39 ng/g into the equation results in:

$$\text{Water Concentration} = 39\ \text{ng/g} \div 211{,}633\ \text{L/kg} \times \frac{1{,}000\ \text{g}}{1\ \text{kg}} = 0.18\ \text{ng/L} < 0.64\ \text{ng/L} \qquad \text{(Calculation 4)}$$

Based on this analysis, the water column concentration of 0.18 ng/L derived from the tPCB fish tissue listing threshold is the more environmentally protective of the two targets, and therefore will be applied in this analysis as the water quality goal/TMDL endpoint.

Similarly, in order to establish whether levels of PCBs in the sediment are protective of the "fish consumption" designated use, a sediment target for the Northeast River embayment was derived based on the tPCB fish tissue listing threshold (see Equation 3 and Calculation 5). This was done with the use of the adjusted sediment bioaccumulation factor (Adj-SediBAF) of 9.1 (unitless) following the method of the Potomac River PCB TMDLs (see Appendix B for the derivation of the Adj-SediBAF) (MDE 2007b).

$$\text{Sediment Target} = \frac{\text{Fish Tissue Threshold}}{\text{Adj} - \text{SediBAF}} \qquad \text{(Equation 3)}$$

Substituting 39 ng/g into Equation 3 results in:

$$\text{Sediment Target} = \frac{39\ \text{ng/g}}{9.1} = 4.3\text{ng/g} \qquad \text{(Calculation 5)}$$

Both of these targets will be used as TMDL endpoints and the more restrictive one will determine the actual TMDL (Section 4.2).

4. TOTAL MAXIMUM DAILY LOADS AND LOAD ALLOCATION

4.1. Overview

A TMDL is the total amount of impairing pollutant that a waterbody can receive and still meet WQSs. The TMDL may be expressed as a mass per unit time, toxicity, or other appropriate measure and should be presented in terms of wasteload allocations (WLAs), load allocations (LAs), and either implicitly or explicitly margin of safety (MOS) (CFR 2007):

$$TMDL = WLAs + LAs + MOS \qquad \text{Equation 4}$$

This section describes how the tPCB TMDL and the corresponding LAs and WLAs have been developed for the Northeast River embayment. The analysis framework for simulating PCB concentrations is described in Section 4.2, Section 4.3 addresses critical conditions and seasonality, and Section 4.4 presents the allocation of loads between point and nonpoint sources. The MOS is discussed in Section 4.5. Finally, the TMDL is summarized in Section 4.6.

4.2. Analysis Framework

A tidal prism model, which incorporates the influences of both freshwater discharge and tidal flushing was used to simulate the dynamic interactions between the water column and bottom sediments within the Northeast River embayment and the Chesapeake Bay (MDE 2005b, Kuo et al. 2005). In general, tidal waters are exchanged through their connecting boundaries. Within the Northeast River embayment, the tide, freshwater discharge, the atmospheric exchange due to volatilization, and the exchange with the bottom sediments (through diffusion, resuspension, and settling) are the dominant processes affecting the transport of PCBs throughout the water column. Burial to the deeper inactive layers and the exchange with the water column (through diffusion, resuspension, and settling) are the dominant processes affecting the transport of PCBs in the bottom sediments. A detailed description of the model is presented in Appendix C and Appendix D.

The observed average tPCB concentrations were used as the inputs to the model representing baseline (2003) conditions. Based on the available literature, the TMDL methodology assumes that the average tPCB concentrations in the Upper Chesapeake Bay are decreasing at a rate of 6.5% per year (see Section 2.3.1). All other inputs (i.e., freshwater inputs, tidal exchange rates, sediment and water column exchange rates, and burial rates) were kept constant.

The model was initially run for 25,000 days to predict the time needed for the water column tPCB concentration to meet the established target TMDL water column endpoint. The results indicated that when the water column target (0.18 ng/L) was met, the tPCB sediment concentration was still higher than the established target TMDL sediment endpoint (4.3 ng/g). Consequently, the model was run again for 25,000 days to predict the time needed for the sediment concentrations to reach the target levels. Figure 7 and Figure 8 show the simulated results: after 13,572 days (about 37 years) the tPCB sediment concentration reached 4.3 ng/g (Figure 7), at which time the water column tPCB concentration was equal to 0.15 ng/L (Figure 8).

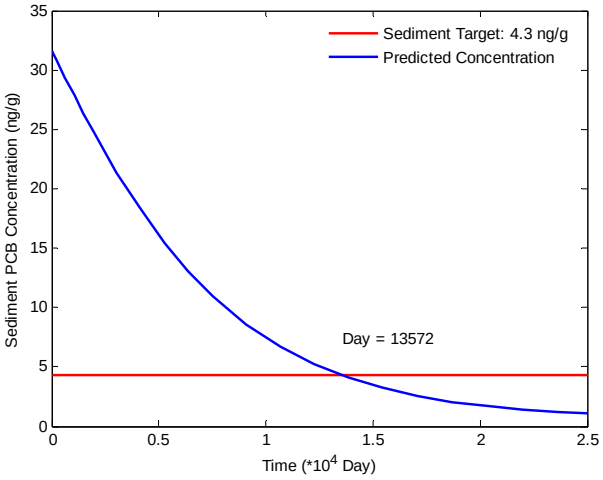

Figure 7: Change of Sediment tPCB Concentration with Time

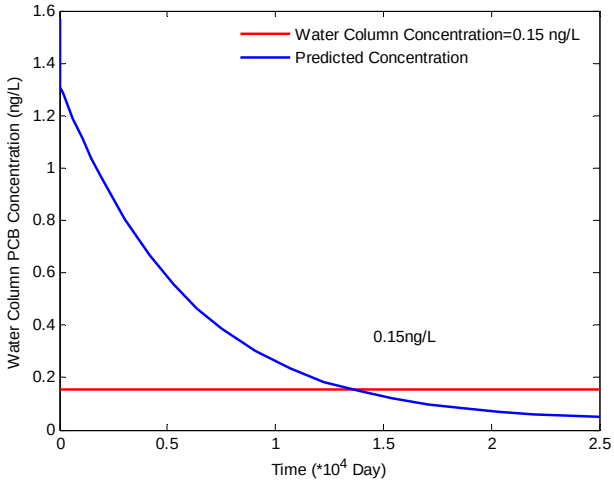

Figure 8: Change of Water Column tPCB Concentration with Time

As presented in Table 8, loadings from the Chesapeake Bay as well as resuspension and diffusion from the bottom sediments are the primary source of tPCB loads resulting in the exceedance of the human health water quality targets in the Northeast River embayment. Attainment of the PCB water quality targets will only be possible with significant reduction in these primary loadings (Table 8), which is expected to take place over time as the Upper Chesapeake Bay concentrations continue to decline resulting also in natural attenuation of tPCB levels in the legacy sediments (i.e., the covering of contaminated sediments with newer, less contaminated materials, flushing of sediments during periods of high stream flow, and biodegradation). Assuming that the tPCB concentrations in the Upper Chesapeake Bay will continue to decline, at or above the current rate, no additional tPCB reductions will be necessary to meet the "fish consumption" designated use in the Northeast River embayment.

4.3. Critical Condition and Seasonality

Federal regulations require TMDL determinations to take into account the impact of critical conditions and seasonality on water quality (CFR 2007). The intent of these requirements is to ensure that the water quality is protected during the most vulnerable times. Figure 9 illustrates seasonal variation in terms of water column tPCB concentrations in the Northeast River embayment.

In general, the tPCB water column concentrations increase between March and October. This indicates that in the spring, due to the high river flow, water column PCBs are likely diluted by the increased river discharge more so than during the low flow period of summer and fall. However, since PCB levels in fish become elevated due to long-term exposure, rather than temporary spikes in water column concentration, it has been determined that the selection of an average tPCB water column concentrations as the baseline conditions adequately considers the impact of seasonal variations and critical conditions on the "fish consumption" designated use in the Northeast River embayment. Furthermore, the water column tPCB target used to develop this TMDL is lower than the current human health criterion for consumption and is more protective than the freshwater and saltwater chronic aquatic life criteria necessary to protect fish and wildlife.

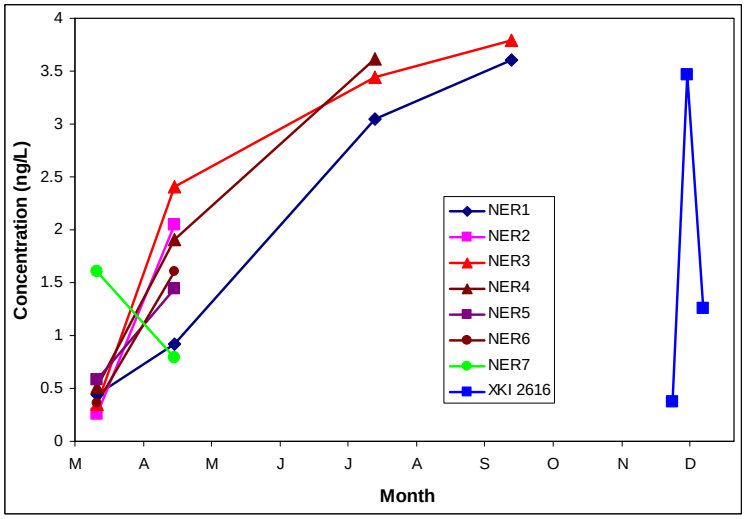

Figure 9: Seasonal Variations of Water Column tPCB Concentrations in Northeast River embayment (2003, 2006)

Selection of the average tPCB concentrations to represent the initial model conditions will not affect the established TMDL, which was established to meet the water column and sediment targets at all times. However, the time required to reach the TMDL targets will depend on the selection of the initial conditions. To better understand this concept, the upper and lower 95% confidence intervals (CIs) of the mean water column tPCB concentrations were estimated and used in the analysis. The time duration required to reach the TMDL targets increased by about 10 percent (4 years) when the higher tPCB water column concentration was used as the baseline. Detailed results are presented in Appendix E.

4.4. TMDL Allocations

All TMDLs need to be presented as a sum of WLAs for point sources, LAs for nonpoint source loads generated within the assessment unit and if applicable LAs for the natural background, tributary, and adjacent segment loads (CFR 2007). The State reserves the right to revise these allocations provided the revisions are consistent with achieving WQSs. The allocations described in this section summarize the tPCB TMDL established to meet the "fish consumption" designated use in the Northeast River embayment.

4.4.1. Point Sources

<u>Waste Water Treatment Plants</u>

Two WWTPs were identified in the Northeast River watershed: Northeast River Advanced WWTP (MD0052027) and Morning Cheer (MD0052299). The estimated tPCB loadings for the WWTPs are 1.03 and 0.03 g/year, respectively (Table 6). For more information on methods used to calculate the WWTP baseline tPCB loads, please see Section 2.3.2. At 0.1% of the TMDL, the current Northeast River cumulative WWTP loads were considered *de minimis* (see Appendix L). Given no appreciable environmental benefit of reducing these WWTP loading and given that these loads are believed to be associated with elevated PCB concentrations in other sources (e.g., source water, atmospheric

deposition, stormwater runoff) at this point WWTP loads will not be subject to the traditional waste load allocation requirements.

NPDES Regulated Stormwater

Per US EPA requirements, "stormwater discharges that are regulated under Phase I or Phase II of the NPDES stormwater program are point sources that must be included in the WLA portion of a TMDL" (US EPA 2002). Phase I and II permits can include the following types of discharges:

- Small, medium, and large MS4s – these can be owned by local jurisdictions, municipalities, and state and federal entities (e.g., departments of transportation, hospitals, military bases),
- General industrial stormwater permitted facilities, and
- Small and large construction sites.

US EPA recognizes that available data and information are usually not detailed enough to determine WLAs for NPDES regulated stormwater discharges on an outfall-specific basis (US EPA 2002). Therefore, NPDES regulated stormwater loads to the Northeast River embayment will be expressed as a single NPDES Regulated Stormwater WLA. Upon approval of the TMDL, "NPDES-regulated municipal stormwater and small construction storm water discharges effluent limits should be expressed as BMPs or other similar requirements, rather than as numeric effluent limits" (US EPA 2002).

NPDES Regulated Stormwater WLA constitutes a proportional allocation of stormwater load to the entire Maryland urban land area and may include any or all of the NPDES stormwater discharges listed above. As stormwater assessment and/or other program monitoring efforts result in a more refined source assessment, MDE reserves the right to revise the current NPDES Regulated Stormwater WLA provided the revisions are consistent with achieving WQSs.

The loadings from NPDES regulated stormwater entering the Northeast River embayment were considered to be insignificant relative to the loads from the open boundary with the Chesapeake Bay and resuspension and diffusion from the bottom sediments. Therefore, at this point, no reductions were applied to these stormwater entities, and their WLA was set equivalent to their baseline load (Table 8). For more information on methods used to calculate the tPCB NPDES Regulated Stormwater Baseline Loads, please see Section 2.3.2. Additionally, a list of NPDES regulated stormwater facilities located in the Northeast River watershed is provided in Appendix H.

4.4.2. Nonpoint Sources

Load allocations have been assigned for the following nonpoint sources: the Chesapeake Bay, bottom sediment, direct atmospheric deposition to the surface of the embayment, Maryland watershed nonpoint sources, contaminated sites, and Pennsylvania Upstream sources. PCB loadings from the Chesapeake Bay and bottom sediments are the most significant sources of PCBs to the Northeast River embayment and as such are the only ones requiring reductions in order to meet the "fish consumption" designated use in the Northeast River embayment. These reductions are expected to take place over time as the Upper Chesapeake Bay concentrations continue to decline resulting also in natural attenuation of tPCB levels in the legacy sediments. Assuming that the tPCB concentrations in the Upper Chesapeake Bay will continue to decline at or above the current rate, no

additional tPCB reductions should be required for the remaining nonpoint sources. At the moment, the remaining LAs were set as equivalent to the corresponding baseline loads (Table 8)

4.5. Margin of Safety

All TMDLs must include a margin of safety to account for any lack of knowledge and the many uncertainties in the understanding and simulation of water quality parameters in natural systems. The MOS is intended to account for such uncertainties in a manner that is conservative from the standpoint of environmental protection. Considering the uncertainty surrounding the estimated rate at which PCB concentrations are decreasing in the upper Bay region and the variation in tPCB concentrations within the 95% CIs, MDE decided to apply a 10% MOS in order to provide an adequate and environmentally protective TMDL (Table 8).

4.6. Summary of Total Maximum Daily Loads

Table 8 summarizes the tPCB TMDL for the Northeast River embayment as well as the corresponding baseline loads, the Maximum Daily Load (MDL, for more details see Appendix G), and the associated load reductions.

Table 8: Northeast River tPCB Baseline Loads, TMDL, Required Reductions, and MDL

Source	Baseline Load (g/year)	TMDL (g/year)	Load Reduction (%)	MDL (g/day)
Chesapeake Bay (Tidal Influence)	5,847.6	480.5	93.7	1.730
Bottom Sediment (Resuspension and Diffusion)	2,248.0	306.8	86.4	1.104
Direct Atmospheric Deposition (to the Surface of the Embayment)	54.4	54.4	0.0	0.196
Maryland Watershed Nonpoint Sources *	83.4	83.4	0.0	0.300
Contaminated Sites *	0.2	0.2	0.0	0.001
Pennsylvania Upstream	13.4	13.4	0.0	0.048
Nonpoint Sources/Load Allocations	***8,247.0***	***938.7***	***88.6***	***3.379***
WWTP *△	1.1	1.1	0.0	0.009
NPDES Regulated Stormwater *	25.4	25.4	0.0	0.091
Point Sources/Waste Load Allocations *	***26.5***	***26.5***	***0.0***	***0.10***
MOS	**-**	***107.2***	**-**	***0.386***
Total	**8,274**	**1,072**	**87.0**	**3.87**

Notes: * These sources were characterized only for the Maryland portion of the watershed.
△ WWTP loads were considered to be *de minimis* and at this point will not be subject to the traditional waste load allocation requirements.

5. ASSURANCE OF IMPLEMENTATION

As discussed in the previous sections, tidal flushing from the Chesapeake Bay and resuspension and diffusion from the bottom sediments have been identified as the two major sources of tPCBs to the Northeast River embayment. As described in Section 2.3.1, it has been estimated that on average tPCB concentrations in the Upper Chesapeake Bay are decreasing at a rate of 6.5% per year. Given this rate of decline in the boundary concentrations, the tPCB levels in the Northeast River embayment are expected to decline over time due to natural attenuation, such as the burial of contaminated sediments (i.e., the covering of contaminated sediments with newer, less contaminated materials, flushing of sediments during periods of high stream flow, and biodegradation).

Aside from the processes of natural attenuation, there are two alternatives that can assist in reducing the tPCB concentrations in the water column so as to meet WQSs. First, the physical removal of the PCB-contaminated sediments (i.e., dredging) would minimize one of the primary sources of tPCB to water column. Second, a reduction in the Chesapeake Bay water column tPCB concentrations would greatly accelerate the process of attenuation.

In this particular situation, dredging is the least desirable alternative because of its potential biological destruction. It damages the habitat of benthic macroinvertebrates and may directly kill some organisms. The process of stirring up suspended sediments during dredging may damage the gills and/or sensory organs of benthic macroinvertebrates and fish. Suspended sediments can also affect the prey gathering ability of sight-feeding fish. In addition, the resuspension of contaminated sediments provides organisms with additional exposure to PCBs.

Natural attenuation is a better implementation method because it involves less habitat disturbance/ destruction and is less costly. Discovering and remediating any existing PCB land sources throughout the upper Chesapeake Bay watershed via future TMDL development and implementation efforts will further help to meet water quality goals in the Northeast River embayment.

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Appendix A. List of Individual tPCB Measurements

The Northeast River polychlorinated biphenyl (PCB) data were collected between 2002 and 2006. The total polychlorinated biphenyls (tPCBs) in fish tissue, sediment, and water column are listed in Table A-1, Table A-2, and Table A-3.

Table A-1: Fish Tissue tPCB Concentrations

Station	Fish Species	Date	tPCB (ng/g – wet weight)
NER	Black Crappie	9/3/2002	27.788
NER	Channel Catfish	9/3/2002	217.419
NER	White Perch	9/3/2002	244.239
NER	White Perch	9/3/2002	275.247
NER	Brown Bullhead Catfish	9/3/2002	143.081
NER	American Eel	9/4/2002	150.576

Table A-2: Sediment tPCB Concentrations

Station	Date	tPCB (ng/g – wet weight)
NER1	7/15/2003	11.044
NER2	7/15/2003	31.965
NER3	7/15/2003	50.035
NER4	7/15/2003	59.143
NER5	7/15/2003	24.658
NER6	7/15/2003	5.903
NER7	7/15/2003	42.531

Table A-3: Water Column tPCB Concentrations

Station	Date	Particulate (ng/L)	Dissolved (ng/L)	Total (ng/L)
NER1	3/11/2003	0.353	0.091	0.444
NER1	4/15/2003	0.520	0.395	0.915
NER1	7/15/2003	2.004	1.044	3.048
NER1	9/15/2003	2.722	0.886	3.608
NER2	3/11/2003	0.199	0.061	0.260
NER2	4/15/2003	1.760	0.286	2.046
NER3	3/11/2003	0.152	0.195	0.347
NER3	4/15/2003	1.873	0.539	2.412
NER3	7/15/2003	2.525	0.914	3.439
NER3	9/15/2003	3.206	0.584	3.790
NER4	3/11/2003	0.263	0.247	0.51
NER4	4/15/2003	1.277	0.634	1.911
NER4	7/15/2003	1.871	1.750	3.621
NER5	3/11/2003	0.497	0.087	0.584
NER5	4/15/2003	0.781	0.666	1.447
NER6	3/11/2003	0.187	0.179	0.366
NER6	4/15/2003	0.336	1.267	1.603
NER7	3/11/2003	1.409	0.195	1.604
NER7	4/15/2003	0.264	0.527	0.791
NER8	3/12/2003	0.030	0.103	0.133
NER8	4/15/2003	0.497	1.153	1.65
NER8	7/15/2003	0.975	0.548	1.523
NER9	3/11/2003	0.119	0.559	0.678
NER9	4/15/2003	0.761	0.726	1.487
NER10	3/11/2003	0.562	0.071	0.633
NER10	4/15/2003	0.127	1.247	1.374
XKI2616	11/27/2006	0.320	0.051	0.371
XKI2616	12/4/2006	3.424	0.035	3.459
XKI2616	12/11/2006	1.173	0.088	1.261
XKI1309	11/27/2006	0.536	0.058	0.594
XKI1309	12/4/2006	2.529	0.057	2.586
XKI1309	12/11/2006	0.331	0.187	0.518

Appendix B. Derivation of Adj-tBAF and Adj-SediBAF

This appendix describes how the Adjusted Total Bioaccumulation Factor (Adj-tBAF) and Sediment Bioaccumulation Factor (Adj-SediBAF) were derived. The method followed the Potomac River PCB TMDL (MDE 2007b).

I. Data Description

The observation-based Adj-tBAF and Adj-SediBAF were calculated for the 5 fish species listed in Table 3 from the available fish tissue, water column, and sediment total polychlorinated biphenyl (tPCB) data. Each fish species was assigned a trophic level and a home range (Table B-1). The Adj-tBAF and Adj-SediBAF were calculated based on the geometric mean tPCB concentrations of all the samples within the home range for each species.

Table B-1: Species Trophic Levels and Home Ranges

Common Name	Scientific Name	Trophic Level	Home Range (Mile)
American Eel	*Anguilla Rostrata*	Predator	5
Black Crappie	*Pomoxis nigromaculatus*	Predator	2
Brown Bullhead Catfish	*Ameiurus nebulosus*	Benthivore-generalist	5
Channel Catfish	*Ictalurus punctatus*	Benthivore-generalist	5
White Perch	*Morone americana*	Predator	10

II. Total BAFs

First, the total BAFs were calculated using Equation B1 (US EPA 2003):

$$\text{Total BAF} = \frac{[\text{tPCB}]_{\text{fish}}}{[\text{tPCB}]_{\text{Water}}} \qquad \text{(B1)}$$

Where: $[\text{tPCB}]_{\text{fish}}$ = tPCB concentration in fish wet tissue (ng/kg)
$[\text{tPCB}]_{\text{water}}$ = water column tPCB concentration in fish species home range (ng/L)

III. Baseline BAFs

As the total BAFs vary depending on the food habits and lipid concentration of each fish species and on the freely-dissolved PCB concentrations in water, the baseline BAFs were calculated as recommended by US EPA (2000):

$$\text{Baseline BAF} = \frac{[\text{PCB}]_{\text{fish}} \ / \ \%\text{Lipid}}{[\text{PCB}]_{\text{Water}} \times \% fd} \qquad \text{(B2)}$$

Where: %fd = fraction of the tPCB concentration in water that is freely-dissolved
%lipid = fraction of tissue that is lipid

The freely-dissolved tPCBs are those not associated with dissolved organic carbon (DOC) or particulate organic carbon (POC). It can be calculated as (US EPA 2003):

$$\%fd = \frac{1}{1 + POC \times K_{ow} + DOC \times 0.08 \times K_{ow}} \quad \text{(B3)}$$

where K_{ow} is the PCB octanol-water partition coefficient, POC and DOC are the particulate and dissolved organic carbon concentrations in the water column.

The K_{ow} of PCB congeners have large ranges. Therefore, a %fd was calculated for each PCB homolog using the midpoint of the homolog's K_{ow} range (Table B-2; MDE 2007b page D-10).

Table B-2: K_{ow} Values of Homologs used in the Baseline BAF Calculation

Homolog	Midpoint K_{ow}
Mono+Di	47,315
Tri	266,073
Tetra	1,011,579
Penta	3,349,654
Hexa	5,370,318
Hepta	17,179,084
Octa	39,810,717
Nona	82,224,265
Deca	151,356,125

The %fd for tPCBs was derived by dividing all the freely-dissolved PCB concentration by the tPCB concentration in water column, and the PCB %fd in Equation B4 was used in Equation B2 to calculate the baseline BAFs:

$$\text{PCB } \%fd = \frac{\sum(\text{Homolog } \%fd \times \text{Homolog Concentration})}{[PCB]_{water}} \quad \text{(B4)}$$

The freely dissolved PCB, POC, and DOC concentrations for each water sample are listed in Table B-3.

Table B-3: Freely Dissolved PCB, POC, and DOC Concentrations for Each Water Sample Involved in the Calculation

Station	Sample Date	Freely-Dissolved PCB (ng/L)	POC (kg/L)*	DOC (kg/L)*
NER1	11-Mar-03	1.7E-01	1.0E-06	6.6E-06
NER1	15-Apr-03	2.0E-01	2.0E-06	4.9E-06
NER1	15-Jul-03	1.1E+00	2.7E-06	5.8E-06
NER1	15-Sep-03	1.2E+00	3.1E-06	6.6E-06
NER2	11-Mar-03	6.9E-02	1.0E-06	6.4E-06
NER2	15-Apr-03	3.6E-01	2.0E-06	4.5E-06
NER3	11-Mar-03	8.9E-02	1.3E-06	7.0E-06
NER3	15-Apr-03	5.4E-01	1.9E-06	4.0E-06
NER3	15-Jul-03	1.3E+00	2.3E-06	5.0E-06
NER3	15-Sep-03	1.2E+00	2.8E-06	4.4E-06
NER4	11-Mar-03	1.7E-01	1.4E-06	6.0E-06
NER4	15-Apr-03	7.0E-01	5.7E-07	2.4E-06
NER4	15-Jul-03	1.5E+00	1.9E-06	3.6E-06
NER5	11-Mar-03	1.0E-01	1.0E-06	3.9E-06
NER5	15-Apr-03	3.7E-01	1.3E-06	2.4E-06
NER6	11-Mar-03	1.6E-01	4.4E-07	5.3E-06
NER6	15-Apr-03	7.9E-01	7.7E-07	4.3E-06
NER7	11-Mar-03	7.1E-01	8.9E-07	4.3E-06
NER7	15-Apr-03	3.0E-01	5.7E-07	2.5E-06
XKI2616	27-Nov-06	2.0E-01	1.3E-06	4.1E-06
XKI2616	04-Dec-06	2.8E-01	1.3E-06	4.1E-06
XKI2616	11-Dec-06	5.8E-02	1.3E-06	4.1E-06
XKI1309	27-Nov-06	2.4E-01	1.3E-06	4.1E-06
XKI1309	04-Dec-06	7.5E-01	1.3E-06	4.1E-06
XKI1309	11-Dec-06	1.8E-01	1.3E-06	4.1E-06
NER8	12-Mar-03	5.7E-02	4.5E-07	4.6E-06
NER8	15-Apr-03	8.6E-01	2.6E-07	3.8E-06
NER8	15-Jul-03	1.0E+00	2.4E-07	4.4E-06
cb1	08-Mar-93	1.2E+00	2.1E-06	1.8E-06
cb1	12-Apr-93	1.5E+00	1.3E-06	2.3E-06
cb1	01-Jun-93	7.7E-01	1.9E-06	2.2E-06
cb1	20-Sep-93	1.4E+00	1.0E-06	3.2E-06
CBTOX1	24-Feb-03	2.0E-01	4.0E-07	2.1E-06
CBTOX1	01-Apr-03	5.4E-01	6.3E-07	2.5E-06
CBTOX1	25-Jun-03	1.5E+00	1.1E-06	4.0E-06
ELR12	13-Mar-03	1.2E+00	7.3E-07	3.4E-06
ELR12	17-Apr-03	7.8E-02	1.7E-06	4.9E-06
ELR4	13-Mar-03	9.9E-01	7.9E-07	3.3E-06
ELR4	17-Apr-03	8.4E-01	1.3E-06	4.4E-06

* When the POC or DOC is not available for the sample, the averaged value within the range is used.

IV. Adjusted Total BAFs

The baseline BAFs was normalized by the species median lipid content and a single freely-dissolved PCB concentration (i.e., median %fd within the fish's home range) representative of the ecosystem, resulting in no variability attribution to differences in fish lipid content or freely-dissolved PCB concentration in the water column:

$$\text{Adj-tBAF} = (\text{Baseline BAF} \times \text{Median \% Lipid} + 1) \times \text{Median \%fd} \quad \text{(B5)}$$

The tPCB fish tissue listing threshold of 39 ng/g can then be divided by the median Adj-tBAF for each species (Table B-4). To be protective, the lowest water column target (white perch) was used as the embayment-wide water column PCB target.

Table B-4: tBAF, bBAF, Adj-tBAF, and Water Column Target, as well as Median %fd and Lipid Content for Each Species

Species Name	tBAF (L/kg)	bBAF (L/kg)	Adj-tBAF (L/kg)	Water Column Target (ng/L)	Median %fd	Median Lipid Content
American Eel	118,403	4,333,577	129,325	0.30	0.29	0.1037
Brown Bullhead Catfish	112,505	38,035,481	122,883	0.32	0.29	0.0112
Black Crappie	22,309	4,871,768	21,765	1.79	0.24	0.0184
Channel Catfish	170,960	13,969,025	186,730	0.21	0.29	0.0464
White Perch	181,618	31,952,636	211,633	0.18	0.33	0.0203

V. BSAFs and Adj-SedBAFs

The BSAFs are derived by the following equation:

$$\text{BSAF} = \frac{\text{tPCB}_{\text{tissue}} / \text{\% Lipid}}{\text{tPCB}_{\text{sediment}} / \text{\% Oraganic Carbon}} \quad \text{(B6)}$$

Where: % Organic Carbon is the species home range's average sediment organic carbon fraction.

As there's no available % Organic Carbon information for the study sites of the Northeast River, a default values of 1% was used (US EPA 2004). Each species' BSAF then was standardized to a common condition by normalizing them to the median lipid content of the species (Table B-4) and a sediment organic carbon fraction representative of the ecosystem:

$$\text{Adj-SedBAF} = \text{BSAF} \times \frac{\text{Median \% Lipid}}{\text{Median \% Oraganic Carbon}} \quad \text{(B7)}$$

The tPCB fish tissue listing threshold of 39 ng/g can then be divided by the median Adj-SedBAF for each species (Table B-5). To be protective, the lowest sediment target of 4.3 ng/g (white perch) was used as the embayment-wide sediment PCB target.

Table B-5: BSAF and Adj-SedBAF for Each Species

Species Name	BSAF	Adj-SedBAF	Sediment Target (ng/g)
American Eel	0.54	5.65	7
Brown Bullhead Catfish	4.78	5.36	7
Black Crappie	0.41	0.76	51
Channel Catfish	1.76	8.15	5
White Perch	4.48	9.11	**4**

Appendix C. Tidal Prism Model

A description of the tidal prism model is presented in this Appendix. It is assumed that a single volume can represent a waterbody, and that the pollutant is well mixed in the waterbody, as shown in Figure C-1. Assuming no decay the polychlorinated biphenyls (PCBs) can enter the water column via loading from upstream and atmosphere (L_f), loading from the Chesapeake Bay (Q_0C_0), resuspension from the sediment (V_rAC_2), and diffusion between sediment-water column interface ($V_dA(F_{do2}C_2 - F_{do1}C)$). PCBs leave the water column via volatilization ($V_vAF_{do1}C_1$), flow to the Chesapeake Bay (Q_bC_1) and sedimentation ($V_sAF_{p1}C_1$). In the sediment, the PCBs enter the system via settling ($V_sAF_{p1}C_1$), and leave the system via diffusion ($V_dA(F_{do2}C_2 - F_{do1}C)$), resuspension ($V_rAC_2$) and burial to a deeper layer (V_bAC_2). Specifically, the mass balance for the PCBs in the water column and sediment can be written as:

$$\frac{dV_1C_1}{dt} = L_f - V_vAF_{do1}C_1 + (1-\alpha)Q_0C_0 - Q_bC_1 + V_rAC_2 - V_sAF_{p1}C_1 + V_dA(F_{do2}C_2 - F_{do1}C_1) \quad \text{(C1)}$$

$$\frac{dV_2C_2}{dt} = -V_rAC_2 + V_sAF_{p1}C_1 - V_dA(F_{do2}C_2 - F_{do1}C_1) - V_bAC_2 \quad \text{(C2)}$$

Where:

L_f = PCB loading from upstream (point and non-point sources);
V_v = volatilization coefficient (m/d);
α = return ratio, which is the percentage of water that flowed to the Chesapeake Bay during the previous ebb tide and flows back to the embayment during the flood tide;
A = area of the embayment (m^2);
Q_0 = quantity of water that enters the embayment through the open boundary (m^3/d);
Q_b = quantity of water that leaves the embayment through the open boundary (m^3/d);
C_0 = tPCB concentrations in the water column of the Chesapeake Bay (ng/L);
C_1 = tPCB concentrations in the water column of the embayment (ng/L);
C_2 = tPCB concentrations in the sediment of the embayment (ng/L);
V_1 = volume of the water column in the embayment (m^3);
V_2 = volume of the active sediment layer of the embayment (m^3);
V_d = diffusive mixing velocity;
F_{p1} = fraction of particular-associated PCBs in the water column;
F_{do1} = fraction of truly dissolved and dissolved organic carbon (DOC)-associated PCBs in the water column;
F_{do2} = fraction of truly dissolved and DOC-associated PCBs in the sediment;
V_r = rates of resuspension (m/d);
V_s = rates of settling (m/d);
V_b = rates of burial (m/d).

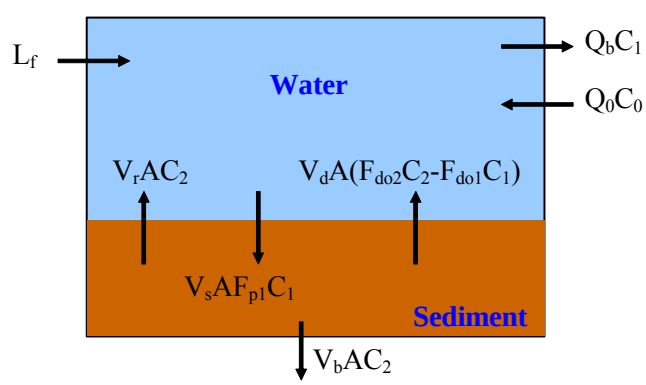

Figure C-1: The Schematic Diagram for the Tidal Prism Model and the PCB Budget

Appendix D. Tidal Prism Model Calculation for Northeast River

For the Northeast River, the parameter values are as follows:

L_f = 487,397 ug/day

V_v = 0.246 m/day. (It was derived from empirical method of Chapra (1997))

α = 0.46; in general, the exchange ratio varies from 0.3 to 0.7 (Kuo et al. 1998, Shen et al. 2002).

A = 1,647,000 m^2.

Q_0 = A × Tidal range ÷ Tidal circle×24 hours=16,470,000×0.579÷12.42×24 = 18,427,304 m^3.

Q_b = $Q_f + Q_0 \times (1-\alpha)$ = 316,465 + 18,427,304×(1-0.46) = 10,267,209 m^3.
The Q_f is the volume of water enter the embayment from upstream. It is obtained by dividing the mean flow recorded at the closest U.S. Geological Survey (USGS) gage station by its drainage area, and multiplying the drainage area of the Northeast River watershed.

C_0 = $1.61\times(0.935)^t$ ng/L. The measurement at the station XKI1309 was used as the boundary concentration at year 2006. The value was back-calculated to the concentration in year 2003 and was used as the initial boundary condition of the model.

C_1 = 1.57 ng/L (measured).

C_2 = Measured PCB concentration on a dry sediment base × Sediment density×(1-porosity)÷ Fraction of particular-associated PCBs in the sediment = 31.60×2,500×(1-0.85) ÷ 0.9976 = 11,878 ng/L, and the porosity (water content on a volume base) of 0.85 is selected based on observations and reference (Thomann and Mueller 1987).

V_1 = 30,487,000 m^3.

V_2 = A × Active sediment layer thickness = 16,470,000×0.10=1,647,000 m^3;
The Active Sediment layer thickness value of 0.10 m is a typical value frequently used in water quality models.

V_d = 69.35× Porosity× (Molecular weight of PCBs)$^{-2/3}$ ÷365= 69.35 × 0.85× (305.6)$^{-2/3}$ ÷ 365 = 0.00356 m/d (Thomann and Mueller 1987).

F_{p1} = 0.2337; F_{do1} = 0.7663; F_{do2}= 0.00242 (see Appendix F for derivation).

V_s = 1 m/d; a default value of settling rate normally used in literature (DRBC 2003).

V_b = 5.836×10^{-6} m/d (average of the measured sedimentation rates through ^{210}Pb technology).

V_r can be calculated via mass balance of the sediment in the active sediment layer at steady state:

$$\frac{d\rho(1-\varphi)}{dt} = V_s \times TSS - V_r \times \rho \times (1-\varphi) - V_b \times \rho \times (1-\varphi) = 0 \qquad \text{(D1)}$$

Where: TSS is the total suspended solid concentration g/m^3 (measured)
ρ is the sediment density g/m^3 (Thomann and Mueller 1987)
φ is the porosity.

Rearrange Equation D1:

$$V_r = \frac{V_s \times TSS}{\rho \times (1-\varphi)} - V_b = \frac{1\times 10.9}{2500000\times(1-0.85)} - 5.836\times10^{-6} = 2.323\times10^{-5} \text{ m/d} \qquad \text{(D2)}$$

Substituting all the necessary parameters to equations (C1) and (C2) results in the changes of C_1 and C_2 through time.

Appendix E. Calculation of 95% CIs

The 95% Confidence Intervals (CIs) for the baseline mean total polychlorinated biphenyl (tPCB) concentration were calculated as follows:

$$\text{Upper 95\% C.I.} = \text{Mean} + \frac{\text{t - value} \times \text{Standard Deviation}}{\sqrt{\text{Sample Size}}}$$

$$\text{Lower 95\% C.I.} = \text{Mean} - \frac{\text{t - value} \times \text{Standard Deviation}}{\sqrt{\text{Sample Size}}}$$

Where: t-value is a tabulated value that can be found in a basic statistics textbook.

The model was run with the mean as well as the upper- and lower- 95% CIs set as the initial conditions in the embayment and outside of the Bay boundary. The results are presented in Figures E-1 and E-2. Time duration required to meet the sediment target and the corresponding water column concentrations are listed in Table E-1. The time duration required to meet the water quality standards in the embayment increased by approximately 10 percent (4 years) when the higher tPCB water column concentration was used as the baseline.

Table E-1: Values for the Mean and its 95% CIs of tPCB Concentration

	Time (days) to Meet the Sediment Target	Water Column tPCB Concentration (ng/L) When Sediment Target is Met
Mean	13,572	0.154
Upper 95% C.I.	15,117	0.152
Lower 95% C.I.	11,214	0.160

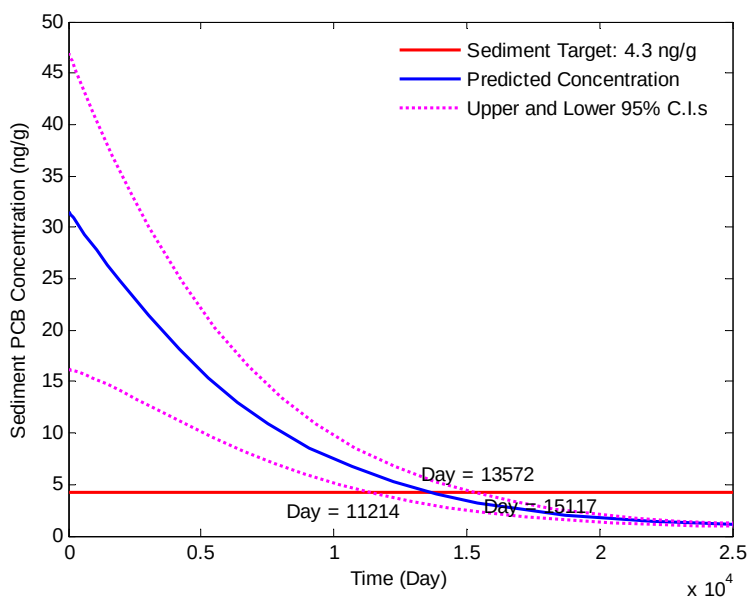

Figure E-1: Predicted Sediment tPCB Concentration (Blue Line) and its 95% CIs (Magenta Lines)

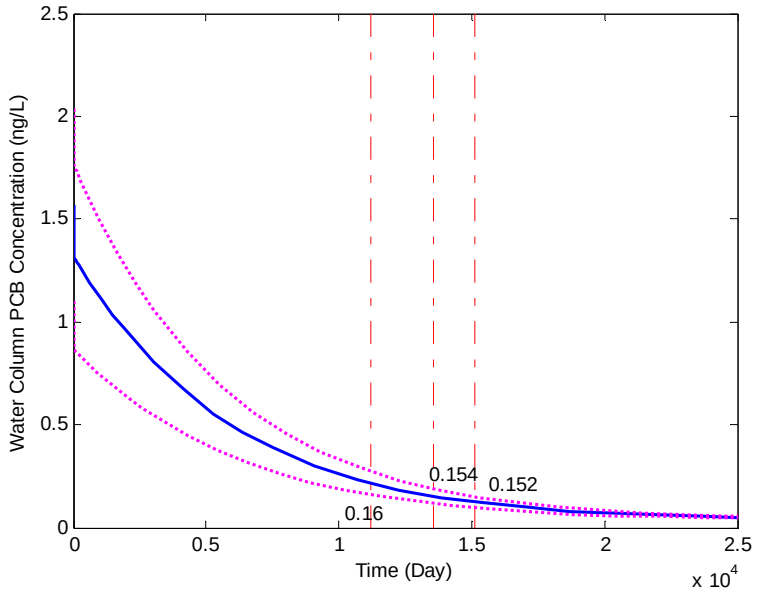

Figure E-2: Predicted Water Column tPCB Concentration in ng/L (Blue Line) and Its 95% CIs (Magenta Lines). The Red Lines Indicate the Times When the Sediment Targets Were Met.

Appendix F. Calculation of Fraction of Different PCB Forms

The fractions in equations (C1) and (C2) can be calculated as follows:

$$F_{p1} = \frac{TSS \times 10^{-6} K_{oc} \times f_{oc1}}{1 + (K_{oc} \times 10^{-6})(TSS \times f_{oc1} + DOC_1)} \quad \text{(F1)}$$

$$F_{do1} = \frac{1 + (K_{oc} \times 10^{-6}) DOC_1}{1 + (K_{oc} \times 10^{-6})(TSS \times f_{oc1} + DOC_1)} \quad \text{(F2)}$$

$$F_{do2} = \frac{\phi + \phi (K_{oc} \times 10^{-6}) DOC_2}{\phi + (K_{oc} \times 10^{-6})(f_{oc2} \times \rho \times (1-\phi) + \phi DOC_2)} \quad \text{(F3)}$$

Where:
K_{oc} is the organic carbon/water partition coefficient of PCBs (L/kg). It describes the ratio of a compound adsorbed to solids and in solution, normalized for organic carbon content. It can be calculated via the relationship of $\log_{10} K_{oc} = 0.00028 + 0.983 \times \log_{10} K_{ow}$ (Hoke et al. 1994), where K_{ow} is the octanol-water partition coefficient with $\log_{10} K_{ow}$ equals to 6.261 (de Bruijn et al. 1989).
f_{oc1} and f_{oc2} are the fractions of organic carbon in suspended solids in the water column and the sediment solids, respectively (US EPA 2004).
DOC_1 and DOC_2 are the dissolved organic carbon concentration in water column and pore water, respectively.
φ is the porosity of the sediment.

Appendix G. Technical Approach Used to Generate Maximum Daily Loads

Summary

This appendix documents the technical approach used to define maximum daily loads of total polychlorinated biphenyls (tPCBs) consistent with the average annual Total Maximum Daily Load (TMDL), which is protective of water quality standards in the Northeast River embayment. The approach builds upon the modeling analysis that was conducted to determine the loadings of polychlorinated biphenyl (PCB) and can be summarized as follows.

- The approach defines maximum daily loads for each of the source categories.
- The approach builds upon the TMDL modeling analysis that was conducted to ensure that average annual loading targets result in compliance with water quality standards.
- The approach converts daily time-series loadings into TMDL values in a manner that is consistent with available US EPA guidance on generating daily loads for TMDLs.
- The approach considers a daily load level of a resolution based on the specific data that exists for each source category.

Introduction

This appendix documents the development and application of the approach used to define total maximum daily loads on a daily basis. It is divided into sections discussing:

- Basis for approach,
- Options considered,
- Selected approach,
- Results of approach.

Basis for Approach

The overall approach for the development of daily loads was based upon the following factors:

- **Average Annual TMDL:** The basis of the average annual tPCB TMDL is that the baseline tPCB loading rates result in levels in the fish tissue that exceed the tPCB fish tissue listing threshold. Thus, the average annual PCB load was calculated to be protective of the fish consumption designated use.
- **Draft U.S. Environmental Protection Agency (US EPA) guidance document entitled *Developing Daily Loads for Load-based TMDLs***: This guidance provides options for defining maximum daily loads when using TMDL approaches that generate daily output.

The rationale for developing TMDLs expressed as *daily* loads was to accept the existing average annual TMDL, but then develop a method for converting this number to a maximum *daily* load – in a manner consistent with US EPA guidance and available information.

Options Considered

The draft US EPA guidance document for developing daily loads does not specify a single approach that must be adhered to, but rather it contains a range of acceptable options. The selection of a specific method for translating a time-series of allowable loads into the expression of a TMDL requires decisions regarding both the level of resolution (e.g., single daily load for all conditions vs. loads that vary with environmental conditions) and level of probability associated with the TMDL.

This section describes the range of options that were considered when developing methods to calculate Northeast River Embayment Maximum Daily Loads.

Level of Resolution

The level of resolution pertains to the amount of detail used in specifying the maximum daily load. The draft US EPA guidance on daily loads provides three categories of options for level of resolution, all of which are potentially applicable for the Northeast River:

1. **Representative daily load:** In this option, a single daily load (or multiple representative daily loads) is specified that covers all time periods and environmental conditions.
2. **Flow-variable daily load:** This option allows the maximum daily load to vary based upon the observed flow condition.
3. **Temporally-variable daily load:** This option allows the maximum daily load to vary based upon seasons or times of varying source or water body behavior.

Probability Level

All TMDLs have some probability of being exceeded, with the specific probability being explicitly specified or implicitly assumed. This level of probability directly or indirectly reflects two separate phenomena:

1. Water quality criteria consist of components describing acceptable magnitude, duration, and frequency. The frequency component addresses how often conditions can allowably surpass the combined magnitude and duration components.
2. Pollutant loads, especially from wet weather sources, typically exhibit a large degree of variability over time. It is rarely practical to specify a “never to be exceeded value” for a daily load, as essentially any loading value has some finite probability of being exceeded.

The draft daily load guidance document states that the probability component of the maximum daily load should be “based on a representative statistical measure” that is dependent upon the specific TMDL and best professional judgment of the developers. This statistical measure represents how often the maximum daily load is expected/allowed to be exceeded. The primary options for selecting this level of protection would be:

1. **The maximum daily load reflects some central tendency:** In this option, the maximum daily load is based upon the mean or median value of the range of loads expected to occur. The variability in the actual loads is not addressed.

2. **The maximum daily load reflects a level of protection implicitly provided by the selection of some "critical" period**: In this option, the maximum daily load is based upon the allowable load that is predicted to occur during some critical period examined during the analysis. The developer does not explicitly specify the probability of occurrence.
3. **The maximum daily load is a value that will be exceeded with a pre-defined probability:** In this option, a "reasonable" upper bound percentile is selected for the maximum daily load based upon a characterization of the variability of daily loads. For example, selection of the 95th percentile value would result in a maximum daily load that would be exceeded 5% of the time.

Selected Approach

The approach selected for defining a Northeast River Embayment Maximum Daily Load was based upon the specific data that exists for each source category. The approach consists of unique methods for each of the following categories of sources:

- Approach for Nonpoint Sources, Estuarine Sediments, Cheseapeake Bay tidal flushing, and Stormwater Point Sources within the Northeast River,
- Approach for WWTP Point Sources within the Northeast River,
- Approach for upstream sources.

Approach for Nonpoint Sources and Stormwater Point Sources within the Northeast River

The level of resolution selected for the Northeast River Embayment Maximum Daily Load was a representative daily load, expressed as a single daily load for each loading source. This approach was chosen due to the nature of PCBs and the focus of this study on a TMDL endpoint for fish tissue consumption. Daily flow and temporal variability do not affect the rate of PCB bioaccumulation in fish tissue over the long term thus establishing no influence on achievement of the TMDL endpoint. A maximum daily load at this level of resolution is unwarranted.

The maximum daily load was estimated based on three factors: a specified probability level, the average annual PCB TMDL, and the coefficient of variation (CV) of the initial condition for ambient water column concentrations in the Northeast River. The probability level (or exceedance frequency) is based upon guidance from US EPA (1991) where examples suggest that when converting from a long-term average to a daily value, the z-score corresponding to the 99th percentile of the log-normal probability distribution should be used.

The CV was calculated using the arithmetic mean and standard deviation of the baseline ambient water column concentrations in the Northeast River. The resulting CV of 0.36 was calculated using the following equation:

$$CV = \frac{\beta}{\alpha} \qquad \text{(Equation G. 1)}$$

Where,

CV = coefficient of variation
α = mean (arithmetic)
β = standard deviation (arithmetic)

The maximum "daily" load for each contributing source is estimated as the long-term average annual load multiplied by a factor that accounts for expected variability of daily loading values. The equation is as follows:

$$MDL = LTA * e^{(z\sigma - 0.5\sigma^2)} \qquad \text{(Equation G. 2)}$$

Where,

MDL = Maximum daily load
LTA = Long-term average (average annual load)
Z = z-score associated with target probability level
$\sigma = \ln(CV^2+1)$
CV = Coefficient of variation based on arithmetic mean and standard deviation

Using a z-score associated with the 99th percent probability, a CV of 0.36, and consistent units, the resulting dimensionless conversion factor from long-term average loads to a maximum daily value is 1.318. The average annual Northeast River Embayment TMDL of PCBs is reported in grams/year, and the conversion from grams/year to a maximum daily load in grams/day is 0.0036 (e.g. 1.318/365)

Approach for WWTP Point Sources within the Northeast River

The TMDL also considers contributions from NPDES permitted WWTP point sources that discharge quantifiable concentrations of tPCBs to the Northeast River embayment. The maximum daily loads were calculated based on the guidance provided in the Technical Support Document (TSD) for Water Quality-based Toxics Control (US EPA 1991). The long-term average annual TMDL was converted to maximum daily limits using Table 5-2 of the TSD assuming a coefficient of variation of 0.6 and a 99th percentile probability. This results in a dimensionless multiplication factor of 3.11. The average annual Northeast River Embayment TMDL of PCBs is reported in grams/yr, and the conversion from grams/yr to a maximum daily load in grams/day is 0.0085 (i.e. 3.11/365). It should be noted, however, that the WWTP loads were considered to be *de minimis* (see Appendix L for details). Given no appreciable environmental benefit of reducing these loadings, at this point, they will not be subject to the traditional waste load allocation requirements.

Approach for Upstream Sources

For the purpose of this analysis only one upstream watershed has been identified: the Pennsylvania portion of the Northeast River watershed. Pennsylvania maximum daily loads were calculated based on the same approach used for nonpoint sources and NPDES regulated stormwater point sources within the Northeast River watershed (see above).

Results of Approach

This section lists the results of the selected approach to define the Northeast River Embayment Maximum Daily Loads.

- Calculation Approach for Non-point Sources (Chesapeake Bay, Bottom Sediment, Direct Atmospheric Deposition, Maryland Watershed Nonpoint Sources, Contaminated Sites, Pennsylvania Upstream Load) and NPDES Stormwater Point Sources within the Northeast River.

  Nonpoint Source LA (grams/day) = Average Annual TMDL Nonpoint Source LA (grams/yr) * 0.0036

  NPDES Stormwater WLA (grams/day) = Average Annual TMDL NPDES Stormwater WLA (grams/yr) * 0.0036

- Calculation Approach for WWTP Point Sources within the Northeast River

  WWTP WLA (grams /day)[△] = Average Annual TMDL WWTP WLA (grams /yr)* 0.0085

- Calculation Approach for Upstream Sources

  PA Contribution LA (grams /day) = Average Annual TMDL LA (PA Contribution) (grams /yr) * .0036

Table G-1: Northeast River Embayment tPCB Maximum Daily Load (g/day)

Source	MDL (g/day)
Chesapeake Bay (Tidal Influence)	1.730
Bottom Sediment (Resuspension and Diffusion)	1.104
Direct Atmospheric Deposition (to the Surface of the Embayment)	0.196
Maryland Watershed Nonpoint Sources [•]	0.300
Contaminated Sites [•]	0.001
Pennsylvania Upstream	0.048
Nonpoint Sources/Load Allocations	***3.379***
WWTP [•, △]	0.009
NPDES Regulated Stormwater [•]	0.091
Point Sources/Waste Load Allocations [•]	***0. 100***
MOS	***0.386***
Total	**3.87**

Notes: [•] These sources were characterized only for the Maryland portion of the watershed.
[△] WWTP loads were considered to be *de minimis* and at this point will not be subject to the traditional waste load allocation requirements.

Appendix H. MDE Permit Information

Table H-1: NPDES Stormwater Permit Summary for Northeast River Watershed

MDE Permit	Facility	City	County	Type	TMDL
02SW2039	Souther States Cooperative, Inc. (Rising Sun Service)	Rising Sun	Cecil	WMA5SW	Stormwater WLA
02SW2043	MDTA - JFK Memorial Highway Maintenance Facility	Elkton	Cecil	WMA5SW	Stormwater WLA
02SW0375	Cecil County Central Landfill	Elkton	Cecil	WMA5SW	Stormwater WLA
02SW0376	Northeast River WWTP	Charlestown	Cecil	WMA5SW	Stormwater WLA
02SW1574	Ritchie Brothers Auctioneers, Inc.	North East	Cecil	WMA5SW	Stormwater WLA
02SW0578	B & H New & Used Auto Parts, Inc.	Elkton	Cecil	WMA5SW	Stormwater WLA
02SW0372	Cecil County Central Garage	Elkton	Cecil	WMA5SW	Stormwater WLA
02SW1638	Albright's Auto Salvage	North East	Cecil	WMA5SW	Stormwater WLA
-	Cecil County MS4	ALL	Cecil	-	Stormwater WLA
-	Elkton MS4	Elkton	Cecil	-	Stormwater WLA
-	State Highway Administration MS4	ALL	ALL	WMA6	Stormwater WLA
-	MDE General Permit To Construct	ALL	ALL	-	Stormwater WLA

Appendix I. Contaminated Site Load Calculation Methodology

The total polychlorinated biphenyl (tPCB) loadings for the previously identified contaminated sites in the Northeast River 8-digit watershed were calculated with the use of the Revised Universal Soil Loss Equation Version II (RUSLE2)[1] in conjunction with soil contamination data and site specific information (i.e., soil type, land cover, slope, etc.). The purpose of this Appendix is to describe the detailed procedures used to calculate these loads.

I. Site Identification Process

A total of 6 possible contaminated sites were identified within the Northeast River 8-digit watershed using a combination of the U.S. Environmental Protection Agency's (US EPA) Superfund database and Maryland Department of the Environment's (MDE) Environmental Restoration and Redevelopment Program's (EERP) Comprehensive Database (see Table I-1) (US EPA 2007; MDE 2007). Of these six contaminated sites, only two, Elkton Sparkler and Ordnance Products, had PCB soil concentrations at or above the method detection levels used in site investigation sampling procedures, as determined via soil samples contained within MDE's Waste Management Administration (WAS) contaminated site surveys. Consequently, these two sites comprise the entirety of the contaminated site PCB loading.

Table I-1: Contaminated Sites in the Northeast River 8-digit Watershed

Site Name	EPA Site Number	MD ID	PCBs Detected	Baseline Load (g/year)
Hog Hill Landfill	MDD985407774	MD-440	No	N/A
Anchor Marina Assessment	MD0001093533	MD-474	No	N/A
Louisa Lane Dump Site	MDD981941503	MD-259	No	N/A
Montgomery Brothers Dump	MDD980705214	MD-137	No	N/A
Ordnance Products	MDD982364341	MD-268	Yes	0.16
Elkton Sparkler Co.	MDN000306101	—	Yes	5.84×10^{-4}

II. PCB Soil Concentration Data Processing

As mentioned above, PCB loadings were only calculated for the two sites were PCB concentrations were found to be at or above method detection limits. Nonditect samples from these two sites were included in the analysis. PCB results were first grouped in terms of minimum and maximum concentrations. This was done in the following manner:

1. If PCBs were detected, the reported concentration was used for both the minimum and maximum concentration values.

[1] RUSLE2 is an advanced, user-friendly software model Developed by the University of Tennessee Biosystems Engineering & Soil Science Department, in cooperation with United States Department of Agriculture – Agricultural Research Service (USDA-ARS), the National Sedimentation Laboratory, the United States Department of Agriculture – Natural Resources Conservation Service (USDA-NRCS), and the Bureau of Land Management.

2. When a sample was tested for multiple PCB congener mixes, and only one was detected, the reported value was used as both the minimum and maximum concentration values. However, if more than one PCB congener mix was detected, the results were first added together and then used as both the minimum and maximum concentrations.
3. When no PCBs were reported above the method detection limit, the value of the detection limit for the specific PCB congener mix was used as the maximum concentration, and the value of half the detection limit was used as the minimum concentration. Similarly, if a given sample had various detection limits for the six different PCB congener mixes analyzed, the value of the lowest detection limit was used to calculate the maximum concentration and the value of half of the lowest detection limit was used as the minimum concentration.

Since, according to the site surveys, there has been no soil remediation/removal conducted at either site, all of the soil samples listed in the surveys were used in the analysis. An average of both the minimum and maximum concentrations was calculated in micrograms of PCBs per kilogram of soil (µg/kg) and then converted to pounds of PCBs per pound of soil (lbs/lb) to be consistent with the RUSLE2 soil loss equation (see Tables I-2 and I-3).

Table I-2: Elkton Sparkler tPCB Soil Sample Concentrations

Sample	Date	Min. Concentration (µg/kg)	Max. Concentration (µg/kg)
S1	11/16/2004	7.0	14.0
S2	11/16/2004	7.0	14.0
S3	11/16/2004	15.0	15.0
S4	11/16/2004	83.0	83.0
S5	11/16/2004	7.0	14.0
S6	11/16/2004	7.0	14.0
S7	11/16/2004	7.0	14.0
S8	11/16/2004	7.0	14.0
S9	11/16/2004	7.0	14.0
S10	11/16/2004	7.0	14.0
S11	11/16/2004	7.0	14.0
S12	11/16/2004	7.0	14.0
S13	11/16/2004	7.0	14.0
S14	11/16/2004	7.0	14.0
Average (µg/kg)		13.0	19.0
Average (lbs/lb)		**1.30×10^{-8}**	**1.90×10^{-8}**

Table I-3: Ordnance Products tPCB Soil Sample Concentrations

Sample	Date	Min. Concentration (µg/kg)	Max. Concentration (µg/kg)
A-SS-A01	7/14/1999	20.0	40.0
A-SS-A02	7/13/1999	19.0	38.0
A-SS-A03	7/13/1999	20.0	40.0
A-SS-A04	7/14/1999	19.5	39.0
A-SS-A06	7/14/1999	18.0	36.0
A-SS-A07	7/13/1999	17.5	35.0
A-SS-A08	7/23/1999	20.5	41.0
A-SS-A09	7/13/1999	18.0	36.0
A-SS-A13	8/11/1999	23.0	46.0
A-SS-A14	8/11/1999	38.0	76.0
A-SS-A15	8/11/1999	19.0	38.0
A-SS-A16	8/10/1999	85.0	170.0
A-SS-A17	8/10/1999	17.5	35.0
A-SS-A18	8/9/1999	330.0	330.0
A-SS-A19	7/14/1999	17.0	34.0
B-SS-B01	8/12/1999	19.5	39.0
B-SS-B02	8/12/1999	18.0	36.0
B-SS-B03	8/12/1999	17.5	35.0
B-SS-B04	8/13/1999	18.5	37.0
B-SS-B05	8/17/1999	19.5	39.0
B-SS-B06	8/16/1999	20.0	40.0
B-SS-B07	8/16/1999	19.0	38.0
B-SS-B08	8/17/1999	19.5	39.0
C-SS-C02	7/21/1999	19.0	38.0
C-SS-C03	7/20/1999	19.0	38.0
C-SS-C04	7/20/1999	19.5	39.0
C-SS-C05	7/19/1999	17.5	35.0
C-SS-C06	7/19/1999	17.0	34.0
C-SS-C07	7/19/1999	17.0	34.0
C-SS-C08	7/21/1999	18.0	36.0
C-SS-K03	8/23/1999	20.0	40.0
C-SS-C09	8/23/1999	19.5	39.0
C-SS-C10	8/24/1999	20.5	41.0
C-SS-C11	8/24/1999	18.5	37.0
C-SS-C12	8/24/1999	19.0	38.0
C-SS-C13	8/20/1999	18.5	37.0
C-SS-C14	8/20/1999	19.0	38.0
C-SS-C15	8/20/1999	19.0	38.0
C-SS-C16	8/20/1999	19.0	38.0
K-SS-C13	8/20/1999	18.5	37.0
D-SS-D01	8/20/1999	24.5	49.0

Sample	Date	Min. Concentration (µg/kg)	Max. Concentration (µg/kg)
E-SS-E01	7/14/1999	17.0	34.0
E-SS-E02	7/27/1999	17.0	34.0
E-SS-E03	7/27/1999	17.0	34.0
F-SS-F05	8/2/1999	21.0	42.0
F-SS-F06	8/2/1999	377.0	377.0
F-SS-F07	8/2/1999	29.5	59.0
F-SS-F09	8/5/1999	27.5	55.0
F-SS-F11	8/4/1999	19.5	39.0
F-SS-F12	8/4/1999	20.5	41.0
F-SS-F13	8/5/1999	560.0	560.0
F-SS-F14	8/4/1999	19.0	38.0
F-SS-F15	8/3/1999	18.5	37.0
K-SS-F07	8/3/1999	81.0	81.0
K-SS-F13	8/3/1999	310.0	310.0
G-SS-G01	7/15/1999	17.0	34.0
G-SS-G02	7/15/1999	36.5	73.0
G-SS-G03	8/19/1999	17.0	34.0
G-SS-G04	8/19/1999	19.0	38.0
H-SS-H01	7/22/1999	18.0	36.0
H-SS-H02	7/22/1999	20.0	40.0
H-SS-H03	7/22/1999	20.0	40.0
H-SS-H04	7/21/1999	18.0	36.0
H-SS-H05	7/16/1999	18.5	37.0
H-SS-H06	7/16/1999	19.0	38.0
H-SS-H07	7/26/1999	58.0	58.0
H-SS-H08	7/15/1999	19.0	38.0
H-SS-H09	7/26/1999	19.0	38.0
H-SS-H10	7/16/1999	19.0	38.0
H-SS-H11	7/23/1999	18.5	37.0
H-SS-H12	7/27/1999	75.0	75.0
H-SS-H13	7/15/1999	21.5	43.0
K-SS-H09	7/15/1999	19.5	39.0
	Average (µg/kg)	43.3	62.1
	Average (lbs/lb)	**4.34×10^{-8}**	**6.21×10^{-8}**

III. RUSLE2 SOIL LOSS CALCULATION PROCEDURES

The RUSLE2 soil loss equation was run for each site with the use of the Maryland state climate database, county soil databases, and management databases that can be downloaded from the following website: http://fargo.nserl.purdue.edu/rusle2_dataweb/RUSLE2_Index.htm. The site characteristics (i.e., site information gathered from WAS site surveys: soil types, land cover, slope, etc.) were selected from the drop down menus provided in the RUSLE2 worksheet. Input

parameters (see Table I-4 for each site's characteristics/input parameters) were selected via the following decision rules:

1. Location: The name of the county where the contaminated site is located was selected from the Maryland state climate database in the RUSLE2 location field. This resulted in an automatic selection of the appropriate climatic factors. Both the Elkton Sparkler and Ordnance products sites are located within Cecil County, Maryland.

2. Soil: The soil type present at the contaminated site, as identified within the WAS site surveys (see Tables I-5 and I-6), was selected from the Cecil County soils database. If subsurface slope was not specified for a particular soil type in the WAS site surveys, the lowest subsurface slope for the given soil type was used. For sites with multiple soil types, soil loss was first calculated for each soil type based on the entire site/sub site's parameters (e.g. slope and slope length). Then, the soil loss values for each soil type were weighted based on the percentage of the site that the given soil type occupied. Finally, the summation of the weighted soil loss values was calculated to produce a total soil loss for the entire site in tons/year (tons/yr). This total soil loss value was then converted from tons/yr to pounds/year (lbs/yr) (see Tables I-7 and I-8).

3. Slope Length: Slope length (length of the site), as identified within the WAS site surveys, was manually inserted into the slope length field. Slope length was calculated based on site descriptions, topographic maps, or non-topographic maps. The maximum slope length permitted by the soil loss equation was 2000 feet. One of the sites had a length greater 2000 feet; however, 2000 had to be used as the slope length.

4. Slope Steepness: Slope Steepness (the difference between max and min elevations/length), as identified within the WAS site surveys, was manually inserted into the slope steepness field. When there was no information regarding average slope in the site description and a precise topographic map was not available for the site, slope was calculated based on the slope of the area where the site was located. If a topographic map of the larger region was not available, or if slope could not be determined because of the flat nature of the site, a minimal slope of 1% was assumed.

5. Management: The management option field was used to represent a site's land cover, as identified by the WAS site surveys. For example, for sites covered by grass, the warm season management option was selected (as opposed to the harvested grass management option); for wooded sites, the established orchard - full cover option was selected (the closest management practice that accurately depicts wooded land cover); and for sites with bare soil, the bare ground management option was selected. The management alternative fields (i.e., contours and strip barriers) were not populated, as they do not apply to these sites.

Table I-4: Contaminated Site Characteristics Required for the RUSLE2 Soil Loss Equation

Site	Total Pervious Area (acres)	Pervious Area Land Cover	Slope Length (ft)	Slope Steepness (%)
Elkton Sparkler Co.	3.0	Grass (100%)	561.0	1.78
Ordnance Products	85.5	Grass (100%)	3200.0	3.125

Table I-5: Elkton Sparkler Soil Types

Soil Type	Weight (%)
Mattapeake Silt Loam	50.0
Sassafras Sandy Loam	50.0

Table I-6: Ordnance Products Soil Types

Soil Type	Weight (%)
Beltsville Silt Loam	20.0
Mattapeake Silt Loam	20.0
Sassafras Sandy Loam	20.0
Sassafras Fine Sandy Loam	20.0
Sassafras Gravelly Loam	20.0

Table I-7: Elkton Sparkler Weighted Soil Loss Calculations

Soil Type	Soil Loss (tons/ac/yr)	x	Pervious Area (acres)	=	Soil Loss (tons/yr)	x	Weight (%)	=	Weighted Soil Loss (tons/yr)
Matapeake Silt Loam	0.023	x	3.0	=	0.069	x	0.5	=	0.0345
Sassafras Sandy Loam	0.010		3.0		0.03		0.5		0.0150
Total (tons/yr)									0.0495
Total (lbs/yr)									**99.00**

Table I-8: Ordnance Products Weighted Soil Loss Calculations/Soil Type

Soil Type	Soil Loss (tons/ac/yr)	x	Pervious Area (acres)	=	Soil Loss (tons/yr)	x	Weight (%)	=	Weighted Soil Loss (tons/yr)
Beltsville Silt Loam	0.049	x	89.5	=	4.3855	x	0.2	=	0.8771
Matapeake Silt Loam	0.057		89.5		5.1015		0.2		1.0203
Sassafras Sandy Loam	0.022		89.5		1.9690		0.2		0.3938
Sassafras Fine Sandy Loam	0.026		89.5		2.3270		0.2		0.4654
Sassafras Gravelly Load	0.035		89.5		3.1325		0.2		0.6265
Total (tons/yr)									3.3831
Total (lbs/yr)									**6,766.20**

Once the actual soil loss had been calculated, the soil loss value could be used to determine PCB loadings based on the PCB concentrations found in the soil. The average minimum and maximum PCB concentrations were multiplied by the soil loss to produce minimum and maximum PCB loadings. These values were finally converted to grams per year and the average of the two PCB loading values was calculated to produce the final PCB loading for each site (Table I-9). A summary of the final PCB loadings per contaminated site is shown in Table I-10.

Table I-10: Contaminated Site PCB Loading Calculations

Site	Data	Soil Loss (lbs/yr)	x	Average PCB Soil Concentration (lbs/lb)	=	PCB Loading (lbs/yr)	=	PCB Loading (g/yr)
Elkton Sparkler Co.	Min	99.00	x	1.30×10^{-8}	=	1.29×10^{-6}	=	5.84×10^{-4}
	Max.	99.00		1.90×10^{-8}		1.88×10^{-6}		8.53×10^{-4}
Average								**7.19×10^{-4}**
Ordnance Products	Min.	6766.20	x	4.34×10^{-8}	=	2.93×10^{-4}	=	0.13
	Max.	6766.20		6.21×10^{-8}		4.20×10^{-4}		0.19
Average								**0.16**

Table I-9: Summary of Contaminated Site PCB Loadings

Site	Average PCBs Loading (g/yr)	Remediation	Latitude	Longitude
Elkton Sparkler Co.	7.19×10^{-4}	NO	37.577262	-81.529188
Ordnance Products	0.16	NO	39.627290	-75.923310
Total	**0.16**			

IV. CONTAMINATED SITE LOADINGS SUMMARY

The total PCB loading to the Northeast River Embayment from contaminated sites is estimated to be 0.16 g/year. This total loading consists of individual PCB loadings from two contaminated sites within the Northeast River 8-digit watershed.

Appendix J. Derivation of the Boundary PCB Concentration

According to Ko and Baker (2004), the PCB loadings of Susquehanna River from 1992 to 1998 are as follows:

Table J-1: The Flow Normalized tPCB loadings of Susquehanna River (kg/m^3/year)

Year	Years Since 1992	Load (kg/m^3/year)	Log ($Load_{Current}/Load_{1992}$)
1992	0	37	0
1993	1	37	0
1994	2	35	-0.02413
1995	3	35	-0.02413
1997	5	24	-0.18799
1998	6	24	-0.18799

A linear regression was developed for Years Since 1992 versus Log ($Load_{Current}/Load_{1992}$), the slope of -0.0292 stands for log (current year load percentage of the previous year). Therefore, current year load percentage of the previous year is $10^{-0.0292} = 0.935$. The decreasing rate is 1 - 0.935 = 6.5% (Figure J-1).

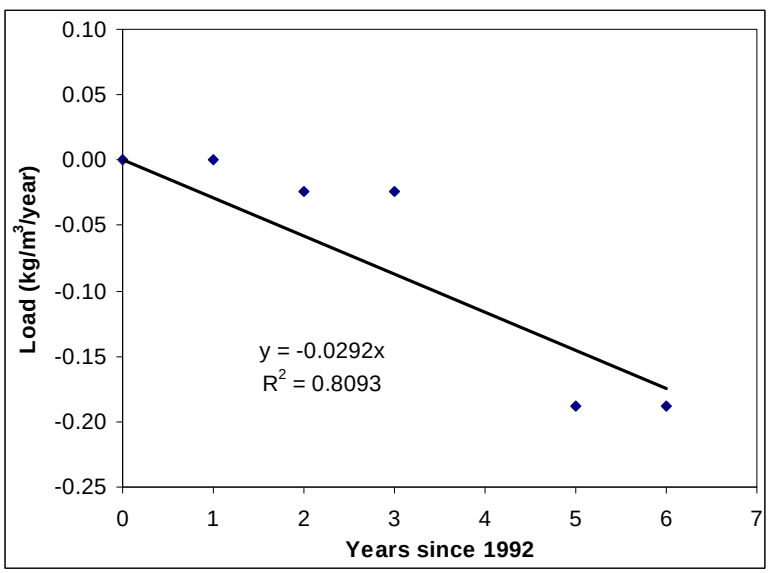

Figure J-1: The Regression Line of the Ko and Baker Loading Data

Appendix K. List of Analyzed PCB Congeners

PCB analytical services were provided by the University of Maryland Center for Environmental Science (UMCES). PCB congeners were identified and quantified by high resolution gas chromatography with electron capture detection. UMCES uses a slightly modified version of the PCB congener specific method described in Ashley and Baker (1999), in which the identities and concentrations of each congener in a mixed Aroclor standard (25:18:18 mixture of Aroclors 1232, 1248, and 1262) are determined based on their chromatographic retention times relative to the internal standards (PCB 30 and PCB 204). Based on this method, 86 chromatographic peaks can be quantified (see Table K-1). Some of the peaks contain one PCB congener, while many are comprised of two or more co-eluting congeners. The PCB analysis presented in this document is based on tPCB concentrations that are calculated as the sum of the detected PCB congeners/congener groups representing most common congeners that were historically used in the Aroclor commercial mixtures.

Table K-1. List of Analyzed PCB Congeners

1	45	110, 77	177
3	46	114	180
4, 10	47, 48	118	183
6	49	119	185
7, 9	51	123, 149	187, 182
8, 5	52	128	189
12, 13	56, 60	129, 178	191
16, 32	63	132, 153, 105	193
17	66, 95	134	194
18	70, 76	135, 144	197
19	74	136	198
22	81, 87	137, 130	199
24	82, 151	141	201
25	83	146	202, 171, 156
26	84, 92	157, 200	203, 196
29	89	158	205
31, 28	91	163, 138	206
33, 21, 53	97	167	207
37, 42	99	170, 190	208, 195
40	100	172	209
41, 64, 71	101	174	
44	107	176	

Appendix L. WWTP Load Evaluation

This Appendix evaluates the significance of Waste Water Treatment Plant (WWTP) total polychlorinated biphenyl (tPCB) loadings from the standpoint of meeting water quality standards. Sources that are considered *de minimis* (i.e., insignificant or negligible) will be exempted from WLA requirements. Such exemption is desirable, because assigning WLAs to these NPDES facilities would result in burdensome regulatory requirements, while producing no appreciable environmental benefit.

At 0.1% of the TMDL (Table L-1), the current Northeast River cumulative WWTP loads are considered *de minimis* because even their complete elimination would not result in any discernible improvement in water quality (Table L-2). Moreover, a possible future increase in these loads (e.g., due to potential future development or expansion of plant capacity) is also not expected to have any significant impact on meeting the PCB water quality targets; even a 10-fold increase in WWTP load (up to 1% of the TMDL) is expected to increase the time it takes to reach the target by only 0.35% or 48 days (Table L-3, Figure L-1 and L-2). Given no appreciable benefit of reducing these WWTP loading and given that these loads are believed to be associated with elevated PCB concentrations in other sources (e.g., source water, atmospheric deposition, stormwater runoff) at this point WWTP loads will not be subject to the traditional waste load allocation requirements.

Table L-1. WWTP Loads as Percent of TMDL

Sources	Allowable Load(g/year)	Percent of TMDL
WWTPs	1.1	0.1%
Other	1,071.3	99.9%
Total	**1,072**	**100%**

Table L-2. Effect of Eliminating WWTP Current Loads on Time Needed to Reach PCB Water Quality Targets

Allowable Load	Nr. of Days Needed to Reach Water Quality Target
Including WWTP Baseline Loads	13,572
Reducing WWTP Baseline Loads by 100%	13,566

Loadings from the Chesapeake Bay as well as resuspension and diffusion from the bottom sediments are the primary source of the PCB loads resulting in human health water quality violations in the Northeast River embayment (See Section 2.3). Attainment of the PCB water quality targets will only be possible with the decline of these primary loadings, which is expected to take place over time as the Upper Chesapeake Bay concentrations continue to decline resulting also in natural attenuation of tPCB levels in the legacy sediments. In the future, if WWTPs are discovered to discharge PCBs at levels that threaten water quality, the assessment of the appropriate waste load allocations will be revisited.

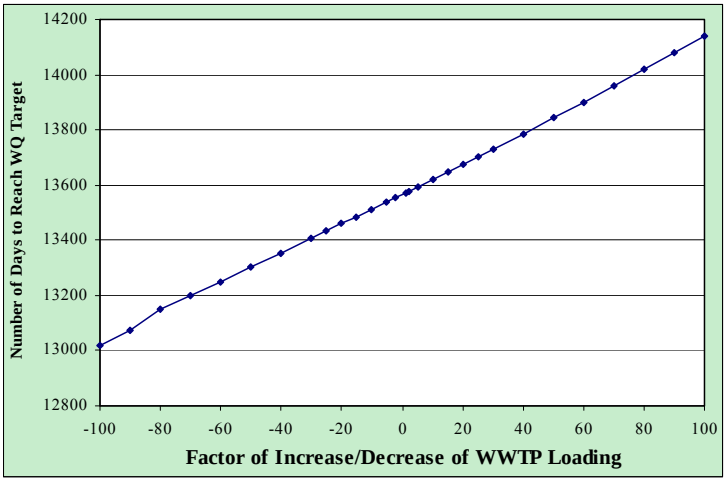

Figure L-1. Effect of Increasing/Decreasing Loads as Factor of WWTP Current Loads on Time Needed to Reach PCB Water Quality Targets (days)

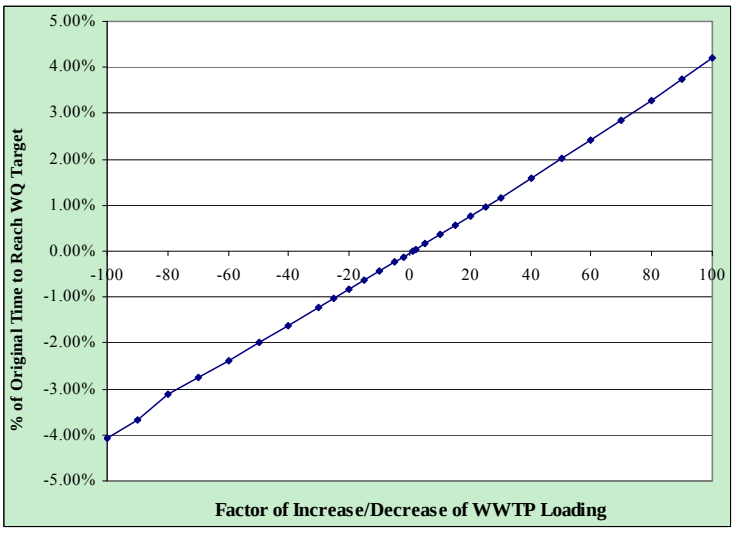

Figure L-2. Effect of Increasing/Decreasing Loads as Factor of WWTP Current Loads on Time Needed to Reach PCB Water Quality Targets (% of time)

Table L-3. Effect of Increasing/Decreasing Loads as Factor of WWTP Current Loads on Time Needed to Reach PCB Water Quality Targets

Factor of Increase/ Decrease of WWTP Loading	Nr. of Days Needed to Reach Water Quality Target	Percent Change
100	14141	4.19%
90	14080	3.74%
80	14019	3.29%
70	13960	2.86%
60	13901	2.42%
50	13844	2.00%
40	13787	1.58%
30	13731	1.17%
25	13703	0.97%
20	13675	0.76%
15	13648	0.56%
10	13620	0.35%
5	13593	0.15%
2	13577	0.04%
1	**13572**	**0.00%**
-2	13555	-0.13%
-5	13539	-0.24%
-10	13513	-0.43%
-15	13486	-0.63%
-20	13460	-0.83%
-25	13433	-1.02%
-30	13406	-1.22%
-40	13354	-1.61%
-50	13302	-1.99%
-60	13250	-2.37%
-70	13199	-2.75%
-80	13149	-3.12%
-90	13075	-3.66%
-100	13020	-4.07%