Total Maximum Daily Loads of Polychlorinated Biphenyls in Northeast River, Tidal Fresh Segment, Cecil County, Maryland

FINAL

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List of Abbreviations

ac	Acre
Adj-SediBAF	Adjusted Sediment Bioaccumulation Factor
Adj-tBAF	Adjusted Total Bioaccumulation Factor
BAF	Bioaccumulation Factor
BSAF	Biota-sediment accumulation factor
CFR	Code of Federal Regulations
CI	Confidence Interval
COMAR	Code of Maryland Regulations
CV	Coefficient of Variation
DOC	Dissolved Organic Carbon
DRBC	Delaware River Basin Commission
g	Gram
ID	Identification
kg	Kilogram
km	Kilometer
Kow	PCB Octanol-Water Partition Coefficient
L	Liter
LA	Load Allocation
Lb	Pound
m	Meter
MDE	Maryland Department of the Environment
MDL	Maximum Daily Load
MDP	Maryland Department of Planning
mg/kg	Milligrams/kilogram, ppm
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
NPDES	National Pollutant Discharge Elimination System
PCB	Polychlorinated Biphenyl
POC	Particulate Organic Carbon
ppb	Parts per billion
ppm	Parts per million
ppt	Parts per trillion
QEA	Quantitative Environmental Analysis
RUSLE2	Revised Universal Soil Loss Equation Version II
TMDL	Total Maximum Daily Load
tPCB	Total PCB
TSD	Technical Support Document
TSS	Total Suspended Solid
UMCES	University of Maryland Center for Environmental Science
US EPA	U. S. Environmental Protection Agency
USGS	U. S. 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 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 water quality regulations state 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 segment (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 Northeast River Tidal Fresh segment (Integrated Report Assessment Unit Identification: MD-NORTF) on the State's Integrated Report as impaired by the following pollutants (listing years in parentheses): lead (1996), nutrients (1996), sediments (1996 – later changed to total suspended solids (TSS) listing), zinc (1996), and polychlorinated biphenyls (PCBs) in fish tissue (2002) (MDE 2008).

Nitrogen and phosphorus TMDLs for the Northeast River were approved by the US EPA in 2005, while water quality analysis (WQAs) for zinc and lead were approved by the US EPA in 2008 and 2009, respectively. In 2008 the TSS impairment was moved from Category 5 of the Integrated Report (i.e., *water body is impaired, does not attain the water quality standard, and a TMDL is required*) to Category 2 (*water body is meeting some* [in this case TSS] *water quality standards but with insufficient data to determine if other water quality standards are being met*). This document, upon US EPA approval, establishes a total PCB (tPCB) TMDL for the Northeast River Tidal Fresh segment. Data solicitation for PCB related information was conducted by MDE and all readily available data have been considered.

The objective of the tPCB TMDL established in this document is to ensure that the "fishing" designated use in the Northeast River embayment is supported to allow consumption of fish protective of human health. This objective was achieved with the use of a tidal prism model and the tPCB fish tissue listing threshold of 39 nanograms/gram (ng/g, ppb) – wet weight (MDE 2008, 72-74). The tidal prism model incorporates the influences of fresh water 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 tPCB 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 of the Northeast River embayment;
3. Based on the available literature, the TMDL methodology assumes that on average the tPCB concentrations in the Upper Chesapeake Bay are decreasing at a rate of 6.5% per year (Appendix J). Given this rate of decline, the model estimates that the time needed for the tPCB concentrations to meet the site-specific water column and sediment TMDL

endpoints of 0.18 nanograms/liter (ng/L) and 4.3 ng/g, respectively is approximately 37 years.

As part of this analysis, point and nonpoint PCB sources have been identified throughout the Northeast River watershed. Two nonpoint sources (i.e., resuspension and diffusion from the bottom sediments and the Chesapeake Bay tidal influence) were determined to be the major sources of tPCBs to the Northeast River embayment. The Chesapeake Bay tPCB loads are transported to 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 in Maryland and upstream in Pennsylvania. 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 Tidal Fresh segment 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 Tidal Fresh segment 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 tPCB loads are at a level expected to support the “fishing” designated use in the Northeast River embayment that is protective of human health.

Table ES- 1: Summary of tPCB Baseline Loads, TMDL Allocations, and Associated Percent Reductions

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 Baseline Loads were considered to be *de minimis*.

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 LAs for natural background, tributary, and adjacent segment loads. WLAs were assigned to NPDES regulated stormwater sources and WWTPs. The WWTP Baseline Loads were considered to be *de minimis*, therefore no appreciable environmental benefit would be gained by reducing these loads (see Appendix L for details). There are currently no effluent PCB limits established in the discharge permits for WWTPs. The sensitivity analysis provided in this document (Appendix L) suggests that there is no "reasonable potential" for PCBs to exceed water quality even at 100 times the current WWTP loadings. Inclusion of a WLA in this document does not reflect any determination to impose an effluent limit.

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 and simulation of water quality parameters in natural systems (CFR 2007). An explicit MOS of 10% or 107.2 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 tPCB levels in fish become elevated due to long-term exposure, rather than temporary spikes in water column tPCB concentration, it has been determined that the selection of the average tPCB concentrations as representing the baseline conditions adequately considers the impact of seasonal variations and critical conditions on the “fishing” designated use in the Northeast River embayment. Furthermore, the site-specific tPCB water column TMDL endpoint used to develop this TMDL is lower than the Maryland fresh and salt water chronic aquatic life tPCB criteria protective of fish and wildlife as well as the Maryland water column human health tPCB criterion protective of human health associated with consumption of PCB contaminated fish.

Resuspension and diffusion from the bottom sediments and the Chesapeake Bay tidal influence have been identified as the two major sources of tPCBs to the Northeast River embayment. Given that on average the tPCB concentrations in the Upper Chesapeake Bay are decreasing at a rate of 6.5% per year (Appendix J), 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 Water Quality Standards Section will continue to monitor PCB levels in fish. This information will be used to evaluate the PCB impairment in the Northeast River embayment on an ongoing basis.

1.0 INTRODUCTION

Section 303(d) of the federal Clean Water Act 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 water quality regulations state 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 segment (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 Northeast River Tidal Fresh segment (Integrated Report Assessment Unit Identification: MD-NORTF) on the State's Integrated Report as impaired by the following pollutants (listing years in parentheses): lead (1996), nutrients (1996), sediments (1996 – later changed to a total suspended solids (TSS) listing), zinc (1996), and polychlorinated biphenyls (PCBs) in fish tissue (2002) (MDE 2008).

Nitrogen and phosphorus TMDLs for the Northeast River were approved by the US EPA in 2005, while water quality analysis (WQAs) for zinc and lead were approved by the US EPA in 2008 and 2009, respectively. In 2008 the TSS impairment was moved from Category 5 of the Integrated Report (i.e., *water body is impaired, does not attain the water quality standard, and a TMDL is required*) to Category 2 (*water body is meeting some* [in this case TSS] *water quality standards but with insufficient data to determine if other water quality standards are being met*). This document, upon US EPA approval, establishes a total PCB (tPCB) TMDL for the Northeast River Tidal Fresh segment. Data solicitation for PCB related information was conducted by MDE and all readily available data have been considered.

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 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, people who ingest fish may become exposed to PCBs. In fact, elevated levels of PCBs in fish are one of the leading causes of fish consumption advisories in the United States.

The Northeast River embayment is identified as impaired by PCBs on the State's Integrated Report based on fish tissue PCB data from MDE's monitoring program that exceeded the tPCB fish tissue listing threshold of 39 nanograms/gram (ng/g, ppb) – wet weight (MDE 2008, 72-74). Besides identifying impaired waterbodies, 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, and white perch.

2.0 SETTING AND WATER QUALITY DESCRIPTION

2.1. General Setting

The Northeast River watershed is located in 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 (see Figure 2). The tidal fresh portion of the watershed extends as far north as the Town of North East. The tidal range is 1.9 feet (0.58 meters (m)) based on the United States National Oceanic and Atmospheric Administration tidal station in Charlestown, MD. The depths of the river range from about 6 inches (0.15 m) at the headwaters of the tidal embayment 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).

There is one Tier II (i.e., high quality) stream segment (Benthic Index of Biotic Integrity/Fish Index of Biotic Integrity aquatic health scores > 4 – scale 1 to 5), the Little Northeast Creek, located within the watershed requiring the implementation of Maryland's antidegradation policy procedures (COMAR 2007d; MDE 2009). The total population in the Maryland portion of the Northeast River watershed is approximately 40,000 (US Census Bureau 2000).

The entire Northeast River watershed stretches over approximately 77 square miles (200 square kilometers (km^2)). The tidal fresh portion of the river is approximately 5.9 miles (9.5 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).

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**

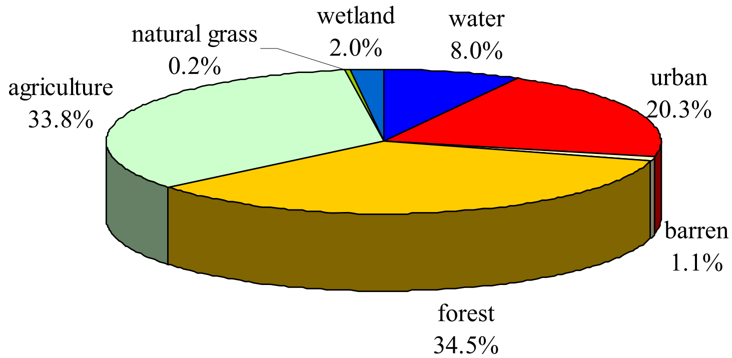

Figure 1: Land Use Distribution in the Northeast River Watershed

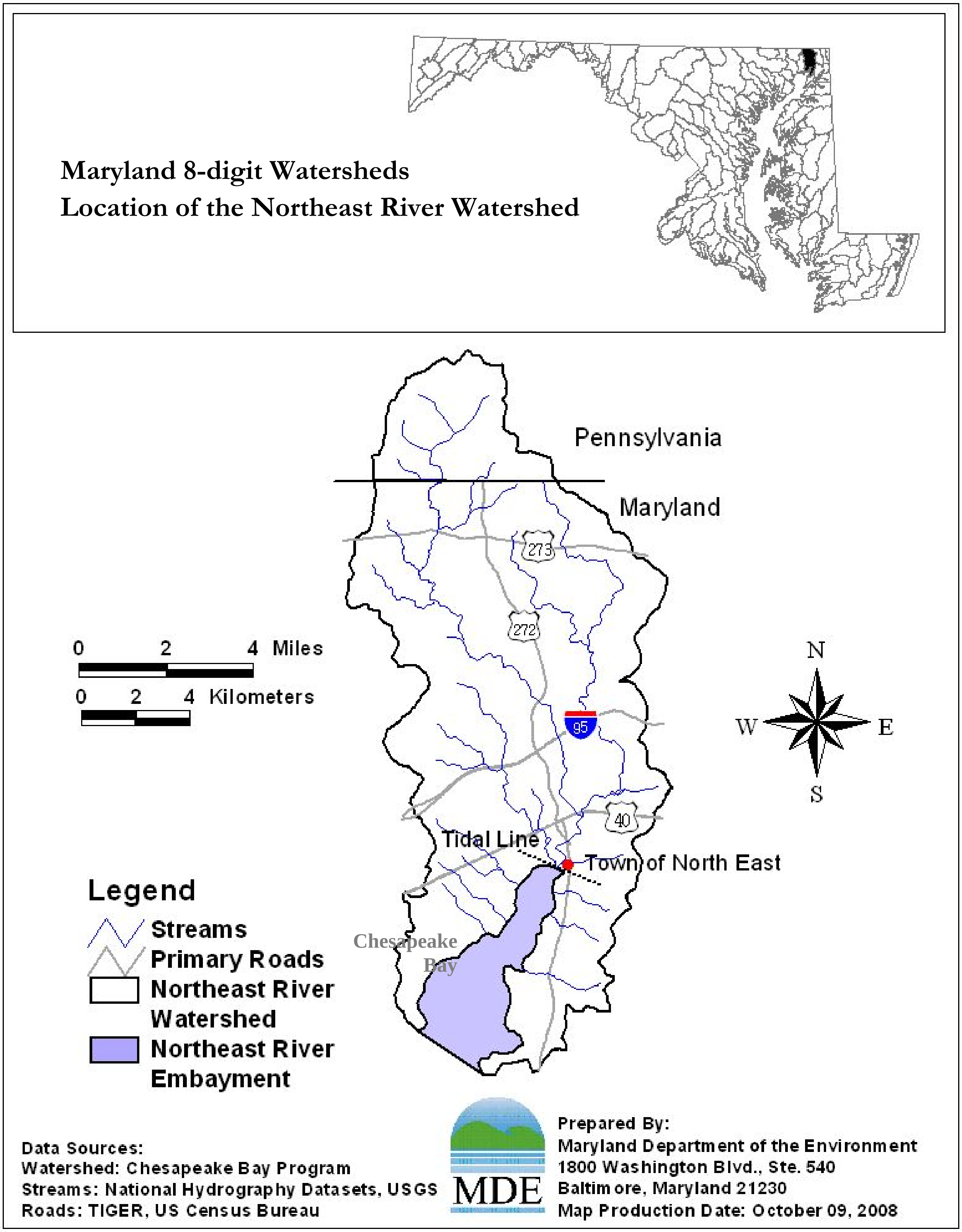

Figure 2: Location Map of the Northeast River Watershed and Embayment

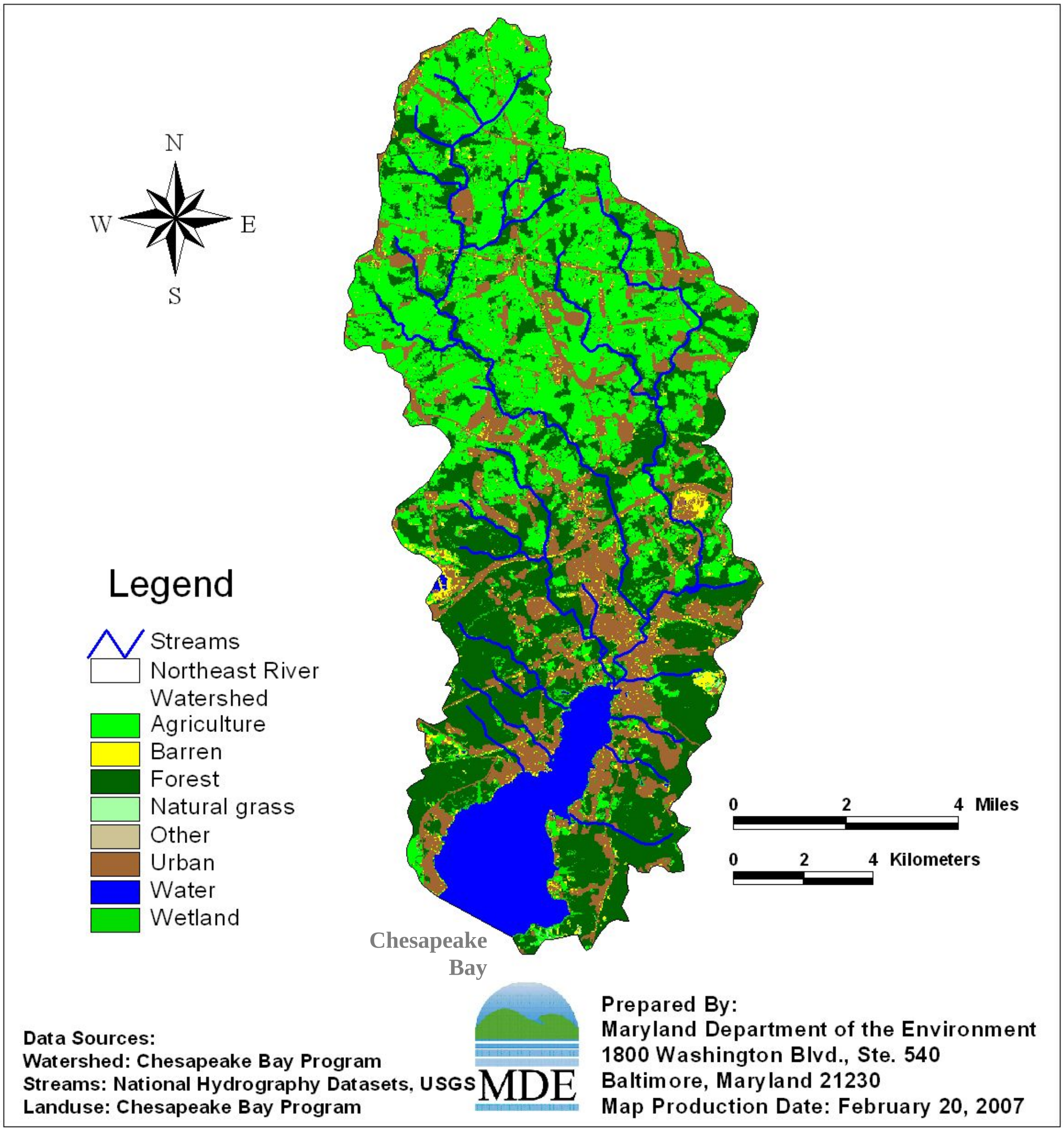

Figure 3: Land Use in the Northeast River Watershed

2.2. Water Quality Characterization and Impairment

The Maryland water quality regulations state 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 segment is Use II – Support of Estuarine and Marine Aquatic Life and Shellfish Harvesting (COMAR 2007b). The State of Maryland adopted three separate water column tPCB criteria: human health criterion for protection of human health associated with consumption of PCB contaminated fish, as well as fresh and salt water chronic tPCB criteria for protection of aquatic life. The Maryland water column human health tPCB 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 of 2 milligrams/kilogram-day^{-1} (mg/kg-day)$^{-1}$, bioconcentration factor 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 fresh and salt water chronic aquatic life tPCB criteria are set at 14 ng/L and 30 ng/L, respectively (COMAR 2007c; US EPA 2006). A sediment tPCB criterion has not been established within Maryland water quality standards.

In addition to the water column criteria described above, fish tissue monitoring data 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 the "fishing" designated use. Currently Maryland applies 39 ng/g as the tPCB fish tissue listing threshold (MDE 2008, 72-74). MDE has collected fish tissue samples in the Northeast River embayment on 09/03/2002 (see Table 2). The average concentration for each of the indicator fish species, except black crappie, exceeded the tPCB listing threshold, indicating PCB impairment.

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 Maryland Threshold
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 tPCB 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 averaged water column tPCB concentrations (particulate + dissolved) exceed the 30 ng/L Maryland salt water chronic aquatic life tPCB criterion, all of them exceeded the 0.64 ng/L Maryland water column human health tPCB 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.

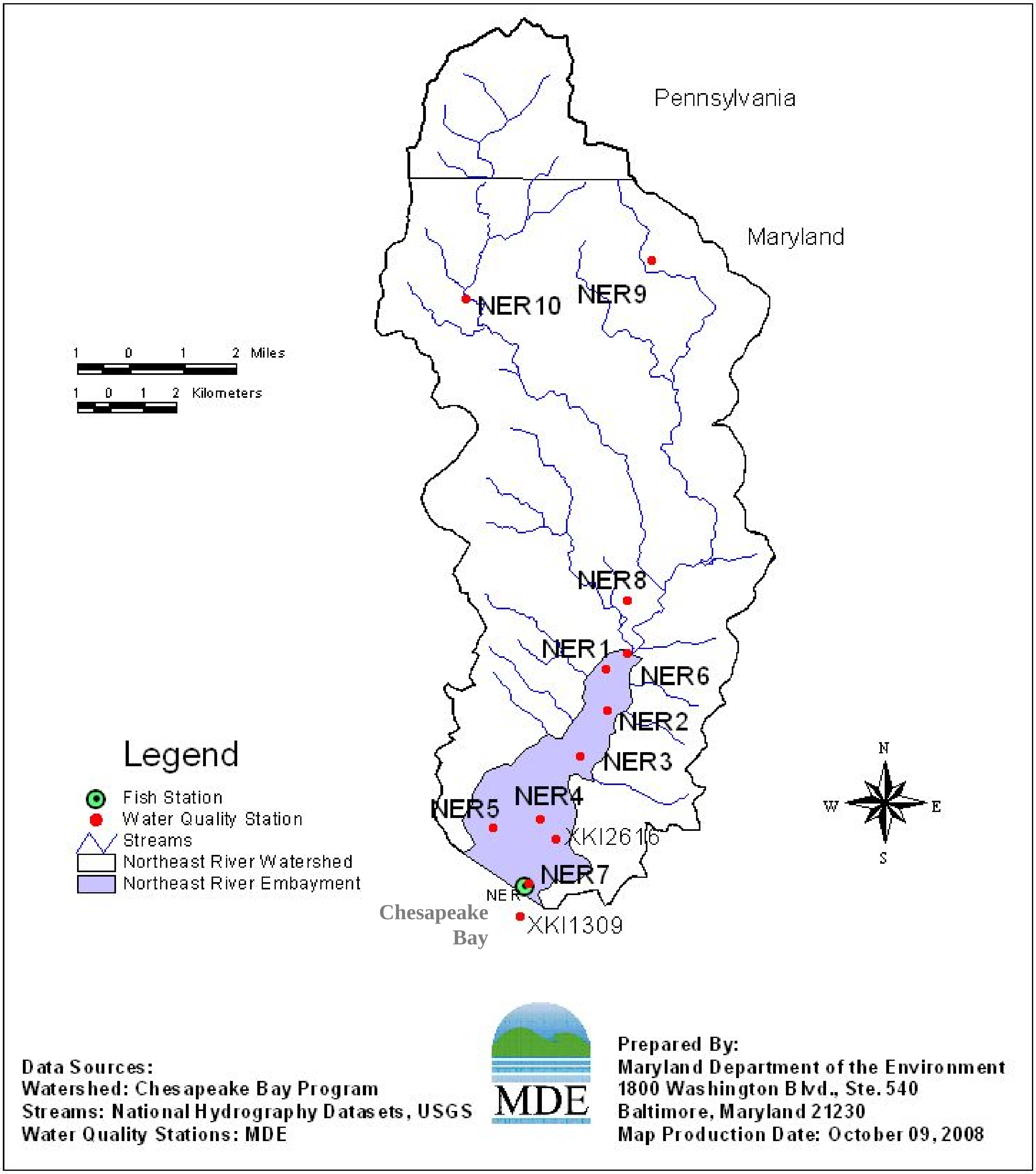

Figure 4: Water Quality Monitoring Stations in the Northeast River Watershed

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 the tPCB concentrations in the Upper Chesapeake Bay are decreasing at a rate of 6.5% per year (p.10). For the 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 others 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. However, 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. This section provides a detailed description of the existing nonpoint and point sources that have been identified as contributing tPCB 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 the bottom sediments, watershed runoff (including runoff associated with atmospheric deposition to the watershed and from the two 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 Chesapeake Bay tPCB Baseline Load of 5847.6 g/year is the major source of tPCBs to the Northeast River embayment (see Table 7, 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 tPCB loads from the Susquehanna River to the Upper Chesapeake Bay, Ko and Baker (2004) measured tPCB concentration downstream of the Susquehanna River and compared their results with those 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 the 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 tPCB concentrations at the Northeast River embayment boundary (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 PCB loads delivered to 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 the bottom sediments. Based on the measured tPCB concentrations in the water column and bottom sediments, the Bottom Sediment tPCB Baseline Load of 2,248.0 g/year is the second largest source of tPCBs to the Northeast River embayment (see Table 7, 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. That being said, it should be pointed out that overall a net loss of tPCB occurs due to volatilization of the dissolved PCBs in the water column to the atmosphere (Totten et al. 2006). The TMDL analysis accounts for both atmospheric deposition and volatilization. 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:

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

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

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

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 that the PCB pass-through efficiency, estimated by Totten et al. for the Delaware River watershed, is about 1%, the atmospheric tPCB loading to the Northeast River embayment from the watershed is approximately 6.1 g/year. The watershed runoff calculation below accounts for this load due to atmospheric deposition. Compared to other sources (see 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 ambient water column tPCB concentration (1.06 ng/L at NER8, NER9, and NER10) by the average watershed stream flow.

Using the 20-year monthly mean flow at the United States Geological Survey (USGS) station located at Northeast Creek (USGS01496000) (see Figure 6) and ratio of the Northeast River watershed area to the USGS station drainage area, the average Northeast River watershed stream flow was estimated to be equal to 3.66 m^3/s (129.4 cubic feet per second). The average stream flow was then distributed between Pennsylvania (0.40 m^3/s) and Maryland (3.26 m^3/s) portions of the watershed, according to the respective watershed areas, and used to calculate the watershed tPCB baseline loads (Calculation 3).

Pennsylvania 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**

Maryland 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**

(Calculation 3)

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

- *Point Source Load*: National Pollutant Discharge Elimination System (NPDES) Regulated Stormwater Baseline Load and
- *Nonpoint Source Loads*: Maryland Watershed Nonpoint Source Baseline Load and Contaminated Site Baseline Load (see Table 4 and Table 5).

Table 4: Breakdown of the Total Watershed tPCB Baseline Load

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 to the entire land surface of the watershed. The remaining load is due to unidentified sources of PCB contamination from historical uses and releases. However, when compared with the Chesapeake Bay and Bottom Sediment Baseline Loads, the Total Watershed tPCB Baseline Load is insignificant and even its complete elimination would not result in noticeable decrease in the tPCB 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 2007a) and MDE's Environmental Restoration and Redevelopment Program (MDE 2007a) (see Figure 5 and Table 5).

Table 5: Contaminated Site tPCB 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

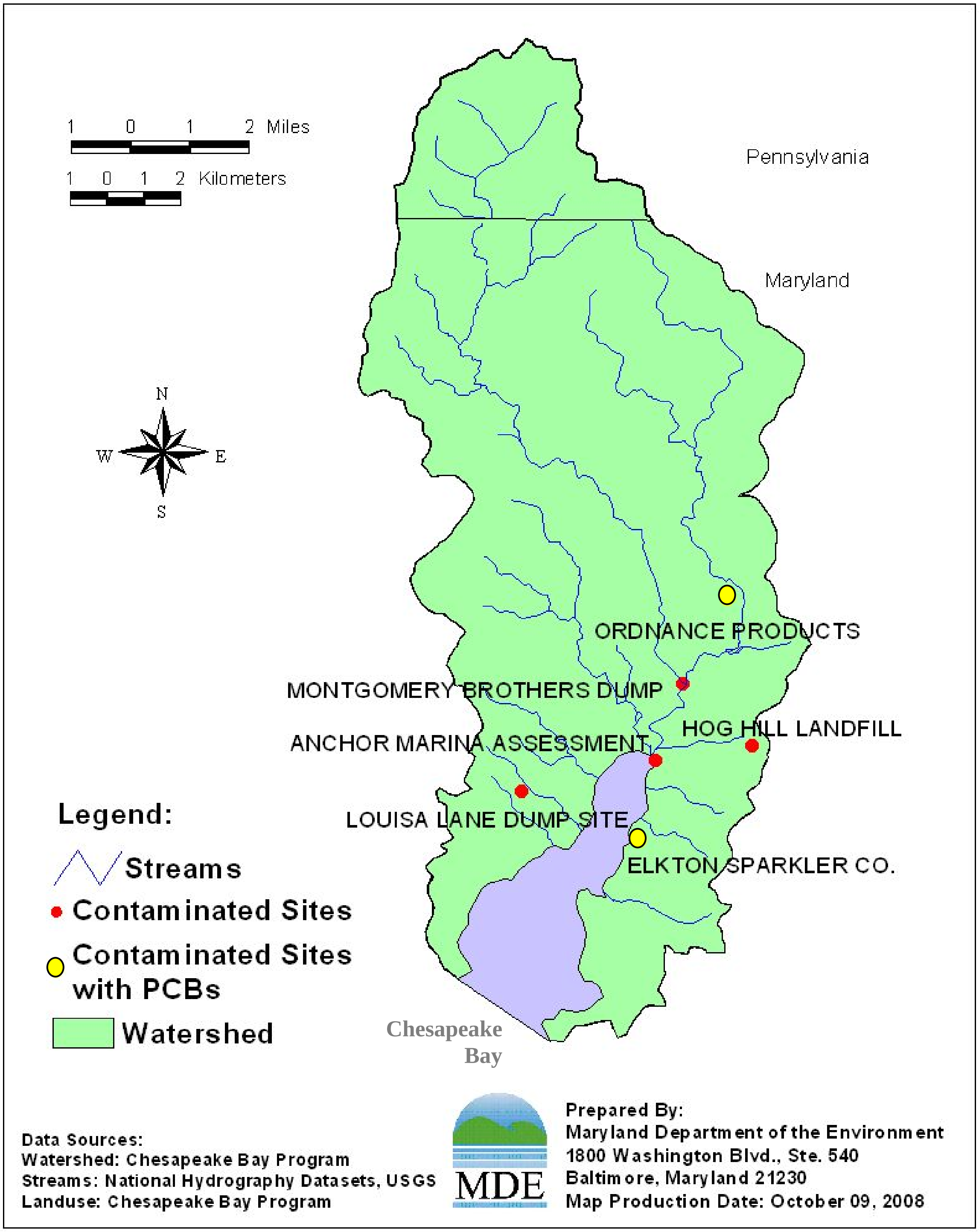

Figure 5: Locations of the Contaminated Sites in the Northeast River Watershed

PCBs were detected at the following two sites: Ordnance Products and the Elkton Sparkler Co., which are located within the urban land use classification 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. The methodology is presented in

Appendix I. This annual erosion factor was subsequently combined with the observed tPCB soil concentrations to estimate the tPCB loads. The tPCB Baseline Loads 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 Baseline Loads from these sites are considered to be insignificant (see Table 7).

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 two wastewater treatment plants (WWTPs). While, for the purpose of this TMDL, the WWTP Baseline Loads have been estimated, they have been considered to be *de minimis* (see Appendix L). This section provides detailed explanation about how the point source baseline loads have been estimated.

Waste Water Treatment Plants

Northeast River Advanced WWTP (MD0052027) and Morning Cheer WWTP (MD0052299) are the two WWTPs located in the watershed (see Figure 6). Both of these facilities discharge directly to the Northeast River embayment. The Northeast River Advanced WWTP was monitored for the discharge of tPCBs 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 tPCB Baseline Loads were calculated based on the permit design flows for the Northeast River Advanced WWTP and Morning Cheer WWTP and the appropriate tPCB concentrations. Thus, the estimated tPCB Baseline Loads for the Northeast River Advanced WWTP and Morning Cheer WWTP are 1.03 and 0.03 g/year, respectively (see Table 6 and Table 7), which for the purpose of this analysis are treated as separate model inputs.

Table 6: WWTP tPCB Baseline Loads

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

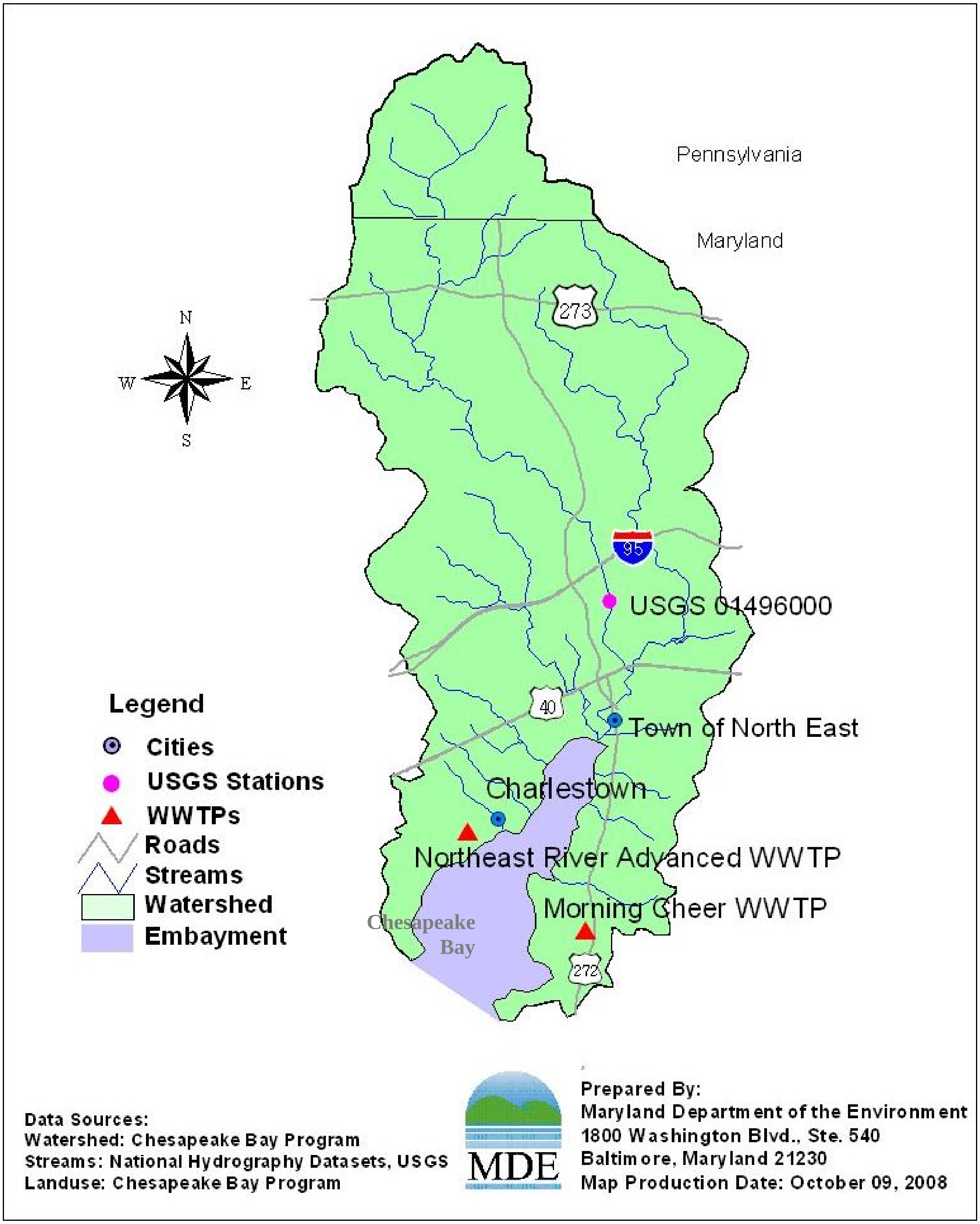

Figure 6: Locations of the WWTPs in the Northeast River Watershed and the USGS Stations Used for Flow Estimation

NPDES Regulated Stormwater

The Maryland portion of the Northeast River watershed is located in Cecil County, which is regulated under a NPDES Phase II jurisdictional municipal separate storm sewer system (MS4) permit. The NPDES regulated stormwater runoff in the watershed include tPCB loadings from: (i) the area covered under Cecil County's Phase II jurisdictional MS4 permit, and (ii) state and federal general MS4s, industrial facilities, and construction permits. 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 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 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 tPCB Baseline Load of 25.4 g/year (see Table 7).

2.3.3. Summary

In summary, the Chesapeake Bay tidal influence and resuspension and diffusion from the bottom sediments are the two major tPCB 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 Total Baseline Load. Table 7 summarizes the estimated Total tPCB Baseline Load from all identified source categories.

Table 7: Summary of the Total tPCB Baseline Load

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.

3.0 WATER COLUMN AND SEDIMENT TMDL ENDPOINTS

The overall objective of the tPCB TMDL established in this document is to ensure that the "fishing" designated use in the Northeast River embayment is protected. As described in Section 2.2, MDE evaluates PCB water quality conditions with the use of either the tPCB fish tissue listing threshold (39 ng/g) or the Maryland water column human health tPCB criterion (0.64 ng/L). In order to determine which one of these targets is more environmentally protective, 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 a site-specific Adjusted Total Bioaccumulation Factor (Adj-tBAF) of 211,633 L/kg following the method of the Tidal Potomac River PCB TMDLs (see Appendix B for the derivation of the Adj-tBAF) (MDE 2007b).

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

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

Based on this analysis, the tPCB 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 site-specific tPCB water column TMDL endpoint.

Similarly, in order to establish whether levels of PCBs in the sediment are protective of the "fishing" designated use, a site-specific tPCB sediment TMDL endpoint 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 site-specific adjusted sediment bioaccumulation factor (Adj-SediBAF) of 9.1 (unitless) following the method of the Tidal Potomac River PCB TMDLs (see Appendix B for the derivation of the Adj-SediBAF) (MDE 2007b).

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

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

Both the site-specific tPCB water column and sediment targets will be used as TMDL endpoints and the more restrictive one will determine the actual TMDL (Section 4.2).

4.0 TOTAL MAXIMUM DAILY LOADS AND LOAD ALLOCATIONS

4.1. Overview

A TMDL is the total amount of impairing substance 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 Tidal Fresh segment. The analysis framework for simulating tPCB 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 fresh water 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 dominant processes affecting the transport of PCBs throughout the water column include: the tidal influence, fresh water discharge, atmospheric exchange (i.e., volatilization and deposition), and exchange with the bottom sediments. 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. Technical 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 on average the 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., fresh water 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 site-specific tPCB water column TMDL endpoint. The results indicated that when the water column TMDL endpoint (0.18 ng/L) was met, the tPCB sediment concentration was still higher than the site-specific sediment TMDL 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 TMDL endpoint. Figure 7 and Figure 8 show the simulated results: after 13,572 days (about 37 years) the tPCB sediment concentration reached the sediment TMDL endpoint of 4.3 ng/g (see Figure 7), at which time the water column tPCB concentration was equal to 0.15 ng/L (see Figure 8).

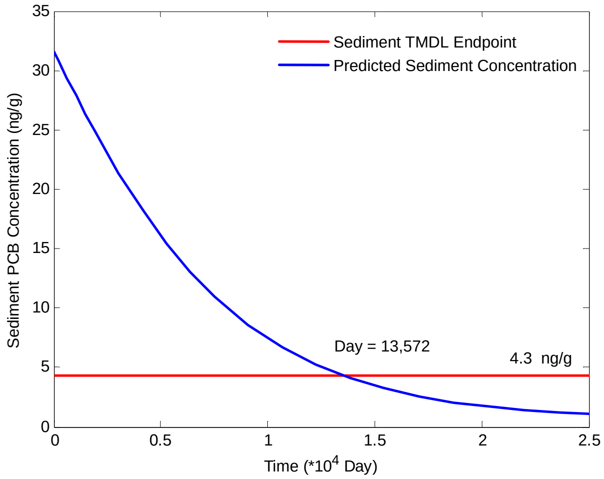

Figure 7: Changes in Sediment tPCB Concentration with Time

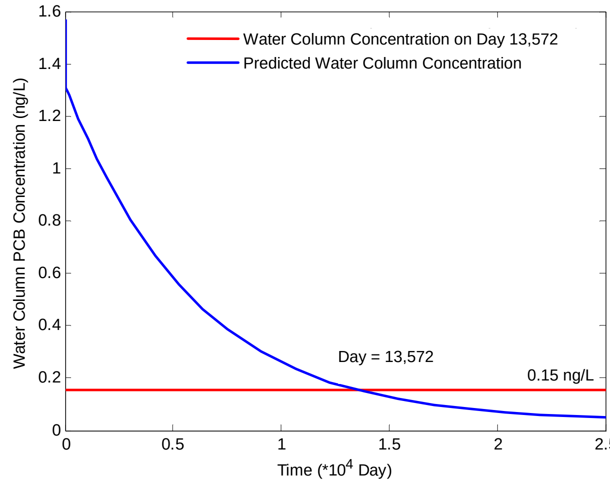

Figure 8: Changes in Water Column tPCB Concentration with Time

As presented in Table 8, the Chesapeake Bay tidal influence as well as resuspension and diffusion from the bottom sediments are the two primary sources of tPCB baseline loads resulting in the PCB impairment in the Northeast River embayment. Attainment of the site-specific tPCB water quality TMDL endpoints will only be possible with significant reduction in these primary loadings (see 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 (see Section 2.3.1 and Appendix J), no additional tPCB reductions will be necessary to meet the “fishing” designated use in the Northeast River embayment.

4.3. Critical Conditions 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 this requirement 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 in the Northeast River embayment increase between March and October. This indicates that during the period of high river flow water column PCBs are likely diluted by the increased river discharge more so than during the low flow period. However, since tPCB levels in fish become elevated due to long-term exposure, rather than temporary spikes in water column tPCB concentration, it has been determined that the selection of the average tPCB concentration as representing the baseline conditions adequately considers the impact of seasonal variations and critical conditions on the “fishing” designated use in the Northeast River embayment. Furthermore, the site-specific tPCB water column TMDL endpoint used to develop this TMDL is lower than the Maryland fresh and salt water chronic aquatic life tPCB criteria protective of fish and wildlife as well as the Maryland water column human health tPCB criterion protective of human health associated with consumption of PCB contaminated fish.

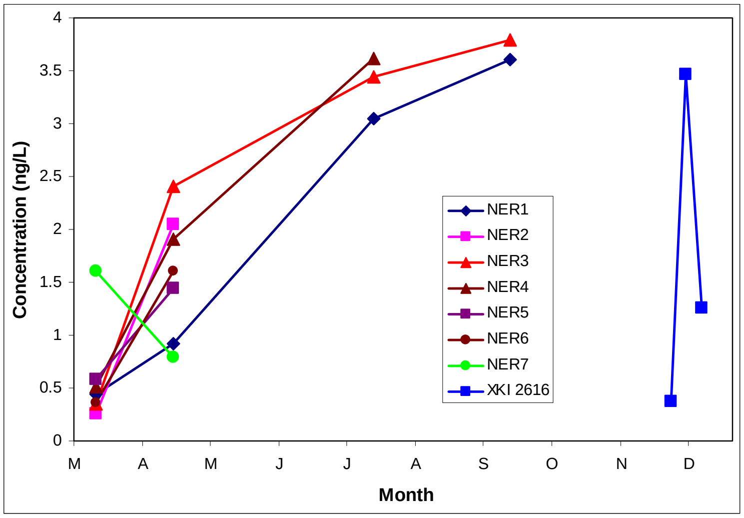

Figure 9: Seasonal Variations of Water Column tPCB Concentrations in Northeast River Embayment (2003, 2006)

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

4.4. TMDL Allocations

All TMDLs need to be presented in terms of WLAs for point sources and 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. This section summarizes the tPCB allocations established to meet the “fishing” 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 WWTP Baseline Loads are 1.03 and 0.03 g/year, respectively (see Table 6). For more information on methods used to calculate these loads, see Section 2.3.2. At 0.1% of the TMDL, the Northeast River cumulative WWTP Baseline Loads were considered *de minimis*, therefore no appreciable environmental benefit would be gained by reducing this load (see Appendix LL). The elevated tPCB concentrations in wastewater are believed to be primarily due to external sources (e.g., source water, atmospheric deposition, and stormwater runoff) infiltrating the waste water collection system through broken sewer lines and connections.. There are currently no effluent PCB limits established in the discharge permits for WWTPs. The sensitivity analysis provided in this document (Appendix L) suggests that there is no "reasonable potential" for PCBs to exceed water quality even at 100 times the current WWTP loadings. Inclusion of a WLA in this document does not reflect any determination to impose an effluent limit.

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 allocations to the Northeast River embayment will be expressed as a single 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).

The NPDES Regulated Stormwater WLA constitutes a proportional allocation of the Watershed tPCB Baseline Load to the entire Maryland urban land area and may include any or all of the NPDES stormwater discharges listed above (see Appendix H for a list of specific stormwater permits within the watershed). 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 NPDES Regulated Stormwater Baseline Load to the Northeast River embayment was considered to be insignificant relative to the loads from the Chesapeake Bay tidal influence and resuspension and diffusion from the bottom sediments. Therefore, no reductions were applied to this source category and the NPDES Regulated Stormwater WLA was set as equivalent to the Baseline Load (see Table 8). For more information on methods used to calculate the NPDES Regulated Stormwater tPCB Baseline Loads, please see Section 2.3.2.

4.4.2. Nonpoint Sources

Load allocations have been assigned to the following nonpoint sources: the Chesapeake Bay tidal influence, 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 tidal influence 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 "fishing" 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 load reductions should be required for the remaining nonpoint sources. The remaining LAs were set as equivalent to the corresponding baseline loads (see Table 8).

4.5. Margin of Safety

All TMDLs must include a margin of safety to account for the 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 tPCB 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 (see Table 8).

4.6. Summary of Total Maximum Daily Load Allocations

Table 8 summarizes the tPCB TMDL allocations for the Northeast River embayment as well as the corresponding baseline loads, the maximum daily load (MDL) (see Appendix G), and the associated load reductions.

Table 8: Summary of tPCB Baseline Loads, TMDL Allocations, MDL, and Associated Percent Reductions

Source	Baseline Load (g/year)	TMDL (g/year)	Load Reduction (%)	MDL[a] (g/day)
Chesapeake Bay (Tidal Influence)	5,847.6	480.5	91.8	2.790
Bottom Sediment (Resuspension and Diffusion)	2,248.0	306.8	86.4	1.781
Direct Atmospheric Deposition (to the Surface of the Embayment)	54.4	54.4	0.0	0.316
Maryland Watershed Nonpoint Sources*	83.4	83.4	0.0	0.484
Contaminated Sites*	0.2	0.2	0.0	0.001
Pennsylvania Upstream	13.4	13.4	0.0	0.078
Nonpoint Sources/Load Allocations	***8,247.0***	***938.7***	***88.6***	***5.450***
WWTP*△	1.1	1.1	0.0	0.009
NPDES Regulated Stormwater*	25.4	25.4	0.0	0.147
Point Sources/Waste Load Allocations*	***26.5***	***26.5***	***0.0***	***0.156***
MOS	**-**	***107.2***	**-**	***0.623***
Total	**8,274**	**1,072**	**87.0**	**6.23**

Notes: * These sources were characterized only for the Maryland portion of the watershed.
△ WWTP Baseline Loads were considered to be *de minimis.*
[a] For details see Appendix G.

5.0 ASSURANCE OF IMPLEMENTATION

As discussed in the previous sections, the Chesapeake Bay tidal influence 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 the tPCB concentrations in the Upper Chesapeake Bay are decreasing at a rate of 6.5% per year. Given this rate of decline, 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 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 the water column. Second, a reduction in the Chesapeake Bay tPCB loads 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.

In the case of the Northeast River Tidal Fresh segment 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. MDE's Water Quality Standards Section will continue to monitor PCB levels in fish. This information will be used to evaluate the PCB impairment in the Northeast River embayment on an ongoing basis.

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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 observed total PCB (tPCB) concentrations 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-tBAFs and Adj-SediBAFs

This appendix describes how the site-specific Adjusted Total Bioaccumulation Factor (Adj-tBAF) and Adjusted Sediment Bioaccumulation Factor (Adj-SediBAF) were derived. These values are then used to convert the total Polychlorinated Biphenyl (tPCB) fish tissue listing threshold to the corresponding site-specific tPCB water column and sediment concentrations protective of the "fishing" designated use in the Northeast River embayment. These methods are based on the approach used in the development of the Tidal Potomac River PCB TMDLs (MDE 2007b).

I. Data Description

The site-specific observation-based Adj-tBAFs and Adj-SediBAFs were calculated based on the available tPCB concentrations for the various fish species and accompanying water column and sediment samples collected in the Northeast River embayment. Each fish species was assigned a trophic level and home range (Table B-1). The Adj-tBAFs and Adj-SediBAFs were calculated based on the geometric mean tPCB concentrations of all the water quality samples within each species' home range.

Table B-1: Trophic Levels and Home Ranges of Sampled Fish Species

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

The Total Bioaccumulation Factors (BAFs) for each fish sample (individual or composited) was calculated using Equation B1 (US EPA 2003):

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

Where: $[\text{tPCB}]_{\text{fish}}$ = fish tissue tPCB concentration (ng/kg – wet weight)
$[\text{tPCB}]_{\text{water}}$ = geometric mean of water column tPCB concentrations within fish species' home range (ng/L).

Next, for fish species with more than one sample, a single Total BAF was calculated as the median of the applicable total BAFs.

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 tPCB concentrations in ambient water, it was determined that for the purpose of the TMDL analysis, Adj-tBAFs should be used. To calculate the site-specific Adj-tBAFs, first Baseline BAFs were calculated as recommended by US EPA (2000):

$$\text{Baseline BAF} = \frac{[\text{tPCB}]_{\text{fish}} \div \%\text{Lipid}}{[\text{tPCB}]_{\text{water}} \times \%fd} \qquad \text{(B2)}$$

Where: $[\text{tPCB}]_{\text{fish}}$ = fish tissue tPCB concentration (ng/kg – wet weight)
$[\text{tPCB}]_{\text{water}}$ = geometric mean of water column tPCB concentrations within fish species' home range (ng/L)
%lipid = fraction of fish tissue that is lipid
%fd = fraction of tPCB concentration in ambient water that is freely-dissolved.

Again, the above calculation was done for each fish sample (individual or composited). Next, for fish species with more than one sample, a single Baseline BAF was calculated as the median of the applicable Baseline BAFs.

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

$$\%\text{fd} = \frac{1}{1 + \text{POC} \times \text{K}_{\text{ow}} + \text{DOC} \times 0.08 \times \text{K}_{\text{ow}}} \qquad \text{(B3)}$$

Where: K_{ow} = PCB octanol-water partition coefficient
POC = particulate organic carbon concentrations in the water column
DOC = dissolved organic carbon concentrations in the water column.

The K_{ow} of different PCB congeners vary widely. Therefore, the %fd value was first calculated for each PCB homolog (Homolog %fd) 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 PCB Homologs

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 tPCB freely dissolved fraction (tPCB %fd) for each water sample within fish species' home range was derived as described in Equation B4 and multiplied by the appropriate water column tPCB concentration. The geometric mean of all of the results within fish species' home range was then used in Equation B2 (in place of $[tPCB]_{water}$ × %fd) to calculate the Baseline BAFs for each fish sample.

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

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

Table B-3: Freely Dissolved tPCB, POC, and DOC Concentrations

Station	Sample Date	Freely-Dissolved tPCB (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

Station	Sample Date	Freely-Dissolved tPCB (ng/L)	POC (kg/L)*	DOC (kg/L)*
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

Note: * When the POC or DOC data were not available, the averaged value within the range was used instead.

IV. Adjusted Total BAFs

Next, the Baseline BAFs was normalized by the species median lipid content and a median freely-dissolved water column tPCB concentration within species' home range, thus minimizing variability associated with the differences in fish lipid content or freely-dissolved water column tPCB concentrations:

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

Finally, the tPCB fish tissue listing threshold of 39 ng/g was divided by the site-specific Adj-tBAF calculated for each fish species (Table B-4). To be environmentally protective, the lowest value (i.e., 0.18 ng/L – white perch) was used as the site-specific tPCB water column TMDL endpoint protective of the "fishing" designated use in the Northeast River embayment.

Table B-4: Site-Specific Total BAF, Baseline BAF, Adj-tBAF, and Water Column Target, as well as Median %fd and Median Lipid Content for Each Fish Species

Species Name	Total BAF (L/kg)	Baseline BAF (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

Similarly as in the case of the Baseline BAF calculation, the biota-sediment accumulation factors (BSAFs) for each fish sample (individual or composited) were derived using the following equation:

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

Where: $[\text{tPCB}]_{\text{fish}}$ = fish tissue tPCB concentration (ng/kg – wet weight)

$[tPCB]_{sediment}$ = geometric mean of sediment tPCB concentrations within fish species' home range (ng/L)
%lipid = fraction of fish tissue that is lipid
%Organic Carbon = sediment organic carbon fraction within fish species' home range.

As the %Organic Carbon data were not available for the Northeast River embayment, a default value of 1% was used (US EPA 2004).

For fish species with more than one result, a single BSAF was calculated as the median of the applicable total BSAFs. Each species' BSAF was then normalized with the use of the median lipid content (Table B-4) and the sediment organic carbon fraction:

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

The tPCB fish tissue listing threshold of 39 ng/g was then divided by the Adj-SedBAF calculated for each species (Table B-5). To be environmentally protective, the lowest value (i.e., 4.3 ng/g – white perch) was used as the site-specific tPCB sediment TMDL endpoint protective of the "fishing" designated use in the Northeast River embayment.

Table B-5: Site-Specific BSAF, Adj-SedBAF, and Sediment Target for Each Fish 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. Detailed information about tidal prism model and its applications can be found at Kuo et al. (1998) and Kuo et al. (2005). 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.

The mass balance of water can be written as follows (Guo and Lordi, 2000):

$$\frac{dV}{dT} = Q_0(1-a) - Q_b + Q_f \qquad \text{(C1)}$$

Where:
V is the volume of the bay (m3);
T is the dominant tidal period (hours);
Q_0 = quantity of water that enters the embayment through the open boundary (m3/d);
Q_b = quantity of water that leaves the embayment through the open boundary (m3/d);
Q_f = the volume of water that enters the embayment from the Bohemia River watershed;
α = return ratio, which is the percentage of water that flowed to the Lower Elk River during the previous ebb tide and flows back to the embayment during the following flood tide;

In a steady-state condition, the mass balance equations for the water can be written as follows:

$$Q_b = Q_0(1-a) + Q_f \qquad \text{(C2)}$$

Knowing Q_0, Q_f, and α , Q_b can be estimated (see Appendix D).

Assuming no decay, the polychlorinated biphenyls (PCBs) can enter the water column via loading from upstream and the atmosphere (L_f), loading from the Lower Elk River (Q_0C_0), resuspension from the sediment (V_rAC_2), and diffusion between sediment-water column interface ($V_dA(F_{do2}C_2 - F_{do1}C_1)$). PCBs leave the water column via volatilization ($V_vAF_{do1}C_1$), flow to the Lower Elk River (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 ($V_dA(F_{do2}C_2 - F_{do1}C_1)$), resuspension ($V_rAC_2$) and burial to a deeper layer (V_bAC_2). Specifically, the mass balance for the PCBs in the water column (Equation C3) and sediment (Equation C4) can be written as (Chapra, S.C. 1997):

$$\frac{dV_1C_1}{dt} = L_f - V_vAF_{do1}C_1 + (1-\alpha)Q_0C_0 - Q_bC_1 + V_rAC_2 - V_sAF_{p1}C_1 + V_dA(F_{do2}C_2 - F_{do1}C_1) \qquad \text{(C3)}$$

$$\frac{dV_2C_2}{dt} = -V_rAC_2 + V_sAF_{p1}C_1 - V_dA(F_{do2}C_2 - F_{do1}C_1) - V_bAC_2 \qquad \text{(C4)}$$

Where:
L_f = tPCB loading from upstream (point and nonpoint sources) and atmosphere;
V_v = volatilization coefficient (m/d);
α = return ratio, which is the percentage of water that flowed to the Lower Elk River during the previous ebb tide and flows back to the embayment during the following 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 Lower Elk River (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 = rate of resuspension (m/d);
V_s = rate of settling (m/d);
V_b = rate of burial (m/d).

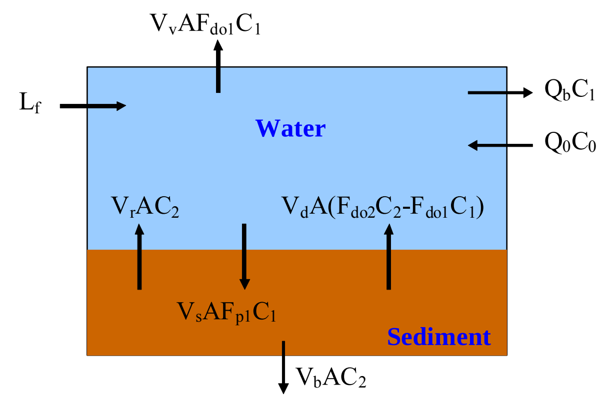

Figure C-1: The Schematic Diagram for the Tidal Prism Model and the tPCB Budget

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. It was obtained by summing all the upstream point and nonpoint source loads and the load from atmosphere.

V_v = 90 m/year = 0.246 m/day. It was derived using the empirical method of Chapra (1997) assuming a wind spped of 1 m/s and a temperature of 10 ℃.

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 estimated from GIS layer.

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

Q_b = Q_f + Q_0 × (1-α) = 316,465 + 18,427,304 × (1-0.46) = 10,267,209 m^3.
Q_f is obtained by dividing the mean flow recorded at the closest U.S. Geological Survey gage station (Northeast Creek, USGS 01496000) by its drainage area, and multiplying by 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 baseline boundary condition of the model. The TMDL methodology assumes that on average the tPCB concentrations at the Bohemia River boundary are decreasing at a rate of 6.5% per year (also see Section 2.3.1 and Appendix J).

C_1 = 1.57 ng/L (measured).

C_2 = Measured tPCB concentration on a dry sediment base × Sediment density × (1-porosity) ÷ Fraction of particular-associated tPCBs in the sediment = 31.60 × 2,500 × (1-0.85) ÷ 0.9976 = 11,878 ng/L; 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 estimated from GIS.

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 default value and 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 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:

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

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:

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

Substituting all the necessary parameters in equations (C3) and (C4) 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:

$$\text{Upper 95\% CI} = \text{Mean} + \frac{\text{t - Value} \times \text{Standard Deviation}}{\sqrt{\text{Sample Size}}}$$

$$\text{Lower 95\% CI} = \text{Mean} - \frac{\text{t - Value} \times \text{Standard Deviation}}{\sqrt{\text{Sample Size}}}$$

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 baseline conditions in the embayment and at the Bay boundary. The results are presented in Figures E-1 and E-2. Time duration required to meet the site-specific tPCB sediment TMDL endpoint and the corresponding water column concentrations are listed in Table E-1. Time duration required to meet the water quality TMDL endpoints in the embayment increased by approximately 10 percent (4 years) when the upper CI (vs. the mean) was used as the baseline.

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

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

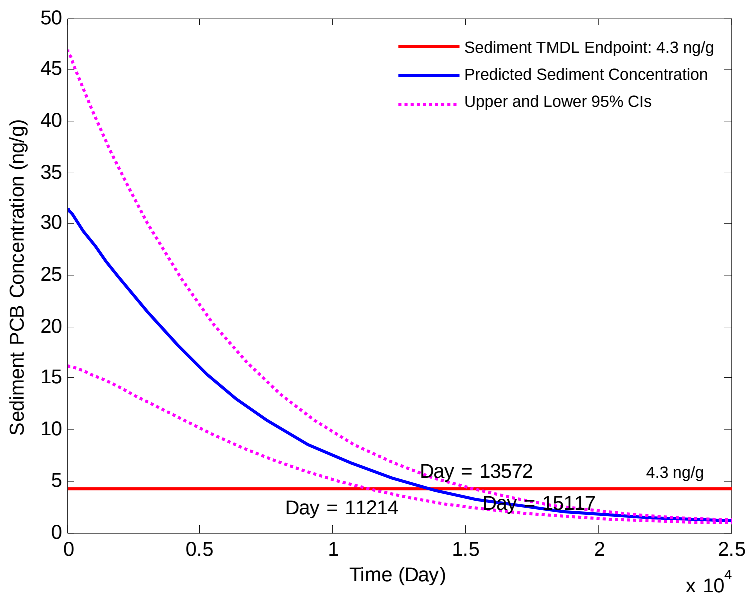

Figure E-1: Predicted Sediment tPCB Concentration in ng/L (Blue Line) and its 95% CIs (Magenta Lines)

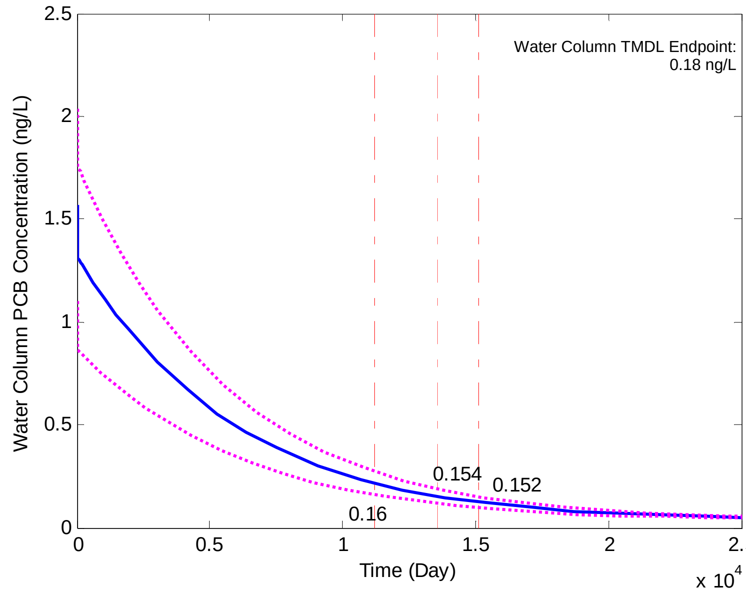

Figure E-2: Predicted Water Column tPCB Concentration in ng/L (Blue Line) and Its 95% CIs (Magenta Lines). The Red Vertical Lines Indicate the Times When the Sediment Endpoint Was Met.

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 concentrations in water column and pore water, respectively.
φ is the porosity of the sediment.

Appendix G. Technical Approach Used to Generate Maximum Daily Load

Summary

This appendix documents the technical approach used to define the maximum daily load (MDL) of total polychlorinated biphenyls (tPCBs) consistent with the average annual Total Maximum Daily Load (TMDL), which is protective of the "fishing" designated use in the Northeast River embayment. The approach builds upon the modeling analysis that was conducted to determine the average annual tPCB TMDL and can be summarized as follows:

- The approach defines an MDL for each of the source categories;
- The approach builds upon the TMDL modeling analysis that was conducted to ensure that the average annual TMDL results in compliance with water quality standards;
- 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 present the average annual tPCB TMDL allocations in terms of daily loads. 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 Load to the Northeast River embayment results in fish tissue concentrations that exceed the tPCB fish tissue listing threshold. Thus, the average annual tPCB TMDL was calculated to be protective of the "fishing" designated use.
- **Draft U.S. Environmental Protection Agency (US EPA) guidance document entitled *Options for the Expression of Daily Loads in TMDLs* (US EPA 2007b).**

The rationale for developing TMDL expressed as daily loads was to accept the existing average annual TMDL, but then develop a method for converting this number to an MDL – 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 (US EPA 2007b). The selection of a specific method for translating a time-series of allowable loads into the expression of an MDL 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 exceedance of the TMDL.

This section describes the options that were considered when developing methods to calculate the Northeast River embayment MDL.

Level of Resolution

The level of resolution pertains to the amount of detail used in specifying the MDL. The draft US EPA guidance on daily loads (US EPA 2007b) provides three categories of options for level of resolution, all of which are potentially applicable to 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 MDL to vary based upon the observed flow conditions;
3. **Temporally-variable daily load:** This option allows the MDL to vary based upon seasons or times of varying source or water body behavior (US EPA 2007b).

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 MDL should be “based on a representative statistical measure” that is dependent upon the specific TMDL and best professional judgment of the developers (US EPA 2007b). This statistical measure represents how often the MDL is expected/allowed to be exceeded. The primary options for selecting this level of protection would be:

1. **The MDL reflects some central tendency:** In this option, the MDL 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 MDL reflects a level of protection implicitly provided by the selection of some “critical” period**: In this option, the MDL 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 MDL is a value that will be exceeded with a pre-defined probability:** In this option, a "reasonable" upper bound percentile is selected for the MDL based upon a characterization of the variability of daily loads. For example, selection of the 95th percentile value would result in an MDL that would be exceeded 5% of the time.

Selected Approach

The level of resolution selected for the Northeast River embayment MDL 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 that is protective of the "fishing" designated use. Daily flow and temporal variability do not affect the rate of PCB bioaccumulation in fish over the long-term thus establishing no influence on achievement of the TMDL endpoint. An MDL at these levels of resolution is unwarranted.

The approach selected for defining a Northeast River embayment MDL 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 and National Pollutant Discharge Elimination System (NPDES) Regulated Stormwater Point Sources within the Northeast River watershed;
- Approach for NPDES permitted waste water treatment plant (WWTP) Point Sources within the Northeast River watershed; and
- Approach for Upstream Sources.

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

The Nonpoint Source and NPDES Regulated Stormwater Point Source MDLs were estimated based on three factors: a specified probability level, the average annual tPCB TMDL allocations, and the coefficient of variation (CV) of the baseline 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 of 0.36 was calculated using the arithmetic mean and standard deviation of the baseline ambient water column concentrations in the Northeast River (see Equation G1).

$$CV = \frac{\beta}{\alpha} \qquad \text{(G1)}$$

Where:

CV = coefficient of variation
α = mean (arithmetic)

β = standard deviation (arithmetic)

The MDL for each contributing source is estimated as the appropriate average annual load allocation multiplied by a conversion factor that accounts for expected variability of daily loading values. The equation is as follows:

$$MDL = LTA * e^{(z\sigma - 0.5\sigma^2)} \qquad \text{(G2)}$$

Where:
MDL = Maximum daily load
LTA = Long-term average (average annual load allocation)
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 (z value of 2.326), a CV of 0.36, and an appropriate unit conversion (i.e., from long-term average load (g/yr) to an MDL (g/day)) results in a conversion factor of 0.0058.

Approach for WWTP Point Sources within the Northeast River Watershed

The TMDL also considers contributions from NPDES permitted WWTP point sources that discharge quantifiable concentrations of tPCBs in the Northeast River watershed. The MDLs were calculated based on the guidance provided in the Technical Support Document (TSD) for Water Quality-based Toxics Control (US EPA 1991). The average annual TMDL allocations were converted to maximum daily limits using Table 5-2 of the TSD assuming a coefficient of variation of 0.6, a 99th percentile probability (z value of 2.326), and an appropriate unit conversion (i.e., from long-term average load (g/yr) to an MDL (g/day)). This results in a conversion factor of 0.0085. It should be noted, however, that the WWTP Baseline Loads were considered to be *de minimis, therefore* no appreciable environmental benefit would be gained by reducing this load (see Appendix L for details).

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 MDL was calculated based on the same approach as was 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 approaches to define the Northeast River embayment MDL.

- Calculation Approach for Nonpoint Sources (Chesapeake Bay, Bottom Sediment, Direct Atmospheric Deposition, Maryland Watershed Nonpoint Sources, and Contaminated Sites) and NPDES Regulated Stormwater Point Sources within the Northeast River:

  Nonpoint Source MDL (g/day) = Average Annual Nonpoint Source LA (g/yr) × 0.0058

  NPDES Regulated Stormwater MDL (g/day) = Average Annual NPDES Regulated Stormwater WLA (g/yr) × 0.0058

- Calculation Approach for WWTP Point Sources within the Northeast River:

  WWTP MDL (g/day)△ = Average Annual WWTP WLA (g/yr) × 0.0085

- Calculation Approach for Upstream Sources:

  Pennsylvania Upstream MDL (g/day) = Average Annual Pennsylvania Upstream LA (g/yr) × 0.0058

Table G-1: Summary of tPCB Maximum Daily Load

Source	MDL (g/day)
Chesapeake Bay (Tidal Influence)	2.790
Bottom Sediment (Resuspension and Diffusion)	1.781
Direct Atmospheric Deposition (to the Surface of the Embayment)	0.316
Maryland Watershed Nonpoint Sources*	0.484
Contaminated Sites*	0.001
Pennsylvania Upstream	0.078
Total Nonpoint Sources	***5.450***
WWTP* △	0.009
NPDES Regulated Stormwater*	0.147
Total Point Sources*	***0.156***
MOS	***0.623***
Total	**6.23**

Notes: * These sources were characterized only for the Maryland portion of the watershed.
△ WWTP Baseline Loads were considered to be *de minimis.*

Appendix H. MDE Permit Information

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

MDE Permit	Facility	City	County	Type	TMDL Allocation
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
-	MDE General Permit to Construct	ALL	ALL	-	Stormwater WLA

Note: [1]Although not listed in this table, some individual process water permits for municipal and industrial discharges may also incorporate stormwater requirements. Loads from such facilities as well as from general Phase II state and federal MS4s (i.e., military bases, hospitals, etc.) are inherently included as part of the NPDES stormwater WLA presented in this document.

Appendix I. Contaminated Site Load Calculation Methodology

The total polychlorinated biphenyl (tPCB) loadings for the previously identified contaminated sites in the Northeast River 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 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 Comprehensive Database (see Table I-1) (US EPA 2007a; MDE 2007a). 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 sample results contained within MDE's Waste Management Administration (WAS) contaminated site surveys. Consequently, these two sites comprise the entirety of the Contaminated Site tPCB Baseline Loads.

Table I-1: Contaminated Sites in the Northeast River 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, tPCB baseline loads were only calculated for the two sites where 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 (feet)	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 tPCB baseline loads based on the tPCB concentrations found in the soil. The average minimum and maximum tPCB concentrations were multiplied by the soil loss to produce minimum and maximum tPCB loadings. These values were finally converted to grams per year and the average of the two tPCB loading values was calculated to produce the final tPCB baseline load for each site (Table I-9). A summary of the final tPCB baseline loads per contaminated site is shown in Table I-10.

Table I-9: Contaminated Site tPCB Baseline Load Calculations

Site	Data	Soil Loss (lbs/yr)	x	Average tPCB Soil Concentration (lbs/lb)	=	tPCB Loading (lbs/yr)	=	tPCB 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-10: Summary of Contaminated Site tPCB Baseline Loads

Site	Average tPCB Baseline Load (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 BASELINE LOAD SUMMARY

The total tPCB baseline load to the Northeast River embayment from the identified contaminated sites is estimated to be 0.16 g/year. This total baseline load consists of individual tPCB loads from two contaminated sites within the Northeast River watershed.

Appendix J. Derivation of the Boundary tPCB Concentration

Northeast River exchanges waters with the Chesapeake Bay. The Susquehanna River is the major source of flow and polychlorinated biphenyls (PCBs) to the Upper Chesapeake Bay (Ko and Baker 2004). According to Ko and Baker (2004), the tPCB loads of Susquehanna River from 1992 to 1998 are as follows:

Table J-1: The Flow Normalized tPCB loads 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* vs. *Log ($Load_{Current}/Load_{1992}$)*, the slope of -0.0292 stands for log of current year's load as a percentage of the previous year's load. The current year's load as a percentage of the previous year's load is $10^{-0.0292} = 0.935$. Thus, on average the tPCB concentrations in the Upper Chesapeake Bay are decreasing at a rate of 1 - 0.935 = 6.5% per year (Figure J-1). This value was used in the model simulation to account for the expected temporal changes in tPCB concentration at the Bay boundary.

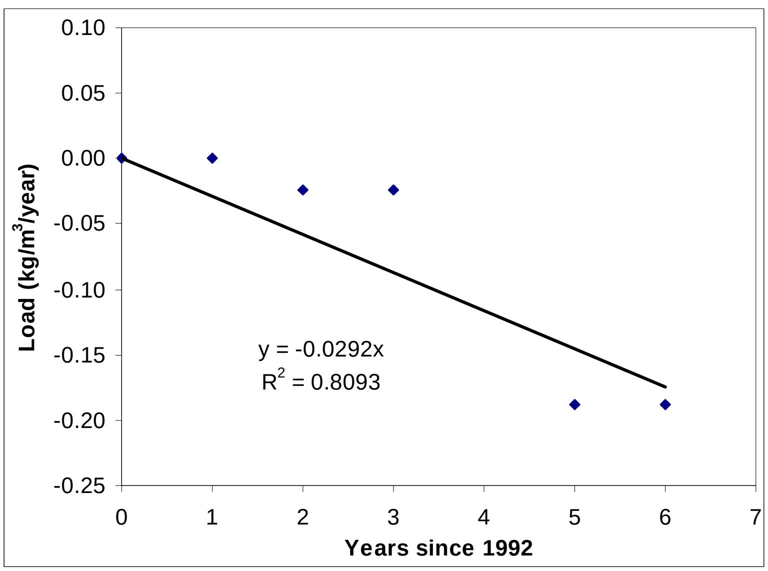

Figure J-1: The Regression Line of the Ko and Baker tPCB Loading Data

Appendix K. List of Analyzed PCB Congeners

Polychlorinated biphenyl (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 total PCB concentrations that are calculated as the sum of the detected PCB congeners/congener groups representing the 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 the Waste Water Treatment Plant (WWTP) Total Polychlorinated Biphenyl (tPCB) Baseline Loads and whether a reduction is necessary in order to meet the TMDL resulting in the attainment of water quality standards. Assigning reductions to loads that are considered *de minimis* (i.e., insignificant or negligible) would produce no appreciable environmental benefit and would require regulated facilities to implement burdensome regulatory requirements.

At 0.1% of the TMDL (Table L-1), the Northeast River cumulative WWTP Baseline 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 site-specific tPCB water quality TMDL endpoints; 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 TMDL endpoints by only 0.35% or 48 days (Table L-3, Figure L-1 and L-2). Therefore, given that even a possible future increase in this load would not have any impact on meeting TMDL endpoints, no appreciable environmental benefit would be gained by reducing this load.

Table L-1. WWTP tPCB 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 Baseline Loads on Time Needed to Reach the TMDL Endpoints

Allowable Load	Nr. of Days Needed to Reach the TMDL Endpoints
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 sources of the tPCB loads resulting in the PCB impairment in the Northeast River embayment (see Section 2.3). Attainment of the tPCB water quality TMDL endpoints 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 WLAs will be revisited.

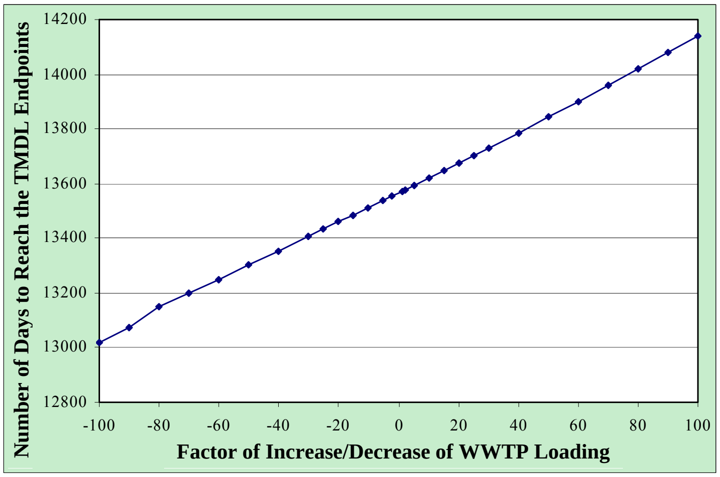

Figure L-1. Effect of Increasing/Decreasing Loads as Factor of WWTP Baseline Loads on Time Needed to Reach the TMDL Endpoints (days)

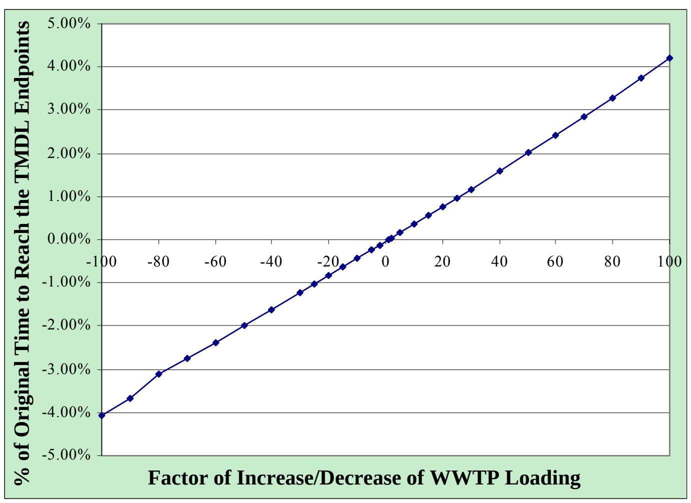

Figure L-2. Effect of Increasing/Decreasing Loads as Factor of WWTP Baseline Loads on Time Needed to Reach the TMDL Endpoints (% of time)

Table L-3. Effect of Increasing/Decreasing Loads as Factor of WWTP Baseline Loads on Time Needed to Reach the TMDL Endpoints

Factor of Increase/ Decrease of WWTP Loading	Nr. of Days Needed to Reach the TMDL Endpoints	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%