Appendix A

Conceptual Site Model

Lower Passaic River Restoration Project

Conceptual Site Model

In partnership with

February 2007

R2-0008955

Lower Passaic River Restoration Project

Conceptual Site Model

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FOR:
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US Army Corps of Engineers
New Jersey Department of Transportation/
Office of Maritime Resources

February 2007

CONCEPTUAL SITE MODEL

LOWER PASSAIC RIVER RESTORATION PROJECT

Prepared by:

Malcolm Pirnie, Inc.

February 2007
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LOWER PASSAIC RIVER RESTORATION PROJECT
CONCEPTUAL SITE MODEL

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LIST OF ATTACHMENTS

Attachment A: Sediment Texture Map Book

Attachment B: Calculation of Groundwater Contribution

Attachment C: Bathymetric Data Analysis

Attachment D: Revised Exposure Pathways and Receptors Figures

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1.0 INTRODUCTION

1.1 OBJECTIVE OF THE CONCEPTUAL SITE MODEL

A conceptual site model (CSM) expresses a site-specific contamination problem through a series of diagrams, figures, and narrative consistent with United States Environmental Protection Agency (USEPA) Office of Solid Waste and Emergency Response (OSWER) remedial investigation and feasibility study guidance (USEPA, 1988). These diagrams, figures, and the narrative are designed to illustrate the potential physical, chemical, and biological processes that transport contaminants from sources to receptors. A CSM is a tool for examining the contamination problem and provides the basis for identifying and evaluating the potential risks to human health and the ecosystem.

A CSM is prepared during the first step of the data quality objective (DQO) process (USEPA, 2000). The CSM continues to evolve throughout the project as historical and recently collected data are evaluated and as the risk assessments are refined. Typical components of a CSM include:

- Physical and chemical processes occurring naturally or anthropogenically at the site and in its environmental setting.
- Spatial variation in physical and chemical processes occurring across the site.
- Changes in physical attributes at the site over the historical period of contamination.
- Potential contamination source area(s).[1]
- Potentially contaminated media and types of contaminants expected.
- Contaminant fate and transport mechanisms and migration pathways.

[1] This CSM identifies geographical regions where sources may originate (*e.g.*, upriver of Dundee Dam, downriver of Dundee Dam, or a particular stretch of the river). Source areas are defined as locations from which contamination originates and becomes available for transfer to other media and other areas (refer to Section 6.0 "Source Area Analyses" for further discussion). This CSM does not identify specific entities that generated potential contaminant input to the Lower Passaic River.

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- Potential exposure pathways.
- Potential human and ecological receptors.

Together, these CSM components present a current understanding of the contamination problem. They identify existing data gaps and the sampling necessary to address these gaps, and they identify potential exposures that may result in existing human and ecological risks. The CSM also provides guidance for future project decision-making. The CSM is a multi-faceted tool that serves a critical project role in risk assessment, numerical model development, project and sample planning, decision making, and ultimately in choosing a remedial strategy. For these reasons, a series of diagrams, figures, and a narrative, which make up the CSM, are necessary to describe the complex system fully, with each diagram or figure individually highlighting a different aspect of the system.

1.2 DEVELOPMENT OF CONCEPTUAL SITE MODEL FOR THE STUDY

The Lower Passaic River Restoration Project (herein referred to as the Study) is an interagency effort to remediate and restore the complex ecosystem of a portion of the Passaic River identified as the Lower Passaic River, which is the 17-mile, tidally-influenced portion of the river located in northeastern New Jersey. The Study Area (118 square miles) is defined as the Lower Passaic River and its basin, which comprises the tidally-influenced portion of the river from the Dundee Dam [River Mile (RM) 17.4] to Newark Bay and the watershed of this river portion, including Saddle River, Second River, and Third River (Figure 1-1).[2] The Upper Passaic River watershed (the area impacting the portion of the Passaic River located above the Dundee Dam) is represented as a point source with solids, water, and contaminants crossing over the dam into the Study Area. Refer to Section 2.0 "Hydro-Geographic Setting" for further discussion on

[2] RM0, which was established for this Study, is defined by an imaginary line between two marker lighthouses at the confluence of the Lower Passaic River and Newark Bay: one in Essex County, New Jersey just offshore of Newark and the other one in Hudson County, New Jersey just offshore of Kearny Point.

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the Lower Passaic River and the relationship of the river with the larger Hudson-Raritan Estuary.

A preliminary CSM for the Study was presented in August 2005 version of the *Work Plan* (Malcolm Pirnie, Inc., 2005a). The objective of the 2005 CSM was to present the contamination problem of the Lower Passaic River by focusing initially on geochemical and transport processes understood at the time. Here, the CSM is updated according to the *Quality Assurance Project Plan* (QAPP; Malcolm Pirnie, Inc., 2005b) to summarize the studies conducted between September 2005 and September 2006.[3] This 2007 CSM represents our current articulation of the site contamination problem and river processes, including:

- Delineation and division of the Lower Passaic River into three river sections (Freshwater, Transitional, and Brackish) to capture important spatial variations in the river's character.
- Description of the major boundary conditions in the Study Area, including those at Dundee Dam and Newark Bay, as well as other boundary conditions that have less impact on the Lower Passaic River.
- Description of solids accumulation conditions and description of net depositional and net erosional areas in the Lower Passaic River.
- Characterization of potential source areas and contaminant inputs to the Lower Passaic River.
- Description of the fate and transport of target contaminants through preliminary mass balances.

This CSM is intended to support the overall remedial investigation and feasibility study for the Lower Passaic River as well as to assist in the development of other tasks. To continue developing a comprehensive understanding of the river, which addresses all

[3] The CSM synthesizes data evaluations that were published in other documents. Consequently, data gaps exist in the CSM where data from the different published documents do not overlap.

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aspects of the Study, future iterations of the CSM should identify site-specific exposure pathways, measurement endpoints, and assessment endpoints as well as identify site-specific chemicals of potential concern (COPCs) and chemicals of potential ecological concern (COPECs). Pathways, endpoints, and contaminants presented in this CSM are preliminary and will be developed as part of the problem-formulation phase of the baseline ecological risk assessment (BERA) (USEPA, 1997).

In addition, the geochemical evaluations presented in this CSM should be further refined to integrate the remaining historical data and the data collected during recent and future field investigations that have not been included here. It is recognized that several other datasets are available; however, the work to date has focused on those datasets that provide the broadest representation of the Lower Passaic River. Currently, the datasets presented in the figures and tables of this CSM are listed in Table 1-1. These datasets are supplements with literature values that are referenced in Section 10 "References."

Table 1-1: Datasets Presented in the CSM

Study Name [a]	Sample Year	Number of Locations	River Mile or Water Body	Type of Sample
1990 Surficial Sediment Investigation	1990	3 [b]	Above Dundee Dam	Sediment Grab
1991 Core Sediment Investigation	1991	1 [b]	Above Dundee Dam	Sediment Core [c]
1995 Remedial Investigation Sampling Program	1995	97	RM0.9 to RM6.8	Sediment Core [c,d]
1999 Sediment Sampling Program	1999	1 [e]	RM6.2	Sediment Core [c]
1999 Late Summer/Early Fall Environmental Sampling Program	1999	45	RM1 to RM6.9	Sediment Grab
1999/2000 Minish Park Monitoring Program	1999	8	RM4.9 to RM5.1	Sediment Core [c]
2000 Spring Environmental Sampling Program	2000	15	RM1 to RM6.9	Sediment Grab
Newark Bay 2005 Remedial Investigation Work Plan Phase 1 Dataset	2005	69	Newark Bay	Sediment Core [c]
2005-2006 USEPA Sampling Program High Resolution Cores	2005	5	RM1.4 to RM12.6	Sediment Core [c,d]
2005-2006 USEPA Sampling Program Low Resolution Cores	2006	10	RM2.8 to RM6.8	Sediment Core [c]

a: Data are available at www.ourpassaic.org.
b: Only sample locations above the Dundee Dam were evaluated.
c: Only surface sediment samples are presented in the CSM.
d: All data from sediment core were evaluated to develop the CSM.
e: Only one sampling location was incorporated into CSM since the other samples were mis-projected.

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Table 1-2 provides an additional list of datasets evaluated in the *Draft Geochemical Evaluation (Step 2)* (Malcolm Pirnie, Inc., 2006a). The conclusions from these evaluations are summarized and presented throughout this CSM.

Table 1-2: Datasets Referenced in the *Draft Geochemical Evaluation (Step 2)* (Malcolm Pirnie, Inc., 2006a)

Study Name [a]	Sample Year	Number of Locations	River Mile or Water Body	Type of Sample
1990 Surficial Sediment Investigation	1990	2 [b]	RM3.2 to RM7	Sediment Grab
1991 Core Sediment Investigation	1991	14 [b]	RM0.2 to 7	Sediment Core [c]
2004 Newark Bay Remedial Investigation Work Plan	1991-1998	32	Newark Bay	Sediment Core [d]
1992 Core Sediment Investigation	1992	4 [b]	RM1.1 to RM7	Sediment Core [d]
1993 Core Sediment Investigation – Part 1 (March 1993)	1993	8 [b]	RM0.3 to RM7	Sediment Core [c]
1993 Core Sediment Investigation – Part 2 (July 1993)	1993	11	RM0.5 to RM3	Sediment Core [c]
1994 Surficial Sediment Investigation	1994	18 [b]	RM3.5 to RM7.8	Sediment Grab
1995 Remedial Investigation Sampling Program	1995	97	RM1 to RM6.8	Sediment Core [c]
1995 Sediment Grab Sampling Program	1995	7	RM2.4 to RM2.7	Sediment Grab
1995 USACE Minish Park Investigation	1995	10	RM3.7 to RM5.5	Sediment Core [c]
1996 Newark Bay Reach A Sediment Sampling Program	1996	4	Newark Bay	Sediment Core [d]
1998 Newark Bay Elizabeth Channel Sampling Program	1998	3	Newark Bay	Sediment Grab and Sediment Core [d]
1999 Late Summer/Early Fall Environmental Sampling Program	1999	45	RM1 to RM6.9	Sediment Grab
1999 Newark Bay Reach ABCD Baseline Sampling Program	1999	10	Newark Bay	Sediment Grab
1999 Sediment Sampling Program	1999	1 [e]	RM6.2	Sediment Core [d]
1999/2000 Minish Park Monitoring Program	1999	8	RM4.9 to RM5.1	Sediment Core [d]
2000 Spring Environmental Sampling Program	2000	15	RM1 to RM6.9	Sediment Grab

a: Data are available at www.ourpassaic.org.
b: Only sampling locations between RM0 and RM7 were evaluated.
c: All data from the sediment core were evaluated in the *Draft Geochemical Evaluation (Step 2)* (Malcolm Pirnie, Inc., 2006a).
d: Only surface sediment samples were evaluated in the *Draft Geochemical Evaluation (Step 2)* (Malcolm Pirnie, Inc., 2006a).
e: Only one sampling location was incorporated into *Draft Geochemical Evaluation (Step 2)* (Malcolm Pirnie, Inc., 2006a) since the other samples were mis-projected.
USACE = United States Army Corp of Engineers

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1.3 CONCEPTUAL SITE MODEL SUMMARY

This section summarizes the salient points of the CSM, including the history of the Lower Passaic River, its physical and chemical setting, inventories of selected contaminants, and its impacts on Newark Bay. Relevant section numbers are included throughout this summary to refer the reader to additional detail on the topics introduced.

1.3.1 HISTORY OF THE LOWER PASSAIC RIVER

The Lower Passaic River was one of the major centers of the American industrial revolution, with early manufacturing, particularly cotton mills, developing in the area around Great Falls in Paterson, New Jersey. In subsequent years, a multitude of industrial operations sprung up along the banks of the Passaic River, as the New Jersey cities of Newark and Paterson grew. These industrial developments included, but were not limited to, manufactured gas plants, paper manufacturing and recycling facilities, and chemical manufacturing facilities. These plants used the river for wastewater disposal. Moreover, the Lower Passaic River has been used as a major means of conveyance for municipal discharges from the middle of the nineteenth century to the present time. Together, these waste streams (industrial and municipal) have delivered a number of contaminants, including but not limited to 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD), polycyclic aromatic hydrocarbons (PAH) from manufacturing gas plants, polychlorinated biphenyls (PCB) from recycling carbon-less copying paper, DDT[4], mercury, and lead.

An important component of the river's development and urbanization was the channelization of the river to permit commercial vessels to travel into the city of Newark and beyond. Several large dredging projects were undertaken at the beginning of the twentieth century to create a ship channel to RM15. The federally mandated channel dimensions are given in Table 1-3 [depths are relative to mean low water (MLW)].

[4] DDT is a common name that refers to a industrially-produced, chlorinated pesticide. DDT is chemically known as dichlorodiphenyltrichloroethane; its metabolites include dichlorodiphenyldichloroethane (DDD) and dichlorodiphenyldichloroethylene (DDE). The term Total DDT refers the sum of the DDT, DDD, and DDE concentrations in a sample.

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Table 1-3: Lower Passaic River Authorized Dimensions of the Federal Navigational Channel

River Mile [a]	Channel Depth (feet) [b,c]	Channel Width (feet)
RM -0.2 to RM2.2	30	300
RM2.2 to RM4.3	20	300
RM4.3 to RM6.9	20 (only constructed to 16 feet)	300
RM6.9 to RM7.9	16	200
RM7.9 to RM15.2	10	200

a: River miles are referenced to the Study-defined river mile scale (refer to Section 1.2 "Development of the Conceptual Site Model for the Study"). These river miles are offset from the scale that is used by the USACE by approximately 0.2 miles.
b: Obtained from the "Report of Channel Conditions 100 to 400 feet Wide" (USACE, 2002) and the USACE map "Newark Bay, Hackensack & Passaic Rivers, N.J. (Passaic River)" dated September 30, 1986 (USACE, 1986).
c: Channel depth relative to MLW

The volumes of sediments removed each year from dredging were recorded by the USACE (USACE, 1917; USACE, 1916; USACE, 1915; USACE, 1913; USACE, 1907; USACE, 1900; USACE, 1884; USACE, 1880) and summarized by Iannuzzi *et al*. (2002). This dredging data is presented in Figure 1-2 to show the total volume of sediment removed by dredging in 6-year increments. The figure also highlights the portion of the dredged volume removed from the Lower Passaic River below RM2. Over time, the total volume of sediments removed by dredging has declined. Since the 1940s, the vast majority of dredging has occurred below RM2. Consequently, the channel depths upriver of RM2 were not maintained and began to fill in (refer to Section 2.2.2 "Dredging History in the Lower Passaic River").

Channels fill by trapping sediments delivered from upland regions. In a typical estuary, sediment entrapment and deposition would occur most rapidly at the salt front via flocculation. These sediments would build up until a major storm or flow event of sufficient magnitude occurred. Then, sediments that were deposited since the last major event could be carried downriver. In this manner, a quasi-equilibrium bottom elevation of the estuary could be established over time reflecting the mass of solids delivered and the strength and frequency of major transport events.

In the case of the Lower Passaic River, however, any approximation of equilibrium has been greatly affected by anthropogenic activity in and around the river. Prior to the

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channel dredging of the early twentieth century, the Lower Passaic River was a relatively shallow estuary, probably not deeper than 15 feet in the center throughout much of its length (Chant and Fugate, 2006). Historical dredging served to create a deep channel relative to prior conditions, greatly enhancing the rate of sediment accumulation in the dredged areas. In particular, the dredged channel probably permitted a much more extensive and permanent salt intrusion, enhancing the rate of sediment trapping in the Lower Passaic River. Based on USACE records (Figure 1-2), it does not appear that this channel was regularly maintained, permitting a large volume of sediment to accumulate over time.

Since the 1940s, the river has delivered sufficient material to build up many feet of deposition, yielding an average rate of deposition substantially greater than what would "naturally" occur. The coincidence of chemical disposal in the river along with the construction and subsequent limited maintenance of the navigation channel created an ideal situation for the accumulation of thick beds of contaminated sediments. The magnitude of this deposition is illustrated in Figure 1-3, which shows the current depth of the river channel as well as the original dredged elevations as reported in USACE records. For the region below RM8, the river has accumulated thick sediment beds, over 15 feet or more in some areas, while no substantive channel deposition occurred above RM8. This evidence is consistent with the observations of recent deposition rates and sediment texture, which change markedly across RM8. Perhaps the most important consideration for the spread of current contamination is that sufficient solids deposition has occurred below RM8 to affect channel flow. Moreover, the rise in the river floor probably hinders the movement of the salt front (the upriver-most, saltwater-fresh water interface) under all but the driest conditions (refer to Section 2.2.2 "Dredging History in the Lower Passaic River").

1.3.2 PHYSICAL ENVIRONMENT OF THE LOWER PASSAIC RIVER

The Lower Passaic River is a partially stratified estuary wherein the degree of stratification and the location of the salt front at any point in time reflect a dynamic balance between the freshwater flow and the tidal exchange with Newark Bay. Tidal

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displacement in the Lower Passaic River is quite large, with the salt front moving several miles during each tidal cycle. The combination of a relatively narrow river cross-sectional area and the strong tidal flows yield tidal velocities that are quite high, reaching several feet per second, homogenizing sediments over much of the Lower Passaic River prior to deposition.

Tidal and freshwater flows also combine to cause highly variable rates of annual deposition, with some years showing a net loss of solids from the Lower Passaic River while other years showing a net solids gain (Malcolm Pirnie, Inc., 2006a). Since the construction of the navigation channel, the river bottom has been and continues to be net depositional. A series of bathymetric surveys of the river bottom provides a basis to assess the annual rates of deposition across the period of 1989 through 2004. Annual sediment deposition averaged approximately 67,000 cubic yards during this period, which is roughly equivalent to 1 inch of sediment accumulation over the Lower Passaic River bottom (RM0 to RM17) or 1.5 inches over the lower 7 miles. Approximately 90 percent of this accumulation occurs from RM0 to RM7 (refer to Section 5.2 "Solids Mass Balance").

For the purposes of the following discussion, fine-grained sediment refers to areas identified as silt or silt/fine sand as interpreted from the side-scan sonar images; medium-grained sediment is defined as areas identified as sand; and coarse-grained sediment refers to areas identified as gravel/coarse sand and rock/coarse gravel. The identification of these areas was primarily derived from a side-scan sonar survey conducted in 2005 (Aqua Survey, Inc., 2006). Figure 1-4 presents an example of the side-scan sonar output (Attachment A contains sediment texture maps as interpreted from side-scan sonar images for RM0 to RM16).

The river bed of the Lower Passaic River can be divided into three main domains with respect to sediment texture (Figure 1-5). The upper region (RM17.4 to RM14) is largely comprised of coarse-grained sediments, with relatively few areas of fine-grained sediments. This region is largely non-depositional. Sediments between RM14 to RM8

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transition from coarse-grained to fine-grained progressing downriver. The lower region (RM0 to RM8) is primarily comprised of fine-grained sediments, which are found over more than 80 percent of the river bottom. (Figure 1-4 shows side-scan sonar output near the boundary between these two of the domains at RM8.) For cross-sectional areas greater than about 3,500 square feet (marked as a dotted line on Figure 1-5), the river bottom is greater than 80 percent fine-grained sediments. For cross-sectional areas less than this value, the river bottom can vary but tends to be primarily coarse-grained. Notably, cross-sectional areas below RM8 are nearly always greater than 3,500 square feet (marked as a dotted cross-hair on Figure 1-6), correlating with the high percentage of fine-grained sediment in this region. Above RM8, cross-sectional areas tend to be less than 3,500 square feet and correspondingly high in coarse-grained sediment areas. This observation suggests a relationship between cross-sectional area and depositional environments, possibly related to the existence of stronger currents in areas of smaller cross-sectional area (refer to Section 3.5 "Upriver Extent of the Salt Front").

Given the high percentage of fine-grained sediment areas below RM8, a series of more limited bathymetric surveys (1995 to 2001) were used to identify those areas in RM0.9 to RM7 that appear to be net depositional, net erosional, or bathymetrically neutral from year-to-year in the time period examined (refer to Section 5.3 "Depositional Environments in the Lower Passaic River"). The results show that most of the area between RM0.9 and RM7 is routinely net depositional, although scattered areas may be undergoing net erosion (Figure 1-7). In particular, the river bends between RM2.5 and RM3.5 contain several large areas of erosion. However, the occurrence of erosional areas throughout RM0.9 to RM7 reflects the very dynamic nature of sediment deposition and erosion in the river. Some or all of these erosional areas are responsible for the on-going release of contaminants from the river bed.

A detailed examination of net sediment accumulation rates between RM0.9 and RM7 indicates a high degree of spatial heterogeneity, with local rates varying from about 6 inches/year of erosion to about 8 inches/year of deposition (Malcolm Pirnie, Inc., 2006a). Historical deposition rates were probably higher than current rates because of the more

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extensive salt intrusion present immediately after the initial channel dredging, which enhanced trapping of suspended matter. Based on solids balance considerations, current head-of-tide solids load to the Lower Passaic River is likely greater than the annual average rate of accumulation in the river (Malcolm Pirnie, Inc., 2006a). Excess solids delivered at the head-of-tide represent the net solids load delivered to Newark Bay. However, the historical rates of sediment accumulation in the Lower Passaic River were probably too large to be sustained solely by the Passaic's head-of-tide solids loads, suggesting that a net solids transport from Newark Bay supplied the additional solids. This observation is based on the estimated volume of contaminated sediments that accumulated between RM0.9 and RM7 after 1940, roughly 6.5 million cubic yards as of 1995. The estimated solids load at the head-of-tide would not deliver the estimated 6.5 million cubic yards (refer to Section 4.2 "Newark Bay Boundary Condition" and Section 5.2 "Solids Mass Balance").

The historical contaminated sediment deposits, which were created when the channel was deeper, may now be undergoing erosion as a result the changes in the channel geometry. The lines of evidence for this suggestion include the volume of sediments deposited, the high tidal velocities observed, the presence of erosional areas throughout the lower 7 miles of the Lower Passaic River, and the continued presence of several historical contaminants in very recently deposited sediments. A particular area of concern is the area near RM3.5 where the river turns sharply and erosional areas are observed on the outsides of the bends (Figure 1-7; refer to Section 5.3 "Depositional Environment in the Lower Passaic River"). The reworking of the historical sediments is an on-going source of contamination to other areas of the Lower Passaic River.

1.3.3 CHEMICAL ENVIRONMENT IN THE LOWER PASSAIC RIVER

The chemical contamination associated with the Lower Passaic River is primarily driven by the contaminant burdens contained within the sediments. While on-going external inputs may exist, the concentrations within the sediments are responsible for much of the contamination within the water column (Miller *et al*., 2007). In fact, the legacy of contamination in the sediments probably extends back at least to the beginning of the

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twentieth century. Based on observations made with dated sediment cores, historical loads of mercury and lead may predate or coincide with the original channel construction. The sand layer that underlies the thick silt beds is contaminated with these compounds (refer to Section 7.2 "Nature and Extent of Contamination"). This contamination may extend to a prehistoric sediment horizon, referred to as the red-brown clay.

Dated sediment cores also provide a record of contaminant load to the Lower Passaic River. For example, initial loads of Total DDT occur in the late 1940s and early 1950s and predate the appearance of major loads of 2,3,7,8-TCDD. Initial loads of 2,3,7,8-TCDD appear in the late 1940s to early 1950s and peak in the late 1950s to early 1960s. This peak occurs after the peak loads of Total DDT. Meanwhile, Total PCB loads appear in the middle 1950s, peaking in the late 1960s, making PCB the most recent of the contaminants. These cores also date the histories of mercury and cadmium, with peak releases of these metals occurring in the early 1960s. However, both metals are present well above background concentrations throughout the core record, predating the appearance of Total DDT. Total PAH contamination is unique in its temporal distribution, with the highest concentrations observed in the deepest core layers, gradually declining to the most recent deposition. The presence of Total PAH contamination in the sand layer underneath the thick silt deposits may represent historic deposition or alternatively a contaminated groundwater source.

Dated cores collected above the head-of-tide on the Upper Passaic River do not provide as extensive a historical record. Nonetheless, the core data are sufficient to suggest that the majority of historical loads of cadmium, lead, mercury, and Total PCB to the Lower Passaic River originated in the Upper Passaic River above the Dundee Dam. Historical loads of copper were more evenly split between Upper Passaic and Lower Passaic sources. Dated sediment cores from the Upper and Lower Passaic River further indicate that relatively little of the Total DDT and less than 1 percent of the 2,3,7,8-TCDD contamination in the Lower Passaic River historically originated above the Dundee Dam.

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The same dated cores that document the magnitude of the historical loads show that current loads throughout the Lower Passaic River are substantively lower. Figure 1-8 shows that the 2,3,7,8-TCDD profiles of three dated cores (RM1.4, RM2.2 and RM11). Evident in each core is a nearly two order of magnitude decline in 2,3,7,8-TCDD concentrations from the late 1950s to the present. In addition, despite the distance separating the cores, the cores record similar contaminant loading histories at similar concentrations. This observation is direct evidence of the effectiveness of tidal mixing in the Lower Passaic River, where sediments are well homogenized prior to deposition (refer to Section 6.2.2 "Tidal Mixing of Sediments"). Moreover, the presence or absence of an interval of high concentration within the sediments at a given location is a function of the depositional history and is not controlled by proximity to source. Thus, thick sequences of contaminated sediments will tend to have similar inventories of contaminants throughout the Brackish River Section and even into the Transitional River Section (refer to Section 6.2.1 "Surface Sediment Concentrations and Gradients").

Further evidence for tidal mixing can be observed in Figure 1-9, which shows the ratio of 2,3,7,8-TCDD to total tetrachlorodibenzodioxin (Total TCDD). Based on the work of Chaky (2003), this ratio is diagnostic of Lower Passaic River 2,3,7,8-TCDD contamination. The consistency of this ratio throughout these cores (post-1945) is indicative of a single source of 2,3,7,8-TCDD, distributed by tidal mixing throughout the Lower Passaic River. In contrast to the ratio for Lower Passaic River sediments, the 2,3,7,8-TCDD/Total TCDD ratios for sewage effluent and atmospheric deposition are less than 0.06. Notably, ratios approaching these levels are observed in the pre-1940s sediments, and these concentrations are orders of magnitude lower than the post-1940s deposition (refer to Section 2.2.1 "Relationship of the Lower Passaic River with the Estuary").

Ratio analysis has provided additional insight on other contaminants as well. Ratio analysis of metal contamination between RM0.9 and RM7.0 showed little variation in the metals pattern. Similarly, analysis of surface metal concentrations also showed relatively little trend with river mile. Like the 2,3,7,8-TCDD results, this evidence demonstrates

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the general homogeneity of surficial sediments in depositional areas of the Lower Passaic River and indicates the effectiveness of tidal mixing (refer to Section 6.2.1 "Surface Sediment Concentrations and Gradients").

Ratio analysis of Total PAH shows that the majority of PAH contamination in the sediments is derived from combustion-related processes. The ratio "fingerprint" suggests that Total PAH originates from two sources: coal tar residue (a by-product of manufactured gas plants) and urban background combustion. Of these sources, coal tar wastes are the dominant source to the Lower Passaic River based on the prevalence of coal tar-like PAH ratios in more-contaminated sediments. The same analysis essentially rules out creosote-derived contamination and suggests that only minor portions of the sediment PAH contamination are derived from a petrogenic source (*e.g.*, oils spills).

Core top samples (collected in 1986 and 1991) from above the Dundee Dam suggest that the Upper Passaic River may still represent an important source of cadmium, mercury and lead to the Lower Passaic River, unlike 2,3,7,8-TCDD and Total DDT, which primarily originate downriver of the dam. A source upriver of the Dundee Dam may have accounted for much of the historic Total PCB load to the Lower Passaic River (Bopp *et al*., 1991b). However, evidence suggests that *circa* 1995, the Upper Passaic River Total PCB source had become less important relative to the Total PCB load occurring within the Lower Passaic River. Nevertheless, the Upper Passaic River source may still comprise one-third of the Total PCB loading in the Lower Passaic River (refer to Section 7.2.5 "Total PCB Contamination").

1.3.4 CONTAMINANT INVENTORIES IN THE LOWER PASSAIC RIVER

The combination of the navigational dredging activities and the long and extensive history of contaminant discharges to the Lower Passaic River have served to create a uniquely large inventory of highly contaminated sediments contained within a relatively small area. Other major Superfund sites may have similar volumes of contaminated sediments [*e.g.*, Hudson River PCB site at 2.6 million cubic yards (USEPA, 2002) and Fox River PCB site at 8 million cubic yards (USEPA, 2003a)], but these inventories are

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spread over much greater distances than the 17 miles of the Lower Passaic River. While data are not sufficient to assess the volume of contaminated sediment for the entire Lower Passaic River, the volume is estimated at 5 to 8 million cubic yards for RM0.9 to RM7, with an average depth of contamination ranging from 7 to 13 feet. The evidence from the side-scan sonar and bathymetric surveys suggests that the conditions observed in RM0.9 to RM7 probably also apply over the area of RM0 to RM8, suggesting that the actual inventory of contaminated sediments is least one-third greater than the values obtained in the *Draft Geochemical Evaluation (Step 2)* (Malcolm Pirnie, Inc., 2006a). The volume of 2,3,7,8-TCDD-contaminated sediments is somewhat smaller than the overall contaminated sediment volume since several contaminants are present at greater depths than 2,3,7,8-TCDD. The estimate of 2,3,7,8-TCDD-contaminated sediment volume ranges from 5 to 6.5 million cubic yards for RM0.9 to RM7 (refer to Section 7.3.1 "Estimates of the Volume of Contamination").

The mass of contaminants contained within the sediments is also quite large (Table 1-4). Moreover, the mass of 2,3,7,8-TCDD represents one of the largest site inventories in the United States.

Table 1-4: Summary of Contaminant Inventory Estimates for RM0.9 to RM7

Inventory Estimate [a]	Total DDT (metric tons)	2,3,7,8-TCDD (kilograms)	Mercury (metric tons)	Total PCB (metric tons)
Based on measured core intervals only	6.4	20	24	6
Based on measured and extrapolated core profiles	11	29	37	8

a: Based on information provided in *Draft Geochemical Evaluation (Step 2)* (Malcolm Pirnie, Inc., 2006a)

The range in volume estimates given above (5 to 8 million cubic yards) reflects the uncertainty related to horizontal interpolation and vertical extrapolation, with the lower value based only on the measured core intervals, and the larger value incorporating the vertically extrapolated mass estimates. This range does not include the volume related to horizontal extrapolation from RM7 to RM8 and from RM0 to RM0.9. To estimate the sediment volume from RM7 to RM8 and from RM0 to RM0.9, the conditions in the one-mile lengths of river adjacent to these stretches were extrapolated. These calculations were performed for mercury to obtain the total volume of contaminated sediment as well

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as the entire mass of mercury, because mercury is one of the oldest (deepest) contaminants (Table 1-5). They were also performed for 2,3,7,8-TCDD to obtain an estimate of the 2,3,7,8-TCDD inventory for the lower 8 miles in total (Table 1-5). The estimated volume of contaminated sediment from RM0 to RM8 thus calculated approaches 10 million cubic yards. This represents an increase of 25 to 50 percent over the original estimates of contaminated sediments in RM0.9 to RM7. The inventory of mercury in the sediments between RM0 to RM8 is estimated at 50 metric tons, and the inventory of 2,3,7,8-TCDD is estimated at 33 kilograms.

Table 1-5: Estimated Mass and Estimated Volume of Contaminated Sediments in RM0 to RM8

Analyte	Average Extrapolated MPA	Extrapolated Mass	Average Extrapolated Depth (feet)	Extrapolated Volume of Sediment (cubic yards)
Mercury	20 g/m^2	50 metric tons	13	9,500,000
2,3,7,8-TCDD	16 mg/m^2	33 kilograms	11	8,700,000

MPA = mass per unit area
g/m^2 = grams per square meter
mg/m^2 = milligrams per square meter

A separate inventory estimate was created for the region above RM8, based solely on the extent of fine-grained sediments as estimated from interpreted side-scan sonar images (Aqua Survey, Inc., 2006) and the depth penetrated by geotechnical borings collected in June 2005. In this region of the river, fine-grained sediments represent only about one-third of the river bottom, as compared to more than 80 percent below RM8. The volume and mass estimates are obtained by multiplying the average MPA for RM6 to RM7 times the nominal thickness of fine-grained sediment determined from the geotechnical cores (*i.e.*, 4 feet). This observation suggests that the fine-grained sediments outside of RM0 to RM8 represent only about 6 percent of the volume of contaminated sediment below RM8. No estimate of the inventory in coarse-grained areas was created due to lack of appropriate data (Table 1-6).

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Table 1-6: Estimated Mass and Estimated Volume of Contaminated Fine-Grained Sediments in RM8 to RM15

Analyte	Average Extrapolated MPA	Extrapolated Mass	Average Extrapolated Depth (feet)	Extrapolated Volume of Sediment (cubic yards)
Mercury [a]	5.2 g/m^2	1.8 metric tons	4 [b]	550,000
2,3,7,8-TCDD	3.1 mg/m^2	1.1 kilograms	4 [b]	550,000

a: The inventory in the coarse-grained areas was not calculated.
b: Geotechnical and high resolution cores collected above RM8 indicate that the average depth of contamination is approximately 4 feet.

The contaminant inventories are not evenly distributed and vary along the length of the Lower Passaic River, with maximum values occurring near the areas encompassing RM1 to RM2, RM3 to RM4, and RM6 to RM7. However, the coring data that forms the basis for these inventories indicate a high degree of local spatial heterogeneity, suggesting that localized areas of relatively higher concentrations typically described as “hot spots” do not exist. Instead, “hot regions” of the river typically exist on the scale of a mile or more, nearly bank to bank in lateral extent. This conclusion does not, however, diminish the significance of potential historic and/or current point sources as the origin of contaminant inventory in the Lower Passaic River. Estuarine mechanisms are believed to quickly render contaminant concentration gradients indistinct on the scales examined here. It is possible that environmental sampling on a finer scale (on the order of less than a quarter mile) would identify localized gradients near prominent historical and/or current source areas.

Despite the observations of local spatial heterogeneity, the inventories of four contaminants (mercury, 2,3,7,8-TCDD, Total PCB, and Total DDT) examined in detail were shown to correlate, indicating that their inventories coincide in space and are consistent with the anticipated geochemical behavior of the compounds (Figure 1-10). Essentially, when a location has a locally high inventory of any one of these four contaminants, the other contaminants will also be concentrated at that location. It is anticipated that similar behavior will be exhibited by any hydrophobic compound in the Lower Passaic River. As noted previously, the variations in inventory are not believed to represent proximity to external point sources. Rather, variations in inventory may

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represent variations in the rate of deposition, with sites having higher rates of deposition generating larger contaminant inventories. Both the coring data and the bathymetric survey analyses performed for the Lower Passaic River suggest a high degree of spatial heterogeneity in inventory and deposition rate, supporting this premise (refer to Section 7.3.2 "Distribution of Inventory with River Mile").

1.3.5 IMPACTS OF THE LOWER PASSAIC RIVER ON NEWARK BAY

The Lower Passaic River is the main source of freshwater to Newark Bay and a major source of contaminants to the bay as well. Solids delivered from the Lower Passaic River to Newark Bay contain contaminant levels similar those found in surficial sediments of the Lower Passaic River. As a result, for several contaminants examined, the history of contamination observed in the Lower Passaic sediments is also observed in Newark Bay. For example, dated sediment cores for the Lower Passaic River (RM0.9 to RM7) are consistent with the observations by Bopp *et al*. (1991a and 1991b) and Chaky (2003) for Newark Bay, specifically that the major releases of 2,3,7,8-TCDD begin in the late 1940s to early 1950s and peak around the late 1950s to early 1960s. The history of Total DDT releases observed in the Lower Passaic River was also consistent with the observations for Newark Bay made by Bopp *et al*. The diagnostic ratio of 2,3,7,8-TCDD/Total TCDD of 0.7 to 0.8 can be used to trace Lower Passaic River 2,3,7,8-TCDD contamination throughout the Newark Bay complex. Recent surficial samples from Newark Bay suggest the mixing of high ratio, high 2,3,7,8,-TCDD concentration sediments from the Lower Passaic River with somewhat lower ratio, lower concentration sediments from the Arthur Kill and Kill van Kull, creating gradients in the ratio and the 2,3,7,8,-TCDD concentration across Newark Bay (Figure 1-11; refer to Section 7.2 "Nature and Extent of Contamination").

Using the historical observations of 2,3,7,8-TCDD concentrations and the 2,3,7,8-TCDD/Total TCDD ratio, it was possible to construct concurrent mass balances for solids, 2,3,7,8-TCDD and Total TCDD in Newark Bay, refining the solids balance analysis performed by Lowe *et al*. (2005). Based on the concurrent mass balances, the Lower Passaic River comprises approximately 10 percent of the total amount of solids

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accumulating in the Newark Bay and more than 80 percent of the 2,3,7,8-TCDD accumulating in the bay. No other single source delivers more than 10 percent of the total 2,3,7,8-TCDD load (refer to Section 7.4.1 "2,3,7,8-TCDD Mass Balance").

The solids mass balance framework constrained by the 2,3,7,8-TCDD mass balances provided a means to examine mercury in Newark Bay. The mercury mass balance shows that, despite the high mercury concentrations in the sediments of the Lower Passaic River, they are only responsible for approximately 20 percent of the total mercury load to Newark Bay. Moreover, the known sources of mercury to Newark Bay cannot account for the annual accumulation of mercury in the sediment beds of the bay. The "missing" mercury source represents the largest single "source" of mercury to Newark Bay, constituting approximately 35 percent of the annual mercury load. The next largest "source" is the solids delivered by the Kill van Kull, which represent about 30 percent of the annual mercury load to Newark Bay. Note that these percentages are subject to revision when more data for Newark Bay and the Kills become available. Another potential source of mercury is exchange of particles from the Hackensack River, although net transport of particles from this tributary is low (refer to Section 7.4.2 "Mercury Mass Balance).

The 2,3,7,8-TCDD mass balance documents the solids contribution that must arise specifically from the Lower Passaic River. Despite the observation that the Lower Passaic River has experienced a net deposition of sediment for a long period of time, the *circa* 1995 solids mass balance indicates that upriver solids are transported through the Lower Passaic River into Newark Bay and potentially beyond. Estimates suggest that 20 to 50 percent of the upriver solids are eventually transported out of the Lower Passaic River. The estimated *circa* 1995 total annual loads of mercury and 2,3,7,8-TCDD to Newark Bay are approximately 400 kilograms and 14 grams, respectively (refer to Section 7.4 "Initial Mass Balance for the Lower Passaic River and Newark Bay").

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1.4 DOCUMENT OVERVIEW

This document is divided into the following sections to describe the CSM.

Section 1.0, INTRODUCTION: explains the objectives of the CSM, provides a brief description of the Study, and summarizes the salient points of the CSM.

Section 2.0, HYDRO-GEOGRAPHIC SETTING: provides an overview of the larger Hudson-Raritan Estuary and the relationship of the Lower Passaic River with the estuary.

Section 3.0, RIVER SECTIONS: describes the division of the Lower Passaic River into three sections to capture important spatial variations in the river's character along its length. These sections are the Freshwater River Section, the Transitional River Section, and the Brackish River Section.

Section 4.0, BOUNDARY CONDITIONS: describes and defines the major boundary conditions (at Dundee Dam and at Newark Bay) of the Study Area as currently understood.

Section 5.0, SEDIMENT TRANSPORT: describes the solids accumulation and sedimentation rates occurring within the Lower Passaic River.

Section 6.0, SOURCE AREA ANALYSES: describes geochemical evaluations conducted to identify contaminant inputs and media.

Section 7.0, CONTAMINANT FATE AND TRANSPORT: describes the fate and transport for chemical classes over time and presents a current preliminary mass balance for selected compounds.

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Section 8.0, UNCERTAINTIES AND FUTURE UPDATES: describes the uncertainties in the CSM and provides a process for addressing data gaps and updating the CSM as the Study proceeds.

Section 9.0, ACRONYMS: lists and defines the acronyms used in this document.

Section 10.0, REFERENCES: lists the references used in this document.

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2.0 HYDRO-GEOGRAPHIC SETTING

The following section provides an overview of the Lower Passaic River and its relationship to the Hudson-Raritan Estuary (Figure 2-1). The purpose of this section is to discuss the basic processes occurring in the estuary and those processes that impact the Lower Passaic River. Technical details supporting an understanding of these processes are provided in the remainder of this document.

The Lower Passaic River and the Hudson-Raritan Estuary are a unique hydrologic system that encompasses a major metropolitan area in the United States, which includes two major cities: New York City, New York and Newark, New Jersey. Since the American industrial revolution, this area has experienced significant urbanization and industrial development, which has consequently impacted the surrounding ecosystems and waterways. Accidental and intentional discharges of industrial waste and municipal sewage have degraded sediment and water quality in the estuary. As contaminated solids and water enter the system, they are diluted and are disseminated throughout the estuary by the incoming and outgoing tides. These tides cause twice-daily mixing of surficial sediments through the resuspension and redeposition of solids. Over time, solids that originated from one end of the estuary (*e.g.*, the Lower Passaic River) are transported to other regions of the estuary (*e.g.*, the Hudson River). Understanding how the estuary operates (*i.e.*, how the Lower Passaic River connects to the estuary and how contaminated solids are transported through the system) is an important tool in discerning how to effectively remediate and restore the Lower Passaic River.

2.1 THE HUDSON-RARITAN ESTUARY

The Hudson-Raritan Estuary encompasses an area of over 42,000 square kilometers, making it one of the largest estuaries on the east coast of the United States. The estuary encompasses several major water bodies, such as the Hudson River, Raritan River, Upper and Lower New York Bay, as well as Newark Bay and its tributaries, including the Lower Passaic River (Figure 2-1). The Hudson River flows south through New York

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State and into Upper New York Bay, which is located between Manhattan Island and New Jersey. Lower New York Bay is bounded on the north by Staten Island and Brooklyn, New York and on the south by New Jersey. (New York Bay connects to the New York Bight and the Atlantic Ocean between Sandy Hook, New Jersey and Rockaway Point, New York.) Historically, Lower New York Bay has been the primary means of marine access to Upper New York Bay and more recently to Port Newark-Elizabeth Marine Terminal in Newark Bay.

Besides the Hudson River, the Hudson-Raritan Estuary is connected to the Lower Passaic River and the Hackensack River through Newark Bay. This bay (approximately 6 miles long and 1 mile wide) is formed by the confluence of these two rivers and is connected to Upper New York Bay by the Kill Van Kull and to Raritan Bay by the Arthur Kill. Newark Bay is enclosed on the west by the New Jersey cities of Newark and Elizabeth and on the east by Jersey City and Bayonne. It is bordered on the south by Staten Island, New York. The banks of Newark Bay are home to numerous active and abandoned commercial and industrial properties. These banks are extensively developed and consist of miles of paved shoreline. Although originally a shallow tidal estuary, deep navigational channels are maintained in Newark Bay to accommodate ocean-going container ship access to Port Newark-Elizabeth Marine Terminal along its western side. There are also federally authorized navigational channels extending from Newark Bay into the Lower Passaic River and the Hackensack River.

2.2 THE LOWER PASSAIC RIVER

2.2.1 RELATIONSHIP OF THE LOWER PASSAIC RIVER WITH THE ESTUARY

The Passaic River, located in northern New Jersey, is approximately 80 miles long. Dundee Dam (which was built in 1845) is located at RM17.4 and divides the Upper Passaic River from the Lower Passaic River (refer to Figure 1-1 and Section 1.2 "Development of Conceptual Site Model for the Study" for discussion on Study Area and river mile definition). The Upper Passaic River meanders across several geologic settings, draining urban, suburban, and rural portions of New Jersey. The Upper Passaic River watershed includes 16 Superfund sites and 2,216 New Jersey Known Contaminated

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Sites in New Jersey.[5] Soils and groundwater at these sites are contaminated with an array of chemicals. For example, Witco Chemical Corporation (Bergen, New Jersey) operated a facility that discharged wastewater in a network of unlined subsurface seepage pits. This discharge resulted in groundwater contaminated with petroleum hydrocarbons and soils contaminated with pesticides and heavy metals, including mercury, cadmium, and lead (USEPA, 2006a). Another site is Caldwell Trucking Corporation (Fairfield, New Jersey), which is contaminated with residential, commercial, and industrial septic waste. Soils were reported to contain Total PAH, Total PCB, and heavy metals (USEPA, 2006b).

The Lower Passaic River is divided into three river sections and is bounded by the Dundee Dam and Newark Bay (Figure 2-2). In general, freshwater and solids flow over the Dundee Dam, enter the Freshwater River Section and flow downriver to Newark Bay. Saline water from Newark Bay moves upriver beneath the freshwater flow. The mixing of fresh and saline waters creates the Brackish and Transitional River Sections (refer to Section 3.0 "River Sections"). Solids originating above the dam, solids eroding along the length of the river, and those solids discharged from other sites (including CSOs and tributaries) are continuously mixed by tidal action, resuspending and redepositing surface sediment (refer to Section 5.0 "Sediment Transport"). These processes cause the continuous re-working of fine-grained sediments on the surface of the river bed.

The Lower Passaic River flows through some of the most urbanized and industrialized areas of the state, including the city of Newark. According to the 2000 United States Census, approximately 2.8 million people reside in the New Jersey counties of Essex, Bergen, Hudson, and Passaic, which encompass the Study Area (United States Census Bureau, 2007). [Refer to Section 1.4 "Community Profile" in the *Community Involvement Plan* (Malcolm Pirnie, Inc., 2006b) for further discussion on population and

[5] Geographic information system data for the 2007 National Priority List were obtained from the USEPA at www.epa.gov/superfund/sites/phonefax/products.htm. Data for the list of 2005 Known Contaminated Sites were obtained from New Jersey Department of Environmental Protection (NJDEP) at www.state.nj.us/dep/gis/lists.html.

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demographics.] The Lower Passaic River, as described in the *Work Plan* (Section 1.2 "Site Background and History;" Malcolm Pirnie, Inc., 2005a), was heavily developed and became a focal point for the American industrial revolution in the 1800s. By the twentieth century, urban and industrial development surrounding the Lower Passaic River resulted in poor water quality, contaminated sediments, bans on fish and shellfish consumption, lost wetlands, and degraded habitats (USACE *et al*., 2003). The watershed of the Lower Passaic River includes 14 Superfund sites and 1,716 New Jersey Known Contaminated Sites. Location maps for these sites are provided in the *Work Plan*.

Several contaminants were identified in the *Pathways Analysis Report* (Battelle, 2005) as potentially posing risk to human health and the ecosystem of the Lower Passaic River. These contaminants represent the following chemical classes: polychlorinated dibenzodioxins/furans (PCDD/F), PCB, PAH, pesticides, metals, and semivolatile organic compounds (SVOC). Contamination in the Lower Passaic River, which is being addressed through the Study, originated from numerous inputs over the past 100 years or more. These inputs, including sources upriver of the Dundee Dam, may include point discharges such as spills, sewers, and wastewater outfalls and non-point discharges through runoff and groundwater migration (refer to Section 6.0 "Source Area Analyses"). External loads of particle-reactive contaminants from these discharges contaminated sediments prior to their deposition on the river bottom.

Maps provided in Figure 2-3 display available historical surface sediment concentrations measured over the past decade (1997 to 2006) for a select group of contaminants (cadmium, copper, lead, mercury, Total PCB, and 2,3,7,8-TCDD). Due to the combination of sediment bed erosion and surficial sediment mixing during each tidal cycle, highly contaminated surface sediments continue to be detected throughout the Lower Passaic River. In fact, while the original sources of some of these contaminants may have been discontinued, surface sediment contaminant concentrations have remained relatively constant over the last decade (1997 to 2006) over a distance of 8 miles (RM0 to RM8). Table 2-1 provides the average concentrations for the analytes displayed in Figure 2-3.

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Table 2-1: Average Surface Sediment Concentrations for Sampling Programs Occurring Between 1997 and 2006

Study Name [a]	Total PCB (µg/kg) [b]	2,3,7,8 TCDD (ng/kg) [b]	Cadmium (mg/kg) [b]	Copper (mg/kg) [b]	Mercury (mg/kg) [b]	Lead (mg/kg) [b]
1997 Outfall Sampling Program	1,200 ± 720 (N = 3)	NA	NA	NA	NA	NA
1999 Sediment Sampling Program	3,200 (N = 1)	810 (N = 1)	7.1 (N = 1)	290 (N = 1)	5.1 (N = 1)	530 (N = 1)
1999 Late Summer/Early Fall Environmental Sampling Program	1,600 ± 1,000 (N = 45)	490 ± 670 (N = 45)	4.2 ± 1.4 (N = 45)	190 ± 340 (N = 45)	2.8 ± 0.88 (N = 45)	260 ± 510 (N = 45)
1999/2000 Minish Park Monitoring Program	1,500 ± 550 (N = 8)	340 ± 100 (N = 8)	4.3 ± 0.74 (N = 8)	210 ± 360 (N = 8)	3.3 ± 1.6 (N = 8)	270 ± 37 (N = 8)
2000 Spring Environmental Sampling Program	2,100 ± 1,500 (N = 15)	310 ± 130 (N = 15)	3.9 ± 1.0 (N = 15)	190 ± 410 (N = 15)	2.3 ± 0.69 (N = 16)	240 ± 540 (N = 15)
2005-2006 USEPA Sampling Program (high resolution cores)	280 ± 60 (N = 3)	280 ± 80 (N = 3)	3.5 ± 7.3 (N = 3)	150 ± 30 (N = 3)	2.0 ± 0.5 (N = 3)	280 ± 150 (N = 3)
2005-2006 USEPA Sampling Program (low resolution cores)	560 ± 500 (N = 8)	3,100 ± 5,900 (N = 10)	7.2 ± 7.0 (N = 10)	200 ± 130 (N = 10)	470 ± 320 (N = 10)	290 ± 150 (N = 10)

a: Sample locations displayed in Figure 2-3. Sample represent either sediment grab samples or the top segment of a sediment core with depth of 0 foot to less than 1 foot (except for the 2006 low resolution coring program with core tops thicknesses ranging from 1.1 feet to 2.3 feet).
b: Arithmetic average and standard deviation (± 1 sigma) based on a normal distribution of sample size; nondetected values are incorporated into the average as half the reported detection limit. Results rounded to two significant figures, whenever possible.
NA = not available
µg/kg = micrograms per kilogram of sediment
mg/kg = milligrams per kilogram of sediment
ng/kg = nanograms per kilogram of sediment

Because of the relationship between the Lower Passaic River and the Hudson-Raritan Estuary, contaminated solids originating in the Lower Passaic River can be distributed throughout the estuary. This phenomenon is reported by Chaky (2003), who identified a tracer of Passaic-contaminated solids, specifically the unique ratio 2,3,7,8-TCDD/Total TCDD. In the Chaky model, Passaic-contaminated solids have a ratio value of approximately 0.7, representing one end member, while sewage, atmospheric, and Upper Hudson River sources have a ratio of 0.06 or less, representing “other” end members. The mixing of solids between these end members is observed throughout the Hudson-Raritan Estuary by the variation of this ratio [Figure 2-4; reprint from Chaky (2003)]. Other studies have reported 2,3,7,8-TCDD/Total TCDD ratios ranging from 0.5 to 0.8 for the Lower Passaic River, which are consistent with Chaky’s work (Figure 2-5). For

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example, surface sediment samples collected in 2005 exhibited a 2,3,7,8-TCDD/Total TCDD ratio of 0.7 ±0.1 [sample size (N) = 5]. This ratio is then observed to steadily decline across Newark Bay (north to south, towards the Goethals Bridge; refer to Figure 2-1) from a ratio of 0.6 to 0.3 at net depositional sites[6] located throughout the bay (Figure 2-6), tracing the mixing of Passaic-contaminated sediments with solids from other areas.

While the source of the Lower Passaic River 2,3,7,8-TCDD contamination has not been quantitatively identified, the primary candidate is the upland area at RM3.2 and the associated chemical manufacturing facility and Superfund sites (USEPA, 2007). It is unlikely that the source of 2,3,7,8-TCDD contamination to the Lower Passaic River originates above the Dundee Dam since the levels of 2,3,7,8-TCDD above the dam are approximately 40 times lower than those concentrations reported in the Lower Passaic River (Bopp *et al*., 1998; Figure 2-7). Further evidence supporting this hypothesis is provided in a surface sediment sample from a 1991 USEPA sediment core located approximately 0.3 miles above Dundee Dam (refer to Section 4.1.2 "Surficial Sediment Chemistry Above Dundee Dam" for other sediment chemistry results). This sample exhibited a ratio of 2,3,7,8-TCDD/Total TCDD equal to 0.1 with a 2,3,7,8-TCDD concentration on the order of 10 ng/kg.[7] For comparison, sediments deposited in the 1990s in Central Park, New York (which represent atmospheric fallout) had a 2,3,7,8-TCDD concentration of 11 ng/kg and a 2,3,7,8-TCDD/Total TCDD ratio of 0.06 (Chaky, 2003). Note that the solids transport over the Dundee Dam represents much more than simple atmospheric fallout. Although the 2,3,7,8-TCDD concentration is comparable to

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[6] Depositional sites are defined as surficial sediment (0-1 inch) having detectable beryllium-7 concentrations that are greater than 0.5 picocuries per gram of sediment (pCi/g).

[7] At the time of collection, PCDD/F analytical techniques were not as sensitive as they are currently. The 2,3,7,8-TCDD/Total TCDD ratio for the 1991 surficial material was approximately 0.1, greater than the sewage, atmospheric fallout, and Upper Hudson River sources of approximately 0.06. However, the proximity of the reported values to their detection limits suggests that this ratio is not well known and is probably not statistically different from the sewage end member ratio. Similarly, the high detection limits reported deeper in the sediment core restricted the quantification of 2,3,7,8-TCDD; hence, no ratio could be calculated for these deeper sediments. Nonetheless, the very low concentrations in the 1991 core samples strongly support the absence of a significant source of 2,3,7,8-TCDD above the Dundee Dam.

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atmospheric fallout, atmospherically derived solids are a very small fraction of the total solids load over the dam. The magnitude of the 2,3,7,8-TCDD concentration implies the occurrence of loads much greater than atmospheric fallout. Nonetheless, the low ratio and low concentration observed above the Dundee Dam relative to the values observed in the Lower Passaic River rule out the Upper Passaic River as a significant load of 2,3,7,8-TCDD to the Lower Passaic River (refer to Section 6.0 "Source Area Analyses" and Section 7.0 "Contaminant Fate and Transport").

2.2.2 DREDGING HISTORY IN THE LOWER PASSAIC RIVER

An important component of the development and urbanization of the Lower Passaic River was the channelization of the river, which permitted commercial vessels easier access into the city of Newark. Several large dredging projects were undertaken at the beginning of the twentieth century to create a ship channel to RM15. The USACE is responsible for delineating and maintaining navigation channels in the Lower Passaic River. Table 2-2 provides a summary of the federally mandated channel depths and widths as wells the years that the river was dredged.

Table 2-2: Lower Passaic River Authorized Dimensions of the Federal Navigational Channel and Dredging Years

River Mile [a]	Channel Depth (feet) [b, c]	Channel Width (feet)	Years Dredged
RM -0.2 to RM2.2	30	300	1907, 1911, 1912, and 1930 (USEPA, 1995) 1940, 1946, 1957, 1965, and 1971 (IT Corporation, 1986) 1884, 1917, 1921, 1922, 1932, 1933, 1941, 1946, 1951, 1953, 1957, 1962, 1965, 1971, 1972, 1977, and 1983 (Iannuzzi *et a*l., 2002)
RM2.2 to RM4.3	20	300	1949 (USEPA, 1995) 1884, 1916, 1921, and 1937 (Iannuzzi *et al*. 2002)
RM4.3 to RM6.9	20 (only constructed to 16 feet)	300	1949, 1950 (USEPA, 1995) 1913, 1919, 1933, and 1950 (Iannuzzi *et al*. 2002)
RM6.9 to RM7.9	16	200	1950 (USEPA, 1995) 1874, 1876, 1878, 1879, 1883, 1899, 1906, 1915, 1916, 1927, 1929, 1930, 1931, 1932, 1934, 1938, 1939, 1940, 1945, 1949, and 1956 (Iannuzzi *et al*. 2002)
RM7.9 to RM15.2	10	200	Record of dredge maintenance not available

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Table 2-2 footnotes (continued)

a: River miles are referenced to the Study-defined river mile scale (refer to Section 1.2 "Development of the Conceptual Site Model for the Study"). These river miles are offset from the scale that is used by the USACE by approximately 0.2 miles.

b: Obtained from the "Report of Channel Conditions 100 to 400 feet Wide" (USACE, 2002) and the USACE map "Newark Bay, Hackensack & Passaic Rivers, N.J. (Passaic River)" dated September 30, 1986.

c: Channel depth is relative to MLW.

The Federal Project Limits to maintain a channel that is 30 feet deep (relative to MLW) and 300 feet wide from RM-0.2 to RM2.2 were originally adopted in 1907. These dimensions were modified in 1911, 1912, and 1930 (USEPA, 1995). The channel was last dredged in 1983 to the Project Depth of 30 feet. Other dredging events are listed in Table 2-2.

The Federal Project Limits from approximately RM2.2 to RM4.3 are a 300-foot wide channel with a Project Depth of 20 feet MLW. Dredging was performed in 1949 to a Project Depth of 20 feet (USEPA, 1995). Other dredging events are listed in Table 2-2.

The USACE has designated the Federal Project Limits from approximately RM4.3 to RM6.9 as a 300-foot wide channel with a Project Depth of 20 feet MLW. Dredging was performed in 1949, but only to a depth of 16 feet MLW (USEPA, 1995).

The USACE has delineated the Federal Project Limits from approximately RM6.9 to RM7.9 as a 200-foot wide channel with a project depth of 16 feet MLW and the Federal Project Limits from approximately RM7.9 to RM15.2 as a 200-foot wide channel with a Project Depth of 10 feet MLW. Dredging in the navigable portion of RM6.9 to RM7.9 was performed in 1950 to a Project Depth of 16 feet MLW (USEPA, 1995). Other dredging events are listed in Table 2-2.

The volumes of sediments removed each year from dredging was recorded by the USACE (USACE, 1917; USACE, 1916; USACE, 1915; USACE, 1913; USACE, 1907; USACE, 1900; USACE, 1884; USACE, 1880) and summarized by Iannuzzi *et al*. (2002). This dredging data is presented in Figure 2-8 to show the total volume of sediment

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removed by dredging in 6-year increments. The figure also highlights the portion of the dredged volume removed from the Lower Passaic River below RM2. Over time, the total volume of sediments removed by dredging has declined over time. Since the 1940s, the vast majority of dredging has occurred below RM2. Based on USACE records (Figure 2-8), it does not appear that this channel was regularly maintained, permitting a large volume of recent sediment to accumulate over time.

Since the 1940s, the river has delivered sufficient material to build up many feet of recent deposition, yielding an average rate of deposition substantially greater than what would normally occur. The coincidence of chemical disposal in the river along with the construction and subsequent limited maintenance of the navigation channel created an ideal situation for the accumulation of thick beds of contaminated sediments in the Lower Passaic River.

Perhaps the most important concern to current contamination is that sufficient solids deposition has occurred in the Lower Passaic River and is now affecting channel flow. The magnitude of the recent deposition is illustrated in Figure 2-9, which shows the current depth of the river channel as well as the original dredged elevations as reported in USACE records. For the region below RM8, the river has accumulated thick sediment beds, over 15 feet or more in some areas, while substantive channel deposition occurred above RM8 (approximately 10 feet). This evidence is consistent with the observations of recent deposition rates and sediment texture, which change markedly across RM8. As noted in Table 2-2, the constructed channel depth was substantially shallower above RM8 (10 feet) than below RM8 (16 feet or more). Historical dredging greatly enhanced the rate of sediment accumulation in the dredged areas because of the deeper water depths that existed after dredging. Consequently, historical deposition rates were probably higher than those currently observed as the navigation channel has not been maintained.

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3.0 RIVER SECTIONS

For the purposes of the Study, the Lower Passaic River has been divided into three river sections based on their relationship to the typical upriver extent of the salt front, which forms as a result of freshwater flowing downriver from Dundee Dam and the saline waters flowing upriver from Newark Bay (refer to Section 4.0 "Boundary Conditions"). The following discussion defines these river sections and provides a preliminary qualitative discussion of related physical features, such as sediment texture, sedimentation rates, and shoreline characterization.

3.1 SALT FRONT DEFINITION

The farthest upriver extent of saline water in an estuary is referred to as the salt front. This location occurs where "sea salt" is first easily detected in the river and defined as a measured salinity of 0.5 parts per thousand, or "per mil" (‰) (USEPA, 2003b). The location of the salt front varies in response to the volume of freshwater flow as well as the twice-daily tidal oscillations. In the Lower Passaic River, the salt front typically moves several miles upriver and downriver with each tidal cycle. Higher freshwater flow events can even push the salt front completely out of the Lower Passaic River while relatively low freshwater flows will allow the salt front to move farther upriver.

The typical range of salinity conditions is used to define three river sections. The Freshwater River Section (RM10 to RM17.4) is the region just above the salt front at its typical farthest upriver location [*i.e.*, this section remains freshwater (less than 0.5 ‰) under all but the lowest flow conditions]. The Transitional River Section (RM6 to RM10) is characterized by the most frequent location of the salt front with water conditions varying from slightly brackish (or oligohaline with salinity values ranging from 0.5 ‰ to 5 ‰) to moderately brackish (or mesohaline with salinity values ranging from 5 ‰ to 18 ‰). The Brackish River Section (RM0 to RM6) lies below the typical farthest downriver location of the salt front. Hence, this section is nearly always mesohaline or polyhaline (salinity values ranging from 18 ‰ to 32 ‰).

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3.2 SALINITY DATA AVAILABLE TO DEFINE THE RIVER SECTIONS

Salinity data were collected between July 2004 and September 2005 from nine mooring stations, which were located between RM1 and RM10 (Table 3-1).[8] Since river conditions change between seasons, the seasonal position of the salt front was discerned using these data over the period of record. The range of the salt front position was then used to define the river sections, as described below.

Table 3-1: Available Salinity Data

River Mile	Buoy Identification	Date of Sample Collection	Owner of Buoy
1	M1	11/20/04 to 1/25/05	Rutgers University [a]
3.1	M2a	11/20/04 to 1/25/05	Rutgers University
3.1	M2b	11/20/04 to 1/25/05	Rutgers University
4.1	M3	11/20/04 to 1/25/05	Rutgers University
5.3	M4	11/20/04 to 1/25/05	Rutgers University
6.7	M5	7/8/04 to 9/10/04 11/20/04 to 1/25/05	Rutgers University
8	M6	7/8/04 to 9/10/05 11/20/04 to 1/25/05	Rutgers University
8.5	3	12/15/04 to 2/21/05	Malcolm Pirnie, Inc. [b]
10	2	12/15/04 to 9/30/05	Malcolm Pirnie, Inc.
Little Falls, New Jersey	USGS Gauge	7/30/62 to 8/19/04	USGS [c]

a: Rutgers University mooring data available at marine.rutgers.edu/cool/passaic
b: Malcolm Pirnie, Inc. mooring data available at www.ourpassaic.org
c: USGS gauging data available at http://waterdata.usgs.gov/nj/nwis/uv/?site_no=01389500&amp. (Site last accessed February 2, 2007).
USGS = United States Geological Survey

Winter Conditions: Downriver of RM5.3, the salinity data indicate that river conditions were mesohaline or polyhaline (Figure 3-1a and 3-1b), representing brackish waters during December 2004 to January 2005. During the same time period, the upriver extent of the salt front ranged between RM5.3 and a point below RM6.7. This characterization is indicated by the presence of oligohaline conditions at RM5.3 and freshwater conditions at RM6.7 (Figure 3-1c). These observations are consistent with data collected during the winter months upriver of RM8.5. These data indicate that, during the winter, salinities at the RM8.5 and RM10 stations were less than 0.5 ‰ (Figure 3-1d). The presence of freshwater at these two sampling locations indicates that the upriver reach of the salt front

[8] Salinity data from fall 2004 to spring 2005 are plotted in Figure 3-1. Salinity data were not continuously measured at all buoys, and gaps exist in the record.

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was consistently below RM8.5 during these winter months. Furthermore, the salinity levels measured at RM8.5 and RM10 are similar in magnitude to readings of less than 0.4 ‰ observed during the same period at the USGS gauge at Little Falls, New Jersey (Figure 2-1), located upriver of the Dundee Dam (Figure 3-1e).

Summer Conditions: In contrast, during the summer months, the salt front was observed farther upriver, reflecting the lower freshwater flow conditions typical of that season. For example, data collected between July 8, 2004 and September 10, 2004 at RM8 show that river salinity was consistently at least oligohaline and was regularly mesohaline (Figure 3-1f; upper right-hand graph). These data indicate that the upriver extent of the salt front was above RM8. Salinity data at RM10 (presented in Figure 3-1d) show temporal trends from fall 2004 to summer 2005 (Figure 3-1g). Similar to the station at RM8, oligohaline conditions (approximately 4 ‰) were detected during the summer months at RM10. No salinity data are available upriver of RM10 precluding a precise determination of the extreme range of the salt front.

Hence, the boundaries of the Transitional River Section have been tentatively defined as RM6 to RM10. The upriver boundary is intended to encompass the seasonal variation in the upriver range of the salt front while recognizing the limitations in the available data. The Brackish and Freshwater River Sections are then defined as occurring between RM0 and RM6 and between RM10 and RM17.4, respectively.

3.3 DESCRIPTION OF RIVER SECTIONS

The following section provides a preliminary qualitative definition for the Freshwater River Section, Transitional River Section, and the Brackish River Section (Figure 2-2).

Freshwater River Section (RM10 to RM17.4) represents the portion of the Lower Passaic River where the water conditions are defined as “almost always” fresh, or where salinity values are less than 0.5 ‰. At high tide, the salt front rarely penetrates this section; however, the water elevations in this section are tidally influenced. Water and solids are preferentially transported from the Freshwater Section to the Transitional Section, except

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perhaps during dry periods when the base flow of the river declines or during extreme tidal events. Additional water and solids delivery occurs at the confluence of the Saddle River (RM15.6). Sediments in this river section tend to be characterized by coarse-grained material. Fine-grained sediment beds are scarce (refer to sediment texture maps provided in Attachment A) and are relatively thin due to low sedimentation rates. The Freshwater River Section supports a freshwater ecosystem (Aqua Survey, Inc., 2005; Germano & Associates, Inc., 2005; Earth Tech, Inc. and Malcolm Pirnie, Inc., 2005a; Earth Tech, Inc. and Malcolm Pirnie, Inc., 2005b). For example, the 2005 benthic invertebrate community survey[9] showed that a mixture of organisms that typically reside in oligohaline and freshwater environments was observed from RM7 to RM15.5 (Germano & Associates, Inc., 2005). This freshwater ecosystem provides habitat for freshwater aquatic plants (vascular and algae), macroinvertebrates, fish, and wildlife species that forage on these prey types.

Transitional River Section (RM6 to RM 10) represents the portion of the Lower Passaic River between the Freshwater River Section and the Brackish River Section, where the salt front ranges under typical flow and tidal conditions. Here, water conditions vary continuously from oligohaline to mesohaline due to the salt front migration. This river section is continuously influenced by saltwater intrusion and mixing, resulting in rapidly fluctuating water chemistry as well as flocculation and settling of dissolved organic matter and particulates. Water and solids are transported between the Transitional Section and Brackish Section primarily due to tidal exchange. Additional water and solids delivery occurs at the confluences of Second River (RM8.1) and Third River (RM11.3). Sediment characteristics in this section transition from relatively thin, coarse-grained sediment beds (approximately 4 feet thick) observed near the boundary with the Freshwater River Section to relatively thick, fine-grained sediment beds observed (approximately 14 feet thick) near the boundary with the Brackish River Section (Aqua Survey, Inc., 2006). A distinct boundary in sediment texture is apparent in this section

[9] The benthic invertebrate community survey was conducted in June 2005 from RM0 to RM15.5. Salinity data indicate that oligohaline conditions existed at RM10.

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near RM8 (Figure 3-2; refer to Attachment A for the complete sediment texture maps). Based on side-scan sonar images (Aqua Survey, Inc., 2006), the fine-grained surficial sediments, which are dominant between RM0 and RM8, appear to end at this point. The habitat in the Transitional Section supports a mixture of freshwater and salt-tolerant species (Aqua Survey, Inc., 2005; Germano & Associates, Inc., 2005; Earth Tech, Inc. and Malcolm Pirnie, Inc., 2005a; Earth Tech, Inc. and Malcolm Pirnie, Inc., 2005b).

Brackish River Section (RM0 to RM6) represents the portion of the Lower Passaic River closest to its confluence with Newark Bay, where water conditions are defined as "almost always" mesohaline or polyhaline. The salt front is rarely found in the Brackish River Section, except under high freshwater flows or abnormally low tides (due to local storms). Water and solids are transported between the Transitional River Section, Brackish River Section, and Newark Bay primarily as a result of tidal exchange. Historical dredging of the Lower Passaic River has created deep channels in this river section (authorized depth of 20 to 30 feet relative to MLW), and the lack of recent maintenance dredging has resulted in the accumulation of thick sediment beds in these channels, which are dominated by fine-grained material. The Brackish River Section supports a salt-tolerant ecosystem (Aqua Survey, Inc., 2005; Germano & Associates, Inc., 2005; Earth Tech, Inc. and Malcolm Pirnie, Inc., 2005a; Earth Tech, Inc. and Malcolm Pirnie, Inc., 2005b). For example, the 2005 benthic invertebrate community survey showed that salt-tolerant benthic organisms, which typically reside in polyhaline environments, were predominantly located from RM0 to RM1, and a mixture of organisms that typically reside in mesohaline and oligohaline environments was observed from RM1 to RM7 (Germano & Associates, Inc., 2005). This environment provides habitat for estuarine aquatic plants (vascular and algae), macroinvertebrates, fish, and wildlife species that forage on these prey types.

3.4 SHORELINE CHARACTERIZATION OF THE RIVER SECTIONS

The river sections were then described in terms of their shoreline conditions and surrounding habitats. This description supplements the shoreline characterization provided in the *Work Plan* (Malcolm Pirnie, Inc., 2005a), which provides information on

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the navigational channel, bridge structures, industrial facilities located along the river, and other features. The shoreline characterization provided here was accomplished using photographs collected during field reconnaissance activities [refer to the *Restoration Opportunities Report* (Earth Tech, Inc. and Malcolm Pirnie, Inc., 2006)]. Selected photographs from the reconnaissance are presented in Figures 3-3a through 3-3e.

The shoreline and land use conditions vary considerably among the Brackish, Transitional, and Freshwater River Sections. The Brackish River Section is characterized by industrial and urban lands, typically with hardened shorelines comprised of bulkheads or riprap (Figure 3-3a and Figure 3-3b). The Transitional River Section is largely surrounded by residential communities; accordingly, the river shoreline in this area more commonly features natural riverine vegetation (Figure 3-3c). The Freshwater River Section is the least industrialized of the three river sections and features the lowest density of development. The Freshwater River Section is also characterized by shorelines with natural vegetation communities, often with overhanging tree canopies (Figure 3-3d). Traveling upriver in the Freshwater River Section, the river gradually transitions from a wide, slowly-flowing river to a narrower and more swiftly-flowing stream above RM15 with a substrate composed of rock and coarse gravel (Figure 3-3e).

Further discussion on the available biological and ecological data for the Lower Passaic River is provided in Section 3.0 "Field Task Status" of the *Field Sampling Plan, Volume 2* (Malcolm Pirnie, Inc., 2006c).

3.5 UPRIVER EXTENT OF THE SALT FRONT

Based on the available salinity data (Figure 3-1d and Figure 3-1g), the salt front appears to extend seasonally upriver of RM10. An evaluation of bathymetric data, sedimentation rates, and sediment texture data was completed in an attempt to estimate the furthest upriver extent of the salt front and to examine other physical features of the Lower Passaic River. Note that the boundaries of the Transitional River Sections are roughly defined by salinity, and the following discussion is presented only to provide some insight on the farthest upriver extent of the salt front.

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3.5.1 EVALUATION OF CROSS-SECTIONAL AREA AND SEDIMENT TEXTURE DATA

For most rivers, the cross-sectional area increases downriver. As the river channel widens, river velocities will decrease and cause the river bed sediments to grade from coarser to finer in the downriver direction. [For this discussion, the cross-sectional area refers to the water-filled area of the river channel when water level is equal to zero feet elevation at National Geodetic Vertical Datum of 1929 (NGVD29).] As expected, the cross-sectional area of the Lower Passaic River increases downriver from RM16.5 (closest data to the Dundee Dam) to RM0.5 (near the mouth of the river).[10] A plot of cross-sectional area versus river mile shows a 40 fold increase moving downriver (Figure 3-4). Consequently, for this evaluation, cross-sectional area is considered an adequate surrogate for long-term average velocities.

Like most estuarine rivers, fine-grained sediments are expected to dominate the lower stretches of a river where water velocities are the slowest and tides continuously cause the resuspension and redeposition of fine-grained sediments. To illustrate this phenomenon in the Lower Passaic River, the cross-sectional areas presented in Figure 3-4 were compared to sediment texture characterization to categorize the grain size distribution at the sediment surface.[11] For each half-mile stretch of the Lower Passaic River, the river bottom area was characterized by the percent spatial coverage of fine-grained sediments (classified as silt and silt/fine sand from interpretation of side-scan sonar images) and coarse-grained sediments (classified as gravel/coarse sand and rock/coarse gravel). Figure 3-5 exhibits the percentage of fine-grained sediment and percentage of coarse-grained sediment per half-mile stretch versus the corresponding

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[10] Cross-sectional areas (unit of square feet) were calculated using the 2004 bathymetry surveyed by Rogers Surveying, Inc. for the USACE. While the dataset extends from RM0 to RM17.4, cross-sectional areas above RM16.5 were not examined since no accompanying sediment texture data were available for comparison.

[11] Sediment texture data were interpreted from side-scan sonar data (Aqua Survey, Inc., 2006), which provide a broad overview of surficial sediment texture. This survey did not resolve local sediment texture variations. Sediment texture data extend from RM0 to RM16.5; the survey was conducted from April to June 2005 (refer to Attachment A for sediment texture maps).

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cross-sectional area calculated in the middle of that half-mile stretch (*e.g.*, sediment texture from RM1.75 to RM2.25 versus cross-sectional area at RM2.0).

A striking feature in this plot is the distinct transition from coarse-grained to fine-grained sediments between RM14 and RM8 as the cross-sectional area increases from 2,500 to 3,500 square feet (Figure 3-5). Downriver of RM8, the surficial sediment is dominated by fine-grained sediments with silt and fine sand covering more than 80 percent of the surveyed area. Upriver of RM14, the surficial sediment is dominated by coarse-grained sediment with 100 percent coverage between RM15 and RM16. This coarse-grained surficial sediment extends to the Dundee Dam (RM17.4) based on field observations of the river (Earth Tech, Inc. and Malcolm Pirnie, Inc., 2005b). This analysis suggests that for cross-sectional areas greater than about 3,500 square feet (marked as a dotted line in Figure 3-4 and Figure 3-5), the river bottom is greater than 80 percent fine-grained sediments. For cross-sectional areas less than this value, the river bottom can vary but tends to be primarily coarse-grained. Notably, cross-sectional areas below RM8 are nearly always greater than 3,500 square feet, correlating with the high percentage of fine-grained sediment in this region. Above RM8, cross-sectional areas tend to be less than 3,500 square feet and correspondingly high in coarse-grained sediment areas.

3.5.2 EVALUATION OF SEDIMENTATION RATES AND SEDIMENT TEXTURE DATA

As part of the *Draft Geochemical Evaluation (Step 2)* (Malcolm Pirnie, Inc., 2006a), sedimentation rates were calculated by comparing the June 1989 Topo Metric, Inc. bathymetric survey to the November 2004 Rogers Surveying, Inc. bathymetric survey. To further investigate the deposition of fine-grained sediments in the Transitional and Freshwater River Sections, these sedimentation rates were compared to sediment texture. Two significant, net non-depositional areas[12] containing fine-grained sediments were

[12] For the purposes of this evaluation, the term "non-depositional" applies to areas where the sedimentation rate is equal to or less than 0 inch/year. Since this evaluation is limited to a single bathymetric comparison (1989 to 2004), it is unclear whether these net non-depositional areas experience continual loss of sediments over time (hence classifying them as net erosional) or if they experience both a loss and gain of solids over time, yielding a bathymetrically neutral area.

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identified by this process. These fine-grained, net non-depositional areas mainly occur between RM6 and RM8 and between RM13 and RM14 (Figure 3-6). The presence of fine-grained, net non-depositional areas between RM6 and RM8 is consistent with previously identified net non-depositional areas located throughout the Brackish River Section (refer to Section 5.3 "Depositional Environment in the Lower Passaic River").

The presence of fine-grained, net non-depositional areas between RM13 and RM14 may represent the extreme upriver reach of the salt front. In this stretch of the river, freshwater is flowing downriver with additional freshwater contributions from the Saddle River, approximately one-tenth the Upper Passaic River flow over Dundee Dam. The river is relatively shallow between Dundee Dam and RM15; the river bottom elevation drops about 10 feet at RM15 and drops another 5 feet at RM13 (Figure 3-7). These changes in river bottom elevation most likely represent the results of historical dredging since the authorized federal navigation channel extends to RM15.

An additional feature of the river is a tight, S-shaped meander that occurs between RM15 and RM14. The high energy of the river as it flows between the Dundee Dam and RM14 results in coarse-grained sediment dominating the river bottom. Sand and silt occur downriver of RM14. Limited observations suggest that they occur in thin beds of fine-grained sediments. Salinity data indicate that the salt front seasonally extends beyond RM10. It is likely that tidal mixing extends at least occasionally to RM13 based on sediment core evidence collected at RM12.6 and elsewhere in the river (refer to Section 6.2 "Sediment: Potential Source Area and Contaminated Medium" for further discussion on this sediment core). Based on the physical features of the river and geochemical observations, tidal mixing of surface sediments likely extends at least from RM0 to RM14.

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4.0 BOUNDARY CONDITIONS

For purposes of the Study, the CSM has two primary boundaries: the Dundee Dam, where freshwater and solids flow into the Freshwater River Section, and Newark Bay, where the brackish bay water enters the Brackish and Transitional River Sections during each tidal cycle (Figure 2-2). Other boundaries such as tributaries, combined sewer overflows (CSOs), and storm water outfalls also contribute water, solids load, and contaminant mass.

4.1 DUNDEE DAM BOUNDARY CONDITION

The Dundee Dam represents the upper boundary of the Lower Passaic River. The Upper Passaic River watershed represents a point source with solids and water crossing over the dam into the Study Area. The dam, which was built in 1845, is located at RM17.4 between Garfield and Clifton, New Jersey. The Dundee Dam is the effective upriver limit of the tide for the Lower Passaic River under all known conditions, and the water flowing over the dam is made up entirely of freshwater from the Upper Passaic River.

4.1.1 RIVER FLOW AT DUNDEE DAM

Flow over Dundee Dam is estimated at 1,160 cubic feet per second (cfs). This flow is derived from the USGS gauging station located 12 miles upriver of the dam at Little Falls, New Jersey where the flow over the last 50 years averages to 1,050 cfs. The flow from the Little Falls gauge must be adjusted by approximately 10 percent to account for the additional watershed area between Little Falls and the Dundee Dam.[13]

River flow within the Lower Passaic River can be further characterized by examining the variation in flow, such as high and low flow events, and by observing whether the range

[13] River flow at Dundee Dam is based on a July 18, 2005 electronic message from Emad Sidhom (Senior Project Engineer at United Water and the New Jersey District Water Supply Commission) to F. Chris Purkiss (Malcolm Pirnie, Inc.). Mr. Sidhom indicated that the flow measurements at Dundee Dam were approximately 10 percent greater than the flows measured at the Little Falls gauging station.

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in flow has changed over time. River flow statistics for the Little Falls gauging station are presented in Table 4-1, which provides flow data for an 11-year time period from 1995 to 2005 along with data for the past 50 years.

Table 4-1: Flow Statistics for the Little Falls USGS Gauging Station

Year [a]	Annual Average River Flow (cfs) [b]	Annual Peak River Flow (cfs) [b]
1995	483	2,850
1996	1,420	9,270
1997	1,400	8,090
1998	1,180	8,840
1999	679	11,300
2000	950	3,140
2001	822	4,450
2002	199	2,020
2003	1,530	6,840
2004	1,510	7,210
2005	1,210	11,700
Average from 1995 to 2005	1,030	6,880
Average from 1956 to 2005	1,050	7,180
Minimum from 1956 to 2005	199	2,020
Maximum from 1956 to 2005	2,010	18,000

a: "Year" is defined as a "water year," which extends from October 1 through September 30. For example, the 1995 water year extends from October 1, 1994 through September 30, 1995.
b: Data source: USGS National Water Information System (http://waterdata.usgs.gov/nwis/dv/?referred_module=sw. Site last accessed February 2, 2007). The site is 01389500 Passaic River (Little Falls, New Jersey).

Between 1995 and 2005, the annual average river flow and annual peak river flow varied by a factor of 7 and 6, respectively, indicating that the Lower Passaic River experiences significant variations in flow (and thus velocity), which will result in variations in sediment mobilization and deposition. However, the average annual river flow and annual peak flow between 1995 and 2005 are comparable to the average flow and peak flow over the past 50 years (Table 4-1). During the time period of 1995 to 2005, the Lower Passaic River experienced both relatively wet and dry years. For example, the water year 1995 (*i.e.*, October 1, 1994 through September 30, 1995) was relatively dry, receiving approximately half the average annual river flow observed over the past 50 years. Meanwhile, the lowest river flow for the past 50 year was recorded during the water year 2002. Conversely, 2003 was a relatively wet water year compared to the average annual flow for the 50-year record, but not as wet as the recorded maximum

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average river flow for the past 50 years. The water year 1999 experienced less than average annual flow but had above average peak river flow (11,300 cfs), which is likely associated with Tropical Storm Floyd. However, this peak flow event was not as large as the maximum peak flow event of 18,000 cfs that occurred in April 1984 during the Passaic River flood. Hence, during the time period of 1995 to 2005, flows recorded on the Lower Passaic River were similar to those flows experienced on the river over the past 50 years.

4.1.2 SURFICIAL SEDIMENT CHEMISTRY ABOVE DUNDEE DAM

Three historical studies are available to characterize the surficial sediment chemistry above Dundee Dam.[14] Bopp *et al*. (1991a, 1991b, and 2006) collected a high resolution sediment core[15] in 1986. Surficial sediments from this datable core represent solids deposited during the time period of 1985-1986. Among the available historical data, this Bopp *et al*. core represents the most temporally constrained sediment sample above the Dundee Dam and provides information on contaminant loads over the Dundee Dam in 1985-1986. These sediments were analyzed for four metals (lead, copper, cadmium, and mercury) and three organic compounds [Total PCB, 2,3,7,8-TCDD, and DDD (a metabolite of DDT)].

In 1990, sediment grab samples (0 to 6 inches) above the Dundee Dam were collected during a USEPA-sponsored investigation; among these samples, three were collected within 1.5 miles upriver of the Dundee Dam. Since grab samples are not temporally constrained, the time period represented by these samples is unknown. As discussed in Section 2.2.1 "Relationship of the Lower Passaic River with the Estuary," a sediment core was collected 0.3 miles above Dundee Dam during a USEPA-sponsored investigation in 1991. However, the core was not datable, so temporal constraints on the

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[14] Data are available from the articles referenced and www.ourpassaic.org.

[15] A high resolution sediment core is a finely-segmented core collected from a depositional area in the river. If continuously depositional, the core segments can be dated through comparison of radioisotope measurements to known radiochemical events and trends. When analyzed for specific contaminants, the individual dated segments can be used to infer contaminant loads historically borne by the river.

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surficial sediments (0 to 2 inches as defined in this study) were not available. Because this sample contains the only available data for calculating the 2,3,7,8-TCDD/Total TCDD ratio, an alternative method to estimate the date of the core top was necessary. The core top sediments were cesium-137 bearing, indicating that the sediments were deposited post-1954. The Total PCB concentration of 3,900 µg/kg measured in the USEPA 1991 sediment core top lies between the concentrations of 480 µg/kg and 15,000 µg/kg reported for the Bopp *et al*. core for sediments that were deposited in 1985-1986 and 1963, respectively (Bopp *et al*., 1991a). This observation suggests that the 1991 core top represents sediments from the 1960s or 1970s.

Sediment chemistry results for these historical samples are provided in Table 4-2. While the USEPA cores were analyzed for a suite of analytes, only contaminants corresponding to those contaminants reported by Bopp *et al*. plus Total PAH are listed for comparison. (The ratio of 2,3,7,8-TCDD/Total TCDD was calculated when detectable concentrations of both analytes were available.)

Table 4-2: Available Historical Surficial Sediment Data Above Dundee Dam

Analytes (units) [a]	Bopp *et al*. Sediment Core Top (1985-1986 time horizon)[b]	USEPA 1990 Sediment Grabs [c]	USEPA 1991 Sediment Core Top (not datable)
Cadmium (mg/kg)	4.2	3.4 ±1.8 (N = 3)	3.9
Copper (mg/kg)	120	49 ±31 (N = 3)	110
Lead (mg/kg)	307	360 ±480 (N = 3)	230
Mercury (mg/kg)	1.8	0.34 ±0.16 (N = 3)	1.4
Total PCB (µg/kg)	480	350 ±370 (N = 3)	3,900
DDD (µg/kg) [d]	58	19 ±15 (N = 3)	8.3
Total PAH (mg/kg)	Not analyzed	13 ±4.7 (N = 2)	24
2,3,7,8-TCDD (ng/kg)	20	10 ±15 (N = 3)	27
Ratio of 2,3,7,8-TCDD/Total TCDD	Not analyzed	Not calculated [e]	0.1

a: Whenever possible, Total PCB represents the sum of Aroclors, and Total PAH represents the sum of 16 PAH compounds. Nondetected concentrations were incorporated into the summation as zero.
b: Reported literature values (Bopp *et al*., 2006; Bopp *et al*., 1991a; Bopp *et al*., 1991b), representing 1985-1986 surficial sediment concentraitons.
c: Arithmetic average and standard deviation (± 1 sigma) based on a normal distribution of sample size; nondetected values are incorporated into the average as half the reported detection limit. Results rounded to two significant figures, whenever possible.
d: DDD concentrations represent the 4,4'-DDD isomer only.
e: Since Total TCDD concentrations were reported as non-detected due to a high detection limits in the samples, no 2,3,7,8-TCDD/Total TCDD ratio could be calculated for these sediments.

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Based on the available historical data, the surficial sediments above Dundee Dam are contaminated relative to the NJDEP sediment guidelines (NJDEP, 1998). Consequently, solids that are transported over the Dundee Dam to the Lower Passaic River are also contaminated, and the Upper Passaic River represents a source to the Lower Passaic River for certain contaminants. As discussed in the *Draft Geochemical Evaluation (Step 2)* (Malcolm Pirnie, Inc., 2006a), the metals concentrations and mass fractions that were observed above the Dundee Dam in 1985-1986 are comparable to the corresponding metals concentrations and mass fractions observed below the dam in 1995 (RM0.9 to RM7).[16] These data suggest that the Upper Passaic River has recently contributed a significant load of lead, mercury, and cadmium to the Lower Passaic River. Once introduced to the Lower Passaic River, these contaminated solids become re-worked in the surface sediments through tidal resuspension and redeposition.

With respect to organic contaminants, the concentrations detected in the Bopp *et al*. core are generally less than the corresponding concentrations reported in surface sediment from depositional areas below the dam in 1995. The concentrations for DDT-derived compounds and Total PCB in the 1985-1986 core top above the Dundee Dam were one-fourth to one-third, respectively, of the concentrations observed in the 1995 surface sediments in the Lower Passaic River. Hence, it can be inferred that the loads are similarly proportioned. It is also unlikely that the source of 2,3,7,8-TCDD contamination to the Lower Passaic River originated above the Dundee Dam. This observation is based on the low 2,3,7,8-TCDD concentrations from the various Upper Passaic River sediments and the low 2,3,7,8-TCDD/Total TCDD ratio observed in the 1991 USEPA core top.

These conclusions, however, must be regarded with some caution since the core top sediments in the Bopp *et al*. core above the dam predate the 14 datable cores from the Lower Passaic River (1995 TSI dataset). Consequently, some additional changes in contaminant load over the Dundee Dam may have occurred in the 9-year period between

[16] The 1995 Tierra Solution, Inc. (TSI) dataset defines surficial sediment as 0-6 inches in the Lower Passaic River.

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sampling events. Note that this caveat largely applies to those compounds where the upriver and downriver concentrations are comparable. For compounds with downriver concentrations substantively greater than the upriver concentrations, interim upriver changes are unlikely to be important.

4.2 NEWARK BAY BOUNDARY CONDITION

Newark Bay represents the lower boundary of the Lower Passaic River. Newark Bay is located at the confluence of the Lower Passaic River and the Hackensack River. The bay is linked to Upper New York Bay by the Kill van Kull and Raritan Bay by the Arthur Kill (refer to Figure 2-1 and Section 2.1 "The Hudson-Raritan Estuary" for further discussion). Like the rest of the Hudson-Raritan Estuary, twice-daily tidal mixing causes the re-working of surface sediments and the mixing of solids in the bay with solids derived from other areas. Consequently, contaminated solids from Newark Bay become distributed throughout the Hudson-Raritan Estuary. However, a solids mass balance performed by Lowe *et al*. (2005) indicated that on a net annual basis, Newark Bay was a receiver of solids, and those solids are removed from Newark Bay during maintenance dredging. Refer to Section 7.4 "Initial Mass Balance for the Lower Passaic River and Newark Bay" for discussion on solids mass balance and the accumulation of solids in Newark Bay.

Newark Bay and its tributaries have been subjected to expanding urban and industrial development, resulting in a dramatic ecological degradation of the Newark Bay area. Surficial sediment chemistry in Newark Bay was characterized in 2005 during a low resolution coring program,[17] which was developed to support the Phase 1 Remedial Investigation of Newark Bay (TSI, 2006).[18] As part of this program, cores were collected from 69 sampling locations. Among these locations, 35 were identified as beryllium-7 bearing and were considered to represent net depositional areas (these areas include

[17] A low resolution sediment core is a coarsely-segmented core that records the general chemistry of the river sediment. In some cases, the cores may provide data to approximate historic contaminant load (time-scale of decades).

[18] Data are available at www.ournewarkbay.org.

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locations within the federal navigational and port channels).[19] Table 4-3 characterizes the surficial sediment (defined as 0 to 6 inches in this study) in net depositional areas located in the federal navigational channel, accounting for 13 to15 sampling locations. These values are compared to the Lower Passaic River, represented by the surface layer of high resolution cores collected in 2005. In general, average surface concentrations in Newark Bay are less than concentrations in the Lower Passaic River, confirming that Newark Bay does not export contamination to the Lower Passaic River in most cases. These concentration gradients and the change in the 2,3,7,8-TCDD/Total TCDD ratio indicate that both contamination and solids are transferred from the Lower Passaic River to Newark Bay. (Refer to Section 6.0 "Source Area Analyses" for further discussion on the interactions between the Lower Passaic River and Newark Bay.)

Table 4-3: Summary of Contaminant Concentrations in Newark Bay and in the Lower Passaic River

Analyte (units)	Lower Passaic River Sediment Core Top (2005-2003 time horizon) [a]	Newark Bay Sediment Core Top (not datable) [a,b]
Cadmium (mg/kg)	3.5 ± 0.68 (N = 5)	1.3 ±2.3 (N = 15)
Copper (mg/kg)	150 ± 29 (N = 5)	120 ±110 (N = 13)
Lead (mg/kg)	209 ± 39 (N = 5)	110 ±75 (N =15)
Mercury (mg/kg)	1.7 ± 0.55 (N = 5)	1.5 ±0.9 (N = 15)
Total PCB (µg/kg) [c]	280 ± 61 (N = 5)	360 ± 170 (N = 13) [d]
2,3,7,8-TCDD (ng/kg)	480 ± 430 (N = 5)	52 +61 (N = 15)
Ratio of 2,3,7,8-TCDD/Total TCDD	0.7 ± 0.1 (N = 5)	0.4 ± 0.1 (N = 15)

a: Arithmetic average and standard deviation (± 1 sigma) based on a normal distribution of sample size; nondetected values are incorporated into the average as half the reported detection limit. Results rounded to two significant figures, whenever possible.
b: Newark Bay sediment core tops represent 0 to 6 inches.
c: Total PCB for the Newark Bay samples represents the sum of 209 congeners while Total PCB for the Lower Passaic River samples represents the sum of 159 congeners.
d: Average Total PCB for Newark Bay excludes the elevated value of 3,700 µg/kg.

While this analysis precludes substantive contaminant transport from Newark Bay to the Lower Passaic River, it does not entirely rule out the transport of *some* Newark Bay solids to the Lower Passaic River. A mass balance suggests that current solids transport from the bay to the river is relatively minor based on the general homogeneity of contaminant concentrations in surficial sediments in depositional areas of the Lower

[19] A depositional environment is defined as a location where sediments (0-1 inch) have detectable beryllium-7 concentrations that are greater than 0.5 pCi/g.

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Passaic River and the estimated mass of the Passaic-derived contamination that must reach Newark Bay (refer to Section 7.4 "Initial Mass Balance for the Lower Passaic River and Newark Bay"). However, this relationship between the Lower Passaic River and Newark Bay was probably not the case historically given the following scenario.

As discussed in the *Draft Geochemical Evaluation (Step 2)* (Malcolm Pirnie, Inc., 2006a), approximately 5 to 6.5 million cubic yards of 2,3,7,8-TCDD-contaminated sediments are located between RM0.9 and RM7. This estimated volume should probably be expanded by roughly one-third to account for deposition in the areas between RM7 and RM8 as well as between RM0 and RM0.9. Given the historical period of 2,3,7,8-TCDD production and the sediment core records, these 2,3,7,8-TCDD-contaminated sediments were deposited between 1940 and 1995, the latter year being the coring basis for the volume estimate. Thus, roughly 55 years were available to have deposited at least 5 to 6.5 million cubic yards and probably another 2 million cubic yards more in RM7 to RM8 and RM0 to RM0.9.

Meanwhile, the Upper Passaic River and the other tributaries to the Lower Passaic River are estimated to deliver an annual solids load of approximately 77,000 cubic yards. Over 55 years, conservatively assuming no losses to Newark Bay, this delivery would represent approximately 4.2 million cubic yards, leaving approximately 0.8 to 2.3 million cubic yards to be made up from other sources to total the estimated contaminated sediment volume between RM0.9 and RM7. These volumes do not include the additional material from RM7 to RM8 and RM0 to RM0.9 mentioned above, which would add to these volume estimates. There are two main potential sources for these sediments: (1) the Upper Passaic River solids load – given the relatively poor dataset used to construct the estimated Upper Passaic River's solids load, a real possibility exists that this load may be underestimated; and (2) Newark Bay – the enhanced channel depth created for navigational purposes could have permitted additional solids transport upriver. The contribution from Newark Bay has probably declined over time, with its greatest contribution occurring soon after the construction of the federal navigational channel in

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the Lower Passaic River and gradually decreasing as the channel filled with sediment and limited the volume of the salt intrusion and its associated Newark Bay solids.

4.3 OTHER BOUNDARY CONDITIONS

While Dundee Dam and Newark Bay are the two primary boundaries, other boundaries continue to impact water and sediment quality in the Lower Passaic River. These boundaries include major tributaries (Saddle River, Second River, and Third River), minor tributaries (Frank's Creek, Lawyer's Creek, Harrison Creek, and Plum Creek), storm water outfalls, CSO sites, known New Jersey Pollutant Discharge Elimination System (NJPDES) sites, and groundwater seepage. [Refer to the *Work Plan* (Malcolm Pirnie, Inc., 2005a) for location maps of storm water outfalls and CSO sites in the Study Area.] Each of these boundaries may contribute or exchange water, solids load, contaminant mass, or a combination of these elements to the Lower Passaic River.

While the chemical contributions of these inputs to the system boundaries have not been fully quantified at the time of this writing, the solids load and volume of surface water for each boundary condition were estimated, where data were available (Table 4-4). These estimated values indicate that the surface water flow and solids load over the Dundee Dam are an order of magnitude greater than contributions from the tributaries and other sites. For example, the surface water flows and solids loads from the tributaries (Saddle River, Third River, and Second River) are approximately 13 percent of the freshwater and solids entering the Lower Passaic River at Dundee Dam. Consequently, tributary contaminant loads in the water and on the solids would have to be greater than 8 times the contaminant load from Dundee Dam to impact the contaminant mass received by the Lower Passaic River from the dam.

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Table 4-4: Estimated Surface Water Flow and Estimated Solids Load on the Lower Passaic River

Gauged Boundary Condition	Estimate Surface Water Flow (cfs)	Estimated Solids Load [a] (cubic yards/year)
Dundee Dam	1,160 [b]	69,000
Saddle River	108 [b]	3,700
Third River	19 [b]	920
Second River	22 [b]	790
Additional ungauged watershed area	67 [c]	2,400 [d]
NJPDES sites	27 [a]	NA
CSO sites	NA	2,500 [d,e]

a: Solids loads derived from information provided in Lowe *et al*., 2005.
b: Refer to Attachment B for calculations and references therein.
c: Additional ungauged watershed area is based on USGS watershed values for the Lower Passaic River. Flow value based on drainage area with Saddle River water yield.
d: Some proportion of the ungauged watershed area is also incorporated within the CSO "sewershed." This results in some unknown overlap of the estimated solids load.
e: For lack of supporting data, this value is based on the assumption that half of the annual CSO solids deposited in Newark Bay (Lowe *et al*., 2005) originated from the Lower Passaic River.

It is unlikely that atmospheric deposition and solids from CSOs are a significant source of metals contamination to the Lower Passaic River. Atmospheric deposition (based on the data available at the New Jersey Atmospheric Deposition Network) cannot yield the observed metals concentrations in the Upper Passaic River and Lower Passaic River (Reinfelder *et al.*, 2004). Furthermore, it is unlikely that CSO inputs could dominate metals loadings to the Lower Passaic River given their relative magnitude. The annual CSO solids load is approximately 2,500 cubic yards, which is approximately 4 percent of the solids load from Dundee Dam.[20] Consequently, for CSO solids to have comparable impact on metals contamination relative to solids transported over the dam, the metals concentrations on CSO solids would have to be 30 times greater than those concentrations above the dam. These concentration levels are unlikely to exist. Nevertheless, CSO sampling or evaluating existing CSO data should be completed to better quantify the importance of this source area to the Lower Passaic River.

[20] Lacking supporting data, the annual CSO solids load value for the Lower Passaic River is a conservatively high value obtained by assuming that half of the annual CSO solids delivered to Newark Bay were first discharged to the Lower Passaic River. The original CSO solids load value is based on solids load calculations provided in Lowe *et al.*, 2005.

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Given their magnitude in both solids load and contaminant concentration, it is likely that the major boundary conditions at Dundee Dam and Newark Bay have the greatest impact on the Lower Passaic River. Consequently, they are the main focus of this CSM along with the main stem of the river. However, future sampling and evaluation of existing tributary and CSO data are necessary to fully assess the impact of these discharges on the Lower Passaic River.

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5.0 SEDIMENT TRANSPORT

As previously reported, the Lower Passaic River is a dynamic environment, experiencing both periods of net erosion and net deposition [refer to Section 3.0 "Sediment Transport" in the *Draft Geochemical Evaluation (Step 2)* (Malcolm Pirnie, Inc., 2006a) for further discussion]. Solids are introduced to the Lower Passaic River from above the Dundee Dam, tributaries, and discharge points. They are homogenized and re-worked through tidal mixing and erosional/depositional events. Eventually, some of these solids are transported through the river sections and deposited in Newark Bay. The following discussion describes sediment transport in the Lower Passaic River by analyzing solids accumulation and erosion/deposition activity. Throughout this discussion, it should be kept in mind that tidal mixing continuously causes surface sediments to resuspend and redeposit in response to the tidal currents. These currents also cause the salt front to advance twice-daily through the Brackish River Section and Transitional River Section, adding to the complexity of sediment transport in the Lower Passaic River.

Since historical investigations of the Lower Passaic River focused on the region between RM0.9 and RM7, multiple bathymetric surveys were conducted in this portion of the river, which roughly coincides with the Brackish River Section (RM0 to RM6). Only two bathymetric surveys are available to characterize the remainder of the river, covering the Transitional River Section (RM6 to RM10) and portions of the Freshwater Section (RM10 to RM17.4; refer to Table 5-1).

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Table 5-1: Summary of Available Bathymetric Surveys

Date	Survey Company	Survey Extent (RM) [a]
November 1989	Topo-Metrics, Inc. for USACE	0 to 15
March/April 1995	Ocean Surveys, Inc. for TSI	0.5 to 8.2
November 1996	Ocean Surveys, Inc. for TSI	0.5 to 6.94
April 1997	Ocean Surveys, Inc. for TSI	0.5 to 6.94
June 1999	Ocean Surveys, Inc. for TSI	0.9 to 6.94
August 2001	Ocean Surveys, Inc. for TSI	0.9 to 6.94
July 2002	TVGA Consultants for USACE	0 to 8.0
November 2004	Rogers Surveying, Inc. for USACE	0 to 17.4

a: The original vertical datum for surveys was MLW as defined by the USACE. The transect density for the surveys was approximately 52 transects per mile.

5.1 SOLIDS ACCUMULATION

To evaluate the net annual solids accumulation in the Lower Passaic River (RM0.9 to RM7), difference among historical bathymetric surveys were evaluated. Available historical surveys from 1989 through 2004 were considered in a series of 10 comparisons [refer to Section 2.1 "Sedimentation Rates and Annual Accumulation" in the *Draft Geochemical Evaluation (Step 2)* (Malcolm Pirnie, Inc., 2006a) for description of methodology]. Net annual solids accumulation ranged from a loss of 166,000 cubic yards (representing a net erosional period between surveys) to a gain of 200,000 cubic yards (representing a net depositional period between surveys; Table 5-2). These results indicate that the Lower Passaic River is a dynamic system, experiencing periods of both net deposition and net erosion superimposed on the gross cycling of solids caused by the twice-daily tidal exchange.

Table 5-2: Net Solids Accumulation and Loss Based on Bathymetric Surveys (1989 to 2004)

Survey Comparison Interval [a]	Net Accumulation and Loss Between Surveys (cubic yards) [b, c]
1989-1995	101,000
1995-1996	144,000
1996-1997	-23,100
1997-1999	94,400
1999-2001	121,000
2001-2002	-166,000 [d]
2002-2004	200,000 [d]

a: Based on evaluations provided in the *Draft Geochemical Evaluation (Step 2)* (Malcolm Pirnie, Inc., 2006a). Each year listed corresponds to a bathymetric survey that covered at least RM0.9 to RM7. The time between surveys varies from less than 1 year to 6 years.

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Table 5-2 footnotes (continued)

b: The actual uncertainty in these estimates of annual accumulation is unknown. However, in the absence of any actual change, a 1-inch offset in the vertical reference plane between any two surveys would represent a volume equivalent to about 36,000 cubic yards.

c: Positive values represent net accumulation of solids while negative values represent a net loss of solids. The volumetric difference between surveys reported here does not necessarily represent an annual net gain or annual net loss of solids since the periods separating the surveys vary significantly from 12 months.

d: The large difference from 2001 to 2002, and again from 2002 to 2004, may be the result of a change in surveying companies in 2002. Refer to the *Draft Geochemical Evaluation (Step 2)* (Malcolm Pirnie, Inc., 2006a).

The variations in sediment volume between bathymetric surveys give testament to the dynamic nature of the river bed of the Lower Passaic River. While the river tends to accumulate sediments in most cases, two of the seven intervals examined had large sediment losses. Notably, the largest loss and one of the largest gains of solids occurred when the bathymetric surveys used in the comparison was conducted by different surveying companies. Nonetheless, the differences in surveys still suggest major solids deposition and erosion events. To place this difference in context, a net change of 36,000 cubic yards represents an average gain of 1 inch over the entire area between RM1 to RM7 of the Lower Passaic River. Solids gains during at least one interval (*i.e.*, the 19-month period from April 1995 to November 1996) would represent a net deposition of approximately 4 inches of sediment over the entire area.

The relationship between net erosional events, net depositional events, and river flow is not well known currently. It is unclear whether net deposition occurs most rapidly during short periods of high flow or long periods of low flow. Similarly, it is not known what type of flow conditions yield periods of net erosion. The volume estimates provided in Table 5-2 suggest that the river is generally depositional over time but is still subject to fairly frequent major erosional events. An evaluation of the interplay between river flow, net erosion, and net deposition is recommended to further this understanding and to provide a basis for the prediction of erosion and deposition as river flow varies.

5.2 SOLIDS MASS BALANCE

Recent work by Lowe *et al*. (2005) provides additional information used to derive the external solids load to the Lower Passaic River. The solids load to the Lower Passaic

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River at the head-of-tide, including the flow over the Dundee Dam as well as the tributaries of the Lower Passaic River, is roughly 77,000 cubic yards/year. The Lowe *et al*. study, however, did not examine solids deposition in the Lower Passaic River. In an effort to complete this calculation and to estimate the solids load at the mouth of the Passaic River, the 1989 and 2004 bathymetric surveys were compared from RM0 to RM15. These surveys were compared because both surveys extend to RM15 and because the 15-year time span between surveying events serves to average out any extreme depositional or erosional events. This comparison yielded average annual net solids accumulation of 67,000 cubic yards for RM0 to RM15, which is roughly equivalent to 1 inch of sediment accumulation over the Lower Passaic River bottom (RM0 to RM17) or 1.5 inches over the lower 7 miles. Approximately 90 percent of this accumulation occurs from RM0 to RM7. However, since the head-of-tide solids load to the Lower Passaic River is likely greater than the annual net solids accumulation, the remaining solids load must be transported out of the river into Newark Bay. A combined solids and 2,3,7,8-TCDD mass balance suggests that an even larger solids volume (approximately 36,000 cubic yards) is transported out of the Lower Passaic River and into Newark Bay (refer to Section 7.4 "Initial Mass Balance for the Lower Passaic River and Newark Bay"). Based on these estimates, a solids load equivalent to 20 to 50 percent of the solids entering the Lower Passaic River over the Dundee Dam is eventually transported to Newark Bay each year (Malcolm Pirnie, Inc. 2006a).

The surficial sediment texture in the Lower Passaic River is consistent with the bathymetric observations of deposition, with coarse-grained sediment present above RM14 transitioning to predominantly fine-grained sediments below RM8 (Figure 3-5). The fine-grained sediments are considered characteristically depositional for the Lower Passaic River while the coarse-grained sediments are characteristic of areas where flow velocities are too great to permit substantive rates of fine-grained deposition. While the Lower Passaic River has experienced, on average, net deposition of sediment (for the period examined), tidal velocities continuously cause surface sediments to resuspend and redeposit. It is likely that the layer of sediments resuspended and redeposited by tidal

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currents (*i.e.*, gross sediment cycling) represents a greater thickness than the net annual accumulation of sediments in most areas.

5.3 DEPOSITIONAL ENVIRONMENT IN THE LOWER PASSAIC RIVER

As noted in the introduction (Section 1.1 "Objective of the Conceptual Site Model"), one objective of a CSM is to assist remedial decision-making. As a preliminary approach to delineate possible remedial targets, it was decided to identify areas of the sediment beds undergoing net erosion, potentially re-releasing older, highly contaminated sediments. The previous section examined the evidence for solids transport, net erosion, and net deposition in the Lower Passaic River as a whole. In addition, a detailed examination of sediment deposition rates on a local scale indicates a high degree of spatial heterogeneity in the Lower Passaic River [refer to Section 3.0 "Sediment Transport" in the *Draft Geochemical Evaluation (Step 2)* (Malcolm Pirnie, Inc., 2006a) for further discussion]. Given the large, fine-grained sediment inventory between RM0.9 and RM7, the heterogeneous nature of sediment deposition, and the particle-reactive nature of most of the contaminants of potential concern, the following analysis focuses on this stretch of the river.

To identify consistently net erosional and depositional areas in RM0.9 to RM7, the evaluation focused on the historical TSI bathymetric surveys performed by Ocean Surveys, Inc. in 1995, 1996, 1997, 1999, and 2001. These surveys were selected because the bathymetric surveying tracks are well aligned, reducing the uncertainty in year-to-year comparisons. The close alignment of the survey tracks meant that differences in river bottom elevation between surveys were largely the result of measured differences and not interpolated ones. While much of the bottom surface elevations were still interpolated values, the relative uncertainty at a given location remains the same across surveys since the distance to measured values remains constant. This level of uncertainty is in contrast to the level of uncertainty associated with the 1989-2004 bathymetric comparison where surveying tracks were not aligned. Thus, TSI-surveyed locations compared year-to-year do not have varying uncertainties depending on survey alignment.

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Uncertainty can be minimized with this approach, but it can still be substantial at locations between survey tracks.

The interpreted bathymetric surveys cover a time period (1995 to 2001) when the Lower Passaic River experienced both relatively "wet" years and relatively "dry" years (Table 4-1). Since the period from 1995 to 2001 includes conditions reasonably representative of high flow events and low flow events on the Lower Passaic River, an evaluation of bathymetric surveys from this period should be sufficient to characterize the general behavior of the river. An important note concerning the original goals of this evaluation is warranted here. The original purpose of this evaluation was to identify areas that might be suitable as remedial targets and not to attempt a fine resolution of the net depositional and erosional environments. The identification process was done on a semi-quantitative basis, recognizing the uncertainties in individual bathymetric survey measurements and the inherent uncertainty in the interpolation schemes despite our efforts to minimize it by survey selection. Such an approach permits the identification of those portions of the Lower Passaic River where the main net erosional areas are concentrated without developing a rigorous statistical basis in an attempt to sharply define these areas. Since net erosion and contaminated sediment volume were important to the selection of remedial targets, this analysis attempted to identify river segments on the scale of one-quarter mile or more (which is the approximate spacing of the 1995 coring transects). The analysis did not attempt to develop the statistics to delineate sharper boundaries.

To accomplish the analysis, individual locations were paired across surveys to assign a value for an indicator variable. Values of -1, 0, and 1 are assigned respectively to indicate areas that were net erosional, bathymetrically neutral, or net depositional to create a map of -1's, 0's, and 1's. These maps were simply summed to identify areas where net erosion was occurring most frequently. Essentially, the more negative the summed value was, the more often that survey comparisons showed net erosion for a location. Both short-term (2 years or less) and longer-term (greater than 2 years) comparisons were made. The short-term comparisons and longer-term comparisons were

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combined into separate maps and compared to each other to identify the consistently erosional areas. (Refer to Attachment C for details on methodology.)

Delineated net erosional and depositional areas based on these comparisons are presented in Figure 5-1. Red or orange colors represent areas of the river that have frequently experienced net erosion. Conversely, green or blue colors represent areas that have frequently experienced net deposition. Grey indicates "bathymetrically neutral" areas, that is, areas that have experienced both erosion and deposition and, therefore, cannot be classified as net erosional or net depositional. The term "bathymetrically neutral" does not in any way discount the short-term gross resuspension and settling that is the result of tidal flows or hydrologic events. Both of these latter phenomena, however, have only a transient effect on the sediment bed elevation compared to the longer-term net changes documented by the various investigations.

One striking feature of Figure 5-1 is the complexity of the Lower Passaic River as denoted by the intertwining of net depositional and net erosional areas, not only along the river but also across the river from bank-to-bank. Net erosional areas are relatively smaller and less densely spaced. They often occur most densely on the outer bank of a meander. For example, this situation occurs downriver of RM7 as the river makes a slight bend to the southwest (RM6.7 to RM6.0). Sporadic net erosional areas then appear downriver of RM6 near a series of bridges. Net erosional areas become prominent again between RM5.1 and RM3.3 as the river bends in an S-shape and the channel shifts from the right-bank descending toward the left-bank descending at RM3.7. Net erosional areas also occur between RM2.4 and RM1.8 as the river makes its final bend in Kearny, New Jersey. Another feature is the frequent occurrence of the bathymetrically neutral areas throughout the river, covering approximately 35 percent of the surveyed area between RM0.9 and RM7.

The semi-quantitative approach described above permitted the identification of some stretches of the river as having a higher density of net erosional areas by examining the fraction of the river bottom that is classified as net depositional, net erosional, or

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bathymetrically neutral within quarter-mile (bank-to-bank) units. Figure 5-2, which distills the information presented on the map in Figure 5-1, shows the relationship between river mile and the percentage of the river bottom that falls into each of these categories. In this line plot, net depositional areas are shown to account for more than 80 percent of the area near RM0.9 and in parts of the area between RM2.5 and RM3.5. While net depositional areas are still common farther upriver, between RM3.5 and RM5, net erosional areas account for more than 20 percent of the river bottom in much of this stretch. Upriver of RM5, net depositional and bathymetrically neutral areas again become prevalent.

The analysis presented here is appropriate for the purposes of preliminarily identifying remedial targets. More detailed information on long-term net deposition and erosion rates and associated areas can be obtained from the data but only after more rigorous analyses. Such analyses would also be very useful constraints on the numerical simulations of sediment transport and long-term recovery of the river bottom.

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6.0 SOURCE AREA ANALYSES

Each of the three river sections as defined in Section 3.0 "River Sections" has been further subdivided into three media: sediment, water, and air (Figure 6-1). These media interact through various natural processes and are impacted by various contamination source areas in the Lower Passaic River. The following section examines these potentially contaminated media, source areas, and potential migration pathways. Source areas are defined as locations from which contamination originates and becomes available for transfer to other media and other areas. For example, a source area may be an area of sediment scour, where older, highly contaminated sediments are being re-released into the water column, contaminating both the water column and the sediment surface in other areas. Alternatively, a source area can be the point of discharge of a CSO or other discharge conduit into the water column, assuming the discharge is contaminated. The water of the Lower Passaic River and its biota are not considered to be source areas, but rather as the ultimate recipients of contamination. Sediments of the river may be both a recipient of contamination and a source area, as noted above.

6.1 IDENTIFICATION OF SOURCE AREAS

A schematic flow diagram is presented in Figure 6-1 to describe how the different contaminated media and source areas interact on the Lower Passaic River. In Figure 6-1, the different media are marked with different colors (*e.g.*, sediment is marked as brown, water is marked as dark blue, and air is marked as light blue), source areas or inventories are denoted in boxes, and release mechanisms or fluxes are marked on the arrows connecting associated inventories.[21] Since limited data are available to assess all sources in each river section, the same potential source areas are listed for each river section (Figure 6-2). However, some source areas will be absent or less significant within a given river section.

[21] In Figure 6-1, the arrow length does *not* reflect the flux magnitude.

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Various datasets are available to identify contaminant input and source areas and to understand the mechanisms impacting the fate and transport of those contaminants. These datasets include available historical data, field data collected in 2005 and 2006 as part of the USEPA field sampling program, field data collected as part of the Phase 1 Remedial Investigation of Newark Bay (TSI, 2006), as well as the dataset and evaluations incorporated in the *Draft Geochemical Evaluation (Step 2)* (Malcolm Pirnie, Inc., 2006a). Table 6-1 and Table 6-2 summarize the available datasets used and evaluations conducted to characterize the source areas on the Lower Passaic River. The source areas listed in these tables correspond to the source areas presented in the schematic diagrams of Figure 6-1 and Figure 6-2. (Refer to Section 8.0 "Uncertainties and Future Updates" for a list of potential actions that are anticipated to occur to address data gaps.)

Table 6-1: Currently Available Data and Identified Data Gaps for the Sediment Beds

Potential Source Area to Sediment Beds	Currently Available Data and Identified Data Gaps
Transport of solids originating above Dundee Dam	• Limited data on solids transport over dam; refer to Section 5.1 on solids load. • Data gap in sediment chemistry above Dundee Dam (refer to Table 4-2); to be addressed by results of USEPA coring event in January 2007. • Refer to Section 7.4 on Dundee Dam contribution to mass balance.
Resuspension and erosion/deposition of solids due to tides	• Limited data on suspended solids collected during dredge pilot study (December 2005). • Data on suspended solids collected by Malcolm Pirnie, Inc. for USEPA and Rutgers University for the New Jersey Department of Transportation (NJDOT) in 2004 and 2005. • Data gap for magnitude of this process - to be addressed by model simulation.
Transport of solids from Newark Bay	• Data on sediment concentrations in both the Lower Passaic River and Newark Bay suggest minimal upriver transport of contaminants from Newark Bay at the current time. • Data on concentrations from historical and recent sediment coring programs (TSI Phase 1 dataset and Bopp *et al.* cores). Refer to Section 4.2. • Refer to Section 7.4 on Newark Bay mass balance. • Data gap for magnitude of this process - to be addressed by subsequent dated sediment core data analysis and model simulation.

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Table 6-1 (continued)	
Resuspension and erosion/deposition of solids from tributaries	• Very limited data on suspended solids collected on tributaries in 2005 by Malcolm Pirnie, Inc. for USEPA. • Data gap in suspended solids and sediment chemistry from tributaries. • Data gap not expected to be substantial for most contaminants due to limited watershed area associated with the tributaries.
Discharge of solids from non-point sources	• Data gap in solids from non-point sources. • Estimates by Lowe *et al*., 2005. • Data gap not expected to be substantial for most contaminants due to limited water volume through this pathway.
Discharge of solids from point sources	• Data gap in solids from point sources. • Estimates by Lowe *et al*., 2005. • Data gap not expected to be substantial for most contaminants due to limited water volume through this pathway and evidence collected on other point sources (such as CSOs) throughout the New York-New Jersey harbor area (Chaky, 2003).
Burial of surficial sediment to deep sediment beds	• Refer to Section 5.0 on sediment transport. • Bathymetry data from RM0 to RM17.4 limited to 1989 and 2004 surveys.
Resuspension and erosion/deposition on mudflats	• Limited sediment chemistry data on shoals (refer to Section 6.3). • Data gap in deposition rates and sediment chemistry on mudflats. • Data gap not expected to be substantial for most contaminants since mudflats are typically non-depositional (<< 1 inch/year) and do not accumulate large temporary sediment volumes.
Resuspension and erosion/deposition on floodplains	• Data gap in sediment chemistry from floodplains. • Data gap not expected to be substantial for most contaminants due to extensive armoring of shoreline areas along much of the Brackish and Transitional River Sections, which limits flood plain deposition and transfer.
Interactions between sediment, groundwater, and porewater	• Refer to Section 6.5 on groundwater discussion. • Data gap for porewater and groundwater conditions.
Remobilization of sediment due to floods	• Suggestive evidence from historical bathymetric surveys; more rigorous analysis of the bathymetric data in concert with hydrographic data would be appropriate. • Modeling analysis by HydroQual, Inc. is ongoing.

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Table 6-2: Currently Available Data and Identified Data Gaps for the Water Column

Potential Source Area to Water Column	Currently Available Data and Identified Data Gaps
Main-stem flow originating above the Dundee Dam	• Refer to Section 4.1 for Dundee Dam flow. • Data gap in water chemistry - to be addressed by results of anticipated sampling event in spring 2007 by Malcolm Pirnie, Inc. for USEPA. • Data gap in suspended solids chemistry - to be addressed by results of coring event in January 2007 and water column sampling event in spring 2007 by Malcolm Pirnie, Inc. for USEPA. • Data gap in suspended solids load above dam.
Tidal exchange with adjacent river sections and Newark Bay	• Refer to Section 3.2 for river section definition. • Data gap in magnitude of transfer process to be addressed by computer simulation of salinity distribution data collected by Malcolm Pirnie, Inc. for USEPA and Rutgers University for NJDOT. • Large and small volume water samples collected in 2005 by Malcolm Pirnie, Inc. for USEPA on the Lower Passaic River. • Semi-permeable membrane devices deployed in 2005 by Malcolm Pirnie, Inc. for USEPA on the Lower Passaic River. • Limited data available on tidal exchange volume through measurements of salinity in 2004 and 2005. • Data gap in water chemistry in Newark Bay.
Discharge of water from tributaries	• Refer to Section 4.3 for estimates of tributary flow. • Tributary water collected in 2005 by Malcolm Pirnie, Inc. for USEPA (limited in temporal extent). • Semi-permeable membrane devices deployed in 2005 by Malcolm Pirnie, Inc. for USEPA on the Lower Passaic River. • Data gap in measurements of magnitude of flow due to lack of gauging stations - not expected to be substantial for most contaminants due to limited watershed area and relatively small flows associated with the tributaries.
Discharge and runoff of water from non-point sources	• Data gap in water chemistry and volume from non-point sources – not expected to be substantial for most contaminants due to limited water volume through this pathway.
Discharge of water from point sources	• Refer to Attachment B for known point source flow discharges. • Data gap in water chemistry from point sources – believed to be addressed by Contaminant Assessment and Reduction Program (CARP); not expected to be substantial for most contaminants due to limited water volume through this pathway.
Exchange between porewater and water column	• Refer to Section 6.5 on groundwater discharges. • Data gap for porewater and groundwater conditions.
Exchange between groundwater and water column	• Refer to Section 6.5 on groundwater discharges. • Data gap for porewater and groundwater conditions.

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Table 6-2 (continued)	
Atmospheric dry and wet deposition and volatilization	• Limited atmospheric data available for some contaminants in the region. • Limited data on dissolved-phase concentration needed to estimate loss by gas exchange. • Data gap not expected to be substantial for most contaminants due to relatively low concentrations associated with atmospheric particles as compared to Lower Passaic River solids concentrations. Gas exchange losses limited to those organics with significant solubilities and vapor pressures (*e.g.*, low molecular weight PAH and PCB compounds and methyl mercury).

As noted in Table 6-1 and Table 6-2, a number of data gaps exist that limit the precision on the estimates of the magnitude of potential source areas in each river section (refer to Section 8.0 "Uncertainties and Future Updates"). With the available data, the following evaluations and discussions are presented on potential source areas and contaminated media, including sediment, water column, and groundwater.

6.2 SEDIMENT: POTENTIAL SOURCE AREA AND CONTAMINATED MEDIUM

6.2.1 SURFACE SEDIMENT CONCENTRATIONS AND GRADIENTS

Surface sediment concentrations were evaluated and discussed in Section 4.4 "Surface Sediment Concentration" and Section 4.5 "Source Analysis" of the *Draft Geochemical Evaluation (Step 2)* (Malcolm Pirnie, Inc., 2006a). The results of these evaluations are summarized below:

- Metals concentrations in surficial sediments reveal a consistent mass fraction pattern between RM0.9 and RM7. A similar mass fraction pattern was generated for sediment collected from the Bopp *et al*. 1985-1986 core that was collected above the Dundee Dam. These observations suggest one potential source area of metals contamination is upriver of RM7 and is likely to originate upriver of the Dundee Dam.

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- Ratio analysis of metals concentrations (RM0.9 to RM7) showed little variation. Analysis of metals concentrations in surface sediments also showed relatively little trend longitudinally. This evidence demonstrates the homogeneity of contaminant concentrations in surficial sediments in depositional areas of the Lower Passaic River and suggests that tidal mixing is able to homogenize local metals loads over long distances, prior to the deposition of the contaminants on the river bottom. Hence, the presence or absence of an interval of high concentration within the sediments at a given location is a function of the depositional history and is not controlled by proximity to source. To a significant degree, this efficient mixing process limits the ability to identify source areas in this region.
- The Upper Passaic River has been and is likely to be a source area of cadmium, lead, mercury, and Total PCB to the Lower Passaic River. Historical loads of Total DDT were unimportant but may have become more important recently (within the last 10 to 15 years). However, additional sources of these contaminants are likely present on the Lower Passaic River as well. Concentrations of 2,3,7,8-TCDD in sediments just upriver of the Dundee Dam are approximately 40 times less than concentrations below the dam; therefore, the Upper Passaic River is likely *not* the source of this contaminant to the Lower Passaic River.

The surface sediment concentrations were further examined by constructing scatter plots that included the 1995 TSI dataset and the 2005 high resolution sediment cores for the Lower Passaic River as well as the 2005 low resolution sediment cores collected in Newark Bay.[22] These plots were supplemented with concentrations from the literature, when available. Figure 6-3 presents the combined datasets of surface sediment concentrations for cadmium, copper, lead, mercury, Total PCB, and 2,3,7,8-TCDD. Table 6-3 provides statistics on these concentrations. Because the various studies were designed to fulfill different DQOs, the results plotted in Figure 6-3 (and summarized in Table 6-3) reflect various depositional environments in the Lower Passaic River. For

[22] The Malcolm Pirnie, Inc. 2006 low resolution cores collected for USEPA on the Lower Passaic River were not incorporated into Table 6-3 because the tops of the cores were not finely sliced, resulting in a lack of temporal resolution.

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example, the 2005 high resolution cores and the Bopp *et al*. cores were collected in consistently net depositional environments and have datable core top segments. The 1995 and 2005 TSI samples were collected from both net depositional and non-depositional locations along a grid pattern; hence, most of the 0-6 inch depth sediment samples are not temporally well-constrained. Samples from the various depositional environments are plotted on one figure to illustrate the range of surface sediment concentrations over the past 2 decades in the Lower Passaic River (from 1985-1986 to 1995 to 2005) and to discuss surface sediment gradients from the Lower Passaic River to Newark Bay in 2005.

Table 6-3: Summary of Surficial Sediment Concentrations from Dundee Dam to Newark Bay

Analyte	Newark Bay 2005 [a,b]	Lower Passaic River 1995 [a,c]	Lower Passaic River 2005 [a,d]	Dundee Dam Sediment Core Top (1985-1986 time horizon) [a,e]
Cadmium (mg/kg)	2.3 ±3.4 (N = 67)	5.1 ±3.1 (N = 95)	3.5 ±0.68 (N = 5)	4.2
Copper (mg/kg)	150 ±130 (N = 67)	230 ±250 (N = 95)	150 ±29 (N = 5)	120
Lead (mg/kg)	160 ±160 (N = 67)	330 ±150 (N = 90)	209 ±39 (N = 5)	307
Mercury (mg/kg)[f]	3.4 ±9.5 (N = 67)	3.3 ±1.9 (N = 92)	1.7 ±0.55 (N = 5)	1.8
Total PCB (μg/kg)[g]	750 ±1,100 (N = 67)	1,300 ±1,800 (N = 90)	280 ±61 (N = 5)	480
2,3,7,8-TCDD (ng/kg)	64 ±80 (N = 67)	830 ±2,000 (N = 95)	480 ±430 (N = 5)	20
Ratio of 2,3,7,8-TCDD/Total TCDD	0.4 ±0.1 (N = 67)	0.7 ±0.1 (N = 95)	0.7 ±0.1 (N = 5)	NA

a: Arithmetic average and standard deviation (± 1 sigma) based on a normal distribution of sample size; nondetected values are incorporated into the average as half the reported detection limit. Results rounded to two significant figures, whenever possible.
b: The 2005 TSI Newark Bay dataset represents surficial sediment (0 to 6 inches) collected from net depositional and net non-depositional sampling locations.
c: The 1995 TSI Lower Passaic River dataset represents surficial sediment (0 to 6 inches) collected from net depositional and net non-depositional sampling locations.
d: The 2005 Malcolm Pirnie, Inc. dataset represents surficial sediment dating from 2003-2005 based on the estimated age of the surface layers used.
e: Literature data
f: This average excludes the one elevated value in Port Newark of 77 mg/kg.
g: Total PCB for the 2005 Newark Bay data and the 2005 Lower Passaic River data were calculated as the sum of congeners, (209 congeners and 159 congeners, respectively). The 1995 Lower Passaic River data and the Dundee Dam data represent the sum of Aroclors.

The 2005 field data provide further insight into the processes occurring within the Lower Passaic River since data are available at RM11 and RM12.6 and in Newark Bay. For the

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metals and Total PCB, the 2005 surficial sediment concentrations at RM11 and RM12.6 are comparable to those at RM1.4 and RM2.2. The close agreement among all the high resolution core surface samples can be observed in the small standard deviation relative to the mean values. The close agreement among the sediment core tops has important implications for tidal mixing.

In addition, the average 2005 surface concentrations for metals and Total PCB are also comparable to solids collected above the Dundee Dam from 1985-1986, implying that the Upper Passaic River may still be contributing a significant portion of the load for these contaminants to the Lower Passaic River (assuming that the contaminant load has not changed over time).[23] Local sources on the Lower Passaic River may also contribute to the contaminant load, resulting in higher surface concentrations in the Lower Passaic River relative to those above the Dundee Dam.

A distinct concentration gradient is shown to extend out of the mouth of the Lower Passaic River and into Newark Bay for several contaminants (based on the data collected in 2005), suggesting that Newark Bay is not contributing a contaminant load to the Lower Passaic River in these cases. Further analysis of the newly available data for the Lower Passaic River and Newark Bay is warranted since some contaminants exhibit a sharp decline to Newark Bay (*e.g.*, 2,3,7,8-TCDD) while others do not (*e.g.*, Total PCB and mercury). Analysis of this information will provide a rigorous constraint on the volume of suspended matter that Newark Bay currently contributes to the Lower Passaic River. This analysis will serve as an important constraint on the numerical simulation of transport between the two water bodies.

6.2.2 TIDAL MIXING OF SEDIMENTS

The 2,3,7,8-TCDD concentration and the ratio of 2,3,7,8-TCDD/Total TCDD are fairly uniform along the Lower Passaic River (Figure 6-3e and Figure 6-3f); however, as discussed in Section 2.2.1 "Relationship of the Lower Passaic River with the Estuary,"

[23] At the time of this writing, high resolution cores have been collected above the Dundee Dam and are being analyzed to assess potential changes in contaminant load over the past two decades.

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2,3,7,8-TCDD does not have an upriver source. The uniform surface concentrations suggest that tidal mixing is impacting sediment quality along the length of the Lower Passaic River, even as far upriver as RM11 and RM12.6. The similarity in sediment concentrations of 2,3,7,8-TCDD as well as other contaminants among core tops considered to represent 2003-2005 deposition shows that sediments are homogenized over at least a distance of 11 miles (RM1.4 to RM12.6) prior to deposition. This also indicates that contaminant releases downriver are transported upriver at least as far as RM12.6.

Salinity data presented in Section 3.2 "Salinity Data Available to Define the River Sections" define the Transitional River Section between RM6 and RM10; however, the salinity data also indicate that the salt front seasonally extends beyond RM10. Apparently the upriver excursion is sufficiently frequent or the tidal velocities are sufficiently strong so as to transport and homogenize the sediments at least as far as RM12.6, the location of the upriver-most core. The geochronological profiles of 2,3,7,8-TCDD and other contaminants over the past 60 years are very similar in absolute concentration and in historical trends for the three high resolution sediment cores (collected at RM1.4, RM2.2, and RM11; Figure 6-4). For 2,3,7,8-TCDD, for example, each core documents the low levels present prior to the 1950s (<1 ng/kg), with levels increasing to peak concentrations in the late 1950s and early 1960s (10,000 ng/kg), and then declining to the 2005 concentration (400 ng/kg). The recent concentration decline likely reflects the cessation of major external loads to the Lower Passaic River while showing the ongoing re-release of previously contaminated and deposited sediments.

A related plot showing the ratio of 2,3,7,8-TCDD/Total TCDD is provided in Figure 6-5. Here, the diagnostic ratio of the Lower Passaic River (0.7 ±0.1; Malcolm Pirnie, Inc., 2006a and Chaky, 2003) is observed in the three cores from the 1950s to 2005. The cores also provide a consistent picture prior to 1950 as the 2,3,7,8-TCDD/Total TCDD ratio and the 2,3,7,8-TCDD concentration in each core declines to levels more typical of atmospheric deposition and sewage discharge (Chaky, 2003). The rigorous mixing of sediments in the Lower Passaic River prevents a simple identification of the source area

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by eliminating local concentration gradients. While the number of samples above the dam from which to draw conclusions are limited, the region upriver of the Dundee Dam does not contribute substantially to the concentrations of 2,3,7,8-TCDD in sediments of the Lower Passaic River, as noted above in Section 6.2.1 "Surface Sediment Concentrations and Gradients." The absence of substantial upriver contributions and the data presented in Figures 6-4 and 6-5 suggest that a single source (or at least a single source type) has generated the 2,3,7,8-TCDD contamination to the Lower Passaic River for the past 55 years.

6.2.3 SHOAL CONTAMINATION

The "shoals" are defined as areas located outside the footprint of the authorized dimensions of the federal navigation channel but below MLW. As a result of tidal currents and hydrologic events, solids are exchanged between shoal and channel, upriver and downriver, through resuspension and deposition processes. The shoals, like the channel, have been subject to extensive deposition as a result of dredging. As part of the construction of the channel itself, the channel walls were either purposefully sloped or the slopes formed as a result of material slumping into the channel. In either case, areas outside the authorized channel footprint were made deeper by the creation of the channel. Additionally, ship traffic needed berths along the river in order to deliver or accept goods from local facilities. To satisfy this, berths would likely have been dug out to the river's edge, locally deepening the shoal. Consequently, various dredging activities would have deepened the shoals in a more haphazard fashion than the channel. With the ensuing lack of channel maintenance, the shoals, like the channel, have filled in with river sediment. Like sediments in the channel, these sediments are extensively contaminated. This scenario is supported by the depth of contamination observed in numerous cores outside the authorized channel boundary.

As further discussed in Section 7.3 "Estimates of the Volume of Contaminated Sediment and the Associated Mass of Contaminants" in this document and in Section 5.2 "MPA Approach" of the *Draft Geochemical Evaluation (Step 2)* (Malcolm Pirnie, Inc., 2006a), the average measured depth of contamination in the sediments (which was estimated

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using historical mercury data) is approximately 9 feet. This average depth incorporates sediment cores collected in the channel and on the shoals of the Lower Passaic River but does not correct for historical cores that showed incomplete concentration profiles.[24] In fact, the average depth of contamination is actually deeper than 9 feet since 48 percent of the historical mercury cores were incomplete with a rising concentration gradient at the bottom of the core. The need to extrapolate these cores to greater depths, either by sampling or by estimation, in order to characterize the complete thickness of contamination virtually guarantees that the actual average depth is greater than 9 feet. The average depth of contamination based on mercury, and accounting for incomplete cores, was estimated to be 13 feet as of 1995, the time of the largest sediment survey.

To investigate the potential depth of contamination in the shoals, historical low resolution cores located outside the authorized federal navigation channel were identified based on their geographical coordinates. Downcore profiles of mercury were then constructed for these selected shoal cores.[25] Of the 59 shoal cores identified, approximately half showed complete mercury concentration profiles (the same percentage observed for the entire river). For these complete cores, the average depth of contamination in the shoals is known, approximately 7 feet (minimum depth of 0.1 foot and maximum depth of 19 feet). Conversely, the other half of the cores showed incomplete mercury concentration profiles; therefore, the depth of contamination is unknown but is greater than the depth of the core bottom. For these incomplete cores, the bottom of the collected core was 7 feet on average, suggesting that the depth of contamination is greater than 7 feet at these incomplete coring locations. This value (7 feet) is slightly shallower than the depth of contamination in the river as a whole (9 feet), but given the uncertainty in both estimates

[24] An incomplete sediment core profile is defined as a core in which the concentration in the bottom segment is not equal to background concentrations, or post-industrial conditions. Hence, the contaminant inventory at that sampling location is uncertain. Incomplete sediment cores result from the presence of dredge horizons or cores that do not penetrate deep enough into the sediment bed.

[25] Mercury was selected as a surrogate to identify depth of contamination because mercury contamination occurs deeper in the sediment bed relative to 2,3,7,8-TCDD and Total PCB (Malcolm Pirnie, Inc., 2006a).

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due to the large percentages of incomplete cores, the difference between shoal contamination depth and that of the entire river may not be significant.

6.3 WATER COLUMN: CONTAMINATED MEDIUM

The water column serves as a means for the transport and dispersal of contaminants throughout the Lower Passaic River. Consequently, the water column is not a potential source area but rather a medium whose inventory is transient and regularly replaced and replenished. The water column inventory at any moment represents a dynamic balance of the various loads and sinks connected to the water column.

The current understanding of typical water column conditions and loads is particularly limited by the lack of available water chemistry data. In 2005, Malcolm Pirnie, Inc. deployed semi-permeable membrane devices and collected small-volume and large-volume water column samples along the main stem of the Lower Passaic River and at the confluences of the major tributaries. (An evaluation of these data has not been completed.) Historical water chemistry data were discussed in the *Draft Geochemical Evaluation (Step 2)* (Malcolm Pirnie, Inc., 2006a) and are summarized below. [Refer to Section 4.7 "Water Column and Biota Evaluations," Appendix C, and Appendix D of the *Draft Geochemical Evaluation (Step 2)* (Malcolm Pirnie, Inc., 2006a) for more information.]

- For mercury, lead, Total PAH, Total PCB, and Total DDT, the suspended-phase concentrations approximate the surficial sediment concentrations, demonstrating the close link between the two media, presumably as the result of tidally driven resuspension and settling.
- In general, contaminants in the water column were primarily borne by the suspended solids as opposed to the dissolved-phase.
- The suspended solids and dissolved-phase both have a 2,3,7,8-TCDD/Total TCDD ratio of approximately 0.5 to 0.8, similar to that observed in the surface sediments of the Lower Passaic River, as would be expected given the close link between the two media.

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6.4 GROUNDWATER: CONTAMINATED MEDIUM

Groundwater represents another potential contaminant source area to the Lower Passaic River. Groundwater may impact surface water quality in two ways: (1) by carrying chemicals from nearby groundwater contamination sites to the surface water body; and (2) by displacing contaminated porewater contained within the sediments. Some studies have also shown that low molecular weight organic chemicals (such as solvents) dissolved in groundwater can mobilize heavier compounds having high soil-water partition coefficients (Huling, 1989).

The potential for groundwater that is discharging to the Lower Passaic River to be contaminated with lighter, organic compounds has not been evaluated. Several documented groundwater contamination sites are located adjacent to the river, so a strong likelihood exists that contaminated groundwater is discharged to the river. There is also anecdotal support for the existence of such contamination, such as observations of solvent odors by the Malcolm Pirnie, Inc. field team staff when processing the low resolution sediment cores (January 2006). The effect of these solvents on the mobilization of heavier hydrophobic compounds cannot be evaluated without knowledge of their distribution and concentration. Moreover, analyses of groundwater contaminant sources and transport mechanisms need to be conducted to assess groundwater's contribution to the river's contaminant load.

To begin to understand the impacts of contaminated groundwater to the Lower Passaic River, an evaluation was done to quantify the volume of water in the Lower Passaic River that originates as groundwater. The groundwater contribution to a river's flow is termed "base flow." When precipitation falls within a river's drainage area (or watershed), the majority of the water evaporates, flows overland to the river, or is removed by plants in transpiration. However, some water infiltrates to the groundwater table and flows underground until the water enters the river through the sediment bed. Because the underground flow encounters greater resistance than the overland flow, groundwater flows more slowly. Consequently, any groundwater surges from storm events are usually damped out before they reach the river, and base flow in many rivers is generally

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constant. While base flow does experience some variations due to seasonal changes and drought conditions, these variations are small compared to the variations observed in the overland flow.

The base flow to the Lower Passaic River was calculated using a water budget and subtracting out other additions to the river flow (refer to Attachment B for calculation). Because no gauging station exists on the Lower Passaic River, three nearby gauges (located in similar watersheds) were used as surrogates to estimate the base flow. The observed flow rates from these gauging stations were divided by their respective drainage areas to calculate the amount of the annual precipitation within the watershed that may enter the river as groundwater, resulting in a groundwater recharge value per unit area. Because the climate, soil type, land use and geologic setting for these watersheds are comparable, the calculated recharge values are similar to one another. The recharge values were averaged and then applied to the Lower Passaic River. When the recharge value was multiplied by the drainage area of the Lower Passaic River, the groundwater contribution was calculated to be about 20 cfs, which is more than 50 times less than the average river flow of 1,150 cfs over the Dundee Dam. The base flow is roughly equivalent to the flow from the Second River or Third River, small tributaries to the Lower Passaic River.

Given the high organic content of Lower Passaic River sediments and the potential for suspension and remobilization of large quantities of hydrophobic compound-laden sediments by erosion as a riverine process, it is unlikely that groundwater contaminant flux, even with enhanced transport potential from dissolved organic compounds, will approach the magnitude of the hydrophobic contaminant contribution presented by sediment resuspension and transport. However, the groundwater transport mechanisms are not quantified by field data, so their relative importance cannot be confirmed.

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7.0 CONTAMINANT FATE AND TRANSPORT

7.1 FATE AND TRANSPORT MODEL

A preliminary fate and transport model for the Lower Passaic River is presented in Figures 7-1 and 7-2. This model will be refined when the results of the problem-formulation phase of the BERA are available. The preliminary model presented in Figures 7-1 and 7-2 depicts the movement of chemicals between the sediment, water column, and air through a series of reactions and pathways to achieve equilibrium. Certain bioavailable, hydrophobic chemicals will also partition from either the sediment or water column into biological tissue. Depending on the chemical nature of these bioavailable chemicals, they may bioaccumulate in the food web, resulting in higher tissue concentrations in higher trophic level receptors.

The abiotic reactions and pathways are presented in Figure 7-1 as black arrows; biological pathways are added to this underlying graphic as green arrows and are presented in Figure 7-2. [For a discussion of biological exposure pathways and receptors, refer to the *Pathways Analysis Report* (Battelle, 2005) and the revised figures presented in Attachment D.] The chemical state (*i.e.*, sorbed chemical, dissolved chemical, or vapor) is denoted in the boxes, which represent inventory, while mechanisms are represented by arrows connecting associated boxes, as appropriate. Identification of complete exposure pathways, ecosystems potentially at risk, assessment endpoints, risk hypotheses, risk questions, and measurement endpoints as well as the refined list of COPECs, their effects, fate, and transport will be provided at the end of the problem-formulation phase of the BERA.

Figure 7-1 and Figure 7-2 portray general reactions and pathways that may occur in the Transitional River Section; however, some reactions and pathways may be absent or less significant for certain chemicals and for certain river sections. Potential mechanisms influencing fate and transport of a given chemical in the water and air include advection,

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flocculation (aggregation) or disaggregation, sorption or desorption, degradation, volatilization, and/or deposition. In the sediment, the potential mechanisms include sorption or desorption, resuspension, degradation, potential burial or bioturbation, and transformations. In biota, the potential mechanisms are bioconcentration and bioaccumulation.

7.2 NATURE AND EXTENT OF CONTAMINATION

The main contaminant transport mechanism for most contaminants in the Lower Passaic River is resuspension and settling of contaminated solids. As these solids move through the Study Area, they become incorporated into the sediment beds throughout the river and into Newark Bay. Geochemical and geochronological analyses of sediment chemistry data can then describe the nature and extent of contamination in the Study Area. The *Draft Geochemical Evaluation (Step 2)* (Malcolm Pirnie, Inc., 2006a) discusses the nature and extent of contamination for several contaminants in the Lower Passaic River. General geochemical observations include:

- The Lower Passaic River is a dynamic system with areas of net erosion intertwined and adjacent to areas of net deposition. Sediment transport is primarily driven by the twice-daily tidal mixing that causes surface sediments to resuspend and redeposit.
- The high degree of spatial heterogeneity exhibited in the coring data (RM0.9 to RM7) with respect to contaminant inventory suggests that localized areas of relatively higher concentrations typically described as “hot spots” do not exist in the Lower Passaic River. That is, local variation is so great that local deposits of significant inventory (as identified by several adjacent cores) are not apparent. Instead, “hot regions” of the river typically exist on the scale of a mile or more, nearly bank to bank in lateral extent. However, this conclusion does not diminish the significance of potential historic and/or current point sources as the origin of contaminant inventory in the Lower Passaic River. Estuarine mechanisms are believed to quickly render contaminant concentration gradients indistinct on the scales examined here. Nonetheless, it is possible that environmental sampling on a finer scale (on the order of less than a quarter mile) would identify localized

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gradients near prominent historical and/or current source areas. For example, evidence of a local source is suggested by two sediment cores (TSI cores 285 and 286; 1995 TSI dataset) on the southern shore of RM3.1.

- Dated sediment cores from the Upper Passaic River and Lower Passaic River were used to differentiate the source area for several major contaminants. These cores suggest that the major historical loads of cadmium, lead, mercury, and Total PCB originated in the Upper Passaic River above the Dundee Dam. A substantial load of copper was shown to have originated above the Dundee Dam, but an additional load was also shown to have been present below the dam in 1995. Smaller contaminant source areas, particularly for mercury, may also have existed in the Lower Passaic River (RM0.9 to RM7).
- Surface sediment data in the RM3.5 to RM4 region had a relatively high density of elevated values, occurring for several contaminants, although this observation was not statistically significant. Bathymetric data show that this region has a higher density of locations undergoing net erosion, re-mobilizing sediment, and exposing older, more-contaminated sediments. The consistent occurrence of these elevated values for several contaminant types tends to rule out the possibility of an ongoing external source since it would need to include all the major contaminants.

In the following sections, chemical-specific (mercury, lead, 2,3,7,8-TCDD, Total PCB, Total DDT, and Total PAH) discussions on the nature and extent of contamination are presented. The sediment bed schematic presented in Figure 7-3 accompanies this discussion. Mercury, lead, 2,3,7,8-TCDD, Total PCB, Total DDT, and Total PAH were selected for illustrative purposes only to describe the nature and extent of contamination and represent examples of the general contaminant classes present in the Study Area. These chemicals were originally presented in the *Draft Geochemical Evaluation (Step 2)* (Malcolm Pirnie, Inc., 2006a). The CSM will be updated with site-specific COPCs and COPECs after the problem-formulation phase of the BERA is completed.

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7.2.1 MERCURY CONTAMINATION

Dated sediment cores from the Upper Passaic River and Lower Passaic River and an examination of metals ratios suggest that the major historical mercury loads primarily originated in the Upper Passaic River above the Dundee Dam. An examination of the 1995 surface sediments in the Lower Passaic River suggests that at least two mercury source areas were present in 1995: one at or below RM1 and one at or above RM7 (which may be the same as the source area above Dundee Dam). Dated sediment cores show a similar condition for mercury in 1963. Peak mercury concentrations appear to have occurred in the 1960s or earlier. Dated sediment cores from the TSI 1995 dataset were insufficient to establish the depth of contamination for mercury; however, analysis of the 2006 low resolution sediment cores indicated that the sand layer underneath the fine-grained sediment beds was contaminated with mercury as well as other metals and Total PAH. The presence of mercury and the other contaminants at this depth suggests that they may have been present in the Lower Passaic River since the time of the original construction of the navigational channel.

7.2.2 LEAD CONTAMINATION

Like mercury, major lead contamination in the Lower Passaic River occurred in the 1960s or earlier. Elevated concentrations of lead (approximately 700 mg/kg) occur at depth in dated sediment cores from the TSI 1995 dataset, usually reaching a maximum at the core bottom. This evidence indicates that the vertical extent of lead (as well as other metals, such as arsenic, chromium, copper, cadmium, and mercury) is undefined for nearly all of the 1995 TSI cores. The 2006 low resolution sediment cores indicated that the sand layer underneath the fine-grained sediment beds was contaminated with lead as well as mercury, other metals, and Total PAH. Major inventories of lead and other metals most likely lie below the documented depth of 2,3,7,8-TCDD contamination. An examination of metals ratios in dated sediment cores and surface sediment samples further supports the origin of the Lower Passaic River lead contamination above the Dundee Dam (Malcolm Pirnie, Inc., 2006a). Further information on metal contaminants (including cadmium and copper) in the Lower Passaic River can be found in the *Draft Geochemical Evaluation (Step 2)* (Malcolm Pirnie, Inc., 2006a).

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7.2.3 2,3,7,8-TCDD CONTAMINATION

Consistent with the observations by Bopp *et al*. (1991a) and Chaky (2003) for Newark Bay, dated sediment cores from the 1995 TSI dataset (RM0.9 to RM7) show that the major releases of 2,3,7,8-TCDD began in the late 1940s to early 1950s and peaked in the late 1950s to early 1960s. Dated sediment cores from the Upper Passaic River and Lower Passaic River further indicate that much less than 1 percent of the 2,3,7,8-TCDD contamination in the Lower Passaic River originated above the Dundee Dam historically. The Upper Passaic River remains a trivial source of 2,3,7,8-TCDD to the Lower Passaic River despite the passage of time.

The diagnostic ratio of 2,3,7,8-TCDD/Total TCDD of 0.7 can be used to trace Lower Passaic River 2,3,7,8-TCDD throughout the Newark Bay complex and over the last 60 years. Based on dated sediment cores, this diagnostic ratio is observed throughout the sediments of the Lower Passaic River as far back as the 1950s. Prior to 1950, however, the 2,3,7,8-TCDD/Total TCDD ratio declines to a value of 0.1, approaching the value of 0.06, which is characteristic of sewage and atmospheric fallout (Chaky, 2003). The 2006 low resolution sediment cores indicated that the sand layer underlying the fine-grained sediment beds is not contaminated with 2,3,7,8-TCDD.

7.2.4 TOTAL DDT CONTAMINATION

Dated sediment cores reveal that Total DDT contamination in the Lower Passaic River began in the 1930s, peaking in the late 1940s or early 1950s, consistent with the observations of Bopp *et al.* (1991a). Results consistently show measurable Total DDT concentrations occurring deeper in the sediment core than measurable 2,3,7,8-TCDD concentrations. Dated sediment cores from the Upper Passaic River and Lower Passaic River further indicate that, *circa* 1995, a small proportion, perhaps one quarter of the input of the Total DDT contamination in the Lower Passaic River, originated above the Dundee Dam. The observation relating the Upper Passaic River to the Lower Passaic River is tempered by the fact that measurements of Total DDT above the Dundee Dam were limited to only one form of DDT, specifically DDD. Thus, the total amount of DDT and its derivatives was not measured.

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7.2.5 TOTAL PCB CONTAMINATION

Total PCB contamination is distributed throughout the Lower Passaic River with peak concentrations (4 to 18 mg/kg) occurring in the sediments dating to the 1960s or later. Hence, the extent of Total PCB contamination in the sediment beds is shallow when compared to mercury, lead, 2,3,7,8-TCDD, and Total DDT. Aroclor 1248 is the most commonly reported PCB mixture, typically comprising 60 percent or more of the Total PCB burden. Dated sediment cores from the Upper Passaic River and Lower Passaic River suggest that the major historical loads of Total PCB primarily originated in the Upper Passaic River above the Dundee Dam. In 1963, the Total PCB input upriver of the Dundee Dam accounted for the majority of the Total PCB load in the Lower Passaic River. However, evidence suggests that recently (*circa* 1995), the Upper Passaic River Total PCB input has become less important relative to Lower Passaic River Total PCB load. Nevertheless, the Upper Passaic River source area may still comprise one-third of the Total PCB loading in the Lower Passaic River. Evidence also suggests that in 1995 at least one source area existed in the Lower Passaic River for Total PCB (Malcolm Pirnie, Inc., 2006a).

7.2.6 TOTAL PAH CONTAMINATION

Total PAH contamination is unique in its temporal distribution, with the highest concentrations observed in the deepest core layers, gradually declining to the most recent deposition. The presence of Total PAH contamination in the sand layer underneath the thick silt deposits may represent historic deposition or alternatively a contaminated groundwater source.

Ratio analysis of Total PAH shows that the majority of PAH contamination in the sediments is derived from combustion-related processes (Malcolm Pirnie, Inc., 2006a). The ratio “fingerprint” suggests that Total PAH originates from two sources: coal tar residue (a by-product of manufactured gas plants) and urban background combustion. Of these sources, coal tar wastes are the dominant source to the Lower Passaic River based on the prevalence of coal tar-like PAH ratios in more-contaminated sediments. The same analysis essentially rules out creosote-derived contamination and suggests that only

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minor portions of the sediment PAH contamination are derived from a petrogenic source (*e.g.*, oils spills).

7.3 ESTIMATES OF THE VOLUME OF CONTAMINATED SEDIMENT AND THE ASSOCIATED MASS OF CONTAMINANTS

7.3.1 ESTIMATES OF THE VOLUME OF CONTAMINATION

The combination of the navigational dredging activities and the long and extensive history of contaminant discharges to the Lower Passaic River have served to create a uniquely large inventory of highly contaminated sediments contained within a relatively small area. Other major Superfund sites may have similar volumes of contaminated sediments [*e.g.*, Hudson River PCB site at 2.6 million cubic yards (USEPA, 2002) and Fox River PCB site at 8 million cubic yards (USEPA, 2003a)], but these inventories are spread over much greater distances than the 17 miles of the Lower Passaic River. While data are not sufficient to assess the volume of contaminated sediment for the entire Lower Passaic River, the volume is estimated at 5 to 8 million cubic yards for RM0.9 to RM7, with an average depth of contamination ranging from 7 to 13 feet. The evidence from the side-scan sonar and bathymetric surveys suggests that the conditions observed in RM0.9 to RM7 probably also apply over the area of RM0 to RM8, suggesting that the actual inventory of contaminated sediments is at least one-third greater than the values obtained in the *Draft Geochemical Evaluation (Step 2)* (Malcolm Pirnie, Inc., 2006a). The volume of 2,3,7,8-TCDD-contaminated sediments is somewhat smaller than the overall contaminated sediment volume, since several contaminants are present at greater depths than 2,3,7,8-TCDD. The estimate of 2,3,7,8-TCDD-contaminated sediment volume ranges from 5 to 6.5 million cubic yards for RM0.9 to RM7.

The mass of contaminants contained within the sediments is also quite large (Table 7-1). Moreover, the mass of 2,3,7,8-TCDD represents one of the largest site inventories in the United States.

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Table 7-1: Summary of Contaminant Inventory Estimates for RM0.9 to RM7

Inventory Estimate [a]	Total DDT (metric tons)	2,3,7,8-TCDD (kilograms)	Mercury (metric tons)	Total PCB (metric tons)
Based on measured core intervals only	6.4	20	24	6
Based on measured and extrapolated core profiles	11	29	37	8
Percent Increase [b]	72 percent	45 percent	54 percent	33 percent

a: Based on information provided in *Draft Geochemical Evaluation (Step 2)* (Malcolm Pirnie, Inc., 2006a).
b: Percent increase is relative to the interpolated mass estimate.

Uncertainties are associated with these estimates, which arise from the lack of horizontal coverage and lack of "completeness" in the vertical direction. As mentioned above, the physical survey data suggest that at least two additional miles (RM7 to RM8 and RM0 to RM0.9) of the Lower Passaic River may contain substantive inventories (extrapolation uncertainty). Additionally, large distances exist between many of the cores located within RM0.9 to RM7, adding some uncertainty to the estimated volumes; however, the direction of any correction is not known (interpolation uncertainty). Finally, many of the cores used in the estimates were not "complete," or they did not penetrate and capture the entire sequence of contaminated sediments (vertical extrapolation uncertainty). These cores were extrapolated based on profiles observed in other cores. The range in volume estimates given above (5 to 8 million cubic yards) reflects the uncertainty related to horizontal interpolation and vertical extrapolation, with the lower value based only on the measured core intervals, and the larger value incorporating the vertically extrapolated mass estimates. This range does not include the volume related to horizontal extrapolation from RM7 to RM8 and from RM0 to RM0.9.

To estimate the sediment volume from RM7 to RM8 and from RM0 to RM0.9, the conditions in the one-mile lengths of river adjacent to these stretches were extrapolated. Extrapolation was performed on the basis of surface area of the river. Thus, the average depth of sediment and the average MPA in these adjacent one-mile lengths were applied to the surface area of these stretches. These calculations were performed for mercury to obtain the total volume of contaminated sediment as well as the entire mass of mercury, because mercury is one of the oldest (deepest) contaminants (Table 7-2). They were also

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performed for 2,3,7,8-TCDD to obtain an estimate of the 2,3,7,8-TCDD inventory for the lower 8 miles in total (Table 7-3).

Table 7-2: Estimated Mass and Estimated Volume of Mercury-Contaminated Sediments

Analyte	Average Extrapolated MPA (g/m^2)	Extrapolated Mercury Mass (kilograms)	Average Extrapolated Depth (feet)	Extrapolated Volume of Sediment (cubic yards)
RM0 to RM0.9	23	7,400	14	1,800,000
RM0.9 to RM7	19	37,000	13	6,500,000
RM7 toRM8	22	5,500	12	1,200,000
Total RM0 to RM8	**20**	**50,000**	**13**	**9,500,000**
RM8 to RM15 [a]	14	4,900	11	1,500,000
RM8 to RM15 [b]	5.2	1,800	4	550,000

a: Values were calculated for the fine-grained sediments only by assuming the average extrapolated mass per unit area and depth of contamination from RM6 to RM7. The inventory in the coarse-grained sediment was not calculated.
b: Values were calculated assuming average depth of contamination of approximately 4 feet based on the geotechnical and high resolution cores collected above RM8.

Table 7-3: Estimated Mass and Estimated Volume of 2,3,7,8-TCDD-Contaminated Sediments

Analyte	Average Extrapolated MPA (mg/m^2)	Extrapolated 2,3,7,8-TCDD Mass (kilograms)	Average Extrapolated Depth (feet)	Extrapolated Volume of Sediment (cubic yards)
RM0 to RM0.9	6.5	2	12	1,500,000
RM0.9 to RM7	19	29	11	6,500,000
RM7 toRM8	11	2.4	7.8	660,000
Total RM0 to RM8	**16**	**33**	**11**	**8,700,000**
RM8 to RM15 [a]	8.5	2.9	11	1,200,000
RM8 to RM15 [b]	3.1	1.1	4	550,000

a: Values were calculated for the fine-grained sediments only by assuming the average extrapolated mass per unit area and depth of contamination from RM6 to RM7. The inventory in the coarse-grained sediment was not calculated.
b: Values were calculated assuming average depth of contamination of approximately 4 feet based on the geotechnical and high resolution cores collected above RM8.

The inventory for RM0 to RM0.9 was estimated using the average MPA, the depth of contamination, and the actual surface area from RM0.9 to RM1.9. The surface area of RM0.9 to RM1.9 was used as a basis to limit the horizontal spread of the estimate where the river widens at its mouth into shallow, non-channel areas, which are unlikely to be contaminated at depth. The inventory for RM7 to RM8 was estimated using the average MPA and the depth of contamination for RM6 to RM7, but using the actual surface area between RM7 and RM8. Based on the inventories estimated from RM0 to RM0.9,

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RM0.9 to RM7 (Table 7-2 and Table 7-3), and RM7 to RM8, the estimated volume of contaminated sediment from RM0 to RM8 thus calculated approaches 10 million cubic yards. This estimate represents an increase of 25 to 50 percent over the original estimates of contaminated sediments in RM0.9 to RM7. The inventory of mercury in the sediments between RM0 to RM8 is estimated at 50,000 kilograms, and the inventory of 2,3,7,8-TCDD is estimated at 33 kilograms.

A separate inventory estimate was created for the region above RM8, based solely on the extent of fine-grained sediments as estimated from interpreted side-scan sonar images (Aqua Survey, Inc., 2006) and the depth penetrated by geotechnical cores collected in June 2005. In this region of the river, fine-grained sediments represent only about a third of the river bottom, as compared to more than 80 percent below RM8. Estimates of the MPA and the depth of contamination were obtained by using the mean values for these parameters based solely on the fine-grained areas in RM6 to RM7. The higher values given in Tables 7-2 and 7-3 use these mean values directly. The lower volume and mass estimates are obtained by multiplying the average MPA for RM6 to RM7 times the nominal thickness of fine-grained sediment determined from the geotechnical cores (*i.e.*, 4 feet). This estimate suggests that the fine-grained sediments outside of RM0 to RM8 represent only about 6 percent of the volume of contaminated sediment below RM8. No estimate of the inventory in coarse-grained areas was created due to lack of appropriate data.

7.3.2 DISTRIBUTION OF INVENTORY WITH RIVER MILE

The contaminant inventories are not evenly distributed and vary along the length of the Lower Passaic River, with maximum values occurring near the areas encompassing RM1 to RM2, RM3 to RM4, and RM6 to RM7. However, the coring data, which form the basis for these inventories, indicate a high degree of local spatial heterogeneity, suggesting that localized areas of relatively higher concentrations typically described as "hot spots" do not exist. Instead, "hot regions" of the river typically exist on the scale of a mile or more, nearly bank to bank in lateral extent. This conclusion does not, however, diminish the significance of potential historic and/or current point sources as the origin of

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contaminant inventory in the Lower Passaic River. Estuarine mechanisms are believed to quickly render contaminant concentration gradients indistinct on the scales examined here. It is possible that environmental sampling on a finer scale (on the order of less than a quarter mile) would identify localized gradients near prominent historical and/or current source areas. For example, evidence of a local source is suggested by two sediment cores (TSI cores 285 and 286; 1995 TSI dataset) on the southern shore of RM3.1.

Despite the observations of local spatial heterogeneity, the inventories of the four examined contaminants (mercury, 2,3,7,8-TCDD, Total PCB, and Total DDT) were shown to correlate, indicating that their inventories coincide in space and are consistent with the anticipated geochemical behavior of the compounds (Figure 7-4). Essentially, when a location has a locally high inventory of any one of these four contaminants, the other contaminants will also be concentrated at that location. It is anticipated that similar behavior will be exhibited by any hydrophobic compound in the Lower Passaic River. As noted previously, the variations in inventory are not believed to represent proximity to external point sources. Rather, variations in inventory may represent variations in the rate of deposition, with sites having higher rates of deposition generating larger contaminant inventories. Both the coring data and the bathymetric survey analyses performed for the Lower Passaic River suggest a high degree of spatial heterogeneity in inventory and deposition rate, supporting this premise.

7.4 INITIAL MASS BALANCE FOR THE LOWER PASSAIC RIVER AND NEWARK BAY

An initial mass balance for the Lower Passaic River and Newark Bay was documented in the *Draft Geochemical Evaluation (Step 2)* (Malcolm Pirnie, Inc., 2006a). In this initial mass balance, contributions from non-point sources and floodplains were not considered because data gaps exist for the solids load and contamination from each of these source areas, and because they were not deemed likely to represent substantive contaminant sources. The mass balance estimates for Newark Bay involve the simultaneous balancing of solids, 2,3,7,8-TCDD, and Total TCDD, thereby forcing the mass balance parameters to reasonably predict all three constituents. The mass balance calculations used the work

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by Lowe, *et al.* (2005) as a starting point, and then adjusted various factors in order to achieve a mass balance for all three constituents. The premise of the mass balance is to equate the annual loads to Newark Bay with the average annual removal of solids and contaminants from Newark Bay by maintenance dredging activities. The results of the 2,3,7,8-TCDD mass balance calculations are discussed below. A mass balance analysis was also attempted for mercury based on the solids loads developed from the simultaneous 2,3,7,8-TCDD and solids balances (refer to Section 7.4.2 "Mercury Mass Balance").

7.4.1 2,3,7,8-TCDD MASS BALANCE

The ratio of 2,3,7,8-TCDD/Total TCDD is a conservative tracer of solids in the Study Area and Newark Bay. Fitting a mass balance to them provides a powerful constraint on the mass balance calculations since loads of both contaminants must be matched with the same set of solids inputs.

The mass balance results for 2,3,7,8-TCDD and Total TCDD are presented in Table 7-4 [excerpted from the *Draft Geochemical Evaluation (Step 2)* (Malcolm Pirnie, Inc., 2006a)]. The total mass of 2,3,7,8-TCDD entering Newark Bay is approximately 14 grams/year, resulting in a calculated Newark Bay sediment concentration of 0.083 μg/kg. Since this calculated concentration approximates the measured 2,3,7,8-TCDD concentration, other major sources of 2,3,7,8-TCDD are unlikely, and the chemical mass balance is considered closed. Similarly for Total TCDD, the mass balance appears closed since the estimated surface concentration matches the measured concentration in Newark Bay. The balance is further verified by the estimated ratio of 2,3,7,8-TCDD/Total TCDD, which also matches the measured data. Based on the concurrent mass balances, the Lower Passaic River comprises approximately 10 percent of the total amount of solids accumulating in the Newark Bay and more than 80 percent of the 2,3,7,8-TCDD accumulating in the bay. No other single source delivers more than 10 percent of the total 2,3,7,8-TCDD load.

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Table 7-4: 2,3,7,8-TCDD Mass Balance for Newark Bay

Source Area [a]	Solids Mass Balance [b]		2,3,7,8-TCDD Concentration	2,3,7,8-TCDD Annual Load	Total TCDD Concentration	Total TCDD Annual Load	Ratio of 2,3,7,8-TCDD to Total TCDD
	cubic yards/year	metric-tons/year	µg/kg [c]	grams/year	µg/kg [c]	grams/year	unitless
Passaic River (RM0.9 to RM7)	35,600	21,200	0.54	12	0.68	14	0.8
Mouth of Hackensack River	6,460	3,870	0.093	0.36	0.14	0.54	0.67
CSO/WWTP [d]	10,500	6,300	Unk [e]	Unk	Unk	Unk	Unk
Atmospheric Deposition	285	170	Unk	Unk	Unk	Unk	Unk
Kill van Kull	241,000	116,000	0.01 [f]	1.16	0.07	7.7	0.15
Arthur Kill	49,300	23,700	0.05	1.19	0.18	4.2	0.28
Total	343,000	171,000		14		26	
Newark Bay Calculated			**0.083**		**0.15**		**0.53**
Newark Bay Measured			**0.076**		**0.16**		**0.56**
Total Annual Load	**343,000 cubic yards/year**			**14 grams/year**		**26 grams/year**	

a: Excerpt from *Draft Geochemical Evaluation (Step 2)* (Malcolm Pirnie, Inc., 2006a).
b: Solids mass balance based on Lowe, *et al*. (2005) with several adjustments made to satisfy the chemical mass balance. Conversion of sediment volume to sediment mass as given by Lowe, *et al* (2005).
c: Concentrations represent average surface sediment concentrations for 1991 to 1995 sediments, unless otherwise noted.
d: WWTP = Wastewater treatment plant
e: Unk = unknown value. Mass fluxes for source areas within unknown values were set to zero for the chemical mass balance.
f. Concentration represents mean New York Bay sediments at the entry to Kill van Kull, 1994 to 1998 (Chaky, 2003).

7.4.2 MERCURY MASS BALANCE

Unlike the 2,3,7,8-TCDD and Total TCDD mass balances, the mercury mass balance required an additional, substantive mercury input to complete the balance [Table 7-5; excerpted from the *Draft Geochemical Evaluation (Step 2)* (Malcolm Pirnie, Inc., 2006a)]. The total mass of mercury entering Newark Bay from known source areas is 259 kg/year. This annual load yields a calculated average Newark Bay sediment concentration for mercury of 1.5 mg/kg. The calculated average concentration is much less than the measured average mercury concentration of 2.4 mg/kg, indicating another

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mercury input. To complete the mercury mass balance, additional source(s) producing 150 kilograms per year (kg/year) are required to meet the measured Newark Bay sediment concentration of 2.4 mg/kg. Atmospheric deposition alone cannot account for the missing mercury load. Annual mercury precipitation fluxes in the State of New Jersey range from 11 to 14 micrograms/square meter/year ($\mu g/m^2/yr$; Reinfelder *et al*., 2004). Using the highest flux, the amount of mercury delivered by the atmosphere to Newark Bay is approximately 250 grams/year, which is significantly less than the missing mercury load of 150 kg/year. Therefore, a significant, but currently unknown, source of mercury must exist on Newark Bay. This mercury source may be related to the exchange of particles from the Hackensack River, which is not accounted in the "net" solids mass balance of Table 7-5, alternatively it may be a local source.

Table 7-5: Mercury Mass Balance for Newark Bay

Source Area [a]	Solids Mass Balance [b]		Mercury Concentration	Mercury Annual Load
	cubic yards/year	metric-tons/year	mg/kg [c]	grams/year
Passaic River (RM0.9 to RM7)	35,600	21,200	3.4	73,000
Mouth of Hackensack River	6,460	3,870	4.0	16,000
CSO/WWTP	10,500	6,300	Unk [d]	Unk
Atmospheric Deposition	285	170	Unk	Unk
Kill van Kull	241,000	116,000	1.1	132,000
Arthur Kill	49,300	23,700	1.6	38,000
Total	343,000	171,000		259,000
Newark Bay Calculated			**1.5**	
Missing Mercury Input				**150,000**
New Newark Bay Calculated			**2.4**	
Newark Bay Measured			**2.4**	
Net Annual Load				**409,000 grams/year**

a: Excerpt from *Draft Geochemical Evaluation (Step 2)* (Malcolm Pirnie, Inc., 2006a).
b: Solids mass balance based on Lowe, *et al*. (2005) with several adjustments made to satisfy the chemical mass balance. Conversion of sediment volume to sediment mass as given by Lowe, *et al.*, 2005.
c: Mercury concentrations represent average surface sediment concentrations for 1991 to 1995 sediments.
d: Mass fluxes for source areas within unknown values were set to zero for the chemical mass balance.

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8.0 UNCERTAINTIES AND FUTURE UPDATES

The CSM presented in this document is based on geochemical, geophysical, and geotechnical data. Together, these data describe the fate and transport of contaminants in the river and the nature and extent of contamination. The quality and amount of data are sufficient to identify the processes occurring within the river, to advance the CSM considerably, and to support the ongoing project needs. However, data gaps do exist in the datasets, which consequently result in uncertainties within the CSM. For example, very limited field data exist for areas upriver of RM7 and between RM0 and RM1. Water column and hydrodynamic data are also incomplete for the Lower Passaic River. Other uncertainties involve the appropriate linkage of the human health and ecological exposure pathways and receptors (Battelle, 2005) to construct a comprehensive CSM.

Tables 8-1 and 8-2 summarize the known data gaps in the CSM and potential action that may occur to address these data gaps (based on source areas originally presented in Tables 6-1 and 6-2).

Table 8-1: Known Data Gaps and Uncertainties in the CSM for the Sediment Beds

Potential Source Area to Sediment Beds	Known Data Gaps	Potential Action to Address Data Gap
Transport of solids originating above Dundee Dam	• Limited data on solids transport over dam. • Data gap in current sediment chemistry above Dundee Dam.	• Evaluate November 2005 (Malcolm Pirnie, Inc.) small volume water column data. • Analyze and evaluate January 2007 (Malcolm Pirnie, Inc.) Dundee Lake high resolution cores.
Resuspension and erosion/deposition of solids due to tides	• Limited data on suspended solids in the river. • Data gap for magnitude of the process.	• Evaluate November 2005 (Malcolm Pirnie, Inc.) small volume water column data. • Evaluate available suspended solids data collected during the dredge pilot study (December 2005). • Evaluate 2005 (Malcolm Pirnie, Inc.) high resolution sediment cores. • Estimate gross resuspension and settling processes via model simulation.

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Table 8-1 (continued)		
Transport of solids from Newark Bay	• Data gap for magnitude of solids exchange • Data gap between RM0 and RM1	• Evaluate data from the anticipated Phase 2 remedial investigation field work. • Additional sediment and water column sampling is expected to be implemented in the near future between RM0 and RM1. • Modeling analysis by HydroQual, Inc. is ongoing.
Resuspension and erosion/deposition of solids from tributaries	• Limited data on suspended solids in the tributaries. • Data gap in suspended solids and sediment chemistry from the tributaries	• Evaluate tributary suspended solids and chemistry data within November 2005 (Malcolm Pirnie, Inc.) small volume water column dataset.
Discharge of solids from non-point sources	• Data gap on solids from non-point sources.	• Evaluate data available under the CARP.
Discharge of solids from point sources	• Data gap on solids from point sources.	• Evaluate data available under the CARP. • A sampling program designed to collect water samples from CSOs and other outfalls to the Lower Passaic River is expected to be implemented in the near future.
Burial of surficial sediment to deep sediment beds	• Data limited to the 1989 and 2004 bathymetric surveys for upriver areas.	• Evaluation of sediment chronologies in high and low resolution sediment cores.
Resuspension and erosion/deposition on mudflats	• Limited sediment chemistry data on the mudflats. • Limited data on sediment transport on the mudflats.	• A mudflat sampling program is outlined in *Field Sampling Plan Volume 1* (Malcolm, Pirnie, Inc., 2006d).
Resuspension and erosion/deposition on floodplains	• Data gap on sediment chemistry and sediment transport on the floodplain.	• Modeling analysis by HydroQual, Inc. is ongoing.
Interactions between sediment, groundwater, and porewater	• Data gap on porewater and groundwater conditions	• This data gap necessitates field investigations of porewater contaminant transport. It is anticipated that the next round of field investigations will begin in the middle of 2007.
Remobilization of sediment due to floods		• Modeling analysis by HydroQual, Inc. is ongoing. • More rigorous analysis of bathymetric data in concert with hydrographic data is needed. • Storm-event suspended solids sampling is necessary.

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Table 8-2: Known Data Gaps and Uncertainties in the CSM for the Water Column

Potential Source Area to the Water Column	Known Data Gaps	Potential Action to Address Data Gap
Main-stem flow originating above the Dundee Dam	• Data gap in water chemistry, suspended solids chemistry, and suspended solids load above dam.	• Evaluate November 2005 (Malcolm Pirnie, Inc.) small volume water column data. • Evaluate January 2007 Dundee Lake high resolution cores.
Tidal exchange with adjacent river sections	• Limited data available on tidal exchange volume and sediment load. • Data gap in water chemistry in Newark Bay.	• Evaluate November 2005 (Malcolm Pirnie, Inc.) small and large volume water column data. • Evaluate data from semi-permeable membrane devices deployed in 2005. • A regular, ongoing water column monitoring program for the Lower Passaic River is required. • Tidal exchange volume to be estimated via computer simulation of salinity data.
Discharge of water from tributaries	• Limited data available on tributary contribution of flow and chemistry.	• Evaluate November 2005 (Malcolm Pirnie, Inc.) small and large volume water column data. • Evaluate data from semi-permeable membrane devices deployed in 2005. • A regular, ongoing water column monitoring program for the Lower Passaic River tributaries is required.
Discharge and runoff of water from non-point sources	• Data gap in water chemistry and volume from non-point sources.	• Evaluate data available under the CARP.
Discharge of water from point sources	• Data gap in water chemistry from point sources.	• Evaluate data available under the CARP. • A sampling program designed to collect and analyze water samples from CSOs and other outfalls to the Lower Passaic River is expected to be implemented in the near future.
Exchange between porewater and water column	• Data gap for porewater conditions.	• Conduct field investigations of porewater contaminant transport.
Exchange between groundwater and water column	• Data gap for groundwater conditions.	• Conduct literature review of vicinity sites with known groundwater contamination; assess need for field investigations of groundwater discharge to the Lower Passaic River.
Atmospheric dry and wet deposition and volatilization	• Limited atmospheric data available for the region.	• Continue to evaluate data available through the New Jersey Atmospheric Deposition Network.

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To address the current data gaps and uncertainties within the CSM, data should continue to be collected and evaluated. Moreover, as relevant data gaps are identified during further application of the CSM and the iterative DQO process, a procedure is needed for maintaining, refining, and updating the CSM to describe site-specific conditions. To accomplish this CSM refinement, appropriate study questions, including risk hypotheses and questions aimed at evaluating risk-based remediation, should continue to be posed. Then, historical data should be evaluated and appropriate field data collected to address the Study questions and to increase the understanding of the system. Due to the complexity of the Study, future iterations of the CSM may include separate models to highlight different aspects of the project. These individual models may focus on source areas, release mechanisms, and media. The CSM should also be refined to include the site-specific exposure pathways, measurement endpoints, assessment endpoints, COPCs, and COPECs that will be identified as part of the problem-formulation phase of the BERA.

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9.0 ACRONYMS

BERA	Baseline Ecological Risk Assessment
CARP	Contaminant Assessment and Reduction Program
cfs	cubic feet per second
COPCs	Chemicals of potential concern
COPECs	Chemicals of potential ecological concern
CSM	Conceptual Site Model
CSOs	Combined Sewer Overflows
DDD	dichlorodiphenyldichloroethane
DDE	dichlorodiphenyldichloroethylene
DDT	dichlorodiphenyltrichloroethane
DQO	Data Quality Objective
g/m^2	grams per squared meter
kg/year	kilograms per year
mg/kg	milligrams per kilogram of sediment
mg/m^2	milligrams per squared meter
MLW	Mean Low Water
MPA	Mass per Unit Area
N	Sample Size
NA	Not available (refer to acronym used in table)
ng/kg	nanograms per kilogram of sediment
NGVD29	National Geodetic Vertical Datum of 1929
NJDEP	New Jersey Department of Environmental Protection
NJDOT	New Jersey Department of Transportation
NJPDES	New Jersey Pollutant Discharge Elimination System
OSWER	Office of Solid Waste and Emergency Response
PAH	Polycyclic Aromatic Hydrocarbons
PCB	Polychlorinated Biphenyls
PCDD/F	Polychlorinated Dibenzodioxins/furans

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pCi/g	picocuries per gram of sediment
QAPP	Quality Assurance Project Plan
RM	River Mile
SVOC	Semivolatile Organic Compounds
2,3,7,8-TCDD	2,3,7,8-Tetrachlorodibenzo-p-dioxin
Total TCDD	Total Tetrachlorodibenzodioxin
TSI	Tierra Solutions, Inc.
Unk	Unknown (refer to acronym used in table)
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
WWTP	Wastewater Treatment Plant
‰	parts per thousand or “per mil”
µg/kg	micrograms per kilogram of sediment
$\mu g/m^2/yr$	microgram/square meter/year

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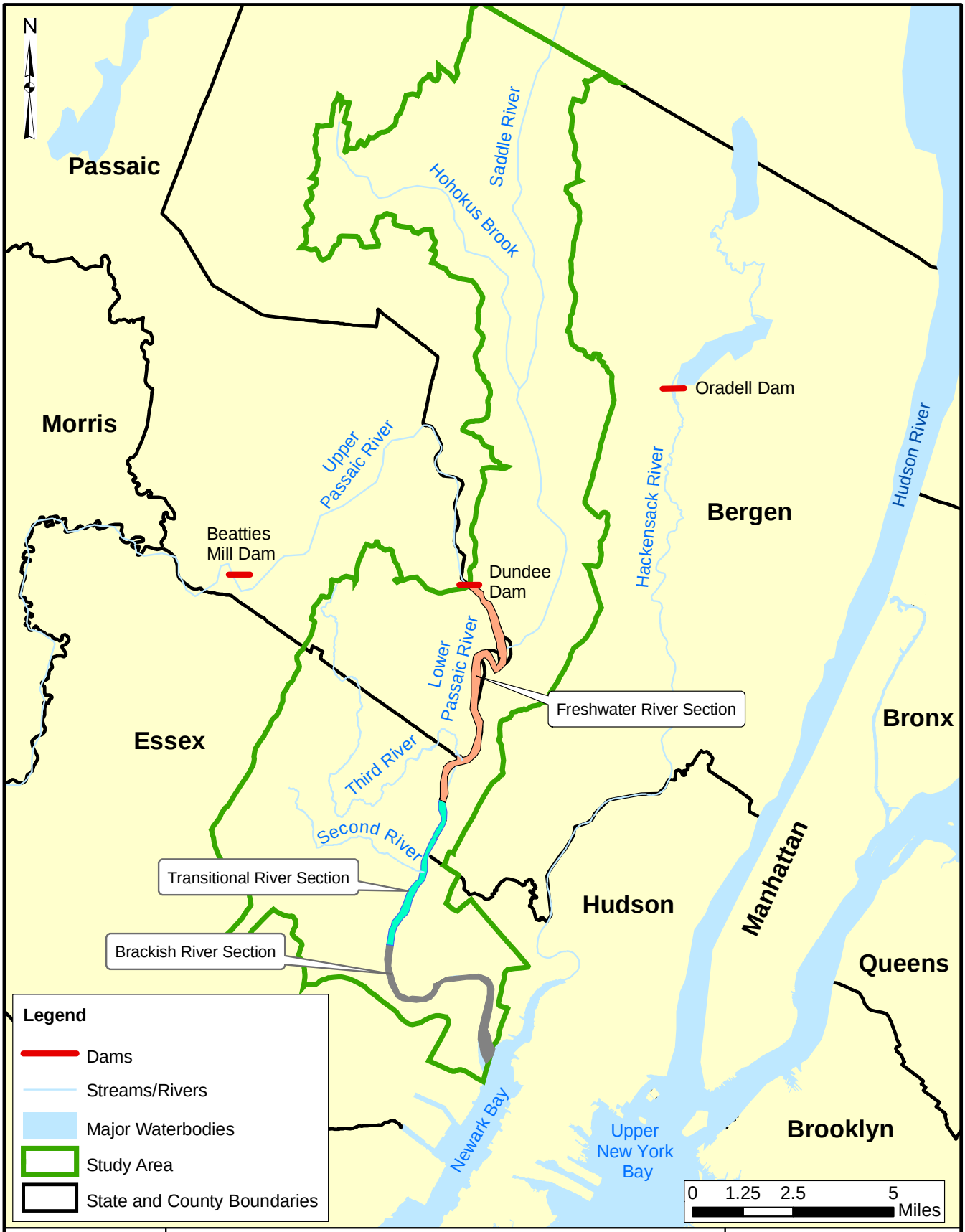
Figures



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Study Area Location Map

Lower Passaic River Restoration Project

Figure 1-1

February 2007

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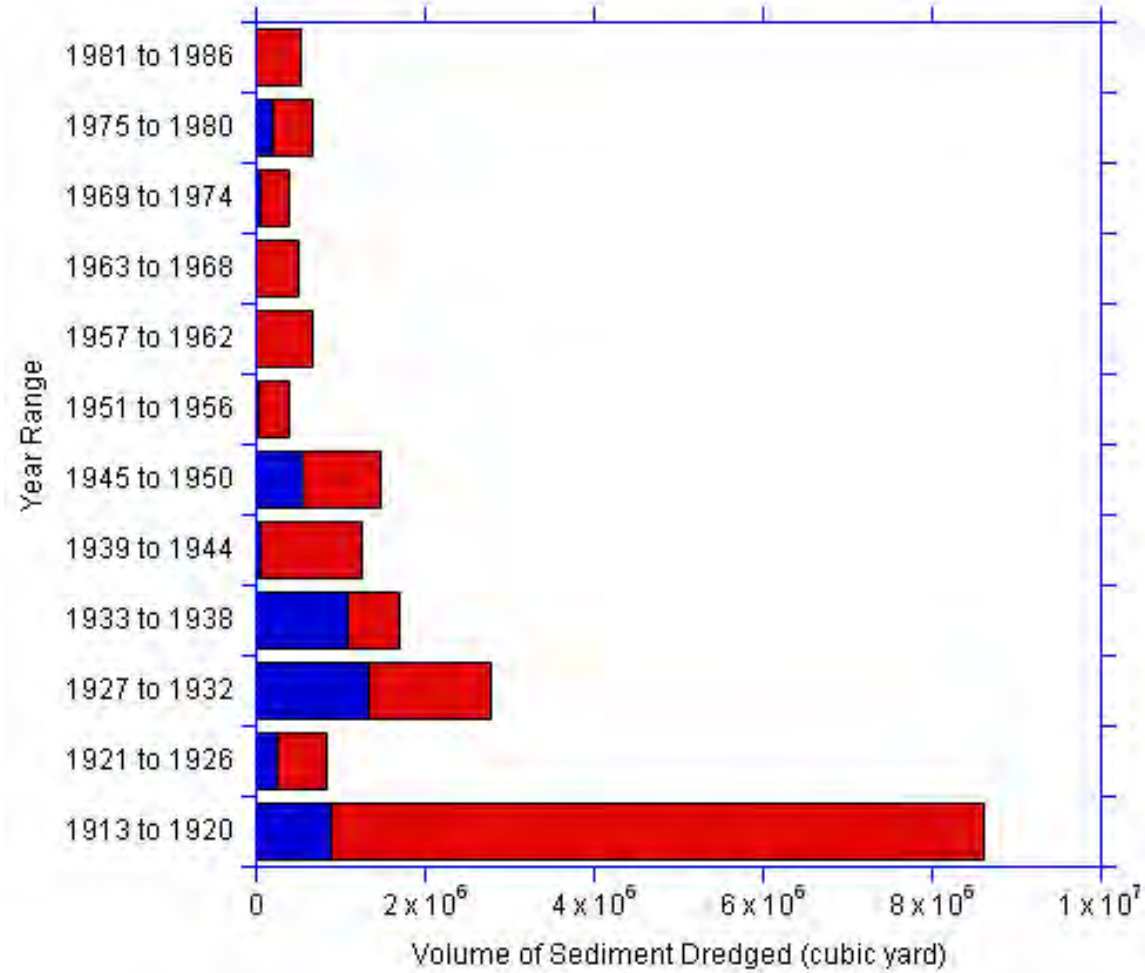


Legend

- Below RM2
- Above RM2

Notes

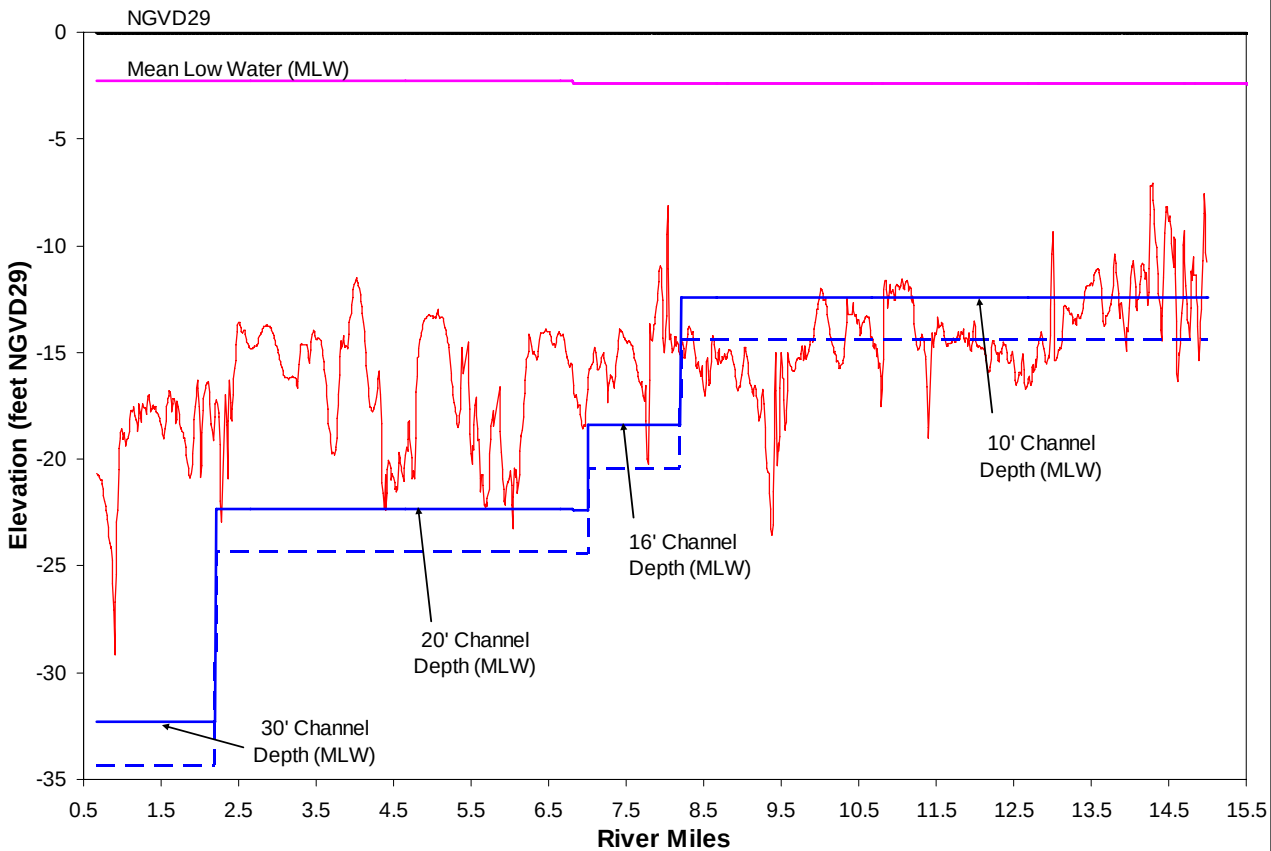
Data Sources: USACE, 1880, USACE, 1884, USACE, 1900, USACE, 1907, USACE, 1913, USACE, 1915, USACE, 1916, and USACE, 1917 as cited in Iannuzzi, *et al*., 2002 (refer to Section 10 "References" for complete citation).

The History of Dredging in the Lower Passaic River

Lower Passaic River Restoration Project

Figure 1-2

February 2007



Legend

- Navigational Channel Centerline Bathymetry
- Navigational Channel Depth
- Navigational Channel Depth + 2 feet

Notes

Channel depths were dredged relative to mean low water (MLW). The difference between NGVD29 and MLW is approximately 2.3 feet.

Solid blue line represents federally mandated channel depth.

Dashed blue line represents the channel depth +2 feet which would have been the dredged depth in order to maintain the federally specified channel depth.

Elevation data estimated from 2004 bathymetric data surveyed by Rogers Survey,Inc. for USACE.

River Bottom Elevation and Authorized Channel Depths

Lower Passaic River Restoration Project

Figure 1-3

February 2007

R2-0009068

Legend

- Rock and Coarse gravel
- Gravel and Sand
- Sand
- Silt and Sand
- Silt
- River Mile Post

2004 USACE Bathymetric Survey

Elevation (Feet) Relative to NGVD29

- -30 to -20
- -8 to 0
- -18 to -10
- 2 to 10

Notes

Data Sources:
Buildings: CADD drawing, 09994X01, dated January 1, 2002 received from BBL.

Roads: 2000 TIGER line data.

Sediment Texture: 2005 Side scan SONAR data from Aqua Survey, Inc.

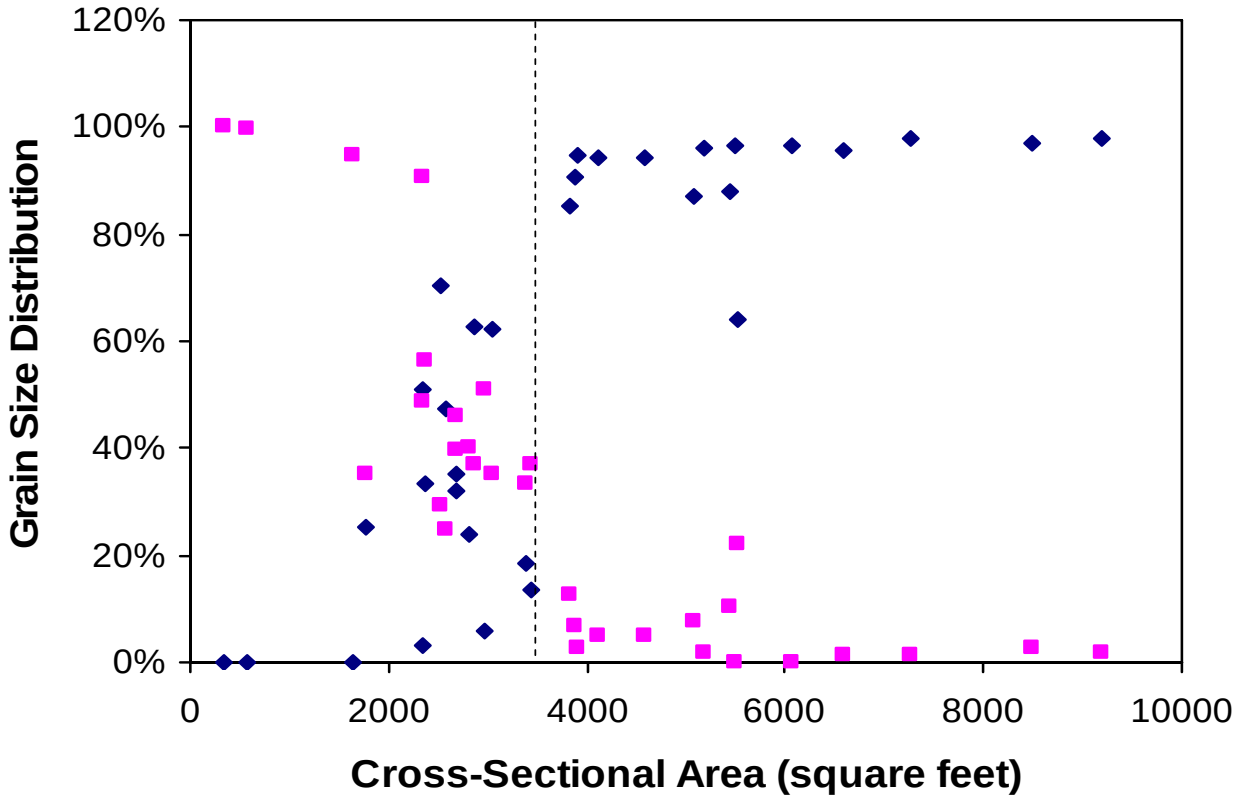
Side-Scan Sonar Survey Interpretation of Lower Passaic River Bottom Sediments near RM8

Lower Passaic River Restoration Project

Figure 1-4

February 2007

R2-0009069



Legend

- ◆ Fine-grained sediment
- ■ Coarse-grained sediment
- ---- Highlights the change to a river cross sectional area of 3,500 square feet

Notes

Cross-sectional area estimated from 2004 bathymetric data surveyed by Rogers Survey, Inc. for USACE.

Sediment texture was evaluated based on data interpolated by Aqua Survey, Inc. using side-scan sonar images (Aqua Survey, Inc., 2006). Sediment texture data extends from RM0 to RM16.5.

Refer to Figure 1-6 for relationship between river mile and cross-sectional area.

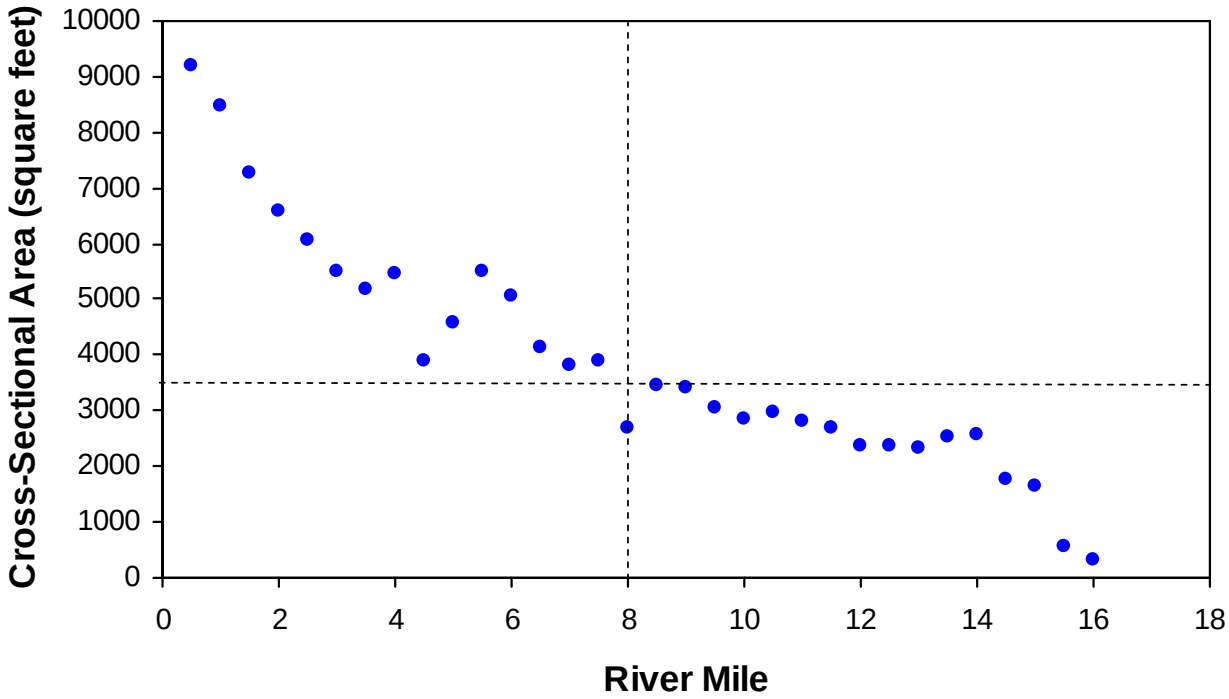
Variation of Lower Passaic River Sediment Type with River Cross-Sectional Area

Lower Passaic River Restoration Project

Figure 1-5

February 2007

R2-0009070



Legend

● Cross-Sectional Area (square feet)

- - - - Highlights the change to a river cross sectional area of 3,500 square feet at RM8

Notes

Cross-sectional area estimated from 2004 bathymetric data surveyed by Rogers Survey, Inc. for USACE.

Cross-sectional area refers to the water filled area of the river channel when water level is equal to 0 feet elevation at NGVD29.

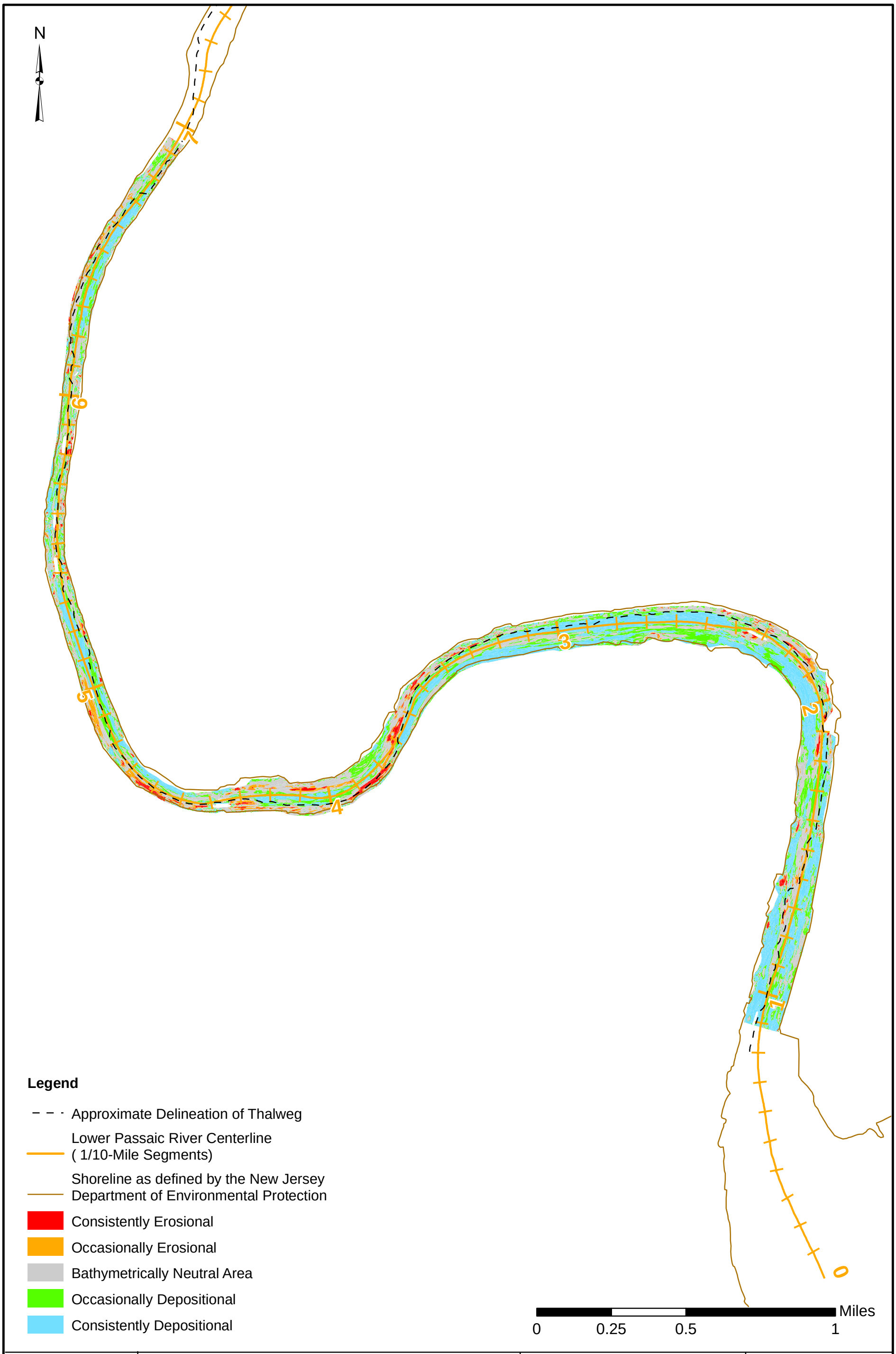
Variation of Lower Passaic River Cross-Sectional Area with River Mile

Lower Passaic River Restoration Project

Figure 1-6

February 2007

R2-0009071



Net Erosional and Net Depositional Areas (RM0.9 to RM7)

Lower Passaic River Restoration Project

Data Sources : Tierra Solutions Inc., Bathymetric Surveys for 1995,1996,1997,1999 and 2001

Figure 1-7

February 2007

Map Document: (S:\Projects\PASSAIC\MapDocuments\4553001-CERCLA\Figure4-1.mxd) 8/25/2006 -- 3:55:03 PM

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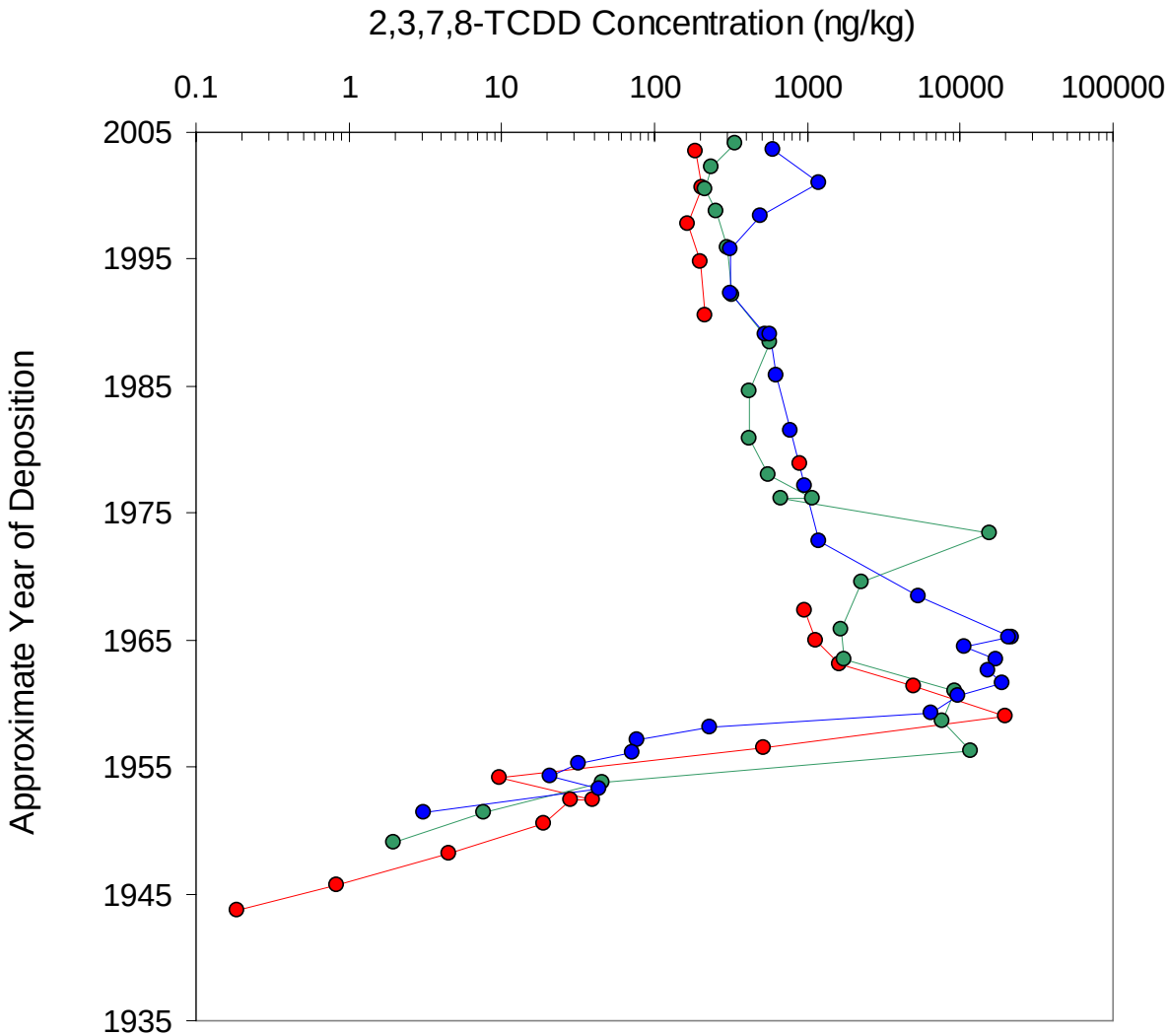


Legend

- 2,3,7,8-TCDD at RM 1.4
- 2,3,7,8-TCDD at RM 2.2
- 2,3,7,8-TCDD at RM 11

Notes

2005 Malcolm Pirnie, Inc. High Resolution Sediment Core Programs.

Depositional years calculated using cesium-137 concentrations.

Note that one criterion for a high resolution sediment core is that the location experiences continuous deposition over time.

The determination of the 1954 horizon in core at RM11 is based on the absence of cesium-137 detection below 191 centimeters. There are some uncertainties with this assignment, and the core may extend 4 years longer than is shown here.

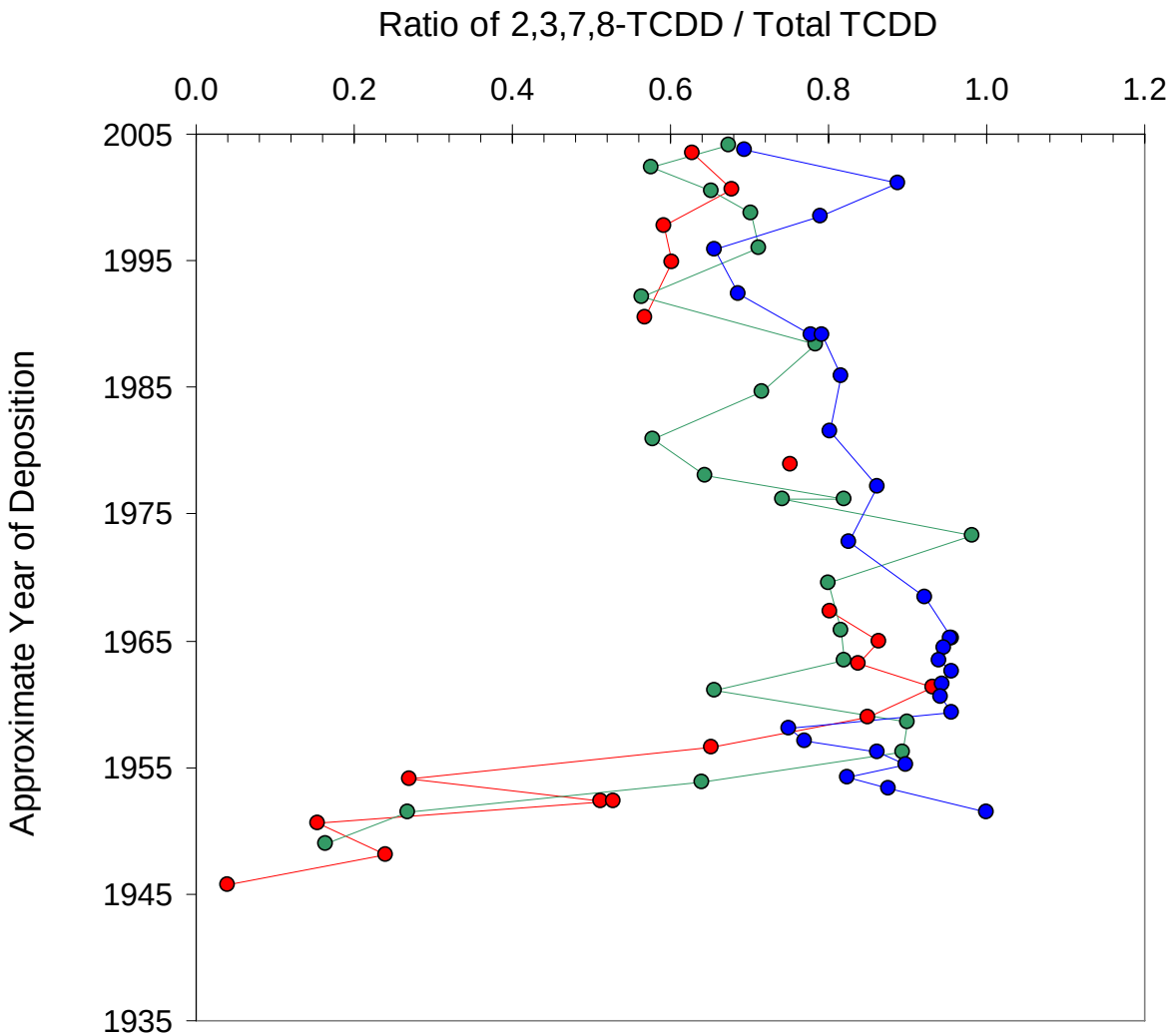
Downcore Profiles of 2,3,7,8-TCDD Concentrations at RM 1.4, RM 2.2, and RM 11

Lower Passaic River Restoration Project

Figure 1-8

February 2007

R2-0009073



Legend

- Ratio at RM 1.4
- Ratio at RM 2.2
- Ratio at RM 11

Notes

2005 Malcolm Pirnie, Inc. High Resolution Sediment Core Programs.

Depositional years calculated using cesium-137 concentrations.

Note that one criterion for a high resolution sediment core is that the location experience continuous deposition over time.

The determination of the 1954 horizon in core at RM11 is based on the absence of cesium-137 detection below 191 centimeters. There are some uncertainties with this assignment, and the core may extend 4 years longer than is shown here.

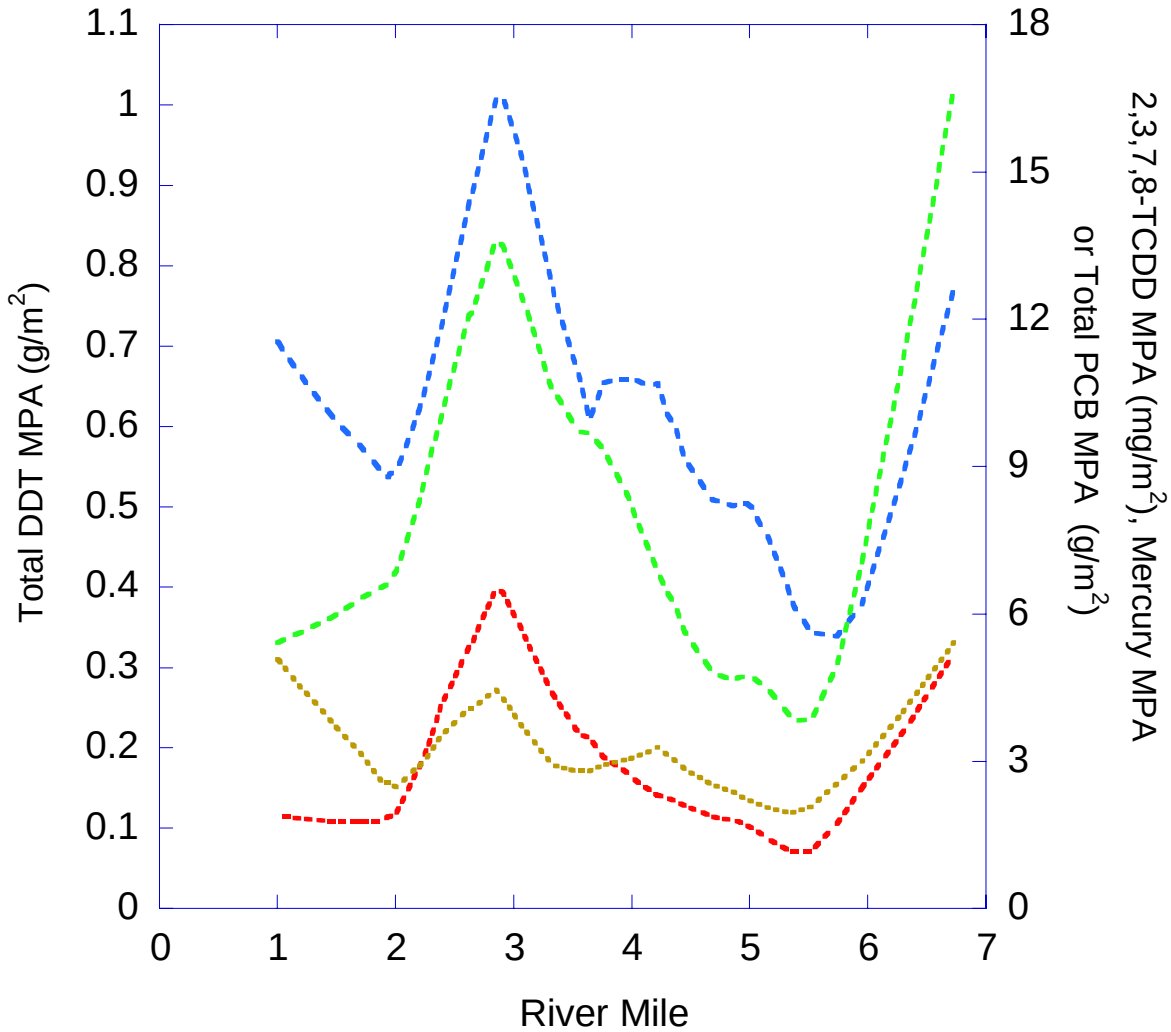
Downcore Profiles of 2,3,7,8-TCDD/Total TCDD Ratio at RM 1.4, RM 2.2, and RM 11

Lower Passaic River Restoration Project

Figure 1-9

February 2007

R2-0009074



Legend

- Mercury
- 2,3,7,8-TCDD
- Total PCB
- Total DDT

Notes

MPA is mass per unit area

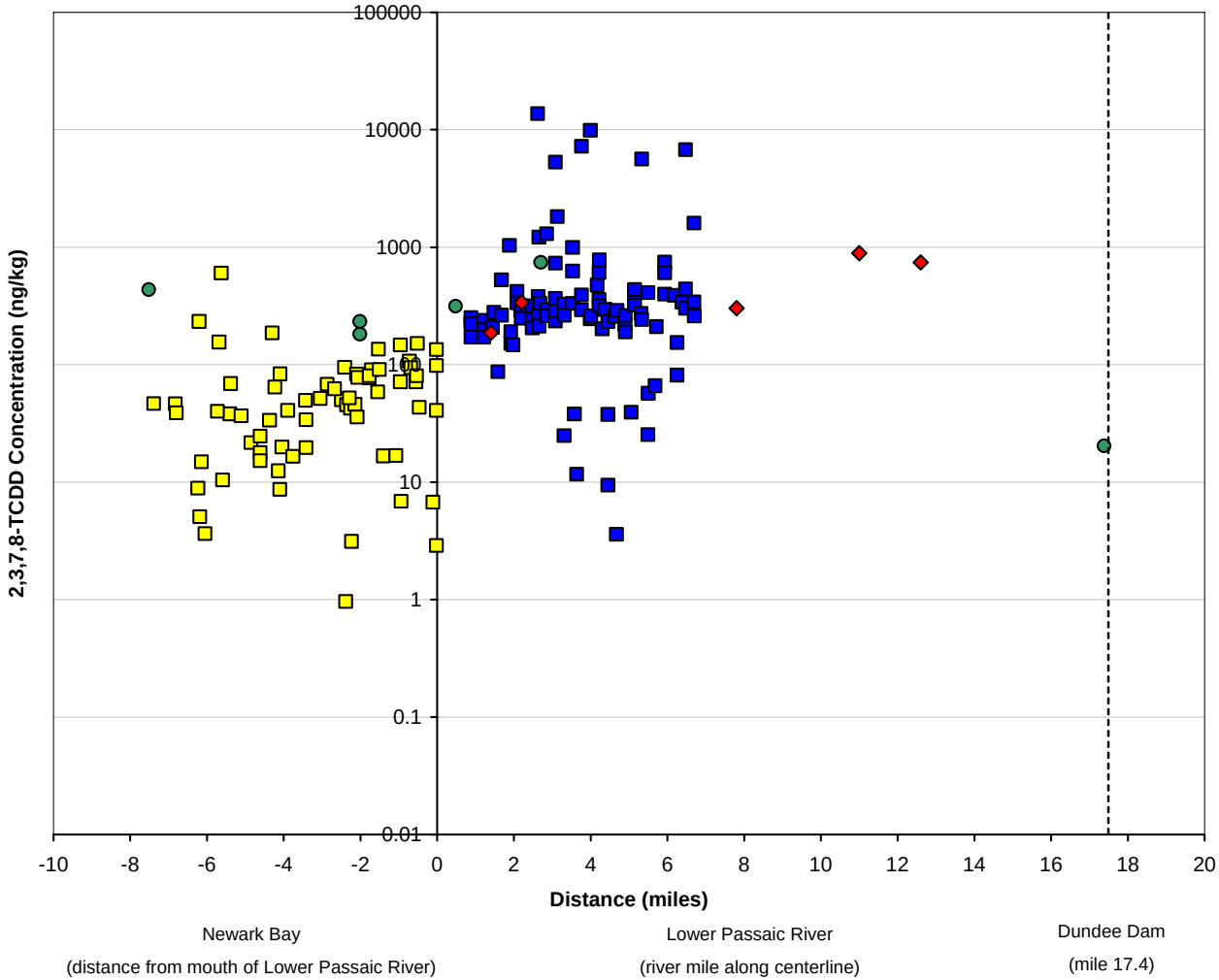
Weighted Curve Sediment Inventory from RM1 to RM7

Lower Passaic River Restoration Project

Figure 1-10

February 2007

R2-0009075



Legend

- Malcolm Pirnie, Inc. (2005) (represents 2003-2005 time horizon)
- TSI (2005) (represents 0-6 inches of sediment)
- TSI (1995) (represents 0-6 inches of sediment)
- Bopp *et al.* (2006) (represents 1985-1986 time horizon)

Notes

Malcolm Pirnie, Inc. Data Source: USEPA 2005-2006 Sampling Program.

TSI Data Source: 2005 Newark Bay Phase I Investigation and 1995 TSI Dataset.

Bopp Data Source: "Contaminant Chronologies from Hudson River Sedimentary Records," Bopp *et al.* (2006).

Nondetect (lab qualifier containing a U) plotted as half the reported value.

Surface concentrations represent a depth of 0 to <1 foot.

Comparison of Surface 2,3,7,8-TCDD Concentrations in 1985-1986, 1995, and 2005

Lower Passaic River Restoration Project

Figure 1-11

February 2007

R2-0009076

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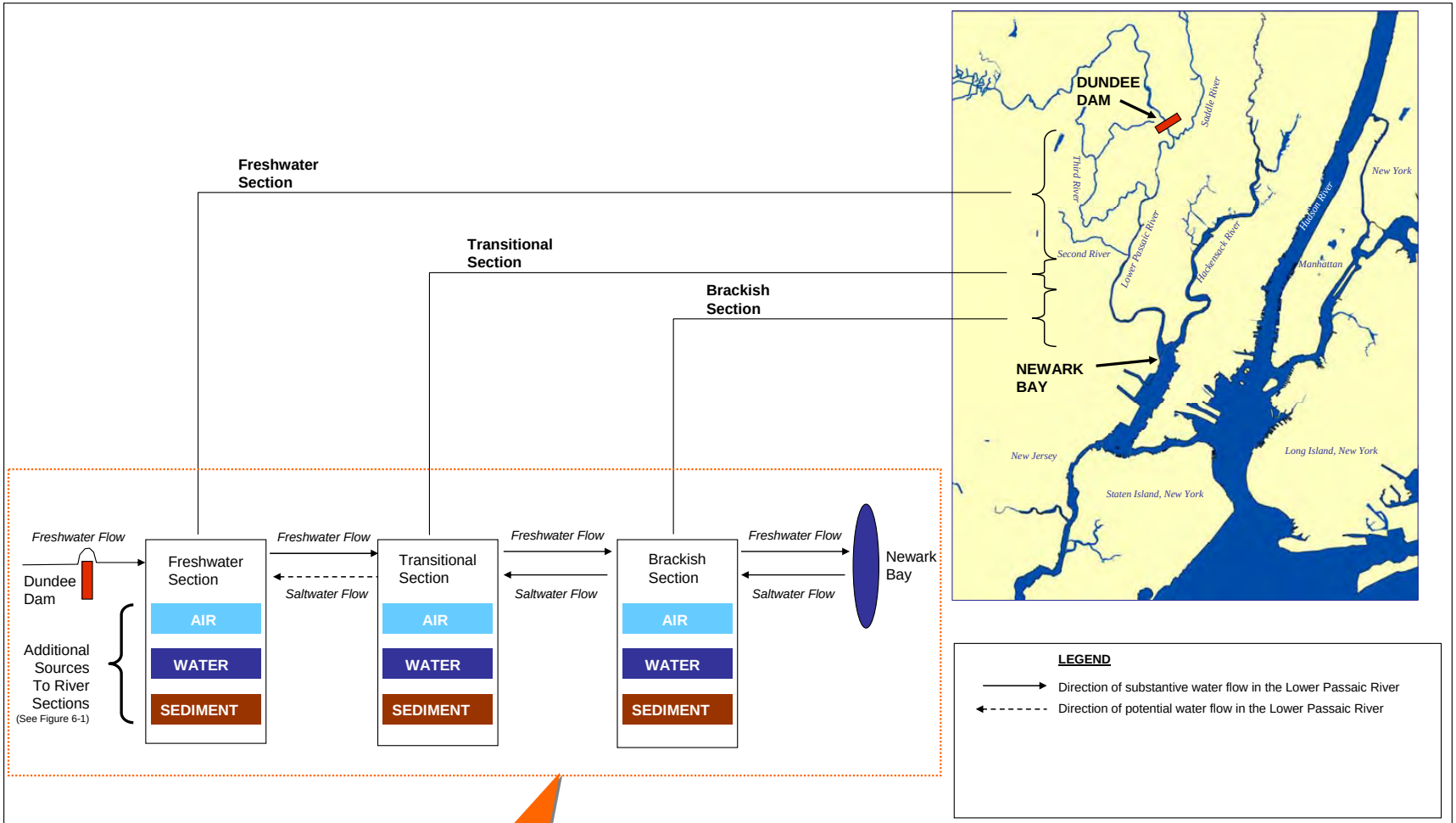
Hudson-Raritan Estuary

Lower Passaic River Restoration Project

Figure 2-1

February 2007

R2-0009077



Input to Human Health and Ecological Evaluations

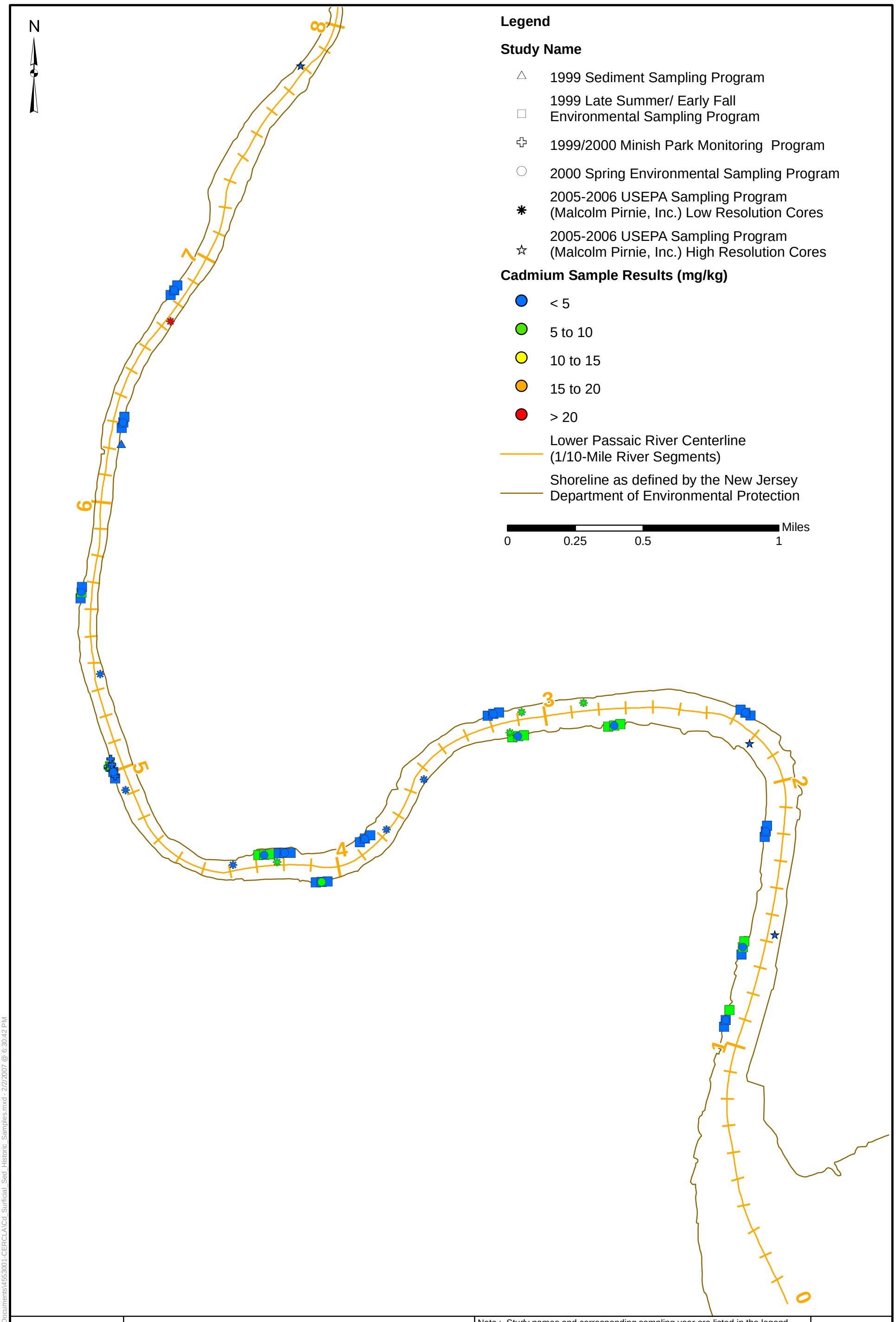
River Sections for the Lower Passaic River

Lower Passaic River Restoration Project

Figure 2-2

February 2007

R2-0009078



Available Cadmium Surface Sediment Samples from 1997 to 2006

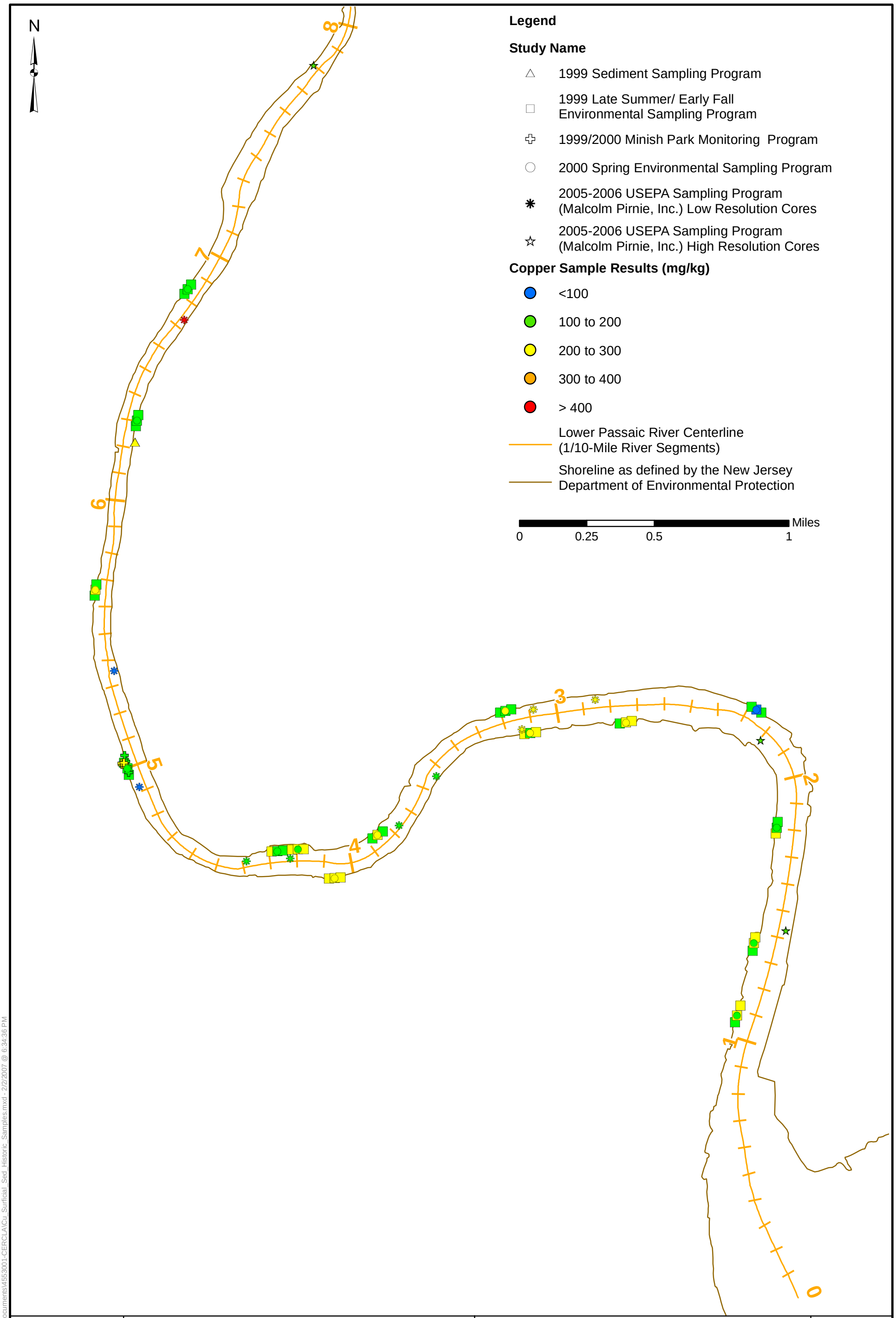
Lower Passaic River Restoration Project

Note : Study names and corresponding sampling year are listed in the legend. Samples represent either sediment grab samples or the top segment of a sediment core. Because each study provided a different definition for "surface sediments," the samples plotted on this figure generally represent sediments from a depth of 0 foot to less than 1 foot. However, low resolution cores represent sediments from a depth of 0 to 2.3 feet. If samples are plotted at the same location, samples from the latest sampling event were plotted on top. Duplicate samples were averaged before plotting. No nondetect values were reported.

Figure 2-3a

February 2007

S:\Projects\PASSAIC\MapDocuments\4553001-CERCLA\Cd_Surficial_Sed_Historic_Samples.mxd - 2/2/2007 @ 6:30:42 PM



Available Copper Surface Sediment Samples from 1997 to 2006

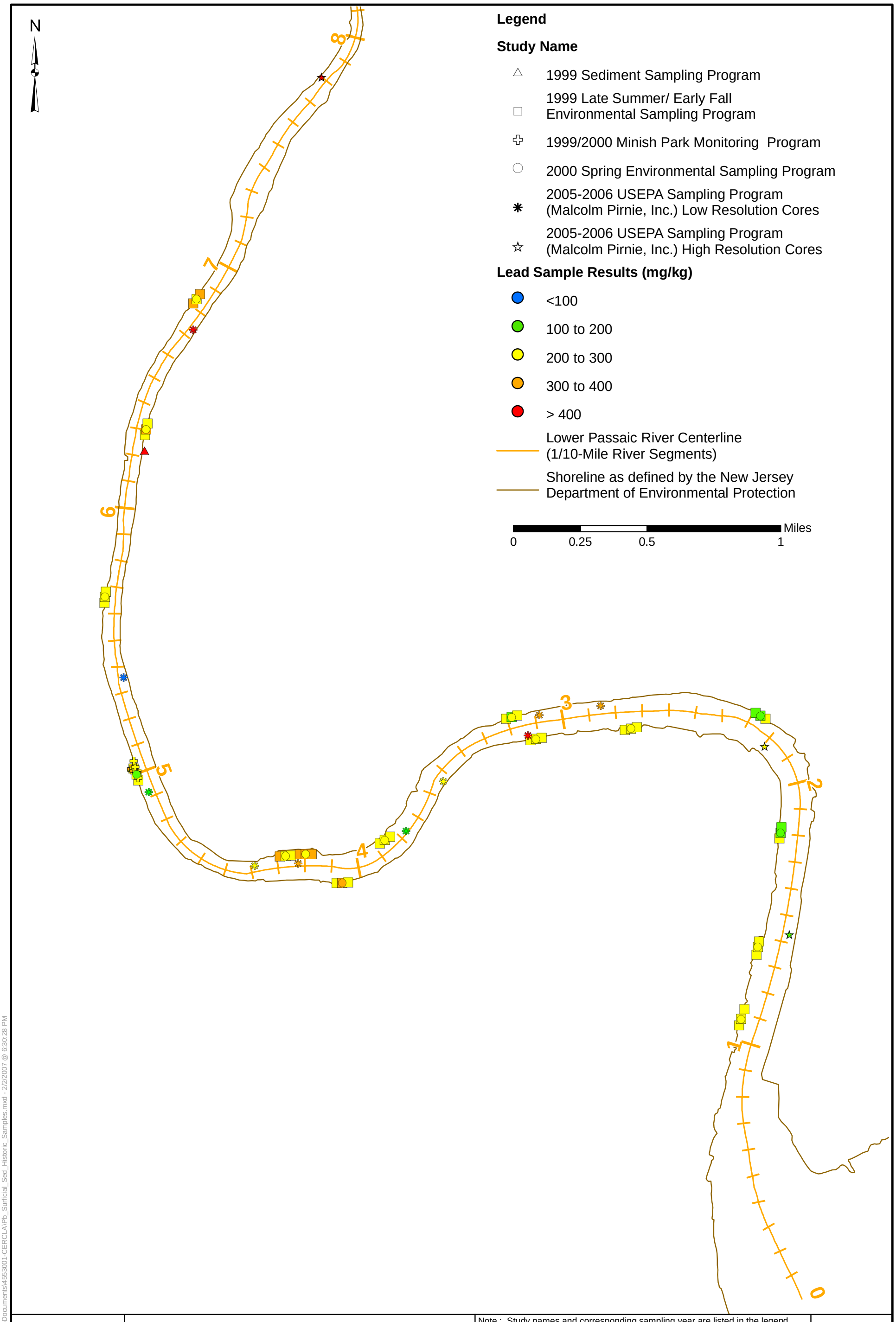
Lower Passaic River Restoration Project

Note : Study names and corresponding sampling year are listed in the legend. Samples represent either sediment grab samples or the top segment of a sediment core. Because each study provided a different definition for "surface sediments," the samples plotted on this figure generally represent sediments from a depth of 0 foot to less than 1 foot. However, low resolution cores represent sediments from a depth of 0 to 2.3 feet. If samples are plotted at the same location, samples from the latest sampling event were plotted on top. Duplicate samples were averaged before plotting. No nondetect values were reported.

Figure 2-3b

February 2007

S:\Projects\PASSAIC\MapDocuments\4553001-CERCLA\Cu_Surficial_Sed_Historic_Samples.mxd - 2/2/2007 @ 6:34:36 PM



Available Lead Surface Sediment Samples from 1997 to 2006

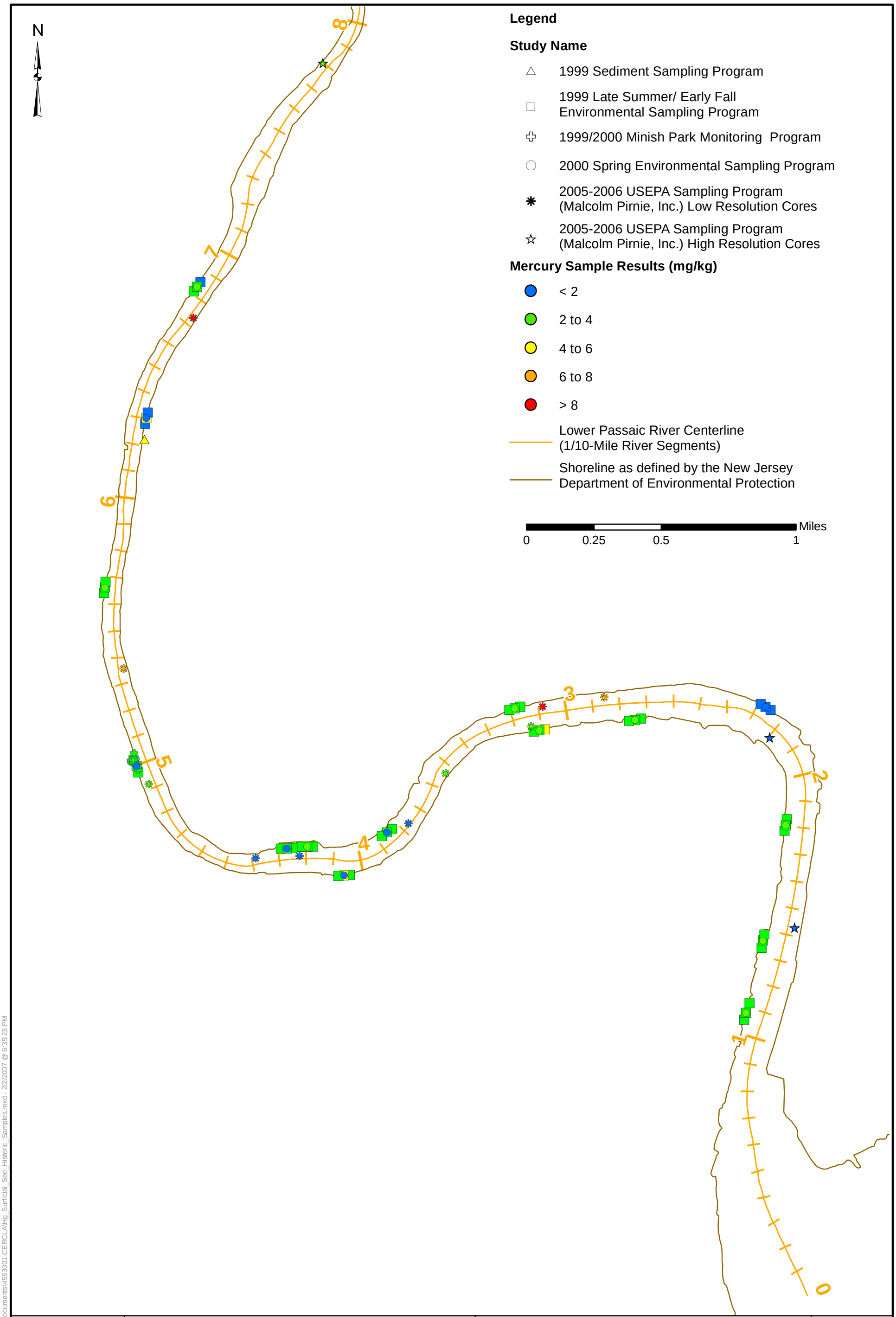
Lower Passaic River Restoration Project

Note : Study names and corresponding sampling year are listed in the legend. Samples represent either sediment grab samples or the top segment of a sediment core. Because each study provided a different definition for "surface sediments," the samples plotted on this figure generally represent sediments from a depth of 0 foot to less than 1 foot. However, low resolution cores represent sediments from a depth of 0 to 2.3 feet. If samples are plotted at the same location, samples from the latest sampling event were plotted on top. Duplicate samples were averaged before plotting. No nondetect values were reported.

Figure 2-3c

February 2007

S:\Projects\PASSAIC\MapDocuments\4553001-CERCLA\Pb_Surficial_Sed_Historic_Samples.mxd - 2/2/2007 @ 6:30:28 PM



Available Mercury Surface Sediment Samples from 1997 to 2006

Lower Passaic River Restoration Project

Note : Study names and corresponding sampling year are listed in the legend. Samples represent either sediment grab samples or the top segment of a sediment core. Because each study provided a different definition for "surface sediments," the samples plotted on this figure generally represent sediments from a depth of 0 foot to less than 1 foot. However, low resolution cores represent sediments from a depth of 0 to 2.3 feet. If samples are plotted at the same location, samples from the latest sampling event were plotted on top. Duplicate samples were averaged before plotting. No nondetect values were reported.

Figure 2-3d

February 2007

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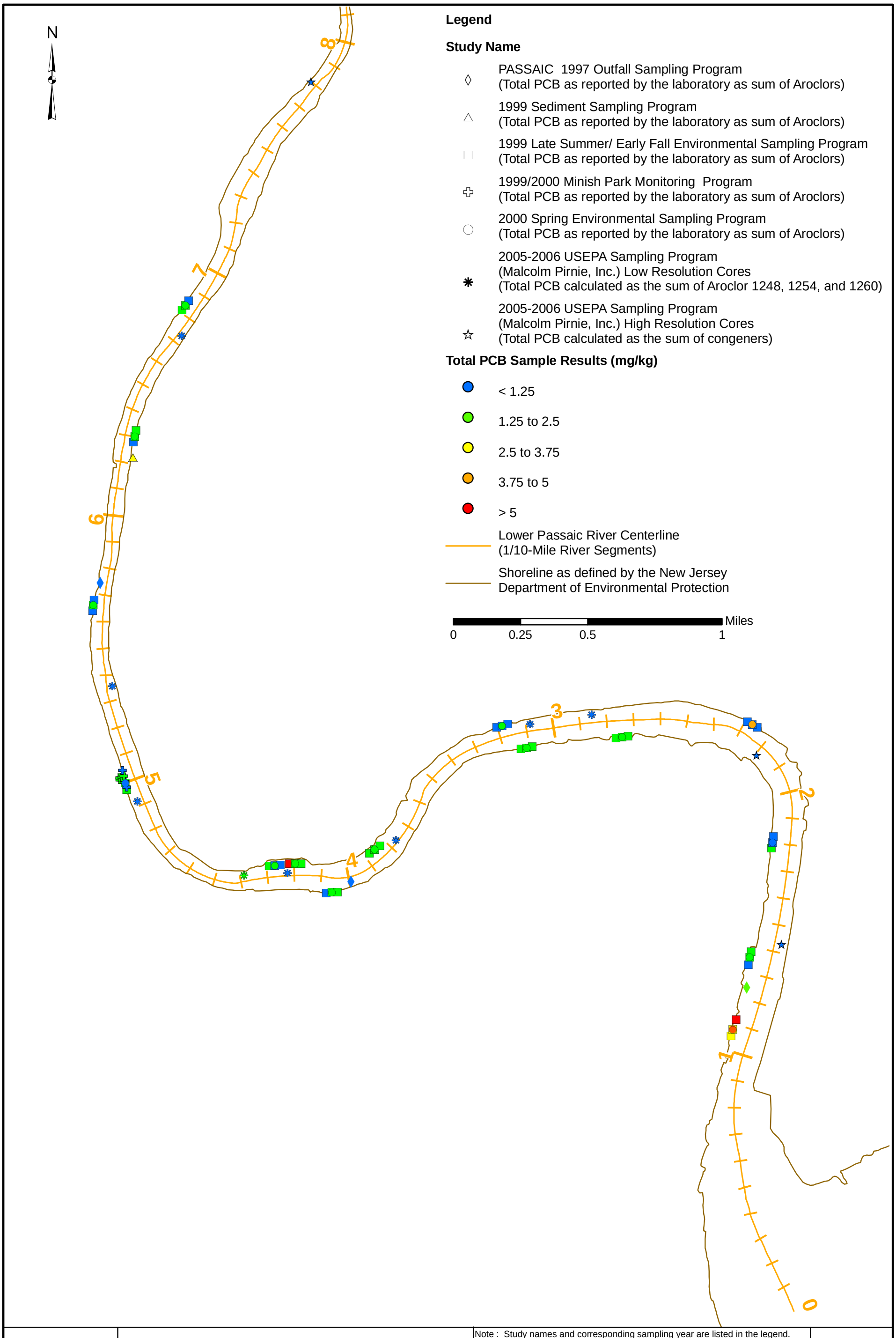


Available Total PCB Surface Sediment Samples from 1997 to 2006

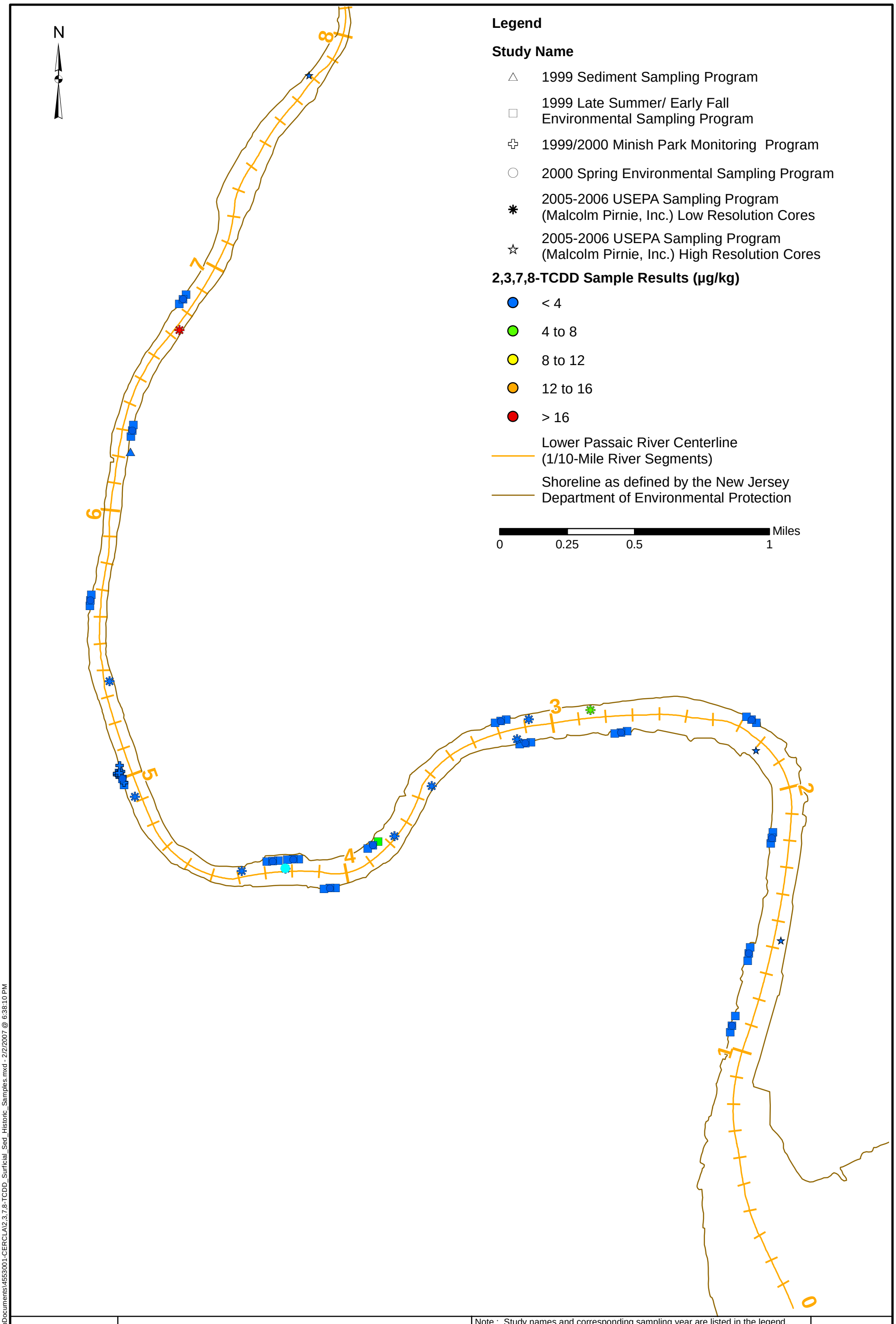
Lower Passaic River Restoration Project

Note : Study names and corresponding sampling year are listed in the legend. Samples represent either sediment grab samples or the top segment of a sediment core. Because each study provided a different definition for "surface sediments," the samples plotted on this figure generally represent sediments from a depth of 0 foot to less than 1 foot. However, low resolution cores represent sediments from a depth of 0 to 2.3 feet. If samples are plotted at the same location, samples from the latest sampling event were plotted on top. Duplicate samples were averaged before plotting. No nondetect values were reported.

Figure 2-3e

February 2007

S:\Projects\PASSAIC\MapDocuments\4553001-CERCLA\TotalPCB_Surficial_Sed_Historic_Samples.mxd - 2/2/2007 @ 6:35:09 PM



Available 2,3,7,8-TCDD Surface Sediment Samples from 1997 to 2006

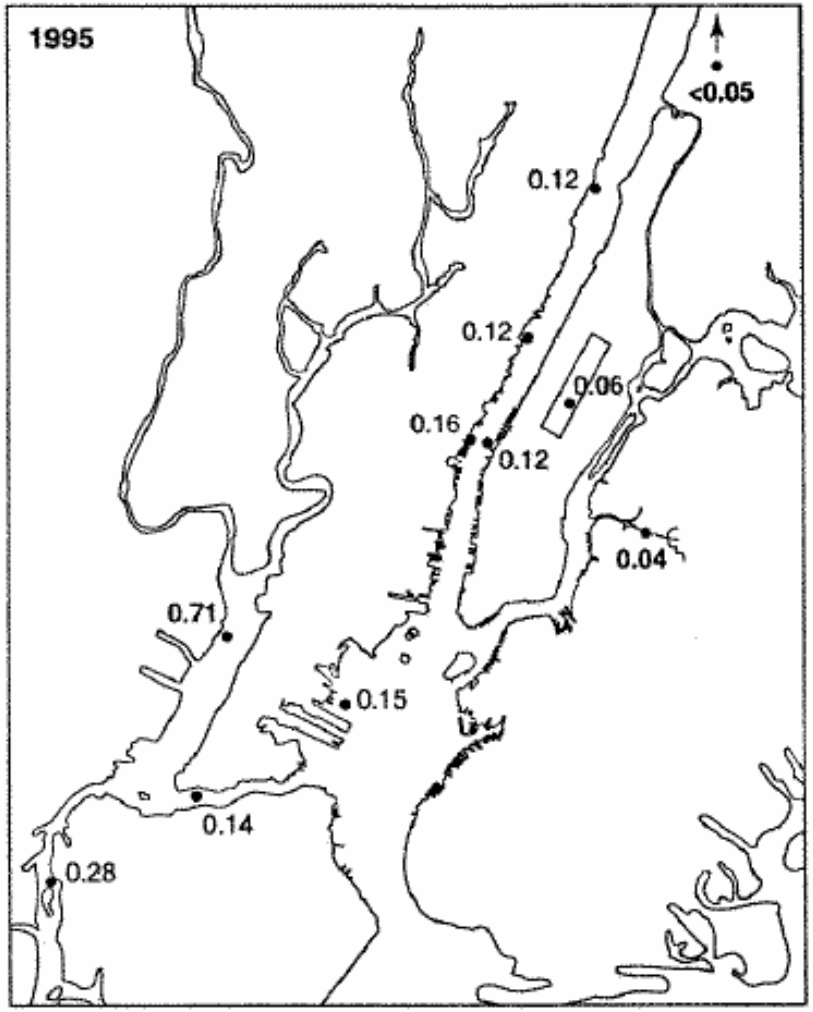
Lower Passaic River Restoration Project

Note : Study names and corresponding sampling year are listed in the legend. Samples represent either sediment grab samples or the top segment of a sediment core. Because each study provided a different definition for "surface sediments," the samples plotted on this figure generally represent sediments from a depth of 0 foot to less than 1 foot. However, low resolution cores represent sediments from a depth of 0 to 2.3 feet. If samples are plotted at the same location, samples from the latest sampling event were plotted on top. Duplicate samples were averaged before plotting. No nondetect values were reported.

Figure 2-3f

February 2007

S:\Projects\PASSAIC\MapDocuments\4553001-CERCLA\2,3,7,8-TCDD_Surficial_Sed_Historic_Samples.mxd - 2/2/2007 @ 6:38:10 PM



Legend

- 2,3,7,8-TCDD/Total TCDD Ratio

Notes

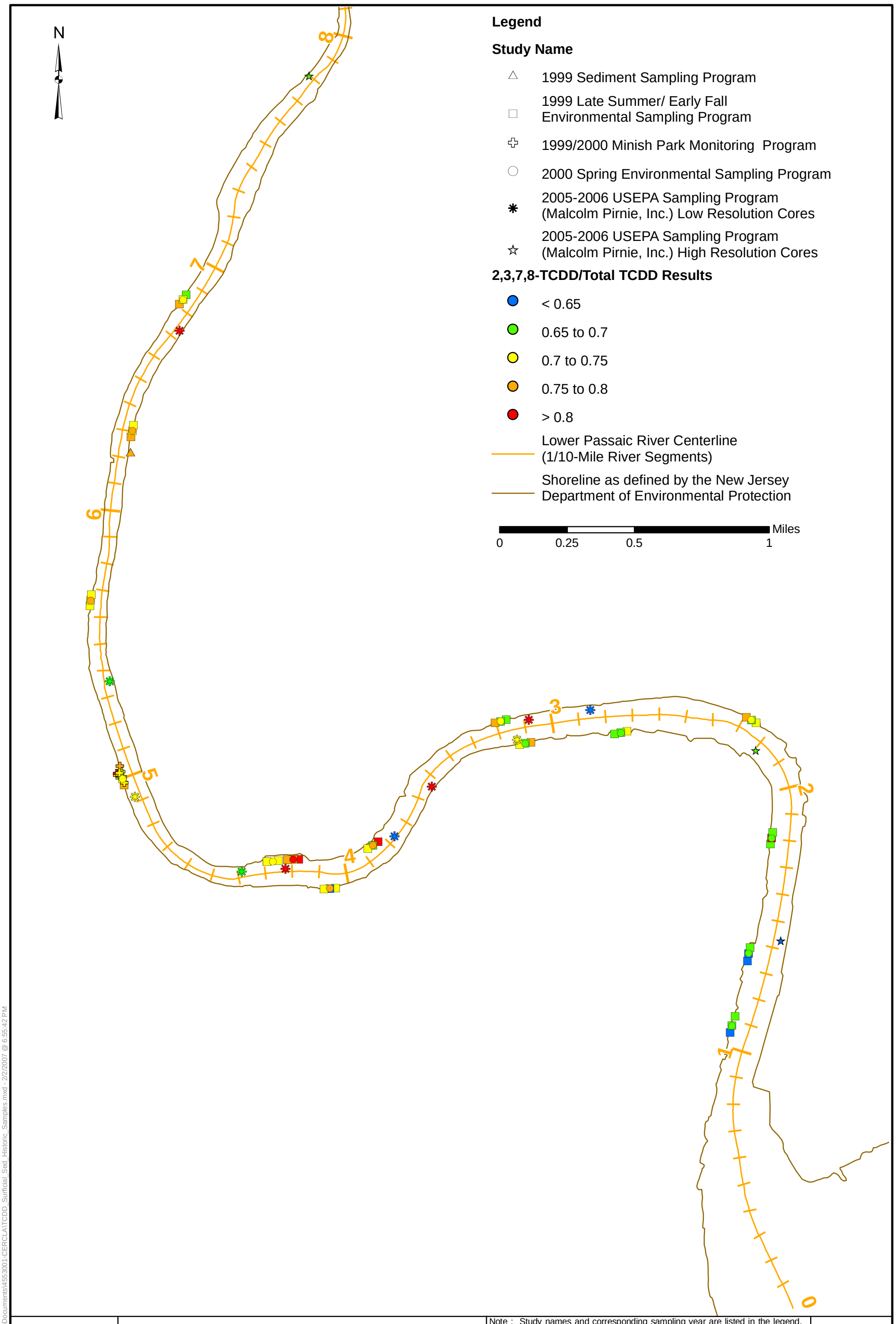
Chaky DA, 2003. "Polychlorinated Biphenyls, Polychlorinated Dibenzo-p-Dioxins and Furans in the New York Metropolitan Area; Interpreting Atmospheric Deposition and Sediment Chronologies." PhD Thesis, Rensselaer Polytechnic Institute, Troy, NY. August 2003.

Reprint from Chaky (2003): Ratio of 2,3,7,8-TCDD/Total TCDD in the Hudson-Raritan Estuary in 1995

Lower Passaic River Restoration Project

Figure 2-4

February 2007



Available 2,3,7,8-TCDD/Total TCDD Surface Sediment Samples from 1997 to 2006

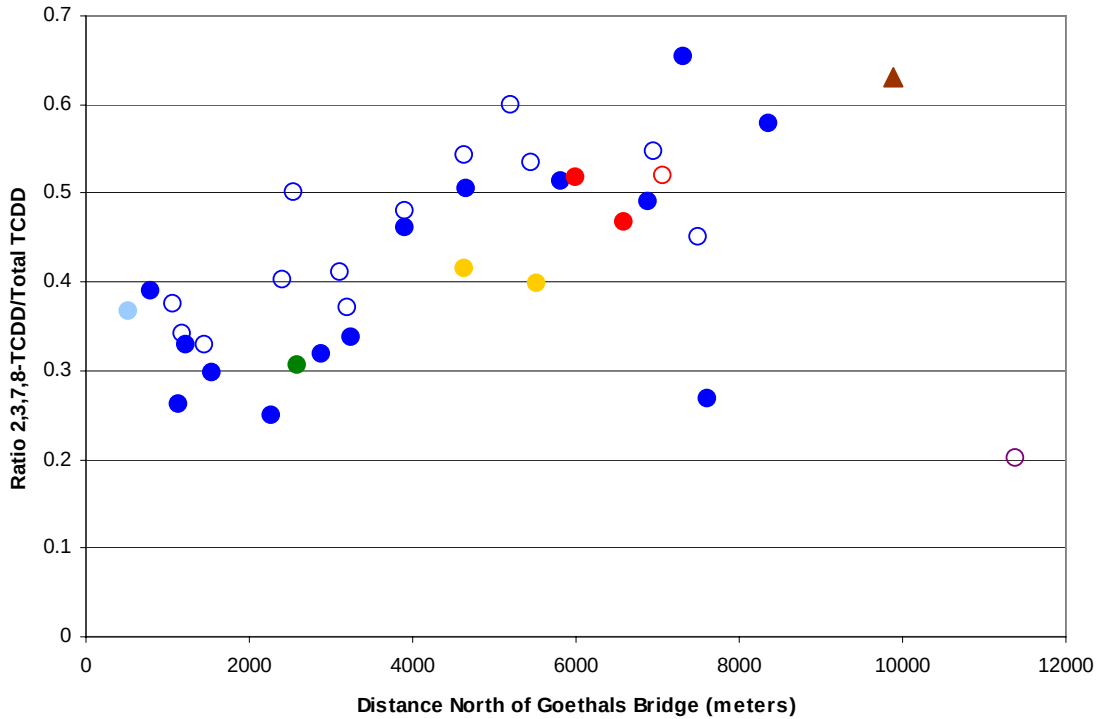
Lower Passaic River Restoration Project

Note : Study names and corresponding sampling year are listed in the legend. Samples represent either sediment grab samples or the top segment of a sediment core. Because each study provided a different definition for "surface sediments," the samples plotted on this figure generally represent sediments from a depth of 0 foot to less than 1 foot. However, low resolution cores represent sediments from a depth of 0 to 2.3 feet. If samples are plotted at the same location, samples from the latest sampling event were plotted on top. Duplicate samples were averaged before plotting. No nondetect values were reported.

Figure 2-5

February 2007

S:\Projects\PASSAIC\MapDocuments\4553001-CERCLA\TCDD_Surficial_Sed_Historic_Samples.mxd - 2/2/2007 @ 6:55:42 PM



Colors Legend

- Newark Bay
- Confluence of unnamed creek with Hackensack River
- Port Newark Channel
- Port Elizabeth Channel
- South Elizabeth Channel
- Arthur Kill
- Lower Passaic River (2005)

Symbols Legend

- Coring Locations in Navigation Channels
- Coring Locations outside Navigation Channels

Notes:

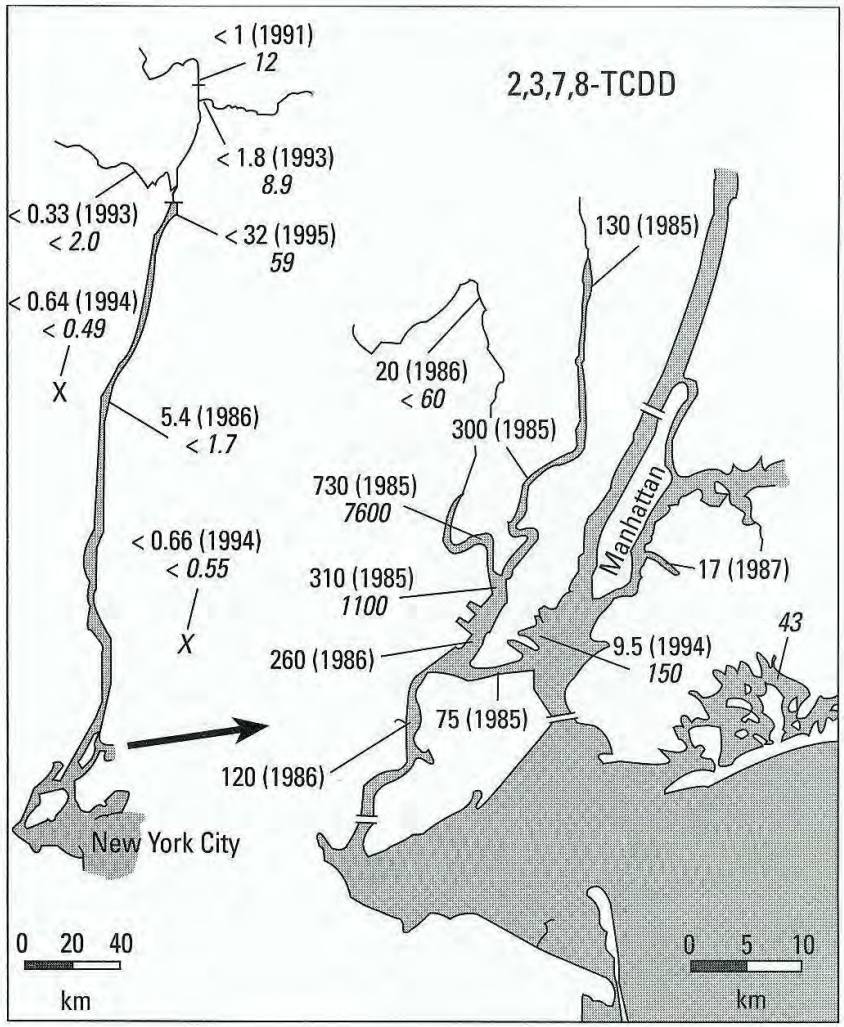
1. 2,3,7,8-TCDD and Total TCDD surface concentrations represent the top 6 inches of the core.
2. When duplicate 2,3,7,8-TCDD or Total TCDD values are provided by the laboratory, the average ratio is plotted.
3. No nondetected 2,3,7,8-TCDD or Total TCDD values were reported for the surface sediment.
4. Concentration ratios are plotted only for depositional environments, indicated by Beryllium-7 detections more than 0.5 pCi/g in the top inch of the core.
5. Data Source: Malcolm Pirnie, Inc. High Resolution Sediment Core in the Lower Passaic River (RM1.4). USEPA 2005-2006 Sampling Program.
6. Data Source: Newark Bay Phase 2 Remedial Investigation Work Plan (October 2006). Samples collected in October to December 2005.

Ratio of 2,3,7,8-TCDD/Total TCDD in Newark Bay Surface Sediments

Lower Passaic River Restoration Project

Figure 2-6

February 2007



Legend

2,3,7,8-TCDD Concentration in ng/kg (Year Sample was collected)

Notes

Levels of 2,3,7,8-TCDD, measured in ng/kg, in sediment samples. Upper numbers represent the concentrations in samples deposited between the mid-1980s and the mid-1990s. Numbers in italics are concentrations in mid-1960s samples.

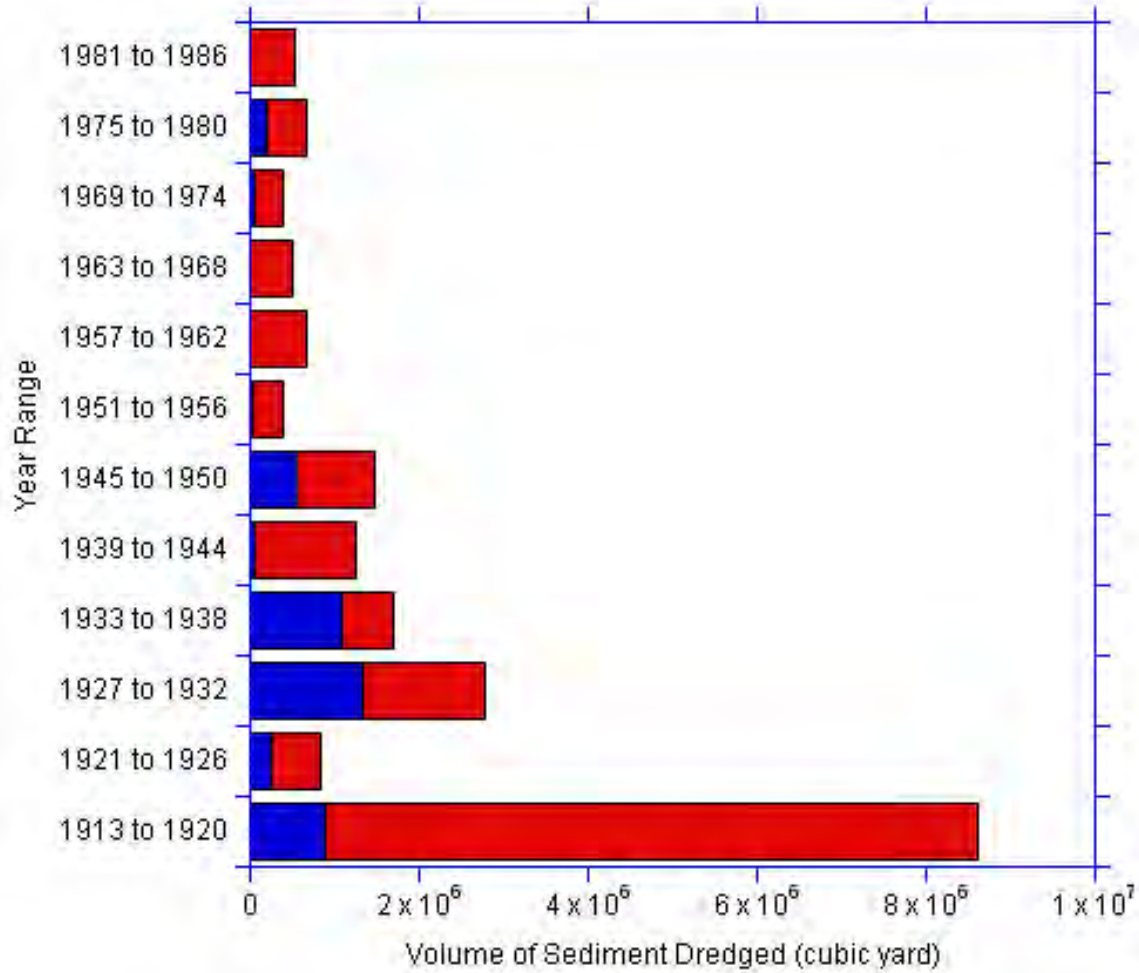
Bopp, R.F., S.N. Chillrud, E.L. Shuster, H.J. Simpson and F.D. Estabrooks, Trends in Chlorinated Hydrocarbon Levels in Hudson River Basin Sediments, *Environ. Health Perspect.*, *106*, Supplement 4, 1075-81, 1998.

Reprint from Bopp et al., 1998: 2,3,7,8-TCDD Concentrations in Dated Sediment Samples from the Hudson-Raritan Estuary

Lower Passaic River Restoration Project

Figure 2-7

February 2007



Legend

- Below RM2
- Above RM2

Notes

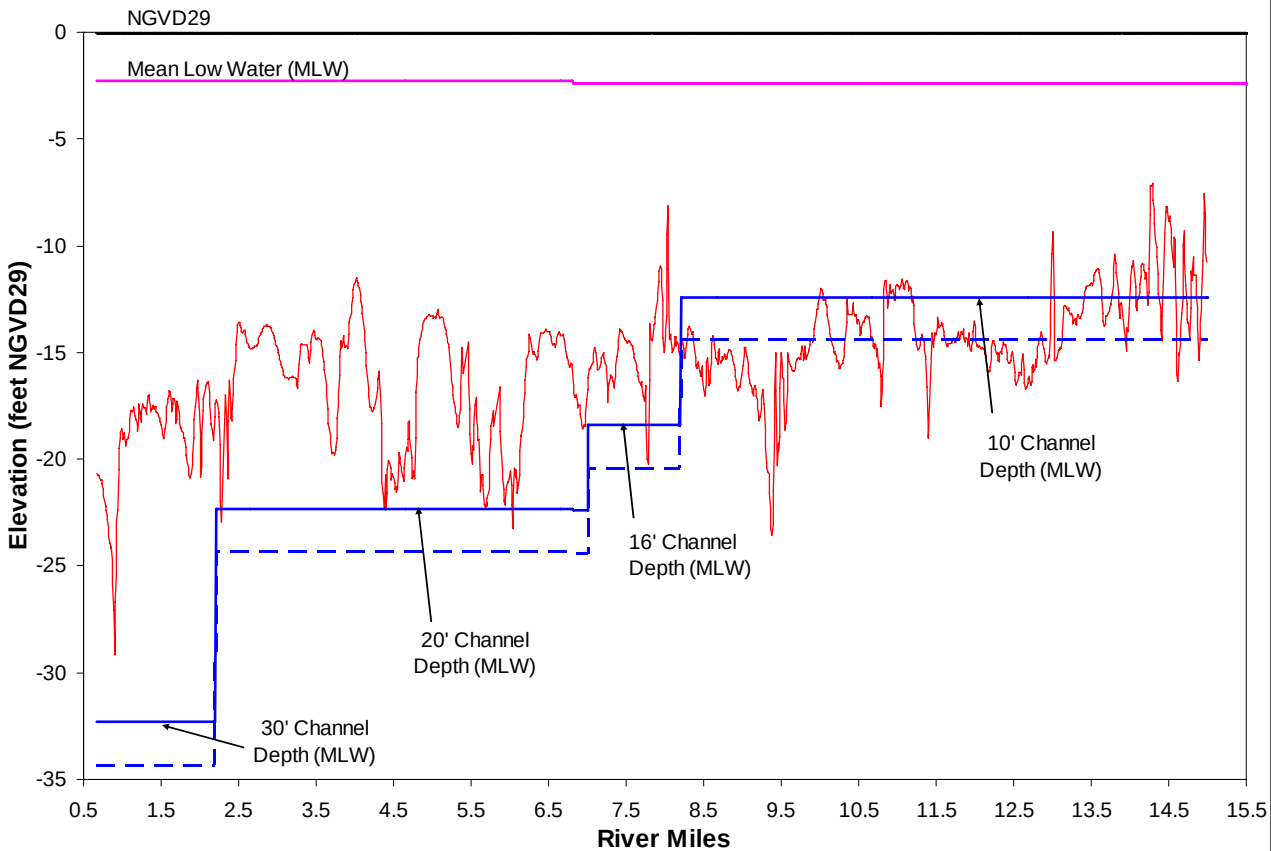
Data Sources: USACE, 1880, USACE, 1884, USACE, 1900, USACE, 1907, USACE, 1913, USACE, 1915, USACE, 1916, and USACE, 1917 as cited in Iannuzzi, *et al*., 2002 (refer to Section 10 "References" for complete citation).

The History of Dredging in the Lower Passaic River

Lower Passaic River Restoration Project

Figure 2-8

February 2007



Legend

- Navigational Channel Centerline Bathymetry
- Navigational Channel Depth
- Navigational Channel Depth + 2 feet

Notes

Channel depths were dredged relative to mean low water (MLW). The difference between NGVD29 and MLW is approximately 2.3 feet.

Solid blue line represents federally mandated channel depth.

Dashed blue line represents the channel depth +2 feet which would have been the dredged depth in order to maintain the federally specified channel depth.

Elevation data estimated from 2004 bathymetric data surveyed by Rogers Survey,Inc. for USACE.

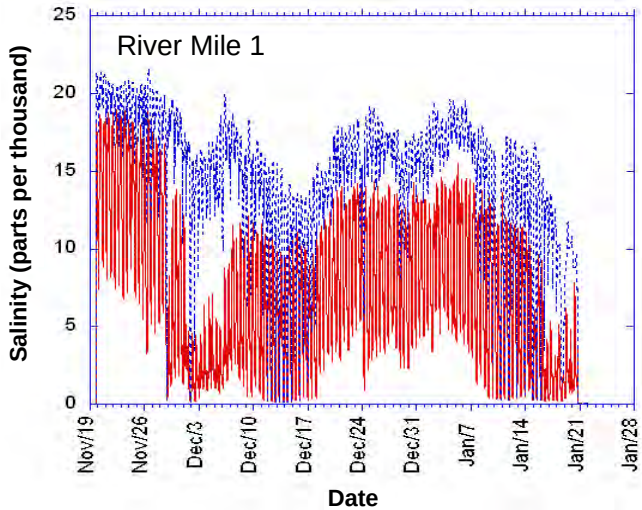
River Bottom Elevation and Authorized Channel Depths

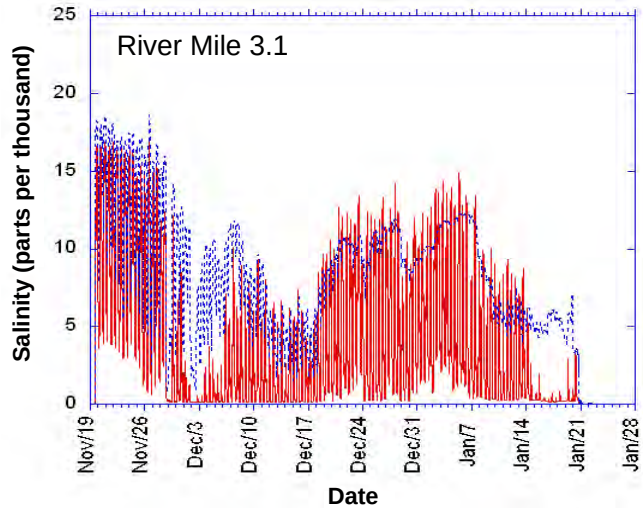
Lower Passaic River Restoration Project

Figure 2-9

February 2007

R2-0009090





Legend

Salinity measurements collected by Rutgers University near the river surface

Salinity measurements collected by Rutgers University near the river bottom

Notes

Measurements were collected between November 20, 2004 and January 25, 2005 by Rutgers University.

River Mile 1 – Data collected from Rutgers University Buoy #M1.

River Mile 3.1 – Data collected from Rutgers University Buoy #M2a.

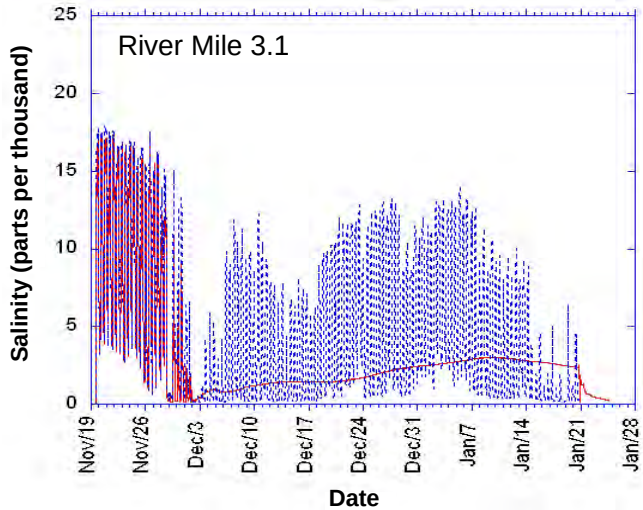
Source for Rutgers University data: http://marine.rutgers.edu/cool/passaic

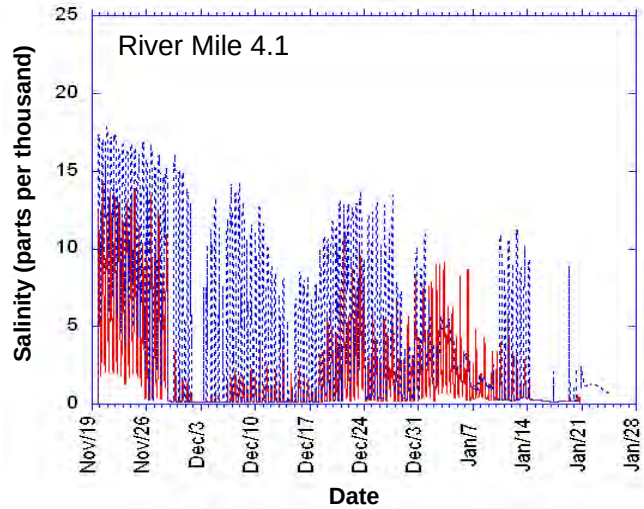
Temporal Trends in Salinity at RM1 and RM3.1

Lower Passaic River Restoration Project

Figure 3-1a

February 2007





Legend

Salinity measurements collected by Rutgers University near the river surface

Salinity measurements collected by Rutgers University near the river bottom

Notes

Measurements were collected between November 20, 2004 and January 25, 2005 by Rutgers University.

River Mile 3.1 – Data collected from Rutgers University Buoy #M2b, which was located next to Buoy #M2a.

River Mile 4.1 – Data collected from Rutgers University Buoy #M3.

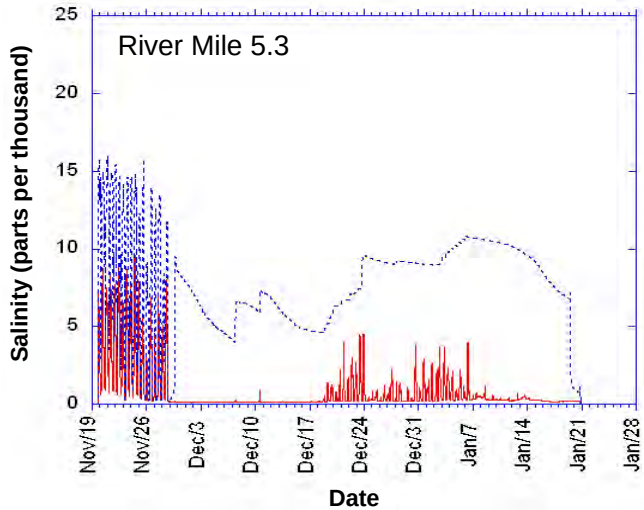
Source for Rutgers University data: http://marine.rutgers.edu/cool/passaic

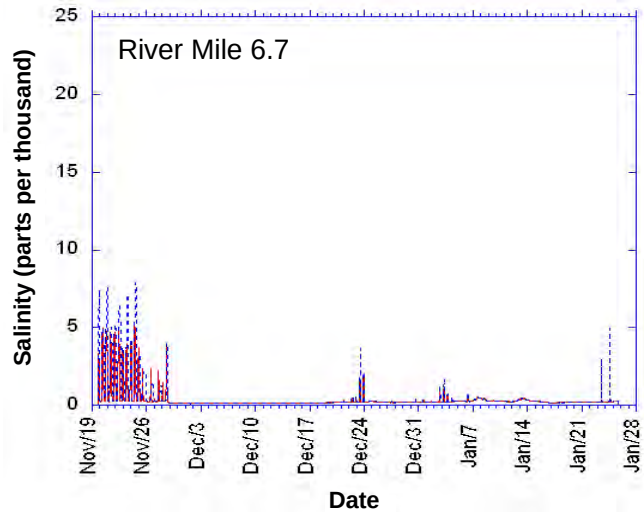
Temporal Trends in Salinity at RM3.1 and RM4.1

Lower Passaic River Restoration Project

Figure 3-1b

February 2007





Legend

Salinity measurements collected by Rutgers University near the river surface

Salinity measurements collected by Rutgers University near the river bottom

Notes

Measurements were collected between November 20, 2004 and January 25, 2005 by Rutgers University.

River Mile 5.3 – Data collected from Rutgers University Buoy #M4.

River Mile 6.7 –Data collected from Rutgers University Buoy #M5.

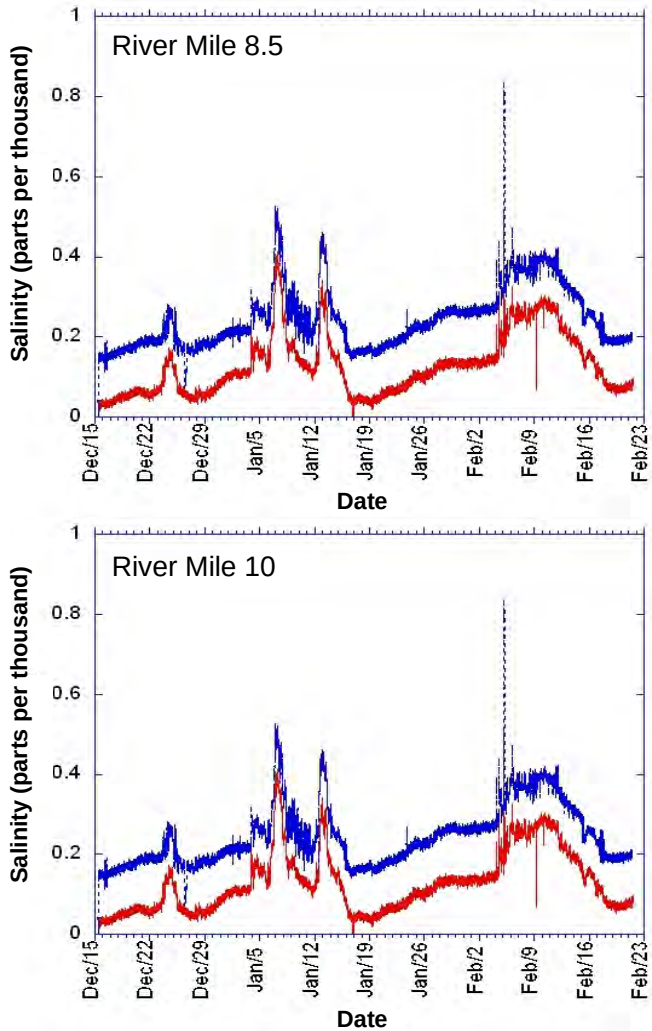
Source for Rutgers University data: http://marine.rutgers.edu/cool/passaic

Temporal Trends in Salinity at RM5.3 and RM6.7

Lower Passaic River Restoration Project

Figure 3-1c

February 2007



Legend

Salinity measurements collected 1 meter from the river surface

Salinity measurements collected 1 meter from the river bottom

Notes

Salinity values were calculated from conductivity, temperature, and depth data recorded by a conductivity temperature depth probe.

Data collected from December 15, 2004 to February 21, 2005 by Malcolm Pirnie, Inc.

River Mile 8.5 – Data collected from Malcolm Pirnie, Inc. Buoy #3.

River Mile 10 – Data collected from Malcolm Pirnie, Inc. Buoy #2.

Salinity values less than 0.5 parts per thousand do not represent "true" salinity, but a calculated value based on dissolved minerals in water.

Salinity values less than 0.5 parts per thousand are considered "freshwater," which are free of seawater influences.

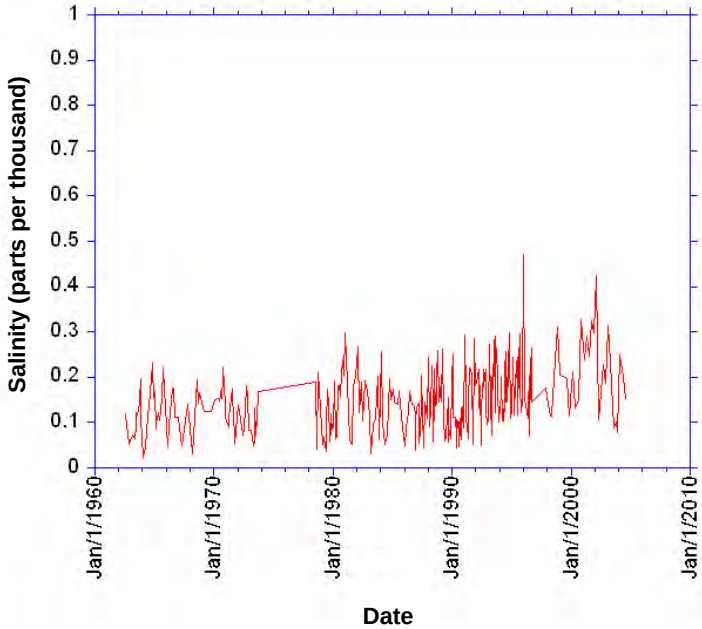
Temporal Trends in Salinity at RM8.5 and RM10

Lower Passaic River Restoration Project

Figure 3-1d

February 2007

R2-0009094



Legend

Salinity measurements recorded by a United States Geological Survey gauging station

Notes

Salinity measurements were taken between July 30, 1962 and August 19, 2004 at the USGS Gauge at Little Falls.

Salinity values less than 0.5 parts per thousand do not represent "true" salinity, but a calculated value based on dissolved minerals in water.

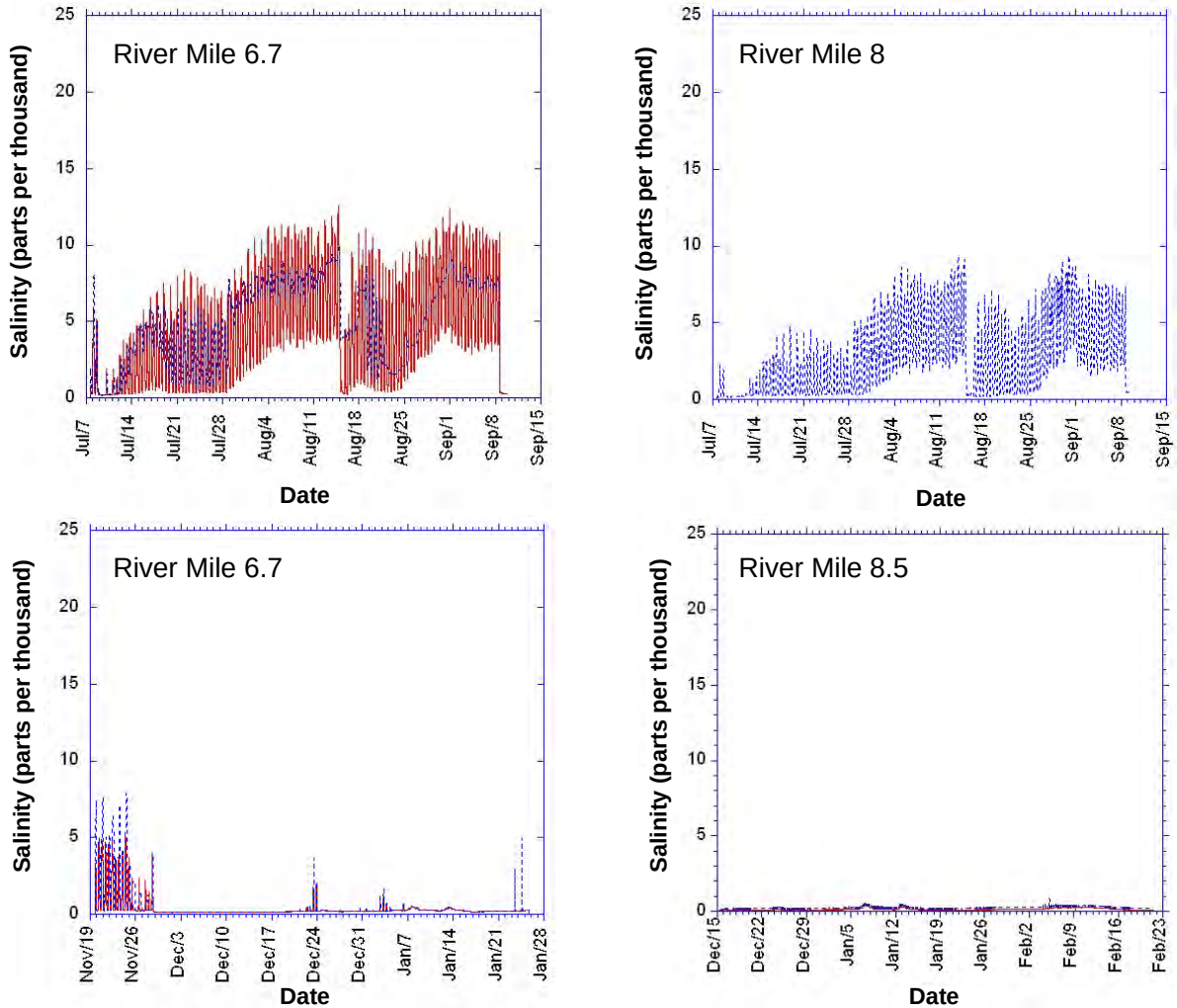
Salinity values less than 0.5 parts per thousand are considered "freshwater," which are free of seawater influences.

Temporal Trends in Salinity at U.S. Geological Survey Gauge at Little Falls

Lower Passaic River Restoration Project

Figure 3-1e

February 2007



Legend

Salinity measurements collected from the river surface

Salinity measurements collected from the river bottom

Notes

River Mile 6.7 – Data collected from July 8, 2004 to September 10, 2004 at Rutgers University Buoy #M5.

River Mile 8 – Data collected from July 8, 2004 to September 10, 2004 at Rutgers University Buoy #M6.

River Mile 6.7 – Data collected from November 20, 2004 to January 25, 2005 at Rutgers University Buoy #M5.

River Mile 8.5 – Data collected from December 15, 2004 to February 21, 2005 at Malcolm Pirnie, Inc. Buoy #3. Same data as Figure 3-1d on a different scale.

Source for Rutgers University data: http://marine.rutgers.edu/cool/passaic

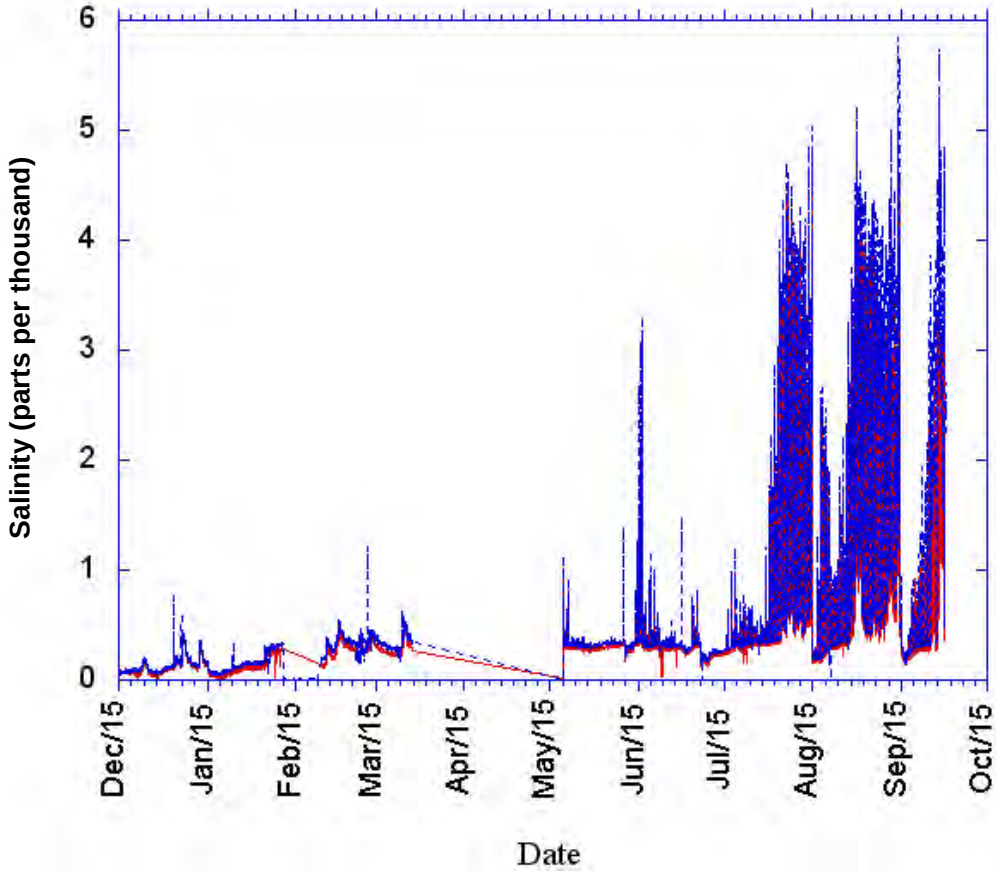
Seasonal Effects on Salinity

Lower Passaic River Restoration Project

Figure 3-1f

February 2007

R2-0009096



Legend

Salinity measurements collected from the river surface

Salinity measurements collected from the river bottom

Notes

Salinity values were calculated from conductivity, temperature, and depth data recorded by a conductivity temperature depth probe.

Data collected from December 15, 2004 to September 30, 2005 by Malcolm Pirnie, Inc.

River Mile 10 – Data collected from Malcolm Pirnie, Inc. Buoy #2.

Temporal Trends in Salinity at RM10

Lower Passaic River Restoration Project

Figure 3-1g

February 2007

R2-0009097

Legend

- Rock and Coarse gravel
- Gravel and Sand
- Sand
- Silt and Sand
- Silt
- River Mile Post

2004 USACE Bathymetric Survey

Elevation (Feet) Relative to NGVD29

- -30 to -20
- -8 to 0
- -18 to -10
- 2 to 10

Notes

Data Sources:
Buildings: CADD drawing, 09994X01, dated January 1, 2002 received from BBL.

Roads: 2000 TIGER line data.

Sediment Texture: 2005 Side scan SONAR data from Aqua Survey, Inc.

Side-Scan Sonar Survey Interpretation of Lower Passaic River Bottom Sediments near RM8

Lower Passaic River Restoration Project

Figure 3-2

February 2007

R2-0009098

River Mile 1.4 (left-bank descending) Kearny, NJ

River Mile 1.6 (left-bank descending) Kearny, NJ

River Mile 1.7 (left-bank descending) Kearny, NJ

River Mile 2.1 (right-bank descending) Newark, NJ

Photolog of Shoreline Conditions and Surrounding Habitat
Brackish River Section (Part 1)

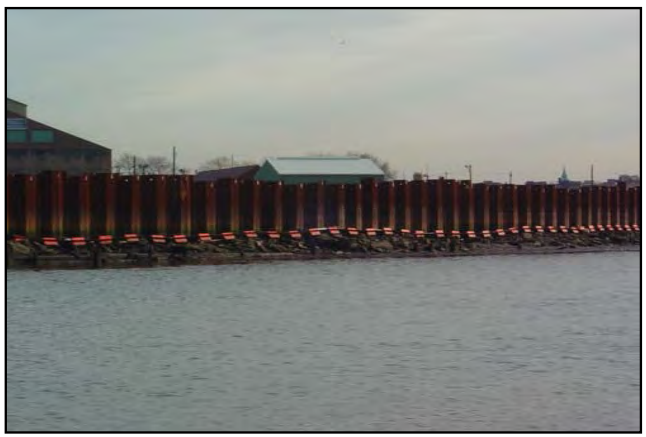
Lower Passaic River Restoration Project

Figure 3-3a

February 2007

River Mile 3.5 (left-bank descending) Newark, NJ

River Mile 4.0 (right-bank descending) Newark, NJ



River Mile 5.1 (right-bank descending) Newark, NJ

River Mile 5.5 (left-bank descending) Harrison, NJ

Photolog of Shoreline Conditions and Surrounding Habitat
Brackish River Section (Part 2)

Lower Passaic River Restoration Project

Figure 3-3b

February 2007

River Mile 6.3 (left-bank descending) Kearny, NJ

River Mile 6.8 (left-bank descending) Kearny, NJ

River Mile 7.1 (left-bank descending) Kearny, NJ

River Mile 7.8 (right-bank descending) Kearny, NJ

Photolog of Shoreline Conditions and Surrounding Habitat
Transitional River Section

Lower Passaic River Restoration Project

Figure 3-3c

February 2007

River Mile 12.8 (right-bank descending) Passaic, NJ

River Mile 15.8 (right-bank descending) Passaic, NJ

River Mile 15.9 (right-bank descending) Passaic, NJ

Photolog of Shoreline Conditions and Surrounding Habitat
Freshwater River Section (Part 1)

Lower Passaic River Restoration Project

Figure 3-3d

February 2007

River Mile 16.6 (left-bank descending) Garfield, NJ

River Mile 17.2 (left-bank descending) Garfield, NJ

River Mile 17.2 (left-bank descending) Garfield, NJ

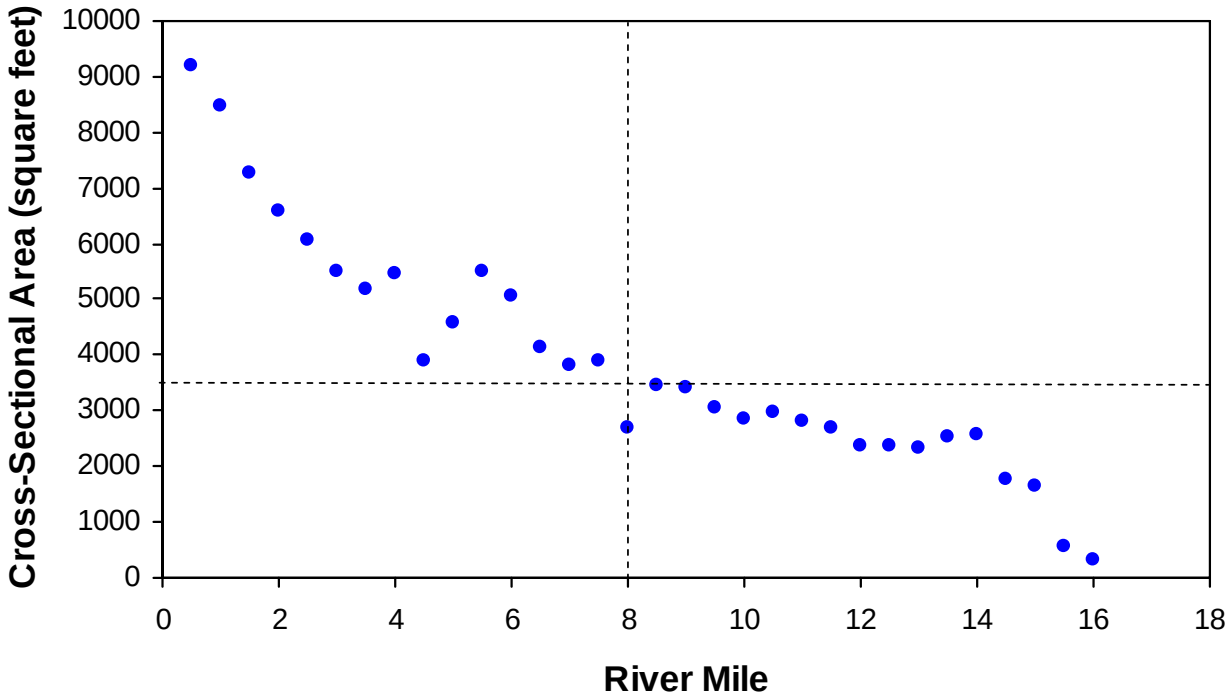
River Mile 17.4 (Dundee Dam) Clifton and Garfield, NJ

Photolog of Shoreline Conditions and Surrounding Habitat
Freshwater River Section (Part 2)

Lower Passaic River Restoration Project

Figure 3-3e

February 2007



Legend

● Cross-Sectional Area (square feet)

- - - - Highlights the change to a river cross sectional area of 3,500 square feet at RM8

Notes

Cross-sectional area estimated from 2004 bathymetric data surveyed by Rogers Survey, Inc. for USACE.

Cross-sectional area refers to the water filled area of the river channel when water level is equal to 0 feet elevation at NGVD29.

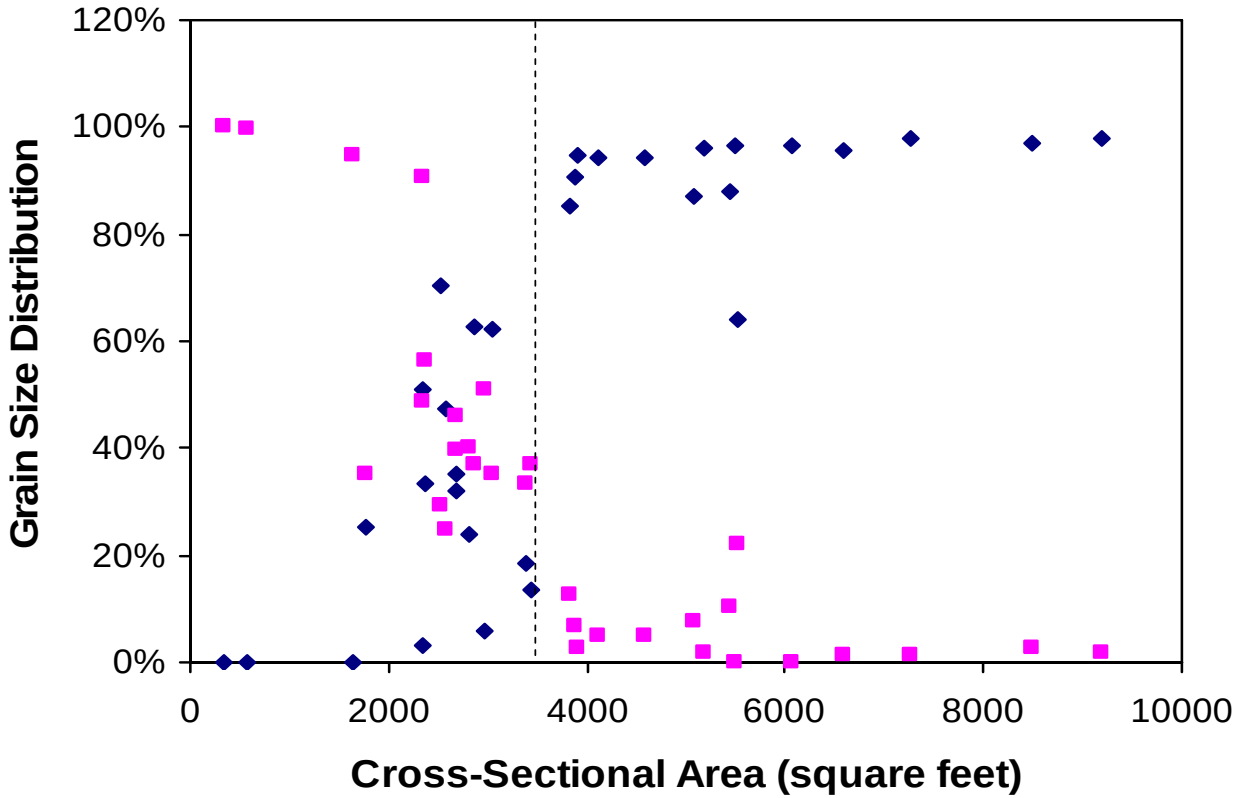
Variation of Lower Passaic River Cross-Sectional Area with River Mile

Lower Passaic River Restoration Project

Figure 3-4

February 2007

R2-0009104



Legend

- Fine-grained sediment
- Coarse-grained sediment
- ---- Highlights the change to a river cross sectional area of 3,500 square feet

Notes

Cross-sectional area estimated from 2004 bathymetric data surveyed by Rogers Survey, Inc. for USACE.

Sediment texture was evaluated based on data interpolated by Aqua Survey, Inc. using side-scan sonar images (Aqua Survey, Inc., 2006). Sediment texture data extends from RM0 to RM16.5.

Refer to Figure 1-6 for relationship between river mile and cross-sectional area.

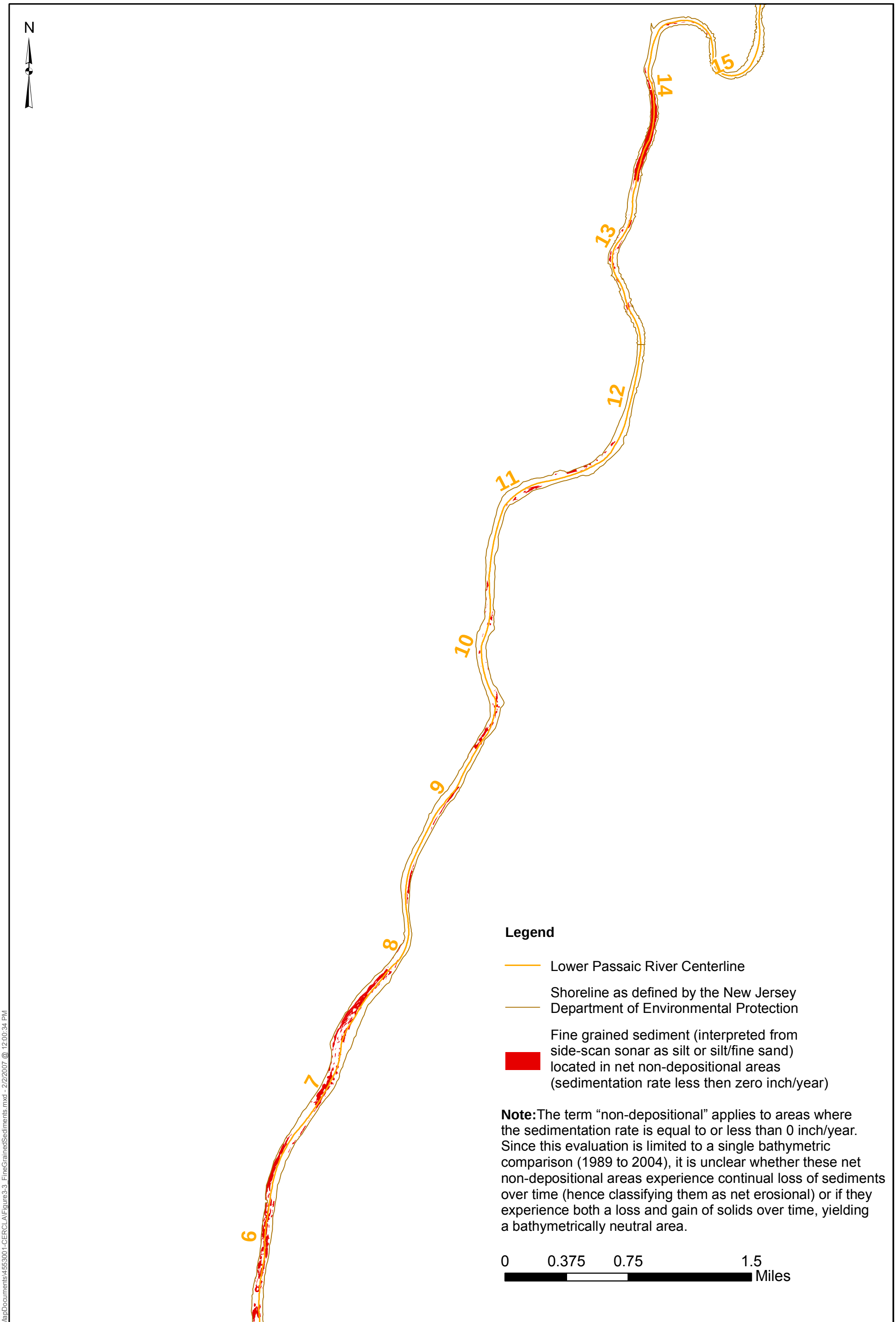
Variation of Lower Passaic River Sediment Type with River Cross-Sectional Area

Lower Passaic River Restoration Project

Figure 3-5

February 2007

R2-0009105



S:\Projects\PASSAIC\MapDocuments\4553001-CERCLA\Figure3-3_FineGrainedSediments.mxd - 2/2/2007 @ 12:00:34 PM

US Army Corp of Engineers

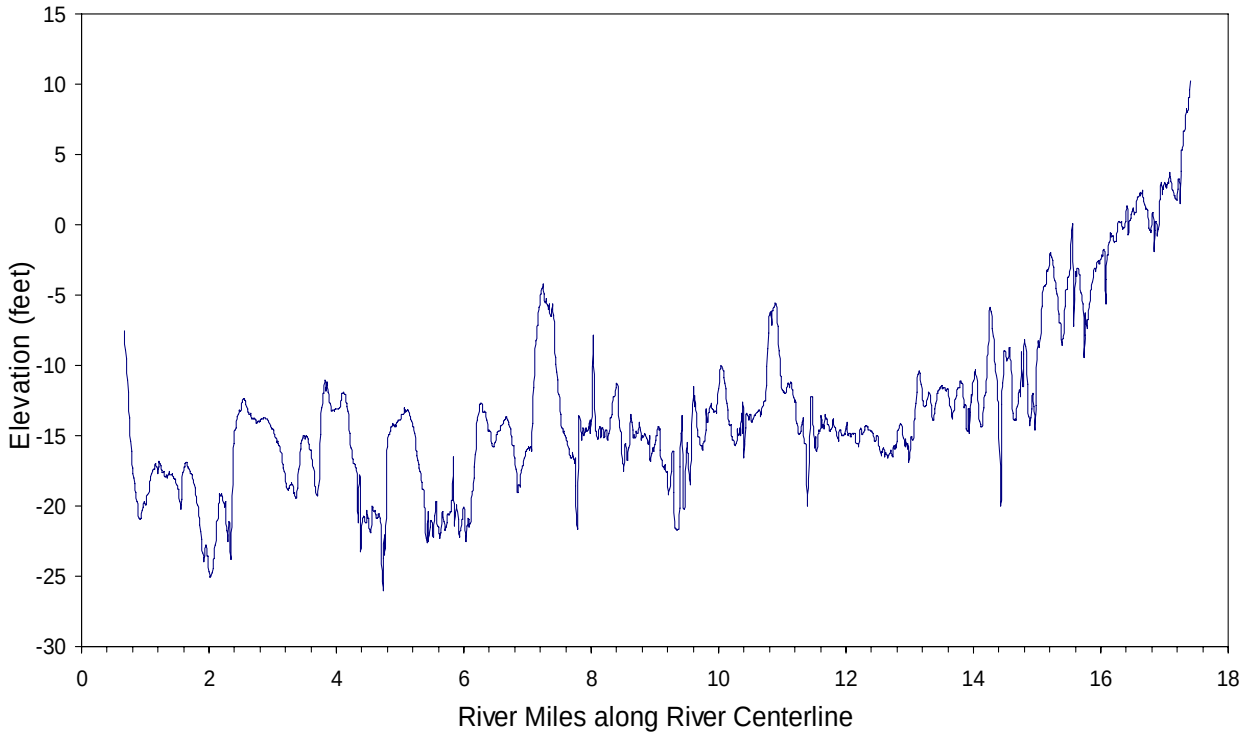
Fine-Grained Sediments in Net Non-Depositional Areas Upriver of RM6

Lower Passaic River Restoration Project

Data Source:
1989 Bathymetric Survey: Topo Metrics,Inc for USACE
2004 Bathymetric Survey: Rogers Surveying for USACE
2005 Sediment Texture: Aqua Survey, Inc.
Note: Analysis was limited by the extent of the 1989 bathymetric survey (RM0 to RM15).

Figure 3-6

February 2007



Legend

Elevation (feet) relative to NGVD29

Notes

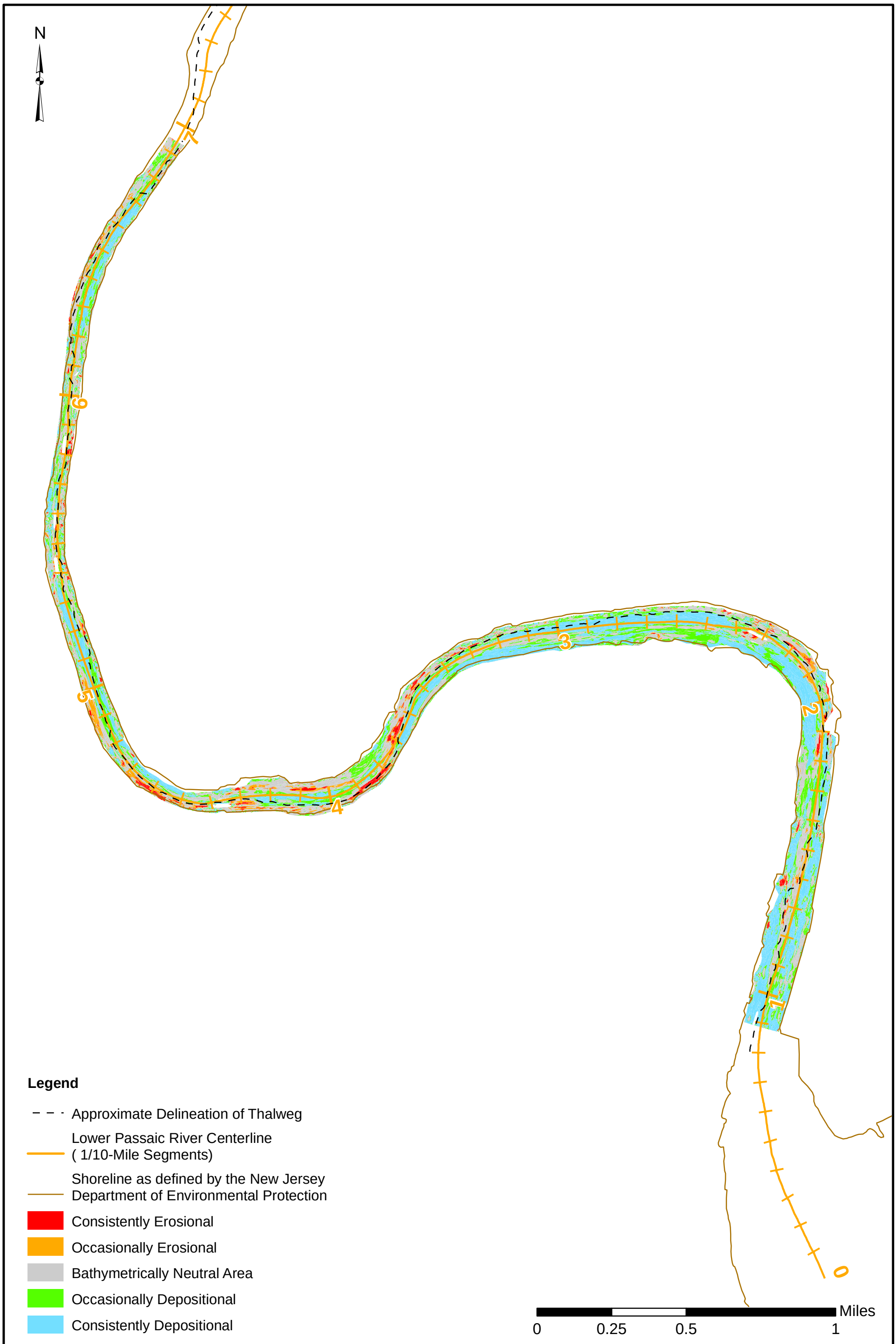
Elevation data estimated from 2004 bathymetric data surveyed by Rogers Survey, Inc. for USACE.

River Bottom Elevation

Lower Passaic River Restoration Project

Figure 3-7

February 2007



Net Erosional and Net Depositional Areas (RM0.9 to RM7)

Lower Passaic River Restoration Project

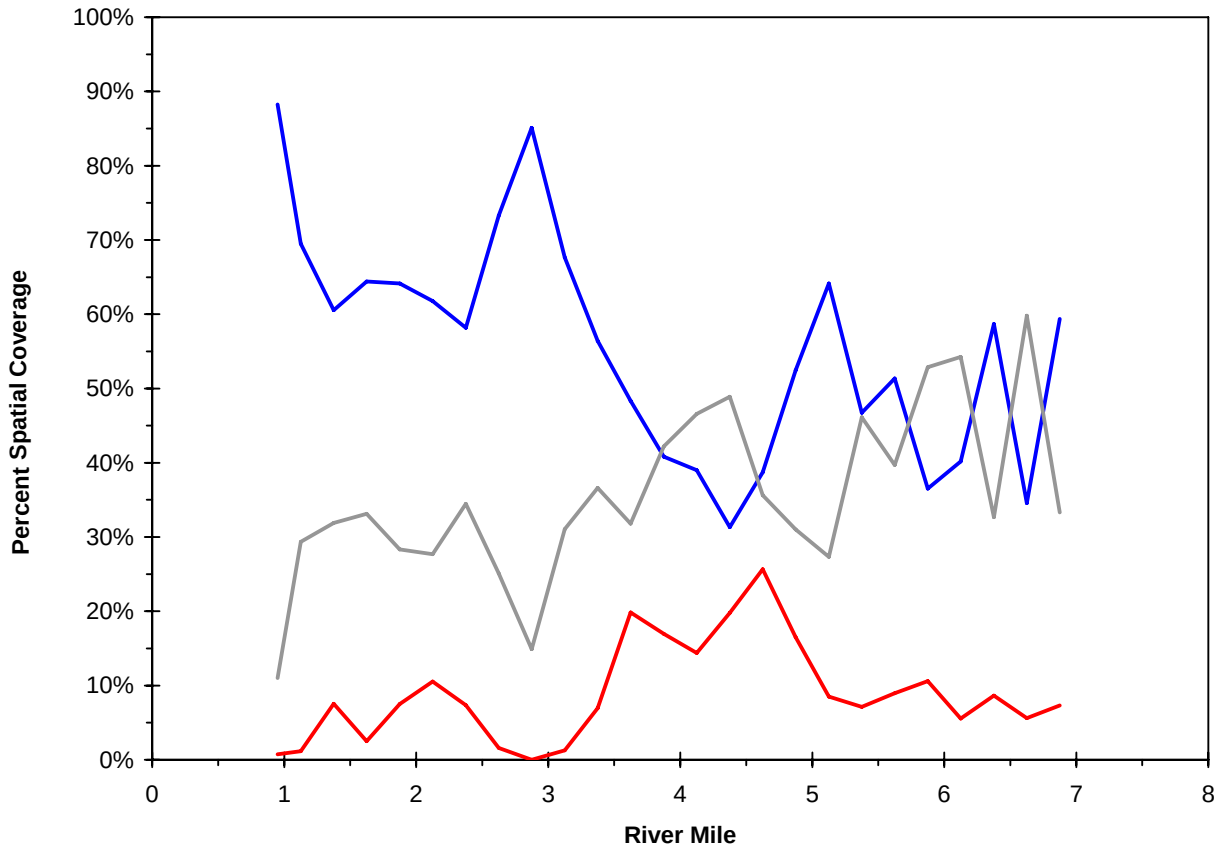
Data Sources : Tierra Solutions Inc., Bathymetric Surveys for 1995,1996,1997,1999 and 2001

Figure 5-1

February 2007

Map Document (S:\Projects\PASSAIC\MapDocuments\4553001-CERCLA\Figure4-1.mxd) 8/25/2006 -- 3:55:03 PM

R2-0009108



Legend

- Consistently and Occasionally Erosional
- Consistently and Occasionally Depositional
- Bathymetrically Neutral Area

Notes

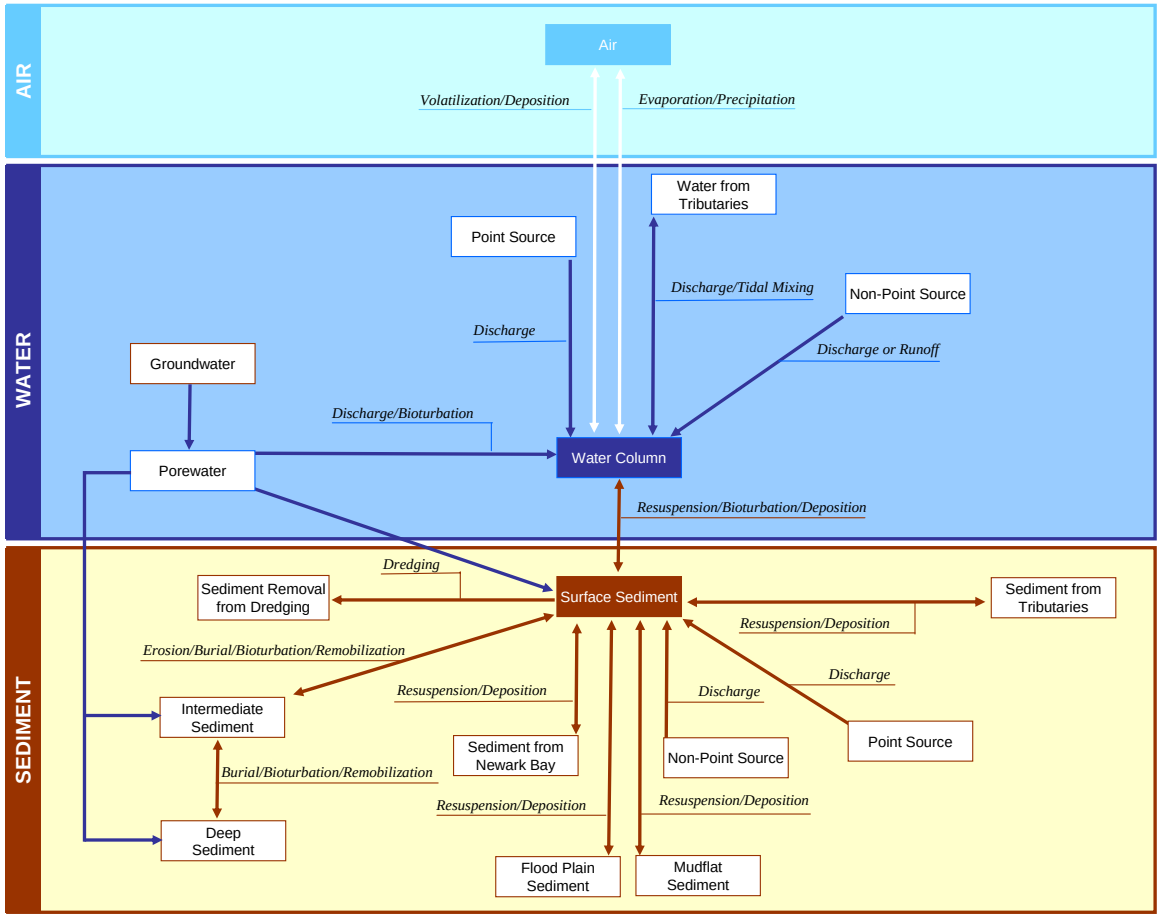
Refer to Figure 5-1 for more detail on net erosional, net depositional, and bathymetrically neutral areas.

Percent Spatial Coverage of Net Erosional, Net Depositional, and Bathymetrically Neutral Areas

Lower Passaic River Restoration Project

Figure 5-2

February 2007



NOTES

Figure 6-1 depicts substantive physical processes that affect the transport of contaminants between different media. Some physical processes may be less significant or absent in certain river sections. Future iterations of the CSM will prioritize these physical processes. Note that the chemical fate and transport processes are depicted in subsequent figures.

The color scheme used in Figure 6-1 reflects different media, including air (light blue), water (dark blue), and sediment (brown), and it represents the media depicted in Figure 2-2.

LEGEND

Groundwater — Sources of contaminants to the Lower Passaic River

Release mechanisms connecting associated inventories (bi-directional arrows are marked with two mechanisms separated by a slash mark)

Input to Human Health and Ecological Evaluations

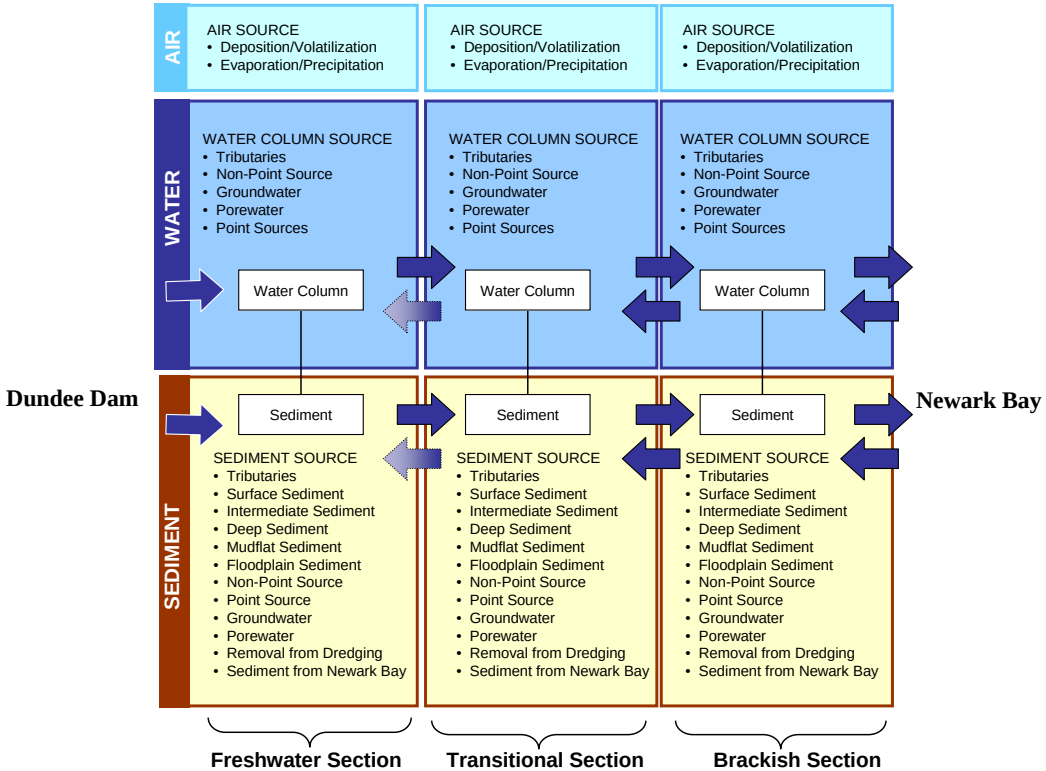
General Sources and Physical Release Mechanisms for Contaminants in Sediment, Water, and Air

Lower Passaic River Restoration Project

Figure 6-1

February 2007

R2-0009110



NOTES

Sources and processes shown in Figure 6-1 are applicable to Figure 6-2; however, for simplicity, arrows presented in Figure 6-1 are not duplicated in Figure 6-2. Note that some sources may be less significant or absent in certain river sections; future iteration of the CSM will prioritize these sources.

The color scheme and boxes used in Figure 6-2 reflect different media, including air (light blue box), water (dark blue box), and sediment (brown box), and they represent the sources, mechanisms, and media depicted in Figure 2-2 and Figure 6-1.

Future iterations of the CSM will prioritize these sources.

LEGEND

Direction of substantive water flow and sediment transport on the Lower Passaic River

Direction of potential water flow and sediment transport on the Lower Passaic River

Input to Human Health and Ecological Evaluations

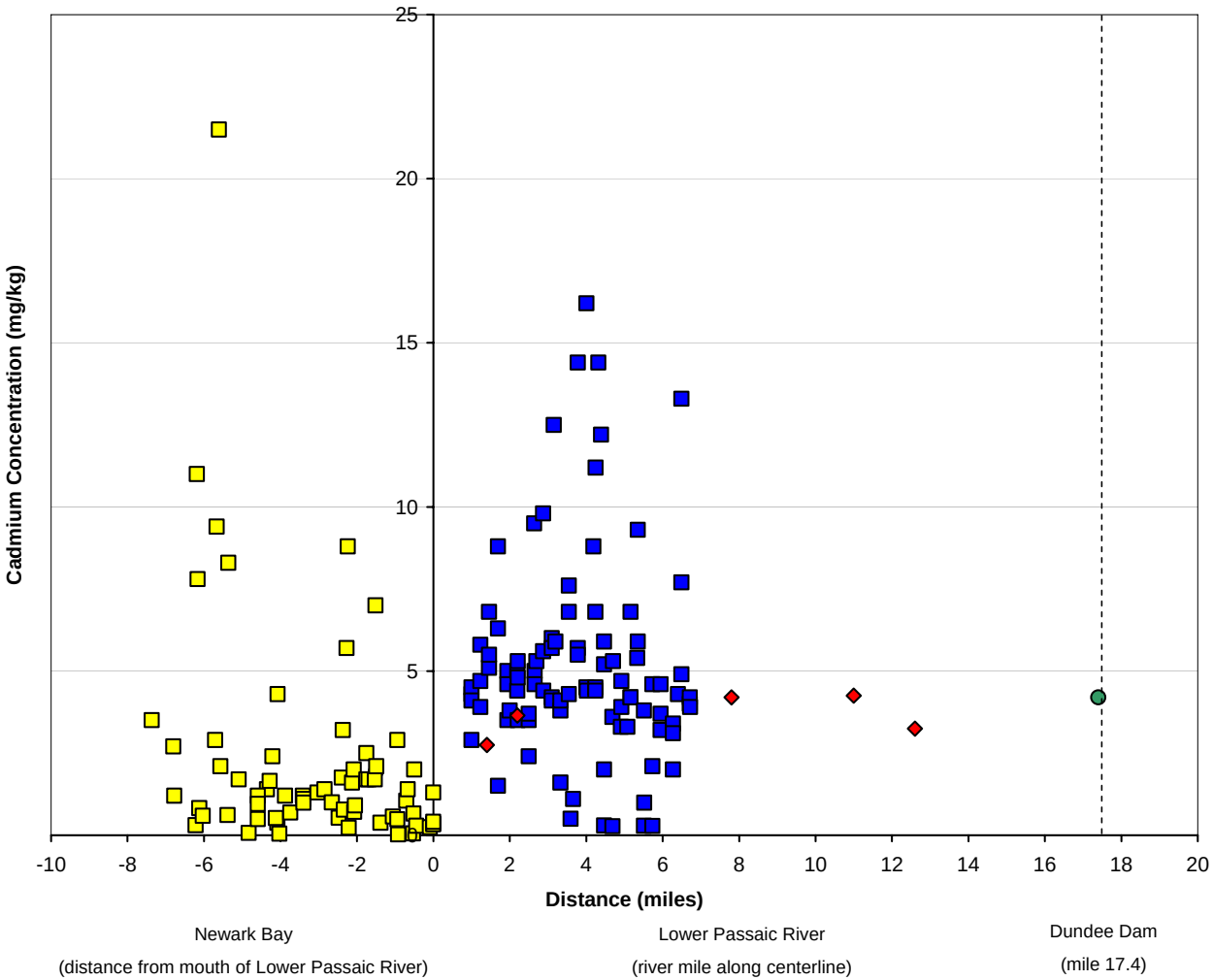
General Sources of Contamination in Each River Section

Lower Passaic River Restoration Project

Figure 6-2

February 2007

R2-0009111



Legend

- Malcolm Pirnie, Inc. (2005) (represents 2003-2005 time horizon)
- TSI (2005) (represents 0-6 inches of sediment)
- TSI (1995) (represents 0-6 inches of sediment)
- Bopp *et al.* (2006) (represents 1985-1986 time horizon)

Notes

Malcolm Pirnie, Inc. Data Source: USEPA 2005-2006 Sampling Program.

TSI Data Source: 2005 Newark Bay Phase I Investigation and 1995 TSI Dataset.

Bopp Data Source: "Contaminant Chronologies from Hudson River Sedimentary Records," Bopp *et al.* (2006).

Nondetect (lab qualifier containing a U) plotted as half the reported value.

Surface concentrations represent a depth of 0 to <1 foot.

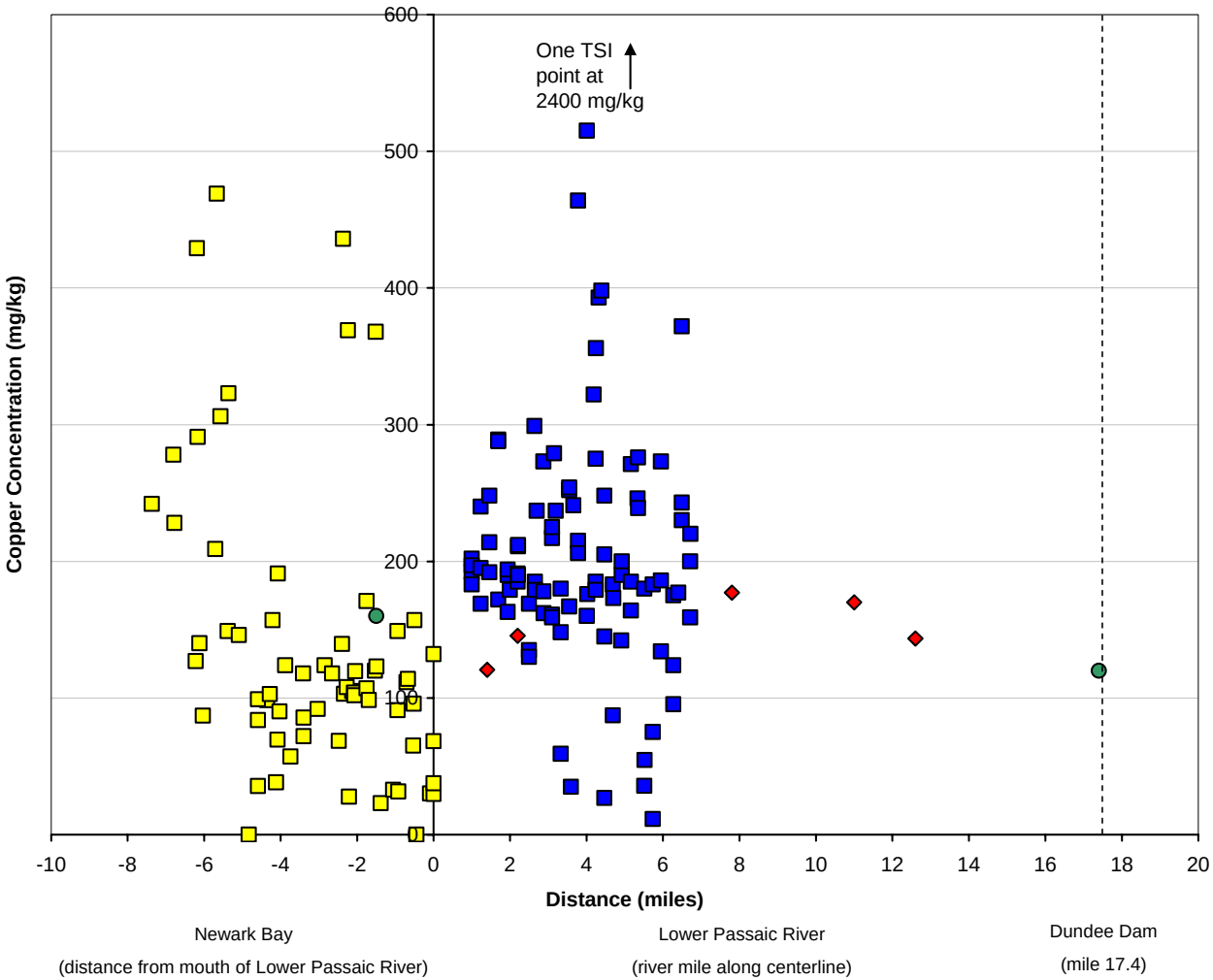
Comparison of Surface Cadmium Concentrations in 1985-1986, 1995, and 2005

Lower Passaic River Restoration Project

Figure 6-3a

February 2007

R2-0009112



Legend

- Malcolm Pirnie, Inc. (2005) (represents 2003-2005 time horizon)
- TSI (2005) (represents 0-6 inches of sediment)
- TSI (1995) (represents 0-6 inches of sediment)
- Bopp *et al.* (2006) (represents 1985-1986 time horizon)

Notes

Malcolm Pirnie, Inc. Data Source: USEPA 2005-2006 Sampling Program.

TSI Data Source: 2005 Newark Bay Phase I Investigation and 1995 TSI Dataset.

Bopp Data Source: "Contaminant Chronologies from Hudson River Sedimentary Records," Bopp *et al.* (2006).

Nondetect (lab qualifier containing a U) plotted as half the reported value.

Surface concentrations represent a depth of 0 to <1 foot.

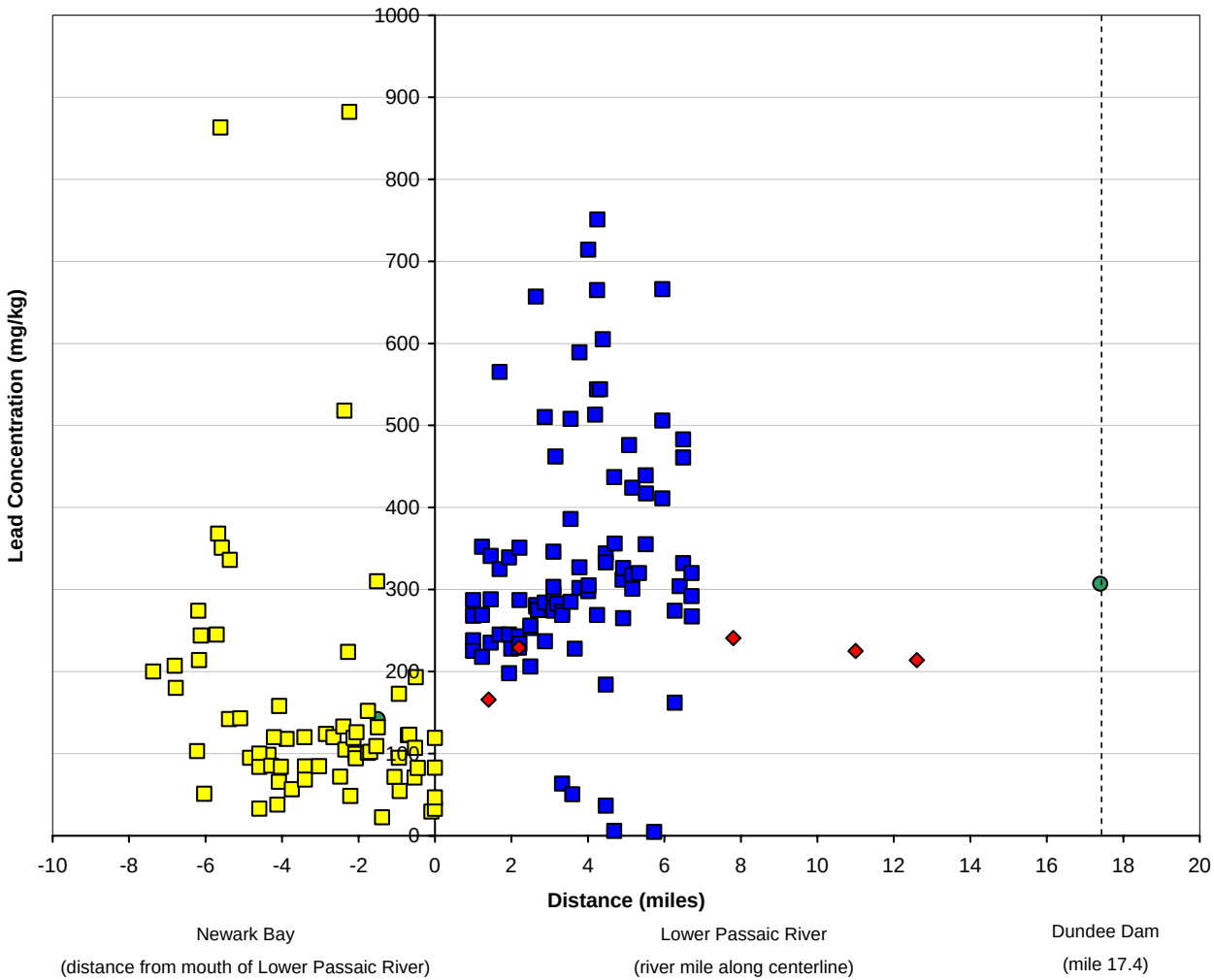
Comparison of Surface Copper Concentrations in 1985-1986, 1995, and 2005

Lower Passaic River Restoration Project

Figure 6-3b

February 2007

R2-0009113



Legend

- Malcolm Pirnie, Inc. (2005) (represents 2003-2005 time horizon)
- TSI (2005) (represents 0-6 inches of sediment)
- TSI (1995) (represents 0-6 inches of sediment)
- Bopp *et al.* (2006) (represents 1985-1986 time horizon)

Notes

Malcolm Pirnie, Inc. Data Source: USEPA 2005-2006 Sampling Program.

TSI Data Source: 2005 Newark Bay Phase I Investigation and 1995 TSI Dataset.

Bopp Data Source: "Contaminant Chronologies from Hudson River Sedimentary Records," Bopp *et al.* (2006).

Nondetect (lab qualifier containing a U) plotted as half the reported value.

Surface concentrations represent a depth of 0 to <1 foot.

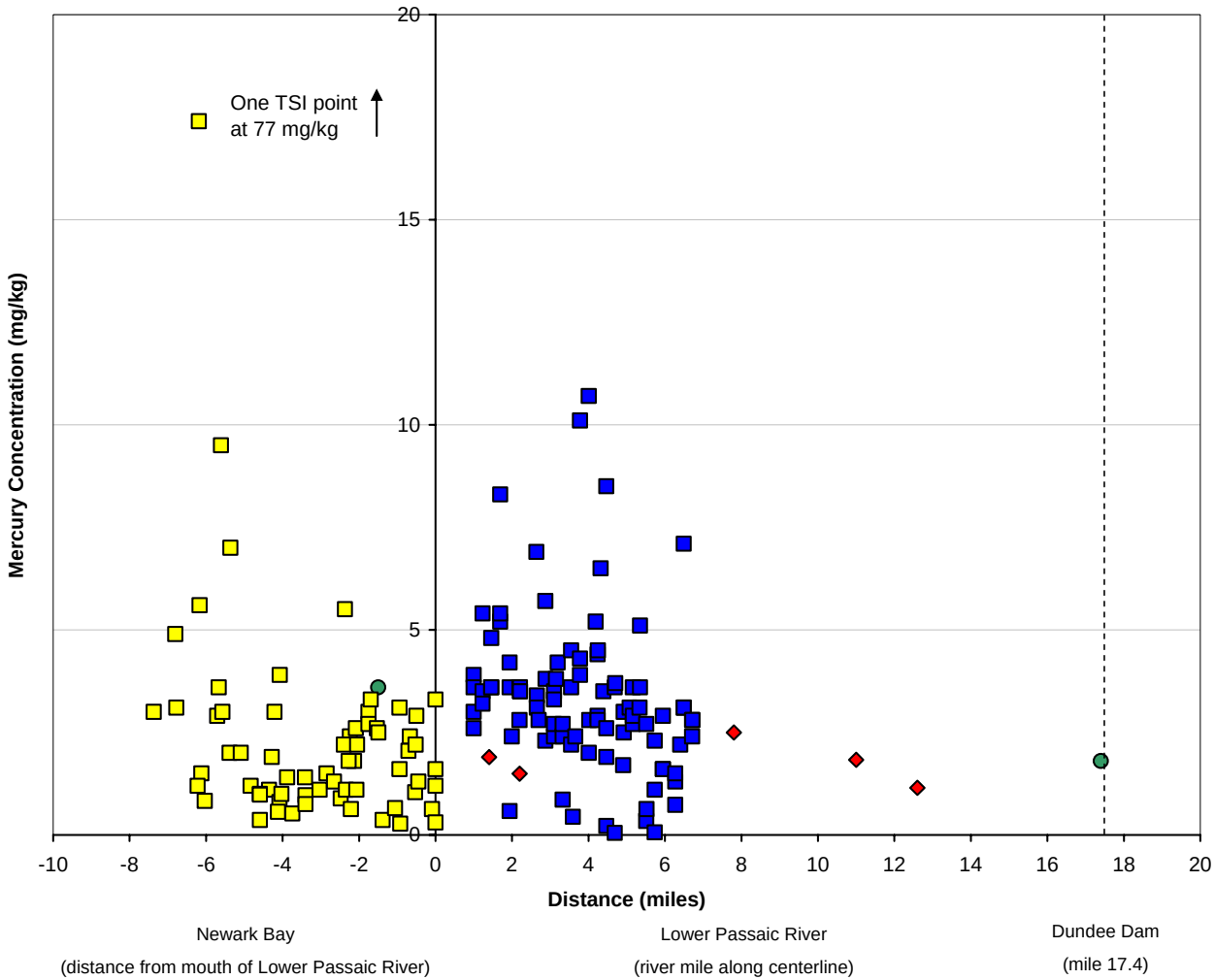
Comparison of Surface Lead Concentrations in 1985-1986, 1995, and 2005

Lower Passaic River Restoration Project

Figure 6-3c

February 2007

R2-0009114



Legend

- Malcolm Pirnie, Inc. (2005) (represents 2003-2005 time horizon)
- TSI (2005) (represents 0-6 inches of sediment)
- TSI (1995) (represents 0-6 inches of sediment)
- Bopp *et al.* (2006) (represents 1985-1986 time horizon)

Notes

Malcolm Pirnie, Inc. Data Source: USEPA 2005-2006 Sampling Program.

TSI Data Source: 2005 Newark Bay Phase I Investigation and 1995 TSI Dataset.

Bopp Data Source: "Contaminant Chronologies from Hudson River Sedimentary Records," Bopp *et al.* (2006).

Nondetect (lab qualifier containing a U) plotted as half the reported value.

Surface concentrations represent a depth of 0 to <1 foot.

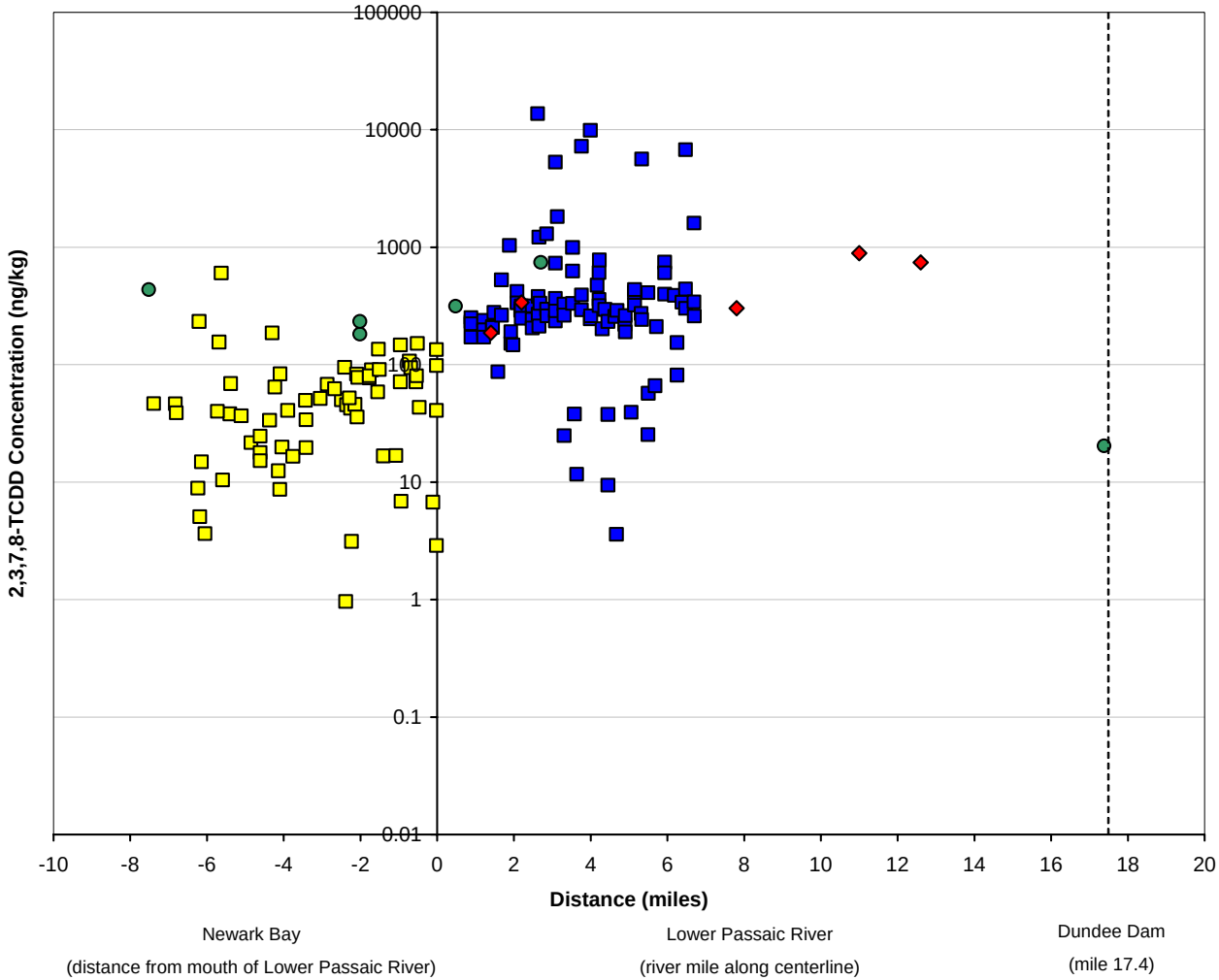
Comparison of Surface Mercury Concentrations in 1985-1986, 1995, and 2005

Lower Passaic River Restoration Project

Figure 6-3d

February 2007

R2-0009115



Legend

- Malcolm Pirnie, Inc. (2005) (represents 2003-2005 time horizon)
- TSI (2005) (represents 0-6 inches of sediment)
- TSI (1995) (represents 0-6 inches of sediment)
- Bopp *et al.* (2006) (represents 1985-1986 time horizon)

Notes

Malcolm Pirnie, Inc. Data Source: USEPA 2005-2006 Sampling Program.

TSI Data Source: 2005 Newark Bay Phase I Investigation and 1995 TSI Dataset.

Bopp Data Source: "Contaminant Chronologies from Hudson River Sedimentary Records," Bopp *et al.* (2006).

Nondetect (lab qualifier containing a U) plotted as half the reported value.

Surface concentrations represent a depth of 0 to <1 foot.

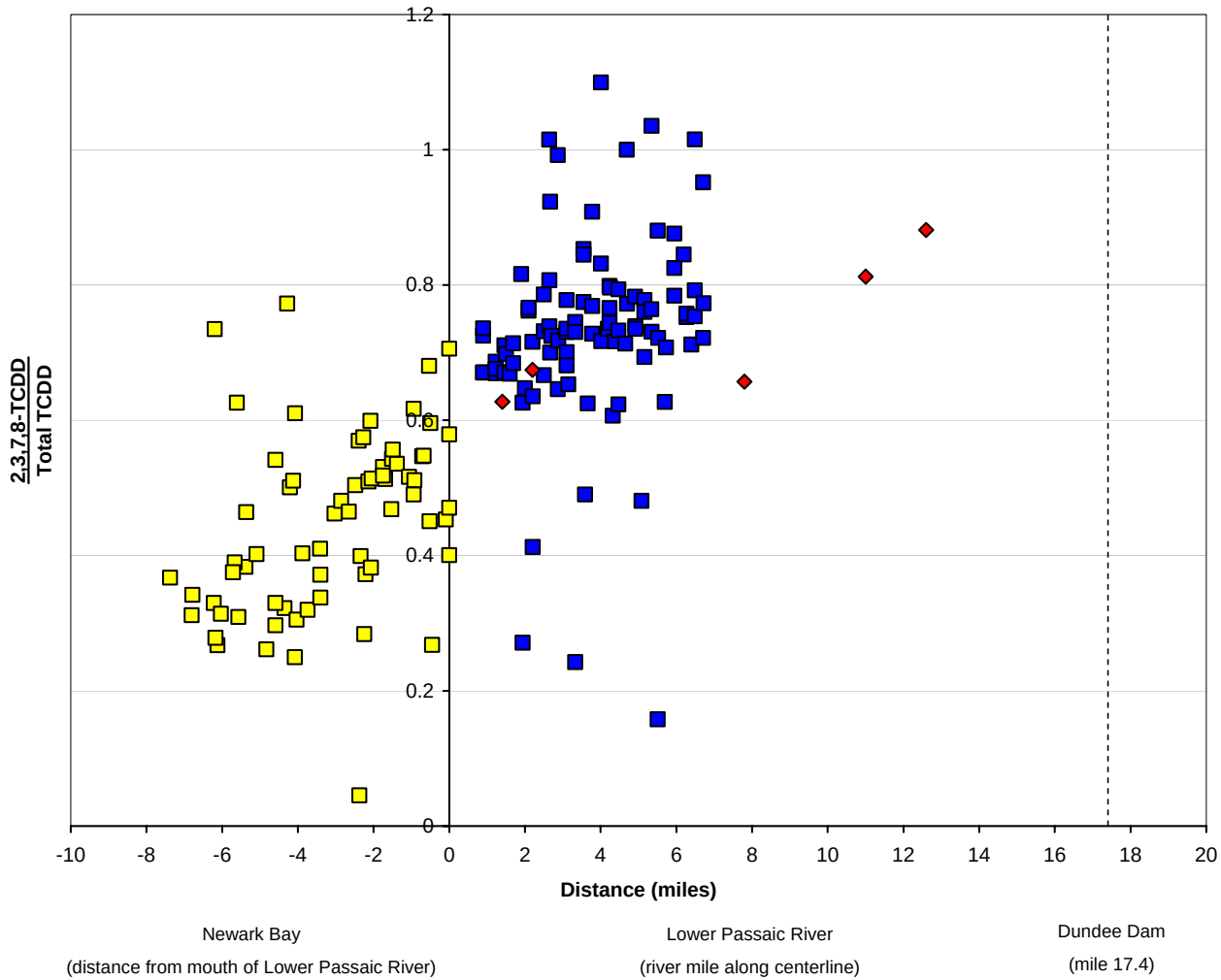
Comparison of Surface 2,3,7,8-TCDD Concentrations in 1985-1986, 1995, and 2005

Lower Passaic River Restoration Project

Figure 6-3e

February 2007

R2-0009116



Legend

- Malcolm Pirnie, Inc. (2005) (represents 2003-2005 time horizon)
- TSI (2005) (represents 0-6 inches of sediment)
- TSI (1995) (represents 0-6 inches of sediment)

Notes

Malcolm Pirnie, Inc. Data Source: USEPA 2005-2006 Sampling Program.

TSI Data Source: 2005 Newark Bay Phase I Investigation and 1995 TSI Dataset.

Nondetect (lab qualifier containing a U) plotted as half the reported value.

Surface concentrations represent a depth of 0 to <1 foot.

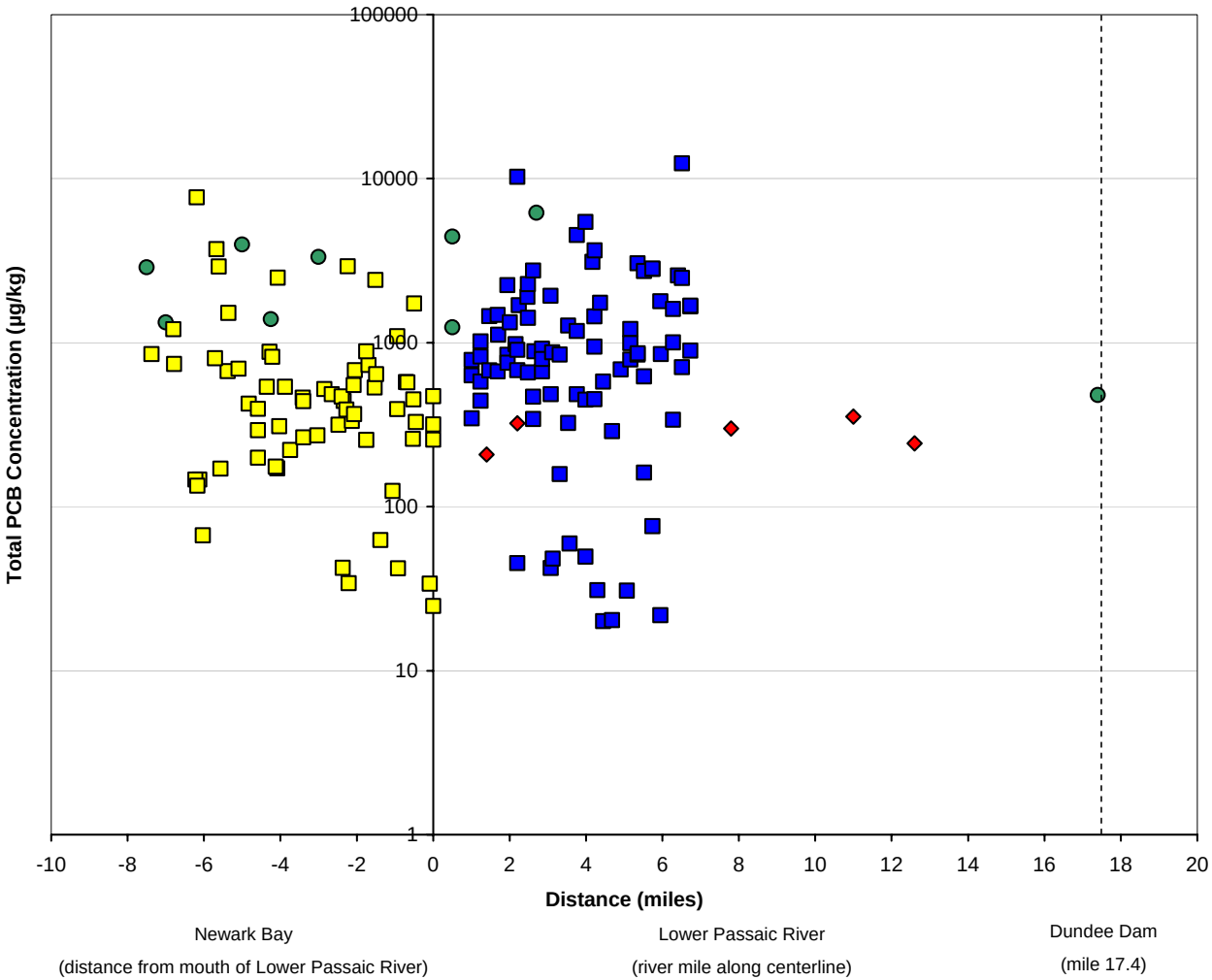
Comparison of Surface 2,3,7,8-TCDD/Total TCDD Ratio in 1985-1986, 1995, and 2005

Lower Passaic River Restoration Project

Figure 6-3f

February 2007

R2-0009117



Legend

- Malcolm Pirnie, Inc. (2005) (represents 2003-2005 time horizon)
- TSI (2005) (represents 0-6 inches of sediment)
- TSI (1995) (represents 0-6 inches of sediment)
- Bopp *et al.* (2006) (represents 1985-1986 time horizon)

Notes

Malcolm Pirnie, Inc. Data Source: USEPA 2005-2006 Sampling Program.

TSI Data Source: 2005 Newark Bay Phase I Investigation and 1995 TSI Dataset.

Bopp Data Source: "Contaminant Chronologies from Hudson River Sedimentary Records," Bopp *et al.* (2006).

Nondetect (lab qualifier containing a U) plotted as half the reported value.

Surface concentrations represent a depth of 0 to <1 foot.

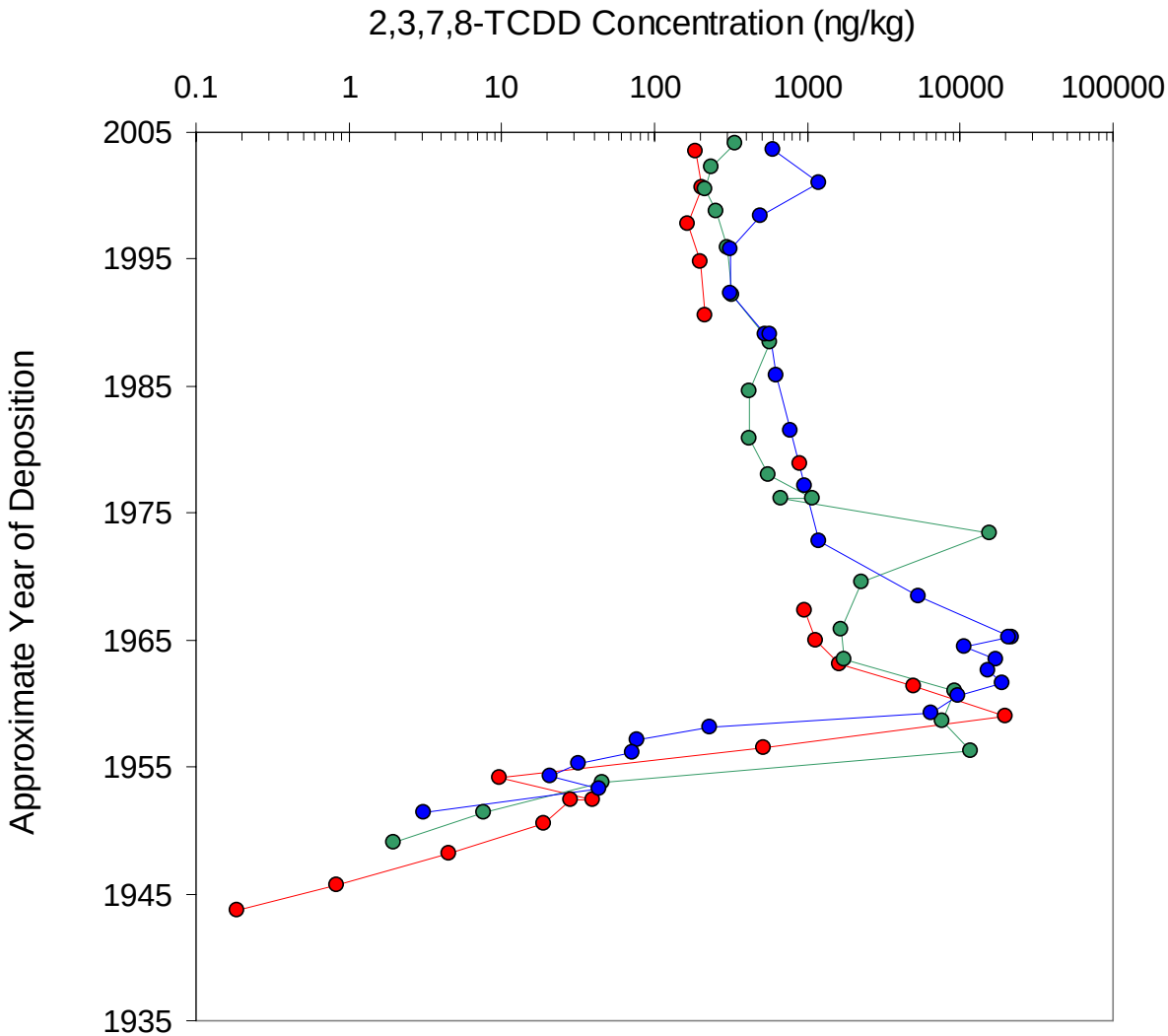
Comparison of Surface Total PCB Concentrations in 1985-1986, 1995, and 2005

Lower Passaic River Restoration Project

Figure 6-3g

February 2007

R2-0009118



Legend

- 2,3,7,8-TCDD at RM 1.4
- 2,3,7,8-TCDD at RM 2.2
- 2,3,7,8-TCDD at RM 11

Notes

2005 Malcolm Pirnie, Inc. High Resolution Sediment Core Programs.

Depositional years calculated using cesium-137 concentrations.

Note that one criterion for a high resolution sediment core is that the location experiences continuous deposition over time.

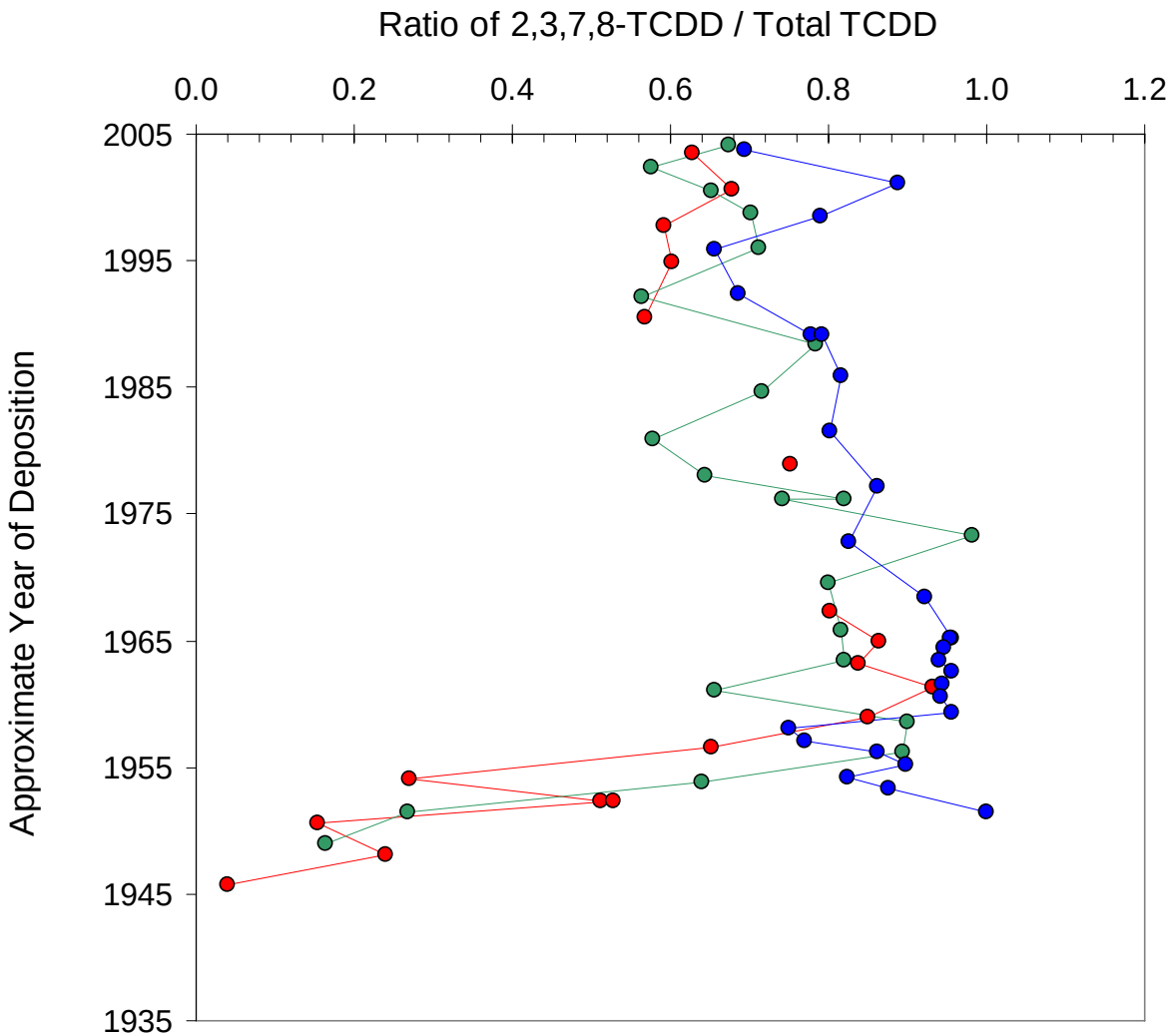
The determination of the 1954 horizon in core at RM11 is based on the absence of cesium-137 detection below 191 centimeters. There are some uncertainties with this assignment, and the core may extend 4 years longer than is shown here.

Downcore Profiles of 2,3,7,8-TCDD Concentrations at RM 1.4, RM 2.2, and RM 11

Lower Passaic River Restoration Project

Figure 6-4

February 2007



Legend

- Ratio at RM 1.4
- Ratio at RM 2.2
- Ratio at RM 11

Notes

2005 Malcolm Pirnie, Inc. High Resolution Sediment Core Programs.

Depositional years calculated using cesium-137 concentrations.

Note that one criterion for a high resolution sediment core is that the location experience continuous deposition over time.

The determination of the 1954 horizon in core at RM11 is based on the absence of cesium-137 detection below 191 centimeters. There are some uncertainties with this assignment, and the core may extend 4 years longer than is shown here.

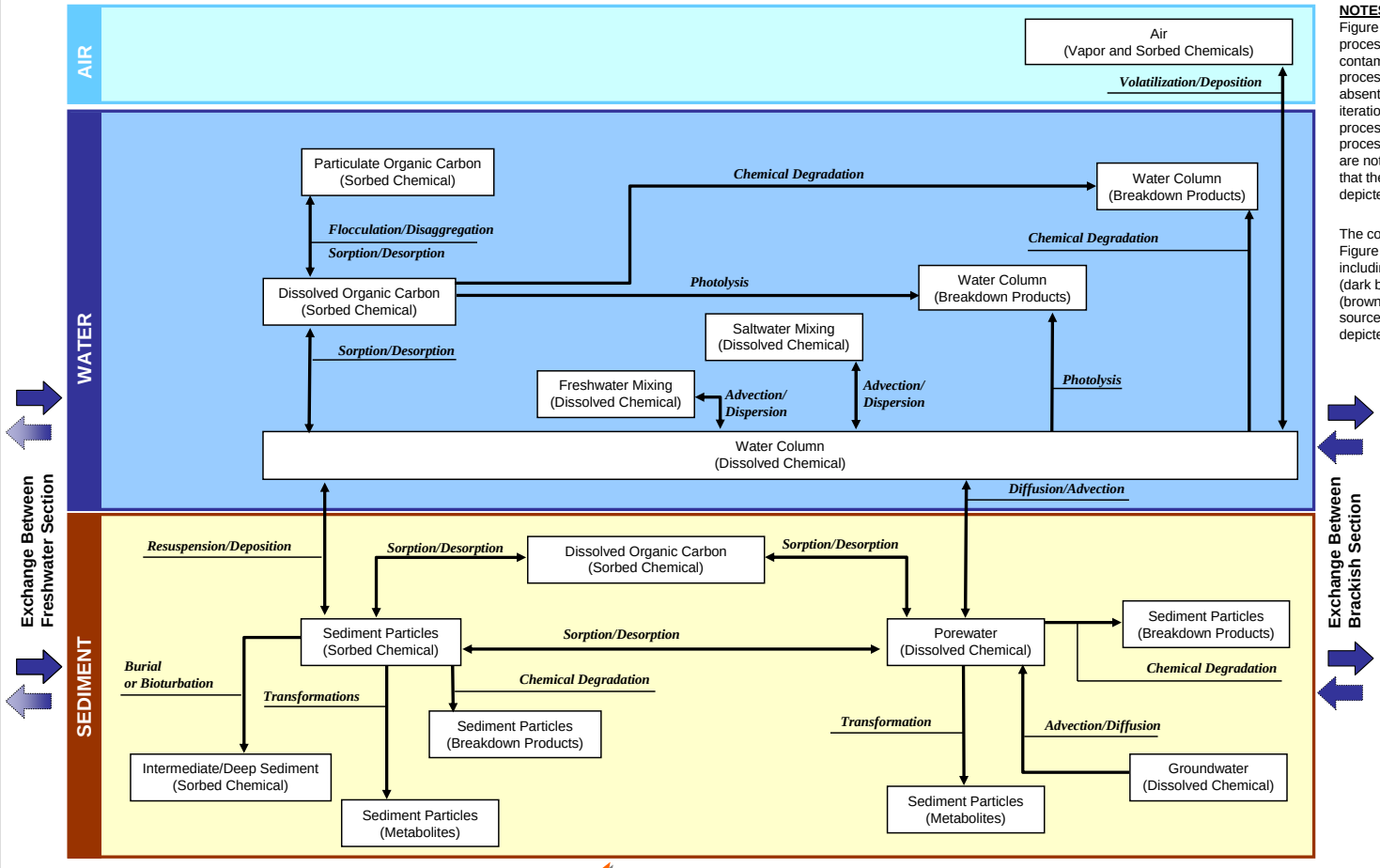
Downcore Profiles of 2,3,7,8-TCDD/Total TCDD Ratio at RM 1.4, RM 2.2, and RM 11

Lower Passaic River Restoration Project

Figure 6-5

February 2007

R2-0009120



NOTES

Figure 7-1 depicts substantive chemical processes that affect the transport of contaminants. Some chemical processes may be less significant or absent in certain river sections. Future iterations of the CSM will prioritize these processes. For simplicity, physical process shown on Figures 6-1 and 6-2 are not duplicated in this figure. Note that the biological processes are depicted in subsequent figures.

The color scheme and boxes used in Figure 7-1 reflect different media, including air (light blue box), water (dark blue box), and sediment (brown box), and they represent the sources, mechanisms, and media depicted in Figures 2-2, 6-1, and 6-2.

LEGEND for Figures 7-1 and 7-2

Inventory with chemical state marked in parentheses, where appropriate

Abiotic reactions or pathways connecting associated inventories

Biotic reactions or pathways connecting associated inventories (see Figure 7-2)

Direction of substantive water flow and sediment transport on the Lower Passaic River

Direction of potential water flow and sediment transport on the Lower Passaic River

Input to
Human Health and
Ecological Evaluations

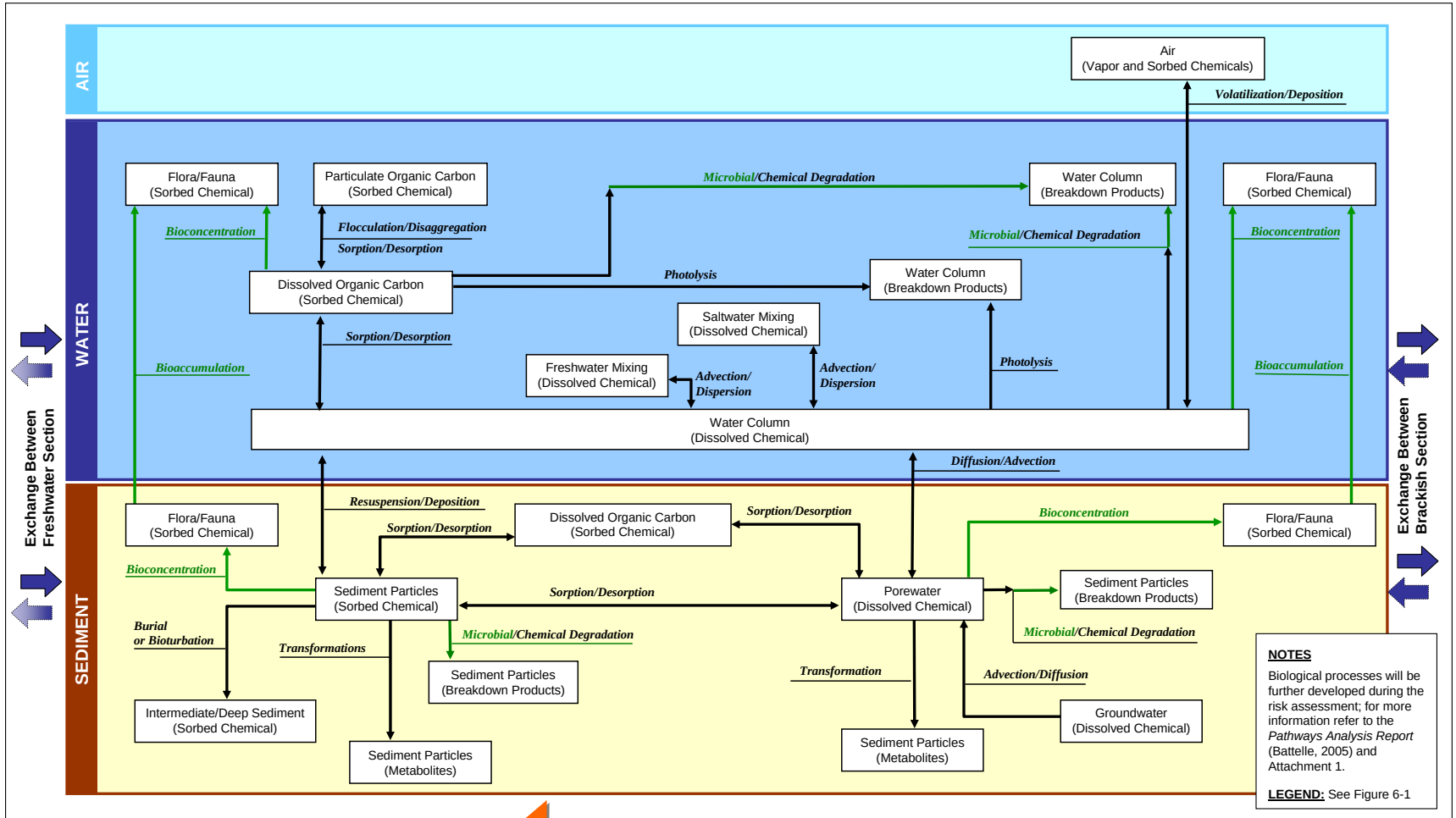
Chemical Fate and Transport Processes in Transitional Section

Lower Passaic River Restoration Project

Figure 7-1

February 2007

R2-0009121



Input to
Human Health and
Ecological Evaluations

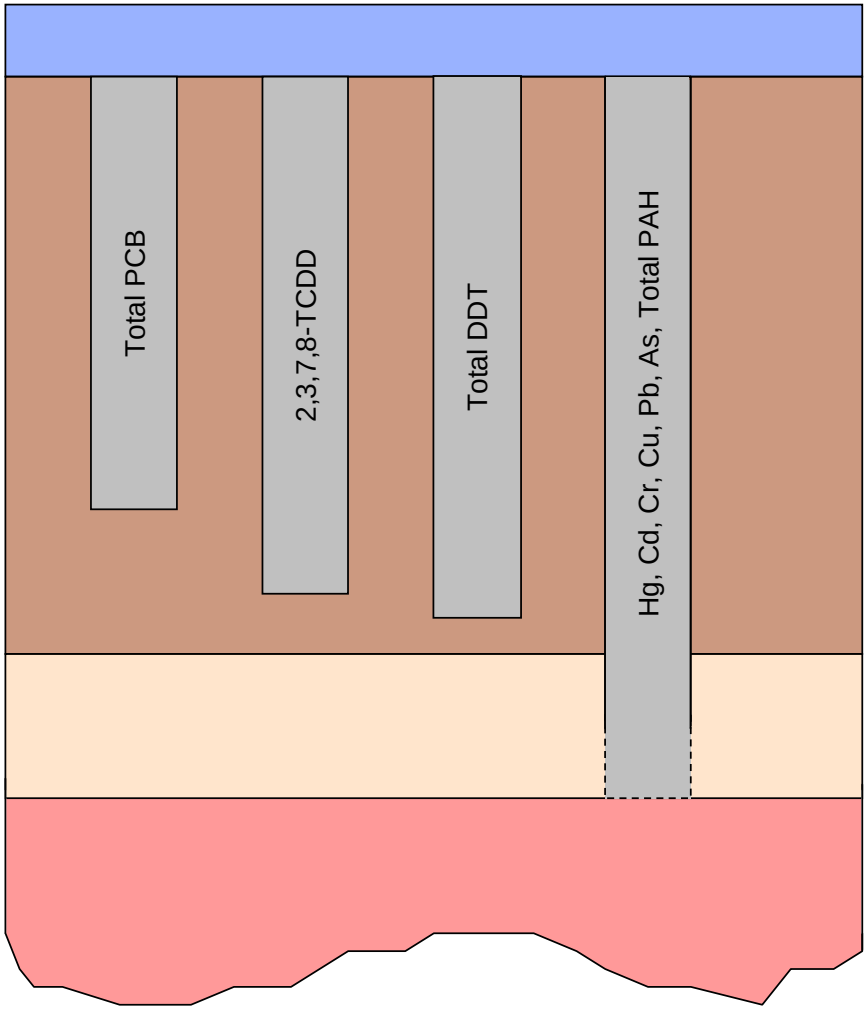
Chemical and Biological Fate and Transport Processes in Transitional Section

Lower Passaic River Restoration Project

Figure 7-2

February 2007

R2-0009122



Legend

- Schematic of Sediment Core
- Water
- Fine-Grained Sediment
- Sand
- Clay

Notes

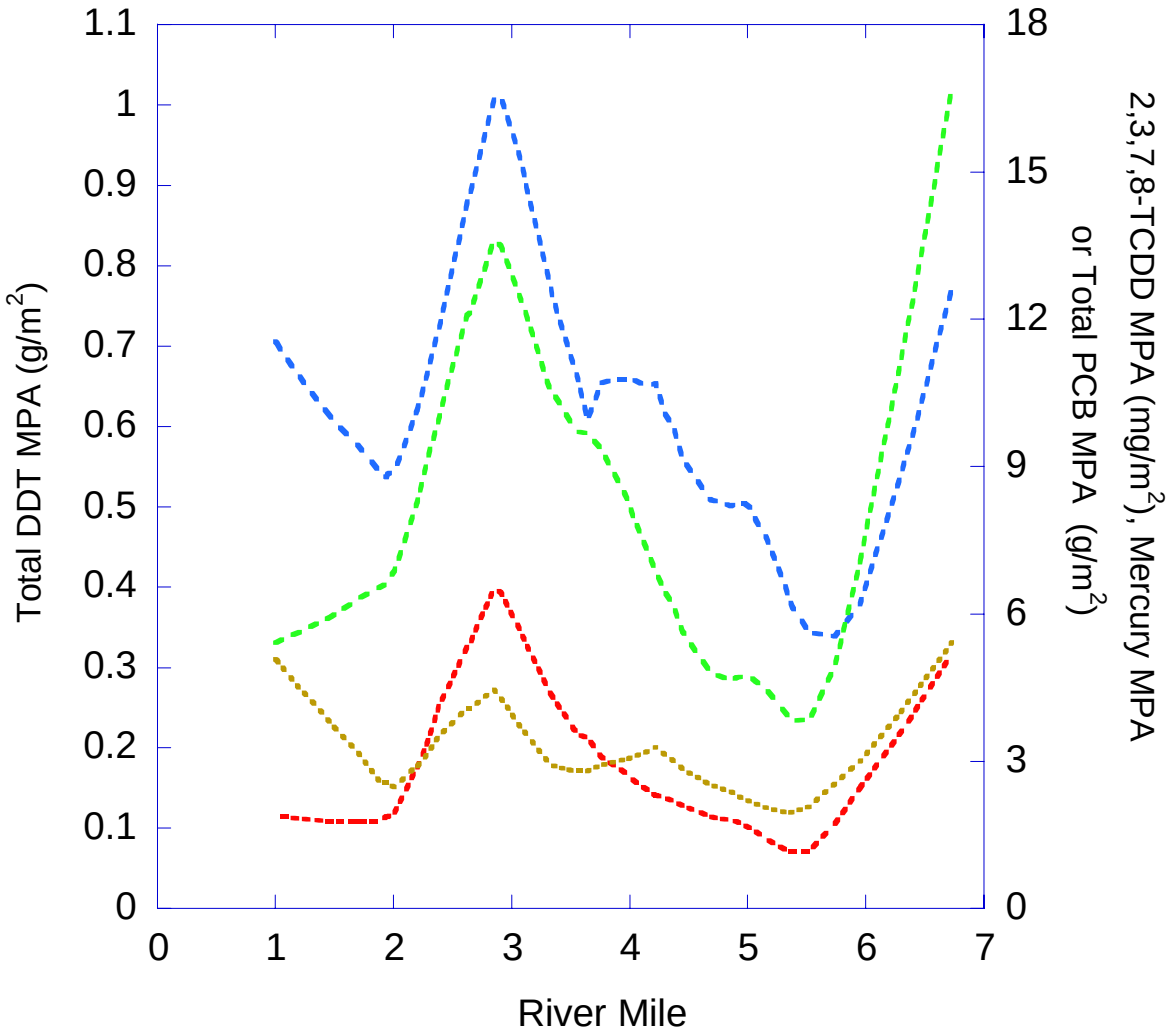
Hg = Mercury
Cd = Cadmium
Cr = Chromium
Pb = Lead
As = Arsenic

Schematic of Nature and Extent of Contamination in Sediment Beds

Lower Passaic River Restoration Project

Figure 7-3

February 2007



Legend

- Mercury
- 2,3,7,8-TCDD
- Total PCB
- Total DDT

Notes

MPA is mass per unit area

Weighted Curve Sediment Inventory from RM1 to RM7

Lower Passaic River Restoration Project

Figure 7-4

February 2007

R2-0009124

Attachment A

Sediment Texture Map Book

Sediment Texture Map

Lower Passaic River Restoration Project

February 2007

Legend

- Rock and Coarse Gravel
- Gravel and Sand
- Sand
- Silt and Sand
- Silt
- River Mile Post

2004 USACE Bathymetric Survey

Elevation (Feet) Relative to NGVD29

- -30 to -20
- -18 to -10
- -8 to 0
- 2 to 10

Coordinate System: State Plane New Jersey
Datum: NAD 83 Units: Feet

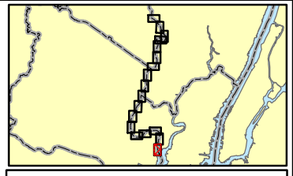
N

0 250 500 1,000

1 " equals 500 '

Bathymetric Control Data:
Benchmark: X 71 (NGS PID: KV0256)
Elevation: 15.12 FEET (NGVD 29)
Benchmark: V 71 (NGS PID: KV0254)
Elevation: 15.76 FEET (NGVD 29)

Data Source:
Buildings: CADD drawing, 09994X01, dated January 1, 2002 received from BBL.
Roads: 2000 TIGER line data.
Sediment Texture: 2005 Side scan SONAR data from Aqua Survey, Inc.



Mile 0 to 1

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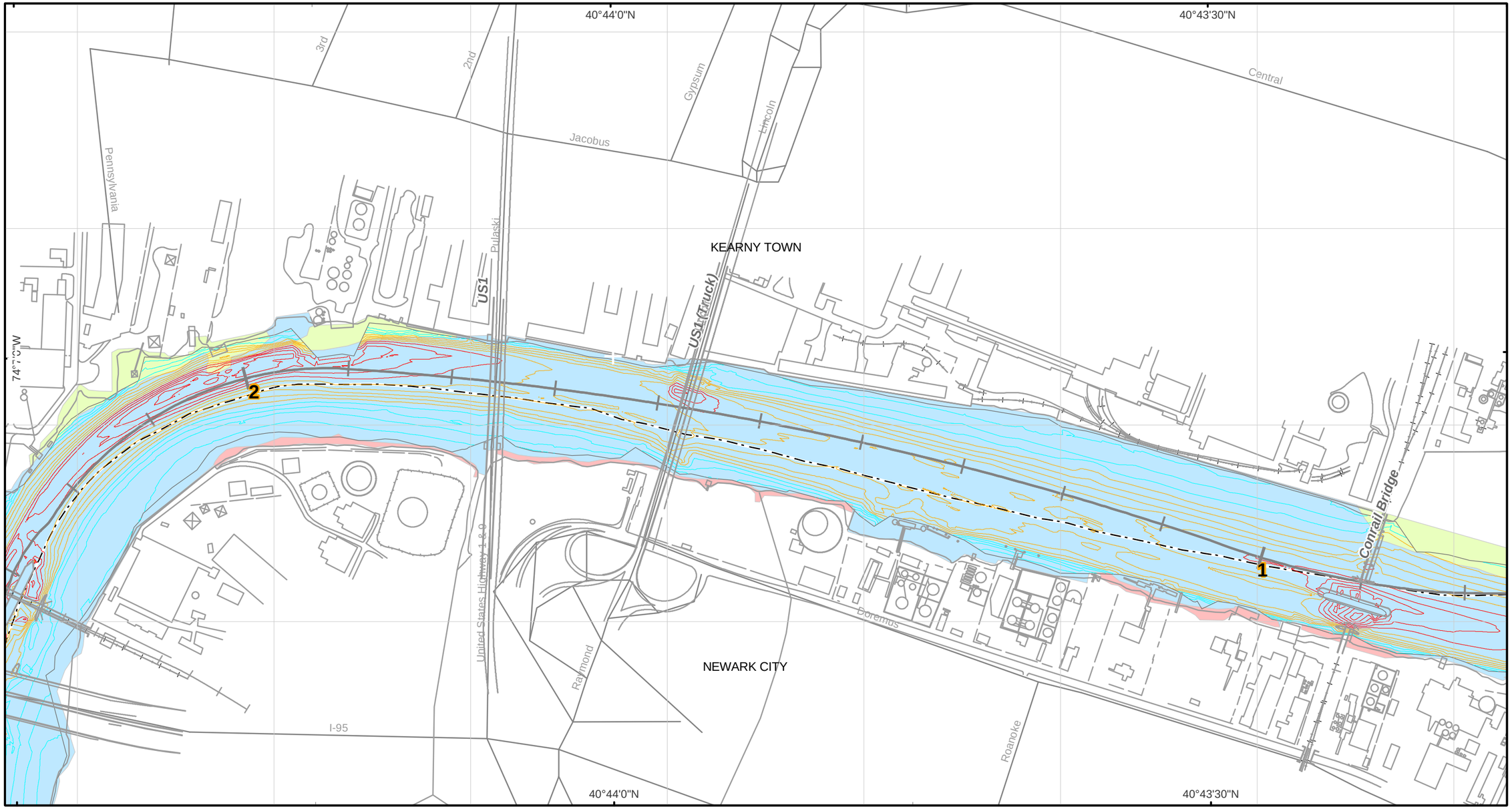


Sediment Texture Map

Lower Passaic River Restoration Project

February 2007

Legend

- Rock and Coarse Gravel
- Gravel and Sand
- Sand
- Silt and Sand
- Silt
- River Mile Post

2004 USACE Bathymetric Survey

Elevation (Feet) Relative to NGVD29

- -30 to -20
- -18 to -10
- -8 to 0
- 2 to 10

Coordinate System: State Plane New Jersey
Datum: NAD 83 Units: Feet

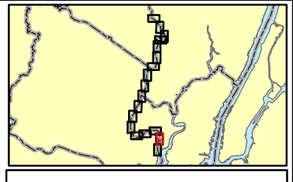
N

0 250 500 1,000

1 " equals 500 '

Bathymetric Control Data:
Benchmark: X 71 (NGS PID: KV0256)
Elevation: 15.12 FEET (NGVD 29)
Benchmark: V 71 (NGS PID: KV0254)
Elevation: 15.76 FEET (NGVD 29)

Data Source:
Buildings: CADD drawing, 09994X01, dated January 1, 2002 received from BBL.
Roads: 2000 TIGER line data.
Sediment Texture: 2005 Side scan SONAR data from Aqua Survey, Inc.



Mile 1 to 2

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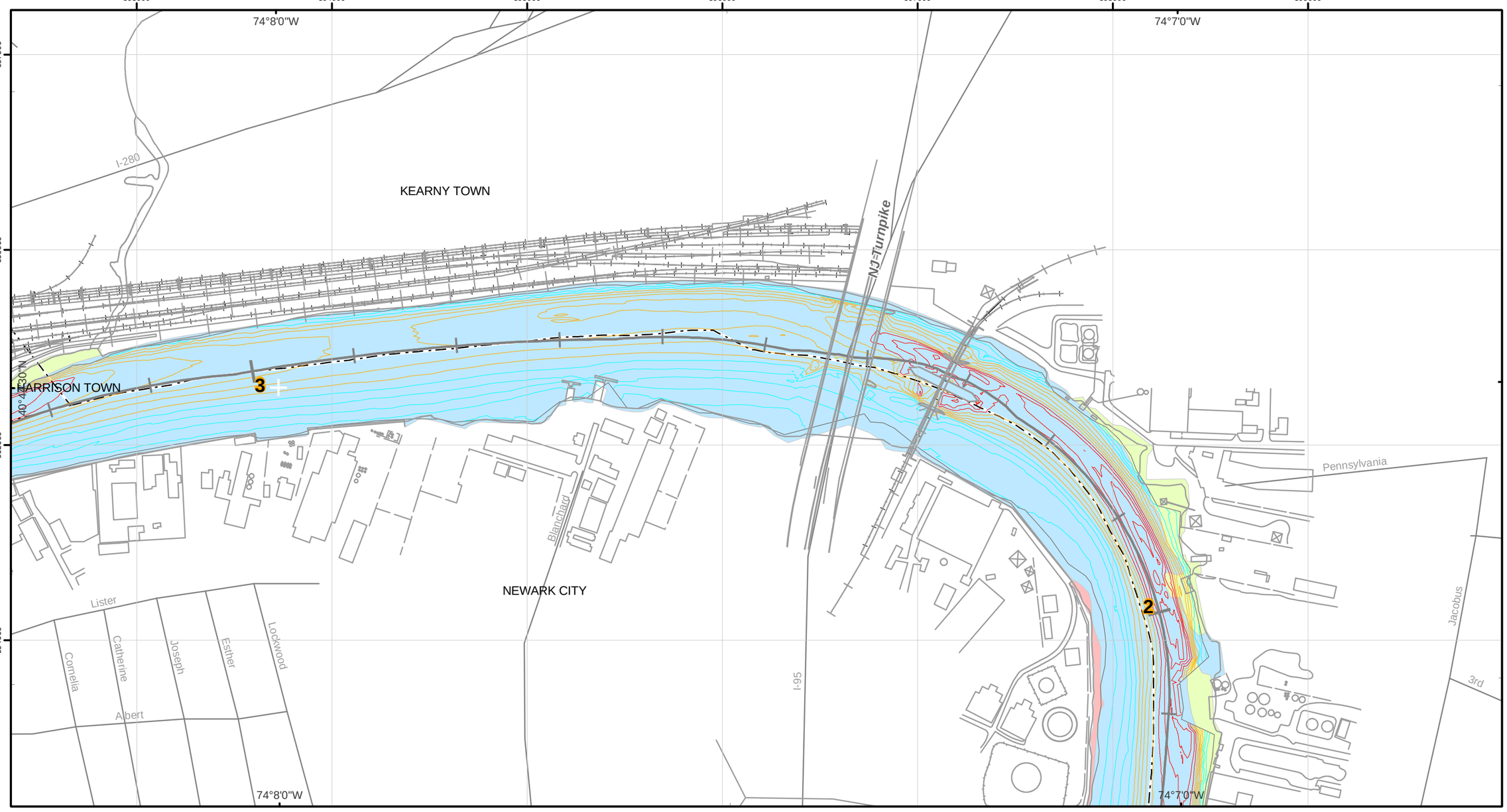
R2-0009127



Sediment Texture Map

Lower Passaic River Restoration Project

February 2007

Legend

- Rock and Coarse Gravel
- Gravel and Sand
- Sand
- Silt and Sand
- Silt
- River Mile Post

2004 USACE Bathymetric Survey

Elevation (Feet) Relative to NGVD29

- -30 to -20
- -18 to -10
- -8 to 0
- 2 to 10

Coordinate System: State Plane New Jersey
Datum: NAD 83 Units: Feet

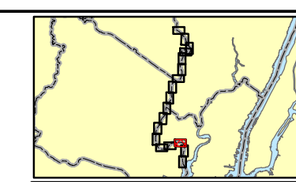
N

0 250 500 1,000

1 " equals 500 '

Bathymetric Control Data:
Benchmark: X 71 (NGS PID: KV0256)
Elevation: 15.12 FEET (NGVD 29)
Benchmark: V 71 (NGS PID: KV0254)
Elevation: 15.76 FEET (NGVD 29)

Data Source:
Buildings: CADD drawing, 09994X01, dated January 1, 2002 received from BBL.
Roads: 2000 TIGER line data.
Sediment Texture: 2005 Side scan SONAR data from Aqua Survey, Inc.



Mile 2 to 3

Map Document: (S:\Projects\PASSAIC\MapDocuments\Proposed Sediments\Coring_Field_Work\Sediment_Texture_Geophysical_Memo_October_2005.mxd)
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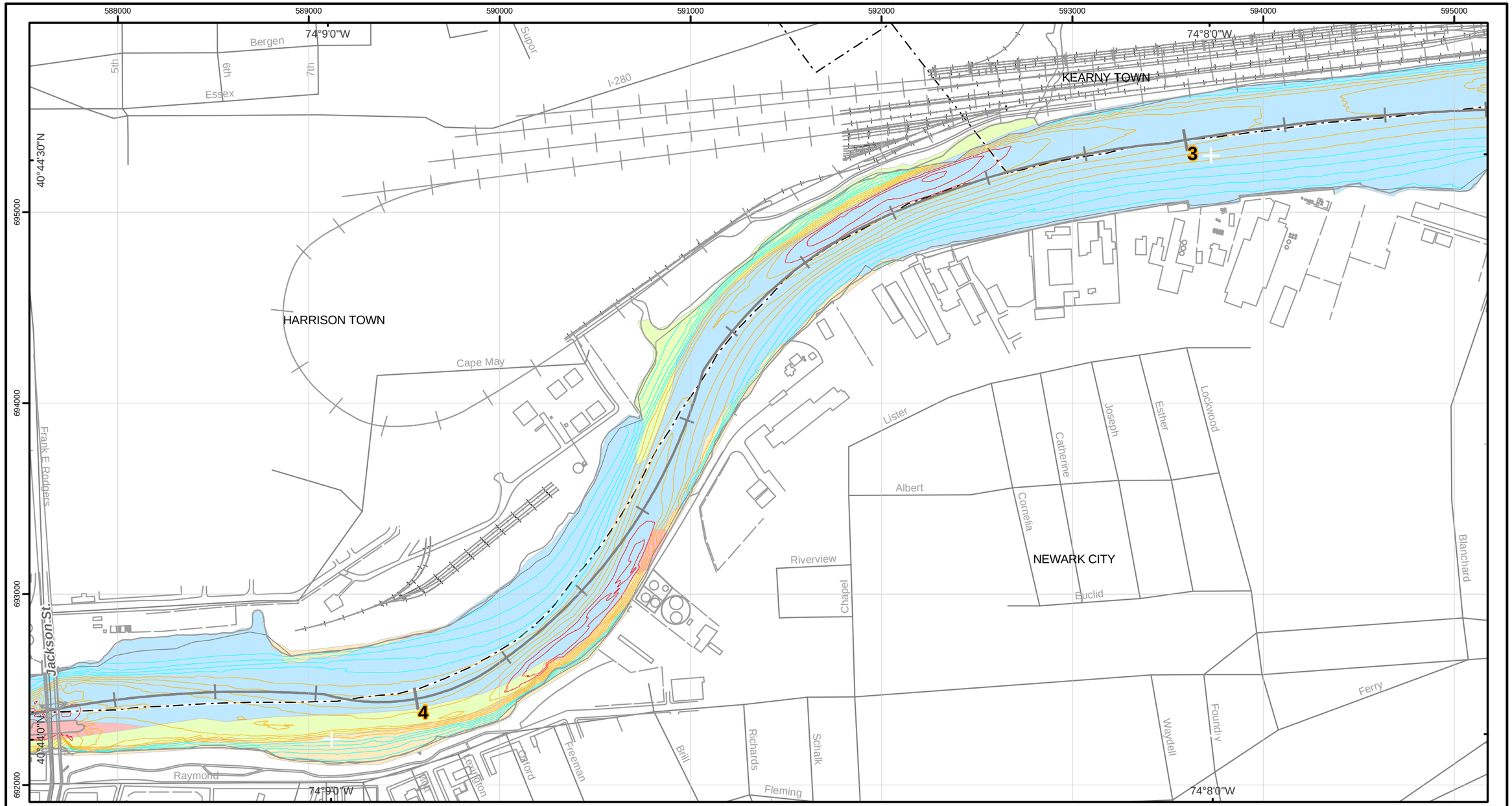
R2-0009128



Sediment Texture Map

Lower Passaic River Restoration Project

February 2007

Legend

- Rock and Coarse Gravel
- Gravel and Sand
- Sand
- Silt and Sand
- Silt
- River Mile Post

2004 USACE Bathymetric Survey

Elevation (Feet) Relative to NGVD29

- -30 to -20
- -18 to -10
- -8 to 0
- 2 to 10

Coordinate System: State Plane New Jersey
Datum: NAD 83 Units: Feet

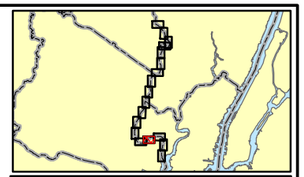
N

0 250 500 1,000

1 " equals 500 '

Bathymetric Control Data:
Benchmark: X 71 (NGS PID: KV0256)
Elevation: 15.12 FEET (NGVD 29)
Benchmark: V 71 (NGS PID: KV0254)
Elevation: 15.76 FEET (NGVD 29)

Data Source:
Buildings: CADD drawing, 09994X01, dated January 1, 2002 received from BBL.
Roads: 2000 TIGER line data.
Sediment Texture: 2005 Side scan SONAR data from Aqua Survey, Inc.



Mile 3 to 4

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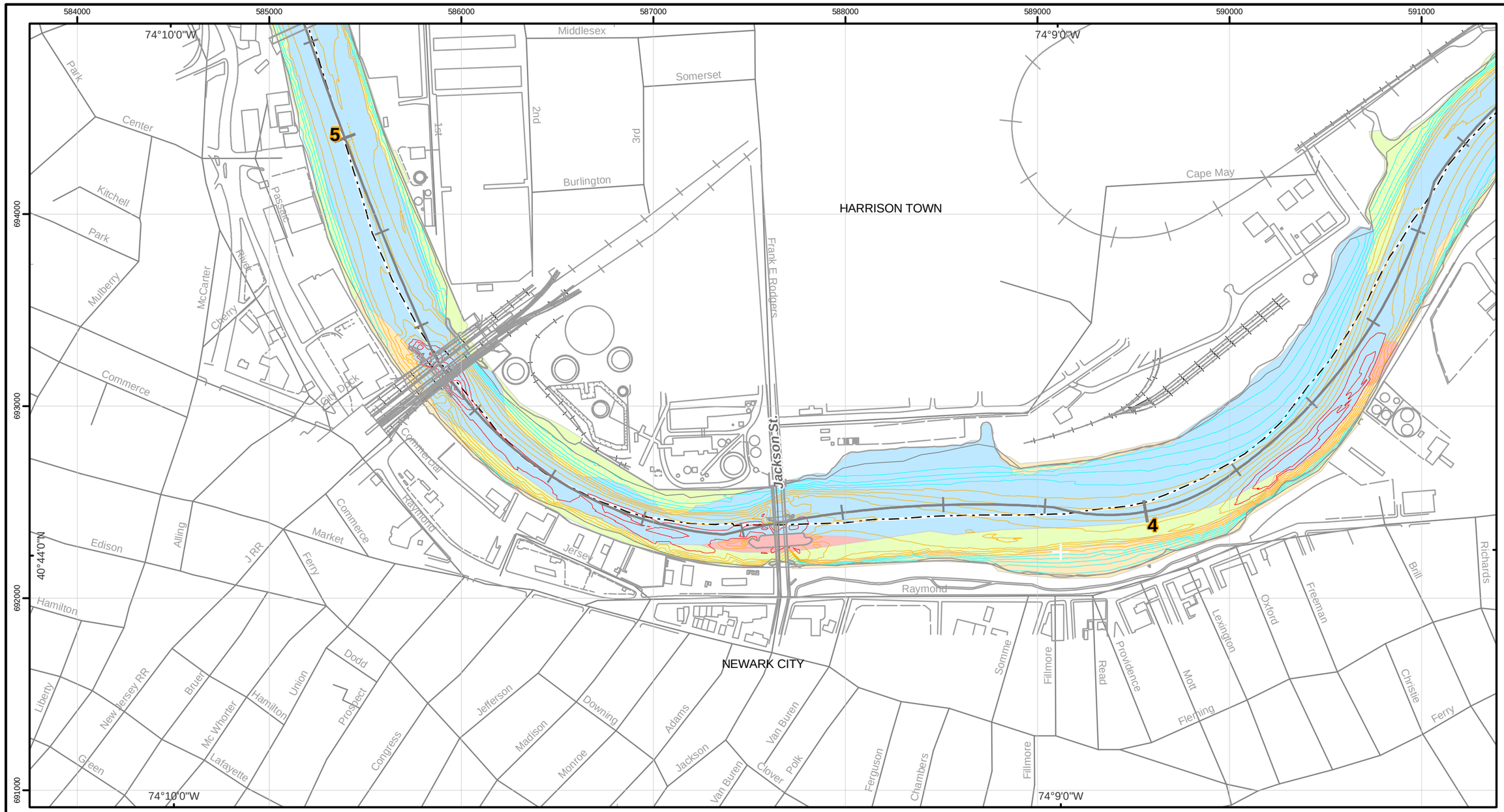


US Army Corps of Engineers

Sediment Texture Map

Lower Passaic River Restoration Project

February 2007

Legend

- Rock and Coarse Gravel
- Gravel and Sand
- Sand
- Silt and Sand
- Silt
- River Mile Post

2004 USACE Bathymetric Survey

Elevation (Feet) Relative to NGVD29

- -30 to -20
- -18 to -10
- -8 to 0
- 2 to 10

Coordinate System: State Plane New Jersey
Datum: NAD 83 Units: Feet

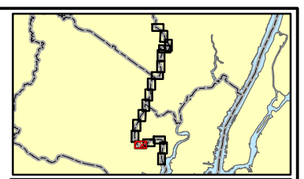
N

0 250 500 1,000

1 " equals 500 '

Bathymetric Control Data:
Benchmark: X 71 (NGS PID: KV0256)
Elevation: 15.12 FEET (NGVD 29)
Benchmark: V 71 (NGS PID: KV0254)
Elevation: 15.76 FEET (NGVD 29)

Data Source:
Buildings: CADD drawing, 09994X01, dated January 1, 2002 received from BBL.
Roads: 2000 TIGER line data.
Sediment Texture: 2005 Side scan SONAR data from Aqua Survey, Inc.



Mile 4 to 5

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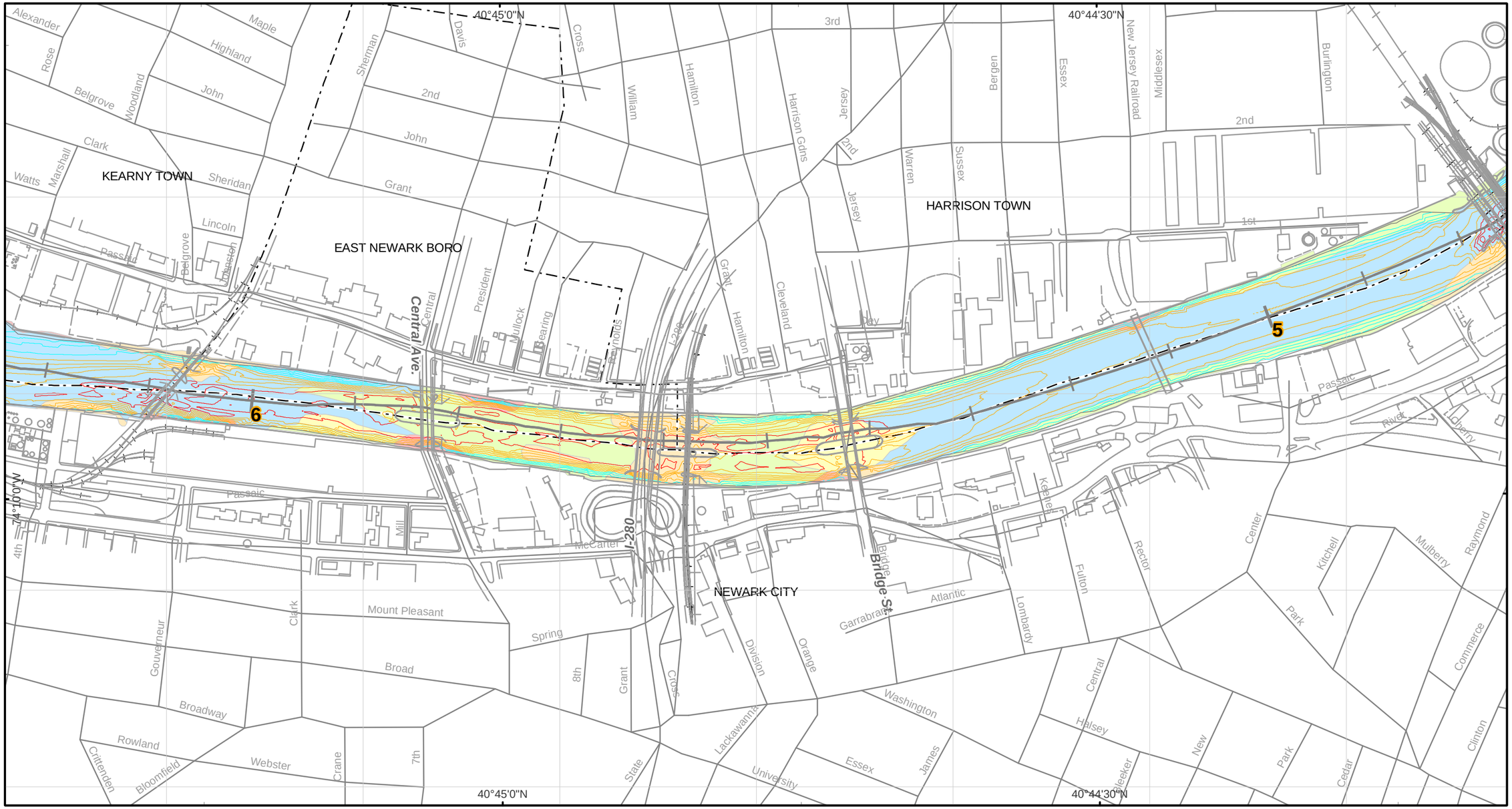


Sediment Texture Map

Lower Passaic River Restoration Project

February 2007

US Army Corps of Engineers®

Legend

- Rock and Coarse Gravel
- Gravel and Sand
- Sand
- Silt and Sand
- Silt
- River Mile Post

2004 USACE Bathymetric Survey

Elevation (Feet) Relative to NGVD29

- -30 to -20
- -18 to -10
- -8 to 0
- 2 to 10

Coordinate System: State Plane New Jersey
Datum: NAD 83 Units: Feet

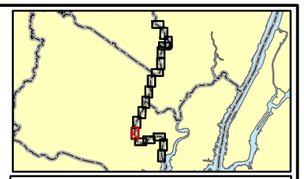
N

0 250 500 1,000

1 " equals 500 '

Bathymetric Control Data:
Benchmark: X 71 (NGS PID: KV0256)
Elevation: 15.12 FEET (NGVD 29)
Benchmark: V 71 (NGS PID: KV0254)
Elevation: 15.76 FEET (NGVD 29)

Data Source:
Buildings: CADD drawing, 09994X01, dated January 1, 2002 received from BBL.
Roads: 2000 TIGER line data.
Sediment Texture: 2005 Side scan SONAR data from Aqua Survey, Inc.



Mile 5 to 6

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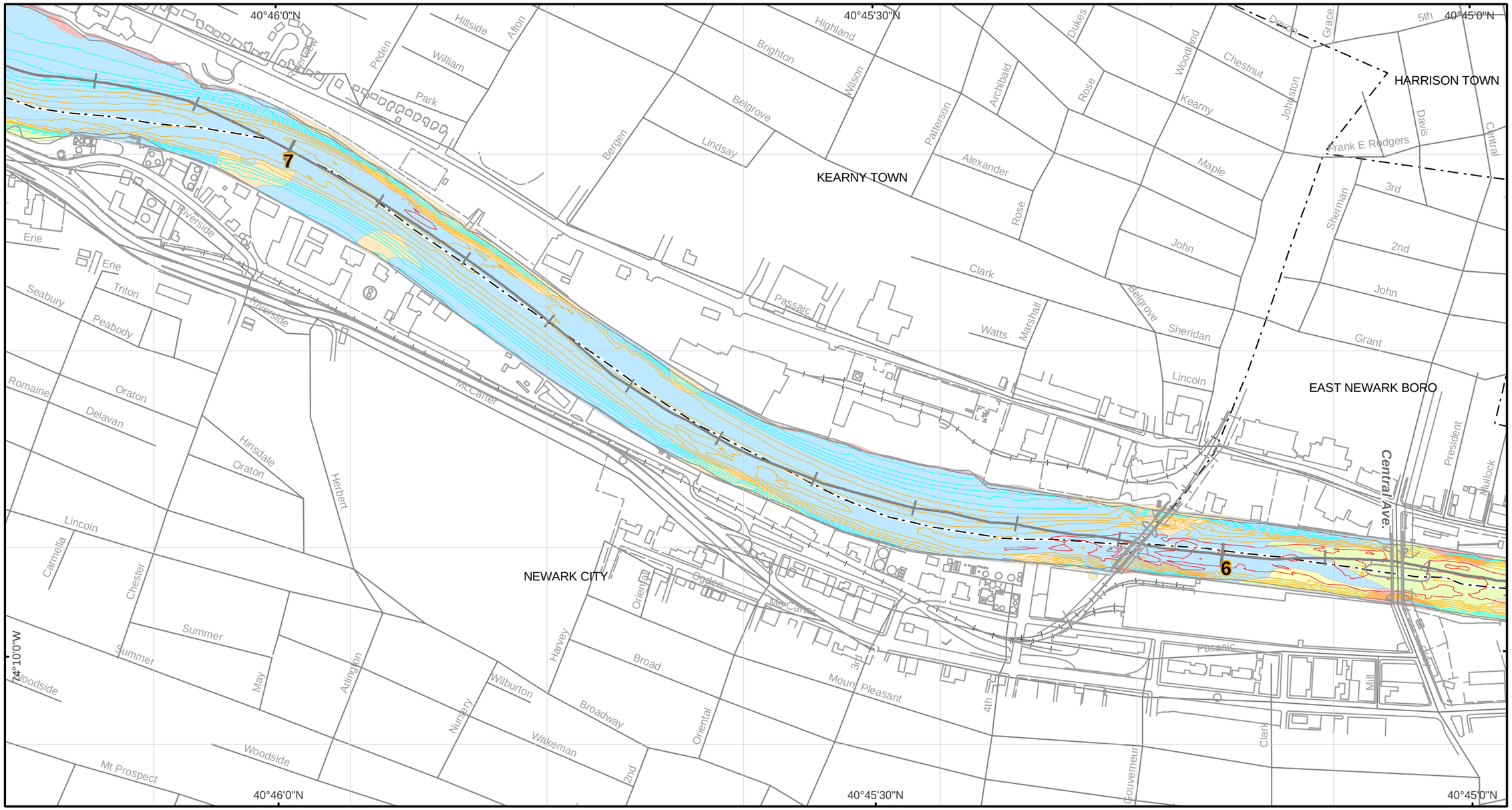


Sediment Texture Map

Lower Passaic River Restoration Project

February 2007

US Army Corps of Engineers®

Legend

- Rock and Coarse Gravel
- Gravel and Sand
- Sand
- Silt and Sand
- Silt
- River Mile Post

2004 USACE Bathymetric Survey

Elevation (Feet) Relative to NGVD29

- -30 to -20
- -18 to -10
- -8 to 0
- 2 to 10

Coordinate System: State Plane New Jersey
Datum: NAD 83 Units: Feet

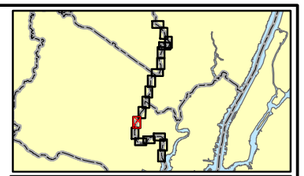
N

0 250 500 1,000

1 " equals 500 '

Bathymetric Control Data:
Benchmark: X 71 (NGS PID: KV0256)
Elevation: 15.12 FEET (NGVD 29)
Benchmark: V 71 (NGS PID: KV0254)
Elevation: 15.76 FEET (NGVD 29)

Data Source:
Buildings: CADD drawing, 09994X01, dated January 1, 2002 received from BBL.
Roads: 2000 TIGER line data.
Sediment Texture: 2005 Side scan SONAR data from Aqua Survey, Inc.



Mile 6 to 7

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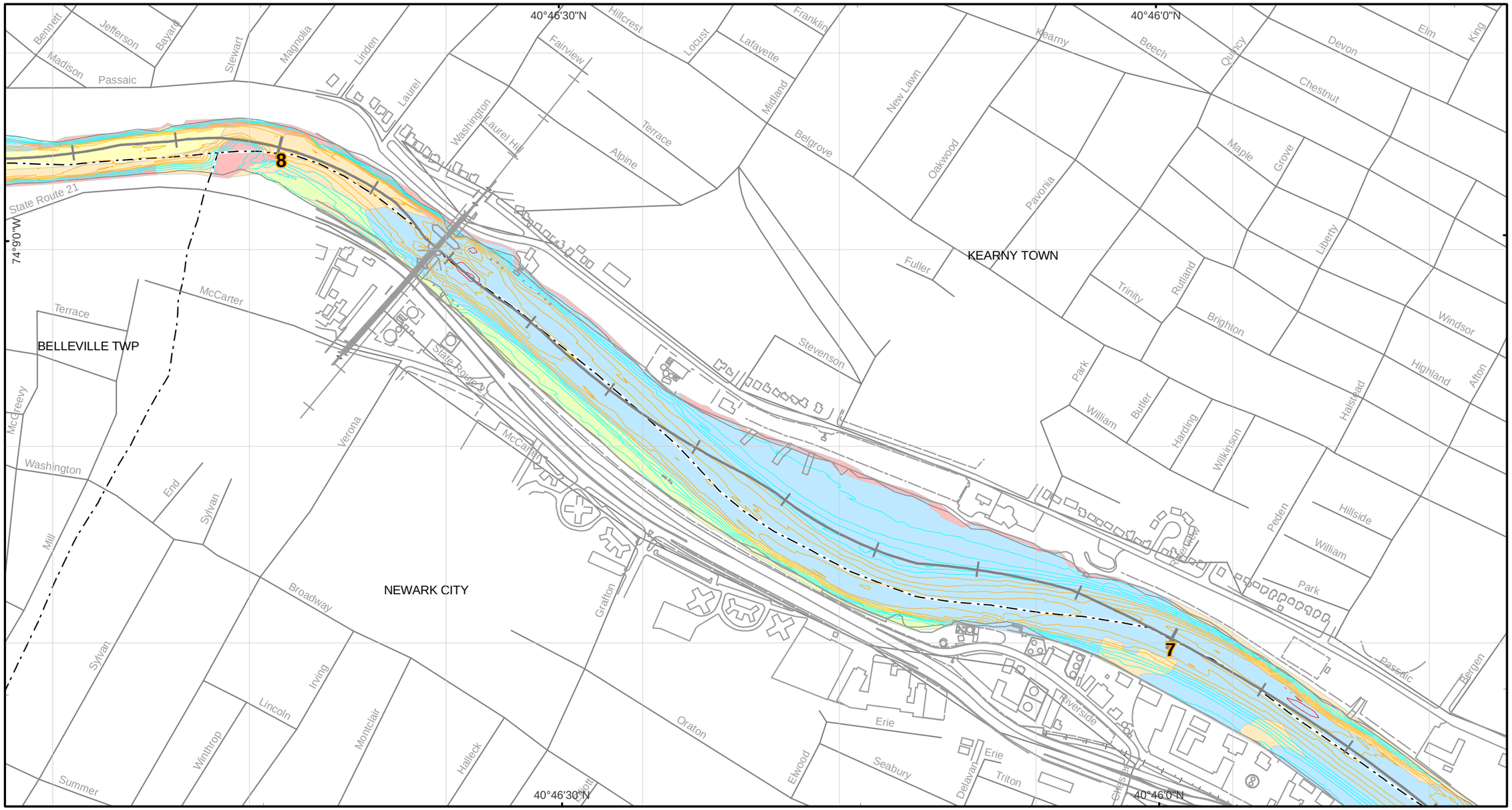


Sediment Texture Map

Lower Passaic River Restoration Project

February 2007

Legend

- Rock and Coarse Gravel
- Gravel and Sand
- Sand
- Silt and Sand
- Silt
- River Mile Post

2004 USACE Bathymetric Survey

Elevation (Feet) Relative to NGVD29

- -30 to -20
- -18 to -10
- -8 to 0
- 2 to 10

Coordinate System: State Plane New Jersey
Datum: NAD 83 Units: Feet

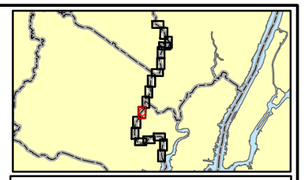
N

0 250 500 1,000

1 " equals 500 '

Bathymetric Control Data:
Benchmark: X 71 (NGS PID: KV0256)
Elevation: 15.12 FEET (NGVD 29)
Benchmark: V 71 (NGS PID: KV0254)
Elevation: 15.76 FEET (NGVD 29)

Data Source:
Buildings: CADD drawing, 09994X01, dated January 1, 2002 received from BBL.
Roads: 2000 TIGER line data.
Sediment Texture: 2005 Side scan SONAR data from Aqua Survey, Inc.



Mile 7 to 8

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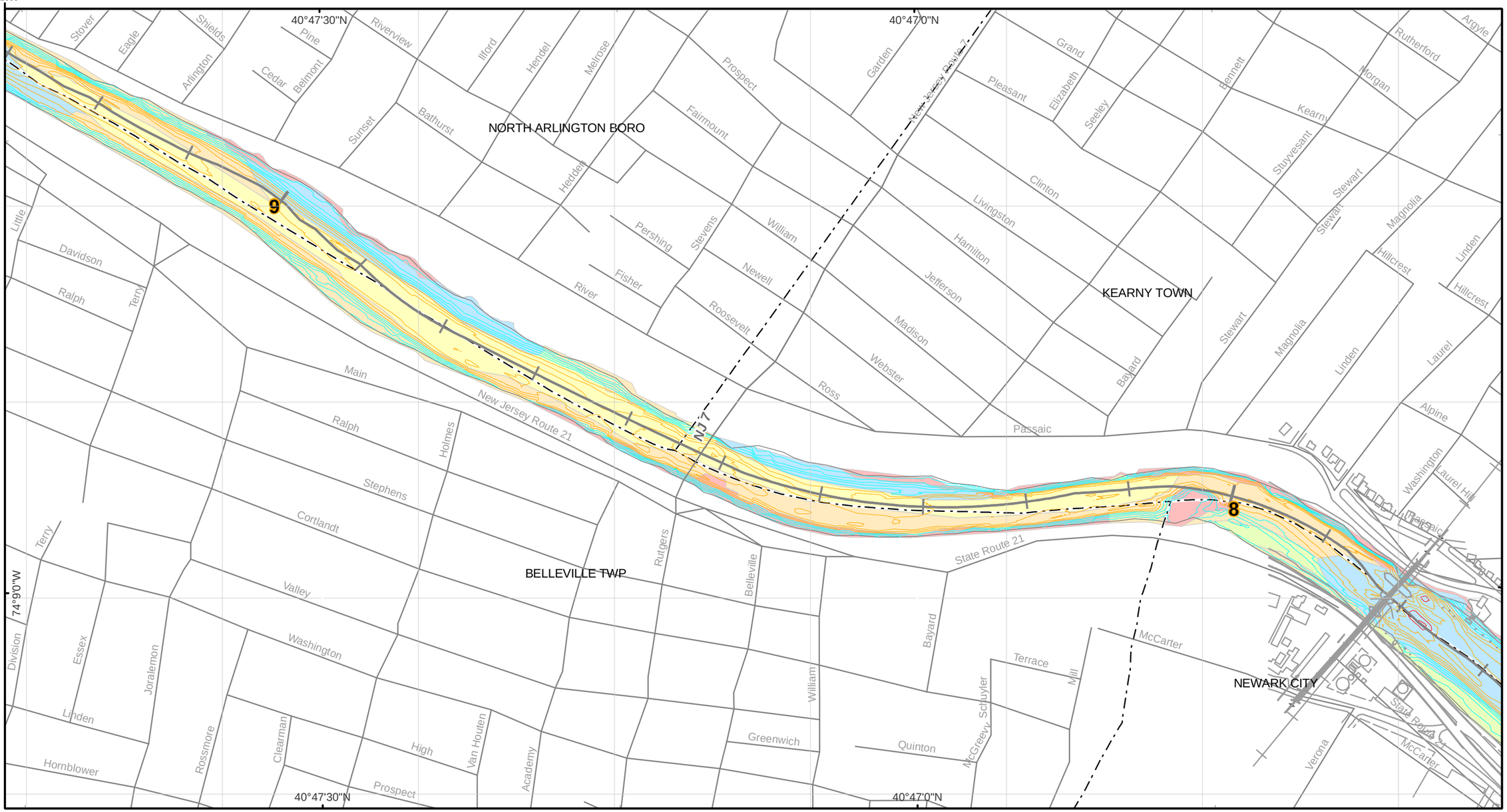

Sediment Texture Map

Lower Passaic River Restoration Project

February 2007

Legend

- Rock and Coarse Gravel
- Gravel and Sand
- Sand
- Silt and Sand
- Silt
- River Mile Post

2004 USACE Bathymetric Survey

Elevation (Feet) Relative to NGVD29

- -30 to -20
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- -8 to 0
- 2 to 10

Coordinate System: State Plane New Jersey
Datum: NAD 83 Units: Feet

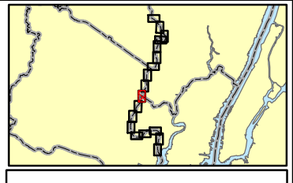
N

0 250 500 1,000

1 " equals 500 '

Bathymetric Control Data:
Benchmark: X 71 (NGS PID: KV0256)
Elevation: 15.12 FEET (NGVD 29)
Benchmark: V 71 (NGS PID: KV0254)
Elevation: 15.76 FEET (NGVD 29)

Data Source:
Buildings: CADD drawing, 09994X01, dated January 1, 2002 received from BBL.
Roads: 2000 TIGER line data.
Sediment Texture: 2005 Side scan SONAR data from Aqua Survey, Inc.



Mile 8 to 9

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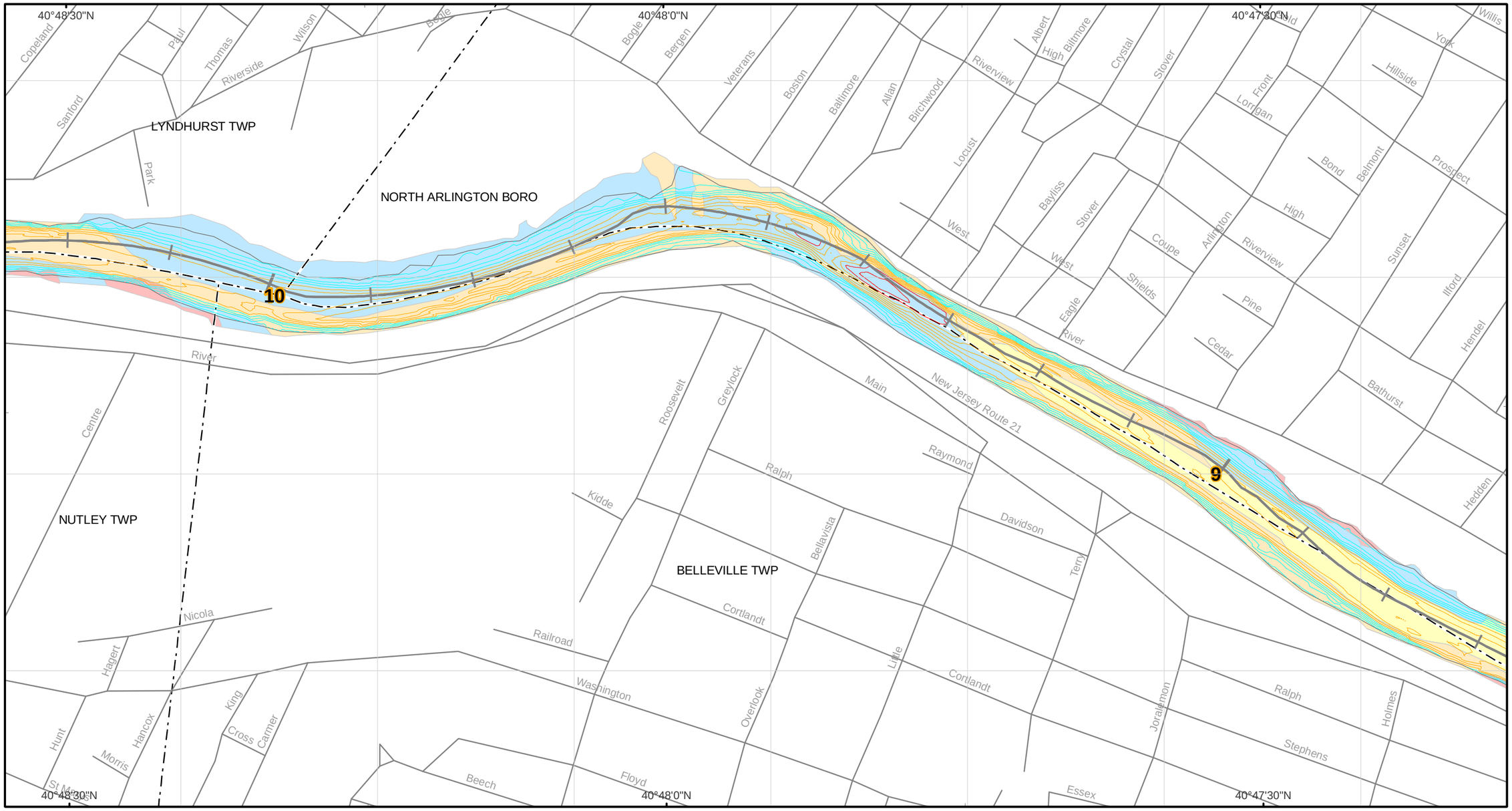


Sediment Texture Map

Lower Passaic River Restoration Project

February 2007

Legend

- Rock and Coarse Gravel
- Gravel and Sand
- Sand
- Silt and Sand
- Silt
- River Mile Post

2004 USACE Bathymetric Survey

Elevation (Feet) Relative to NGVD29

- -30 to -20
- -18 to -10
- -8 to 0
- 2 to 10

Coordinate System: State Plane New Jersey
Datum: NAD 83 Units: Feet

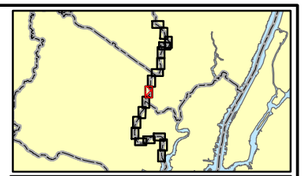
N

0 250 500 1,000

1 " equals 500 '

Bathymetric Control Data:
Benchmark: X 71 (NGS PID: KV0256)
Elevation: 15.12 FEET (NGVD 29)
Benchmark: V 71 (NGS PID: KV0254)
Elevation: 15.76 FEET (NGVD 29)

Data Source:
Buildings: CADD drawing, 09994X01, dated January 1, 2002 received from BBL.
Roads: 2000 TIGER line data.
Sediment Texture: 2005 Side scan SONAR data from Aqua Survey, Inc.



Mile 9 to 10

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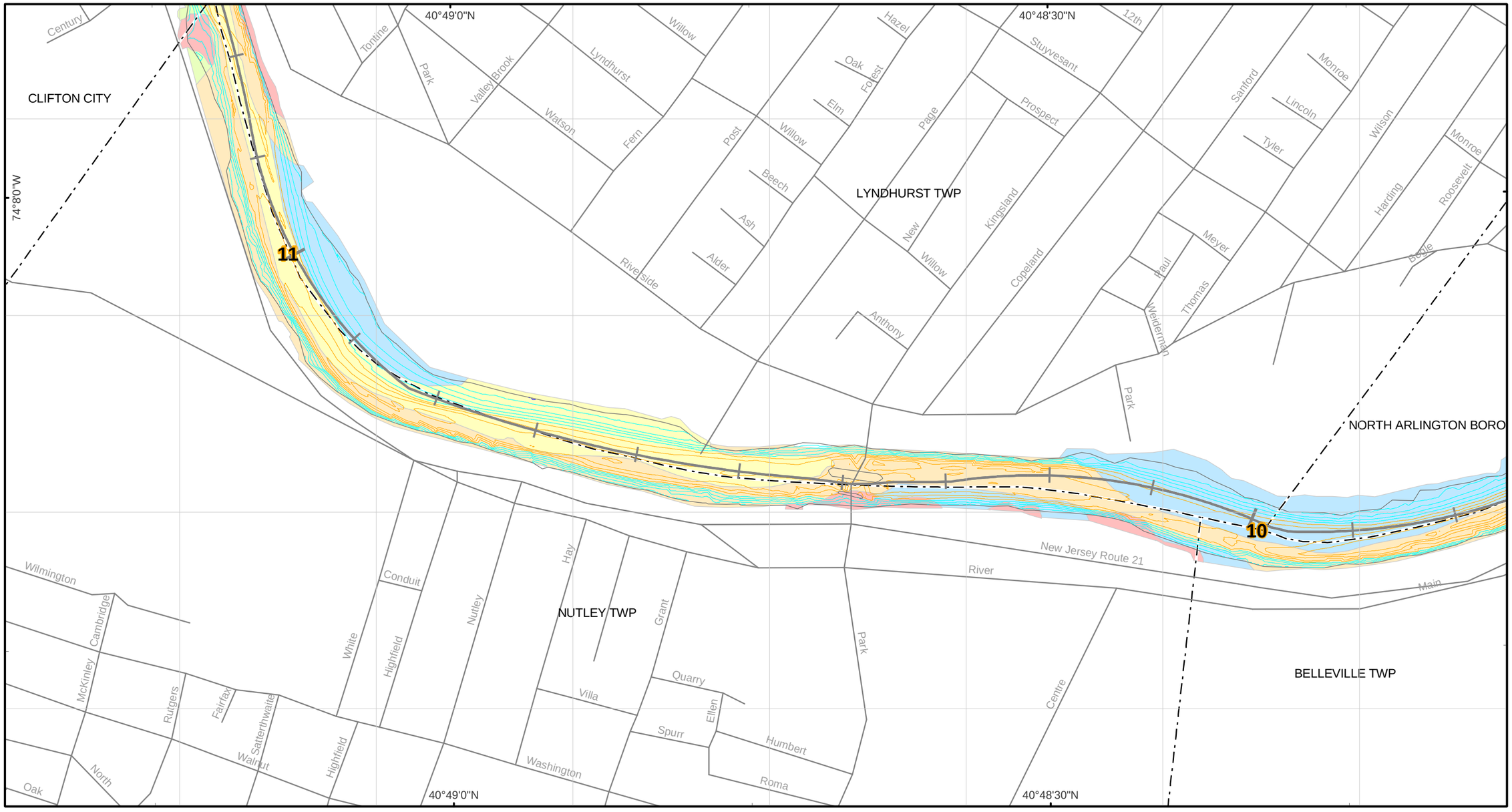


Sediment Texture Map

Lower Passaic River Restoration Project

February 2007

Legend

- Rock and Coarse Gravel
- Gravel and Sand
- Sand
- Silt and Sand
- Silt
- River Mile Post

2004 USACE Bathymetric Survey

Elevation (Feet) Relative to NGVD29

- -30 to -20
- -18 to -10
- -8 to 0
- 2 to 10

Coordinate System: State Plane New Jersey
Datum: NAD 83 Units: Feet

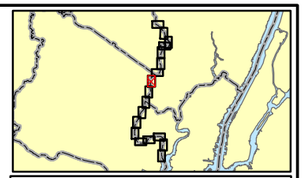
N

0 250 500 1,000

1 " equals 500 '

Bathymetric Control Data:
Benchmark: X 71 (NGS PID: KV0256)
Elevation: 15.12 FEET (NGVD 29)
Benchmark: V 71 (NGS PID: KV0254)
Elevation: 15.76 FEET (NGVD 29)

Data Source:
Buildings: CADD drawing, 09994X01, dated January 1, 2002 received from BBL.
Roads: 2000 TIGER line data.
Sediment Texture: 2005 Side scan SONAR data from Aqua Survey, Inc.



Mile 10 to 11

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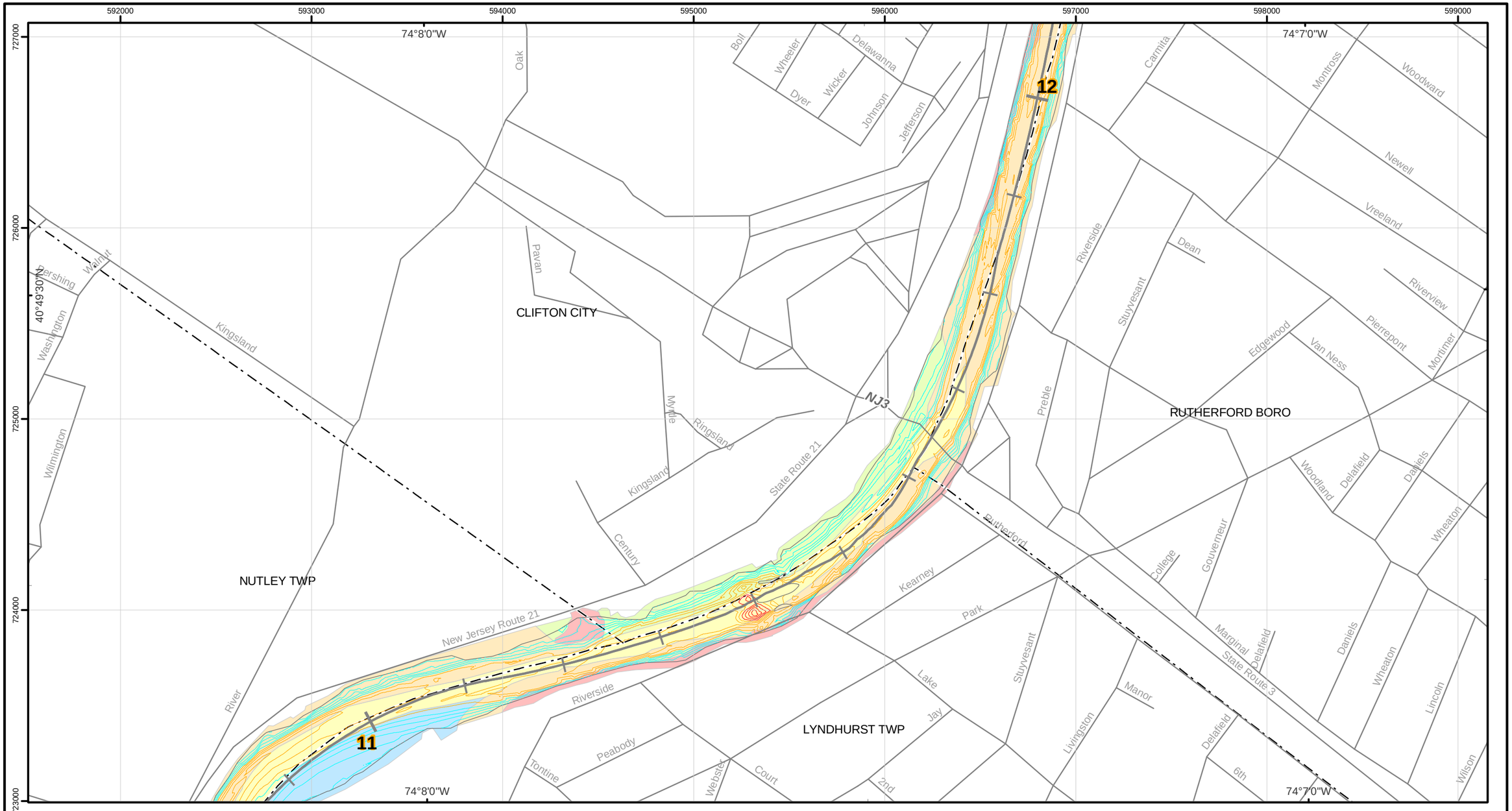


Sediment Texture Map

Lower Passaic River Restoration Project

February 2007

Legend

- Rock and Coarse Gravel
- Gravel and Sand
- Sand
- Silt and Sand
- Silt
- River Mile Post

2004 USACE Bathymetric Survey

Elevation (Feet) Relative to NGVD29

- -30 to -20
- -18 to -10
- -8 to 0
- 2 to 10

Coordinate System: State Plane New Jersey
Datum: NAD 83 Units: Feet

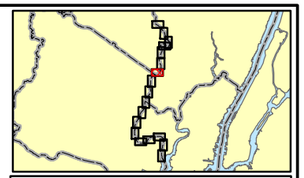
N

0 250 500 1,000

1 " equals 500 '

Bathymetric Control Data:
Benchmark: X 71 (NGS PID: KV0256)
Elevation: 15.12 FEET (NGVD 29)
Benchmark: V 71 (NGS PID: KV0254)
Elevation: 15.76 FEET (NGVD 29)

Data Source:
Buildings: CADD drawing, 09994X01, dated January 1, 2002 received from BBL.
Roads: 2000 TIGER line data.
Sediment Texture: 2005 Side scan SONAR data from Aqua Survey, Inc.



Mile 11 to 12

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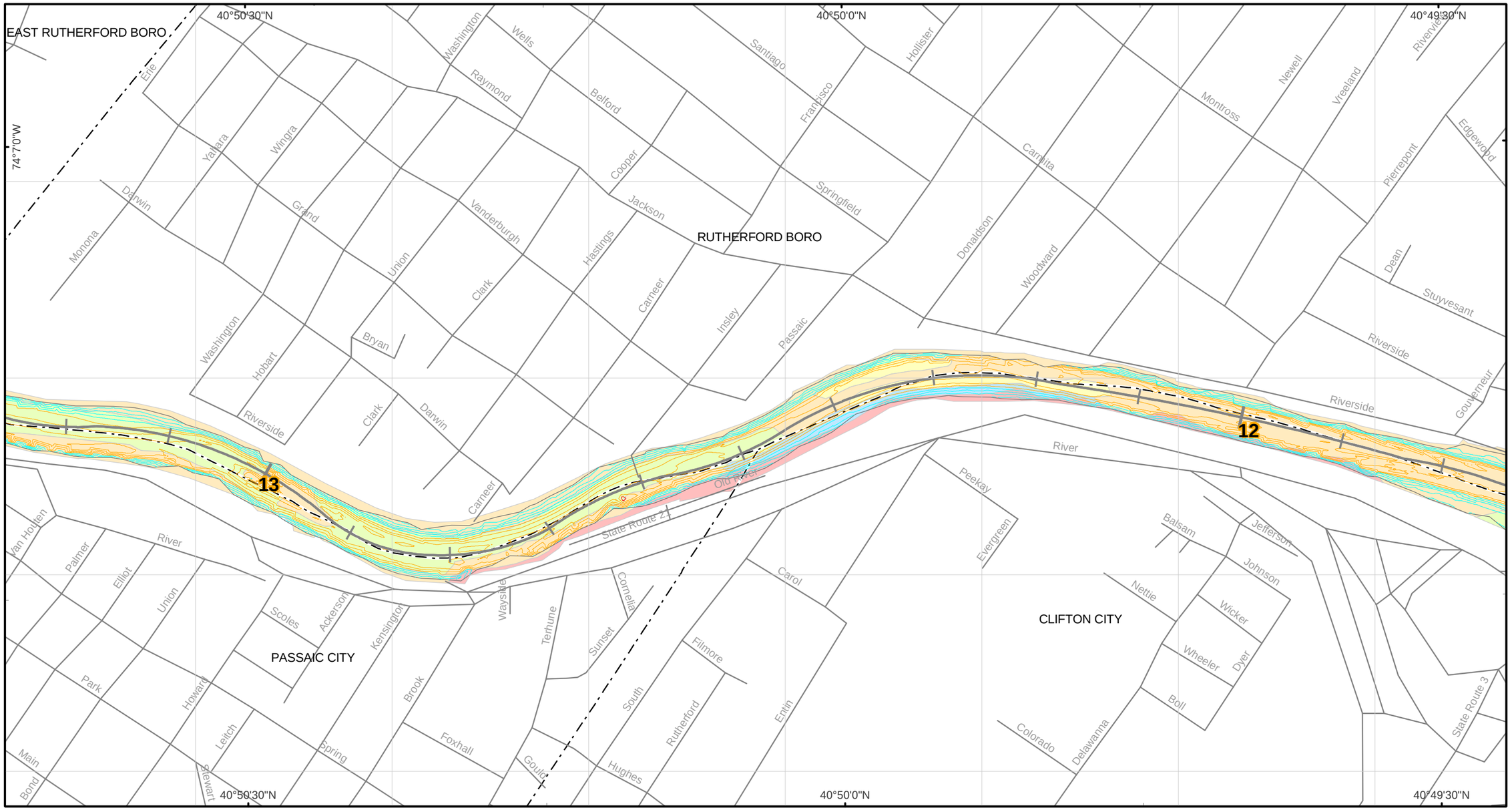


Sediment Texture Map

Lower Passaic River Restoration Project

February 2007

Legend

- Rock and Coarse Gravel
- Gravel and Sand
- Sand
- Silt and Sand
- Silt
- River Mile Post

2004 USACE Bathymetric Survey

Elevation (Feet) Relative to NGVD29

- -30 to -20
- -18 to -10
- -8 to 0
- 2 to 10

Coordinate System: State Plane New Jersey
Datum: NAD 83 Units: Feet

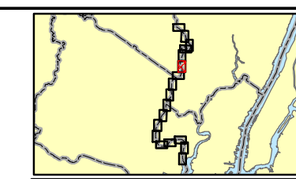
N

0 250 500 1,000

1 " equals 500 '

Bathymetric Control Data:
Benchmark: X 71 (NGS PID: KV0256)
Elevation: 15.12 FEET (NGVD 29)
Benchmark: V 71 (NGS PID: KV0254)
Elevation: 15.76 FEET (NGVD 29)

Data Source:
Buildings: CADD drawing, 09994X01, dated January 1, 2002 received from BBL.
Roads: 2000 TIGER line data.
Sediment Texture: 2005 Side scan SONAR data from Aqua Survey, Inc.



Mile 12 to 13

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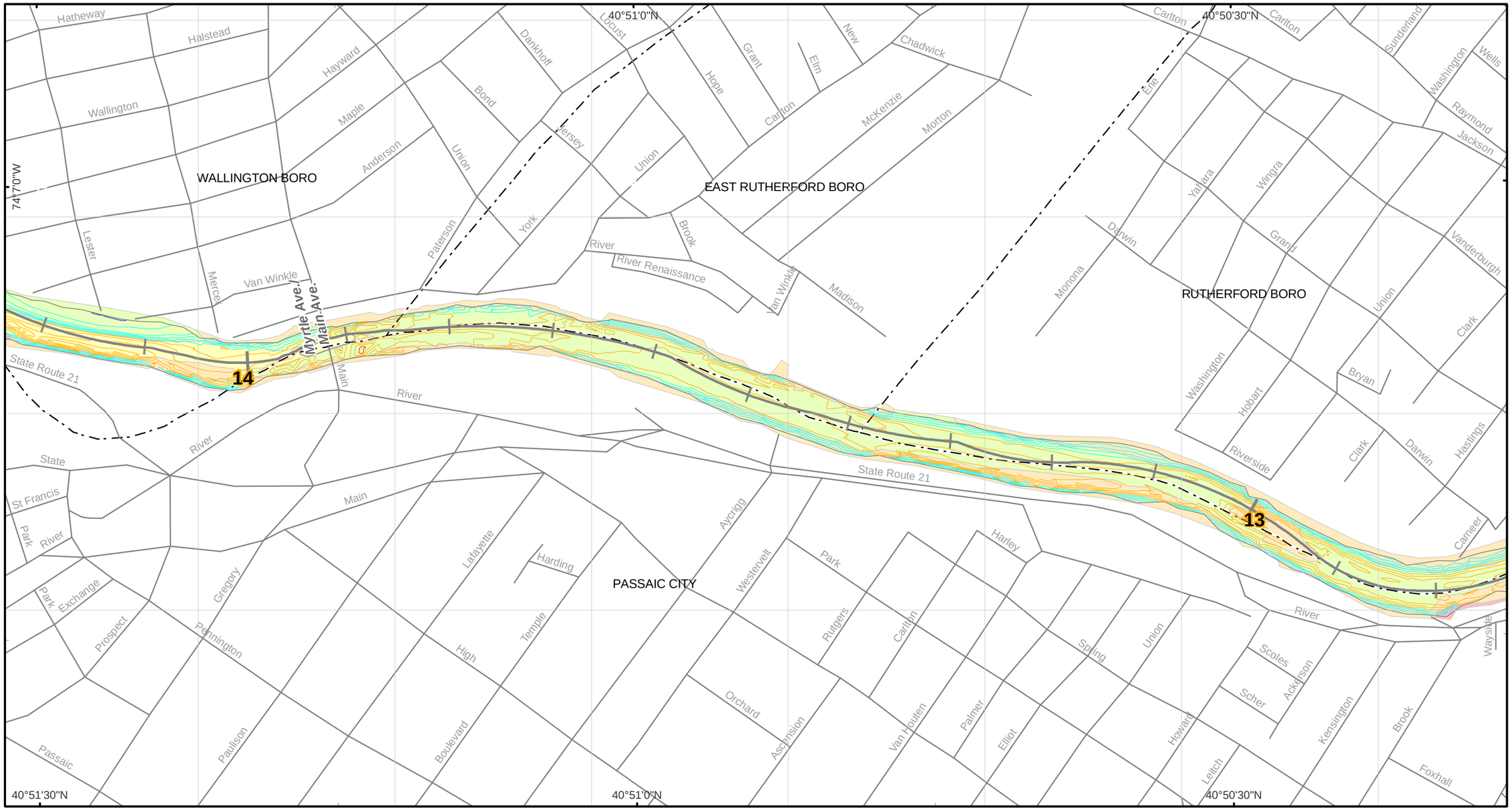

Sediment Texture Map

Lower Passaic River Restoration Project

February 2007

Legend

- Rock and Coarse Gravel
- Gravel and Sand
- Sand
- Silt and Sand
- Silt
- River Mile Post

2004 USACE Bathymetric Survey

Elevation (Feet) Relative to NGVD29

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- 2 to 10

Coordinate System: State Plane New Jersey
Datum: NAD 83 Units: Feet

N

0 250 500 1,000

1 " equals 500 '

Bathymetric Control Data:
Benchmark: X 71 (NGS PID: KV0256)
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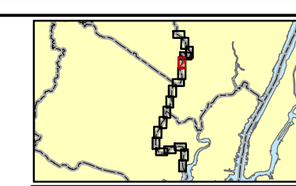
Elevation: 15.76 FEET (NGVD 29)

Data Source:
Buildings: CADD drawing, 09994X01, dated January 1, 2002 received from BBL.
Roads: 2000 TIGER line data.
Sediment Texture: 2005 Side scan SONAR data from Aqua Survey, Inc.



Mile 13 to 14

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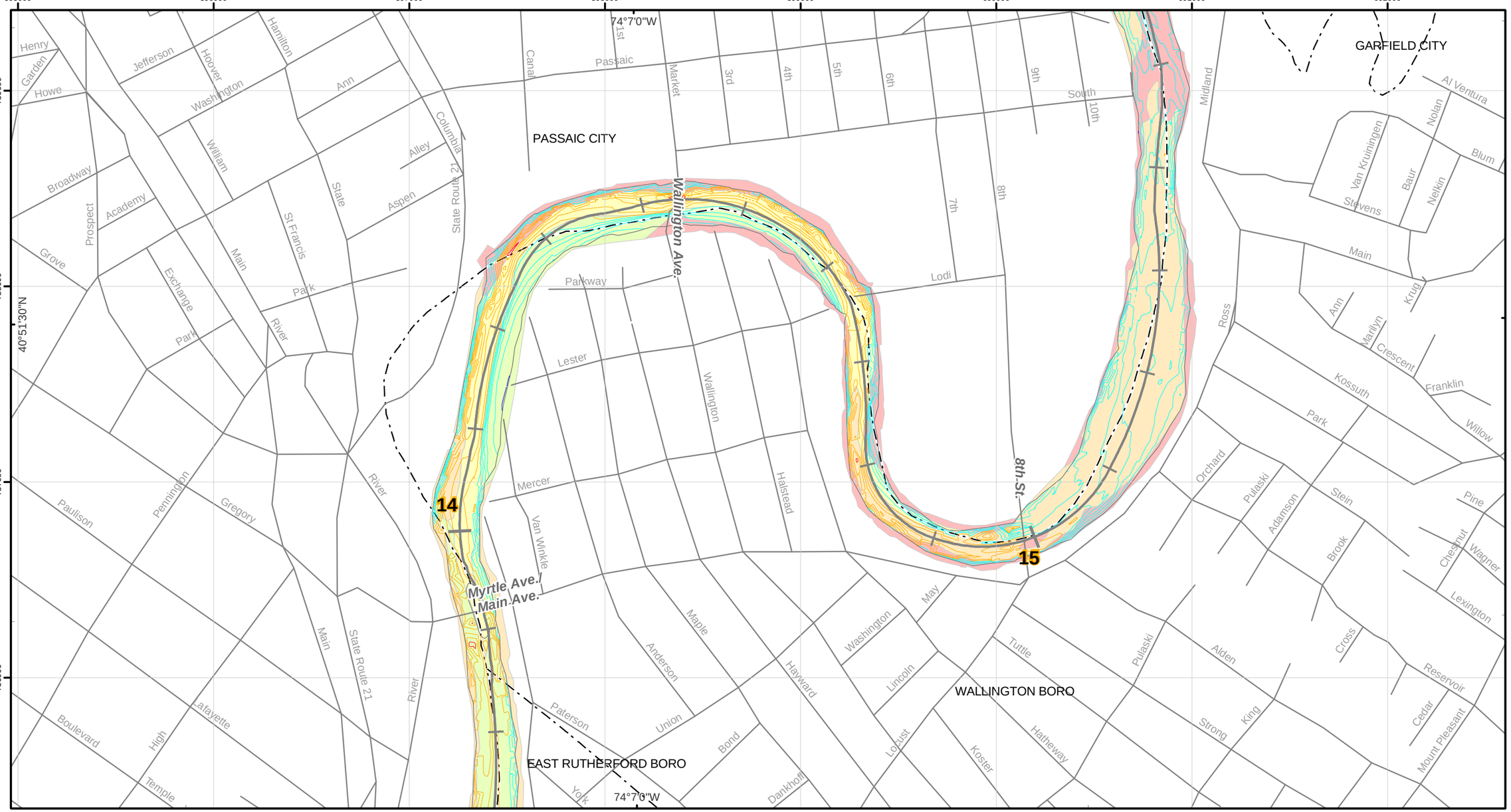

US Army Corps of Engineers®

Sediment Texture Map

Lower Passaic River Restoration Project

February 2007

Legend

- Rock and Coarse Gravel
- Gravel and Sand
- Sand
- Silt and Sand
- Silt
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2004 USACE Bathymetric Survey

Elevation (Feet) Relative to NGVD29

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Coordinate System: State Plane New Jersey
Datum: NAD 83 Units: Feet

N

0 250 500 1,000

1 " equals 500 '

Bathymetric Control Data:
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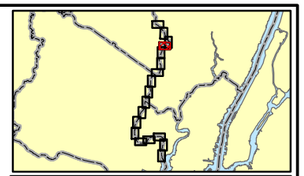
Data Source:
Buildings: CADD drawing, 09994X01, dated January 1, 2002 received from BBL.
Roads: 2000 TIGER line data.
Sediment Texture: 2005 Side scan SONAR data from Aqua Survey, Inc.



Mile 14 to 15

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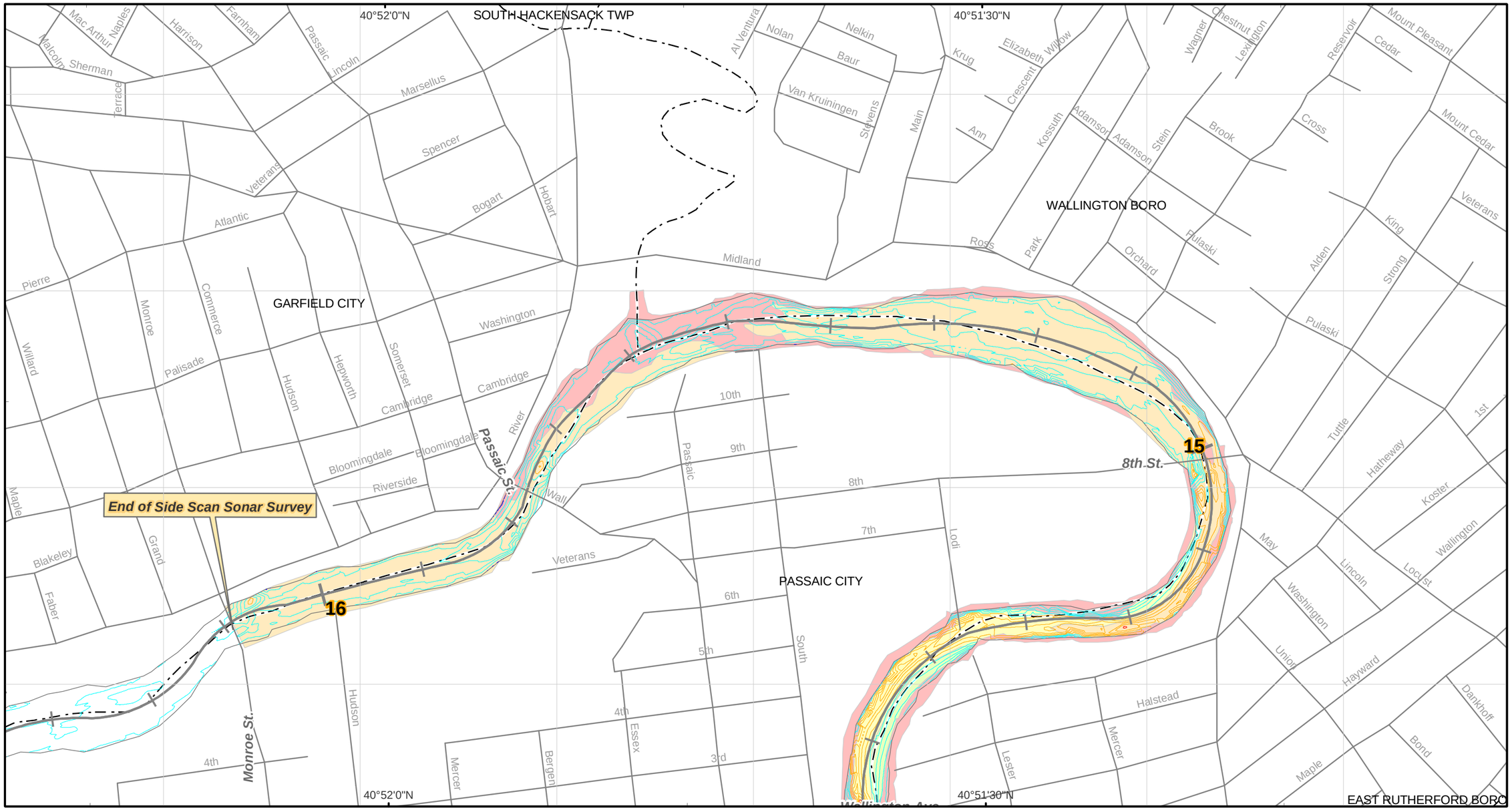

US Army Corps of Engineers®

Sediment Texture Map

Lower Passaic River Restoration Project

February 2007

Legend

- Rock and Coarse Gravel
- Gravel and Sand
- Sand
- Silt and Sand
- Silt
- River Mile Post

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- 2 to 10

Coordinate System: State Plane New Jersey
Datum: NAD 83 Units: Feet

N

0 250 500 1,000

1 " equals 500 '

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Data Source:
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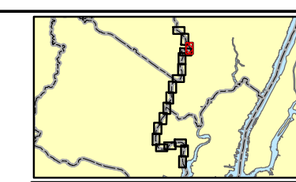
Roads: 2000 TIGER line data.
Sediment Texture: 2005 Side scan SONAR data from Aqua Survey, Inc.



Mile 15 to 16

Map Document: (S:\Projects\PASSAIC\MapDocuments\Proposed Sediments\Coring_Field_Work\Sediment_Texture_Geophysical_Memo_October_2005.mxd)
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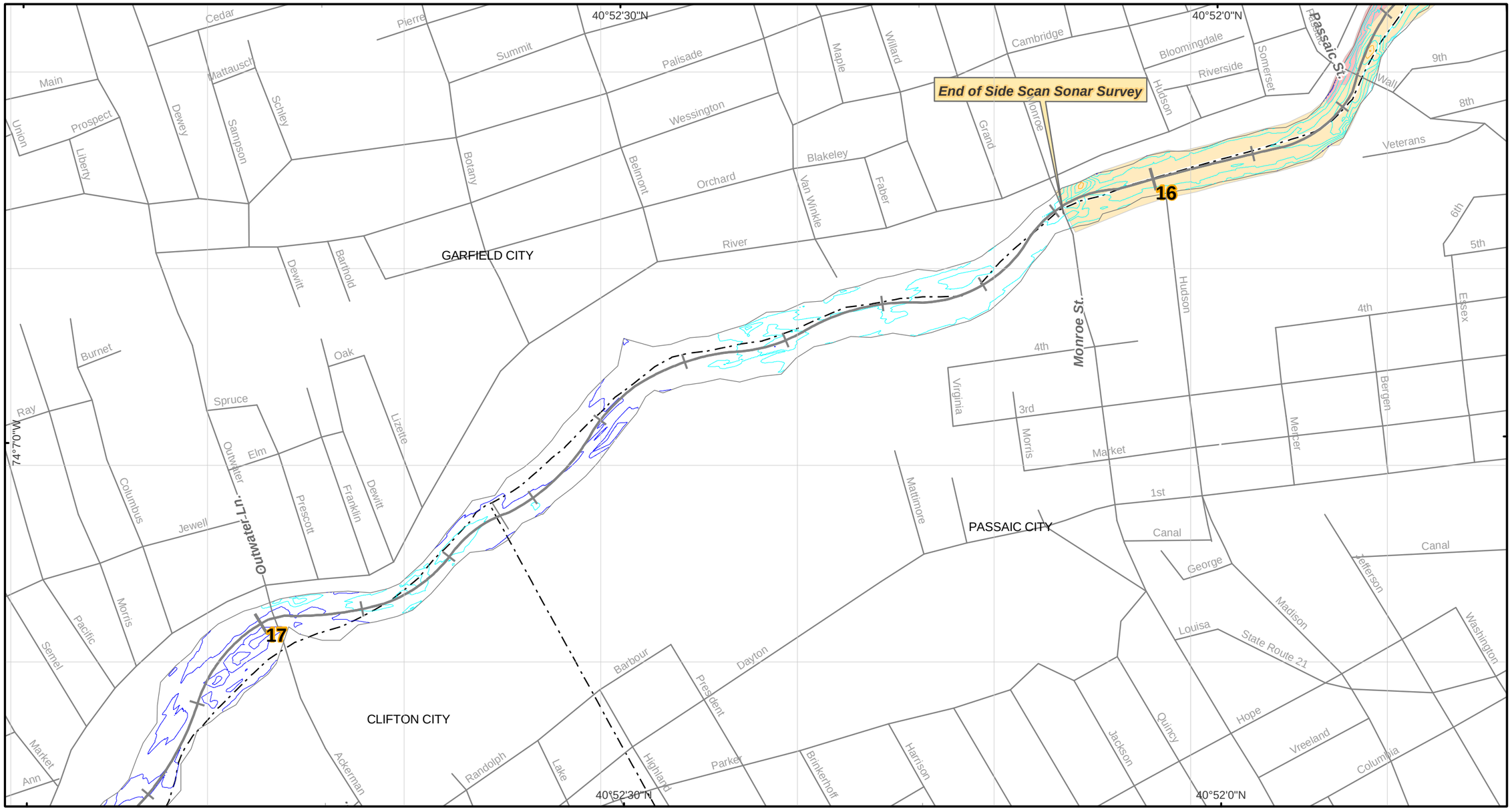

Sediment Texture Map

Lower Passaic River Restoration Project

February 2007

Legend

- Rock and Coarse Gravel
- Gravel and Sand
- Sand
- Silt and Sand
- Silt
- River Mile Post

2004 USACE Bathymetric Survey

Elevation (Feet) Relative to NGVD29

- -30 to -20
- -18 to -10
- -8 to 0
- 2 to 10

Coordinate System: State Plane New Jersey
Datum: NAD 83 Units: Feet

N

0 250 500 1,000

1 " equals 500 '

Bathymetric Control Data:
Benchmark: X 71 (NGS PID: KV0256)
Elevation: 15.12 FEET (NGVD 29)
Benchmark: V 71 (NGS PID: KV0254)
Elevation: 15.76 FEET (NGVD 29)

Data Source:
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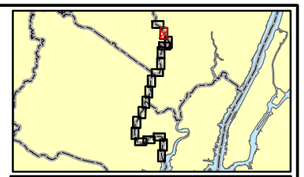
Roads: 2000 TIGER line data.
Sediment Texture: 2005 Side scan SONAR data from Aqua Survey, Inc.



Mile 16 to 17

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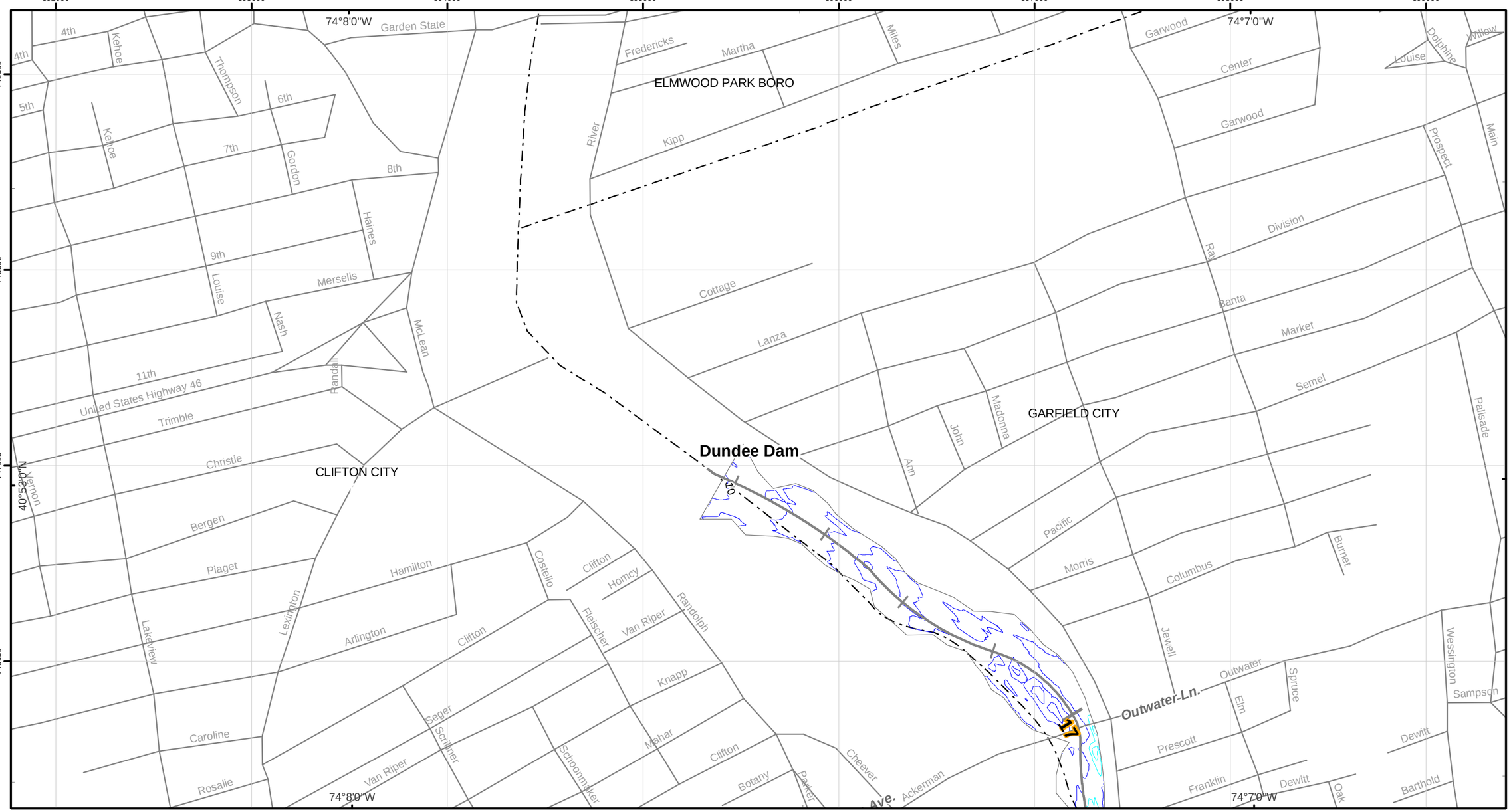

US Army Corps of Engineers®

Sediment Texture Map

Lower Passaic River Restoration Project

February 2007

Legend

- Rock and Coarse Gravel
- Gravel and Sand
- Sand
- Silt and Sand
- Silt
- River Mile Post

2004 USACE Bathymetric Survey

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0 250 500 1,000

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Bathymetric Control Data:
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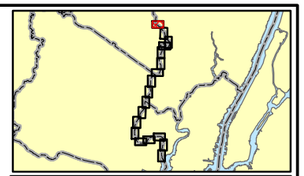
Sediment Texture: 2005 Side scan SONAR data from Aqua Survey, Inc.



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Attachment B

Calculation of Groundwater Contribution

LOWER PASAIC RIVER RESTORATION PROJECT
CALCULATION OF GROUNDWATER CONTRIBUTION

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1.0 BASEFLOW ESTIMATION

1.1 RIVER HYDROLOGY

The flow in the Lower Passaic River consists of 3 components: surface water runoff, artificial outfalls, and groundwater seepage. Figure B-1 shows an idealized cross-section of the Lower Passaic River (or any other river in a similar environment). When the rain falls to the ground, some of it escapes as runoff, some infiltrates to recharge the groundwater table, and some evaporates or is used by plants (evapotranspiration). All of the surface runoff within a given watershed will eventually flow to the river. The infiltrating water will also reach the river, but it will travel underground. This portion of the river is called "baseflow" because it is generally present even when it is not raining. Since more resistance exists to flow underground than above ground, the groundwater arrival will be delayed and damped out. Changes in groundwater heads around the river (caused by season or drought conditions) can result in some variation in baseflow. However, these variations are small compared to the variations in surface run off (which can have large daily variations). For this application, an average baseflow was calculated and was assumed to be constant.

The magnitude of the baseflow is dependent on the volume of infiltration within the river's watershed. Although baseflow is a volume of water added to the river over a given time period, it is often divided by the watershed area, to produce units similar to precipitation (depth per time). When expressed in this fashion, baseflow is independent of the size of the watershed and it can be applied to any other watershed with identical meteorological, hydrologic and geologic conditions.

One way to determine the baseflow in a river is to subtract the run off and artificial discharges from the total flow in a river. The run-off can be subtracted by looking for a dry period in the stream flow dataset when none of the flow in the river can be attributed to surface run off. When flow information is available, it is simple to add up the artificial discharges and subtract them from the total flow.

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1.2 SELECTION OF A COMPARABLE WATERSHED

Ideally, the groundwater component to stream flow would be estimated by analyzing one or more stream flow gauges on the river of interest. However, because there is no stream flow gauge station in the Lower Passaic River, and because the river is tidal (the tidal influence would add an additional component to the flow), the analysis could not be performed using data from the Lower Passaic River. Instead, Malcolm Pirnie, Inc. searched for one or more nearby watersheds with similar precipitation, soil type, geology, land use, and vegetation. The resulting recharge value was divided by the watershed area and then applied to the Lower Passaic River watershed.

Several nearby drainage areas were considered. The Little Falls station [United States Geological Survey (USGS) 01389500] is located about 12 miles upriver of Dundee Dam on the Passaic River. However, the drainage area for Little Falls is very large (762 square miles). Although the size does not preclude its usefulness in this application, this particular watershed extends far to the north and west of the station, where land uses and geologic settings vary significantly from conditions in the drainage area of the Lower Passaic River. (Refer to Figure B-2 for the locations and stations for each watershed.) In addition, the watershed above the Little Falls gauge includes over 300 New Jersey Pollutant Discharge Elimination System (NJPDES) permits [New Jersey Department of Environmental Protection (NJDEP), 2005], only about one-third of which have flow data available online from the NJDEP website (NJDEP, 2006).

The drainage areas of three tributaries on the Lower Passaic River were also considered (Figure B-2). Saddle River has two stream flow stations, which are not very useful for this analysis because the drainage areas for these stations extend far to the north where geology, soil types, and land use vary significantly. The other two tributaries (Second River and Third River) have the right geologic characteristics, but are only marginally useful because the periods of record on these stream gauges are fairly short (about 25 and 20 years, respectively) and do not contain recent data. The baseflow for these two drainage areas was also computed (refer to Section 1.5 “Comparison to Second and Third

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Rivers"), but Malcolm Pirnie, Inc. also wanted to find a nearby watershed with a longer period of record for comparison.

The Elizabeth River basin with a station at Ursino Lake (USGS 01393450) is nearby and has over 80 years in the data record. This watershed is small (16.9 square miles) and covers an urban area much like the Lower Passaic River. The underlying geology is the same geologic formation as is found under the Lower Passaic drainage area (the Triassic-aged Brunswick Formation). Elizabeth River empties into the Arthur Kill about six miles southwest of the mouth of the Passaic River. (Refer to Figure B-2 and Figure B-3 for the relative locations of the Lower Passaic River, Second River, Third River, and Elizabeth River). Because of the similarities between these three drainage areas and the Lower Passaic Drainage area, the recharge per unit area of the watershed to the Elizabeth River can be calculated and applied to the Lower Passaic River. The recharge per unit area to the Second and Third Rivers was also calculated for comparison.

1.3 ANALYSIS OF PERMITTED DISCHARGES

There are 18 NJPDES permits in the drainage area for the Elizabeth River stream gauge (Figure B-4). Discharge information is available for about half of them at NJDEP's Open Public Records Act (OPRA) website (NJDEP, 2006). For each of the permits within the drainage area, the greatest flow measurement over the most recent year of data is listed in Table 2-1. The OPRA website provided data for only about half of the permits, but none of the facilities are expected to have large outflows with respect to the flow in the Elizabeth River (there are no permitted municipal wastewater treatment plants on the river above the gauge). The total flow of the known locations is less than 0.3 cubic feet per second (cfs), which is a small flow compared to the flow over the Dundee Dam (more than 1,100 cfs).

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Table 2-1: Summary of NJPDES Permit Information for Elizabeth River Drainage

NJPDES Identification	NJPDES Facility Name	Flow (million gallons/day)	Flow (cfs)
NJ0060194.001A	American Aluminum Casting	unk	
NJ0107204.001A	Ardell Industries – ASRC	unk	
NJ0080071.001A	Ardell Industries (ECRA)	0.00043	0.001
NJ0069515.001A	Ariston Div - Graphic Design Tech	unk	
NJ0070696.001A	Atlantic Metal Products	0.0178	0.028
NJ0035980.001A	Atlas Tool Co Inc	0.0312	0.049
NJ0027871.001A	Coastal Oil Company	unk	
NJ0031186.002A	ECD Inc	0.0005	0.001
NJG0105082.001A	Exxon S/S 3-0065	0.0034	0.005
NJG0109835.001A	Exxon S/S 3-0209	unk	
NJ0131407.001A	Exxon S/S 3-1799	unk	
NJG0109592.001A	Jersey Plastic Molders	unk	
NJG0108626.001A	Merit Oil of NJ - Merit S/S	0.009	0.014
NJ0105813.001A	Peter A Droback Co	unk	
NJG0068802.001A	Ronald Mark Associates	0.078	0.123
NJ0002291.001A	Schering Corp	unk	
NJ0104001.001A	Star Enterprise	unk	
NJ0087882.001A	Sunoco S/S 6-9096	unk	
NJ0034266.001A	Tuscan Dairy Farms Inc	0.027	0.043
	Sum	**0.167**	**0.264**

unk = unknown value

1.4 DETERMINATION OF BASEFLOW IN ELIZABETH RIVER

The USGS website (USGS, 2007) provides daily average flow rates for the stream gauge on Elizabeth River from June 1922 through September 2005. To determine the baseflow, various years were analyzed separately. For example, Figure B-5 shows the flow data for the randomly selected year 1983, which is representative of the other years in the record. The low points between the storm events are considered to be baseflow.

The information from the stream gauge shown in Figure B-5 was analyzed by calculating the 7-day minimum flow for each day of the year. (The seven days included the three previous days and the three subsequent days.) The point was considered to represent baseflow if the measurement for that day was within 1 cfs of the 7-day minimum. Figure B-6 shows the same stream flow data as Figure B-5 but with the estimated baseflow values connected with a red line. The red line in Figure B-6 probably shows more

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baseflow variation than reality. Some low points may be below baseflow because of evapotranspiration. Some instances when the baseflow seems to be high may indicate times when closely spaced storms prevented the river from returning to steady baseflow conditions.

Figure B-6 shows that for the year 1983, the baseflow varied between 4 and 19 cfs with an average of about 8 cfs. This analysis was repeated for the rest of the years in the record (Figure B-7). With the exception of the first 10 or 20 years of the record, there is not a lot of variation in the average baseflow value. At the same time, there is a perceptible increase in the minimum baseflow value and a marked decrease in the maximum value. The range of variability generally decreases over the last century, probably due to more engineering in the water system.

The average baseflow over the entire record was calculated by averaging each of the annual averages. The result was about 8.2 cfs. When Malcolm Pirnie, Inc. subtracted out 0.3 cfs for the NJPDES permits and divided the flow by the basin area (16.9 square miles), the recharge per unit area for the Elizabeth River basin was calculated to be 6.3 inches/year. This means that about 6.3 inches of the annual rainfall in the Elizabeth River drainage area infiltrates to the water table and makes its way to the river, where it seeps through the bottom sediments and joins the river water.

1.5 COMPARISON TO SECOND AND THIRD RIVERS

We applied the process described in Section 1.3 “Analysis of Permitted Discharges” and Section 1.4 “Determination of Baseflow in Elizabeth River” to the drainage areas for the Second and Third Rivers for a check of the results. Table 2-2 shows the NJPDES permit information for each of these basins.

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Table 2-2: NJPDES Information for Second and Third River Drainage Basin

Second River Drainage Basin			
NJPDES Identification	Facility Name	Flow (Million gallons/day)	Flow (cfs)
NJ0034185.001A	Hoffmann-La Roche Inc	unk	
NJ0107654.001A	Hobart Brothers Co	0.011	0.016
NJ0052078.001A	ABB Lummus Global	0.002	0.003
NJ0002909.001A	Montclair State University	unk	
NJG0156426.001A	Grove St Pumping Station	unk	
	Total	0.01	0.02
Third River Drainage Basin			
NJPDES Identification	Facility Name	Flow (Million gallons/day)	Flow (cfs)
NJ0029335.001A	Peerless Tube Company	unk	
NJ0032280.007A	Clara Maass Hospital	0.042	0.065
NJ0066516.001A	Chevron USA Inc	unk	
NJ0100048.001A	McGraw-Edison Worthington	unk	
NJ0108502.001B	Viacom Incorporated	0.0001	0.0002
NJG0029327.001A	Peerless Tube Company	1.67	2.59
NJG0075221.001A	Exxon S/S 3-1062	unk	
NJG0108758.001A	Newark City	unk	
NJG0127710.001A	Gulf S/S - Frank & Rick's Inc	unk	
	Total	**1.72**	**2.65**

unk = unknown value

As with Elizabeth River, the OPRA website did not provide data for some of the permits. The totals for the Second River watershed result in a very small, negligible flow rate. However, the total artificial flow for the Third River watershed is significant.

The same process detailed in Section 1.4 “Determination of Baseflow in Elizabeth River” was used to separate out the baseflow for all the years of data in the Second and Third River stations. The NJPDES permitted flows were subtracted from the result, and then both flow rates were divided by the basin areas to determine a recharge value in inches/year. Figure B-8 compares the calculated baseflow for each of the 3 drainage basins (after subtracting out NJPDES permitted flows) and shows a good correlation.

Results for all the years of each of the three records were averaged to calculate a single recharge value for each basin. The results, along with an average recharge value are shown in Table 2-3.

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Table 2-3: Calculated Recharge for 3 Basins Near the Lower Passaic River

Basin	Average Estimated Low Flow (cfs)	Total NJPDES Flow (cfs)	Baseflow (cfs)	Drainage Area (square mile)	Recharge (inch/year)
Elizabeth River	8.2	0.3	7.9	16.9	6.3
Second River	7.8	2.7	5.1	11.6	6.0
Third River	8.8	0.0	8.8	11.8	10.1
Average					**7.5**

As these three basins are near the Lower Passaic River and have similar geologic settings and land use, the recharge from these smaller basins can be applied to the Lower Passaic River. The Lower Passaic River has a drainage area of 39.5 square miles below Dundee Dam when the basins for Saddle River, Third River, and Second River are removed (Figure B-3). When the recharge is applied to this larger basin, the baseflow to the Lower Passaic River is calculated to be 22 cfs (or about 14 million gallons/day). This value is the amount of flow that infiltrates to the groundwater table after a rain event and slowly makes its way to the river, where it enters by flowing through the bottom sediments.

1.6 CALCULATING SURFACE WATER FLOWS

The nearest streamflow gauge on the Lower Passaic River is the Little Falls Station, about 12 miles above Dundee Dam. The average flow at Little Falls was determined by using the USGS website (USGS, 2007) to extract average yearly flows for each complete year of the record. For the Little Falls Station, this included 107 years between 1898 and 2005. These yearly averages were then averaged to obtain a single flow value for the whole record. This value was found to be about 7 percent higher than the average over the last 50 years. For this reason the average used in the analysis was based only on the last 50 years of the record (1996-2005). The average river flow at Little Falls USGS gauging station from 1956 to 2005 was calculated as 1,050 cfs, or 247 billion gallons/year. The flow from the Little Falls gauge must be adjusted by approximately 10

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percent[1] to account for the additional watershed area between Little Falls and the Dundee Dam, yielding an average river flow at the Dundee Dam of 1,160 cfs.

There are three major inflows to the Lower Passaic River: Saddle River, Second River, and Third River. Each has (or had) a USGS station near the intersection with the Lower Passaic River. The watersheds and station locations are shown in Figure B-3. The USGS website was used to obtain yearly average flow rates for each station. Although the differences between the average over the entire record and that over the last 10 years of the record were small (less than 5 percent), each average was based on the last 10 years for uniformity (Table 2-4).

Table 2-4: Surface Flow Sources to the Lower Passaic River

Location	Average Flow over Last 10 Years of each Record (cfs)	Source/Record
Dundee Dam	1,160	10 percent higher than Little Falls (1042 cfs) Record: 1898-2005
Saddle River at Lodi (USGS 01391500)	106	Record: 1924-2005
Third River at Passaic (USGS 01392210)	19	Record: 1978-1997
Second River at Belleville (USGS 01392500)	20	Record: 1938-1964

Figure B-3 shows that the three tributary stations are slightly upstream from the confluence points in each case. This means that the groundwater component between the station and the confluence should be added to the station measured flow. Malcolm Pirnie, Inc. also needs to add in any NJPDES permitted flows between the station and the confluence. Following with this method, we can estimate the total surface flow entering the Lower Passaic River from each tributary.

[1] River flow at Dundee Dam is based on a July 18, 2005 electronic message from Emad Sidhom (Senior Project Engineer at United Water and the New Jersey District Water Supply Commission) to F. Chris Purkiss (Malcolm Pirnie, Inc.). Mr. Sidhom indicated that the flow measurements at Dundee Dam were approximately 10 percent greater than the flows measured at the Little Falls gauging station.

The Saddle River calculation is simple since the station falls on the boundary of a hydrologic unit as defined by the NJDEP (Figure B-3). The area of the drainage basin for that lowest section of the Saddle River is 3,162 acres. When the 7.5 inch/year of recharge (Table 2-3) is applied to this area, the groundwater component in the lowest section of the Saddle River is calculated to be 2.7 cfs. In addition, there are several NJPDES outflow locations within this drainage area (Figure B-4 and Table 2-5) resulting in an additional 2.1 cfs. When these flows are added to the station average flow, the Saddle River surface water addition to the Lower Passaic River becomes 108 cfs.

Table 2-5: NJPDES Permits Below the Lodi Station

NJPDES Identification	Facility Name	Flow (million gallons/day)	Flow (cfs)
NJ0003182.001A	Stepan Company	1.4	2.1
NJ0033511.001A	Farmland Dairies	unk	
NJ0035262.002A	Bergen Cable Technologies	unk	
NJ0104591.020A	Novus Fine Chemicals LLC	unk	
NJ0131032.001A	Former Inmont Division	unk	
NJ0145378.001A	Hexcel Corp	0.003	0.005
NJG0157163.001A	BP S/S 1557	unk	
	Total	**1.4**	**2.1**

unk = unknown value

The Second River and Third River components are calculated differently because the hydrologic unit coverage does not separate the zone above the station. The recharge area below the station can be calculated by comparing the USGS reported drainage area (which includes only the area that contributes to the station flow) to the hydrologic unit area in the NJDEP coverage (which extends to the confluence with the Passaic River). For Third River, USGS reports a drainage area of 11.8 square miles for the station. The NJDEP hydrologic unit area is 12.5 square miles. Subtracting these two areas yields a drainage area of 0.7 square miles for the river reach below the station. When the 7.5 inch/yr (Table 2-3) of recharge is applied, the groundwater component between the station and the confluence is calculated to be 0.4 cfs. In addition, there are a few NJPDES permits downstream of the station but inside the drainage area for Third River (Figure B-4). The information for these permits is listed in Table 2-6. When the groundwater component (0.4 cfs) and the artificial flows (0.2 cfs) are added to the station

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average flow, the surface water addition from Third River into the Lower Passaic River is calculated to be 19 cfs.

Table 2-6: NJPDES Permits on Third River Below the Station Location

NJPDES Identification	Facility Name	Flow (million gallons/day)	Flow (cfs)
NJG0020214.001A	ITT Avionics Division	0.11	0.17
NJ0105490.001A	ADT Security System Mfg	0.02	0.03
NJ0020435.001A	ITT Aerospace Communications	Unk	
	Total	**0.12**	**0.19**

The Second River calculation is the same as that for Third River. The USGS reported drainage area is 11.6 square miles while the NJDEP hydrologic unit area is 9,315 acres. The calculation increases the Second River component from 20 cfs to 22 cfs. There are no NJPDES permit sites within the drainage area and below this station (Figure B-4). Finally, all the NJPDES permitted flows for the Lower Passaic River were added to the surface water flow. The permit information is listed in Table 2-7 while Table 2-8 summarizes the final flow data.

Table 2-7: NJPDES Permits on the Lower Passaic River

NJPDES Identification	NJDES Facility Name	Flow (million gallons/day)	Flow (cfs)
NJ0000035.001A	National Standard Company	Unk	
NJ0000124.001A	Kalama Chemical Inc	Unk	
NJ0000566.001A	PSE&G Harrison Plant	Unk	
NJ0000639.343A	PSE&G - Essex G S	Unk	
NJ0001431.001A	Amerada Hess Corp - Newark Term	Unk	
NJ0002160.001A	Motiva-Newark Sales Terminal	0.007	0.01
NJ0002194.001A	SparTech Compound	0.043	0.07
NJ0002232.001A	J L Prescott Company	Unk	
NJ0002283.001A	General Chemical-Newark Works	17	26
NJ0002615.21AA	Okonite Company	Unk	
NJ0002771.001A	Sun Refining and Manufacturing	Unk	
NJ0003573.001A	Finetex Inc	0.06	0.09
NJ0003841.001A	Sun Chemical Corp	Unk	
NJ0020478.001A	Pantasote Polymers Inc.	Unk	
NJ0022161.001A	Kearny STP	Unk	
NJ0026034.001A	Getty Terminals Corp	0.005	0.01
NJ0027758.001A	US Postal Service	Unk	
NJ0029505.001A	969 Newark Turnpike Inc	Unk	
NJ0030376.001A	L & M Laplace	0.000	0.00
NJ0031313.001A	Kleer Kast Inc	Unk	

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Table 2-7 Continued			
NJ0031992.002A	NJ Transit – Meadows Maint	Unk	
NJ0033146.001A	Custom Chemical Co	0.081	0.12
NJ0034193.001A	Mansol Industries Inc	Unk	
NJ0034223.001A	Mansol Industries Inc	Unk	
NJ0034959.001A	NJDOT- Interstate 280	Unk	
NJ0034983.001A	V H Swenson Co Inc	Unk	
NJ0053783.001A	Toc Terminal Inc	0.073	0.11
NJ0055247.001A	American Ref – Fuel Co	Unk	
NJ0055808.001A	Flexon Industries Corp	Unk	
NJ0063738.001A	Reichhold Chemicals Inc	0.12	0.19
NJ0072109.001A	Getty S/S 56924	Unk	
NJ0076058.001A	Amerada Hess Newark Terminal	Unk	
NJ0076431.001A	Mobil S/S 15-JQ2	Unk	
NJ0078221.001A	Motiva Enterprises LLC	Unk	
NJ0078344.001A	Mobil S/S 15-LAE	Unk	
NJ0081248.001A	Penco of Lyndhurst Inc	Unk	
NJ0083259.001A	Motiva Enterprises LLC	Unk	
NJ0100196.001A	Material Recovery Facility	Unk	
NJ0100714.001A	US Postal Service	Unk	
NJ0102636.001A	Amoco S/S 0925	Unk	
NJ0104167.001A	SpectraServ	Unk	
NJ0106798.001A	Recycle Fibers	Unk	
NJ0107000.001A	Newark Boxboard Co	Unk	
NJ0107395.001A	Nimco Shredding Co	Unk	
NJ0107646.001A	Pramar Realty Co LP	Unk	
NJ0108367.002A	US Postal Service	0.0069	0.01
NJ0108499.001A	Deleet Merchandising Corp	Unk	
NJ0116068.001A	Clayton Block Co LlC	Unk	
NJ0117846.001A	East Newark Borough Of	Unk	
NJ0127272.001A	Parkway Iron & Metal Co Inc	Unk	
NJ0128261.001A	S & W Waste Inc	Unk	
NJ0128287.001A	Transplastic Inc	Unk	
NJ0129046.001A	Newark Asphalt Corp	Unk	
NJ0130508.001A	Spartech Polycom	Unk	
NJ0131814.001A	Presto Lock Inc	0.16	0.25
NJ0132390.001A	Stanley Tools Facility (former)	Unk	
NJ0133396.001A	Mobil S/S 15-JQ2	Unk	
NJ0136727.001D	Getty S/S 56868	Unk	
NJ0137545.001A	Route 21 Associates Site	Unk	
NJ0137774.001A	Joashlin Construction (former River Oil)	Unk	
NJG0020214	ITT Avionics Division	0.066	0.10

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Table 2-7 continued			
NJG0029815.001A	Duro Test Corporation	Unk	
NJG0033430.001A	Fairmount Chemical Co	0.040	0.06
NJG0064220.001A	Exxon S/S 3-2138	Unk	
NJG0073741.001A	Honeyware Inc	0.22	0.33
NJG0086720.001A	Getty S/S 56844	Unk	
NJG0103071.001A	Styertowne Mall	0.0054	0.01
NJG0104256.002A	Sun Company Inc (Newark Term)	0.0079	0.01
NJG0108758.002A	Newark City	Unk	
NJG0108871.007A	Harrison Town	Unk	
NJG0111244.002A	Kearny Town	Unk	
NJG0128317.001A	Clifton Fire House 6	Unk	
NJG0146714.001A	General Hospital Center (Passaic)	0.023	0.04
NJG0158658.001A	Branch Brook Park	Unk	
NJG0160741.001A	Chemaid Laboratories Inc	Unk	
	Total	**18**	**27**

unk = unknown value

Table 2-8: Flow Components in the Lower Passaic River

Source	Flow rate (cfs)	Notes
Dundee Dam	1,160	Value from Table 2-4
Saddle River	108	Value from Table 2-4
Third River	19	Value from Table 2-4
Second River	22	Value from Table 2-4
NJPDES Flows	27	Permitted flows on Lower Passaic River. Value from Table 2-7
Total Surface Water Component	**1,322**	
Groundwater Component	22	From baseflow separation analysis (Section 1.4 and Section 1.5)
Total Flow in River	**1,344**	

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2.0 ACRONYMS

cfs	Cubic feet per second
NJDEP	New Jersey Department of Environmental Protection
NJPDES	New Jersey Pollutant Discharge Elimination System
OPRA	Open Public Records Act
USGS	United States Geological Survey

R2-0009160

3.0 REFERENCES

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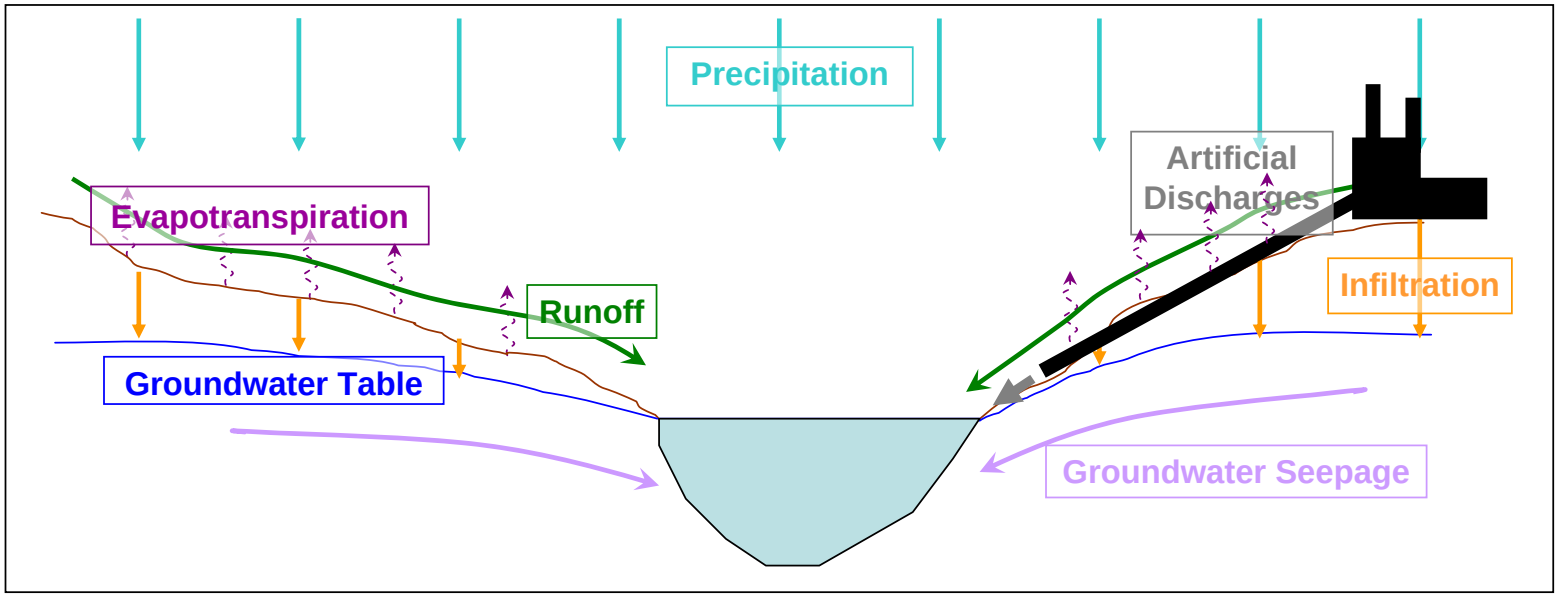
NJDEP, 2005. New Jersey Department of Environmental Protection: Division of Water Quality. "njpdes related GIS downloads." Last modified on 29 March 2005. Last accessed on 10 January 2007. http://www.state.nj.us/dep/dwq/njpdes_gis.htm.

USGS, 2007. "USGS Surface – Water Data for the Nation". Last accessed on 10 January 2007. http://waterdata.usgs.gov/nwis/sw.

United Water New Jersey. 2005. Personal communication between F.Chris Purkiss (Malcolm Pirnie, Inc.) and Emad Sidhom. July 18, 2005.

R2-0009161



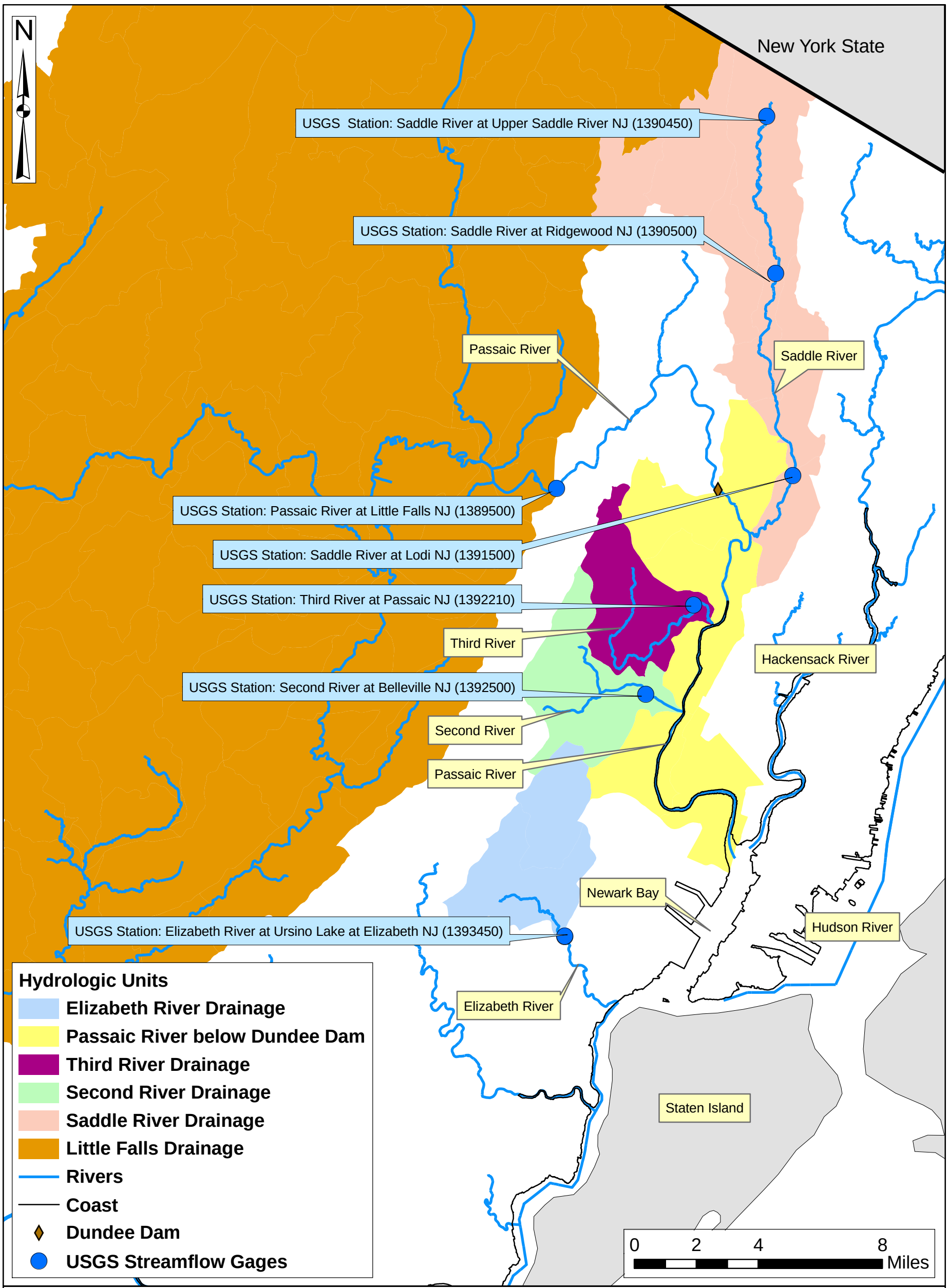
Idealized Cross-Section of the Lower Passaic River

Lower Passaic River Restoration Project

Figure B-1

February 2007

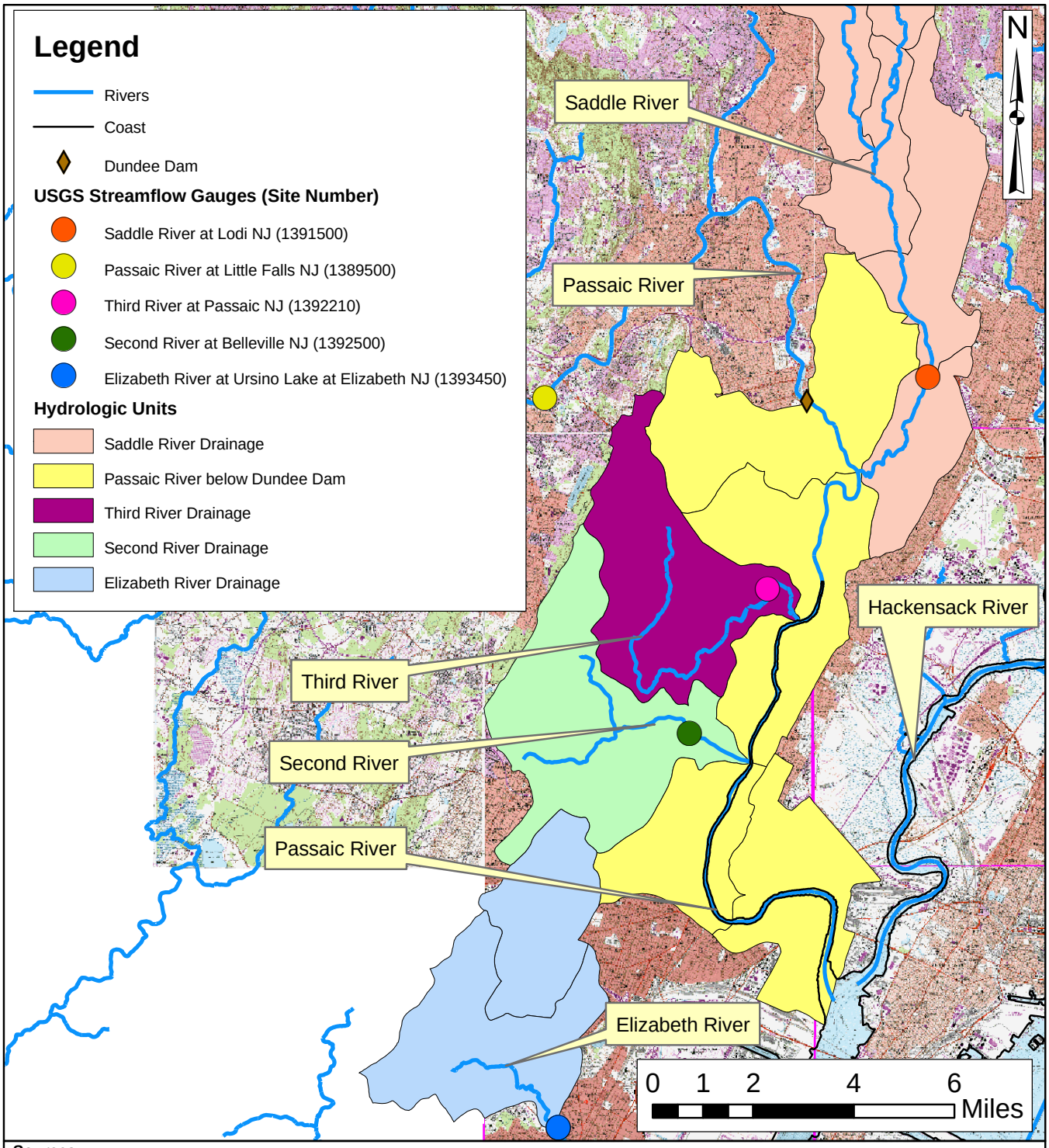
R2-0009162



Sources:
Drainage Areas developed from the Hydrologic Unit Coverage from www.state.nj.us/dep/gis/digidownload/zips/statewide/dephuc14.zip.
Rivers coverage from www.state.nj.us/dep/gis/digidownload/zips/statewide/stateriv.zip. Only Level 1 and 2 rivers are shown. (Second River, which is not Level 1 or 2, was digitized from USGS quad map.)
Coastline coverage from www.state.nj.us/dep/gis/digidownload/zips/statewide/coast.zip.
USGS station locations from USGS National Water Information System: waterdata.usgs.gov/nwis/sw. (Stations plotted show current or existing locations.)

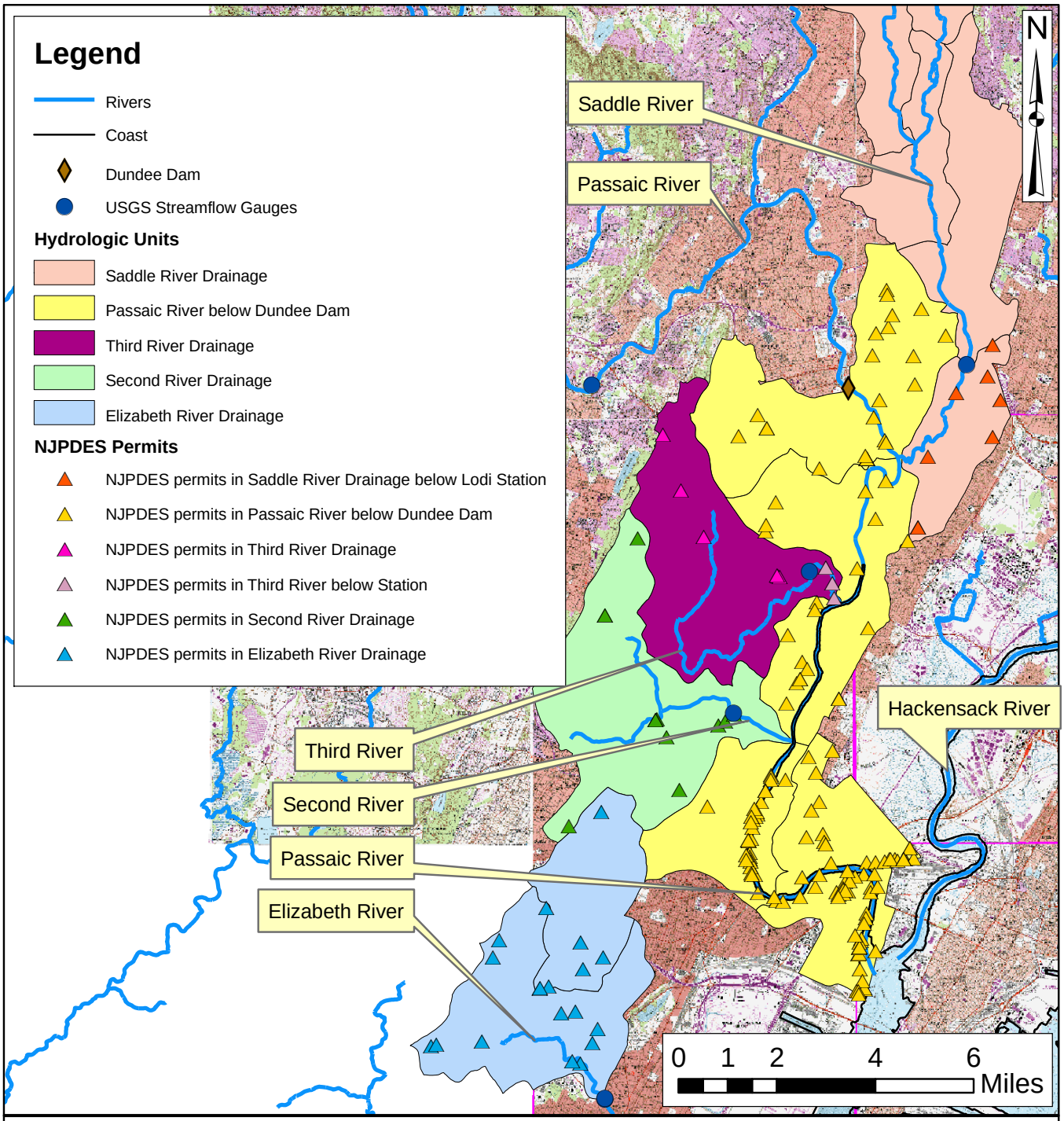
Notes: Although this map stops at the New Jersey/New York border, the drainage area for the Little Falls and Saddle River Stations extend north into the state of New York. The USGS Stations are labeled on the map with the Site Name and Number.

	Drainage Areas and USGS Streamflow Gauges Near the Lower Passaic River *Lower Passaic River Restoration Project*	Figure B-2 February 2007



Sources:
Background Maps from USGS quad maps.
Drainage Areas developed from the Hydrologic Unit Coverage: www.state.nj.us/dep/gis/digidownload/zips/statewide/dephuc14.zip.
Rivers coverage from www.state.nj.us/dep/gis/digidownload/zips/statewide/stateriv.zip. (Second River digitized from USGS quad map.)
Coastline coverage from www.state.nj.us/dep/gis/digidownload/zips/statewide/coast.zip.
USGS station locations (with Site Numbers) from USGS National Water Information System: waterdata.usgs.gov/nwis/sw.

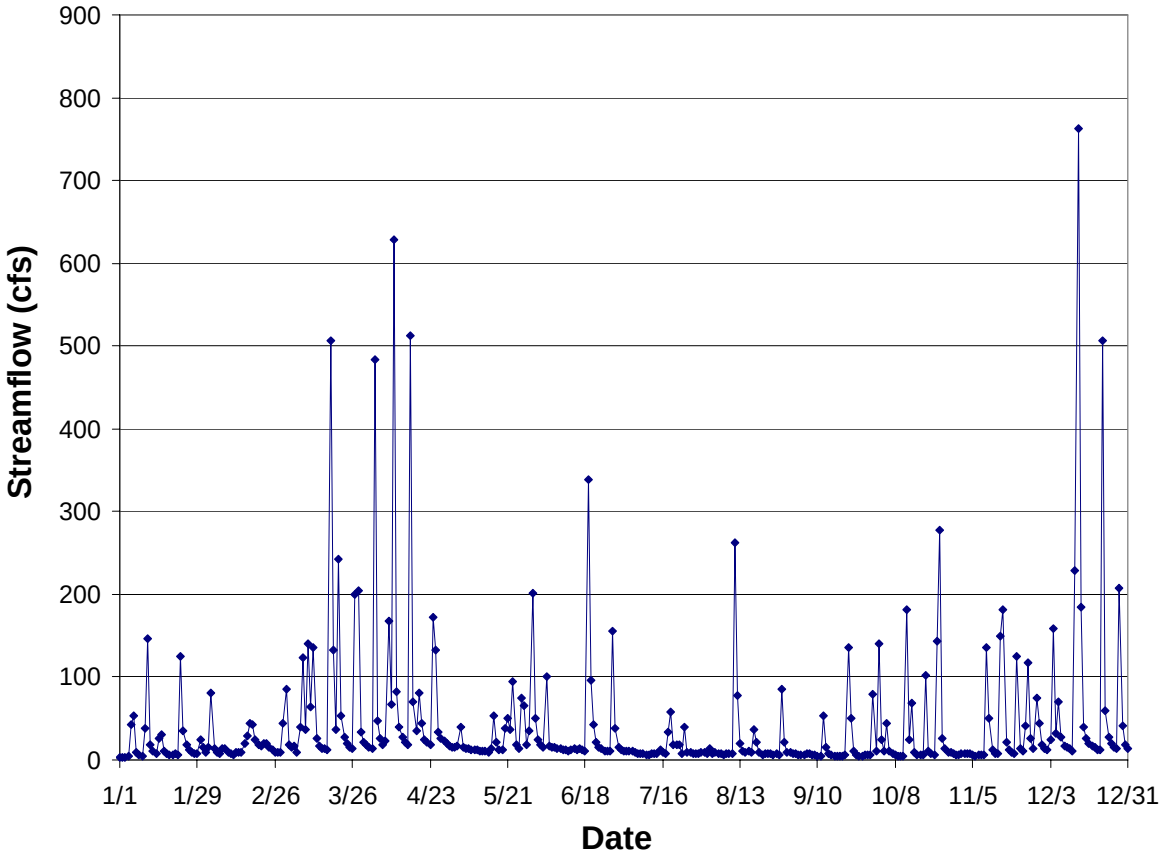
	Drainage Areas and USGS Streamflow Gauges for Calculating Baseflow *Lower Passaic River Restoration Project*	Figure B-3 February 2007



Sources:
Background Maps from USGS quad maps.
Drainage Areas developed from the Hydrologic Unit Coverage: www.state.nj.us/dep/gis/digidownload/zips/statewide/dephuc14.zip.
Rivers coverage from www.state.nj.us/dep/gis/digidownload/zips/statewide/stateriv.zip. (Second River digitized from USGS quad map.)
Coastline coverage from www.state.nj.us/dep/gis/digidownload/zips/statewide/coast.zip.
USGS station locations from USGS National Water Information System: waterdata.usgs.gov/nwis/sw.
Hydrologic Unit Code coverage from www.state.nj.us/dep/gis/digidownload/zips/statewide/dephuc14.zip.
NJPDES Permit Locations from www.state.nj.us/dep/dwq/njpdes_gis.htm.

US Army Corp of Engineers	NJPDES Permitted Locations *Lower Passaic River Restoration Project*	Figure B-4 February 2007

R2-0009165



Notes

Average Daily Streamflow data from USGS: http://waterdata.usgs.gov/nwis/sw.

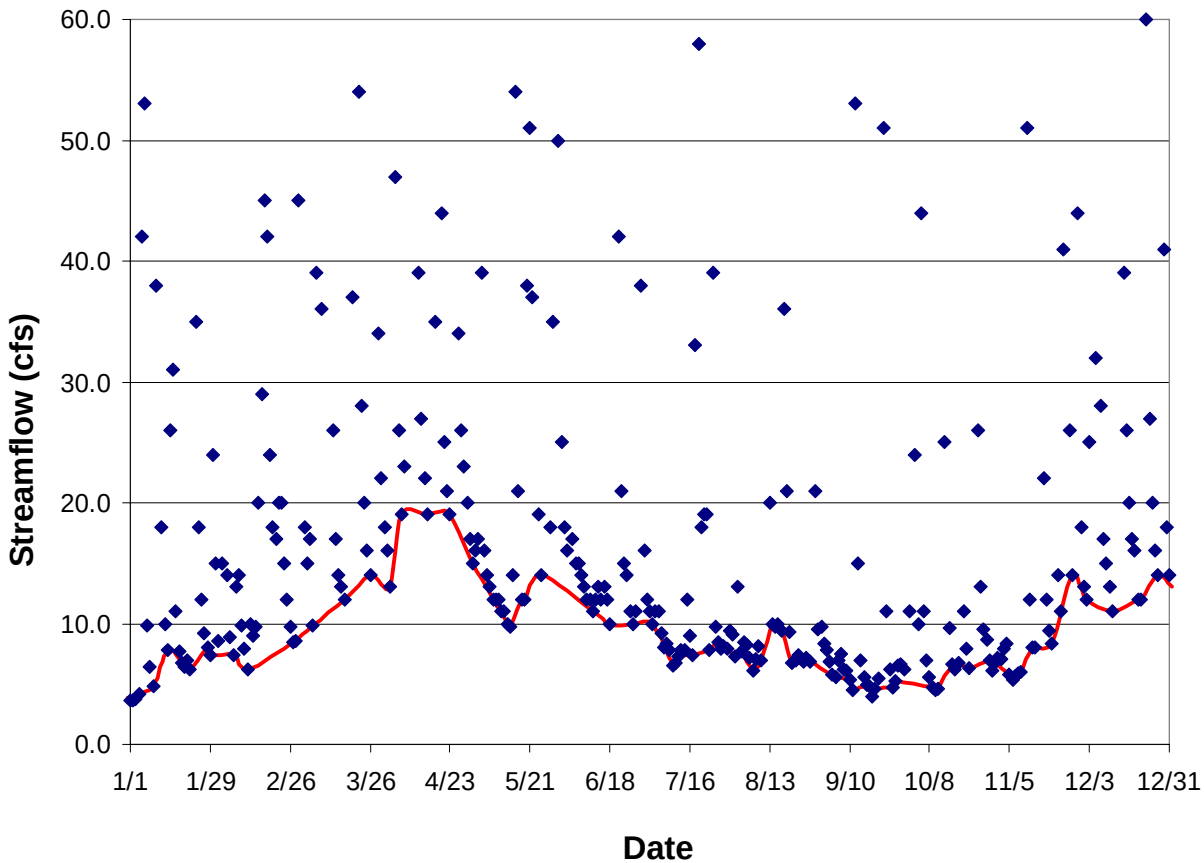
Station: Elizabeth River Station at Ursino Lake (USGS 1393450)

Elizabeth River Average Daily Streamflow - 1983

Lower Passaic River Restoration Project

Figure B-5

February 2007



Legend

Measured Average Daily Streamflow at Elizabeth River

Estimated Baseflow

Notes

Average Daily Streamflow data from USGS: http://waterdata.usgs.gov/nwis/sw.

Station: Elizabeth River Station at Ursino Lake (USGS 1393450)

For clarity, only streamflows below 60 cfs are shown.

Baseflow estimated by connecting any points within 1 cfs of the 7-day minimum flow.

Elizabeth River Average Daily Streamflow with Estimated Baseflow - 1983

Lower Passaic River Restoration Project

Figure B-6

February 2007

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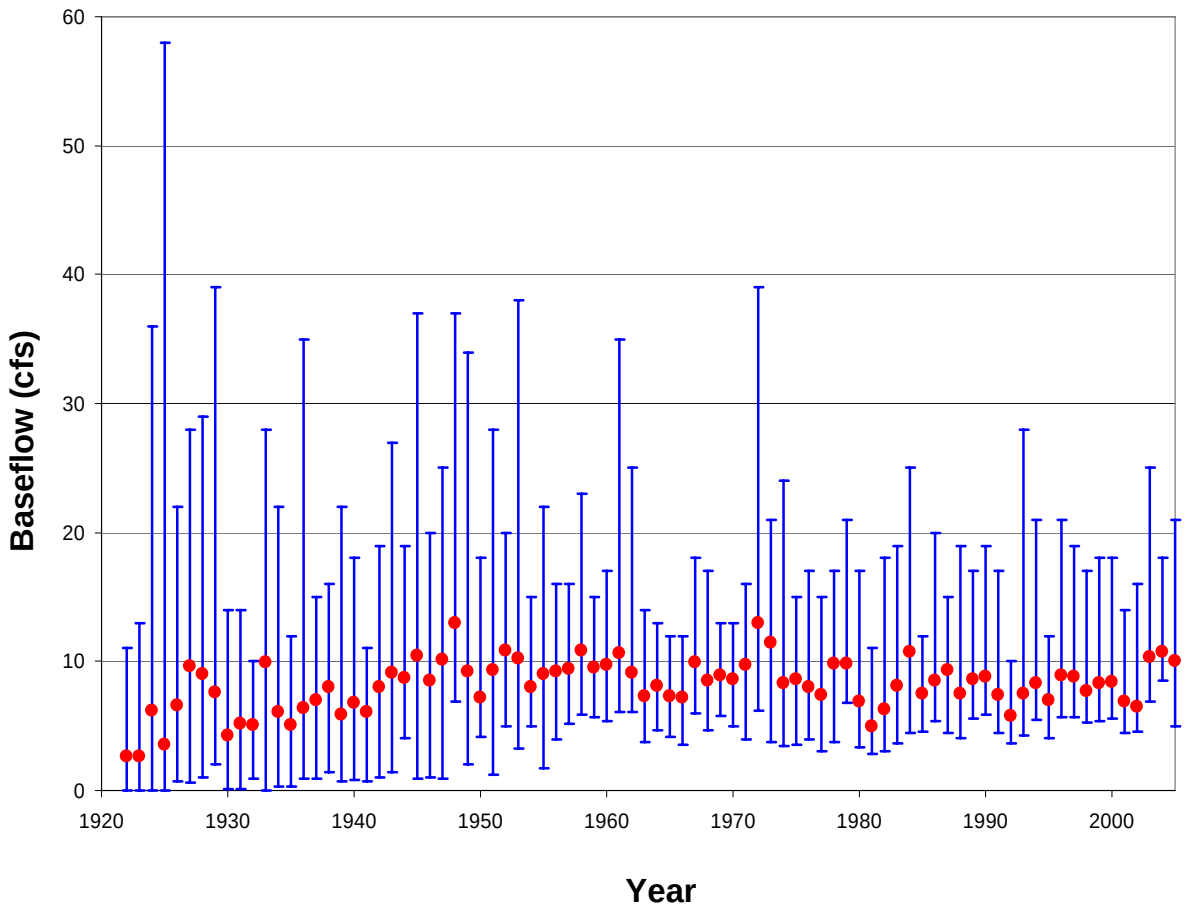


Legend

Maximum Estimated Baseflow for Year

Average Estimated Baseflow for Year

Minimum Estimated Baseflow for Year

Notes

Baseflow estimates based on USGS Streamflow data for Elizabeth River at Ursino Lake (USGS 1393450) available at http://waterdata.usgs.gov/nwis/sw.

Data points were considered to represent baseflow if the measured flow was within 1 cfs of the 7-day minimum flow (comprising the three previous days, the current day and the three subsequent days).

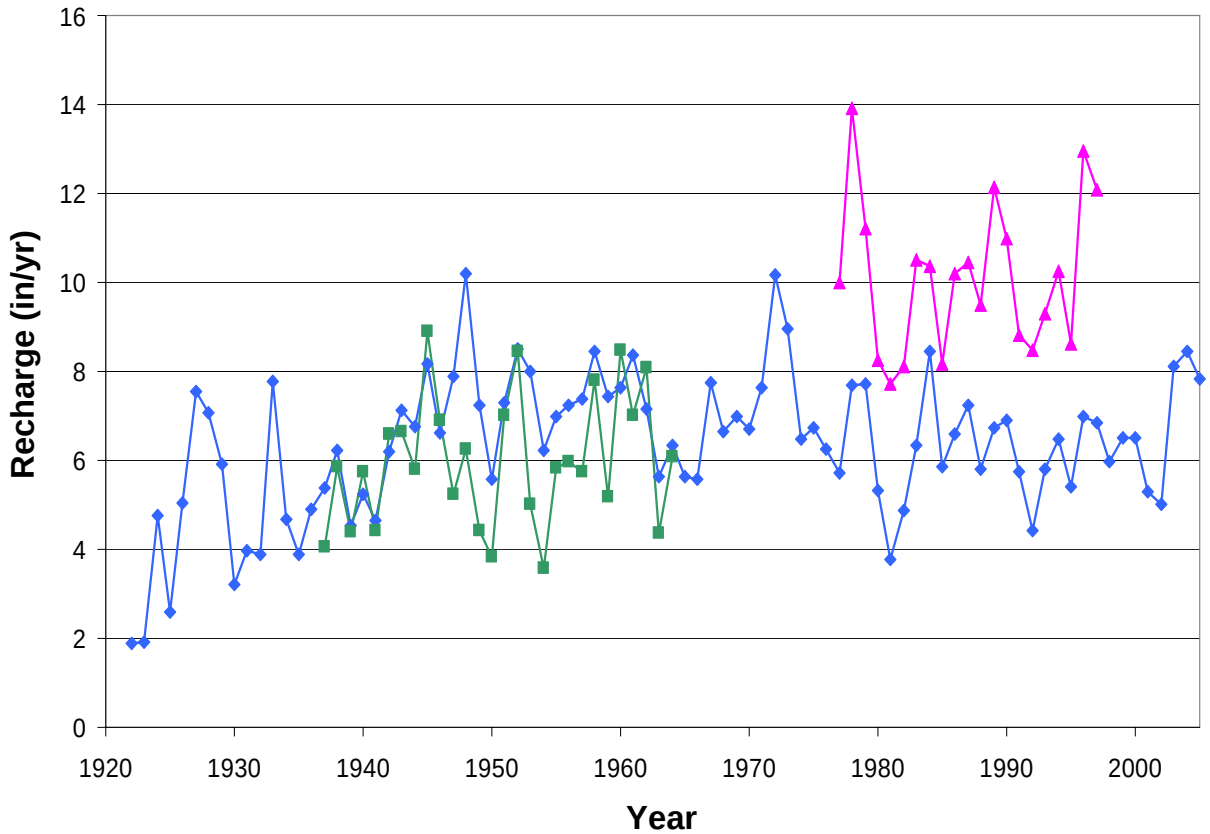
The maximum, minimum and average baseflows represent the statistics on the list of measurements representing baseflow for each year.

Minimum, Average and Maximum Estimated Baseflow for Elizabeth River 1922-2005

Lower Passaic River Restoration Project

Figure B-7

February 2007



Legend

- Elizabeth River
- Second River
- Third River

Notes

USGS Stations: Elizabeth River at Ursino Lake (USGS 1393450), Second River at Belleville (USGS 1392500), and Third River at Passaic (USGS 1392210).

The recharge was estimated using the baseflow separation techniques discussed in the text.

Comparison of Average Estimated Recharge to Elizabeth River, Second River and Third River

Lower Passaic River Restoration Project

Figure B-8

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Attachment C

Bathymetric Data Analysis

LOWER PASSAIC RIVER RESTORATION PROJECT
BATHYMETRIC DATA ANALYSIS

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1.0 BATHYMETRIC DATA ANALYSIS

Historical Tierra Solutions, Inc. (TSI) bathymetric data (surveyed by Ocean Surveys, Inc.) include bathymetric surveys conducted from 1995 to 2001 and extending from river mile (RM) 0.9 to RM7.[1] These data were examined in two separate evaluations to delineate net erosional and net depositional areas in the Lower Passaic River. The TSI surveys were selected because the bathymetric surveying tracks are well aligned, reducing the uncertainty in direct measurement-to-measurement comparisons. The evaluations presented here build on the bathymetric surfaces previously created for the *Draft Geochemical Evaluation (Step 2)* [Malcolm Pirnie, Inc. (2006); refer to Section 2.1 "Sedimentation Rates and Annual Accumulation" for more detail]. All analyses were conducted using Environmental Systems Research Institute, Inc. (ESRI) ArcGIS software and the Spatial Analyst extension. Aerial coverage (*e.g.*, total acreage or percent area) was calculated using the XTools Pro function in ArcGIS. Input and results are in the form of raster (*i.e.*, grid) datasets. A raster dataset is a spatial data model consisting of rows and columns to form grid cells, where each cell contains an attribute value and location coordinates (Kennedy, 2001).

1.1. INITIAL SCREENING TO IDENTIFY APPARENTLY NET EROSIONAL AND NET DEPOSITIONAL AREAS

For the initial screening of the data, consecutive bathymetric surveys were compared to identify areas of the Lower Passaic River that experienced frequent intense erosional or depositional events (gain or loss of 2 inches/year or more). The four year-to-year comparisons include: 1995-1996, 1996-1997, 1997-1999, and 1999-2001. For each comparison, a separate grid was generated, and for each grid cell, the annual sedimentation rate was calculated as the change in depth between the two examined bathymetric surveys divided by the number of years covered by the two surveys (units

[1] The surveying area common to all five bathymetric surveys includes RM0.9 to RM7, which encompasses 94 percent of the total bank-to-bank area based on the shoreline delineated by the New Jersey Department of Environmental Protection Shoreline Type Geographic Information System data.

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converted to inches/year). The sedimentation values for each grid cell were then scored and classified as defined in Table 1-1.

Table 1-1: Criteria for Scoring and Classifying Sedimentation Rates in the Year-to-Year Analysis

Sedimentation Rates	Score	Classification
Greater than +2 inches/year	+1	Apparently Net Depositional
Between +2 and -2 inches/year	0	Bathymetrically Neutral Area
Less than -2 inches/year	-1	Apparently Net Erosional

The criteria of +2 inches/year or -2 inches/year used in this scoring process were based on previous annual solids load calculations, which suggested that the largest sediment transport events are roughly equivalent to 2 inches or more of loss or gain of sediment [refer to Section 3.0 "Sediment Transport" of the *Draft Geochemical Evaluation (Step 2)* (Malcolm Pirnie, Inc., 2006)]. Hence, areas experiencing more than 2 inches/year of net deposition or net erosion can be identified as "apparently depositional" or "apparently erosional," respectively.

The scoring process resulted in four grids (one grid for each year-to-year comparison) with grid cells assigned values of +1, 0, or -1 (refer to Table 1-1 for designations). The four grids were then added using the Spatial Analyst Raster Calculator, resulting in a single grid, where each grid cell had integer values ranging from -4 to +4. These integrated values represent the following cases:

- Score -4: Apparently net erosional in all 4 comparison periods.
- Score -3: Apparently net erosional in 3 periods and bathymetrically neutral in 1 period.
- Score -2: Either apparently net erosional in 3 periods and apparently net depositional in 1 period; OR apparently net erosional in 2 periods and bathymetrically neutral in 2 periods.
- Score -1: Either apparently net erosional in 2 periods, apparently net depositional in 1 period, and bathymetrically neutral in 1 period; OR net erosional in 1 period and bathymetrically neutral in 3 periods.

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- Score 0: Either apparently net erosional in 2 periods and apparently net depositional in 2 periods; OR apparently net erosional in 1 period, bathymetrically neutral in 2 periods, and apparently net depositional in 1 period; OR bathymetrically neutral in all 4 periods.
- Score +1: Either apparently net depositional in 2 periods, apparently net erosional in 1 period, and bathymetrically neutral in 1 period; OR apparently net depositional in 1 period and bathymetrically neutral in 3 periods.
- Score +2: Either apparently net depositional in 3 periods and apparently net erosional in 1 period; OR apparently net depositional in 2 periods and bathymetrically neutral in 2 periods.
- Score +3: Apparently net depositional in 3 periods and bathymetrically neutral in 1 period.
- Score +4: Apparently net depositional in all 4 comparison periods.

Areas scored with values of -3 or -4 were judged to be apparently net erosional between 1995 and 2001. Similarly, areas scored with values of +3 or +4 were judged to be net apparently depositional during this same time period. In the remaining areas, both erosion and deposition may have occurred, or the area may have been effectively bathymetrically neutral (*i.e.*, change in depth is not significant relative to the potential uncertainty in the bathymetric data).

1.2. DELINEATING ADDITIONAL NET EROSIONAL AND NET DEPOSITIONAL AREAS

In a second screening of the data, longer time periods were examined to minimize the uncertainty in comparing yearly bathymetric surveys. The same scoring process was applied to delineate additional net erosional and net depositional areas that may have been overlooked in the first screening method. Three comparisons were completed using the historical TSI bathymetric data, including 1995 to 2001 (6-year time period), 1996 to 2001 (5-year time period), and 1995 to 1999 (4-year time period).

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Following a similar scoring process as described above in Section 1.1 "Initial Screening to Identify Apparently Net Erosional and Net Depositional Areas," sedimentation rates were calculated for each time period. Then, the sedimentation rates were scored based on criteria (*i.e.*, score of +1 represents "potentially net depositional," score of 0 represents "bathymetrically neutral area," and score of -1 represents "potentially net erosional"). The criteria were then adjusted for each time period compared (Table 1-2) to account for uncertainty in bathymetric measurements. The expected accuracy for the type of equipment used for these surveys is ±3 inches assuming good horizontal and navigational control of the boat for repetitive work (*i.e.*, re-occupying the same transects for subsequent surveys). If the water is calm, then the accuracy can often be improved further.[2]

Table 1-2: Criteria for Scoring and Classifying Sedimentation Rates in the Longer-Time Period Analysis

Score and Classification	1995-2001 Criteria	1996-2001 Criteria	1999-2001 Criteria
Score = +1, Potentially Net Depositional	Greater than +0.5 inch/year [a]	Greater than +0.6 inch/year [b]	Greater than +0.75 inch/year [c]
Score = 0,Bathymetrically Neutral Area	Between +0.5 inch/year and -0.5 inch/year	Between +0.6 inch/year and -0.6 inch/year	Between +0.75 inch/year and -0.75 inch/year
Score = -1, Potentially Net Erosional	Less than -0.5 inch/year	Less than -0.6 inch/year	Less than -0.75 inch/year

a: 3 inch uncertainty divided by 6-year time period yields a criterion of 0.5 inch/year
b: 3 inch uncertainty divided by 5-year time period yields a criterion of 0.6 inch/year
c: 3 inch uncertainty divided by 4-year time period equals a criterion of 0.75 inch/year

This scoring process resulted in three separate grids (one for each longer time period comparison) with grid cells assigned values of +1, 0, or -1. The grids were then added using the Spatial Analyst Raster Calculator, resulting in a single grid where each grid cell contains an integer value ranging from -3 to +3. These integrated values represent the following cases:

[2] According to Ocean Surveys, Inc. (2006), a well-respected contractor experienced in conducting bathymetric surveys can achieve this level of accuracy (personal communication, June 7, 2006).

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- Score -3: Potentially net erosional in all 3 comparisons.
- Score -2: Potentially net erosional in 2 comparisons and bathymetrically neutral in 1 comparison.
- Score -1: Either potentially net erosional in 2 comparisons and potentially net depositional in 1 comparison; OR potentially net erosional in 1 comparison and bathymetrically neutral in 2 comparisons.
- Score 0: Potentially net erosional in 1 comparison, potentially net depositional in 1 comparison, and bathymetrically neutral in 1 comparison; OR bathymetrically neutral in all 3 comparisons.
- Score +1: Either potentially net depositional in 2 comparisons and potentially net erosional in 1 comparison; OR potentially net depositional in 1 comparison and bathymetrically neutral in 2 comparisons.
- Score +2: Potentially net depositional in 2 comparisons and bathymetrically neutral in 1 comparison.
- Score +3: Potentially net depositional in all 3 comparisons.

Areas scored with values of -3 or -2 were judged to be potentially net erosional between 1995 and 2001. Similarly, areas scored with values of +3 or +2 were judged to be potentially net depositional during this same time period. In the remaining areas, both erosion and deposition may have occurred, or the changes may not be discernable due to the uncertainty in the bathymetric measurements.

1.3. NET EROSIONAL AND NET DEPOSITIONAL AREAS

Delineated net erosional areas and net depositional areas based on the 1995 through 2001 bathymetric data are displayed in Figure C-1 and Figure C-2, respectively. The red areas marked in Figure C-1 represent grid cells that scored either -4 or -3 (or apparently net erosional areas) in the first delineation, which evaluated successive year-to-year

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comparisons.[3] These red areas account for 0.43 percent of the total area (345 acres) between RM0.9 and RM7 and highlight the areas of the Lower Passaic River that have apparently experienced frequent erosional events of greater than 2 inches/year. Surrounding these red areas are "halos" representing additional likely net erosional areas. These additional areas were delineated using the second delineation method, which considered longer surveying intervals: score of -3 (orange area), score of -2 (yellow area), and score of -1 (light green area). Of these three color schemes, the orange area (accounting for 2.8 percent of the total area between RM0.9 and RM7) highlights areas that have consistently experienced erosion over a 4 to 6-year time period (note that the sedimentation rate in these areas varied from -0.75 to -0.5 inches/year, depending on the respective criteria for the longer term comparisons). Other erosional areas account for an additional 23.9 percent of the total area between RM0.9 and RM7.

The sparsely spaced erosional areas between RM0.9 and RM7.0 of the Lower Passaic River are anticipated since in this area the river tends to experience net deposition (Malcolm Pirnie, Inc., 2006). The large spatial extent of net depositional areas in RM0.9 to RM7.0 is displayed in Figure C-2, which is organized similarly to Figure C-1. The dark blue areas in Figure C-2 represent grid cells that scored either +4 or +3 in the first delineation, which identifies areas that apparently consistently experienced more than 2 inches/year of sediment deposition. These dark blue areas account for 6.3 percent of the total area while other depositional areas account for an additional 67 percent of the total area between RM0.9 and RM7.

To account for the two delineations and to prioritize the various scores, five categories were defined for the sedimentation processes in the Lower Passaic River: "consistently erosional," "occasionally erosional," "bathymetrically neutral area" (experiencing both erosion and deposition), "occasionally depositional," and "consistently depositional." The categories encompass the combined areas corresponding to the scores from the two

[3] Scores of -2 and -1 denoting other potential erosional areas are not displayed on Figure C-1 to simplify the graphic display of the figure. Likewise, scores of +2 and +1 denoting other potential depositional areas are not displayed on Figure C-2.

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delineations (Table 1-3) and are displayed in Figure 5-1 in the Conceptual Site Model text.

Table 1-3: Categories to Define Erosional and Depositional Areas

Category	Score from First Delineation [a]	Score from Second Delineation [b]
Consistently Erosional	-4 -3	 -3
Occasionally Erosional	-2	-2
Bathymetrically Neutral Area	-1 0 +1	-1 0 +1
Occasionally Depositional	+2	+2
Consistently Depositional	+3 +4	+3

a: Yearly comparison of surveys
b: Comparison of surveys over 4 to 6-year periods

A score of 0 in either delineation method may suggest that the sediment beds experienced no changes in elevation during the time periods examined. However, a score of 0 may also suggest that an area experienced both erosion and deposition, since a combination of positive and negative scores can yield a zero result. Likewise, a score of -1 or +1 in either delineation method may suggest that the sediment beds experienced periods of both net erosion and net deposition. Consequently, the “bathymetrically neutral area” category (including scores of -1, 0, and +1) may encompass areas that have commonly experienced both net erosion and net deposition.

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2.0 ACRONYMS

ESRI	Environmental Systems Research Institute, Inc.
RM	River Mile
TSI	Tierra Solutions, Inc.

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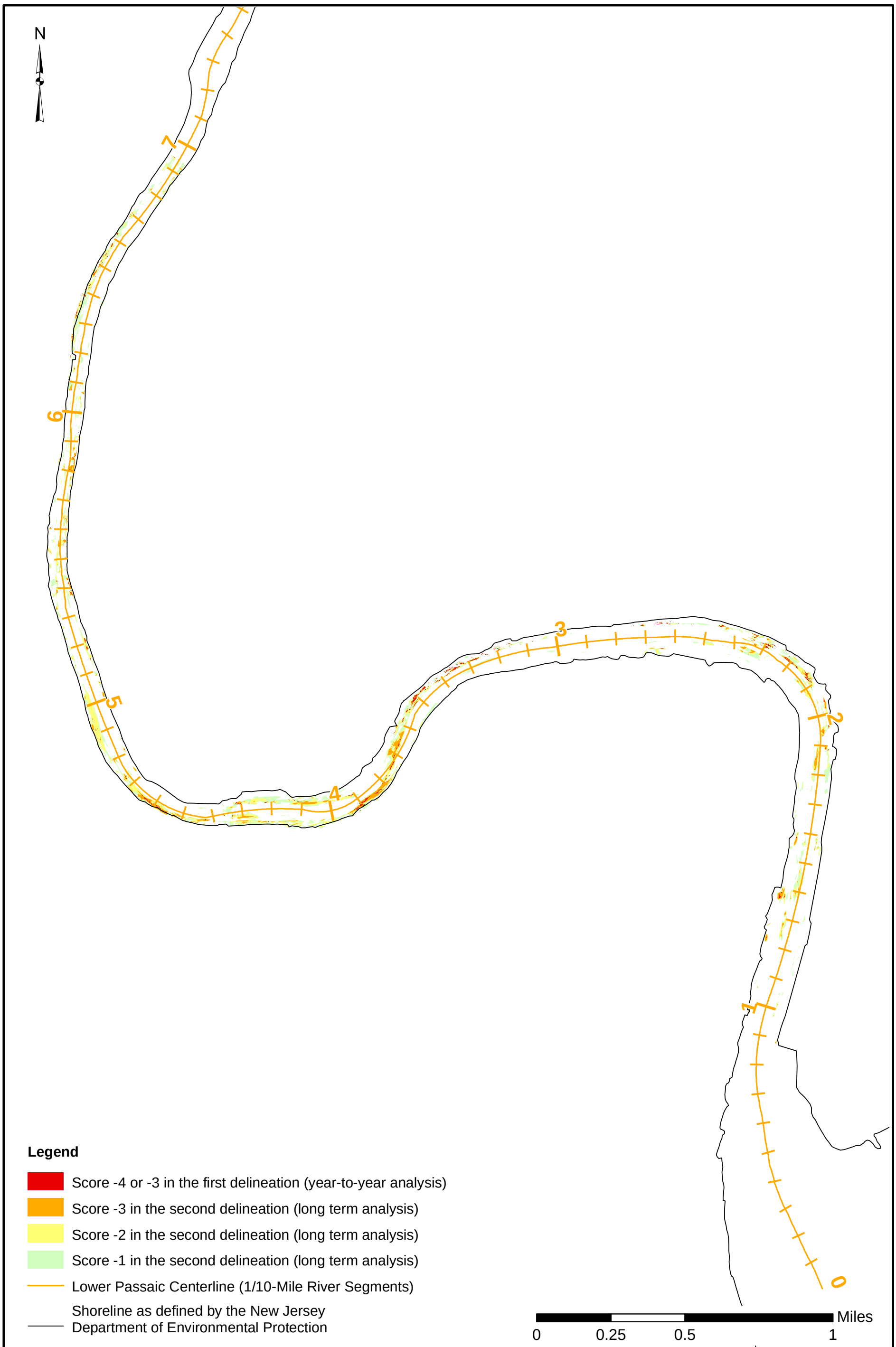
3.0 REFERENCES

Kennedy H. 2001. Dictionary of GIS Terminology. ESRI Press. (Redlands, California.)

Malcolm Pirnie, Inc., 2006. "Draft Geochemical Evaluation (Step 2)." Lower Passaic River Restoration Project. March 2006.

Ocean Surveys, Inc., 2006. Personal communication between Bruce Fidler (Malcolm Pirnie, Inc.) and Steve Bartlett. June 7, 2006.

R2-0009182



US Army Corp of Engineers

Delineating Net Potential Erosional Areas

Lower Passaic River Restoration Project

Data Sources : Tierra Solutions Inc., Bathymetric Surveys for 1995,1996,1997,1999 and 2001

FIGURE C-1

February 2007

Map Document: (S:\Projects\PASSAIC\MapDocuments\4553001-CERCLA\Figure3-1.mxd) 6/27/2006 -- 3:55:03 PM

US Army Corp of Engineers

Delineating Net Potential Depositional Areas

Lower Passaic River Restoration Project

Data Sources : Tierra Solutions Inc., Bathymetric Surveys for 1995,1996,1997,1999 and 2001

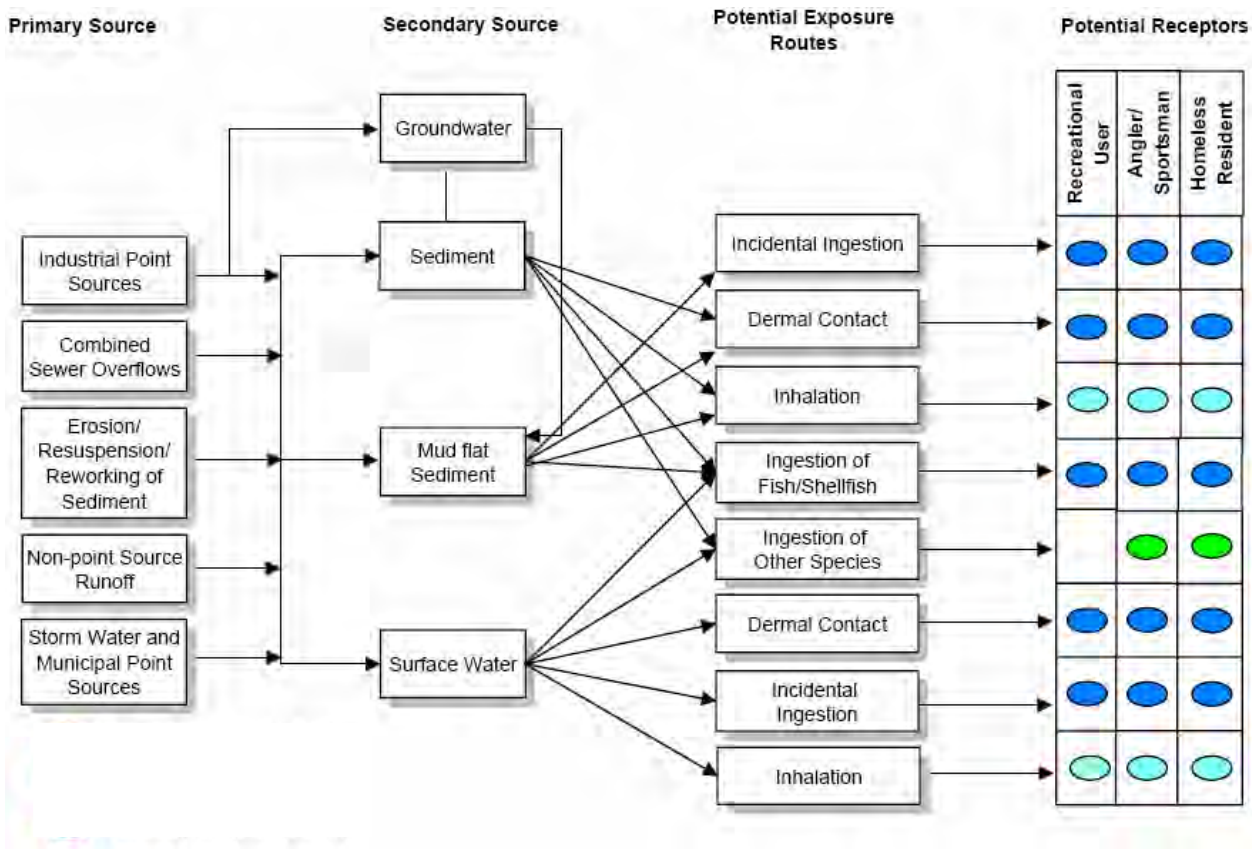
FIGURE C-2

February 2007

Map Document: (S:\Projects\PASSAIC\MapDocuments\4553001-CERCLA\Figure3-2.mxd) 6/27/2006 -- 3:55:03 PM

Attachment D

Exposure Pathways and Receptors Figures



Legend

- Complete, Quantitative Pathway
- Complete, Qualitative Pathway
- Potentially Complete Pathway

Notes

Taken from Battelle, 2005. "Pathways Analysis Report." Lower Passaic River Restoration Project. July 2005.

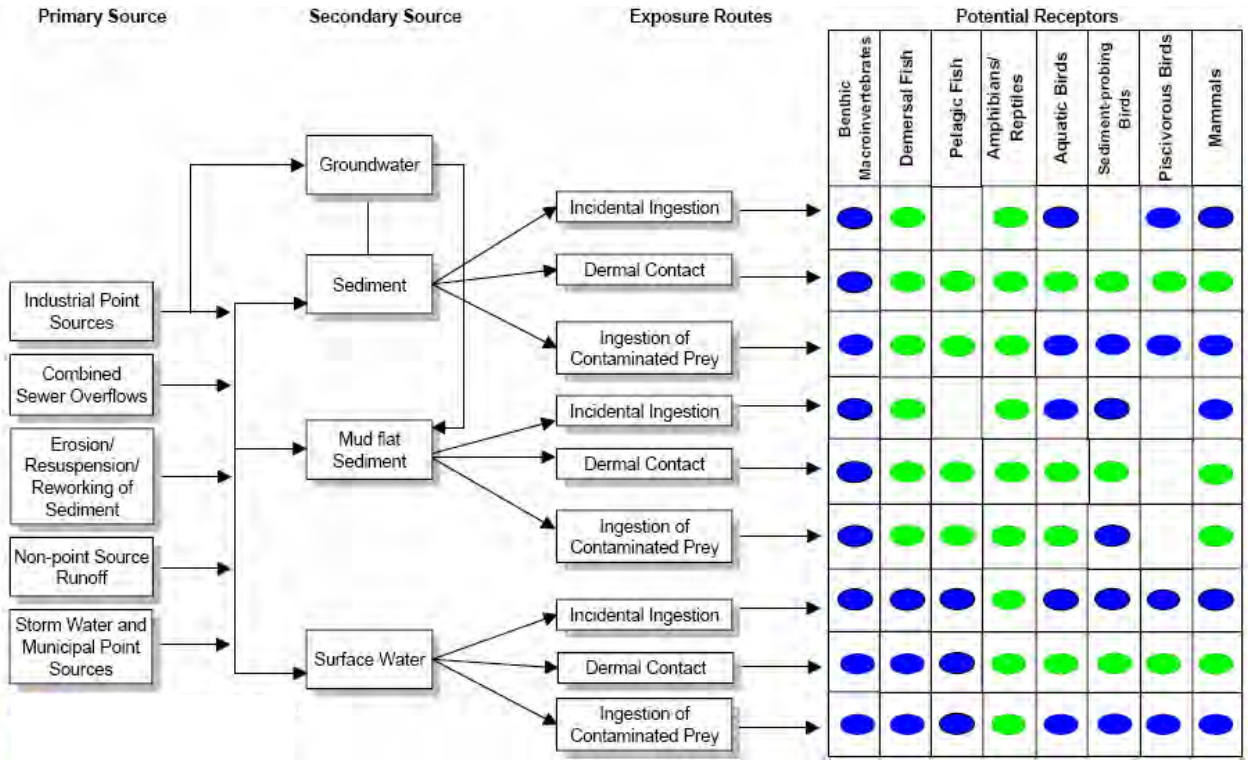
Figure revised by Battelle, January 2007.

Human Health Conceptual Site Model

Lower Passaic River Restoration Project

Figure D-1

February 2007



Legend

- Complete, Quantitative Pathway
- Complete, Qualitative Pathway

Notes

Taken from Battelle, 2005. "Pathways Analysis Report." Lower Passaic River Restoration Project. July 2005.

Figure revised by Battelle, January 2007.

Ecological Conceptual Site Model

Lower Passaic River Restoration Project

Figure D-2

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Appendix B

Sediment TBCs

Development of Preliminary Remediation Goals

Draft Contractor Document: Subject to Continuing Agency Review

Sediment TBCs

Table B-1: Bibliography of Chemical-Specific TBCs for Sediment
Focused Feasibility Study
Lower Passaic River Restoration Project

Screening Value	Source	Document	URL for Document	Comment
TBC	U.S. Environmental Protection Agency (USEPA) Region 4 (2001)	USEPA Region 4 Waste Management Division Sediment Screening Values for Hazardous Waste Sites	http://www.epa.gov/region4/waste/ots/ecolbul.htm, accessed September 11, 2006	Ecological screening values are based on contaminant levels associated with a low probability of unacceptable risks to ecological receptors. The Office of Technical Services (OTS) has developed the screening values for surface water, sediment, and soil for use at Region 4 hazardous waste sites. Since these numbers are based on conservative endpoints and sensitive ecological effects data, they represent a preliminary screening of site contaminant levels to determine if there is a need to conduct further investigations at the site. Ecological screening values should not be used as remediation levels. For sediments, these are the higher of two values, the EPA Contract Laboratory Program Practical Quantitation Limit and the Effects Value, which is the lower of the Effects Range – Low (ER-L) and the Threshold Effects Level (TEL). These are possible effects benchmarks.
TBC	USEPA Region 5 (2003)	Resource Conservation and Recovery Act (RCRA) Ecological Screening Levels	http://www.epa.gov/reg5rcra/ca/ESL.pdf, accessed September 11, 2006	Environmental Data Quality Levels/Ecological Screening Levels (EDQLs/ESLs). EDQLs are media-specific (soil, water, sediment, and air) values that can be used for initial screening levels to use in ecological risk assessments; values are included for organics, pesticides, PCBs, and inorganics.
TBC	New Jersey Department of Environmental Protection (NJDEP)	Guidance for Sediment Quality Investigations (NJDEP 1998)	http://www.state.nj.us/dep/srp/regs/sediment/sediment.pdf, accessed September 11, 2006	Cites TBCs used by USEPA Region 2 Biological Technical Assistance Group (BTAG) for Screening Level Ecological Risk Assessments. Freshwater sediment screening values used are the Ontario Ministry of the Environment Lowest Effects Levels (Persaud et al., 1993), and marine/estuarine sediment screening values are the ER-L values (Long et al., 1995).
TBC	NJDEP (1998)	N.J.A.C. 7:26E Technical Requirements for Site Remediation (NJDEP 2005)	http://www.state.nj.us/dep/srp/regs/techrule/techrl03.pdfhttp://www.state.nj.us/dep/, accessed May 3, 2007	Sediment criteria referenced in Chapter 3.11 are: EPA 440/5-89-002 (Briefing Report to the EPA Science Advisory Board on the Equilibrium Partitioning Approach to Generate Sediment Quality Criteria), EPA-822-R-93-011 (Technical Basis for Deriving Sediment Quality Criteria for Nonionic Organic Contaminants...), Long et. al. (1995), and Persaud et al. (1993).
TBCs	U.S. Department of Energy, Office of Environmental Management	Jones, D.S., G.W. Suter II, R.N. Hull. November 1997. Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Sediment-Associated Biota: 1997 Revision. ES/ER/TM-95/R4. (Section 3, Recommended Sediment Benchmarks)	http://www.hsrd.ornl.gov/ecorisk/tm95r4.pdf, accessed September 11, 2006	USEPA Office of Solid Waste and Emergency Response (OSWER) Ecotox Thresholds (ETs) are available for screening of 8 metals and 41 organics at Superfund sites. Sediment Quality Benchmarks (SQBs) used to calculate the ETs are from the Great Lakes Water Quality Initiative, Suter and Mabrey (1994), or were calculated by OSWER.
				ER-L and Effects Range-Median (ER-M) values were calculated by Long et al. (1995), incorporating National Oceanic and Atmospheric Administration (NOAA) sediment sampling data.
				TELs and Probable Effects Levels (PELs) were calculated by MacDonald (1994) and are employed by the Florida Department of Environmental Protection.
				Equilibrium Partitioning (EqP) Benchmarks developed by Oak Ridge National Laboratory (ORNL). Lowest chronic values developed for fish, daphnids, and non-daphnid invertebrates.
				Sediment effects concentrations (SECs) calculated by the National Biological Service for the EPA Great Lakes National Program Office as part of the Assessment and Remediation of Contaminated Sediment (ARCS) Program.
				Screening Level Concentration (SLC) benchmarks developed by the Ontario Ministry of the Environment. Lowest effect levels and severe effect levels are provided (Persaud et al. 1993).
TBC	Canadian Sediment Quality	Canadian Sediment Quality Guidelines for the Protection of Aquatic Life. (Canadian Council of Ministers of the Environment) 1999. updated 2001.	http://www.ec.gc.ca/ceqg-rcqe/English/PDF/sediment_summary_table.pdf, accessed September 11, 2006	Dioxin and furan values given in the units of ng Toxicity Equivalent Quotient (TEQ)/kg.

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Table B-2: Sediment Screening Values
Focused Feasibility Study
Lower Passaic River Restoration Project

ARAR: Applicable or Relevant and Appropriate Requirement
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CAS No.	Description	Class	TBC			TBC	TBC		TBC		TBC
			(1) USEPA Region 4, 2001			(2) USEPA Region 5, 2003	(3) NJDEP 1998		(3) NJDEP 1998		(3) NJDEP 1998
			Region 4 Waste Management Division Sediment Screening Values for Hazardous Waste Sites (note: also given in ARCS)			RCRA Ecological Screening Levels (f)	Freshwater Sediment Screening Guidelines (Persaud et al., 1993) (k)		Marine/Estuarine Sediment Screening Guidelines (Long et al., 1995) (k)		Volatile Organic Sediment Screening Guidelines, Freshwater and Estuarine/Marine Systems (MacDonald et al., 1992)
TOC (used for NJDEP 1998, SEL)	**0.01**		Effects Value	CLP PQL (a)	Screening Value		Lowest Effects Level (LEL)	Severe Effects Level (SEL)	Effects Range - Low (ER-L)	Effects Range - Median (ER-M)	Chronic Value
			Inorg: (mg/kg); Org: (ug/kg)	Inorg: (mg/kg); Org: (ug/kg)	Inorg: (mg/kg); Org: (ug/kg); Dioxin (ng/kg)	(ug/kg)	(mg/kg, dry weight)	Inorg: (mg/kg dry wt); Org: (mg/kg OC, dry wt)	(mg/kg, dry weight)	(mg/kg, dry weight)	(mg/kg dry weight at 1% TOC)
591-78-6	2-HEXANONE (Historical)	VOA				58.2 (j)					
108-10-1	4-METHYL-2-PENTANONE (Historical)	VOA				25.1 (j)					
67-64-1	ACETONE	VOA				9.9 (j)					
71-43-2	BENZENE	VOA				142					0.34
75-25-2	BROMOFORM	VOA				492 (j)					
75-15-0	CARBON DISULFIDE	VOA				23.9 (j)					
108-90-7	CHLOROBENZENE	VOA				291					
67-66-3	CHLOROFORM	VOA				121					
75-27-4	DICHLOROBROMOMETHANE	VOA				--					
100-41-4	ETHYLBENZENE	VOA				175					1.4
74-87-3	METHYL CHLORIDE	VOA				--					
78-93-3	METHYL ETHYL KETONE	VOA				42.4 (j)					
75-09-2	METHYLENE CHLORIDE	VOA				159 (j)					
108-88-3	TOLUENE	VOA				1220 (j)					
127-18-4	Tetrachloroethene	VOA				990					0.45
79-01-6	TRICHLOROETHYLENE	VOA				112(j)					1.6
1330-20-7	XYLENE (Historical) (total)	VOA				433 (j)					>0.12
95-94-3	1,2,4,5-TETRACHLOROBENZENE	SV				1252 (j)					
120-82-1	1,2,4-TRICHLOROBENZENE	SV				5062 (j)					
105-67-9	2,4-DIMETHYLPHENOL	SV				304					
51-28-5	2,4-DINITROPHENOL	SV				6.21					
606-20-2	2,6-DINITROTOLUENE	SV				39.8					
95-57-8	2-CHLOROPHENOL	SV				31.9					
99-09-2	3-NITROANILINE	SV				--					
59-50-7	4-CHLORO-3-METHYLPHENOL	SV				388					
106-44-5	4-METHYLPHENOL	SV				20.2					
100-02-7	4-NITROPHENOL	SV				13.3					
117-81-7	BIS(2-ETHYLHEXYL)PHTHALATE	SV	182 (c)	3.6	182	182 (g)					
85-68-7	BUTYL BENZYL PHTHALATE	SV				1970 (j)					
510-15-6	CHLOROBENZILATE	SV				860					
132-64-9	DIBENZOFURAN	SV				449 (j)					
84-74-2	DI-N-BUTYL PHTHALATE	SV				1114					
117-84-0	DI-N-OCTYL PHTHALATE	SV				40600					
87-68-3	HEXACHLOROBUTADIENE	SV				26.5 (j)					
541-73-1	M-DICHLOROBENZENE (1,3-DCB)	SV				1315 (j)					
86-30-6	N-NITROSO-DI-PHENYLAMINE	SV				--					
621-64-7	N-NITROSO-DI-PROPYLAMINE	SV				--					
95-48-7	O-CRESOL (2-Methylphenol)	SV				55.4					
95-50-1	O-DICHLOROBENZENE (1,2-DCB)	SV				294					
1825-21-4	PENTACHLOROANISOLE	SV									
608-93-5	PENTACHLOROBENZENE	SV				24 (j)					
82-68-8	PENTACHLORONITROBENZENE	SV				--					
108-95-2	PHENOL	SV				49.1					
106-46-7	1,4-Dichlorobenzene	PAH				318 (j)					
90-12-0	1-Methylnaphthalene	PAH									
91-57-6	2-Methylnaphthalene	PAH	20.2 (c)	330	330	20.2 (g)	See Marine/Estuarine	--	0.07	0.67	
83-32-9	Acenaphthene	PAH	6.71 (c)	330	330	6.71 (g)	See Marine/Estuarine	--	0.016	0.5	

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CAS No.	Description	Class	NOAA: TBC, FL DEP: TBC				TBC				
			(4) Jones et al. (1997)				(5) Jones et al. (1997)				
			Selected Integrative Sediment Quality Benchmarks for Marine and Estuarine Sediments				Selected Integrative Sediment Quality Benchmarks for Marine and Estuarine Sediments (p)				
TOC (used for NJDEP 1998, SEL)	**0.01**		NOAA (l): ER-L	NOAA (l): ER-M	FL DEP (l): TEL	FL DEP (l): PEL	NAWQC Chronic	Secondary Chronic Value	Fish	Daphnids	Nondaphnid invertebrates
			Inorg: (mg/kg dry wt); Org: (ug/kg dry wt)	Inorg: (mg/kg dry wt); Org: (ug/kg dry wt)	Inorg: (mg/kg dry wt); Org: (ug/kg dry wt)	Inorg: (mg/kg dry wt); Org: (ug/kg dry wt)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)
591-78-6	2-HEXANONE (Historical)	VOA					-- (r)	22 (r)	7,400 (r)	-- (r)	-- (r)
108-10-1	4-METHYL-2-PENTANONE (Historical)	VOA					-- (r)	33 (r)	15,000 (r)	-- (r)	-- (r)
67-64-1	ACETONE	VOA					-- (r)	8.7 (r)	3,000 (r)	9.1 (r)	-- (r)
71-43-2	BENZENE	VOA					--	160	--	> 120,000	--
75-25-2	BROMOFORM	VOA									
75-15-0	CARBON DISULFIDE	VOA					--	0.85	8800	230	--
108-90-7	CHLOROBENZENE	VOA					--	410	7800	97,000	--
67-66-3	CHLOROFORM	VOA					--	22	960	3500	--
75-27-4	DICHLOROBROMOMETHANE	VOA									
100-41-4	ETHYLBENZENE	VOA					--	89	> 5400	160,000	--
74-87-3	METHYL CHLORIDE	VOA									
78-93-3	METHYL ETHYL KETONE	VOA					-- (r)	270 (r)	5,400 (r)	27,000 (r)	-- (r)
75-09-2	METHYLENE CHLORIDE	VOA					--	370	18,000	7200	--
108-88-3	TOLUENE	VOA					--	50	6400	130,000	--
127-18-4	Tetrachloroethene	VOA					--	410	3500	3200	--
79-01-6	TRICHLOROETHYLENE	VOA					--	220	51,000	33,000	--
1330-20-7	XYLENE (Historical) (total)	VOA					--	160	740,000	--	--
95-94-3	1,2,4,5-TETRACHLOROBENZENE	SV									
120-82-1	1,2,4-TRICHLOROBENZENE	SV					--	9600	--	--	--
105-67-9	2,4-DIMETHYLPHENOL	SV									
51-28-5	2,4-DINITROPHENOL	SV									
606-20-2	2,6-DINITROTOLUENE	SV									
95-57-8	2-CHLOROPHENOL	SV									
99-09-2	3-NITROANILINE	SV									
59-50-7	4-CHLORO-3-METHYLPHENOL	SV									
106-44-5	4-METHYLPHENOL	SV									
100-02-7	4-NITROPHENOL	SV									
117-81-7	BIS(2-ETHYLHEXYL)PHTHALATE	SV	--	--	182	2647	--	890,000	--	--	--
85-68-7	BUTYL BENZYL PHTHALATE	SV					--	11,000	--	--	--
510-15-6	CHLOROBENZILATE	SV									
132-64-9	DIBENZOFURAN	SV					--	420	--	110,000	--
84-74-2	DI-N-BUTYL PHTHALATE	SV					--	11,000	240,000	240,000	--
117-84-0	DI-N-OCTYL PHTHALATE	SV									
87-68-3	HEXACHLOROBUTADIENE	SV									
541-73-1	M-DICHLOROBENZENE (1,3-DCB)	SV					--	1700	-	--	--
86-30-6	N-NITROSO-DI-PHENYLAMINE	SV									
621-64-7	N-NITROSO-DI-PROPYLAMINE	SV									
95-48-7	O-CRESOL (2-Methylphenol)	SV					-- (r)	12 (r)	440 (r)	1200 (r)	-- (r)
95-50-1	O-DICHLOROBENZENE (1,2-DCB)	SV					--	330	--	--	--
1825-21-4	PENTACHLOROANISOLE	SV									
608-93-5	PENTACHLOROBENZENE	SV					--	700	--	--	--
82-68-8	PENTACHLORONITROBENZENE	SV									
108-95-2	PHENOL	SV					31	--	< 57	570	--
106-46-7	1,4-Dichlorobenzene	PAH					--	340	--	--	--
90-12-0	1-Methylnaphthalene	PAH					--	130	34000	--	--
91-57-6	2-Methylnaphthalene	PAH	70	670	20.2	201					
83-32-9	Acenaphthene	PAH	16	500	6.71	88.9	1300 (q)	--	5300	470,000	16,000

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CAS No.	Description	Class	TBC					TBC		TBC			
			(6) Jones et al. (1997)					(7) Jones et al. (1997)		(8) Canadian Sediment Guidelines			
			Summary of Selected Toxicity Test- and Screening Level Concentration-Based Sediment Quality Benchmarks for Freshwater Sediments					Sediment Screening Values (aa)		Interim Freshwater Sediment Quality Guidelines (dd)		Interim Marine Sediment Quality Guidelines (dd)	
TOC (used for NJDEP 1998, SEL)	**0.01**		ARCS (b) - TEC	ARCS (u) - PEC	ARCS (u) - NEC	Ontario MOE (v) - Low	Ontario MOE (v) - Severe	OSWER (bb)		ISQG (dd)	PEL (dd)	ISQG (dd)	PEL (dd)
			Inorg: (mg/kg dry wt); Org: (ug/kg dry wt)	Inorg: (mg/kg dry wt); Org: (ug/kg dry wt)	Inorg: (mg/kg dry wt); Org: (ug/kg dry wt)	Inorg: (mg/kg dry wt); Org: (ug/kg dry wt)	Inorg: (mg/kg dry wt); Org: (ug/kg dry wt)	Inorg: (mg/kg dry wt); Org: (ug/kg dry wt)	Type (cc)	ug/kg	ug/kg	ug/kg	ug/kg
591-78-6	2-HEXANONE (Historical)	VOA											
108-10-1	4-METHYL-2-PENTANONE (Historical)	VOA											
67-64-1	ACETONE	VOA											
71-43-2	BENZENE	VOA						57	SQB				
75-25-2	BROMOFORM	VOA											
75-15-0	CARBON DISULFIDE	VOA											
108-90-7	CHLOROBENZENE	VOA						820	SQB				
67-66-3	CHLOROFORM	VOA											
75-27-4	DICHLOROBROMOMETHANE	VOA											
100-41-4	ETHYLBENZENE	VOA						3600	SQB				
74-87-3	METHYL CHLORIDE	VOA											
78-93-3	METHYL ETHYL KETONE	VOA											
75-09-2	METHYLENE CHLORIDE	VOA											
108-88-3	TOLUENE	VOA						670	SQB				
127-18-4	Tetrachloroethene	VOA						530	SQB				
79-01-6	TRICHLOROETHYLENE	VOA						1600	SQB				
1330-20-7	XYLENE (Historical) (total)	VOA						25	SQB				
95-94-3	1,2,4,5-TETRACHLOROBENZENE	SV											
120-82-1	1,2,4-TRICHLOROBENZENE	SV						9200	SQB				
105-67-9	2,4-DIMETHYLPHENOL	SV											
51-28-5	2,4-DINITROPHENOL	SV											
606-20-2	2,6-DINITROTOLUENE	SV											
95-57-8	2-CHLOROPHENOL	SV											
99-09-2	3-NITROANILINE	SV											
59-50-7	4-CHLORO-3-METHYLPHENOL	SV											
106-44-5	4-METHYLPHENOL	SV											
100-02-7	4-NITROPHENOL	SV											
117-81-7	BIS(2-ETHYLHEXYL)PHTHALATE	SV						--					
85-68-7	BUTYL BENZYL PHTHALATE	SV						11,000	SQB				
510-15-6	CHLOROBENZILATE	SV											
132-64-9	DIBENZOFURAN	SV						2000	SQB				
84-74-2	DI-N-BUTYL PHTHALATE	SV						11,000	SQB				
117-84-0	DI-N-OCTYL PHTHALATE	SV											
87-68-3	HEXACHLOROBUTADIENE	SV											
541-73-1	M-DICHLOROBENZENE (1,3-DCB)	SV						1700	SQB				
86-30-6	N-NITROSO-DI-PHENYLAMINE	SV											
621-64-7	N-NITROSO-DI-PROPYLAMINE	SV											
95-48-7	O-CRESOL (2-Methylphenol)	SV											
95-50-1	O-DICHLOROBENZENE (1,2-DCB)	SV						340	SQB				
1825-21-4	PENTACHLOROANISOLE	SV											
608-93-5	PENTACHLOROBENZENE	SV											
82-68-8	PENTACHLORONITROBENZENE	SV											
108-95-2	PHENOL	SV											
106-46-7	1,4-Dichlorobenzene	PAH						350	SQB				
90-12-0	1-Methylnaphthalene	PAH											
91-57-6	2-Methylnaphthalene	PAH						--		20.2	201	20.2	201
83-32-9	Acenaphthene	PAH						620	SQC	6.71	88.9	6.71	88.9

Table B-2: Sediment Screening Values
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Lower Passaic River Restoration Project

CAS No.	Description	Class	(1) USEPA Region 4, 2001			(2) USEPA Region 5, 2003	(3) NJDEP 1998		(3) NJDEP 1998		(3) NJDEP 1998
			Region 4 Waste Management Division Sediment Screening Values for Hazardous Waste Sites (note: also given in ARCS)			RCRA Ecological Screening Levels (f)	Freshwater Sediment Screening Guidelines (Persaud et al., 1993) (k)		Marine/Estuarine Sediment Screening Guidelines (Long et al., 1995) (k)		Volatile Organic Sediment Screening Guidelines, Freshwater and Estuarine/Marine Systems (MacDonald et al., 1992)
TOC (used for NJDEP 1998, SEL)	**0.01**		Effects Value	CLP PQL (a)	Screening Value		Lowest Effects Level (LEL)	Severe Effects Level (SEL)	Effects Range - Low (ER-L)	Effects Range - Median (ER-M)	Chronic Value
			Inorg: (mg/kg); Org: (ug/kg)	Inorg: (mg/kg); Org: (ug/kg)	Inorg: (mg/kg); Org: (ug/kg); Dioxin (ng/kg)	(ug/kg)	(mg/kg, dry weight)	Inorg: (mg/kg dry wt); Org: (mg/kg OC, dry wt)	(mg/kg, dry weight)	(mg/kg, dry weight)	(mg/kg dry weight at 1% TOC)
208-96-8	Acenaphthylene	PAH	5.87 (c)	330	330	5.87 (g)	See Marine/Estuarine	--	0.044	0.64	
120-12-7	Anthracene	PAH	46.9 (c)	330	330	57.2 (i)	0.22	370	0.085	1.1	
56-55-3	Benzo[a]anthracene	PAH	74.8 (c)	330	330	108 (i)	0.32	1480	0.261	1.6	
50-32-8	Benzo[a]pyrene	PAH	88.8 (c)	330	330	150 (i)	0.37	1440	0.43	1.6	
205-99-2	Benzo[b]fluoranthene	PAH				10400					
192-97-2	Benzo[e]pyrene	PAH					0.37	1440			
191-24-2	Benzo[g,h,i]perylene	PAH				170 (h)	0.17	320	See Freshwater	--	
207-08-9	Benzo[k]fluoranthene	PAH				240 (h)	0.24	1340	See Freshwater	--	
92-52-4	biphenyl	PAH									
218-01-9	Chrysene	PAH	108 (c)	330	330	166 (i)	0.34	460	0.384	2.8	
53-70-3	Dibenz[a,h]anthracene	PAH	6.22 (c)	330	330	33 (i)	0.06	130	0.063	0.26	
206-44-0	Fluoranthene	PAH	113 (c)	330	330	423 (i)	0.75	1020	0.6	5.1	
86-73-7	Fluorene	PAH	21.2 (c)	330	330	77.4 (i)	0.19	160	0.019	0.54	
T_HMW_PAH	High molecular weight PAHs, total (Historical)	PAH	655 (c)	330	655						
193-39-5	Indeno[1,2,3-c,d]-pyrene	PAH				200 (h)	0.2	320	See Freshwater	--	
T_LMW_PAH	Low molecular weight PAHs, total (Historical)	PAH	312 (c)	330	330						
91-20-3	Naphthalene	PAH	34.6 (c)	330	330	176 (i)	See Marine/Estuarine	--	0.16	2.1	
T_PAH	PAHs, total (Historical)	PAH									
85-01-8	Phenanthrene	PAH	86.7 (c)	330	330	204 (i)	0.56	950	0.24	1.5	
129-00-0	Pyrene	PAH	153 (c)	330	330	195 (i)	0.49	850	0.665	2.6	
CARP407	Total PAH	PAH	1684 (c)	330	1684		4	10000	4	45	
7429-90-5	ALUMINUM	MET									
7440-36-0	ANTIMONY	MET	2 (b)	12	12						
7440-38-2	Arsenic	MET	7.24 (c)	2	7.24	9790 (i)	6	33	8.2	70	
7440-43-9	Cadmium	MET	0.676 (c)	1	1	990 (i)	0.6	10	1.2	9.6	
7440-47-3	Chromium	MET	52.3 (c)	2	52.3	43400 (i)	26	110	81	370	
7440-48-4	COBALT	MET				50000 (h)					
7440-50-8	Copper	MET	18.7 (c)	5	18.7	31600 (i)	16	110	34	270	
57-12-5	CYANIDE	MET				0.1 (h)					
7439-89-6	IRON	MET									
7439-92-1	Lead	MET	30.2 (c)	0.6	30.2	35800 (i)	31	250	47	218	
7439-96-5	MANGANESE	MET									
7439-97-6	Mercury	MET	0.13 (c)	0.02	0.13	174 (g)	0.2	2	0.15	0.71	
7440-02-0	Nickel	MET	15.9 (d)	8	15.9	22700 (i)	16	75	21	52	
7782-49-2	SELENIUM	MET				--					
7440-22-4	Silver	MET	0.733 (c)	2	2	500 (h)	See Marine/Estuarine	--	1	3.7	
7440-28-0	Thallium	MET				--					
7440-31-5	TIN	MET				--					
7440-62-2	VANADIUM	MET				--					
7440-66-6	Zinc	MET	124 (c)	4	124	121000 (i)	120	820	150	410	
	2,3,7,8-TCDD (toxic equivalent)										
1746-01-6	2,3,7,8-TCDD	DIOX/F				1.2E-04 (j)					
51207-31-9	2,3,7,8-TCDF	DIOX/F				--					
	Dioxin (ng/kg - Region 4 entry)				2.5 (e)						
PCDD-S	Polychlorinated dibenzo-p-dioxins (ug/kg - Region 5 entry)					0.011					
87-86-5	2,3,4,5,6-PENTACHLOROPHENOL	PCB				23000 (j)					

Table B-2: Sediment Screening Values
Focused Feasibility Study
Lower Passaic River Restoration Project

CAS No.	Description	Class	(4) Jones et al. (1997)				(5) Jones et al. (1997)				
			Selected Integrative Sediment Quality Benchmarks for Marine and Estuarine Sediments				Selected Integrative Sediment Quality Benchmarks for Marine and Estuarine Sediments (p)				
TOC (used for NJDEP 1998, SEL)	**0.01**		NOAA (l): ER-L	NOAA (l): ER-M	FL DEP (l): TEL	FL DEP (l): PEL	NAWQC Chronic	Secondary Chronic Value	Fish	Daphnids	Nondaphnid invertebrates
			Inorg: (mg/kg dry wt); Org: (ug/kg dry wt)	Inorg: (mg/kg dry wt); Org: (ug/kg dry wt)	Inorg: (mg/kg dry wt); Org: (ug/kg dry wt)	Inorg: (mg/kg dry wt); Org: (ug/kg dry wt)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)
208-96-8	Acenaphthylene	PAH	44	640	5.87	128					
120-12-7	Anthracene	PAH	85.3	1100	46.9	245	--	220	27	<620	--
56-55-3	Benzo[a]anthracene	PAH	261	1600	74.8	693	--	110	--	2600	--
50-32-8	Benzo[a]pyrene	PAH	430	1600	88.8	763	--	140	--	3000	--
205-99-2	Benzo[b]fluoranthene	PAH									
192-97-2	Benzo[e]pyrene	PAH									
191-24-2	Benzo[g,h,i]perylene	PAH									
207-08-9	Benzo[k]fluoranthene	PAH									
92-52-4	biphenyl	PAH					--	1100	--	--	--
218-01-9	Chrysene	PAH	384	2800	108	846					
53-70-3	Dibenz[a,h]anthracene	PAH	63.4	260	6.22	135					
206-44-0	Fluoranthene	PAH	600	5100	113	1494	6200 (q)	--	32,000	16,000	--
86-73-7	Fluorene	PAH	19	540	21.2	144	--	540	--	--	--
T_HMW_PAH	High molecular weight PAHs, total (Historical)	PAH	1700 (o)	9600 (o)	655 (o)	6676 (o)					
193-39-5	Indeno[1,2,3-c,d]-pyrene	PAH									
T_LMW_PAH	Low molecular weight PAHs, total (Historical)	PAH	552 (o)	3160 (o)	312 (o)	1442 (o)					
91-20-3	Naphthalene	PAH	160	2100	34.6	391	--	240	12,000	23,000	--
T_PAH	PAHs, total (Historical)	PAH	4022 (o)	44792 (o)	1684 (o)	16770 (o)					
85-01-8	Phenanthrene	PAH	240	1500	86.7	544	1800 (q)	--	--	59,000	--
129-00-0	Pyrene	PAH	665	2600	153	1398					
CARP407	Total PAH	PAH									
7429-90-5	ALUMINUM	MET									
7440-36-0	ANTIMONY	MET	2 (m)	25 (m)	--	--					
7440-38-2	Arsenic	MET	8.2	70	7.24	41.6					
7440-43-9	Cadmium	MET	1.2	9.6	0.68	4.21					
7440-47-3	Chromium	MET	81	370	52.3	160					
7440-48-4	COBALT	MET									
7440-50-8	Copper	MET	34	270	18.7	108					
57-12-5	CYANIDE	MET									
7439-89-6	IRON	MET									
7439-92-1	Lead	MET	46.7	218	30.2	112					
7439-96-5	MANGANESE	MET									
7439-97-6	Mercury	MET	0.15	0.71	0.13	0.7					
7440-02-0	Nickel	MET	20.9	51.6	15.9	42.8					
7782-49-2	SELENIUM	MET									
7440-22-4	Silver	MET	1	3.7	0.73	1.77					
7440-28-0	Thallium	MET									
7440-31-5	TIN	MET									
7440-62-2	VANADIUM	MET									
7440-66-6	Zinc	MET	150	410	124	271					
	2,3,7,8-TCDD (toxic equivalent)										
1746-01-6	2,3,7,8-TCDD	DIOX/F									
51207-31-9	2,3,7,8-TCDF	DIOX/F									
	Dioxin (ng/kg - Region 4 entry)										
PCDD-S	Polychlorinated dibenzo-p-dioxins (ug/kg - Region 5 entry)										
87-86-5	2,3,4,5,6-PENTACHLOROPHENOL	PCB									

Table B-2: Sediment Screening Values
Focused Feasibility Study
Lower Passaic River Restoration Project

CAS No.	Description	Class	(6) Jones et al. (1997)					(7) Jones et al. (1997)		(8) Canadian Sediment Guidelines			
			Summary of Selected Toxicity Test- and Screening Level Concentration-Based Sediment Quality Benchmarks for Freshwater Sediments					Sediment Screening Values (aa)		Interim Freshwater Sediment Quality Guidelines (dd)		Interim Marine Sediment Quality Guidelines (dd)	
TOC (used for NJDEP 1998, SEL)	**0.01**		ARCS (b) - TEC	ARCS (u) - PEC	ARCS (u) - NEC	Ontario MOE (v) - Low	Ontario MOE (v) - Severe	OSWER (bb)		ISQG (dd)	PEL (dd)	ISQG (dd)	PEL (dd)
			Inorg: (mg/kg dry wt); Org: (ug/kg dry wt)	Inorg: (mg/kg dry wt); Org: (ug/kg dry wt)	Inorg: (mg/kg dry wt); Org: (ug/kg dry wt)	Inorg: (mg/kg dry wt); Org: (ug/kg dry wt)	Inorg: (mg/kg dry wt); Org: (ug/kg dry wt)	Inorg: (mg/kg dry wt); Org: (ug/kg dry wt)	Type (cc)	ug/kg	ug/kg	ug/kg	ug/kg
208-96-8	Acenaphthylene	PAH						--		5.87	128	5.87	128
120-12-7	Anthracene	PAH	31.62	547.72	1700	220	3700	--		46.9	245	46.9	245
56-55-3	Benzo[a]anthracene	PAH	260	4200	3500	320	14,800	--		31.7	385	74.8	693
50-32-8	Benzo[a]pyrene	PAH	350	393.7	440	370	14,400	430	ER-L	31.9	782	88.8	763
205-99-2	Benzo[b]fluoranthene	PAH											
192-97-2	Benzo[e]pyrene	PAH											
191-24-2	Benzo[g,h,i]perylene	PAH	290	6300	3800	170	3200						
207-08-9	Benzo[k]fluoranthene	PAH	--	--	--	240	13,400						
92-52-4	biphenyl	PAH						1100	SQB				
218-01-9	Chrysene	PAH	500	5200	4000	340	4600	--		57.1	862	108	846
53-70-3	Dibenz[a,h]anthracene	PAH	--	28.2	870	60	1300	--		6.22	135	6.22	135
206-44-0	Fluoranthene	PAH	64.23	834.27	7500	750	10,200	2900	SQC	111	2355	113	1494
86-73-7	Fluorene	PAH	34.64	651.92	1800	190	1600	--		21.2	144	21.2	144
T_HMW_PAH	High molecular weight PAHs, total (Historical)	PAH	2900	4353.82	51,000	--	--	--					
193-39-5	Indeno[1,2,3-c,d]-pyrene	PAH	78	836.66	3800	200	3200						
T_LMW_PAH	Low molecular weight PAHs, total (Historical)	PAH	786	3369	3040	--	--	--					
91-20-3	Naphthalene	PAH	32.75	687.39	290	--	--	480	SQB	34.6	391	34.6	391
T_PAH	PAHs, total (Historical)	PAH	3553	13,660	84,600	4000	100,000						
85-01-8	Phenanthrene	PAH	--	--	--	560	9500	850	SQC	41.9	515	86.7	544
129-00-0	Pyrene	PAH	570	3225	6100	490	8500	660	ER-L	53	875	153	1398
CARP407	Total PAH	PAH						4000	ER-L				
7429-90-5	ALUMINUM	MET	--	58,030	73,160	--	--						
7440-36-0	ANTIMONY	MET						--					
7440-38-2	Arsenic	MET	12.1	57	92.9	6	33	8.2	ER-L	5900	17,000	7240	4160
7440-43-9	Cadmium	MET	0.592	11.7	41.1	0.6	10	1.2	ER-L	600	3500	700	4200
7440-47-3	Chromium	MET	56	159	312	26	110	81	ER-L	37,000	90,000	52,300	160,000
7440-48-4	COBALT	MET											
7440-50-8	Copper	MET	28	77.7	54.8	16	110	34	ER-L	35,700	197,000	18,700	108,000
57-12-5	CYANIDE	MET											
7439-89-6	IRON	MET	--	--	--	2%	4%						
7439-92-1	Lead	MET	34.2	396	68.7	31	250	47	ER-L	35,000	91,300	30,200	112,000
7439-96-5	MANGANESE	MET	1673	1081	819	460	1110						
7439-97-6	Mercury	MET	--	--	--	0.2	2	0.15	ER-L	170	486	130	700
7440-02-0	Nickel	MET	39.6	38.5	37.9	16	75	21	ER-L				
7782-49-2	SELENIUM	MET											
7440-22-4	Silver	MET						--					
7440-28-0	Thallium	MET											
7440-31-5	TIN	MET											
7440-62-2	VANADIUM	MET											
7440-66-6	Zinc	MET	159	1532	541	120	820	150	ER-L	123,000	315,000	124,000	271,000
	2,3,7,8-TCDD (toxic equivalent)												
1746-01-6	2,3,7,8-TCDD	DIOX/F											
51207-31-9	2,3,7,8-TCDF	DIOX/F											
	Dioxin (ng/kg - Region 4 entry)												
PCDD-S	Polychlorinated dibenzo-p-dioxins (ug/kg - Region 5 entry)									0.85 (ee)	21.5 (ee)	0.85 (ee)	21.5 (ee)
87-86-5	2,3,4,5,6-PENTACHLOROPHENOL	PCB											

Table B-2: Sediment Screening Values
Focused Feasibility Study
Lower Passaic River Restoration Project

CAS No.	Description	Class	(1) USEPA Region 4, 2001			(2) USEPA Region 5, 2003	(3) NJDEP 1998		(3) NJDEP 1998		(3) NJDEP 1998
			Region 4 Waste Management Division Sediment Screening Values for Hazardous Waste Sites (note: also given in ARCS)			RCRA Ecological Screening Levels (f)	Freshwater Sediment Screening Guidelines (Persaud et al., 1993) (k)		Marine/Estuarine Sediment Screening Guidelines (Long et al., 1995) (k)		Volatile Organic Sediment Screening Guidelines, Freshwater and Estuarine/Marine Systems (MacDonald et al., 1992)
TOC (used for NJDEP 1998, SEL)	**0.01**		Effects Value	CLP PQL (a)	Screening Value		Lowest Effects Level (LEL)	Severe Effects Level (SEL)	Effects Range - Low (ER-L)	Effects Range - Median (ER-M)	Chronic Value
			Inorg: (mg/kg); Org: (ug/kg)	Inorg: (mg/kg); Org: (ug/kg)	Inorg: (mg/kg); Org: (ug/kg); Dioxin (ng/kg)	(ug/kg)	(mg/kg, dry weight)	Inorg: (mg/kg dry wt); Org: (mg/kg OC, dry wt)	(mg/kg, dry weight)	(mg/kg, dry weight)	(mg/kg dry weight at 1% TOC)
1336-36-3	PCB, TOTAL	PCB_SUM	21.6 (c)	33 (67 for Aroclor 1221)	33 (67 for Aroclor 1221)	59.8 (i)	0.07	530	0.023	0.18	
11096-82-5	Aroclor 1260	PCB-AROCLOR					0.005	24	See Freshwater	--	
11097-69-1	Aroclor 1254	PCB-AROCLOR					0.06	34	See Freshwater	--	
11104-28-2	Aroclor 1221	PCB-AROCLOR		67	67						
11141-16-5	Aroclor 1232	PCB-AROCLOR									
12672-29-6	Aroclor 1248	PCB-AROCLOR					0.03	150	See Freshwater	--	
12674-11-2	Aroclor 1016	PCB-AROCLOR					0.007	53	See Freshwater	--	
53469-21-9	Aroclor 1242	PCB-AROCLOR									
	DDD		2 (b)	3.3	3.3						
	DDE		2 (b)	3.3	3.3						
	DDT		1 (b)	3.3	3.3						
72-54-8	4,4'-DDD	PEST	1.22 (c)	3.3	3.3	4.88 (i,j)	0.008	0.06			
72-55-9	4,4'-DDE	PEST	2.07 (c)	3.3	3.3	3.16 (i)	0.005	0.19	0.0022	0.027	
50-29-3	4,4'-DDT	PEST	1.19 (c)	3.3	3.3	4.16 (i)					
	2,4'-DDD + 4,4'-DDD	PEST									
	2,4'-DDT + 4,4'-DDT	PEST					0.008	0.71			
	DDT, Total	PEST									
309-00-2	Aldrin	PEST				2 (h)	0.002	8	See Freshwater	--	
319-84-6	BHC, alpha	PEST				6 (h)	0.006	10			
319-85-7	BHC, beta	PEST				5 (h)	0.005	21			
319-86-8	BHC, delta	PEST				71500					
58-89-9	BHC, gamma (Lindane)	PEST	0.32 (c)	3.3	3.3	2.37 (i)	0.003	1			
BHC_TOTAL	BHCs, total (Historical)	PEST					0.003	12	See Freshwater	--	
57-74-9	CHLORDANE	PEST	0.5 (b)	1.7	1.7	3.24 (i,j)	0.007	6	See Freshwater	--	
DDT_TOTAL	DDTS, total of 6 isomers (Historical)	PEST					0.007	12	0.0016	0.046	
60-57-1	Dieldrin	PEST	0.02 (b)	3.3	3.3	1.9 (i,j)	0.002	91	See Freshwater	--	
1031-07-8	Endosulfan sulfate	PEST				34.6					
959-98-8	Endosulfan, alpha	PEST				3.26					
33213-65-9	Endosulfan, beta	PEST				1.94					
72-20-8	Endrin	PEST	0.02 (b)	3.3	3.3	2.22 (i,j)	0.003	130	See Freshwater	--	
7421-93-4	Endrin aldehyde	PEST				480 (j)					
76-44-8	Heptachlor	PEST				0.6 (g)					
1024-57-3	Heptachlor epoxide	PEST				2.47 (i)	0.005	5	See Freshwater	--	
118-74-1	Hexachlorobenzene	PEST				20 (h)	0.02	24	See Freshwater	--	
72-43-5	Methoxychlor	PEST				13.6					
2385-85-5	Mirex	PEST					0.007	130	See Freshwater	--	
CARP406	Total DDT	PEST	1.58 (d)	3.3	3.3						
8001-35-2	Toxaphene	PEST				0.077 (j)					
CARP409	TPH	TPH									

Table B-2: Sediment Screening Values
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CAS No.	Description	Class	(4) Jones et al. (1997)				(5) Jones et al. (1997)				
			Selected Integrative Sediment Quality Benchmarks for Marine and Estuarine Sediments				Selected Integrative Sediment Quality Benchmarks for Marine and Estuarine Sediments (p)				
TOC (used for NJDEP 1998, SEL)	**0.01**		NOAA (l): ER-L	NOAA (l): ER-M	FL DEP (l): TEL	FL DEP (l): PEL	NAWQC Chronic	Secondary Chronic Value	Fish	Daphnids	Nondaphnid invertebrates
			Inorg: (mg/kg dry wt); Org: (ug/kg dry wt)	Inorg: (mg/kg dry wt); Org: (ug/kg dry wt)	Inorg: (mg/kg dry wt); Org: (ug/kg dry wt)	Inorg: (mg/kg dry wt); Org: (ug/kg dry wt)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)
1336-36-3	PCB, TOTAL	PCB_SUM	22.7	180	21.6	189					
11096-82-5	Aroclor 1260	PCB-AROCLOR					--	4,500,000	< 63,000	--	--
11097-69-1	Aroclor 1254	PCB-AROCLOR					--	810	--	71,000	--
11104-28-2	Aroclor 1221	PCB-AROCLOR					--	120	25,000	--	--
11141-16-5	Aroclor 1232	PCB-AROCLOR					--	600	130,000	--	--
12672-29-6	Aroclor 1248	PCB-AROCLOR					--	1000	--	--	--
12674-11-2	Aroclor 1016	PCB-AROCLOR									
53469-21-9	Aroclor 1242	PCB-AROCLOR					--	170	29,000	--	16,000
	DDD										
	DDE										
	DDT						--	340 (t)	19,000	420	--
72-54-8	4,4'-DDD	PEST	--	--	1.22	7.81	--	110	17,000	--	--
72-55-9	4,4'-DDE	PEST	2.2	27	2.07	374					
50-29-3	4,4'-DDT	PEST	--	--	1.19	4.77					
	2,4'-DDD + 4,4'-DDD	PEST	2 (m)	20 (m)	--	--					
	2,4'-DDT + 4,4'-DDT	PEST	1 (m)	7 (m)	--	--					
	DDT, Total	PEST	1.58 (n)	46.1 (n)	3.89 (n)	51.7 (n)					
309-00-2	Aldrin	PEST									
319-84-6	BHC, alpha	PEST	--	--	--	--	-- (s)	120 (s)	-- (s)	5200 (s)	-- (s)
319-85-7	BHC, beta	PEST	--	--	--	--	-- (s)	120 (s)	-- (s)	5200 (s)	-- (s)
319-86-8	BHC, delta	PEST					-- (s)	120 (s)	-- (s)	5200 (s)	-- (s)
58-89-9	BHC, gamma (Lindane)	PEST	--	--	0.32	0.99	3.7	--	680	670	150
BHC_TOTAL	BHCs, total (Historical)	PEST	--	--	--	--					
57-74-9	CHLORDANE	PEST	0.5 (m)	6 (m)	2.26	4.79	2800	--	26,000	260,000	18,000
DDT_TOTAL	DDTS, total of 6 isomers (Historical)	PEST									
60-57-1	Dieldrin	PEST	0.02 (m)	8 (m)	0.72	4.3	110 (q)	--	--	--	--
1031-07-8	Endosulfan sulfate	PEST									
959-98-8	Endosulfan, alpha	PEST					--	5.5	--	--	--
33213-65-9	Endosulfan, beta	PEST					--	5.5	--	--	--
72-20-8	Endrin	PEST	0.02 (m)	45 (m)	--	--	42 (q)	--	--	--	--
7421-93-4	Endrin aldehyde	PEST									
76-44-8	Heptachlor	PEST					--	68	12,000	31,000	--
1024-57-3	Heptachlor epoxide	PEST									
118-74-1	Hexachlorobenzene	PEST									
72-43-5	Methoxychlor	PEST					--	19	--	--	--
2385-85-5	Mirex	PEST									
CARP406	Total DDT	PEST									
8001-35-2	Toxaphene	PEST									
CARP409	TPH	TPH									

Table B-2: Sediment Screening Values
Focused Feasibility Study
Lower Passaic River Restoration Project

CAS No.	Description	Class	(6) Jones et al. (1997)					(7) Jones et al. (1997)		(8) Canadian Sediment Guidelines			
			Summary of Selected Toxicity Test- and Screening Level Concentration-Based Sediment Quality Benchmarks for Freshwater Sediments					Sediment Screening Values (aa)		Interim Freshwater Sediment Quality Guidelines (dd)		Interim Marine Sediment Quality Guidelines (dd)	
TOC (used for NJDEP 1998, SEL)	**0.01**		ARCS (b) - TEC	ARCS (u) - PEC	ARCS (u) - NEC	Ontario MOE (v) - Low	Ontario MOE (v) - Severe	OSWER (bb)		ISQG (dd)	PEL (dd)	ISQG (dd)	PEL (dd)
			Inorg: (mg/kg dry wt); Org: (ug/kg dry wt)	Inorg: (mg/kg dry wt); Org: (ug/kg dry wt)	Inorg: (mg/kg dry wt); Org: (ug/kg dry wt)	Inorg: (mg/kg dry wt); Org: (ug/kg dry wt)	Inorg: (mg/kg dry wt); Org: (ug/kg dry wt)	Inorg: (mg/kg dry wt); Org: (ug/kg dry wt)	Type (cc)	ug/kg	ug/kg	ug/kg	ug/kg
1336-36-3	PCB, TOTAL	PCB_SUM	31.62	244.66	194	70 (a)	5300 (z)	23	ER-L	34.1	277	21.5	189
11096-82-5	Aroclor 1260	PCB-AROCLOR	--	--	--	5 (x,z)	240 (y,z)						
11097-69-1	Aroclor 1254	PCB-AROCLOR	--	--	--	60 (x,z)	340 (y,z)			60	340	63.3	709
11104-28-2	Aroclor 1221	PCB-AROCLOR											
11141-16-5	Aroclor 1232	PCB-AROCLOR											
12672-29-6	Aroclor 1248	PCB-AROCLOR	--	--	--	30 (x,z)	1500 (y,z)						
12674-11-2	Aroclor 1016	PCB-AROCLOR	--	--	--	7 (x,z)	530 (y,z)						
53469-21-9	Aroclor 1242	PCB-AROCLOR											
	DDD							--		3.54	8.51	1.22	7.81
	DDE							--		1.42	6.75	2.07	374
	DDT							--		1.19	4.77	1.19	4.77
72-54-8	4,4'-DDD	PEST	--	--	--	8	60	--					
72-55-9	4,4'-DDE	PEST	--	--	--	5	190						
50-29-3	4,4'-DDT	PEST						--					
	2,4'-DDD + 4,4'-DDD	PEST											
	2,4'-DDT + 4,4'-DDT	PEST	--	--	--	8	710						
	DDT, Total	PEST	-- (w)	-- (w)	-- (w)	7 (w)	120 (w)						
309-00-2	Aldrin	PEST	--	--	--	2	80						
319-84-6	BHC, alpha	PEST	--	--	--	6	100						
319-85-7	BHC, beta	PEST	--	--	--	5	210						
319-86-8	BHC, delta	PEST											
58-89-9	BHC, gamma (Lindane)	PEST	--	--	--	3 (x,z)	10 (y,z)	3.7	SQB				
BHC_TOTAL	BHCs, total (Historical)	PEST	--	--	--	3	120						
57-74-9	CHLORDANE	PEST	--	--	--	7	60	--		4.5	8.87	2.26	4.79
DDT_TOTAL	DDTS, total of 6 isomers (Historical)	PEST											
60-57-1	Dieldrin	PEST	--	--	--	2	910	52	SQC	2.85	6.67	0.71	4.3
1031-07-8	Endosulfan sulfate	PEST											
959-98-8	Endosulfan, alpha	PEST						2.9	SQB				
33213-65-9	Endosulfan, beta	PEST						14	SQB				
72-20-8	Endrin	PEST	--	--	--	3	1300	20	SQC	2.67	62.4	2.67	62.4
7421-93-4	Endrin aldehyde	PEST											
76-44-8	Heptachlor	PEST											
1024-57-3	Heptachlor epoxide	PEST	--	--	--	5 (x)	50 (y)			0.6	2.74	0.69	2.74
118-74-1	Hexachlorobenzene	PEST				20	240						
72-43-5	Methoxychlor	PEST						19	SQB				
2385-85-5	Mirex	PEST	--	--	--	7	1300						
CARP406	Total DDT	PEST						1.6	ER-L				
8001-35-2	Toxaphene	PEST						28	SQB	0.1		0.1	
CARP409	TPH	TPH											

Table B-2: Sediment Screening Values
Focused Feasibility Study
Lower Passaic River Restoration Project

(1) USEPA 2001 Supplemental Guidance to RAGS: Region 4 Bulletins, Ecological Risk Assessment. Originally published November 1995. Website version last updated November 30, 2001: http://www.epa.gov/region4/waste/ots/ecolbul.htm
(a): Contract Laboratory Program Practical Quantification Limit.
(b): Long, Edward R., and Lee G. Morgan. 1991. The Potential for Biological Effects of Sediment-Sorbed Contaminants Tested in the National Status and Trends Program. NOAA Technical Memorandum NOS OMA 52.
(c): MacDonald, D.D. 1994. Approach to the Assessment of Sediment Quality in Florida Coastal Waters. Florida Department of Environmental Protection.
(d): Long, Edward R., Donald D. MacDonald, Sherri L. Smith, and Fred D. Calder. 1995. Incidence of Adverse Biological Effects within Ranges of Chemical Concentrations in Marine and Estuarine Sediments. Environmental Management 19(1):81-97.
(e): USEPA. 1993. Interim Report on Data and Methods for Assessment of 2,3,7,8 - Tetrachlorodibenzo-p-dioxin Risks to Aquatic Life and Associated Wildlife. EPA/600/R-93/055.
(2) USEPA 2003 U.S. EPA, Region 5, RCRA. Ecological Screening Levels. August 22, 2003.
(f): Unless noted otherwise, all sediment Ecological Screening Levels were derived using equilibrium partitioning equation and the corresponding water ESL. $ESL_{sediment} = K_{oc} \times ESL_{water} \times 0.01$
(g): Environment Canada. September 1994. Interim Sediment Quality Assessment Values. Ecosystem Conservation Directorate. Evaluation and Interpretation Branch.
(h): Ontario Ministry of the Environment. August 1993. Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario.
(i): Consensus based threshold effect concentrations (TECs) as presented in MacDonald et al., 2000. Development and evaluation of consensus-based guidelines for freshwater ecosystems.
Arch Environ Contam Toxicol 39:20-31 (see Table 2 of Region 5 ESLs). The TEC for mercury had a high incidence of toxicity and was not used.
These values do not consider bioaccumulation or biomagnification.
(j): New ESL data is lower than the previous table.
(3) NJDEP, 1998 Guidance for Sediment Quality Evaluations. NJDEP. November 1998.
(k): NJDEP = New Jersey Department of Environmental Protection; LEL = Lowest Effect Level; SEL = Severe Effect Level; LEL are ecological screening levels to be used in the Baseline Ecological Evaluation.
(4) Jones et al. (1997) Jones, D.S., G.W. Suter II, R.N. Hull. November 1997. Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Sediment-Associated Biota: 1997 Revision. ES/ER/TM-95/R4
(l): NOAA = National Oceanic and Atmospheric Administration; ER-L = Effects Range-Low; ER-M = Effects Range Median; except where noted, effects levels are the updated and revised values from Long et al. (1995).
FL DEP = Florida Department of Environmental Protection; TEL = Threshold Effects Level; PEL = Probable Effects Level. Source document is MacDonald (1994).
(m): Source document is Long and Morgan (1991).
(n): Total DDT is the sum of the concentrations of the o,p'- and p,p'-isomers of DDD, DDE, and DDT.
(o): LMW = low molecular weight and is the sum of the concentrations of acenaphthene, acenaphthylene, anthracene, fluorene, 2-methylnaphthalene, naphthalene, and phenanthrene.
HMW = high molecular weight and is the sum of the concentrations of benz(a)anthracene, benzo(a)pyrene, chrysens, dibenzo(a,h)anthracene, fluoranthene, and pyrene.
Total is the sum of the concentrations of the aforementioned low and high molecular weight PAHs.
(5) Jones et al. (1997) Equilibrium Partitioning-Derived Sediment Quality Benchmarks for Nonionic Organic Chemicals Corresponding to Conventional Aqueous Benchmarks
(p): Conventional aqueous benchmars are presented in Suter and Tsao (1996). Estimated to 2 significant figures assuming 1% TOC.
Estimated sediment quality benchmarks greater than 10% (100,000,000 ug/kg) not included because such concentrations are assumed unlikely to be exceeded under natural conditions [applies to bis(2-ethylhexyl)phthalate and di-n-octylphthalate].
(q): Denotes proposed EPA sediment quality criteria.
(r) Column C denotes polar nonionic compounds, for which the EqP model is likely to provide a conservative estimate of exposure.
(s): Most conservative (i.e., lowest) recommended value for reported configurations. BHC (other) is lowest of alpha-, beta-, and delta-BHC only.
(t): Source is USEPA (1995b) and Source is ATSDR (1989).
(6) Jones et al. (1997) Summary of Selected Toxicity Test- and Screening Level Concentration-Based Sediment Quality Benchmarks for Freshwater Sediments
(u): ARCS = Assessment and Remediation of Contaminated Sediments Program; TEC = Threshold Effect Concentration; PEC = Probable Effect Concentration; NEC = high No Effect Concentration from EPA (1996).
(v): Ontario MOE = Ontario Ministry of the Environment;
Low = lowest effect level and is the 5th percentile of the screening level concentration except where noted otherwise;
Severe = severe effect level and is the 95th percentile of the screening level concentration except where noted otherwise;
Source document is Persaud et al. (1993). Values for organic chemicals were normalized assuming 1% TOC.
(w): Total DDT is the sum of the concentrations of the o,p'- and p,p'-isomers of DDD, DDE, and DDR.
(x): 10th percentile of the screening level concentration.
(y): 90th percentile of the screening level concentration.
(z): Denotes tentative guideline.
(7) Jones et al. (1997) OSWER Sediment Screening Values
(aa): Screening values are presented with the same number of significant digits used in the EPA source documents.
(bb): OSWER = EPA Office of Solid Waste and Emergency Response Ecotox Thresholds (ET). Only the most preferred ET, as defined in OSWER (1996), is presented
(cc): ER-L = effects range-low and, except where noted otherwise, is from Long et al. (1995);
SQC = the lower limit of the 95% confidence interval of the proposed EPA sediment quality criteria, assuming 1% TOC;
SQB = the EPA sediment quality benchmark based EPA Tier II Chronic value (USEPA, Region IV, 1995), assuming 1% TOC.
(8) Canadian Reference Canadian Sediment Quality Guidelines for the Protection of Aquatic Life. (Canadian Council of Ministers of the Environment) 1999. updated 2001.
(dd): ISQG = Interim Sediment Quality Guidelines; PEL = Probable Effects Level
(ee): Values expressed as ng TEC/kg; TEQ = units of Toxicity Equivalence Quotient
Based on WHO 1998 TEF values for fish.
(9) " --" Indicates that the chemical was listed in the guidance document but no value was provided.
(10) Jones et al. (1997)
sources:

Long, E.R., and L.G. Morgan. 1991. *The Potential for Biological Effects of Sediment-Sorbed Contaminants in the National Status and Trends Program* , NOAA Technical Memorandum NOS OMA 52, National Oceanic and Atmospheric Administration.
Suter, G.W. II, and C.L. Tsao. 1996. *Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota: 1996 Revision* , ES/ER/TM-96/R2, Oak Ridge National Laboratory, Oak Ridge, Tennessee.
U.S. Environmental Protection Agency, 1995b. *National Sediment Inventory: Documentation of Derivation of Freshwater Sediment Quality* , Office of Water, Washington, D.C.
ATSDR (Agency for Toxic Substances and Disease Registry) 1989. *Toxicological Profile for Selected PCBs* , ATSDR/TP-88/21, U.S. Public Health Service, Washington, D.C.
Persaud, D., R. Jaagumagi, and A. Hayton. August 1993. *Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario* , Ontario Ministry of the Environment and Energy.
Long, E.R., D.D. MacDonald, S.L. Smith, and F.D. Calder. 1995. "Incidence of Adverse Biological Effects within Ranges of Chemical Concentrations in Marine and Estuarine Sediments," *Environmental Management* **19**(1), 81-97.
U.S. Environmental Protection Agency, Region IV. 1995. *Ecological Screening Values* , Ecological Risk Assessment Bulletin No. 2, Waste Management Division, U.S. Environmental Protection Agency Region IV, Atlanta, GA.
U.S. Environmental Protection Agency. 1996. *Calculation and Evaluation of Sediment Effect Concentrations for the Amphipod Hyalella azteca and the Midge Chironomus riparius* , EPA 905-R96-008, Great Lakes National Program Office, Chicago, IL.
Office of Solid Waste and Emergency Response (OSWER). 1996. "Ecotox Thresholds," *ECO Update* 3(2):1-12.

Development of Preliminary Remediation Goals

LOWER PASSAIC RIVER RESTORATION PROJECT
DEVELOPMENT OF PRELIMINARY REMEDIATION GOALS

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DEVELOPMENT OF PRELIMINARY REMEDIATION GOALS

Human health and ecological risk assessments (HHRA and ERA, respectively) were conducted to assess the potential for unacceptable risks following exposure to contaminated environmental media in the Lower Passaic River Restoration Project (LPRRP) study area. The risk assessments are provided in Appendix C. The following sections summarize the technical approaches employed and present the preliminary remediation goals (PRG) to support the Draft Focused Feasibility Study (FFS). Health protective PRGs were developed for both sediment and fish media; the latter are provided for consideration during a potential long-term monitoring phase following implementation of a remedial alternative.

1.0 HUMAN HEALTH PRELIMINARY REMEDIATION GOALS

The HHRA [provided as Appendix C of the Draft FFS (Battelle, 2007)] was conducted by estimating carcinogenic risks and noncarcinogenic health hazards for exposures to an adult angler/sportsman and other family members (*i.e.*, adolescent and child) from ingestion of self-caught fish and blue crab from the Lower Passaic River. The results of the HHRA determined that total cancer risks are above the National Contingency Plan (NCP) risk range of 10^{-4} (one in ten thousand) to 10^{-6} (one in a million) and noncancer health hazards are above a hazard quotient (HQ) of 1.0. The following chemicals of potential concern (COPC) have individual cancer risks above 10^{-4}:

- Dioxins/furans as tetrachlorodibenzodioxin (TCDD) toxic equivalency quotients (TEQ) [TCDD TEQ Dioxins/furans (D/F)]
- Polychlorinated biphenyls (PCB) as total PCBs (sum of Aroclors)
- PCB dioxin-like congeners evaluated as TCDD TEQ [TCDD TEQ (PCB)]

The following COPCs have individual noncarcinogenic health hazards above a HQ of 1.0:

- Total PCBs (sum of Aroclors)
- Total chlordane
- Methyl mercury

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The HHRA evaluated cancer risks and non-cancer health hazards under a reasonably maximum exposure (RME) and a central tendency exposure (CTE) or average exposure to describe the magnitude and range of exposure that might be incurred by the receptor groups. The United States Environmental Protection Agency (USEPA, 1989) defines the RME as the highest exposure that is reasonably expected to occur at a site. According to USEPA guidance (1995), central-tendency estimates are intended to reflect central (more typical) estimates of exposure or dose. The objective of providing both the RME and CTE exposure cases is to bound the risk estimates, although decisions are based on the RME consistent with the NCP (USEPA, 1985).

1.1 CALCULATION OF PRELIMINARY REMEDIATION GOALS

Human health risk-based PRGs were calculated for fish and crab tissue for those COPCs individually exceeding the NCP criteria of 10^{-4} for cancer risk or 1.0 for noncancer health hazards: namely, TCDD TEQ, total PCBs, total chlordane, and methyl mercury. A PRG based on carcinogenic effects was calculated for total PCBs, but not for the TCDD TEQ (PCB), for two reasons. First, the estimated carcinogenic risks determined during the HHRA for total PCBs and dioxin-like PCB congeners [TCDD TEQ (PCB)] are comparable, and calculated PRGs using both total PCBs and coplanar PCBs separately would not significantly differ. Second, any remedial action based on total PCB PRGs would address the presence of the dioxin-like PCB congeners.

Exposure Assumptions for Fish Ingestion. The PRGs were calculated following Risk Assessment Guidance for Superfund Part B (USEPA, 1991). For this analysis, the exposure assumptions used in the HHRA were used in the calculation of the PRGs. As described in the HHRA, the adult annualized ingestion rate for fish of 25 grams per day (g/day) was based on data collected for recreational freshwater anglers obtained from the Exposure Factors Handbook (EFH) (USEPA, 1997). The ingestion rate is the amount of fish or crab an individual consumes on a daily basis (units g/day) based on averaging the reported consumption rate in one year [365 days per year (days/year)]. As an annualized rate, 25 g/day of fish equates to approximately 40 eight-ounce fish meals per year [25 g/day x 365 days/year, assuming a portion size of eight ounces (USEPA, 1997)].

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Exposure Assumptions for Crab Ingestion. There is limited information in the published literature regarding the rates of crab consumption by humans. Studies conducted in the Newark Bay Complex area were reviewed (Burger, 2002; Burger *et al.*, 1999; and May and Burger, 1996) to identify an appropriate consumption rate. Of the studies reviewed, the Burger study (2002) was the only one that contained sufficient information regarding crab consumption in the area of the Lower Passaic River. Therefore, the Burger study (2002) was used to derive the consumption rate used in the HHRA. Based on the crab consumption patterns for people who catch crab only, as reported in Burger (2002), the RME ingestion rate for the adult angler/sportsman was selected as 23 g/day. Separate fish and crab PRGs have not been developed because the ingestion rate for crab of 23 g/day used in the HHRA is very close to the ingestion rate for fish (25 g/day), and as such, PRGs for each tissue type would not be significantly different. Although the ingestion rate used to develop the PRGs is the higher ingestion rate of 25 g/day, the PRGs are applicable to either fish or crab tissue.

Calculations. Equations used to derive PRGs for carcinogenic and noncarcinogenic effects are provided below as Equations 1 and 2, respectively. These equations are the same equations used in the HHRA (refer to Sections 5.1.4 and 5.3 of the HHRA in Appendix C) to calculate the RME chemical intake from ingesting fish/crab and to estimate cancer risk and noncancer health hazards. The equations have been rearranged to solve for the biota tissue concentration (C_b) using substituted target risk levels (*e.g.*, 10^{-6}) and hazard quotients (*e.g.*, 1.0). USEPA (1991) states that an appropriate point of departure for remediation of carcinogenic risk is a concentration that corresponds to a risk of 10^{-6} for one chemical in a particular medium; however, concentrations corresponding to the other risk levels addressed in the NCP (*e.g.*, 10^{-5} and 10^{-4}) also have been used as substituted target risk levels in order to provide a range of concentrations to assist in the risk management decision process. Table 1 provides a summary of the exposure parameter definitions and values.

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For carcinogenic effects:

$$C_b = \frac{\text{BW x AT x TR}}{\text{ED x EF x IR x FI x CF x CSF}} \qquad \text{Equation 1}$$

For noncarcinogenic effects:

$$C_b = \frac{\text{BW x AT x THQ}}{\text{ED x EF x IR x FI x CF x } 1/\text{RfD}} \qquad \text{Equation 2}$$

Table 1: Summary of Exposure Parameters for Calculation of PRGs

Exposure Parameter	Definition	Units	Value
C_b	Chemical Concentration in Biota (*i.e.*, fish or crab)	mg/kg	Chemical-specific
TR	Target Risk	unitless	1×10^{-6} 1×10^{-5} 1×10^{-4}
THQ	Target Hazard Quotient	unitless	1.0
IR	Ingestion Rate	grams/meal	227 (8 ounces)[a]
EF	Exposure Frequency	meals/year[b]	40
ED	Exposure Duration	years	24
BW	Body Weight	kg	70
AT	Averaging Time	days	25,550 for carcinogenic effects; 8,760 (ED x 365 days) for noncarcinogenic effects
FI	Fraction from Source	unitless	1.0
CF	Conversion Factor	kg/g	0.001
CSF	Oral Cancer Slope Factor	$(\text{mg/kg-day})^{-1}$	Chemical-specific[c]
RfD	Oral Reference Dose	mg/kg-day	Chemical-specific[c]

mg/kg: milligrams per kilogram
a: Source: New Jersey Department of Environmental Protection (NJDEP), 2006; USEPA, 1997; and USEPA, 2000.
b: 40 meals/year = ~1 fish meal every 1.5 weeks; 12 meals/year = 1 fish meal every month; 6 meals/year = 1 fish meal every other month; 2 meals/year = 1 fish meal every six months.
c: Refer to Table 2.

For development of the PRGs, the IR is defined as the amount of fish (in grams) consumed at one meal. USEPA (1997; 2000) and NJDEP (2006) have identified a value of eight ounces (227 grams) of uncooked fish fillet per 70-kg consumer body weight as an average meal size for adults in the general population. At this time, USEPA recommends that the same default value for meal size be used for shellfish (USEPA,

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2000). No cooking loss was assumed for calculation of the PRGs. Oral toxicity values, such as the CSF and RfD, are chemical-specific and are provided in Table 2 for each of the COPCs.

Table 2: Oral Toxicity Values and PRGs Developed for Fish/Crab Tissue

COPC	Oral Toxicity Values	
	CSF	RfD
	$(mg/kg\text{-}day)^{-1}$	mg/kg-day
TCDD TEQ	1.50×10^{5}	NA[a]
Total PCBs	2.00×10^{0}	2.0×10^{-5}
Total Chlordane	3.5×10^{-1}	5.0×10^{-4}
Methyl mercury	NA[b]	1.0×10^{-4}

NA: Not Available
a: No toxicity data at this time.
b: Classification — C; possible human carcinogen, but an oral cancer slope factor has not been developed for this chemical.

Calculated PRGs. The PRGs developed for the adult angler who consumes fish or crab from the Lower Passaic River are summarized in Table 3. When available data indicate that a COPC is associated with both carcinogenic and noncarcinogenic health effects, as is the case for total PCBs and total chlordane, PRGs based on both types of effects were calculated. For total PCBs, it is recommended that the toxicological effect resulting in the more conservative PRG be used to be protective of both types of health effects. Although total chlordane is also associated with both carcinogenic risk and non-cancer health hazards, only the non-cancer health endpoint is considered in selecting the PRG because the current cancer risks estimated for this COPC were within the NCP risk range.

Table 3: Summary of the PRGs Developed for Fish/Crab Tissue

COPC	PRGs[a] for Fish/Crab Tissue for an Adult Angler			
	Cancer PRGs (ng/g)			Noncancer PRGs (ng/g)
	1×10^{-6}	1×10^{-5}	1×10^{-4}	
TCDD TEQ	0.00005	0.00055	0.0055	ND[b]
Total PCBs	4.1	41	410	56
Total Chlordane	23	234	2345	1407
Methyl mercury	ND[c]			281

ng/g: nanograms per gram
ND: Not Determined
a: Assumes 40 eight-ounce fish or crab meals per year.
b: No toxicity data at this time.
c: Classification —There is no quantitative estimate of carcinogenic risk from oral exposure.

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1.2 ALTERNATIVE TISSUE CONCENTRATIONS COMPARABLE TO CONSUMPTION ADVISORIES

Statewide fish consumption advisories developed by NJDEP may indicate "do not eat" or do not eat more than one meal per week, one meal per month, four meals per year, or one meal per year, where a meal is defined as an eight-ounce serving (NJDEP, 2006). Additional risk-based tissue concentrations were developed based on the number of fish meals of a specified meal size (*i.e.*, eight ounces) that may be consumed over a period of time as is often prepared for fish advisories. The additional concentrations that have been developed for each of the COPCs were based on numbers of fish meals per year, ranging from one meal per year up to 12 meals per year, and are summarized in Table 4. The PRG value derived for the 40 meals per year also has been included in Table 4 for comparison purposes. These values may provide interim remediation goals.

1.3 SEDIMENT CONCENTRATIONS ESTIMATED FROM RISK-BASED TISSUE CONCENTRATIONS

Sediment concentrations required for biota to meet the risk-based concentration levels were estimated by dividing the tissue concentrations by a chemical-specific bioaccumulation factor (BAF). The estimated risk-based sediment concentrations are presented in Table 5. BAFs were derived as the ratio of biota (*i.e.*, fish and crab) tissue concentration to sediment concentration and are also presented in Table 5. A detailed description of how the BAFs were derived is provided in Section 7 of the risk assessment (Appendix C).

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Table 4: Summary of Alternative Risk-Based Tissue Levels Based on the Number of Fish Meals per Year for the Adult Angler Receptor

			Risk-Based Tissue Concentrations Based on # Fish Meals[a] per Year for an Adult															Noncancer Tissue Concentrations Based on # Fish Meals[a] per Year for an Adult				
			40 meals per year			12 meals per year			6 meals per year			2 meals per year			1 meal per year							
CASRN	Units	Chemical	$1x10^{-6}$	$1x10^{-5}$	$1x10^{-4}$	$1x10^{-6}$	$1x10^{-5}$	$1x10^{-4}$	$1x10^{-6}$	$1x10^{-5}$	$1x10^{-4}$	$1x10^{-6}$	$1x10^{-5}$	$1x10^{-4}$	$1x10^{-6}$	$1x10^{-5}$	$1x10^{-4}$	40 meals per year	12 meals per year	6 meals per year	2 meals per year	1 meal per year
Inorganics																						
22967-92-6	ng/g	Methyl Mercury	Classification — C; possible human carcinogen; There is no quantitative estimate of carcinogenic risk from oral exposure.															281	938	1,876	5,628	11,256
Pesticides																						
12789-03-6	ng/g	Total Chlordane	23	234	2345	78	782	7816	156	1563	15633	469	4690	46898	938	9380	93796	1407	4690	9,380	28,139	56,278
PCB Aroclors																						
SUM_PCB	ng/g	Total PCBs[b]	4.1	41	410	14	137	1,368	27	274	2,736	82	821	8,207	164	1,641	16,414	56	188	375	1,126	2,251
Dioxins/Furans																						
1746-01-6	ng/g	TCDD TEQ	0.00005	0.00055	0.0055	0.00018	0.0018	0.018	0.00036	0.0036	0.036	0.0011	0.011	0.11	0.0022	0.022	0.22	No toxicity data at this time				

CASRN: Chemical Abstracts Service Registry Number

a: 40 meals/year = ~1 fish meal every 1.5 weeks; 12 meals/year = 1 fish meal every month; 6 meals/year = 1 fish meal every other month; 2 meals/year = 1 fish meal every six months.

b: For total PCBs, PRGs have been calculated for both carcinogenic and noncarcinogenic health effects. It is recommended that the toxicological effect resulting in the more conservative PRG be used to be protective of both types of health effects.

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Table 5: **Summary of Estimated Sediment Concentrations**

			Sediment Concentrations Based on # Fish Meals[a] per Year for an Adult																Noncancer Sediment Concentrations Based on # Fish Meals per Year and BAF[b]				
				40 meals per year			12 meals per year			6 meals per year			2 meals per year			1 meal per year							
CASRN	Units	Chemical	BAF[b]	1.E-06	1.E-05	1.E-04	1.E-06	1.E-05	1.E-04	1.E-06	1.E-05	1.E-04	1.E-06	1.E-05	1.E-04	1.E-06	1.E-05	1.E-04	40 meals per year	12 meals per year	6 meals per year	2 meals per year	1 meal per year
22967-92-6	ng/g	Mercury	0.1	Classification — C; possible human carcinogen; There is no quantitative estimate of carcinogenic risk from oral exposure															2814	9380	18759	56278	112555
12789-03-6	ng/g	Total Chlordane	19.6	1	12	120	4	40	399	8	80	798	24	239	2393	48	479	4786	72	239	479	1436	2871
SUM_PCB	ng/g	Total PCBs	2.2	2	19	187	6	62	622	12	124	1244	37	373	3731	75	746	7461	26	85	171	512	1023
1746-01-6	ng/g	2,3,7,8-TCDD	0.2	0.00027	0.0027	0.027	0.00091	0.0091	0.091	0.0018	0.018	0.18	0.0055	0.055	0.55	0.011	0.11	1.1	No toxicity data at this time				

a: 40 meals/year = ~1 fish meal every 1.5 weeks; 12 meals/year = 1 fish meal every month; 6 meals/year = 1 fish meal every other month; 2 meals/year = 1 fish meal every six months
b: Sediment PRG = Tissue PRG/BAF

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2.0 ECOLOGICAL PRELIMINARY REMEDIATION GOALS

Appendix C also presents the ERA that evaluated hazards to wildlife, fish, and benthos associated with direct contact exposures to contaminated LPRRP study area sediment and dietary exposures to those constituents capable of bioaccumulating in the estuarine food web. A residue-based analysis was also employed to evaluate the potential hazards associated with tissue burdens measured in fish. Based on the findings of the ERA it was determined that ecological hazards (as represented by HQs) to the receptor categories evaluated substantially exceed a value of 1.0.

Ecological PRGs were developed for all chemicals of potential ecological concern (COPECs), as determined in the FFS COPEC screening process documented in Attachment 4 to the ERA (Appendix C). COPECs include copper, lead, mercury (including methyl mercury), low- and high-molecular weight polycyclic aromatic hydrocarbons (PAH) (LPAH and HPAH, respectively), total PCBs (sum of Aroclors), the sum of DDD (dichlorodiphenyldichloroethane), DDE (dichlorodiphenyldichloro-ethylene), and DDT (dichlorodiphenyltrichloroethane) isomers (total DDx), dieldrin, TCDD TEQ (D/F)[1], and TCDD TEQ (PCB).

2.1 CALCULATION OF PRELIMINARY REMEDIATION GOALS

Sediment PRGs were developed for benthic organisms (including bivalves) and for estuarine-dependent wildlife for the subset of COPECs that are capable of bioaccumulating (*i.e.*, all except PAHs) in estuarine biota. It was assumed that the PRGs developed for these two categories of receptors will be sufficiently protective of fish species as well[2]. A residue-based analysis was conducted in the ERA to evaluate the significance of measured tissue burdens in fish and the toxicity data utilized in this

[1] Consistent with the Toxic Equivalency approach (Tillitt, 1999), the toxicological basis for the PRGs for dioxin, furan, and coplanar PCB compounds is 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (2,3,7,8-TCDD). TCDD TEQ refers to the combined equivalency associated with all aryl hydrocarbon receptor (AhR) mediated toxicity.

[2] However, see later text discussion (which is developed more fully in the ERA) regarding the potential sediment toxicity of PAHs to fish.

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assessment [*i.e.*, Critical Body Residues (CBR)] were selected as PRGs for the fish tissue medium along with calculated wildlife-protective values.

Benthos. Sediment concentrations protective of benthic infauna exposed directly to various constituents were derived for marine and estuarine habitats by Long *et al.* (1995). These values, termed Effects Range Low (ER-L)[3], represent the low end of a range of levels at which adverse effects have been observed in compiled studies. As such, ER-Ls represent threshold levels in sediment above which toxicity could be anticipated to occur in sensitive species (Long *et al.*, 1995).

An ER-L is not available for 2,3,7,8-TCDD; therefore a site-specific PRG for bivalves was derived by the United States Fish and Wildlife Service (USFWS) using Newark Bay sediment, oyster tissue chemistry, and ecological effects presented in Wintermyer and Cooper (2003).

Wildlife. Wildlife-protective sediment concentrations for bioaccumulative COPECs were calculated with the same exposure dose equations as used in the ERA. The otter (*Lutra canadensis*) and belted kingfisher (*Ceryle alcyon*) were selected as the model receptors due to their relatively large dietary exposures to sediment-associated chemicals that can bioaccumulate in biological tissue. Equation 3 was used to estimate PRGs for piscivorous wildlife receptors in the LPRRP study area.

$$PRG_{sed} = \frac{THQ * TRV * BW}{\left(BAF_{fish} * IR_{fish} * P_{fish} * SFF\right)} \qquad \text{Equation 3}$$

[3] It is important to recognize that the ER-Ls were developed for use in screening-level analyses, and the authors specifically recommend against the use of these values in establishing sediment remediation goals (Long *et al.*, 1995). These values should be considered with due caution and careful consideration of the relevant uncertainties, particularly if an ER-L was to be identified as the basis for establishing a remediation goal for any sediment constituent.

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Where

PRG_{sed}: Preliminary Remediation Goal for sediment protective of bioaccumulation hazards associated with the fish consumption pathway [micrograms (μg) COPEC/g sediment].

THQ: Target Hazard Quotient for the COPEC based on tissue residue effects (dimensionless); a THQ of 1.0 was used.

TRV: Toxicity Reference Value: receptor-specific literature-based toxicity threshold value. The selected value is the geometric mean of the No Observed Adverse Effects Level (NOAEL)- and Lowest Observed Adverse Effects Level (LOAEL)-based values.

BW: Receptor body weights (kg).

BAF_{fish}: Bioaccumulation Factor between sediment and fish prey consumed by the receptor [g sediment (dry weight)/g fish (wet weight)].

IR_{fish}: Daily fish ingestion rate (kg fish consumed per day).

P_{fish}: Percentage of fish in the diet.

SFF: Site Foraging Frequency (unitless); fraction of time receptor is assumed to forage at the site.

Wildlife PRGs were also derived for prey tissue (Equation 4) based on a piscivorous diet.

$$PRG_{biota} = \frac{THQ * TRV * BW}{\left(IR_{fish} * P_{fish} * SFF\right)} \qquad \text{Equation 4}$$

Where

PRG_{biota}: Preliminary Remediation Goal for prey tissue protective of bioaccumulation hazards associated with the fish consumption pathway (μg COPEC/g biota).

THQ: Target Hazard Quotient for the COPEC based on tissue residue effects (dimensionless); a THQ of 1.0 was used.

R2-0009214

TRV: Toxicity Reference Value: receptor-specific literature-based toxicity threshold value. The selected TRV value is the geometric mean of the NOAEL- and LOAEL-based values.

BW: Receptor body weights (kg).

IR_{fish}: Daily fish ingestion rate (kg fish consumed per day).

P_{fish}: Percentage of fish in the diet.

SFF: Site Foraging Frequency (unitless); fraction of time receptor is assumed to forage at the site.

Table 6 summarizes the exposure parameters used in the development of the PRGs protective of wildlife. BAFs are presented in Table 7.

Table 6: Summary of Exposure Parameters Used to Develop Ecological PRGs for Wildlife

Parameter	Value	Units	Reference
PRG_{sed}	Calculated using Equation 1	µg COPEC/g sediment	-
THQ	1	unitless	-
TRV	Chemical-specific	µg COPEC/g-day	Table 8
BW	7.4 (otter)	kg	USEPA, 1993a
	0.136 (kingfisher)		USEPA, 1993a; Brooks and Davis,1987
BAF_{fish}	Chemical-specific	unitless	Table 7
IR_{fish}	0.4 (otter)	kg/day	USEPA, 1993a
	0.068 (kingfisher)		USEPA, 1993a; Alexander, 1977
P_{fish}	100	%	Assumption
SFF	1	unitless	Assumption

Table 7: Summary of Bioaccumulation Factors Used to Develop Ecological PRGs for Wildlife

COPEC	BAF (g_{sed}/g_{tissue})	Reference
Copper	1.6	Bechtel Jacobs, 1998
Lead	0.066	Bechtel Jacobs, 1998
Mercury	1.1	Bechtel Jacobs, 1998
Total PCB (sum of Aroclors)	1.9	USEPA, 2004
Total DDx	7.7	USEPA, 2004
Dieldrin	1.8	USEPA, 2004
2,3,7,8-TCDD	0.025	USEPA, 2004

g_{sed}/g_{tissue}: gram of sediment per gram of tissue

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Table 8: Summary of Toxicity Reference Values Used to Develop Ecological PRGs for Wildlife

COPEC	Units	TRV			Reference
		Low	High	Geometric mean	
Mammal					
Copper	ng/g	2,670	632,000	41,078	USEPA, 2002
Lead	ng/g	1,000	241,000	15,524	USEPA, 2002
Mercury	ng/g	32	160	72	Sample *et al.*, 1996
Total PCB (sum of Aroclors)	ng/g	360	1,280	679	USEPA, 2002
Total DDx	ng/g	800	16,000	3,578	USEPA, 2002
Dieldrin	ng/g	20	200	63	Sample *et al.*, 1996
2,3,7,8-TCDD[a]	ng/g	-	-	-	-
Bird					
Copper	ng/g	2,300	52,300	10,968	USEPA, 2002
Lead	ng/g	14	8,750	350	USEPA, 2002
Mercury	ng/g	6	64	20	Sample *et al.*, 1996
Total PCB (sum of Aroclors)	ng/g	90	1,270	338	USEPA, 2002
Total DDx	ng/g	9	600	73	USEPA, 2002
Dieldrin	ng/g	77	770	243	Sample *et al.*, 1996
2,3,7,8-TCDD[a]	ng/g	-	-	-	-

a: PRGs obtained from USEPA, 1993b; no TRV necessary.

Rather than deriving PRGs for TCDD using the above approach, sediment concentrations protective of piscivorous mammals [2.5 picograms/gram (pg/g) or parts per trillion] and birds (21 pg/g) derived by USEPA (1993b) were used. The lower of these values was selected as the wildlife PRG value for fish tissue.

Fish. CBRs for whole body[4] fish tissue were compiled to support the ERA; further details regarding their development is provided in Appendix C[5].

Calculated PRGs. Table 9 presents the ecological PRGs for the selected sediment COPECs for each category of receptor considered in the ERA. The overall ecological

[4] In the case of 2,3,7,8-TCDD, a CBR value was established based on threshold concentrations determined in fish eggs, as the embryo is known to be the most sensitive life stage. Application of this CBR to whole body tissue assumes a 1:1 correspondence between these two compartments in adult females, which is believed to be a conservative assumption (Phillip Cook, personnel communication).

[5] The fish tissue PRGs are believed to be generally protective of the fish species likely to be encountered in the Lower Passaic River; however, PAH compounds are metabolized by most species into more toxicologically active compounds (Barron *et al.*, 2004; Incardona *et al.*, 2006) that are not routinely analyzed. It is thus reassuring that the ER-Ls appear to be protective of sediment exposures of sensitive benthivorous fish as well as invertebrate species. A review of fish injury studies from Puget Sound demonstrated that the sediment threshold for sublethal effects in English sole (a species known to be sensitive to hepatic lesions) is approximately 1,000 ng/g (Johnson, 1999).

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PRG is the lower of the two values. The fish tissue PRGs presented in Table 10 include results of the residue-based (fish) and dose-based (wildlife) analyses conducted as part of the ERA.

Table 9: Summary of Sediment PRGs for Ecological Receptors

CASRN	Units	Chemical	Sediment PRGs		Lowest
			Benthos[a]	Wildlife[b]	
Inorganics					
7440-50-8	ng/g	Copper	34,000	13,318	Wildlife PRG
7439-92-1	ng/g	Lead	46,700	10,606	Wildlife PRG
7439-97-6	ng/g	Mercury	150	37	Wildlife PRG
PAHs					
SUM_LOW_PAH	ng/g	Low Molecular Weight PAHs	552	-	NOAA ER-L
SUM_HIGH_PAH	ng/g	High Molecular Weight PAHs	1,700	-	NOAA ER-L
PCB Aroclors					
SUM_PCB	ng/g	Total PCBs	22.7	365	NOAA ER-L
Pesticides/Herbicides					
SUM_TDDT	ng/g	DDx	1.58	19	NOAA ER-L
60-57-1	ng/g	Dieldrin	0.02	271	NOAA ER-L
Dioxins/Furans					
TCDD TEQ	ng/g	TCDD TEQ[c]	0.0032	0.0025	Wildlife PRG

NOAA: National Oceanic and Atmospheric Administration
a: ER-L = Effects Range-Low from Long *et al.*, 1995, except where noted.
b: Derived as described in the FFS COPEC Screening Technical Memorandum (Appendix C).
c: Benthic benchmark for 2,3,7,8-TCDD derived by USFWS using sediment chemistry for Newark Bay and oyster effect data presented in Wintermyer and Cooper, 2003; wildlife value from USEPA, 1993b.

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Table 10: Summary of Fish Tissue PRGs for Ecological Receptors

CASRN	Units	Chemical	Fish Tissue PRGs		Lowest
			Fish[a]	Wildlife[b]	
Inorganics					
7440-50-8	ng/g	Copper	6.3	21,935	Fish
7439-92-1	ng/g	Lead	88	700	Fish
7439-97-6	ng/g	Mercury	19	40	Fish
PAHs					
SUM_LOW_PAH	ng/g	Low Molecular Weight PAHs	89	-	Fish
SUM_HIGH_PAH	ng/g	High Molecular Weight PAHs	89	-	Fish
PCB Aroclors					
SUM_PCB	ng/g	Total PCBs	7.9	676	Fish
Pesticides/Herbicides					
SUM_TDDT	ng/g	DDx	0.3	147	Fish
60-57-1	ng/g	Dieldrin	35	487	Fish
Dioxins/Furans					
TCDD TEQ	ng/g	TCDD TEQ[c]	0.050	0.0007	Wildlife

a: Based on CBRs as summarized in Appendix C.
b: Derived as described in the FFS COPEC Screening Technical Memorandum (Appendix C); lowest of mammal and avian values.
c: Low risk fish concentrations for 2,3,7,8-TCDD from USEPA, 1993b.

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3.0 **ACRONYMS**

2,3,7,8-TCDD	2,3,7,8-Tetrachlorodibenzo-*p*-dioxin
AhR	Aryl Hydrocarbon Receptor
AT	Averaging Time
BAF	Bioaccumulation Factor
BTAG	Biological Technical Assistance Group
BW	Body Weight of Receptor
CASRN	Chemical Abstracts Service Registry Number
C_b	Chemical Concentration in Biota
CBR	Critical Body Residue
CF	Conversion Factor
COPC	Chemical of Potential Concern
COPEC	Chemical of Potential Ecological Concern
CSF	Oral Cancer Slope Factor
CTE	Central Tendency Exposure
D.C.	District of Columbia
DDD	Dichlorodiphenyldichloroethane
DDE	Dichlorodiphenyldichloroethylene
D/F	Dioxin/Furan
DDT	Dichlorodiphenyltrichloroethane
ED	Exposure Duration
EF	Exposure Frequency
EFH	Exposure Factors Handbook
ERA	Ecological Risk Assessment
ER-L	Effects Range-Low
FI	Fraction from Source
FFS	Focused Feasibility Study
g	gram
g_{sed}	gram of sediment
g_{tissue}	gram of tissue

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HHRA	Human Health Risk Assessment
HPAH	High Molecular Weight PAH
HQ	Hazard Quotient
IR	Ingestion Rate
kg	kilogram
LOAEL	Lowest Observed Adverse Effects Level
LPAH	Low Molecular Weight PAH
LPRRP	Lower Passaic River Restoration Project
mg	milligram
NA	Not Available
NCP	National Contingency Plan
ND	Not Determined
ng	nanogram
NJDEP	New Jersey Department of Environmental Protection
NOAA	National Oceanic and Atmospheric Administration
NOAEL	No Observed Adverse Effects Level
P	Percentage of Fish in a Receptor's Diet
PAH	Polycyclic Aromatic Hydrocarbon
PCB	Polychlorinated Biphenyl
pg	picogram
PRG	Preliminary Remediation Goal
RfD	Oral Reference Dose
RME	Reasonably Maximum Exposure
SFF	Site Foraging Frequency
TCDD	Tetrachlorodibenzodioxin
TEQ	Toxic Equivalency Quotient
THQ	Target Hazard Quotient
Total DDx	Sum of DDD, DDE, and DDT Isomers
TR	Target Risk
TRV	Toxicity Reference Value
µg	microgram

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USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service

R2-0009221

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Appendix C

Risk Assessment

R2-0009226

APPENDIX C
LOWER PASSAIC RIVER RESTORATION PROJECT
DRAFT FOCUSED FEASIBILITY STUDY RISK ASSESSMENT

Submitted to

U.S. Environmental Protection Agency,
Region 2

and

U.S. Army Corps of Engineers,
Kansas City District

June 1, 2007

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ACRONYMS

ADD	Average daily dose
AE	Assessment endpoint
AE/WP	American eel and white perch
AT	Averaging time
ATSDR	Agency for Toxic Substances and Disease Registry
BAF	Bioaccumulation factor
BSAF	Biota sediment accumulation factor
BW	Body weight
CalEPA	California Environmental Protection Agency
CARP	Contaminant Assessment and Reduction Program
CBR	Critical body residue
CL	Cooking loss
CLH	Chemical Land Holdings, Inc.
COPC	Contaminant of potential concern
COPEC	Contaminant of potential ecological concern
CSF	Cancer slope factor
CSM	Conceptual site model
C_t	Biota tissue concentration
CTE	Central tendency exposure
DDD	Dichlorodiphenyldichloroethane
DDE	Dichlorodiphenyldichloroethylene
DDT	Dichlorodiphenyltrichloroethane
DDx	Sum of DDD, DDE, and DDT
D/F	Dioxin/furan
DSRT	Division of Science, Research and Technology (NJDEP)
DQO	Data quality objective
Eco-SSL	Ecological Soil Screening Level
ED	Exposure duration
EF	Exposure frequency
EFH	Exposure Factors Handbook
EPC	Exposure point concentration
ER-L	Effects Range-Low
ERA	Ecological risk assessment
ESP	Ecological Sampling Program
FDA	Food and Drug Administration
FFS	Focused Feasibility Study
FI	Fraction ingested from contaminated source
g	Gram
HEAST	Health Effects Assessment Summary Tables
Hg	Mercury
HHRA	Human health risk assessment
HI	Hazard index

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HPAH	High molecular weight PAH
HQ	Hazard quotient
IR	Ingestion rate
IRIS	Integrated Risk Information System
kg	Kilogram
LADD	Lifetime average daily dose
LOAEL	Lowest observed-adverse-effects level
LOED	Lowest observed effect dose
LPAH	Low molecular weight PAH
LPRRP	Lower Passaic River Restoration Project
µg/g	Micrograms per gram (equivalent to parts per million)
µg/kg	Micrograms per kilogram
MDL	Method detection limit
mg	Milligram
mg/kg	Milligrams per kilogram
mg/kg-day	Milligrams per kilogram of body weight per day
MRL	Minimal risk level
NA	Not applicable
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NHANES	National Health and Nutrition Examination Survey
NJ	New Jersey
NJDEP	New Jersey Department of Environmental Protection
NOAA	National Oceanic and Atmospheric Administration
NOAEL	No observed-adverse-effects level
NS&T	National Status and Trends
NY	New York
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
OSWER	Office of Solid Waste and Emergency Response (USEPA)
PAH	Polycyclic aromatic hydrocarbon
PAR	Pathways Analysis Report
PCB	Polychlorinated biphenyl
PPRTVs	Provisional peer-reviewed toxicity value
ppm	Parts per million (equivalent to microgram per gram)
PREmis	Passaic River Estuary management information system
QAPP	Quality Assurance Project Plan
QA/QC	Quality assurance/quality control
RAGS	Risk Assessment Guidance for Superfund
RfD	Reference dose
RI/FS	Remedial Investigation/Feasibility Study
RM	River mile
RME	Reasonable maximum exposure

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SSD	Species sensitive distributions
SUF	Site use factor
SVOC	Semivolatile organic compound
TCDD	Tetrachlorodibenzo-p-dioxin
TCDF	Tetrachlorodibenzofuran
TEF	Toxic equivalency factor
TEQ	Toxic equivalency
TSI	Tierra Solutions, Inc.
TRV	Toxicity reference value
UCL	Upper confidence limit of the mean
USACE	Unites States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
VOC	Volatile organic compound
WHO	World Health Organization

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1.0 INTRODUCTION

This document presents the human health and ecological risk assessments to support the Focused Feasibility Study (FFS) for the Lower Passaic River Restoration Project (LPRRP). The FFS was undertaken to evaluate the need for, and feasibility of implementing an early action to control the sediments of the lower 8 miles of the Passaic River. Those sediments were identified as a major source of contamination to the 17-mile tidal portion of the Passaic River during a comprehensive study, which is still on-going. The FFS evaluates alternative remedial actions within three target areas for the lower 8 miles of the Lower Passaic River. These target areas have been defined based on sediment and bathymetric data collection and evaluation.

Human health and ecological risk assessments are designed to aid in risk management decisions regarding the actions necessary to address the hazardous substances at a site. This document assesses current risk to assist the United States Environmental Protection Agency (USEPA) in evaluating the need for undertaking early action in the sediments of the lower 8 miles of the Passaic River. The overall process for assessing risk is as follows: (1) risks associated with current conditions are estimated, and (2) risks under current conditions are then compared to future risks estimated to remain after remediation of specific target areas. The comparison of current and future conditions was used to evaluate the benefits of remediating each of the three target areas. This comparison ultimately determines the areal extent of the active alternatives developed for the FFS.

As part of the FFS, this document follows a screening level risk assessment approach based on USEPA Risk Assessment Guidance for Superfund (RAGS) (1989; 1997a; 1998). It relies on data and analytical tools that existed at the time that the FFS was undertaken, within the on-going, comprehensive 17-mile study of the Lower Passaic River. It provides the information necessary to develop a remedial action prior to the completion of a baseline risk assessment and a full Remedial Investigation/Feasibility Study (RI/FS). This sort of phased approach to evaluating early action during an on-going RI/FS is consistent with USEPA's Contaminated Sediment Remediation Guidance for Hazardous Waste Sites (USEPA 2005a). As the comprehensive 17-mile study proceeds to conclusion, a baseline human health risk assessment (HHRA) and ecological risk assessment (ERA) will be developed, based on the full range of data and analytical tools expected to be completed for the comprehensive study, to support a final remedial decision for the 17 miles of the Lower Passaic River.

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2.0 COMPILATION OF AVAILABLE DATA

The Lower Passaic River has been extensively sampled since the 1990s, and those environmental sampling programs conducted since 1993 that were included in this analysis are summarized in Table 2-1. Analytical chemistry data derived from these studies were obtained from www.ourPassaic.org, which is a database compiled by various groups (*e.g.*, USEPA, Tierra Solutions, Inc. [TSI], New Jersey Department of Environmental Protection [NJDEP]), as well as from the Contaminant Assessment and Reduction Program (CARP). Data were used to assess current and potential future cancer risks and noncancer health hazards to human and ecological receptors. Analytical data from fish and blue crab tissue samples were used to estimate current cancer risks and noncancer health hazards; analytical data from surface sediment samples were used to estimate future biota concentrations for use in evaluating potential future cancer risks and noncancer health hazards associated with the site following remedial action. Much of the analytical data was collected in the 1990s and may not represent current surface conditions in the river. Therefore, for this assessment, only surface sediment and tissue data collected from 1993 to the present were used to better represent current conditions. For each dataset, the top (surface) sediment interval was selected. In some cases, the top interval spanned from 0-6 inches, in other cases, it spanned from 0-1 foot, and the largest interval was from 0-2.3 feet (Table 2-1).

It should be noted that, based on the objectives of the risk assessments and the schedule for implementing risk management decisions, the analytical data used in the human heath and ecological risk assessments did not undergo a full data usability assessment in accordance with guidance from USEPA (1992). However, the majority of the data were collected under USEPA assurance/quality control (QA/QC) Quality Assurance Project Plans (QAPP). Appropriate QA/QC procedures appear to have been conducted on most datasets, and the data are deemed to be of sufficient quality to perform these risk assessments. It is anticipated that a complete evaluation of the usability of the risk assessment datasets will be conducted in preparation for the baseline human health and ecological risk assessments as part of the 17-mile Lower Passaic River RI/FS. Table 2-1 provides a detailed list of the datasets used for this task and their QA/QC procedures, if available.

The sampling locations for sediment are depicted in Figure 2-1; sampling locations for biota are depicted in Figure 2-2; the full dataset is provided in Attachment 1.

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Table 2-1. Summary of Data Used for the Risk Assessments.

Name of Study in Database	Depth (ft)	Number of Samples	River Mile Range	QA/QC Procedures[a]
Sediment				
PASSAIC 1994 Surficial Sediment Investigation[b]	0.5	40	3.5-6.9	Quantitative QA/QC[b]
PASSAIC 1995 USACE Minish Park Investigation	2	2	3.9-5.4	Not Specified
PASSAIC 1995 Sediment Grab Sampling Program	0.5	7	2.5-2.7	USEPA Region 2 Validation; full validation
PASSAIC 1995 RI Sampling Program	0.5	195	1.0-6.7	USEPA Region 2 Validation; full validation
PASSAIC 1997 Outfall Sampling Program	0.5	3	1.2-5.7	Quantitative QA/QC[b]
PASSAIC 1999 Sediment Sampling Program	1.0	3	0.7-6.2	Quantitative QA/QC[b]
PASSAIC 1999 Late Summer/Early Fall Ecological Sampling Program (ESP)[d]	0.5	48	1.0-6.9	USEPA Region 2 Validation
PASSAIC 1999/2000 Minish Park Monitoring Program	0.5	9	5.0-5.1	Quantitative QA/QC[b]
PASSAIC 2000 Spring ESP	0.5	17	1.0-6.8	USEPA Region 2 Validation
Pirnie Study (2005) HIGH RES CORE	0.6	44	1.4-3.5	USEPA Region 2 Validation or Third Party Full Data Validation[c]
Pirnie Study (2006) LOW RES CORE	2.3	31	2.9-6.7	USEPA Region 2 Validation or Third Party Full Data Validation[c]
NOAA National Status and Trends (NS&T) Hudson-Raritan Phase II- 1993	0	1	7.37	Quantitative QA/QC[b]
Pirnie Study Dredge Pilot Coring Program 2004 – Earth Tech	1.0	15	2.8-2.9	Third Party Full and Partial Data Validation[c]

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Table 2-1 Summary of Data Used for the Risk Assessments (continued).

Name of Study in Database	Depth (ft)	Number of Samples	River Mile Range	QA/QC Procedures[a]
Tissue				
NYSDEC 1993	NA	8	0.1	Information not available
PASSAIC 1995 Biological Sampling Program	NA	13	1.1-4.5	USEPA Region 2 Validation
PASSAIC 1999 Late Summer/Early Fall ESP	NA	267	1.0-6.9	USEPA Region 2 Validation
PASSAIC 2000 Spring ESP	NA	80	1.0-6.8	USEPA Region 2 Validation
PASSAIC 2001 RI Supplemental ESP Biota Sampling Program	NA	14	6.0-6.9	USEPA Region 2 Validation
CARP Datasets 2000-2004 Harbor Crustacean Collection Harbor Fish Collection	NA	67	2.6-10.0	Partial Third Party Validation[e]

a. QA/QC procedures for Passaic River Estuary management information system (PREmis) datasets as described by TSI (2004) in Table 3-49 (Sediment) and Tables 3-53, 3-65 (Tissue).

b. Quantitative QA/QC includes the analysis of field and laboratory duplicates, rinsate blanks, matrix spike/matrix spike duplicates, and other quantitative measures of precision and accuracy but without specification of implementing USEPA Region 2 data validation procedures.

c. Data validation activities were performed by Severn-Trent Laboratories in accordance with the USEPA Method, the Laboratories' Standard Operating Procedure, and the Malcolm Pirnie, Inc. Statement of Work.

d. Includes the 1999-2001 analytical data, in accordance with the work plan published in 1999 by Chemical Land Holdings, Inc. (CLH).

e. In addition to internal QA/QC procedures, partial datasets were verified by Booz Allen Hamilton.

NA = Not Applicable
USACE = United States Army Corps of Engineers
RI = Remedial Investigation
ESP = Ecological Sampling Program
CARP = Contaminant Assessment and Reduction Program
NYSDEC = New York State Department of Environmental Conservation

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Figure 2-1. Sediment Sampling Locations along the Lower 8 Miles of the Passaic River.

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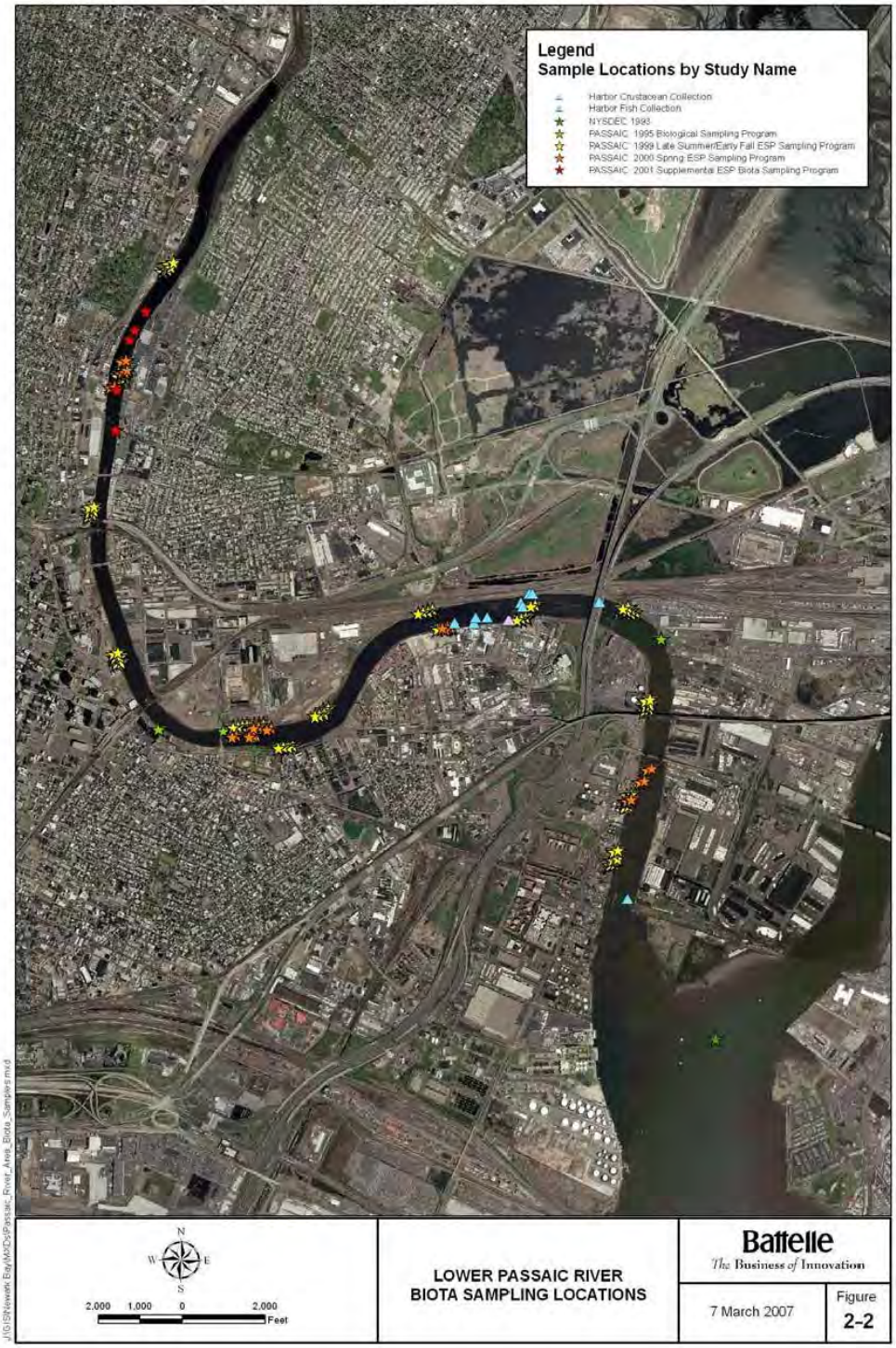

Figure 2-2. Biota Sampling Locations along the Lower 8 Miles of the Passaic River.

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For this biological and sediment data review, the following chemical classes were examined:

- Polychlorinated dibenzodioxins (dioxins);
- Polychlorinated dibenzofurans (furans);
- Polychlorinated biphenyl (PCB) congeners;
- PCB Aroclors;
- Pesticides;
- Polycyclic aromatic hydrocarbon (PAH); and,
- Metals.

In addition, the following Toxic Equivalency (TEQ) calculations were performed for dioxins/furans (D/F) and coplanar (dioxin-like) PCB congeners:

- Tetrachlorodibenzo-p-dioxin (TCDD) TEQ for D/F – sum of the products of the congener concentration and congener-specific Toxic Equivalency Factors[1] (TEF) for all D/F congeners (Table 2-2);
- TCDD TEQ for PCB coplanar congeners – sum of the products of the congener concentration and their TEFs (Table 2-2) for 12 coplanar PCB compounds (*i.e.*, the World Health Organization [WHO] congeners); and,
- Total TCDD TEQ – the sum of the above two results.

The tissue data were obtained from the database prepared for the Geochemical Evaluation Biota Plots (Malcolm Pirnie, 2006). Non-detects (data qualifiers including "U" or as "ND") were reported as one-half the detection limit value for all database exports including sums and individual parameters. New queries were added to calculate the TEQ values for D/F, PCB congeners, and total chlordane. Table 2-3 provides a summary of the matrices sampled for crab and fish tissue. For crab, all tissue matrices were used in the dataset for the human health and ecological risk assessments. For fish, all tissue matrices listed in Table 2-3 were used to compile the data for both the human health and ecological assessments. Information regarding the specific characteristics of crab and fish samples was missing from the database, including age, length, weight, and sex of the fish. This lack of information could be a potential source of uncertainty when estimating exposure concentrations and determining whether the fish or crab was an appropriate size for human consumption.

Sediment data for the various studies were downloaded from PREmis and compiled into a Microsoft Access database. For the purposes of the COPEC screening process (Attachment 2), non-detected sediment data with "U" data qualifiers were assigned a value equal to the reported detection limit, and results reported as a zero value with a "ND" (non-detected) qualifier were excluded from the database query outputs. This approach resulted in the selection of compounds for consideration in the FFS that was both conservative and convenient. However, non-detected values with "U" qualifiers were treated somewhat differently in the human health and ecological risk assessments; non-detect values were set to one-half of the reported detection limits. This methodology was consistent with available risk assessment guidance. However, as discussed further in the uncertainty analysis section of this document (Section 5.4), it is recognized that this method may overestimate the concentration of total PCB Aroclors.

[1] A TEF is a measure of the relative potency of a compound to cause a particular toxic or biological effect relative to 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (TCDD). By convention, TCDD is assigned a TEF of 1.0, and the TEFs for other compounds with dioxin-like effects range from 0 to 1. When TEFs are derived based on the relative binding affinity to the aryl hydrocarbon (Ah) receptor or induction of cytochrome P4501A1, it is assumed that these biochemical responses correlate with toxicologically important effects (Van den Berg *et al*., 1998).

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Data queries were performed using Microsoft Access for each parameter group of interest. The individual analytical results were summed in Access for the following chemicals: Total DDx (sum of dichlorodiphenyldichloroethane (DDD), dichlorodiphenyldichloroethylene (DDE), and dichlorodiphenyltrichloroethane (DDT), and PCB Aroclors. The data extracted from the project database did not always include all parameters used for the summation (*e.g.*, there were not always data for all seven PCB Aroclors). The reason for these inconsistencies was not investigated, and the summations were calculated based only on the available parameters.

TEQ values for D/F and PCB congeners were calculated using congener-specific TEFs (see Table 2-2). The TEFs were calculated separately for each individual parameter and summed to derive the TEQ value.

Table 2-2. TEQ Factors for Dioxin/Furans and Dioxin-like PCB Congeners.

Congener	TEF			
	Mammal[a]	Mammal[b]	Fish[a]	Bird[a]
Dioxins/Furans				
2,3,7,8- TCDD	1	1	1	1
1,2,3,7,8-PeCDD	1	1	1	1
1,2,3,4,7,8-HxCDD	0.1	0.1	0.5	0.05
1,2,3,6,7,8-HxCDD	0.1	0.1	0.01	0.01
1,2,3,7,8,9-HxCDD	0.1	0.1	0.01	0.1
1,2,3,4,6,7,8-HpCDD	0.01	0.01	0.001	0.001
OCDD	0.0001	0.0003	0.0001	0.0001
2,3,7,8-TCDF	0.1	0.1	0.05	1
1,2,3,7,8-PeCDF	0.05	0.03	0.05	0.1
2,3,4,7,8-PeCDF	0.5	0.3	0.5	1
1,2,3,4,7,8-HxCDF	0.1	0.1	0.1	0.1
1,2,3,6,7,8-HxCDF	0.1	0.1	0.1	0.1
1,2,3,7,8,9-HxCDF	0.1	0.1	0.1	0.1
2,3,4,6,7,8-HxCDF	0.1	0.1	0.1	0.1
1,2,3,4,6,7,8-HpCDF	0.01	0.01	0.01	0.01
1,2,3,4,7,8,9-HpCDF	0.01	0.01	0.01	0.01
OCDF	0.0001	0.0003	0.0001	0.0001
PCB Congeners				
3,3',4,4'-Tetrachlorobiphenyl (77)	0.0001	0.0001	0.0001	0.05
3,4,4',5-Tetrachlorobiphenyl (81)	0.0001	0.0003	0.0005	0.1
3,3',4,4',5-Pentachlorobiphenyl (126)	0.1	0.1	0.005	0.1
3,3',4,4',5,5'-Hexachlorobiphenyl (169)	0.01	0.03	0.00005	0.001
2,3,3',4,4'-Pentachlorobiphenyl (105)	0.0001	0.00003	0.000005	0.0001
2,3,4,4',5-Pentachlorobiphenyl (114)	0.0005	0.00003	0.000005	0.0001
2,3',4,4',5-Pentachlorobiphenyl (118)	0.0001	0.00003	0.000005	0.00001
2',3,4,4',5-Pentachlorobiphenyl (123)	0.0001	0.00003	0.000005	0.00001
2,3,3',4,4',5-Hexachlorobiphenyl (156)	0.0005	0.00003	0.000005	0.0001
2,3,3',4,4',5'-Hexachlorobiphenyl (157)	0.0005	0.00003	0.000005	0.0001
2,3',4,4',5,5'-Hexachlorobiphenyl (167)	0.00001	0.00003	0.000005	0.00001
2,3,3',4,4',5,5'-Heptachlorobiphenyl (189)	0.0001	0.00003	0.000005	0.00001

Source: [a.] Van den Berg *et al.*, 1998

[b.] Van den Berg *et al.*, 2006.

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Table 2-3. Sample Matrices for Crab and Fish Tissue.

Sample Type	Matrix[a]
Crab	All edible tissue
	Hepatopancreas
	Muscle
	Tissue
Fish	Whole organism
	Tissue
	Whole organism without the head and viscera

[a.] Identification of sample matrix as provided with dataset; no additional descriptive information available.

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3.0 IDENTIFICATION OF CONTAMINANTS OF POTENTIAL CONCERN (COPC)

Conclusions presented in the Pathways Analysis Report (PAR) (Battelle, 2006a) identified several classes of COPCs, including various metals, pesticides, PAHs, D/F, PCBs, and volatile and semivolatile organic compounds (VOC/SVOC). For human health, no additional screening for COPCs was performed to support the FFS; rather, a subset of the COPCs identified in the PAR was used to capture the primary risk drivers and carried through the risk assessment process. For the ecological assessment, a more refined screening analysis of COPCs was conducted for the FFS. The screening process used to develop a refined list of COPCs is presented in Attachment 2. It should be noted that the list of COPCs/COPECs is only for the purposes of evaluating the need for an early action source control and is not meant to be comprehensive. The larger set of COPCs/COPECs identified in the PAR will be assessed as part of the RI/FS process.

<u>COPCs for the Human Health Risk Assessment</u>

For human health, COPCs evaluated in the FFS represent those compounds that are considered to be most bioaccumulative, most persistent in the environment, and relatively toxic to human and ecological receptors. In addition, these COPCs represent the contaminants that have triggered states to issue fish and shellfish consumption advisories or bans (USEPA, 2000a; USEPA, 2005b). USEPA (2005b) reports that advisories have been issued in the United States for 36 chemical contaminants; however, 98% of these advisories in effect in 2004 involved five bioaccumulative chemicals: mercury, PCBs, chlordane, dioxins, and DDT. The larger set of COPCs identified in the PAR will be assessed as part of the RI/FS process. Human health COPCs identified for this assessment are summarized in Table 3-1 and include the following:

- Dioxins/furans (D/F) (as TCDD TEQ);
- Total PCBs (sum Aroclors);
- PCBs (12 dioxin-like congeners as TCDD TEQ);
- DDE, DDD, and DDT;
- Dieldrin;
- Total chlordane; and,
- Mercury (including methyl mercury).

Data for total mercury and methyl mercury were assumed to be equivalent and treated as if all were methyl mercury. Once mercury is released to the environment, it can be converted to a biologically toxic form of methyl mercury. Methyl mercury is of particular concern because it readily crosses biological membranes and can accumulate and biomagnify up the food chain (Brightbill *et al*., 2004). Most of the mercury consumed in fish or other seafood is the highly absorbable methyl mercury form (Agency for Toxic Substances and Disease Registry [ATSDR], 1999). USEPA (2000a) recognizes that most mercury in fish and shellfish tissue is present as methyl mercury. Various studies, as summarized in USEPA (2000a), report that mercury concentrations are greater in upper-trophic-level fish species. Studies conducted to assess the correlation between total mercury and methyl mercury in fish tissue (Grieb *et al*., 1990; Bloom, 1992; and Kannan *et al*., 1998) reported that contributions of methyl mercury to total mercury ranged between 83% and 99%. Because of the relatively high analytical cost for methyl mercury, USEPA recommends determining total mercury in tissue, then conservatively assuming all of the mercury present is methyl mercury. Due to a lack of methyl mercury analytical results in the tissue dataset used for this HHRA, results for elemental mercury (the form of mercury for which most of the data were available) were used as a surrogate for methyl mercury. Therefore, exposure point

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concentrations (EPC) derived using mercury data may slightly overestimate the methyl mercury concentration.

Table 3-1. Summary of COPCs (Human Health Risk Assessment) and COPECs (Ecological Risk Assessment).

Analyte	Human Health COPC	Ecological COPEC
Inorganic Compounds		
Copper		√
Lead		√
Mercury	√	√
Semivolatile Organic Compounds (PAHs)		
LPAHs		√
HPAHs		√
Polychlorinated biphenyls (PCBs)		
Total PCBs (sum Aroclors)	√	√
Pesticides/Herbicides		
Chlordane	√	
Dieldrin	√	√
DDE	√	
DDD	√	
DDT	√	
Total DDx		√
Dioxins and Furans (D/F)		
TCDD TEQ (D/F)	√	√
TCDD TEQ (PCBs)	√	√
TCDD TEQ (Total)	√	√

PAHs were not selected as COPCs for human health. Although potentially toxic to certain fish species, PAHs are not expected to bioaccumulate in the tissues of aquatic organisms because fish and most crustaceans have the ability to metabolize PAHs and eliminate the breakdown products in feces and urine (ATSDR, 1995). Copper and lead were also not selected as COPCs for human health assessment. The compounds selected were intended to represent the most bioaccumulative, persistent, and relatively toxic compounds to human receptors and, therefore, contribute the most to potential risks. Lead and copper will be included as part of the complete set of COPCs assessed as part of the RI/FS process for the entire 17-mile stretch of the Lower Passaic River.

COPECs for Ecological Risk Assessment

For the ERA in support of the FFS, sediment contaminants of potential ecological concern (COPEC) were identified based on a three-tier screening process that included the following factors:

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1. Bioaccumulation screen (indirect toxicological effects to wildlife through the food chain);
2. Essential nutrient screen; and,
3. Effects value screen (direct toxicological effects to benthic invertebrates).

The screening process is described in detail in Attachment 2. Ten COPECs (see Table 3-1) were identified as comprising the largest contribution of total potential risk and were carried through this assessment. These compounds had hazard quotients (HQ) that exceeded 100 for inorganic compounds and greater than 1,000 for organic compounds. Ecological COPECs identified for this assessment include the following:

- Dioxins/furans (D/F) (as TCDD TEQ);
- PCB congeners (12 dioxin-like congeners as TCDD TEQ);
- Total PCB (sum Aroclors);
- Total DDx (sum of DDE, DDD, and DDT isomers);
- Dieldrin;
- Low molecular weight PAHs (LPAH);
- High molecular weight PAHs (HPAH);
- Copper;
- Lead; and,
- Mercury (including methyl mercury).

As done in the human health assessment, data for total mercury and methyl mercury were assumed to be equivalent and treated as if all were methyl mercury.

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4.0 HUMAN HEALTH AND ECOLOGICAL CONCEPTUAL SITE MODELS

An overall project conceptual site model (CSM) is a multidisciplinary tool that serves a critical role in risk assessment, numerical modeling development, project and sample planning, decision making, and ultimately in developing a remedial strategy. The CSM is developed during the first step of the data quality objective (DQO) process (USEPA, 2006) and continues to evolve throughout a project as historical and recently collected data are evaluated, DQOs are updated, and risk assessments are refined. Typical risk assessment components of a CSM include the following:

- Potential source of contamination;
- Potentially contaminated media and types of contaminants;
- Contaminant fate and transport mechanisms and migration pathways;
- Potential exposure pathways; and,
- Potential human and ecological receptors.

The CSM for the Lower Passaic River includes the lower 17 miles of the river, from the Dundee Dam to the confluence with Newark Bay (see Appendix A of the FFS). The river has been divided into three sections, based on water salinity measurements and geomorphology. The freshwater section, with salinity values less than 0.5 parts per thousand (‰) extends from the Dundee Dam to river mile (RM) 9. The transitional section represents the portion between the freshwater and brackish sections, where the salt wedge typically advances under high-tide conditions. Here, water conditions can range from slightly brackish (0.5 to 5.0 ‰) to moderately brackish (5.0 to 18 ‰). The brackish section has almost always moderately brackish conditions, with salinities ranging from 5 to 18 ‰. This assessment focuses on the lower and brackish sections of the river, extending up to RM 8.

This section provides a summary of the CSM. Appendix A- Conceptual Site Model, as well as previous reports (*i.e.*, PAR Battelle 2006a) contains more detailed information. Appendix A contains detailed sections regarding the sources and releases of chemicals, source area analysis, and environmental fate and transport mechanisms. The PAR provides details regarding the selection of COPCs, potential receptors, and potential exposure pathways. Information provided here addresses the nature and extent of the COPCs and the potential for human and ecological exposures. Further development of the CSM is anticipated as part of the RI/FS process for the entire Lower Passaic River.

4.1 Environmental Setting

The Lower Passaic River has been used as a major means of conveyance for industrial and municipal discharges from the middle of the 19th century to the present. Together, these waste streams have delivered a number of contaminants, including 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD), PAHs, PCBs, DDT, mercury, lead, and other contaminants, into the river. The river has undergone major physical changes over this period as well. For instance, several large dredging projects were undertaken at the beginning of the 20th century to create a ship channel to RM 15. However, since the 1940s, little maintenance dredging above RM 2 has occurred and the channel has been extensively filled in, particularly between RM 2 and RM 8. The coincidence of chemical disposal in the river along with the construction, and subsequent limited maintenance, of the navigation channel created an ideal situation for the accumulation of contaminated sediments. As a result, the river has accumulated substantial sediment beds measuring 15 feet thick or more in some areas. These thick beds exist primarily below RM 8, where the wider river channel has permitted rapid sediment accumulation.

Despite the prevalence of thick sediment deposits downstream of RM 8, some of the sediments in this region are unstable, resulting in several erosional areas throughout the lower 8 miles of the river. Some or

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all of these erosional areas are believed to be responsible for the continued release of contaminants from the river bed. A detailed examination of sediment deposition rates between RM 0.9 and RM 7 indicates a high degree of spatial heterogeneity, with local rates varying from about -6 inches/year of erosion to about +8 inches/year of deposition. Historical deposition rates were probably higher than current rates because of the more extensive salt intrusion present immediately after the initial channel dredging, which enhanced trapping of suspended matter. Based on solids balance considerations, current head-of-tide solids load to the Lower Passaic River is greater than the annual average rate of accumulation in the river. However, the historical rates of sediment accumulation in the Lower Passaic River were probably too large to be sustained solely by the Passaic's head-of-tide solids loads, suggesting that a net solids transport from Newark Bay supplied the additional solids.

The chemical contamination associated with the Lower Passaic River is largely driven by the contaminant burdens contained within the sediments, particularly for 2,3,7,8-TCDD. While ongoing external inputs may exist, the concentrations within the sediments are responsible for much of the contamination within the water column. In fact, the legacy of contamination in the sediments probably extends back at least to the mid-19th century. The oldest contaminants found in the sediments are PAH compounds, cadmium, mercury, and lead, which probably pre-date the turn of the 20th century. Following these contaminants are, in order of appearance in the river, DDT, 2,3,7,8-TCDD, and PCBs. Other contaminants, such as arsenic, chromium, and copper, are also present in the sediment record. The available evidence indicates that several of these compounds (*i.e.*, PAHs, PCBs, mercury, and lead) at least partially originated above the head-of-tide and Dundee Dam. Others, like 2,3,7,8-TCDD and DDT, are nearly exclusively the result of discharges to the Lower Passaic River.

One important observation from the extent of chemical contamination in the Lower Passaic River is the extent of tidal mixing throughout the river. Recently deposited sediments anywhere within the Lower Passaic River have similar concentrations of contaminants, which indicate that sediments are well homogenized prior to deposition. Thus, the presence or absence of an interval of high concentration within the sediments at a given location is a function of the depositional history at that location and is generally not controlled by proximity to source. As a result, thick sequences of contaminated sediments will tend to have similar inventories of contaminants regardless of their location in the river. The coring data that form the basis for estimating these inventories show a high degree of local spatial heterogeneity, indicating that localized areas of relatively higher concentrations typically described as "hot spots" do not exist. Instead, "hot" regions of the river typically exist on the scale of a mile or more, nearly bank to bank in lateral extent. This understanding underlies the delineation of remedial target areas used as a basis to develop remedial alternatives. This conclusion does not, however, diminish the significance of potential historic and/or current point sources as the origin of contaminant inventory in the Lower Passaic River. Estuarine mechanisms are believed to quickly render contaminant concentration gradients indistinct on the scales examined here. It is possible that environmental sampling on a finer scale (on the order of less than a quarter mile) would identify localized gradients near prominent historical and/or current source areas.

The three target areas for remediation were identified using geochemical evaluations, analytical results from the low resolution cores, and evaluations of the bathymetric data. As a result of these analyses, candidate target areas for remediation are identified as follows:

- **Primary erosional zone:** Locations adjacent to erosional zones between RM 3.45 and RM 5.05;
- **Primary inventory zone:** Locations that are consistently depositional with high contaminant inventory between RM 2.4 and RM 3.3; and,
- **Area of focus:** The entire bank-to-bank river area from RM 0 to RM 8, including both erosional and depositional areas.

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4.2 Exposure Assessment

The objective of the exposure assessment is to estimate the magnitude, frequency, duration, and routes of current and reasonably anticipated future exposure to COPCs associated with the site. The exposure assessment is based on the receptor scenarios described in the CSMs that define the conditions of exposure to site-related COPCs.

An exposure pathway defines the most probable pathway in which a receptor may come in contact with a contaminated medium. For an exposure pathway to be complete, the following four elements must be present

1. A source and mechanism of chemical release;
2. A retention or transport medium;
3. A point of contact between the receptor and the medium; and,
4. A route of exposure for the potential receptor at the contact point.

There must be a complete exposure pathway from the source of chemicals in the environment (*i.e.*, from sediment or biota tissue) to receptors for chemical intake to occur. If at least one exposure pathway is complete, chemical intake may occur and adverse effects may be associated with site-related COPCs.

The complete exposure pathways identified in the PAR (Battelle, 2006a) are:

- Direct contact with surface water and/or sediment;
- Inhalation, incidental ingestion of sediment and/or surface water; and,
- Ingestion of fish/shellfish.

Individual CSMs were developed for the human health and ecological risk assessments to define the exposure pathways for each assessment. Summaries of each of the relevant pathways with respect to human and ecological health are provided in the following sections.

4.2.1 Human Exposures

Currently, the banks of the Lower Passaic River are extensively developed and surrounded by a mixture of residential, commercial, and industrial activities. Intensive commercial and industrial uses occur in the area due to a highly developed transportation infrastructure that includes highway, railway, and marine services. Individuals are known to catch fish and crab along the river banks and from docks and bulkheads (May and Burger, 1996; Burger *et al*., 1999; Kirk-Pflugh *et al.*, 1999). In addition, several rowing clubs engage in crew and other boating activities for adults and children, and a few parks, docks, and mudflat areas are used by residents and visitors for recreational purposes. Currently, there are only a few parks located along the river; however, future plans for the area include development of additional parks, which may potentially increase the availability of the areas along the river for recreational uses by local residents and visitors. Based on this information and ongoing initiatives to restore the Passaic River, it was assumed that exposure to contaminants in the river would be associated with current recreational activities such as swimming, wading, fishing, crabbing, and boating. Human receptors identified as engaging in these activities include a Recreational User and an Angler/Sportsman. In addition, a transient community has occasionally constructed temporary housing along the banks of the river. There is limited information regarding the length of their occupancy and their activities while on the river; however, a residential scenario (homeless resident) was also included in the CSM to address potential exposures to this community. The receptors and exposure scenarios associated with future use are not expected to differ significantly from those being evaluated under the current use scenarios. A summary of each of these receptors and the complete exposure pathways associated with each is provided below and depicted on Figure 4-1.

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Angler/Sportsman: The angler/sportsman is defined as an adult individual catching and consuming a variety of fish and blue crab from the river and surrounding areas. In addition, the possibility that individuals might also catch and consume other species such as waterfowl, turtles, or frogs from the river is considered. However, consumption of other species is speculative at this time, as there are no available historical data on chemical concentrations in the tissues of these organisms. The collection and consumption of fish and shellfish from the Passaic River has been well documented (Belton *et al*., 1985; May and Burger, 1996; NJDEP, 2002); therefore, it is clear that this exposure pathway is complete for the angler/sportsman.

It is assumed that an adult angler/sportsman shares his or her catch with an adolescent (age 10 to 18 years) and a child (age 0 to 6 years) family member. Evaluation of subsistence fishing is not proposed in this assessment because there is no evidence that any individuals rely solely on his or her daily catch. Direct exposures (*i.e.*, dermal contact and incidental ingestion) to sediments and surface water contacted during collection activities are potential pathways relevant to the adult angler/sportsman. Inhalation exposures may also occur if activities occur in areas where VOCs are present in sediments or surface water. It is assumed that any children accompanying the angler/sportsman during these activities would engage in typical recreational activities defined under the Recreational User scenario. Fish and crab species common to the lower portion of the river and species commonly caught and eaten from this area are discussed further in Section 5.1.2.

Recreational User: Recreational use along the Passaic River includes swimming, wading, and sculling. Because the likelihood of swimming in the Passaic River depends on the location along the river, it may not be appropriate to include swimming as a potential means of exposure at all locations. When swimming is feasible, exposure to chemicals in surface water and sediment is likely. Wading includes an individual walking around the mudflat areas, as well as along shallower parts of the river; thus, exposure is primarily to sediment but may include exposure to surface water as well, depending on the location on the river. Scullers, for the most part, are expected to remain in their boats except for the occasional fall into the river, where exposure to surface water and sediment is likely. For swimming and wading recreational activities, an adult, an adolescent, and a child are all potential receptors. The sculler can be an adult or an adolescent. Potential exposure pathways identified are direct contact (ingestion and dermal contact) with sediment and surface water and inhalation exposures if activities occur in mudflat areas or near sediment where VOCs are present. Ingestion of fish and other biota has been identified only for the angler because his or her exposure would be higher than that of the recreational user.

Homeless Resident: A number of transient individuals have been observed living in temporary makeshift shelters along the banks of the Passaic River. Although minimal information is available regarding the daily routine of these individuals, it is assumed that they would likely contact sediment and surface water during daily activities. Therefore, the Homeless Resident scenario evaluates the potential risks to an adult, an adolescent, and a child living along the river. The adult and child exposures are evaluated separately since it is unlikely that a child introduced to this lifestyle would continue to reside near the Passaic River into adulthood. Complete exposure pathways associated with this receptor are direct contact (ingestion and dermal contact) with sediment and surface water, ingestion of fish/other biota, and inhalation exposures if activities occur in mudflat areas or near sediment based on the presence of VOCs in the environment.

Based on the results of other Superfund HHRAs conducted for similar river sites and COPCs having the potential to bioaccumulate such as dioxins and PCBs (*e.g*., Hudson River [TAMS Consultants, Inc. and Gradient Corporation, 2000]; Housatonic River [Weston Solutions, 2005]; Centredale Manor Woonasquatucket River [USEPA Region 1, 2005]), consumption of fish and shellfish is anticipated to be associated with the highest cancer risks compared to ingestion, dermal contact, or inhalation of chemicals

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in surface water or sediment. Despite New Jersey's fish/crab consumption advisories and prohibitions on taking or attempting to take blue crabs in the Newark Bay Complex, NJDEP determined through angler surveys that fishing and crabbing continue to occur in this area (NJDEP, 1995; Kirk-Pflugh, *et al*., 1999). Therefore, for the purposes of the FFS, the adult angler/sportsman and other family members (*i.e*., adolescent and child) are the only receptors evaluated for exposure to COPCs associated with consumption of self-caught fish and blue crab. Carcinogenic risks and noncarcinogenic health hazards are estimated using exposure assumptions provided in the PAR (Battelle, 2006a) specifically for the angler/sportsman. Recreational swimming, wading, and boating are also complete exposure pathways that will be evaluated as part of the final RI/FS for the entire 17 miles of the Lower Passaic River.

4.2.2 Ecological Exposure

A wide range of ecological receptors is potentially at risk from COPECs in the Lower Passaic River, including benthic invertebrates, fish, and a variety of piscivorous or aquatic avian and mammalian predator species.

To estimate current and future risk to ecological receptors in the lower 8 miles, benthic invertebrates and two upper-trophic-level piscivorous receptors, the great blue heron and the mink, were selected to represent bird and mammal populations, respectively. These species were selected as conservative surrogates because the great blue heron is a known resident bird species that is anticipated to receive substantial exposures to contaminants which can bioaccumulate in aquatic food webs, and the mink is known to be particularly sensitive to dioxin and PCBs (Aulerich and Ringer, 1977; Aulerich *et al*., 1985; Restum *et al*., 1998; Tillet *et al*., 1966. To assess exposures to sensitive early life stages, the most sensitive life stage to dioxin-like effects (Gilbertson *et al*., 1991; USEPA, 1993b, 2003b; Hoffman *et al.*, 1996), herring gull embryo viability was also selected as an endpoint for this assessment. Mummichogs were selected as a conservative surrogate to represent the demersal forage fish. They are relatively common in the area and provide a forage food base for the upper-trophic-level wildlife species. In addition, risk to piscivorous fish (*i.e.*, predatory fish that consume smaller fish) was also evaluated using data on American eel and white perch (AE/WP) to represent the pelagic fish. The current ecological CSM for the Lower Passaic River is presented in Figure 4-2.

Sediment-probing birds, amphibians, and reptiles were not selected as receptors of concern for this assessment. Aquatic birds (*e.g.*, herring gull) and piscivorous birds (*e.g.*, great blue heron) are expected to have a higher exposure to contaminated media and are generally considered to be more sensitive to chemical contaminants than non-piscivorous birds. The presence of amphibians and reptiles is not well documented in the lower 8 miles of the Passaic River but there appears to be little viable habitat to support this ecological group. A more comprehensive analysis of the ecological receptors likely to be exposed will be conducted as part of the baseline risk assessment (BERA).

Based on the identified receptors of concern, the following assessment endpoints (AE) were identified and evaluated in the ecological risk assessment (Section 6.0):

- AE(1): Protection and maintenance (*i.e.*, survival, growth, and reproduction) of benthic invertebrate communities that serve as a forage base for fish and wildlife populations.

- AE(2): Protection and maintenance (*i.e.*, survival, growth, and reproduction) of demersal, benthivorous fish populations that serve as a forage base for fish and wildlife populations.

- AE(3): Protection and maintenance (*i.e.*, survival, growth, and reproduction) of piscivorous, or semi-piscivorous fish populations that serve as a forage base for wildlife populations or sports fishery.

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- AE(4): Protection and maintenance (*i.e.*, survival, growth, and reproduction) of piscivorous bird populations.

- AE(5): Protection and maintenance (*i.e.*, survival, growth, and reproduction) of aquatic bird populations.

- AE(6): Protection and maintenance (*i.e.*, survival, growth, and reproduction) of piscivorous mammal populations.

4.2.3 EPC Development for Comparative Risk Assessment

Estimates of chemical concentrations at points of potential exposure are necessary for evaluating chemical intakes by potentially exposed receptors. The concentrations of chemicals in the exposure medium at the exposure point are termed "exposure point concentrations" (EPC). USEPA guidance uses an average concentration to represent "a reasonable estimate of the concentration likely to be contacted over time" (USEPA, 1989) and recommends that the 95% upper confidence limit (95% UCL) on the average be used "because of the uncertainty associated with estimating the true average concentration at a site".

Calculation of the EPCs followed guidance provided by USEPA (2002a), using distribution shift tests to determine the underlying population distribution. Specifically, the ProUCL software package (version 3.0) developed by USEPA (2004) was used to determine the underlying distributions and to determine the most applicable EPC for a given contaminant based on the characteristics of the data. Depending on the statistical distributions identified by the software application, the program provides a recommended EPC. For those cases when more than one estimate of the 95% UCL is recommended by the software program, the first value is chosen as the 95% UCL. When evaluating data, one-half the detection limit (USEPA, 1989) was used to represent non-detected values. The output files for each of the COPCs for human and ecological receptors from USEPA ProUCL software are provided in Attachment 3. A summary of the EPCs for sediment and tissue[2] is provided in Table 4-1.

[2] EPCs for tissue samples were based on direct measures of concentrations in biota and were not derived from models which predict tissue concentrations from sediment. As such, it was not necessary to lipid-normalize chemical concentrations for this assessment.

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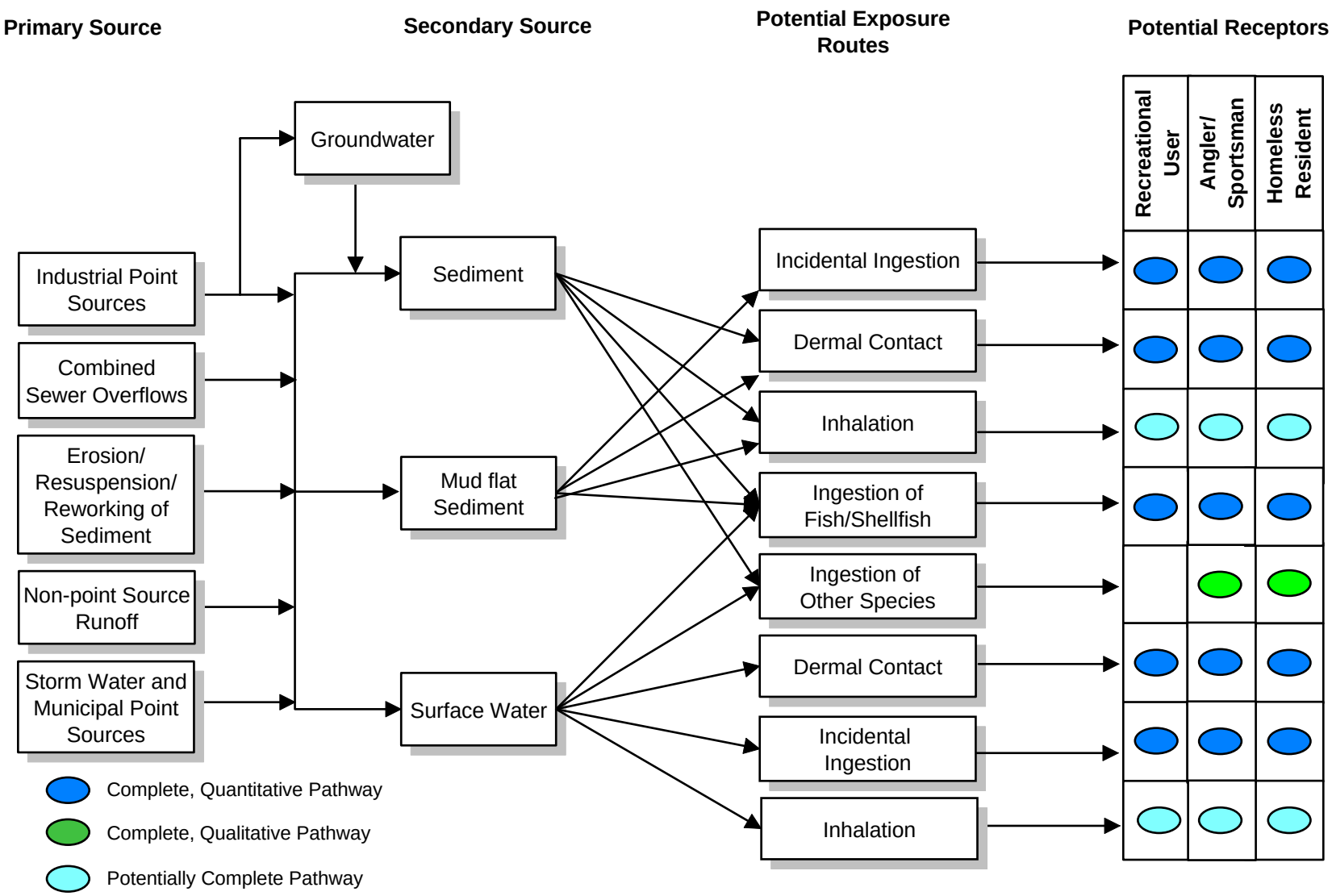

Figure 4-1. Human Health Conceptual Site Model.

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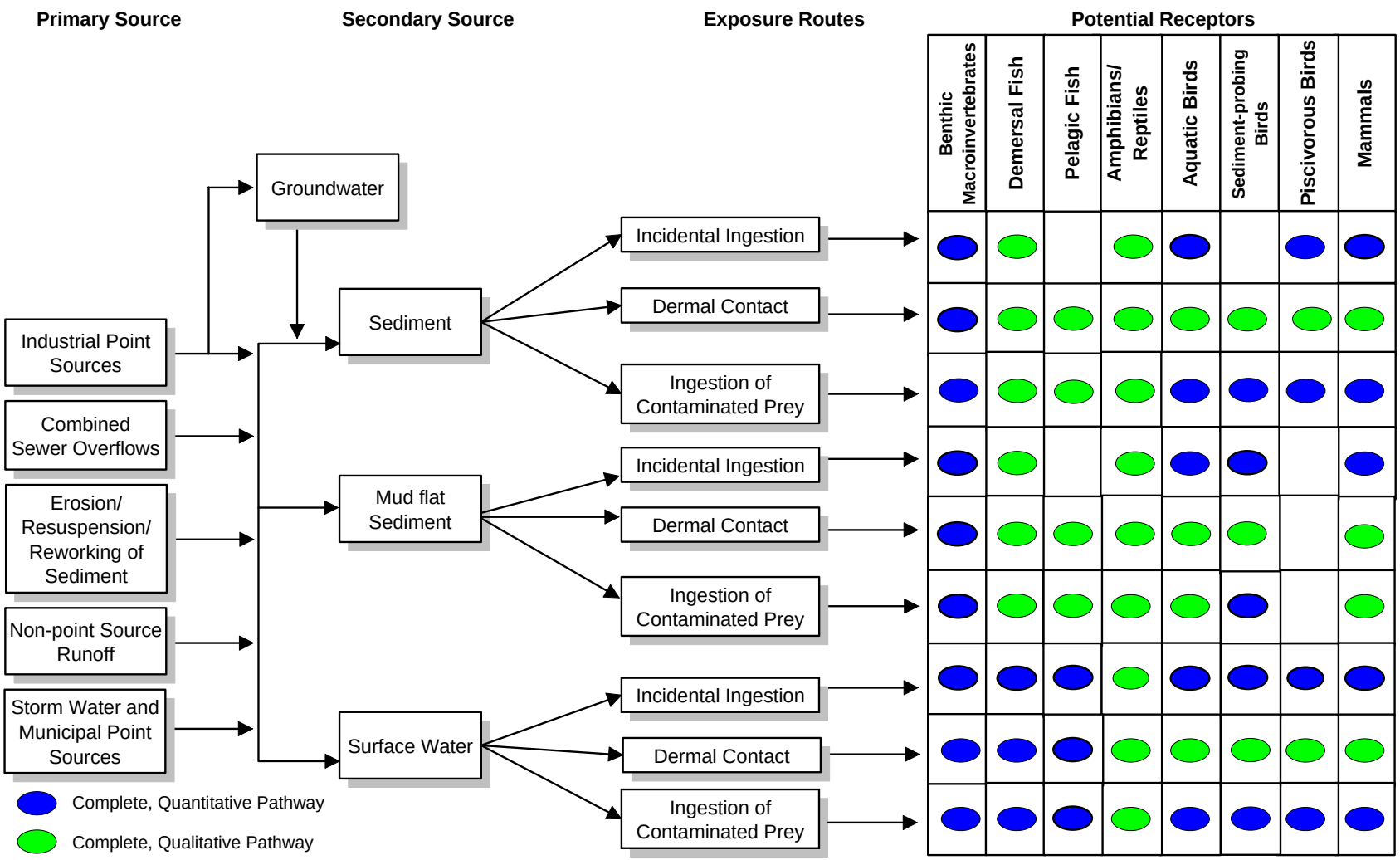

Figure 4-2. Ecological Conceptual Site Model.

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Table 4-1. EPCs Based on 95% UCLs on the Arithmetic Mean for Sediment and Tissue.

COPC		95% UCLs[a] (µg/g = ppm)				
		Sediment	AE/WP[b]	Mummichogs[c]	Crab[d]	Crab[e]
Chlordane		0.041	1.8	0.04	0.037	0.037
Copper		236	25	3.9	NA	35
Dieldrin		0.019	0.027	0.0042	0.018	0.022
Lead		375	0.63	1.2	NA	0.55
Mercury		3.6	0.35	0.041[f]	0.097	0.097
LPAH[g]		41	0.17	0.17	NA	0.15
HPAH[g]		61	0.1	0.065	NA	0.16
TCDD TEQ (D/F)	Mammal	0.0016	0.00025	0.00014	0.00022	0.00022
	Bird	0.0018	0.00028	0.00015	NA	0.00027
	Fish	0.0016	0.00025	0.00014	NA	0.00022
TCDD TEQ (PCB)	Mammal	0.000045	0.000076	0.000027	0.0004	0.00044
	Bird	0.00075	0.00086	0.0002	NA	0.0028
	Fish	0.0000038	0.0000051	0.0000017	NA	0.000025
Total PCBs[h]		1.8	3.4	0.72	5.18	5.5
DDD		0.214	0.15	NA	0.138	NA
DDE		0.094	0.303	NA	0.317	NA
DDT		0.096	0.076	NA	0.235	NA
Total DDx		0.38	0.519	0.088	NA	0.56[i]

a. 95% UCLs calculated based on the data queries from PREmis and CARP databases; samples included in the 95% UCL calculations are listed in Attachment 1. 95% UCLs on the mean calculated using USEPA ProUCL software (version 3.0); output files are included in Attachment 3.

b. EPC derived from a combination of AE/WP tissue concentrations.

c. EPC derived from tissue concentration of mummichog for the ERA.

d. EPC derived from entire blue crab tissue data (including hepatopancreas) for HHRA. Note, a sample discrepancy was discovered in the quality control process associated with the identification of hepatopancreas data in the matrix field of the database. This resulted in the omission of four hepatopancreas data points from the dataset for HHRA. Review of the omitted data revealed that the concentrations were consistent with the 95% UCLs on the mean, therefore, it was not necessary to re-run the risk calculations.

e. EPC derived from entire blue crab data (including hepatopancreas) for the ERA.

f. In the instance when ProUCL recommended more than one value, the first value (Student's-t UCL) was selected.

g. LPAH and HPAH added as ecological COPECs, based on a screening benchmark analysis (see Attachment 2).

h. Total PCBs represent the non-dioxin-like PCBs.

i. The EPC for total DDx is less than the sum of the EPCs for DDD, DDE, and DDT as a result of calculating 95% UCLs.
NA = not applicable
D/F = dioxin/furan
µg/g = microgram per gram (equivalent to ppm = parts per million)

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5.0 HUMAN HEALTH RISK ASSESSMENT – CURRENT CONDITIONS

This section describes the methodology and results of the current HHRA based on potential exposure of human receptors to COPCs in fish and crab tissue as identified in Section 4.0. The HHRA was conducted according to USEPA's RAGS Volume I, Human Health Evaluation Manual (Part A) (USEPA, 1989), and other appropriate USEPA guidance, guidelines and policies, including RAGS Part D (USEPA, 2001).

The purpose of the HHRA is to assess and document the magnitude of potential risk to human receptors based on current exposure to COPCs within the Lower Passaic River (RM 0 to RM 8), in the absence of remedial action. In addition, the risk assessment assesses the overall cancer risks and noncancer hazards to human health considering a "no action" approach, which serves as a basis for comparison for the remediation of contaminated sediment options proposed for the three target areas to address requirements in National Oil and Hazardous Substances Pollution Contingency Plan (NCP) Section 300.430(e)(9)(iii). The results of the assessment will be used to inform risk management decisions regarding the potential remedial action.

5.1 Exposure Assessment

The objective of the exposure assessment is to estimate the magnitude, frequency, duration, and routes of current and reasonably anticipated future human exposure to COPCs associated with the lower 8 miles of the Lower Passaic River. The exposure assessment is based on the receptor scenarios that define the conditions of exposure to site-related COPCs. The exposure assessment evaluates cancer risks and noncancer health hazards to an individual exposed to a reasonable maximum exposure (RME) and a central tendency exposure (CTE) to describe the magnitude and range of exposure that might be incurred by the receptor groups. USEPA (1989) defines the RME as the highest exposure that is reasonably expected to occur at a site. According to USEPA guidance (1998), CTEs are intended to reflect central (more typical) estimates of exposure or dose. The objective of providing both the RME and CTE exposure cases is to set boundaries for the risk estimates, although risk decisions are based on the RME consistent with the NCP (USEPA, 1985).

5.1.1 Exposure Pathways

Consumption of fish and shellfish is anticipated to be the primary exposure pathway. For purposes of establishing current risks and comparing the relative risk reductions, cancer risks and noncancer health hazards are estimated using exposure assumptions provided in the PAR (Battelle, 2006a) specifically for the adult/adolescent angler/sportsman and the young child (0 to 6 years) who may consume fish/crabs caught by a parent. These pathways will be included in the baseline HHRA for the 17-mile Lower Passaic River.

5.1.2 Exposure Media

5.1.2.1 Fish

To account for possible species preferences in human consumption of fish, available published information was reviewed to evaluate whether different species are preferentially targeted for consumption by anglers in the Lower Passaic River Study Area. Information reviewed included fishing licenses (NJDEP's E-Fishing Log Program that helps identify which fish are targeted [NJDEP, 2006a]), angler surveys, and other published information obtained for the study area. Table 5-1 summarizes the predominant fish species of the lower 8 miles of the Lower Passaic River.

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Table 5-1. Fish Species Located Within the Lower 8 Miles of the Passaic River.

Fish Species at Sampling Locations Within the Lower 8 Miles
Common carp[a]
Channel catfish[a]
Bluefish[c]
Blue crab[c,d]
American eel[a]
Striped bass[a]
White perch[a]
Atlantic menhaden[a]
Brown bullhead[a]
Weakfish[b]
Gizzard shad[b]

a. ChemRisk, 1995. (Study area only included lower 6 miles)
b. Iannuzzi and Ludwig, 2004. (Study area only included lower 6 miles)
c. NJDEP, 2006b.
d. Desvousges *et al.*, 2001.

For purposes of this risk assessment, fish species common to the lower portion of the river and species commonly eaten as reported in angler/creel surveys and published literature were identified and further evaluated for use in determining the dataset to use for development of the EPCs. The EPCs for fish tissue-residue samples are based on a composite of tissue samples, rather than a single species, from those species that are of recreational importance (*i.e.*, may be appreciably consumed by recreational anglers/sportsmen). For this risk assessment, a review of the Passaic River Study Area Creel/Angler Survey (Desvousges *et al*., 2001) in conjunction with the fish community data collected by TSI (2002) in accordance with the Passaic River Study Area Ecological Sampling Plan (TSI, 1999), resulted in the identification of two target fish species for the Lower Passaic River: the white perch and the American eel. In addition to being commonly caught and abundant in the study area, these species represent two distinct ecological groups of fish: predators (the white perch) and bottom-feeders (the American eel, which feeds on crabs, fish, and crayfish). This allows for the assessment of a variety of habitats, feeding strategies, and physiological factors that might result in differences in the uptake of contaminants. For instance, bottom-feeding species may bioaccumulate high contaminant concentrations from direct physical contact with contaminated sediment or by consuming epibenthic organisms and benthic invertebrates that live in contaminated sediment. Predator species are good indicators of persistent contaminants such as mercury, which may be biomagnified through several trophic levels of the food web.

The creel/angler survey (Desvousges *et al*., 2001) identified the white perch and American eel as the most commonly caught (and the most commonly consumed) fish species at 65% and 17%, respectively. Striped bass, catfish (no specific species), and carp each represented 7% of the catch (Desvousges *et al*., 2001). The fish community survey (TSI, 2002) identified striped bass, American eel, and white perch as being present throughout the lower 8-mile study area. The most common species identified in the lower 8 miles of the Passaic River were inland silverside, mummichog, and Atlantic menhaden, none of which are species of interest for anglers. These three fish species are relatively small (up to 5 inches) and therefore would be of limited interest for human consumption, but they are forage fish for the bigger game fish. Other species that were not as prevalent as the forage fish but were identified in the fish community data survey are the striped bass and white perch. American eel were observed, but not in

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overabundant quantities. White catfish, channel catfish (more common than white catfish), and carp were similarly identified at low percentages. Based on a review of the Third River Watershed Document (Clifton Health Department/Clifton Environmental Protection Commission, 1999), white perch, striped bass, and American eel were also found in the upper reaches of the river (RM 8 to RM 17).

Average concentrations derived from the historical data for the four most common species identified (white perch, American eel, striped bass, and brown bullhead [representing the only "catfish" data available in the historical data collected for the Passaic River]) have been plotted for four of the COPCs and are shown on Figures 5-1 and 5-2. White perch and striped bass are predatory fish; the American eel and the brown bullhead are bottom feeders. Comparisons of average concentrations of TCDD TEQs are shown on Figure 5-1 for each fish species. Average concentrations are highest in the white perch and lowest in the American eel. Similarly, average concentrations of total PCBs are highest in the white perch (Figure 5-2), but lowest in the brown bullhead. Average concentrations of mercury and total DDx are fairly consistent among the four species (Figure 5-2).

Based on the consumption data from the creel/angler survey (Desvousges *et al.*, 2001), the community surveys, and the extent of the historical analytical data available for each fish species, the white perch and American eel data (representing the upper and lower bounds of fish concentrations) were selected to derive an equal-weighted average concentration to represent the EPC for fish, similar to the methodology used in the Hudson River Risk Assessment (TAMS Consultants and Gradient Corp., 2000). Historical data for the brown bullhead were not as abundant as that for the American eel, and because this particular species of catfish was not identified in any of the surveys as being caught and consumed, data for this species were not included in the dataset to derive the EPC. Although the amount of historical data for the striped bass was similar to the white perch, concentrations of dioxins and PCBs were higher in the white perch, which is caught and consumed more frequently than striped bass (Desvousges *et al*., 2001). Furthermore, striped bass have a larger home range than white perch because they are an anadromous species, meaning they enter the river to spawn, but then return to the sea. This means that these fish may accumulate chemicals in their tissues from areas outside of the Lower Passaic River. Thus, data for the white perch rather than the striped bass were used to provide a more conservative weighted average concentration for deriving the EPC. In the absence of site-specific data to support percent species intake, equal intake of the two representative species (white perch and American eel) is assumed. The RI/FS will further analyze fish species preferences and consumption patterns.

Fish tissue data from the white perch and American eel may overestimate or underestimate exposure to some COPCs, as shown on Figures 5-1 and 5-2. For bioaccumulative contaminants, tissue concentration should be strongly related to age; however, because data used for this HHRA were not identifiable by age or weight classifications, it is uncertain if the data are representative of consumable fish. This uncertainty will be addressed in the RI/FS. In addition, excluding other species (striped bass, catfish, and carp) known to be present in the river and reported as being caught and kept less frequently (Desvousges *et al*., 2001) adds to the uncertainty of the EPC. The exclusion of these species is addressed in Section 5.4 and will be further evaluated during the RI/FS.

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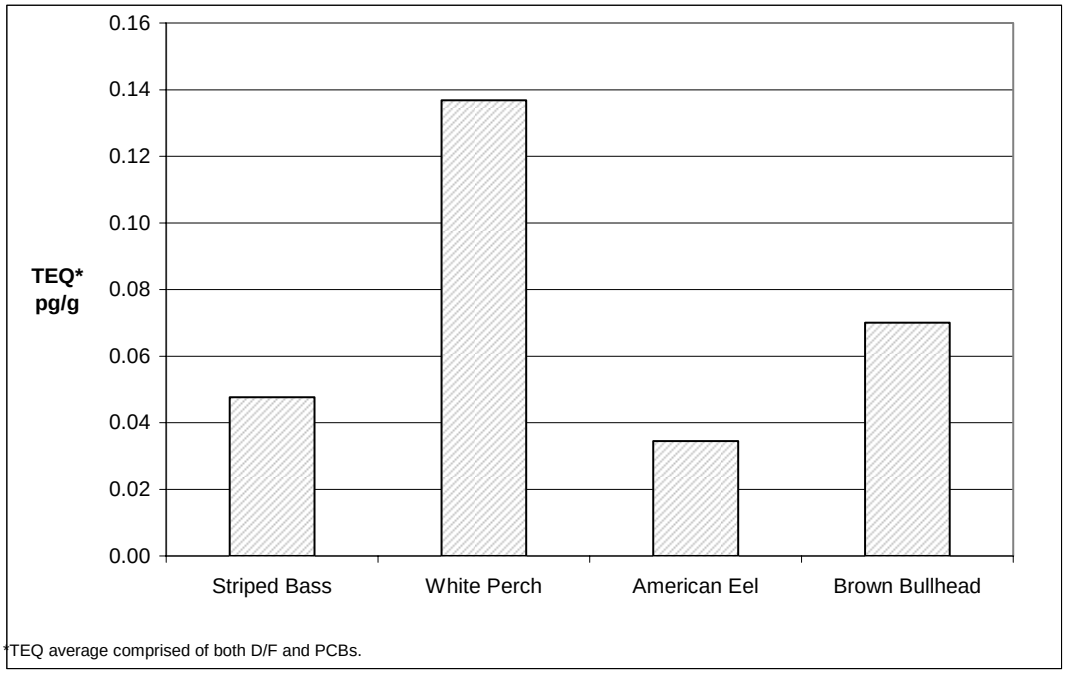

Figure 5-1. Comparison of Average Total TCDD TEQ Concentrations in Fish Tissue Samples.

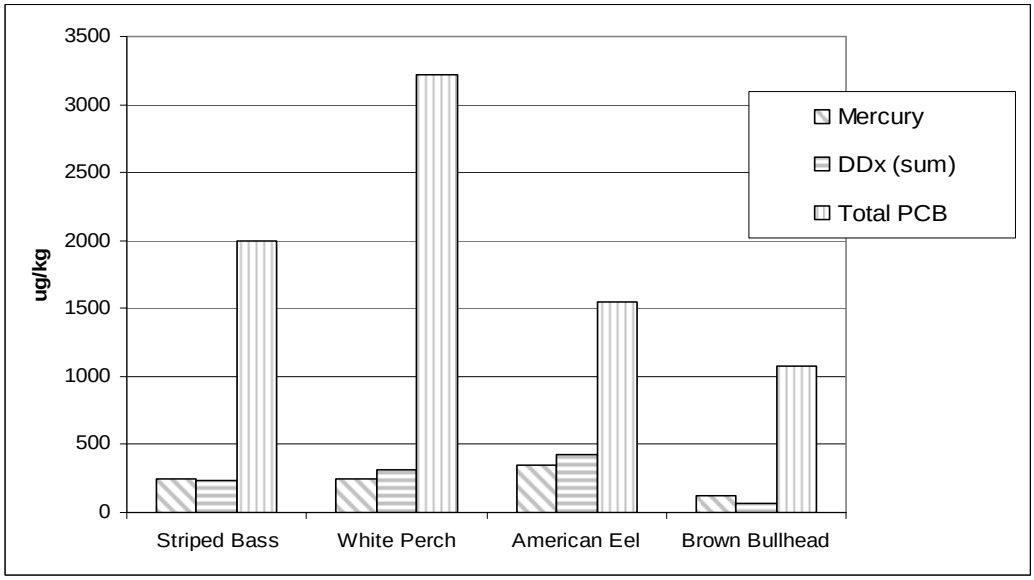

Figure 5-2. Comparison of Average Mercury, Total DDx, and Total PCB Concentrations in Fish Tissue Samples.

5.1.2.2 Crab

For crab tissue, only the blue crab is of interest in the study area because it is the most commonly caught and consumed in the river as evidenced by the NJDEP state consumption advisories (NJDEP, 2006b;c). However, the amount of chemical with which an individual comes into contact depends on which parts of the crab are consumed. The highest levels of most chemical contaminants are found in the hepatopancreas (NJDEP, 2002), commonly known as the tomalley or green gland (the yellowish-green

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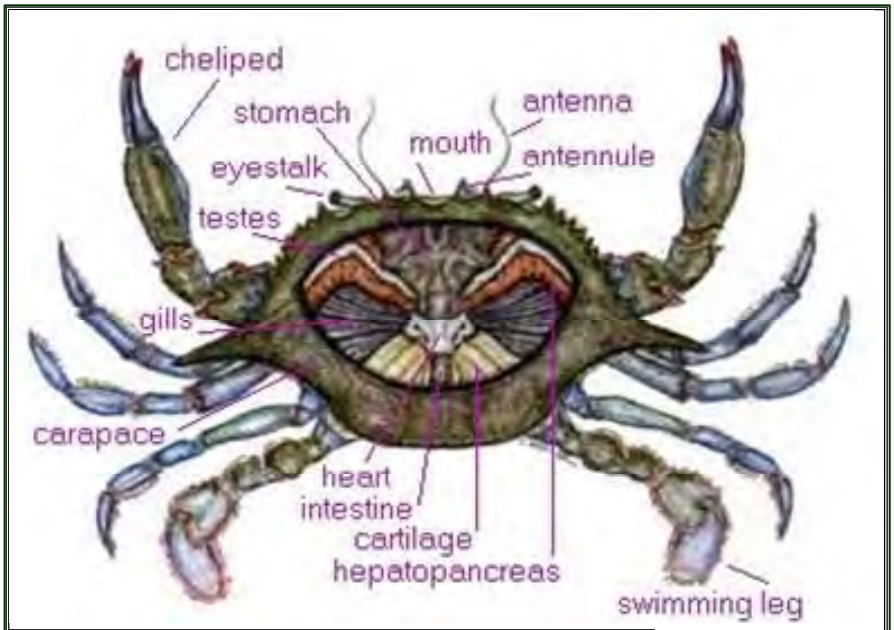
gland under the gills). The anatomy of the blue crab is depicted on Figure 5-3. Information obtained from published literature reports that individuals catching and consuming crab (*i.e.*, crabbers) may consume the edible white meat (or muscle), which includes the thoracic, claw, leg, and tail meat, and the hepatopancreas (Belton *et al*., 1985; May and Burger, 1996; NJDEP, 2002). Belton *et al*. (1985) stated that all of the crab tissues are considered edible food, whereas May and Burger (1996) and NJDEP (2002) report that only a small percentage of individuals purposefully consume the hepatopancreas. May and Burger (1996) reported that most crabbers in the Newark Bay Complex ate only cleaned crabs (hepatopancreas discarded), with fewer than 3% eating the whole crab. NJDEP (2002) reported that 15% of the population they surveyed in the Newark Bay Complex ate the hepatopancreas.

Comparisons of chemical concentrations found in muscle tissue and hepatopancreas samples have been reported in the literature. Belton *et al.* (1985) performed a differential analysis of the muscle and hepatopancreas samples for PCBs and organochlorine pesticides; the analysis indicated that both the PCBs and pesticide concentrations were much higher in the hepatopancreas samples (refer to Table 2C in Belton *et al.* 1985). Although Belton *et al.* (1985) did not specifically report the mean concentrations for the pesticide compounds, they did report mean PCB concentrations of 6,520 micrograms per kilogram (µg/kg) in the hepatopancreas and 130 µg/kg in muscle tissue. NJDEP (2002) summarized mean dioxin (as 2,3,7,8-TCDD TEQ) concentrations, originally reported in Skinner *et al.* (1997), as 0.19 µg/kg for the hepatopancreas samples (n=6) and 0.008 µg/kg for the muscle samples (n=6). In addition, NJDEP (2002) summarized the mean concentrations of 2,3,7,8-TCDD in hepatopancreas and muscle samples from a field sampling study conducted by Chemical Land Holdings, Inc. (CLH) (2001) as 0.262 µg/kg and 0.018 µg/kg, respectively. Therefore, based on the analytical results for the two sample types, it can be assumed that an individual who consumes only the muscle tissue will be exposed to a smaller amount of the chemical versus someone who eats the hepatopancreas as well as the muscle tissue, unless cooking practices (discussed below) are considered.



Source: Virginia Institute of Marine Science (http://www.marine-ed.org/bridge/bluecrabworkshop2.pdf)

Figure 5-3. Anatomy of a Blue Crab.

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Exposure to the contaminant depends not only on the specific part of the crab the consumer eats, but also on the method of cooking. NJDEP (2002) acknowledges that even those consumers who do not deliberately eat the hepatopancreas are likely to be exposed to all or part of its content due to its fluid nature and its dispersion in the cooking liquid. Both Belton *et al.* (1985) and May and Burger (1996) state that boiling was the preferred method of cooking crabs among the individuals surveyed. Because the crab is cooked whole, consumption of only the muscle tissue would still result in exposure to the contaminants initially contained in the hepatopancreas. Although the State of New Jersey prohibits catching and consuming crabs from the Lower Passaic/Newark Bay Complex, the NJDEP guidance for consumption of fish and crab (NJDEP, 2006b) provides crab preparation methods for those crabs obtained outside this region. NJDEP (2006b) states that no specific cooking method is available to reduce the chemical contaminant levels in blue crabs and offers the following steps for proper preparation:

- Do not eat the green gland (hepatopancreas);
- Remove the green gland (hepatopancreas) before cooking;
- After cooking, discard the cooking water; and,
- Do not use the cooking water or green gland (hepatopancreas) in any juices, sauces, bisques, or soups.

As evidenced in the published literature and addressed in the NJDEP guidance for consumption of fish and crab (2006c), even if the consumer does not eat the hepatopancreas, exposure to the chemical contaminant may still potentially occur if the crab is cooked before the hepatopancreas is removed and if the liquid used to boil the crab is used in juices, sauces, bisques, or soups.

For the purposes of this risk assessment, exposure to COPCs in the hepatopancreas and muscle is anticipated based on crab cooking practices. Therefore, analytical results for both types of tissue samples were combined and used to determine the EPC for crab consumption, similar to the composite sample approach described in NJDEP (2002). The uncertainties associated with an EPC derived using a composite hepatopancreas/muscle approach are addressed in Section 5.4 because this approach may underestimate or overestimate total risk.

5.1.3 Potential Receptors and Exposure Routes

The angler/sportsman is defined as an adult individual catching and consuming fish and blue crab from the river. The adolescent evaluated in this survey, aged 10 to 18 years, is another possible angling population that may catch fish/crab and consume their catch. This information is based on studies of angling activities that have found that children typically begin fishing at about the age of 10 years (USEPA, 2000a). In addition, many states with licensing programs require children to have licenses beginning at the age of 16 years before they can legally fish (NJDEP, 2006c). Young children (0 to 6 years) are assumed to consume fish caught by their angling parent. The collection and consumption of fish and shellfish from the Passaic River has been well documented in a creel survey conducted by Belton *et al*. (1985) for NJDEP, as well as in other published literature regarding anglers' perception of risk from contaminated fish (May and Burger, 1996; Burger *et al*., 1999; Kirk-Pflugh *et al*., 1999); therefore, it is clear that this exposure pathway is complete for the Angler/Sportsman.

In addition to the routes of exposure mentioned previously, individuals may be exposed to COPCs in the Lower Passaic River via other potential pathways. One such pathway is exposure from eating game (*e.g.*, turtles, waterfowl) found along the banks of the Lower Passaic River. Snapping turtles and waterfowl may contain high concentrations of dioxins and PCBs in their fat and internal organs. Although public health advisories for consumption of these animals have not been issued by NJDEP, two neighboring states, Pennsylvania and New York, have issued consumption advisories for certain game (New York

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State Department of Health [NYSDOH], 2006; Pennsylvania Department of Environmental Protection [DEP], 2006) associated with the presence of PCBs in their waterways. However, because there are no historical data on chemical concentrations in the tissues of these organisms, consumption of waterfowl, turtles, and other species is not addressed in this HHRA quantitatively but rather qualitatively as an area of uncertainty. For individuals who consume these animals in addition to fish and crab, risks would be expected to be higher.

It is assumed that an adult and/or adolescent angler/sportsman shares his or her catch with an adolescent and a child family member. Although young children and adolescents under age 15 typically are not required to have fishing licenses, several sources indicate that many children consume sport-caught freshwater fish (Connelly *et al.*, 1990; Connelly *et al.*, 1992; Wendt, 1986). Subpopulations of highly exposed or less-exposed anglers have not been explicitly characterized, but instead are assumed to be represented in the overall fish ingestion rate; this assumption will be further evaluated in the RI/FS baseline HHRA. It is possible, however, that distinct subpopulations may fish in the 8-mile FFS area and consume higher amounts of fish but are not explicitly identified in the creel surveys used in this analysis. It is uncertain whether these subpopulations have been adequately addressed in this risk assessment. Subsistence fishing was not evaluated in the HHRA but may be evaluated in the RI/FS after further analysis of the creel surveys.

Other potential exposure pathways relevant to the adult angler/sportsman, as indicated in the CSM (Figure 4-1), include direct exposures (*i.e.*, dermal contact and incidental ingestion) to sediments and surface water contacted during collection activities. Because consumption of biota (fish and crab) is anticipated to be a risk driver, it is the only pathway evaluated in this assessment. The other pathways and potential higher-end ingestion rates will be further evaluated in the RI/FS. Omitting other applicable exposure pathways and higher end ingestion rates leads to an underestimate of risk, as discussed in Section 5.4.

5.1.4 Estimation of Chemical Intake

Intake is estimated by combining EPCs with the variables that describe exposure:

- Rate of contact with the medium;
- Frequency of contact;
- Duration of contact; and,
- Body weight of the exposed individual.

Chemical intake from ingesting fish is estimated following USEPA (1989) guidance and other applicable guidance, guidelines, and policies. An intake factor is the amount of a chemical in a quantity of a medium (*e.g.*, fish tissue) taken into the body through an exposure route (*e.g.*, ingestion) and available for absorption. It is expressed in units of milligram (mg) of chemical per kilogram (kg) body weight per day (mg/kg-day). Intake of a chemical that results in carcinogenic effects is calculated by averaging the dose over a lifetime (70 years x 365 days/year) (USEPA, 2005c). The intake factor for carcinogenic effects is termed the lifetime average daily dose (LADD). Intake of COPCs that produce noncancer health effects is averaged over the period of exposure [exposure duration (ED) x 365 days/year]. The intake factor for exposure durations equal to or longer than 7 years is termed the chronic average daily dose (ADD) (USEPA, 1989). Intake will be estimated for LADD and ADD ingestion of fish and crab for an adult, adolescent, and child, with appropriate adjustments for ingestion rates and bodyweights.

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The equation used to calculate the LADD/ADD for ingestion of biota (fish and crab) is:

$$LADD / ADD = \frac{C_t xIRxEFxFIx(1 - Loss)xED}{BWxAT} \qquad (5\text{-}1)$$

where:

C_t = biota tissue concentration (mg/kg)
ED = exposure duration (years)
EF = exposure frequency (days/year)
IR = annualized ingestion rate (kg/day)
FI = fraction from contaminated source (unitless)
Loss = cooking loss (g/g)
BW = body weight (kg)
AT = averaging time (days) - period over which exposure is averaged (days); over a lifetime for evaluating cancer risks and over the appropriate exposure duration for evaluating noncancer health hazards.

5.1.4.1 Exposure Point Concentrations

As explained in Section 4.2.3, EPCs for COPCs in fish and crab were calculated as the 95% UCL of the arithmetic average following guidance in USEPA (2002a). For this risk assessment, the EPCs used in the RME and CTE evaluations are the same. Note that the EPCs are assumed to remain constant in fish/crab throughout a lifetime and do not consider any attenuation or degradation of the chemical in sediment that may occur over time. The RME and CTE exposures differ with regard to the receptor-specific exposure variables, which are described further below and are summarized in Attachment 4 (Tables 4-5 through 4-10). The EPCs for each of the COPCs in fish and crab are presented in Table 4-1of this appendix. Consistent with USEPA RAGS Part D guidance (2001), the EPCs are also presented in the risk assessment tables provided in Attachment 4, Tables 4-1 and 4-3, for the fish RME and CTE, respectively, and in Attachment 4, Tables 4-2 and 4-4, for the crab RME and CTE, respectively.

As described in Section 5.1.2.1, white perch and American eel were identified as the fish species that people are most likely to catch and eat from the Lower Passaic River. As such, the historical analytical data for white perch and American eel collected throughout the lower 8 miles of the Lower Passaic River were combined for each of the COPCs and used to determine the EPCs to evaluate exposures associated with consumption of fish. Fish tissue data were noted as "whole organism," which is assumed to include the skin, organs, and head. Specific data for fillet samples were not available for this HHRA; therefore, comparisons of concentration differences between fillets and whole organism samples could not be prepared. Therefore, EPCs derived for COPCs in fish may be overestimated because whole organism samples were used rather than fillet samples.

Historical blue crab analytical data were used to determine the EPCs for ingestion of crab. The historical blue crab data set consists of three tissue sample types: muscle, hepatopancreas, and all soft tissue (*i.e.*, all tissue excluding the hepatopancreas). The muscle sample type makes up roughly 50% of the dataset, whereas the hepatopancreas sample type makes up 20% and the soft tissue sample type makes up 30% of the dataset. All historical blue crab tissue data, including analytical results from different investigations and different sample types, were combined for each of the COPCs and used to determine the EPCs representative of the entire 8 miles of the Lower Passaic River. As described in Section 5.1.2.2, higher concentrations of contaminants are usually found in the hepatopancreas rather than the muscle tissue. To demonstrate the concentration differences among the sample types, comparisons of the average concentrations observed for the three types of samples collected for crabs are provided on Figures 5-4

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through 5-7 for 2,3,7,8-TCDD, total PCBs, total DDx, and mercury. The data used for these comparisons are a subset of the historical crab dataset that were collected by CLH in 1999-2000 in accordance with an USEPA-approved Ecological Sampling Plan (CLH, 2001). The CLH data have been chosen to demonstrate concentration differences among sample types because these data consist of 15 co-located samples of the hepatopancreas, muscle, and all soft tissue (*i.e.*, edible tissue minus the hepatopancreas).

Figures 5-4 through 5-7 compare the average concentrations observed for the three types of samples collected from crabs to demonstrate the range of concentrations for each sample type. As shown on Figures 5-4 through 5-6 (the organic compounds), concentrations associated with the hepatopancreas samples are much higher than those for the other sample types, similar to what Belton *et al*. (1985) observed with their data. Conversely, mercury concentrations are higher in the muscle tissue (Figure 5-7).

The EPC used in this risk assessment was derived by combining all of the sample results, represented by the "All Soft Tissue + Hepatopancreas" values shown on Figures 5-4 through 5-7. An EPC that has been derived by compositing the sample types therefore may be more representative for those consumers who do not deliberately eat the hepatopancreas but are likely to be exposed to all or part of its content as a result of how the crab is cooked (see Section 5.1.2.2). Conversely, the EPC may be overestimated or underestimated for those individuals specifically eating only the muscle tissue or the hepatopancreas.

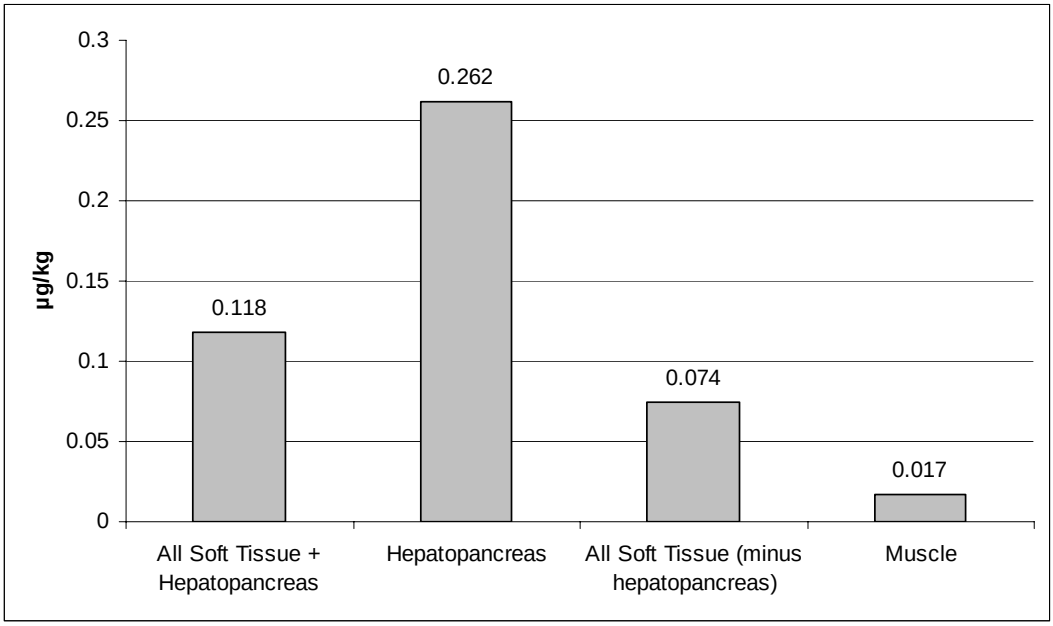

Figure 5-4. Comparison of Average 2,3,7,8-TCDD Concentrations Among Crab Sample Types.

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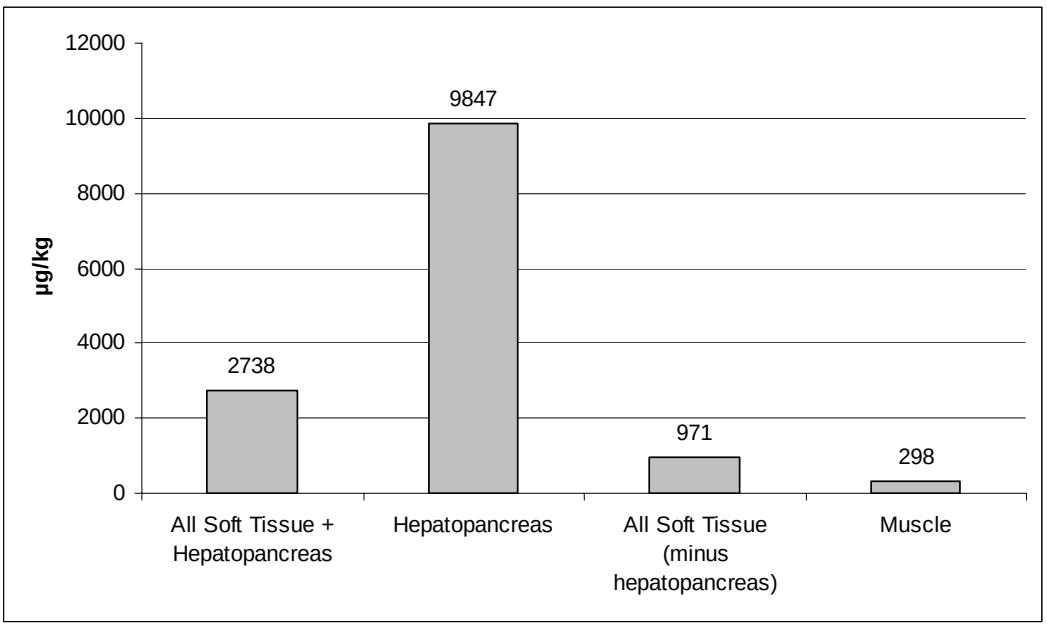

Figure 5-5. Comparison of Average Total PCB Concentrations Among Crab Sample Types.

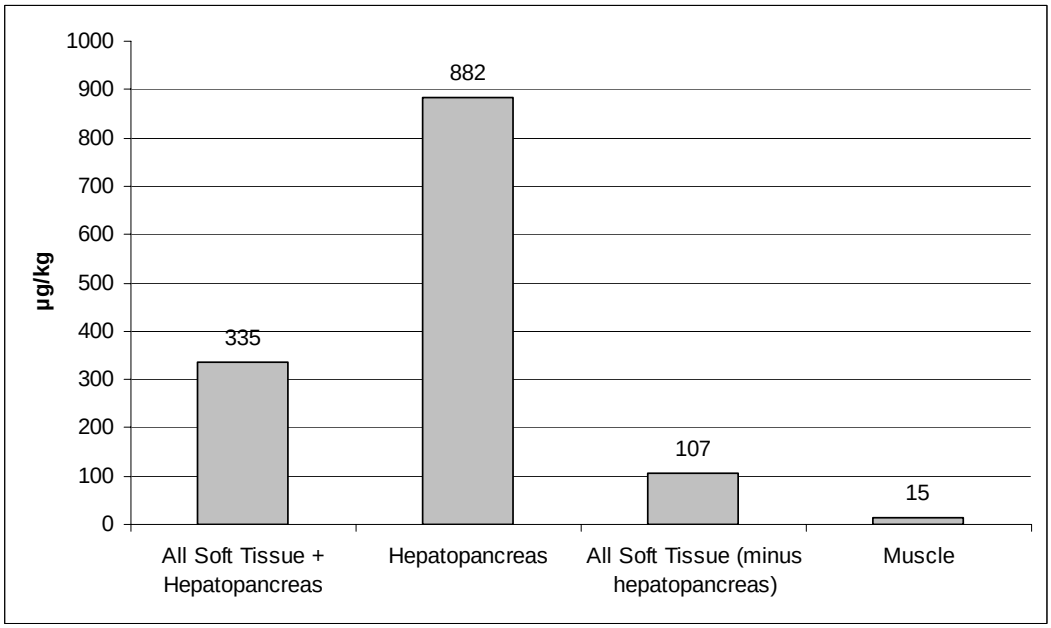

Figure 5-6. Comparison of Average Total DDx Concentrations Among Crab Sample Types.

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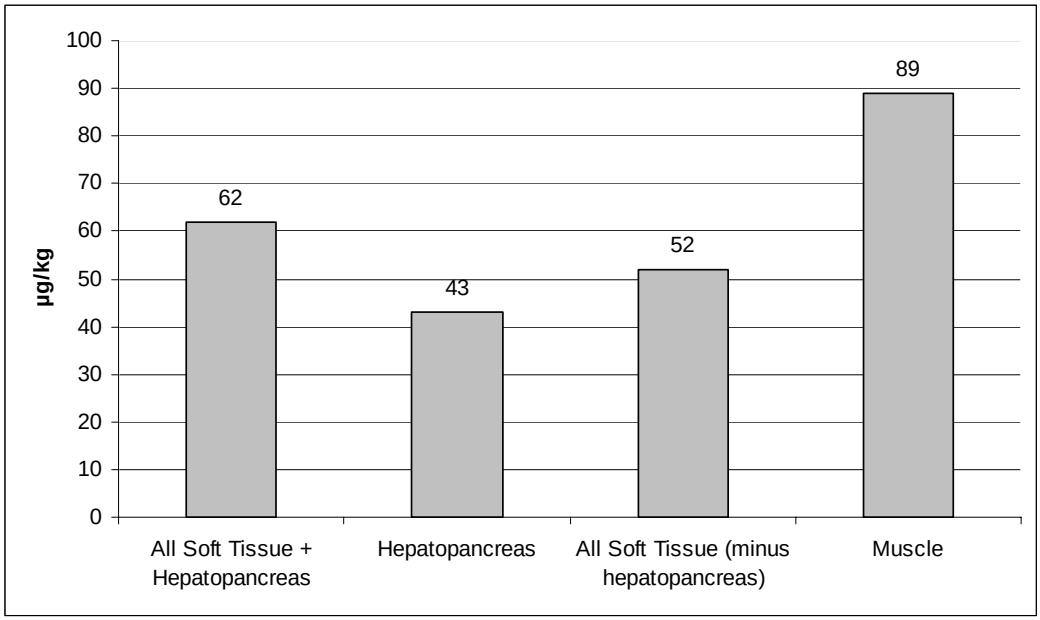

Figure 5-7. Comparison of Average Mercury Concentrations Among Crab Sample Types.

For comparison purposes, NJDEP routine monitoring data have been summarized and are presented in Table 5-2. In 2004, blue crabs were collected from the Lower Passaic River and Newark Bay Complex by Dr. Richard Horwitz under the statewide "Routine Monitoring Program for Toxics in Fish" as developed by NJDEP's Division of Science, Research and Technology (DSRT) (NJDEP, 2006d). The objective of the program is to update human health consumption advisories for fish and shellfish of concern and to identify contaminant concentrations in marine and estuarine species along New Jersey's coast. Muscle meat and hepatopancreas composite tissue samples from five blue crabs collected specifically from the Lower Passaic River were analyzed for total PCBs, total DDx, total mercury, and 2,3,7,8-TCDD. A comparison of the NJDEP data in Table 5-2 with the site data in Figures 5-5 and 5-6 shows that average concentrations of total PCBs and total DDx compounds determined by NJDEP for hepatopancreas and muscle tissue samples were much lower than those associated with the site data. Conversely, NJDEP data for the average total mercury concentrations in hepatopancreas and muscle samples were approximately double those concentrations determined for the site (see Figure 5-7). Hepatopancreas and muscle tissue samples for both NJDEP and the site were consistent for 2,3,7,8-TCDD.

5.1.4.2 Exposure Factors

The population of concern in this HHRA consists of the inhabitants of the towns, cities, and rural areas surrounding the 8-mile stretch of the Passaic River who may fish and/or crab in the river or eat catch from this area. The angler population is defined as those individuals who consume self-caught fish from the 8-mile stretch of the Passaic River regardless of the fish/crab consumption advisories. The assessment of fish consumption by the angler population includes young children (ages 0-6), adolescents (ages 10 to 18 years), and adults (over 18). Prenatal and neonatal exposures are evaluated qualitatively.

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Table 5-2. Summary Statistics for Blue Crab Contaminants[a].

Analyte	Tissue	Count	Concentration (µg/kg wet weight)		
			Minimum	Maximum	Average
Total PCBs	Hepatopancreas	5	1,668	7,020	3,597
	Muscle	5	48.7	97.3	70.3
	Combined	10	48.7	7,020	1,834
Total DDx	Hepatopancreas	5	263	1182	596
	Muscle	5	14.5	22.9	18.1
	Combined	10	14.5	1,182	307
Total Mercury	Hepatopancreas	5	60.0	100	86.0
	Muscle	5	150	210	182
	Combined	10	60.0	210	134
2,3,7,8-TCDD	Hepatopancreas	5	0.175	0.394	0.288
	Muscle	4[b]	0.009	0.013	0.011
	Combined	9[b]	0.009	0.394	0.165

Note: Data are draft and subject to change.
[a] Source: NJDEP, 2006d.
[b] One result was not detected and the method detection limit (MDL) was not available.

Specific exposure parameter values proposed for estimating intake for the RME and CTE for ingestion of fish are presented in RAGS Part D tables (USEPA, 2001) in Attachment 4, Tables 4-5 through 4-7 for the adult, adolescent, and child receptors, respectively. Similarly in Attachment 4, Tables 4-8 through 4-10 present the specific exposure parameter values proposed for estimating intake for the RME and CTE for ingestion of crab for the adult, adolescent, and child receptors, respectively. The key exposure parameters and the rationale for their selection are described below.

Self-Caught Ingestion Rates of Fish (IR_f)

The ingestion rate is the amount of fish an individual consumes on a daily basis based on averaging the reported consumption rate in 1 year over 365 days. Ingestion rates for fish have been annualized and are presented in grams eaten per day (g/day). The ingestion rate assumes the fish are caught while angling from the Lower Passaic River only. It is expected that ingestion of fish from other sources would add to the amount an individual ingested annually.

For consumption of fish, ingestion rates based on data collected for recreational freshwater anglers were obtained from the Exposure Factors Handbook (EFH) (USEPA, 1997b). For the adult angler/sportsman, 25 g/day, which is the 95th percentile, was used for the RME, whereas the recommended mean of 8 g/day was used for the CTE. The values in the EFH are based on fish ingestion studies from several different freshwater locations within the country. The surveys include a 1992 Maine angler survey (Ebert *et al.*, 1993), a 1992 Lake Ontario diary study (Connelly *et al.*, 1996), and a 1989 Michigan sport angler survey (West *et al.*, 1989). The ingestion rate for fish and crab identified in a more recent consumption survey (Burger, 2002) found that 8% to 25% of the population ingested 1,500 g/month, which is equivalent to 50% from fish and 50% from crabs (as discussed below for the crab ingestion rate).

Ingestion rates for the adolescent and child were based on the assumptions that the intake for the adolescent will be approximately two-thirds that of the adult and the intake for the child will be approximately one-third that of the adult (USEPA, 1997b). This assumption is based on the fish consumption rates provided in Table 10-1 of the EFH (USEPA, 1997b) for a child aged 0 to 9 years, an

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adolescent from 10 to 19 years of age, and an adult aged 20 to 70+ years of age (intake averaged over six adult age groups). According to Table 10-1 of the EFH (USEPA, 1997b), the 95th percentile intake for children aged 0 to 9 years is 16.5 g/day. For adolescents aged 10 to 19, the 95th percentile intake in USEPA's EFH is 26.8 g/day. The selected ingestion rates are consistent with those presented in the EFH considering the specific ages of the populations being evaluated in this assessment and also are within the upper bounds of the ingestion rates at the 90th percentile or above (USEPA, 1997b). Thus, for the RME, an ingestion rate of 8 g/day is used for the child receptor and 17 g/day is used for the adolescent receptor. For the CTE, an ingestion rate of 3 g/day is used for the child receptor and 5 g/day is used for the adolescent receptor.

Self-Caught Ingestion Rates of Crab (IR_c)

The ingestion rate is the amount of crab an individual consumes on a daily basis based on averaging the reported consumption rate in 1 year over 365 days. Ingestion rates for crab have been annualized and are presented in grams eaten per day (g/day). The ingestion rate assumes the crabs are caught while angling from the Lower Passaic River only. It is expected that ingestion of crab from other sources would add to the amount an individual ingested annually.

Information in the published literature regarding the consumption rates of crabs is limited. Studies conducted in the Newark Bay Complex area were reviewed (Burger, 2002; Burger *et al.*, 1999; and May and Burger, 1996) to identify an appropriate consumption rate. Of the studies reviewed, the 2002 Burger study was the only one that contained sufficient information regarding crab consumption in the area of the Lower Passaic River, which was used to derive a consumption rate for this risk assessment.

In 1999, a published study by Burger *et al.* included interviews with 267 people angling at several locations within the Newark Bay Complex, including parts of the Passaic River, on a regular basis between May 15 and September 15. The survey included questions regarding the consumption pattern of the individual who was fishing and/or crabbing, along with questions for demographics, knowledge of advisories, and reasons for angling. Results of the study indicated that there were no ethnic differences (Asian, Hispanic, Black, White) in the percentage of people who crabbed, nor were there ethnic differences in age, annual income, or health ratings. However, Burger *et al*. (1999) did identify differences in consumption patterns across the various ethnic groups. They found that consumption increased with the angler's age and decreased with income. They also noted that Asians ate few crabs and mainly fish, while the other ethnic groups ate mainly crabs. Overall, 49% of Whites did not eat their catch, while 40% of Hispanics, 24% of Asians, and 22% of Blacks did not eat their catch. In addition, a higher percentage of Blacks and Hispanics reported eating more of their catch (fish, crab, or both) per month than Whites and Asians.

A yearly consumption rate for self-caught crab was developed by Burger (2002) by multiplying the number of crab meals eaten per month by the number of crabs eaten at each meal by the number of months per year crabs are caught, assuming the average serving size from one crab is 70 g. Crab consumption patterns for people surveyed were determined for two groups of individuals: (1) people who caught only crab; and (2) people who caught both crab and fish. Burger (2002) notes that the majority of people interviewed mainly fished or mainly crabbed, and that more than 30% of the people who fished and crabbed in the Newark Bay Complex did not eat their catch. However, the study also reports that 8% to 25% of the people ate more than 1,500 g/month of self-caught fish and crab. Table 5-3 summarizes the crab consumption patterns for people who caught crab only and for those who caught both crab and fish. Note that people reported crabbing only 3 months out of the year; only data from this 3-month period were used to calculate the annual ingestion rate. This may potentially underestimate the risks and hazards.

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Table 5-3. Crab Consumption Patterns for Consumers Surveyed in the Newark Bay Complex in 1999.[a]

Parameter	Consumers of Crab Only	Consumers of Both Crab and Fish
Sample size (n)	110	33
Number of times per month self-caught crabs are consumed	3.39 ± 0.42	2.96 ± 0.45
Number of self-caught crabs (*i.e.*, serving size)	6.15 ± 0.85	7.27 ± 0.91
Amount of self-caught crabs for each serving (g)	439 ± 61.2	509 ± 63.8
Monthly consumption of self-caught crabs (g)	1,980 ± 561	1,620 ± 330
Number of months per year crabs are caught	3.31 ± 0.13	3.50 ± 0.37
Yearly consumption of self-caught crab (g)[b]	5,760 ± 1,360	6,230 ± 1,790

Source: Burger, 2002 (Table 2).

a. Values provided are means ± standard errors based on computed yearly consumption for each person individually; therefore, yearly consumption values provided in the table are not exactly reproducible.

b. Assumes average weight of meat from crabs is 70 g.

For purposes of this risk assessment, consumption of crab and fish were assumed to occur in separate populations so that people ate either fish or crab, but not both. This approach may potentially underestimate risks for those individuals who consume both fish and crabs. As shown in Table 5-3, individuals who caught both fish and crab reported eating more crab per year than those who caught only crab. The uncertainty associated with assuming individuals did not eat both fish and crab is further addressed in Section 5.4, "Uncertainty Analysis".

Based on the crab consumption patterns for people who caught crab only, as reported in Burger (2002), the RME ingestion rate for the adult angler/sportsman was calculated as 23 g/day. This value is the 95% UCL of the yearly consumption value, derived as follows:

$$95\%UCL = \frac{5{,}760\frac{g}{year} + \left(1.96 \times 1{,}360\frac{g}{year}\right)}{365\frac{days}{year}} \qquad (5\text{-}2)$$

Although Burger (2002) did not identify the distribution of the data, the data were assumed to be normally distributed based on the central limit theorem. This states that sampling distribution means tend toward normality as n gets large. In this particular case, n=110, which justifies the use of procedures based on the normal distribution even if the underlying population is not normal (McBean and Rovers, 1998).

The average yearly consumption rate of 5,760 g/year (16 g/day) was selected as the adult CTE ingestion rate. Ingestion rates for the child and adolescent receptors were estimated assuming rates 1/3 and 2/3 those of the adult ingestion rate, respectively, as was assumed for fish ingestion.

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Crab consumption data were obtained for the Newark Bay Complex area by NJDEP from an angler survey conducted by NJDEP in 1995 (NJDEP, 2002). Based on the results of this survey, 65% of the population surveyed consumed self-caught crab once per week or less, whereas 28% of the individuals reportedly consumed crab at least two to three times per week. The survey results indicated that the majority of surveyed individuals (56%) consumed between one and six crabs at each meal; seven crabs or more were eaten by 35% of the population. NJDEP used this consumption information to estimate a range of the amount of crab consumed per meal per day, assuming the edible mass of the crab was 75 g. Depending on the number of crab meals per day (*i.e.*, one crab meal/day or 0.14 crab meal/day) and the number of crabs eaten at each meal (*i.e.*, 2, 5, or 15 crabs), the amount of crab consumed per day ranged from 21 g/day to 1,125 g/day. The consumption rate of 23 g/day derived from the Burger (2002) data is consistent with the lower value derived from the NJDEP survey data. The majority of the NJDEP surveyed population is most likely represented by this lower daily ingestion rate. However, for the small percentage of the population who consume a larger portion of crab, the risks/hazards are likely to be underestimated with the use of the lower ingestion rate. This issue is addressed as an uncertainty in the uncertainty analysis (Section 5.4).

Fraction from Contaminated Source (FI)

This factor is applied to account for possible exposures to contaminants from other sources with similar contaminants. This is particularly relevant for the site, given that the Lower Passaic River watershed consists of over 100 square miles of highly developed urban area that supports a large population of people. Although it is possible that an angler catches and consumes fish from other rivers in the area, this risk assessment assumes that 100% of the catch is obtained from the Lower Passaic River. Therefore, an FI of 1 is used for the RME and CTE scenarios.

Cooking Loss (CL) for Fish

Preparation and cooking procedures can modify the amount of contaminant ingested by consumers, consequently modifying exposure and dose. Several studies have been conducted in an attempt to quantify this modification, and a variety of factors have been investigated, including the species of fish, preparation method (*e.g.*, skin on vs. skin off), cooking method (baking, broiling, deep frying, *etc*.), fattiness of the fish sampled (within the same species), and water body where the fish were collected. The USEPA (2000a) summarized the percent reductions of organic contaminants resulting from preparation method, cooking method, species, and location. Ranges of percent reductions for the COPCs are summarized in Table 5-4, with the exception of PCBs. These studies show wide ranges in the percent reduction for each chemical investigated, so selecting a reduction factor that can be applied for a particular chemical presents a challenge. Therefore, cooking loss values are selected based on percent losses derived by combining all cooking methods and by using USEPA default recommendations, which are further described below.

Summary statistics of the range of percent reductions for the COPCs, as reported by the USEPA (2000a), are summarized in Table 5-5. Note that Table 5-5 summarizes the percent loss values for skin-on, skin-off, and combined (skin-off plus skin-on). Because there were no consistent differences in contaminant losses between cooking methods, the results were grouped only according to contaminant, not by cooking method.

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Table 5-4. Summary of Contaminant Loss from Fish Due to Cooking (Skin Off and Skin On).

Contaminant	Preparation Method	Percent Loss Value (%)	Study Reference
p,p'-DDD	Skin off	4 to 88	Zabik *et al.*, 1995a; 1996
p,p'-DDD	Skin on	10 to 54	Zabik *et al.*, 1995a
p,p'-DDE	Skin off	7 to 61	Zabik *et al.*, 1995a; 1996
p,p'-DDE	Skin on	16 to 59	Zabik *et al.*, 1995b
DDE	Trimmed	52 to 54	Skea *et al.*, 1979
p,p'-DDT	Skin off	1 to 80	Zabik *et al.*, 1994; 1995a; 1996
p,p'-DDT	Skin on	23 to 60	Zabik *et al.*, 1994; 1995a
DDT	Trimming/Skin off	1 to 62	Reinert *et al.*,1972; Zabik *et al.* 1994
DDT	Skin on	4 to 16	Zabik *et al.*, 1994
Dieldrin	Skin off	4 to 88	Zabik *et al.*, 1994; 1995a;b; 1996
Dieldrin	Skin on	3 to 93	Zabik *et al.*, 1994; 1995a;b
α-Chlordane	Skin off	3 to 63	Zabik *et al.*, 1994; 1995a; 1996
α-Chlordane	Skin on	(-)25 to 63	Zabik *et al.*, 1994;1995a
γ-Chlordane	Skin off	1 to 83	Zabik *et al.*, 1995a; 1996
γ-Chlordane	Skin on	20 to 50	Zabik *et al.*, 1995a
Chlordane Complex	Skin on	3 to 60	Zabik *et al.*, 1995b
TCDD	Skin off	~54 to ~57	Zabik and Zabik, 1995
TCDD	Skin on	~ 37 to ~80	Zabik and Zabik, 1995

Source: USEPA, 2000a.

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Table 5-5. Summary Statistics for Contaminant Percent Loss[a] from Fish Due to Cooking.

	Skin-Off					Skin-On						Combined[(b)]				
Contaminant [(c)]	Minimum	Average	50th Percentile	90th Percentile	Maximum	Minimum	Average	50th Percentile	90th Percentile	95th Percentile	Maximum	Minimum	Average	50th Percentile	90th Percentile	Maximum
DDD	4	30	19	61	88	10	37	36	54	54	54	4	31	30	58	88
DDE	7	30	27	52	75	7	39	39	49	54	59	7	32	35	52	75
DDT	0	38	30	69	141	4	33	29	58	59	60	0	37	30	64	141
Chlordane	1	29	30	51	83	3	38	38	52	57	63	1	32	33	51	83
Dieldrin	4	29	25	52	88	3	36	38	58	61	93	3	32	30	55	93
TCDD	54	56	56	57	57	37	51	44	69	75	80	37	53	49	69	80

Source: USEPA, 2000a

a. Percent losses are derived by combining all cooking methods.

b. Combined includes both skin-on and skin-off results.

c. Contaminants have all been grouped under one heading. For example, alpha chlordane and gamma chlordane have been combined and results summarized as “chlordane”.

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For this particular review of cooking loss, PCBs were not included because numerous studies regarding PCB cooking loss were evaluated in the HHRA for the Hudson River (TAMS/Gradient Corp., 2000). The 12 studies reviewed in the Hudson River HHRA regarding cooking loss found the rate of cooking loss ranged from 0% to 74% with most PCB losses between 10% and 40%. Based on the results provided in the Hudson River risk assessment, (USEPA, 2000a) a factor of 20% as the cooking loss factor for the CTE was used, noting that the value of 20% is the midpoint between 0% and 40%. For the RME, 0% cooking loss is assumed.

Generally, chemical contaminants are not distributed uniformly in fish. Fatty tissues, for example, will concentrate many organic chemicals more readily than muscle tissue. For those chemicals that accumulate in the fatty tissues, removing the skin and fat that collects beneath the skin and along the lateral line will reduce contaminant exposure. Also, to adjust dose accurately, it is important to match the dose modification factors to the type of sample that is the source of the measured contaminant concentrations. For example, it would not be appropriate to apply a modification factor based on removal of skin if the sample analyzed for contaminants was already a "skin-off" fillet.

The EFH (USEPA, 1997b) provides a recommended default adjustment for cooking and preparation loss. The values given in the EFH for fish are 30% for mean net cooking loss (includes dripping and volatile losses during cooking, averaged over various cuts and preparation methods) and 11% for mean net post-cooking loss (includes losses from cutting, shrinkage, excess fat, bones, scraps, and juices, averaged over various cuts and preparation methods). The EFH recommends that the modified intake rates be calculated as:

$$I_A = I \times (1 - L_1) \times (1 - L_2) \qquad (5\text{-}3)$$

where:

I_A = adjusted intake rate
I = intake rate
L_1 = cooking loss
L_2 = post-cooking loss

By applying the mean percent weight losses presented in the EFH, the adjusted intake rate is calculated as follows:

$$I_A = I \times (1 - 0.30) \times (1 - 0.11) \qquad (5\text{-}4)$$

$$I_A = I \times 0.7 \times 0.89 \qquad (5\text{-}5)$$

$$I_A = I \times 0.62 \qquad (5\text{-}6)$$

Thus, the total cooking loss and preparation adjustment amounts to 38% contaminant concentration reduction, which is similar to the values listed in Table 5-5 under the combined 50th percentile column heading. Note that the mean cooking loss percentages are based on averages over a variety of fish, including bass, bluefish, butterfish, cod, flounder, haddock, halibut, lake trout, mackerel, perch, porgy, red snapper, rockfish, salmon, sea trout, shad, smelt, sole, spot, squid, swordfish steak, trout, and whitefish.

In general, for heavy metals, tissue residues are not significantly reduced by processing or cooking methods. Therefore, preparation and cooking loss adjustments should not be applied for metals in most cases (USEPA, 2000a). Mercury, however, may be an exception. Mercury binds strongly to proteins and thus concentrates in the muscle tissue of the fish. It also concentrates in the liver and kidneys, although to a lesser extent (USEPA, 2000a). Several studies on the effects of preparation and cooking on mercury

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have shown that mercury concentrations are less in raw fish than in cooked fish, although the total amounts of mercury remain the same. The higher concentrations in cooked fish are attributed to the loss of liquid and fat during cooking, which results in a higher concentration. Morgan *et al.* (1997) found that mercury concentrations in pan-fried, baked, and broiled walleye fillets and deep-fried and baked whitefish livers ranged from 1.1 to 1.5 times higher than corresponding raw portions. In lake trout, mercury concentrations were 1.5 to 2.0 times higher in smoked fish than in the raw portions. Burger *et al.* (2003) calculated preparation factors of 1.5 to 1.8 for deep-fried largemouth bass. They concluded that based on these two studies, a preparation factor of 2 would be a suitable, protective default for estimating safe consumption levels.

The losses reported generally do not include an accounting for degradation of the contaminants. Until there is more information about the toxicity of the byproducts generated during the degradation of PCBs, D/F, organochlorine pesticides, or other chemicals of concern, USEPA recommends that no dose modification be assumed due to degradation alone (USEPA, 2000a).

Table 5-5 summarizes the range of cooking losses from fish that are examined in this risk assessment. For RME, a cooking loss of 0% is proposed for all contaminants to be consistent with the PCB cooking loss. For CTE, the 50th percentile cooking loss percent value for combined skin-on/skin-off is used as shown in Table 5-6. For mercury, both the RME and CTE estimates are 0% with USEPA (2000a), which states that preparation and cooking loss adjustments should not be applied for metals in most cases. The effects of cooking method on mercury concentrations are addressed further in Section 5.4.

Table 5-6. Range of Cooking Losses from Fish.[a]

COPC	Exposure Scenario	
	RME (%)	CTE (%)
DDD	0	30[b]
DDE	0	35[b]
DDT	0	30[b]
Chlordane	0	33[b]
Dieldrin	0	30[b]
Dioxins	0	49[b]
PCBs	0	20
Mercury[c]	0	0

RME – reasonable maximum exposure

CTE – central tendency estimate

a. Refer to Table 5-5, "combined column".

b. The USEPA EFH (1997b) provides a recommended default adjustment for cooking and preparation loss. The values given in the EFH for fish are 30% for mean net cooking loss and 11% for mean net post cooking loss.

c. Preparation and cooking loss adjustments should not be applied for metals in most cases (USEPA, 2000a).

Cooking Loss (CL) for Crab

Blue crabs are most often cooked whole by boiling or steaming (Sea Grant Marine Advisory Program, 2006). Exposure to the contaminant depends not only on the specific part of the crab consumed, but also on the method of cooking, as discussed in Section 5.1.2.2. Zabik *et al*. (1992) looked at the changes in the distribution of PCBs in blue crab caused by boiling or steaming and found that both cooking procedures reduced PCBs by more than 20% with and without the hepatopancreas intact; however, the cooking water contained 80% of the PCBs lost from the crab. NJDEP (2006c) reports that no specific cooking method can be relied on to reduce the chemical contaminant levels in blue crabs. Because the

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crab is cooked whole, even if the consumer does not eat the hepatopancreas, exposure to the chemical contaminant may still occur if the crab is cooked before the hepatopancreas is removed and if the liquid used to boil the crab is used in juices, sauces, bisques, or soups. It is assumed for this assessment that the cooking liquid is consumed along with the crab meat. Therefore, cooking loss for crabs is assumed to be 0% for the RME and CTE because data are not currently available from USEPA or published literature to support any type of reduction in concentrations under this type of exposure scenario.

Exposure Frequency (EF)
The ingestion rates for fish and crabs are annualized and presented on a daily basis. Therefore, the exposure frequency for the fish and crab consumption is assumed to be 365 days per year (USEPA, 1989) for both the RME and CTE scenarios.

Exposure Duration (ED)
For the adult angler/sportsman, exposure is assumed to occur for 6 years as a child and 24 years as an adult, for a total RME exposure duration of 30 years. An exposure duration of 9 years is assumed for the CTE. These assumptions are based on recommendations by USEPA (1989; 1991) and represent upper bound and average residential tenure at a single location. For the adolescent angler/sportsman, exposure is assumed to occur for 9 years (from ages 10 through 18 years) for the RME; for the CTE exposures, the residential default of 6 years is used (USEPA, 1991). The residential default of 6 years for the RME is assumed for the child receptor (USEPA, 1991); the RME is halved for the CTE.

Connelly *et al.* (1992) found that individuals may travel up to 37 miles to fish. It is possible that individuals may live in one section of the 8-mile stretch of the Passaic River and travel to another portion of the river to fish or crab. Therefore, individuals may be exposed for longer periods of time than the 30 years identified in this assessment. During the RI/FS, in- and out-migration census data will be evaluated to determine if the ED is longer than 30 years. The use of the 30-year ED may potentially underestimate the cancer risks for this site.

Body Weight (BW)
Age-specific body weights are used in this assessment. For the adult and child receptors, the default weights of 70 kg and 15 kg are used (USEPA, 1991). For the adolescent receptor, the applicable weight of 54.5 kg is used, which was derived by averaging the mean body weight estimates for males and females age 10 years to 17 years (USEPA, 2002b). Although the adolescent receptor evaluated in this HHRA is assumed to be from 10 to 18 years of age, the recommendation provided in USEPA (2002b) is to use the male and female mean body weight estimates based on data from the third National Health and Nutrition Examination Survey (NHANES III) summarized in Table 11-6 of the USEPA guidance, which presents data only up to 17 years of age. Body weight estimates from NHANES II also were provided in USEPA (2002b), which presented male and female mean body weight data up to 18 years of age. Using the NHANES II data, an estimated mean adolescent body weight (for males and females aged 10 to 18 combined) is 53.1 kg, slightly lower than the 54.5 kg derived using the recommended NHANES III body weight values. According to USEPA (2002b), an upward trend in body weight was observed between NHANES II (1976-1980) to NHANES III (1988-1994), and this trend may still be valid. Given the upward trend in body weights over the years, and given the USEPA recommendation to use data from NHANES III, the body weight of 54.5 kg is used for the adolescent receptor.

5.2 Toxicity Assessment

The toxicity assessment determines the relationship between the magnitude of exposure to a COPC and the nature and magnitude of adverse health effects that may result from such exposure. For purposes of this assessment, COPCs are classified into two broad categories: noncarcinogens and carcinogens.

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Toxicity studies with laboratory animals or epidemiological studies of human populations provide the data used to develop toxicity criteria.

Carcinogens are agents that induce cancer. Potential carcinogenic effects are expressed as the probability that an individual will develop cancer over a lifetime based on the exposure assumptions used in the risk assessment. The cancer slope factor (CSF) is a plausible upper bound estimate of carcinogenic potency used to calculate cancer risk from exposure to carcinogens, by relating estimates of lifetime average chemical intake to the incremental probability of an individual developing cancer over a lifetime. CSFs are derived based on an analysis of the animal and/or human data to determine the most appropriate model to use in the extrapolation from animal to humans or direct use of human epidemiological studies (USEPA, 1996; 1999; 2005b). Chemical-specific CSFs use data to determine whether a threshold exists or if the chemical is a non-threshold carcinogen (USEPA, 2005c). The slope factor is protective and assumes that exposure to any concentration of a carcinogen has the potential to produce an increased risk. The CSFs developed by the USEPA are plausible upper-bound estimates, which means that the USEPA is reasonably confident that the actual cancer risk will not exceed the estimated risk calculated using the CSF. Cancer risks from exposure to multiple carcinogens and multiple pathways are assumed to be additive (USEPA, 1989; 2000b).

Noncarcinogenic health effects were evaluated using reference doses (RfD) developed by USEPA. A RfD is an estimate of a daily oral exposure for a given duration to the human population (including susceptible subgroups) that is likely to be without an appreciable risk of adverse health effects over a lifetime [USEPA's Integrated Risk Information System (IRIS) definition]. RfDs are expressed in milligrams of contaminant per kilogram of body weight per day (mg/kg-day). The RfD is a health-based criterion based on the assumption that thresholds exist for noncancer health effects (*e.g.*, liver or kidney damage) over a length of time of exposure (*e.g.*, chronic). Chronic RfDs are specifically developed to be protective against long-term exposure to a contaminant.

A table summarizing the toxicity criteria, target organ, weight of evidence classifications, uncertainty factors, and other relevant information for each chemical is provided in Attachment 4, Tables 4-11 and 4-12, for noncancer and cancer toxicity, respectively. Toxicity criteria have been selected according to the USEPA (2003a) Office of Solid Waste and Emergency Response (OSWER) Directive 9285.7-53, which recommends a hierarchy of human health toxicity values for use in risk assessments at Superfund sites. The hierarchy is as follows: (1) USEPA's IRIS; (2) USEPA's Provisional Peer-Reviewed Toxicity Values (PPRTV) (Office of Research and Development, National Center for Environmental Assessment, Superfund Health Risk Technical Support Center); and (3) other sources of information, such as toxicity values from the State of California's Environmental Protection Agency (CalEPA) and the ATSDR's minimal risk levels (MRLs) for noncarcinogenic constituents.

At the current time, USEPA is reassessing the toxicity of dioxins and related compounds. In 2006, the National Academy of Sciences evaluated USEPA's 2003 dioxin reassessment and provided comments that are currently being reviewed by USEPA. This assessment used the toxicity values available in Health Effects Assessment Summary Tables (HEAST) for dioxin as the basis for the cancer risk assessment for the dioxin; noncancer health effects were evaluated qualitatively. The RI/FS that will be developed will evaluate the status of USEPA's reassessment to determine whether modifications are necessary. In July 2006, the WHO released its re-evaluation of human and mammalian TEFs for dioxins and dioxin-like compounds performed in 2005. The HHRA was completed using the 1998 TEFs. D/F and PCB congeners with revised TEFs are summarized in Table 5-7. Calculations for this HHRA were performed using the WHO 1998 TEFs. For this risk assessment, TEQs may have been underestimated or overestimated based on the revised TEFs, as further discussed in the uncertainty analysis (Section 5.4).

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Table 5-7. Dioxin/Furan and PCB Congeners with Updated TEFs.

Congener	WHO 1998 TEF[a]	WHO 2005 TEF[b]
Chlorinated dibenzo-p-dioxins		
OCDD	0.0001	**0.0003**
Chlorinated dibenzofurans		
1,2,3,7,8-PeCDF	0.05	**0.03**
2,3,4,7,8-PeCDF	0.5	**0.3**
OCDF	0.0001	**0.0003**
Non-ortho substituted PCBs		
PCB 81	0.0001	**0.0003**
PCB 169	0.01	**0.03**
Mono-ortho substituted PCBs		
PCB 105	0.0001	**0.00003**
PCB 114	0.0005	**0.00003**
PCB 118	0.0001	**0.00003**
PCB 123	0.0001	**0.00003**
PCB 156	0.0005	**0.00003**
PCB 157	0.0005	**0.00003**
PCB 167	0.00001	**0.00003**
PCB 189	0.0001	**0.00003**

[a.] Source: Van den Berg *et al.*, 1998.
[b.] Source: Van den Berg *et al.*, 2006.

Commercial PCBs tested in laboratory animals were not subject to prior selective retention of persistent congeners through the food chain (*i.e.*, laboratory test animals were fed Aroclor mixtures, not environmental mixtures that had been bioaccumulated). According to USEPA's analysis of published studies, bioaccumulated PCBs appear to be more toxic than commercial PCBs and appear to be more persistent in the body (USEPA, 1996; 1999). CSFs of 2.0 and 1.0 $(mg/kg\text{-}day)^{-1}$ are used to evaluate cancer risks for the upper-bound and central estimate exposures to PCBs via ingestion of fish from the Passaic River (Attachment 4, Table 4-12). The CSFs are based on the IRIS chemical file, which is based on the 1996 PCB reassessment (USEPA, 1996). Two RfDs are available for PCBs, one for Aroclor 1016 and the other for Aroclor 1254. For the noncancer toxicity assessment, the RfD for Aroclor 1254 is used to assess noncancer toxicity since the bioaccumulation of PCBs is more consistent with the more heavily chlorinated Aroclor 1254. Dioxin-like PCBs also have been evaluated. TEFs for these congeners are summarized in Table 5-7.

All other chemicals were evaluated using the toxicity values presented in their respective IRIS chemical files.

5.3 Risk Characterization

Risk characterization involves estimating the magnitude of the potential adverse health effects associated with the COPCs. It also involves making summary judgments about the nature of the human health threat to the defined receptor populations. The risk characterization combines the results of the dose-response (toxicity assessment) and exposure assessment to calculate cancer risks and noncancer health hazards. In

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accordance with USEPA's guidelines for evaluating the potential toxicity of complex mixtures (USEPA, 1986; 2000b), this assessment assumes that the effects of all constituents are additive through a specific pathway within an exposure scenario (USEPA, 1986; 2000b).

Risks are estimated as probabilities for COPCs that elicit a carcinogenic response. The excess lifetime cancer risk is the incremental increase in the probability of developing cancer associated with exposures to contaminated media at the site. A risk of 10^{-6}, for example, represents the probability that one person in one million exposed to a carcinogen over a lifetime (70 years) will develop cancer. The upper-bound excess lifetime cancer risks derived in this assessment are compared to the regulation of the NCP that includes a risk range of 10^{-4} (one in ten thousand) to 10^{-6} (one in one million) (USEPA, 1990).

The excess cancer risk is estimated using CSFs where risk is directly related to intake (USEPA, 1989):

$$\text{Risk} = \text{CSF} \times \text{LADD} \qquad (5\text{–}7)$$

where:

Risk	=	excess lifetime cancer risk (probability)
CSF	=	cancer slope factor $(\text{mg/kg-day})^{-1}$
LADD	=	lifetime average daily dose (mg/kg-day)

Only LADDs are used in conjunction with CSFs to obtain excess lifetime cancer risk estimates because slope factors are based on average lifetime exposures. CSFs are derived for specific routes of exposure; because the primary route of exposure to humans is ingestion, only oral toxicity values are applied in this assessment. Cancer risks from exposure to multiple carcinogens are assumed to be additive (USEPA, 1989). To estimate the total excess cancer risks from all carcinogens, cancer risks from each compound are summed. Excess cancer risks that are less than the acceptable NCP risk range are identified as *de minimis* risk.

The potential for noncarcinogenic health effects is estimated by comparing the ADD of a chemical with the RfD for the specific route of exposure (*e.g.*, oral). The ratio of the intake to reference dose (ADD/RfD) for an individual chemical is termed the hazard quotient (HQ). When an RfD is available for the chemical, these ratios are calculated for each chemical that elicits a noncarcinogenic health effect. Typically, chemical-specific HQs are summed to calculate pathway hazard index (HI) values. The HI is calculated by summing all HQs for all noncarcinogenic constituents through an exposure pathway:

$$\begin{aligned} HI &= HQ_1 + HQ_2 + \ldots + HQ_j \qquad (5\text{–}8) \\ &= (ADD_1/RfD_1) + (ADD_2/RfD_2) + \ldots + (ADD_j/RfD_j) \end{aligned}$$

where:

HQ_j	=	hazard quotient of the jth chemical
ADD_j	=	average daily dose of the jth chemical
RfD_j	=	reference dose for the jth chemical

When the HI exceeds unity, there may be a concern for health effects (USEPA, 1989). This approach can result in a situation where HI values exceed 1 even though no chemical-specific HQs exceed 1 (*i.e.*, adverse systemic health effects would be expected to occur only if the receptor were exposed to several contaminants simultaneously). In this case, chemicals are segregated by similar effect on a target organ, and a separate HI value for each effect/target organ is calculated (USEPA, 1989). If any of the separate HI values exceed 1, adverse, noncarcinogenic health effects are possible. It is important to note, however, that an HI exceeding 1 does not predict a specific disease.

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5.3.1 RME Results

The cancer risks associated with current conditions are summarized in Attachment 4, Tables 4-13 through 4-15, for the RME and are depicted on Figure 5-8. The calculated total cancer risks for the adult sportsman/angler (estimated for a 30-year exposure duration [ED] by summing the risks for the adult [based on 24-year exposure] and the child [based on 6-year exposure]) are 1×10^{-2} and 2×10^{-2} for ingestion of fish and crab, respectively. The ingestion risks for the adolescent receptor are 2×10^{-3} and 4×10^{-3} for fish and crab, respectively. TCDD TEQ (D/F), TCDD TEQ (PCBs), and total PCBs are the primary contributors to a combined risk above 10^{-2} for ingestion of both fish and crab, with individual cancer risks above 10^{-4} for each receptor, which exceeds the risk range described above. Approximate contributions to total risk are 65% from TCDD TEQ (D/F), 20% from TCDD TEQ (PCBs), and 10% from total PCBs. For ingestion of fish, the risk for chlordane was estimated at 1×10^{-4}, contributing approximately 1% to the total risk. However, the estimated risk associated with chordane for ingestion of crab was much lower at 2×10^{-6}. TCDD TEQ (D/F) comprises over three-fourths of the risk associated with the dioxins (*i.e.*, TCDD TEQ [D/F] and TCDD TEQ [PCBs]). As shown on Figure 5-8, RME cancer risks are outside the risk range of 10^{-4} and 10^{-6} (USEPA, 1990). These risks are the risks associated with continuance of current EPCs throughout the exposure duration even though EPCs would be expected to decline over time based on natural recovery processes. These processes and contaminant-specific half-lives are used to estimate future EPCs and future risk estimates under a no action alternative, which are provided in Sections 7.0 and 8.0, respectively. Specific details regarding the natural recovery processes and half-lives are provided in Appendix D. The future risks under a no action alternative may need to account for any changes in the EPCs over time; this is discussed further in Section 8.1.4.

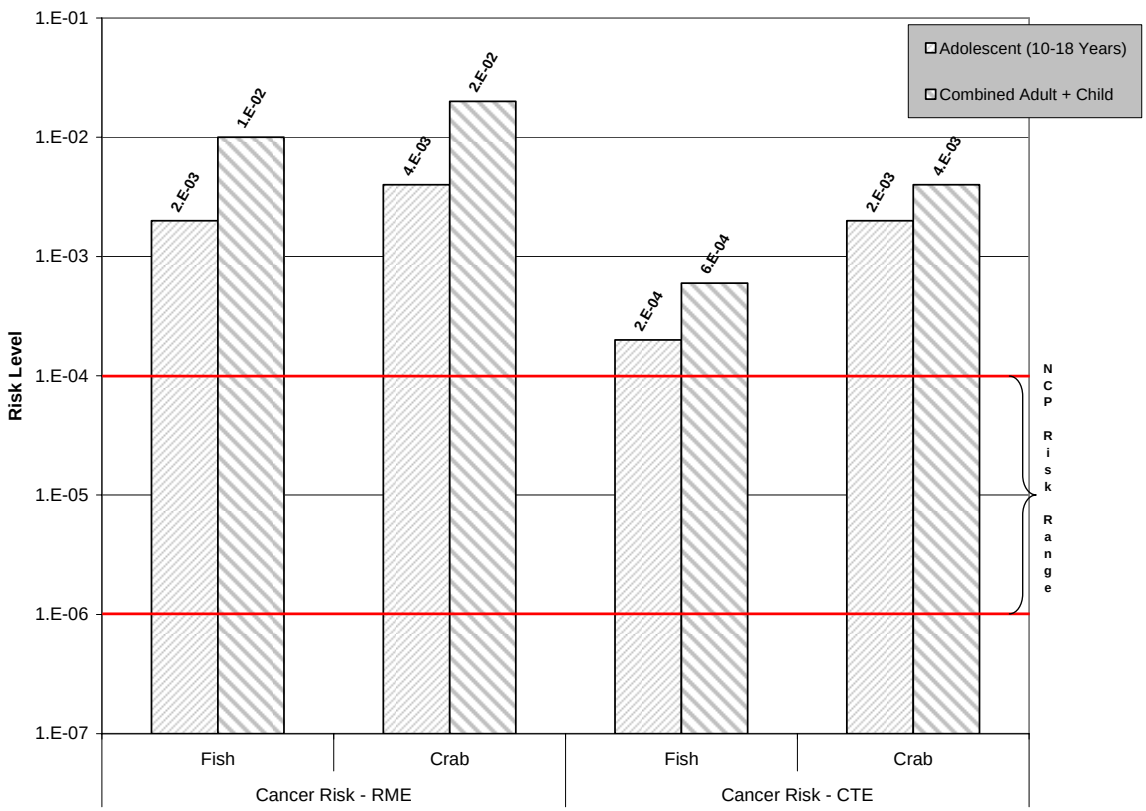

Figure 5-8. Current Cancer Risks for RME and CTE.

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The noncancer HIs are summarized in Attachment 4, Tables 4-16 through 4-18, and are shown on Figure 5-9. For ingestion of fish, the HIs are 64 for the adult, 55 for the adolescent, and 99 for the child. For ingestion of crab, the HIs are 86 for the adult, 72 for the adolescent, and 140 for the child. Total PCBs are the primary contributor to the excess hazard for all receptors for ingestion of both fish and crab.

The HQ for ingestion of methyl mercury in fish is 1 for the adult and adolescent receptors and slightly higher at 2 for the child receptor. In addition, the HQs for ingestion of chlordane in fish for all of the receptors are greater than 1. Exceedance of the NCP criterion of 1 is clearly indicated for the fish and crab RME scenarios, as shown on Figure 5-9.

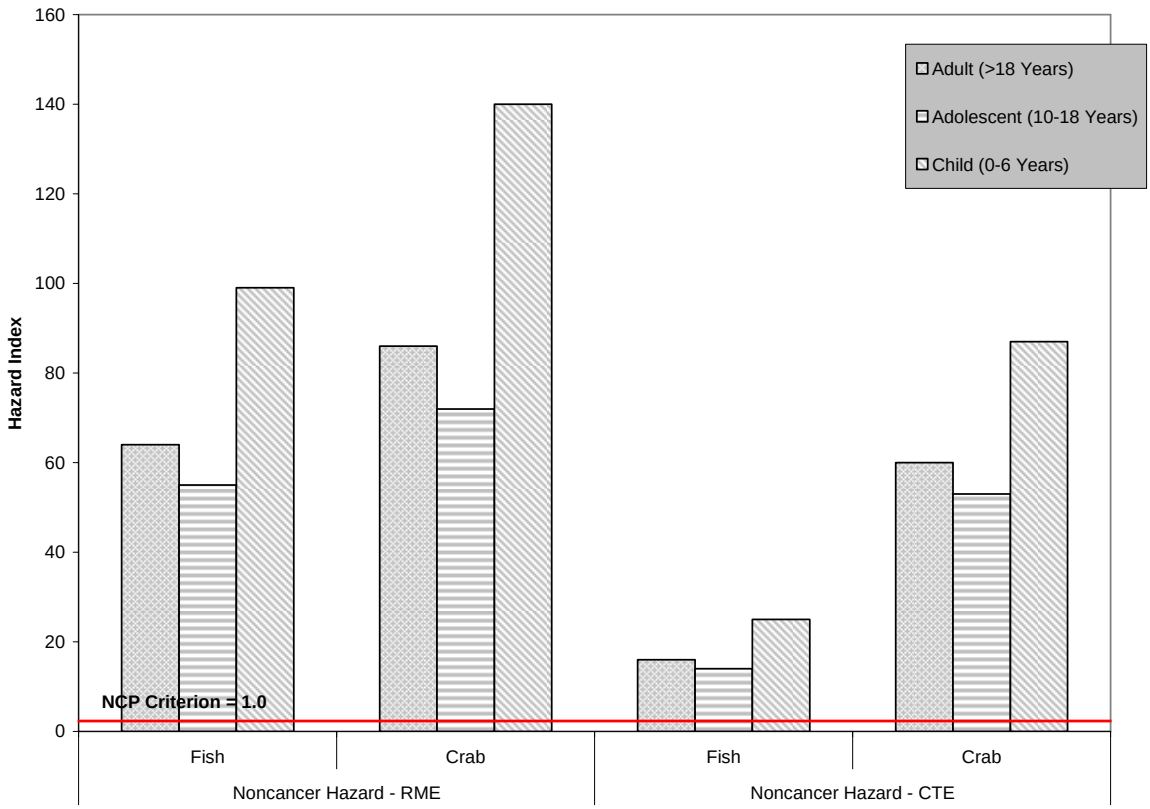

Figure 5-9. Current Noncancer Hazards for RME and CTE.

5.3.2 CTE Results

The cancer risks are summarized in Attachment 4, Tables 4-19 through 4-21, for the CTE and are depicted in Figure 5-8. The calculated total cancer risks for the 30-year exposure duration (*i.e.*, angler/sportsman adult + child receptors) are 6×10^{-4} and 4×10^{-3} for ingestion of fish and crab, respectively. The ingestion risks for the adolescent receptor are 2×10^{-4} and 2×10^{-3} for fish and crab, respectively. TCDD TEQ (D/F) and TCDD TEQ (PCBs) in fish and TCDD TEQ (D/F), TCDD TEQ (PCBs), and total PCBs in crab are the primary contributors to the total cancer risks. Only the individual cancer risks for fish for TCDD TEQ (D/F) exceed 10^{-4}. However, the individual cancer risks for crab for TCDD TEQ (D/F), TCDD TEQ (PCBs), and total PCBs are at or above 10^{-4} for each receptor. Estimated risks for chlordane were much lower at 9×10^{-6} and 6×10^{-7} for fish and crab ingestion, respectively. As shown on Figure 5-8, CTE cancer risks are above the risk range of 10^{-4}.

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The noncancer HIs are summarized in Attachment 4, Tables 4-22 through 4-24, and are shown on Figure 5-9. For ingestion of fish, HIs are 16 for the adult, 14 for the adolescent, and 25 for the child. For ingestion of crab, the HIs are 60 for the adult, 53 for the adolescent, and 87 for the child. Total PCBs are the primary contributor to the excess hazard for all receptors for both ingestion of fish and crab. The HQ for ingestion of methyl mercury in fish is less than 1 for each of the receptors. Exceedence of the NCP criterion of 1 is clearly indicated for the fish and crab CTE scenarios, as shown on Figure 5-9.

5.4 Human Health Uncertainty Analysis

This risk assessment is consistent with USEPA guidance, guidelines, and policies. The application of these procedures is designed to reduce potential uncertainty and ensure consistency.

A qualitative evaluation is provided in this section to address uncertainties associated with the estimates of risk/hazard presented in this report. Risk results are best estimates based on the most recent information and techniques available for predicting risk. Two primary sources of uncertainty associated with risk estimates are:

- Model uncertainty (*i.e.*, methods/models used to calculate EPCs and risk); and,
- Parameter uncertainty (*i.e.*, uncertainty in model input parameter exposure variables).

For the assessment of risk in response to existing concentrations, model uncertainty is not discussed because standard, accepted exposure and risk models have been employed in this assessment; therefore, it is assumed that the formulations of the models used to predict exposure and risk are valid at this time. Large uncertainties can often arise in risk estimates that are based on models that simulate the fate/transport of contaminants. However, risks here are based on measured contaminant data, and there is no dependency on the use of fate/transport modeling to predict EPCs for current conditions. However, the projection of future exposure concentrations is a major source of uncertainty in the estimate of LADD and associated cancer risks under the no action alternative presented in Section 8.0.

Conversely, parameter uncertainty is discussed here because this type of uncertainty is the most likely source of uncertainty impacting the calculated cancer risks and noncancer health hazards. Parameters involved in the risk assessment are categorized according to the step in which they occur (*i.e.*, hazard identification, exposure assessment, dose-response [toxicity] assessment, and risk characterization). The various parameter uncertainties and the likely impact of these uncertainties on the calculated risks are summarized in this section and in Table 5-8.

The following discussion identifies uncertainties based on overestimates or underestimates of cancer risks and noncancer health hazards.

One of the major uncertainties associated with the hazard identification process is the identification of COPCs. Not all of the COPCs identified in biota were evaluated. Only a subset of contaminants that capture the chemicals with the greatest potential to bioaccumulate through the food chain and the primary risk drivers were carried through the risk assessment. In addition, COPCs associated with other environmental media (*e.g.*, sediment and surface water) in conjunction with other potentially complete exposure pathways (*e.g.*, dermal contact, incidental ingestion) were not included in the risk assessment because the ingestion of biota and the COPCs identified for this medium are thought to drive risks and therefore cleanup objectives. In the absence of the quantification of these additional risk pathways and COPCs, the risks may be underestimated.

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There is a concern for the potential to double-count PCB concentrations and PCB risk when both dioxin-like PCB congener data and total PCB (as Aroclor) data are used to determine risk, particularly with those risks then being added together. Therefore, select PCB data were reviewed to address this concern. The results of the PCB enhancement assessment is presented in Attachment 4. Briefly, the results of the assessment indicate that the total PCB concentration (and total PCB-based risk) would be reduced by 8% if the contribution of the 12 dioxin-like PCB congeners is considered (*i.e.*, subtracted from the total PCB concentration). The overall risk associated with PCBs therefore would be reduced by 1% to 3%, resulting in the total cancer risk value declining by approximately 1% for both fish and crab risk estimations. This decrease in the total cancer risk, however, does not significantly impact the risk values. The estimated risk values at one significant figure would still be reported as the same values summarized in Section 5.3 and presented in Attachment 4.

Although methyl mercury was identified as a COPC, tissue data for methyl mercury were fairly sparse. As a result, analytical data for total mercury were used to represent methyl mercury results. This assumes that all the mercury bioaccumulated in the food chain is present as methyl mercury in the tissue, which is generally a reasonable assumption for human exposure via ingestion of piscivorous fish; however, this assumption may result in an overestimate of the noncancer health hazards.

Several parameters associated with the exposure assessment have uncertainties associated with them that impart uncertainty to the calculated cancer risks and the noncancer health hazards. These include EPCs, potential receptors, and exposure assumptions evaluated. Each of these is discussed below.

- Based on USEPA risk assessment guidance (USEPA, 1989), the 95% UCL of the arithmetic mean is used as the EPC because it is a health-protective estimate of the average site-wide concentration that a receptor would be exposed to. The 95% UCL is a statistic, and thus by nature is uncertain; however, to minimize the uncertainty in the EPCs, 95% UCLs were calculated using several statistical methods, and the most appropriate value was selected based on factors such as distribution of the raw data (*e.g.*, normal, lognormal). The 95% UCL is used to represent the RME encountered at the site; therefore, risks may be overestimated for some receptors who may experience less than the RMEs.
- For non-detected tissue data, one-half the detection limit is assumed (USEPA, 1989). Risks for some compounds with low frequency of detection may be overestimated with this approach. For instance, potentially large errors may be present in the total PCB value (*i.e.*, sum of Aroclors) used to estimate hazards associated with PCBs (USEPA, 1989). This is because the inclusion of one-half the detection limit for non-detects has a large impact on the total PCB estimate. The total PCB value is about twice as high when these values are included than when they are not included for a number of the samples. This is due to the high detection limits (*i.e.*, poor sensitivity) of the Aroclor analysis method, which likely resulted in an overestimation of the total PCB values because some of the less common non-detected Aroclors are probably not present in these samples and/or are not detected even with significantly more sensitive methods (*e.g.*, Aroclor 1221 and 1232). The three widely detected Aroclors (1248, 1254, and 1260) most likely comprise the vast majority of the total PCB in these samples (possibly over 90%), rather than one-half the total PCB concentration, which the data would suggest when the non-detect results are used.
- Historical data (from 1994 to 2001) used to calculate the EPC for fish included samples consisting of the whole body rather than fillets. Incorporating all portions of the fish may result in overestimating the concentrations if in fact individuals tend to eat mainly fillets. The calculated risks may overestimate the cancer risks and noncancer health hazards.
- Information regarding the specific characteristics of crab and fish samples was missing from the database. This includes data that would correlate with the age, length, weight, and sex of the fish. This lack of information could be a potential cause of uncertainty in estimating exposure

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concentrations and determining whether the fish or crab was an appropriate size for human consumption.

- Similarly, historical data used to calculate the EPCs for crab incorporated the hepatopancreas for results labeled as "edible tissue". Based on the biology of the crab, the potential exists for the hepatopancreas to be ingested while eating the other tissues from the crab. In addition, several cultures specifically consume the hepatopancreas as a delicacy. Incorporation of this organ results in an overestimation of the EPC concentration, resulting in an overestimation of risk.
- Use of the white perch and American eel to derive the EPC for fish ingestion assumes that individuals consume only white perch and American eel from the Lower Passaic River and that each of these species is equally consumed; these assumptions add uncertainty to the risk estimate. Risk estimates for individuals who consume only white perch would be underestimated because concentrations in white perch were always higher than the American eel. Averaging the two fish species would therefore dilute the EPC. On the other hand, the risk for those individuals consuming only American eel would be overestimated. This may result in an underestimation or overestimation of risks.
- There is uncertainty in the receptors evaluated in the risk assessment and their angling activities/habits. To minimize uncertainty in the calculated risks, exposure assumptions and parameters for these receptors were obtained from published literature sources (*e.g.*, creel surveys) for the Lower Passaic River or surrounding areas. In some instances, exposure assumptions and parameters were based on professional judgment and default exposure values recommended by USEPA. Risks are more likely to be overestimated than underestimated because of the conservative nature of the exposure assumptions. The uncertainties in the calculated risks are high. It is possible that subsistence populations who live in the area may consume higher amounts of fish or crab than a recreational angler. Crab consumption was assessed based on a creel survey of the Newark Bay Complex, which includes the Passaic River study area. However, it was noted that specific distributions of fish ingestion were not available for the survey. The potential exists that the risks may be either underestimated or overestimated.
- Angling, crabbing, and consumption of catch within the lower portion of the Lower Passaic River was assumed to be a frequent event for the receptors, even though this portion of the river is industrial in nature and fish and crab advisories have been issued. However, there is evidence that individuals do fish in this area, although the time spent and the amount caught are uncertain. There is also uncertainty about how changes in water quality might cause changes in the fishing activities on the river over time. As such, the uncertainty in the calculated risks may result in either an underestimation or overestimation of risk.
- The ingestion rate for crab consumption was based on a 3-month period during which individuals reported catching crab. This rate did not take into consideration the number of meals eaten throughout the remainder of the year when anglers may continue to catch crab or may consume frozen crab caught during the 3-month period. The ingestion rate may be underestimated; therefore, risks may be somewhat underestimated.
- Exposure to dioxin, dioxin-like compounds, and other bioaccumulative compounds in sensitive subpopulations, such as breast-fed children, was not evaluated quantitatively. These compounds are lipophilic and concentrate in breast milk. Therefore, risks are more likely to be underestimated for these sensitive populations.

As discussed below, the primary aspects of the toxicity assessment that impart uncertainty to the calculated risks include uncertainty in the toxicity data for constituents detected at the site.

- The toxicity assessments included human epidemiological studies in addition to animal studies. Following careful review of the data, the most appropriate studies were used to develop toxicity values. The toxicity values for dioxins, mercury, and PCBs, the primary

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chemical risk drivers, were extensively peer-reviewed. The toxicity values are designed to be protective of human health, and the potential exists that the risks may be lower (USEPA, 2005c).

- The cancer toxicity for D/F is being evaluated through the USEPA reassessment. Only a cancer assessment was evaluated in this HHRA based on the availability of a CSF. The noncancer assessment, or a margin of exposure, was not calculated. The potential exists that the dioxin risks may be either overestimated or underestimated.
- In July 2006, the WHO released its re-evaluation of human and mammalian TEFs for dioxins and dioxin-like compounds performed in 2005. The HHRA was completed using the 1998 TEFs. D/F and PCB congeners with revised TEFs are summarized in Table 5-7. In the 2006 WHO re-evaluation, some of the chlorinated D/F TEFs increased by factors ranging from 1.7 up to 3 over the corresponding 1998 values. Others decreased by a factor of 1.7. The non-ortho substituted PCBs all increased by a factor of 3, whereas the mono-ortho substituted PCBs decreased by factors ranging from 3.3 to 16.7. Calculations were performed (although not presented in this HHRA) using the revised TEFs, and the risk results were virtually unchanged compared to the calculations derived using the 1998 TEF values. For this risk assessment, TEQs may have been underestimated or overestimated based on the revised TEFs.

Finally, uncertainty in the calculated risks can arise from uncertainty in the way in which risks were calculated or aggregated, as discussed below. Table 5-8 summarizes all of the uncertainties discussed in this section.

- The assessment did not evaluate the potential cancer risks and noncancer health hazards based on background concentrations. The contributions from background concentrations will be evaluated in the RI/FS. If background and ambient constituents are included in the risk assessment, the calculated risks overestimate the risk attributed to chemical releases from the site.
- Risks were derived assuming that the receptors ate fish or crab, but not both. Although Burger (2002) reported survey results indicating that the majority of people caught either fish or crab, it is likely that some anglers may catch, and eat, both fish and crab. Therefore, risks may be underestimated for individuals who eat both fish and crab. However, for individuals eating both crab and fish at each meal, the respective ingestion rates for both would be expected to decrease (*i.e.*, if someone eats both fish and crab during a meal, than the fish ingestion rate and the crab ingestion rate may be lower than the respective ingestion rates when only fish or only crab is consumed during a meal). Therefore, risks would be overestimated if the same respective consumption rates were assumed for an individual consuming both fish and crab during a meal. As such, the uncertainties in the calculated risks for this site are considered low.
- The HQ for ingestion of methyl mercury in fish is 1 for the adult and adolescent receptors and 2 for the child receptor based on an EPC of 0.3 mg/kg. The oral RfD for mercury is based on human epidemiological studies; therefore, the overall confidence in the RfD for methyl mercury is high. Because the HQ for the child receptor is above 1, there may be concern for potential health effects as a result of methyl mercury exposure. Thresholds that have been used to establish consumption advisories are 1.0 mg/kg wet weight (used by the Food and Drug Administration [FDA] for restriction of commercial sale of fish) and 0.5 mg/kg (with advisories of no or restricted consumption of fish with higher assessment of total mercury concentrations in fish from rivers, lakes, and reservoirs in New Jersey) (Horwitz *et al*., 2002). In 1994, NJDEP and the Toxics in Biota Committee derived a risk-based criterion for mercury concentrations as low as 0.08 mg/kg as a

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trigger for State advisories restricting consumption among the most vulnerable segments of the human population (*e.g*., children and pregnant women) (Horwitz *et al*., 2002). The uncertainties associated with the exposure assumptions used in the calculation of the noncancer HQ for mercury are similar to the other fish contaminants of concern identified above. The information presented regarding the concentration of mercury in fish used to establish fish advisories for the general and vulnerable portions of the human population (*e.g*., children and pregnant women) also identify potential concerns for the ingestion of mercury-contaminated fish at varying concentrations.

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Table 5-8. Summary of Major Uncertainties in the HHRA and Estimated Impacts on Calculated Risks.

Risk Assessment Step	Source of Parameter Uncertainty	Description of Uncertainty	Impact on Calculated Risks
Hazard Identification	Identification of COPCs for quantitative evaluation	Only a subset of contaminants that capture the primary risk drivers were carried through the risk assessment process.	Risks are underestimated.
		COPCs associated with other environmental media (*e.g.*, sediment and surface water) were not evaluated.	Risks are underestimated.
	Mercury and methyl mercury	Due to lack of methyl mercury data in the biota tissue data, results for mercury were used as surrogate for methyl mercury based on fate and transport properties of mercury in the environment and the toxicokinetics of mercury in the biota. This assumes that all mercury contained in fish and crab eaten by humans is present as methyl mercury.	Risks are likely overestimated.
Exposure Assessment	EPCs for biota	95% UCLs on the mean were calculated from measured data collected from numerous samples distributed across the exposure area and used as the EPC to calculate risk. The difference between the 95% UCL and mean indicates the level of uncertainty associated with EPC estimation.	Risks for some compounds with low frequency of detection may be overestimated by using ½ the detection limit for non-detected values.
	Fish and crab tissue data used to derive EPC	Historical data used to calculate the EPC for fish may have at times included samples consisting of the whole body rather than only fillets. Historical data used to calculate the EPC for crab incorporated the hepatopancreas results.	Incorporating all portions of the fish may result in overestimating the concentrations if in fact individuals tend to mainly eat fillets or muscle tissue. Risks for ingestion of crab may be overestimated because data from the hepatopancreas-specific samples were included in the EPC.
	Use of a the white perch and American eel to derive the EPC for fish ingestion	Use of a weighted average fish concentration, consisting of white perch and American eel, was used to represent a broad range of fish species that could be caught and consumed. However, the assumption is that fish species are equally caught and consumed.	Risks may be overestimated or underestimated for individuals who consume only a specific species. For example, risks for individuals who consume only white perch would be underestimated because concentrations in white perch were always higher than the American eel. A weighted average of the two fish species lowered the EPC. On the other hand, the risk for those individuals consuming only American eel would be overestimated.

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Table 5–8. Summary of Major Uncertainties in the HHRA and Estimated Impacts on Calculated Risks, continued.

Risk Assessment Step	Source of Parameter Uncertainty	Description of Uncertainty	Impact on Calculated Risks
	Receptors and exposure parameters	Selecting the most representative exposure parameters for the angling activities/habits is difficult, especially for exposure duration, exposure frequency, and fish ingestion rates.	Risks may be overestimated or underestimated for this site.
	Receptors and exposure parameters	Ingestion rate for consumption of crab was based on a 3-month period during which individuals reported they caught crab.	This rate did not take into consideration the number of meals eaten throughout the year when individuals continued to catch crab beyond the 3-month period or ate crab that had been caught during the 3- month period and frozen. Therefore, risks may be underestimated.
		Other potentially complete exposure pathways for the anglers were not included (*e.g.*, dermal contact with sediment). In addition, exposure to dioxin and dioxin-like compounds in sensitive subpopulations such as breast-fed children was not evaluated.	Exclusion of these additional pathways would underestimate the risks for the site.
Toxicity Assessment	Toxicity data (general)	Toxicity values for dioxin, PCBs, and mercury are based on an assessment of animal and human data. In some cases, animal data were used as the basis for the toxicity values that were further extrapolated to humans.	Because the most conservative values available are typically used, risks are more likely to be overestimated than underestimated.
	1998 vs. 2005 TEF values	The WHO released its re-evaluation of human and mammalian TEFs for dioxins and dioxin-like compounds performed in 2005.	Risks using the 2005 TEF values were virtually equal to those based on the 1998 values.
	Dioxin reassessment	USEPA is conducting a scientific reassessment of the health risks of exposure to dioxin and dioxin-like compounds in light of significant advances in scientific understanding of mechanisms of dioxin toxicity, significant new studies of dioxin's carcinogenic potential in humans, and increased evidence of other adverse health effects.	Future modifications for determining cancer and noncancer effects may lead to an overestimation or underestimation of risks and noncancer health hazards.
Risk Characterization	Distinguishing site-related risks from background and/or ambient risks	Contributions from background conditions were not assessed in the risk assessment based on the lack of information.	The calculated risks may be overestimated, but the extent of this overestimation cannot be determined.

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Table 5–8. Summary of Major Uncertainties in the HHRA and Estimated Impacts on Calculated Risks, continued.

Risk Assessment Step	Source of Parameter Uncertainty	Description of Uncertainty	Impact on Calculated Risks
	Consumption of both fish and crab	Risks were derived assuming that the receptors ate fish or crab, but not both.	Risks may be underestimated for individuals who eat both fish and crab. However, for individuals eating both crab and fish, the ingestion rates for both these would be expected to decrease; therefore, risks would be overestimated if the same ingestion rates were assumed.
	Thresholds that have been used for establishing consumption advisories	The information presented regarding the concentration of mercury in fish used to establish fish advisories for the general and vulnerable portions of the human population (*e.g.*, children and pregnant women) also identify potential concerns for the ingestion of mercury contaminated fish at varying concentrations.	Noncancer risks may be underestimated for vulnerable portions of the population.

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6.0 ECOLOGICAL RISK ASSESSMENT – CURRENT CONDITIONS

The purpose of the ERA is to assess and characterize potential risks to ecological receptors under current conditions in the lower 8 miles of the Lower Passaic River. This section evaluates current risk following USEPA (1998) guidance and includes the exposure assessment, toxicity assessment, risk characterization, and uncertainty analysis. A comparison of current risks to post-remediation risks is presented in Section 8.0.

6.1 Exposure Assessment

The exposure assessment determines the degree of co-occurrence between COPECs and the ecological receptors to be evaluated. To do this, EPCs are calculated for each COPEC over the entire lower 8-mile stretch of river. These are used to estimate exposures associated with direct contact for non-wildlife receptors (*i.e.*, fish) as well as used in the food web models to estimate daily doses to wildlife receptors.

6.1.1 EPCs

As discussed in Section 4.2.3, EPCs for all media evaluated were calculated as the 95% UCL of the arithmetic means of the available data. The EPCs used in this assessment are defined in Table 4-1 of this appendix.

6.1.2 Dose Model

The exposure assessment estimates the potential exposure of receptors to COPECs identified at the site. An exposure model incorporating natural history information and species characteristics, such as diet composition, ingestion rates, body weights, and foraging ranges, for each wildlife receptor was developed to evaluate the exposure of the receptor to each COPEC. Equation 6-1 is a dose model that is used to assess daily exposure of COPECs to upper-trophic wildlife receptors (*i.e.*, mink and great blue heron) and to characterize exposure:

$$\text{Dose} = \frac{[(C_{sed} \times IR_{sed}) + (C_{food} \times IR_{food})] \times SUF}{BW} \qquad (6\text{-}1)$$

where,

Dose	=	daily dose resulting from ingestion of sediment and food (mg/kg-day)
C_{sed}	=	concentration of COPEC in surface sediment (mg/kg)
IR_{sed}	=	estimate of receptor's daily ingestion rate of surface sediment (kg/day)
C_{food}	=	concentration of COPEC in food tissue (mg/kg)
IR_{food}	=	estimate of daily ingestion rate of food tissue (kg/day)
SUF	=	site use factor (unitless)
BW	=	body weight (kg)

Because the exposure (and therefore the dose) for each receptor is different, the exposure factors used in the dose equation vary slightly based on the receptor being evaluated. The exposure parameters for the mink and great blue heron are summarized in Tables 6-1 and 6-2, respectively.

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Table 6-1. Exposure Parameters for the Mink.[a]

Exposure Parameter	Abbreviation	Unit	Value	Source
Body weight	BW	kg	0.6	Mitchell, 1961
Daily ingestion rate of sediment[b]	IR_{sed}	kg/day	0.003	Assumption
Daily ingestion rate of fish and crabs[c]	IR_{fish}	kg/day	0.17	USEPA, 1993a
Site Use Factor (max of 1)	SUF	unitless	1	Assumption

a. Because of the piscivorous nature of this species, its diet will be considered 80% fish and 20% shellfish (crab).
b. The amount of sediment in its diet is estimated here as 2% and multiplied by the daily ingestion rate.
c. Calculated using regression equation for mammals: IR_{food} (g/day) = 0.235 * BW $^{0.822}$ (g)

Table 6-2. Exposure Parameters for the Great Blue Heron.[a]

Exposure Parameter	Abbreviation	Unit	Value	Source
Body weight	BW	kg	2.2	USEPA, 1993a
Daily ingestion rate of sediment[b]	IR_{sed}	kg/day	0.019	Assumption
Daily ingestion rate of fish and crabs[c]	IR_{fish}	kg/day	0.39	Kushlan, 1978
Site Use Factor (max of 1)	SUF	Unitless	1	Assumption

a. Because of the piscivorous nature of this species, its diet will be considered 85% fish and 15% shellfish (crab).
b. Assume 5% of daily food ingestion rate.
c. Calculated using regression equation for wading birds: log(IR_{food}) (g/day) = 0.966 * log(BW) - 0.64 (g)

6.1.3 Avian Egg Residue Analysis

The embryo is the most sensitive avian life stage to dioxin-like effects (Gilbertson *et al*., 1991; USEPA, 1993b, 2003b; Hoffman *et al.*, 1996) and avian embryo viability was also selected as an assessment endpoint for this study. *In lieu* of site-specific tissue residue data that could be unambiguously linked to Passaic River sediment, a study that analyzed dioxin/furan and PCB congeners and various organochlorine pesticide concentrations in herring gull whole body, liver, and egg tissue (Braune and Norstrom, 1989) was used to estimate organochlorine COPEC concentrations in piscivorous bird eggs. Lipid-normalized gull egg/alewife tissue Biological Magnification Factors (BMFs) were derived using results provided in Braune and Norstrom (1989); calculated values are provided in Attachment 5 (Table 5-2). Fish tissue EPCs (derived using the American eel/white perch dataset) were multiplied by the BMFs to estimate avian egg concentrations.

$$C_{eggnorm} = C_{fishnorm} * BMF \qquad (6\text{-}2)$$

where,

$C_{eggnorm}$ = lipid-normalized egg tissue concentration (µg/g $_{egg\ lipid}$)
$C_{fishnorm}$ = lipid-normalized fish tissue concentration (µg/g $_{fish\ lipid}$)
BMF = Biological Magnification Factor (g $_{fish\ lipid}$/g $_{egg\ lipid}$).

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The fish EPC was lipid normalized using the average lipid content of Passaic River American eel and white perch samples (*i.e.*, 7.0%) used in the ERA. The lipid content in herring gull eggs (7.7%) reported in Braune and Norstrom (1989) was used to normalize the avian egg tissue concentrations. The estimated avian egg tissue concentrations were compared to embryo-based CBRs, which are described in Section 6.2.

Parsons (2003) measured chemical residues in cormorants (*Phalacrocorax auritus*) nesting in the greater New York Harbor area, which included sampling locations on Shooter's Island in the southern portion of Newark Bay. The majority of dioxin and furan congeners were detected in all cormorant eggs from Shooter's Islands collected in 1999. In comparison to the estimated gull egg tissue concentration for 2,3,7,8-TCDD (0.0018 µg/g, Table 5-4) the maximum detected concentration from the Shooter's Island samples (0.000201 µg/g) is approximately 9 times less. Maximum detected concentrations of PCBs 77, 81, and 126, which are among the most toxic to birds, in the Shooter's Island samples were 0.000040, 0.000040, and 0.000070 µg/g, respectively; estimated egg tissue concentrations of PCBs 77, 81, and 126 in eggs of gulls feeding entirely in the Lower Passaic River are 0.0023, 0.0021, and 0.00058 µg/g, respectively. Higher concentrations in the Passaic River samples would be expected and these comparisons suggest that the modeling approach is consistent with available empirical data.

6.2 Toxicity Assessment

Three general categories of toxicological data were used to evaluate ecological risks:

- Sediment benchmarks – used to evaluate direct contact exposures to sediment by benthic macroinvertebrates and fish;
- Toxicity Reference Values (TRVs) – used to estimate toxicological effects associated with contaminant exposure by wildlife associated with the incidental sediment ingestion and contaminated prey consumption pathways; and,
- Critical Body Residues (CBRs) – used to estimate the toxicological effects associated with bioaccumulated tissue residues measured or estimated in benthic macroinvertebrates, fish, and avian eggs.

Each of these categories is briefly discussed and the selected toxicity benchmarks, TRVs, and CBRs are summarized in this section. Finally, brief toxicity profiles are presented that provides the basis for the selected TRVs and CBRs.

6.2.1 Sediment Benchmarks

The sediment benchmarks used to evaluate direct contact exposures to benthic macroinvertebrates were the lower of available NOAA Effects Range-Low (ER-L) values and NJDEP sediment screening values; however, both of these compilations are based on values published by Long *et al.* (1995). In addition, USFWS developed a sediment benchmark for 2,3,7,8-TCDD based on sediment and suspended solids analytical data collected from the Arthur Kill and oyster effect data presented in Wintermyer and Cooper (2003). The sediment benchmarks used in the analysis are summarized in Table 6-16.

The potential toxicity of sediment associated-PAH compounds to fish receptors has been subject of considerable scientific study over the last several decades (Douben, 2003; Hylland, 2006; Barron, 2007). Various difficulties are associated with establishing sediment protective concentrations for these compounds for fish receptors, including a range of physicochemical properties (affecting both bioavailability and pharmacokinetics within organisms) and the nature of the adverse effects, for which early life stages are most sensitive (Barron *et al*., 2004). In addition, for some effects, such as tumor development, relatively long periods of time may separate the significant exposure period and the effect (Landahl *et al*., 1990; Myers *et al*., 2003). Moreover, in the majority of fish species, which are capable of

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rapidly metabolizing PAHs, the etiological agents are degradation products of metabolic pathways rather than the parent compound measured in abiotic media (Leadly *et al*., 1999; Schanke *et al*., 2001; Incardona *et al*., 2006). Some of these daughter compounds are known to form DNA adducts that can result in a range of genotoxic responses in exposed individuals.

Based on work with English sole (*Pleuronectes vetulus*) and supported by work with other fish including winter flounder (*Pseudopleuronectes americanus*), brown bullhead (*Ameirus nebulous*), and mummichogs, total PAH concentrations in sediment of 1 µg/g represent a threshold for adverse effects to estuarine fish species (Horness *et al.*, 1998; Johnson *et al*., 2002). Concentrations above this threshold are significantly correlated with measures of reduced embryonic growth and female fish fertility, along with increases in direct damage to the DNA molecule and incidence of liver tumors. This sediment threshold concentration is comparable to the NOAA ER-L values for LPAH and HPAH (0.55 and 1.7 µg/g, respectively); consequently, results of the sediment benchmark analysis for the benthos can reasonably be extended to assessing effects to fish populations in the Lower Passaic River.

6.2.2 Toxicity Reference Values

Chemical- and receptor-specific toxicity reference values (TRV) are compared to the ingestion dose estimates to evaluate the potential effects to wildlife associated with exposure to COPECs in the Passaic River, which results in a HQ (Equation 6-3). In general, an HQ above 1.0 indicates the potential for risk; an HQ below 1 indicates a low potential for risk.

$$HQ = dose/TRV \qquad (6\text{-}3)$$

A TRV is defined as a dose level (based on laboratory toxicological investigations) above which a particular ecologically relevant effect may be expected to occur in an organism following chronic dietary exposure and below which it is reasonably expected that such effects will not occur (USEPA, 2005d). TRV derivation may incorporate uncertainty (or extrapolation) factors (ept, 1996; Chapman *et al.*, 1998) to account for a wide range of limitations, such as interspecies sensitivities. The TRVs presented in this document are considered to be sufficiently conservative, and the use of additional uncertainty factors is not scientifically warranted.

Rather than deriving a single point-estimate associated with specific adverse biological effects, both high and low TRVs are derived for each receptor and each COPEC to reflect the variability of potential risk. The low TRV value is consistent with a chronic, no observed-adverse-effects level (NOAEL). It represents a level at which adverse effects are unlikely to occur and is used to identify sites posing little or no risk. Conversely, the high TRV is an estimator of potential adverse effects, representing a level at which adverse effects are more likely to occur, and is consistent with a chronic, lowest observed-adverse-effects level (LOAEL).

Table 6-3 summarizes the TRVs that were identified for the selected COPECs: copper, lead, mercury, LPAHs, HPAHs, total PCBs, TCDD, DDx, and dieldrin. Generally, two separate wildlife TRVs are developed for each COPEC to characterize risk to the two main categories of wildlife receptors (*i.e.*, birds and mammals).

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Table 6-3. TRVs Selected from Available Literature.

COPEC	Test Species	Wildlife Receptors	Low TRV[a] (NOAEL)	High TRV[a] (LOAEL)	Reference
Copper	Chicken	Avifauna	4.1	12	USEPA, 2007
	Pig	Mammals	5.6	9.3	USEPA, 2007
Lead	Chicken	Avifauna	1.6	3.3	USEPA, 2005d
	Rat	Mammals	4.7	8.9	USEPA, 2005d
Mercury[b]	Mallard	Avifauna	0.0078[c]	0.078	Heinz, 1979
	Mink	Piscivorous mammals	0.055	0.18	Wobeser *et al.*, 1976a,b
LPAH		Avifauna	-	-	Not necessary
		Mammals	-	-	Not necessary
HPAH		Avifauna	-	-	Not available
HPAH	Mouse	Mammals	1.0	10	Sample *et al.*, 1996
Total PCBs	Chicken	Avifauna	0.10	0.40	Chapman, 2003
	Mink	Mammals	0.080	0.096	Chapman, 2003
Total DDx	Brown pelican	Piscivorous birds	0.0028	0.028	Anderson *et al.*, 1975
	Rat	Mammals	0.80	4.0	Fitzhugh, 1948; as cited in Sample *et al.*, 1996
Dieldrin	Mallard	Avifauna	0.071	3.8[c]	Nebeker *et al.*, 1992
	Rat	Mammals	0.015	0.030[c]	Harr *et al.*, 1970
TCDD	Pheasant	Avifauna	1.4×10^{-6}	1.4×10^{-5}	Nosek *et al.*, 1992a,b
	Mink	Piscivorous mammals	8.0×10^{-8}	2.2×10^{-6}	Tillet *et al.*, 1996

a. Units are µg COPEC/g body weight-day
b. TRV based on methyl mercury.
c. High TRVs are equivalent to the LOAEL from the study that the low TRV (NOAEL) was selected; units in µg COPEC/g body weight-day.

6.2.3 Critical Body Residues

Critical Body Residues (CBRs) were also developed to support the residue-based analysis. In general, a CBR is a contaminant- and taxon-specific threshold concentration measured in biological tissue above which adverse effects of ecological relevance would be anticipated to occur. This residue-based approach to evaluating risk provides a number of distinct advantages over the exposure-based approach, such as the explicit consideration of contaminant bioavailability and metabolism (McCarty and MacKay, 1993). The CBRs selected for this assessment were based on conservative values previously identified for the CSM Technical Memorandum (Battelle, 2006b); CBRS are summarized in Table 6-4 and details regarding their derivation presented in Attachment 5.

Figures 5-1 through 5-16 in Attachment 5 summarize available information on the range of tissue concentrations of COPECs associated with adverse effects in various fish and aquatic invertebrate species. Although benchmark CBRs were typically selected from the low-end of the range of reported effect concentrations, the selected endpoints are all ecologically relevant and the majority of the species for which the CBRs were developed could occur in the Lower Passaic River. It is known that salmonids fish species are particularly sensitive to exposure to dioxin-like compounds (Elonen *et al*., 1998); however, the lowest tissue effect data for mummichogs are within an order of magnitude of the lowest salmonid data (Figure 5-9; Attachment 5). Table 5-1 of Attachment 5 summarizes the basis for the CBR values selected for the study, as summarized in Table 6-4, below; included are the specific species, effect measure, body part, and exposure route.

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Table 6-4. Summary of CBRs for Various Ecological Receptorsa.

COPEC	CBR (µg/g)		Species	Endpoint
	NOAEL	LOAEL		
American Eel/White Perch				
Copper	0.002	0.02	Channel catfish	Growth - LOED
Lead	0.028	0.28	Rainbow trout	Growth - ED_{11}
Mercury	0.006	0.06	Channel catfish	Mortality - LD_{50}
Methyl mercury	0.001	0.01	Mummichog	Growth – ED_{146}
LPAHs	0.21	2.1	Pacific sand sole	Mortality - LD_{51}
HPAHs	0.21	2.1	Pacific sand sole	Mortality - LD_{51}
Total PCBs	0.0025	0.025	Japanese medaka	Reproduction – ED_{11}
Dieldrin	0.011	0.11	Rainbow trout	Growth - LOED
Total DDx	0.000039	0.0018	Japanese medaka	Mortality - LOED
TCDD TEQ – fish[a]	0.000034	0.000058	Lake trout	Growth - LOED
Mummichog				
Copper	0.002	0.02	Channel catfish	Growth - LOED
Lead	0.028	0.28	Rainbow trout	Growth - ED_{11}
Mercury	0.006	0.06	Channel catfish	Mortality - LD50
Methyl mercury	0.001	0.01	Mummichog	Growth – $ED\text{-}_{146}$
LPAHs	0.21	2.1	Pacific sand sole	Mortality - LD_{51}
HPAHs	0.21	2.1	Pacific sand sole	Mortality - LD_{51}
Total DDx	0.16	0.85	Mummichog	Reproduction - ED_{20}
Total PCBs	0.0044	0.044	Fundulus	Reproduction – ED_{114}
Dieldrin	12.8	34	Sheepshead minnow	Mortality - LOED
TCDD TEQ – fish[b]	0.0000635	0.000635	Mummichog	Mortality - LOED
Benthic Macroinvertebrates				
Copper	0.086	0.86	Littleneck clam	Mortality - LD_{11}
Lead	0.52	5.2	Freshwater amphipod	Mortality - LD_{25}
Mercury	0.0095	0.095	Estuarine copepod	Reproduction – ED_{50}
Methyl mercury	0.0095	0.095	Estuarine copepod	Reproduction – ED_{50}
LPAHs	0.022	0.22	Blue mussel	Reproduction - LOED
HPAHs	0.022	0.22	Blue mussel	Reproduction - LOED
Total DDx	0.00018	0.0018	Freshwater amphipod	Mortality – LD_{50}
Total PCBs	0.42	1.1	Grass shrimp	Mortality - LOED
Dieldrin	0.01	0.08	Pink shrimp	Mortality - LOED
TCDD TEQ - fish[b]	0.00000015	0.0000013	Eastern oyster	Reproduction - LOED
Avian Embryos				
Dieldrin	-	0.059	Peregrine falcon	Egg shell thinning
Total DDx	-	0.10	Golden eagle	Egg shell thinning
TCDD-TEQ - bird[b]	0.000059	0.00015	Various	Various

[a] See Attachment 5 for further details and literature citations.
[b] Benchmark used to evaluate hazards posed by exposure to dioxin, furan, and coplanar congeners (*i.e.*, TCDD TEQ (D/F) and (PCBs).
LOED – Lowest observed effect dose

Tables 5-5 and 5-6 in Attachment 5 present a comparison of estimated fish egg tissue TCDD TEQ concentrations (based on American eel/white perch and mummichog EPCs, respectively) for dioxin/furan and PCB congeners to tissue-residue benchmarks based on an SSD for fish embryos developed by

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Steevens *et al* (2005). Congener-specific egg concentrations were estimated by multiplying the adult (female) tissue EPC values by egg/adult BMFs derived for lake trout (Cook *et al*., 2003) and by the fish TEFs (Tables 5-5 and 5-6 in Attachment 5).

6.2.4 Ecotoxicological Profiles

The following section presents ecotoxicological profiles for each COPEC.

Copper (Cu) is a reddish metal that occurs naturally in rock, water, soil, and sediment. It is an essential element at low levels for all organisms, including humans and other animals; however, at higher levels, toxic effects can occur. Copper can enter the environment through releases from the mining of copper and other metals and from factories that make or use copper metal or compounds. Copper can also enter the environment through waste dumps, domestic waste water, and combustion of fossil fuels, wood production, fertilizer production, and natural sources such as dust from soils, volcanoes, and forest fires.

Copper strongly adsorbs to organic matter, carbonates, and clay, which reduces its bioavailability. Copper is highly toxic in aquatic environments and causes adverse effects in fish, invertebrates, and amphibians, with all three groups equally sensitive to chronic toxicity (USEPA, 1993a; Horne and Dunson, 1995). Copper bioconcentrates in various organs in both fish and mollusks (Owen, 1981). Toxic effects in birds include reduced growth rates, lowered egg production, and developmental abnormalities (USEPA Region 5, 2006). While mammals are not as sensitive to copper toxicity as aquatic organisms, toxicity in mammals includes a wide range of animals and effects such as liver cirrhosis, necrosis in kidneys and the brain, gastrointestinal distress, lesions, low blood pressure, and fetal mortality. (ATSDR, 2004; Kabata-Pendias and Pendias, 1992; Ware, 1983; Vymazal, 1995).

TRVs for copper have been developed by USEPA (2007) and are listed in Table 6-5; these values were used in the wildlife exposure modeling conducted to support the FFS.

Table 6-5. TRVs for Copper from USEPA Eco-SSL Document.

COPEC	Test Species	Wildlife Receptor	Low TRV	High TRV[a]	Reference
Copper	Chicken (*Gallus domesticus*)	Avifauna	4.05	12.1	Ankari *et al*., 1998
Copper	Pig (*Sus scrofa*)	Mammals	5.6	9.34	Allcroft *et al*., 1961

a. High TRVs are equivalent to the LOAEL from the study that the low TRV (NOAEL) was selected; units in µg COPEC/g body weight – day.

Lead (Pb) occurs naturally in the environment; however, most of the elevated levels found throughout the environment come from anthropogenic activities such as mining or factories that make or use lead, lead alloys, or lead compounds. Lead is also released into the air during burning of coal, oil, or waste.

Lead partitions primarily to sediments but becomes more bioavailable under low pH, low hardness, and low organic matter content (among other factors). It can be bioconcentrated from water, but it does not bioaccumulate and tends to decrease with increasing trophic levels in freshwater habitats (Eisler, 1988). Fish exposed to high levels of lead exhibit a wide range of effects, including muscular and neurological degeneration and destruction, growth inhibition, mortality, reproductive problems, and paralysis (Eisler, 1988; USEPA, 1976). Lead also adversely affects invertebrate reproduction.

At elevated levels in plants, lead can cause reduced growth, photosynthesis, mitosis, and water absorption (Eisler, 1988). Lead poisoning in higher organisms primarily affects hematologic and neurologic processes and has been associated with lead shot and organolead compounds, but not with food chain

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exposure to inorganic lead (other than lead shot, sinkers, or paint) (Eisler, 1988). Birds and mammals suffer effects from lead poisoning such as damage to the nervous system, kidneys, liver, sterility, growth inhibition, developmental retardation, and detrimental effects in blood (Eisler, 1988; Amdur *et al*., 1991). Lead adversely affects reproduction, liver and thyroid function, and the immune system (Eisler, 1988).

TRVs for lead have been developed by USEPA (2005c) and are listed in Table 6-6; these values were used in the wildlife exposure modeling conducted to support the FFS.

Table 6-6. TRVs for Lead from USEPA Eco-SSL Document.

COPEC	Test Species	Wildlife Receptors	Low TRV	High TRV[a]	Reference
Lead	Chicken	Avifauna	1.6	3.3	Edens and Garlich, 1983
Lead	Rat	Mammals	4.7	8.9	Kimmel *et al.*, 1980

a. High TRVs are equivalent to the LOAEL from the study that the low TRV (NOAEL) was selected; units in µg COPEC/g body weight – day.

Methyl mercury is the organic, bioavailable fraction of elemental mercury (Hg), which comes from a variety of environmental sources, including mine tailings, gaseous emissions, industrial effluent, and atmospheric deposition. The transformation of inorganic mercury to methyl mercury occurs by anaerobic microorganisms in soils and sediment (ATSDR, 1999), as well as in hypoxic bottom waters. When consumed by aquatic organisms such as fish and shellfish, mercury is not purged or easily metabolized and is capable of bioaccumulating and biomagnifying in successive upper-trophic-level organisms that feed on contaminated prey.

Piscivorous mammals and birds that consume sufficient amounts of mercury-contaminated prey show signs of mercury toxicoses, including damage to nervous, excretory, and reproductive systems (RAIS, 1998). Although methyl mercury exhibits a range of toxic effects in several target tissues (*e.g*., liver, kidney), its primary effects are on the central nervous system. Methyl mercury readily penetrates the blood/brain barrier, producing brain lesions, spinal cord degeneration, and central nervous system dysfunctions (Wolfe *et al.*, 1998).

Symptoms of acute methyl mercury poisoning in birds include reduced food intake, weight loss, weakness in wings and legs, difficult maneuvering, and inability to coordinate muscle movement (Wolfe *et al.*, 1998). Methyl mercury is a potent embryo and nervous system stressor in birds with chronic exposures, characterized by symptoms that range from embryo lethality (*i.e.*, reduced egg hatchability), reduced clutch size, eggshell thinning, and aberrant juvenile behavior that may include auditory or visual impairment (Wolfe *et al.*, 1998; Eisler, 1987a).

Several long-term feeding studies have been conducted using a variety of bird species, including mallards, black ducks, ring-necked pheasants, Japanese quail, chickens, and great egrets; the most relevant studies are summarized in Table 6-7. These laboratory studies are consistent with a field study of the common loon in northwestern Ontario (Barr, 1986; as cited in Wolfe *et al.*, 1998), which found that reduction in egg laying and aberrant territorial and nest building behavior occurred when concentration of methyl mercury in the diet exceeded 0.2 to 0.3 µg/g wet weight. There is reasonable consistency in the levels of methyl mercury in the diet associated with the onset of significant reproductive effects in chronically exposed birds. Although Heinz (1974; 1975; 1976a,b; 1979) failed to identify a NOAEL value, the recommended LOAEL (0.078 µg methyl mercury/g-day) was selected because these studies are well-

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defined and they evaluated the most sensitive endpoints over three generations. Results indicate that piscivorous birds may be as sensitive to the effects of methyl mercury intoxication as are ducks.

Reproductive effects of methyl mercury in mammals include developmental alterations that produce behavioral deficits after birth, impaired fertility, and fetal death. Behavioral effects of low doses of methyl mercury were noted in swimming ability, operant learning, avoidance, maze learning, and development of reflexes. At higher doses, changes in spontaneous activity, visual function, vocalization, and convulsions may occur (Wolfe *et al.*, 1998). Several long-term feeding studies have been conducted using a variety of mammal species, including the river otter, mink, cat, rat, and laboratory mouse. Table 6-7 also summarizes available long-term laboratory feeding studies for mammals.

Work by Wobeser *et al.* (1976a,b) on long-term feeding studies with mink is the basis for the recommended mammalian wildlife TRV for methyl mercury (NOAEL – 0.055 μg methyl mercury/g-day; LOAEL – 0.18 μg methyl mercury/g-day), because the mink is a receptor of concern at the site and the species is known to be sensitive to mercury. The neurological effects that are the basis for the suggested threshold do not relate directly to the typical ecological endpoint types (*i.e.*, mortality, growth, and reproduction); however, intoxicated animals are likely to be less successful at foraging, predator avoidance, and mating, all of which have population-level significance. The selected rat study suggests that chronic reproductive effects also occur at these low exposure levels.

Table 6-7. Summary of Chronic Feeding Studies with Methyl Mercury.

Species	NOAEL (μg/g-d)	LOAEL (μg/g-d)	Effect	Reference
Birds				
Chicken (*Gallus domesticus*)	-	1.1	Growth inhibition	Fimreite, 1970
Ring-necked pheasant (*Phasianus colchicus*)	-	0.18	Reduced survival, reduced egg production	Fimreite, 1971
Mallard (*Anas platyrhynchos*)	-	**0.078**	Reduced number viable eggs, reduced duckling growth, reduced chick survival to day 7	Heinz, 1974, 1975, 1976a,b, 1979
Great egret (*Ardea albus*)	-	0.5 μg/g (food)	Behavioral effects including reduced inclination to forage	Bouton *et al.*, 1999
Black duck (*Anas rubripes*)	-	3 μg/g (food)	Reduced clutch size, egg production, hatchability and duckling survival	Finley and Stendell, 1978
Coturnix (Japanese) quail (*Coturnix japonica*)	8 μg/g food	32 μg/g food	Enzyme induction (AChE, LDH)	Hill and Soares, 1984
Mammals				
Mink (*Mustela vison*)	**0.055**	**0.18**	Anorexia, ataxia; nerve tissue lesions	Wobeser *et al.*, 1976a,b
River otter (L*utra canadensis*)	-	2 μg/g[a]	Anorexia and ataxia	O'Connor and Nielsen, 1981
Cat (*Felis domesticus*)	0.020	0.046	Ataxia, loss of balance, motor incoordination	Charbonneau *et al.*, 1974; 1976
Rat (*Rattus norvegicus*)	0.032	0.16	Reproduction	Verschuuren *et al.*, 1976
Mouse (*Mus musculus*)	0.15	0.73	Sensory neuropathy, cerebral and cerebellar neuronal necrosis	Hirano *et al.*, 1986

Note: Bolded values indicate the selected TRV.
[a.] Concentration in diet (wet weight basis).

Polycyclic Aromatic Hydrocarbons (PAH) are a group of ubiquitous chemicals that are a major component of petroleum products (*i.e.*, petrogenic) or are formed during the incomplete burning of coal, oil, gas, wood, garbage, or other organic substances (*i.e.*, pyrogenic). There are more than 100 different

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PAHs, which generally occur as complex mixtures. Pyrogenically derived PAHs mainly enter the environment as releases to air from volcanoes, forest fires, residential wood burning, and exhaust from automobiles and trucks; petrogenically derived PAHs are typically released as direct spills to surface water, soils, or sediments. PAHs include some compounds that are highly potent carcinogens capable of producing tumors in some organisms at even single doses; other, noncancer-causing effects are not well understood (Eisler, 1987b). Their effects are wide-ranging within an organism and have been found in many types of organisms, including non-human mammals, birds, invertebrates, plants, amphibians, fish, and humans. However, their effects are varied, so generalizations cannot be readily made. Effects on benthic invertebrates include inhibited reproduction, delayed emergence, sediment avoidance, and mortality. Fish exposed to PAHs in sediment and surface water have exhibited fin erosion, liver abnormalities, cataracts, and immune system impairments leading to increased susceptibility to disease (Fabacher *et al*., 1991; Weeks and Warinner, 1984; 1986; O'Conner and Huggett, 1988, Payne *et al.*, 2003). Early mechanistic models categorized effects of individual PAHs as either being receptor mediated (*e.g.*, AhR) with metabolites forming DNA adducts or generally narcotic in nature; however, recent studies suggest that the toxicology is much more complicated (Barron *et al*., 2004; Incardona *et al*., 2006).

Mammals can absorb PAHs by inhalation, dermal contact, or ingestion (Eisler, 1987b). The oral toxicity of PAHs ranges from very toxic to moderately toxic in rats. In addition to tumor induction, other effects in mammals include adverse effects on reproduction, development, and immunity (ATSDR, 1995). Although a large literature on the effects of oil spills on birds is available, toxicity data for birds associated with the ingestion pathway are limited and no PAH TRV for this receptor group was developed. There are also limited mammalian data available for the 2- and 3-ring PAHs (which are not anticipated to be bioavailable to wildlife at any rate). As a result, only a mammalian TRV for HPAHs was selected to support the FFS. As summarized in Sample *et al.* (1996), Mackenzie and Angevine (1981) exposed female mice via oral intubation during days 7-16 of gestation. The study included three dosing levels and various reproductive endpoints, including pregnancy rates, percentage of viable litters, and pup weights, were measured. Pup weights were significantly reduced at all dose levels, and a LOAEL of 10 µg/g-day was identified; a chronic NOAEL was estimated by applying a 10-fold uncertainty factor (1 µg/g-day) (Sample *et al*., 1996).

Polychlorinated biphenyls (PCBs) are mixtures of up to 209 individual chlorinated compounds (known as congeners). Some commercial PCB mixtures are known in the United States by their industrial trade name, Aroclor. Because they do not burn easily and are good insulating materials, PCBs were used widely as coolants and lubricants in transformers, capacitors, and other electrical equipment. The manufacture of PCBs stopped in the United States in 1977 because there was evidence that PCBs build up in the environment and may cause harmful effects. Once released into the environment, PCBs do not readily break down and therefore may remain for long periods of time, cycling between air, water, and soil. As a consequence, PCBs are found all over the world. The WHO has recognized 12 PCB congeners that are structurally similar to dioxins and have similar toxic effects. These congeners are listed in Table 6-8.

PCBs are taken up into the bodies of small organisms and fish in water. They are also ingested by other animals that feed on these aquatic animals. PCBs especially accumulate in fish and marine mammals (such as seals and whales), reaching levels that may be many thousands of times higher than in water.

Animals exposed to PCBs show various kinds of health effects, including anemia, acne-like skin conditions, and liver, stomach, and thyroid gland injuries (ATSDR, 2000). Other effects include reductions in the immune system function, behavioral alterations, and impaired reproduction (ATSDR, 2000). Some PCBs can mimic or block the action of hormones from the thyroid and other endocrine glands. Because hormones influence the normal functioning of many organs, some of the effects of PCBs

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may result from endocrine changes. Inhalation and dermal exposure to PCBs may cause liver, kidney, and skin damage in animals (ATSDR, 2000).

Table 6-8. 12 Dioxin-like PCB Congeners.

3,3',4,4'-Tetrachlorobiphenyl (PCB 77)
3,4,4',5-Tetrachlorobiphenyl (PCB 81)
3,3',4,4',5-Pentachlorobiphenyl (PCB 126)
3,3',4,4',5,5'-Hexachlorobiphenyl (PCB 169)
2,3,3',4,4'-Pentachlorobiphenyl (PCB 105)
2,3,4,4',5-Pentachlorobiphenyl (PCB 114)
2,3',4,4',5-Pentachlorobiphenyl (PCB 118)
2',3,4,4',5-Pentachlorobiphenyl (PCB 123)
2,3,3',4,4',5-Hexachlorobiphenyl (PCB 156)
2,3,3',4,4',5'-Hexachlorobiphenyl (PCB 157)
2,3',4,4',5,5'-Hexachlorobiphenyl (PCB 167)
2,3,3',4,4',5,5'-Heptachlorobiphenyl (PCB 189)

A TEQ approach is employed to normalize the assessment of potential risks associated with wildlife exposure to compounds with dioxin-like toxicological properties (including certain PCB congeners). Consequently, the specific TRVs for PCBs are used to evaluate the non-dioxin like effects attributable to PCB compounds.

The selected avian TRVs for PCBs are based on an analysis conducted by USEPA Region 5 (Chapman, 2003) for the chicken, which is believed to be one of the most sensitive bird species. These results are summarized in Table 6-9. TRVs were developed individually for Aroclors 1242, 1248, and 1254 based on reported dose response data from multiple collated studies for Aroclor exposure and growth or reproductive effects in chickens. The interpolated no-effect and low-effect doses for Aroclor 1242 (NOAEL – 0.1 µg PCB/g-day; LOAEL – 0.4 µg PCB/g-day) were selected as the avian TRVs for total PCBs.

Table 6-9. Summary of Avian TRVs for PCB Mixture Based on Chicken Data.

Aroclor Mixture	No Effect[a] (µg/g-d)	Low Effect[a] (µg/g-d)	Effect	Reference
Aroclor 1242[b]	**0.1**	**0.4**	Chick hatchability	Chapman, 2003
Aroclor 1248	0.4	0.5	Chick hatchability	Chapman, 2003
Aroclor 1254	0.6	1.2	Chick hatchability	Chapman, 2003

Note: Bolded values indicate the selected TRV.

[a.] These values are interpreted as the interpolated dose resulting in a 10% or 25% decrease in endpoint response relative to the control group for the NOAEL and LOAEL, respectively; see Chapman, 2003.

[b.] Chapman (2003) reports two dose-response patterns in the chicken studies for Aroclor 1242; this may be due to the difference in the batch tested, organisms, feed characteristics, or experimental design. Selected values are derived from the more sensitive response data.

Table 6-10 summarizes the selected mammalian TRVs for PCBs that were derived as part of the Chapman (2003) analysis; no mink study for Aroclor 1248 was identified, but the author concluded that this mixture is as toxic as Aroclor 1254 based on *in vitro* bioassay data. The interpolated no-effect and low-effect doses for Aroclor 1254 (NOAEL – 0.080 µg PCB/g-day; LOAEL – 0.096 µg PCB/g-day) were selected as the mammalian TRVs for total PCBs.

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Table 6-10. Summary of Mammalian TRVs for PCB Mixtures Based on Mink Data.

Aroclor Mixture	No Effect[a,b] (µg/g-d)	Low Effect[a,b] (µg/g-d)	Effect	Reference
Aroclor 1242	0.208	0.224	Decrease in live kit production	Chapman, 2003
Aroclor 1254	**0.080**	**0.096**	Decrease in number of live kits per mated female; kit birth weight	Chapman, 2003

Note: Bolded values indicate the selected TRV.

a. These values are interpreted as the interpolated dose resulting in a 10% or 25% decrease in endpoint response relative to the control group for the NOAEL and LOAEL, respectively; see Chapman, 2003.

b. Data converted from diet-based TRV to dose assuming that a female mink consumes 0.16 g/g body weight-day (average farm-raised individuals in Michigan [Bleavins and Aulerich, 1981]).

2,3,7,8-TCDD belongs to a class of compounds known as chlorinated dibenzodioxins that are ubiquitous in the environment as a result of various industrial processes (*e.g.*, solid waste incineration; the production, use, and disposal of pesticides and PCBs; the bleaching process for paper manufacturing; and the production and recycling of metals). Dioxins are usually generated concurrently with other chemicals known as chlorinated dibenzofurans; both of these chemicals are highly persistent and have been detected in all environmental media (*i.e.*, air, water, soil, animal tissue). Although a variety of dioxin and furan congeners have been detected in environmental media associated with the Lower Passaic River, 2,3,7,8-TCDD, which is believed to be the most toxic congener, typically constitutes a significant majority of both the total dioxin and furan congener concentrations. It is thus appropriate to focus the risk analysis on this particular compound, although a TEQ approach was utilized in developing measures of exposure.

Laboratory toxicity data show that fish are generally more sensitive to TCDD than plants, aquatic invertebrates, and other aquatic vertebrates (*e.g.*, amphibians) (USEPA, 1993b). The high lipid content in fish makes them highly susceptible to bioaccumulation of TCDD in their tissues, which can essentially be transferred up the food chain to higher-trophic-level organisms such as birds and mammals (including humans). Effects of TCDD exposure to mammals and birds are similar to fish; the effects include delayed mortality, a "wasting" syndrome characterized by reduced food intake and reduced body weight, reproductive toxicity, histopathological alterations, developmental abnormalities, and immunosupression (USEPA, 1993b).

Several long-term feeding studies have been conducted using a variety of bird species; information on the two most relevant studies with chickens and ring-necked pheasants is summarized in Table 6-11. The Nosek *et al.* (1992a,b) study was selected as the basis for establishing a TCDD TEQ TRV for birds.

A 10-fold subchronic-to-chronic extrapolation factor was applied to the pheasant NOAEL/LOAELs because the exposure duration was likely inadequate to achieve steady-state conditions in the laying hens (USEPA, 1993b); moreover, the dose-response function appears to be steep. The recommended TRVs (NOAEL – 1.4×10^{-6} µg TCDD/g-day; LOAEL – 1.4×10^{-5} µg TCDD/g-day) are consistent with the early-life-stage study with chickens exposed to 2,3,7,8- TCDF conducted by McKinney *et al* (1976). Table 6-11 also summarizes the most relevant chronic feeding studies with mammals available for TCDD. A feeding study by Tillet *et al.* (1996) with mink is the basis for the recommended mammalian wildlife TRV for TCDD (NOAEL – 0.8×10^{-7}µg TCDD/g-day; LOAEL – 2.24×10^{-6}µg TCDD/g-day) because the mink is a receptor of concern at the site and the species is known to be sensitive to dioxin-like compounds.

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Table 6-11. Summary of Chronic Feeding Studies with TCDD/TCDF.

Species	NOAEL (µg/g-d)	LOAEL (µg/g-d)	Effect	Reference
Birds				
Ring-necked pheasant (*Phasianus colchicus*)	**1.4×10^{-6}[a]**	**1.4×10^{-5}[a]**	Significant reduction in egg production; 100% embryotoxicity	Nosek *et al.*, 1992a,b
Chicken (*Gallus domesticus*)	0.1×10^{-5}[b]	0.1×10^{-4}[b]	Survival of newly hatched chicks to 21 days	McKinney *et al.*, 1976
Mammals				
Rat (Sprague Dawley)	0.1×10^{-5}	0.1×10^{-4}	Decreases in fertility in F_1 and F_2 generations	Murray *et al.*, 1979
Mink (*Mustela vison*)	**0.8×10^{-7}**	**2.24×10^{-6}**	Reduced kit body weights (3 wks) and reduced 9 survival (3 and 6 wks)	Tillet *et al.*, 1996

Note: Bolded values indicate the selected TRV.

a. Reported doses were based on exposures via interperitoneal injection and converted to an ingestion dose (USEPA, 1993b).

b. Based on dietary exposures to tetrachlorodibenzofuran (TCDF).

Table 6-12 summarizes the available LD_{50} study results for various mammal species. The guinea pig appears to be the most sensitive mammal (USEPA, 1993b), with the mink appearing to be only slightly less sensitive to the acute effects of TCDD exposure.

Table 6-12. Summary of Estimated Mammalian LD_{50} Benchmarks for TCDD TEQs.

Species	LD_{50} (µg/g)	Reference
Guinea pig (*Cavia porcellus*)	0.0006 – 0.002	As cited in USEPA, 1993b
Mink (*Mustela vison*)	0.0042	Hochstein *et al.*, 1988
Rat (*Rattus norvegicus*)	0.022 – 0.045	As cited in USEPA, 1993b
Rabbit (*Oryctolagus cuniculus*)	0.115	As cited in USEPA, 1993b
Mouse (*Mus musculus*)	0.114 – 0.284	As cited in USEPA, 1993b
Hamster (various species)	1.157 – 5.0	As cited in USEPA, 1993b

Table 6-13 summarizes laboratory and field studies that analyzed TCDD or TCDD-TEQ in avian eggs along with ecologically meaningful effects. A large variability in the sensitivity of bird species to exposure to TCDD in the embryonic stage is evident.

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Table 6-13. Summary of Avian Egg Residues Associated with Adverse Effects[a] to TCDD

Species	NOAEL (µg/g)	LOAEL (µg/g)	Effect	Reference[b]
Laboratory Studies				
Chicken (*Gallus domesticus*)	0.000066	0.00008	Embryo mortality; reduced hatchling weight	Henshel *et al*., 1997; Powell *et al*., 1996a,b; Brunstrom, 1988, 1989, 1990; Brunstrom *et al*., 1990; Zhao *et al*., 1997; Lipsitz *et al*., 1997; Brunstrom and Andersson, 1988; Brunstrom and Lund, 1988
American kestrel (*Falco sparverius*)	0.00023	0.0034	Teratata, chick edema	Hoffman *et al*., 1998
Ring-necked pheasant (*Phasianus colchicus*)	0.00071	0.0079	Embryo mortality	Nosek *et al*., 1992; Brunstrom and Reutergardh, 1986
Double-crested cormorant (*Phalcrocorax auritus*)	0.0037	0.0011	Embryo mortality	Powell *et al*., 1997a,b; Powell *et al*., 1998
Turkey (*Meleagris gallopavo*)	0.010	0.010	Embryo mortality	Brunstrom and Lund, 1988
Mallard (*Anas platyrhynchos*)	0.035	-	Embryo mortality	Brunstrom and Reutergardh, 1986; Brunstrom, 1988
Greylag goose (*Anser anser*)	0.050	-	Embryo mortality	Brunstrom, 1988
Bucephala clangula	0.050	-	Embryo mortality	Brunstrom and Reutergardh, 1986;
Black-headed gull (*Larus ridibundus*)	0.050	-	Embryo mortality	Brunstrom and Reutergardh, 1986;
Herring gull (*Larus argentatus*)	0.050	-	Embryo mortality	Brunstrom, 1988
Common tern (*Sterna hirundo*)	-	0.0044	Embryo mortality	Hoffman *et al*., 1998
Field Studies				
Wood duck (*Aix sponsa*)	0.000005	0.00002	Reproduction	White and Seginak, 1994
Great blue heron (*Ardea herodias*)	0.000013	0.0001	Terata, reduced fledging, and brain asymmetries	Hart *et al*., 1991; Henshel *et al*., 1995
Osprey (*Pandion haliaetus*)	0.00014	-	Reduced hatching/fledging	Woodford *et al*., 1998
Forster's tern (*Sterna forsteri*)	0.00035	-	Reduced hatching/fledging	Kubiak *et al*., 1989; Harris *et al*., 1993
Double-crested cormorant (*Phalcrocorax auritus*)	-	0.00035	Terata	Yamashita *et al*., 1993
Caspian tern (*Sterna caspia*)	0.0014	0.0014	Wasting syndrome, terata	Yamashita *et al*., 1993, Ludwig *et al*., 1993; Ewins *et al*., 1994

a. Data on avian toxicity associated with compounds with dioxin-like effects as presented in USEPA (2003a); values are Toxic Equivalencies (TEQs) and in the case of multiple studies, are based on geometric means.
b. As cited in USEPA (2003a).

USEPA developed Species Sensitivity Distributions (SSD) using both available laboratory and field data. These distributions were then used to derive logistic regression models to describe the relationship

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between TEQs in avian eggs, embryo mortality, and developmental effects (USEPA, 2003b). Estimated NOAEL and LOAEL values that are protective of 95% of species from development effects observed in laboratory tests are 59 and 150 pg TEQ/g egg, respectively; (geometric mean of 94 pgTEQ/g). The mean value is only slightly greater than the geometric mean of available LOAEL values for the species believed to be the most sensitive to embryotoxicological effects attributable to dioxin exposure; however, based on USEPA's (2003b) analysis there is no sound rationale for eliminating the chicken data (*i.e.*, on the grounds that there are no similarly sensitive wildlife analogues). Moreover, there are a number of avian species of special concern that may occur in the study area that would warrant this more conservative approach.

Dichlorodiphenyltrichloroethane (DDT) and its primary metabolites (DDD and DDE) are manufactured organochloride pesticides (collectively referred to as DDx). DDT use in the United States was banned in 1972, but it was still manufactured for export until the mid-1980s. DDT is a broad-spectrum insecticide that was very popular due its effectiveness, long residual persistence, low acute mammalian toxicity, and low cost. DDT has been widely used to control insects on agricultural crops such as peanuts, soybeans, and cotton and has been sprayed to decrease the incidence and spread of diseases such as malaria by controlling mosquitoes.

Upon introduction into the environment, DDT enters soil, water, or air. DDT and its metabolites are strongly adsorbed onto particulates in water and settle into sediments, where they become essentially immobile. DDT is highly toxic to aquatic life, including both invertebrates (crustaceans) and vertebrates (fish, birds). Furthermore, DDT and its analogues accumulate in lipid tissues of fish and other organisms, and subsequently bioconcentrate up the food chain.

The best known effect of DDT toxicity is impairment of nerve impulse conduction. Effects of DDT on the nervous system have been observed in animals and can vary from mildly altered sensations to tremors and convulsions. Death in animals following high exposure to DDT is usually caused by respiratory arrest. In addition to being a neurotoxicant, DDT is capable of inducing marked alterations on reproduction and development, which is attributed to hormone-altering actions of DDT isomers and/or its metabolites (ATSDR, 2002a). Egg-shelling thinning in upper-trophic-level birds is believed to have resulted in population crashes in the1960s and 1970s. Due to the ban on the production and use of DDT in the United States and other parts of the world, exposures of wildlife have been declining since the early 1970s, as evidenced by marked decreases in the levels of DDT compounds in fish, shellfish, aquatic mammals, and birds (ATSDR, 2002a).

The well-publicized decline in wild raptor populations, including the bald eagle, during the 1950s and 1960s was attributed partly to reproductive impairment, particularly eggshell thinning. Egg production, fertility, and hatchability were largely unaffected in numerous studies in a variety of bird species. However, increased embryolethality, decreased egg size, delayed oviposition after mating, and increased testicular effects were observed with some regularity among experimental studies in birds. Several authors speculated that the effects were due to DDT-induced hormonal imbalances, and in fact, blood hormone levels (estrogen, luteinizing hormone) were altered in three of four studies in birds consuming either DDT or DDE in the diet (ATSDR, 2002a).

The most extensively studied species include the mallard duck (*Anas platyrhyncus*), Japanese quail (*Coturnix coturnix japonica*), domestic fowl, brown pelican (*Pelecanus occidentalis*), and ringed turtle dove (*Streptopelia risoria*). The most commonly reported endpoints were lethality, neurological, and reproductive endpoints. Of particular interest are those effects that were observed consistently across species and in spite of variability in exposure scenarios. The significant health effects most consistently reported were lethality (several taxa), hepatic (liver enzyme induction and liver damage in birds), endocrine (estrogenic effects in several taxa, and reduced thyroid weight and altered thyroid activity in

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birds), neurological (tremors in several taxa), reproductive (oviposition delay and eggshell thinning in birds), and developmental (reduced chick survival in birds, testicular feminization) (ATSDR, 2002a). Table 6-14 presents the TRVs and various feeding studies with DDT. The Anderson *et al.* study was selected as the basis for developing the NOAEL and LOAEL TRVs for bird receptors, as the brown pelican is believed to be one of the most sensitive piscivorous bird species to DDT. The long-term reproduction study conducted by Fitzhugh (1948) of Sprague-Dawley rats evaluated multi-generational toxicity and sensitive endpoints and was selected as the basis for establishing mammalian TRVs for this assessment.

USEPA (2000c) summarizes available avian embryo effect data for DDT and related compounds. A study of British golden eagles (*Aquila chrysaetos*) measured mean percent eggshell thinning of up to 7% at an egg concentration of 0.1 µg/g as *p,p'*-DDE (Ratcliffe, 1967). This was selected as a LOAEL value for total DDT for the avian egg residue analysis. No NOAEL value was identified.

Table 6-14. Summary of Chronic Feeding Studies with DDT.

Species	NOAEL (µg/g-d)	LOAEL (µg/g-d)	Effect	Reference
Birds				
Brown pelican (*Pelecanus occidentalis*)	**0.003**	**0.03**	Reproductive	Anderson *et al.*, 1975
Mallard duck (*Anas platyrhynchos*)	-	1.5	Reproductive	USEPA, 1995
Pelican (*Pelecanus occidentalis*)	0.009	-	Reproductive	USEPA, 1995
Mammals				
Rat (Sprague Dawley)	**0.8**	**4**	Reproductive	Fitzhugh, 1948; as cited in Sample *et al.*, 1996

Note: Bolded values indicate the selected TRV.

Dieldrin and aldrin are structurally similar, and aldrin readily converts to dieldrin once it enters the environment or is ingested or inhaled by organisms. These compounds are discussed together because both are COPECs for the LPRRP. Dieldrin is an organochloride pesticide, belonging to the cyclodiene group of pesticides, which also includes endrin, endosulfan, and aldrin. Dieldrin is no longer produced or used, but it was once used extensively as an insecticide on crops such as corn and cotton and was also used to control termites. Aldrin is a more effective pesticide than dieldrin and therefore was more extensively used as a soil insecticide (ATSDR, 2002b).

Many species of aquatic invertebrates concentrate dieldrin from very low water concentrations, yielding high concentration factors. The bioconcentration of dieldrin in aquatic organisms is principally from the water rather than by ingestion of food. Aldrin and dieldrin are both highly toxic to aquatic crustaceans and fish. Effects on mammals include liver damage, central nervous system effects, and suppression of the immune system. Dieldrin and aldrin also disrupt the endocrine and reproductive systems (ATSDR, 2002a).

TRVs for dieldrin have been developed by USEPA (2005c) as part of the process of developing Ecological Soil Screening Levels (Eco-SSL) for mammals and birds for 23 contaminants using a transparent, ecologically relevant, and comprehensive process. The TRVs used in the wildlife dose assessment are listed in Table 6-15. A study of eggshell thinning in Peregrine falcons (*Falco peregrinus*) nesting in the Kola peninsula in Russia measured mean percent eggshell thinning of 11.4% at a egg

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concentration of 0.0591 µg dieldrin/g (Henny *et al*., 1994). This was selected as a LOAEL value for dieldrin for the avian egg residue analysis; no NOAEL value was identified.

Table 6-15. TRVs for Dieldrin from USEPA Eco-SSL Derivation[a].

COPEC	Test Species	Wildlife Receptors	Low TRV	High TRV[b]	Reference
Dieldrin	Mallard duck (*Anas platyrhynchos*)	Avifauna	0.071	3.8	Nebeker *et al.*, 1992
Dieldrin	Rat (Sprague Dawley)	Mammals	0.015	0.030	Harr *et al.*, 1970

a. Re-release of the Eco-SSL document is currently pending

b. High TRVs are equivalent to the LOAEL from the study that the low TRV (NOAEL) was selected; units in µg COPEC/g body weight-day.

6.3 Risk Characterization

The risk characterization combines the exposure assessment with the toxicity assessment to derive a quantitative estimate of risk. Risks are derived based on both the high and low estimates of toxicity to provide a NOAEL and LOAEL estimate of risk. Individual risk estimates to a given receptor for each chemical and for each exposure medium are calculated and then summed to provide a total cumulative estimate of risk, the HI.

6.3.1 Benthic Invertebrate Risk Estimates

Risks to benthic invertebrates were evaluated based on sediment benchmarks developed for marine and estuarine ecosystems (Table 6-16). For macroinvertebrates, such as blue crab, grass shrimp, and Eastern oyster, risks were based on estimates of critical body residues (CBR) (Table 6-4).

Based on the magnitude of exceedance of the sediment benchmarks, dieldrin had the highest relative contribution of total risk (49.3%) with an HQ of 936. TCDD TEQ for dioxins and furans was the next largest contributor to the total risk, comprising 26.0% of the overall risk. Copper and lead contributed the least, with HQs of 6.9 and 8.0, respectively.

Current condition risk evaluated for the macroinvertebrates based on CBRs compared measured tissue concentrations to NOAEL and LOAEL body residue concentrations that are associated with adverse responses in morality, growth, and reproduction. The details of these analyses are provided in Attachment 5 and are summarized in Figure 6-1 through Figure 6-3. Both the LOAEL and NOAEL estimates of risk were calculated; the total HI is 5,100 for the NOAEL scenario and 540 for the LOAEL. Total DDx and TCDD TEQ for dioxins and furans contribute the most to the LOAEL and NOEL HI; total DDx accounts for over 50% of the total HI, and the TCDD TEQ accounts for approximately 30%. PAHs contributed the least, with the LOAEL HI just above 1 for total PAHs.

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Table 6-16. Summary of Hazard Quotients for Benthic Invertebrates.

Chemical Parameter	*Marine/ Estuarine Values*		Lowest Sediment Benchmark[c] (µg/g)	Sediment EPC[d] (µg/g)	Hazard Quotient[e]	Relative Magnitude[f]
	NOAA ER-L[a] (µg/g)	NJDEP[b] (µg/g)				
Copper	34	34	34	236	6.9	0.4%
Lead	47	47	47	375	8.0	0.4%
Mercury	0.15	0.15	0.15	3.6	24	1.3%
LPAHs	0.55	-	0.55	41	74	3.9%
HPAHs	1.7	-	1.7	61	36	1.9%
Total PCBs	0.023	0.023	0.023	1.8	79	4.2%
Dieldrin	0.000020	-	0.000020	0.019	936	49.3%
Total DDx	0.0016	0.0016	0.0016	0.38	239	12.6%
TCDD TEQ (D/F)	0.0000032[g]	-	0.0000032	0.0016[h]	493	26.0%
TCDD TEQ (PCBs)	0.0000032[g]	-	0.0000032	0.0000038	1.2	0.1%
TCDD TEQ (Total)	0.0000032[g]	-	0.0000032	0.0016	494	

a. NOAA – National Oceanic and Atmospheric Administration; ER-L = Effects Range-Low from Long *et al.*, 1995.
b. NJDEP Guidance For Sediment Quality Evaluations, November 1998. References Long *et al*. (1995).
c. Minimum of the ER-L and the NJ sediment benchmark values.
d. Exposure Point Concentration (EPC) is based on the 95% UCL on the arithmetic mean of the values in the assessment data set as discussed in the text. TEQs calculated using fish TEFs.
e. Hazard Quotient (HQ) is the ratio of the EPC to the benchmark value.
f. Percentage of the COPEC HQ to the sum of all HQs (excluding the TCDD TEQ [total] value).
g. Derived by USFWS using sediment chemistry for the Arthur Kill and oyster effect data presented in Wintermyer and Cooper (2003).
h. TCDD TEQ for dioxin is based on fish TEF

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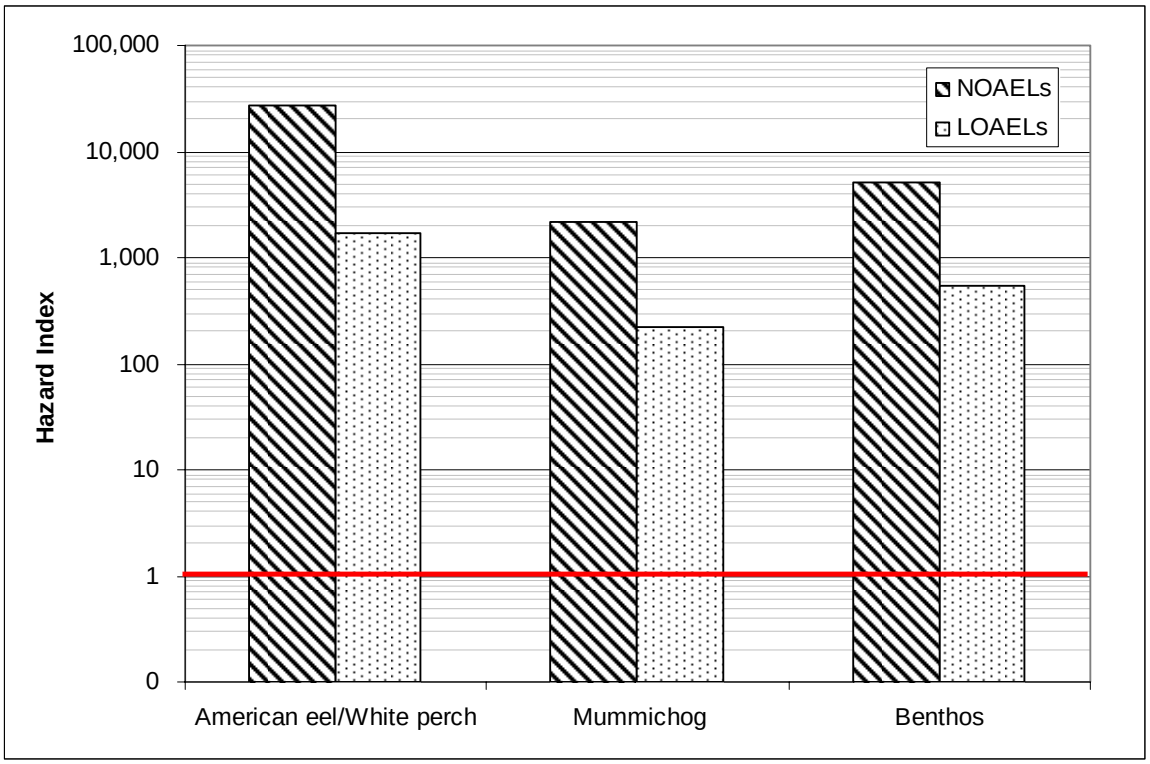

Figure 6-1. HIs for American Eel/White Perch, Mummichog, and Benthic Receptors Based on Tissue Residue Under Current Conditions.

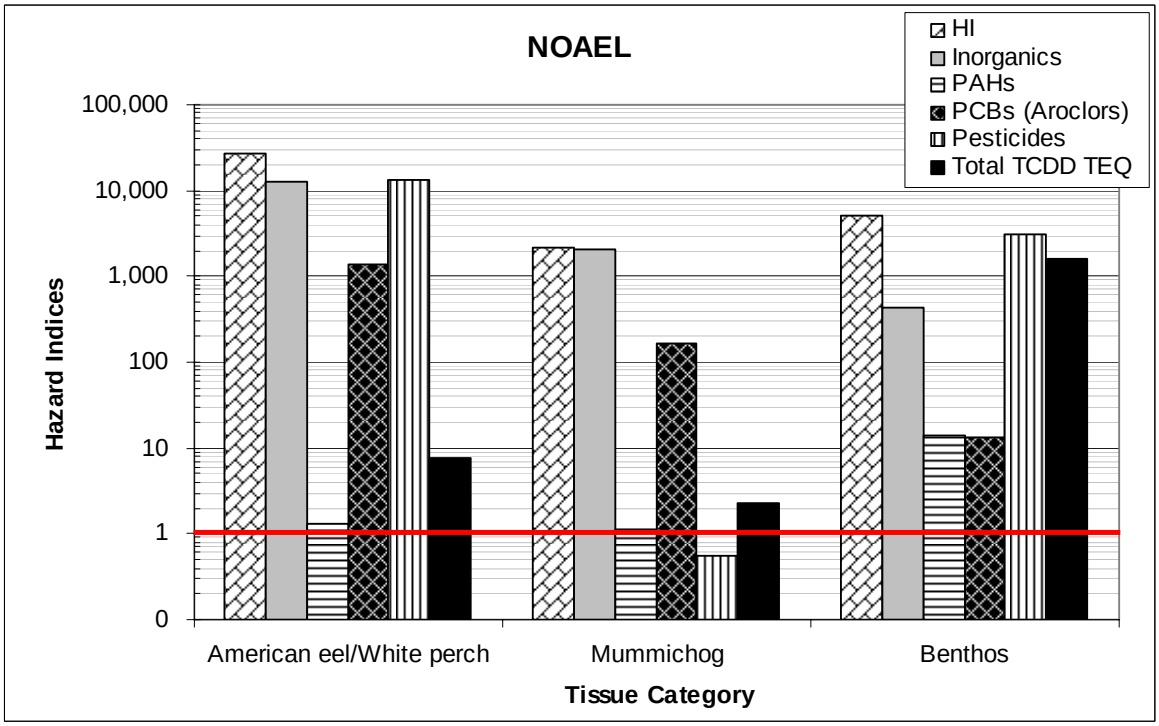

Figure 6-2. Hazard Ratios for American Eel/White Perch, Mummichog, and Benthic Receptors Based on NOAEL Tissue Residue Under Current Conditions.

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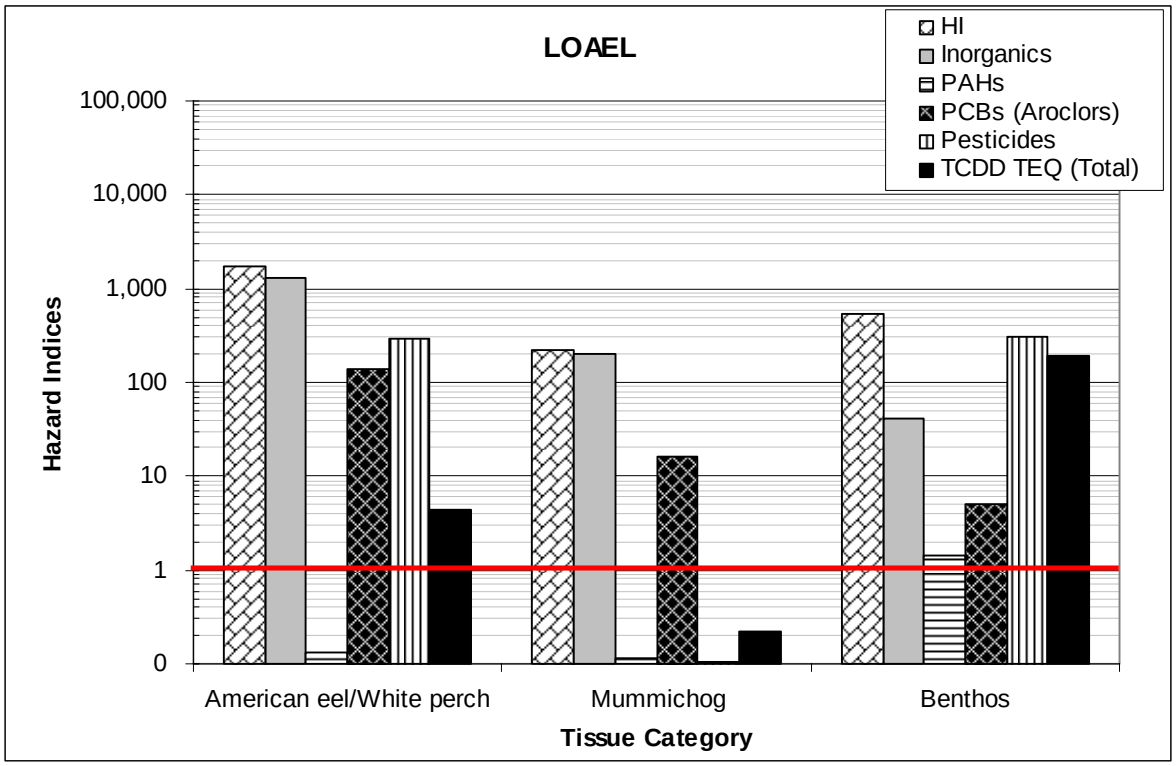

Figure 6-3. Hazard Ratios for American Eel/White Perch, Mummichog, and Benthic Receptors Based on LOAEL Tissue Residue Under Current Conditions

6.3.2 Fish Risk Estimates

Risks evaluated for forage fish and for the large AE/WP fish receptor are based on estimates of CBRs (see Figures 6-1 through 6-3). As discussed in the previous section for benthic invertebrates, both LOAEL and NOAEL estimates of risk were calculated for the two fish receptors, based on CBR data. Results are presented in detail in Attachment 6.

For the mummichog under current conditions, the total HI is 2,200 for the NOAEL scenario and 220 for the LOAEL. Copper contributes the most to the NOAEL and LOAEL (approximately 88% for both). PCBs contribute the next-largest portion to the total risk (7%), whereas the pesticides (total DDx and dieldrin) and the PAHs have an HQ of 1.1 or less. For the AE/WP receptor, the total HI is 28,000 for the NOAEL and 1,700 for the LOAEL. Copper and total DDx account for over 90% of the total risk for both the LOAEL and NOAEL scenarios.

6.3.3 Wildlife Risk Estimates

Wildlife risks were evaluated using both dose- and residue-based analyses; the latter were restricted to assessment impacts to avian embryos.

Dose Assessment. Current risks calculated for the mink and the great blue heron (Attachment 6) are summarized in Figures 6-4 through 6-6. For the mink, a diet consisting completely of piscivorous fish (*i.e.*, AE/WP) is assumed. The total HI across all chemicals and exposure scenarios is 1,600 for the NOAEL and 72 for the LOAEL. For both the LOAEL and NOAEL exposures, the majority of risks are

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associated with total TCDD TEQ (80% and 99%, respectively), with dioxin/furan compounds accounting for over 50% of the TEQ in both cases. Total PCBs make up 17% of the LOAEL risk and 1% of the NOAEL risk. For the LOAEL and NOAEL risks, the other COPECs (copper, mercury, lead, dieldrin, HPAH, LPAH, total DDx) have a combined HQ slightly above 1.0.

The fish consumption pathway (AE/WP) contributes to the majority of the risks to the mink, accounting for 61% and 63% of the total risk for the NOAEL and LOAEL scenarios, respectively. Minimal risk is associated with sediment exposures (8%), with HQs below 1 for all COPECs except for total TCDD TEQ.

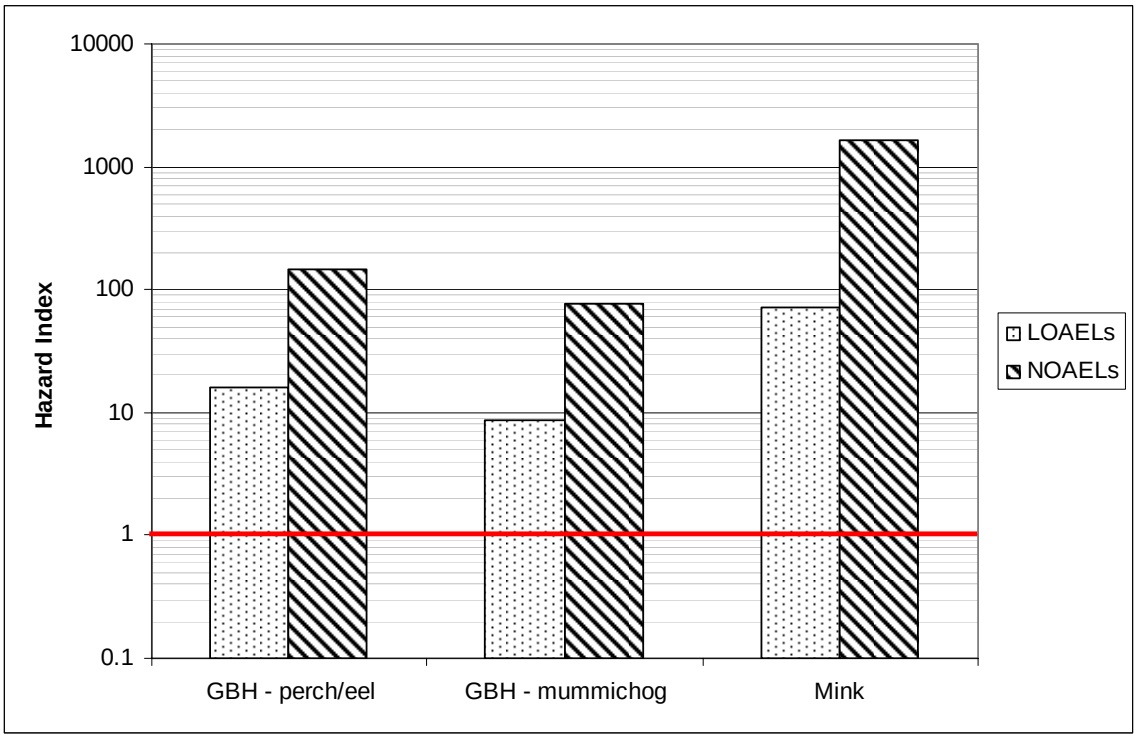

Figure 6-4 Hazard Indices for Wildlife Receptors Under Current Conditions.

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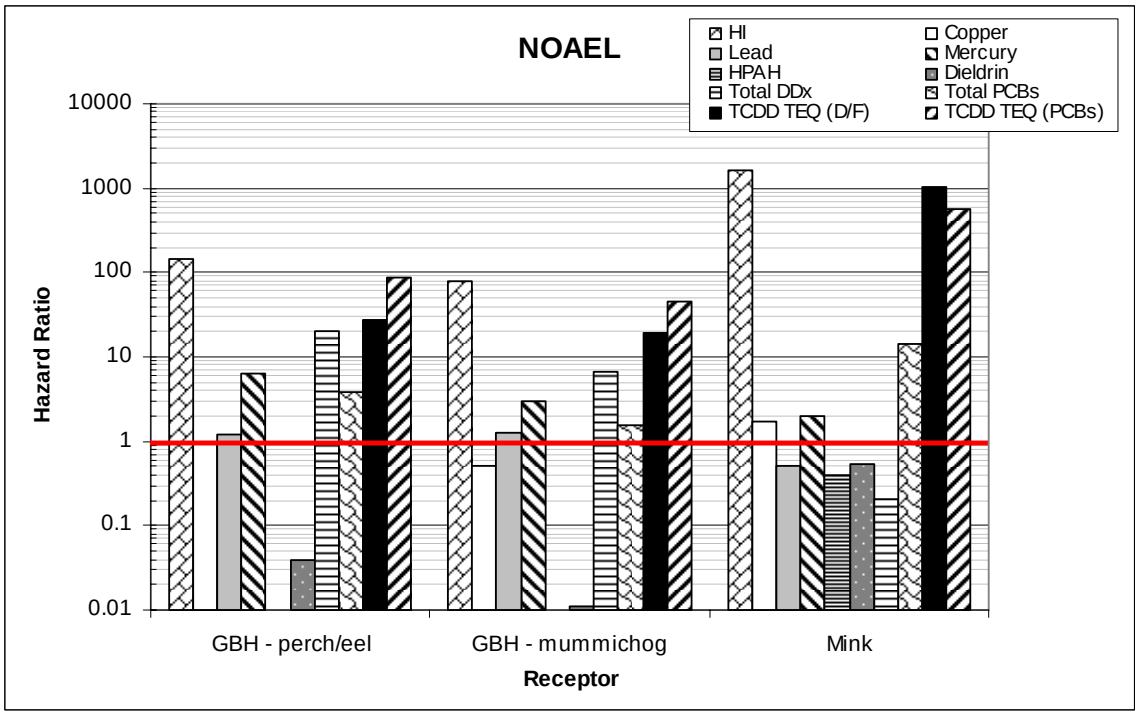

Figure 6-5. Hazard Ratios for Wildlife Receptors Based on NOAEL Tissue Residue Under Current Conditions.

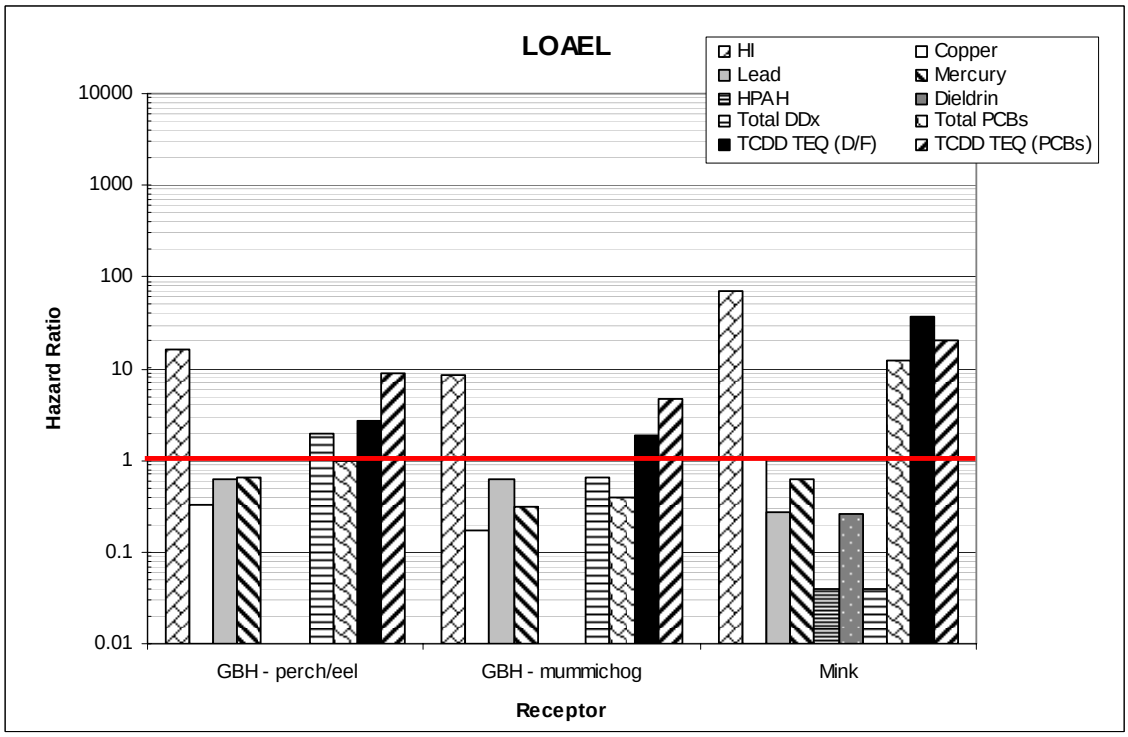

Figure 6-6. Hazard Ratios for Wildlife Receptors Based on LOAEL Tissue Residue Under Current Conditions.

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Two scenarios are evaluated for the great blue heron. The first is based on a diet consisting primarily of mummichogs, and the other is based on an AE/WP fish diet (see Figure 6-4 through Figure 6-6). For the AE/WP fish diet, the total risk is 150 for the NOAEL and 16 for the LOAEL. TCDD TEQ (PCBs) is the primary risk driver, contributing more than 55% each for the NOAEL and LOAEL risks. For both the NOAEL and LOAEL, TCDD TEQ (D/F) contribute 18% and 17%, respectively, to the total risk. For the NOAEL, the HQ for total DDx (HQ=20), mercury (HQ=6.5), total PCBs (HQ=3.9), and lead (HQ=1.2) were all above 1.0. For the LOAEL, only the HQs TCDD TEQ (PCB and D/F) and total DDx were greater than 1.0. The remaining compounds (mercury, lead, cooper, dieldrin, LPAHs, and HPAHs) had HQs less than 1.0. The fish consumption pathway contributes to the majority of the risk (more than 60%), and HQs associated with sediment exposures are below 1.0 for all COPECs except the NOAEL TCDD TEQs (both D/F and PCBs), mercury, and lead, which are slightly above 1.0.

Assuming that the great blue heron consumes primarily mummichogs, the risks are lower, with a total HI of 78 for the NOAEL and 8.6 for the LOAEL, respectively. As with the AE/WP fish diet, TCDD TEQ (PCBs) is the primary risk driver for the mummichog diet, contributing 59% to the total NOAEL risk and 53% to the LOAEL risk. TCDD TEQ (D/F) contributes 24% to the NOAEL risk and 22% to the LOAEL risk. For the NOAEL, there is an added risk from lead, mercury, and TCDD TEQ (PCBs) with HQs above 1.0. For the LOAEL, all COPECs the HQs are below 1.0.

Residue-based Assessment. Figure 6-7 presents the results of the piscivorous bird egg residue analysis. NOAEL- and LOAEL-based HIs are approximately the same, which is an artifact of the lack of NOAEL CBRs for the pesticide COPECs. Considering the LOAEL-based results, pesticides (mainly DDT compounds) account for approximately 63% of the overall HI with dioxin, furan, and PCB congeners accounting for the remainder of the hazard estimate. As noted for the wildlife dose assessment, PCB congeners (especially PCBs 77, 81, and to a lesser extent, 126) make a larger contribution to the estimated TEQ hazards than do the dioxin and furan congeners.

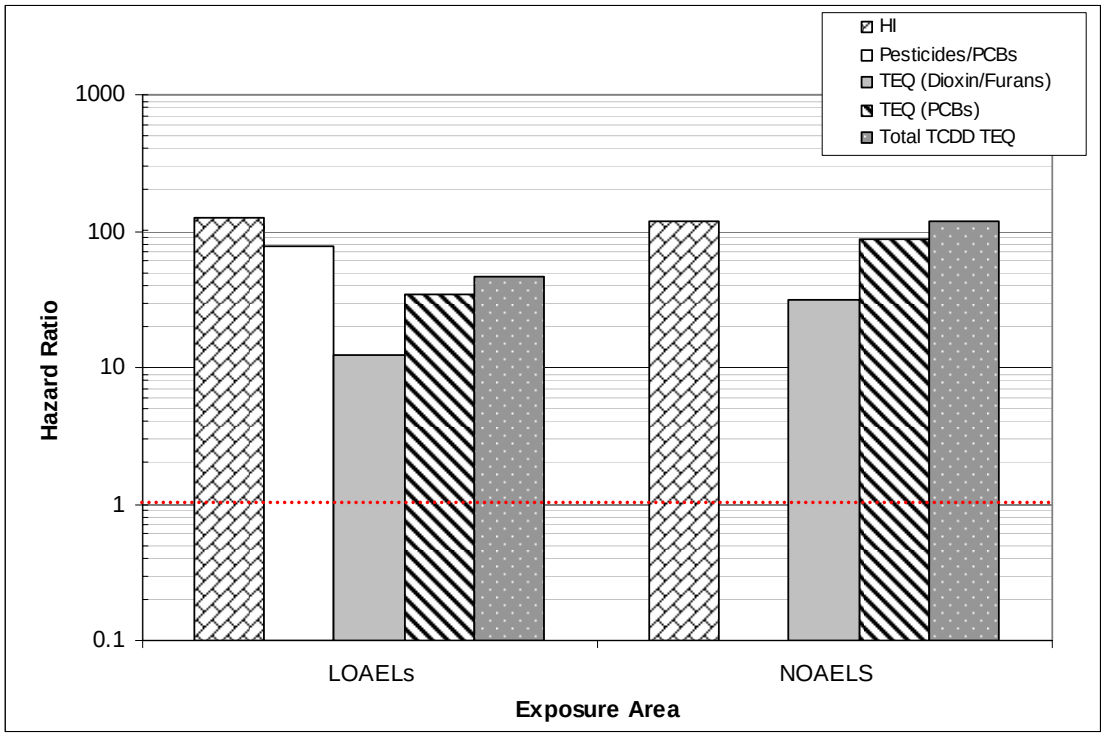

Figure 6-7. Hazard Ratios for Piscivorous Avian Receptors Based on NOAEL- and LOAEL-based CBRs Under Current Conditions.

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6.3.4 Summary of Current Risks

The current risks for ecological receptors are summarized in Table 6-17 for the benthic invertebrates, AE/WP, and mummichog receptors. Table 6-18 summarizes the current risk to wildlife receptors; details are presented in Attachment 6. Under current conditions, risks for the benthic invertebrates, AE/WP, and mummichogs are driven by copper and total DDx. For the wildlife receptors, the risks are primarily driven by TCDD TEQ (D/F) and TCDD TEQ (PCBs). Risks to the mink are greater than those for the heron and are primarily associated with TCDD TEQ (D/F), whereas TCDD TEQ (PCBs) is the primary risk driver for the heron.

As discussed in Section 6.2.2, hazards were also derived by comparing CBRs to estimated fish egg TCDD TEQ concentrations. The total TEQ (sum of the individual congeners) was then compared to the Lower and Upper Confidence Levels (LCLs and UCLs) for the 95% "species protection level" estimates of the fish egg SSD (Steevens *et al*., 2005) to estimate the HQs for dioxin/furan and PCB congeners; a total TCDD TEQ was also calculated as the sum of the two. The estimated LCL and UCL HQs for Total TCDD TEQ in American eel/white perch are 28 and 2.3, respectively (Table 5-5); for mummichog the comparable values are 36 and 3 (Table 5-6). These HQs are somewhat higher than the equivalent analysis for adult tissue summarized in Table 6-17.

Table 6-17. Summary of Ecological Risk Estimates for Benthic Invertebrates, AE/WP, and Mummichogs Under Current Conditions.

COPECs	Benthic Invertebrates			American Eel/White Perch (AE/WP)		Mummichog	
	Sediment Benchmarks	Macroinvertebrates					
	HQ	NOAEL HQ	LOAEL HQ	NOAEL HQ	LOAEL HQ	NOAEL HQ	LOAEL HQ
Inorganic Compounds							
Copper	6.9	410	41	12,400	**1,200**	**1,900**	**190**
Lead	8	1.0	0.1	23	2.3	45	4.5
Mercury	24	10	1.0	350	35	41	4.1
Semivolatile Organic Compounds (PAHs)							
LPAHs	74	6.9	0.69	0.82	0.082	0.82	0.082
HPAHs	36	74	0.74	0.48	0.048	0.31	0.031
Polychlorinated biphenyls (PCBs)							
Total PCBs (sum Aroclors)	79	13	5	1,400	140	160	16
Pesticides/Herbicides							
Dieldrin	936	2.2	0.28	2.5	0.25	0.00033	0.00012
Total DDx	239	**3,000**	**300**	**13,000**	290	0.55	0.1
Dioxin-Like Compounds							
TCDD TEQ (D/F)	493	1500	170	7.4	4.3	2.2	0.22
TCDD TEQ (PCBs)	1.2	170	19	0.15	0.088	0.027	0.0027
TCDD TEQ (Total)	494.2	1670	189	7.55	4.4	2.23	0.22
Total HI	**1,897**	**5,187**	**538**	**27,184**	**1,672**	**2,150**	**215**

Bolded values indicate the most significant contribution toward total risk for the receptor.

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Table 6-18. Summary of Ecological Risk Estimates Wildlife Receptors Under Current Conditions.

COPECs	Mink		Great Blue Heron (AE/WP) Diet		Great Blue Heron (Mummichog Diet)	
	NOAEL HQ	LOAEL HQ	NOAEL HQ	LOAEL HQ	NOAEL HQ	LOAEL HQ
Inorganic Compounds						
Copper	1.7	1	0.97	0.32	0.52	0.17
Lead	0.52	0.27	1.2	0.61	1.6	0.63
Mercury	2	0.62	6.5	0.65	3.1	0.31
Semivolatile Organic Compounds (PAHs)						
LPAHs	--	--	--	--	--	--
HPAHs	0.04	0.04	--	--	--	--
Polychlorinated biphenyls (PCBs)						
Total PCBs (sum Aroclors)	15	12	3.9	0.98	1.6	0.39
Pesticides/Herbicides						
Dieldrin	0.53	0.26	0.039	0.00074	0.011	0.00021
Total DDx	0.2	0.04	20	2	6.5	0.65
Dioxin-Like Compounds						
TCDD TEQ (D/F)	**1,000**	**37**	27	2.7	19	1.9
TCDD TEQ (PCBs)	560	20	**87**	**8.7**	**46**	**4.6**
TCDD TEQ (Total)	1560	57	114	11.4	65	6.5
Total HI	**1,580**	**72**	**147**	**16**	**78**	**9**

Bolded values indicate the most significant contribution toward total risk for the receptor.

6.4 Ecological Uncertainty Analysis

This section discusses limitations of the analyses, describes the primary sources of uncertainties, and evaluates whether these uncertainties and limitations may have resulted in an overestimation or underestimation of risk. Uncertainties in the quantification of risk associated with the analysis are identified and their impacts on risk estimates are discussed below.

Uncertainties associated with the problem formulation (including development of the CSM, receptor identification, and the selection of COPECs), exposure assessment, effects assessment, and overall risk characterizations are discussed. Table 6-19 summarizes the principal ecological risk uncertainties and identifies the projected impact on the ecological risk conclusions.

As with the HHRA, a significant uncertainty associated with the ecological assessment is the decision to focus the analysis on a limited subset of COPECs. As a result, the assessment did not attempt to quantify total site risk, but rather to determine whether existing (current) conditions pose a sufficient hazard to warrant consideration of a remedial action. In addition, the analysis also did not evaluate all potentially complete exposure pathways (*e.g.*, surface water) or ecological receptor categories or life stages (*e.g.*, early-life-stage exposures). Although conservative assumptions were employed throughout the assessment, the limited focus of the analysis indicates that there is a low to moderate level of uncertainty

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and that, overall, the risk assessment tended to underestimate ecological hazards associated with these elements (Table 6-19).

Several parameters associated with the exposure assessment have uncertainties associated with them that impart uncertainty to the calculated risks, including EPCs, potential receptors, and exposure assumptions evaluated in the risk assessment. Each of these is discussed below and summarized in Table 6-19.

- Based on USEPA risk assessment guidance, the 95% UCL of the arithmetic mean is used as the EPC because it is a conservative estimate of the average site-wide concentration that a receptor would be exposed to. As discussed for the HHRA, the amount of uncertainty in the calculated risks resulting from uncertainty in the EPCs is considered low.
- Risk estimates for individual mink that only consume white perch would be underestimated because concentrations of COPECs in white perch were always higher than in the American eel. Averaging the two fish species would therefore dilute the EPC. On the other hand, the risk for those individuals consuming only American eel would be overestimated. Exposures would also be overestimated to the extent that wildlife receptors consumed more migratory species such as striped bass, which tend to have lower tissue COPEC concentrations.
- The great blue heron exposure scenario, which assumes a site fidelity of 100% (SUF=1), may lead to overestimates of risk because 95% UCL levels in the river are assumed to be higher than other regional sources of food that herons could encounter.

As discussed below and summarized in Table 6-19, the primary aspects of the toxicity assessment that impart uncertainty to the calculated risks include uncertainty in the toxicity data for constituents detected at the site.

- TRVs are typically based on results of tests performed on test animals and extrapolated to wildlife species; selected values are generally conservatively developed as the lowest LOAEL for well-conducted studies that evaluated ecologically relevant endpoints. Because the most conservative values available are typically used, risks are more likely to be overestimated than underestimated. In the case of the mink receptor, well-conducted toxicity test results are available and were used to develop the TRVs.
- Use of the most sensitive species to select CBRs likely resulted in the residue-based analysis overestimating risks. Species such as salmon and trout are not found in the Lower Passaic River, and hazards identified in the residue-based analysis for the AE/WP were likely conservatively estimated. A separate set of CBRs was also developed for estuarine forage fish such as *Fundulus* spp. and CBRs for these species were, in some cases, higher than those for the AE/WP (such as for TCDD and total DDx). A more comprehensive analysis of the potential ecological receptors and a determination of the most appropriate toxicological endpoints will be conducted as part of the BERA.
- In several cases, CBR NOAELs were estimated using an assumed 10-fold extrapolation factor; this may have underestimated or overestimated hazards in the assessment. In addition, the literature studies queried in the tissue residue effects databases vary in terms of quality and relevance to the study objectives. Although the conservative procedures employed in the selection of CBRs tended to result in risks being overestimated, suitable tissue residue data for certain COPECs were limited and may not have included relevant sensitive species or life stages.

Finally, uncertainty in the calculated risks can arise from uncertainty in the way in which risks are calculated or aggregated, as discussed below and in Table 6-19.

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- A portion of the calculated risks may be attributed to the presence of naturally occurring constituents or constituents that are present at the site because of regional anthropogenic sources (*e.g.*, mercury). The effect of including background and ambient constituents in the risk assessment is that the calculated risks overestimate the site-related risks that are due to chemical releases. The significance of this effect is explored more fully in the residual risk analysis in Section 8.0.

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Table 6-19. Summary of Major Uncertainties in the ERE and Estimated Impacts on Calculated Risks.

Risk Assessment Step	Source of Parameter Uncertainty	Description of Uncertainty	Impact on Calculated Risks
Problem Formulation	Identification of COPECs for quantitative evaluation	Only a subset of contaminants likely comprising the primary risk drivers at the site were selected and evaluated.	Risks are somewhat underestimated; however, exposures to the selected COPECs likely represent a substantial majority of the total hazards posed to ecological receptors.
		COPECs associated with other environmental media (*e.g.*, surface water) were not considered.	Risks are underestimated.
	Mercury and methyl mercury	Due to lack of methyl mercury data in the biota tissue data, results for mercury were used as surrogate methyl mercury. This assumes that all mercury bioaccumulated in the food chain is present as methyl mercury.	Although the hazards may be overestimated, the overall uncertainty is considered low because methyl mercury generally constitutes a substantial majority of the mercury bioaccumulated in fish tissue.
	Evaluated exposure pathways	Other potentially complete exposure pathways for fish and wildlife and fish were not included (*e.g.*, dermal contact with sediment; consumption of contaminated drinking water). In addition, exposure to dioxin and dioxin-like compounds in sensitive critical life stages (*e.g.*, fish embryos) was not explicitly evaluated.	Exclusion of these additional pathways would underestimate the risks for the site.
	Receptors and life stage evaluated	Wildlife species with foraging habits other than piscivorous were not evaluated.	It is anticipated that wildlife consumption of aquatic prey, including fish and shellfish, would result in the highest dietary exposures to COPECs; it is likely that risk to other wildlife species are of lower magnitude than reported in this assessment.
Exposure Assessment	EPCs for biota tissue	95% UCLs were calculated from measured data collected from numerous samples distributed across the exposure area and used as the EPC to calculate risk.	Risks for some compounds with low frequency of detection may be overestimated or underestimated because it was assumed that samples reported as "ND" contained a concentration equal to one-half the detection limit.

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Table 6-19. Summary of Major Uncertainties in the ERA and Estimated Impacts on Calculated Risks, continued.

Risk Assessment Step	Source of Parameter Uncertainty	Description of Uncertainty	Impact on Calculated Risks
	Use of a AE/WP fish composite	Use of EPCs based on a combination of AE/WP tissue data to represent exposures to piscivorous wildlife assumes that they are from the Lower Passaic River and that each of these species is equally consumed.	Risk estimates for individual mink that consume only white perch would be underestimated because concentrations in white perch were always higher than the American eel. Averaging the two fish species would therefore dilute the EPCs. On the other hand, the risk for those individuals consuming only American eel would be overestimated. Exposures would also be overestimated to the extent that wildlife receptors consumed more migratory species such as striped bass, which tend to have lower tissue COPEC concentrations.
	Receptors exposure parameters	Selecting the most representative exposure parameters for the angling activities/habits is difficult, especially for exposure duration, exposure frequency, and fish ingestion rates.	Risk estimates were based on conservative values derived from standard ecological risk guidance (USEPA, 1993a) or professional judgment. It is likely that hazards were overestimated because of the general tendency to select conservative values.
	Use of historical data	Sediment samples dating back to 1994 and biota tissue samples dating back to 1995 were used to develop EPCs in the assessment. These data are up to 12 years old and may not be representative of current conditions.	Inclusion of the historical data may tend to overestimate current exposures and hazards based on trends observed in sediment cores. Calculated multipliers to translate 1995 sediment concentrations to equivalent present-day concentrations range from 0.6 (total PCBs) to 1.0 (DDT); the estimated average multiplier for TCDD is 0.9. The use of historical data would have different impacts on the calculated risks, depending on which COPECs were identified as the primary risk drivers.
	Wildlife diet composition	Literature was referenced to quantify the relative proportion of fish and shellfish in the diets of the modeled wildlife receptors.	Ranges of estimated values generally did not differ dramatically (ranging from 0 to 30% in different studies, depending on the particular habitat) and the tissue EPCs are fairly comparable. However, this uncertainty has more significance for the future residual risk analysis because of significant differences in the estimated bioaccumulation factors (BAF) for higher-trophic-level fish and shellfish. This uncertainty is discussed further in Section 7.0.

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Table 6-19. Summary of Major Uncertainties in the ERA and Estimated Impacts on Calculated Risks, continued.

Risk Assessment Step	Source of Parameter Uncertainty	Description of Uncertainty	Impact on Calculated Risks
	Fish prey trophic level	Wading birds generally take smaller forage fish rather than larger, higher-trophic-status species. Concentrations in mummichog (a forage fish) are approximately an order of magnitude lower than in AE/WP.	Use of the fish EPCs based on a higher-trophic-level dataset likely overestimates risks to wading birds such as the heron. The magnitude of this impact was evaluated by also including an assessment of a diet that consisted of mummichogs.
Toxicity Assessment	Ingestion toxicity data	TRVs are typically based on results of tests performed on test animals and extrapolated to wildlife species; selected values are generally conservatively developed as the lowest LOAEL for well-conducted studies that evaluated ecologically relevant endpoints.	Because the most conservative values available are typically used, risks are more likely to be overestimated than underestimated. In the case of the mink receptor, well-conducted toxicity test results are available and were used to develop the TRVs.
	1998 vs. 2005 TEF values	The WHO released its re-evaluation of human and mammalian TEFs for dioxins and dioxin-like compounds performed in 2005.	An evaluation of the hazards posed based on use of the 2005 TEF values demonstrates that they are comparable to those based on the 1998 values.
	CBR effect thresholds	CBRs were selected based on a review of several large compilations of tissue residue effect data. Study quality is variable and relevance of particular endpoints uneven relative to the assessment endpoints.	Likely risks were overestimated; however, suitable tissue residue data for certain COPECs were limited and may not have included relevant sensitive species or life stages.
		Use of toxicologically unbounded study results to develop CBRs.	In several cases, NOAELs were estimated using an assumed 10-fold extrapolation factor; this may have underestimated or overestimated hazards in the assessment.
		In general, the most sensitive saltwater or estuarine fish species was selected to develop the CBRs. In many cases, CBRs are based on exposure to salmonid species that are known to be sensitive to COPECs such as dioxins, DDT, and mercury.	Species such as salmon and trout are not found in the Lower Passaic River, and hazards identified in the residue-based analysis for the AE/WP are likely overestimated. A separate set of CBRs was also developed for estuarine forage fish such as *Fundulus* spp., and CBRs for these species were, in some cases, higher than for the AE/WP (such as those for TCDD and total DDx).

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Table 6-19. Summary of Major Uncertainties in the ERA and Estimated Impacts on Calculated Risks, continued.

Risk Assessment Step	Source of Parameter Uncertainty	Description of Uncertainty	Impact on Calculated Risks
Risk Characterization	Distinguishing site-related risks from background and/or ambient risks	A portion of the estimated hazards may be attributed to the presence of naturally occurring constituents or constituents that are present at the site because of regional anthropogenic sources (*e.g.*, mercury).	The effect of including background and ambient constituents in the risk assessment is that the calculated risks overestimate the site-related risks that are due to chemical releases. The significance of this effect is explored more fully in the residual risk analysis.

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7.0 DEVELOPMENT OF EPCs FOR FUTURE CONDITIONS

To help assess remedial action alternatives for the FFS, potential future risks to human health and ecological receptors were calculated assuming three remediation scenarios (as described in the FFS):

- Remediation of the primary erosional zone and/or the primary inventory zone;
- Remediation of the area of focus; and,
- Monitored natural recovery.

The same COPCs/COPECs evaluated for the current scenario were also selected as COPCs/COPECs for the future scenario. All environmental media evaluated in the current risk scenarios were also evaluated in the future risk scenarios. An empirical mass balance model was used to predict surface sediment concentrations as average annual concentrations for each of the COPCs/COPECs. These annualized sediment concentrations were then applied to each of the remediation scenarios to develop future EPCs for sediment, fish (piscivorous and forage), and blue crab. A description of the empirical mass balance approach used to estimate surface sediment concentrations is provided in Appendix D to the FFS. A summary of the model is provided in Section 7.1. Section 7.2 explains how the predicted average annualized surface sediment concentrations generated from the model were used to derive EPCs for the future risk assessments.

7.1 Summary of Mass Balance Approach

Future concentrations of COPECs/COPCs in the Lower Passaic River surface sediments were estimated using an empirical method. First, an empirical mass balance was developed to quantify the contribution of different potential sediment and contaminant sources to the sediment present in the river, such as sediment resuspension, the Upper Passaic River, tributaries, combined sewer overflows/stormwater outfalls, and tidal exchange with Newark Bay. Then, contaminant concentration reduction trajectory curves were estimated for each of the evaluated COPECs/COPCs using dated chemical data from high-resolution sediment cores. By assuming that the portion of contaminant load at any instant is a function of the contributions of each source, the effect on the trajectory of removing a portion of any one source—specifically the sediment resuspension term that will be addressed by dredging, capping, or both—was estimated as a step in the trajectory. The trajectory was then projected to the future to predict the future concentration of each COPEC/COPC in surface sediments, assuming that concentration trends observed over the past 25 years would continue for the next 30 years following remediation (*i.e.*, 2018 to 2048). The empirical mass balance and contaminant concentration projections are described in detail in Appendix D of the FFS.

7.2 Calculations of Future EPCs

In general, several sets of future EPCs were developed for each of the COPCs/COPECs, corresponding to each of the remediation scenarios at three time periods. The first time period was selected to represent the year remediation is expected to be complete (*i.e.*, 2018). For the first time period, predicted average annual concentrations at 2018 are used to represent concentrations for that specific period in time for both the human and ecological receptors. For ecological receptors, the second time period evaluated is at 2048. For this second time period, predicted average annual concentrations specifically determined for 2048 are used to represent concentrations (only for the ecological receptors) 30 years post-remediation. For protection of human health, however, future EPCs for subsequent time periods need to consider the exposure duration (*i.e.*, "ED") component of the risk/hazard equation which is assessed differently for cancer risks and non-cancer health hazards. To derive EPCs to estimate future cancer risks, the predicted average annual concentrations derived from years 2019 through 2048 are used to derive an average concentration over the total exposure duration of 30 years (*i.e.*, 6 years as a child and 24 years as an

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adult). Thus, a 6-year average of the average annual sediment concentrations is used for the child, and a 24-year average of the average annual sediment concentrations is used to represent the adult for cancer exposure only.

For estimating non-cancer health hazards, the predicted average annual concentrations derived from years 2019 through 2024 and 2019 through 2025 are used to derive EPCs for the child and adult, respectively. For noncarcinogens, the AT for the child is 6 years, while the AT for the adult was averaged over a period equal to a chronic exposure duration (7 years). Therefore, the AT for the non-cancer hazard assessment for the adult is set to 2,555 days (7 years x 365 days/year). As the duration of exposure increases, the EPC and thus the average daily dose decreases, allowing the intake to be averaged over a longer period of time (*i.e.*, greater than 7 years). Because this would underestimate the RME risk to the adult, only a 7-year exposure duration (as opposed to a 24-year exposure duration) is assumed for the adult for noncarcinogenic exposures occurring through the year 2048. Based on this same principle, the first 7 years after remediation, rather than the second or third 7-year period, is used to determine the EPCs for assessing a RME to the adult and child receptors. Because the EPC and thus the average daily dose decreases over time, which only impacts exposure to noncarcinogens, a third set of EPCs is derived for the adult to provide a lower bound on risk at a period in time closer to 2048. Whereas the first 7 years post-remediation is used to derive an EPC representing the RME for the adult, the last 7-year period (*i.e.*, 2042-2048) is used to derive a second EPC for the adult. This EPC is more representative of the actual concentrations 30 years post-remediation. Only the adult receptor is evaluated for the 2042-2048 time period to assist risk management decisions regarding the selection of a remedial action. The health hazard for the adult may be more heavily relied upon for risk management decisions because datasets supporting the ingestion rates are available for an adult, but not a child receptor. Figure 7-1 provides an example of how the predicted average annual sediment concentrations were compiled for each of the exposure durations for the future HHRAs.

For the monitored natural recovery and the primary erosional zone/primary inventory zone remediation scenarios, the predicted average annual sediment concentrations produced from the model were adjusted to take into account the legacy sediments that would remain throughout the lower 8 miles after the remedial action occurred. The adjustment consisted of multiplying the predicted average annual sediment concentrations determined by the model for each of the COPCs/COPECs by a ratio of the 1995 surface sediment mean concentration from TSI to the 1990s high-resolution core sediment mean concentration from Malcom Pirnie's studies (see Table 7-1).

Applying this ratio provided average concentrations for each of the COPCs/COPECs over the entire 8-mile exposure area (*i.e.*, RM 0 to RM 8). Table 7-1 summarizes the ratios for each of the COPCs/COPECs. For remediation of the area of focus, none of the historical sediment is expected to remain exposed, either because it has been removed or because it has been capped; thus, no adjustment to determine average concentrations throughout RM 0 to RM 8 was necessary for this remediation scenario.

The future EPCs for COPCs/COPECs in fish, crab, and sediment are based upon modeled projections of future concentrations in sediment. As such, the approach used to determine EPCs for the current risk scenarios where USEPA guidance (2002a) was followed for determining the underlying population distribution could not be followed to derive the future EPCs. Therefore, an approach was developed to relate the future EPCs based on an average concentration to a 95% UCL to be consistent with USEPA (1989). The approach consisted of taking the predicted average annual sediment concentrations and multiplying them by the ratio of the current sediment 95% UCL concentrations to the current mean sediment concentrations to obtain a future 95% UCL estimate in sediment. For the monitored natural recovery and primary erosional zone/primary inventory zone remediation scenarios, the adjusted average concentration (*i.e.*, the average concentration assumed for the entire stretch from RM 0 to RM 8) was multiplied by this ratio, whereas for the area of focus scenario, the unadjusted predicted average

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concentrations generated directly from the model were multiplied by the ratios. Table 7-2 summarizes the historical sediment means and 95% UCLs for the COPCs/COPECs. Tables 7-3 through 7-5 summarize the predicted average annual sediment concentrations and the respective future 95% UCLs estimated for sediment. Note that this approach most likely overestimates future 95% UCL concentrations for remediation of the primary erosional zone and/or the primary inventory zone and the remediation of the area of focus scenarios because future sediment concentrations will have a substantially smaller range, and therefore a smaller confidence interval than current sediment concentrations. This is because, as defined, the remediation will remove excessively high sediment chemical concentrations.

The future 95% UCLs for biota were then derived by multiplying the future estimated 95% UCLs in sediment by chemical-specific bioaccumulation factors (BAF). The BAFs were derived as the ratio of the current biota (*i.e.*, piscivorous, forage, and crab) mean tissue concentrations to the current mean sediment concentrations and are provided in Table 7-2. Tables 7-6 through 7-8 summarize the 95% UCLs for fish and crab for the human and ecological future risk assessments.

7.3 Uncertainties Related to Development of Future EPCs

Uncertainties related to development of the future EPCs are summarized below and discussed in more detail in Section 8.3.

Forecast Numbers. The empirical mass balance model used to predict the future average annual sediment concentrations (*i.e.*, forecast numbers) over a 30-year period employed various assumptions that impact the uncertainty of these future sediment concentrations. If future predicted sediment concentrations were overestimated based on these assumptions, future estimated risks are overestimated. Conversely, if future predicted sediment concentrations are underestimated, the future estimated risks are underestimated.

BAFs. There is uncertainty associated with the methodology used to derive the BAFs as well as the uncertainty associated with using BAFs to estimate future EPCs in fish and shellfish tissue. As explained previously, tissue concentrations were estimated by applying BAFs to the estimated sediment concentrations. These uncertainties may over- or underestimate risk.

Extrapolation to 95% UCL. The methodology employed to estimate future sediment 95% UCL EPCs (*i.e.*, taking the predicted average annual sediment concentrations and multiplying them by the ratio of the current sediment 95% UCL concentrations to the current mean sediment concentrations) most likely overestimates concentrations for the remediation scenarios involving capping or removal of sediments (*e.g.*, the primary erosional zone and/or the primary inventory zone and the remediation of the area of focus). Therefore, the future estimated risks for these two remediation scenarios are most likely overestimated.

Future Assessment of Avian Egg Residues. The mass balance approach did not assess future trends in individual dioxin, furan, and PCB congener concentrations and, consequently, no evaluation of future avian egg residues was possible. Given that the magnitude of hazards to avian receptors identified for both dose- and residue-based analyses were similar, it is anticipated that the residual hazards to the avian embryo endpoint should be qualitatively consistent with those determined using the dose assessment approach (as discussed in Section 8.0).

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Figure 7-1. Example of Averaging Future Average Annual Concentrations

EXAMPLE CALCULATION FOR DERIVING THE AVERAGE FORECAST CONCENTRATIONS FOR HUMAN HEALTH EXPOSURE DURATIONS OF 6 YEARS (CHILD), 7 YEARS (ADULT - NONCANCER HAZARDS) AND 24 YEARS (ADULT - CANCER RISKS)

Malcolm Pirnie, Inc. DRAFT 4/5/07

Chemical	Half-Life	Lambda
Total PCB Congeners	14	0.0495

y = -0.0494x + 106.64
R2 = 0.4287
x = 1979
y = 8.88
1979 concentration = 7,168 ug/kg

Time	Year Difference	Total PCB Congeners ug/kg
1979	0	7,168
1980	1	6,822
1982	3	6,179
1985	6	5,326
1987	8	4,824
1990	11	4,158
1992	13	3,766
1995	16	3,247
1997	18	2,941
2000	21	2,535
2002	23	2,296
2005	26	1,979
2007	28	1,793
2010	31	1,545
2012	33	1,400
2015	36	1,206
2018	39	1,040
2019	40	990
2020	41	942
2021	42	896
2022	43	853
2023	44	812
2024	45	773
2025	46	735
2026	47	700
2027	48	666
2028	49	634
2029	50	603
2030	51	574
2031	52	546
2032	53	520
2033	54	495
2034	55	471
2035	56	448
2036	57	427
2037	58	406
2038	59	386
2039	60	368
2040	61	350
2041	62	333
2042	63	317
2043	64	302
2044	65	287
2045	66	273
2046	67	260
2047	68	247
2048	69	236

Remediation complete

Human and Ecological - remediation complete

6-year average - cancer and non-cancer Child

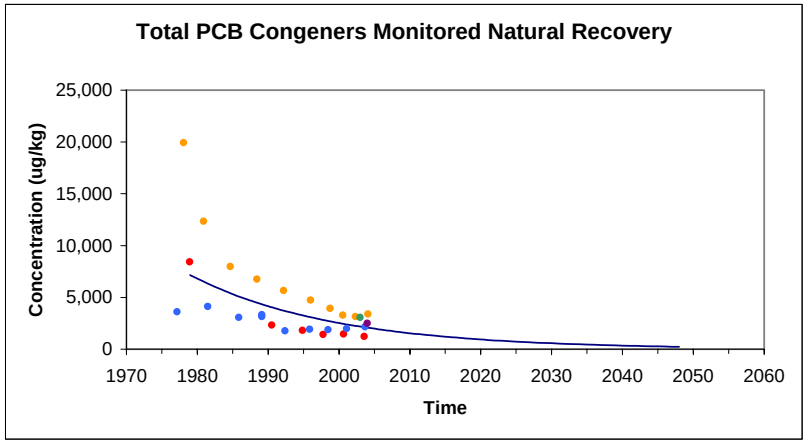
7-year average - RME non-cancer Adult

24-year average - cancer Adult

Ecological - 30 years after remediation

7-year average - lower bound non-cancer Adult

30 years after remediation completed



	Total PCB Congeners ug/kg
6-year avg - cancer and non-cancer	878
24 year avg - cancer adult	441
7 year avg - RME noncancer adult	857
7 year avg - 30 years after remediation (lower bound) noncancer adult	275

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Table 7-1. A Ratio of 1995 TSI Surface Sediment to 1990s MPI High-Resolution Cores Mean Concentrations for the COPCs/COPECs.

Analyte	MPI 1990s Concentrations in Lower Passaic River High-Resolution Cores		1995 TSI Surface Sediment Data (0-6 in.)		Ratio (Surface Conc/ Forecast Conc) [a]	Std. Error on the Ratio
	Mean	Std. Error	Mean	Std. Error		
Copper (mg/kg)	154	6.8	226	25	1.5	0.18
Lead (mg/kg)	237	11	334	15	1.4	0.09
Mercury (mg/kg)	2.0	0.11	3.3	0.20	1.7	0.14
LPAHs (µg/kg)	11,400	773	23,500	15,200	2.1	1.34
HPAHs (µg/kg)	28,900	1,360	39,700	15,200	1.4	0.53
Total PCBs (µg/kg)	1,258	108.3	1,290	184	1.0[b]	0.17
Total chlordane (µg/kg)	85	4.2	47	4	1.0[c]	--
Dieldrin (µg/kg)	7.2	1.87	25	2.53	3.5	0.98
DDE (µg/kg)	59	2.91	66	6.43	1.7[d]	--
DDD (µg/kg)	94	23.0	154	71	1.7[d]	--
DDT (µg/kg)	36	10.0	122	42	1.7 [d]	--
Total DDx (µg/kg)	178	31	304	78	1.7	0.53
2,3,7,8-TCDD (µg/kg)	0.29	0.03	0.82	0.21	2.9	0.79

MPI – Malcolm Pirnie, Inc.

a. These values are used as multipliers to modify the forecast concentrations for the COPCs/COPECs to estimate the average surface concentration over the lower 8 miles of the Lower Passaic River.

b. Ratio was assigned to 1 because the 1995 total PCB values based on the sum of Aroclors was lower than the sum of PCB congeners obtained from the high-resolution cores. The sum of congeners should be used as the estimate for the sum of Aroclors, if available, in all risk assessment calculations. Aroclor analyses are limited with regard to the specific congeners that may be present. After release to the environment, PCB mixtures change through partitioning, transformation, weathering, and bioaccumulation, and differ considerably from commercial mixtures (*i.e.*, Aroclors)

c. Actual ratio is less than unity. A value of unity was assigned based on the observations of greater contamination at depth and the assumption that average surface concentrations are higher than or equal to the recently deposited materials recorded in the high-resolution cores.

d. Ratios for the DDT metabolites varied from 1.1 to 3.1. A value of 1.5 was selected because it represents the approximate mean of these estimates and is also the value obtained for total DDx and DDD.

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Table 7-2. Summary of Current Sediment and Biota Data.

COPC/COPEC	Current Sediment			Current Biota Data			BAF[a]		
	Mean (ppm)	95% UCL (ppm)	Ratio of Sediment Historical 95% UCL to Historical Mean	Mean Piscivorous Fish Concentrations (ppm)	Mean Forage Fish Concentrations (ppm)	Mean Blue Crab Concentrations (ppm)	Piscivorous Fish	Forage Fish	Blue Crab
Total PCBs	1.32	1.80	1.37	2.85	0.67	2.70	2.17	0.51	2.05
4,4'-DDD	0.10	0.21	2.19	0.12	NA	0.05	1.21	NA	0.55
4,4'-DDE	0.06	0.08	1.44	0.25	NA	0.14	4.25	NA	2.35
4,4'-DDT	0.09	0.09	0.94	0.06	NA	0.08	0.65	NA	0.86
Total chlordane	0.04	0.04	1.11	0.73	0.02	0.02	19.59	0.46	0.53
Dieldrin	0.01	0.02	1.38	0.02	0.003	0.01	1.59	0.22	0.67
Methyl mercury	3.13	3.65	1.17	0.32	0.04	0.09	0.10	0.01	0.03
TEQ PCB-mammals	0.00004	0.00005	1.24	0.0001	0.00003	0.0001	1.77	0.70	2.56
TEQ PCB-birds	0.0005	0.0008	1.40	0.00058	0.00016	0.00070	1.08	0.29	1.31
TEQ PCB-fish	0.000003	0.000004	1.30	0.000005	0.000002	0.00001	1.47	0.52	2.08
TEQ D/F-mammals	0.0008	0.0016	2.02	0.0002	0.00008	0.00012	0.20	0.10	0.15
TEQ D/F-birds	0.0009	0.0018	2.07	0.00017	0.00008	0.00015	0.20	0.09	0.17
TEQ D/F-fish	0.0008	0.0016	2.06	0.00016	0.00008	0.00012	0.20	0.10	0.15
Total DDx	0.23	0.38	1.62	0.42	0.07	0.26	1.82	0.32	1.12
Lead	328.0	375.0	1.14	0.40	0.71	0.46	0.001	0.002	0.001
HPAH	34.4	61.0	1.77	0.09	0.06	0.11	0.003	0.002	0.003
LPAH	13.7	41.0	2.99	0.15	0.13	0.10	0.01	0.01	0.01
Copper	217	236	1.09	8.81	3.66	30.36	0.04	0.02	0.14

[a] BAF= mean of the biota tissue divided by the mean sediment concentration.

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Table 7-3. Summary of Input Parameters and 95% UCLs Estimated for Sediment for the Monitored Natural Recovery Remediation Scenario.

									Average Sediment Concentration in RM 0-8[i]						95% UCL Sediment Concentration in RM 0-8[j]					
COPC/COPEC	Ratio of Sediment Historical 95% UCL to Historical Mean[a]	Predicted Average Sediment Concentration in HR Cores at Year=2018[b] (ppm)	Predicted Average Concentration in Sediment from HR Cores for Years 2019-2024[c] (ppm)	Predicted Average Concentration in Sediment from HR Cores for Years 2019-2025[d] (ppm)	Predicted Average Concentration in Sediment from HR Cores for Years 2025-2048[e] (ppm)	Predicted Average Concentration in Sediment from HR Cores for Year 2048[f] (ppm)	Predicted Average Concentration in Sediment from HR Cores for Years 2042 - 2048[g] (ppm)	Ratio of 1995 TSI Surface Sediment to 1990s HR Cores[h]	Year 2018	Years 2019-2024	Years 2019-2025	Years 2025-2048	Year 2048	Years 2042-2048	Year 2018	Years 2019-2024	Years 2019-2025	Years 2025-2048	Year 2048	Years 2042-2048
Total PCBs	1.37	0.42	0.35	0.342	0.176	0.094	0.11	1.00	4.15E-01	3.50E-01	3.42E-01	1.76E-01	9.40E-02	1.10E-01	5.67E-01	4.79E-01	4.68E-01	2.41E-01	1.29E-01	1.50E-01
4,4'-DDD	2.19	0.04	0.0325	0.032	0.0198	NA	0.0144	1.70	6.29E-02	5.53E-02	5.44E-02	3.37E-02	NA	2.45E-02	1.38E-01	1.21E-01	1.19E-01	7.38E-02	NA	5.37E-02
4,4'-DDE	1.44	0.03	0.023	0.023	0.014	NA	0.0103	1.70	4.42E-02	3.91E-02	3.91E-02	2.38E-02	NA	1.75E-02	6.36E-02	5.63E-02	5.63E-02	3.43E-02	NA	2.52E-02
4,4'-DDT	0.94	0.01	0.00695	0.007	0.00425	NA	0.0031	1.70	1.36E-02	1.18E-02	1.19E-02	7.23E-03	NA	5.27E-03	1.28E-02	1.12E-02	1.12E-02	6.82E-03	NA	4.98E-03
Total chlordane	1.11	0.054	0.051	0.051	0.042	0.036	0.0373	1.00	5.40E-02	5.10E-02	5.13E-02	4.20E-02	3.60E-02	3.73E-02	5.97E-02	5.64E-02	5.67E-02	4.64E-02	3.98E-02	4.12E-02
Dieldrin	1.38	0.0042	0.0042	0.0042	0.0042	0.0042	0.0042	3.50	1.47E-02	1.47E-02	1.47E-02	1.47E-02	1.47E-02	1.47E-02	2.03E-02	2.03E-02	2.03E-02	2.03E-02	2.03E-02	2.03E-02
Methyl mercury	1.17	0.78	0.686	0.673	0.398	0.25	0.278	1.70	1.33	1.17	1.14	6.77E-01	4.25E-01	4.73E-01	1.55	1.36	1.33	7.89E-01	4.95E-01	5.51E-01
TEQ PCB-mammals	1.24	0.0000074	0.000006	0.000006	0.000003	0.000002	0.000002	1.00	7.40E-06	1.00E-05	1.00E-05	3.00E-06	2.00E-06	2.00E-06	9.16E-06	1.24E-05	1.24E-05	3.71E-06	2.48E-06	2.48E-06
TEQ PCB-birds	1.40	0.000118	NA	NA	NA	0.00003	NA	1.00	1.18E-04	NA	NA	NA	3.00E-05	NA	1.65E-04	NA	NA	NA	4.20E-05	NA
TEQ PCB-fish	1.30	0.0000006	NA	NA	NA	0.0000002	NA	1.00	6.00E-07	NA	NA	NA	2.00E-07	NA	7.79E-07	NA	NA	NA	2.60E-07	NA
TEQ D/F-mammals	2.02	0.000160	0.00014	0.00013	0.00008	0.00005	0.00005	2.90	4.64E-04	4.06E-04	3.77E-04	2.32E-04	1.45E-04	1.45E-04	9.37E-04	8.20E-04	7.61E-04	4.68E-04	2.93E-04	2.93E-04
TEQ D/F-birds	2.07	0.000160	NA	NA	NA	0.00005	NA	2.90	4.64E-04	NA	NA	NA	1.45E-04	NA	9.60E-04	NA	NA	NA	3.00E-04	NA
TEQ D/F-fish	2.06	0.00015	NA	NA	NA	0.00004	NA	2.90	4.35E-04	NA	NA	NA	1.16E-04	NA	8.96E-04	NA	NA	NA	2.39E-04	NA
Total DDx	1.62	0.07	NA	NA	NA	0.025	NA	1.70	1.21E-01	NA	NA	NA	4.25E-02	NA	1.96E-01	NA	NA	NA	6.90E-02	NA
Lead	1.14	147	NA	NA	NA	68	NA	1.40	2.06E+02	NA	NA	NA	9.52E+01	NA	2.35E+02	NA	NA	NA	1.09E+02	NA
HPAH	1.77	34.5	NA	NA	NA	34.5	NA	1.40	4.83E+01	NA	NA	NA	4.83E+01	NA	8.57E+01	NA	NA	NA	8.57E+01	NA
LPAH	2.99	5.3	NA	NA	NA	5.3	NA	2.10	1.11E+01	NA	NA	NA	1.11E+01	NA	3.33E+01	NA	NA	NA	3.33E+01	NA
Copper	1.09	85	NA	NA	NA	43	NA	1.50	1.28E+02	NA	NA	NA	6.45E+01	NA	1.38E+02	NA	NA	NA	7.01E+01	NA

HR - High resolution.
NA -Not applicable because the specific COPC/COPEC was not evaluated in the HHRA or ERA.
RM - River mile.
UCL - Upper confidence limit.

a. See Table 7-2 for summary of the mean and 95% UCL for sediment data.
b. As determined from the model at year 2018 (the year that remediation is expected to be completed); see Appendix D of the FFS for model output.
c. This is an average concentration derived by averaging the first 6 years (*i.e.*, years 2019-2024) after remediation is completed; used to develop the EPC for the child receptor.
d. This is an average concentration derived by averaging the first 7 years (*i.e.*, years 2019-2025) after remediation is completed; used to develop the noncancer EPC for the adult receptor.
e. This is an average concentration derived by averaging years 7 through 30 (*i.e.*, years 2025-2048) assuming remediation is completed in 2018; used to develop the cancer EPC for the adult receptor.
f. This is the average concentration at year 2048, 30 years after remediation is completed; used for the ecological EPCs.
g. This is an average concentration derived by averaging the last 7 years in the 30-year period (*i.e.*, years 2042-2048) after remediation is completed; used to develop the noncancer EPC for the adult receptor.
h. Multipliers used to modify the forecast concentrations for the COPCs/COPECs to estimate the average surface concentration over the lower 8 miles of the Lower Passaic River. These factors are not used for the capping and dredging of RM 0-8 scenario.
i. Average sediment concentration = predicted average sediment concentration in high-resolution cores at the specified year multiplied by the ratio of the 1995 surface sediment mean concentration from TSI to the 1990s high-resolution core sediment mean concentration from Malcolm Pirnie's studies.
j. 95% UCL sediment concentration in RM 0-8 = the average sediment concentration in RM 0-8 multiplied by the ratio of the historical 95% UCL to the historical mean.

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Table 7-4. Summary of Input Parameters and 95% UCLs in Sediment for the Primary Erosional Zone/Primary Inventory Zone Remediation Scenario.

									Average Sediment Concentration in RM 0-8[i]						95% UCL Sediment Concentration in RM 0-8[j]					
COPC/COPEC	Ratio of Sediment Historical 95% UCL to Historical Mean[a]	Predicted Average Sediment Concentration in HR Cores at Year=2018[b] (ppm)	Predicted Average Concentration in Sediment from HR Cores for Years 2019-2024[c] (ppm)	Predicted Average Concentration in Sediment from HR Cores for Years 2019-2025[d] (ppm)	Predicted Average Concentration in Sediment from HR Cores for Years 2025-2048[e] (ppm)	Predicted Average Concentration in Sediment from HR Cores for Year 2048[f] (ppm)	Predicted Average Concentration in Sediment from HR Cores for Years 2042 – 2048[g] (ppm)	Ratio of 1995 TSI Surface Sediment to 1990s HR Cores[h]	Year 2018	Years 2019-2024	Years 2019-2025	Years 2025-2048	Year 2048	Years 2042-2048	Year 2018	Average for Years 2019-2024	Years 2019-2025	Years 2025-2048	Year 2048	Years 2042-2048
Total PCBs	1.37	0.369	0.322	0.309	0.157	0.084	0.098	1.00	3.69E-01	3.22E-01	3.09E-01	1.57E-01	8.40E-02	9.80E-02	5.05E-01	4.40E-01	4.23E-01	2.15E-01	1.15E-01	1.34E-01
4,4'-DDD	2.19	0.03	0.029	0.028	0.017	NA	0.012	1.70	5.44E-02	4.93E-02	4.76E-02	2.89E-02	NA	2.04E-02	1.19E-01	1.08E-01	1.04E-01	6.34E-02	NA	4.47E-02
4,4'-DDE	1.44	0.02	0.0205	0.02	0.012	NA	0.009	1.70	3.91E-02	3.49E-02	3.40E-02	2.04E-02	NA	1.53E-02	5.63E-02	5.02E-02	4.90E-02	2.94E-02	NA	2.20E-02
4,4'-DDT	0.94	0.01	0.0062	0.006	0.004	NA	0.003	1.70	1.19E-02	1.05E-02	1.02E-02	6.80E-03	NA	5.10E-03	1.12E-02	9.95E-03	9.63E-03	6.42E-03	NA	4.82E-03
Total chlordane	1.11	0.054	0.052	0.052	0.042	0.036	0.037	1.00	5.40E-02	5.20E-02	5.20E-02	4.20E-02	3.60E-02	3.70E-02	5.97E-02	5.75E-02	5.75E-02	4.64E-02	3.98E-02	4.09E-02
Dieldrin	1.38	0.0039	0.0039	0.0039	0.0039	0.0039	0.0039	3.50	1.37E-02	1.37E-02	1.37E-02	1.37E-02	1.37E-02	1.37E-02	1.89E-02	1.89E-02	1.89E-02	1.89E-02	1.89E-02	1.89E-02
Methyl mercury	1.17	0.69	0.623	0.613	0.353	0.22	0.246	1.70	1.17	1.06	1.04	6.00E-01	3.74E-01	4.18E-01	1.37	1.23	1.21	6.99E-01	4.36E-01	4.87E-01
TEQ PCB-mammals	1.24	0.000007	0.000006	0.000006	0.000003	0.000002	0.000002	1.00	7.00E-06	6.00E-06	6.00E-06	3.00E-06	2.00E-06	2.00E-06	8.67E-06	7.43E-06	7.43E-06	3.71E-06	2.48E-06	2.48E-06
TEQ PCB-birds	1.40	0.000105	NA	NA	NA	0.000026	NA	1.00	1.05E-04	NA	NA	NA	2.60E-05	NA	1.47E-04	NA	NA	NA	3.64E-05	NA
TEQ PCB-fish	1.30	0.00000057	NA	NA	NA	0.0000001	NA	1.00	5.70E-07	NA	NA	NA	1.00E-07	NA	7.40E-07	NA	NA	NA	1.30E-07	NA
TEQ D/F-mammals	2.02	0.0001	0.0001	0.0001	0.00005	0.00003	0.00004	2.90	3.19E-04	2.90E-04	2.90E-04	1.45E-04	8.70E-05	1.16E-04	6.44E-04	5.86E-04	5.86E-04	2.93E-04	1.76E-04	2.34E-04
TEQ D/F-birds	2.07	0.0001	NA	NA	NA	0.00003	NA	2.90	3.19E-04	NA	NA	NA	8.70E-05	NA	6.60E-04	NA	NA	NA	1.80E-04	NA
TEQ D/F-fish	2.06	0.0001	NA	NA	NA	0.00003	NA	2.90	2.90E-04	NA	NA	NA	8.70E-05	NA	5.97E-04	NA	NA	NA	1.79E-04	NA
Total DDx	1.62	0.06	NA	NA	NA	0.0216	NA	1.70	1.04E-01	NA	NA	NA	3.67E-02	NA	1.68E-01	NA	NA	NA	5.96E-02	NA
Lead	1.14	141	NA	NA	NA	65	NA	1.40	1.97E+02	NA	NA	NA	9.10E+01	NA	2.26E+02	NA	NA	NA	1.04E+02	NA
HPAH	1.77	34.5	NA	NA	NA	34.5	NA	1.40	4.83E+01	NA	NA	NA	4.83E+01	NA	8.57E+01	NA	NA	NA	8.57E+01	NA
LPAH	2.99	5.26	NA	NA	NA	5.26	NA	2.10	1.10E+01	NA	NA	NA	1.10E+01	NA	3.30E+01	NA	NA	NA	3.30E+01	NA
Copper	1.09	82	NA	NA	NA	41	NA	1.50	1.23E+02	NA	NA	NA	6.15E+01	NA	1.34E+02	NA	NA	NA	6.68E+01	NA

HR - High resolution.
NA - Not applicable because the specific COPC/COPEC was not evaluated in the HHRA or ERA.
RM - River mile.
UCL - Upper confidence limit.

a. See Table 7-2 for summary of the mean and 95% UCL for sediment data.
b. As determined from the model at year 2018 (the year that remediation is expected to be completed); see Appendix D of the FFS for model output.
c. This is an average concentration derived by averaging the first 6 years (*i.e.*, years 2019-2024) after remediation is completed; used to develop the EPC for the child receptor.
d. This is an average concentration derived by averaging the first 7 years (*i.e.*, years 2019-2025) after remediation is completed; used to develop the noncancer EPC for the adult receptor.
e. This is an average concentration derived by averaging years 7 through 30 (*i.e.*, years 2025-2048) assuming remediation is completed in 2018; used to develop the cancer EPC for the adult receptor.
f. This is the average concentration at year = 2048, 30 years after remediation is completed; used for the ecological EPCs.
g. This is an average concentration derived by averaging the last 7 years in the 30-year period (*i.e.*, years 2042-2048) after remediation is completed; used to develop the noncancer EPC for the adult receptor.
h. Multipliers used to modify the forecast concentrations for the COPCs/COPECs to estimate the average surface concentration over the lower 8 miles of the Lower Passaic River. These factors are not used for the capping and dredging of RM0-8 scenario.
i. Average sediment concentration = predicted average sediment concentration in high-resolution cores at the specified year multiplied by the ratio of the 1995 surface sediment mean concentration from TSI to the 1990s high-resolution core sediment mean concentration from Malcolm Pirnie's studies.
j. 95% UCL sediment concentration in RM 0-8 = the average sediment concentration in RM 0-8 multiplied by the ratio of the historical 95% UCL to the historical mean.

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Table 7-5. Summary of Input Parameters and 95% UCLs in Sediment Estimated for the Area of Focus Remediation Scenario.

									95% UCL Sediment Concentration in RM 0-8[i]					
COPC/COPEC	Ratio of Sediment Historical 95% UCL to Historical Mean[a]	Predicted Average Sediment Concentration in HR Cores at Year=2018[b] (ppm)	Predicted Average Concentration in Sediment from HR Cores for Years 2019-2024[c] (ppm)	Predicted Average Concentration in Sediment from HR Cores for Years 2019-2025[d] (ppm)	Predicted Average Concentration in Sediment from HR Cores for Years 2025-2048[e] (ppm)	Predicted Average Concentration in Sediment from HR Cores for Year 2048[f] (ppm)	Predicted Average Concentration in Sediment from HR Cores for Years 2042 – 2048[g] (ppm)	Ratio of 1995 TSI Surface Sediment to 1990s HR Cores[h]	Year 2018	Average for Years 2019-2024	Years 2019-2025	Years 2025-2048	Year 2048	Years 2042-2048
Total PCBs	1.37	0.28	0.246	0.241	0.12	0.064	0.075	NA	3.87E-01	3.36E-01	3.30E-01	1.64E-01	8.75E-02	1.03E-01
4,4'-DDD	2.19	0.022	0.020	0.0197	0.012	NA	0.009	NA	4.83E-02	4.39E-02	4.32E-02	2.63E-02	NA	1.97E-02
4,4'-DDE	1.44	0.016	0.014	0.014	0.009	NA	0.006	NA	2.30E-02	2.02E-02	2.02E-02	1.30E-02	NA	8.64E-03
4,4'-DDT	0.94	0.005	0.004	0.004	0.003	NA	0.002	NA	4.72E-03	3.78E-03	3.78E-03	2.45E-03	NA	1.89E-03
Total chlordane	1.11	0.054	0.052	0.052	0.042	0.036	0.037	NA	5.97E-02	5.75E-02	5.75E-02	4.64E-02	3.98E-02	4.09E-02
Dieldrin	1.38	0.0034	0.0034	0.0034	0.0034	0.0034	0.0034	NA	4.70E-03	4.64E-03	4.70E-03	4.64E-03	4.70E-03	4.70E-03
Methyl mercury	1.17	0.53	0.472	0.464	0.267	0.17	0.186	NA	6.18E-01	5.50E-01	5.41E-01	3.11E-01	1.98E-01	2.17E-01
TEQ PCB-mammals	1.24	0.000005	0.000004	0.000004	0.000002	0.000001	0.000001	NA	6.19E-06	4.95E-06	4.95E-06	2.48E-06	1.24E-06	1.24E-06
TEQ PCB-birds	1.40	0.000080	NA	NA	NA	0.00002	NA	NA	1.12E-04	NA	NA	NA	2.80E-05	NA
TEQ PCB-fish	1.30	0.0000004	NA	NA	NA	0.0000001	NA	NA	5.19E-07	NA	NA	NA	1.30E-07	NA
TEQ D/F-mammals	2.02	0.000022	0.00002	0.00002	0.00001	0.0000066	0.00001	NA	4.44E-05	4.04E-05	4.04E-05	2.02E-05	1.33E-05	2.02E-05
TEQ D/F-birds	2.07	0.000023	NA	NA	NA	0.0000067	NA	NA	4.76E-05	NA	NA	NA	1.39E-05	NA
TEQ D/F-fish	2.06	0.000021	NA	NA	NA	0.0000062	NA	NA	4.32E-05	NA	NA	NA	1.28E-05	NA
Total DDx	1.62	0.04	NA	NA	NA	0.015	NA	NA	6.98E-02	NA	NA	NA	2.44E-02	NA
Lead	1.14	129	NA	NA	NA	60	NA	NA	1.47E+02	NA	NA	NA	6.86E+01	NA
HPAH	1.77	34.5	NA	NA	NA	34.5	NA	NA	6.12E+01	NA	NA	NA	6.12E+01	NA
LPAH	2.99	5.2	NA	NA	NA	5.2	NA	NA	1.56E+01	NA	NA	NA	1.56E+01	NA
Copper	1.09	75	NA	NA	NA	38	NA	NA	8.15E+01	NA	NA	NA	4.13E+01	NA

HR - High resolution
NA - Not applicable because the specific COPC/COPEC was not evaluated in the HHRA or ERA.
RM - River mile
UCL - Upper confidence limit

a. See Table 7-2 for summary of the mean and 95% UCL for sediment data.
b. As determined from the model at year 2018 (the year that remediation is expected to be completed); see Appendix D of the FFS for model output.
c. This is an average concentration derived by averaging the first 6 years (i.e., years 2019-2024) after remediation was completed; used to develop the EPC for the child receptor.
d. This is an average concentration derived by averaging the first 7 years (i.e., years 2019-2025) after remediation is completed; used to develop the noncancer EPC for the adult receptor.
e. This is an average concentration derived by averaging years 7 through 30 (i.e., years 2025-2048) assuming remediation is completed in 2018; used to develop the EPC for the adult receptor.
f. This is the average concentration at year = 2048, 30 years after remediation is completed; used for the ecological EPCs.
g. This is an average concentration derived by averaging the last 7 years in the 30-year period (*i.e.*, years 2042-2048) after remediation is completed; used to develop the noncancer EPC for the adult receptor.
h. Multipliers used to modify the forecast concentrations for the COPCs/COPECs to estimate the average surface concentration over the lower 8 miles of the Lower Passaic River. These factors are not used for the capping and dredging of RM 0-8 scenario.
i. 95% UCL sediment concentration in RM0-8 = the average sediment concentration in RM0-8 multiplied by the ratio of the historical 95% UCL to the historical mean.

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Table 7-6. Summary of 95% UCLs for Fish and Crab for Future Risk Assessments Assuming the Monitored Natural Recovery Scenario.

COPC/COPEC	Future Human Health Biota EPCs[a]										Future Ecological Biota EPCs[a]					
	Year = 2018		6-, 7-, and 24-year Average													
	Fish	Crab	Fish				Crab				Year 2018			Year 2048		
	Adult and Child (ppm)	Adult and Child (ppm)	Child (6 years) (ppm)	Adult (7 years) (ppm)	Adult (24 years) (ppm)	Adult (7 years) 2042-2048 (ppm)	Child (6 years) (ppm)	Adult (7 years) (ppm)	Adult (24 years) (ppm)	Adult (7 years) 2042-2048 (ppm)	Piscivorous Fish	Forage Fish	Blue Crab	Piscivorous Fish	Forage Fish	Blue Crab
Total PCBs	1.23	1.16	1.04E+00	1.01E+00	5.21E-01	3.26E-01	9.80E-01	9.58E-01	4.93E-01	3.08E-01	1.23	2.88E-01	1.16	2.78E-01	6.52E-02	2.63E-01
4,4'-DDD	1.67E-01	7.62E-02	1.46E-01	1.44E-01	8.92E-02	6.49E-02	6.69E-02	6.59E-02	4.08E-02	2.96E-02	NA	NA	NA	NA	NA	NA
4,4'-DDE	2.71E-01	1.50E-01	2.39E-01	2.39E-01	1.46E-01	1.07E-01	1.32E-01	1.32E-01	8.05E-02	5.92E-02	NA	NA	NA	NA	NA	NA
4,4'-DDT	8.39E-03	1.11E-02	7.29E-03	7.34E-03	4.46E-03	3.25E-03	9.61E-03	9.68E-03	5.88E-03	4.29E-03	NA	NA	NA	NA	NA	NA
Total chlordane	1.17	3.18E-02	1.10E+00	1.11E+00	9.10E-01	8.08E-01	3.00E-02	3.02E-02	2.47E-02	2.20E-02	1.17	2.76E-02	3.18E-02	7.80E-01	1.84E-02	2.12E-02
Dieldrin	3.24E-02	1.37E-02	3.23E-02	3.23E-02	3.23E-02	3.24E-02	1.37E-02	1.37E-02	1.37E-02	1.37E-02	3.24E-02	4.54E-03	1.37E-02	3.24E-02	4.54E-03	1.37E-02
Methyl mercury	1.57E-01	4.32E-02	1.38E-01	1.36E-01	8.02E-02	5.60E-02	3.80E-02	3.73E-02	2.21E-02	1.54E-02	1.57E-01	1.91E-02	4.32E-02	5.03E-02	6.11E-03	1.39E-02
TEQ PCB-mammals	1.63E-05	2.34E-05	2.20E-05	2.20E-05	6.59E-06	4.39E-06	3.17E-05	3.17E-05	9.50E-06	6.33E-06	1.63E-05	6.45E-06	2.34E-05	4.39E-06	1.74E-06	6.33E-06
TEQ PCB-birds	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1.78E-04	4.81E-05	2.16E-04	4.53E-05	1.22E-05	5.49E-05
TEQ PCB-fish	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1.14E-06	4.02E-07	1.62E-06	3.81E-07	1.34E-07	5.40E-07
TEQ D/F-mammals	1.87E-04	1.43E-04	1.64E-04	1.52E-04	9.37E-05	5.86E-05	1.25E-04	1.16E-04	7.15E-05	4.47E-05	1.87E-04	9.37E-05	1.43E-04	5.86E-05	2.93E-05	4.47E-05
TEQ D/F-birds	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1.93E-04	8.91E-05	1.63E-04	6.03E-05	2.79E-05	5.09E-05
TEQ D/F-fish	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1.79E-04	8.99E-05	1.36E-04	4.77E-05	2.40E-05	3.62E-05
Total DDx	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	3.57E-01	6.25E-02	2.19E-01	1.26E-01	2.20E-02	7.72E-02
Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	2.84E-01	5.08E-01	3.33E-01	1.31E-01	2.35E-01	1.54E-01
HPAH	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	2.16E-01	1.53E-01	2.72E-01	2.16E-01	1.53E-01	2.72E-01
LPAH	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	3.68E-01	3.12E-01	2.48E-01	3.68E-01	3.12E-01	2.48E-01
Copper	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	5.62	2.33	1.94E+01	2.84	1.18	9.79

[a] The EPC is derived by multiplying the respective 95% UCL sediment concentration in RM 0-8 by the BAF.

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Table 7-7. Summary of 95% UCLs for Fish and Crab for Future Risk Assessments Assuming the Primary Erosional Zone/Primary Inventory Zone Remediation Scenario.

COPC/COPEC	Future Human Health Biota EPCs[a]										Future Ecological Biota EPCs[a]					
	Year = 2018		6-, 7-, and 24-year Average													
	Fish	Crab	Fish				Crab				Year 2018			Year 2048		
	Adult and Child (ppm)	Adult and Child (ppm)	Child (6 years) (ppm)	Adult (7 years) (ppm)	Adult (24 years) (ppm)	Adult (7 years) 2042-2048 (ppm)	Child (6 years) (ppm)	Adult (7 years) (ppm)	Adult (24 years) (ppm)	Adult (7 years) 2042-2048 (ppm)	Piscivorous Fish	Forage Fish	Blue Crab	Piscivorous Fish	Forage Fish	Blue Crab
Total PCBs	1.09	1.03	9.53E-01	9.15E-01	4.65E-01	2.90E-01	9.02E-01	8.66E-01	4.40E-01	2.75E-01	1.09	2.56E-01	1.03	2.49E-01	5.83E-02	2.35E-01
4,4'-DDD	1.44E-01	6.59E-02	1.31E-01	1.26E-01	7.66E-02	5.41E-02	5.97E-02	5.76E-02	3.50E-02	2.47E-02	NA	NA	NA	NA	NA	NA
4,4'-DDE	2.39E-01	1.32E-01	2.13E-01	2.08E-01	1.25E-01	9.36E-02	1.18E-01	1.15E-01	6.90E-02	5.17E-02	NA	NA	NA	NA	NA	NA
4,4'-DDT	7.34E-03	9.68E-03	6.50E-03	6.29E-03	4.20E-03	3.15E-03	8.58E-03	8.30E-03	5.53E-03	4.15E-03	NA	NA	NA	NA	NA	NA
Total chlordane	1.17	3.18E-02	1.13	1.13	9.10E-01	8.01E-01	3.06E-02	3.06E-02	2.47E-02	2.18E-02	1.17	2.76E-02	3.18E-02	7.80E-01	1.84E-02	2.12E-02
Dieldrin	3.00E-02	1.27E-02	3.00E-02	3.00E-02	3.00E-02	3.00E-02	1.27E-02	1.27E-02	1.27E-02	1.27E-02	3.00E-02	4.21E-03	1.27E-02	3.00E-02	4.21E-03	1.27E-02
Methyl mercury	1.39E-01	3.82E-02	1.25E-01	1.23E-01	7.11E-02	4.95E-02	3.45E-02	3.40E-02	1.96E-02	1.36E-02	1.39E-01	1.69E-02	3.82E-02	4.43E-02	5.38E-03	1.22E-02
TEQ PCB-mammals	1.54E-05	2.22E-05	1.32E-05	1.32E-05	6.59E-06	4.39E-06	1.90E-05	1.90E-05	9.50E-06	6.33E-06	1.54E-05	6.10E-06	2.22E-05	4.39E-06	1.74E-06	6.33E-06
TEQ PCB-birds	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1.58E-04	4.28E-05	1.92E-04	3.92E-05	1.06E-05	4.76E-05
TEQ PCB-fish	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1.09E-06	3.82E-07	1.54E-06	1.90E-07	6.70E-08	2.70E-07
TEQ D/F-mammals	1.29E-04	9.83E-05	1.17E-04	1.17E-04	5.86E-05	4.69E-05	8.94E-05	8.94E-05	4.47E-05	3.58E-05	1.29E-04	6.44E-05	9.83E-05	3.52E-05	1.76E-05	2.68E-05
TEQ D/F-birds	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1.33E-04	6.13E-05	1.12E-04	3.62E-05	1.67E-05	3.05E-05
TEQ D/F-fish	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1.19E-04	5.99E-05	9.06E-05	3.57E-05	1.80E-05	2.72E-05
Total DDx	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	3.07E-01	5.37E-02	1.88E-01	1.09E-01	1.90E-02	6.67E-02
Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	2.73E-01	4.87E-01	3.20E-01	1.26E-01	2.25E-01	1.47E-01
HPAH	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	2.16E-01	1.53E-01	2.72E-01	2.16E-01	1.53E-01	2.72E-01
LPAH	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	3.65E-01	3.09E-01	2.46E-01	3.65E-01	3.09E-01	2.46E-01
Copper	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	5.42	2.25	1.87E+01	2.71	1.13	9.34

[a] The EPC is derived by multiplying the respective 95% UCL sediment concentration in RM 0-8 by the BAF.

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Table 7-8. Summary of 95% UCLs for Fish and Crab for Future Risk Assessments Assuming the Area of Focus Remediation Scenario.

COPC/COPEC	Future Human Health Biota EPCs[a]										Future Ecological Biota EPCs[a]					
	Year = 2018		6-, 7-, and 24-year Average													
	Fish	Crab	Fish				Crab				Year 2018			Year 2048		
	Adult and Child (ppm)	Adult and Child (ppm)	Child (6 years) (ppm)	Adult (7 years) (ppm)	Adult (24 years) (ppm)	Adult (7 years) 2042-2048 (ppm)	Child (6 years) (ppm)	Adult (7 years) (ppm)	Adult (24 years) (ppm)	Adult (7 years) 2042-2048 (ppm)	Piscivorous Fish	Forage Fish	Blue Crab	Piscivorous Fish	Forage Fish	Blue Crab
Total PCBs	8.38E-01	7.93E-01	7.28E-01	7.14E-01	3.55E-01	2.22E-01	6.89E-01	6.75E-01	3.36E-01	2.10E-01	8.38E-01	1.96E-01	7.93E-01	1.89E-01	4.44E-02	1.79E-01
4,4'-DDD	5.83E-02	2.66E-02	5.30E-02	5.22E-02	3.18E-02	2.39E-02	2.42E-02	2.39E-02	1.45E-02	1.09E-02	NA	NA	NA	NA	NA	NA
4,4'-DDE	9.79E-02	5.41E-02	8.57E-02	8.57E-02	5.51E-02	3.67E-02	4.74E-02	4.74E-02	3.05E-02	2.03E-02	NA	NA	NA	NA	NA	NA
4,4'-DDT	3.09E-03	4.07E-03	2.47E-03	2.47E-03	1.60E-03	1.23E-03	3.25E-03	3.25E-03	2.11E-03	1.63E-03	NA	NA	NA	NA	NA	NA
Total chlordane	1.17	3.18E-02	1.13	1.13	9.10E-01	8.01E-01	3.06E-02	3.06E-02	2.47E-02	2.18E-02	1.17	2.76E-02	3.18E-02	7.80E-01	1.84E-02	2.12E-02
Dieldrin	7.48E-03	3.17E-03	7.39E-03	7.48E-03	7.39E-03	7.48E-03	3.13E-03	3.17E-03	3.13E-03	3.17E-03	7.48E-03	1.05E-03	3.17E-03	7.48E-03	1.05E-03	3.17E-03
Methyl mercury	6.28E-02	1.73E-02	5.59E-02	5.50E-02	3.16E-02	2.20E-02	1.54E-02	1.51E-02	8.71E-03	6.06E-03	6.28E-02	7.62E-03	1.73E-02	2.01E-02	2.44E-03	5.54E-03
TEQ PCB-mammals	1.10E-05	1.58E-05	8.79E-06	8.79E-06	4.39E-06	2.20E-06	1.27E-05	1.27E-05	6.33E-06	3.17E-06	1.10E-05	4.36E-06	1.58E-05	2.20E-06	8.71E-07	3.17E-06
TEQ PCB-birds	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1.21E-04	3.26E-05	1.46E-04	3.02E-05	8.14E-06	3.66E-05
TEQ PCB-fish	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	7.62E-07	2.68E-07	1.08E-06	1.90E-07	6.70E-08	2.70E-07
TEQ D/F-mammals	8.89E-06	6.78E-06	8.08E-06	8.08E-06	4.04E-06	4.04E-06	6.16E-06	6.16E-06	3.08E-06	3.08E-06	8.89E-06	4.44E-06	6.78E-06	2.67E-06	1.33E-06	2.03E-06
TEQ D/F-birds	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	9.56E-06	4.42E-06	8.08E-06	2.78E-06	1.29E-06	2.35E-06
TEQ D/F-fish	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	8.63E-06	4.34E-06	6.56E-06	2.55E-06	1.28E-06	1.94E-06
Total DDx	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1.27E-01	2.23E-02	7.81E-02	4.43E-02	7.76E-03	2.72E-02
Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1.78E-01	3.18E-01	2.09E-01	8.28E-02	1.48E-01	9.72E-02
HPAH	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1.55E-01	1.09E-01	1.94E-01	1.55E-01	1.09E-01	1.94E-01
LPAH	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1.72E-01	1.46E-01	1.16E-01	1.72E-01	1.46E-01	1.16E-01
Copper	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	3.30	1.37	1.14E+01	1.67	6.96E-01	5.77

[a] The EPC is derived by multiplying the respective 95% UCL sediment concentration in RM 0-8 by the BAF.

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8.0 REMEDIAL ALTERNATIVES FUTURE RISK ASSESSMENT

This section describes the results of a quantitative risk assessment performed to (1) assess the relative magnitude of risk associated with the Lower Passaic River in the future; (2) assess the relative reduction in risk afforded by the remedial scenarios compared to current risks; and (3) compare the relative reduction of risk associated with each of the three remediation scenarios. The objective of the risk assessment is to assess the overall protection of human health and the environment considering a "no action", or monitored natural recovery, approach versus remediation of contaminated sediment to address requirements in NCP Section 300.430(e)(9)(iii). The remedial action objectives and the remedial alternatives identified for the site have been summarized in the text of the FFS. The results of the future risk assessment will be used to assist risk management decisions regarding the selection of a remedial action. Note that the goal of the alternative risk assessment is to provide estimates of relative risk reduction that incorporate considerable professional judgment and uncertainty. As with the current risk assessment provided in Sections 5.0 and 6.0, this future risk assessment is consistent with USEPA guidance, guidelines, and policies and the application of these procedures is designed to reduce potential uncertainty and ensure consistency. However, a qualitative evaluation is provided in this section (Section 8.3) to address uncertainties associated with the estimates of risk/hazard.

8.1 Comparison of Human Health Risk Reduction by Remediation Scenario

The process of evaluating remedial alternatives for human health uses the same set of COPCs and the same risk assessment methodology, including potential exposure scenarios and most assumptions, presented in the current risk evaluation described in Section 5.0. Unlike the current risk assessment, the future risk assessment assumes declining concentrations of the COPCs over time (as discussed below). Results from the current risk assessment are then used to assess the relative risk reduction afforded by each of the remediation scenarios. In addition, the relative risk reduction among the three remediation scenarios is examined.

Consumption of fish and crab is the primary exposure pathway for the Lower Passaic River and is the only one evaluated in this remedial alternative risk assessment, as discussed in Section 4.0. For purposes of comparing relative risk reductions, carcinogenic risks and noncarcinogenic health hazards are estimated only for the reasonably maximally exposed individual and only for the adult and child angler/sportsman. For carcinogenic risk, a 30-year exposure period is evaluated, assuming 24 years as an adult and 6 years as a child to depict a scenario resulting in the most health protective calculations of cancer risks. For noncarcinogens, both a child receptor (age 0-6 years) and an adult receptor (assuming a 7-year exposure period[3]) are evaluated to depict scenarios resulting in the most health-protective noncancer health hazards. To take into account the declining concentrations over time, the adult receptor is evaluated for two time periods for noncarcinogenic exposure: (1) the first 7 years post-remediation (*i.e.*, 2019-2025) to represent a RME, and (2) the last 7-year period (*i.e.*, 2042-2048) is used to represent conditions 30 years post-remediation. Based on body weight and other considerations, the child receptor

[3] The assessment of monitored natural recovery indicates that there is a general trend of a projected decline in concentrations of contaminants in fish tissue over time. Due to this decline, the average concentration over longer exposure durations is less than the average concentrations over a shorter time period. As a result of the decline in concentrations, chronic exposures are greatest during the initial exposure period (*i.e.*, 2019 to 2025) when compared to later timeframes (*i.e.*, 2041 to 2048). Relying on an analysis of the entire time period, or the 95% UCL on the mean for the entire exposure duration (*i.e.*, 24 years for the adult and 6 years for the child or a total of 30 years as assumed in the cancer assessment) would result in a potential underestimation of non-cancer health hazards. To address this issue, separate calculations are provided for the chronic exposure period of 7 years after the remediation and for the last 7 year period evaluated (*i.e.*, 2041 to 2048). These bounding estimates provide an indication of the non-cancer health hazards directly after the remediation and at the end of the modeled period.

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results in the largest noncancer HI. However, the HI for the adult may be more heavily relied upon because datasets supporting the adult ingestion rate for fish (USEPA, 1997b) and, to a lesser extent, crab (Burger, 2002) were used in this assessment, whereas the child ingestion rate was derived by assuming a percentage of the adult rate (refer to Section 5.1.4.2). Note, however, that derivation of the child ingestion rate (*i.e.*, derived from the adult ingestion rate based on relative body weight) is consistent with the assessment provided in the EFH (USEPA, 1997b). Therefore, only the adult receptor is evaluated for the 2042-2048 time period to assist risk management decisions regarding the selection of a remedial action. The health hazard for the adult may be more heavily relied upon for risk management decisions because datasets supporting the ingestion rates are available for an adult, but not a child receptor.

Future chemical concentrations in fish and crab were estimated from an empirical mass balance model using current sediment data, as discussed in Section 7.0. Future EPCs for each of the remediation scenarios are summarized in Tables 7-6 through 7-8. Results of the risk evaluation performed for each remediation scenario are summarized by COPC in Tables 8-1 through 8-4. Tables 8-5 and 8-6 summarize total risks and hazards, respectively, by remediation scenario. Attachment 7 provides the detailed risk calculations. Results of the risk assessment are discussed below.

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Table 8-1. Summary of Risks/Hazards for an Adult – Ingestion of Fish.

COPC	Adult – Fish														
	Monitored Natural Recovery					Primary Erosional Zone/Primary Inventory Zone					Area of Focus				
	2018		2019- 2048	2019-2025	2042-2048	2018		2019- 2048	2019-2025	2042-2048	2018		2019- 2048	2019-2025	2042-2048
	Risk	Hazard	Risk	Hazard	Hazard	Risk	Hazard	Risk	Hazard	Hazard	Risk	Hazard	Risk	Hazard	Hazard
TCDD TEQ (D/F)	3.44E-03	ND	1.72E-03	ND	ND	2.37E-03	ND	1.08E-03	ND	ND	1.63E-04	ND	7.42E-05	ND	ND
TCDD TEQ (PCBs)[a]	2.99E-04	ND	1.21E-04	ND	ND	2.82E-04	ND	1.21E-04	ND	ND	2.02E-04	ND	8.07E-05	ND	ND
Total PCBs[a]	3.01E-04	2.19E+01	1.28E-04	1.81E+01	5.82E+00	2.68E-04	1.95E+01	1.14E-04	1.63E+01	5.18E+00	2.05E-04	1.50E+01	8.70E-05	1.25E+01	3.97E+00
4,4'-DDD	4.90E-06	ND	2.62E-06	ND	ND	4.24E-06	ND	2.25E-06	ND	ND	1.71E-06	ND	9.35E-07	ND	ND
4,4'-DDE	1.13E-05	ND	6.06E-06	ND	ND	9.96E-06	ND	5.20E-06	ND	ND	4.08E-06	ND	2.29E-06	ND	ND
4,4'-DDT	3.49E-07	5.99E-03	1.86E-07	5.24E-03	2.32E-03	3.06E-07	5.24E-03	1.75E-07	4.50E-03	2.25E-03	1.28E-07	2.20E-03	6.65E-08	1.76E-03	8.81E-04
Total chlordane	5.01E-05	8.35E-01	3.90E-05	7.93E-01	5.77E-01	5.01E-05	8.35E-01	3.90E-05	8.04E-01	5.72E-01	5.01E-05	8.35E-01	3.90E-05	8.04E-01	5.72E-01
Dieldrin[b]	6.34E-05	2.31E-01	6.32E-05	2.31E-01	2.31E-01	5.89E-05	2.15E-01	5.89E-05	2.15E-01	2.15E-01	1.47E-05	5.35E-02	1.45E-05	5.35E-02	5.35E-02
Methyl mercury	ND	5.61E-01	ND	4.84E-01	2.00E-01	ND	4.96E-01	ND	4.41E-01	1.77E-01	ND	2.24E-01	ND	1.96E-01	7.87E-02
Total	4.17E-03	2.36E+01	2.08E-03	1.96E+01	6.83E+00	3.04E-03	2.11E+01	1.42E-03	1.78E+01	6.15E+00	6.41E-04	1.61E+01	2.99E-04	1.36E+01	4.67E+00

ND – not determined because toxicity values are not available for this exposure route.
[a.] There is a concern for the potential to double-count PCB concentrations and PCB risk when both dioxin-like PCB congener data and total PCB (as Aroclor) data are used to determine risk, particularly with those risks then being added together.
Therefore, select PCB data were reviewed to address this concern. The results of the PCB enhancement assessment is presented in Attachment 4.
[b.] Predicted future concentrations do not appreciably decline over the 30 years; slight differences in risk/hazard values are due to rounding.

Table 8-2. Summary of Risks/Hazards for a Child – Ingestion of Fish.

COPC	Child - Fish											
	Monitored Natural Recovery				Primary Erosional Zone/ Primary Inventory Zone				Area of Focus			
	2018		2019-2048	2019-2024	2018		2019-2048	2019-2024	2018		2019-2048	2019-2024
	Risk	Hazard	Risk	Hazard	Risk	Hazard	Risk	Hazard	Risk	Hazard	Risk	Hazard
TCDD TEQ (D/F)	1.34E-03	ND	1.17E-03	ND	9.21E-04	ND	8.37E-04	ND	6.35E-05	ND	5.77E-05	ND
TCDD TEQ (PCBs)	1.16E-04	ND	1.57E-04	ND	1.10E-04	ND	9.41E-05	ND	7.85E-05	ND	6.28E-05	ND
Total PCBs	1.17E-04	3.41E+01	9.87E-05	2.88E+01	1.04E-04	3.03E+01	9.08E-05	2.65E+01	7.98E-05	2.33E+01	6.94E-05	2.02E+01
4,4'-DDD	1.91E-06	ND	1.67E-06	ND	1.65E-06	ND	1.49E-06	ND	6.66E-07	ND	6.06E-07	ND
4,4'-DDE	4.38E-06	ND	3.87E-06	ND	3.87E-06	ND	3.45E-06	ND	1.59E-06	ND	1.39E-06	ND
4,4'-DDT	1.36E-07	9.32E-03	1.18E-07	8.10E-03	1.19E-07	8.16E-03	1.05E-07	7.23E-03	5.00E-08	3.43E-03	4.00E-08	2.74E-03
Total chlordane	1.95E-05	1.30E+00	1.84E-05	1.23E+00	1.95E-05	1.30E+00	1.88E-05	1.25E+00	1.95E-05	1.30E+00	1.88E-05	1.25E+00
Dieldrin[a]	2.47E-05	3.60E-01	2.46E-05	3.59E-01	2.29E-05	3.34E-01	2.29E-05	3.34E-01	5.70E-06	8.32E-02	5.63E-06	8.21E-02
Methyl mercury	ND	8.73E-01	ND	7.67E-01	ND	7.72E-01	ND	6.97E-01	ND	3.49E-01	ND	3.11E-01
Total	1.62E-03	3.67E+01	1.48E-03	3.11E+01	1.18E-03	3.28E+01	1.07E-03	2.88E+01	2.49E-04	2.50E+01	2.16E-04	2.19E+01

ND – not determined because toxicity values are not available for this exposure route.
[a.] Predicted future concentrations do not appreciably decline over the 30 years; slight differences in risk/hazard values are due to rounding.

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Table 8-3. Summary of Risks/Hazards for an Adult – Ingestion of Crab.

COPC	Adult - Crab														
	Monitored Natural Recovery					Primary Erosional Zone/Primary Inventory Zone					Area of Focus				
	2018		2019- 2048	2019-2025	2042-2048	2018		2019- 2048	2019-2025	2042-2048	2018		2019- 2048	2019-2025	2042-2048
	Risk	Hazard	Risk	Hazard	Hazard	Risk	Hazard	Risk	Hazard	Hazard	Risk	Hazard	Risk	Hazard	Hazard
TCDD TEQ (D/F)	2.42E-03	ND	1.21E-03	ND	ND	1.66E-03	ND	7.55E-04	ND	ND	1.15E-04	ND	5.21E-05	ND	ND
TCDD TEQ (PCBs)[a]	3.96E-04	ND	1.61E-04	ND	ND	3.75E-04	ND	1.61E-04	ND	ND	2.68E-04	ND	1.07E-04	ND	ND
Total PCBs[a]	2.62E-04	1.91E+01	1.11E-04	1.57E+01	5.06E+00	2.33E-04	1.70E+01	9.91E-05	1.42E+01	4.51E+00	1.79E-04	1.30E+01	7.57E-05	1.09E+01	3.45E+00
4,4'-DDD	2.06E-06	ND	1.10E-06	ND	ND	1.78E-06	ND	9.46E-07	ND	ND	7.20E-07	ND	3.93E-07	ND	ND
4,4'-DDE	5.73E-06	ND	3.08E-06	ND	ND	5.07E-06	ND	2.64E-06	ND	ND	2.07E-06	ND	1.17E-06	ND	ND
4,4'-DDT	4.24E-07	7.27E-03	2.25E-07	6.36E-03	2.82E-03	3.71E-07	6.36E-03	2.12E-07	5.45E-03	2.73E-03	1.56E-07	2.67E-03	8.07E-08	2.14E-03	1.07E-03
Total chlordane	1.25E-06	2.09E-02	9.75E-07	1.98E-02	1.44E-02	1.25E-06	2.09E-02	9.75E-07	2.01E-02	1.43E-02	1.25E-06	2.09E-02	9.75E-07	2.01E-02	1.43E-02
Dieldrin[b]	2.47E-05	9.00E-02	2.46E-05	8.98E-02	9.00E-02	2.29E-05	8.36E-02	2.29E-05	8.36E-02	8.36E-02	5.71E-06	2.08E-02	5.64E-06	2.08E-02	2.08E-02
Methyl mercury	ND	1.42E-01	ND	1.23E-01	5.06E-02	ND	1.26E-01	ND	1.12E-01	4.48E-02	ND	5.68E-02	ND	4.97E-02	1.99E-02
Total	3.11E-03	1.94E+01	1.51E-03	1.60E+01	5.22E+00	2.30E-03	1.72E+01	1.04E-03	1.44E+01	4.66E+00	5.71E-04	1.31E+01	2.43E-04	1.10E+01	3.51E+00

ND – not determined because toxicity values are not available for this exposure route.
[a.] There is a concern for the potential to double-count PCB concentrations and PCB risk when both dioxin-like PCB congener data and total PCB (as Aroclor) data are used to determine risk, particularly with those risks then being added together.
Therefore, select PCB data were reviewed to address this concern. The results of the PCB enhancement assessment is presented in Attachment 4
[b.] Predicted future concentrations do not appreciably decline over the 30 years; slight differences in risk/hazard values are due to rounding.

Table 8-4. Summary of Risks/Hazards for a Child – Ingestion of Crab.

COPC	Child - Crab											
	Monitored Natural Recovery				Primary Erosional Zone/ Primary Inventory Zone				Area of Focus			
	2018		2019-2048	2019-2024	2018		2019-2048	2019-2024	2018		2019-2048	2019-2024
	Risk	Hazard	Risk	Hazard	Risk	Hazard	Risk	Hazard	Risk	Hazard	Risk	Hazard
TCDD TEQ (D/F)	9.81E-04	ND	8.58E-04	ND	6.74E-04	ND	6.13E-04	ND	4.65E-05	ND	4.23E-05	ND
TCDD TEQ (PCBs)	1.61E-04	ND	2.17E-04	ND	1.52E-04	ND	1.30E-04	ND	1.09E-04	ND	8.69E-05	ND
Total PCBs	1.06E-04	3.10E+01	8.96E-05	2.61E+01	9.45E-05	2.76E+01	8.25E-05	2.41E+01	7.25E-05	2.11E+01	6.30E-05	1.84E+01
4,4'-DDD	8.36E-07	ND	7.34E-07	ND	7.23E-07	ND	6.55E-07	ND	2.92E-07	ND	2.66E-07	ND
4,4'-DDE	2.32E-06	ND	2.06E-06	ND	2.06E-06	ND	1.83E-06	ND	8.42E-07	ND	7.36E-07	ND
4,4'-DDT	1.72E-07	1.18E-02	1.49E-07	1.03E-02	1.51E-07	1.03E-02	1.33E-07	9.15E-03	6.32E-08	4.34E-03	5.06E-08	3.47E-03
Total chlordane	5.09E-07	3.39E-02	4.80E-07	3.20E-02	5.09E-07	3.39E-02	4.90E-07	3.27E-02	5.09E-07	3.39E-02	4.90E-07	3.27E-02
Dieldrin[a]	1.00E-05	1.46E-01	9.99E-06	1.46E-01	9.30E-06	1.36E-01	9.30E-06	1.36E-01	2.32E-06	3.38E-02	2.29E-06	3.34E-02
Methyl mercury	ND	2.31E-01	ND	2.03E-01	ND	2.04E-01	ND	1.84E-01	ND	9.22E-02	ND	8.21E-02
Total	1.26E-03	3.14E+01	1.18E-03	2.65E+01	9.33E-04	2.79E+01	8.38E-04	2.44E+01	2.32E-04	2.13E+01	1.96E-04	1.85E+01

ND – not determined because toxicity values are not available for this exposure route.
[a.] Predicted future concentrations do not appreciably decline over the 30 years; slight differences in risk/hazard values are due to rounding.

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Table 8-5. Summary of Future Cancer Risk Associated with the Remediation Scenarios for Fish and Crab Consumption.

	Remediation Scenario[a]	Time Period[b]	Adult Risk	Child Risk	Adult + Child Combined Risk
Fish	Monitored Natural Recovery	2018	4.E-03	2.E-03	6.E-03
		2019-2048	2.E-03	1.E-03	4.E-03
	Primary Erosional Zone/Primary Inventory Zone	2018	3.E-03	1.E-03	4.E-03
		2019-2048	1.E-03	1.E-03	2.E-03
	Area of Focus	2018	6.E-04	2.E-04	9.E-04
		2019-2048	3.E-04	2.E-04	5.E-04
	Current[c]	2007	7.E-03	3.E-03	1.E-02
Crab	**Remediation Scenario[a]**	**Time Period[b]**	**Adult Risk**	**Child Risk**	**Adult + Child Combined Risk**
	Monitored Natural Recovery	2018	3.E-03	1.E-03	4.E-03
		2019-2048	2.E-03	1.E-03	3.E-03
	Primary Erosional Zone/Primary Inventory Zone	2018	2.E-03	9.E-04	3.E-03
		2019-2048	1.E-03	8.E-04	2.E-03
	Area of Focus	2018	6.E-04	2.E-04	8.E-04
		2019-2048	2.E-04	2.E-04	4.E-04
	Current[c]	2007	1.E-02	5.E-03	2.E-02

Note that the risks are presented in this table at one significant figure.

a. The remediation scenarios represent future exposures.

b. The time period 2018 represents the year remediation is expected to be complete and the predicted average annual concentrations at 2018 are used as the EPCs. For 2019-2048, the predicted average annual concentrations derived from years 2019 through 2048 are used to derive an average concentration over the total exposure duration of 30 years *(i.e.*, 6 years as a child and 24 years as an adult). Thus, a 6-year average of the average annual sediment concentrations is used for the child, and a 24-year average of the average annual sediment concentrations is used to represent the adult for cancer exposure only.

c. The current scenario is assumed to represent the risks in 2007, before remediation is initiated and prior to accounting for natural degradation (*e.g.*, monitored natural recovery). Current risk represents the RME as described in Section 5.3.1 and provided in Attachment 4, Tables 4-16 and 4-18.

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Table 8-6. Summary of Future Non-cancer Health Hazards Associated with the Remediation Scenarios for Fish and Crab Consumption.

	Remediation Scenario[a]	Time Period[b]	Adult Hazard	Child Hazard
Fish	Monitored Natural Recovery	2018	24	37
		2019-2025	20	31
		2042-2048	6.8	ND
	Primary Erosional Zone/Primary Inventory Zone	2018	21	33
		2019-2025	18	29
		2042-2048	6.1	ND
	Area of Focus	2018	16	25
		2019-2025	14	22
		2042-2048	4.7	ND
	Current[c]	2007	64	99
Crab	**Remediation Scenario[a]**	**Time Period[b]**	**Adult Hazard**	**Child Hazard**
	Monitored Natural Recovery	2018	19	31
		2019-2025	16	27
		2042-2048	5.2	ND
	Primary Erosional Zone/Primary Inventory Zone	2018	17	28
		2019-2025	14	24
		2042-2048	4.7	ND
	Area of Focus	2018	13	21
		2019-2025	11	19
		2042-2048	3.5	ND
	Current[c]	2007	86	140

ND – not determined. Only the adult receptor is evaluated for non-cancer health hazards for the 2042-2048 time period to assist risk management decisions regarding the selection of a remedial action. The health hazard for the adult, rather than the child, may be more heavily relied upon for risk management decisions because datasets supporting the ingestion rates are available for an adult, but not a child receptor.

Note that the hazard values are presented in this table at one significant figure.

a. The remediation scenarios represent future exposures.

b. The time period 2018 represents the year remediation is expected to be complete and the predicted average annual concentrations at 2018 were used as the EPCs. For 2019-2025, the predicted average annual concentrations derived for the years 2019 through 2024 and 2019 through 2025 are used to derive the EPCs for the child and the adult receptors, respectively. Allowing the intake to be averaged over a 24-year period of time would underestimate the RME risk to the adult; therefore, only a 7-year exposure duration, as opposed to a 24-year exposure duration is assumed for the adult for noncarcinogenic exposures. The first 7 years post-remediation is used to derive an EPC assumed to be representative of the RME for the adult, while the last 7-year period (throughout the 30 years of exposure) is used to represent more likely conditions 30 years post-remediation.

c. The current scenario is assumed to represent the health hazards in 2007, before remediation is initiated and prior to accounting for natural degradation (*e.g.*, monitored natural recovery). The current health hazards represent the RME as described in Section 5.3.1 and provided in Attachment 4, Tables 4-16 and 4-18.

8.1.1 Monitored Natural Recovery

Monitored natural recovery relies on naturally occurring processes to contain, destroy, or reduce the bioavailability or toxicity of contaminants in sediments. The naturally occurring processes may include

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physical processes (sedimentation, advection, diffusion, dilution, dispersion, bioturbation, or volatilization), biological processes (biodegradation, biotransformation, phytoremediation, or biological stabilization), and chemical processes (sorption or oxidation/reduction reactions). For purposes of estimating risk/hazard for this remedial scenario, it is assumed that some of these naturally occurring processes are occurring in the Lower Passaic River to some extent, and that concentrations would be expected to decline based only on these processes. It is assumed that State fish consumption advisories will be used to limit exposure (*i.e.*, limiting number of meals) as the concentrations of COPCs in sediment and fish continue to decline following remedial action.

As shown in Table 8-5, under the monitored natural recovery remediation scenario, the calculated total cancer risks for ingestion of fish are 6×10^{-3} for the year remediation is complete (*i.e.*, 2018) and 4×10^{-3} for the 30-year exposure duration (*i.e.*, 2019-2048). For ingestion of crab, the calculated total cancer risks are 4×10^{-3} and 3×10^{-3} for the years 2018 and 2019-2048, respectively. TCDD TEQ (D/F), TCDD TEQ (PCBs), and total PCBs are the primary contributors to both the total fish and crab risks above 10^{-3}, with individual cancer risks above 10^{-4} (Tables 8-1 through 8-4). Total cancer risks for the monitored natural recovery scenario continue to be above the NCP risk range of 10^{-4} and 10^{-6} (USEPA, 1990) more than 30 years into the future. As identified in the current risk assessment (Section 5.0), there is concern for the potential to double-count PCB concentrations and PCB risk when both dioxin-like PCB congener data and total PCB (as Aroclor) data are used to determine risk, particularly with those risks then being added together. Based on the way risks to PCBs was assessed, the total cancer risk may be somewhat overestimated. The uncertainty associated with PCB risk is further addressed in Section 8.3.

The noncancer HIs are summarized in Table 8-6 for fish and crab consumption. For ingestion of fish, the HIs for the child and adult receptors are 37 and 24, respectively, at 2018. These HIs will be expected to decrease to 31 and 20, respectively, over the next 6 to 7 years (2019-2025). For ingestion of crab, the HIs for the child and adult are 31 and 19, respectively, at 2018, and are estimated to decrease to 27 and 16, respectively, within the first 7-year period. Total PCBs are the primary contributor to the excess hazard for both ingestion of fish and crab (Tables 8-1 through 8-4). Total HIs for the adult are predicted to decrease more than 3-fold after 30 years as shown in Table 8-6 for the years 2042-2048 for both ingestion of fish and crab, but after 30 years, the future noncarcinogenic HIs for ingestion of crab and fish are predicted to be 5 to 7 times higher than the criterion of 1.

8.1.2 Primary Erosional Zone/Primary Inventory Zone

As discussed in the FFS, it is assumed that the primary erosional zone remedial scenario would control a one-mile stretch of river (between RM 0 and RM 8) where there is the greatest potential for erosion. The primary inventory zone remedial scenario would control a one-mile stretch of river (between RM 0 and RM 8) where there is the greatest inventory of contaminants. Both scenarios would thereby reduce the contaminant contribution load over time. It is assumed that State fish consumption advisories will be used to limit exposure (*i.e.*, limiting number of meals) as the concentrations of COPCs in sediment and fish continue to decline following remedial action.

As shown in Table 8-5, under the primary erosional zone/primary inventory zone remediation scenario, the calculated total cancer risks for ingestion of fish are 4×10^{-3} for the year remediation is complete (*i.e.*, 2018) and 2×10^{-3} 30 years after the remedial action is completed (*i.e.*, 2048). For ingestion of crab, the calculated total cancer risks are 3×10^{-3} and 2×10^{-3} for the years 2018 and by 2048, respectively. TCDD TEQ (D/F), TCDD TEQ (PCBs), and total PCBs are the primary contributors to both the total fish and crab risks above 10^{-3}, with individual cancer risks above 10^{-4} (Tables 8-1 through 8-4). Total cancer risks for the primary erosional zone/primary inventory zone scenario continue to be above the NCP risk range of 10^{-4} and 10^{-6} (USEPA, 1990) 30 years following remediation. As identified in the current risk assessment (Section 5.0), there is a concern for the potential to double-count PCB concentrations and

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PCB risk when both dioxin-like PCB congener data and total PCB (as Aroclor) data are used to determine risk, particularly with those risks then being added together. Based on the way risks to PCBs was assessed, the total cancer risk may be somewhat overestimated. The uncertainty associated with PCB risk is further addressed in Section 8.3.

The noncancer HIs are summarized in Table 8-6 for fish and crab consumption. For ingestion of fish, the HI for a child is 33 at 2018, which decreases to 29 by 2024; the HI for the adult receptor is 21 at 2018, 18 at 7 years post-remediation, and 6 by 2048. For ingestion of crab, the HI for a child is 28 at 2018, which decreases 7 years later to 24. For the ingestion of crab for the adult receptor, the HI at 2018 is 17, which reduces to 14 over the next 7 years, and by 2048 is estimated to be 5. Total PCBs are the primary contributor to the excess hazard for both ingestion of fish and crab (Tables 8-1 through 8-4). After 30 years post-remediation, the total HIs for the adult are predicted to be 5 to 6-fold higher than the criterion of 1 for ingestion of crab and fish.

8.1.3 Area of Focus

The area of focus remedial scenario entails the physical isolation or immobilization of contaminated sediments throughout the entire 8-mile stretch of the Lower Passaic River without treatment, for example, by an engineering cap, by dredging, or a combination of both. This alternative would isolate contaminated sediments (via capping) or remove them (via dredging), thus limiting the potential exposure and mobility of contaminants in the sediments. It is assumed that State fish consumption advisories will be used to limit exposure (*i.e.*, limiting number of meals) as the concentrations of COPCs in sediment and fish continue to decline following remedial action.

As shown in Table 8-5, under the area of focus remediation scenario, the calculated total cancer risks for ingestion of fish are 9×10^{-4} for the year remediation is complete (*i.e.*, 2018) and 5×10^{-4} for the 30-year exposure duration (*i.e.*, 2048). For ingestion of crab, the calculated total cancer risks are 8×10^{-4} and 4×10^{-4} for the years 2018 and by 2048, respectively. TCDD TEQ (D/F), TCDD TEQ (PCBs), and total PCBs are the primary contributors to both the total fish and crab risks above 10^{-4}, with individual cancer risks above 10^{-4}, at least for risks calculated for 2018 (Tables 8-1 through 8-4). However, risks for the dioxins, TCDD TEQ (PCBs), and total PCBs are estimated to be at the upper end of the NCP risk range 30 years following remedation (*i.e.*, by 2048). Total cancer risks for the area of focus scenario achieve a 10^{-4} risk level 30 years following remediation. As identified in the current risk assessment (Section 5.0), there is a concern for the potential to double-count PCB concentrations and PCB risk when both dioxin-like PCB congener data and total PCB (as Aroclor) data are used to determine risk, particularly with those risks then being added together. Based on the way risks to PCBs was assessed, the total cancer risk may be somewhat overestimated. The uncertainty associated with PCB risk is further addressed in Section 8.3.

The noncancer HIs are summarized in Table 8-6 for fish and crab consumption. For ingestion of fish, the HI for a child is 25 at 2018, which decreases to 22 by 2024; the HI for the adult receptor is 16 at 2018, 14 by 2025, and 5 by 2048. For ingestion of crab, the HI for a child is 21 at 2018, which decreases to 19 by 2024. For the ingestion of crab for the adult receptor, the HI at 2018 is 13, which reduces to 11 over the next 7 years. By 2048, the HI for the adult is more likely to be around 5. Total PCBs are the primary contributor to the excess hazard for both ingestion of fish and crab (Tables 8-1 through 8-4). Total HIs for the adult are predicted to be only 4 to 5 times higher than the criterion of 1 for ingestion of crab and fish 30 years following remediation.

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8.1.4 Alternative Risk Reduction Comparisons

8.1.1.1 Comparison to Current Risks

The relative reductions in cancer risks and non-cancer health hazards attributed to each remediation scenario compared to the estimated current risks/hazards are shown in Tables 8-7 and 8-8, respectively.

As shown on Tables 8-7 and 8-8, the greater reduction in risks/hazards is observed for the area of focus remediation scenario. For consumption of fish, the relative reduction in risk (Table 8-6a) is greatest for the area of focus remediation scenario, with risk declining 95% by 2048. The relative reduction in risk for the primary erosional zone/primary inventory zone scenario is 75% by 2048. For the monitored natural recovery scenario, the relative risk reduction after 40 years is estimated to be only 64%. For noncancer health hazards (Table 8-8), the greatest reduction in hazard is observed for the area of focus scenario at 2048, at approximately 92% by 2048.

Table 8-7. Summary of Relative Cancer Risk Reductions[a] for Each Future Remediation Scenario Compared to Risks Estimated for the Current Scenario.

Fish Consumption	Time Period[b]	Adult + Child Combined Risk
Monitored Natural Recovery	2018	42%
	2019-2048	64%
Primary Erosional Zone/ Primary Inventory Zone	2018	58%
	2019-2048	75%
Area of Focus	2018	91%
	2019-2048	95%
Crab Consumption	**Time Period[b]**	**Adult + Child Combined Risk**
Monitored Natural Recovery	2018	78%
	2019-2048	87%
Primary Erosional Zone/ Primary Inventory Zone	2018	84%
	2019-2048	91%
Area of Focus	2018	96%
	2019-2048	98%

a. See Table 8-5 for estimated total current and total future risks for each remediation scenario. Relative risk reduction is based on a comparison to current risks.

b. The time period 2018 represents the year remediation is expected to be complete and the predicted average annual concentrations at 2018 were used as the EPCs. For 2019-2048, the predicted average annual concentrations derived from years 2019 through 2048 were used to derive an average concentration over the total exposure duration of 30 years *(i.e.,* 6 years as a child and 24 years as an adult). Thus, a 6-year average of the average annual sediment concentrations was used for the child, and a 24-year average of the average annual sediment concentrations was used to represent the adult for cancer exposure only.

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Table 8-8. Summary of Relative Noncancer Health Hazard Reductions[a] for Each Future Remediation Scenario Compared to Hazards Estimated for the Current Scenario.

Fish Consumption	Time Period[b]	Adult Hazard	Child Hazard
Monitored Natural Recovery	2018	63%	63%
	2019-2025	69%	69%
	2042-2048	89%	ND
Primary Erosional Zone/ Primary Inventory Zone	2018	67%	67%
	2019-2025	72%	71%
	2042-2048	91%	ND
Area of Focus	2018	75%	75%
	2019-2025	79%	78%
	2042-2048	92%	ND
Crab Consumption	**Time Period[b]**	**Adult Hazard**	**Child Hazard**
Monitored Natural Recovery	2018	77%	78%
	2019-2025	81%	81%
	2042-2048	94%	ND
Primary Erosional Zone/ Primary Inventory Zone	2018	80%	80%
	2019-2025	83%	83%
	2042-2048	94%	ND
Area of Focus	2018	85%	85%
	2019-2025	87%	87%
	2042-2048	95%	ND

ND – not determined. Only the adult receptor is evaluated for non-cancer health hazard for the 2042-2048 time period to assist risk management decisions regarding the selection of a remedial action. The health hazard for the adult, rather than the child, may be more heavily relied upon for risk management decisions because datasets supporting the ingestion rates are available for an adult, but not a child receptor.

[a.] See Table 8-6 for estimated total current and total future hazards for each remediation scenario. Relative reduction in health hazard is based on a comparison to current hazards.

[b.] The time period 2018 represents the year remediation is expected to be complete and the predicted average annual concentrations at 2018 were used as the EPCs. For 2019-2025, the predicted average annual concentrations derived for the years 2019 through 2024 and 2019 through 2025 were used to derive the EPCs for the child and the adult receptors, respectively. Allowing the intake to be averaged over a 24-year period of time would underestimate the RME hazard to the adult; therefore, only a 7-year exposure duration, as opposed to a 24-year exposure duration was assumed for the adult for noncarcinogenic exposures. The first 7 years post-remediation is used to derive an EPC assumed to be representative of the RME for the adult, while the last 7-year period (throughout the 30 years of exposure) is used to represent more likely conditions 30 years post-remediation.

Total PCBs are the primary driver for excess noncancer health hazard. This predicted excess hazard is most likely the result of the continuing contribution of PCBs from sources not included in the scope of the remediation (*e.g.*, above Dundee Dam).

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8.1.1.2 Comparison Among Remediation Scenarios

The primary erosional zone/primary inventory zone and area of focus remediation scenarios were compared against the monitored natural recovery scenario to determine which scenario offered the greater relative risk reductions. Figure 8-1 illustrates the relative reductions in risk/hazard. Compared to monitored natural recovery, the relative reductions in risk associated with ingestion of fish and crab range from about 30% for the primary erosional zone/primary inventory zone scenario up to 90% for the area of focus scenario. For the noncancer hazards during the first 7 years after remediation (*i.e.*, 2019-2025), the relative reductions for the primary erosional zone/primary inventory zone scenario and area of focus scenario range from about 10% to 30%, respectively, compared to monitored natural recovery for consumption of both fish and crab (adult and child). Relative reductions in hazard for the adult and child receptors are virtually identical (see Table 8-8). The contribution of contaminants in sediments from outside sources (*i.e.*, sources that are not included in the scope of the remediation) or from sediments not included in the particular remediation scenario may explain why the relative reductions in 2048 are less than those observed in 2018.

8.2 Comparison of Ecological Risk Reduction by Remediation Scenario

The ecological risk analysis of remedial alternatives generally followed the same approach used in the human health assessment, described in Section 8.1. The same set of COPECs, exposure factors, and toxicity benchmarks that were used to assess current ecological risks (see Section 6.0) were also employed to estimate potential future hazards associated with each remedial alternatives being considered. Results from the assessment of current conditions were then used to evaluate the relative reduction in hazards associated with each alternative to aid in decision-making. In addition, the relative reduction in hazards among the three remediation scenarios was evaluated.

Consistent with the assessment of current conditions, three broad ecological receptor categories were evaluated: macroinvertebrates, fish, and aquatic-dependent wildlife. The specific species and measurement endpoint tools employed were as follows:

- *Macroinvertebrates* (including both benthic and epibenthic organisms) – comparison of predicted sediment EPCs to sediment benchmarks. For the blue crab - comparison of predicted biota tissue EPCs to CBRs.
- *Fish* (AE/WP and mummichog) – comparison of predicted biota tissue EPCs to CBRs.
- *Aquatic-dependent wildlife* (mink and great blue heron) – comparison of estimated daily dose levels to TRVs. For wildlife, exposure pathways included consumption of contaminated prey and incidental ingestion of sediment. The diet of these two piscivorous species was assumed to be represented by the predicted AE/WP EPCs; for the heron, a second exposure scenario using futurecast mummichog EPCs was also evaluated.

Ecological risks are estimated for two future time points: immediately following the completion of the remedial actions (year 2018) and 30 years thereafter (year 2048). Where possible, the estimated hazards are bounded by presenting estimates based both on NOAEL- and LOAEL-based toxicity values. Results of the ERA were evaluated in the context of available information on the relative magnitude of anticipated spatial variability among the various COPECs.

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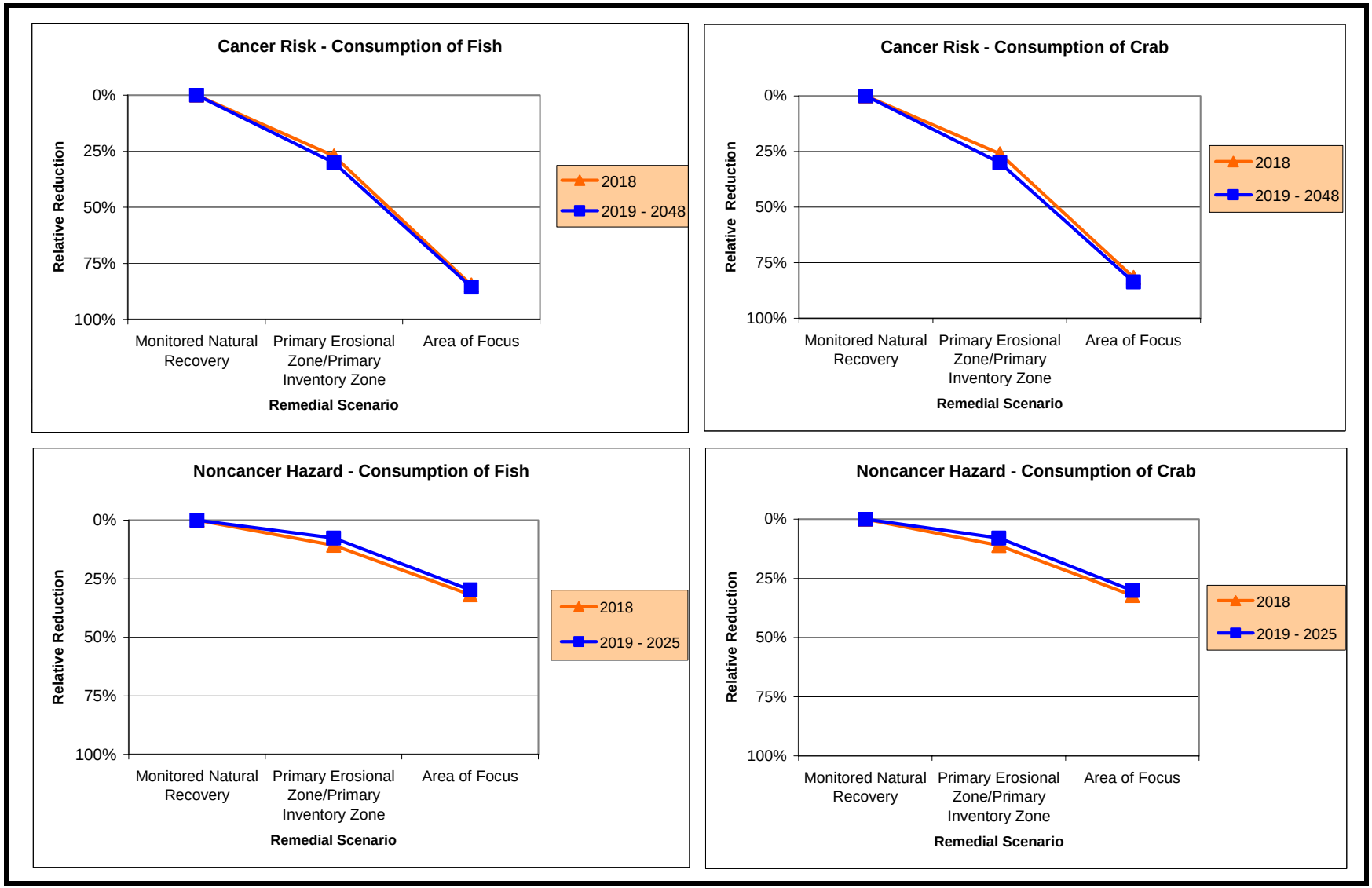

Figure 8-1. Relative Risk Reduction Comparison Among Future Actions.

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Information supporting the assessment of future ecological risks is included in Attachment 8. Tables 8-1 through 8-6 of Attachment 8 compare future sediment EPCs for each remediation scenario to sediment benchmarks. Tables 8-7 through 8-12 of Attachment 8, Tables 8-13 through 8-18 of Attachment 8, and Tables 8-19 through 8-24 of Attachment 8 compare future tissue EPCs to CBRs for blue crab, AE/WP, and mummichog, respectively. Results of the wildlife dose modeling calculations are provided as well.

Figures 8-1 through 8-5 of Attachment 8 show the results of the above receptor/endpoint assessment for sediment benchmarks, white perch and American eel/CBR, mummichog/CBR, mink/dose model, and heron/dose model. HIs, along with contaminant class HIs, are presented for current conditions and for each remediation scenario.

Future chemical concentrations in biota were estimated from an empirical mass balance model using current sediment data, as discussed in Section 7.0. Future EPCs for the monitored natural recovery, primary erosional zone/primary inventory zone, and area of focus scenarios are summarized in Tables 7-3 through 7-5 of this appendix, respectively. Results of the risk assessment performed for each remediation scenario are summarized in Tables 8-9 through 8-14 below. Attachment 8 provides the detailed calculations used in the analysis. Results of the predictive ERA are discussed in the following section.

8.2.1 Monitored Natural Recovery

Macroinvertebrates. The estimated futurecast hazard estimates for macroinvertebrates based on the sediment benchmark and crab CBR endpoints are presented in Tables 8-9 and 8-10, respectively. The year 2018 HI for the sediment benchmark endpoint exceeds 1,000 (1,600) and the overall hazard estimate is anticipated to decrease by less than 20% by year 2048 (HI = 1,300). Dieldrin accounts for greater than 60% of the HI in year 2018, increasing its contribution to over 75% by 2048[4]. The year 2018 HQs for total DDx and TCDD TEQ (D/F) are both substantial as well (120 and 280, respectively).

NOAEL- and LOAEL-based HIs for the blue crab CBR endpoint in year 2018 are 2,400 and 250, respectively, decreasing to 810 and 84 by year 2048 (Table 8-10). Under both time scenarios, the major contributors to the HIs are total DDx, TCDD TEQ (D/F), and copper.

Fish. The estimated futurecast hazard estimates for fish based on the CBR endpoints are presented in Tables 8-11 and 8-12 (AE/WP and mummichog). NOAEL- and LOAEL-based HIs for the AE/WP CBR endpoint in year 2018 are 13,000 and 550, respectively, decreasing to 4,800 and 230 by year 2048 (Table 8-11). Under both time scenarios, the major contributors to the HIs are total DDx, copper, and total Aroclor. Total DDx and copper account for greater than 90% of the year 2018 NOAEL-based HI (71% and 22%, respectively).

NOAEL- and LOAEL-based HIs for the mummichog CBR endpoint in year 2018 are 2,900 and 170, respectively, decreasing to 1,200 and 76 by year 2048 (Table 8-12). Although projected hazards to mummichog are lower than those based on the AE/WP analysis, the primary contributors to the risk estimates are the same.

Wildlife. The estimated futurecast hazard estimates for wildlife based on dose modeling are presented in Tables 8-13 and 8-14 (mink and heron). NOAEL- and LOAEL-based HIs for the mink in year 2018 are 810 and 34, respectively decreasing to 250 and 11 by year 2048 (Table 8-13). TCDD TEQ (D/F) accounts for between 80% and 90% of the overall HI estimates. TCDD TEQ (PCBs) is the only other substantial contribution to the mink hazard estimates, accounting for up to 8% of the HI.

[4] As presented in Appendix D, concentrations of dieldrin, along with PAHs, are assumed to remain constant in Lower Passaic River sediment in the future. Consequently, the significance of these contaminants as ecological risk drivers increases with time as the relative role of other COPECs diminishes due to reduced loadings.

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Table 8-9. Summary of Hazards for Benthic Macroinvertebrates – Sediment Benchmarks.

COPEC	Monitored Natural Recovery		Primary Erosional Zone/Primary Inventory Zone		Area of Focus	
	Year = 2018	Year = 2048	Year = 2018	Year = 2048	Year = 2018	Year = 2048
Copper	**4.1E+00**	**2.1E+00**	**3.9E+00**	**2.0E+00**	**2.4E+00**	**1.2E+00**
Lead	**5.0E+00**	**2.3E+00**	**4.8E+00**	**2.2E+00**	**3.2E+00**	**1.5E+00**
Mercury	**1.0E+01**	**3.3E+00**	**9.1E+00**	**2.9E+00**	**4.1E+00**	**1.3E+00**
Mercury (methyl)	**1.0E+01**	**3.3E+00**	**9.1E+00**	**2.9E+00**	**4.1E+00**	**1.3E+00**
LPAHs	**6.0E+01**	**6.0E+01**	**6.0E+01**	**6.0E+01**	**2.8E+01**	**2.8E+01**
HPAHs	**5.0E+01**	**5.0E+01**	**5.0E+01**	**5.0E+01**	**3.6E+01**	**3.6E+01**
Aroclor, Total	**2.5E+01**	**5.7E+00**	**2.2E+01**	**5.1E+00**	**1.7E+01**	**3.9E+00**
Dieldrin	**1.0E+03**	**1.0E+03**	**9.4E+02**	**9.4E+02**	**2.3E+02**	**2.3E+02**
Total DDx	**1.2E+02**	**4.4E+01**	**1.1E+02**	**3.8E+01**	**4.4E+01**	**1.5E+01**
TCDD TEQ (D/F)	**2.8E+02**	**7.5E+01**	**1.9E+02**	**5.6E+01**	**1.3E+01**	**4.0E+00**
TCDD TEQ (PCBs)	2.5E-01	8.2E-02	2.3E-01	4.1E-02	1.6E-01	4.1E-02
Total TCDD TEQ	**2.8E+02**	**7.5E+01**	**1.9E+02**	**5.6E+01**	**1.3E+01**	**4.1E+00**
Total	**1.6E+03**	**1.3E+03**	**1.4E+03**	**1.2E+03**	**3.8E+02**	**3.3E+02**

Table 8-10. Summary of Hazards for Blue Crab – Critical Body Residues.

COPEC	Monitored Natural Recovery				Primary Erosional Zone/Primary Inventory Zone				Area of Focus			
	Year = 2018		Year = 2048		Year = 2018		Year = 2048		Year = 2018		Year = 2048	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
Copper	**2.3E+02**	**2.3E+01**	**1.1E+02**	**1.1E+01**	**2.2E+02**	**2.2E+01**	**1.1E+02**	**1.1E+01**	**1.3E+02**	**1.3E+01**	**6.7E+01**	**6.7E+00**
Lead	6.4E-01	6.4E-02	3.0E-01	3.0E-02	6.1E-01	6.1E-02	2.8E-01	2.8E-02	4.0E-01	4.0E-02	1.9E-01	1.9E-02
Mercury	**4.6E+00**	4.6E-01	**1.5E+00**	1.5E-01	**4.0E+00**	4.0E-01	**1.3E+00**	1.3E-01	**1.8E+00**	1.8E-01	5.8E-01	5.8E-02
Mercury (methyl)	**4.6E+00**	4.6E-01	**1.5E+00**	1.5E-01	**4.0E+00**	4.0E-01	**1.3E+00**	1.3E-01	**1.8E+00**	1.8E-01	5.8E-01	5.8E-02
LPAHs	**1.1E+01**	**1.1E+00**	**1.1E+01**	**1.1E+00**	**1.1E+01**	**1.1E+00**	**1.1E+01**	**1.1E+00**	**5.3E+00**	5.3E-01	**5.3E+00**	5.3E-01
HPAHs	**1.2E+01**	**1.2E+00**	**1.2E+01**	**1.2E+00**	**1.2E+01**	**1.2E+00**	**1.2E+01**	**1.2E+00**	**8.8E+00**	8.8E-01	**8.8E+00**	8.8E-01
Aroclor, Total	**2.8E+00**	**1.1E+00**	6.3E-01	2.4E-01	**2.5E+00**	9.4E-01	5.6E-01	2.1E-01	**1.9E+00**	7.2E-01	4.3E-01	1.6E-01
Dieldrin	**1.4E+00**	1.7E-01	**1.4E+00**	1.7E-01	**1.3E+00**	1.6E-01	**1.3E+00**	1.6E-01	3.2E-01	4.0E-02	3.2E-01	4.0E-02
Total DDx	**1.2E+03**	**1.2E+02**	**4.2E+02**	**4.2E+01**	**1.0E+03**	**1.0E+02**	**3.6E+02**	**3.6E+01**	**4.2E+02**	**4.2E+01**	**1.5E+02**	**1.5E+01**
TCDD TEQ (D/F)	**9.1E+02**	**1.0E+02**	**2.4E+02**	**2.8E+01**	**6.0E+02**	**7.0E+01**	**1.8E+02**	**2.1E+01**	**4.2E+01**	**4.8E+00**	**1.3E+01**	**1.5E+00**
TCDD TEQ (PCBs)	**1.1E+01**	**1.2E+00**	**3.6E+00**	4.2E-01	**1.0E+01**	**1.2E+00**	**1.8E+00**	2.1E-01	**7.2E+00**	8.3E-01	**1.8E+00**	2.1E-01
Total TCDD TEQ	**9.2E+02**	**1.1E+02**	**2.5E+02**	**2.8E+01**	**6.1E+02**	**7.1E+01**	**1.8E+02**	**2.1E+01**	**4.9E+01**	**5.6E+00**	**1.5E+01**	**1.7E+00**
Total	**2.4E+03**	**2.5E+02**	**8.1E+02**	**8.4E+01**	**1.9E+03**	**2.0E+02**	**6.8E+02**	**7.1E+01**	**6.2E+02**	**6.4E+01**	**2.5E+02**	**2.5E+01**

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Table 8-11. Summary of Hazards for White Perch/American Eel – Critical Body Residues.

COPEC	Monitored Natural Recovery				Primary Erosional Zone/Primary Inventory Zone				Area of Focus			
	Year = 2018		Year = 2048		Year = 2018		Year = 2048		Year = 2018		Year = 2048	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
Copper	**2.8E+03**	**2.8E+02**	**1.4E+03**	**1.4E+02**	**2.7E+03**	**2.7E+02**	**1.4E+03**	**1.4E+02**	**1.7E+03**	**1.7E+02**	**8.4E+02**	**8.4E+01**
Lead	**1.0E+01**	**1.0E+00**	**4.7E+00**	4.7E-01	**9.8E+00**	9.8E-01	**4.5E+00**	4.5E-01	**6.4E+00**	6.4E-01	**3.0E+00**	3.0E-01
Mercury	**2.6E+01**	**2.6E+00**	**8.4E+00**	8.4E-01	**2.3E+01**	**2.3E+00**	**7.4E+00**	7.4E-01	**1.0E+01**	**1.0E+00**	**3.4E+00**	3.4E-01
Mercury (methyl)	**2.6E+01**	**2.6E+00**	**8.4E+00**	8.4E-01	**2.3E+01**	**2.3E+00**	**7.4E+00**	7.4E-01	**1.0E+01**	**1.0E+00**	**3.4E+00**	3.4E-01
LPAHs	**1.8E+00**	1.8E-01	**1.8E+00**	1.8E-01	**1.7E+00**	1.7E-01	**1.7E+00**	1.7E-01	8.2E-01	8.2E-02	8.2E-01	8.2E-02
HPAHs	**1.0E+00**	1.0E-01	**1.0E+00**	1.0E-01	**1.0E+00**	1.0E-01	**1.0E+00**	1.0E-01	7.4E-01	7.4E-02	7.4E-01	7.4E-02
Aroclor, Total	**4.9E+02**	**4.9E+01**	**1.1E+02**	**1.1E+01**	**4.4E+02**	**4.4E+01**	**9.9E+01**	**9.9E+00**	**3.4E+02**	**3.4E+01**	**7.6E+01**	**7.6E+00**
Dieldrin	**2.9E+00**	2.9E-01	**2.9E+00**	2.9E-01	**2.7E+00**	2.7E-01	**2.7E+00**	2.7E-01	6.8E-01	6.8E-02	6.8E-01	6.8E-02
Total DDx	**9.2E+03**	**2.0E+02**	**3.2E+03**	**7.0E+01**	**7.9E+03**	**1.7E+02**	**2.8E+03**	**6.0E+01**	**3.3E+03**	**7.1E+01**	**1.1E+03**	**2.5E+01**
TCDD TEQ (D/F)	**5.3E+00**	**3.1E+00**	**1.4E+00**	8.2E-01	**3.5E+00**	**2.1E+00**	**1.1E+00**	6.2E-01	2.4E-01	1.4E-01	7.5E-02	4.4E-02
TCDD TEQ (PCBs)	3.4E-02	2.0E-02	1.1E-02	6.6E-03	3.2E-02	1.9E-02	5.6E-03	3.3E-03	2.2E-02	1.3E-02	5.6E-03	3.3E-03
Total TCDD TEQ	**5.3E+00**	**3.1E+00**	**1.4E+00**	8.3E-01	**3.5E+00**	**2.1E+00**	**1.1E+00**	6.2E-01	2.6E-01	1.5E-01	8.1E-02	4.7E-02
Total	**1.3E+04**	**5.5E+02**	**4.8E+03**	**2.3E+02**	**1.1E+04**	**5.0E+02**	**4.3E+03**	**2.1E+02**	**5.3E+03**	**2.8E+02**	**2.1E+03**	**1.2E+02**

Table 8-12. Summary of Hazards for Mummichog – Critical Body Residues .

COPEC	Monitored Natural Recovery				Primary Erosional Zone/Primary Inventory Zone				Area of Focus			
	Year = 2018		Year = 2048		Year = 2018		Year = 2048		Year = 2018		Year = 2048	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
Copper	**1.2E+03**	**1.2E+02**	**5.9E+02**	**5.9E+01**	**1.1E+03**	**1.1E+02**	**5.6E+02**	**5.6E+01**	**6.9E+02**	**6.9E+01**	**3.5E+02**	**3.5E+01**
Lead	**1.8E+01**	**1.8E+00**	**8.5E+00**	8.5E-01	**1.8E+01**	**1.8E+00**	**8.1E+00**	8.1E-01	**1.1E+01**	**1.1E+00**	**5.3E+00**	5.3E-01
Mercury	**3.2E+00**	3.2E-01	**1.0E+00**	1.0E-01	**2.8E+00**	2.8E-01	9.0E-01	9.0E-02	**1.3E+00**	1.3E-01	4.1E-01	4.1E-02
Mercury (methyl)	**3.2E+00**	3.2E-01	**1.0E+00**	1.0E-01	**2.8E+00**	2.8E-01	9.0E-01	9.0E-02	**1.3E+00**	1.3E-01	4.1E-01	4.1E-02
LPAHs	**1.5E+00**	1.5E-01	**1.5E+00**	1.5E-01	**1.5E+00**	1.5E-01	**1.5E+00**	1.5E-01	6.9E-01	6.9E-02	6.9E-01	6.9E-02
HPAHs	7.3E-01	7.3E-02	7.3E-01	7.3E-02	7.3E-01	7.3E-02	7.3E-01	7.3E-02	5.2E-01	5.2E-02	5.2E-01	5.2E-02
Aroclor, Total	**1.2E+02**	**1.2E+01**	**2.6E+01**	**2.6E+00**	**1.0E+02**	**1.0E+01**	**2.3E+01**	**2.3E+00**	**7.9E+01**	**7.9E+00**	**1.8E+01**	**1.8E+00**
Dieldrin	4.1E-01	4.1E-02	4.1E-01	4.1E-02	3.8E-01	3.8E-02	3.8E-01	3.8E-02	9.5E-02	9.5E-03	9.5E-02	9.5E-03
Total DDx	**1.6E+03**	**3.5E+01**	**5.7E+02**	**1.2E+01**	**1.4E+03**	**3.0E+01**	**4.9E+02**	**1.1E+01**	**5.7E+02**	**1.2E+01**	**2.0E+02**	**4.3E+00**
TCDD TEQ (D/F)	**2.6E+00**	**1.6E+00**	7.1E-01	4.1E-01	**1.8E+00**	**1.0E+00**	5.3E-01	3.1E-01	1.2E-01	7.1E-02	3.8E-02	2.2E-02
TCDD TEQ (PCBs)	1.2E-02	6.9E-03	3.9E-03	2.3E-03	1.1E-02	6.6E-03	2.0E-03	1.2E-03	7.9E-03	4.6E-03	2.0E-03	1.2E-03
Total TCDD TEQ	**2.7E+00**	**1.6E+00**	7.1E-01	4.2E-01	**1.8E+00**	**1.0E+00**	5.3E-01	3.1E-01	1.3E-01	7.6E-02	4.0E-02	2.3E-02
Total	**2.9E+03**	**1.7E+02**	**1.2E+03**	**7.6E+01**	**2.7E+03**	**1.6E+02**	**1.1E+03**	**7.1E+01**	**1.4E+03**	**9.1E+01**	**5.7E+02**	**4.2E+01**

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Table 8-13. Summary of Hazards for Mink – Ingestion of Fish and Sediment.

COPEC	Monitored Natural Recovery				Primary Erosional Zone/Primary Inventory Zone				Area of Focus			
	Year = 2018		Year = 2048		Year = 2018		Year = 2048		Year = 2018		Year = 2048	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
Copper	6.0E-01	3.6E-01	3.0E-01	1.8E-01	5.8E-01	3.5E-01	2.9E-01	1.7E-01	3.5E-01	2.1E-01	1.8E-01	1.1E-01
Lead	3.2E-01	1.7E-01	1.5E-01	7.8E-02	3.1E-01	1.6E-01	1.4E-01	7.5E-02	2.0E-01	1.1E-01	9.3E-02	4.9E-02
Mercury	9.0E-01	2.8E-01	2.9E-01	8.9E-02	8.0E-01	2.4E-01	2.6E-01	7.8E-02	3.6E-01	1.1E-01	1.2E-01	3.5E-02
LPAHs	-	-	-	-	-	-	-	-	-	-	-	-
HPAHs	5.8E-01	5.8E-02	5.8E-01	5.8E-02	5.8E-01	5.8E-02	5.8E-01	5.8E-02	4.2E-01	4.2E-02	4.2E-01	4.2E-02
Aroclor, Total	**4.6E+00**	**3.8E+00**	**1.0E+00**	8.7E-01	**4.1E+00**	**3.4E+00**	9.3E-01	7.8E-01	**3.1E+00**	**2.6E+00**	7.1E-01	5.9E-01
Dieldrin	5.8E-01	2.9E-01	5.8E-01	2.9E-01	5.4E-01	2.7E-01	5.4E-01	2.7E-01	1.3E-01	6.7E-02	1.3E-01	6.7E-02
Total DDx	1.3E-01	2.5E-02	4.4E-02	8.8E-03	1.1E-01	2.2E-02	3.8E-02	7.6E-03	4.5E-02	8.9E-03	1.6E-02	3.1E-03
TCDD TEQ (D/F)	**7.4E+02**	**2.7E+01**	**2.3E+02**	**8.3E+00**	**5.1E+02**	**1.8E+01**	**1.4E+02**	**5.0E+00**	**3.2E+01**	**1.1E+00**	**1.1E+01**	3.8E-01
TCDD TEQ (PCBs)	**6.4E+01**	**2.3E+00**	**1.8E+01**	6.5E-01	**6.4E+01**	**2.3E+00**	**1.8E+01**	6.5E-01	**4.5E+01**	**1.6E+00**	**9.1E+00**	3.2E-01
Total TCDD TEQ	**8.1E+02**	**2.9E+01**	**2.5E+02**	**8.9E+00**	**5.7E+02**	**2.1E+01**	**1.6E+02**	**5.6E+00**	**7.7E+01**	**2.8E+00**	**2.0E+01**	7.0E-01
Total	**8.1E+02**	**3.4E+01**	**2.5E+02**	**1.1E+01**	**5.8E+02**	**2.5E+01**	**1.6E+02**	**7.1E+00**	**8.2E+01**	**5.9E+00**	**2.1E+01**	**1.6E+00**

Table 8-14. Summary of Hazards for Great Blue Heron – Ingestion of Fish and Sediment.

COPEC	Monitored Natural Recovery				Primary Erosional Zone/Primary Inventory Zone				Area of Focus			
	Year = 2018		Year = 2048		Year = 2018		Year = 2048		Year = 2018		Year = 2048	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
Copper	3.7E-01	1.2E-01	1.9E-01	6.3E-02	3.6E-01	1.2E-01	1.8E-01	6.0E-02	2.2E-01	7.3E-02	1.1E-01	3.7E-02
Lead	7.6E-01	3.8E-01	3.5E-01	1.8E-01	7.3E-01	3.6E-01	3.4E-01	1.7E-01	4.8E-01	2.4E-01	2.2E-01	1.1E-01
Mercury	**2.9E+00**	2.9E-01	9.2E-01	9.2E-02	**2.5E+00**	2.5E-01	8.1E-01	8.1E-02	**1.1E+00**	1.1E-01	3.7E-01	3.7E-02
LPAHs	-	-	-	-	-	-	-	-	-	-	-	-
HPAHs	-	-	-	-	-	-	-	-	-	-	-	-
Aroclor, Total	**1.3E+00**	3.2E-01	2.9E-01	7.3E-02	**1.1E+00**	2.9E-01	2.6E-01	6.5E-02	8.7E-01	2.2E-01	2.0E-01	4.9E-02
Dieldrin	4.4E-02	8.3E-04	4.4E-02	8.3E-04	4.1E-02	7.7E-04	4.1E-02	7.7E-04	1.0E-02	1.9E-04	1.0E-02	1.9E-04
Total DDx	**1.3E+01**	**1.3E+00**	**4.5E+00**	4.5E-01	**1.1E+01**	**1.1E+00**	**3.9E+00**	3.9E-01	**4.5E+00**	4.5E-01	**1.6E+00**	1.6E-01
TCDD TEQ (D/F)	**1.7E+01**	**1.7E+00**	**5.4E+00**	5.4E-01	**1.2E+01**	**1.2E+00**	**3.3E+00**	3.3E-01	7.5E-01	7.5E-02	2.5E-01	2.5E-02
TCDD TEQ (PCBs)	**1.4E+01**	**1.4E+00**	**3.6E+00**	3.6E-01	**1.3E+01**	**1.3E+00**	**3.1E+00**	3.1E-01	**9.6E+00**	9.6E-01	**2.4E+00**	2.4E-01
Total TCDD TEQ	**3.1E+01**	**3.1E+00**	**9.0E+00**	9.0E-01	**2.4E+01**	**2.4E+00**	**6.4E+00**	6.4E-01	**1.0E+01**	**1.0E+00**	**2.6E+00**	2.6E-01
Total	**5.0E+01**	**5.5E+00**	**1.5E+01**	**1.8E+00**	**4.0E+01**	**4.6E+00**	**1.2E+01**	**1.4E+00**	**1.8E+01**	**2.1E+00**	**5.1E+00**	**6.6E-01**

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NOAEL- and LOAEL-based HIs for the heron in year 2018 are 50 and 5.5, respectively, decreasing to 15 and 1.8 by year 2048 (see Table 8-14). In contrast to the mink, where TCDD TEQ (D/F) accounts for a majority of the projected hazard, total DDx, TCDD TEQ (D/F) and TCDD TEQ (PCBs) all contribute equally to the heron HIs. Together, these three COPECs account for approximately 88% of the HI; by year 2048, these are the only contaminant parameters with HQs exceeding 1 (see Table 8-14).

8.2.2 Primary Erosional Zone/Primary Inventory Zone

Macroinvertebrates. The estimated futurecast hazard estimates for macroinvertebrates based on the sediment benchmark and crab CBR endpoints are presented in Tables 8-9 and 8-10, respectively. The year 2018 HI for the sediment benchmark endpoint is 1,400; 30 years later, the HI has decreased by 14% (year 2048 HI = 1,200). Dieldrin accounts for nearly 70% of the HI in year 2018, increasing its contribution to 78% by 2048. The year 2018 HQs for total DDx and TCDD TEQ (D/F) are both substantial as well (110 and 190, respectively).

NOAEL- and LOAEL-based HIs for the blue crab CBR endpoint in year 2018 are 1,900 and 200, respectively, decreasing to 680 and 71 by year 2048 (see Table 8-10). Under both time scenarios, the major contributors to the HIs are total DDx, TCDD TEQ (D/F), and copper.

Fish. The estimated futurecast hazard estimates for fish based on the CBR endpoints are presented in Tables 8-11 and 8-12 (AE/WP and mummichog). NOAEL- and LOAEL-based HIs for the AE/WP CBR endpoint in year 2018 are 11,000 and 500, respectively, decreasing to 4,300 and 210 by year 2048 (see Table 8-11). Under both time scenarios, the major contributors to the HIs are total DDx, copper, and total Aroclor. Total DDx and copper account for greater than 95% of the year 2018 NOAEL-based HI (72% and 25%, respectively).

NOAEL- and LOAEL-based HIs for the mummichog CBR endpoint in year 2018 are 2,700 and 160, respectively, decreasing to 1,100 and 71 by year 2048 (see Table 8-12). The primary hazard contributors to the mummichog and AE/WP analyses are identical (*i.e.*, total DDx, copper, and total Aroclor).

Wildlife. The estimated futurecast hazard estimates for wildlife based on dose modeling are presented in Tables 8-13 and 8-14 (mink and heron). NOAEL- and LOAEL-based HIs for the mink in year 2018 are 580 and 25, respectively, decreasing to 160 and 71 by year 2048 (see Table 8-13). TCDD TEQ (D/F) accounts for between 70% and 90% of the overall HI estimates. TCDD TEQ (PCBs) is the only other substantial contribution to the mink hazard estimates, accounting for up to 11% of the HI. Ninety-nine percent of the overall NOAEL-based HI in year 2018 is accounted for by the total TCDD TEQ.

NOAEL- and LOAEL-based HIs for the heron in year 2018 are 40 and 4.6, respectively, decreasing to 12 and 1.4 by year 2048 (see Table 8-14). In contrast to the mink, where TCDD TEQ (D/F) accounts for a majority of the projected hazard, total DDx, TCDD TEQ (D/F), and TCDD TEQ (PCBs) all contribute equally to the heron HIs. Together, these three COPECs account for greater than 85% of the HI; by year 2048, these are the only contaminant parameters with HQs exceeding 1 (see Table 8-14).

8.2.3 Area of Focus

Macroinvertebrates. The estimated futurecast hazard estimates for macroinvertebrates based on the sediment benchmark and crab CBR endpoints are presented in Tables 8-9 and 8-10, respectively. The year 2018 HI for the sediment benchmark endpoint is 380; 30 years later, the HI has decreased by 13% (year 2048 HI = 330). Dieldrin accounts for approximately 60% of the HI in year 2018, increasing its contribution to 70% by 2048. The year 2018 HQs for total DDx, LPAH, and HPAH are substantial as well (44, 28, and 36, respectively).

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NOAEL- and LOAEL-based HIs for the blue crab CBR endpoint in year 2018 are 620 and 64, respectively, decreasing to 250 and 25 by year 2048 (see Table 8-10). Under both time scenarios, the major contributors to the HIs are total DDx and copper; the significance of TCDD TEQ (D/F) in contributing to the HI is less relative to the other two remediation scenarios.

Fish. The estimated futurecast hazard estimates for fish based on the CBR endpoints are presented in Tables 8-11 and 8-12 (AE/WP and mummichog). NOAEL- and LOAEL-based HIs for the AE/WP CBR endpoint in year 2018 are 5,300 and 280, respectively, decreasing to 2,100 and 120 by year 2048 (see Table 8-11). Under both time scenarios, the major contributors to the HIs are total DDx, copper, and total Aroclor. Total DDx and copper account for 92% of the year 2048 NOAEL-based HI (52% and 40%, respectively).

NOAEL- and LOAEL-based HIs for the mummichog CBR endpoint in year 2018 are 1,400 and 91, respectively, decreasing to 570 and 42 by year 2048 (see Table 8-12). The primary hazard contributors to the mummichog and AE/WP analyses are identical (*i.e.*, total DDx, copper, and total Aroclor).

Wildlife. The estimated futurecast hazard estimates for wildlife based on dose modeling are presented in Tables 8-13 and 8-14 (mink and heron, respectively). NOAEL- and LOAEL-based HIs for the mink in year 2018 are 82 and 5.9, respectively, decreasing to 21 and 1.6 by year 2048 (see Table 8-13). Total TCDD TEQ accounts for approximately 95% of the overall HI estimates, with both PCB and D/F congeners contributing substantially to the TEQ estimate.

NOAEL- and LOAEL-based HIs for the heron in year 2018 are 18 and 2.1, respectively, decreasing to 5.1 and 0.66 by year 2048 (see Table 8-14). In contrast to the mink, where TCDD TEQ (D/F) accounts for a majority of the projected hazard, total DDx and TCDD TEQ (PCBs) are the primary contributors to the heron HI under this remedial scenario; by year 2048, these are the only contaminant parameters with HQs exceeding 1 (see Table 8-14).

8.2.4 Alternative Risk Reduction Comparisons

8.2.4.1 Comparison to Current Hazards

Comparisons of estimated future and current ecological hazards for each of the receptor/endpoint combinations evaluated are shown in Figures 8-2 through 8-4. In each figure, a horizontal bar (at an HI of 1.0) is provided to allow the reader to compare the projected results for each remediation scenario with what is generally regarded to be a safe hazard level for ecological receptors. Figures 8-5 and 8-6 present the reduction in hazards[5] to ecological receptors starting with year 2006, based on current estimates.

Figure 8-2 summarizes the HIs based on the sediment benchmark and blue crab CBR endpoints for current conditions and at years 2018 and 2048 for each of the three remedial alternatives. As anticipated, the area of focus remediation scenario provides for the greatest reduction in ecological hazards; furthermore, these benefits are realized earlier than with the other alternatives (Figure 8-5). A comparison of the monitored natural recovery alternative with current conditions for the sediment benchmark endpoint demonstrates that the diminution of hazards attributable to natural processes alone is anticipated to be a slow process. However, in the case of this endpoint, even the area of focus remedial scenario will only affect an approximately order-of-magnitude reduction in hazards relative to current conditions, with an HI of 330 predicted at year 2048 (Figure 8-5).

[5] Values presented in Figures 8-5 and 8-6 are the geometric means of the NOAEL- and LOAEL-based HIs, except in the case of the sediment benchmark endpoint, for which only a single HI was calculated for each scenario/time period combination.

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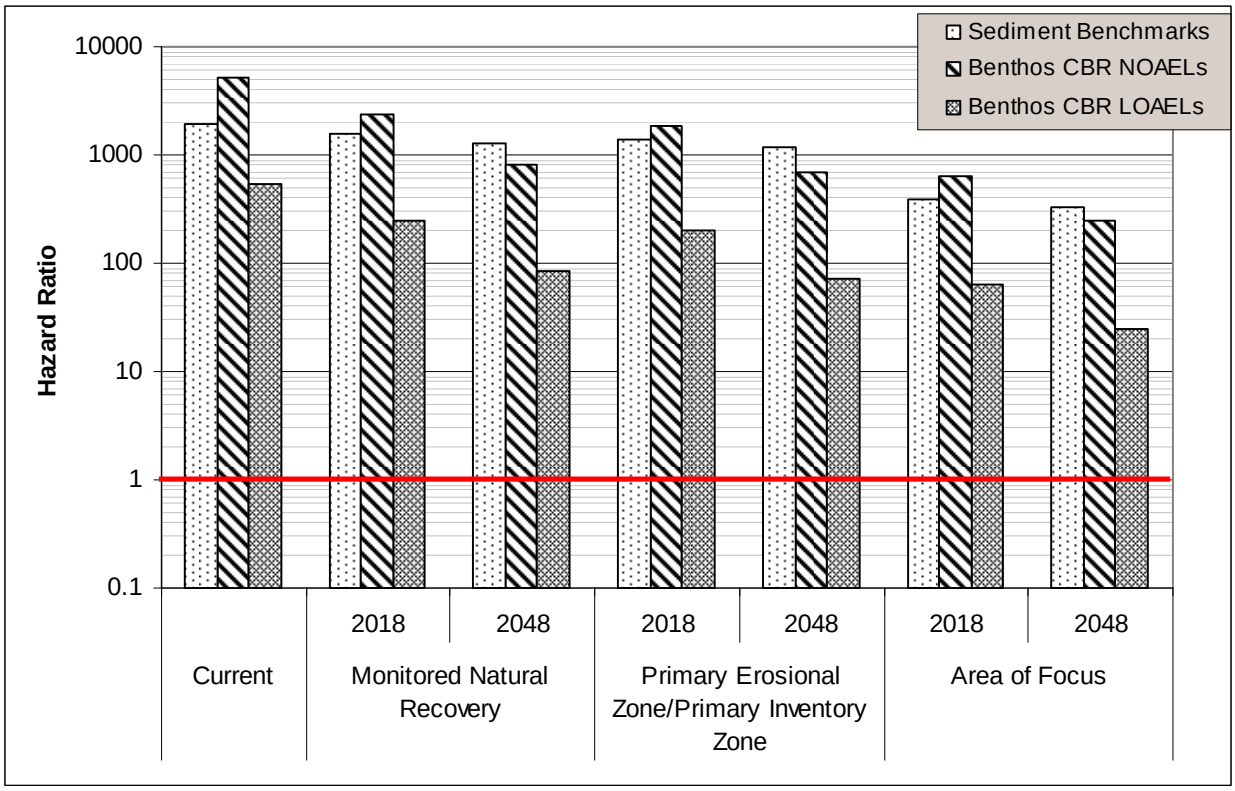

Figure 8-2. Comparison of Current and Future Hazards for Each Remediation Scenario Based on Sediment Benchmarks.

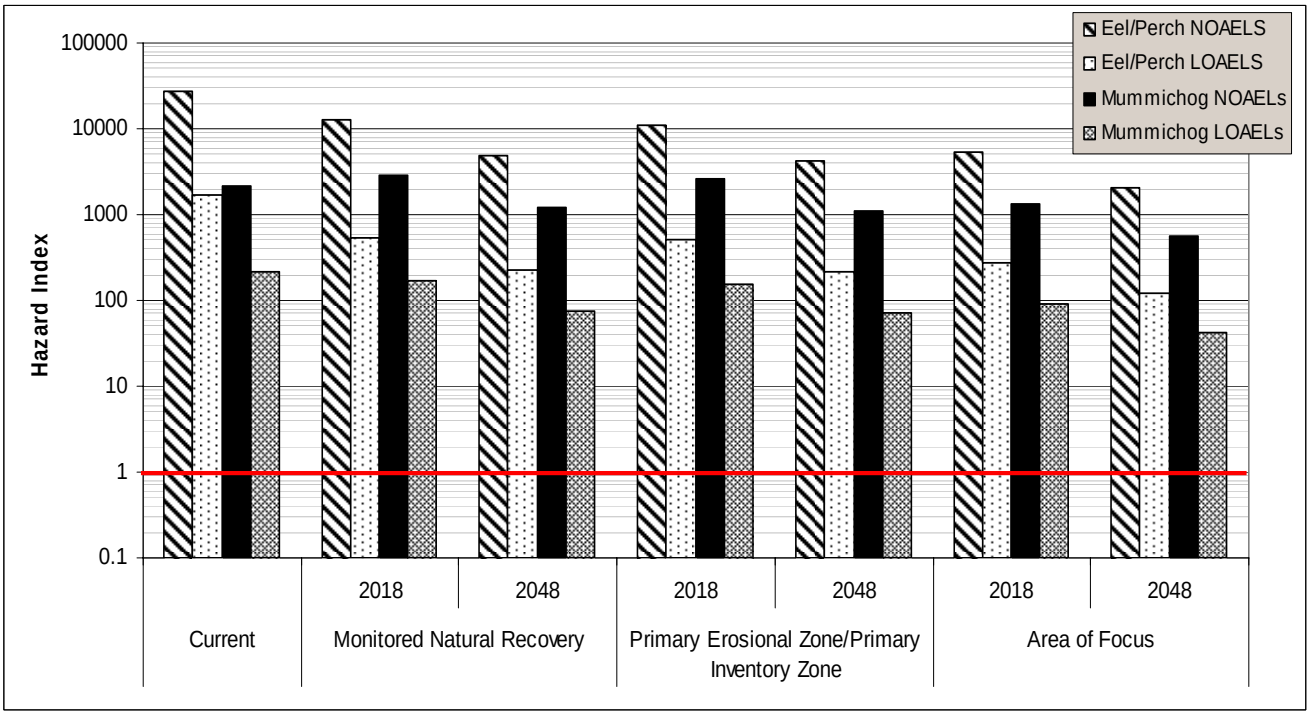

Figure 8-3 Comparison of Current and Future Hazards for Each Remediation Scenario Based on Fish CBRs.

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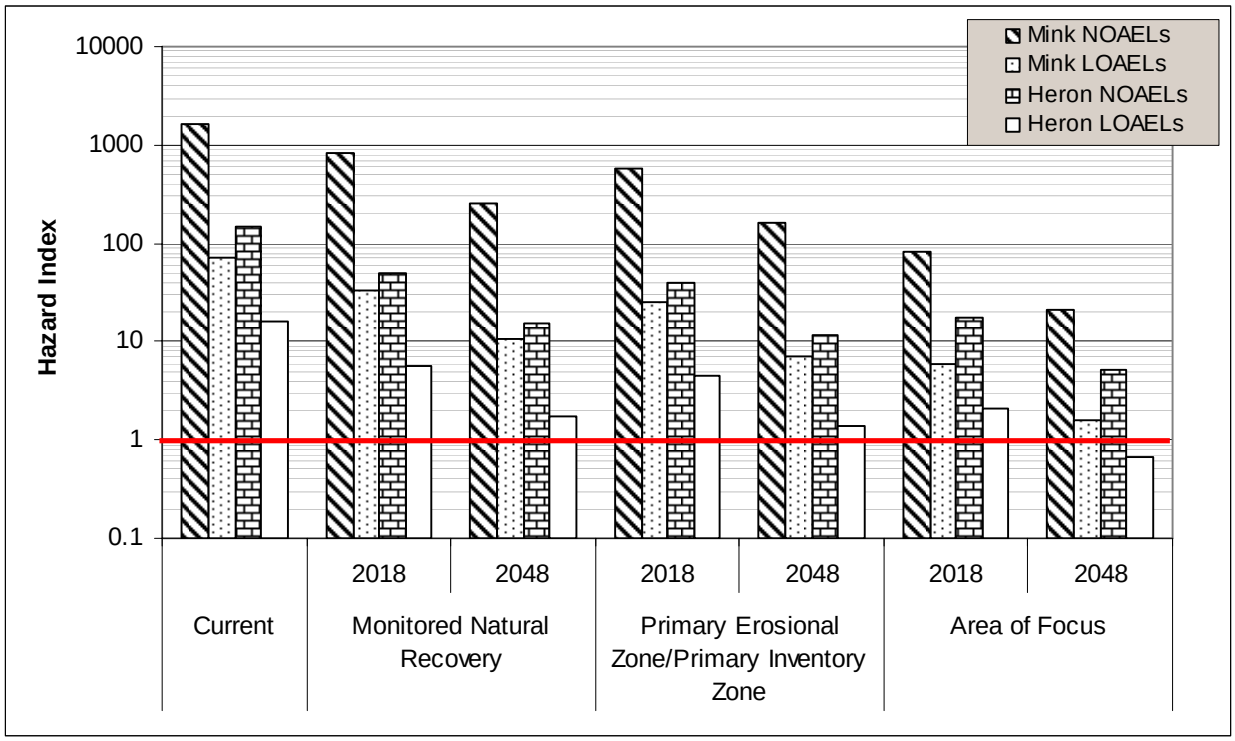

Figure 8-4. Comparison of Current and Future Hazards for Each Remediation Scenario Based on Wildlife Dietary Exposure Modeling.

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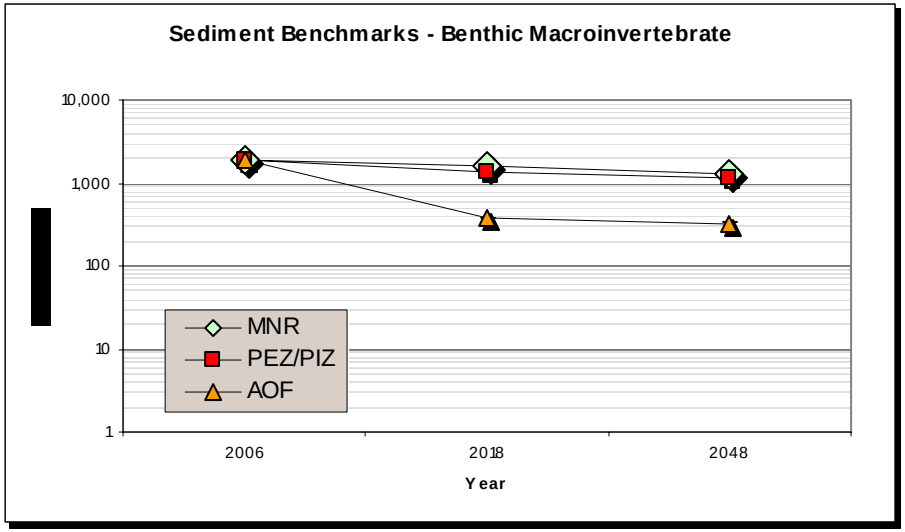

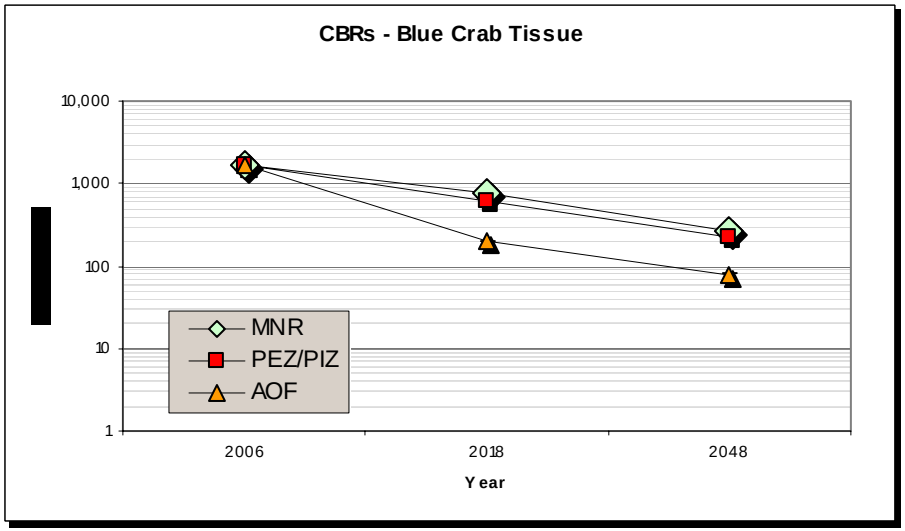

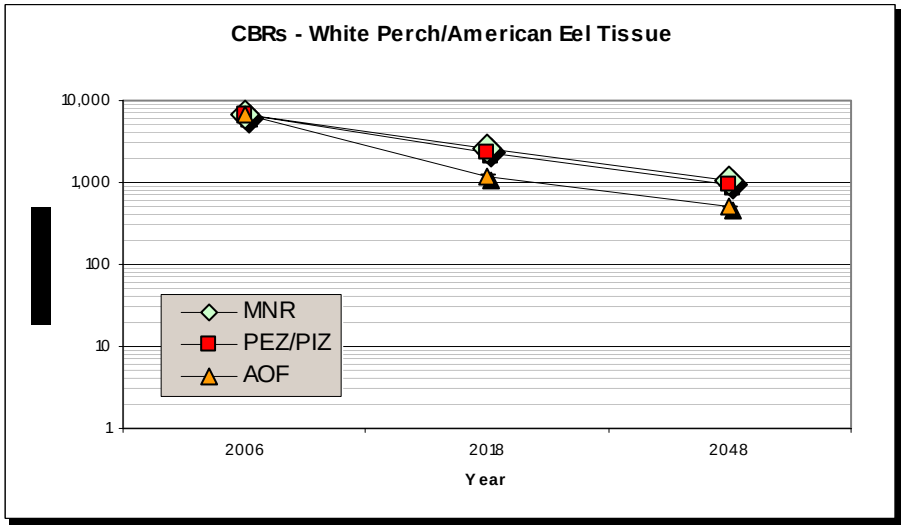

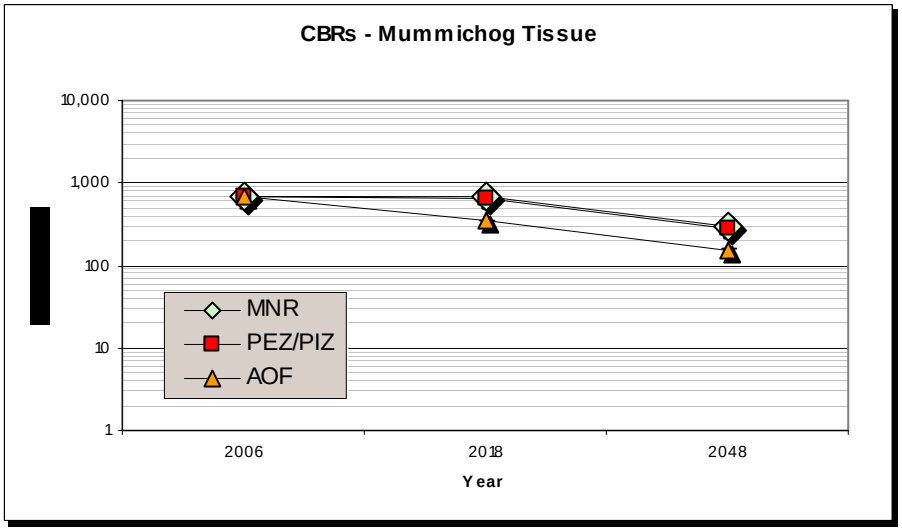

MNR – monitored natural recovery; PEZ/PIZ – primary erosional zone/primary inventory zone

Figure 8-5. Hazard Reductions over Time for Each Remediation Scenario – Benthic Macroinvertebrate and Fish Endpoints.

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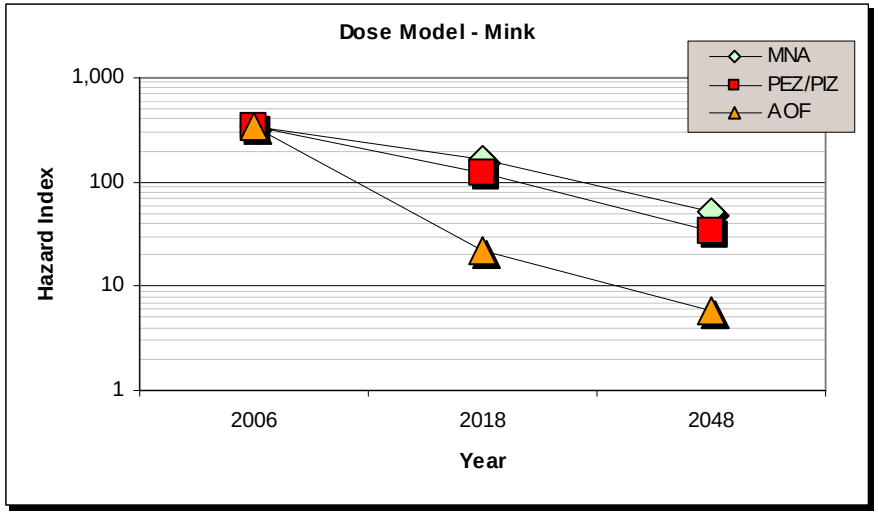

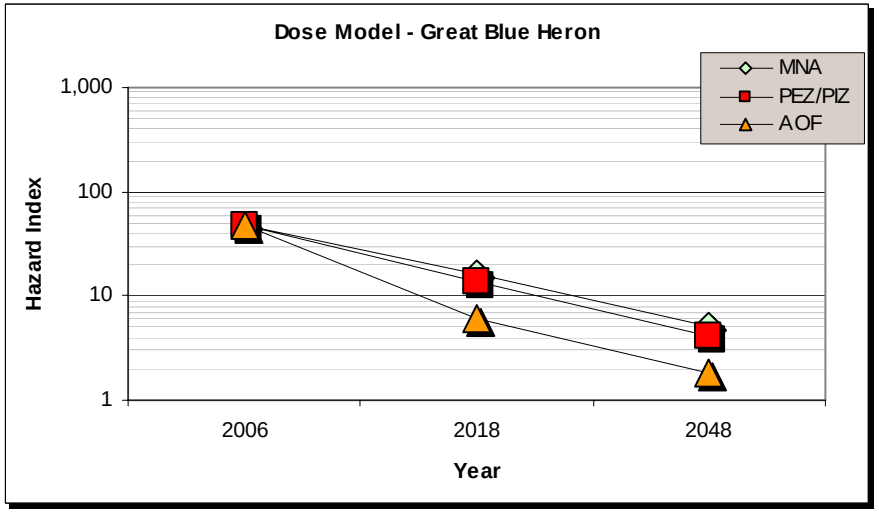

MNR – monitored natural recovery; PEZ/PIZ – primary erosional zone/primary inventory zone; AOF – area of focus

Figure 8-6. Hazard Reductions over Time for Each Remediation Scenario – Wildlife Receptors

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Figure 8-3 presents the current and future hazard estimates for the fish CBR endpoints, and a pattern similar to that seen in Figure 8-2 is evident. In all scenarios, projected hazards at year 2048 are between one and two orders of magnitude greater than levels associated with no adverse ecological effects. However, by 2048 under the area of focus remediation scenario, projected hazards for the modeled wildlife receptors provide the greatest risk reduction (see Figure 8-4 and 8-6). The geometric mean of the NOAEL- and LOAEL-based HIs are below 10 for the mink in year 2048 for the area of focus alternative, as are the similar values for the heron under all three remediation scenarios (see Figure 8-6).

Also evident in Figure 8-5 is the importance of the trajectories of primary drivers on the hazard reduction time course. For the sediment benchmark endpoint, where dieldrin is the primary contributor to the hazard estimate, there is little further reduction in hazards anticipated following implementation of the remedy. On the other hand, further hazard reduction is evident for those receptor/endpoint combinations where the primary hazard drivers have decreasing trajectories (*e.g.*, mink in Figure 8-6). As noted in Section 8.1.4.1, the contribution of contaminants in sediments from outside sources or from sediments not included in the particular remediation scenario likely explain the differences in hazard reductions evident in these figures.

8.2.4.2 Comparison among Remediation Scenarios

The primary erosional zone/primary inventory zone and area of focus remediation scenarios were compared to the monitored natural recovery scenario to determine which offered the greatest relative hazard reductions. Figures 8-7 and 8-8 illustrate the relative hazard reduction anticipated for non-wildlife and wildlife receptors, respectively. As with Figures 8-5 and 8-6, the geometric mean of the NOAEL- and LOAEL-based HIs are plotted to simplify the discussion. Two sets of curves are included in these figures: the predicted hazard reduction relative to the MNR remedial alternative (*i.e.*, square and diamond symbols) and relative to current conditions (*i.e.*, circle and triangle symbols). The first set of curves allows a visual assessment of the relative benefit of the active remedial alternatives compared to the MNR alternatives and the second set allows a perspective on how much improvement is anticipated relative to existing conditions.

The primary erosional zone/primary inventory zone remediation scenario is anticipated to achieve between a 10% and 25% reduction in projected ecological hazards to benthic macroinvertebrates and fish relative to monitored natural recovery, while the area of focus scenario is expected to result in between a 50% and 75% reduction in hazards (box and diamond symbols in Figure 8-7). As noted above, the remediation scenarios evaluated appear to have a more dramatic effect in attenuating hazards to wildlife receptors (Figure 8-8). For wildlife receptors, the area of focus scenario is expected to achieve an 89% and a 65% reduction in hazards (mink and heron, respectively) compared to monitored natural recovery. The difference between these two receptors is attributable to the nature of the primary contributors to the HI and their respective trajectories[6].

The anticipated hazard reductions associated with the various remediation scenarios relative to current conditions are also presented in Figure 8-7 and 8-8 (circle and triangle symbols).

[6] Appendix D provides a thorough discussion of the key geochemical attributes of the study area that influence the anticipated remedial outcomes as influenced by ecological exposure and toxicity.

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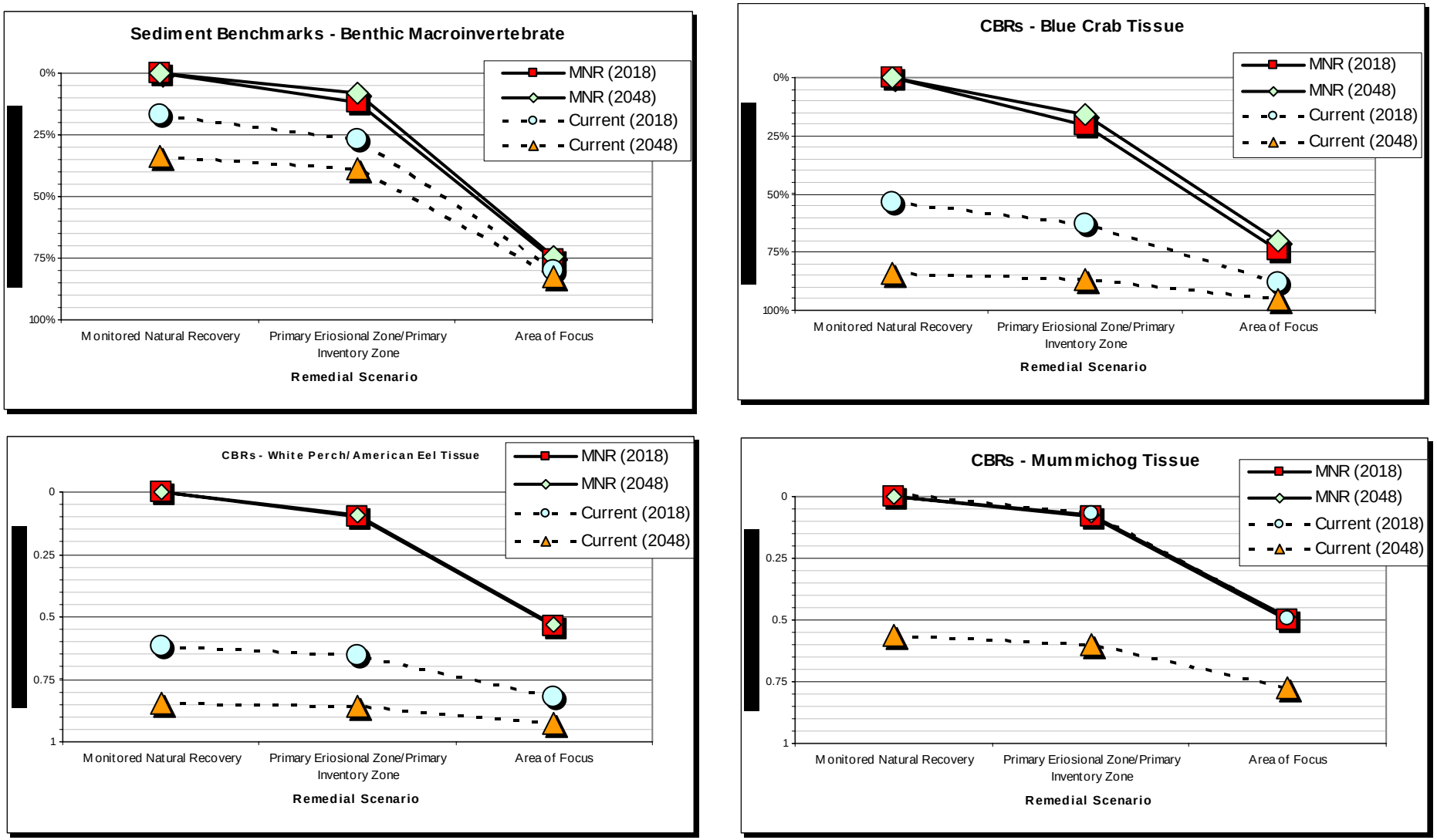

MNR – monitored natural recovery

Figure 8-7. Relative Hazard Reduction Comparison among Remedial Alternatives – Benthic Macroinvertebrate and Fish Endpoints.

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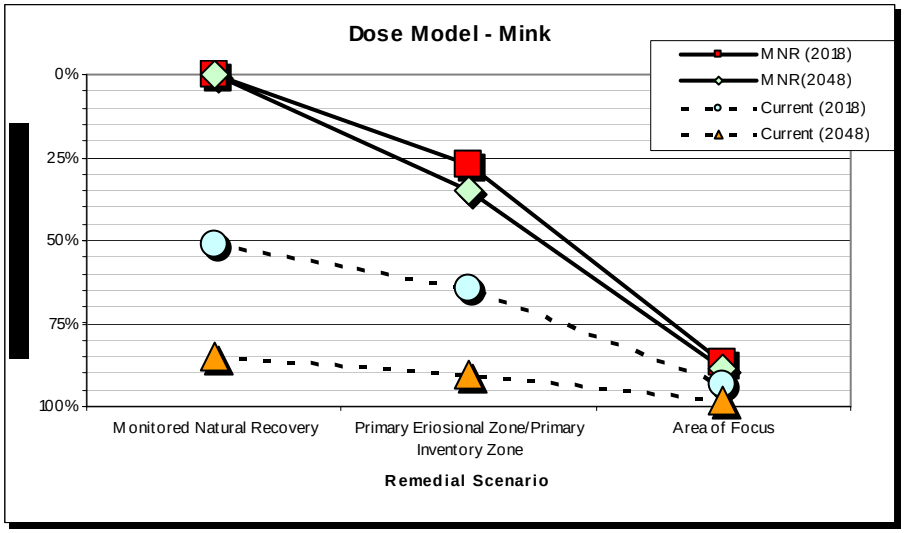

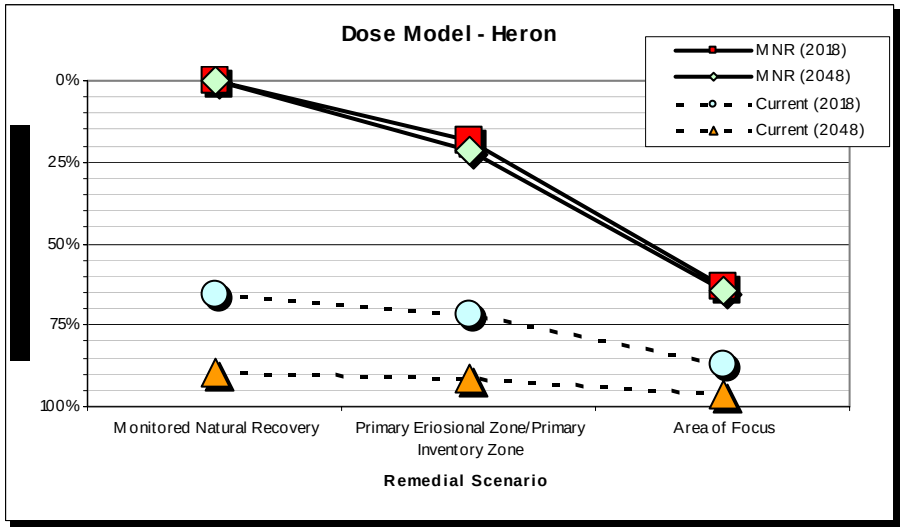

MNR – monitored natural recovery

Figure 8-8. Relative Hazard Reduction Comparison among Remedial Alternatives – Wildlife Receptors.

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8.3 Future Risk Assessment Uncertainties

A qualitative evaluation is provided in this section to address uncertainties associated with the estimates of future risk/hazard presented in this report. Risk results are best estimates based on the most recent information and techniques available for predicting risk. Two primary sources of uncertainty associated with risk estimates are:

- Parameter uncertainty (*i.e.*, uncertainty in model input parameter exposure variables); and,
- Model uncertainty (*i.e.*, methods/models used to calculate EPCs and risk).

8.3.1 Parameter Uncertainty

Many of the risk uncertainties discussed in detail in Sections 5.0 and 6.0 also apply to the future estimated risks. The primary aspects of the toxicity assessment that impart uncertainty to the calculated risks include uncertainty in the toxicity data for constituents detected at the site. The uncertainties that would have a greater impact on future risk estimates are summarized below for both the human and ecological assessments.

8.3.1.1 Human Health

The same toxicity uncertainties identified for the current risk also apply to the future estimated risks and therefore have not been reiterated here. Exposure parameter uncertainty is discussed here because this type of uncertainty is the most likely source of uncertainty impacting the future calculated cancer risks and noncancer health hazards. The following discussion identifies uncertainties based on overestimates or underestimates of cancer risks and noncancer health hazards.

- One of the major uncertainties associated with the hazard identification process is the identification of COPCs. Not all of the COPCs identified in biota were evaluated. Only a subset of contaminants that capture the chemicals with the greatest potential to bioaccumulate through the food chain and the primary risk drivers were carried through the risk assessment. In addition, COPCs associated with other environmental media (*e.g.*, sediment and surface water) in conjunction with other potentially complete exposure pathways (*e.g.*, dermal contact, incidental ingestion) were not included in the risk assessment because the ingestion of biota and the COPCs identified for this medium are thought to drive risks and therefore cleanup objectives. In the absence of the quantification of these additional risk pathways and COPCs, the risks may be underestimated.
- There is a concern for the potential to double-count PCB concentrations and PCB risk when both dioxin-like PCB congener data and total PCB (as Aroclor) data are used to determine risk, particularly with those risks then being added together. Therefore, historical site-specific PCB data were reviewed to address this concern. The results of the PCB enhancement assessment is presented in Attachment 4. Briefly, the results of the assessment indicate that the total PCB concentration (and total PCB-based risk) would be reduced by 8% if the contribution of the 12 dioxin-like PCB congeners is considered (*i.e.*, subtracted from the total PCB concentration). The overall risk associated with PCBs therefore would be reduced by 1% to 3%, resulting in the total cancer risk value declining by approximately 1%. Assuming the ratio of dioxin-like PCBs would remain constant in the future, this decrease in the total cancer risk would most likely not significantly impact the risk values.
- There is uncertainty in the receptors evaluated in the risk assessment and their angling activities/habits. To minimize uncertainty in the calculated risks, exposure assumptions and parameters for these receptors were obtained from published literature sources (*e.g.*, creel

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surveys) for the Lower Passaic River or surrounding areas. In some instances, exposure assumptions and parameters were based on professional judgment and default exposure values recommended by USEPA. Risks are more likely to be overestimated than underestimated because of the conservative nature of the exposure assumptions. The uncertainties in the calculated risks are high. It is possible that subsistence populations who live in the area may consume higher amounts of fish or crab than a recreational angler. Crab consumption was assessed based on a creel survey of the Newark Bay Complex, which includes the Passaic River study area. However, it was noted that specific distributions of fish ingestion were not available for the survey. The potential exists that the risks may be either underestimated or overestimated. Angling, crabbing, and consumption of catch within the lower portion of the Lower Passaic River was assumed to be a frequent event for the receptors, even though this portion of the river is industrial in nature and fish and crab advisories have been issued. However, there is evidence that individuals do fish in this area, although the time spent and the amount caught are uncertain. There is also uncertainty about how changes in water quality might cause changes in the fishing activities on the river over time. As such, the uncertainty in the calculated risks may result in either an underestimation or overestimation of risk.

- The ingestion rate for crab consumption was based on a 3-month period during which individuals reported catching crab. This rate did not take into consideration the number of meals eaten throughout the remainder of the year when anglers may continue to catch crab or may consume frozen crab caught during the 3-month period. The ingestion rate may be underestimated; therefore, risks may be somewhat underestimated.
- Exposure to dioxin, dioxin-like compounds, and other bioaccumulative compounds in sensitive subpopulations, such as breast-fed children, was not evaluated quantitatively. These compounds are lipophilic and concentrate in breast milk. Therefore, risks are more likely to be underestimated for these sensitive populations.
- The assessment did not evaluate the potential cancer risks and noncancer health hazards based on background concentrations. The contributions from background concentrations will be evaluated in the RI/FS. If background and ambient constituents are included in the risk assessment, the calculated risks overestimate the risk attributed to chemical releases from the site.
- Risks were derived assuming that the receptors ate fish or crab, but not both. Although Burger (2002) reported survey results indicating that the majority of people caught either fish or crab, it is likely that some anglers may catch, and eat, both fish and crab. Therefore, risks may be underestimated for individuals who eat both fish and crab. However, for individuals eating both crab and fish at each meal, the respective ingestion rates for both would be expected to decrease (*i.e.*, if someone eats both fish and crab during a meal, than the fish ingestion rate and the crab ingestion rate may be lower than the respective ingestion rates when only fish or only crab is consumed during a meal). Therefore, risks would be overestimated if the same respective consumption rates were assumed for an individual consuming both fish and crab during a meal. As such, the uncertainties in the calculated risks for this site are considered low.

8.3.1.2 Ecological

The same toxicity uncertainties identified for the current risk also apply to the future estimated risks and therefore have not been reiterated here. Future exposure estimates to gull embryos were not derived because it was not technically feasible to forecast individual dioxin, furan, and PCB congener concentrations as part of the FFS analysis. Based on the comparability of hazard estimates between the

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avian dose- and residue-based analyses, it is likely that both endpoints would experience a similar time course of risk reduction (see Figure 8-8).

8.3.2 Model Uncertainty

These additional uncertainties relate to the procedures used to estimate future sediment and biota tissue concentrations. Appendix D of the FFS discusses the assumptions employed in forecasting sediment exposures in the Lower Passaic River 30 years out. There are obviously significant uncertainties associated with developing the future sediment EPC terms, which are compounded by the limited nature of existing sediment core data above the Dundee Dam. As explained in the mass empirical model (Appendix D), only one core surface sediment sample was used in the empirical mass balance model to represent sediment conditions above the dam. Although the data can be considered reflective of contaminant concentrations on suspended solids transported over the Dundee Dam to the Lower Passaic River, the limited number of data may introduce uncertainty regarding the actual representativeness of this one sample.

As discussed in Section 7.2, the ratio of the 95%UCL to arithmetic mean contaminant concentration was used to derive the futurecast EPCs (*i.e.*, 95%UCL on futurecast average concentration) used in the risk analysis. Table 7-2 summarizes the ratios used to derive the futurecast EPCs. This procedure assumes that the surficial sediment data will exhibit a similar degree of variability in the future; if in fact, the future sediment concentrations are less variable than assumed, then the forecast exposure and risk estimates would also be less than estimated in this analysis.

8.3.2.1 Forecast Numbers

Several uncertainties associated with the forecast multiplier calculations were used in Section 7.0 to estimate future COPC/COPEC concentrations. Approximate estimates of the variation in forecast concentrations provided for monitored natural recovery and the remediation scenarios compared to the high-resolution core surface sediment concentrations obtained in 2005 are summarized in Table 8-15 for each of the COPCs/COPECs. Appendix D of the FFS provides the details of how these percent ranges were derived.

Human Health. To show the variability of the forecast concentrations on total risk/hazard estimates for human health, upper and lower bounds on total risk/hazard were derived using these percent ranges. Figure 8-9 shows the future cancer risks estimated for the 30-year exposure duration (*i.e.*, assuming 24 years as an adult and 6 years as a child) and the noncancer health hazard estimated for the adult, 7 years following remediation (*i.e.*, 2019-2025) for consumption of fish. The upper and lower bounds on total risk/hazard estimates are also shown on this figure. Impacts to the overall total cancer risk and noncancer hazard estimates were determined based on the percent range estimated for each COPC. As shown on Figure 8-9, cancer risks may be overestimated or underestimated by a factor of 1.4 to 2, and the noncancer health hazards may be overestimated or underestimated by a factor ranging from 1.2 to 1.4. Concentrations, and thus risk/hazard, will continue to decline past 2048 and institutional controls, including fish consumption advisories, will be maintained to reduce exposures until the ultimate remedial objectives are achieved (as discussed in Section 2.0 of the FFS). Concentration trajectories were not extended past 2048 due to the limitations of the model as discussed in Appendix D.

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Table 8-15. Lower Passaic River High-Resolution Cores 2005 Surface Sediment Concentrations for the COPCS/COPECs

Analyte	2005 Surface Sediment		Historical Sediment
	Mean	+/- Percent Range on the Mean	Ratio of Sediment Historical 95% UCL to Historical Mean[a]
Copper (mg/kg)	149	13%	1.09
Lead (mg/kg)	212	18%	1.14
Mercury (mg/kg)	1.8	38%	1.17
LPAHs (µg/kg)	11,200	32%	2.99
HPAHs (µg/kg)	30,900	30%	1.77
Total PCBs (µg/kg)	995	27%	1.37
Total chlordane (a+g) (µg/kg)	70	24%	1.11
Dieldrin (µg/kg)	6.2	52%	1.38
DDE (µg/kg)	54	21%	1.44
DDD (µg/kg)	83	65%	2.19
DDT (µg/kg)	45	199%	0.94
Total DDx (µg/kg)	201	80%	1.62
2,3,7,8-TCDD (µg/kg)	0.43	64%	2.02[b]

a. Derived from ProUCL output (Attachment 3) for the risk assessment dataset used to develop EPCs. As explained in Section 7.2, these ratios were used to relate the future EPCs based on an average concentration to a 95% UCL on the mean.

b. Ratio for TEQ D/F - mammals

Ecological. It is noted that the COPECs identified with the largest variability based on the 2005 high-resolution core analytical data (Table 8-13) are among the primary risk drivers (*e.g.*, 2,3,7,8-TCDD [as evaluated as TEQs], dieldrin, total DDx). Table 8-13 also includes the ratio of 95% UCLs to the arithmetic mean concentrations for the historical sediment data used to develop EPCs for the risk assessments. As described in Section 7.0, these ratios were applied to the estimated average surface concentration over the lower 8 miles of the Lower Passaic River to estimate a conservative upper bound on the forecast mean concentrations. In general, there appears to be general agreement between the estimates of variability derived from high-resolution core results and those associated with the historical sediment data.

The other data useful in understanding the uncertainties in the forecast estimates are the standard error of the ratio of sediment surface to forecast concentrations (see Table 7-1). The large standard error on the ratio for dieldrin is of note, specifically with the forecast hazards for the sediment benchmark endpoint. In this case, however, the projected hazards are of large enough magnitude that this uncertainty source is not expected to qualitatively alter the conclusions of this assessment.

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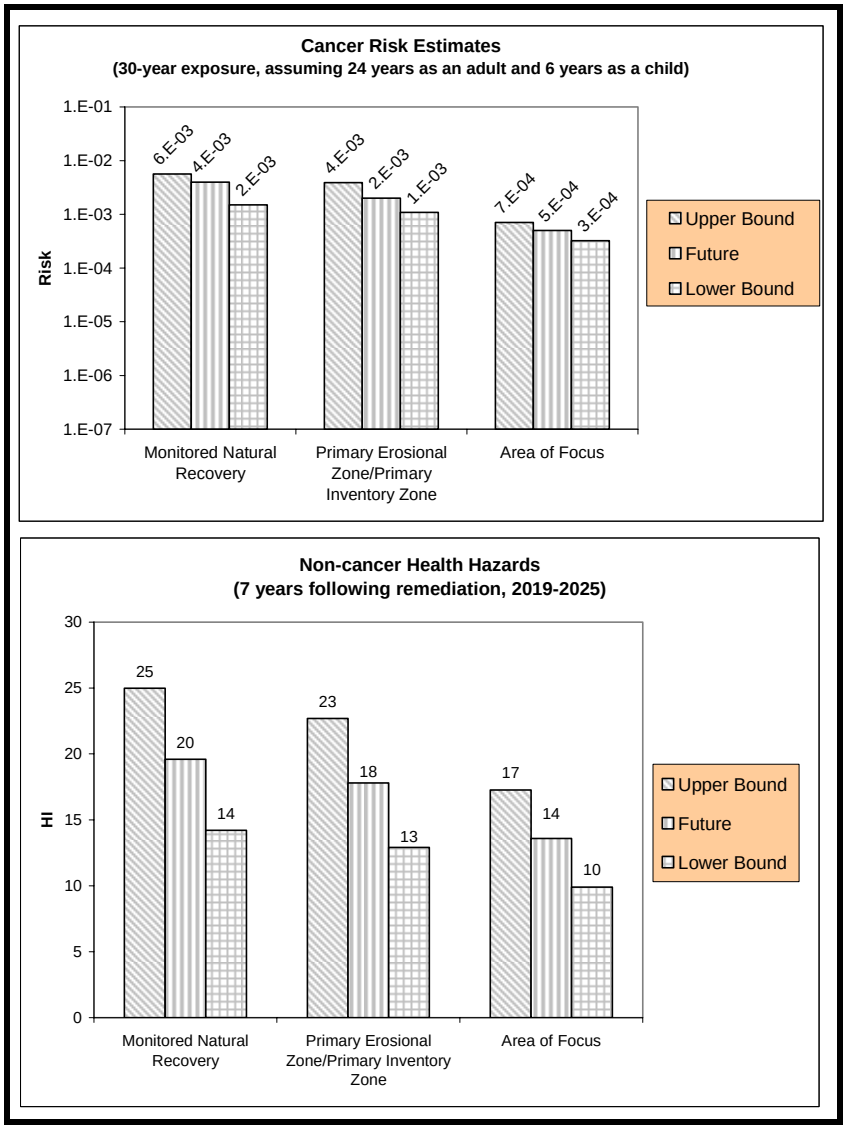

Figure 8-9. Upper and Lower Bounds on the Estimated Adult Future Risk /Hazard for Consumption of Fish.

8.3.3 Estimation of Future EPCs

Another uncertainty focuses on estimating the EPC concentrations in fish and shellfish tissue. As discussed in the previous section, tissue concentrations were estimated by applying BAFs to the estimated sediment concentrations. The empirically derived BAFs were calculated as the ratio of the mean for biota tissue (AE/WP, mummichogs, or blue crab) divided by the corresponding mean for sediment. As summarized in Table 7-2, the BAFs range from 0.001 to 19.6. These values appear reasonable for the COPCs, which were selected primarily because of the potential bioaccumulation hazard posed by these contaminants. BAFs derived for AE/WP tissue for chlordane is 19 and for the six TEQ values range from 0.2 to 1.77 (see Table 7-2). BAFs for the TCDD TEQs (based on mammal, bird, and fish TEFs for D/F congeners) range from 0.09 to 0.2, while the range of BAFs for the TCDD TEQ (PCBs) is somewhat larger (*i.e.*, 0.29 to 2.6). The TCDD TEQ (PCBs) BAFs calculated using available crab tissue data were up to an order of magnitude higher than those obtained for the fish species. Because the fish consumption

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pathway is typically associated with the majority of risk to both human and wildlife receptors and is the basis for the tissue exposures evaluated in the residue-based analysis, the uncertainties associated with these values have a potentially large bearing on the outcome of both the ecological and the human health assessments.

Fish tissue residues represent an integration of contaminant uptake via multiple pathways resulting from both direct (surface water and sediment contact and ingestion) and indirect (biota consumption) exposures. The following attributes influence the partitioning behavior of a contaminant between sediment and biota tissue (Burkhard *et al.*, 2003):

- Partitioning between sediment and water (including both dissolved and particulate- and colloidal-bound fractions);
- Contaminant hydrophobicity;
- Degree of linkage between the food chain and sediment and surface water fractions;
- Length and complexity of the aquatic food chain; and,
- Pharmacokinetics (including absorption efficiency and organismic metabolic capacity).

Thermodynamic principles result in the prediction that under equilibrium conditions, the relationship between carbon-normalized sediment and lipid-normalized tissue concentration of non-ionic hydrophobic organic compounds should be approximately 1 (Mackay, 1991; Di Toro *et al.*, 1991). These ratios, termed biota sediment accumulation factors (BSAFs), for 2,3,7,8-TCDD and other D/F congeners typically range between 0.1 and 0.8 (Comber *et al.*, 2003; Endicott and Cook, 1994; Kuehl *et al.*, 1987; van der Oost *et al.*, 1996; USEPA, 2003b). Parkerton (1991) calculated BSAFs for 2,3,7,8-TCDD for Lower Passaic River biota and reported values of 0.081, 0.09, and 0.055 for carp, American eel/striped bass, and blue crab, respectively. The BAFs derived for the TCDD TEQ (D/F), although a more simplistic approach, are in agreement with these literature values and support their use in estimating future tissue concentrations in the river. However, the discrepancy between the Parkerton (1991) value for Passaic River blue crabs (*i.e.*, 0.055) and the BAF derived in this current evaluation is noteworthy. Possible reasons for the discrepancy include the ratio of lipid-to-sediment organic carbon, inadequacy of the available surficial sediment data to accurately characterize exposures to these migratory animals, and possible differences in the specific tissue matrices evaluated. The inclusion of available hepatopancreas tissue data in the current study may have contributed to the higher BAFs, although the details of the earlier study were not available to assess this point.

Regardless, it is reasonable to assume that whatever factors are responsible for the current relationship between sediment and biota tissue would be relevant for evaluating future scenarios as well.

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9.0 SUMMARY AND CONCLUSIONS

Results of both the HHRA and the ERA support the conclusion that current conditions within the Lower Passaic River pose significant risks to human and ecological receptors. This evaluation examines receptors, exposure pathways, and chemicals most likely to pose the greatest risk. Although it may provide the basis for evaluating the value of a preliminary action, it is not intended to be a complete baseline risk assessment that includes an assessment of risks for all chemicals, receptors, and exposure pathways. The uncertainties associated with these calculations are also provided in the risk characterization.

To help assess remedial action alternatives for the FFS, potential future risks to human health and ecological receptors were calculated, assuming three remediation scenarios:

- Remediation of the primary erosional zone and/or the primary inventory zone;
- Remediation of the area of focus; and,
- Monitored natural recovery.

The objective of the future risk assessments was to assess the overall protection of human health and the environment considering a "no action", or monitored natural recovery, approach versus remediation of contaminated sediment to address requirements in NCP Section 300.430(e)(9)(iii). The remedial action objectives and the remedial alternatives identified for the site are summarized in the text of the FFS. The results of the future risk assessments will be used to assist risk management decisions regarding the selection of a remedial action. Note that the goal of the future risk assessments was not to provide an absolute estimate of risk reduction, but rather to provide order-of-magnitude estimates that incorporate considerable professional judgment and uncertainty.

The same COPCs/COPECs evaluated for the current scenario were also selected as COPCs/COPECs for the future scenarios. All environmental media evaluated in the current risk scenarios were also evaluated in the future risk scenarios. An empirical mass balance model was used to predict surface sediment concentrations which decline over time as average annual concentrations from the time remediation is expected to be completed (2019) through the year 2048 for each of the COPCs/COPECs for each of the remediation scenarios and used to develop future EPCs for sediment, fish (piscivorous and forage) and blue crab.

It is expected that the baseline human health and ecological risk assessments, which will be conducted as part of the RI/FS process for the entire 17 miles of the Lower Passaic River, will provide additional input regarding any management decision for this site.

9.1 Human Health Risk Assessment Summary

9.1.1 Current Risk Assessment

Potential risk to human health is evaluated for consumption of fish and crab. For purposes of establishing current risks and comparing the relative risk reductions, cancer risks and noncancer health hazards were estimated for an adult and a child receptor. The exposure duration for the combined adult/child of 30 years is used to represent the most conservative standard receptor for evaluation of carcinogens. The child, age 0-6 years, is assumed to represent the most conservative standard receptor for noncarcinogens. Cancer risks and noncancer health hazards were evaluated for a reasonably maximally exposed individual (RME) and a central tendency exposure (CTE) to describe the magnitude and range of exposure that

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might be incurred by the receptor groups. The objective of providing both the RME and CTE exposure cases is to bound the risk estimates, although decisions are based on the RME consistent with the NCP (USEPA, 1985). The cancer risks derived in the HHRE are compared to the NCP risk range of 10^{-4} (one in ten thousand) to 10^{-6} (one in a million) and noncancer threshold of 1 (USEPA, 1991). The cancer risks and noncancer hazards associated with current conditions are summarized in Table 9-1.

For the RME cancer risks, TCDD TEQ (D/F), TCDD TEQ (PCBs), and total PCBs are the primary contributors to a combined risk above 10^{-2} for both fish and crab consumption, which exceeds the NCP risk range described above. Approximate contributions to total risk from TCDD TEQ (D/F), TCDD TEQ (PCBs), and total PCBs are 65%, 20%, and 10%, respectively. TCDD TEQ (D/F) comprises over three quarters of the risk associated with the dioxins [*i.e.*, TCDD TEQ (D/F) and TCDD TEQ (PCBs)]. For the RME noncancer health hazards, total PCBs is the primary contributor to hazard indices above the threshold of 1.

Table 9-1. Summary of Current Risk Associated with Fish and Crab Consumption.

Fish Consumption			
RME		**CTE**	
Cancer Risk[a]	**Hazard Index[b]**	**Cancer Risk[a]**	**Hazard Index[b]**
1×10^{-2}	99	6×10^{-4}	25
Crab Consumption			
RME		**CTE**	
Cancer Risk[a]	**Hazard Index[b]**	**Cancer Risk[a]**	**Hazard Index[b]**
2×10^{-2}	140	4×10^{-3}	87

a. Results based on the combined adult/child receptor (6 years as a child and 24 years as an adult).
b. Results based on the child receptor.

For the CTE cancer risks, TCDD TEQ (D/F) and TCDD TEQ (PCBs) in fish and TCDD TEQ (D/F) and TCDD TEQ (PCBs) and total PCBs in crab are the primary contributors to the total cancer risks. Only the individual cancer risks for fish for TCDD TEQ (D/F) exceeds 10^{-4}. However, the individual cancer risks for crab for TCDD TEQ (D/F), TCDD TEQ (PCBs), and total PCBs are at or above 10^{-4} for each receptor. For the noncancer CTE hazard indices, total PCBs is the primary contributor to the excess hazard for all receptors for both ingestion of fish and crab.

9.1.2 Future Risk Assessment

The process of evaluating remedial alternatives for human health used the same set of COPCs and the same risk assessment methodology, including potential exposure scenarios and assumptions, that were evaluated in the current risk evaluation described in Section 5.0. Results from the current risk assessment presented in Section 5.3.1 were then used to assess the relative risk reduction afforded by each remediation scenario. In addition, the relative risk reduction among the three remediation scenarios was examined.

For purposes of comparing relative risk reductions, carcinogenic risks and noncarcinogenic health hazards were estimated only for the reasonably maximally exposed individual and only for the adult and child angler/sportsman. For carcinogenic risk, a 30-year exposure period was evaluated, assuming 24 years as an adult and 6 years as a child, to depict a scenario resulting in the most health protective calculations of cancer risks. For noncarcinogens, both a child receptor (age 0-6 years) and an adult (assuming a 7-year exposure period) were evaluated to depict scenarios resulting in the most health protective noncancer

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health hazards. Based on body weight and other considerations, the child receptor results in the largest noncancer HI. However, the HI for the adult may be more heavily relied upon because datasets supporting the adult ingestion rate for fish (USEPA, 1997b) and, to a lesser extent, crab (Burger, 2002) were used in this assessment.

Future chemical concentrations in fish and crab were estimated from an empirical mass balance model using current sediment data as discussed in Section 7.0. In general, several sets of future EPCs were developed for each of the COPCs, corresponding to each of the remediation scenarios at three time periods. The first time period was selected to represent the year remediation is expected to be complete (*i.e.*, 2018). For the first time period, predicted average annual concentrations at 2018 are used to represent concentrations for that specific period in time. Future EPCs for subsequent time periods need to consider the exposure duration (*i.e.*, "ED") component of the risk/hazard equation which is assessed differently for cancer risk and non-cancer hazard. To derive EPCs to estimate future cancer risks, the predicted average annual concentrations derived from years 2019 through 2048 are used to derive an average concentration over the total exposure duration of 30 years (*i.e.*, 6 years as a child and 24 years as an adult). Thus, a 6-year average of the average annual sediment concentrations is used for the child, and a 24-year average of the average annual sediment concentrations is used to represent the adult for cancer exposure only.

For estimating non-cancer health hazards, the predicted average annual concentrations derived from years 2019 through 2024 and 2019 through 2025 are used to derive EPCs for the child and adult, respectively. For noncarcinogens, the AT for the child is 6 years, while the AT for the adult is averaged over a period equal to a chronic exposure duration (7 years). Therefore, the AT for the noncancer hazard assessment for the adult is set to 2,555 days (7 years x 365 days/year). As the duration of exposure increases, the EPC and thus the average daily dose decreases, allowing the intake to be averaged over a longer period of time (*i.e.*, greater than 7 years). Since this would underestimate the RME risk to the adult, only a 7-year exposure duration (as opposed to a 24-year exposure duration) is assumed for the adult for noncarcinogenic exposures occurring through the year 2048. Based on this same principle, the first 7 years after remediation, rather than the second or third 7-year period, is used to determine the EPCs for assessing a RME to the adult and child receptors. Because the EPC and thus the average daily dose decreases over time (which only impacts exposure to noncarcinogens) a third set of EPCs is derived for the adult to provide a lower bound on risk at a period in time closer to 2048. While the first 7 years post-remediation is used to derive an EPC representing the RME for the adult, the last 7-year period (*i.e.*, 2042-2048) is used to derive a second EPC for the adult. This EPC is more representative of the actual concentrations 30 years post-remediation. Only the adult receptor is evaluated for the 2042-2048 time period to assist risk management decisions regarding the selection of a remedial action. The health hazard for the adult may be more heavily relied upon for risk management decisions because datasets supporting the ingestion rates are available for an adult, but not a child receptor.

Table 9-2 summarizes the estimated total future cancer risks for each remediation scenario and Table 9-3 summarizes the estimated HIs for each remediation scenario. Total cancer risks for each scenario (Table 9-2) are outside the NCP risk range of 10^{-4} to 10^{-6}, however, cancer risks determined for each of the COPCs individually fall within the NCP risk range of 10^{-4} to 10^{-6} for the area of focus remedial scenario (see Tables 8-1 and 8-3). Non-cancer HIs are estimated to be considerably higher than the threshold of 1 for all remediation scenarios within the first 7 years post-remediation (Table 9-3); however, nearly 30 years post-remediation, the HIs are estimated at levels more comparable to the threshold of 1. Total PCBs are the primary driver for excess noncancer health hazard. This predicted excess hazard is most likely the result of the continuing contribution of PCBs from sources not included in the scope of the remediation (*e.g.*, above Dundee Dam)..

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Table 9-2. Summary of Estimated Future Risks for Each Remediation Scenario.

	Remediation Scenario[a]	Time Period[b]	Adult Risk	Child Risk	Adult + Child Combined Risk
Fish	Monitored Natural Recovery	2018	4.E-03	2.E-03	6.E-03
		2019-2048	2.E-03	1.E-03	4.E-03
	Primary Erosional Zone/Primary Inventory Zone	2018	3.E-03	1.E-03	4.E-03
		2019-2048	1.E-03	1.E-03	2.E-03
	Area of Focus	2018	6.E-04	2.E-04	9.E-04
		2019-2048	3.E-04	2.E-04	5.E-04
Crab	**Remediation Scenario[a]**	**Time Period[b]**	**Adult Risk**	**Child Risk**	**Adult + Child Combined Risk**
	Monitored Natural Recovery	2018	3.E-03	1.E-03	4.E-03
		2019-2048	2.E-03	1.E-03	3.E-03
	Primary Erosional Zone/Primary Inventory Zone	2018	2.E-03	9.E-04	3.E-03
		2019-2048	1.E-03	8.E-04	2.E-03
	Area of Focus	2018	6.E-04	2.E-04	8.E-04
		2019-2048	2.E-04	2.E-04	4.E-04

Note that the risks are presented in this table at one significant figure.

a. The remediation scenarios represent future exposures.

b. The time period 2018 represents the year remediation is expected to be complete and the predicted average annual concentrations at 2018 were used as the EPCs. For 2019-2048, the predicted average annual concentrations derived from years 2019 through 2048 are used to derive an average concentration over the total exposure duration of 30 years (*i.e.*, 6 years as a child and 24 years as an adult). Thus, a 6-year average of the average annual sediment concentrations is used for the child, and a 24-year average of the average annual sediment concentrations is used to represent the adult for cancer exposure only.

Although the total cancer risk and noncancer hazard estimates were still above the NCP criteria, considerable reduction in risk/hazard would be achieved with remediation of sediments. The relative reductions in risks/hazards attributed to each of the remediation scenarios as compared to the estimated current risks/hazards as summarized in Tables 8-6a and 8-6b. For consumption of fish, the relative reduction in risk (Table 8-6) was greatest for the area of focus remediation scenario, with risk declining 92% by 2048. The relative reduction in risk for the primary erosional zone/primary inventory zone scenario was 72% by 2048. For the monitored natural recovery scenario, the relative risk reduction after 40 years was estimated to be only 60%. Relative reductions in risk for crab consumption were higher than the fish, but followed a similar increasing pattern with respect to the remediation scenarios. For noncancer health hazards, the relative reductions in risk were not as significant but still demonstrated declines ranging from 30% to almost 70%. Total PCBs were the primary drivers for excess noncancer health hazard. As stated previously, the predicted excess hazard for total PCBs is most likely the result of the continuing contribution of PCBs from sources not included in the scope of the remediation (*e.g.*, above Dundee Dam).

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Table 9-3. Summary of Estimated Future Health Hazards for Each Remediation Scenario.

	Remediation Scenario[a]	Time Period[b]	Adult Hazard	Child Hazard
Fish	Monitored Natural Recovery	2018	24	37
		2019-2025	20	31
		2042-2048	7	ND
	Primary Erosional Zone/Primary Inventory Zone	2018	21	33
		2019-2025	18	29
		2042-2048	6	ND
	Area of Focus	2018	16	25
		2019-2025	14	22
		2042-2048	5	ND
Crab	Remediation Scenario[a]	Time Period[b]	Adult Hazard	Child Hazard
	Monitored Natural Recovery	2018	19	31
		2019-2025	16	27
		2042-2048	5	ND
	Primary Erosional Zone/Primary Inventory Zone	2018	17	28
		2019-2025	14	24
		2042-2048	5	ND
	Area of Focus	2018	13	21
		2019-2025	11	19
		2042-2048	4	ND

ND – not determined. Only the adult receptor is evaluated for the 2042-2048 time period to assist risk management decisions regarding the selection of a remedial action. The health hazard for the adult may be more heavily relied upon for risk management decisions because datasets supporting the ingestion rates are available for an adult, but not a child receptor.

Note that the hazard values are presented in this table at one significant figure.

a. The remediation scenarios represent future exposures.

b. The time period 2018 represents the year remediation is expected to be complete and the predicted average annual concentrations at 2018 were used as the EPCs. For 2019-2025, the predicted average annual concentrations derived for the years 2019 through 2024 and 2019 through 2025 are used to derive the EPCs for the child and the adult receptors, respectively. Allowing the intake to be averaged over a 24-year period of time would underestimate the RME risk to the adult; therefore, only a 7-year exposure duration, as opposed to a 24-year exposure duration, is assumed for the adult for noncarcinogenic exposures. The first 7 years post-remediation is used to derive an EPC assumed to be representative of the RME for the adult, while the last 7-year period (throughout the 30 years of exposure) is used to represent more likely conditions 30 years post-remediation.

The primary erosional zone/primary inventory zone and area of focus remediation scenarios were compared against the monitored natural recovery scenario to determine which scenario offered the greater relative risk reductions. Compared to monitored natural recovery, the percent reductions in risk associated with ingestion of fish and crab range from about 30% for the primary erosional zone/primary inventory zone scenario to 80% for the area of focus scenario. For the noncancer hazards, the percent reductions within the first 7 years (*i.e.*, 2019-2025) for the primary erosional zone/primary inventory zone and area of focus range from about 10% to nearly 30%, respectively, compared to monitored natural recovery for consumption of both fish and crab (adult and child). Thus, the area of focus scenario provides the greater relative risk reduction.

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As discussed in Section 2.0 of the FFS, the concentrations estimated for each of the remedial scenarios will continue to decline over time (*i.e.*, past 2048) and institutional controls, including fish consumption advisories, will be maintained to reduce exposures until the ultimate remedial objectives are achieved.

9.2 Ecological Risk Assessment Summary

9.2.1 Current Ecological Risk Assessment

The ERA conducted to support the FFS evaluated direct contact exposures by sediment-associated receptors to contaminated sediment. In addition, the bioaccumulation hazards to aquatic organisms that forage in the Lower Passaic River and the wildlife that consume them were evaluated. Receptors of interest included sediment-dwelling and epibenthic macroinvertebrates, pelagic and demersal fish, and piscivorous wildlife (mink and great blue heron).

A chemical screening process was used to select nine COPECs for consideration: copper, lead, mercury, LPAHs, HPAHs, dieldrin, total DDx, total PCBs, and TCDD TEQ (including contributions from D/F and PCB congeners). Screening-level exposure assumptions were used to model dietary exposures and protective toxicity values (*e.g.*, NOAA ER-Ls, low-end NOAEL/LOAEL CBRs, and ingestion toxicity data) to ensure that potential ecological hazards were conservatively estimated in the assessment.

Table 9-4 summarizes the HIs calculated for the evaluated receptors for current conditions in the Lower Passaic River. These findings strongly support a conclusion that ecological receptors residing in the river are being adversely impacted.

Table 9-4. Summary of Current Ecological Risk Hazards

Receptor Category	Species	Endpoint	Hazard Estimate	
			NOAEL	LOAEL
Macroinvertebrate	Generic	Sediment benchmark	1,900	
	Blue crab	CBR	5,100	540
Fish	AE/WP	CBR	27,000	1,700
	Mummichog	CBR	2,200	220
Mammal	Mink	Ingestion dose model	1,600	72
Bird[a]	Great blue heron	Ingestion dose model	150	16
	Herring gull	CBR	120	120

[a] Based on AE/WP diet; hazards associated with a mummichog diet approximately 50% lower.

9.2.2 Future Ecological Risk Assessment

The process of evaluating remedial alternatives to address ecological concerns employed the same risk assessment methodology, including potential exposure scenarios and toxicological data, used in the assessment of current conditions (presented in Section 6.0). This assessment examines receptors, exposure pathways, and chemicals most likely associated with the greatest contribution to overall risks. Results for current conditions were then used to assess the relative risk reduction afforded by each of the remediation scenarios evaluated. In addition, the relative risk reduction among the three scenarios was examined. Incremental hazard estimates (*i.e.*, those based on "factoring out" the influence of background conditions) were not derived because extant background data are too limited to develop meaningful EPC concentrations. This information will be forthcoming and utilized to support the baseline risk assessments.

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In general, six sets of future EPCs were developed for each COPEC, corresponding to each of the remediation scenarios at two time periods (*i.e.*, 2018 and 2048). The results of the assessment of future conditions associated with the remedial scenarios are summarized in Table 9-5.

The following general conclusions obtain from the risk assessment:

- In all instances, the area of focus remediation scenario resulted in the greatest reduction in ecological hazards. Furthermore, ecological improvements are predicted to occur in a substantially shorter period of time.
- None of the remediation scenarios would result in a condition of no significant risk of harm for any of the ecological receptors over the time periods assessed; however, by year 2048, it is anticipated that wildlife receptors would be well on the way to recovering under the area of focus remediation scenario.

The differential between the least and most extensive remedy would result in a reduction in ecological hazards of between one and two orders of magnitude.

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Table 9-5. Summary of Estimated Future Ecological Hazards for Each Remediation Scenario.

Receptor Category	Species	Remediation Scenario	Time Period	Hazard Estimate	
				NOAEL	LOAEL
Macroinvertebrate	Generic	Monitored Natural Recovery	2018	1,600	
			2048	1,300	
		Primary Erosional Zone/Primary Inventory Zone	2018	1,400	
			2048	1,200	
		Area of Focus	2018	380	
			2048	330	
	Blue crab	Monitored Natural Recovery	2018	2,400	250
			2048	810	84
		Primary Erosional Zone/Primary Inventory Zone	2018	1,900	200
			2048	680	71
		Area of Focus	2018	620	64
			2048	250	25
Fish	AE/WP	Monitored Natural Recovery	2018	13,000	550
			2048	4,800	230
		Primary Erosional Zone/Primary Inventory Zone	2018	11,000	500
			2048	4,300	210
		Area of Focus	2018	5,300	280
			2048	2,100	120
	Mummichog	Monitored Natural Recovery	2018	2,900	170
			2048	1,200	76
		Primary Erosional Zone/Primary Inventory Zone	2018	2,700	160
			2048	1,100	71
		Area of Focus	2018	1,400	91
			2048	570	42
Mammal	Mink	Monitored Natural Recovery	2018	810	34
			2048	250	11
		Primary Erosional Zone/Primary Inventory Zone	2018	580	25
			2048	160	7.1
		Area of Focus	2018	82	5.9
			2048	21	1.6
Bird[a]	Great blue heron	Monitored Natural Recovery	2018	50	5.5
			2048	15	1.8
		Primary Erosional Zone/Primary Inventory Zone	2018	40	4.6
			2048	12	1.4
		Area of Focus	2018	18	2.1
			2048	5.1	0.66

[a] Based on AE/WP diet; hazards associated with a mummichog diet approximately 50% lower.

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ATTACHMENT 1
SUPPORTING DATA

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Table 1-1 Summary of CARP Fish Tissue Data Used in Assessment

Lower Passaic River Risk Assessment - Focused Feasibility Study

	Parameter							Group								
STUDY_NAME	Sample_ID	river_mile_update	LATITUDE	LONGITUDE	Species_Code	MEDIUM	Datetime_Placed	Aroclor	Chlordane	DDT	Dieldrin	Dioxin/Furan	HMW PAH	LMW PAH	Mercury	PCBs
Harbor Fish Collection	2DMR00162	2.78	40.66333	-74.13528	Mummichog	WHOLE ORGANISM	9/28/1999	1	1	1	1	1	1	1	1	1
	2DMR00193	2.96	40.74117	-74.13333	White perch	W-H/V	9/10/1999	1	1	1	1	1	1	1	1	1
	2DMR00195	2.96	40.74117	-74.13333	White perch	W-H/V	9/10/1999	1	1	1	1	1	1	1	1	1
	2DMR00196	2.96	40.74117	-74.13333	White perch	W-H/V	9/10/1999	1	1	1	1	1	1	1	1	1
	2DMR00197	2.96	40.74117	-74.13333	White perch	W-H/V	9/10/1999	1	1	1	1	1	1	1	1	1
	2DMR00198	2.96	40.74117	-74.13333	White perch	W-H/V	9/10/1999	1	1	1	1				1	1
	2DMR00199	2.96	40.74117	-74.13333	White perch	W-H/V	9/10/1999	1	1	1	1	1	1	1	1	1
	2DMR00200	2.96	40.74117	-74.13333	White perch	W-H/V	9/10/1999	1	1	1	1				1	1
	2DMR00201	2.96	40.74117	-74.13333	White perch	W-H/V	9/10/1999	1	1	1	1				1	1
	2DMR00202	2.96	40.74117	-74.13333	White perch	W-H/V	9/10/1999	1	1	1	1	1	1	1	1	1
	2DMR00203	2.96	40.74117	-74.13333	White perch	W-H/V	9/10/1999	1	1	1	1				1	1
	2DMR00216	2.96	40.7415	-74.13217	American eel	W-H/V	9/10/1999	1	1	1	1	1			1	1
	2DMR00230	3.22	40.74117	-74.135	American eel	W-H/V	9/30/1999	1	1	1	1	1	1	1	1	1
	2DMR00231	3.22	40.74117	-74.135	American eel	W-H/V	9/30/1999	1	1	1	1	1	1	1	1	1
	2DMR00232	3.22	40.74117	-74.135	American eel	W-H/V	9/30/1999	1	1	1	1	1	1	1	1	1
	2DMR00233	3.22	40.74117	-74.135	American eel	W-H/V	9/30/1999	1	1	1	1	1	1	1	1	1
	2DMR00234	3.22	40.74117	-74.135	American eel	W-H/V	9/30/1999	1	1	1	1				1	1
	2DMR00235	3.22	40.74117	-74.135	American eel	W-H/V	9/30/1999	1	1	1	1				1	1
	2DMR00236	3.22	40.74117	-74.135	American eel	W-H/V	9/30/1999	1	1	1	1	1	1	1	1	1
	2DMR00237	3.22	40.74117	-74.135	American eel	W-H/V	9/30/1999	1	1	1	1				1	1
	2DMR00333	2.59	40.7425	-74.12933	Mummichog	WHOLE ORGANISM	11/15/1999	1	1	1	1	1	1	1	1	1
	2DMR00375	3.04	40.74117	-74.13333	White perch	WHOLE ORGANISM	11/15/1999	1	1	1	1				1	1
	2DMR00376	2.59	40.7425	-74.1225	White perch	W-H/V	11/15/1999	1	1	1	1	1	1	1	1	1
	2DMR00377	3.04	40.7425	-74.1225	White perch	W-H/V	11/15/1999	1	1	1	1	1	1	1	1	1
	2DMR00378	2.59	40.7425	-74.1225	White perch	WHOLE ORGANISM	11/15/1999	1	1	1	1				1	1
	2DMR00379	2.59	40.7425	-74.1225	White perch	W-H/V	11/15/1999	1	1	1	1				1	1
	2DMR00380	2.59	40.7425	-74.1225	White perch	W-H/V	11/15/1999	1	1	1	1	1	1	1	1	1
	2DMR00381	2.59	40.7425	-74.1225	White perch	W-H/V	11/15/1999	1	1	1	1	1	1	1	1	1
	2DMR00382	3.97	40.723	-74.12017	White perch	W-H/V	12/21/1999	1	1	1	1				1	1
	2DMR00383	3.97	40.723	-74.12017	White perch	W-H/V	12/21/1999	1	1	1	1	1	1	1	1	1
	2DMR00384	3.97	40.723	-74.12017	White perch	W-H/V	12/21/1999	1	1	1	1	1	1	1	1	1
	2DMR00603	2.71	40.74306	-74.12833	Mummichog	WHOLE ORGANISM	2/18/2000	1	1	1	1	1	1	1	1	1
	2DMR00727	3.07	40.7415	-74.13317	White perch	W-H/V	3/15/2000	1	1	1	1				1	1
	2DMR00728	3.07	40.7415	-74.13317	White perch	W-H/V	3/15/2000	1	1	1	1	1	1	1	1	1
	2DMR00729	3.07	40.7415	-74.13317	White perch	W-H/V	3/15/2000	1	1	1	1	1	1	1	1	1
	2DMR00730	3.07	40.7415	-74.13317	White perch	W-H/V	3/15/2000	1	1	1	1				1	1
	2DMR00731	3.07	40.7415	-74.13317	White perch	W-H/V	3/15/2000	1	1	1	1	1	1	1	1	1
	2DMR00732	3.07	40.7415	-74.13317	White perch	W-H/V	3/15/2000	1	1	1	1				1	1
	2DMR00733	3.07	40.7415	-74.13317	White perch	W-H/V	3/15/2000	1	1	1	1				1	1
	2DMR00734	3.07	40.7415	-74.13317	White perch	W-H/V	3/15/2000	1	1	1	1	1	1	1	1	1
	2DMR00735	3.07	40.7415	-74.13317	White perch	W-H/V	3/15/2000	1	1	1	1				1	1
	2DMR00736	3.07	40.7415	-74.13317	White perch	W-H/V	3/15/2000	1	1	1	1				1	1
	2DMR01365	2.73	40.74306	-74.12861	Mummichog	WHOLE ORG--HOMOGENIZED	5/2/2000					1	1	1	1	
	2DMR01413	2.76	40.74222	-74.12917	White perch	W-H/V	5/2/2000					1	1	1	1	
	2DMR01414	2.76	40.74222	-74.12917	White perch	W-H/V	5/2/2000					1	1	1	1	
	2DMR01415	2.76	40.74222	-74.12917	White perch	W-H/V	5/2/2000					1	1	1	1	
	2DMR01416	2.76	40.74222	-74.12917	White perch	W-H/V	5/2/2000					1	1	1	1	
	2DMR01417	2.76	40.74222	-74.12917	White perch	W-H/V	5/2/2000								1	
	2DMR01418	2.76	40.74222	-74.12917	White perch	W-H/V	5/2/2000					1	1	1	1	
	2DMR01419	2.76	40.74222	-74.12917	White perch	W-H/V	5/2/2000					1	1	1	1	
	2DMR01420	2.76	40.74222	-74.12917	White perch	W-H/V	5/2/2000								1	
	2DMR01421	2.76	40.74222	-74.12917	White perch	W-H/V	5/2/2000								1	
	2DMR01422	2.76	40.74222	-74.12917	White perch	W-H/V	5/2/2000								1	
Grand Total								42	42	42	42	32	31	31	53	42

Table 1-2 Summary of CARP Blue Crab Tissue Data Used in Assessment

Lower Passaic River Risk Assessment - Focused Feasibility Study

	Parameter							Group									
STUDY_NAME	Sample_ID	river_mile_update	LATITUDE	LONGITUDE	Species_Code	Matrix	Datetime_Placed	Aroclor	Chlordane	DDT	Dieldrin	Dioxin/Furan	Mercury	PCBs	Lead	HMW PAH	LMW PAH
Harbor Crustacean Collection	2DMR00958	2.96	40.74117	-74.13333	Blue crab	HEPATOPANCREAS	9/10/1999	1					1	1	1		
	2DMR00959	2.96	40.74117	-74.13333	Blue crab	MUSCLE TISSUE	9/10/1999	1	1	1	1		1	1	1		
	2DMR00960	2.96	40.74117	-74.13333	Blue crab	HEPATOPANCREAS	9/10/1999									1	1
	2DMR00961	2.96	40.74117	-74.13333	Blue crab	MUSCLE TISSUE	9/10/1999									1	1
	2DMR00962	2.96	40.74117	-74.13333	Blue crab	HEPATOPANCREAS	9/10/1999	1	1	1	1		1	1	1		
	2DMR00963	2.96	40.74117	-74.13333	Blue crab	MUSCLE TISSUE	9/10/1999	1	1	1	1		1	1	1		
	2DMR00964	2.96	40.74117	-74.13333	Blue crab	HEPATOPANCREAS	9/10/1999									1	1
	2DMR00965	2.96	40.74117	-74.13333	Blue crab	MUSCLE TISSUE	9/10/1999									1	1
	2DMR00980	2.78	40.74133	-74.13033	Blue crab	HEPATOPANCREAS	9/23/1999						1	1	1		
	2DMR00981	2.78	40.74133	-74.13033	Blue crab	MUSCLE TISSUE	9/23/1999						1	1	1		
	2DMR00983	2.78	40.74133	-74.13033	Blue crab	MUSCLE TISSUE	9/23/1999									1	1
	2DMR00994	2.96	40.74117	-74.13333	Blue crab	ALL EDIBLE TISSUE	9/10/1999		1	1	1	1	1	1	1	1	1
	2DMR00995	2.96	40.74117	-74.13333	Blue crab	ALL EDIBLE TISSUE	9/10/1999	1	1	1	1		1	1	1		
	2DMR00998	2.96	40.74117	-74.13333	Blue crab	ALL EDIBLE TISSUE	9/10/1999	1	1	1	1		1	1	1		
	2DMR00999	2.96	40.74117	-74.13333	Blue crab	ALL EDIBLE TISSUE	9/10/1999	1	1	1	1		1	1	1		
	2DMR01000	2.96	40.74117	-74.13333	Blue crab	ALL EDIBLE TISSUE	9/10/1999	1	1	1	1	1	1	1	1	1	1
	2DMR01001	2.96	40.74117	-74.13333	Blue crab	ALL EDIBLE TISSUE	9/10/1999	1	1	1	1	1	1	1	1	1	1
	2DMR01002	2.78	40.74133	-74.13033	Blue crab	ALL EDIBLE TISSUE	9/23/1999	1	1	1	1	1	1	1	1	1	1
	2DMR01003	2.78	40.74133	-74.13033	Blue crab	ALL EDIBLE TISSUE	9/23/1999	1	1	1	1	1	1	1	1	1	1
Grand Total								11	11	11	11	5	14	14	14	10	10

Table 1-3 Summary of PREmis Tissue Data Used in Assessment

Lower Passaic River Risk Assessment - Focused Feasibility Study

	Parameter							Group											
Study_Name	Sample_ID	river_mile_update	X_Coord	Y_Coord	Species_Code	Matrix	Datetime_Placed	Aroclor	Chlordane	Copper	DDT	Dieldrin	Dioxin/Furan	HMW PAH	Lead	LMW PAH	Mercury	Methyl Mercury	PCBs
93F64HR: HACKENSACK RIVER	DMDAT004674	0.01	598160.4136	683396.7222	MACOMA NASUTA	TISSUE	7/1/1993		1	1	1	1		1	1	1	1		1
	DMDAT004675	0.01	598160.4136	683396.7222	NEREIS VIRENS	TISSUE	7/1/1993		1	1	1	1	1	1	1	1	1		1
NYSDEC 1993	125520_NY085	0.1	599511.1474	685133.0802	BUTFS	SF	10/19/1993	1	1		1	1					1		
	125521_NY085	0.1	599511.1474	685133.0802	BUTFS	SF	10/19/1993	1	1		1	1					1		
	125522_NY085	0.1	599511.1474	685133.0802	BUTFS	SF	10/19/1993	1	1		1	1					1		
	125527A_NY085	0.1	599511.1474	685133.0802	STB	HEP	10/19/1993								1		1		
	125527B_NY085	0.1	599511.1474	685133.0802	STB	MSCL	10/19/1993								1		1		
	125527STB_NY085	0.1	599511.1474	685133.0802	STB	SF	10/19/1993	1	1		1	1					1		
	125528A_NY085	0.1	599511.1474	685133.0802	BCRAB	HEP	10/19/1993	1	1		1	1							
	125528B_NY085	0.1	599511.1474	685133.0802	BCRAB	MSCL	10/19/1993	1	1		1	1							
	125529A_NY085	0.1	599511.1474	685133.0802	BCRAB	HEP	10/19/1993								1		1		
	125529B_NY085	0.1	599511.1474	685133.0802	BCRAB	MSCL	10/19/1993								1		1		
	125530A_NY085	0.1	599511.1474	685133.0802	BCRAB	HEP	10/19/1993						1						
	125530B_NY085	0.1	599511.1474	685133.0802	BCRAB	MSCL	10/19/1993						1						
	125532_NY085	0.1	599511.1474	685133.0802	SCUP	SF	10/19/1993	1	1		1	1					1		
	125534A_NY085	0.1	599511.1474	685133.0802	BCRAB	HEP	10/19/1993						1						
	125534B_NY085	0.1	599511.1474	685133.0802	BCRAB	MSCL	10/19/1993						1						
NYSDEC 1994	129238_NY086	0.85	597003.1844	688182.2936	WP	SF	4/22/1994	1	1		1	1					1		
	129239_NY086	0.85	597003.1844	688182.2936	WP	SF	4/22/1994	1	1		1	1					1		
	129240_NY086	0.85	597003.1844	688182.2936	WP	SF	4/22/1994	1	1		1	1					1		
	129242_NY086	0.85	597003.1844	688182.2936	WP	SF	4/22/1994	1	1		1	1					1		
	129243_NY086	0.85	597003.1844	688182.2936	WP	SF	4/22/1994	1	1		1	1	1				1		
PASSAIC 1995 Biological Sampling Program	BCH1	1.99	598212	694717	Crab	TISSUE	9/14/1995	1	1	1	1	1	1	1	1	1	1	1	1
	BCH2	4.5	586142	692573	Crab	TISSUE	9/14/1995	1	1	1	1	1	1	1	1	1	1	1	1
	BCM1A	1.99	598212	694717	Crab	TISSUE	9/14/1995	1	1	1	1	1	1	1	1	1	1	1	1
	BCM1B	1.83	597808	693258	Crab	TISSUE	9/14/1995	1	1	1	1	1	1	1	1	1	1	1	1
	BCM2A	4.5	586142	692573	Crab	TISSUE	9/14/1995	1	1	1	1	1	1	1	1	1	1	1	1
	BCM2B	4.36	587691	692539	Crab	TISSUE	9/14/1995	1	1	1	1	1	1	1	1	1	1	1	1
	MUM1A	1.99	598212	694717	Mummichog	TISSUE	9/14/1995	1	1	1	1	1	1	1	1	1	1	1	1
	MUM1B	1.83	597808	693258	Mummichog	TISSUE	9/14/1995	1	1	1	1	1	1	1	1	1	1	1	1
	MUM2A	4.5	586142	692573	Mummichog	TISSUE	9/14/1995	1	1	1	1	1	1	1	1	1	1	1	1
	MUM2B	4.36	587691	692539	Mummichog	TISSUE	9/14/1995	1	1	1	1	1	1	1	1	1	1	1	1
	MUM3A	4.36	587691	692539	Mummichog	TISSUE	9/14/1995	1	1	1	1	1	1	1	1	1	1	1	1
	SB1	1.08	597437	689395	Striped Bass	TISSUE	9/14/1995	1	1	1	1	1	1	1	1	1	1	1	1
	SB2	1.41	597665	691072	Striped Bass	TISSUE	9/14/1995	1	1	1	1	1	1	1	1	1	1	1	1
PASSAIC 1999 Late Summer/Early Fall ESP Sampling Program	DTIBV01A	1.37	597422	690947	Transplant Ribbed Mussel	TISSUE	9/7/1999						1						1
	DTIBV01A - DUP-NWB	1.38	597535.1502	690981.5328	Transplanted Ribbed Mussel	TISSUE	9/7/1999						1						1
	DTIBV01B	2.29	597378	695377	Transplant Ribbed Mussel	TISSUE	9/7/1999	1	1	1	1	1		1	1	1	1		
	DTIBV01B - DUP-NWB	2.28	597490.535	695414.2147	Transplanted Ribbed Mussel	TISSUE	9/7/1999	1	1	1	1	1		1	1	1	1		
	DTIBV01C	4.22	588428	692596	Transplant Ribbed Mussel	TISSUE	9/7/1999							1		1			
	DTIBV01C - DUP-NWB	4.2	588541.0401	692631.3764	Transplanted Ribbed Mussel	TISSUE	9/7/1999							1		1			
	DTIBW01	1.8	597839	693098	Crab	TISSUE	10/22/1999	1	1	1	1	1	1	1	1	1	1		1
	DTIBW01 - DUP-NWB	1.81	597953.1846	693134.5475	Crab	TISSUE	10/22/1999	1	1	1	1	1	1	1	1	1	1		1
	DTIMW01	4.21	588447	692644	Mummichog	TISSUE	10/19/1999	1	1	1	1	1	1	1	1	1	1		1
	DTIMW01 - DUP-NWB	4.19	588559.1292	692679.3379	Mummichog	TISSUE	10/19/1999	1	1	1	1	1	1	1	1	1	1		1
	DTIMW02	4.2	588552	692644	Mummichog	TISSUE	10/20/1999	1	1	1	1	1	1	1	1	1	1		1
	DTIMW02 - DUP-NWB	4.17	588666.1216	692680.1357	Mummichog	TISSUE	10/20/1999	1	1	1	1	1	1	1	1	1	1		1
	DTIMW05	1.8	597839	693098	Crab	TISSUE	10/25/1999	1	1	1	1	1	1	1	1	1	1		1
	DTIMW05 - DUP-NWB	1.81	597953.1846	693134.5475	Crab	TISSUE	10/25/1999	1	1	1	1	1	1	1	1	1	1		1
	DTIMW06	2.29	597378	695384	Crab	TISSUE	10/26/1999	1	1	1	1	1	1	1	1	1	1		1
	DTIMW06 - DUP-NWB	2.28	597491.5443	695419.2123	Crab	TISSUE	10/26/1999	1	1	1	1	1	1	1	1	1	1		1
	DTIMW07	1.48	597844	691422	Adult Striped Bass	TISSUE	10/27/1999	1	1	1	1	1	1	1	1	1	1		1
	DTIMW07 - DUP-NWB	1.49	597956.0159	691458.6944	Adult Striped Bass	TISSUE	10/27/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9901TIBH1	1.35	597386	690845	Crab	TISSUE	10/25/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9901TIBH1-NWB	1.36	597499.9643	690881.6084	Crab	TISSUE	10/25/1999						1						
	PR9901TIBM1	1.35	597386	690845	Crab	TISSUE	10/22/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9901TIBM1-NWB	1.36	597499.9643	690881.6084	Crab	TISSUE	10/22/1999						1						
	PR9901TIBV	1.37	597422	690947	Transplant Ribbed Mussel	TISSUE	9/7/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9901TIBW1	1.35	597386	690845	Crab	TISSUE	10/22/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9901TIBW1-NWB	1.36	597499.9643	690881.6084	Crab	TISSUE	10/22/1999						1						
	PR9901TIFF13	1.48	597844	691422	Adult Striped Bass	TISSUE	10/28/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9901TIFF13-NWB	1.49	597956.0159	691458.6944	Adult Striped Bass	TISSUE	10/28/1999						1				1		
	PR9901TIFF3	1.48	597844	691422	Adult Striped Bass	TISSUE	10/27/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9901TIFF3-NWB	1.49	597956.0159	691458.6944	Adult Striped Bass	TISSUE	10/27/1999												1
	PR9901TIFF4	1.48	597844	691422	Adult Striped Bass	TISSUE	10/27/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9901TIFF4-NWB	1.49	597956.0159	691458.6944	Adult Striped Bass	TISSUE	10/27/1999						1						1
	PR9901TIFF8	1.48	597844	691422	Bluefish	TISSUE	10/28/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9901TIFW10	1.48	597844	691422	Atlantic Menhaden	TISSUE	10/28/1999	1	1	1	1	1	1	1	1	1	1		1

Table 1-3 Summary of PREmis Tissue Data Used in Assessment

Lower Passaic River Risk Assessment - Focused Feasibility Study

	Parameter							Group										
Study_Name	Sample_ID	river_mile_update	X_Coord	Y_Coord	Species_Code	Matrix	Datetime_Placed	Aroclor	Chlordane	Copper	DDT	Dieldrin	Dioxin/Furan	HMW PAH	Lead	LMW PAH	Mercury	Methyl Mercury	PCBs
PASSAIC 1999 Late Summer/Early Fall ESP Sampling Program	PR9901TIFW15	1.48	597844	691422	Atlantic Menhaden	TISSUE	10/28/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9901TIFW16	1.48	597844	691422	Adult Striped Bass	TISSUE	10/28/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9901TIFW16-NWB	1.49	597956.0159	691458.6944	Adult Striped Bass	TISSUE	10/28/1999						1						
	PR9901TIFW23	1.48	597844	691422	Bluefish	TISSUE	10/28/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9901TIFW23-NWB	1.49	597956.0159	691458.6944	Bluefish	TISSUE	10/28/1999						1						
	PR9901TIFW24	1.48	597844	691422	Atlantic Menhaden	TISSUE	10/28/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9901TIFW25	1.48	597844	691422	Bluefish	TISSUE	10/28/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9901TIFW5	1.48	597844	691422	Adult Striped Bass	TISSUE	10/27/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9901TIFW5-NWB	1.49	597956.0159	691458.6944	Adult Striped Bass	TISSUE	10/27/1999						1						1
	PR9901TIMWL	1.32	597321	690677	Mummichog	TISSUE	10/20/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9901TIMWL-NWB	1.33	597433.6546	690714.7488	Mummichog	TISSUE	10/20/1999						1		1				
	PR9901TIMWM	1.34	597339	690826	Mummichog	TISSUE	10/20/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9901TIMWM-NWB	1.36	597452.9345	690863.6989	Mummichog	TISSUE	10/20/1999						1		1				
	PR9901TIMWU	1.37	597386	690969	Mummichog	TISSUE	10/20/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9901TIMWU-NWB	1.39	597500.1949	691003.5969	Mummichog	TISSUE	10/20/1999						1		1				
	PR9902TIBH1	1.8	597839	693098	Crab	TISSUE	10/25/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9902TIBM1	1.8	597839	693098	Crab	TISSUE	10/25/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9902TIBM1-NWB	1.81	597953.1846	693134.5475	Crab	TISSUE	10/25/1999												1
	PR9902TIBV	1.8	597842	693098	Transplant Ribbed Mussel	TISSUE	9/7/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9902TIBW1	1.8	597839	693098	Crab	TISSUE	10/22/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9902TIMWL	1.78	597804	692989	Mummichog	TISSUE	10/20/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9902TIMWL-NWB	1.78	597917.9817	693025.6239	Mummichog	TISSUE	10/20/1999						1		1				
	PR9902TIMWM	1.8	597815	693098	Mummichog	TISSUE	10/20/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9902TIMWM-NWB	1.81	597926.1852	693133.5986	Mummichog	TISSUE	10/20/1999						1		1				
	PR9902TIMWU	1.82	597833	693226	Mummichog	TISSUE	10/20/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9902TIMWU-NWB	1.83	597947.4271	693262.5468	Mummichog	TISSUE	10/20/1999						1		1				
	PR9903TIBH1	2.29	597378	695384	Crab	TISSUE	10/25/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9903TIBM1	2.29	597378	695384	Crab	TISSUE	10/26/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9903TIBM1-NWB	2.28	597491.5443	695419.2123	Crab	TISSUE	10/26/1999								1				1
	PR9903TIBV	2.29	597378	695377	Transplant Ribbed Mussel	TISSUE	9/7/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9903TIBW1	2.29	597378	695384	Crab	TISSUE	10/22/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9903TIBW1-NWB	2.28	597491.5443	695419.2123	Crab	TISSUE	10/22/1999						1						
	PR9903TIMWL	2.27	597497	695337	Mummichog	TISSUE	10/19/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9903TIMWL-NWB	2.26	597609.4487	695373.9936	Mummichog	TISSUE	10/19/1999						1						
	PR9903TIMWM	2.29	597386	695399	Mummichog	TISSUE	10/19/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9903TIMWM-NWB	2.28	597498.572	695434.1977	Mummichog	TISSUE	10/19/1999						1						
	PR9903TIMWU	2.31	597303	695453	Mummichog	TISSUE	10/19/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9903TIMWU-NWB	2.3	597414.6854	695490.3511	Mummichog	TISSUE	10/19/1999						1						
	PR9903TISVL	2.27	597497	695337	Silverside	TISSUE	10/26/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9903TISVL-NWB	2.26	597609.4487	695373.9936	Silverside	TISSUE	10/26/1999								1				
	PR9903TISVM	2.29	597386	695399	Silverside	TISSUE	10/26/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9903TISVM-NWB	2.28	597498.572	695434.1977	Silverside	TISSUE	10/26/1999								1				
	PR9903TISVU	2.31	597303	695453	Silverside	TISSUE	10/26/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9903TISVU-NWB	2.3	597414.6854	695490.3511	Silverside	TISSUE	10/26/1999						1		1				
	PR9904TIBH1	2.77	594818	695227	Crab	TISSUE	10/25/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9904TIBH1-NWB	2.75	594932.4707	695264.0623	Crab	TISSUE	10/25/1999						1						
	PR9904TIBM1	2.77	594818	695227	Crab	TISSUE	10/22/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9904TIBM1-NWB	2.75	594932.4707	695264.0623	Crab	TISSUE	10/22/1999						1						1
	PR9904TIBV	2.77	594818	695235	Transplant Ribbed Mussel	TISSUE	9/7/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9904TIBW1	2.77	594818	695227	Crab	TISSUE	10/22/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9904TIFF1	2.72	595066	695516	Adult Striped Bass	TISSUE	10/27/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9904TIFF1-NWB	2.7	595178.9913	695550.5705	Adult Striped Bass	TISSUE	10/27/1999						1						1
	PR9904TIFW1	2.72	595066	695516	Adult Striped Bass	TISSUE	10/28/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9904TIFW2	2.72	595066	695516	White Perch	TISSUE	10/27/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9904TIFW2-NWB	2.7	595178.9913	695550.5705	White Perch	TISSUE	10/27/1999						1						
	PR9904TIMWL	2.74	594973	695232	Mummichog	TISSUE	10/19/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9904TIMWM	2.77	594838	695206	Mummichog	TISSUE	10/19/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9904TIMWM-NWB	2.75	594951.4255	695241.0285	Mummichog	TISSUE	10/19/1999						1						
	PR9904TIMWU	2.79	594733	695176	Mummichog	TISSUE	10/19/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9904TIMWU-NWB	2.77	594846.3763	695210.2298	Mummichog	TISSUE	10/19/1999						1						
	PR9905TIBH1	3.2	592501	695349	Crab	TISSUE	10/25/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9905TIBH1-NWB	3.18	592612.8988	695385.4346	Crab	TISSUE	10/25/1999						1						
	PR9905TIBM1	3.2	592501	695349	Crab	TISSUE	10/22/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9905TIBM1-NWB	3.18	592612.8988	695385.4346	Crab	TISSUE	10/22/1999						1						
	PR9905TIBV	3.2	592507	695341	Transplant Ribbed Mussel	TISSUE	9/7/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9905TIBW1	3.2	592501	695349	Crab	TISSUE	10/22/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9905TIBW1-NWB	3.18	592612.8988	695385.4346	Crab	TISSUE	10/22/1999						1						
	PR9905TIMWL	3.18	592606	695415	Mummichog	TISSUE	10/19/1999	1	1	1	1	1	1	1	1	1	1		1

Table 1-3 Summary of PREmis Tissue Data Used in Assessment

Lower Passaic River Risk Assessment - Focused Feasibility Study

	Parameter							Group											
Study_Name	Sample_ID	river_mile_update	X_Coord	Y_Coord	Species_Code	Matrix	Datetime_Placed	Aroclor	Chlordane	Copper	DDT	Dieldrin	Dioxin/Furan	HMW PAH	Lead	LMW PAH	Mercury	Methyl Mercury	PCBs
PASSAIC 1999 Late Summer/Early Fall ESP Sampling Program	PR9905TIMWL-NWB	3.16	592718.0104	695449.2302	Mummichog	TISSUE	10/19/1999						1						
	PR9905TIMWM	3.21	592490	695378	Mummichog	TISSUE	10/19/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9905TIMWM-NWB	3.18	592603.9525	695413.449	Mummichog	TISSUE	10/19/1999						1						
	PR9905TIMWU	3.23	592374	695334	Mummichog	TISSUE	10/19/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9905TIMWU-NWB	3.21	592486.8779	695368.6743	Mummichog	TISSUE	10/19/1999						1						
	PR9906TIBH1	3.88	590020	692898	Crab	TISSUE	10/25/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9906TIBH1-NWB	3.86	590132.4751	692933.3424	Crab	TISSUE	10/25/1999						1						
	PR9906TIBM1	3.88	590020	692898	Crab	TISSUE	10/26/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9906TIBM1-NWB	3.86	590132.4751	692933.3424	Crab	TISSUE	10/26/1999								1				1
	PR9906TIBV	3.88	590029	692887	Transplant Ribbed Mussel	TISSUE	9/7/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9906TIBV-NWB	3.86	590142.4535	692922.3245	Transplanted Ribbed Mussel	TISSUE	9/7/1999						1						
	PR9906TIBW1	3.88	590020	692898	Crab	TISSUE	10/22/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9906TIBW1-NWB	3.86	590132.4751	692933.3424	Crab	TISSUE	10/22/1999						1						
	PR9906TIMWL	3.85	590114	693022	Mummichog	TISSUE	10/19/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9906TIMWL-NWB	3.83	590227.701	693057.1514	Mummichog	TISSUE	10/19/1999						1						
	PR9906TIMWM	3.88	590012	692934	Mummichog	TISSUE	10/19/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9906TIMWM-NWB	3.85	590123.544	692969.356	Mummichog	TISSUE	10/19/1999						1						
	PR9906TIMWU	3.9	589904	692875	Mummichog	TISSUE	10/19/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9906TIMWU-NWB	3.88	590015.444	692911.5655	Mummichog	TISSUE	10/19/1999						1						
	PR9907TIBH1	4.07	589145	692158	Crab	TISSUE	10/25/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9907TIBM1	4.07	589145	692158	Crab	TISSUE	10/22/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9907TIBM1-NWB	4.06	589256.1507	692193.0646	Crab	TISSUE	10/22/1999						1						1
	PR9907TIBV	4.07	589147	692169	Transplant Ribbed Mussel	TISSUE	9/7/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9907TIBV-NWB	4.06	589260.1711	692204.0561	Transplanted Ribbed Mussel	TISSUE	9/7/1999						1						
	PR9907TIBW1	4.07	589145	692158	Crab	TISSUE	10/22/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9907TIBW1-NWB	4.06	589256.1507	692193.0646	Crab	TISSUE	10/22/1999						1						
	PR9907TIMWL	4.06	589264	692141	Mummichog	TISSUE	10/19/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9907TIMWL-NWB	4.04	589377.1097	692176.8376	Mummichog	TISSUE	10/19/1999						1						
	PR9907TIMWM	4.07	589139	692129	Mummichog	TISSUE	10/19/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9907TIMWM-NWB	4.06	589253.0961	692164.073	Mummichog	TISSUE	10/19/1999						1						
	PR9907TIMWU	4.09	589031	692118	Mummichog	TISSUE	10/19/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9907TIMWU-NWB	4.07	589145.0868	692154.278	Mummichog	TISSUE	10/19/1999						1						
	PR9908TIBH1	4.22	588428	692607	Crab	TISSUE	10/25/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9908TIBH1-NWB	4.2	588542.0627	692643.3734	Crab	TISSUE	10/25/1999						1						
	PR9908TIBM1	4.22	588428	692607	Crab	TISSUE	10/25/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9908TIBM1-NWB	4.2	588542.0627	692643.3734	Crab	TISSUE	10/25/1999												1
	PR9908TIBV	4.22	588428	692596	Transplant Ribbed Mussel	TISSUE	9/7/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9908TIBV-NWB	4.2	588541.0401	692631.3764	Transplanted Ribbed Mussel	TISSUE	9/7/1999						1						
	PR9908TIBW1	4.22	588428	692607	Crab	TISSUE	10/22/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9908TIBW1-NWB	4.2	588542.0627	692643.3734	Crab	TISSUE	10/22/1999						1						
	PR9908TIFF14	4.23	588368	692396	Adult Striped Bass	TISSUE	10/28/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9908TIFW11	4.23	588368	692396	Atlantic Menhaden	TISSUE	10/28/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9908TIFW11-NWB	4.21	588479.6695	692432.5102	Atlantic Menhaden	TISSUE	10/28/1999						1						
	PR9908TIFW17	4.23	588368	692396	Atlantic Menhaden	TISSUE	10/27/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9908TIFW18	4.23	588368	692396	Atlantic Menhaden	TISSUE	10/27/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9908TIMWL	4.2	588552	692644	Mummichog	TISSUE	10/20/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9908TIMWL-NWB	4.17	588666.1216	692680.1357	Mummichog	TISSUE	10/20/1999						1		1				
	PR9908TIMWM	4.21	588447	692644	Mummichog	TISSUE	10/19/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9908TIMWM-NWB	4.19	588559.1292	692679.3379	Mummichog	TISSUE	10/19/1999						1						
	PR9908TIMWU	4.24	588325	692636	Mummichog	TISSUE	10/21/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9908TIMWU-NWB	4.22	588437.123	692670.5692	Mummichog	TISSUE	10/21/1999								1				
	PR9909TIBH1	5	585113	694267	Crab	TISSUE	10/25/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9909TIBM1	5	585113	694267	Crab	TISSUE	10/25/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9909TIBM1-NWB	5	585226.4785	694301.4897	Crab	TISSUE	10/25/1999												1
	PR9909TIBV	5	585124	694270	Transplant Ribbed Mussel	TISSUE	9/7/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9909TIBV-NWB	5	585237.487	694306.4685	Transplanted Ribbed Mussel	TISSUE	9/7/1999		1				1						
	PR9909TIBW1	5	585113	694267	Crab	TISSUE	10/22/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9909TIBW1-NWB	5	585226.4785	694301.4897	Crab	TISSUE	10/22/1999						1						
	PR9909TIMWL	4.97	585141	694132	Mummichog	TISSUE	10/21/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9909TIMWL-NWB	4.97	585253.221	694166.4512	Mummichog	TISSUE	10/21/1999						1		1				
	PR9909TIMWM	5	585102	694270	Mummichog	TISSUE	10/20/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9909TIMWM-NWB	5	585213.491	694307.5137	Mummichog	TISSUE	10/20/1999						1		1				
	PR9909TIMWU	5.02	585063	694368	Mummichog	TISSUE	10/20/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9909TIMWU-NWB	5.02	585174.6796	694405.5783	Mummichog	TISSUE	10/20/1999						1		1				
	PR9910TIBH1	5.66	584484	697751	Crab	TISSUE	10/25/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9910TIBH1-NWB	5.66	584597.1172	697785.3679	Crab	TISSUE	10/25/1999						1						
	PR9910TIBM1	5.66	584484	697751	Crab	TISSUE	10/25/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9910TIBM1-NWB	5.66	584597.1172	697785.3679	Crab	TISSUE	10/25/1999							1		1			1

Table 1-3 Summary of PREmis Tissue Data Used in Assessment

Lower Passaic River Risk Assessment - Focused Feasibility Study

	Parameter							Group										
Study_Name	Sample_ID	river_mile_update	X_Coord	Y_Coord	Species_Code	Matrix	Datetime_Placed	Aroclor	Chlordane	Copper	DDT	Dieldrin	Dioxin/Furan	HMW PAH	Lead	LMW PAH	Mercury	Methyl Mercury	PCBs
PASSAIC 1999 Late Summer/Early Fall ESP Sampling Program	PR9910TIBV	5.66	584507	697751	Transplant Ribbed Mussel	TISSUE	9/7/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9910TIBW1	5.66	584484	697751	Crab	TISSUE	10/22/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9910TIBW1-NWB	5.66	584597.1172	697785.3679	Crab	TISSUE	10/22/1999						1						
	PR9910TIMWL	5.63	584452	697663	Mummichog	TISSUE	10/19/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9910TIMWL-NWB	5.65	584564.9593	697700.4363	Mummichog	TISSUE	10/19/1999						1						
	PR9910TIMWM	5.66	584462	697765	Mummichog	TISSUE	10/19/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9910TIMWM-NWB	5.66	584575.1493	697801.408	Mummichog	TISSUE	10/19/1999						1						
	PR9910TIMWU	5.67	584484	697867	Mummichog	TISSUE	10/19/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9910TIMWU-NWB	5.68	584596.3403	697903.3588	Mummichog	TISSUE	10/19/1999						1						
	PR9911TIBH1	6.29	585239	701076	Crab	TISSUE	10/25/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9911TIBM1	6.29	585239	701076	Crab	TISSUE	10/26/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9911TIBM1-NWB	6.31	585352.3527	701110.6587	Crab	TISSUE	10/26/1999								1				1
	PR9911TIBV	6.3	585231	701083	Transplant Ribbed Mussel	TISSUE	9/7/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9911TIBW1	6.29	585239	701076	Crab	TISSUE	10/22/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9911TIBW1-NWB	6.31	585352.3527	701110.6587	Crab	TISSUE	10/22/1999						1						
	PR9911TIFF2	6.28	585170	701003	Adult Striped Bass	TISSUE	10/27/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9911TIFF2-NWB	6.29	585283.2242	701039.7954	Adult Striped Bass	TISSUE	10/27/1999						1						1
	PR9911TIFW13	6.28	585170	701003	White Perch	TISSUE	10/27/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9911TIFW13-NWB	6.29	585283.2242	701039.7954	White Perch	TISSUE	10/27/1999						1						
	PR9911TIFW14	6.28	585170	701003	White Perch	TISSUE	10/27/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9911TIFW21	6.28	585170	701003	White Perch	TISSUE	10/27/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9911TIFW21-NWB	6.29	585283.2242	701039.7954	White Perch	TISSUE	10/27/1999						1						
	PR9911TIFW22	6.28	585170	701003	White Perch	TISSUE	10/27/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9911TIFW22-NWB	6.29	585283.2242	701039.7954	White Perch	TISSUE	10/27/1999						1						1
	PR9911TIFW26	6.28	585170	701003	Juvenile Striped Bass	TISSUE	10/28/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9911TIFW26-NWB	6.29	585283.2242	701039.7954	Juvenile Striped Bass	TISSUE	10/28/1999						1						
	PR9911TIFW3	6.28	585170	701003	White Perch	TISSUE	10/27/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9911TIFW3-NWB	6.29	585283.2242	701039.7954	White Perch	TISSUE	10/27/1999						1						
	PR9911TIFW4	6.28	585170	701003	Juvenile Striped Bass	TISSUE	10/27/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9911TIFW4-NWB	6.29	585283.2242	701039.7954	Juvenile Striped Bass	TISSUE	10/27/1999						1						1
	PR9911TIMWL	6.27	585231	700941	Mummichog	TISSUE	10/20/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9911TIMWL-NWB	6.28	585345.0993	700976.6837	Mummichog	TISSUE	10/20/1999						1		1				
	PR9911TIMWM	6.29	585261	701069	Mummichog	TISSUE	10/20/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9911TIMWM-NWB	6.31	585374.3394	701104.6177	Mummichog	TISSUE	10/20/1999						1		1				
	PR9911TIMWU	6.32	585297	701182	Mummichog	TISSUE	10/20/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9911TIMWU-NWB	6.33	585408.5524	701218.5434	Mummichog	TISSUE	10/20/1999						1		1				
	PR9911TISVL	6.27	585231	700941	Silverside	TISSUE	10/26/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9911TISVL-NWB	6.28	585345.0993	700976.6837	Silverside	TISSUE	10/26/1999						1		1				
	PR9911TISVM	6.29	585261	701069	Silverside	TISSUE	10/26/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9911TISVM-NWB	6.31	585374.3394	701104.6177	Silverside	TISSUE	10/26/1999								1				
	PR9911TISVU	6.32	585297	701182	Silverside	TISSUE	10/26/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9911TISVU-NWB	6.33	585408.5524	701218.5434	Silverside	TISSUE	10/26/1999								1				1
	PR9912TIBH1	6.82	586310	703612	Crab	TISSUE	10/25/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9912TIBH1-NWB	6.84	586421.0689	703646.4253	Crab	TISSUE	10/25/1999						1						
	PR9912TIBM1	6.82	586310	703612	Crab	TISSUE	10/26/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9912TIBM1-NWB	6.84	586421.0689	703646.4253	Crab	TISSUE	10/26/1999								1				1
	PR9912TIBV	6.82	586321	703608	Transplant Ribbed Mussel	TISSUE	9/7/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9912TIBV-NWB	6.84	586433.066	703645.4027	Transplanted Ribbed Mussel	TISSUE	9/7/1999		1										
	PR9912TIBW1	6.82	586310	703612	Crab	TISSUE	10/22/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9912TIBW1-NWB	6.84	586421.0689	703646.4253	Crab	TISSUE	10/22/1999						1						
	PR9912TIMWL	6.8	586238	703539	Mummichog	TISSUE	10/20/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9912TIMWL-NWB	6.82	586350.9386	703574.564	Mummichog	TISSUE	10/20/1999						1		1				
	PR9912TIMWM	6.82	586296	703626	Mummichog	TISSUE	10/20/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9912TIMWM-NWB	6.84	586407.1005	703662.4504	Mummichog	TISSUE	10/20/1999						1		1				
	PR9912TIMWU	6.84	586378	703729	Mummichog	TISSUE	10/20/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9912TIMWU-NWB	6.86	586491.2883	703765.2826	Mummichog	TISSUE	10/20/1999						1		1				
	PR9913TIBH1	1.07	597049	689419	Crab	TISSUE	10/25/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9913TIBH1-NWB	1.08	597162.2935	689453.3759	Crab	TISSUE	10/25/1999						1						
	PR9913TIBM1	1.07	597049	689419	Crab	TISSUE	10/26/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9913TIBM1-NWB	1.08	597162.2935	689453.3759	Crab	TISSUE	10/26/1999								1				1
	PR9913TIBV	1.04	597013	689291	Transplant Ribbed Mussel	TISSUE	9/8/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9913TIBV-NWB	1.05	597127.0585	689327.4539	Transplanted Ribbed Mussel	TISSUE	9/8/1999						1						
	PR9913TIBW1	1.07	597049	689419	Crab	TISSUE	10/22/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9913TIMWL	1.04	596980	689291	Mummichog	TISSUE	10/20/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9913TIMWL-NWB	1.05	597094.0577	689325.5164	Mummichog	TISSUE	10/20/1999						1		1				
	PR9913TIMWM	1.06	597007	689408	Mummichog	TISSUE	10/21/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9913TIMWM-NWB	1.07	597120.2803	689444.4561	Mummichog	TISSUE	10/21/1999						1		1				
	PR9913TIMWU	1.1	597067	689619	Mummichog	TISSUE	10/20/1999	1	1	1	1	1	1	1	1	1	1		1

Table 1-3 Summary of PREmis Tissue Data Used in Assessment

Lower Passaic River Risk Assessment - Focused Feasibility Study

	Parameter							Group										
Study_Name	Sample_ID	river_mile_update	X_Coord	Y_Coord	Species_Code	Matrix	Datetime_Placed	Aroclor	Chlordane	Copper	DDT	Dieldrin	Dioxin/Furan	HMW PAH	Lead	LMW PAH	Mercury	Methyl Mercury	PCBs
PASSAIC 1999 Late Summer/Early Fall ESP Sampling Program	PR9913TIMWU-NWB	1.12	597180.6718	689654.323	Mummichog	TISSUE	10/20/1999						1		1				
	PR9914TIBH1	3.14	592966	694986	Crab	TISSUE	10/25/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9914TIBH1-NWB	3.11	593077.1749	695023.5899	Crab	TISSUE	10/25/1999						1						
	PR9914TIBM1	3.14	592966	694986	Crab	TISSUE	10/26/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9914TIBM1-NWB	3.11	593077.1749	695023.5899	Crab	TISSUE	10/26/1999								1				
	PR9914TIBV	3.14	592963	694990	Transplant Ribbed Mussel	TISSUE	9/8/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9914TIBW1	3.14	592966	694986	Crab	TISSUE	10/22/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9914TIBW1-NWB	3.11	593077.1749	695023.5899	Crab	TISSUE	10/22/1999						1						
	PR9914TIMWL	3.11	593076	694994	Mummichog	TISSUE	10/21/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9914TIMWL-NWB	3.09	593188.1745	695028.3797	Mummichog	TISSUE	10/21/1999						1		1				
	PR9914TIMWM	3.14	592957	694983	Mummichog	TISSUE	10/21/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9914TIMWM-NWB	3.11	593071.166	695018.6017	Mummichog	TISSUE	10/21/1999						1		1				
	PR9914TIMWU	3.16	592847	694957	Mummichog	TISSUE	10/21/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9914TIMWU-NWB	3.14	592960.1249	694991.814	Mummichog	TISSUE	10/21/1999						1		1				
	PR9914TISVL	3.11	593076	694994	Silverside	TISSUE	10/26/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9914TISVL-NWB	3.09	593188.1745	695028.3797	Silverside	TISSUE	10/26/1999								1				
	PR9914TISVM	3.14	592957	694983	Silverside	TISSUE	10/26/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9914TISVM-NWB	3.11	593071.166	695018.6017	Silverside	TISSUE	10/26/1999								1				
	PR9914TISVU	3.16	592847	694957	Silverside	TISSUE	10/26/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9914TISVU-NWB	3.14	592960.1249	694991.814	Silverside	TISSUE	10/26/1999								1				
	PR9915TIBH1	4.29	588035	692577	Crab	TISSUE	10/25/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9915TIBM1	4.29	588035	692577	Crab	TISSUE	10/26/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9915TIBM1-NWB	4.27	588148.041	692614.1205	Crab	TISSUE	10/26/1999								1				1
	PR9915TIBV	4.29	588040	692566	Transplant Ribbed Mussel	TISSUE	9/8/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9915TIBV-NWB	4.27	588152.0198	692603.1139	Transplanted Ribbed Mussel	TISSUE	9/8/1999		1										
	PR9915TIBW1	4.29	588035	692577	Crab	TISSUE	10/22/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9915TIBW1-NWB	4.27	588148.041	692614.1205	Crab	TISSUE	10/22/1999						1						
	PR9915TIMWL	4.27	588156	692628	Mummichog	TISSUE	10/21/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9915TIMWL-NWB	4.25	588269.1285	692665.8871	Mummichog	TISSUE	10/21/1999								1				
	PR9915TIMWM	4.29	588051	692617	Mummichog	TISSUE	10/21/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9915TIMWM-NWB	4.27	588163.1115	692652.0886	Mummichog	TISSUE	10/21/1999								1				
	PR9915TIMWU	4.31	587940	692609	Mummichog	TISSUE	10/21/1999	1	1	1	1	1	1	1	1	1	1		1
	PR9915TIMWU-NWB	4.29	588054.1041	692643.2953	Mummichog	TISSUE	10/21/1999								1				
	PR997/15TIFF6	4.23	588368	692396	Adult Striped Bass	TISSUE	10/27/1999	1	1	1	1	1	1	1	1	1	1		1
	PR997/15TIFF6-NWB	4.21	588479.6695	692432.5102	Adult Striped Bass	TISSUE	10/27/1999						1						1
	PR997/15TIFW6	4.23	588368	692396	White Perch	TISSUE	10/27/1999	1	1	1	1	1	1	1	1	1	1		1
	PR997/15TIFW6-NWB	4.21	588479.6695	692432.5102	White Perch	TISSUE	10/27/1999						1						
	PR997/15TIFW7	4.23	588368	692396	White Perch	TISSUE	10/27/1999	1	1	1	1	1	1	1	1	1	1		1
	PR997/15TIFW7-NWB	4.21	588479.6695	692432.5102	White Perch	TISSUE	10/27/1999						1						
	PR997/15TIFW8	4.23	588368	692396	Juvenile Striped Bass	TISSUE	10/27/1999	1	1	1	1	1	1	1	1	1	1		1
	PR997/15TIFW8-NWB	4.21	588479.6695	692432.5102	Juvenile Striped Bass	TISSUE	10/27/1999						1						
	PR997/15TIFW9	4.23	588368	692396	White Perch	TISSUE	10/27/1999	1	1	1	1	1	1	1	1	1	1		1
	PR997/15TIFW9-NWB	4.21	588479.6695	692432.5102	White Perch	TISSUE	10/27/1999						1						
PASSAIC 2000 Spring ESP Sampling Program	DTIFF01	4.24	588315	692385	Adult Striped Bass	TISSUE	5/15/2000	1	1	1	1	1	1	1	1	1	1		1
	DTIFF01 - DUP-NWB	4.22	588426.6496	692419.6115	Adult Striped Bass	TISSUE	5/15/2000	1	1	1	1	1	1	1	1	1	1		1
	DTIFW01	1.51	597871	691594	Adult Striped Bass	TISSUE	5/16/2000	1	1	1	1	1	1	1	1	1	1		1
	DTIFW01 - DUP-NWB	1.52	597985.3347	691628.6236	Adult Striped Bass	TISSUE	5/16/2000	1	1	1	1	1	1	1	1	1	1		1
	DTIFW02	6.35	585257	701367	Adult Striped Bass	TISSUE	5/17/2000	1	1	1	1	1	1	1	1	1	1		1
	DTIFW02 - DUP-NWB	6.36	585369.9045	701402.6011	Adult Striped Bass	TISSUE	5/17/2000	1	1	1	1	1	1	1	1	1	1		1
	PR0001TIBM	1.35	597386	690845	Crab	TISSUE	5/12/2000	1	1	1	1	1	1	1	1	1	1		1
	PR0001TIBM-NWB	1.36	597499.9643	690881.6084	Crab	TISSUE	5/12/2000						1						
	PR0001TIBW	1.35	597386	690845	Crab	TISSUE	5/12/2000	1	1	1	1	1	1	1	1	1	1		1
	PR0001TIBW-NWB	1.36	597499.9643	690881.6084	Crab	TISSUE	5/12/2000						1						
	PR0001TIFF1	1.51	597871	691594	White Perch	TISSUE	5/12/2000	1	1	1	1	1	1	1	1	1	1		1
	PR0001TIFF1-NWB	1.52	597985.3347	691628.6236	White Perch	TISSUE	5/12/2000						1						
	PR0001TIFF2	1.51	597871	691594	White Perch	TISSUE	5/12/2000	1	1	1	1	1	1	1	1	1	1		1
	PR0001TIFF2-NWB	1.52	597985.3347	691628.6236	White Perch	TISSUE	5/12/2000						1						
	PR0001TIFF3	1.51	597871	691594	Adult Striped Bass	TISSUE	5/16/2000	1	1	1	1	1	1	1	1	1	1		1
	PR0001TIFF3-NWB	1.52	597985.3347	691628.6236	Adult Striped Bass	TISSUE	5/16/2000						1		1				
	PR0001TIFW1	1.51	597871	691594	Adult Striped Bass	TISSUE	5/16/2000	1	1	1	1	1	1	1	1	1	1		1
	PR0001TIFW1-NWB	1.52	597985.3347	691628.6236	Adult Striped Bass	TISSUE	5/16/2000						1		1				
	PR0001TIFW2	1.51	597871	691594	White Perch	TISSUE	5/16/2000	1	1	1	1	1	1	1	1	1	1		1
	PR0001TIFW2-NWB	1.52	597985.3347	691628.6236	White Perch	TISSUE	5/16/2000						1		1				
	PR0001TIFW3	1.51	597871	691594	White Perch	TISSUE	5/16/2000	1	1	1	1	1	1	1	1	1	1		1
	PR0001TIFW3-NWB	1.52	597985.3347	691628.6236	White Perch	TISSUE	5/16/2000						1		1				
	PR0001TIFW4	1.51	597871	691594	White Perch	TISSUE	5/16/2000	1	1	1	1	1	1	1	1	1	1		1
	PR0001TIFW4-NWB	1.52	597985.3347	691628.6236	White Perch	TISSUE	5/16/2000						1		1				
	PR0001TIFW5	1.45	597700	691294	American Eel	TISSUE	5/17/2000	1	1	1	1	1	1	1	1	1	1		1

Table 1-3 Summary of PREmis Tissue Data Used in Assessment

Lower Passaic River Risk Assessment - Focused Feasibility Study

	Parameter							Group											
Study_Name	Sample_ID	river_mile_update	X_Coord	Y_Coord	Species_Code	Matrix	Datetime_Placed	Aroclor	Chlordane	Copper	DDT	Dieldrin	Dioxin/Furan	HMW PAH	Lead	LMW PAH	Mercury	Methyl Mercury	PCBs
PASSAIC 2000 Spring ESP Sampling Program	PR0001TIFW5-NWB	1.46	597814.7867	691330.9728	American Eel	TISSUE	5/17/2000	1					1						
	PR0001TIMWM	1.35	597359	690841	Mummichog	TISSUE	5/17/2000	1	1	1	1	1	1	1	1	1	1		1
	PR0001TIMWM-NWB	1.36	597470.9593	690877.6635	Mummichog	TISSUE	5/17/2000						1						
	PR0008TIBM	4.22	588428	692607	Crab	TISSUE	5/12/2000	1	1	1	1	1	1	1	1	1	1		1
	PR0008TIBM-NWB	4.2	588542.0627	692643.3734	Crab	TISSUE	5/12/2000						1						
	PR0008TIBW	4.22	588428	692607	Crab	TISSUE	5/12/2000	1	1	1	1	1	1	1	1	1	1		1
	PR0008TIBW-NWB	4.2	588542.0627	692643.3734	Crab	TISSUE	5/12/2000						1						
	PR0008TIFF1	4.24	588315	692385	White Perch	TISSUE	5/12/2000	1	1	1	1	1	1	1	1	1	1		1
	PR0008TIFF1-NWB	4.22	588426.6496	692419.6115	White Perch	TISSUE	5/12/2000						1						
	PR0008TIFF2	4.24	588315	692385	Adult Striped Bass	TISSUE	5/15/2000	1	1	1	1	1	1	1	1	1	1		1
	PR0008TIFF2-NWB	4.22	588426.6496	692419.6115	Adult Striped Bass	TISSUE	5/15/2000						1						
	PR0008TIFF3	4.24	588315	692385	White Perch	TISSUE	5/12/2000	1	1	1	1	1	1	1	1	1	1		1
	PR0008TIFF3-NWB	4.22	588426.6496	692419.6115	White Perch	TISSUE	5/12/2000						1						
	PR0008TIFF4	4.24	588315	692385	Adult Striped Bass	TISSUE	5/15/2000	1	1	1	1	1	1	1	1	1	1		1
	PR0008TIFF4-NWB	4.22	588426.6496	692419.6115	Adult Striped Bass	TISSUE	5/15/2000						1						
	PR0008TIFW1	4.24	588315	692385	Adult Striped Bass	TISSUE	5/16/2000	1	1	1	1	1	1	1	1	1	1		1
	PR0008TIFW1-NWB	4.22	588426.6496	692419.6115	Adult Striped Bass	TISSUE	5/16/2000								1				
	PR0008TIFW2	4.24	588315	692385	White Perch	TISSUE	5/16/2000	1	1	1	1	1	1	1	1	1	1		1
	PR0008TIFW2-NWB	4.22	588426.6496	692419.6115	White Perch	TISSUE	5/16/2000						1		1				
	PR0008TIFW3	4.24	588315	692385	White Perch	TISSUE	5/16/2000	1	1	1	1	1	1	1	1	1	1		1
	PR0008TIFW3-NWB	4.22	588426.6496	692419.6115	White Perch	TISSUE	5/16/2000						1		1				
	PR0008TIFW4	4.24	588315	692385	White Perch	TISSUE	5/16/2000	1	1	1	1	1	1	1	1	1	1		1
	PR0008TIFW4-NWB	4.22	588426.6496	692419.6115	White Perch	TISSUE	5/16/2000						1		1				
	PR0008TIFW5	4.32	587908	692394	American Eel	TISSUE	5/17/2000	1	1	1	1	1	1	1	1	1	1		1
	PR0008TIFW5-NWB	4.3	588019.7027	692429.3795	American Eel	TISSUE	5/17/2000						1						
	PR0008TIFW6	4.32	587908	692394	American Eel	TISSUE	5/17/2000	1	1	1	1	1	1	1	1	1	1		1
	PR0008TIFW6-NWB	4.3	588019.7027	692429.3795	American Eel	TISSUE	5/17/2000	1					1						
	PR0008TIMWM	4.16	588744	692561	Mummichog	TISSUE	5/17/2000	1	1	1	1	1	1	1	1	1	1		1
	PR0008TIMWM-NWB	4.14	588856.9497	692597.7825	Mummichog	TISSUE	5/17/2000						1						
	PR0011TIBM	6.29	585239	701076	Crab	TISSUE	5/12/2000	1	1	1	1	1	1	1	1	1	1		1
	PR0011TIBW	6.29	585239	701076	Crab	TISSUE	5/12/2000	1	1	1	1	1	1	1	1	1	1		1
	PR0011TIBW-NWB	6.31	585352.3527	701110.6587	Crab	TISSUE	5/12/2000						1						
	PR0011TIFF1	6.35	585257	701367	White Perch	TISSUE	5/12/2000	1	1	1	1	1	1	1	1	1	1		1
	PR0011TIFF1-NWB	6.36	585369.9045	701402.6011	White Perch	TISSUE	5/12/2000						1						
	PR0011TIFF3	6.35	585257	701367	White Perch	TISSUE	5/15/2000	1	1	1	1	1	1	1	1	1	1		1
	PR0011TIFF3-NWB	6.36	585369.9045	701402.6011	White Perch	TISSUE	5/15/2000						1						
	PR0011TIFW1	6.35	585257	701367	White Perch	TISSUE	5/16/2000	1	1	1	1	1	1	1	1	1	1		1
	PR0011TIFW1-NWB	6.36	585369.9045	701402.6011	White Perch	TISSUE	5/16/2000						1		1				
	PR0011TIFW2	6.35	585257	701367	White Perch	TISSUE	5/16/2000	1	1	1	1	1	1	1	1	1	1		1
	PR0011TIFW2-NWB	6.36	585369.9045	701402.6011	White Perch	TISSUE	5/16/2000						1		1				
	PR0011TIFW3	6.35	585257	701367	White Perch	TISSUE	5/16/2000	1	1	1	1	1	1	1	1	1	1		1
	PR0011TIFW3-NWB	6.36	585369.9045	701402.6011	White Perch	TISSUE	5/16/2000						1		1				
	PR0011TIFW4	6.35	585257	701367	Adult Striped Bass	TISSUE	5/17/2000	1	1	1	1	1	1	1	1	1	1		1
	PR0011TIFW4-NWB	6.36	585369.9045	701402.6011	Adult Striped Bass	TISSUE	5/17/2000						1						
	PR0011TIFW5	6.23	584988	700762	American Eel	TISSUE	5/17/2000	1	1	1	1	1	1	1	1	1	1		1
	PR0011TIFW5-NWB	6.24	585099.7798	700797.1625	American Eel	TISSUE	5/17/2000						1						
	PR0011TIFW6	6.23	584988	700762	American Eel	TISSUE	5/17/2000	1	1	1	1	1	1	1	1	1	1		1
	PR0011TIFW6-NWB	6.24	585099.7798	700797.1625	American Eel	TISSUE	5/17/2000	1					1						
	PR0011TIFW7	6.23	584988	700762	American Eel	TISSUE	5/17/2000	1	1	1	1	1	1		1		1		1
	PR0011TIFW7-NWB	6.24	585099.7798	700797.1625	American Eel	TISSUE	5/17/2000	1					1						
	PR0011TIMWM	6.31	585286	701127	Mummichog	TISSUE	5/17/2000	1	1	1	1	1	1	1	1	1	1		1
	PR0011TIMWM-NWB	6.32	585399.4508	701164.5652	Mummichog	TISSUE	5/17/2000						1						
	PR0014TIBW	3.14	592966	694986	Crab	TISSUE	5/12/2000	1	1	1	1	1	1	1	1	1	1		1
	PR0014TIBW-NWB	3.11	593077.1749	695023.5899	Crab	TISSUE	5/12/2000						1						
	PR0014TIMWM	3.12	593043	694965	Mummichog	TISSUE	5/17/2000	1	1	1	1	1	1	1	1	1	1		1
	PR0014TIMWM-NWB	3.1	593157.1262	695001.4408	Mummichog	TISSUE	5/17/2000	1					1						

Table 1-3 Summary of PREmis Tissue Data Used in Assessment

Lower Passaic River Risk Assessment - Focused Feasibility Study

	Parameter							Group											
Study_Name	Sample_ID	river_mile_update	X_Coord	Y_Coord	Species_Code	Matrix	Datetime_Placed	Aroclor	Chlordane	Copper	DDT	Dieldrin	Dioxin/Furan	HMW PAH	Lead	LMW PAH	Mercury	Methyl Mercury	PCBs
PASSAIC 2001 Supplemental ESP Biota Sampling Program	DPRTIFF-1	6.22	585149	700711	American Eel	TISSUE	8/9/2001	1	1	1	1	1	1	1	1	1	1		1
	DPRTIFF-1 - DUP-NWB	6.22	585146.6165	700713.081	American Eel	TISSUE	8/9/2001	1	1	1	1	1	1	1	1	1	1		1
	PR01TIAE-1	6.22	585149	700711	American Eel	TISSUE	8/9/2001	1	1	1	1	1	1	1	1	1	1		1
	PR01TIAE-2	6.51	585590	702126	American Eel	TISSUE	8/6/2001	1	1	1	1	1	1	1	1	1	1		1
	PR01TIAE-3	6.61	585848	702576	American Eel	TISSUE	8/8/2001	1	1	1	1	1	1	1	1	1	1		1
	PR01TIAE-4	6.04	585125	699738	American Eel	TISSUE	8/6/2001	1	1	1	1	1	1	1	1	1	1		1
	PR01TIAE-5	6.46	585455	701896	American Eel	TISSUE	8/7/2001	1	1	1	1	1	1	1	1	1	1		1
	PR01TIAE-6	6.22	585149	700711	American Eel	TISSUE	8/9/2001	1	1	1	1	1	1	1	1	1	1		1
	PR01TICT-1	6.74	586234	703149	Brown Bullhead	TISSUE	8/9/2001	1	1	1	1	1	1	1	1	1	1		1
	PR01TICT-2	6.91	586746	703872	Brown Bullhead	TISSUE	8/9/2001	1	1	1	1	1	1	1	1	1	1		1
	PR01TICT-3	6.49	585443	702111	Brown Bullhead	TISSUE	8/9/2001	1	1	1	1	1	1	1	1	1	1		1
	PR01TICT-4	6.65	585978	702776	Brown Bullhead	TISSUE	8/9/2001	1	1	1	1	1	1	1	1	1	1		1
	PR01TICT-5	6.77	586330	703266	Brown Bullhead	TISSUE	8/9/2001	1	1	1	1	1	1	1	1	1	1		1
	PR01TICT-6	6.74	586234	703149	Brown Bullhead	TISSUE	8/9/2001	1	1	1	1	1	1	1	1	1	1		1
Grand Total								247	247	232	244	244	364	234	290	234	247	13	253

Table 1-4 Summary of Sediment Data Used in Assessment

Lower Passaic River Risk Assessment - Focused Feasibility Study

	Parameter								Group										
STUDY_NAME	SAMPLE_ID	RIVER_MILE	X_COORD	Y_COORD	DEPTH_TOP	DEPTH_BOTTOM	DEPTH_UNIT	DATETIME_PLACED	Aroclor	Chlordane	Copper	DDT	Dieldrin	Dioxin/Furan	HMW PAH	Lead	LMW PAH	Mercury	PCBs
HIGH RES CORE	LPRP-SCSH-PSR-000780	1.4	598078.73	691133.57	0	15	CM	9/20/2005							1		1		
	LPRP-SCSH-PSR-000854	2.2	597588.66	694851.81	0	18	CM	9/21/2005							1		1		
	LPRP-SCSH-PSR-000895	3.5	591083.92	694324.88	0	4	CM	9/27/2005							1		1		
	LPRP-SCSH-PSR-000896	3.5	591083.92	694324.88	4	8	CM	9/27/2005							1		1		
	LPRP-SCSH-PSR-000897	3.5	591083.92	694324.88	8	12	CM	9/27/2005							1		1		
	LPRP-SCSH-PSR-000898	3.5	591083.92	694324.88	12	16	CM	9/27/2005							1		1		
	LPRP-SCSH-PSR-000990	1.4	598078.73	691133.57	0	7.5	CM	9/20/2005			1					1			1
	LPRP-SCSH-PSR-000991	1.4	598078.73	691133.57	7.5	15	CM	9/20/2005			1					1			1
	LPRP-SCSH-PSR-001038	2.2	597588.66	694851.81	0	9	CM	9/21/2005			1					1			1
	LPRP-SCSH-PSR-001039	2.2	597588.66	694851.81	9	18	CM	9/21/2005			1					1			1
	LPRP-SCSH-PSR-001074	3.5	591083.92	694324.88	0	4	CM	9/27/2005			1					1			1
	LPRP-SCSH-PSR-001075	3.5	591083.92	694324.88	4	8	CM	9/27/2005			1					1			1
	LPRP-SCSH-PSR-001076	3.5	591083.92	694324.88	8	12	CM	9/27/2005			1					1			1
	LPRP-SCSH-PSR-001077	3.5	591083.92	694324.88	12	16	CM	9/27/2005			1					1			1
	LPRP-SCSH-PSR-001462	3.5	591083.92	694324.88	0	4	CM	9/27/2005		1		1		1					1
	LPRP-SCSH-PSR-001471	1.4	598078.73	691133.57	0	15	CM	9/20/2005		1		1		1					1
	LPRP-SCSH-PSR-001473	2.2	597588.66	694851.81	0	18	CM	9/21/2005		1		1		1					1
LOW RES CORE	LPRP-SCSH-PSR-001262	4.4	692488	587534	0	65	CM	1/12/2006	1		1				1	1	1	1	
	LPRP-SCSH-PSR-001270	4.2	692539	588391	0	70	CM	1/13/2006	1		1				1	1	1	1	
	LPRP-SCSH-PSR-001276	3.2	695065	592921	0	69	CM	1/13/2006	1		1				1	1	1	1	
	LPRP-SCSH-PSR-001283	4.9	693941	585444	0	44	CM	1/17/2006	1						1		1		
	LPRP-SCSH-PSR-001290	3.6	694150	591251	0	64	CM	1/17/2006	1						1		1		
	LPRP-SCSH-PSR-001296	3.8	693178	590521	0	58	CM	1/18/2006	1		1				1	1	1	1	
	LPRP-SCSH-PSR-001297	4.9	693941	585444	0	44	CM	1/17/2006		1		1	1	1					1
	LPRP-SCSH-PSR-001299	3.2	695065	592921	0	69	CM	1/13/2006		1		1	1	1					1
	LPRP-SCSH-PSR-001327	4.4	692488	587534	0	65	CM	1/12/2006		1		1	1	1					1
	LPRP-SCSH-PSR-001338	3.6	694150	591251	0	64	CM	1/17/2006		1		1	1	1					1
	LPRP-SCSH-PSR-001359	4.2	692539	588391	0	70	CM	1/13/2006		1		1	1	1					1
	LPRP-SCSH-PSR-001390	2.9	695644	594356	0	52	CM	1/18/2006	1		1				1	1	1	1	
	LPRP-SCSH-PSR-001397	3.1	695458	593148	0	49	CM	1/19/2006	1		1				1	1	1	1	
	LPRP-SCSH-PSR-001404	5.4	696206	584950	0	35	CM	1/19/2006	1		1				1	1	1	1	
	LPRP-SCSH-PSR-001409	6.7	703070	586317	0	49	CM	1/20/2006	1		1				1	1	1	1	
	LPRP-SCSH-PSR-001433	6.7	703070	586317	0	49	CM	1/20/2006		1		1	1	1					1
	LPRP-SCSH-PSR-001436	2.9	695644	594356	0	52	CM	1/18/2006		1		1	1	1					1
	LPRP-SCSH-PSR-001442	3.8	693178	590521	0	58	CM	1/18/2006		1		1	1	1					1
	LPRP-SCSH-PSR-001448	5.4	696206	584950	0	35	CM	1/19/2006		1		1	1	1					1
	LPRP-SCSH-PSR-001454	3.1	695458	593148	0	49	CM	1/19/2006		1		1	1	1					1
NOAA NS&T Hudson-Raritan Phase II- 1993	Q:1502:9300:27	7.37	587825.3141	706006.2663	0	0	(blank)	1/1/1993						1					
PASSAIC 1990 Surficial Sediment Investigation	R5	7	587167.2675	704316.9622	0	0.5	(blank)	2/21/1990	1		1	1	1	1	1	1	1	1	
PASSAIC 1991 Core Sediment Investigation	09A001	7.96	589394.5551	708774.3794	0	0.17	(blank)	12/3/1991	1	1		1	1	1	1	1	1	1	1
PASSAIC 1994 Surficial Sediment Investigation	HP1	(blank)	586511.5214	703894.2216	0	0.5	(blank)	9/1/1994	1	1	1	1	1	1	1	1	1	1	1
	HP10	(blank)	586501.4678	703864.2441	0	0.5	(blank)	9/1/1994	1	1	1	1	1	1	1	1	1	1	1
	HP2	(blank)	586503.5457	703897.2469	0	0.5	(blank)	9/1/1994	1	1	1	1	1	1	1	1	1	1	1
	HP3	(blank)	586511.5214	703891.2269	0	0.5	(blank)	9/1/1994	1	1	1	1	1	1	1	1	1	1	1
	HP4	(blank)	586519.5276	703886.2154	0	0.5	(blank)	9/1/1994	1	1	1	1	1	1	1	1	1	1	1
	HP5	(blank)	586521.5445	703897.2163	0	0.5	(blank)	9/1/1994	1	1	1	1	1	1	1	1	1	1	1
	HP6	(blank)	586513.5688	703907.2393	0	0.5	(blank)	9/1/1994	1	1	1	1	1	1	1	1	1	1	1
	HP7	(blank)	586514.5161	703883.2207	0	0.5	(blank)	9/1/1994	1	1	1	1	1	1	1	1	1	1	1
	HP8	(blank)	586497.5258	703883.2512	0	0.5	(blank)	9/1/1994	1	1	1	1	1	1	1	1	1	1	1
	HP9	(blank)	586499.4815	703873.2588	0	0.5	(blank)	9/1/1994	1	1	1	1	1	1	1	1	1	1	1
	IS1	(blank)	591528.1211	701795.9197	0	0.5	(blank)	9/1/1994	1	1	1	1	1	1	1	1	1	1	1
	IS10	(blank)	591735.9772	701718.5466	0	0.5	(blank)	9/1/1994	1	1	1	1	1	1	1	1	1	1	1
	IS2	(blank)	591554.126	701790.8776	0	0.5	(blank)	9/1/1994	1	1	1	1	1	1	1	1	1	1	1
	IS3	(blank)	591586.0898	701784.8271	0	0.5	(blank)	9/1/1994	1	1	1	1	1	1	1	1	1	1	1
	IS4	(blank)	591615.0894	701779.7544	0	0.5	(blank)	9/1/1994	1	1	1	1	1	1	1	1	1	1	1
	IS5	(blank)	591657.0762	701771.6871	0	0.5	(blank)	9/1/1994	1	1	1	1	1	1	1	1	1	1	1
	IS6	(blank)	591687.0537	701765.6366	0	0.5	(blank)	9/1/1994	1	1	1	1	1	1	1	1	1	1	1
	IS7	(blank)	591712.0808	701783.5742	0	0.5	(blank)	9/1/1994	1	1	1	1	1	1	1	1	1	1	1
	IS8	(blank)	591706.0609	701762.5808	0	0.5	(blank)	9/1/1994	1	1	1	1	1	1	1	1	1	1	1
	IS9	(blank)	591719.9954	701741.5568	0	0.5	(blank)	9/1/1994	1	1	1	1	1	1	1	1	1	1	1
	SR1	(blank)	588788.2215	708058.5867	0	0.5	(blank)	9/1/1994	1	1	1	1	1	1	1	1	1	1	1
	SR10	(blank)	588794.1497	708019.564	0	0.5	(blank)	9/1/1994	1	1	1	1	1	1	1	1	1	1	1
	SR2	(blank)	588798.214	708051.5583	0	0.5	(blank)	9/1/1994	1	1	1	1	1	1	1	1	1	1	1

Table 1-4 Summary of Sediment Data Used in Assessment

Lower Passaic River Risk Assessment - Focused Feasibility Study

	Parameter								Group										
STUDY_NAME	SAMPLE_ID	RIVER_MILE	X_COORD	Y_COORD	DEPTH_TOP	DEPTH_BOTTOM	DEPTH_UNIT	DATETIME_PLACED	Aroclor	Chlordane	Copper	DDT	Dieldrin	Dioxin/Furan	HMW PAH	Lead	LMW PAH	Mercury	PCBs
PASSAIC 1994 Surficial Sediment Investigation	SR3	(blank)	588806.2202	708045.5384	0	0.5	(blank)	9/1/1994	1	1	1	1	1	1	1	1	1	1	1
	SR4	(blank)	588814.1959	708039.5184	0	0.5	(blank)	9/1/1994	1	1	1	1	1	1	1	1	1	1	1
	SR5	(blank)	588798.2445	708060.5729	0	0.5	(blank)	9/1/1994	1	1	1	1	1	1	1	1	1	1	1
	SR6	(blank)	588808.237	708061.5508	0	0.5	(blank)	9/1/1994	1	1	1	1	1	1	1	1	1	1	1
	SR7	(blank)	588789.2299	708049.572	0	0.5	(blank)	9/1/1994	1	1	1	1	1	1	1	1	1	1	1
	SR8	(blank)	588791.1856	708039.5795	0	0.5	(blank)	9/1/1994	1	1	1	1	1	1	1	1	1	1	1
	SR9	(blank)	588792.194	708029.587	0	0.5	(blank)	9/1/1994	1	1	1	1	1	1	1	1	1	1	1
	WA1	(blank)	590674.5114	694559.183	0	0.5	(blank)	9/1/1994	1	1	1	1	1	1	1	1	1	1	1
	WA10	(blank)	590853.0317	694319.852	0	0.5	(blank)	9/1/1994	1	1	1	1	1	1	1	1	1	1	1
	WA2	(blank)	590692.5101	694562.1471	0	0.5	(blank)	9/1/1994	1	1	1	1	1	1	1	1	1	1	1
	WA3	(blank)	590701.3719	694495.1332	0	0.5	(blank)	9/1/1994	1	1	1	1	1	1	1	1	1	1	1
	WA4	(blank)	590718.4539	694535.1032	0	0.5	(blank)	9/1/1994	1	1	1	1	1	1	1	1	1	1	1
	WA5	(blank)	590726.4296	694527.0664	0	0.5	(blank)	9/1/1994	1	1	1	1	1	1	1	1	1	1	1
	WA6	(blank)	590720.3791	694493.0858	0	0.5	(blank)	9/1/1994	1	1	1	1	1	1	1	1	1	1	1
	WA7	(blank)	590756.3154	694467.0198	0	0.5	(blank)	9/1/1994	1	1	1	1	1	1	1	1	1	1	1
	WA8	(blank)	590747.3924	694506.0424	0	0.5	(blank)	9/1/1994	1	1	1	1	1	1	1	1	1	1	1
	WA9	(blank)	590774.1307	694368.9894	0	0.5	(blank)	9/1/1994	1	1	1	1	1	1	1	1	1	1	1
PASSAIC 1995 RI Sampling Program	20101A	(blank)	597095.6832	689130.538	0	0.5	(blank)	4/11/1995	1	1	1	1	1	1	1	1	1	1	1
	20201B	1	597325.5106	689047.1144	0	0.5	(blank)	4/14/1995			1			1		1		1	1
	20201F	1	597312.5234	689057.1374	0	0.5	(blank)	4/14/1995	1		1	1	1	1	1	1	1	1	1
	20301A	1	597673.2922	688944.4697	0	0.5	(blank)	4/13/1995	1	1	1	1	1	1	1	1	1	1	1
	20401A	1.23	597394.8469	690286.8562	0	0.5	(blank)	4/24/1995	1	1	1	1	1	1	1	1	1	1	1
	20501A	1.23	597664.6748	690203.3714	0	0.5	(blank)	4/24/1995	1	1	1	1	1	1	1	1	1	1	1
	20601A	1.23	598014.4733	690115.7003	0	0.5	(blank)	4/24/1995	1	1	1	1	1	1	1	1	1	1	1
	20701A	(blank)	597700.9779	691423.1894	0	0.5	(blank)	4/18/1995	1	1	1	1	1	1	1	1	1	1	1
	20801A	1.46	597968.8501	691369.6821	0	0.5	(blank)	4/19/1995	1	1	1	1	1	1	1	1	1	1	1
	20901B	1.46	598197.7302	691320.2391	0	0.5	(blank)	4/19/1995	1	1	1	1	1	1	1	1	1	1	1
	21001A	(blank)	597869.2001	692607.7432	0	0.5	(blank)	4/17/1995	1	1	1	1	1	1	1	1	1	1	1
	21101B	1.69	598145.0786	692553.2276	0	0.5	(blank)	4/17/1995	1	1	1	1	1	1	1	1	1	1	1
	21201A	1.69	598362.0105	692525.817	0	0.5	(blank)	4/18/1995	1	1	1	1		1	1	1	1	1	1
	21301A	(blank)	597950.4541	693810.4792	0	0.5	(blank)	4/26/1995	1	1	1	1	1	1	1	1	1	1	1
	21401A	1.94	598323.5073	693854.7884	0	0.5	(blank)	5/10/1995	1	1	1	1	1	1	1	1	1	1	1
	21501B	1.94	598473.5781	693891.4887	0	0.5	(blank)	4/20/1995	1	1	1	1	1	1	1	1	1	1	1
	21601A	(blank)	597458.2549	694743.326	0	0.5	(blank)	4/20/1995	1	1	1	1	1	1	1	1	1	1	1
	21701A	2.21	597718.8849	695072.8034	0	0.5	(blank)	4/27/1995	1	1	1	1	1	1	1	1	1	1	1
	21801A	2.21	597813.0955	695195.6163	0	0.5	(blank)	4/26/1995	1	1	1	1	1	1	1	1	1	1	1
	21901A	2.5	596320.6383	695414.4123	0	0.5	(blank)	6/8/1995	1	1	1	1	1	1	1	1	1		1
	22001A	2.5	596350.9214	695564.3608	0	0.5	(blank)	6/16/1995	1	1	1	1	1	1	1	1	1		1
	22101A	2.5	596377.1402	695689.2823	0	0.5	(blank)	6/16/1995	1	1	1	1	1	1	1	1	1		1
	22201A	2.65	595562.7976	695458.8437	0	0.5	(blank)	4/27/1995	1	1	1	1	1	1	1	1	1	1	1
	22301A	2.65	595560.0168	695588.8379	0	0.5	(blank)	5/1/1995	1	1	1	1	1	1	1	1	1	1	1
	22401A	2.64	595561.3614	695765.8303	0	0.5	(blank)	4/21/1995	1	1	1	1	1	1	1	1	1	1	1
	22501A	2.87	594372.6516	695340.1255	0	0.5	(blank)	5/16/1995	1	1	1	1	1	1	1	1	1	1	1
	22601A	2.88	594355.9058	695466.1471	0	0.5	(blank)	5/10/1995	1	1	1	1	1	1	1	1	1	1	1
	22701A	2.87	594345.241	695639.1365	0	0.5	(blank)	5/16/1995	1		1	1	1	1	1	1	1	1	1
	22801B	3.1	593187.5783	695244.3565	0	0.5	(blank)	5/17/1995	1	1	1	1	1	1	1	1	1	1	1
	22901A	3.1	593169.7323	695328.3912	0	0.5	(blank)	5/1/1995	1	1	1	1	1	1	1	1	1	1	1
	23001A	3.1	593148.9834	695455.4212	0	0.5	(blank)	5/17/1995	1	1	1	1	1	1	1	1	1	1	1
	23101A	3.33	592070.9856	694871.5172	0	0.5	(blank)	5/18/1995	1	1	1	1	1	1	1	1	1	1	1
	23201A	3.33	592028.1737	694971.5644	0	0.5	(blank)	5/2/1995			1			1		1		1	1
	23301C	3.33	591963.4211	695101.6808	0	0.5	(blank)	4/25/1995	1	1	1	1	1	1	1	1	1	1	1
	23401B	3.55	591239.6833	694156.1523	0	0.5	(blank)	4/25/1995	1	1	1	1	1	1	1	1	1	1	1
	23501A	3.55	591150.8203	694213.2959	0	0.5	(blank)	5/18/1995	1	1	1	1	1	1	1	1	1	1	1
	23601A	3.55	591048.9091	694265.4891	0	0.5	(blank)	5/2/1995	1	1	1	1	1	1	1	1	1	1	1
	23701A	3.78	590669.7443	693099.3007	0	0.5	(blank)	5/4/1995	1		1	1	1	1	1	1	1	1	1
	23801A	3.78	590616.8177	693129.4004	0	0.5	(blank)	5/3/1995	1	1	1	1	1	1	1	1	1	1	1
	23901A	3.78	590510.9339	693192.5945	0	0.5	(blank)	5/3/1995	1		1	1	1	1	1	1	1	1	1
	24001A	4.01	589630.433	692361.3533	0	0.5	(blank)	5/15/1995	1		1	1	1	1	1	1	1	1	1
	24101A	4.01	589594.7412	692519.3998	0	0.5	(blank)	5/15/1995	1	1	1	1	1	1	1	1	1	1	1
	24201A	4.02	589569.928	692611.4407	0	0.5	(blank)	5/4/1995	1	1	1	1	1	1	1	1	1	1	1
	24301A	4.24	588403.434	692311.6659	0	0.5	(blank)	5/5/1995	1		1	1	1	1	1	1	1	1	1
	24401A	4.24	588399.6142	692403.6763	0	0.5	(blank)	4/28/1995	1	1	1	1	1	1	1	1	1	1	1
	24501B	4.24	588390.8746	692544.6713	0	0.5	(blank)	5/1/1995	1	1	1	1	1	1	1	1	1	1	1

Table 1-4 Summary of Sediment Data Used in Assessment

Lower Passaic River Risk Assessment - Focused Feasibility Study

	Parameter								Group										
STUDY_NAME	SAMPLE_ID	RIVER_MILE	X_COORD	Y_COORD	DEPTH_TOP	DEPTH_BOTTOM	DEPTH_UNIT	DATETIME_PLACED	Aroclor	Chlordane	Copper	DDT	Dieldrin	Dioxin/Furan	HMW PAH	Lead	LMW PAH	Mercury	PCBs
PASSAIC 1995 RI Sampling Program	24601A	4.47	587173.5319	692295.9896	0	0.5	(blank)	5/8/1995			1	1		1	1	1	1	1	1
	24701A	4.47	587190.6444	692355.9445	0	0.5	(blank)	5/9/1995	1	1	1	1	1	1	1	1	1	1	1
	24801A	4.47	587217.8411	692458.8948	0	0.5	(blank)	5/15/1995	1		1	1	1	1	1	1	1	1	1
	24901B	(blank)	586070.6293	692830.0228	0	0.5	(blank)	5/11/1995	1		1	1		1	1	1	1	1	1
	25001A	4.69	586141.8296	692939.8791	0	0.5	(blank)	5/12/1995	1	1	1	1	1	1	1	1	1	1	1
	25101B	4.7	586181.9524	693012.7907	0	0.5	(blank)	5/19/1995		1	1	1	1	1	1	1	1	1	1
	25201C	4.92	585447.7942	693942.0929	0	0.5	(blank)	5/9/1995	1	1	1	1	1	1	1	1	1	1	1
	25301A	4.92	585541.8215	693973.9344	0	0.5	(blank)	5/8/1995	1		1	1	1	1	1	1	1	1	1
	25401A	4.91	585629.8899	694002.7507	0	0.5	(blank)	5/9/1995	1	1	1	1	1	1	1	1	1	1	1
	25501A	5.16	585045.1303	695170.742	0	0.5	(blank)	5/22/1995	1	1	1	1	1	1	1	1	1	1	1
	25601B	5.16	585177.2023	695208.5118	0	0.5	(blank)	5/22/1995	1	1	1	1	1	1	1	1	1	1	1
	25701C	5.16	585242.1994	695219.3905	0	0.5	(blank)	5/23/1995	1	1	1	1	1	1	1	1	1	1	1
	25801C	5.34	584736.0046	696147.2564	0	0.5	(blank)	5/23/1995	1	1	1	1	1	1	1	1	1	1	1
	25901B	5.35	584824.073	696177.0811	0	0.5	(blank)	5/24/1995	1	1	1	1	1	1	1		1	1	1
	26001B	5.35	584958.1008	696211.8257	0	0.5	(blank)	5/25/1995	1	1	1	1	1	1	1		1	1	1
	26101C	5.51	584652.7033	697033.3189	0	0.5	(blank)	6/6/1995	1		1	1	1	1	1	1	1	1	1
	26201A	5.52	584732.7349	697058.1626	0	0.5	(blank)	5/11/1995	1	1	1	1	1	1	1	1	1	1	1
	26301B	5.51	584807.7245	697060.0266	0	0.5	(blank)	5/23/1995	1	1	1	1	1	1	1	1	1	1	1
	26401A	(blank)	584710.947	698226.1234	0	0.5	(blank)	5/24/1995	1	1	1	1	1	1	1		1	1	1
	26501A	5.73	584772.9188	698215.0003	0	0.5	(blank)	5/25/1995	1	1	1	1	1	1	1	1	1	1	1
	26601A	5.73	584840.9105	698208.8581	0	0.5	(blank)	5/26/1995	1	1	1	1	1	1	1		1	1	1
	26701A	5.95	584856.0368	699331.7457	0	0.5	(blank)	6/5/1995	1		1	1	1	1	1	1	1	1	1
	26801B	5.95	585024.9925	699328.4149	0	0.5	(blank)	6/5/1995	1	1	1	1	1	1	1	1	1	1	1
	26901C	5.95	585058.0258	699334.3737	0	0.5	(blank)	6/6/1995	1	1	1	1	1	1	1	1	1	1	1
	27001A	(blank)	585041.2494	701044.2517	0	0.5	(blank)	5/30/1995	1	1	1	1	1	1	1		1	1	1
	27101A	6.27	585143.1912	701024.0528	0	0.5	(blank)	5/30/1995	1	1	1	1	1	1	1	1	1	1	1
	27201A	6.27	585243.1773	701013.877	0	0.5	(blank)	5/31/1995	1	1	1	1	1	1	1	1	1	1	1
	27301A	6.49	585518.3529	702181.2572	0	0.5	(blank)	6/1/1995	1	1	1	1	1	1	1	1	1	1	1
	27401A	6.49	585602.2654	702137.1008	0	0.5	(blank)	6/5/1995	1	1	1	1	1	1	1	1	1	1	1
	27501A	6.49	585643.2438	702116.0157	0	0.5	(blank)	6/2/1995	1	1	1	1	1	1	1	1	1	1	1
	27601A	6.71	586130.3092	703230.0109	0	0.5	(blank)	6/1/1995	1	1	1	1	1	1	1	1	1	1	1
	27701B	6.72	586236.1624	703162.8137	0	0.5	(blank)	5/31/1995	1		1	1	1	1	1	1	1	1	1
	27801B	6.71	586324.9948	703082.6598	0	0.5	(blank)	5/31/1995	1	1	1	1	1	1	1	1	1	1	1
	28201A	(blank)	597545.0399	694629.1915	0	0.5	(blank)	6/15/1995	1	1	1	1	1	1	1	1	1	1	1
	28301A	(blank)	597284.4099	694805.6645	0	0.5	(blank)	6/9/1995	1	1	1	1	1	1	1	1	1	1	1
	28401B	(blank)	595458.3195	695202.0641	0	0.5	(blank)	6/15/1995	1	1	1	1	1	1	1	1	1	1	1
	28501A	(blank)	592960.0733	694966.8279	0	0.5	(blank)	6/7/1995	1	1	1	1	1	1	1	1	1	1	1
	28601B	(blank)	593249.1528	695021.2519	0	0.5	(blank)	6/7/1995	1		1	1	1	1	1	1	1	1	1
	28701B	3.59	590821.618	694101.9422	0	0.5	(blank)	6/12/1995	1	1	1	1	1	1	1	1	1	1	1
	28801B	3.66	590712.0673	693807.1789	0	0.5	(blank)	6/13/1995			1	1		1	1	1	1	1	1
	28901A	4.19	588676.2261	692728.1115	0	0.5	(blank)	6/13/1995	1	1	1	1	1	1	1	1	1	1	1
	29001B	4.25	588319.1548	692686.797	0	0.5	(blank)	6/13/1995	1	1	1	1	1	1	1	1	1	1	1
	29101A	4.32	587986.0105	692591.4252	0	0.5	(blank)	6/12/1995	1	1	1	1		1	1	1	1	1	1
	29201C	4.39	587589.9776	692548.1855	0	0.5	(blank)	6/14/1995	1	1	1	1	1	1	1	1	1	1	1
	29301A	5.08	585441.4687	694838.0255	0	0.5	(blank)	6/14/1995	1	1	1	1		1	1	1	1	1	1
	29401A	3.15	592895.0151	695462.908	0	0.5	(blank)	6/8/1995	1		1	1	1	1	1	1	1	1	1
	29501B	2	598386.2125	694222.6161	0	0.5	(blank)	6/8/1995	1		1	1	1	1	1	1	1	1	1
	29601B	6.4	585527.337	701638.2705	0	0.5	(blank)	6/14/1995	1	1	1	1	1	1	1	1	1	1	1
	D00595A	1.23	598014.4733	690115.7003	0	0.5	(blank)	4/24/1995	1	1		1	1						1
	D00695A	2.21	597813.0955	695195.6163	0	0.5	(blank)	4/26/1995	1	1		1	1		1		1		1
	D01195A	4.47	587173.5319	692295.9896	0	0.5	(blank)	5/8/1995						1					1
	D03095B	4.39	587589.9776	692548.1855	0	0.5	(blank)	6/14/1995			1					1		1	
	D03295	2.5	596350.9214	695564.3608	0	0.5	(blank)	6/16/1995	1	1		1	1		1		1		1
PASSAIC 1995 Sediment Grab Sampling Program	Grab-1	2.67	595407.4403	695799.1081	0	0.5	(blank)	9/14/1995						1					
	Grab-2	2.67	595407.043	695589.1434	0	0.5	(blank)	9/14/1995						1					
PASSAIC 1995 USACE Minish Park Investigation	WTH-3-A (0-2)	(blank)	587753.28	692187.9056	0	2	(blank)	2/9/1995									1		
	WTH-7-C (0-2)	(blank)	585177.7524	694437.5618	0	2	(blank)	2/1/1995						1					
PASSAIC 1997 Outfall Sampling Program	Location 1	1.23	597394.8469	690286.8562	0	0.5	(blank)	9/18/1997	1										
	Location 2	(blank)	584710.947	698226.1234	0	0.5	(blank)	9/18/1997	1										
	Location 3	4.01	589630.433	692361.3533	0	0.5	(blank)	9/18/1997	1										
PASSAIC 1999 Late Summer/Early Fall ESP Sampling	DSD01-1999	(blank)	586450.283	703763.3719	0	0.5	(blank)	10/6/1999	1	1	1	1	1	1	1	1	1	1	1
	DSD02-1999	4.31	588027.1722	692674.3293	0	0.5	(blank)	10/7/1999	1	1	1	1	1	1	1	1	1	1	1
	DSD03	(blank)	597923.4102	693250.5938	0	0.5	(blank)	10/11/1999	1	1	1	1	1	1	1	1	1	1	1

Table 1-4 Summary of Sediment Data Used in Assessment

Lower Passaic River Risk Assessment - Focused Feasibility Study

	Parameter								Group										
STUDY_NAME	SAMPLE_ID	RIVER_MILE	X_COORD	Y_COORD	DEPTH_TOP	DEPTH_BOTTOM	DEPTH_UNIT	DATETIME_PLACED	Aroclor	Chlordane	Copper	DDT	Dieldrin	Dioxin/Furan	HMW PAH	Lead	LMW PAH	Mercury	PCBs
PASSAIC 1999 Late Summer/Early Fall ESP Sampling	PR9901SDL	(blank)	597431.6999	690736.7629	0	0.5	(blank)	10/11/1999	1	1	1	1	1	1	1	1	1	1	1
	PR9901SDM	(blank)	597454.9852	690883.6862	0	0.5	(blank)	10/11/1999	1	1	1	1	1	1	1	1	1	1	1
	PR9901SDU	(blank)	597482.1819	690996.6289	0	0.5	(blank)	10/11/1999	1	1	1	1	1	1	1	1	1	1	1
	PR9902SDL	(blank)	597882.004	693027.7031	0	0.5	(blank)	10/11/1999	1	1	1	1	1	1	1	1	1	1	1
	PR9902SDM	(blank)	597903.2113	693139.6374	0	0.5	(blank)	10/11/1999	1	1	1	1	1	1	1	1	1	1	1
	PR9902SDU	(blank)	597923.4102	693250.5938	0	0.5	(blank)	10/11/1999	1	1	1	1	1	1	1	1	1	1	1
	PR9903SDL	2.26	597604.4754	695391.0048	0	0.5	(blank)	10/10/1999	1	1	1	1	1	1	1	1	1	1	1
	PR9903SDM	2.28	597506.5978	695449.1874	0	0.5	(blank)	10/15/1999	1	1	1	1	1	1	1	1	1	1	1
	PR9903SDU	2.3	597412.7234	695506.3616	0	0.5	(blank)	10/15/1999	1	1	1	1	1	1	1	1	1	1	1
	PR9904SDL	2.74	595072.3708	695224.7993	0	0.5	(blank)	10/8/1999	1	1	1	1	1	1	1	1	1	1	1
	PR9904SDM	(blank)	594954.3555	695198.0304	0	0.5	(blank)	10/8/1999	1	1	1	1	1	1	1	1	1	1	1
	PR9904SDU	(blank)	594835.3011	695175.2646	0	0.5	(blank)	10/8/1999	1	1	1	1	1	1	1	1	1	1	1
	PR9905SDL	3.18	592711.0248	695454.2295	0	0.5	(blank)	10/10/1999	1	1	1	1	1	1	1	1	1	1	1
	PR9905SDM	3.2	592599.9767	695424.4659	0	0.5	(blank)	10/10/1999	1	1	1	1	1	1	1	1	1	1	1
	PR9905SDU	3.22	592492.9012	695388.6518	0	0.5	(blank)	10/10/1999	1	1	1	1	1	1	1	1	1	1	1
	PR9906SDL	3.85	590203.7028	693064.1894	0	0.5	(blank)	10/7/1999	1	1	1	1	1	1	1	1	1	1	1
	PR9906SDM	3.87	590099.5914	692996.4116	0	0.5	(blank)	10/7/1999	1	1	1	1	1	1	1	1	1	1	1
	PR9906SDU	3.9	590000.4915	692928.6032	0	0.5	(blank)	10/7/1999	1	1	1	1	1	1	1	1	1	1	1
	PR9907SDL	(blank)	589373.0728	692162.848	0	0.5	(blank)	10/5/1999	1	1	1	1	1	1	1	1	1	1	1
	PR9907SDM	(blank)	589261.0774	692154.0472	0	0.5	(blank)	10/6/1999	1	1	1	1	1	1	1	1	1	1	1
	PR9907SDU	(blank)	589147.0651	692145.2771	0	0.5	(blank)	10/5/1999	1	1	1	1	1	1	1	1	1	1	1
	PR9908SDL	4.19	588654.1937	692721.1443	0	0.5	(blank)	10/5/1999	1	1	1	1	1	1	1	1	1	1	1
	PR9908SDM	4.21	588541.1899	692718.3635	0	0.5	(blank)	10/5/1999	1	1	1	1	1	1	1	1	1	1	1
	PR9908SDU	4.23	588426.1998	692713.5964	0	0.5	(blank)	10/5/1999	1	1	1	1	1	1	1	1	1	1	1
	PR9909SDL	(blank)	585235.2322	694173.4787	0	0.5	(blank)	10/13/1999	1	1	1	1	1	1	1	1	1	1	1
	PR9909SDM	(blank)	585204.4602	694296.5362	0	0.5	(blank)	10/13/1999	1	1	1	1	1	1	1	1	1	1	1
	PR9909SDU	(blank)	585140.6854	694406.637	0	0.5	(blank)	10/13/1999	1	1	1	1	1	1	1	1	1	1	1
	PR9910SDL	(blank)	584566.9267	697676.4444	0	0.5	(blank)	10/8/1999	1	1	1	1	1	1	1	1	1	1	1
	PR9910SDM	(blank)	584580.1278	697789.3872	0	0.5	(blank)	10/8/1999	1	1	1	1	1	1	1	1	1	1	1
	PR9910SDU	(blank)	584595.3152	697897.3489	0	0.5	(blank)	10/8/1999	1	1	1	1	1	1	1	1	1	1	1
	PR9911SDL	6.27	585370.1156	700991.6307	0	0.5	(blank)	10/6/1999	1	1	1	1	1	1	1	1	1	1	1
	PR9911SDM	6.29	585393.3397	701102.5871	0	0.5	(blank)	10/7/1999	1	1	1	1	1	1	1	1	1	1	1
	PR9911SDU	6.31	585419.528	701210.5183	0	0.5	(blank)	10/6/1999	1	1	1	1	1	1	1	1	1	1	1
	PR9912SDL	(blank)	586318.9443	703581.6123	0	0.5	(blank)	10/6/1999	1	1	1	1	1	1	1	1	1	1	1
	PR9912SDM	(blank)	586386.111	703670.4753	0	0.5	(blank)	10/6/1999	1	1	1	1	1	1	1	1	1	1	1
	PR9912SDU	(blank)	586450.283	703763.3719	0	0.5	(blank)	10/6/1999	1	1	1	1	1	1	1	1	1	1	1
	PR9913SDL	(blank)	597090.091	689336.5301	0	0.5	(blank)	10/15/1999	1	1	1	1	1	1	1	1	1	1	1
	PR9913SDM	(blank)	597125.3245	689467.4409	0	0.5	(blank)	10/15/1999	1	1	1	1	1	1	1	1	1	1	1
	PR9913SDU	(blank)	597192.6746	689657.2983	0	0.5	(blank)	10/15/1999	1	1	1	1	1	1	1	1	1	1	1
	PR9914SDL	(blank)	593193.1398	695013.3679	0	0.5	(blank)	10/12/1999	1	1	1	1	1	1	1	1	1	1	1
	PR9914SDM	3.13	593082.1223	694991.58	0	0.5	(blank)	10/12/1999	1	1	1	1	1	1	1	1	1	1	1
	PR9914SDU	(blank)	592973.091	694969.792	0	0.5	(blank)	10/12/1999	1	1	1	1	1	1	1	1	1	1	1
	PR9915SDL	4.27	588253.1798	692690.9223	0	0.5	(blank)	10/7/1999	1	1	1	1	1	1	1	1	1	1	1
	PR9915SDM	4.29	588142.1623	692681.1132	0	0.5	(blank)	10/7/1999	1	1	1	1	1	1	1	1	1	1	1
	PR9915SDU	4.31	588027.1722	692674.3293	0	0.5	(blank)	10/7/1999	1	1	1	1	1	1	1	1	1	1	1
PASSAIC 1999 Sediment Sampling Program	PRP-99-04-SD-1	6.21	585356.5478	700683.6968	0	1	(blank)	7/30/1999	1	1	1	1	1	1	1	1	1	1	1
	PRP-99-05-SD-1	(blank)	595663.456	687348.3901	0	1	(blank)	8/3/1999			1			1		1		1	1
	PRP-99-06-SD-1	(blank)	594360.5201	686800.9113	0	1	(blank)	8/3/1999	1	1	1	1	1	1	1	1	1	1	1
PASSAIC 1999/2000 Minish Park Monitoring Program	PR-99-BBD-D-1	(blank)	585101.6322	694370.7312	0	0.5	(blank)	12/2/1999	1	1	1	1	1	1	1	1	1	1	1
	PR-99-BBD-SD-1	(blank)	585236.3017	694215.4655	0	0.5	(blank)	12/2/1999	1	1	1	1	1	1	1	1	1	1	1
	PR-99-BBD-SD-2	(blank)	585203.5434	694328.5305	0	0.5	(blank)	12/2/1999	1	1	1	1	1	1	1	1	1	1	1
	PR-99-BBD-SD-3	(blank)	585101.6322	694370.7312	0	0.5	(blank)	12/2/1999	1	1	1	1	1	1	1	1	1	1	1
	PR-99-BBD-SD-4	(blank)	585098.668	694403.7339	0	0.5	(blank)	12/2/1999	1	1	1	1	1	1	1	1	1	1	1
	PR-99-BBD-SD-5	(blank)	585177.7524	694438.5702	0	0.5	(blank)	12/3/1999	1	1	1	1	1	1	1	1	1	1	1
	PR-99-BBD-SD-6	(blank)	585150.9529	694553.6214	0	0.5	(blank)	12/3/1999	1	1	1	1	1	1	1	1	1	1	1
	PR-99-BBD-SD-7	(blank)	585144.6274	694375.6511	0	0.5	(blank)	12/3/1999	1	1	1	1	1	1	1	1	1	1	1
	PR-99-BBD-SD-8	(blank)	585141.6938	694410.6401	0	0.5	(blank)	12/3/1999	1	1	1	1	1	1	1	1	1	1	1
PASSAIC 2000 Spring ESP Sampling Program	DSD01-2000	(blank)	589261.0774	692154.0472	0	0.5	(blank)	5/22/2000	1	1	1	1	1	1	1	1	1	1	1
	DSD02-2000	(blank)	597454.9852	690883.6862	0	0.5	(blank)	5/23/2000	1	1	1	1	1	1	1	1	1	1	1
	PR0001SDM	(blank)	597454.9852	690883.6862	0	0.5	(blank)	5/23/2000	1	1	1	1	1	1	1	1	1	1	1
	PR0002SDM	(blank)	597903.2113	693139.6374	0	0.5	(blank)	5/24/2000	1	1	1	1	1	1	1	1	1	1	1
	PR0003SDM	2.28	597506.5978	695449.1874	0	0.5	(blank)	5/24/2000	1	1	1	1	1	1	1	1	1	1	1
	PR0004SDM	(blank)	594954.3555	695198.0304	0	0.5	(blank)	5/17/2000	1	1	1	1	1	1	1	1	1	1	1

Table 1-4 Summary of Sediment Data Used in Assessment

Lower Passaic River Risk Assessment - Focused Feasibility Study

	Parameter								Group										
STUDY_NAME	SAMPLE_ID	RIVER_MILE	X_COORD	Y_COORD	DEPTH_TOP	DEPTH_BOTTOM	DEPTH_UNIT	DATETIME_PLACED	Aroclor	Chlordane	Copper	DDT	Dieldrin	Dioxin/Furan	HMW PAH	Lead	LMW PAH	Mercury	PCBs
PASSAIC 2000 Spring ESP Sampling Program	PR0005SDM	3.2	592599.9767	695424.4659	0	0.5	(blank)	5/17/2000	1	1	1	1	1	1	1	1	1	1	1
	PR0006SDM	3.87	590099.5914	692996.4116	0	0.5	(blank)	5/22/2000	1	1	1	1	1	1	1	1	1	1	1
	PR0007SDM	(blank)	589261.0774	692154.0472	0	0.5	(blank)	5/22/2000	1	1	1	1	1	1	1	1	1	1	1
	PR0008SDM	4.21	588541.1899	692718.3635	0	0.5	(blank)	5/22/2000	1	1	1	1	1	1	1	1	1	1	1
	PR0009SDM	(blank)	585204.4602	694296.5362	0	0.5	(blank)	5/24/2000	1	1	1	1	1	1	1	1	1	1	1
	PR0010SDM	(blank)	584580.1278	697789.3872	0	0.5	(blank)	5/18/2000	1	1	1	1	1	1	1	1	1	1	1
	PR0011SDM	6.29	585393.3397	701102.5871	0	0.5	(blank)	5/18/2000	1	1	1	1	1	1	1	1	1	1	1
	PR0012SDM	(blank)	586386.111	703670.4753	0	0.5	(blank)	5/19/2000	1	1	1	1	1	1	1	1	1	1	1
	PR0013SDM	(blank)	597125.3245	689467.4409	0	0.5	(blank)	5/23/2000	1	1	1	1	1	1	1	1	1	1	1
	PR0014SDM	3.13	593082.1223	694991.58	0	0.5	(blank)	5/17/2000	1	1	1	1	1	1	1	1	1	1	1
	PR0015SDM	4.29	588142.1623	692681.1132	0	0.5	(blank)	5/22/2000	1	1	1	1	1	1	1	1	1	1	1
Pirnie Study	LPRP-SCSH-PSR-001162	(blank)	588848.4	708051.8	0	3	CM	10/12/2005							1		1		
	LPRP-SCSH-PSR-001163	(blank)	588848.4	708051.8	3	6	CM	10/12/2005							1		1		
	LPRP-SCSH-PSR-001164	(blank)	588848.4	708051.8	6	9	CM	10/12/2005							1		1		
	LPRP-SCSH-PSR-001165	(blank)	588848.4	708051.8	9	12	CM	10/12/2005							1		1		
	LPRP-SCSH-PSR-001166	(blank)	588848.4	708051.8	12	15	CM	10/12/2005							1		1		
	LPRP-SCSH-PSR-001222	(blank)	588848.4	708051.8	0	3	CM	10/12/2005			1							1	
	LPRP-SCSH-PSR-001223	(blank)	588848.4	708051.8	3	6	CM	10/12/2005			1							1	
	LPRP-SCSH-PSR-001224	(blank)	588848.4	708051.8	6	9	CM	10/12/2005			1							1	
	LPRP-SCSH-PSR-001225	(blank)	588848.4	708051.8	9	12	CM	10/12/2005			1							1	
	LPRP-SCSH-PSR-001226	(blank)	588848.4	708051.8	12	15	CM	10/12/2005			1							1	
	LPRP-SCSH-PSR-001466	(blank)	588848.4	708051.8	0	3	CM	10/12/2005		1		1	1	1					1
	LPRP-SCSH-PSR-001538	(blank)	588848.4	708051.8	3	6	CM	10/12/2005		1		1	1						
	LPRP-SCSH-PSR-001539	(blank)	588848.4	708051.8	6	9	CM	10/12/2005		1		1	1						
	LPRP-SCSH-PSR-001540	(blank)	588848.4	708051.8	9	15	CM	10/12/2005		1		1	1						
	LPRP-SCSS-PSR-000500	(blank)	594252.49	695472.2	0	1	ft	7/12/2004	1	1		1	1						
	LPRP-SCSS-PSR-000508	(blank)	594259.82	695322.2	0	1	ft	7/12/2004	1	1		1	1						
	LPRP-SCSS-PSR-000512	(blank)	594315.31	695481.7	0	1	ft	7/13/2004	1	1		1	1						
	LPRP-SCSS-PSR-000516	(blank)	594325.6	695405.2	0	1	ft	7/13/2004	1	1		1	1						
	LPRP-SCSS-PSR-000520	(blank)	594324.08	695332.1	0	1	ft	7/13/2004	1	1		1	1						
	LPRP-SCSS-PSR-000524	(blank)	594376.25	695485.26	0	1	ft	7/13/2004	1	1		1	1						
	LPRP-SCSS-PSR-000528	(blank)	594379.1	695410.08	0	1	ft	7/13/2004	1	1		1	1						
	LPRP-SCSS-PSR-000532	(blank)	594386.43	695329.55	0	1	ft	7/13/2004	1	1		1	1						
	LPRP-SCSS-PSR-000536	(blank)	594428.8	695478.7	0	1	ft	7/13/2004	1	1		1	1						
	LPRP-SCSS-PSR-000540	(blank)	594440.3	695404.6	0	1	ft	7/13/2004	1	1		1	1						
	LPRP-SCSS-PSR-000544	(blank)	594443.79	695346.31	0	1	ft	7/13/2004	1	1		1	1						
	LPRP-SCSS-PSR-000548	(blank)	594493.5	695497.48	0	1	ft	7/14/2004	1	1		1	1						
	LPRP-SCSS-PSR-000552	(blank)	594506.35	695423.5	0	1	ft	7/14/2004	1	1		1	1						
	LPRP-SCSS-PSR-000556	(blank)	594505.5	695356.6	0	1	ft	7/14/2004	1	1		1	1						
	LPRP-SCSS-PSR-000560	(blank)	594386.35	695329.32	0	1	ft	7/13/2004	1	1		1	1						
Grand Total									238	227	234	245	236	232	233	225	234	232	230

*The X and Y coordinates reported in the PREmis database for locations from studies Passaic 1994 Surficial Sediment Investigation and Passaic 1999 Sediment Sampling Program plotted on land. Samples affected in studies Passaic 1994 Surficial Sediment Investigation were IS1, IS2, IS3, IS4, IS5, IS6, IS7, IS8, IS9, and IS10. Samples affected in Passaic 1999 Sediment Sampling Program were PRP-99-05-SD-1 and PRP-99-06-SD-1. These points were relocated manually into the river in Figure 2-1 after conferring with Malcolm Pirnie and jointly concluding that these were in fact sediment samples with incorrect position coordinates in the PREmis database. The 1994 Surficial Sediment Investigation points were moved due west until they were in the river. The 1999 Sediment Sampling Program points were moved together to the southeast until both points were just in the water, on opposite shores.

ATTACHMENT 2
SCREENING PROCESS FOR COPECS

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Technical Memorandum

Technical Approach to Identify Contaminants of Potential Ecological Concern (COPECs) to Support the Focused Feasibility Study – Ecological Risk Assessment
Lower Passaic River Restoration Project
February 21, 2007

This technical memorandum presents the process used to identify Contaminants of Potential Ecological Concern (COPECs) to support the Focused Feasibility Study (FFS) for the Lower Passaic River Restoration Project (LPRRP). The FFS evaluates alternative remedial actions within three target areas for the lower seven miles of the Lower Passaic River. This memorandum identifies those chemicals whose sediment concentrations exceed sediment benchmarks and presents hazard quotients (HQs) to categorize the magnitude of benchmark exceedances. These hazard estimates were developed to provide risk managers a better understanding of which chemicals are likely to pose the greatest ecological concern in the Lower Passaic River. In turn, this will provide a basis for selecting a final set of COPECs for assessment in the FFS.

This analysis is not a screening-level ecological risk assessment (SLERA) but provides the information necessary to develop an early final action prior to the completion of a baseline ecological risk assessment and a full Remedial Investigation/Feasibility Study (RI/FS).

COMPILATION OF AVAILABLE DATA

Surface sediment data from the lower seven miles of the Lower Passaic River, obtained from www.ourPassaic.org, were utilized in this evaluation. Only surface (0-2.3 ft) sediment data collected from 1994 to the present were used. Table 1 provides a list of the specific sampling programs that were utilized for this task and associated QA/QC procedures, if available. The sampling locations are depicted in Figure 1. The full dataset used in this evaluation is provided in Attachment A.

Sediment data for the various studies were loaded into a Microsoft Access database and the data were compiled into one table and loaded into an Oracle database. All queries and summations use the detection limit where qualifiers are reported as “U”. Data where the result was reported as 0 and qualified as “ND” were not included in the calculations.

Data queries were performed in the Oracle database for each parameter group of interest. The individual analytical results were summed in Oracle for the following chemicals: Total DDTs (sum of dichlorodiphenyldichloroethylene, dichlorodiphenyldichloroethane, and dichlorodiphenyltrichloroethane isomers); hexachlorocyclohexane (BHC, sum of alpha, beta and gamma isomers); total endosulfan (sum of endosulfan sulfate and alpha and beta isomers); chlordane (sum of alpha and gamma isomers); endrin (sum of endrin aldehyde and endrin ketone); and total polychlorinated biphenyls (PCBs, sum of Aroclors). In addition, low molecular weight (LMW) PAHs (*i.e.*, 2- and 3-ring compounds), high molecular weight (MHW) PAHs (*i.e.*, greater than 3-ring compounds), and total PAHs were summed.

The data set includes analytical results for dioxin and furan congeners as well as data for individual PCB congeners, Only 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (TCDD), considered the most toxic of this class of compounds was evaluated in this analysis. It should be understood that TCDD is considered to be a surrogate for the class of compounds that can produce “dioxin-like” effects (i.e., dioxins, furans, and coplanar PCBs) and that the potential ecological effects associated with exposure to these compounds will be evaluated using a toxic equivalency (TEQ) approach (Tillitt, 1999) in the baseline risk assessments.

Table 1. Summary of Data Used for the COPEC Selection Process

Name of Study in Database	Depth (ft)	Number of Samples	River Mile Range	QA/QC Procedures[a]
PASSAIC 1994 Surficial Sediment Investigation	0.5	30	3.5-6.9	Quantitative QA/QC[b]
PASSAIC 1995 USACE Minish Park Investigation	0.5	2	3.9-5.4	Not Specified
PASSAIC 1995 Sediment Grab Sampling Program	0.5	7	2.5-2.7	USEPA Region 2 Validation; full validation
PASSAIC 1995 RI Sampling Program	0.5	194	1.0-6.7	USEPA Region 2 Validation; full validation
PASSAIC 1997 Outfall Sampling Program	0.5	3	1.2-5.7	Quantitative QA/QC[b]
PASSAIC 1999 Sediment Sampling Program	1.0	3	0.7-6.2	Quantitative QA/QC[b]
PASSAIC 1999 Late Summer/Early Fall ESP Sampling Program	0.5	48	1.0-6.9	USEPA Region 2 Validation
PASSAIC 1999/2000 Minish Park Monitoring Program	0.5	2	5.0-5.1	Quantitative QA/QC[b]
PASSAIC 2000 Spring ESP Sampling Program	0.5	17	1.0-6.8	USEPA Region 2 Validation
Dredge Pilot Coring Program 2004 – Earth Tech	1.0	15	2.8-2.9	Third Party Full and Partial Data Validation[c]
Low-Res Sediment Coring- Pirnie Study	2.297	21	2.9-6.7	USEPA Region 2 Validation
High Res Core Sampling- Pirnie Study	0.984	79	1.4-7.8	USEPA Region 2 Validation

a. QA/QC procedures from PREmis datasets as described by TSI (2004).
b. Quantitative QA/QC includes the analysis of field and laboratory duplicates, rinsate blanks, matrix spike/matrix spike duplicates, and other quantitative measures of precision and accuracy but without specification of implementing USEPA Region 2 data validation procedures.
c. Data validation activities were performed by Severn-Trent Laboratories (STL) in accordance with the USEPA Method, the Laboratories Standard Operating Procedure (SOP) and the Malcolm Pirnie, Inc. Statement of Work (SOW).
RI = Remedial Investigation
ESP = Ecological Sampling Program

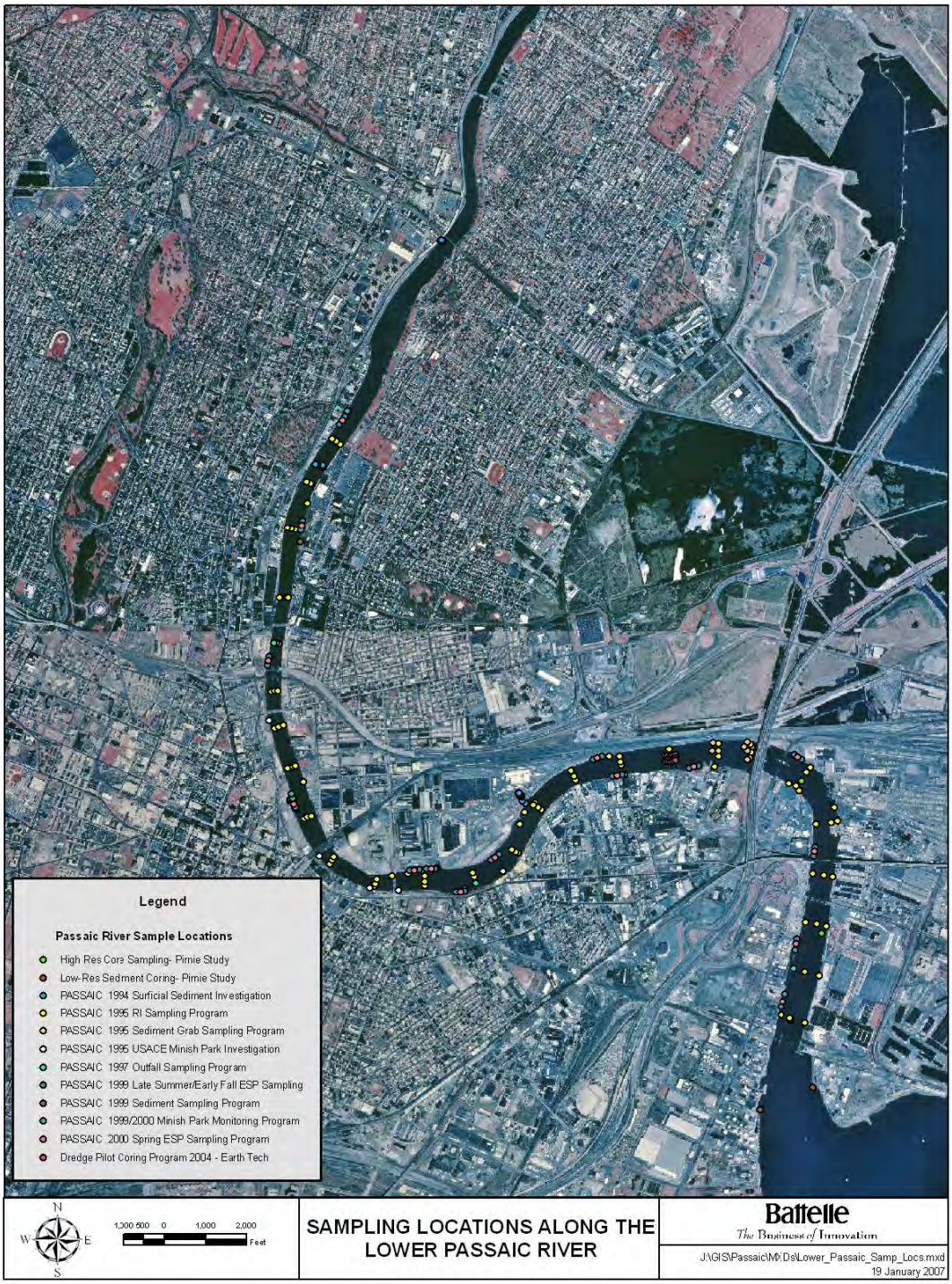

Figure 1. Sampling Locations along the Lower Seven Miles of the Passaic River

IDENTIFICATION OF PRELIMINARY CONTAMINANTS OF POTENTIAL ECOLOGICAL CONCERN (COPECS)

To support the FFS, sediment COPECs were identified based on a review of historical data that were collected by various agencies including USEPA, USACE, and NOAA NS&T, as well as Tierra Solutions Inc. (TSI), and which are currently stored in an online database at www.ourPassaic.org. Preliminary COPECs were identified using a three-tier screening process that included the following factors:

1. Bioaccumulation screen (indirect toxicological effects to wildlife through the food chain);
2. Essential nutrient screen; and,
3. Effects value screen (direct toxicological effects to benthic invertebrates).

The screening process is described below and is depicted graphically in Figure 2. The sediment screening values used in the analysis are presented in Table 2.

Maximum chemical concentrations were used in the screening evaluation. As noted previously, the reported detection limit was used to represent values reported as nondetect ("U" qualified data). In some instances, values based on detection limits represent the maximum available value for an individual chemical. The detection frequency was considered in the analysis insofar that chemicals that were not reported as detected in any sample are not proposed for further consideration in the FFS.

Bioaccumulation Screen

Any detected bioaccumulative compound, as recognized by USEPA (2000), was evaluated for both direct and indirect toxicological effects. Potential risks to higher trophic level organisms were assessed using Protective Concentration Levels (PCL), which are sediment concentrations derived using conservative exposure assumptions to be protective of bioaccumulative hazards to higher trophic level receptors (Table 2). Maximum concentrations of bioaccumulative compounds were compared to PCLs and available screening values so that the potential toxicity to both wildlife and benthic invertebrates could be considered. Those compounds that exceeded either their PCL or their screening value (*e.g.*, NOAA ER-Ls) were retained as preliminary COPECs. In many cases, wildlife PCLs are lower than marine/estuarine sediment benchmarks because sediment benchmarks are protective of benthic invertebrates without consideration of bioaccumulation, while PCLs are protective of bioaccumulative hazards to higher trophic level receptors.

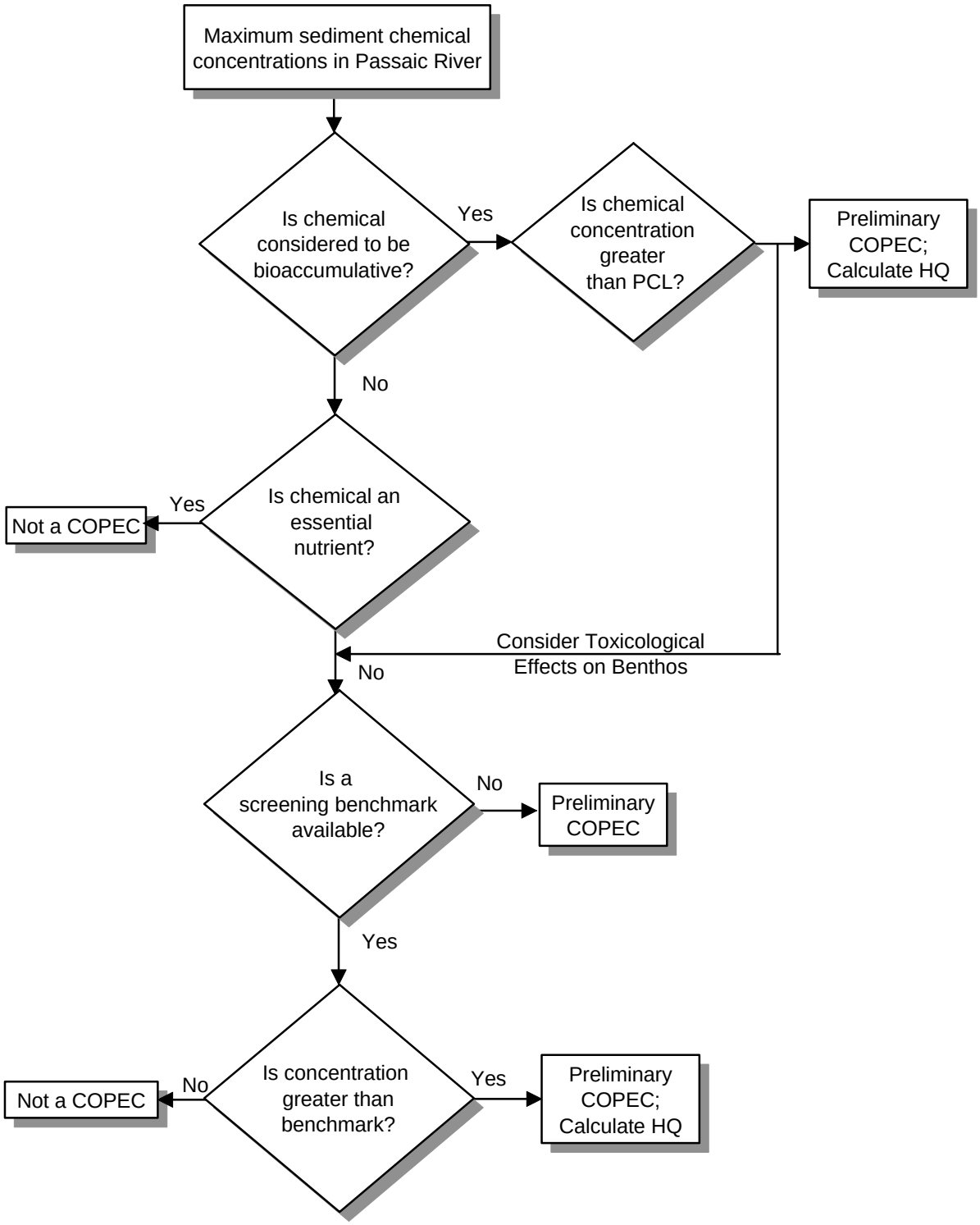

Figure 2. Sediment Preliminary COPEC Decision Diagram to Support the Focused Feasibility Study for the Lower Passaic River Restoration Project

Table 2. Summary of Screening Values Used in the Assessment

CASRN	Units	Chemical	Marine/ Estuarine Values		Lowest Aquatic Benchmark	USEPA List of Bioaccumulators[c]	Wildlife-Based PCL[d]	Basis
			NOAA ER-L[a]	NJDEP[b]				
Inorganics								
7429-90-5	ng/g	Aluminum	-	-	-	N	-	
7664-41-7	ng/g	Ammonia	-	-	-	N	-	
7440-36-0	ng/g	Antimony	-	-	-	N	-	
7440-38-2	ng/g	Arsenic	8,200	8,200	8,200	Y	173,228	NOAA ER-L
7440-39-3	ng/g	Barium	-	-	-	N	-	
7440-41-7	ng/g	Beryllium	-	-	-	N	-	
7440-43-9	ng/g	Cadmium	1,200	1,200	1,200	Y	2,971	NOAA ER-L
7440-70-2	ng/g	Calcium	-	-	-	N	-	
7440-47-3	ng/g	Chromium	81,000	81,000	81,000	Y	41,409	Wildlife PCL
7440-48-4	ng/g	Cobalt	-	-	-	N	-	
7440-50-8	ng/g	Copper	34,000	34,000	34,000	Y	13,318	Wildlife PCL
57-12-5	ng/g	Cyanide	-	-	-	N	-	
7439-89-6	ng/g	Iron	-	-	-	N	-	
7439-92-1	ng/g	Lead	46,700	47,000	46,700	Y	10,606	Wildlife PCL
7439-95-4	ng/g	Magnesium	-	-	-	N	-	
7439-96-5	ng/g	Manganese	-	-	-	N	-	
7439-97-6	ng/g	Mercury	150	150	150	Y	37	Wildlife PCL
7440-02-0	ng/g	Nickel	20,900	21,000	20,900	Y	21,551	NOAA ER-L
7440-09-7	ng/g	Potassium	-	-	-	N	-	
7782-49-2	ng/g	Selenium	-	-	-	Y	925	Wildlife PCL
7440-22-4	ng/g	Silver	1,000	1,000	1,000	Y	1,298,747	NOAA ER-L
7440-21-3	ng/g	Silicon	-	-	-	N	-	
7440-23-5	ng/g	Sodium	-	-	-	N	-	
7440-28-0	ng/g	Thallium	-	-	-	N	-	
7440-31-5	ng/g	Tin	-	-	-	N	-	
7440-32-6	ng/g	Titanium	-	-	-	N	-	
7440-62-2	ng/g	Vanadium	-	-	-	N	-	
7440-66-6	ng/g	Zinc	150,000	150,000	150,000	Y	46,688	Wildlife PCL
Volatile Organic Compounds (VOCs)								
630-20-6	ng/g	1,1,1,2-Tetrachloroethane	-	-		N	-	
71-55-6	ng/g	1,1,1-Trichloroethane	-	-		N	-	
79-34-5	ng/g	1,1,2,2-Tetrachloroethane	-	-		N	-	
76-13-1	ng/g	1,1,2-Trichloro-1,2,2-trifluoroethane	-	-	-	N	-	

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CASRN	Units	Chemical	Marine/ Estuarine Values		Lowest Aquatic Benchmark	USEPA List of Bioaccumulators[c]	Wildlife-Based PCL[d]	Basis
			NOAA ER-L[a]	NJDEP[b]				
79-00-5	ng/g	1,1,2-Trichloroethane	-	-	-	N	-	
75-34-3	ng/g	1,1-Dichloroethane	-	-	-	N	-	
75-35-4	ng/g	1,1-Dichloroethene	-	-	-	N	-	
563-58-6	ng/g	1,1-Dichloropropene	-	-	-	N	-	
96-18-4	ng/g	1,2,3-Trichloropropane	-	-	-	N	-	
96-12-8	ng/g	1,2-Dibromo-3-chloropropane	-	-	-	N	-	
106-93-4	ng/g	1,2-Dibromoethane	-	-	-	N	-	
107-06-2	ng/g	1,2-Dichloroethane	-	-	-	N	-	
540-59-0	ng/g	1,2-Dichloroethylene	-	-	-	N	-	
540-59-0	ng/g	1,2-Dichloroethylene	-	-	-	N	-	
78-87-5	ng/g	1,2-Dichloropropane	-	-	-	N	-	
142-28-9	ng/g	1,3-Dichloropropane	-	-	-	N	-	
594-20-7	ng/g	2,2-Dichloropropane	-	-	-	N	-	
591-78-6	ng/g	2-Hexanone	-	-	-	N	-	
59-50-7	ng/g	4-Chloro-3-methylphenol	-	-	-	N	-	
106-43-4	ng/g	4-Chlorotoluene	-	-	-	N	-	
108-10-1	ng/g	4-Methy-2-pentanone	-	-	-	N	-	
67-64-1	ng/g	Acetone	-	-	-	N	-	
98-86-2	ng/g	Acetophenone	-	-	-	N	-	
107-02-8	ng/g	Acrolein	-	-	-	N	-	
107-13-1	ng/g	Acrylonitrile	-	-	-	N	-	
71-43-2	ng/g	Benzene	-	340	340	N	-	NJ Benchmark
74-97-5	ng/g	Bromochloromethane	-	-	-	N	-	
75-25-2	ng/g	Bromoform	-	-	-	N	-	
75-15-0	ng/g	Carbon disulfide	-	-	-	N	-	
56-23-5	ng/g	Carbon Tetrachloride	-	-	-	N	-	
108-90-7	ng/g	Chlorobenzene	-	-	-	N	-	
124-48-1	ng/g	Chlorodibromomethane	-	-	-	N	-	
75-00-3	ng/g	Chloroethane	-	-	-	N	-	
67-66-3	ng/g	Chloroform	-	-	-	N	-	
156-59-2	ng/g	cis-1,2-Dichloroethylene	-	-	-	N	-	
1006-10-15	ng/g	cis-1,3-Dichloropropene	-	-	-	N	-	
110-82-7	ng/g	cyclohexane	-	-	-	N	-	
75-27-4	ng/g	Dichlorobromomethane	-	-	-	N	-	
75-71-8	ng/g	Dichlorodifluoromethane	-	-	-	N	-	

CASRN	Units	Chemical	Marine/ Estuarine Values		Lowest Aquatic Benchmark	USEPA List of Bioaccumulators[c]	Wildlife-Based PCL[d]	Basis
			NOAA ER-L[a]	NJDEP[b]				
100-41-4	ng/g	Ethylbenzene	-	1400	1400	N	-	NJ Benchmark
98-82-8	ng/g	Isopropylbenzene	-	-	-	N	-	
M&PXYLENE	ng/g	m&p-Xylene	-	120	120	N	-	NJ Benchmark
79-20-9	ng/g	methyl acetate	-	-	-	N	-	
74-83-9	ng/g	Methyl bromide	-	-	-	N	-	
74-87-3	ng/g	Methyl Chloride	-	-	-	N	-	
108-87-2	ng/g	Methyl Cyclohexane	-	-	-	N	-	
78-93-3	ng/g	Methyl Ethyl Ketone	-	-	-	N	-	
74-95-3	ng/g	Methylene Bromide	-	-	-	N	-	
75-09-2	ng/g	Methylene Chloride	-	-	-	N	-	
1634-04-4	ng/g	Methyl-t-Butyl Ether	-	-	-	N	-	
104-51-8	ng/g	n-Butylbenzene	-	-	-	N	-	
103-65-1	ng/g	n-Propylbenzene	-	-	-	N	-	
95-47-6	ng/g	O-Xylene	-	120	120	N	-	NJ Benchmark
99-87-6	ng/g	p-Isopropyltoluene	-	-	-	N	-	
100-42-5	ng/g	Styrene	-	-	-	N	-	
127-18-4	ng/g	Tetrachloroethylene	-	450	450	N	-	NJ Benchmark
108-88-3	ng/g	Toluene	-	2500	2500	N	-	NJ Benchmark
BTEX	ng/g	Total BTEX	-	-	-	N	-	
1330-20-7	ng/g	Total Xylenes	-	120	120	N	-	NJ Benchmark
156-60-5	ng/g	trans-1,2-Dichloroethylene	-	-	-	N	-	
10061-02-6	ng/g	Trans-1,3-dichloropropene	-	-	-	N	-	
79-01-6	ng/g	Trichloroethylene	-	1,600	1,600	N	-	NJ Benchmark
75-69-4	ng/g	Trichlorofluoromethane	-	-	-	N	-	
75-01-4	ng/g	Vinyl Chloride	-	-	-	N	-	
Semi-Volatile Organic Compounds (Non-PAHs)								
108-60-1	ng/g	1-Chloropropane	-	-	-	N	-	
95-50-1	ng/g	1,2-Dichlorobenzene	-	-	-	Y	2,746,538	Wildlife PCL
541-73-1	ng/g	1,3-Dichlorobenzene	-	-	-	Y	560,635	Wildlife PCL
106-46-7	ng/g	1,4-Dichlorobenzene	-	-	-	Y	560,635	Wildlife PCL
123-91-1	ng/g	1,4-Dioxane	-	-	-	N	-	
87-61-6	ng/g	1,2,3-Trichlorobenzene	-	-	-	Y	3,845,153	Wildlife PCL
120-82-1	ng/g	1,2,4-Trichlorobenzene	-	-	-	Y	3,845,153	Wildlife PCL
95-63-6	ng/g	1,2,4-Trimethylbenzene	-	-	-	N	-	
108-67-8	ng/g	1,3,5-Trimethylbenzene	-	-	-	N	-	
95-94-3	ng/g	1,2,4,5-Tetrachlorobenzene	-	-	-	Y	13,238	Wildlife PCL

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CASRN	Units	Chemical	Marine/ Estuarine Values		Lowest Aquatic Benchmark	USEPA List of Bioaccumulators[c]	Wildlife-Based PCL[d]	Basis
			NOAA ER-L[a]	NJDEP[b]				
95-95-4	ng/g	2,4,5-Trichlorophenol	-	-	-	N	-	
88-06-2	ng/g	2,4,6-Trichlorophenol	-	-	-	N	-	
120-83-2	ng/g	2,4-Dichlorophenol	-	-	-	N	-	
105-67-9	ng/g	2,4-Dimethylphenol	-	-	-	N	-	
51-28-5	ng/g	2,4-Dinitrophenol	-	-	-	N	-	
121-14-2	ng/g	2,4-Dinitrotoluene	-	-	-	N	-	
28804-88-8	ng/g	2,6/2,7-Dimethylnaphthalene	-	-	-	N	-	
606-20-2	ng/g	2,6-Dinitrotoluene	-	-	-	N	-	
91-58-7	ng/g	2-Chloronaphthalene	-	-	-	N	-	
95-57-8	ng/g	2-Chlorophenol	-	-	-	N	-	
95-48-7	ng/g	2-Methylphenol	-	-	-	N	-	
88-74-4	ng/g	2-Nitroanaline	-	-	-	N	-	
88-75-5	ng/g	2-Nitrophenol	-	-	-	N	-	
91-94-1	ng/g	3,3'-Dichlorobenzidine	-	-	-	N	-	
99-09-2	ng/g	3-Nitroaniline	-	-	-	N	-	
101-55-3	ng/g	4-Bromophenyl Phenyl Ether	-	-	-	Y	5,850,214	Wildlife PCL
106-47-8	ng/g	4-Chloroaniline	-	-	-	N	-	
7005-72-3	ng/g	4-Chlorophenyl Phenyl Ether	-	-	-	Y	73,676,722	Wildlife PCL
106-44-5	ng/g	4-Methylphenol	-	-	-	N	-	
100-01-6	ng/g	4-Nitroaniline	-	-	-	N	-	
100-02-7	ng/g	4-Nitrophenol	-	-	-	N	-	
534-52-1	ng/g	4,6-Dinitro-2-Methylphenol	-	-	-	N	-	
95-15-8	ng/g	Benzo(b)thiophene	-		-	N	-	
92-87-5	ng/g	Benzidine	-		-	N	-	
65-85-0	ng/g	Benzoic Acid	-		-	N	-	
100-51-6	ng/g	Benzyl Alcohol	-	-	-	N	-	
111-91-1	ng/g	Bis(2-Chloroethoxy)methane	-	-	-	N	-	
111-44-4	ng/g	Bis(2-Chloroethyl)ether	-	-	-	N	-	
117-81-7	ng/g	Bis(2-Ethylhexyl)phthalate	-	-	-	N	-	
108-86-1	ng/g	Bromobenzene	-	-	-	N	-	
85-68-7	ng/g	Butyl Benzyl Phthalate	-	-	-	N	-	
86-74-8	ng/g	Carbazole	-	-	-	N	-	
1861-32-1	ng/g	Dacthal	-	-	-	N	-	

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CASRN	Units	Chemical	Marine/ Estuarine Values		Lowest Aquatic Benchmark	USEPA List of Bioaccumulators[c]	Wildlife-Based PCL[d]	Basis
			NOAA ER-L[a]	NJDEP[b]				
132-64-9	ng/g	Dibenzofuran	-	-	-	N	-	
132-65-0	ng/g	Dibenzothiophene	-	-	-	N	-	
1002-53-5	ng/g	Dibutyltin	-	-	-	N	-	
84-66-2	ng/g	Diethyl Phthalate	-	-	-	N	-	
131-11-3	ng/g	Dimethylphthalate	-	-	-	N	-	
84-74-2	ng/g	Di-n-butyl Phthalate	-	-	-	N	-	
117-84-0	ng/g	Di-n-Octyl Phthalate	-	-	-	N	-	
87-68-3	ng/g	Hexachlorobutadiene	-	-	-	Y	117,004	Wildlife PCL
77-47-4	ng/g	Hexachlorocyclopentadiene	-	-	-	Y	-	
67-72-1	ng/g	Hexachloroethane	-	-	-	Y	-	
78-59-1	ng/g	Isophorone	-	-	-	N	-	
78763-54-9	ng/g	Monobutyltin	-	-	-	N	-	
98-95-3	ng/g	Nitrobenzene	-	-	-	N	-	
621-64-7	ng/g	N-nitrosodipropylamine	-	-	-	N	-	
86-30-6	ng/g	N-Nitroso-diI-phenylamine	-	-	-	N	-	
87-86-5	ng/g	Pentachlorophenol	-	-	-	Y	415,862	Wildlife PCL
108-95-2	ng/g	Phenol	-	-	-	N	-	
1461-25-2	ng/g	Tetrabutyltin	-	-	-	N	-	
56573-85-4	ng/g	Tributyltin	25	-	25	Y	3,583	NOAA ER-L
Semi-Volatile Organic Compounds (PAHs)								
90-12-0	ng/g	1-Methylnaphthalene	-	-	-	N	-	
832-69-9	ng/g	1-Methylphenanthrene	-	-	-	N	-	
91-57-6	ng/g	2-Methylnaphthalene	70	70	70	N	-	NOAA ER-L
2245-38-7	ng/g	2,3,5-Trimethylnaphthalene	-	-	-	N	-	
581-42-0	ng/g	2,6-Dimethylnaphthalene	-	-	-	N	-	
83-32-9	ng/g	Acenaphthene	16	16	16	Y	-	NOAA ER-L
208-96-8	ng/g	Acenaphthylene	44	44	44	Y	-	NOAA ER-L
120-12-7	ng/g	Anthracene	85.3	85	85	Y	-	NJ Benchmark
56-55-3	ng/g	Benzo[a]anthracene	261	261	261	Y	-	NOAA ER-L
50-32-8	ng/g	Benzo[a]pyrene	430	430	430	Y	-	NOAA ER-L
205-99-2	ng/g	Benzo[b]fluoranthene	-	-	-	Y	-	
192-97-2	ng/g	Benzo[e]pyrene	-	-	-	N	-	
191-24-2	ng/g	Benzo[g,h,i]perylene	-	-	-	Y	-	
92-52-4	ng/g	Biphenyl	-	-	-	Y	-	
207-08-9	ng/g	Benzo[k]fluoranthene	-	-	-	Y	-	
218-01-9	ng/g	Chrysene	384	384	384	Y	-	NOAA ER-L

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CASRN	Units	Chemical	Marine/ Estuarine Values		Lowest Aquatic Benchmark	USEPA List of Bioaccumulators[c]	Wildlife-Based PCL[d]	Basis
			NOAA ER-L[a]	NJDEP[b]				
53-70-3	ng/g	Dibenz[a,h]anthracene	63.4	63	63	Y	-	NJ Benchmark
206-44-0	ng/g	Fluoranthene	600	600	600	Y	-	NOAA ER-L
86-73-7	ng/g	Fluorene	19	19	19	Y	-	NOAA ER-L
193-39-5	ng/g	Indeno[1,2,3-c,d]-pyrene	-	-	-	Y	-	
91-20-3	ng/g	Naphthalene	160	160	160	N	-	NOAA ER-L
198-55-0	ng/g	Perylene	-	-	-	N	-	
85-01-8	ng/g	Phenanthrene	240	240	240	Y	-	NOAA ER-L
129-00-0	ng/g	Pyrene	665	665	665	Y	-	NOAA ER-L
SUM_HIGH_PAH	ng/g	Low Molecular Weight PAHs	552	552		N	-	NOAA ER-L
SUM_LOW_PAH	ng/g	High Molecular Weight PAHs	1,700	1,700		N	-	NOAA ER-L
SUM_PAH	ng/g	Total PAHs	4,022	4,000	4,000	N	-	NJ Benchmark
PCB Aroclors								
12674-11-2	ng/g	Aroclor 1016	-	-	-	Y	365	Wildlife PCL
11104-28-2	ng/g	Aroclor 1221	-	-	-	Y	365	Wildlife PCL
11141-16-5	ng/g	Aroclor 1232	-	-	-	Y	365	Wildlife PCL
53469-21-9	ng/g	Aroclor 1242	-	-	-	Y	365	Wildlife PCL
12672-29-6	ng/g	Aroclor 1248	-	-	-	Y	365	Wildlife PCL
11097-69-1	ng/g	Aroclor 1254	-	-	-	Y	365	Wildlife PCL
11096-82-5	ng/g	Aroclor 1260	-	-	-	Y	365	Wildlife PCL
37324-23-5	ng/g	Aroclor-1262	-	-	-	Y	365	Wildlife PCL
SUM_PCB	ng/g	Total PCBs	22.7	23	22.7	Y	365	NOAA ER-L
Pesticides/Herbicides								
93-76-5	ng/g	2,4,5-T	-	-	-	N	-	
93-72-1	ng/g	2,4,5-TP	-	-	-	N	-	
94-75-7	ng/g	2,4-D	-	-	-	N	-	
94-82-6	ng/g	2,4-DB	-	-	-	N	-	
53-19-0	ng/g	2,4-DDD	2	-	2	Y	830	NOAA ER-L
3424-82-6	ng/g	2,4-DDE	2.2	-	2.2	Y	19	NOAA ER-L
789-02-6	ng/g	2,4-DDT	1	-	1	Y	139	NOAA ER-L
72-54-8	ng/g	4,4'-DDD	2	-	2	Y	830	NOAA ER-L
72-55-9	ng/g	4,4'-DDE	2.2	2.2	2.2	Y	19	NOAA ER-L
50-29-3	ng/g	4,4'-DDT	1	-	1	Y	139	NOAA ER-L
SUM_TDDT	ng/g	Total DDTs, sum of 6 isomers	1.58	1.6	1.58	Y	19	NOAA ER-L
309-00-2	ng/g	Aldrin	-	-	-	Y	463	Wildlife PCL
319-84-6	ng/g	BHC-alpha	-	-	-	Y	1,247	Wildlife PCL

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CASRN	Units	Chemical	Marine/ Estuarine Values		Lowest Aquatic Benchmark	USEPA List of Bioaccumulators[c]	Wildlife-Based PCL[d]	Basis
			NOAA ER-L[a]	NJDEP[b]				
319-85-7	ng/g	BHC-beta	-	-	-	Y	1,247	Wildlife PCL
58-89-9	ng/g	BHC-gamma (Lindane)	-	-	-	Y	1,247	Wildlife PCL
319-86-8	ng/g	BHC, delta	-	-	-	Y	1,247	Wildlife PCL
SUM_BHC	ng/g	SUM_BHC	-	-	-	Y	1,247	Wildlife PCL
5103-71-9	ng/g	Chlordane, alpha (cis)	-	-	-	Y	2,006	Wildlife PCL
5103-74-2	ng/g	Chlordane, gamma (trans)	-	-	-	Y	2,006	Wildlife PCL
SUM_CHLORDANE	ng/g	Total Chlordane	-	-	-	Y	2,006	Wildlife PCL
60-57-1	ng/g	Dieldrin	0.02	-	0.02	Y	271	NOAA ER-L
1031-07-8	ng/g	Endosulfan Sulfate	-	-	-	Y	4,875	Wildlife PCL
959-98-8	ng/g	Endosulfan, alpha	-	-	-	Y	4,875	Wildlife PCL
33213-65-9	ng/g	Endosulfan, beta	-	-	-	Y	4,875	Wildlife PCL
SUM_ENDOSULFAN	ng/g	Total Endosulfan	-	-	-	Y	4,875	Wildlife PCL
7421-93-4	ng/g	Endrin Aldehyde	-	-	-	Y	35	Wildlife PCL
53494-70-5	ng/g	Endrin Ketone	-	-	-	Y	35	Wildlife PCL
SUM_ENDRIN	ng/g	Total Endrin	-	-	-	Y	35	Wildlife PCL
1024-57-3	ng/g	Heptachlor Epoxide	-	-	-	Y	9,663	Wildlife PCL
76-44-8	ng/g	Total Heptachlor	-	-	-	Y	-	
118-74-1	ng/g	Hexachlorobenzene	-	-	-	Y	92,898	Wildlife PCL
72-43-5	ng/g	Methoxychlor	-	-	-	Y	114,909	Wildlife PCL
2385-85-5	ng/g	Mirex	-	-	-	Y	-	
5103-73-1	ng/g	Total Nonachlor	-	-	-	N	-	
8001-35-2	ng/g	Toxaphene	-	-	-	Y	1,398	Wildlife PCL
Dioxins/Furans								
1746-01-6	ng/g	2,3,7,8-TCDD	0.0032	-	0.0032	Y	0.0025	Wildlife PCL

- no value available
a. ER-L = Effects Range-Low from Long and Morgan, 1991 and Long *et al.*, 1995; except where noted.
b NJDEP Guidance For Sediment Quality Evaluations, November 1998. References Long *et al.*, 1995.
c. From USEPA 2000. Bioaccumulation Testing and Interpretation for the Purpose of Sediment Quality Assessment. USEPA-823-R-00-001.
d. Protective Concentration Levels (PCLs) derived as discussed in the text; see Attachments B and C.

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Protective Concentration Levels (PCLs)

Wildlife-protective sediment concentrations for bioaccumulating compounds were calculated to provide a sediment benchmark based on exposures to higher trophic level organisms. Equation 1 was used to estimate PCLs for piscivorous wildlife receptors in the LPRRP study area. The otter (*Lutra canadensis*) and belted kingfisher (*Ceryle alcyon*) were selected as the model receptors due to their relatively large dietary exposures to sediment-associated chemicals that can bioaccumulate in biological tissue.

$$PCL_{sed} = \frac{THQ * TRV * BW}{\left(BAF_{fish} * IR_{fish} * P_{fish} * SFF\right)} \qquad \text{Equation 1}$$

where:

PCL_{sed}	=	Protective Concentration Level for sediment protective of bioaccumulation hazards associated with the fish consumption pathway (µg COPEC/g sediment).
THQ	=	Target Hazard Quotient for the COPEC based on tissue residue effects (dimensionless); a THQ of 1 was used.
TRV	=	Toxicity Reference Value. Receptor-specific literature-based toxicity threshold value. NOAEL and LOAEL-based TRV values are presented in Attachment B. The MATC-based TRV is the geometric mean of the NOAEL- and LOAEL-based values.
BW	=	Receptor body weights (Kg) are summarized in Attachment B.
BAF_{fish}	=	Bioaccumulation Factor between sediment and fish prey consumed by the receptor (g sediment [dry weight]/ g fish [wet weight])
IR_{fish}	=	Daily fish ingestion rate (Kg fish consumed per day).
P_{fish}	=	Percentage of fish in the diet
SFF	=	Site Foraging Frequency (unitless); fraction of time receptor is assumed to forage at the site.

Table 3. Summary of Exposure Parameters Used to Develop the PCLs

Parameter	Value	Units	Reference
PCL_{sed}	Calculated using Equation 1	µg COPEC/g sediment	
THQ	1	unitless	
TRV	Chemical specific	µg COPEC/g-day	See Attachment B and Attachment C
BW	7.4 (otter)	Kg	USEPA, 1993a
	0.136 (kingfisher)		USEPA, 1993a; Brooks and Davis, 1987
BAF_{fish}	Chemical specific		See Attachment B and Attachment C
IR_{fish}	0.4 (otter)	Kg/day	USEPA, 1993a
	0.068 (kingfisher)		USEPA, 1993a; Alexander, 1977
P_{fish}	100	%	Assumption
SFF	1	unitless	Assumption

Chemical-specific TRVs and BAFs are presented in Attachments B and C, and the calculated PCLs for both receptors are provided in Table 2. For each chemical, the lower of the two PCL values was identified as the wildlife PCL and used in the screening evaluation. Note that there are relatively few TRVs for avian receptors and, consequently, for some COPECs, the wildlife value is based solely on the mammalian PCL.

Rather than derive PCLs for TCDD using the above approach, sediment concentrations protective of piscivorous mammals (2.5 picograms/gram [pg/g] or parts per trillion) and birds (21 pg/g) derived by USEPA (1993b) were used. The lower of these values was selected as the wildlife PCL value.

Essential Nutrients

Inorganic constituents considered to be “essential nutrients”, which are not likely to be toxic at anticipated environmental levels, were excluded from consideration in this analysis. These analytes include calcium, magnesium, potassium, and sodium.

Effects Values

The maximum concentrations of all constituents that were detected, including those considered bioaccumulative, and not considered essential nutrients, were screened against a hierarchy of effects-based sediment screening values. Screening values for sediments were obtained from sediment quality guidelines developed for marine and estuarine waters for NOAA by Long *et al.*, 1995; the Effects Range Low (ER-L). The ER-L values represent the low end of a range of levels at which adverse effects were observed in compiled studies and represent values at which toxicity may begin to be observed in sensitive species (Long *et al.*, 1995). Therefore, concentrations below the ER-L are considered to be within the "no effects range.” The ER-L values used in the selection of COPECs are listed in Table 2. Additional sediment quality values for New Jersey Department of Environmental Protection are also used (NJDEP, 1998) in this evaluation. These screening levels were developed specifically for sediment evaluations for use in the ecological risk assessment process. Although the NJDEP sediment guidelines are also based primarily on the Long *et al*., 1995 study, several VOC benchmarks are also provided that were derived using an equilibrium partitioning approach (NJDEP, 1998).

A NOAA ER-L is not available for TCDD; therefore a site-specific screening benchmark (3.1 pg/g) as presented by Wintermyer and Cooper (2003), was derived by the U.S. Fish and Wildlife Service (USFWS) using Arthur Kill sediment and oyster tissue chemistry and ecological effects.

Chemicals for which no effects-based sediment screening value was readily available were retained as preliminary COPECs. These are further addressed in a refinement step. In addition, as part of future risk assessment activities, a literature review will be conducted to identify appropriate screening values for chemicals currently lacking screening values.

Preliminary Sediment COPEC Selection

Inorganic Constituents

Surface sediments were analyzed for 26 inorganic constituents and these were all detected in at least one of the samples. A total of ten inorganic constituents are included on the USEPA list of bioaccumulative compounds (USEPA, 2000) and were compared to appropriate PCLs and sediment effects benchmarks where available. Four essential nutrients (calcium, magnesium, potassium, and sodium) were detected but eliminated from consideration as COPECs.

Sediment screening values were not available for 12 inorganic analytes (Table 4) detected in surface sediment samples. Excluding the essential nutrients, the remaining 12 analytes were retained as preliminary COPECs. Analytes that do not have sediment screening values will be discussed further in the refinement step. Hazard quotients were calculated for each of the analytes retained as preliminary COPECs and range from 8 for selenium to 290 for mercury (Attachment A).

Volatile Organic Compounds (VOCs)

Surface sediment samples were analyzed for a total of 61 VOCs and 21 VOCs were detected at least once among the samples evaluated. Sediment screening levels are available for a total of eight compounds. Only toluene slightly exceeded its screening value (HQ= 1.1) and was retained as a preliminary COPEC. Relevant screening values are not available for 53 VOCs that were retained as preliminary COPECs (Attachment A). Of these, 40 were reported as non-detects; however, in the absence of a screening level, the appropriateness of the detection level could not be fully evaluated. These compounds will be discussed further in the refinement step.

No VOC is included on the USEPA list of bioaccumulative compounds (USEPA, 2000).

Semivolatile Organic Compounds (SVOCs), Excluding PAHs

A total of 56 SVOCs were analyzed in surface sediment and 31 SVOCs were detected. Of the 31 compounds detected, only tributyltin exceeded the available screening level and was retained as a preliminary COPEC. In addition, the detection limit for hexachlorobutadiene was above the screening level and was therefore retained as a preliminary COPEC.

Forty-five additional SVOCs (Table 4) were identified as preliminary COPECs because they lack available sediment screening benchmarks. It should be noted that 26 of these compounds were also reported as non-detected, however, in the absence of a screening level, the appropriateness of the detection level could not be evaluated.

Polycyclic Aromatic Hydrocarbons (PAHs)

A total of 28 individual PAHs were detected in surface sediment samples. Sediment screening values are available for 16 PAHs, including total PAHs, total LMW PAHs, and total HMW PAHs. Nineteen constituents or summed totals were detected at maximum concentrations greater than the available sediment screening value and were retained as preliminary COPECs. No sediment screening value is available for six of the PAHs; therefore these constituents were also retained as preliminary COPECs.

Nineteen individual PAHs or summed totals are considered to be bioaccumulative compounds (USEPA, 2000). Nine were detected at maximum concentrations that exceed their respective PCL sediment screening values and were selected as preliminary COPECs.

Polychlorinated Biphenyls (PCBs)

Total PCBs (sum of Aroclor mixtures) and eight Aroclor mixtures were analyzed in Passaic River sediment samples. All PCBs are considered to be bioaccumulative compounds and were consequently evaluated by comparing maximum concentrations to the conservative wildlife-based PCLs. Four Aroclor mixtures were reported as non-detected (Table 4). The maximum concentrations of Total PCBs and

Aroclor mixtures 1242, 1248, 1254, and 1260 exceed their respective sediment screening values and were retained as preliminary COPECs.

Pesticides/Herbicides

Passaic River sediments were analyzed for 32 individual pesticides and herbicides, and total chlordane, total endosulfan, total endrin, total BHC, and total DDT (sum of six DDT isomers). Screening levels were not available for six of these compounds, including the four herbicides. Fourteen additional individual compounds and summed totals exceeded screening values and were retained as preliminary COPECs.

Dioxins/Furans

For dioxins, 2,3,7,8-TCDD was selected as an indicator for screening PCDDs, PCDFs, and coplanar PCBs for the purpose of this assessment. 2,3,7,8-TCDD was detected in almost all the samples (detection frequency of 99.6%). Dioxin/furan compounds are considered to be bioaccumulative compounds (USEPA, 2000). The maximum concentration substantially exceeds the PCL screening value (HQ=7,800) and TCDD was retained as a preliminary COPEC.

REFINEMENT AND IDENTIFICATION OF COPECS

A conservative screening evaluation was used to develop a list of preliminary COPECs. These compounds were screened based on their maximum concentration and using conservative screening values such as the NOAA ER-Ls. Further refinement of this list of COPECs was conducted to identify those chemicals that provide the best basis for making sediment management decisions in the FFS. Although a category of preliminary COPECs was identified based on the unavailability of sediment screening benchmarks, these are not considered to be likely risk drivers that would provide the primary rationale for a possible early action at the LPRRP site. This is supported by the following arguments:

- Protective screening benchmarks were established for all detected sediment constituents considered to pose a bioaccumulation hazard to wildlife; as a result these risk uncertainties are limited to macroinvertebrate receptors. While lower trophic levels provide important ecosystem functions such as providing a prey base and in cycling nutrients, they are generally not considered to have the same societal relevance as do fish and wildlife species.

- The lack of readily available benchmarks suggests that in at least some cases the particular constituent is not typically bioavailable and/or toxic at environmental concentrations.

- It is unlikely that the potential ecological hazards attributable to constituents that lack screening benchmarks would be of a comparable magnitude to those definitively identified as a result of this screening process. Given the advancements in scientific understanding of ecotoxicological principles made during the last four decades, it is reasonable to conclude that a list of COPCs that include some of the most toxic components of all major chemical classes should provide an adequate basis for proceeding to characterize substantive environmental risks and to facilitate decision making.

Table 4 provides a summary of preliminary COPECs that were identified as non-detect and/or lack of available screening values. It is recommended that these compounds not be considered further in the FFS due to the uncertainty associated with these values.

Table 4. Preliminary COPECs Reported as Non-Detect or Lacking Established Sediment Screening Values

Chemical	Units	Maximum Concentration[a]	Qualifier[b]	Number Samples	Detection Frequency	Non Detect[c]	No Benchmark[d]
Inorganics							
Aluminum	ng/g	2.4E+07	M	320	100%		√
Ammonia	ng/g	2.9E+06		77	97%		√
Antimony	ng/g	3.8E+04		301	38%		√
Barium	ng/g	1.3E+06		315	99%		√
Beryllium	ng/g	3.1E+03		318	69%		√
Calcium	ng/g	3.7E+07	M	320	100%		√
Cobalt	ng/g	4.1E+04		318	93%		√
Cyanide	ng/g	2.7E+05		220	16%		√
Iron	ng/g	4.8E+07		320	100%		√
Magnesium	ng/g	9.8E+06	M	320	100%		√
Manganese	ng/g	8.6E+05	M	315	100%		√
Potassium	ng/g	5.9E+06	NJH	277	99%		√
Sodium	ng/g	1.4E+07	M	320	100%		√
Thallium	ng/g	4.9E+03	M	304	50%		√
Titanium	ng/g	7.4E+05	N*JL	134	100%		√
Vanadium	ng/g	9.9E+04	M	318	100%		√
Volatile Organic Compounds							
1,1,1,2-Tetrachloroethane	ng/g	3.1E+00	U	1	0%	√	√
1,1,1-Trichloroethane	ng/g	6.6E+01	U	162	0%	√	√
1,1,2,2-Tetrachloroethane	ng/g	6.6E+01	U	162	0%	√	√
1,1,2-trichloro-1,2,2-trifluoroethane	ng/g	6.6E+01	U	25	0%	√	√
1,1,2-Trichloroethane	ng/g	6.6E+01	U	162	0%	√	√
1,1-Dichloroethane	ng/g	6.6E+01	U	162	0%	√	√
1,1-Dichloroethane	ng/g	6.6E+01	U	162	0%	√	√
1,1-Dichloroethene	ng/g	6.6E+01	U	162	0%	√	√
1,1-Dichloropropene	ng/g	3.3E+00	U	1	0%	√	√
1,2,3-Trichloropropane	ng/g	5.6E+00	U	1	0%	√	√
1,2-Dibromo-3-chloropropane	ng/g	6.6E+01	U	26	0%	√	√
1,2-Dibromoethane	ng/g	6.6E+01	U	26	0%	√	√
1,2-Dichloroethylene	ng/g	3.8E+01	U, UJL	136	2%		√
1,2-Dichloropropane	ng/g	6.6E+01	U	162	0%	√	√
1,3-Dichloropropane	ng/g	5.6E+00	U	1	0%	√	√
2,2-Dichloropropane	ng/g	1.1E+01	U	1	0%	√	√
2-Hexanone	ng/g	6.6E+01	U	161	0%	√	√
4-Chloro-3-Methylphenol	ng/g	1.2E+04	UM	219	0%	√	√
4-Chlorotoluene	ng/g	2.5E+00	U	1	0%	√	√
4-Methyl-2-Pentanone	ng/g	6.6E+01	U	161	0%	√	√
Acetone	ng/g	4.3E+02	M	161	64%		√
Acetophenone	ng/g	4.2E+02	U	10	20%		√
Bromochloromethane	ng/g	4.6E+00	U	1	0%	√	√
Bromoform	ng/g	6.6E+01	U	162	0%	√	√
Carbon Disulfide	ng/g	6.6E+01	U	161	1%		√
Carbon Tetrachloride	ng/g	6.6E+01	U	162	0%	√	√
Chlorobenzene	ng/g	1.4E+03		162	15%		√
Chlorodibromomethane	ng/g	6.6E+01	U	162	0%	√	√
Chloroethane	ng/g	6.6E+01	U	162	0%	√	√
Chloroform	ng/g	6.6E+01	U	162	0%	√	√
Cis-1,2-Dichloroethylene	ng/g	6.6E+01	U	26	0%	√	√

Chemical	Units	Maximum Concentration[a]	Qualifier[b]	Number Samples	Detection Frequency	Non Detect[c]	No Benchmark[d]
cis-1,3-Dichloropropene	ng/g	6.6E+01	U	162	0%	√	√
Cyclohexane	ng/g	6.6E+01	U	25	0%	√	√
Dichlorobromomethane	ng/g	6.6E+01	U	162	0%	√	√
Dichlorodifluoromethane	ng/g	6.6E+01	U	26	0%	√	√
Isopropylbenzene	ng/g	6.6E+01	U	26	12%		√
Methyl acetate	ng/g	6.6E+01	U	25	0%	√	√
Methyl Bromide	ng/g	6.6E+01	U	162	1%		√
Methyl Chloride	ng/g	6.6E+01	U	162	7%		√
Methyl cyclohexane	ng/g	6.6E+01	U	25	4%		√
Methyl Ethyl Ketone	ng/g	8.3E+01	JL	161	18%		√
Methylene Bromide	ng/g	6.2E+00	U	1	0%	√	√
Methylene Chloride	ng/g	6.6E+01	U	162	6%		√
Methyl-t-Butyl Ether	ng/g	6.6E+01	U	25	0%	√	√
n-Butylbenzene	ng/g	8.7E+00		1	100%		√
n-Propylbenzene	ng/g	7.7E+00		1	100%		√
p-Isopropyltoluene	ng/g	3.7E+00		1	100%		√
Styrene	ng/g	6.6E+01	U	162	0%	√	√
Tetrachloroethylene	ng/g	6.6E+01	U	162	0%	√	
Total BTEX	ng/g	2.8E+03		22	100%		√
Total xylenes	ng/g	6.6E+01	U	15	0%	√	
Trans-1,2-Dichloroethylene	ng/g	6.6E+01	U	26	0%	√	√
Trans-1,3-dichloropropene	ng/g	6.6E+01	U	162	0%	√	√
Trichlorofluoromethane	ng/g	6.6E+01	U	26	0%	√	√
Vinyl Chloride	ng/g	6.6E+01	U	162	0%	√	√
Semi-Volatile Organic Compounds (Non PAHs)							
1,2,3-Trichlorobenzene	ng/g	5.0E+00	U	1	0%	√	
1,2,4,5-Tetrachlorobenzene	ng/g	4.2E+02	U	10	0%	√	
1,2,4-Trimethylbenzene	ng/g	7.1E+00		1	100%		√
1,3,5-Trimethylbenzene	ng/g	1.9E+01		1	100%		√
1,4-Dioxane	ng/g	4.0E+02	U	10	10%		√
1-Chloropropane	ng/g	1.2E+04	UM	219	0%	√	√
2,4,5-Trichlorophenol	ng/g	1.2E+04	U, UM	219	2%		√
2,4,6-Trichlorophenol	ng/g	1.2E+04	UM	219	0%		√
2,4-Dichlorophenol	ng/g	1.2E+04	UM	219	4%		√
2,4-Dimethylphenol	ng/g	1.2E+04	UM	219	0%	√	√
2,4-Dinitrophenol	ng/g	7.1E+04	UM	219	0%	√	√
2,4-Dinitrotoluene	ng/g	1.2E+04	UM	219	0%	√	√
2,6-Dinitrotoluene	ng/g	1.2E+04	UM	219	0%	√	√
2-Chloronaphthalene	ng/g	1.2E+04	UM	219	0%	√	√
2-Chlorophenol	ng/g	1.2E+04	UM	219	0%		√
2-Methylphenol	ng/g	1.2E+04	UM	219	0%		√
2-Nitroanaline	ng/g	1.2E+04	U, UM	219	0%	√	√
2-Nitrophenol	ng/g	1.2E+04	UM	219	0%	√	√
3,3'-Dichlorobenzidine	ng/g	2.4E+04	UM	218	0%		√
3-Nitroaniline	ng/g	1.2E+04	UJ, UM	218	0%	√	√
4,6-Dinitro-2-Methylphenol	ng/g	3.0E+04	UM	219	0%	√	√
4-Bromophenyl Phenyl Ether	ng/g	1.2E+04	UM	219	0%	√	
4-Chloroaniline	ng/g	1.2E+04	UM	219	3%		√
4-Chlorophenyl Phenyl Ether	ng/g	1.2E+04	UM	219	0%	√	
4-Methylphenol	ng/g	1.2E+04	UM	219	2%		√
4-Nitroaniline	ng/g	1.2E+04	U, UM	219	0%	√	√
4-Nitrophenol	ng/g	3.0E+04	UM	219	0%		√
Bis(2-Chloroethoxy)methane	ng/g	1.2E+04	UM	219	0%	√	√
Bis(2-Chloroethyl)ether	ng/g	1.2E+04	UM	219	0%	√	√

Chemical	Units	Maximum Concentration[a]	Qualifier[b]	Number Samples	Detection Frequency	Non Detect[c]	No Benchmark[d]
Bis(2-Ethylhexyl)phthalate	ng/g	2.3E+07	DM	220	97%		√
Bromobenzene	ng/g	3.3E+00	U	1	0%	√	√
Butyl Benzyl Phthalate	ng/g	3.6E+05	J	219	45%		√
Carbazole	ng/g	1.2E+04	UM	219	34%		√
Dibenzofuran	ng/g	7.0E+04		219	22%		√
Dibenzothiophene	ng/g	1.4E+03		103	97%		√
Dibutyltin	ng/g	2.1E+02	M	74	99%		√
Diethyl Phthalate	ng/g	4.5E+04		219	1%		√
Dimethylphthalate	ng/g	1.2E+04	UM	219	1%		√
Di-n-butyl Phthalate	ng/g	1.2E+04	UM	219	15%		√
Di-n-Octyl Phthalate	ng/g	1.2E+04	UM	219	47%		√
Hexachlorobutadiene	ng/g	1.2E+04	UM	220	0%	√	
Hexachlorocyclopentadiene	ng/g	2.4E+04	UM	219	0%	√	√
Hexachloroethane	ng/g	1.2E+04	UM	219	0%	√	√
Isophorone	ng/g	1.2E+04	UM	219	0%	√	√
Monobutyltin	ng/g	2.8E+01	JL	74	57%		√
Nitrobenzene	ng/g	1.2E+04	UM	219	0%	√	√
N-Nitroso-di-phenylamine	ng/g	1.2E+04	UM	219	9%		√
N-nitrosodipropylamine	ng/g	1.2E+04	UJ	219	0%	√	√
Pentachlorophenol	ng/g	3.0E+04	UM	219	0%	√	
Phenol	ng/g	1.2E+04	UM	219	1%		√
Tetrabutyltin	ng/g	1.6E+00	M	74	15%		√
Semi-Volatile Organic Compounds (PAHs)							
1-Methylnaphthalene	ng/g	9.1E+02	M	84	89%		√
1-Methylphenanthrene	ng/g	3.0E+03		103	98%		√
2,3,5-Trimethylnaphthalene	ng/g	2.1E+03		103	92%		√
2,6-Dimethylnaphthalene	ng/g	1.8E+03		103	93%		√
Benzo[b/j]fluoranthene	ng/g	8.4E+03		19	100%		√
Benzo[b]fluoranthene	ng/g	1.0E+05		294	96%		√
Benzo[e]pyrene	ng/g	8.3E+03	NJ	103	100%		√
Benzo[g,h,i]perylene	ng/g	6.3E+04		313	82%		√
Benzo[k]fluoranthene	ng/g	6.3E+04		313	95%		√
Biphenyl	ng/g	4.2E+02	U	84	88%		√
Indeno[1,2,3-c,d]-pyrene	ng/g	5.7E+04		312	83%		√
Perylene	ng/g	2.6E+03		103	99%		√
PCB Aroclors							
Aroclor 1016	ng/g	9.7E+02	UJ	229	0%	√	
Aroclor 1221	ng/g	1.4E+03	UM	229	0%	√	
Aroclor 1232	ng/g	9.7E+02	UJ	229	0%	√	
Aroclor-1262	ng/g	8.2E+00	U	10	0%	√	
Pesticide/Herbicides							
2,4,5-T	ng/g	4.1E+02	U	167	0%	√	√
2,4,5-TP	ng/g	4.1E+02	U	177	6%		√
2,4-D	ng/g	1.0E+03	U	166	0%	√	√
2,4-DB	ng/g	6.9E+02	UM	166	11%		√
Toxaphene	ng/g	3.4E+03	UM	231	0%	√	

Notes:
a. Obtained from query of PREmis database; units in ng/g (ppb).
b. Data qualifiers from PREmis database; metadata not available.
c. Symbol indicates that the chemical parameter was not detected in the evaluated dataset.
d. Symbol indicates that no benchmark was identified for the particular chemical parameter.

As previously stated, future risk assessment activities will include a literature review to identify appropriate screening values for chemicals currently lacking screening values as well as a data usability assessment. Although not considered as part of the FFS, these compounds will be evaluated further in the baseline risk assessment activities.

The refinement step also considers the magnitude of exceedances. The magnitude of exceedances was assessed using a hazard quotient methodology. Table 5 provides a summary of the magnitude HQ of exceedances. The magnitudes of exceedances were categorized in relationship to the chemical-specific HQ. Exceedances were categorized in a range from 1 to 1,000 times the HQ and are summarized in Table 5.

Table 5. Summary of FFS COPECs and Magnitude of Hazard Quotient Exceedances

Chemical[a]	Units	Maximum Concentration	Qualifier[b]	Number Samples	Detection Frequency	Sediment Benchmarks		Hazard Quotient		Hazard Quotient Exceedance Category[c]					
						Aquatic	Wildlife	Aquatic	Wildlife	1	10	50	100	500	1000
Inorganics															
Arsenic	ng/g	1.08E+05		309	98%	8.2E+03	1.7E+05	1.3E+01	6.2E-01	√	√				
Cadmium	ng/g	2.53E+04		321	98%	1.2E+03	3.0E+03	2.1E+01	8.5E+00	√	√				
Chromium	ng/g	6.70E+05		318	100%	8.1E+04	4.1E+04	8.3E+00	1.6E+01	√	√				
Copper	ng/g	2.47E+06		321	100%	3.4E+04	1.3E+04	7.3E+01	1.9E+02	√	√	√	√		
Lead	ng/g	1.55E+06		316	100%	4.7E+04	1.1E+04	3.3E+01	1.5E+02	√	√	√	√		
Mercury	ng/g	1.07E+04	M	260	97%	1.5E+02	3.7E+01	7.1E+01	2.9E+02	√	√	√	√		
Nickel	ng/g	3.69E+05		303	100%	2.1E+04	2.2E+04	1.8E+01	1.7E+01	√	√				
Selenium	ng/g	7.40E+03	U	245	44%		9.2E+02		8.0E+00	√					
Silver	ng/g	3.95E+04		245	88%	1.0E+03	1.3E+06	4.0E+01	3.0E-02	√	√				
Zinc	ng/g	1.62E+06		313	100%	1.5E+05	4.7E+04	1.1E+01	3.5E+01	√	√				
Volatile Organic Compounds															
Toluene	ng/g	2.80E+03	DJL	162	10%	2.5E+03	-	1.1E+00		√					
Semi-Volatile Organic Compounds (Non-PAHs)															
Tributyltin	ng/g	6.90E+02	IM	74	93%	2.5E+01	3.6E+03	2.8E+01	1.9E-01	√	√				
Semi-Volatile Organic Compounds (PAHs)															
2-Methylnaphthalene	ng/g	2.40E+04	M	312	49%	7.0E+01	-	3.4E+02		√	√	√	√		
Acenaphthene	ng/g	4.20E+05		312	58%	1.6E+01	-	2.6E+04		√	√	√	√	√	√
Acenaphthylene	ng/g	1.20E+04	UM	312	62%	4.4E+01	-	2.7E+02		√	√	√	√		
Anthracene	ng/g	2.30E+05	D	312	78%	8.5E+01	-	2.7E+03		√	√	√	√	√	√
Benzo[a]anthracene	ng/g	1.50E+05		313	95%	2.6E+02	-	5.7E+02		√	√	√	√	√	
Benzo[a]pyrene	ng/g	1.30E+05		313	97%	4.3E+02	-	3.0E+02		√	√	√	√		
Chrysene	ng/g	1.50E+05		313	99%	3.8E+02	-	3.9E+02		√	√	√	√		
Dibenz[a,h]anthracene	ng/g	2.50E+04		312	70%	6.3E+01	-	4.0E+02		√	√	√	√		
Fluoranthene	ng/g	3.20E+05	D	313	99%	6.0E+02	-	5.3E+02		√	√	√	√	√	
Fluorene	ng/g	1.40E+05		312	59%	1.9E+01	-	7.4E+03		√	√	√	√	√	√
Naphthalene	ng/g	4.00E+04	D	313	51%	1.6E+02	-	2.5E+02		√	√	√	√		
Phenanthrene	ng/g	5.70E+05	D	313	91%	2.4E+02	-	2.4E+03		√	√	√	√	√	√
Pyrene	ng/g	3.40E+05	D	313	99%	6.7E+02	-	5.1E+02		√	√	√	√	√	
SUM_HIGH_PAH	ng/g	1.40E+06		239	0%	5.5E+02	-	2.5E+03		√	√	√	√	√	√
SUM_LOW_PAH	ng/g	1.41E+06		240	0%	1.7E+03	-	8.3E+02		√	√	√	√	√	
SUM_PAH	ng/g	2.81E+06		240	0%	4.0E+03	-	7.0E+02		√	√	√	√	√	
PCB Aroclors															
Aroclor 1242	ng/g	1.72E+04	D	229	1%		3.7E+02		4.7E+01	√	√				
Aroclor 1248	ng/g	7.45E+03	DM	235	72%		3.7E+02		2.0E+01	√	√				
Aroclor 1254	ng/g	5.80E+03		231	65%		3.7E+02		1.6E+01	√	√				
Aroclor 1260	ng/g	2.16E+03	DM	228	38%		3.7E+02		5.9E+00	√					
SUM_PCB AROCLORS	ng/g	1.75E+04		236	0%	2.3E+01	3.7E+02	7.7E+02	4.8E+01	√	√	√	√	√	
Pesticide/Herbicides															
2,4-DDD	ng/g	6.87E+02	T	22	95%	2.0E+00	8.3E+02	3.4E+02	8.3E-01	√	√	√	√		
2,4-DDE	ng/g	3.03E+02		22	100%	2.2E+00	1.9E+01	1.4E+02	1.6E+01	√	√	√	√		
2,4-DDT	ng/g	1.45E+02	T	22	95%	1.0E+00	1.4E+02	1.5E+02	1.0E+00	√	√	√	√		
4,4'-DDD	ng/g	5.98E+03	DM	236	91%	2.0E+00	8.3E+02	3.0E+03	7.2E+00	√	√	√	√	√	√
4,4'-DDE	ng/g	1.01E+03		237	91%	2.2E+00	1.9E+01	4.6E+02	5.3E+01	√	√	√	√		
4,4'-DDT	ng/g	2.47E+03	DM	234	75%	1.0E+00	1.4E+02	2.5E+03	1.8E+01	√	√	√	√	√	√
SUM_TDDT	ng/g	5.99E+03		248	0%	1.6E+00	1.9E+01	3.8E+03	3.1E+02	√	√	√	√	√	√
Aldrin	ng/g	6.60E+02		236	7%		4.6E+02		1.4E+00	√					
BHC-beta	ng/g	2.00E+03		227	3%		1.2E+03		1.6E+00	√					
SUM_BHC	ng/g	2.01E+03		233	0%		1.2E+03		1.6E+00	√					
Dieldrin	ng/g	1.41E+02	PDJ	236	46%	2.0E-02	2.7E+02	7.1E+03	5.2E-01	√	√	√	√	√	√

Table 5. Summary of FFS COPECs and Magnitude of Hazard Quotient Exceedances (continued)

Chemical[a]	Units	Maximum Concentration	Qualifier[b]	Number Samples	Detection Frequency	Sediment Benchmarks		Hazard Quotient		Hazard Quotient Exceedance Category[e]					
						Aquatic	Wildlife	Aquatic	Wildlife	1	10	50	100	500	1000
Endrin aldehyde	ng/g	6.70E+01		227	7%		3.5E+01		1.9E+00	√					
Endrin ketone	ng/g	2.36E+03	D	229	27%		3.5E+01		6.7E+01	√	√	√			
SUM_ENDRIN	ng/g	2.37E+03		233	0%		3.5E+01		6.7E+01	√	√	√			
Dioxin/Furans															
2,3,7,8-TCDD	ng/g	1.94E+01	BD	230	100%	3.2E-03	2.5E-03	6.1E+03	7.8E+03	√	√	√	√	√	√

Notes:
a. Detected chemicals with maximum concentration exceeding the selected sediment benchmark; units in ng/g (ppb).
b. Data qualifiers from PREmis database; metadata not available.
c. Derivation of sediment benchmarks described in the text.
d. Sediment benchmarks were selected as the lowest of the NOAA Effects Range-Low, the NJDEP sediment screening guidelines, and the estimated wildlife PCL values.
e. Checks indicate that the Hazard Quotient exceeds the indicated HQ exceedance category.

Inorganic Constituents

No sediment screening values were available for 16 inorganic analytes (including the four essential nutrients); it is recommended that these not be retained as COPECs for the FFS. Hazard quotients for the remaining 10 inorganic analytes exceed 1 (Table 5) and are retained for further consideration as COPECs. The highest magnitude of exceedances were associated with copper (HQ=190), lead (HQ = 150, and mercury (HQ = 290).

Volatile Organic Compounds (VOCs)

Sediment screening values were only available for eight VOC compounds. The majority of VOCs were reported as non-detect and lack sediment screening benchmarks (Table 4). Because VOCs have a propensity for rapid dispersion and degradation in environmental media (*e.g.*, surface water, sediment, surface soil, and biota), it is unlikely that these compounds are risk drivers for ecological receptors. Only the HQ for toluene (i.e., 1.1) exceeds 1 and only slightly (Table 5).

Semivolatile Organic Compounds (SVOCs) Excluding PAHs

A total of 31 SVOCs were detected but only the maximum concentration of tributyltin exceeds the screening value (HQ=28) (Table 5). The remaining compounds were either reported as non-detect and/or lacked an available screening value.

Polycyclic Aromatic Hydrocarbons (PAHs)

Thirteen individual PAH compounds, HMW PAHs, LMW PAHs, and total PAHs are recommended for further consideration as potential COPECs (Table 5). The magnitude of exceedances for these compounds range from 250 (naphthalene) to 26,000 (acenaphthene).

Polychlorinated Biphenyls (PCBs)

Maximum concentrations of four Aroclor mixtures and total PCB exceed the established screening levels (Table 5). The highest HQs are associated with total PCBs (HQ=770) and Aroclor 1242 (HQ=47).

Pesticides/Herbicides

Fourteen pesticide compounds or their summed totals were retained for further consideration as COPECs. The maximum concentrations of total DDTs (HQ=3,800), 4,4'DDD (HQ=3,000) and dieldrin (HQ= 7,100) exceed the screening values by the greatest degree (Table 5).

Dioxins/Furans

As stated previously, 2,3,7,8-TCDD was selected as an indicator for screening individual PCDDs, PCDFs, and coplanar PCBs for the purpose of this assessment. 2,3,7,8-TCDD was retained for further consideration as a COPEC with an HQ of 7,800 based on the maximum detected concentration (Table 5).

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Attachment A
Analytical Data Summary Used in Ecological Screening

Lower Passaic River Restoration Project
Focused Feasibility Study

CASRN	Chemical	Units	Database Query Results[a] Min Value	Qualifier[b]	Max Value	Qualifier[b]	Min MDL[c]	Max MDL	Number of Samples	Number of Detected Results	NOAA ER-L[d]	NJDEP Benchmark[e]	USEPA[f] List Bioaccumulators	Wildlife Based PCL[g]	Hazard Quotient[h] Aquatic	Hazard Quotient[h] Wildlife	Basis[i]
Inorganics																	
7429-90-5	Aluminum	ng/g	36.7		23,700,000.	M	20,000.	20,000.	320.	320.	-	-	N				
7664-41-7	Ammonia	ng/g	81,000.	G	2,880,000.		190,000.	830,000.	77.	75.			N				
7440-36-0	Antimony	ng/g	0.0017	GJL	38,000.		0.003	21,900.	301.	114.	-		N				
7440-38-2	Arsenic	ng/g	0.0085		108,000.		1,000.	12,300.	309.	303.	8200	8200	Y	1.7E+05	1.3E+01	6.2E-01	NOAA ER-L
7440-39-3	Barium	ng/g	0.191		1,280,000.		10,000.	41,400.	315.	312.	-	-	N				
7440-41-7	Beryllium	ng/g	0.0134	G	3,100.		260.	1,800.	318.	218.	-	-	N				
7440-43-9	Cadmium	ng/g	0.00576	G	25,300.		550.	1,000.	321.	316.	1200	1200	Y	3.0E+03	2.1E+01	8.5E+00	NOAA ER-L
7440-70-2	Calcium	ng/g	58.8		36,500,000.	M	500,000.	549,000.	320.	319.	-	-	N				
7440-47-3	Chromium	ng/g	0.331		670,000.		2,000.	2,000.	318.	318.	81000	81000	Y	4.1E+04	8.3E+00	1.6E+01	Wildlife PCL
7440-48-4	Cobalt	ng/g	0.0192	GJ	41,100.		1,000.	18,300.	318.	296.	-	-	N				
7440-50-8	Copper	ng/g	0.0123		2,470,000.		2,000.	2,000.	321.	321.	34000	34000	Y	1.3E+04	7.3E+01	1.9E+02	Wildlife PCL
57-12-5	Cyanide	ng/g	170.	NUJL	269,000.		170.	2,500.	220.	35.	-	-	N				
7439-89-6	Iron	ng/g	47.1		47,500,000.		10,000.	10,000.	320.	320.	-	-	N				
7439-92-1	Lead	ng/g	0.3		1,550,000.		1,000.	1,000.	316.	316.	46700	47000	Y	1.1E+04	3.3E+01	1.5E+02	Wildlife PCL
7439-95-4	Magnesium	ng/g	51.2		9,820,000.	M	500,000.	500,000.	320.	320.	-	-	N				
7439-96-5	Manganese	ng/g	1.29		861,000.	M	1,000.	1,000.	315.	315.	-	-	N				
7439-97-6	Mercury	ng/g	0.00005		10,700.	M	0.00017	120.	260.	251.	150	150	Y	3.7E+01	7.1E+01	2.9E+02	Wildlife PCL
7440-02-0	Nickel	ng/g	0.068	J	369,000.		1,000.	1,000.	303.	303.	20900	21000	Y	2.2E+04	1.8E+01	1.7E+01	NOAA ER-L
7440-09-7	Potassium	ng/g	6.11		5,860,000.	NJH	500,000.	1,110,000.	277.	274.	-		N				
7782-49-2	Selenium	ng/g	0.0039		7,400.	U	0.0046	7,400.	245.	107.	-	-	Y	9.2E+02		8.0E+00	Wildlife PCL
7440-22-4	Silver	ng/g	0.0019		39,500.		0.0068	3,700.	245.	215.	1000	1000	Y	1.3E+06	4.0E+01	3.0E-02	NOAA ER-L
7440-23-5	Sodium	ng/g	28.6	J	13,900,000.	M	500,000.	563,000.	320.	319.	-		N				
7440-28-0	Thallium	ng/g	0.0017	G	4,900.	M	0.0044	3,200.	304.	152.	-	-	N				
7440-32-6	Titanium	ng/g	141,000.	NJH	735,000.	N*JL	100,000.	100,000.	134.	134.	-	-	N				
7440-62-2	Vanadium	ng/g	0.079		98,800.	M	1,000.	1,000.	318.	318.	-	-	N				
7440-66-6	Zinc	ng/g	1.27		1,620,000.		2,000.	2,000.	313.	313.	150000	150000	Y	4.7E+04	1.1E+01	3.5E+01	Wildlife PCL
Volatile Organic Compounds																	
630-20-6	1,1,1,2-Tetrachloroethane	ng/g	3.1	U	3.1	U	3.1	3.1	1.	0.			N				
71-55-6	1,1,1-Trichloroethane	ng/g	5.	U	66.	U	5.	66.	162.	0.	-	-	N				
79-34-5	1,1,2,2-Tetrachloroethane	ng/g	10.	U	66.	U	10.	66.	162.	0.	-	-	N				
76-13-1	1,1,2-Trichloro-1,2,2-Trifluoroethan	ng/g	11.	U	66.	U	11.	66.	25.	0.			N				
79-00-5	1,1,2-Trichloroethane	ng/g	7.7	U	66.	U	7.7	66.	162.	0.	-		N				
107-06-2	1,2-Dichloroethane	ng/g	6.4	U	66.	U	6.4	66.	162.	0.	-		N				
75-34-3	1,1-Dichloroethane	ng/g	2.9	U	66.	U	2.9	66.	162.	0.			N				
75-35-4	1,1-Dichloroethene	ng/g	3.5	U	66.	U	3.5	66.	162.	0.	-	-	N				
563-58-6	1,1-Dichloropropene	ng/g	3.3	U	3.3	U	3.3	3.3	1.	0.			N				
96-18-4	1,2,3-Trichloropropane	ng/g	5.6	U	5.6	U	5.6	5.6	1.	0.			N				
96-12-8	1,2-Dibromo-3-chloropropane	ng/g	7.3	U	66.	U	7.3	66.	26.	0.			N				
106-93-4	1,2-Dibromoethane	ng/g	7.7	U	66.	U	7.7	66.	26.	0.			N				
540-59-0	1,2-Dichloroethylene	ng/g	7.		38.	U, UJL	12.	38.	136.	3.	-	-	N				
78-87-5	1,2-Dichloropropane	ng/g	3.7	U	66.	U	3.7	66.	162.	0.	-	-	N				
142-28-9	1,3-Dichloropropane	ng/g	5.6	U	5.6	U	5.6	5.6	1.	0.			N				
594-20-7	2,2-Dichloropropane	ng/g	11.	U	11.	U	11.	11.	1.	0.			N				
591-78-6	2-Hexanone	ng/g	12.	U	66.	U	12.	66.	161.	0.	-	-	N				
59-50-7	4-Chloro-3-Methylphenol	ng/g	290.	U	12,000.	UM	290.	12,000.	219.	0.			N				
106-43-4	4-Chlorotoluene	ng/g	2.5	U	2.5	U	2.5	2.5	1.	0.			N				
108-10-1	4-Methyl-2-Pentanone	ng/g	12.	U	66.	U	12.	66.	161.	0.			N				
67-64-1	Acetone	ng/g	8.		430.	M	12.	240.	161.	103.	-	-	N				
98-86-2	Acetophenone	ng/g	82.	J	420.	U	290.	420.	10.	2.			N				
71-43-2	Benzene	ng/g	7.	J	300.	M	8.	91.	162.	8.	-	340 1	N		8.8E-01		NJ Benchmark
74-97-5	Bromochloromethane	ng/g	4.6	U	4.6	U	4.6	4.6	1.	0.			N				
75-25-2	Bromoform	ng/g	6.8	U	66.	U	6.8	66.	162.	0.	-	-	N				
75-15-0	Carbon Disulfide	ng/g	6.	J	66.	U	6.	66.	161.	2.			N				
56-23-5	Carbon Tetrachloride	ng/g	4.6	U	66.	U	4.6	66.	162.	0.	-	-	N				
108-90-7	Chlorobenzene	ng/g	2.9	U	1,400.		2.9	66.	162.	25.	-	-	N				

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			Database Query Results[a]							Number of Detected Results	NOAA ER-L[d]	NJDEP Benchmark[e]		USEPA[f] List Bioaccumulators	Wildlife Based PCL[g]	Hazard Quotient[h]		
CASRN	Chemical	Units	Min Value	Qualifier[b]	Max Value	Qualifier[b]	Min MDL[c]	Max MDL	Number of Samples							Aquatic	Wildlife	Basis[i]
124-48-1	Chlorodibromomethane	ng/g	4.8	U	66.	U	4.8	66.	162.	0.	-	-		N				
75-00-3	Chloroethane	ng/g	4.1	U	66.	U	4.1	66.	162.	0.	-	-		N				
67-66-3	Chloroform	ng/g	3.3	U	66.	U	3.3	66.	162.	0.	-	-		N				
156-59-2	Cis-1,2-Dichloroethylene	ng/g	3.3	U	66.	U	3.3	66.	26.	0.				N				
1006-10-15	cis-1,3-Dichloropropene	ng/g	5.2	U	66.	U	5.2	66.	162.	0.	-	-		N				
110-82-7	Cyclohexane	ng/g	11.	U	66.	U	11.	66.	25.	0.				N				
75-27-4	Dichlorobromomethane	ng/g	4.1	U	66.	U	4.1	66.	162.	0.	-	-		N				
75-71-8	Dichlorodifluoromethane	ng/g	11.	U	66.	U	11.	66.	26.	0.	-			N				
100-41-4	Ethylbenzene	ng/g	4.	J	240.	JL	4.	66.	162.	7.	-	1400	1	N		1.7E-01		NJ Benchmark
98-82-8	Isopropylbenzene	ng/g	2.	J	66.	U	2.	66.	26.	3.				N				
M&PXYLENE	m&p-Xylene	ng/g	38.		38.				1.	1.		120	1	N		3.2E-01		NJ Benchmark
79-20-9	Methyl acetate	ng/g	11.	U	66.	U	11.	66.	25.	0.				N				
74-83-9	Methyl Bromide	ng/g	5.6	U	66.	U	5.6	66.	162.	1.				N				
74-87-3	Methyl Chloride	ng/g	3.		66.	U	4.4	66.	162.	11.	-	-		N				
108-87-2	Methyl cyclohexane	ng/g	10.	J	66.	U	10.	66.	25.	1.				N				
78-93-3	Methyl Ethyl Ketone	ng/g	9.		83.	JL	12.	70.	161.	29.	-	-		N				
74-95-3	Methylene Bromide	ng/g	6.2	U	6.2	U	6.2	6.2	1.	0.	-	-		N				
75-09-2	Methylene Chloride	ng/g	7.7		66.	U	5.	66.	162.	10.	-	-		N				
1634-04-4	Methyl-t-Butyl Ether	ng/g	11.	U	66.	U	11.	66.	25.	0.				N				
104-51-8	n-Butylbenzene	ng/g	8.7		8.7				1.	1.				N				
103-65-1	n-Propylbenzene	ng/g	7.7		7.7				1.	1.				N				
95-47-6	O-Xylene	ng/g	13.	U	23.		13.	23.	11.	3.		120	1	N		1.9E-01		NJ Benchmark
99-87-6	p-Isopropyltoluene	ng/g	3.7		3.7				1.	1.				N				
100-42-5	Styrene	ng/g	2.9	U	66.	U	2.9	66.	162.	0.	-	-		N				
127-18-4	Tetrachloroethylene	ng/g	3.1	U	66.	U	3.1	66.	162.	0.	-	450	1	N		1.5E-01		NJ Benchmark
108-88-3	Toluene	ng/g	3.		2,800.	DJL	12.	72.	162.	17.		2500	1	N		1.1E+00		NJ Benchmark
BTEX	Total BTEX	ng/g	5.		2,800.				22.	22.	-	-		N				
1330-20-7	total xylenes	ng/g	40.	U	66.	U	40.	66.	15.	0.	-	120	1	N		5.5E-01		NJ Benchmark
156-60-5	Trans-1,2-Dichloroethylene	ng/g	3.7	U	66.	U	3.7	66.	26.	0.				N				
10061-02-6	Trans-1,3-dichloropropene	ng/g	7.5	U	66.	U	7.5	66.	162.	0.	-	-		N				
79-01-6	Trichloroethylene	ng/g	4.6	U	66.	U	3.	66.	162.	1.	-	1600	1	N		4.1E-02		NJ Benchmark
75-69-4	Trichlorofluoromethane	ng/g	2.3	U	66.	U	2.3	66.	26.	0.	-			N				
75-01-4	Vinyl Chloride	ng/g	2.9	U	66.	U	2.9	66.	162.	0.	-	-		N				
Semi-Volatile Organic Compounds (Non PAHs)																		
87-61-6	1,2,3-Trichlorobenzene	ng/g	5.	U	5.	U	5.	5.	1.	0.				N	3.8E+06		1.3E-06	Wildlife PCL
95-94-3	1,2,4,5-Tetrachlorobenzene	ng/g	290.	U	420.	U	290.	420.	10.	0.				N	1.3E+04		3.2E-02	Wildlife PCL
120-82-1	1,2,4-Trichlorobenzene	ng/g	3.9	U	12,000.	UM	3.	12,000.	235.	11.	-	-		Y	3.8E+06		3.1E-03	Wildlife PCL
95-63-6	1,2,4-Trimethylbenzene	ng/g	7.1		7.1				1.	1.				N				
95-50-1	1,2-Dichlorobenzene	ng/g	11.	U	12,000.	UM	11.	12,000.	235.	2.	-	-		Y	2.7E+06		4.4E-03	Wildlife PCL
108-67-8	1,3,5-Trimethylbenzene	ng/g	19.		19.				1.	1.				N				
541-73-1	1,3-Dichlorobenzene	ng/g	11.	U	12,000.	UM	11.	12,000.	235.	2.	-	-		Y	5.6E+05		2.1E-02	Wildlife PCL
106-46-7	1,4-Dichlorobenzene	ng/g	11.	U	12,000.	UM	11.	12,000.	235.	50.				N	5.6E+05		2.1E-02	Wildlife PCL
123-91-1	1,4-Dioxane	ng/g	24.	J	400.	U	24.	400.	10.	1.				N				
108-60-1	1-Chloropropane	ng/g	160.	U	12,000.	UM	160.	12,000.	219.	0.	-	-		N				
95-95-4	2,4,5-Trichlorophenol	ng/g	290.	U	12,000.	U, UM	290.	12,000.	219.	5.	-	-		N				
88-06-2	2,4,6-Trichlorophenol	ng/g	290.	U	12,000.	UM	290.	12,000.	219.	1.	-	-		N				
120-83-2	2,4-Dichlorophenol	ng/g	290.	U	12,000.	UM	290.	12,000.	219.	9.	-	-		N				
105-67-9	2,4-Dimethylphenol	ng/g	290.	U	12,000.	UM	290.	12,000.	219.	0.	-	-		N				
51-28-5	2,4-Dinitrophenol	ng/g	290.	U	71,000.	UM	290.	71,000.	219.	0.	-	-		N				
121-14-2	2,4-Dinitrotoluene	ng/g	160.	U	12,000.	UM	160.	12,000.	219.	0.	-	-		N				
606-20-2	2,6-Dinitrotoluene	ng/g	160.	U	12,000.	UM	160.	12,000.	219.	0.	-	-		N				
91-58-7	2-Chloronaphthalene	ng/g	160.	U	12,000.	UM	160.	12,000.	219.	0.	-	-		N				
95-57-8	2-Chlorophenol	ng/g	160.	U	12,000.	UM	160.	12,000.	219.	1.	-	-		N				
95-48-7	2-Methylphenol	ng/g	160.	U	12,000.	UM	160.	12,000.	219.	1.	-	-		N				
88-74-4	2-Nitroanaline	ng/g	290.	U	12,000.	U, UM	290.	12,000.	219.	0.	-	-		N				
88-75-5	2-Nitrophenol	ng/g	290.	U	12,000.	UM	290.	12,000.	219.	0.	-	-		N				
91-94-1	3,3'-Dichlorobenzidine	ng/g	93.		24,000.	UM	290.	24,000.	218.	1.	-	-		N				
99-09-2	3-Nitroaniline	ng/g	290.	U	12,000.	UJ, UM	290.	12,000.	218.	0.	-	-		N				
534-52-1	4,6-Dinitro-2-Methylphenol	ng/g	290.	U	30,000.	UM	290.	30,000.	219.	0.	-	-		N				
101-55-3	4-Bromophenyl Phenyl Ether	ng/g	160.	U	12,000.	UM	160.	12,000.	219.	0.	-	-		Y	5.9E+06		2.1E-03	Wildlife PCL

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106-47-8	4-Chloroaniline	ng/g	78.	J	12,000.	UM	290.	12,000.	219.	6.	-	-	N				
7005-72-3	4-Chlorophenyl Phenyl Ether	ng/g	160.	U	12,000.	UM	160.	12,000.	219.	0.	-	-	Y	7.4E+07		1.6E-04	Wildlife PCL
106-44-5	4-Methylphenol	ng/g	130.	G	12,000.	UM	290.	12,000.	219.	5.	-	-	N				
100-01-6	4-Nitroaniline	ng/g	290.	U	12,000.	U, UM	290.	12,000.	219.	0.	-	-	N				
100-02-7	4-Nitrophenol	ng/g	200.	J	30,000.	UM	290.	30,000.	219.	1.	-	-	N				
111-91-1	Bis(2-Chloroethoxy)methane	ng/g	290.	U	12,000.	UM	290.	12,000.	219.	0.	-	-	N				
111-44-4	Bis(2-Chloroethyl)ether	ng/g	160.	U	12,000.	UM	160.	12,000.	219.	0.	-	-	N				
117-81-7	Bis(2-Ethylhexyl)phthalate	ng/g	410.	U	23,000,000.	DM	290.	28,000.	220.	214.	-	-	N				
108-86-1	Bromobenzene	ng/g	3.3	U	3.3	U	3.3	3.3	1.	0.			N				
85-68-7	Butyl Benzyl Phthalate	ng/g	89.		360,000.	J	230.	12,000.	219.	99.	-	-	N				
86-74-8	Carbazole	ng/g	91.	J	12,000.	UM	160.	12,000.	219.	74.	-	-	N				
132-64-9	Dibenzofuran	ng/g	81.	GM	70,000.		160.	12,000.	219.	49.	-	-	N				
132-65-0	Dibenzothiophene	ng/g	6.4	U	1,390.		0.468	93.7	103.	100.	-	-	N				
1002-53-5	Dibutyltin	ng/g	1.	UJ	212.	M	1.	1.	74.	73.	-	-	N				
84-66-2	Diethyl Phthalate	ng/g	290.	U	45,000.		290.	12,000.	219.	2.	-	-	N				
131-11-3	Dimethylphthalate	ng/g	270.		12,000.	UM	290.	12,000.	219.	3.	-	-	N				
84-74-2	Di-n-butyl Phthalate	ng/g	60.	J	12,000.	UM	290.	12,000.	219.	32.	-	-	N				
117-84-0	Di-n-Octyl Phthalate	ng/g	92.	J	12,000.	UM	290.	12,000.	219.	104.	-	-	N				
87-68-3	Hexachlorobutadiene	ng/g	3.7	U	12,000.	UM	3.7	12,000.	220.	0.	-	-	Y	1.2E+05		1.0E-01	Wildlife PCL
77-47-4	Hexachlorocyclopentadiene	ng/g	290.	U	24,000.	UM	290.	24,000.	219.	0.	-	-	Y	0.0E+00			
67-72-1	Hexachloroethane	ng/g	160.	U	12,000.	UM	160.	12,000.	219.	0.	-	-	Y	0.0E+00			
78-59-1	Isophorone	ng/g	160.	U	12,000.	UM	160.	12,000.	219.	0.	-	-	N				
78763-54-9	Monobutyltin	ng/g	0.233	GJ	28.1	JL	1.	1.	74.	42.	-	-	N				
98-95-3	Nitrobenzene	ng/g	160.	U	12,000.	UM	160.	12,000.	219.	0.	-	-	N				
86-30-6	N-Nitroso-di-phenylamine	ng/g	65.	G	12,000.	UM	160.	12,000.	219.	20.			N				
621-64-7	N-nitrosodipropylamine	ng/g	160.	U	12,000.	UJ	160.	12,000.	219.	0.	-	-	N				
87-86-5	Pentachlorophenol	ng/g	290.	U	30,000.	UM	290.	30,000.	219.	0.	-	-	Y	4.2E+05		7.2E-02	Wildlife PCL
108-95-2	Phenol	ng/g	290.	U	12,000.	UM	290.	12,000.	219.	3.	-	-	N				
1461-25-2	Tetrabutyltin	ng/g	0.508	GM	1.57	M	1.	1.	74.	11.	-	-	N				
56573-85-4	Tributyltin	ng/g	5.81	UM	690.	IM	5.81	10.3	74.	69.	25	-	Y	3.6E+03	2.8E+01	1.9E-01	NOAA ER-L
Semi-Volatile Organic Compounds (PAHs)[j]																	
90-12-0	1-Methylnaphthalene	ng/g	109.		911.	M	154.	420.	84.	75.	-	-	N				
832-69-9	1-Methylphenanthrene	ng/g	90.7	M	2,960.		0.331	420.	103.	101.	-	-	N				
2245-38-7	2,3,5-Trimethylnaphthalene	ng/g	36.4	NJ	2,130.		1.78	420.	103.	95.	-	-	N				
581-42-0	2,6-Dimethylnaphthalene	ng/g	78.	J	1,830.		1.1	420.	103.	96.	-	-	N				
91-57-6	2-Methylnaphthalene	ng/g	62.	G	24,000.	M	1.06	12,000.	312.	153.	70	70	N		3.4E+02		NOAA ER-L
83-32-9	Acenaphthene	ng/g	62.	J	420,000.		0.597	12,000.	312.	182.	16	16	Y		2.6E+04		NOAA ER-L
208-96-8	Acenaphthylene	ng/g	79.	J	12,000.	UM	0.448	12,000.	312.	192.	44	44	Y		2.7E+02		NOAA ER-L
120-12-7	Anthracene	ng/g	87.		230,000.	D	1.81	12,000.	312.	244.	85.3	85	Y		2.7E+03		NJ Benchmark
56-55-3	Benzo[a]anthracene	ng/g	160.	J	150,000.		1.16	1,200.	313.	297.	261	261	Y		5.7E+02		NOAA ER-L
50-32-8	Benzo[a]pyrene	ng/g	150.	J	130,000.		2.91	1,200.	313.	305.	430	430	Y		3.0E+02		NOAA ER-L
205-99-2	Benzo[b]fluoranthene	ng/g	190.	J	100,000.		290.	1,200.	294.	283.	-	-	Y				
192-97-2	Benzo[e]pyrene	ng/g	110.	J	8,300.	NJ	2.79	420.	103.	103.	-	-	N				
191-24-2	Benzo[g,h,i]perylene	ng/g	100.	J	63,000.		4.66	3,800.	313.	258.	-	-	Y				
207-08-9	Benzo[k]fluoranthene	ng/g	160.	U	63,000.		2.13	3,800.	313.	296.	-	-	Y				
205-82-3	Benzo[b/j]fluoranthene	ng/g	3,040.		8,350.		2.13	22.7	19.	19.			N				
92-52-4	Biphenyl	ng/g	73.4		420.	U	290.	420.	84.	74.			Y				
218-01-9	Chrysene	ng/g	170.	J	150,000.		2.37	1,200.	313.	309.	384	384	Y		3.9E+02		NOAA ER-L
53-70-3	Dibenz[a,h]anthracene	ng/g	82.	J	25,000.		2.98	12,000.	312.	218.	63.4	63	Y		4.0E+02		NJ Benchmark
206-44-0	Fluoranthene	ng/g	320.	J	320,000.	D	1.28	1,200.	313.	310.	600	600	Y		5.3E+02		NOAA ER-L
86-73-7	Fluorene	ng/g	64.		140,000.		0.616	12,000.	312.	185.	19	19	Y		7.4E+03		NOAA ER-L
193-39-5	Indeno[1,2,3-c,d]-pyrene	ng/g	95.	J	57,000.		5.3	3,800.	312.	259.	-	-	Y				
91-20-3	Naphthalene	ng/g	7.1		40,000.	D	1.88	12,000.	313.	159.	160	160	N		2.5E+02		NOAA ER-L
198-55-0	Perylene	ng/g	190.	J	2,630.		2.67	420.	103.	102.	-	-	N				
85-01-8	Phenanthrene	ng/g	140.	J	570,000.	D	1.57	3,800.	313.	284.	240	240	Y		2.4E+03		NOAA ER-L
129-00-0	Pyrene	ng/g	360.		340,000.	D	1.22	1,200.	313.	310.	665	665	Y		5.1E+02		NOAA ER-L
SUM_HIGH_PAH	SUM_HIGH_PAH	ng/g	2,645.		1,398,000.				239.		552	552	Y		2.5E+03		NOAA ER-L
SUM_LOW_PAH	SUM_LOW_PAH	ng/g	7.1		1,413,300.				240.		1700	1700	Y		8.3E+02		NOAA ER-L
SUM_PAH	SUM_PAH	ng/g	7.1		2,811,300.				240.		4022	4000	Y		7.0E+02		NJ Benchmark
PCB Aroclors																	

Attachment A
Analytical Data Summary Used in Ecological Screening

Lower Passaic River Restoration Project
Focused Feasibility Study

			Database Query Results[a]							Number of Detected Results	NOAA ER-L[d]		NJDEP Benchmark[e]	USEPA[f] List Bioaccumulators	Wildlife Based PCL[g]	Hazard Quotient[h]		
CASRN	Chemical	Units	Min Value	Qualifier[b]	Max Value	Qualifier[b]	Min MDL[c]	Max MDL	Number of Samples							Aquatic	Wildlife	Basis[i]
12674-11-2	Aroclor 1016	ng/g	5.7	U	970.	UJ	5.7	970.	229.	0.	-		-	Y	3.7E+02		2.7E+00	Wildlife PCL
11104-28-2	Aroclor 1221	ng/g	5.7	U	1,350.	UM	5.7	1,350.	229.	0.	-		-	Y	3.7E+02		3.7E+00	Wildlife PCL
11141-16-5	Aroclor 1232	ng/g	5.7	U	970.	UJ	5.7	970.	229.	0.	-		-	Y	3.7E+02		2.7E+00	Wildlife PCL
53469-21-9	Aroclor 1242	ng/g	5.7	U	17,200.	D	5.7	970.	229.	3.	-		-	Y	3.7E+02		4.7E+01	Wildlife PCL
12672-29-6	Aroclor 1248	ng/g	5.7	U	7,450.	DM	5.7	2,890.	235.	169.	-		-	Y	3.7E+02		2.0E+01	Wildlife PCL
11097-69-1	Aroclor 1254	ng/g	38.5	U	5,800.		5.7	2,070.	231.	151.	-		-	Y	3.7E+02		1.6E+01	Wildlife PCL
11096-82-5	Aroclor 1260	ng/g	5.7	U	2,160.	DM	5.7	970.	228.	87.	-		-	Y	3.7E+02		5.9E+00	Wildlife PCL
37324-23-5	Aroclor-1262	ng/g	5.7	U	8.2	U	5.7	8.2	10.	0.			-	N	3.7E+02		2.2E-02	Wildlife PCL
SUM_PCB	SUM_PCB AROCLORS	ng/g	73.2		17,506.5				236.		22.7		23	N	3.7E+02	7.7E+02	4.8E+01	NOAA ER-L
Pesticides/Herbicides																		
93-76-5	2,4,5-T	ng/g	38.	U	410.	U	5.	410.	167.	0.	-		-	N				
93-72-1	2,4,5-TP	ng/g	1.9	GPNJ	410.	U	5.	410.	177.	10.	-		-	N				
94-75-7	2,4-D	ng/g	240.	U	1,000.	U	50.	1,000.	166.	0.	-		-	N				
94-82-6	2,4-DB	ng/g	18.	GPJ	685.	UM	54.3	685.	166.	18.	-		-	N				
53-19-0	2,4-DDD	ng/g	16.7	T	687.	T	1.61	26.1	22.	21.	2	1	-	Y	8.3E+02	3.4E+02	8.3E-01	NOAA ER-L
3424-82-6	2,4-DDE	ng/g	11.8	K	303.		0.956	32.3	22.	22.	2.2	1	-	Y	1.9E+01	1.4E+02	1.6E+01	NOAA ER-L
789-02-6	2,4-DDT	ng/g	5.91	UT	145.	T	2.73	36.7	22.	21.	1	1	-	Y	1.4E+02	1.5E+02	1.0E+00	NOAA ER-L
72-54-8	4,4'-DDD	ng/g	4.07	U	5,980.	DM	2.26	66.5	236.	215.	2		-	Y	8.3E+02	3.0E+03	7.2E+00	NOAA ER-L
72-55-9	4,4'-DDE	ng/g	4.07	U	1,010.		1.26	66.5	237.	215.	2.2		2.2	Y	1.9E+01	4.6E+02	5.3E+01	NOAA ER-L
50-29-3	4,4'-DDT	ng/g	3.85	U	2,470.	DM	2.73	79.2	234.	175.	1		-	Y	1.4E+02	2.5E+03	1.8E+01	NOAA ER-L
SUM_TDDT	SUM_TDDT	ng/g	10.54		5,989				248.		1.58		1.6	N	1.9E+01	3.8E+03	3.1E+02	NOAA ER-L
309-00-2	Aldrin	ng/g	0.619	U	660.		0.576	34.3	236.	17.	-		-	Y	4.6E+02		1.4E+00	Wildlife PCL
319-86-8	BHC, delta	ng/g	0.211	QJB	74.		0.159	37.	231.	11.			-	N	1.2E+03		5.9E-02	Wildlife PCL
319-84-6	BHC-alpha	ng/g	0.34	U	34.3	UM	0.205	34.3	233.	8.	-		-	Y	1.2E+03		2.8E-02	Wildlife PCL
319-85-7	BHC-beta	ng/g	0.776	U	2,000.		0.776	41.9	227.	6.	-		-	Y	1.2E+03		1.6E+00	Wildlife PCL
58-89-9	BHC-gamma (Lindane)	ng/g	0.542	UD	34.3	UM	0.529	34.3	232.	10.	-		-	Y	1.2E+03		2.8E-02	Wildlife PCL
SUM_BHC	SUM_BHC	ng/g	1.132		2,012				233.				-	N	1.2E+03		1.6E+00	Wildlife PCL
5103-71-9	Chlordane,alpha (cis)	ng/g	2.06	U	330.		0.0967	233.	221.	120.			-	N	2.0E+03		1.6E-01	Wildlife PCL
5103-74-2	Chlordane,gamma (trans)	ng/g	2.09	U	125.	PDNJ	0.0815	48.2	212.	120.			-	N	2.0E+03		6.2E-02	Wildlife PCL
SUM_CHLORDANE	SUM_CHLORDANE	ng/g	3.19		335				231.				-	N	2.0E+03		1.7E-01	Wildlife PCL
60-57-1	Dieldrin	ng/g	1.38	DJ	141.	PDJ	0.163	93.5	236.	109.	0.02		-	Y	2.7E+02	7.1E+03	5.2E-01	NOAA ER-L
1031-07-8	Endosulfan sulfate	ng/g	0.422	UD	71.	UM	0.33	71.	224.	8.			-	N	4.9E+03		1.5E-02	Wildlife PCL
959-98-8	Endosulfan, alpha	ng/g	0.18	U	94.	U	0.18	94.	231.	1.			-	N	4.9E+03		1.9E-02	Wildlife PCL
33213-65-9	Endosulfan, beta	ng/g	0.341	UD	177.	PDJ	0.341	38.	234.	108.			-	N	4.9E+03		3.6E-02	Wildlife PCL
SUM_ENDOSULFAN	SUM_ENDOSULFAN	ng/g	1.331		244.8				240.				-	N	4.9E+03		5.0E-02	Wildlife PCL
7421-93-4	Endrin aldehyde	ng/g	0.501	U	67.		0.442	66.5	227.	15.			-	N	3.5E+01		1.9E+00	Wildlife PCL
53494-70-5	Endrin ketone	ng/g	0.248	QJ	2,360.	D	0.106	93.5	229.	62.			-	N	3.5E+01		6.7E+01	Wildlife PCL
SUM_ENDRIN	SUM_ENDRIN	ng/g	0.947		2,366				233.				-	N	3.5E+01		6.7E+01	Wildlife PCL
1024-57-3	Heptachlor epoxide	ng/g	0.421	UD	87.		0.315	58.	231.	18.	-		-	Y	9.7E+03		9.0E-03	Wildlife PCL
118-74-1	Hexachlorobenzene	ng/g	91.	GM	12,000.	UM	160.	12,000.	219.	2.	-		-	Y	9.3E+04		1.3E-01	Wildlife PCL
72-43-5	Methoxychlor	ng/g	1.63	QJ	7,900.		0.26	343.	231.	21.	-		-	Y	1.1E+05		6.9E-02	Wildlife PCL
8001-35-2	Toxaphene	ng/g	45.3	U	3,430.	UM	45.3	3,430.	231.	0.	-		-	Y	1.4E+03		2.5E+00	Wildlife PCL
Dioxins/Furans																		
1746-01-6	2,3,7,8-TCDD		0.	DJ	19.4	BD	0.00011	0.0044	230.	229.	3.2E-03	2	-	Y	2.5E-03	6.1E+03	7.8E+03	Wildlife PCL

Notes
a. Data obtained from a query of the PREmis database completed on 10 January 2007.
b. Data qualifiers as provided in PREmis.
c. Method Detection Limits (MDLs) as provided in PREmis.
d. ER-L = Effects Range-Low from Long and Morgan, 1991 and Long *et al.* , 1995; except where noted.
1. Based on value for the para position isomer.
2. Derived by USFWS using sediment chemistry for the Arthur Kill and oyster effect data presented in Wintermyer and Cooper, 2003.
e. Sediment benchmarks from NJDEP, 1998. Guidance for Sediment Quality Evaluations.
1. NJ Volatile Organic Sediment Screening Guidelines derived from MacDonald et al., 1992.
f. From USEPA 2000b. Bioaccumulation Testing and Interpretation for the Purpose of Sediment Quality Assessment; USEPA 823-R-00-001.
g. Derivation of Wildlife PCLs discussed in the text and summarized in Attachment B.
h. Hazard Quotient is the ratio of the maximum concentration to either the aquatic- or wildlife-based screening benchmark.
i Basis for the lowest benchmark value is indicated.
j. Although a number of PAHs are identified as bioaccumulating compounds, no wildlife PCLs were derived for this class of COPEC because they are generally metabolized quickly in the tissues of higher organisms including aquatic wildife prey.

Attachment B
Derviation of Protective Concentrations (PCLs) for Wildlife

Lower Passaic River Restoration Project
Focused Feasibility Study

CASRN	Chemical Name	Units	TRV[a]		BAF[b]	PCL_{sed}[c]		
			Mammal	Bird		Mammal	Bird	Wildlife
Inorganics								
7440-38-2	Arsenic	ug/g	1.2E+00	1.1E+01	1.3E-01	1.8E+02	1.7E+02	1.7E+02
7440-43-9	Cadmium	ug/g	4.0E-01	9.1E-01	6.1E-01	1.2E+01	3.0E+00	3.0E+00
7440-47-3	Chromium	ug/g	6.6E+00	2.2E+00	1.1E-01	1.1E+03	4.1E+01	4.1E+01
7440-50-8	Copper	ug/g	4.1E+01	1.1E+01	1.6E+00	4.6E+02	1.3E+01	1.3E+01
7439-92-1	Lead	ug/g	1.6E+01	3.5E-01	6.6E-02	4.4E+03	1.1E+01	1.1E+01
7439-97-6	Mercury	ug/g	7.2E-02	2.0E-02	1.1E+00	1.2E+00	3.7E-02	3.7E-02
7440-02-0	Nickel	ug/g	2.1E+00	8.8E+00	8.2E-01	4.6E+01	2.2E+01	2.2E+01
7782-49-2	Selenium	ug/g	2.5E-01	4.6E-01	1.0E+00	4.6E+00	9.2E-01	9.2E-01
7440-22-4	Silver	ug/g	7.0E+01		1.0E+00	1.3E+03		1.3E+03
7440-66-6	Zinc	ug/g	6.3E+01	5.4E+01	2.3E+00	5.0E+02	4.7E+01	4.7E+01
SVOCs (Non PAHs)								
101-55-3	4-Bromophenyl Phenyl Ether	ug/g	3.2E+02	-	1.0E+00	5.9E+03		5.9E+03
7005-72-3	4-Chlorophenyl Phenyl Ether	ug/g	3.2E+02	-	7.9E-02	7.4E+04		7.4E+04
87-68-3	Hexachlorobutadiene	ug/g	6.3E+00		1.0E+00	1.2E+02		1.2E+02
77-47-4	Hexachlorocyclopentadiene	ug/g	-	-	-			0.0E+00
67-72-1	Hexachloroethane	ug/g	-	-	1.0E+00			0.0E+00
87-86-5	Pentachlorophenol	ug/g	7.6E-01	2.4E+01	3.4E-02	4.2E+02	1.4E+03	4.2E+02
56573-85-4	Tributyltin	ug/g	1.9E+00	-	1.0E+01	3.6E+00		3.6E+00
95-50-1	1,2-Dichlorobenzene	ug/g	1.5E+02	-	1.0E+00	2.7E+03		2.7E+03
541-73-1	1,3-Dichlorobenzene	ug/g	3.0E+01	-	1.0E+00	5.6E+02		5.6E+02
120-82-1	1,2,4-Trichlorobenzene	ug/g	2.1E+02	-	1.0E+00	3.8E+03		3.8E+03
106-46-7	1,4-Dichlorobenzene	ug/g	3.0E+01	-	1.0E+00	5.6E+02		5.6E+02
87-61-6	1,2,3-Trichlorobenzene (Historical)	ug/g	2.1E+02	-	1.0E+00	3.8E+03		3.8E+03
120-82-1	1,2,4-Trichlorobenzene	ug/g	2.1E+02	-	1.0E+00	3.8E+03		3.8E+03
95-94-3	1,2,4,5-Tetrachlorobenzene	ug/g	7.2E-01	-	1.0E+00	1.3E+01		1.3E+01
PCB Aroclors								
12674-11-2	Aroclor 1016	ug/g	6.8E-01	3.4E-01	1.9E+00	6.8E+00	3.7E-01	3.7E-01
11104-28-2	Aroclor 1221	ug/g	6.8E-01	3.4E-01	1.9E+00	6.8E+00	3.7E-01	3.7E-01
11141-16-5	Aroclor 1232	ug/g	6.8E-01	3.4E-01	1.9E+00	6.8E+00	3.7E-01	3.7E-01
53469-21-9	Aroclor 1242	ug/g	6.8E-01	3.4E-01	1.9E+00	6.8E+00	3.7E-01	3.7E-01
12672-29-6	Aroclor 1248	ug/g	6.8E-01	3.4E-01	1.9E+00	6.8E+00	3.7E-01	3.7E-01
11097-69-1	Aroclor 1254	ug/g	6.8E-01	3.4E-01	1.9E+00	6.8E+00	3.7E-01	3.7E-01
11096-82-5	Aroclor 1260	ug/g	6.8E-01	3.4E-01	1.9E+00	6.8E+00	3.7E-01	3.7E-01
37324-23-5	Aroclor-1262	ug/g	6.8E-01	3.4E-01	1.9E+00	6.8E+00	3.7E-01	3.7E-01
SUM_PCB	SUM_PCB AROCLORS	ug/g	6.8E-01	3.4E-01	1.9E+00	6.8E+00	3.7E-01	3.7E-01
Pesticides								
53-19-0	2,4-DDD	ug/g	3.6E+00	1.2E-01	2.8E-01	2.4E+02	8.3E-01	8.3E-01
3424-82-6	2,4-DDE	ug/g	3.6E+00	7.3E-02	7.7E+00	8.6E+00	1.9E-02	1.9E-02
789-02-6	2,4-DDT	ug/g	3.6E+00	1.2E-01	1.7E+00	4.0E+01	1.4E-01	1.4E-01
72-54-8	4,4'-DDD	ug/g	3.6E+00	1.2E-01	2.8E-01	2.4E+02	8.3E-01	8.3E-01
72-55-9	4,4'-DDE	ug/g	3.6E+00	7.3E-02	7.7E+00	8.6E+00	1.9E-02	1.9E-02
50-29-3	4,4'-DDT	ug/g	3.6E+00	1.2E-01	1.7E+00	4.0E+01	1.4E-01	1.4E-01
SUM_TDDT	SUM_TDDT	ug/g	3.6E+00	7.3E-02	7.7E+00	8.6E+00	1.9E-02	1.9E-02
309-00-2	Aldrin	ug/g	3.2E-01	4.2E-01	1.8E+00	3.3E+00	4.6E-01	4.6E-01
319-84-6	BHC-alpha	ug/g	4.3E-01	1.1E+00	1.8E+00	4.5E+00	1.2E+00	1.2E+00
319-85-7	BHC-beta	ug/g	4.3E-01	1.1E+00	1.8E+00	4.5E+00	1.2E+00	1.2E+00
58-89-9	BHC-gamma (Lindane)	ug/g	4.3E-01	1.1E+00	1.8E+00	4.5E+00	1.2E+00	1.2E+00
319-86-8	BHC, delta	ug/g	4.3E-01	1.1E+00	1.8E+00	4.5E+00	1.2E+00	1.2E+00
SUM_BHC	SUM_BHC	ug/g	4.3E-01	1.1E+00	1.8E+00	4.5E+00	1.2E+00	1.2E+00
5103-71-9	Chlordane,alpha (cis)	ug/g	6.5E+00	4.8E+00	4.8E+00	2.5E+01	2.0E+00	2.0E+00
5103-74-2	Chlordane,gamma (trans)	ug/g	6.5E+00	4.8E+00	4.8E+00	2.5E+01	2.0E+00	2.0E+00
57-74-9	Total Chlordane	ug/g	6.5E+00	4.8E+00	4.8E+00	2.5E+01	2.0E+00	2.0E+00

Attachment B
Derviation of Protective Concentrations (PCLs) for Wildlife

Lower Passaic River Restoration Project
Focused Feasibility Study

CASRN	Chemical Name	Units	TRV[a]		BAF[b]	PCL_{sed}[c]		
			Mammal	Bird		Mammal	Bird	Wildlife
Inorganics								
SUM_CHLORDANE	SUM_CHLORDANE	ug/g	6.5E+00	4.8E+00	4.8E+00	2.5E+01	2.0E+00	2.0E+00
60-57-1	Dieldrin	ug/g	6.3E-02	2.4E-01	1.8E+00	6.5E-01	2.7E-01	2.7E-01
1031-07-8	Endosulfan sulfate	ug/g	4.7E-01	3.2E+01	1.8E+00	4.9E+00	3.5E+01	4.9E+00
959-98-8	Endosulfan, alpha	ug/g	4.7E-01	3.2E+01	1.8E+00	4.9E+00	3.5E+01	4.9E+00
33213-65-9	Endosulfan, beta	ug/g	4.7E-01	3.2E+01	1.8E+00	4.9E+00	3.5E+01	4.9E+00
115-29-7	Total Endosulfan	ug/g	4.7E-01	3.2E+01	1.8E+00	4.9E+00	3.5E+01	4.9E+00
SUM_ENDOSULFAN	SUM_ENDOSULFAN	ug/g	4.7E-01	3.2E+01	1.8E+00	4.9E+00	3.5E+01	4.9E+00
7421-93-4	Endrin aldehyde	ug/g	2.9E-01	3.2E-02	1.8E+00	3.0E+00	3.5E-02	3.5E-02
53494-70-5	Endrin ketone	ug/g	2.9E-01	3.2E-02	1.8E+00	3.0E+00	3.5E-02	3.5E-02
72-20-8	Total Endrin	ug/g	2.9E-01	3.2E-02	1.8E+00	3.0E+00	3.5E-02	3.5E-02
SUM_ENDRIN	SUM_ENDRIN	ug/g	2.9E-01	3.2E-02	1.8E+00	3.0E+00	3.5E-02	3.5E-02
1024-57-3	Heptachlor epoxide	ug/g	9.4E-01	1.3E+02	1.8E+00	9.7E+00	1.5E+02	9.7E+00
76-44-8	Total Heptachlor	ug/g	9.4E-01	2.1E+00	1.8E+00	9.7E+00	2.4E+00	2.4E+00
SUM_HEPTACHLOR	SUM_HEPTACHLOR	ug/g	9.4E-01	2.1E+00	1.8E+00	9.7E+00	2.4E+00	2.4E+00
118-74-1	Hexachlorobenzene	ug/g		4.2E+00	9.0E-02		9.3E+01	9.3E+01
72-43-5	Methoxychlor	ug/g	1.1E+01	2.5E+02	1.8E+00	1.1E+02	2.8E+02	1.1E+02
2385-85-5	Mirex	ug/g	1.1E+00	1.0E+01	1.3E+00	1.6E+01	1.6E+01	1.6E+01
8001-35-2	Toxaphene	ug/g	2.5E+01	1.3E+00	1.8E+00	2.6E+02	1.4E+00	1.4E+00
Dioxin/Furan Congeners								
1746-01-6	2,3,7,8-TCDD[d]	ug/g	-	-	2.5E-02	2.5E-06	2.1E-05	2.5E-06

a. TRVs presented in Attachment C.
b. Aquatic BAFs presented in Attachment C.
c. Wildife PCLs calculated using the following equation and parameters provided in Table 3.

$$PCL_{sed} = \frac{THQ * TRV * BW}{\left(BAF_{fish} * IR_{fish} * P_{fish} * SFF\right)}$$

d. Wildlife PCLs for 2,3,7,8-TCDD as presented in Table 5-1 (USEPA, 1993) "Low Risk" sediment concentrations for mammalian and avian receptors.

R2-0009442

Attachment C
Supporting Data for PCL Derivation

Lower Passaic River Restoration Project
Focused Feasibility Study

			TRVs[a]								MATCs[b]				
			Mammals				Birds								
CASRN	Chemical Name	Units	TRV_{low}	TRV_{high}	Source		TRV_{low}	TRV_{high}	Source		Mammal	Bird	BAFs[c]		
Inorganics															
7440-38-2	Arsenic	ug/g-d	0.32	4.7	DTSC, 2002		5.5	22	DTSC, 2002		1.2E+00	1.1E+01	0.127	1	1998, Bechtel Jacobs Company, LLC
7440-43-9	Cadmium	ug/g-d	0.06	2.64	DTSC, 2002		0.08	10.4	DTSC, 2002		4.0E-01	9.1E-01	0.614	1	1998, Bechtel Jacobs Company, LLC
7440-47-3	Chromium	ug/g-d	3.28	13.4	ORNL, 1996		1	5	ORNL, 1996		6.6E+00	2.2E+00	0.108	1	1998, Bechtel Jacobs Company, LLC
7440-50-8	Copper	ug/g-d	2.67	632	DTSC, 2002		2.3	52.3	DTSC, 2002		4.1E+01	1.1E+01	1.647	1	1998, Bechtel Jacobs Company, LLC
7439-92-1	Lead	ug/g-d	1	241	DTSC, 2002		0.014	8.75	DTSC, 2002		1.6E+01	3.5E-01	0.066	1	1998, Bechtel Jacobs Company, LLC
7439-97-6	Mercury	ug/g-d	0.032	0.16	ORNL, 1996		0.0064	0.064	ORNL, 1996		7.2E-02	2.0E-02	1.081	1	1998, Bechtel Jacobs Company, LLC
7440-02-0	Nickel	ug/g-d	0.133	31.6	DTSC, 2002		1.38	56.3	DTSC, 2002		2.1E+00	8.8E+00	0.818	1	1998, Bechtel Jacobs Company, LLC
7782-49-2	Selenium	ug/g-d	0.05	1.21	DTSC, 2002		0.23	0.93	DTSC, 2002		2.5E-01	4.6E-01	1		Assumption
7440-22-4	Silver	ug/g-d	22.2	222	ATSDR, 1990; Matuk et al., 1981		-	-	-		7.0E+01		1		Assumption
7440-66-6	Zinc	ug/g-d	9.6	411	DTSC, 2002		17.2	172	DTSC, 2002		6.3E+01	5.4E+01	2.33	1	1998, Bechtel Jacobs Company, LLC
SVOCs (Non-PAHs)															
95-50-1	1,2-Dichlorobenzene	ug/g-d	86	257	ATSDR, 1998; NTP, 1985		-	-	-		1.5E+02	-	1		National Quality Sediment Survey
541-73-1	1,3-Dichlorobenzene	ug/g-d	21	43	ATSDR, 1998; NTP, 1987		-	-	-		3.0E+01	-	1		National Quality Sediment Survey
106-46-7	1,4-Dichlorobenzene	ug/g-d	21.4	42.9	ATSDR, 1998; NTP, 1987		-	-	-		3.0E+01	-	1		National Quality Sediment Survey
120-82-1	1,2,4-Trichlorobenzene	ug/g-d	120	360	IRIS, 2002; Kitchin and Ebron, 1980		-	-	-		2.1E+02	-	1		National Quality Sediment Survey
87-61-6	1,2,3-Trichlorobenzene (Historical)	ug/g-d	120	360	IRIS, 2002; Kitchin and Ebron, 1980		-	-	-		2.1E+02	-	1		National Quality Sediment Survey
120-82-1	1,2,4-Trichlorobenzene	ug/g-d	120	360	IRIS, 2002; Kitchin and Ebron, 1980		-	-	-		2.1E+02	-	1		National Quality Sediment Survey
95-94-3	1,2,4,5-Tetrachlorobenzene	ug/g-d	0.32	1.6	ATSDR, 2000; Arnold et al., 1985		-	-	-		7.2E-01	-	1		National Quality Sediment Survey
123-91-1	1,4-DIOXANE	ug/g-d	0.5	1	ORNL, 1996		-	-	-		7.1E-01	-	1		Assumption
101-55-3	4-Bromophenyl Phenyl Ether	ug/g-d	100	1000	INCHEM 1994; Francis, 1989		-	-	-		3.2E+02	-	1		National Quality Sediment Survey
7005-72-3	4-Chlorophenyl Phenyl Ether	ug/g-d	100	1000	INCHEM 1994; Francis, 1989		-	-	-		3.2E+02	-	0.079		National Quality Sediment Survey
87-68-3	Hexachlorobutadiene	ug/g-d	2	20	IRIS, 2002; Kociba, 1977a		-	-	-		6.3E+00		1		National Quality Sediment Survey
77-47-4	Hexachlorocyclopentadiene	ug/g-d	-	-	-		-	-	-		-	-	-		
67-72-1	Hexachloroethane	ug/g-d	-	-	-		-	-	-		-	-	1		National Quality Sediment Survey
87-86-5	Pentachlorophenol	ug/g-d	0.24	2.4	ORNL, 1996		7.6	76	Hudson et al., 1984		7.6E-01	2.4E+01	0.034		National Quality Sediment Survey
56573-85-4	Tributyltin	ug/g-d	0.25	15	DTSC, 2002		-	-	-		1.9E+00	-	10		Meador, 2000
PCB Aroclors															
12674-11-2	Aroclor 1016	ug/g-d	0.36	1.28	DTSC, 2002	2	0.09	1.27	DTSC, 2002	2	6.8E-01	3.4E-01	1.85		National Quality Sediment Survey
11104-28-2	Aroclor 1221	ug/g-d	0.36	1.28	DTSC, 2002	2	0.09	1.27	DTSC, 2002	2	6.8E-01	3.4E-01	1.85		National Quality Sediment Survey
11141-16-5	Aroclor 1232	ug/g-d	0.36	1.28	DTSC, 2002	2	0.09	1.27	DTSC, 2002	2	6.8E-01	3.4E-01	1.85		National Quality Sediment Survey
53469-21-9	Aroclor 1242	ug/g-d	0.36	1.28	DTSC, 2002	2	0.09	1.27	DTSC, 2002	2	6.8E-01	3.4E-01	1.85		National Quality Sediment Survey
12672-29-6	Aroclor 1248	ug/g-d	0.36	1.28	DTSC, 2002	2	0.09	1.27	DTSC, 2002	2	6.8E-01	3.4E-01	1.85		National Quality Sediment Survey
11097-69-1	Aroclor 1254	ug/g-d	0.36	1.28	DTSC, 2002	2	0.09	1.27	DTSC, 2002	2	6.8E-01	3.4E-01	1.85		National Quality Sediment Survey
11096-82-5	Aroclor 1260	ug/g-d	0.36	1.28	DTSC, 2002	2	0.09	1.27	DTSC, 2002	2	6.8E-01	3.4E-01	1.85		National Quality Sediment Survey
37324-23-5	Aroclor-1262	ug/g-d	0.36	1.28	DTSC, 2002	2	0.09	1.27	DTSC, 2002	2	6.8E-01	3.4E-01	1.85		National Quality Sediment Survey
SUM_PCB	SUM_PCB AROCLORS	ug/g-d	0.36	1.28	DTSC, 2002		0.09	1.27	DTSC, 2002		6.8E-01	3.4E-01	1.85		National Quality Sediment Survey
Pesticides															
53-19-0	2,4-DDD	ug/g-d	0.8	16	DTSC, 2002	3	0.009	1.5	DTSC, 2002	3	3.6E+00	1.2E-01	0.28	1	National Quality Sediment Survey
3424-82-6	2,4-DDE	ug/g-d	0.8	16	DTSC, 2002	3	0.009	0.6	DTSC, 2002		3.6E+00	7.3E-02	7.7	1	National Quality Sediment Survey
789-02-6	2,4-DDT	ug/g-d	0.8	16	DTSC, 2002	3	0.009	1.5	DTSC, 2002		3.6E+00	1.2E-01	1.67	1	National Quality Sediment Survey
72-54-8	4,4'-DDD	ug/g-d	0.8	16	DTSC, 2002		0.009	1.5	DTSC, 2002	3	3.6E+00	1.2E-01	0.28		National Quality Sediment Survey
72-55-9	4,4'-DDE	ug/g-d	0.8	16	DTSC, 2002	3	0.009	0.6	DTSC, 2002		3.6E+00	7.3E-02	7.7		National Quality Sediment Survey
50-29-3	4,4'-DDT	ug/g-d	0.8	16	DTSC, 2002	3	0.009	1.5	DTSC, 2002		3.6E+00	1.2E-01	1.67		National Quality Sediment Survey
SUM_TDDT	SUM_TDDT	ug/g-d	0.8	16	DTSC, 2002		0.009	0.6	DTSC, 2002		3.6E+00	7.3E-02	7.7		National Quality Sediment Survey
309-00-2	Aldrin	ug/g-d	0.1	1	DTSC, 2002		0.13	1.3	Hudson et al., 1970		3.2E-01	4.2E-01	1.8		National Quality Sediment Survey
319-84-6	BHC-alpha	ug/g-d	0.05	3.75	DTSC, 2002	4	0.56	2.25	ORNL, 1996	4	4.3E-01	1.1E+00	1.8		National Quality Sediment Survey
319-85-7	BHC-beta	ug/g-d	0.05	3.75	DTSC, 2002	4	0.56	2.25	ORNL, 1996	4	4.3E-01	1.1E+00	1.8		National Quality Sediment Survey
58-89-9	BHC-gamma (Lindane)	ug/g-d	0.05	3.75	DTSC, 2002		0.56	2.25	ORNL, 1996		4.3E-01	1.1E+00	1.8		National Quality Sediment Survey
319-86-8	BHC, delta	ug/g-d	0.05	3.75	DTSC, 2002		0.56	2.25	ORNL, 1996		4.3E-01	1.1E+00	1.8		National Quality Sediment Survey
SUM_BHC	SUM_BHC	ug/g-d	0.05	3.75	DTSC, 2002		0.56	2.25	ORNL, 1996		4.3E-01	1.1E+00	1.8		National Quality Sediment Survey

Attachment C
Supporting Data for PCL Derivation

Lower Passaic River Restoration Project
Focused Feasibility Study

			TRVs[a]								MATCs[b]				
			Mammals				Birds								
CASRN	Chemical Name	Units	TRV_{low}	TRV_{high}	Source		TRV_{low}	TRV_{high}	Source		Mammal	Bird	BAFs[c]		
5103-71-9	Chlordane,alpha (cis)	ug/g-d	4.6	9.2	ORNL, 1996		2.14	10.7	ORNL, 1996		6.5E+00	4.8E+00	4.77		National Quality Sediment Survey
5103-74-2	Chlordane,gamma (trans)	ug/g-d	4.6	9.2	ORNL, 1996		2.14	10.7	ORNL, 1996		6.5E+00	4.8E+00	4.77		National Quality Sediment Survey
57-74-9	Total Chlordane	ug/g-d	4.6	9.2	ORNL, 1996		2.14	10.7	ORNL, 1996		6.5E+00	4.8E+00	4.77		National Quality Sediment Survey
SUM_CHLORDANE	SUM_CHLORDANE	ug/g-d	4.6	9.2	ORNL, 1996		2.14	10.7	ORNL, 1996		6.5E+00	4.8E+00	4.77		National Quality Sediment Survey
60-57-1	Dieldrin	ug/g-d	0.02	0.2	ORNL, 1996		0.077	0.77	ORNL, 1996	5	6.3E-02	2.4E-01	1.8		National Quality Sediment Survey
1031-07-8	Endosulfan sulfate	ug/g-d	0.15	1.5	ORNL, 1996		10	100	ORNL, 1996		4.7E-01	3.2E+01	1.8		National Quality Sediment Survey
959-98-8	Endosulfan, alpha	ug/g-d	0.15	1.5	ORNL, 1996		10	100	ORNL, 1996		4.7E-01	3.2E+01	1.8		National Quality Sediment Survey
33213-65-9	Endosulfan, beta	ug/g-d	0.15	1.5	ORNL, 1996		10	100	ORNL, 1996		4.7E-01	3.2E+01	1.8		National Quality Sediment Survey
115-29-7	Total Endosulfan	ug/g-d	0.15	1.5	ORNL, 1996	5	10	100	ORNL, 1996	5	4.7E-01	3.2E+01	1.8		National Quality Sediment Survey
SUM_ENDOSULFAN	SUM_ENDOSULFAN	ug/g-d	0.15	1.5	ORNL, 1996	5	10	100	ORNL, 1996	5	4.7E-01	3.2E+01	1.8		National Quality Sediment Survey
7421-93-4	Endrin aldehyde	ug/g-d	0.092	0.92	ORNL, 1996		0.01	0.1	ORNL, 1996		2.9E-01	3.2E-02	1.8		National Quality Sediment Survey
53494-70-5	Endrin ketone	ug/g-d	0.092	0.92	ORNL, 1996		0.01	0.1	ORNL, 1996		2.9E-01	3.2E-02	1.8		National Quality Sediment Survey
72-20-8	Total Endrin	ug/g-d	0.092	0.92	ORNL, 1996		0.01	0.1	ORNL, 1996		2.9E-01	3.2E-02	1.8		National Quality Sediment Survey
SUM_ENDRIN	SUM_ENDRIN	ug/g-d	0.092	0.92	ORNL, 1996		0.01	0.1	ORNL, 1996		2.9E-01	3.2E-02	1.8		National Quality Sediment Survey
1024-57-3	Heptachlor epoxide	ug/g-d	0.13	6.8	DTSC, 2002		41.6	416	Hudson et al., 1984		9.4E-01	1.3E+02	1.8		National Quality Sediment Survey
76-44-8	Total Heptachlor	ug/g-d	0.13	6.8	DTSC, 2002		0.7	6.7	Hill et al., 1975		9.4E-01	2.1E+00	1.8		National Quality Sediment Survey
SUM_HEPTACHLOR	SUM_HEPTACHLOR	ug/g-d	0.13	6.8	DTSC, 2002		0.7	6.7	Hill et al., 1975		9.4E-01	2.1E+00	1.8		National Quality Sediment Survey
118-74-1	Hexachlorobenzene	ug/g-d	-	-	-		1.3	13.2	Hill et al., 1975			4.2E+00	0.09		National Quality Sediment Survey
72-43-5	Methoxychlor	ug/g-d	2.5	50	DTSC, 2002		80	800	Hudson et al., 1970		1.1E+01	2.5E+02	1.8		National Quality Sediment Survey
2385-85-5	Mirex	ug/g-d	0.7	1.8	IRIS, 2007		3.3	33.0	Hill et al., 1975		1.1E+00	1.0E+01	1.31		National Quality Sediment Survey
8001-35-2	Toxaphene	ug/g-d	8	80	ORNL, 1996	5	0.398	3.98	Hudson et al., 1970		2.5E+01	1.3E+00	1.8		National Quality Sediment Survey
Dioxin/Furan Congeners															
1746-01-6	2,3,7,8-TCDD[d]	ug/g-d											0.025		National Quality Sediment Survey

Notes

a. Toxicity Reference Values (TRV) - based on dietary doses below which adverse ecological effects are not anticipated ($TRVl_{ow}$) or above which are anticipate (TRV_{high}). The TRV_{low} and TRV_{high} terminology is used in the DTSC, 2002 compilation; comparable values from other reference sources are the No Observed Adverse Effect Level (NOAEL) and Lowest Observed Adverse Effect Level (LOAEL).

1. LD50 study result converted to a TRV using the following assumptions:

Parameter	Value	Units	Reference
mouse body weight	0.03	kg	USEPA, 1988a, from ORNL, 1996
mouse ingestion rate	0.0055	kg/day	Calculated using allometric equation from EPA 1988a.
LD_{50}	8.5	mg/kg	NTPChemIDPLus
Equivalent dose	0.0016	ug/g-day	
LD50 - Acute NOAEL	0.2	unitless	
Acute/Chronic	0.1	unitless	
TRV_{low}	3.1E-05	ug/g-day	

2. Based on value for Total PCBs (Aroclors).
3. Based on value for DDT
4. Based on value for gamma-BHC (Lindane).
5. LOAEL estimated using a 10 fold extrapolation factor

b. Maximum Allowable Toxicant Concentration (MATC) - geometric mean of the $TRVl_{ow}$ and TRV_{high}.

1. Value for corresponding para-isomer.

c. Bioaccumulation Factors (BAFs) - literature--derived ratio between aquatic biological tissue and sediment (wet weight/dry weight basis).

1. Values were taken from Table 2, median, non-dep for each analyte.

d. TRVs not calculated for 2,3,7,8-TCDD, instead protective sediment concentrations available in USEPA (1993) used in the screening process.

DTSC, 2002 reference available at http://www.dtsc.ca.gov/AssessingRisk/upload/Eco_Btag-mammal-bird-TRV-table.pdf
*Bechtel Jacobs Company LLC.1998. Biota Sediment Accumulation Factors for Invertebrates: Review and Recommendations for the Oak Ridge Reservation. Used median literature values for non-depurated literature values (Table 2)

ATTACHMENT 3
ProUCL OUTPUT WORKSHEETS

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Attachment 3

Type	HHRA and ERA
Medium	Fish
Chemical	Chlordane
Units	µg/kg

Data File

Raw Statistics

Number of Valid Samples	77
Number of Unique Samples	61
Minimum	4
Maximum	3773
Mean	728.2083
Median	125
Standard Deviation	945.8552
Variance	894642.1
Coefficient of Variation	1.29888
Skewness	1.387574

Gamma Statistics

k hat	0.449095
k star (bias corrected)	0.440256
Theta hat	1621.502
Theta star	1654.058
nu hat	69.16061
nu star	67.79937
Approx.Chi Square Value (.05)	49.84466
Adjusted Level of Significance	0.046883
Adjusted Chi Square Value	49.55161

Log-transformed Statistics

Minimum of log data	1.386294
Maximum of log data	8.235626
Mean of log data	5.152205
Standard Deviation of log data	2.106326
Variance of log data	4.43661

RECOMMENDATION

Data are Non-parametric (0.05)

Use 99% Chebyshev (Mean, Sd) UCL

Variable: Chlordane

Normal Distribution Test

Lilliefors Test Statisitic	0.259638
Lilliefors 5% Critical Value	0.100969

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	907.6953

Gamma Distribution Test

A-D Test Statistic	1.814783
A-D 5% Critical Value	0.830205
K-S Test Statistic	0.168283
K-S 5% Critical Value	0.108348

Data do not follow gamma distribution at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	990.5188
Adjusted Gamma UCL	996.3766

Lognormal Distribution Test

Lilliefors Test Statisitic	0.143329
Lilliefors 5% Critical Value	0.100969

Data not lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	3710.364
95% Chebyshev (MVUE) UCL	3852.455
97.5% Chebyshev (MVUE) UCL	4888.853
99% Chebyshev (MVUE) UCL	6924.655

95% Non-parametric UCLs

CLT UCL	905.5074
Adj-CLT UCL (Adjusted for skewness)	923.72
Mod-t UCL (Adjusted for skewness)	910.5361
Jackknife UCL	907.6953
Standard Bootstrap UCL	903.5621
Bootstrap-t UCL	929.0454
Hall's Bootstrap UCL	924.2973
Percentile Bootstrap UCL	902.1575
BCA Bootstrap UCL	931.0065
95% Chebyshev (Mean, Sd) UCL	1198.055
97.5% Chebyshev (Mean, Sd) UCL	1401.358
99% Chebyshev (Mean, Sd) UCL	**1800.707**

R2-0009447

Attachment 3

Type	HHRA
Medium	Crab
Chemical	Chlordane
Units	µg/kg

Data File

Variable: Chlordane - crab

Raw Statistics	
Number of Valid Samples	139
Number of Unique Samples	38
Minimum	0.38535
Maximum	203.05
Mean	19.21562
Median	4
Standard Deviation	33.56967
Variance	1126.923
Coefficient of Variation	1.746999
Skewness	3.009624

Gamma Statistics	
k hat	0.574577
k star (bias corrected)	0.566972
Theta hat	33.44309
Theta star	33.89167
nu hat	159.7323
nu star	157.6182
Approx.Chi Square Value (.05)	129.5888
Adjusted Level of Significance	0.048273
Adjusted Chi Square Value	129.3245

Log-transformed Statistics	
Minimum of log data	-0.9536
Maximum of log data	5.313452
Mean of log data	1.873426
Standard Deviation of log data	1.389059
Variance of log data	1.929484

RECOMMENDATION

Data are Non-parametric (0.05)

Use 97.5% Chebyshev (Mean, Sd) UCL

Normal Distribution Test	
Lilliefors Test Statisitic	0.360562
Lilliefors 5% Critical Value	0.07515
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	23.93073

Gamma Distribution Test	
A-D Test Statistic	13.14024
A-D 5% Critical Value	0.812264
K-S Test Statistic	0.273276
K-S 5% Critical Value	0.083534
Data do not follow gamma distribution at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	23.37185
Adjusted Gamma UCL	23.41961

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.21263
Lilliefors 5% Critical Value	0.07515
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	23.08266
95% Chebyshev (MVUE) UCL	28.61985
97.5% Chebyshev (MVUE) UCL	33.70948
99% Chebyshev (MVUE) UCL	43.70706

95% Non-parametric UCLs	
CLT UCL	23.89908
Adj-CLT UCL (Adjusted for skewness)	24.67573
Mod-t UCL (Adjusted for skewness)	24.05187
Jackknife UCL	23.93073
Standard Bootstrap UCL	23.83198
Bootstrap-t UCL	24.91228
Hall's Bootstrap UCL	25.27798
Percentile Bootstrap UCL	24.05748
BCA Bootstrap UCL	24.97802
95% Chebyshev (Mean, Sd) UCL	31.6269
97.5% Chebyshev (Mean, Sd) UCL	**36.99727**
99% Chebyshev (Mean, Sd) UCL	47.54632

R2-0009448

Attachment 3

Type	HHRA
Medium	Fish
Chemical	DDD
Units	µg/kg

Data File

Raw Statistics

Number of Valid Samples	77
Number of Unique Samples	56
Minimum	5
Maximum	679.79
Mean	116.2053
Median	70
Standard Deviation	128.7583
Variance	16578.69
Coefficient of Variation	1.108024
Skewness	2.446144

Gamma Statistics

k hat	1.277994
k star (bias corrected)	1.23686
Theta hat	90.92791
Theta star	93.95188
nu hat	196.8111
nu star	190.4764
Approx.Chi Square Value (.05)	159.5425
Adjusted Level of Significance	0.046883
Adjusted Chi Square Value	159.0056

Log-transformed Statistics

Minimum of log data	1.609438
Maximum of log data	6.521784
Mean of log data	4.315621
Standard Deviation of log data	0.946111
Variance of log data	0.895126

RECOMMENDATION

Data are lognormal (0.05)

Use H-UCL

Variable: DDD

Normal Distribution Test

Lilliefors Test Statisitic	0.246613
Lilliefors 5% Critical Value	0.100969

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	140.6387

Gamma Distribution Test

A-D Test Statistic	1.91655
A-D 5% Critical Value	0.775056
K-S Test Statistic	0.157247
K-S 5% Critical Value	0.104122

Data do not follow gamma distribution at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	138.7365
Adjusted Gamma UCL	139.205

Lognormal Distribution Test

Lilliefors Test Statisitic	0.090721
Lilliefors 5% Critical Value	0.100969

Data are lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	**148.5262**
95% Chebyshev (MVUE) UCL	180.2688
97.5% Chebyshev (MVUE) UCL	208.0118
99% Chebyshev (MVUE) UCL	262.5077

95% Non-parametric UCLs

CLT UCL	140.3409
Adj-CLT UCL (Adjusted for skewness)	144.7115
Mod-t UCL (Adjusted for skewness)	141.3204
Jackknife UCL	140.6387
Standard Bootstrap UCL	140.5377
Bootstrap-t UCL	144.9212
Hall's Bootstrap UCL	145.0503
Percentile Bootstrap UCL	141.2753
BCA Bootstrap UCL	145.4869
95% Chebyshev (Mean, Sd) UCL	180.165
97.5% Chebyshev (Mean, Sd) UCL	207.8405
99% Chebyshev (Mean, Sd) UCL	262.2035

R2-0009449

Attachment 3

Type	HHRA
Medium	Crab
Chemical	DDD
Units	µg/kg

Data File

Raw Statistics

Number of Valid Samples	74
Number of Unique Samples	38
Minimum	1.05
Maximum	823
Mean	53.16514
Median	9.8
Standard Deviation	116.9784
Variance	13683.95
Coefficient of Variation	2.200284
Skewness	4.783628

Gamma Statistics

k hat	0.472585
k star (bias corrected)	0.462436
Theta hat	112.4985
Theta star	114.9677
nu hat	69.94263
nu star	68.44045
Approx.Chi Square Value (.05)	50.39508
Adjusted Level of Significance	0.046757
Adjusted Chi Square Value	50.08809

Log-transformed Statistics

Minimum of log data	0.04879
Maximum of log data	6.712956
Mean of log data	2.617466
Standard Deviation of log data	1.638032
Variance of log data	2.683148

RECOMMENDATION

Data are Non-parametric (0.05)

Use 97.5% Chebyshev (Mean, Sd) UCL

Variable: DDD - HH crab

Normal Distribution Test

Lilliefors Test Statisitic	0.327975
Lilliefors 5% Critical Value	0.102995

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	75.82012

Gamma Distribution Test

A-D Test Statistic	4.591953
A-D 5% Critical Value	0.824166
K-S Test Statistic	0.202051
K-S 5% Critical Value	0.110148

Data do not follow gamma distribution at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	72.20241
Adjusted Gamma UCL	72.64494

Lognormal Distribution Test

Lilliefors Test Statisitic	0.216535
Lilliefors 5% Critical Value	0.102995

Data not lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	92.11958
95% Chebyshev (MVUE) UCL	109.3418
97.5% Chebyshev (MVUE) UCL	134.8771
99% Chebyshev (MVUE) UCL	185.0362

95% Non-parametric UCLs

CLT UCL	75.53262
Adj-CLT UCL (Adjusted for skewness)	83.61263
Mod-t UCL (Adjusted for skewness)	77.08044
Jackknife UCL	75.82012
Standard Bootstrap UCL	75.378
Bootstrap-t UCL	96.42714
Hall's Bootstrap UCL	178.6165
Percentile Bootstrap UCL	78.07797
BCA Bootstrap UCL	85.18459
95% Chebyshev (Mean, Sd) UCL	112.4395
97.5% Chebyshev (Mean, Sd) UCL	**138.0875**
99% Chebyshev (Mean, Sd) UCL	188.4681

R2-0009450

Attachment 3

Type	HHRA
Medium	Crab
Chemical	DDE
Units	µg/kg

Data File

Raw Statistics

Number of Valid Samples	74
Number of Unique Samples	59
Minimum	1.45
Maximum	1740
Mean	136.9135
Median	41
Standard Deviation	248.274
Variance	61639.98
Coefficient of Variation	1.813364
Skewness	4.120717

Gamma Statistics

k hat	0.507718
k star (bias corrected)	0.496144
Theta hat	269.6643
Theta star	275.9551
nu hat	75.14232
nu star	73.42934
Approx.Chi Square Value (.05)	54.69258
Adjusted Level of Significance	0.046757
Adjusted Chi Square Value	54.37208

Log-transformed Statistics

Minimum of log data	0.371564
Maximum of log data	7.46164
Mean of log data	3.671263
Standard Deviation of log data	1.670752
Variance of log data	2.791411

RECOMMENDATION

Data are Non-parametric (0.05)

Use 97.5% Chebyshev (Mean, Sd) UCL

Variable: DDE - HH crab

Normal Distribution Test

Lilliefors Test Statisitic	0.292663
Lilliefors 5% Critical Value	0.102995

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	184.9963

Gamma Distribution Test

A-D Test Statistic	2.847709
A-D 5% Critical Value	0.816854
K-S Test Statistic	0.149462
K-S 5% Critical Value	0.109683

Data do not follow gamma distribution at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	183.8178
Adjusted Gamma UCL	184.9013

Lognormal Distribution Test

Lilliefors Test Statisitic	0.165591
Lilliefors 5% Critical Value	0.102995

Data not lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	284.2828
95% Chebyshev (MVUE) UCL	335.273
97.5% Chebyshev (MVUE) UCL	414.57
99% Chebyshev (MVUE) UCL	570.3335

95% Non-parametric UCLs

CLT UCL	184.3861
Adj-CLT UCL (Adjusted for skewness)	199.1585
Mod-t UCL (Adjusted for skewness)	187.3005
Jackknife UCL	184.9963
Standard Bootstrap UCL	184.5245
Bootstrap-t UCL	213.8093
Hall's Bootstrap UCL	360.9452
Percentile Bootstrap UCL	191.8673
BCA Bootstrap UCL	200.5447
95% Chebyshev (Mean, Sd) UCL	262.7169
97.5% Chebyshev (Mean, Sd) UCL	**317.1521**
99% Chebyshev (Mean, Sd) UCL	424.0795

R2-0009451

Attachment 3

Type	HHRA
Medium	Fish
Chemical	DDE
Units	µg/kg

Data File

Raw Statistics

Number of Valid Samples	77
Number of Unique Samples	66
Minimum	14.79
Maximum	1685.65
Mean	248.3113
Median	185
Standard Deviation	243.9676
Variance	59520.21
Coefficient of Variation	0.982507
Skewness	3.322651

Gamma Statistics

k hat	1.68757
k star (bias corrected)	1.630478
Theta hat	147.1413
Theta star	152.2935
nu hat	259.8858
nu star	251.0937
Approx.Chi Square Value (.05)	215.3976
Adjusted Level of Significance	0.046883
Adjusted Chi Square Value	214.771

Log-transformed Statistics

Minimum of log data	2.693951
Maximum of log data	7.429907
Mean of log data	5.190035
Standard Deviation of log data	0.81295
Variance of log data	0.660888

RECOMMENDATION

Data are lognormal (0.05)

Use H-UCL

Variable: DDE

Normal Distribution Test

Lilliefors Test Statisitic	0.219857
Lilliefors 5% Critical Value	0.100969

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	294.607

Gamma Distribution Test

A-D Test Statistic	1.106821
A-D 5% Critical Value	0.767391
K-S Test Statistic	0.125948
K-S 5% Critical Value	0.103415

Data do not follow gamma distribution at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	289.4619
Adjusted Gamma UCL	290.3064

Lognormal Distribution Test

Lilliefors Test Statisitic	0.083187
Lilliefors 5% Critical Value	0.100969

Data are lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	**302.9996**
95% Chebyshev (MVUE) UCL	362.0166
97.5% Chebyshev (MVUE) UCL	411.2003
99% Chebyshev (MVUE) UCL	507.8122

95% Non-parametric UCLs

CLT UCL	294.0427
Adj-CLT UCL (Adjusted for skewness)	305.2915
Mod-t UCL (Adjusted for skewness)	296.3616
Jackknife UCL	294.607
Standard Bootstrap UCL	293.8614
Bootstrap-t UCL	315.6088
Hall's Bootstrap UCL	325.121
Percentile Bootstrap UCL	296.4174
BCA Bootstrap UCL	307.7962
95% Chebyshev (Mean, Sd) UCL	369.5004
97.5% Chebyshev (Mean, Sd) UCL	421.9391
99% Chebyshev (Mean, Sd) UCL	524.9446

R2-0009452

Attachment 3

Type	HHRA
Medium	Crab
Chemical	DDT
Units	µg/kg

Data File

Raw Statistics

Number of Valid Samples	74
Number of Unique Samples	43
Minimum	0.1265
Maximum	480
Mean	77.53997
Median	5.84
Standard Deviation	136.0593
Variance	18512.14
Coefficient of Variation	1.754699
Skewness	1.726344

Gamma Statistics

k hat	0.368439
k star (bias corrected)	0.362512
Theta hat	210.4552
Theta star	213.8965
nu hat	54.52903
nu star	53.65172
Approx.Chi Square Value (.05)	37.82049
Adjusted Level of Significance	0.046757
Adjusted Chi Square Value	37.55671

Log-transformed Statistics

Minimum of log data	-2.06751
Maximum of log data	6.173786
Mean of log data	2.540874
Standard Deviation of log data	2.053976
Variance of log data	4.218819

RECOMMENDATION

Data are Non-parametric (0.05)

Use 99% Chebyshev (Mean, Sd) UCL

Variable: DDT- HH crab

Normal Distribution Test

Lilliefors Test Statisitic	0.369243
Lilliefors 5% Critical Value	0.102995

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	103.8903

Gamma Distribution Test

A-D Test Statistic	5.421298
A-D 5% Critical Value	0.849034
K-S Test Statistic	0.226031
K-S 5% Critical Value	0.111698

Data do not follow gamma distribution at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	109.9973
Adjusted Gamma UCL	110.7699

Lognormal Distribution Test

Lilliefors Test Statisitic	0.161385
Lilliefors 5% Critical Value	0.102995

Data not lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	240.25
95% Chebyshev (MVUE) UCL	251.5671
97.5% Chebyshev (MVUE) UCL	318.7361
99% Chebyshev (MVUE) UCL	450.6766

95% Non-parametric UCLs

CLT UCL	103.5559
Adj-CLT UCL (Adjusted for skewness)	106.9475
Mod-t UCL (Adjusted for skewness)	104.4193
Jackknife UCL	103.8903
Standard Bootstrap UCL	103.5913
Bootstrap-t UCL	108.6983
Hall's Bootstrap UCL	106.3559
Percentile Bootstrap UCL	105.2138
BCA Bootstrap UCL	106.2337
95% Chebyshev (Mean, Sd) UCL	146.4828
97.5% Chebyshev (Mean, Sd) UCL	176.3144
99% Chebyshev (Mean, Sd) UCL	**234.9129**

R2-0009453

Attachment 3

Type	HHRA
Medium	Fish
Chemical	DDT
Units	µg/kg

Data File

Raw Statistics

Number of Valid Samples	77
Number of Unique Samples	53
Minimum	1
Maximum	380
Mean	58.81383
Median	33.2
Standard Deviation	71.29391
Variance	5082.821
Coefficient of Variation	1.212196
Skewness	1.858971

Gamma Statistics

k hat	0.607023
k star (bias corrected)	0.592031
Theta hat	96.88897
Theta star	99.34253
nu hat	93.48153
nu star	91.17273
Approx.Chi Square Value (.05)	70.15105
Adjusted Level of Significance	0.046883
Adjusted Chi Square Value	69.80046

Log-transformed Statistics

Minimum of log data	0
Maximum of log data	5.940171
Mean of log data	3.05824
Standard Deviation of log data	1.749043
Variance of log data	3.059153

RECOMMENDATION

Data follow gamma distribution (0.05)

Use Approximate Gamma UCL

Variable: DDT

Normal Distribution Test

Lilliefors Test Statisitic	0.231949
Lilliefors 5% Critical Value	0.100969

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	72.34268

Gamma Distribution Test

A-D Test Statistic	0.796739
A-D 5% Critical Value	0.807441
K-S Test Statistic	0.086486
K-S 5% Critical Value	0.106835

Data follow gamma distribution at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	**76.43816**
Adjusted Gamma UCL	76.82209

Lognormal Distribution Test

Lilliefors Test Statisitic	0.115657
Lilliefors 5% Critical Value	0.100969

Data not lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	181.7935
95% Chebyshev (MVUE) UCL	212.1786
97.5% Chebyshev (MVUE) UCL	263.4441
99% Chebyshev (MVUE) UCL	364.1451

95% Non-parametric UCLs

CLT UCL	72.17776
Adj-CLT UCL (Adjusted for skewness)	74.0169
Mod-t UCL (Adjusted for skewness)	72.62954
Jackknife UCL	72.34268
Standard Bootstrap UCL	72.51518
Bootstrap-t UCL	75.11264
Hall's Bootstrap UCL	75.27769
Percentile Bootstrap UCL	72.75049
BCA Bootstrap UCL	74.18344
95% Chebyshev (Mean, Sd) UCL	94.22855
97.5% Chebyshev (Mean, Sd) UCL	109.5525
99% Chebyshev (Mean, Sd) UCL	139.6535

R2-0009454

Attachment 3

Type	HHRA and ERA
Medium	Fish
Chemical	Dieldrin
Units	µg/kg

Data File

Raw Statistics

Number of Valid Samples	77
Number of Unique Samples	51
Minimum	0.3
Maximum	140.0891
Mean	21.86835
Median	16.5
Standard Deviation	23.29433
Variance	542.6256
Coefficient of Variation	1.065207
Skewness	2.213871

Gamma Statistics

k hat	0.889693
k star (bias corrected)	0.863688
Theta hat	24.57966
Theta star	25.31974
nu hat	137.0127
nu star	133.0079
Approx.Chi Square Value (.05)	107.3595
Adjusted Level of Significance	0.046883
Adjusted Chi Square Value	106.9219

Log-transformed Statistics

Minimum of log data	-1.20397
Maximum of log data	4.942279
Mean of log data	2.427005
Standard Deviation of log data	1.333832
Variance of log data	1.779109

RECOMMENDATION

Assuming gamma distribution (0.05)

Use Approximate Gamma UCL

Variable: Dieldrin

Normal Distribution Test

Lilliefors Test Statisitic	0.177248
Lilliefors 5% Critical Value	0.100969

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	26.28871

Gamma Distribution Test

A-D Test Statistic	0.787328
A-D 5% Critical Value	0.786562
K-S Test Statistic	0.10202
K-S 5% Critical Value	0.105217

Data follow approximate gamma distibution at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	**27.09275**
Adjusted Gamma UCL	27.20361

Lognormal Distribution Test

Lilliefors Test Statisitic	0.136486
Lilliefors 5% Critical Value	0.100969

Data not lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	40.92574
95% Chebyshev (MVUE) UCL	50.37743
97.5% Chebyshev (MVUE) UCL	60.49795
99% Chebyshev (MVUE) UCL	80.37776

95% Non-parametric UCLs

CLT UCL	26.23483
Adj-CLT UCL (Adjusted for skewness)	26.95047
Mod-t UCL (Adjusted for skewness)	26.40034
Jackknife UCL	26.28871
Standard Bootstrap UCL	26.16137
Bootstrap-t UCL	27.36468
Hall's Bootstrap UCL	27.58395
Percentile Bootstrap UCL	26.36148
BCA Bootstrap UCL	26.96494
95% Chebyshev (Mean, Sd) UCL	33.43963
97.5% Chebyshev (Mean, Sd) UCL	38.44654
99% Chebyshev (Mean, Sd) UCL	48.28163

Attachment 3

Type	HHRA
Medium	Crab
Chemical	Dieldrin
Units	µg/kg

Data File

Raw Statistics

Number of Valid Samples	75
Number of Unique Samples	21
Minimum	0.753
Maximum	33
Mean	9.269307
Median	2.5
Standard Deviation	12.40813
Variance	153.9617
Coefficient of Variation	1.338626
Skewness	1.328876

Gamma Statistics

k hat	0.732375
k star (bias corrected)	0.711969
Theta hat	12.6565
Theta star	13.01926
nu hat	109.8562
nu star	106.7953
Approx.Chi Square Value (.05)	83.94128
Adjusted Level of Significance	0.0468
Adjusted Chi Square Value	83.54575

Log-transformed Statistics

Minimum of log data	-0.28369
Maximum of log data	3.496508
Mean of log data	1.406668
Standard Deviation of log data	1.22869
Variance of log data	1.509679

RECOMMENDATION

Data are Non-parametric (0.05)

Use 97.5% Chebyshev (Mean, Sd) UCL

Variable: Dieldrin - HH crab

Normal Distribution Test

Lilliefors Test Statisitic	0.331126
Lilliefors 5% Critical Value	0.102306

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	11.65588

Gamma Distribution Test

A-D Test Statistic	8.205953
A-D 5% Critical Value	0.794616
K-S Test Statistic	0.259913
K-S 5% Critical Value	0.107315

Data do not follow gamma distribution at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	11.79299
Adjusted Gamma UCL	11.84882

Lognormal Distribution Test

Lilliefors Test Statisitic	0.209525
Lilliefors 5% Critical Value	0.102306

Data not lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	12.36598
95% Chebyshev (MVUE) UCL	15.23676
97.5% Chebyshev (MVUE) UCL	18.13608
99% Chebyshev (MVUE) UCL	23.83121

95% Non-parametric UCLs

CLT UCL	11.626
Adj-CLT UCL (Adjusted for skewness)	11.86091
Mod-t UCL (Adjusted for skewness)	11.69252
Jackknife UCL	11.65588
Standard Bootstrap UCL	11.59448
Bootstrap-t UCL	11.96134
Hall's Bootstrap UCL	11.78995
Percentile Bootstrap UCL	11.7012
BCA Bootstrap UCL	11.72637
95% Chebyshev (Mean, Sd) UCL	15.5146
97.5% Chebyshev (Mean, Sd) UCL	**18.21694**
99% Chebyshev (Mean, Sd) UCL	23.52517

R2-0009456

Attachment 3

Type	HHRA and ERA
Medium	Fish
Chemical	Mercury
Units	µg/kg

Data File

Raw Statistics

Number of Valid Samples	87
Number of Unique Samples	68
Minimum	78.6
Maximum	931
Mean	317.9494
Median	305
Standard Deviation	154.8203
Variance	23969.32
Coefficient of Variation	0.486934
Skewness	1.186466

Gamma Statistics

k hat	4.498614
k star (bias corrected)	4.351152
Theta hat	70.6772
Theta star	73.07247
nu hat	782.7588
nu star	757.1004
Approx.Chi Square Value (.05)	694.2386
Adjusted Level of Significance	0.047241
Adjusted Chi Square Value	693.2341

Log-transformed Statistics

Minimum of log data	4.364372
Maximum of log data	6.836259
Mean of log data	5.646649
Standard Deviation of log data	0.493037
Variance of log data	0.243086

RECOMMENDATION

Data follow gamma distribution (0.05)

Use Approximate Gamma UCL

Variable: Mercury

Normal Distribution Test

Lilliefors Test Statisitic	0.100647
Lilliefors 5% Critical Value	0.094989

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	345.5488

Gamma Distribution Test

A-D Test Statistic	0.428302
A-D 5% Critical Value	0.755176
K-S Test Statistic	0.067579
K-S 5% Critical Value	0.096155

Data follow gamma distribution

at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	**346.7391**
Adjusted Gamma UCL	347.2415

Lognormal Distribution Test

Lilliefors Test Statisitic	0.0996
Lilliefors 5% Critical Value	0.094989

Data not lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	352.7346
95% Chebyshev (MVUE) UCL	396.9765
97.5% Chebyshev (MVUE) UCL	430.518
99% Chebyshev (MVUE) UCL	496.4038

95% Non-parametric UCLs

CLT UCL	345.2515
Adj-CLT UCL (Adjusted for skewness)	347.5075
Mod-t UCL (Adjusted for skewness)	345.9007
Jackknife UCL	345.5488
Standard Bootstrap UCL	345.8926
Bootstrap-t UCL	349.4925
Hall's Bootstrap UCL	348.7972
Percentile Bootstrap UCL	346
BCA Bootstrap UCL	347.9425
95% Chebyshev (Mean, Sd) UCL	390.3005
97.5% Chebyshev (Mean, Sd) UCL	421.6069
99% Chebyshev (Mean, Sd) UCL	483.1022

R2-0009457

Attachment 3

Type	HHRA
Medium	Crab
Chemical	Mercury
Units	µg/kg

Data File

Raw Statistics

Number of Valid Samples	82
Number of Unique Samples	60
Minimum	29
Maximum	280
Mean	87.4622
Median	73
Standard Deviation	54.41212
Variance	2960.679
Coefficient of Variation	0.622122
Skewness	1.592654

Gamma Statistics

k hat	3.326303
k star (bias corrected)	3.212739
Theta hat	26.29411
Theta star	27.22356
nu hat	545.5137
nu star	526.8893
Approx.Chi Square Value (.05)	474.6442
Adjusted Level of Significance	0.047073
Adjusted Chi Square Value	473.7646

Log-transformed Statistics

Minimum of log data	3.367296
Maximum of log data	5.63479
Mean of log data	4.313423
Standard Deviation of log data	0.549507
Variance of log data	0.301958

RECOMMENDATION

Data are lognormal (0.05)

Use H-UCL

Variable: Mercury - HH crab

Normal Distribution Test

Lilliefors Test Statisitic	0.164979
Lilliefors 5% Critical Value	0.097842

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	97.46016

Gamma Distribution Test

A-D Test Statistic	1.402979
A-D 5% Critical Value	0.75801
K-S Test Statistic	0.100658
K-S 5% Critical Value	0.099278

Data do not follow gamma distribution
at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	97.08933
Adjusted Gamma UCL	97.2696

Lognormal Distribution Test

Lilliefors Test Statisitic	0.08077
Lilliefors 5% Critical Value	0.097842

Data are lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	**97.38705**
95% Chebyshev (MVUE) UCL	111.1048
97.5% Chebyshev (MVUE) UCL	121.6708
99% Chebyshev (MVUE) UCL	142.4255

95% Non-parametric UCLs

CLT UCL	97.34581
Adj-CLT UCL (Adjusted for skewness)	98.47505
Mod-t UCL (Adjusted for skewness)	97.6363
Jackknife UCL	97.46016
Standard Bootstrap UCL	97.49415
Bootstrap-t UCL	99.2656
Hall's Bootstrap UCL	98.58715
Percentile Bootstrap UCL	97.86463
BCA Bootstrap UCL	98.2439
95% Chebyshev (Mean, Sd) UCL	113.654
97.5% Chebyshev (Mean, Sd) UCL	124.9872
99% Chebyshev (Mean, Sd) UCL	147.2491

R2-0009458

Attachment 3

Type	HHRA
Medium	Crab
Chemical	TCDD TEQ (D/F) - Mammal
Units	µg/kg

Data File

Variable: Human Crab Diox TEQ mammal

Raw Statistics	
Number of Valid Samples	71
Number of Unique Samples	70
Minimum	0.002338
Maximum	0.752665
Mean	0.114213
Median	0.066466
Standard Deviation	0.14111
Variance	0.019912
Coefficient of Variation	1.235499
Skewness	2.149888

Gamma Statistics	
k hat	0.822948
k star (bias corrected)	0.797565
Theta hat	0.138785
Theta star	0.143202
nu hat	116.8586
nu star	113.2542
Approx.Chi Square Value (.05)	89.68227
Adjusted Level of Significance	0.04662
Adjusted Chi Square Value	89.2492

Log-transformed Statistics	
Minimum of log data	-6.0583
Maximum of log data	-0.28414
Mean of log data	-2.88821
Standard Deviation of log data	1.271501
Variance of log data	1.616716

Normal Distribution Test	
Lilliefors Test Statisitic	0.2568253
Lilliefors 5% Critical Value	0.1051489
Data not normal at 5% significance level	
95% UCL (Assuming Normal Distribution)	
Student's-t UCL	0.1421278

Gamma Distribution Test	
A-D Test Statistic	1.78354
A-D 5% Critical Value	0.7891368
K-S Test Statistic	0.1543445
K-S 5% Critical Value	0.1096284
Data do not follow gamma distribution	
at 5% significance level	
95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	0.1442321
Adjusted Gamma UCL	0.1449319

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.1302347
Lilliefors 5% Critical Value	0.1051489
Data not lognormal at 5% significance level	
95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	0.1835401
95% Chebyshev (MVUE) UCL	0.2257003
97.5% Chebyshev (MVUE) UCL	0.2703641
99% Chebyshev (MVUE) UCL	0.3580975

95% Non-parametric UCLs	
CLT UCL	0.1417583
Adj-CLT UCL (Adjusted for skewness)	0.1463239
Mod-t UCL (Adjusted for skewness)	0.1428399
Jackknife UCL	0.1421278
Standard Bootstrap UCL	0.1406257
Bootstrap-t UCL	0.1486922
Hall's Bootstrap UCL	0.1477866
Percentile Bootstrap UCL	0.1436837
BCA Bootstrap UCL	0.1476682
95% Chebyshev (Mean, Sd) UCL	0.1872094
97.5% Chebyshev (Mean, Sd) UCL	**0.2187952**
99% Chebyshev (Mean, Sd) UCL	0.2808394

RECOMMENDATION

Data are Non-parametric (0.05)

Use 97.5% Chebyshev (Mean, Sd) UCL

R2-0009459

Attachment 3

Type	HHRA
Medium	Crab
Chemical	TCDD TEQ (PCB) - Mammal
Units	µg/kg

Data File		Variable:	Human Crab PCB TEQ - mammal
Raw Statistics		Normal Distribution Test	
Number of Valid Samples	73	Lilliefors Test Statisitic	0.41347705
Number of Unique Samples	73	Lilliefors 5% Critical Value	0.103698456
Minimum	0.00046	Data not normal at 5% significance level	
Maximum	3.62334		
Mean	0.092967	95% UCL (Assuming Normal Distribution)	
Median	0.028336	Student's-t UCL	0.175494319
Standard Deviation	0.423162		
Variance	0.179066	Gamma Distribution Test	
Coefficient of Variation	4.551737	A-D Test Statistic	3.840993491
Skewness	8.292291	A-D 5% Critical Value	0.841330641
		K-S Test Statistic	0.18058701
Gamma Statistics		K-S 5% Critical Value	0.111944887
k hat	0.400407	Data do not follow gamma distribution	
k star (bias corrected)	0.393085	at 5% significance level	
Theta hat	0.232182		
Theta star	0.236507	95% UCLs (Assuming Gamma Distribution)	
nu hat	58.45946	Approximate Gamma UCL	0.130217927
nu star	57.39035	Adjusted Gamma UCL	0.131110963
Approx.Chi Square Value (.05)	40.973		
Adjusted Level of Significance	0.046712	Lognormal Distribution Test	
Adjusted Chi Square Value	40.69392	Lilliefors Test Statisitic	0.143147822
		Lilliefors 5% Critical Value	0.103698456
Log-transformed Statistics		Data not lognormal at 5% significance level	
Minimum of log data	-7.68472		
Maximum of log data	1.287396	95% UCLs (Assuming Lognormal Distribution)	
Mean of log data	-4.01866	95% H-UCL	0.153137073
Standard Deviation of log data	1.739594	95% Chebyshev (MVUE) UCL	0.177404335
Variance of log data	3.026188	97.5% Chebyshev (MVUE) UCL	0.220547121
		99% Chebyshev (MVUE) UCL	0.305292768
		95% Non-parametric UCLs	
		CLT UCL	0.174432462
		Adj-CLT UCL (Adjusted for skewness)	0.225794101
		Mod-t UCL (Adjusted for skewness)	0.183505696
		Jackknife UCL	0.175494319
		Standard Bootstrap UCL	0.171270265
		Bootstrap-t UCL	0.646637333
RECOMMENDATION		Hall's Bootstrap UCL	0.501530574
Data are Non-parametric (0.05)		Percentile Bootstrap UCL	0.190860126
		BCA Bootstrap UCL	0.247622414
Use 97.5% Chebyshev (Mean, Sd) UCL		95% Chebyshev (Mean, Sd) UCL	0.308852009
		97.5% Chebyshev (Mean, Sd) UCL	**0.402265549**
		99% Chebyshev (Mean, Sd) UCL	0.58575836

R2-0009460

Attachment 3

Type	HHRA
Medium	Crab
Chemical	Total TEQ - Mammal
Units	µg/kg

Data File	
Raw Statistics	
Number of Valid Samples	77
Number of Unique Samples	77
Minimum	0.00046
Maximum	3.928891
Mean	0.193451
Median	0.08249
Standard Deviation	0.473021
Variance	0.223748
Coefficient of Variation	2.445175
Skewness	6.776818
Gamma Statistics	
k hat	0.544657
k star (bias corrected)	0.532095
Theta hat	0.355179
Theta star	0.363564
nu hat	83.87719
nu star	81.94258
Approx.Chi Square Value (.05)	62.07848
Adjusted Level of Significance	0.046883
Adjusted Chi Square Value	61.74963
Log-transformed Statistics	
Minimum of log data	-7.68472
Maximum of log data	1.368357
Mean of log data	-2.79372
Standard Deviation of log data	1.629381
Variance of log data	2.654884

RECOMMENDATION

Data are lognormal (0.05)

Use H-UCL

Variable:	Human Crab Total TEQ mammal
Normal Distribution Test	
Lilliefors Test Statisitic	0.3416381
Lilliefors 5% Critical Value	0.1009691
Data not normal at 5% significance level	
95% UCL (Assuming Normal Distribution)	
Student's-t UCL	0.2832118
Gamma Distribution Test	
A-D Test Statistic	1.9721286
A-D 5% Critical Value	0.8137573
K-S Test Statistic	0.1392631
K-S 5% Critical Value	0.1072865
Data do not follow gamma distribution	
at 5% significance level	
95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	0.2553517
Adjusted Gamma UCL	0.2567116
Lognormal Distribution Test	
Lilliefors Test Statisitic	0.0878546
Lilliefors 5% Critical Value	0.1009691
Data are lognormal at 5% significance level	
95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	**0.39842**
95% Chebyshev (MVUE) UCL	0.4762235
97.5% Chebyshev (MVUE) UCL	0.5861823
99% Chebyshev (MVUE) UCL	0.802175
95% Non-parametric UCLs	
CLT UCL	0.2821176
Adj-CLT UCL (Adjusted for skewness)	0.3266008
Mod-t UCL (Adjusted for skewness)	0.2901502
Jackknife UCL	0.2832118
Standard Bootstrap UCL	0.2797654
Bootstrap-t UCL	0.4190146
Hall's Bootstrap UCL	0.6378384
Percentile Bootstrap UCL	0.2920667
BCA Bootstrap UCL	0.3413734
95% Chebyshev (Mean, Sd) UCL	0.4284201
97.5% Chebyshev (Mean, Sd) UCL	0.5300916
99% Chebyshev (Mean, Sd) UCL	0.7298056

Attachment 3

Type	HHRA and ERA
Medium	Fish
Chemical	Total PCB
Units	µg/kg

Data File

Raw Statistics

Number of Valid Samples	77
Number of Unique Samples	77
Minimum	83
Maximum	13990
Mean	2854.514
Median	1795
Standard Deviation	2649.939
Variance	7022179
Coefficient of Variation	0.928333
Skewness	1.612867

Gamma Statistics

k hat	1.206722
k star (bias corrected)	1.168365
Theta hat	2365.511
Theta star	2443.17
nu hat	185.8352
nu star	179.9282
Approx.Chi Square Value (.05)	149.8972
Adjusted Level of Significance	0.046883
Adjusted Chi Square Value	149.3772

Log-transformed Statistics

Minimum of log data	4.418841
Maximum of log data	9.546098
Mean of log data	7.488195
Standard Deviation of log data	1.084117
Variance of log data	1.175309

RECOMMENDATION

Data follow gamma distribution (0.05)

Use Approximate Gamma UCL

Variable: Total PCBs

Normal Distribution Test

Lilliefors Test Statisitic	0.171094
Lilliefors 5% Critical Value	0.100969

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	3357.37

Gamma Distribution Test

A-D Test Statistic	0.472836
A-D 5% Critical Value	0.77671
K-S Test Statistic	0.074764
K-S 5% Critical Value	0.104284

Data follow gamma distribution

at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	**3426.398**
Adjusted Gamma UCL	3438.325

Lognormal Distribution Test

Lilliefors Test Statisitic	0.103874
Lilliefors 5% Critical Value	0.100969

Data not lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	4291.961
95% Chebyshev (MVUE) UCL	5266.362
97.5% Chebyshev (MVUE) UCL	6170.027
99% Chebyshev (MVUE) UCL	7945.101

95% Non-parametric UCLs

CLT UCL	3351.241
Adj-CLT UCL (Adjusted for skewness)	3410.55
Mod-t UCL (Adjusted for skewness)	3366.621
Jackknife UCL	3357.37
Standard Bootstrap UCL	3348.646
Bootstrap-t UCL	3413.527
Hall's Bootstrap UCL	3464.444
Percentile Bootstrap UCL	3375.299
BCA Bootstrap UCL	3403.161
95% Chebyshev (Mean, Sd) UCL	4170.851
97.5% Chebyshev (Mean, Sd) UCL	4740.432
99% Chebyshev (Mean, Sd) UCL	5859.262

R2-0009462

Attachment 3

Type	HHRA
Medium	Crab
Chemical	Total PCB
Units	µg/kg

Data File

Raw Statistics

Number of Valid Samples	75
Number of Unique Samples	54
Minimum	82.37
Maximum	14000
Mean	2427.953
Median	600
Standard Deviation	3817.157
Variance	14570684
Coefficient of Variation	1.572171
Skewness	1.629632

Gamma Statistics

k hat	0.571811
k star (bias corrected)	0.557828
Theta hat	4246.073
Theta star	4352.513
nu hat	85.77171
nu star	83.67418
Approx.Chi Square Value (.05)	63.58811
Adjusted Level of Significance	0.0468
Adjusted Chi Square Value	63.24598

Log-transformed Statistics

Minimum of log data	4.411221
Maximum of log data	9.546813
Mean of log data	6.706487
Standard Deviation of log data	1.414531
Variance of log data	2.000898

RECOMMENDATION

Data are Non-parametric (0.05)

Use 97.5% Chebyshev (Mean, Sd) UCL

Variable: Total PCBs - crab

Normal Distribution Test

Lilliefors Test Statisitic	0.370377
Lilliefors 5% Critical Value	0.102306

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	3162.142

Gamma Distribution Test

A-D Test Statistic	7.241358
A-D 5% Critical Value	0.810663
K-S Test Statistic	0.236845
K-S 5% Critical Value	0.1085

Data do not follow gamma distribution at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	3194.89
Adjusted Gamma UCL	3212.172

Lognormal Distribution Test

Lilliefors Test Statisitic	0.144546
Lilliefors 5% Critical Value	0.102306

Data not lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	3454.203
95% Chebyshev (MVUE) UCL	4227.236
97.5% Chebyshev (MVUE) UCL	5118.617
99% Chebyshev (MVUE) UCL	6869.562

95% Non-parametric UCLs

CLT UCL	3152.951
Adj-CLT UCL (Adjusted for skewness)	3241.574
Mod-t UCL (Adjusted for skewness)	3175.966
Jackknife UCL	3162.142
Standard Bootstrap UCL	3156.373
Bootstrap-t UCL	3280.973
Hall's Bootstrap UCL	3255.173
Percentile Bootstrap UCL	3177.28
BCA Bootstrap UCL	3225.525
95% Chebyshev (Mean, Sd) UCL	4349.213
97.5% Chebyshev (Mean, Sd) UCL	**5180.544**
99% Chebyshev (Mean, Sd) UCL	6813.532

R2-0009463

Attachment 3

Type	ERA
Medium	Mummichog
Chemical	Chlordane
Units	µg/kg

Data File

Raw Statistics

Number of Valid Samples	61
Number of Unique Samples	24
Minimum	4
Maximum	335.26
Mean	17.23672
Median	6
Standard Deviation	46.60451
Variance	2171.98
Coefficient of Variation	2.703792
Skewness	5.868271

Gamma Statistics

k hat	0.77292
k star (bias corrected)	0.745837
Theta hat	22.30077
Theta star	23.11058
nu hat	94.29629
nu star	90.9921
Approx.Chi Square Value (.05)	69.9925
Adjusted Level of Significance	0.046066
Adjusted Chi Square Value	69.5476

Log-transformed Statistics

Minimum of log data	1.386294
Maximum of log data	5.814906
Mean of log data	2.075667
Standard Deviation of log data	0.893677
Variance of log data	0.798658

RECOMMENDATION

Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

Variable: Chlordane - Mumm

Normal Distribution Test

Lilliefors Test Statisitic	0.388197
Lilliefors 5% Critical Value	0.113441

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	27.20564

Gamma Distribution Test

A-D Test Statistic	9.288737
A-D 5% Critical Value	0.790936
K-S Test Statistic	0.284591
K-S 5% Critical Value	0.118277

Data do not follow gamma distribution at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	22.40819
Adjusted Gamma UCL	22.55154

Lognormal Distribution Test

Lilliefors Test Statisitic	0.220238
Lilliefors 5% Critical Value	0.113441

Data not lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	15.26554
95% Chebyshev (MVUE) UCL	18.54009
97.5% Chebyshev (MVUE) UCL	21.46723
99% Chebyshev (MVUE) UCL	27.21704

95% Non-parametric UCLs

CLT UCL	27.05172
Adj-CLT UCL (Adjusted for skewness)	31.84231
Mod-t UCL (Adjusted for skewness)	27.95288
Jackknife UCL	27.20564
Standard Bootstrap UCL	26.87975
Bootstrap-t UCL	45.90513
Hall's Bootstrap UCL	49.19513
Percentile Bootstrap UCL	27.5277
BCA Bootstrap UCL	34.91459
95% Chebyshev (Mean, Sd) UCL	**43.24669**
97.5% Chebyshev (Mean, Sd) UCL	54.50122
99% Chebyshev (Mean, Sd) UCL	76.60858

R2-0009464

Attachment 3

Type	ERA
Medium	Mummichog
Chemical	Copper
Units	µg/kg

Data File

Variable: Copper

Raw Statistics

Number of Valid Samples	58
Number of Unique Samples	29
Minimum	1900
Maximum	7200
Mean	3662.069
Median	3500
Standard Deviation	1022.8662
Variance	1046255.3
Coefficient of Variation	0.2793137
Skewness	1.3062076

Gamma Statistics

k hat	14.625269
k star (bias corrected)	13.880283
Theta hat	250.39328
Theta star	263.83243
nu hat	1696.5312
nu star	1610.1129
Approx.Chi Square Value (.05)	1517.9036
Adjusted Level of Significance	0.0458621
Adjusted Chi Square Value	1515.6389

Log-transformed Statistics

Minimum of log data	7.5496092
Maximum of log data	8.8818363
Mean of log data	8.1712067
Standard Deviation of log data	0.2611952
Variance of log data	0.0682229

RECOMMENDATION

Data follow gamma distribution (0.05)

Use Approximate Gamma UCL

Normal Distribution Test

Lilliefors Test Statisitic	0.11878
Lilliefors 5% Critical Value	0.116337
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)

Student's-t UCL	3886.637

Gamma Distribution Test

A-D Test Statistic	0.621957
A-D 5% Critical Value	0.749889
K-S Test Statistic	0.088242
K-S 5% Critical Value	0.116665
Data follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	**3884.532**
Adjusted Gamma UCL	3890.336

Lognormal Distribution Test

Lilliefors Test Statisitic	0.08111
Lilliefors 5% Critical Value	0.116337
Data are lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	3887.139
95% Chebyshev (MVUE) UCL	4212.994
97.5% Chebyshev (MVUE) UCL	4453.079
99% Chebyshev (MVUE) UCL	4924.678

95% Non-parametric UCLs

CLT UCL	3882.987
Adj-CLT UCL (Adjusted for skewness)	3907.602
Mod-t UCL (Adjusted for skewness)	3890.477
Jackknife UCL	3886.637
Standard Bootstrap UCL	3877.258
Bootstrap-t UCL	3933.152
Hall's Bootstrap UCL	3921.145
Percentile Bootstrap UCL	3896.552
BCA Bootstrap UCL	3913.793
95% Chebyshev (Mean, Sd) UCL	4247.508
97.5% Chebyshev (Mean, Sd) UCL	4500.828
99% Chebyshev (Mean, Sd) UCL	4998.426

R2-0009465

Attachment 3

Type	ERA
Medium	Mummichog
Chemical	DDx - Sum
Units	µg/kg

Data File

Raw Statistics

Number of Valid Samples	62
Number of Unique Samples	56
Minimum	0.4644
Maximum	365.41
Mean	74.13622
Median	55.65
Standard Deviation	60.48349
Variance	3658.253
Coefficient of Variation	0.815843
Skewness	2.425711

Gamma Statistics

k hat	1.785201
k star (bias corrected)	1.709573
Theta hat	41.52821
Theta star	43.36534
nu hat	221.365
nu star	211.9871
Approx.Chi Square Value (.05)	179.2865
Adjusted Level of Significance	0.046129
Adjusted Chi Square Value	178.574

Log-transformed Statistics

Minimum of log data	-0.76701
Maximum of log data	5.90102
Mean of log data	4.0004
Standard Deviation of log data	0.92631
Variance of log data	0.85805

RECOMMENDATION

Data follow gamma distribution (0.05)

Use Approximate Gamma UCL

Variable: DDx - Mumm

Normal Distribution Test

Lilliefors Test Statisitic	0.159908
Lilliefors 5% Critical Value	0.112522

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	86.96586

Gamma Distribution Test

A-D Test Statistic	0.594749
A-D 5% Critical Value	0.765523
K-S Test Statistic	0.079804
K-S 5% Critical Value	0.114748

Data follow gamma distribution

at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	**87.65816**
Adjusted Gamma UCL	88.0079

Lognormal Distribution Test

Lilliefors Test Statisitic	0.132703
Lilliefors 5% Critical Value	0.112522

Data not lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	108.8998
95% Chebyshev (MVUE) UCL	132.5784
97.5% Chebyshev (MVUE) UCL	153.9992
99% Chebyshev (MVUE) UCL	196.0763

95% Non-parametric UCLs

CLT UCL	86.77101
Adj-CLT UCL (Adjusted for skewness)	89.29952
Mod-t UCL (Adjusted for skewness)	87.36025
Jackknife UCL	86.96586
Standard Bootstrap UCL	86.94134
Bootstrap-t UCL	90.53693
Hall's Bootstrap UCL	92.37471
Percentile Bootstrap UCL	86.87082
BCA Bootstrap UCL	89.30995
95% Chebyshev (Mean, Sd) UCL	107.6187
97.5% Chebyshev (Mean, Sd) UCL	122.1066
99% Chebyshev (Mean, Sd) UCL	150.5653

R2-0009466

Attachment 3

Type	ERA
Medium	Mummichog
Chemical	Dieldrin
Units	µg/kg

Data File

Raw Statistics

Number of Valid Samples	61
Number of Unique Samples	15
Minimum	1.65
Maximum	11.1
Mean	3.069004
Median	2.5
Standard Deviation	2.170103
Variance	4.709347
Coefficient of Variation	0.707103
Skewness	2.442029

Gamma Statistics

k hat	3.267146
k star (bias corrected)	3.117396
Theta hat	0.939353
Theta star	0.984477
nu hat	398.5919
nu star	380.3223
Approx.Chi Square Value (.05)	336.1137
Adjusted Level of Significance	0.046066
Adjusted Chi Square Value	335.1137

Log-transformed Statistics

Minimum of log data	0.500775
Maximum of log data	2.406945
Mean of log data	0.960577
Standard Deviation of log data	0.524713
Variance of log data	0.275323

RECOMMENDATION

Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

Variable: Dieldrin - Mumm

Normal Distribution Test

Lilliefors Test Statisitic	0.256592
Lilliefors 5% Critical Value	0.113441

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	3.533199

Gamma Distribution Test

A-D Test Statistic	4.14192
A-D 5% Critical Value	0.756848
K-S Test Statistic	0.237424
K-S 5% Critical Value	0.114618

Data do not follow gamma distribution at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	3.472666
Adjusted Gamma UCL	3.483029

Lognormal Distribution Test

Lilliefors Test Statisitic	0.252188
Lilliefors 5% Critical Value	0.113441

Data not lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	3.405478
95% Chebyshev (MVUE) UCL	3.91724
97.5% Chebyshev (MVUE) UCL	4.317921
99% Chebyshev (MVUE) UCL	5.104981

95% Non-parametric UCLs

CLT UCL	3.526032
Adj-CLT UCL (Adjusted for skewness)	3.61886
Mod-t UCL (Adjusted for skewness)	3.547678
Jackknife UCL	3.533199
Standard Bootstrap UCL	3.521184
Bootstrap-t UCL	3.648005
Hall's Bootstrap UCL	3.653233
Percentile Bootstrap UCL	3.558184
BCA Bootstrap UCL	3.620912
95% Chebyshev (Mean, Sd) UCL	**4.280138**
97.5% Chebyshev (Mean, Sd) UCL	4.804197
99% Chebyshev (Mean, Sd) UCL	5.833609

R2-0009467

Attachment 3

Type	ERA
Medium	Mummichog
Chemical	Lead
Units	µg/kg

Data File

Variable: Lead

Raw Statistics	
Number of Valid Samples	30
Number of Unique Samples	21
Minimum	125
Maximum	2800
Mean	708.1667
Median	530
Standard Deviation	679.6811
Variance	461966.4
Coefficient of Variation	0.959776
Skewness	2.410436

Gamma Statistics	
k hat	1.715203
k star (bias corrected)	1.565905
Theta hat	412.8764
Theta star	452.2413
nu hat	102.9122
nu star	93.95427
Approx.Chi Square Value (.05)	72.59543
Adjusted Level of Significance	0.041
Adjusted Chi Square Value	71.51306

Log-transformed Statistics	
Minimum of log data	4.828314
Maximum of log data	7.937375
Mean of log data	6.243686
Standard Deviation of log data	0.807942
Variance of log data	0.65277

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.633453
Shapiro-Wilk 5% Critical Value	0.927
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	919.0151

Gamma Distribution Test	
A-D Test Statistic	2.057217
A-D 5% Critical Value	0.761067
K-S Test Statistic	0.223651
K-S 5% Critical Value	0.162556
Data do not follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	916.5217
Adjusted Gamma UCL	930.3935

Lognormal Distribution Test	
Shapiro-Wilk Test Statisitic	0.861497
Shapiro-Wilk 5% Critical Value	0.927
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	995.5323
95% Chebyshev (MVUE) UCL	1203.212
97.5% Chebyshev (MVUE) UCL	1419.44
99% Chebyshev (MVUE) UCL	1844.178

95% Non-parametric UCLs	
CLT UCL	912.2802
Adj-CLT UCL (Adjusted for skewness)	970.6328
Mod-t UCL (Adjusted for skewness)	928.1169
Jackknife UCL	919.0151
Standard Bootstrap UCL	906.0479
Bootstrap-t UCL	1021.053
Hall's Bootstrap UCL	1014.046
Percentile Bootstrap UCL	917.6667
BCA Bootstrap UCL	988.5
95% Chebyshev (Mean, Sd) UCL	**1249.072**
97.5% Chebyshev (Mean, Sd) UCL	1483.122
99% Chebyshev (Mean, Sd) UCL	1942.869

RECOMMENDATION

Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

R2-0009468

Attachment 3

Type	ERA
Medium	Mummichog
Chemical	Mercury
Units	µg/kg

Data File

Raw Statistics

Number of Valid Samples	67
Number of Unique Samples	38
Minimum	18.5
Maximum	150
Mean	38.56716
Median	33
Standard Deviation	19.09539
Variance	364.6338
Coefficient of Variation	0.49512
Skewness	3.391077

Gamma Statistics

k hat	6.406648
k star (bias corrected)	6.129733
Theta hat	6.019866
Theta star	6.291817
nu hat	858.4908
nu star	821.3843
Approx.Chi Square Value (.05)	755.8591
Adjusted Level of Significance	0.046418
Adjusted Chi Square Value	754.488

Log-transformed Statistics

Minimum of log data	2.917771
Maximum of log data	5.010635
Mean of log data	3.572332
Standard Deviation of log data	0.377085
Variance of log data	0.142193

RECOMMENDATION

Data are lognormal (0.05)

Use Student's-t UCL
Use Modified-t UCL
Use H-UCL

Variable: Mercury- Mumm

Normal Distribution Test

Lilliefors Test Statisitic	0.160009
Lilliefors 5% Critical Value	0.108242

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	**42.45903**

Gamma Distribution Test

A-D Test Statistic	1.27414
A-D 5% Critical Value	0.753061
K-S Test Statistic	0.121411
K-S 5% Critical Value	0.109091

Data do not follow gamma distribution
at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	41.91054
Adjusted Gamma UCL	41.9867

Lognormal Distribution Test

Lilliefors Test Statisitic	0.10207
Lilliefors 5% Critical Value	0.108242

Data are lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	**41.52446**
95% Chebyshev (MVUE) UCL	46.08083
97.5% Chebyshev (MVUE) UCL	49.49979
99% Chebyshev (MVUE) UCL	56.21568

95% Non-parametric UCLs

CLT UCL	42.4044
Adj-CLT UCL (Adjusted for skewness)	43.43709
Mod-t UCL (Adjusted for skewness)	**42.62011**
Jackknife UCL	42.45903
Standard Bootstrap UCL	42.40196
Bootstrap-t UCL	44.0377
Hall's Bootstrap UCL	47.28418
Percentile Bootstrap UCL	42.59701
BCA Bootstrap UCL	43.95821
95% Chebyshev (Mean, Sd) UCL	48.73592
97.5% Chebyshev (Mean, Sd) UCL	53.13595
99% Chebyshev (Mean, Sd) UCL	61.77895

R2-0009469

Attachment 3

Type	ERA
Medium	Mummichog
Chemical	LPAH
Units	µg/kg

Data File

Variable: LPAH

Raw Statistics

Number of Valid Samples	61
Number of Unique Samples	58
Minimum	29.561
Maximum	421.7
Mean	128.2723
Median	88
Standard Deviation	78.1926
Variance	6114.082
Coefficient of Variation	0.609583
Skewness	1.532691

Gamma Statistics

k hat	3.371114
k star (bias corrected)	3.21625
Theta hat	38.05041
Theta star	39.88255
nu hat	411.2759
nu star	392.3825
Approx.Chi Square Value (.05)	347.4597
Adjusted Level of Significance	0.046066
Adjusted Chi Square Value	346.4426

Log-transformed Statistics

Minimum of log data	3.386456
Maximum of log data	6.044294
Mean of log data	4.698565
Standard Deviation of log data	0.552754
Variance of log data	0.305537

Normal Distribution Test

Lilliefors Test Statisitic	0.206425
Lilliefors 5% Critical Value	0.113441
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)

Student's-t UCL	144.998

Gamma Distribution Test

A-D Test Statistic	2.295735
A-D 5% Critical Value	0.75641
K-S Test Statistic	0.186631
K-S 5% Critical Value	0.114569
Data do not follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	144.8565
Adjusted Gamma UCL	145.2818

Lognormal Distribution Test

Lilliefors Test Statisitic	0.166302
Lilliefors 5% Critical Value	0.113441
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	146.4399
95% Chebyshev (MVUE) UCL	169.3723
97.5% Chebyshev (MVUE) UCL	187.4711
99% Chebyshev (MVUE) UCL	223.0228

95% Non-parametric UCLs

CLT UCL	144.7398
Adj-CLT UCL (Adjusted for skewness)	146.8391
Mod-t UCL (Adjusted for skewness)	145.3255
Jackknife UCL	144.998
Standard Bootstrap UCL	145.0199
Bootstrap-t UCL	145.623
Hall's Bootstrap UCL	147.7375
Percentile Bootstrap UCL	144.8721
BCA Bootstrap UCL	146.801
95% Chebyshev (Mean, Sd) UCL	**171.9115**
97.5% Chebyshev (Mean, Sd) UCL	190.7943
99% Chebyshev (Mean, Sd) UCL	227.8858

RECOMMENDATION

Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

R2-0009470

Attachment 3

Type	ERA
Medium	Mummichog
Chemical	HPAH
Units	µg/kg

Data File

Variable: HPAH

Raw Statistics	
Number of Valid Samples	61
Number of Unique Samples	54
Minimum	9.9
Maximum	110.8
Mean	61.45375
Median	61.5
Standard Deviation	15.39518
Variance	237.0116
Coefficient of Variation	0.250517
Skewness	-0.23615

Gamma Statistics	
k hat	11.103
k star (bias corrected)	10.56788
Theta hat	5.534876
Theta star	5.815143
nu hat	1354.566
nu star	1289.282
Approx.Chi Square Value (.05)	1206.892
Adjusted Level of Significance	0.046066
Adjusted Chi Square Value	1204.977

Log-transformed Statistics	
Minimum of log data	2.292535
Maximum of log data	4.707727
Mean of log data	4.072577
Standard Deviation of log data	0.353249
Variance of log data	0.124785

Normal Distribution Test	
Lilliefors Test Statisitic	0.216217
Lilliefors 5% Critical Value	0.113441
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	**64.74685**

Gamma Distribution Test	
A-D Test Statistic	6.317423
A-D 5% Critical Value	0.750888
K-S Test Statistic	0.276729
K-S 5% Critical Value	0.113827
Data do not follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	65.64897
Adjusted Gamma UCL	65.75327

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.310238
Lilliefors 5% Critical Value	0.113441
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	67.76397
95% Chebyshev (MVUE) UCL	75.05328
97.5% Chebyshev (MVUE) UCL	80.51972
99% Chebyshev (MVUE) UCL	91.25747

95% Non-parametric UCLs	
CLT UCL	64.69601
Adj-CLT UCL (Adjusted for skewness)	64.63233
Mod-t UCL (Adjusted for skewness)	**64.73692**
Jackknife UCL	64.74685
Standard Bootstrap UCL	64.63656
Bootstrap-t UCL	64.75195
Hall's Bootstrap UCL	64.96825
Percentile Bootstrap UCL	64.72595
BCA Bootstrap UCL	64.43366
95% Chebyshev (Mean, Sd) UCL	70.0458
97.5% Chebyshev (Mean, Sd) UCL	73.76359
99% Chebyshev (Mean, Sd) UCL	81.06646

RECOMMENDATION

Data are Non-parametric (0.05)

Use Student's-t UCL
or Modified-t UCL

R2-0009471

Attachment 3

Type	ERA
Medium	Mummichog
Chemical	TCDD TEQ (D/F) - Fish
Units	µg/kg

Data File

Variable: - Mummichog Dioxin TEQ

Raw Statistics	
Number of Valid Samples	62
Number of Unique Samples	62
Minimum	0.005489
Maximum	0.838984
Mean	0.078046
Median	0.058716
Standard Deviation	0.120358
Variance	0.014486
Coefficient of Variation	1.542152
Skewness	5.140289

Gamma Statistics	
k hat	1.5863
k star (bias corrected)	1.520296
Theta hat	0.0492
Theta star	0.051336
nu hat	196.7012
nu star	188.5167
Approx.Chi Square Value (.05)	157.7487
Adjusted Level of Significance	0.046129
Adjusted Chi Square Value	157.0816

Log-transformed Statistics	
Minimum of log data	-5.20506
Maximum of log data	-0.17556
Mean of log data	-2.89764
Standard Deviation of log data	0.69348
Variance of log data	0.480915

Normal Distribution Test	
Lilliefors Test Statisitic	0.441129
Lilliefors 5% Critical Value	0.112522
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	0.103576

Gamma Distribution Test	
A-D Test Statistic	7.491272
A-D 5% Critical Value	0.767875
K-S Test Statistic	0.327241
K-S 5% Critical Value	0.115023
Data do not follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	0.093268
Adjusted Gamma UCL	0.093664

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.240057
Lilliefors 5% Critical Value	0.112522
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	0.083763
95% Chebyshev (MVUE) UCL	0.099201
97.5% Chebyshev (MVUE) UCL	0.111918
99% Chebyshev (MVUE) UCL	0.136897

95% Non-parametric UCLs	
CLT UCL	0.103188
Adj-CLT UCL (Adjusted for skewness)	0.113851
Mod-t UCL (Adjusted for skewness)	0.105239
Jackknife UCL	0.103576
Standard Bootstrap UCL	0.103497
Bootstrap-t UCL	0.231305
Hall's Bootstrap UCL	0.113233
Percentile Bootstrap UCL	0.107275
BCA Bootstrap UCL	0.120597
95% Chebyshev (Mean, Sd) UCL	**0.144674**
97.5% Chebyshev (Mean, Sd) UCL	0.173504
99% Chebyshev (Mean, Sd) UCL	0.230135

RECOMMENDATION

Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

R2-0009472

Attachment 3

Type	ERA
Medium	Mummichog
Chemical	TCDD TEQ (D/F) - Bird
Units	µg/kg

Data File	
Raw Statistics	
Number of Valid Samples	62
Number of Unique Samples	62
Minimum	0.006655
Maximum	0.84293
Mean	0.080749
Median	0.061573
Standard Deviation	0.120612
Variance	0.014547
Coefficient of Variation	1.493678
Skewness	5.133278
Gamma Statistics	
k hat	1.660682
k star (bias corrected)	1.591079
Theta hat	0.048624
Theta star	0.050751
nu hat	205.9245
nu star	197.2938
Approx.Chi Square Value (.05)	165.7896
Adjusted Level of Significance	0.046129
Adjusted Chi Square Value	165.1052
Log-transformed Statistics	
Minimum of log data	-5.01234
Maximum of log data	-0.17087
Mean of log data	-2.84676
Standard Deviation of log data	0.676684
Variance of log data	0.457901

RECOMMENDATION

Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

Variable:	Mummichog Dioxin TEQ
Normal Distribution Test	
Lilliefors Test Statisitic	0.442149
Lilliefors 5% Critical Value	0.112522
Data not normal at 5% significance level	
95% UCL (Assuming Normal Distribution)	
Student's-t UCL	0.106333
Gamma Distribution Test	
A-D Test Statistic	7.611742
A-D 5% Critical Value	0.766995
K-S Test Statistic	0.331517
K-S 5% Critical Value	0.11492
Data do not follow gamma distribution	
at 5% significance level	
95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	0.096093
Adjusted Gamma UCL	0.096491
Lognormal Distribution Test	
Lilliefors Test Statisitic	0.246333
Lilliefors 5% Critical Value	0.112522
Data not lognormal at 5% significance level	
95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	0.086655
95% Chebyshev (MVUE) UCL	0.102357
97.5% Chebyshev (MVUE) UCL	0.115217
99% Chebyshev (MVUE) UCL	0.140478
95% Non-parametric UCLs	
CLT UCL	0.105944
Adj-CLT UCL (Adjusted for skewness)	0.116614
Mod-t UCL (Adjusted for skewness)	0.107997
Jackknife UCL	0.106333
Standard Bootstrap UCL	0.106365
Bootstrap-t UCL	0.150889
Hall's Bootstrap UCL	0.115574
Percentile Bootstrap UCL	0.108289
BCA Bootstrap UCL	0.122232
95% Chebyshev (Mean, Sd) UCL	**0.147517**
97.5% Chebyshev (Mean, Sd) UCL	0.176408
99% Chebyshev (Mean, Sd) UCL	0.233159

R2-0009473

Attachment 3

Type	ERA
Medium	Mummichog
Chemical	TCDD TEQ (D/F) - Mammal
Units	µg/kg

Data File		Variable:	Mummichog Dioxin TEQ
Raw Statistics		Normal Distribution Test	
Number of Valid Samples	62	Lilliefors Test Statisitic	0.440879
Number of Unique Samples	62	Lilliefors 5% Critical Value	0.112522
Minimum	0.005506	Data not normal at 5% significance level	
Maximum	0.838225		
Mean	0.078014	95% UCL (Assuming Normal Distribution)	
Median	0.058768	Student's-t UCL	0.103529
Standard Deviation	0.120289		
Variance	0.01447	Gamma Distribution Test	
Coefficient of Variation	1.541899	A-D Test Statistic	7.481559
Skewness	5.137015	A-D 5% Critical Value	0.767925
		K-S Test Statistic	0.326692
Gamma Statistics		K-S 5% Critical Value	0.115029
k hat	1.582058	Data do not follow gamma distribution	
k star (bias corrected)	1.51626	at 5% significance level	
Theta hat	0.049312		
Theta star	0.051451	95% UCLs (Assuming Gamma Distribution)	
nu hat	196.1752	Approximate Gamma UCL	0.093253
nu star	188.0162	Adjusted Gamma UCL	0.09365
Approx.Chi Square Value (.05)	157.2906		
Adjusted Level of Significance	0.046129	Lognormal Distribution Test	
Adjusted Chi Square Value	156.6246	Lilliefors Test Statisitic	0.239916
		Lilliefors 5% Critical Value	0.112522
Log-transformed Statistics		Data not lognormal at 5% significance level	
Minimum of log data	-5.20192		
Maximum of log data	-0.17647	95% UCLs (Assuming Lognormal Distribution)	
Mean of log data	-2.89907	95% H-UCL	0.083896
Standard Deviation of log data	0.696426	95% Chebyshev (MVUE) UCL	0.099404
Variance of log data	0.485009	97.5% Chebyshev (MVUE) UCL	0.112191
		99% Chebyshev (MVUE) UCL	0.137308
		95% Non-parametric UCLs	
		CLT UCL	0.103142
		Adj-CLT UCL (Adjusted for skewness)	0.113791
		Mod-t UCL (Adjusted for skewness)	0.10519
		Jackknife UCL	0.103529
		Standard Bootstrap UCL	0.10213
		Bootstrap-t UCL	0.134346
RECOMMENDATION		Hall's Bootstrap UCL	0.112217
Data are Non-parametric (0.05)		Percentile Bootstrap UCL	0.107619
		BCA Bootstrap UCL	0.115259
Use 95% Chebyshev (Mean, Sd) UCL		**95% Chebyshev (Mean, Sd) UCL**	**0.144604**
		97.5% Chebyshev (Mean, Sd) UCL	0.173417
		99% Chebyshev (Mean, Sd) UCL	0.230016

R2-0009474

Attachment 3

Type	ERA
Medium	Mummichog
Chemical	TCDD TEQ (PCB) - Fish
Units	µg/kg

Data File		Variable:	Mummichog PCB TEQ
Raw Statistics		Normal Distribution Test	
Number of Valid Samples	61	Lilliefors Test Statisitic	0.082318
Number of Unique Samples	61	Lilliefors 5% Critical Value	0.113441
Minimum	9.45E-05	Data are normal at 5% significance level	
Maximum	0.003333		
Mean	0.00159	95% UCL (Assuming Normal Distribution)	
Median	0.001498	**Student's-t UCL**	**0.001695**
Standard Deviation	0.000494		
Variance	2.44E-07	Gamma Distribution Test	
Coefficient of Variation	0.310611	A-D Test Statistic	1.315441
Skewness	0.47429	A-D 5% Critical Value	0.752236
		K-S Test Statistic	0.116838
Gamma Statistics		K-S 5% Critical Value	0.114016
k hat	7.590283	Data do not follow gamma distribution	
k star (bias corrected)	7.227919	at 5% significance level	
Theta hat	0.000209		
Theta star	0.00022	95% UCLs (Assuming Gamma Distribution)	
nu hat	926.0145	Approximate Gamma UCL	0.001722
nu star	881.8061	Adjusted Gamma UCL	0.001726
Approx.Chi Square Value (.05)	813.8712		
Adjusted Level of Significance	0.046066	Lognormal Distribution Test	
Adjusted Chi Square Value	812.3031	Lilliefors Test Statisitic	0.164188
		Lilliefors 5% Critical Value	0.113441
Log-transformed Statistics		Data not lognormal at 5% significance level	
Minimum of log data	-9.2674		
Maximum of log data	-5.70398	95% UCLs (Assuming Lognormal Distribution)	
Mean of log data	-6.51147	95% H-UCL	0.001828
Standard Deviation of log data	0.448742	95% Chebyshev (MVUE) UCL	0.002069
Variance of log data	0.201369	97.5% Chebyshev (MVUE) UCL	0.002254
		99% Chebyshev (MVUE) UCL	0.002618
		95% Non-parametric UCLs	
		CLT UCL	0.001694
		Adj-CLT UCL (Adjusted for skewness)	0.001698
		Mod-t UCL (Adjusted for skewness)	0.001696
		Jackknife UCL	0.001695
		Standard Bootstrap UCL	0.00169
		Bootstrap-t UCL	0.001701
RECOMMENDATION		Hall's Bootstrap UCL	0.001711
Data are normal (0.05)		Percentile Bootstrap UCL	0.001688
		BCA Bootstrap UCL	0.001697
Use Student's-t UCL		95% Chebyshev (Mean, Sd) UCL	0.001865
		97.5% Chebyshev (Mean, Sd) UCL	0.001985
		99% Chebyshev (Mean, Sd) UCL	0.002219

R2-0009475

Attachment 3

Type	ERA
Medium	Mummichog
Chemical	TCDD TEQ (PCB) - Mammal
Units	µg/kg

Data File		Variable:	Mummichog PCB TEQ
Raw Statistics		Normal Distribution Test	
Number of Valid Samples	61	Lilliefors Test Statisitic	0.066611
Number of Unique Samples	61	Lilliefors 5% Critical Value	0.113441
Minimum	0.001861	Data are normal at 5% significance level	
Maximum	0.043456		
Mean	0.025584	95% UCL (Assuming Normal Distribution)	
Median	0.02476	**Student's-t UCL**	**0.027172**
Standard Deviation	0.007426		
Variance	5.52E-05	Gamma Distribution Test	
Coefficient of Variation	0.290278	A-D Test Statistic	1.152409
Skewness	-0.03882	A-D 5% Critical Value	0.751889
		K-S Test Statistic	0.116384
Gamma Statistics		K-S 5% Critical Value	0.113966
k hat	8.345927	Data do not follow gamma distribution	
k star (bias corrected)	7.946401	at 5% significance level	
Theta hat	0.003065		
Theta star	0.00322	95% UCLs (Assuming Gamma Distribution)	
nu hat	1018.203	Approximate Gamma UCL	0.027614
nu star	969.4609	Adjusted Gamma UCL	0.027665
Approx.Chi Square Value (.05)	898.1725		
Adjusted Level of Significance	0.046066	Lognormal Distribution Test	
Adjusted Chi Square Value	896.524	Lilliefors Test Statisitic	0.162448
		Lilliefors 5% Critical Value	0.113441
Log-transformed Statistics		Data not lognormal at 5% significance level	
Minimum of log data	-6.28663		
Maximum of log data	-3.13602	95% UCLs (Assuming Lognormal Distribution)	
Mean of log data	-3.7269	95% H-UCL	0.029073
Standard Deviation of log data	0.42354	95% Chebyshev (MVUE) UCL	0.032732
Variance of log data	0.179386	97.5% Chebyshev (MVUE) UCL	0.035522
		99% Chebyshev (MVUE) UCL	0.041003
		95% Non-parametric UCLs	
		CLT UCL	0.027148
		Adj-CLT UCL (Adjusted for skewness)	0.027143
		Mod-t UCL (Adjusted for skewness)	0.027172
		Jackknife UCL	0.027172
		Standard Bootstrap UCL	0.027138
		Bootstrap-t UCL	0.027098
RECOMMENDATION		Hall's Bootstrap UCL	0.027154
Data are normal (0.05)		Percentile Bootstrap UCL	0.02712
		BCA Bootstrap UCL	0.027074
Use Student's-t UCL		95% Chebyshev (Mean, Sd) UCL	0.029728
		97.5% Chebyshev (Mean, Sd) UCL	0.031522
		99% Chebyshev (Mean, Sd) UCL	0.035045

R2-0009476

Attachment 3

Type	ERA
Medium	Mummichog
Chemical	TCDD TEQ (PCB) - Bird
Units	µg/kg

Data File		Variable:	Mummichog PCB TEQ
Raw Statistics		Normal Distribution Test	
Number of Valid Samples	61	Lilliefors Test Statisitic	0.181207
Number of Unique Samples	61	Lilliefors 5% Critical Value	0.113441
Minimum	0.004174	Data not normal at 5% significance level	
Maximum	0.56848		
Mean	0.156583	95% UCL (Assuming Normal Distribution)	
Median	0.142257	Student's-t UCL	0.173627
Standard Deviation	0.079681		
Variance	0.006349	Gamma Distribution Test	
Coefficient of Variation	0.508874	A-D Test Statistic	2.012804
Skewness	2.613471	A-D 5% Critical Value	0.753714
		K-S Test Statistic	0.128743
Gamma Statistics		K-S 5% Critical Value	0.114264
k hat	4.13768	Data do not follow gamma distribution	
k star (bias corrected)	3.945117	at 5% significance level	
Theta hat	0.037843		
Theta star	0.03969	95% UCLs (Assuming Gamma Distribution)	
nu hat	504.797	Approximate Gamma UCL	0.174687
nu star	481.3042	Adjusted Gamma UCL	0.175148
Approx.Chi Square Value (.05)	431.4229		
Adjusted Level of Significance	0.046066	Lognormal Distribution Test	
Adjusted Chi Square Value	430.2871	Lilliefors Test Statisitic	0.175342
		Lilliefors 5% Critical Value	0.113441
Log-transformed Statistics		Data not lognormal at 5% significance level	
Minimum of log data	-5.4789		
Maximum of log data	-0.56479	95% UCLs (Assuming Lognormal Distribution)	
Mean of log data	-1.97985	95% H-UCL	0.191682
Standard Deviation of log data	0.598357	95% Chebyshev (MVUE) UCL	0.223585
Variance of log data	0.358031	97.5% Chebyshev (MVUE) UCL	0.24911
		99% Chebyshev (MVUE) UCL	0.299249
		95% Non-parametric UCLs	
		CLT UCL	0.173364
		Adj-CLT UCL (Adjusted for skewness)	0.177011
		Mod-t UCL (Adjusted for skewness)	0.174196
		Jackknife UCL	0.173627
		Standard Bootstrap UCL	0.172892
		Bootstrap-t UCL	0.178157
RECOMMENDATION		Hall's Bootstrap UCL	0.187403
Data are Non-parametric (0.05)		Percentile Bootstrap UCL	0.173519
		BCA Bootstrap UCL	0.179495
Use 95% Chebyshev (Mean, Sd) UCL		**95% Chebyshev (Mean, Sd) UCL**	**0.201053**
		97.5% Chebyshev (Mean, Sd) UCL	0.220295
		99% Chebyshev (Mean, Sd) UCL	0.258092

R2-0009477

Attachment 3

Type	ERA
Medium	Mummichog
Chemical	Total TEQ - Fish
Units	µg/kg

Data File		Variable:	Mummichog Total TEQ
Raw Statistics		Normal Distribution Test	
Number of Valid Samples	62	Lilliefors Test Statisitic	0.442262
Number of Unique Samples	62	Lilliefors 5% Critical Value	0.112522
Minimum	0.005489	Data not normal at 5% significance level	
Maximum	0.840348		
Mean	0.07961	95% UCL (Assuming Normal Distribution)	
Median	0.060299	Student's-t UCL	0.105124
Standard Deviation	0.120284		
Variance	0.014468	Gamma Distribution Test	
Coefficient of Variation	1.510919	A-D Test Statistic	7.591827
Skewness	5.141668	A-D 5% Critical Value	0.767296
		K-S Test Statistic	0.330882
Gamma Statistics		K-S 5% Critical Value	0.114955
k hat	1.635297	Data do not follow gamma distribution	
k star (bias corrected)	1.566922	at 5% significance level	
Theta hat	0.048682		
Theta star	0.050807	95% UCLs (Assuming Gamma Distribution)	
nu hat	202.7768	Approximate Gamma UCL	0.094871
nu star	194.2984	Adjusted Gamma UCL	0.095267
Approx.Chi Square Value (.05)	163.0435		
Adjusted Level of Significance	0.046129	Lognormal Distribution Test	
Adjusted Chi Square Value	162.365	Lilliefors Test Statisitic	0.245482
		Lilliefors 5% Critical Value	0.112522
Log-transformed Statistics		Data not lognormal at 5% significance level	
Minimum of log data	-5.20506		
Maximum of log data	-0.17394	95% UCLs (Assuming Lognormal Distribution)	
Mean of log data	-2.86652	95% H-UCL	0.08557
Standard Deviation of log data	0.683827	95% Chebyshev (MVUE) UCL	0.101189
Variance of log data	0.467619	97.5% Chebyshev (MVUE) UCL	0.114012
		99% Chebyshev (MVUE) UCL	0.139201
		95% Non-parametric UCLs	
		CLT UCL	0.104737
		Adj-CLT UCL (Adjusted for skewness)	0.115395
		Mod-t UCL (Adjusted for skewness)	0.106787
		Jackknife UCL	0.105124
		Standard Bootstrap UCL	0.104971
		Bootstrap-t UCL	0.22436
RECOMMENDATION		Hall's Bootstrap UCL	0.120178
Data are Non-parametric (0.05)		Percentile Bootstrap UCL	0.106251
		BCA Bootstrap UCL	0.12212
Use 95% Chebyshev (Mean, Sd) UCL		**95% Chebyshev (Mean, Sd) UCL**	**0.146197**
		97.5% Chebyshev (Mean, Sd) UCL	0.175009
		99% Chebyshev (Mean, Sd) UCL	0.231605

R2-0009478

Attachment 3

Type	ERA
Medium	Mummichog
Chemical	Total TEQ - Mammal
Units	µg/kg

Data File		Variable:	Mummichog Total TEQ
Raw Statistics		Normal Distribution Test	
Number of Valid Samples	62	Lilliefors Test Statisitic	0.421266
Number of Unique Samples	62	Lilliefors 5% Critical Value	0.112522
Minimum	0.005506	Data not normal at 5% significance level	
Maximum	0.860873		
Mean	0.103185	95% UCL (Assuming Normal Distribution)	
Median	0.083114	Student's-t UCL	0.128555
Standard Deviation	0.119603		
Variance	0.014305	Gamma Distribution Test	
Coefficient of Variation	1.159111	A-D Test Statistic	7.805189
Skewness	5.106277	A-D 5% Critical Value	0.761565
		K-S Test Statistic	0.323908
Gamma Statistics		K-S 5% Critical Value	0.114296
k hat	2.279732	Data do not follow gamma distribution	
k star (bias corrected)	2.180175	at 5% significance level	
Theta hat	0.045262		
Theta star	0.047329	95% UCLs (Assuming Gamma Distribution)	
nu hat	282.6868	Approximate Gamma UCL	0.11959
nu star	270.3417	Adjusted Gamma UCL	0.120009
Approx.Chi Square Value (.05)	233.2574		
Adjusted Level of Significance	0.046129	Lognormal Distribution Test	
Adjusted Chi Square Value	232.4418	Lilliefors Test Statisitic	0.262695
		Lilliefors 5% Critical Value	0.112522
Log-transformed Statistics		Data not lognormal at 5% significance level	
Minimum of log data	-5.20192		
Maximum of log data	-0.14981	95% UCLs (Assuming Lognormal Distribution)	
Mean of log data	-2.50631	95% H-UCL	0.114866
Standard Deviation of log data	0.615608	95% Chebyshev (MVUE) UCL	0.1343
Variance of log data	0.378973	97.5% Chebyshev (MVUE) UCL	0.149907
		99% Chebyshev (MVUE) UCL	0.180564
		95% Non-parametric UCLs	
		CLT UCL	0.12817
		Adj-CLT UCL (Adjusted for skewness)	0.138695
		Mod-t UCL (Adjusted for skewness)	0.130197
		Jackknife UCL	0.128555
		Standard Bootstrap UCL	0.127286
		Bootstrap-t UCL	0.158343
RECOMMENDATION		Hall's Bootstrap UCL	0.193601
Data are Non-parametric (0.05)		Percentile Bootstrap UCL	0.130077
		BCA Bootstrap UCL	0.141283
Use 95% Chebyshev (Mean, Sd) UCL		**95% Chebyshev (Mean, Sd) UCL**	**0.169395**
		97.5% Chebyshev (Mean, Sd) UCL	0.198044
		99% Chebyshev (Mean, Sd) UCL	0.254319

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Attachment 3

Type	ERA
Medium	Mummichog
Chemical	Total TEQ - Bird
Units	µg/kg

Data File		Variable:	Mummichog Total TEQ
Raw Statistics		Normal Distribution Test	
Number of Valid Samples	62	Lilliefors Test Statisitic	0.228569
Number of Unique Samples	62	Lilliefors 5% Critical Value	0.112522
Minimum	0.006655	Data not normal at 5% significance level	
Maximum	0.964373		
Mean	0.234806	95% UCL (Assuming Normal Distribution)	
Median	0.2087	Student's-t UCL	0.263747
Standard Deviation	0.136439		
Variance	0.018615	Gamma Distribution Test	
Coefficient of Variation	0.58107	A-D Test Statistic	2.75441
Skewness	3.105192	A-D 5% Critical Value	0.75519
		K-S Test Statistic	0.157292
Gamma Statistics		K-S 5% Critical Value	0.113589
k hat	3.690983	Data do not follow gamma distribution	
k star (bias corrected)	3.52314	at 5% significance level	
Theta hat	0.063616		
Theta star	0.066647	95% UCLs (Assuming Gamma Distribution)	
nu hat	457.6819	Approximate Gamma UCL	0.263428
nu star	436.8693	Adjusted Gamma UCL	0.264147
Approx.Chi Square Value (.05)	389.4025		
Adjusted Level of Significance	0.046129	Lognormal Distribution Test	
Adjusted Chi Square Value	388.3425	Lilliefors Test Statisitic	0.177522
		Lilliefors 5% Critical Value	0.112522
Log-transformed Statistics		Data not lognormal at 5% significance level	
Minimum of log data	-5.01234		
Maximum of log data	-0.03628	95% UCLs (Assuming Lognormal Distribution)	
Mean of log data	-1.59054	95% H-UCL	0.28627
Standard Deviation of log data	0.612779	95% Chebyshev (MVUE) UCL	0.334538
Variance of log data	0.375498	97.5% Chebyshev (MVUE) UCL	0.373266
		99% Chebyshev (MVUE) UCL	0.449339
		95% Non-parametric UCLs	
		CLT UCL	0.263307
		Adj-CLT UCL (Adjusted for skewness)	0.270609
		Mod-t UCL (Adjusted for skewness)	0.264886
		Jackknife UCL	0.263747
		Standard Bootstrap UCL	0.262852
		Bootstrap-t UCL	0.277223
RECOMMENDATION		Hall's Bootstrap UCL	0.291417
Data are Non-parametric (0.05)		Percentile Bootstrap UCL	0.265774
		BCA Bootstrap UCL	0.274777
Use 95% Chebyshev (Mean, Sd) UCL		**95% Chebyshev (Mean, Sd) UCL**	**0.310336**
		97.5% Chebyshev (Mean, Sd) UCL	0.343017
		99% Chebyshev (Mean, Sd) UCL	0.407214

R2-0009480

Attachment 3

Type	ERA
Medium	Mummichog
Chemical	Total PCB
Units	µg/kg

Data File

Raw Statistics

Number of Valid Samples	61
Number of Unique Samples	60
Minimum	121.4
Maximum	1194
Mean	668.5607
Median	669
Standard Deviation	233.4864
Variance	54515.92
Coefficient of Variation	0.349237
Skewness	-0.08324

Gamma Statistics

k hat	6.467469
k star (bias corrected)	6.160326
Theta hat	103.3728
Theta star	108.5268
nu hat	789.0313
nu star	751.5598
Approx.Chi Square Value (.05)	688.9327
Adjusted Level of Significance	0.046066
Adjusted Chi Square Value	687.4917

Log-transformed Statistics

Minimum of log data	4.799091
Maximum of log data	7.085064
Mean of log data	6.42583
Standard Deviation of log data	0.445077
Variance of log data	0.198093

RECOMMENDATION

Data are normal (0.05)

Use Student's-t UCL

Variable: Total PCBs - Mumm

Normal Distribution Test

Lilliefors Test Statisitic	0.047868
Lilliefors 5% Critical Value	0.113441

Data are normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	**718.5045**

Gamma Distribution Test

A-D Test Statistic	0.876495
A-D 5% Critical Value	0.752751
K-S Test Statistic	0.096409
K-S 5% Critical Value	0.114089

Data follow approximate gamma distibution at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	729.3358
Adjusted Gamma UCL	730.8646

Lognormal Distribution Test

Lilliefors Test Statisitic	0.126691
Lilliefors 5% Critical Value	0.113441

Data not lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	757.3925
95% Chebyshev (MVUE) UCL	856.8107
97.5% Chebyshev (MVUE) UCL	933.0203
99% Chebyshev (MVUE) UCL	1082.719

95% Non-parametric UCLs

CLT UCL	717.7334
Adj-CLT UCL (Adjusted for skewness)	717.3929
Mod-t UCL (Adjusted for skewness)	718.4514
Jackknife UCL	718.5045
Standard Bootstrap UCL	715.5446
Bootstrap-t UCL	718.7863
Hall's Bootstrap UCL	718.7782
Percentile Bootstrap UCL	717.9672
BCA Bootstrap UCL	716.959
95% Chebyshev (Mean, Sd) UCL	798.8694
97.5% Chebyshev (Mean, Sd) UCL	855.2541
99% Chebyshev (Mean, Sd) UCL	966.0109

R2-0009481

Attachment 3

Type	ERA
Medium	Crab
Chemical	Chlordane
Units	µg/kg

Data File

Raw Statistics

Number of Valid Samples	142
Number of Unique Samples	41
Minimum	0.38535
Maximum	203.05
Mean	19.79332
Median	4
Standard Deviation	33.56385
Variance	1126.532
Coefficient of Variation	1.695716
Skewness	2.919435

Gamma Statistics

k hat	0.576897
k star (bias corrected)	0.569404
Theta hat	34.30998
Theta star	34.76148
nu hat	163.8387
nu star	161.7106
Approx.Chi Square Value (.05)	133.3039
Adjusted Level of Significance	0.04831
Adjusted Chi Square Value	133.0416

Log-transformed Statistics

Minimum of log data	-0.9536
Maximum of log data	5.313452
Mean of log data	1.908049
Standard Deviation of log data	1.40701
Variance of log data	1.979677

RECOMMENDATION

Data are Non-parametric (0.05)

Use 97.5% Chebyshev (Mean, Sd) UCL

Variable: Chlordane

Normal Distribution Test

Lilliefors Test Statisitic	0.351465
Lilliefors 5% Critical Value	0.074351

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	24.45688

Gamma Distribution Test

A-D Test Statistic	12.48797
A-D 5% Critical Value	0.812105
K-S Test Statistic	0.265327
K-S 5% Critical Value	0.082707

Data do not follow gamma distribution at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	24.01122
Adjusted Gamma UCL	24.05857

Lognormal Distribution Test

Lilliefors Test Statisitic	0.207996
Lilliefors 5% Critical Value	0.074351

Data not lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	24.56363
95% Chebyshev (MVUE) UCL	30.47778
97.5% Chebyshev (MVUE) UCL	35.92422
99% Chebyshev (MVUE) UCL	46.6227

95% Non-parametric UCLs

CLT UCL	24.42624
Adj-CLT UCL (Adjusted for skewness)	25.16357
Mod-t UCL (Adjusted for skewness)	24.57188
Jackknife UCL	24.45688
Standard Bootstrap UCL	24.54995
Bootstrap-t UCL	25.518
Hall's Bootstrap UCL	25.76892
Percentile Bootstrap UCL	24.65808
BCA Bootstrap UCL	25.2743
95% Chebyshev (Mean, Sd) UCL	32.07066
97.5% Chebyshev (Mean, Sd) UCL	**37.38307**
99% Chebyshev (Mean, Sd) UCL	47.81829

R2-0009482

Attachment 3

Type	ERA
Medium	Crab
Chemical	Copper
Units	µg/kg

Data File

Variable: Copper

Raw Statistics

Number of Valid Samples	64
Number of Unique Samples	56
Minimum	8400
Maximum	78500
Mean	30362.5
Median	23200
Standard Deviation	19563.2511
Variance	382720793.7
Coefficient of Variation	0.644322803
Skewness	0.974501413

Gamma Statistics

k hat	2.773030739
k star (bias corrected)	2.653461589
Theta hat	10949.21148
Theta star	11442.60016
nu hat	354.9479345
nu star	339.6430834
Approx.Chi Square Value (.05)	297.9312931
Adjusted Level of Significance	0.04625
Adjusted Chi Square Value	297.0365361

Log-transformed Statistics

Minimum of log data	9.035986985
Maximum of log data	11.2708539
Mean of log data	10.12995161
Standard Deviation of log data	0.616363062
Variance of log data	0.379903424

RECOMMENDATION

Data are lognormal (0.05)

Use H-UCL

Normal Distribution Test

Lilliefors Test Statisitic	0.182607
Lilliefors 5% Critical Value	0.11075

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	34444.87

Gamma Distribution Test

A-D Test Statistic	1.843919
A-D 5% Critical Value	0.759004
K-S Test Statistic	0.116009
K-S 5% Critical Value	0.112331

Data do not follow gamma distribution at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	34613.39
Adjusted Gamma UCL	34717.66

Lognormal Distribution Test

Lilliefors Test Statisitic	0.110405
Lilliefors 5% Critical Value	0.11075

Data are lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	**35253.06**
95% Chebyshev (MVUE) UCL	41166.33
97.5% Chebyshev (MVUE) UCL	45900.96
99% Chebyshev (MVUE) UCL	55201.22

95% Non-parametric UCLs

CLT UCL	34384.84
Adj-CLT UCL (Adjusted for skewness)	34703.13
Mod-t UCL (Adjusted for skewness)	34494.51
Jackknife UCL	34444.87
Standard Bootstrap UCL	34358.44
Bootstrap-t UCL	34861.1
Hall's Bootstrap UCL	34510.44
Percentile Bootstrap UCL	34365.63
BCA Bootstrap UCL	34817.19
95% Chebyshev (Mean, Sd) UCL	41021.78
97.5% Chebyshev (Mean, Sd) UCL	45634.06
99% Chebyshev (Mean, Sd) UCL	54693.99

R2-0009483

Attachment 3

Type	ERA
Medium	Crab
Chemical	DDx - Sum
Units	µg/kg

Data File

Raw Statistics

Number of Valid Samples	80
Number of Unique Samples	64
Minimum	3.41
Maximum	2564.515
Mean	259.9749
Median	63.358
Standard Deviation	433.1621
Variance	187629.4
Coefficient of Variation	1.666169
Skewness	2.720577

Gamma Statistics

k hat	0.507912
k star (bias corrected)	0.497198
Theta hat	511.8507
Theta star	522.8798
nu hat	81.26585
nu star	79.55172
Approx.Chi Square Value (.05)	59.99802
Adjusted Level of Significance	0.047
Adjusted Chi Square Value	59.68738

Log-transformed Statistics

Minimum of log data	1.226712
Maximum of log data	7.849525
Mean of log data	4.313046
Standard Deviation of log data	1.63675
Variance of log data	2.678952

RECOMMENDATION

Data are Non-parametric (0.05)

Use 97.5% Chebyshev (Mean, Sd) UCL

Variable: DDx sum

Normal Distribution Test

Lilliefors Test Statisitic	0.307194
Lilliefors 5% Critical Value	0.099058

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	340.5787

Gamma Distribution Test

A-D Test Statistic	3.993932
A-D 5% Critical Value	0.818123
K-S Test Statistic	0.182166
K-S 5% Critical Value	0.105424

Data do not follow gamma distribution at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	344.7022
Adjusted Gamma UCL	346.4962

Lognormal Distribution Test

Lilliefors Test Statisitic	0.145868
Lilliefors 5% Critical Value	0.099058

Data not lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	487.9531
95% Chebyshev (MVUE) UCL	585.4545
97.5% Chebyshev (MVUE) UCL	719.9935
99% Chebyshev (MVUE) UCL	984.2693

95% Non-parametric UCLs

CLT UCL	339.6335
Adj-CLT UCL (Adjusted for skewness)	355.3734
Mod-t UCL (Adjusted for skewness)	343.0338
Jackknife UCL	340.5787
Standard Bootstrap UCL	340.6798
Bootstrap-t UCL	357.3623
Hall's Bootstrap UCL	369.5855
Percentile Bootstrap UCL	341.1111
BCA Bootstrap UCL	356.3883
95% Chebyshev (Mean, Sd) UCL	471.072
97.5% Chebyshev (Mean, Sd) UCL	**562.4139**
99% Chebyshev (Mean, Sd) UCL	741.8373

R2-0009484

Attachment 3

Type	ERA
Medium	Crab
Chemical	Dieldrin
Units	µg/kg

Data File

Raw Statistics

Number of Valid Samples	77
Number of Unique Samples	23
Minimum	0.753
Maximum	100
Mean	10.79088
Median	2.5
Standard Deviation	16.28106
Variance	265.0729
Coefficient of Variation	1.508779
Skewness	2.679379

Gamma Statistics

k hat	0.673414
k star (bias corrected)	0.655835
Theta hat	16.02414
Theta star	16.45365
nu hat	103.7058
nu star	100.9986
Approx.Chi Square Value (.05)	78.80766
Adjusted Level of Significance	0.046883
Adjusted Chi Square Value	78.43511

Log-transformed Statistics

Minimum of log data	-0.28369
Maximum of log data	4.60517
Mean of log data	1.476369
Standard Deviation of log data	1.288996
Variance of log data	1.661512

RECOMMENDATION

Data are Non-parametric (0.05)

Use 97.5% Chebyshev (Mean, Sd) UCL

Variable: Dieldrin

Normal Distribution Test

Lilliefors Test Statisitic	0.319642
Lilliefors 5% Critical Value	0.100969

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	13.8804

Gamma Distribution Test

A-D Test Statistic	7.805107
A-D 5% Critical Value	0.800717
K-S Test Statistic	0.258354
K-S 5% Critical Value	0.106354

Data do not follow gamma distribution at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	13.82942
Adjusted Gamma UCL	13.89511

Lognormal Distribution Test

Lilliefors Test Statisitic	0.204005
Lilliefors 5% Critical Value	0.100969

Data not lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	14.61197
95% Chebyshev (MVUE) UCL	18.00695
97.5% Chebyshev (MVUE) UCL	21.53446
99% Chebyshev (MVUE) UCL	28.46357

95% Non-parametric UCLs

CLT UCL	13.84274
Adj-CLT UCL (Adjusted for skewness)	14.44809
Mod-t UCL (Adjusted for skewness)	13.97482
Jackknife UCL	13.8804
Standard Bootstrap UCL	13.90621
Bootstrap-t UCL	14.60703
Hall's Bootstrap UCL	15.38842
Percentile Bootstrap UCL	13.83466
BCA Bootstrap UCL	14.214
95% Chebyshev (Mean, Sd) UCL	18.87838
97.5% Chebyshev (Mean, Sd) UCL	**22.37785**
99% Chebyshev (Mean, Sd) UCL	29.25187

R2-0009485

Attachment 3

Type	ERA
Medium	Crab
Chemical	Lead
Units	µg/kg

Data File

Variable: Lead

Raw Statistics

Number of Valid Samples	71
Number of Unique Samples	56
Minimum	55
Maximum	2400
Mean	464.8355
Median	410
Standard Deviation	412.4835
Variance	170142.7
Coefficient of Variation	0.887375
Skewness	2.466842

Gamma Statistics

k hat	1.643858
k star (bias corrected)	1.583789
Theta hat	282.7711
Theta star	293.4958
nu hat	233.4279
nu star	224.898
Approx.Chi Square Value (.05)	191.18
Adjusted Level of Significance	0.04662
Adjusted Chi Square Value	190.5395

Log-transformed Statistics

Minimum of log data	4.007333
Maximum of log data	7.783224
Mean of log data	5.807673
Standard Deviation of log data	0.849704
Variance of log data	0.721996

RECOMMENDATION

Data follow gamma distribution (0.05)

Use Approximate Gamma UCL

Normal Distribution Test

Lilliefors Test Statisitic	0.160214
Lilliefors 5% Critical Value	0.105149

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	546.4356

Gamma Distribution Test

A-D Test Statistic	0.563363
A-D 5% Critical Value	0.767397
K-S Test Statistic	0.074362
K-S 5% Critical Value	0.10756

Data follow gamma distribution
at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	**546.8176**
Adjusted Gamma UCL	548.6558

Lognormal Distribution Test

Lilliefors Test Statisitic	0.10675
Lilliefors 5% Critical Value	0.105149

Data not lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	591.8266
95% Chebyshev (MVUE) UCL	712.522
97.5% Chebyshev (MVUE) UCL	815.599
99% Chebyshev (MVUE) UCL	1018.074

95% Non-parametric UCLs

CLT UCL	545.3557
Adj-CLT UCL (Adjusted for skewness)	560.669
Mod-t UCL (Adjusted for skewness)	548.8242
Jackknife UCL	546.4356
Standard Bootstrap UCL	544.8819
Bootstrap-t UCL	573.229
Hall's Bootstrap UCL	582.2578
Percentile Bootstrap UCL	546.1679
BCA Bootstrap UCL	562.7614
95% Chebyshev (Mean, Sd) UCL	678.2157
97.5% Chebyshev (Mean, Sd) UCL	770.5456
99% Chebyshev (Mean, Sd) UCL	951.9096

R2-0009486

Attachment 3

Type	ERA
Medium	Crab
Chemical	Mercury
Units	µg/kg

Data File

Raw Statistics

Number of Valid Samples	86
Number of Unique Samples	64
Minimum	25
Maximum	280
Mean	87.70349
Median	74.5
Standard Deviation	53.85081
Variance	2899.909
Coefficient of Variation	0.61401
Skewness	1.538957

Gamma Statistics

k hat	3.314502
k star (bias corrected)	3.206632
Theta hat	26.46053
Theta star	27.35066
nu hat	570.0943
nu star	551.5407
Approx.Chi Square Value (.05)	498.06
Adjusted Level of Significance	0.047209
Adjusted Chi Square Value	497.2014

Log-transformed Statistics

Minimum of log data	3.218876
Maximum of log data	5.63479
Mean of log data	4.31559
Standard Deviation of log data	0.555633
Variance of log data	0.308728

RECOMMENDATION

Assuming gamma distribution (0.05)

Use Approximate Gamma UCL

Variable: Mercury

Normal Distribution Test

Lilliefors Test Statisitic	0.153875
Lilliefors 5% Critical Value	0.09554

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	97.36021

Gamma Distribution Test

A-D Test Statistic	1.126889
A-D 5% Critical Value	0.758014
K-S Test Statistic	0.09401
K-S 5% Critical Value	0.097021

Data follow approximate gamma distibution at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	**97.12091**
Adjusted Gamma UCL	97.28862

Lognormal Distribution Test

Lilliefors Test Statisitic	0.07281
Lilliefors 5% Critical Value	0.09554

Data are lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	97.79176
95% Chebyshev (MVUE) UCL	111.4578
97.5% Chebyshev (MVUE) UCL	121.9659
99% Chebyshev (MVUE) UCL	142.607

95% Non-parametric UCLs

CLT UCL	97.25496
Adj-CLT UCL (Adjusted for skewness)	98.28463
Mod-t UCL (Adjusted for skewness)	97.52081
Jackknife UCL	97.36021
Standard Bootstrap UCL	97.1688
Bootstrap-t UCL	98.73079
Hall's Bootstrap UCL	99.16866
Percentile Bootstrap UCL	97.33023
BCA Bootstrap UCL	98.16163
95% Chebyshev (Mean, Sd) UCL	113.0151
97.5% Chebyshev (Mean, Sd) UCL	123.9675
99% Chebyshev (Mean, Sd) UCL	145.4812

R2-0009487

Attachment 3

Type	ERA
Medium	Crab
Chemical	LPAH
Units	µg/kg

Data File

Variable: LPAH

Raw Statistics

Number of Valid Samples	74
Number of Unique Samples	71
Minimum	8.2
Maximum	835
Mean	102.028
Median	82.55
Standard Deviation	98.26711
Variance	9656.425
Coefficient of Variation	0.963138
Skewness	5.86084

Gamma Statistics

k hat	2.220212
k star (bias corrected)	2.139213
Theta hat	45.95419
Theta star	47.6942
nu hat	328.5914
nu star	316.6035
Approx.Chi Square Value (.05)	276.3726
Adjusted Level of Significance	0.046757
Adjusted Chi Square Value	275.631

Log-transformed Statistics

Minimum of log data	2.104134
Maximum of log data	6.727432
Mean of log data	4.383454
Standard Deviation of log data	0.723766
Variance of log data	0.523837

RECOMMENDATION

Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

Normal Distribution Test

Lilliefors Test Statisitic	0.222834
Lilliefors 5% Critical Value	0.102995

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	121.0592

Gamma Distribution Test

A-D Test Statistic	3.293892
A-D 5% Critical Value	0.762128
K-S Test Statistic	0.208025
K-S 5% Critical Value	0.104957

Data do not follow gamma distribution at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	116.88
Adjusted Gamma UCL	117.1945

Lognormal Distribution Test

Lilliefors Test Statisitic	0.251783
Lilliefors 5% Critical Value	0.102995

Data not lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	123.3607
95% Chebyshev (MVUE) UCL	145.7334
97.5% Chebyshev (MVUE) UCL	163.9461
99% Chebyshev (MVUE) UCL	199.7213

95% Non-parametric UCLs

CLT UCL	120.8177
Adj-CLT UCL (Adjusted for skewness)	129.1338
Mod-t UCL (Adjusted for skewness)	122.3564
Jackknife UCL	121.0592
Standard Bootstrap UCL	120.3681
Bootstrap-t UCL	140.1528
Hall's Bootstrap UCL	202.8794
Percentile Bootstrap UCL	123.1675
BCA Bootstrap UCL	133.1176
95% Chebyshev (Mean, Sd) UCL	**151.8211**
97.5% Chebyshev (Mean, Sd) UCL	173.3666
99% Chebyshev (Mean, Sd) UCL	215.6886

R2-0009488

Attachment 3

Type	ERA
Medium	Crab
Chemical	HPAH
Units	µg/kg

Data File

Variable: HPAH

Raw Statistics

Number of Valid Samples	73
Number of Unique Samples	67
Minimum	11.75
Maximum	761
Mean	109.2359
Median	75.1
Standard Deviation	104.3947
Variance	10898.25
Coefficient of Variation	0.955681
Skewness	3.90221

Gamma Statistics

k hat	1.90173
k star (bias corrected)	1.832709
Theta hat	57.44028
Theta star	59.60351
nu hat	277.6526
nu star	267.5755
Approx.Chi Square Value (.05)	230.6876
Adjusted Level of Significance	0.046712
Adjusted Chi Square Value	230.002

Log-transformed Statistics

Minimum of log data	2.463853
Maximum of log data	6.634633
Mean of log data	4.408119
Standard Deviation of log data	0.757637
Variance of log data	0.574014

RECOMMENDATION

Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

Normal Distribution Test

Lilliefors Test Statisitic	0.186215
Lilliefors 5% Critical Value	0.103698

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	129.5955

Gamma Distribution Test

A-D Test Statistic	1.306061
A-D 5% Critical Value	0.764492
K-S Test Statistic	0.125018
K-S 5% Critical Value	0.105885

Data do not follow gamma distribution at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	126.7032
Adjusted Gamma UCL	127.0808

Lognormal Distribution Test

Lilliefors Test Statisitic	0.14522
Lilliefors 5% Critical Value	0.103698

Data not lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	131.1796
95% Chebyshev (MVUE) UCL	155.848
97.5% Chebyshev (MVUE) UCL	176.177
99% Chebyshev (MVUE) UCL	216.1093

95% Non-parametric UCLs

CLT UCL	129.3335
Adj-CLT UCL (Adjusted for skewness)	135.2962
Mod-t UCL (Adjusted for skewness)	130.5255
Jackknife UCL	129.5955
Standard Bootstrap UCL	129.6286
Bootstrap-t UCL	140.9162
Hall's Bootstrap UCL	205.2007
Percentile Bootstrap UCL	130.2318
BCA Bootstrap UCL	135.5666
95% Chebyshev (Mean, Sd) UCL	**162.495**
97.5% Chebyshev (Mean, Sd) UCL	185.5402
99% Chebyshev (Mean, Sd) UCL	230.8082

R2-0009489

Attachment 3

Type	ERA
Medium	Crab
Chemical	TCDD TEQ (D/F) - Bird
Units	µg/kg

Data File

Raw Statistics

Number of Valid Samples	75
Number of Unique Samples	72
Minimum	0.003614
Maximum	0.933819
Mean	0.147555
Median	0.094616
Standard Deviation	0.173772
Variance	0.030197
Coefficient of Variation	1.177679
Skewness	2.023753

Gamma Statistics

k hat	0.832964
k star (bias corrected)	0.808535
Theta hat	0.177144
Theta star	0.182497
nu hat	124.9447
nu star	121.2802
Approx.Chi Square Value (.05)	96.84423
Adjusted Level of Significance	0.0468
Adjusted Chi Square Value	96.41816

Log-transformed Statistics

Minimum of log data	-5.62307
Maximum of log data	-0.06847
Mean of log data	-2.62232
Standard Deviation of log data	1.283685
Variance of log data	1.647846

RECOMMENDATION

Data are Non-parametric (0.05)

Use 97.5% Chebyshev (Mean, Sd) UCL

Variable: Crab Diox TEQ bird

Normal Distribution Test

Lilliefors Test Statisitic	0.251739
Lilliefors 5% Critical Value	0.102306

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	0.180978

Gamma Distribution Test

A-D Test Statistic	1.681257
A-D 5% Critical Value	0.788992
K-S Test Statistic	0.145131
K-S 5% Critical Value	0.10683

Data do not follow gamma distribution at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	0.184786
Adjusted Gamma UCL	0.185603

Lognormal Distribution Test

Lilliefors Test Statisitic	0.1257
Lilliefors 5% Critical Value	0.102306

Data not lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	0.241636
95% Chebyshev (MVUE) UCL	0.297569
97.5% Chebyshev (MVUE) UCL	0.356067
99% Chebyshev (MVUE) UCL	0.470976

95% Non-parametric UCLs

CLT UCL	0.18056
Adj-CLT UCL (Adjusted for skewness)	0.18557
Mod-t UCL (Adjusted for skewness)	0.18176
Jackknife UCL	0.180978
Standard Bootstrap UCL	0.180103
Bootstrap-t UCL	0.187073
Hall's Bootstrap UCL	0.18993
Percentile Bootstrap UCL	0.181552
BCA Bootstrap UCL	0.185064
95% Chebyshev (Mean, Sd) UCL	0.235018
97.5% Chebyshev (Mean, Sd) UCL	**0.272864**
99% Chebyshev (Mean, Sd) UCL	0.347204

R2-0009490

Attachment 3

Type	ERA
Medium	Crab
Chemical	TCDD TEQ (D/F) – Fish
Units	µg/kg

Data File

Raw Statistics

Number of Valid Samples	75
Number of Unique Samples	72
Minimum	0.002294
Maximum	0.744832
Mean	0.117984
Median	0.07182
Standard Deviation	0.137917
Variance	0.019021
Coefficient of Variation	1.168951
Skewness	2.032284

Gamma Statistics

k hat	0.852278
k star (bias corrected)	0.827076
Theta hat	0.138434
Theta star	0.142652
nu hat	127.8417
nu star	124.0614
Approx.Chi Square Value (.05)	99.33276
Adjusted Level of Significance	0.0468
Adjusted Chi Square Value	98.90103

Log-transformed Statistics

Minimum of log data	-6.07744
Maximum of log data	-0.2946
Mean of log data	-2.82787
Standard Deviation of log data	1.26956
Variance of log data	1.611783

RECOMMENDATION

Data are Non-parametric (0.05)

Use 97.5% Chebyshev (Mean, Sd) UCL

Variable: Crab Diox TEQ Fish

Normal Distribution Test

Lilliefors Test Statisitic	0.231374
Lilliefors 5% Critical Value	0.102306

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	0.144511

Gamma Distribution Test

A-D Test Statistic	1.563381
A-D 5% Critical Value	0.788093
K-S Test Statistic	0.148216
K-S 5% Critical Value	0.106747

Data do not follow gamma distribution at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	0.147356
Adjusted Gamma UCL	0.147999

Lognormal Distribution Test

Lilliefors Test Statisitic	0.126432
Lilliefors 5% Critical Value	0.102306

Data not lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	0.19199
95% Chebyshev (MVUE) UCL	0.236489
97.5% Chebyshev (MVUE) UCL	0.282601
99% Chebyshev (MVUE) UCL	0.373179

95% Non-parametric UCLs

CLT UCL	0.144179
Adj-CLT UCL (Adjusted for skewness)	0.148172
Mod-t UCL (Adjusted for skewness)	0.145134
Jackknife UCL	0.144511
Standard Bootstrap UCL	0.143915
Bootstrap-t UCL	0.150603
Hall's Bootstrap UCL	0.148659
Percentile Bootstrap UCL	0.145785
BCA Bootstrap UCL	0.147643
95% Chebyshev (Mean, Sd) UCL	0.187401
97.5% Chebyshev (Mean, Sd) UCL	**0.217438**
99% Chebyshev (Mean, Sd) UCL	0.276439

R2-0009491

Attachment 3

Type	ERA
Medium	Crab
Chemical	TCDD TEQ (D/F)– Mammal
Units	µg/kg

Data File		Variable:	Eco Crab Diox TEQ mammal
Raw Statistics		Normal Distribution Test	
Number of Valid Samples	75	Lilliefors Test Statisitic	0.23234
Number of Unique Samples	72	Lilliefors 5% Critical Value	0.102306
Minimum	0.002338	Data not normal at 5% significance level	
Maximum	0.752665		
Mean	0.119212	95% UCL (Assuming Normal Distribution)	
Median	0.07279	Student's-t UCL	0.146014
Standard Deviation	0.139346		
Variance	0.019417	Gamma Distribution Test	
Coefficient of Variation	1.168894	A-D Test Statistic	1.578906
Skewness	2.028979	A-D 5% Critical Value	0.788193
		K-S Test Statistic	0.148311
Gamma Statistics		K-S 5% Critical Value	0.106756
k hat	0.850133	Data do not follow gamma distribution	
k star (bias corrected)	0.825017	at 5% significance level	
Theta hat	0.140228		
Theta star	0.144497	95% UCLs (Assuming Gamma Distribution)	
nu hat	127.52	Approximate Gamma UCL	0.148934
nu star	123.7525	Adjusted Gamma UCL	0.149585
Approx.Chi Square Value (.05)	99.05624		
Adjusted Level of Significance	0.0468	Lognormal Distribution Test	
Adjusted Chi Square Value	98.62514	Lilliefors Test Statisitic	0.12652
		Lilliefors 5% Critical Value	0.102306
Log-transformed Statistics		Data not lognormal at 5% significance level	
Minimum of log data	-6.0583		
Maximum of log data	-0.28414	95% UCLs (Assuming Lognormal Distribution)	
Mean of log data	-2.81948	95% H-UCL	0.194357
Standard Deviation of log data	1.271803	95% Chebyshev (MVUE) UCL	0.239397
Variance of log data	1.617482	97.5% Chebyshev (MVUE) UCL	0.286137
		99% Chebyshev (MVUE) UCL	0.377948
		95% Non-parametric UCLs	
		CLT UCL	0.145679
		Adj-CLT UCL (Adjusted for skewness)	0.149707
		Mod-t UCL (Adjusted for skewness)	0.146642
		Jackknife UCL	0.146014
		Standard Bootstrap UCL	0.144937
		Bootstrap-t UCL	0.151402
RECOMMENDATION		Hall's Bootstrap UCL	0.151379
Data are Non-parametric (0.05)		Percentile Bootstrap UCL	0.145903
		BCA Bootstrap UCL	0.148798
Use 97.5% Chebyshev (Mean, Sd) UCL		95% Chebyshev (Mean, Sd) UCL	0.189348
		97.5% Chebyshev (Mean, Sd) UCL	**0.219696**
		99% Chebyshev (Mean, Sd) UCL	0.279309

R2-0009492

Attachment 3

Type	ERA
Medium	Crab
Chemical	TCDD TEQ (PCB)– Mammal
Units	µg/kg

Data File		Variable:	Ecolog Crab PCB TEQ mammal
Raw Statistics		Normal Distribution Test	
Number of Valid Samples	76	Lilliefors Test Statisitic	0.415071
Number of Unique Samples	76	Lilliefors 5% Critical Value	0.101631
Minimum	0.00046	Data not normal at 5% significance level	
Maximum	3.62334		
Mean	0.112918	95% UCL (Assuming Normal Distribution)	
Median	0.029222	Student's-t UCL	0.199801
Standard Deviation	0.454792		
Variance	0.206836	Gamma Distribution Test	
Coefficient of Variation	4.027613	A-D Test Statistic	4.837882
Skewness	6.895852	A-D 5% Critical Value	0.846946
		K-S Test Statistic	0.206112
Gamma Statistics		K-S 5% Critical Value	0.110111
k hat	0.377482	Data do not follow gamma distribution	
k star (bias corrected)	0.371354	at 5% significance level	
Theta hat	0.299136		
Theta star	0.304073	95% UCLs (Assuming Gamma Distribution)	
nu hat	57.37732	Approximate Gamma UCL	0.158652
nu star	56.44576	Adjusted Gamma UCL	0.159705
Approx.Chi Square Value (.05)	40.17463		
Adjusted Level of Significance	0.046842	Lognormal Distribution Test	
Adjusted Chi Square Value	39.90961	Lilliefors Test Statisitic	0.140916
		Lilliefors 5% Critical Value	0.101631
Log-transformed Statistics		Data not lognormal at 5% significance level	
Minimum of log data	-7.68472		
Maximum of log data	1.287396	95% UCLs (Assuming Lognormal Distribution)	
Mean of log data	-3.94072	95% H-UCL	0.182369
Standard Deviation of log data	1.786759	95% Chebyshev (MVUE) UCL	0.210403
Variance of log data	3.192506	97.5% Chebyshev (MVUE) UCL	0.262037
		99% Chebyshev (MVUE) UCL	0.363462
		95% Non-parametric UCLs	
		CLT UCL	0.198728
		Adj-CLT UCL (Adjusted for skewness)	0.24282
		Mod-t UCL (Adjusted for skewness)	0.206678
		Jackknife UCL	0.199801
		Standard Bootstrap UCL	0.196304
		Bootstrap-t UCL	0.716291
RECOMMENDATION		Hall's Bootstrap UCL	0.563392
Data are Non-parametric (0.05)		Percentile Bootstrap UCL	0.206371
		BCA Bootstrap UCL	0.256618
Use 97.5% Chebyshev (Mean, Sd) UCL		95% Chebyshev (Mean, Sd) UCL	0.340314
		97.5% Chebyshev (Mean, Sd) UCL	**0.438709**
		99% Chebyshev (Mean, Sd) UCL	0.631986

R2-0009493

Attachment 3

Type	ERA
Medium	Crab
Chemical	TCDD TEQ (PCB)– Fish
Units	µg/kg

Data File

Raw Statistics

Number of Valid Samples	76
Number of Unique Samples	76
Minimum	2.22E-05
Maximum	0.210475
Mean	0.006401
Median	0.001725
Standard Deviation	0.025887
Variance	0.00067
Coefficient of Variation	4.044524
Skewness	7.12721

Gamma Statistics

k hat	0.385668
k star (bias corrected)	0.379216
Theta hat	0.016596
Theta star	0.016878
nu hat	58.62158
nu star	57.64091
Approx.Chi Square Value (.05)	41.18497
Adjusted Level of Significance	0.046842
Adjusted Chi Square Value	40.91644

Log-transformed Statistics

Minimum of log data	-10.717
Maximum of log data	-1.55839
Mean of log data	-6.76767
Standard Deviation of log data	1.747509
Variance of log data	3.053788

RECOMMENDATION

Data are Non-parametric (0.05)

Use 97.5% Chebyshev (Mean, Sd) UCL

Variable: Crab PCB TEQ fish

Normal Distribution Test

Lilliefors Test Statisitic	0.420215
Lilliefors 5% Critical Value	0.101631

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	0.011346

Gamma Distribution Test

A-D Test Statistic	4.886462
A-D 5% Critical Value	0.845016
K-S Test Statistic	0.202503
K-S 5% Critical Value	0.109992

Data do not follow gamma distribution at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	0.008958
Adjusted Gamma UCL	0.009017

Lognormal Distribution Test

Lilliefors Test Statisitic	0.12052
Lilliefors 5% Critical Value	0.101631

Data not lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	0.009835
95% Chebyshev (MVUE) UCL	0.011456
97.5% Chebyshev (MVUE) UCL	0.014229
99% Chebyshev (MVUE) UCL	0.019676

95% Non-parametric UCLs

CLT UCL	0.011285
Adj-CLT UCL (Adjusted for skewness)	0.013879
Mod-t UCL (Adjusted for skewness)	0.011751
Jackknife UCL	0.011346
Standard Bootstrap UCL	0.011337
Bootstrap-t UCL	0.038151
Hall's Bootstrap UCL	0.029782
Percentile Bootstrap UCL	0.011716
BCA Bootstrap UCL	0.01601
95% Chebyshev (Mean, Sd) UCL	0.019344
97.5% Chebyshev (Mean, Sd) UCL	**0.024945**
99% Chebyshev (Mean, Sd) UCL	0.035947

R2-0009494

Attachment 3

Type	ERA
Medium	Crab
Chemical	TCDD TEQ (PCB)– Bird
Units	µg/kg

Data File

Raw Statistics

Number of Valid Samples	76
Number of Unique Samples	76
Minimum	0.00203
Maximum	25.46595
Mean	0.7006
Median	0.198613
Standard Deviation	2.951071
Variance	8.708822
Coefficient of Variation	4.212204
Skewness	8.118283

Gamma Statistics

k hat	0.425901
k star (bias corrected)	0.417861
Theta hat	1.644985
Theta star	1.676635
nu hat	64.73692
nu star	63.51485
Approx.Chi Square Value (.05)	46.17745
Adjusted Level of Significance	0.046842
Adjusted Chi Square Value	45.89218

Log-transformed Statistics

Minimum of log data	-6.19949
Maximum of log data	3.237342
Mean of log data	-1.88539
Standard Deviation of log data	1.609541
Variance of log data	2.590621

RECOMMENDATION

Data are Non-parametric (0.05)

Use 97.5% Chebyshev (Mean, Sd) UCL

Variable: Crab PCB TEQ bird

Normal Distribution Test

Lilliefors Test Statisitic	0.411837
Lilliefors 5% Critical Value	0.101631

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	1.264365

Gamma Distribution Test

A-D Test Statistic	4.859616
A-D 5% Critical Value	0.83553
K-S Test Statistic	0.204732
K-S 5% Critical Value	0.109403

Data do not follow gamma distribution at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	0.963642
Adjusted Gamma UCL	0.969632

Lognormal Distribution Test

Lilliefors Test Statisitic	0.12894
Lilliefors 5% Critical Value	0.101631

Data not lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	0.950422
95% Chebyshev (MVUE) UCL	1.13783
97.5% Chebyshev (MVUE) UCL	1.399135
99% Chebyshev (MVUE) UCL	1.912418

95% Non-parametric UCLs

CLT UCL	1.257402
Adj-CLT UCL (Adjusted for skewness)	1.594231
Mod-t UCL (Adjusted for skewness)	1.316904
Jackknife UCL	1.264365
Standard Bootstrap UCL	1.250201
Bootstrap-t UCL	3.355504
Hall's Bootstrap UCL	3.056983
Percentile Bootstrap UCL	1.336213
BCA Bootstrap UCL	1.989167
95% Chebyshev (Mean, Sd) UCL	2.176136
97.5% Chebyshev (Mean, Sd) UCL	**2.814601**
99% Chebyshev (Mean, Sd) UCL	4.068743

Attachment 3

Type	ERA
Medium	Crab
Chemical	Total TEQ – Bird
Units	µg/kg

Data File

Raw Statistics

Number of Valid Samples	84
Number of Unique Samples	82
Minimum	2.22E-05
Maximum	25.84094
Mean	0.690495
Median	0.184071
Standard Deviation	2.856913
Variance	8.161949
Coefficient of Variation	4.137484
Skewness	8.456347

Gamma Statistics

k hat	0.354777
k star (bias corrected)	0.350043
Theta hat	1.946277
Theta star	1.972599
nu hat	59.60262
nu star	58.80729
Approx.Chi Square Value (.05)	42.17284
Adjusted Level of Significance	0.047143
Adjusted Chi Square Value	41.92739

Log-transformed Statistics

Minimum of log data	-10.717
Maximum of log data	3.25196
Mean of log data	-2.26154
Standard Deviation of log data	2.380359
Variance of log data	5.66611

RECOMMENDATION

Data are Non-parametric (0.05)

Use 99% Chebyshev (Mean, Sd) UCL

Variable: Crab Total TEQ Bird

Normal Distribution Test

Lilliefors Test Statisitic	0.404512
Lilliefors 5% Critical Value	0.096671

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	1.209008

Gamma Distribution Test

A-D Test Statistic	2.869557
A-D 5% Critical Value	0.853133
K-S Test Statistic	0.147952
K-S 5% Critical Value	0.105134

Data do not follow gamma distribution at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	0.962851
Adjusted Gamma UCL	0.968487

Lognormal Distribution Test

Lilliefors Test Statisitic	0.157492
Lilliefors 5% Critical Value	0.096671

Data not lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	4.821691
95% Chebyshev (MVUE) UCL	4.539114
97.5% Chebyshev (MVUE) UCL	5.822761
99% Chebyshev (MVUE) UCL	8.344238

95% Non-parametric UCLs

CLT UCL	1.20322
Adj-CLT UCL (Adjusted for skewness)	1.510533
Mod-t UCL (Adjusted for skewness)	1.256942
Jackknife UCL	1.209008
Standard Bootstrap UCL	1.206803
Bootstrap-t UCL	3.050194
Hall's Bootstrap UCL	3.014608
Percentile Bootstrap UCL	1.273988
BCA Bootstrap UCL	1.65503
95% Chebyshev (Mean, Sd) UCL	2.049228
97.5% Chebyshev (Mean, Sd) UCL	2.637153
99% Chebyshev (Mean, Sd) UCL	**3.792017**

R2-0009496

Attachment 3

Type	ERA
Medium	Crab
Chemical	Total TEQ – Fish
Units	µg/kg

Data File

Raw Statistics

Number of Valid Samples	84
Number of Unique Samples	82
Minimum	0.00203
Maximum	3.591548
Mean	0.186261
Median	0.082646
Standard Deviation	0.410101
Variance	0.168183
Coefficient of Variation	2.201757
Skewness	7.120127

Gamma Statistics

k hat	0.623778
k star (bias corrected)	0.609437
Theta hat	0.298601
Theta star	0.305627
nu hat	104.7948
nu star	102.3854
Approx.Chi Square Value (.05)	80.03414
Adjusted Level of Significance	0.047143
Adjusted Chi Square Value	79.69059

Log-transformed Statistics

Minimum of log data	-6.19949
Maximum of log data	1.278583
Mean of log data	-2.66552
Standard Deviation of log data	1.478403
Variance of log data	2.185677

RECOMMENDATION

Data are Non-parametric (0.05)

Use 97.5% Chebyshev (Mean, Sd) UCL

Variable: Crab Total TEQ fish

Normal Distribution Test

Lilliefors Test Statisitic	0.326632
Lilliefors 5% Critical Value	0.096671

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	0.260691

Gamma Distribution Test

A-D Test Statistic	1.693578
A-D 5% Critical Value	0.806142
K-S Test Statistic	0.137431
K-S 5% Critical Value	0.102276

Data do not follow gamma distribution at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	0.238278
Adjusted Gamma UCL	0.239305

Lognormal Distribution Test

Lilliefors Test Statisitic	0.122149
Lilliefors 5% Critical Value	0.096671

Data not lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	0.322966
95% Chebyshev (MVUE) UCL	0.396262
97.5% Chebyshev (MVUE) UCL	0.480275
99% Chebyshev (MVUE) UCL	0.645301

95% Non-parametric UCLs

CLT UCL	0.259861
Adj-CLT UCL (Adjusted for skewness)	0.297004
Mod-t UCL (Adjusted for skewness)	0.266485
Jackknife UCL	0.260691
Standard Bootstrap UCL	0.259921
Bootstrap-t UCL	0.357823
Hall's Bootstrap UCL	0.552465
Percentile Bootstrap UCL	0.269256
BCA Bootstrap UCL	0.324471
95% Chebyshev (Mean, Sd) UCL	0.381302
97.5% Chebyshev (Mean, Sd) UCL	**0.465697**
99% Chebyshev (Mean, Sd) UCL	0.631474

R2-0009497

Attachment 3

Type	ERA
Medium	Crab
Chemical	Total TEQ – Mammal
Units	µg/kg

Data File	
Raw Statistics	
Number of Valid Samples	84
Number of Unique Samples	82
Minimum	0.00046
Maximum	3.928891
Mean	0.208604
Median	0.088806
Standard Deviation	0.483112
Variance	0.233397
Coefficient of Variation	2.315929
Skewness	6.102938
Gamma Statistics	
k hat	0.548059
k star (bias corrected)	0.536422
Theta hat	0.380623
Theta star	0.38888
nu hat	92.07395
nu star	90.11893
Approx.Chi Square Value (.05)	69.22634
Adjusted Level of Significance	0.047143
Adjusted Chi Square Value	68.90784
Log-transformed Statistics	
Minimum of log data	-7.68472
Maximum of log data	1.368357
Mean of log data	-2.71008
Standard Deviation of log data	1.62483
Variance of log data	2.640074

RECOMMENDATION

Data are lognormal (0.05)

Use H-UCL

Variable:	Eco Crab Total TEQ mammal
Normal Distribution Test	
Lilliefors Test Statisitic	0.333292
Lilliefors 5% Critical Value	0.096671
Data not normal at 5% significance level	
95% UCL (Assuming Normal Distribution)	
Student's-t UCL	0.296286
Gamma Distribution Test	
A-D Test Statistic	2.054503
A-D 5% Critical Value	0.813849
K-S Test Statistic	0.13276
K-S 5% Critical Value	0.102802
Data do not follow gamma distribution	
at 5% significance level	
95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	0.271561
Adjusted Gamma UCL	0.272816
Lognormal Distribution Test	
Lilliefors Test Statisitic	0.090324
Lilliefors 5% Critical Value	0.096671
Data are lognormal at 5% significance level	
95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	**0.417389**
95% Chebyshev (MVUE) UCL	0.504439
97.5% Chebyshev (MVUE) UCL	0.618643
99% Chebyshev (MVUE) UCL	0.842976
95% Non-parametric UCLs	
CLT UCL	0.295307
Adj-CLT UCL (Adjusted for skewness)	0.332812
Mod-t UCL (Adjusted for skewness)	0.302136
Jackknife UCL	0.296286
Standard Bootstrap UCL	0.297098
Bootstrap-t UCL	0.410302
Hall's Bootstrap UCL	0.661687
Percentile Bootstrap UCL	0.3084
BCA Bootstrap UCL	0.354466
95% Chebyshev (Mean, Sd) UCL	0.438369
97.5% Chebyshev (Mean, Sd) UCL	0.537789
99% Chebyshev (Mean, Sd) UCL	0.73308

R2-0009498

Attachment 3

Type	ERA
Medium	Crab
Chemical	Total PCB
Units	µg/kg

Data File

Raw Statistics

Number of Valid Samples	79
Number of Unique Samples	58
Minimum	82.37
Maximum	14000
Mean	2681.425
Median	625
Standard Deviation	3961.776
Variance	15695671
Coefficient of Variation	1.477489
Skewness	1.492731

Gamma Statistics

k hat	0.575331
k star (bias corrected)	0.561922
Theta hat	4660.661
Theta star	4771.879
nu hat	90.90237
nu star	88.78371
Approx.Chi Square Value (.05)	68.05577
Adjusted Level of Significance	0.046962
Adjusted Chi Square Value	67.71964

Log-transformed Statistics

Minimum of log data	4.411221
Maximum of log data	9.546813
Mean of log data	6.813438
Standard Deviation of log data	1.457489
Variance of log data	2.124273

RECOMMENDATION

Data are Non-parametric (0.05)

Use 97.5% Chebyshev (Mean, Sd) UCL

Variable: Total PCB

Normal Distribution Test

Lilliefors Test Statisitic	0.352347
Lilliefors 5% Critical Value	0.099683

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	3423.405

Gamma Distribution Test

A-D Test Statistic	6.514867
A-D 5% Critical Value	0.81099
K-S Test Statistic	0.223282
K-S 5% Critical Value	0.105655

Data do not follow gamma distribution at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	3498.114
Adjusted Gamma UCL	3515.477

Lognormal Distribution Test

Lilliefors Test Statisitic	0.141141
Lilliefors 5% Critical Value	0.099683

Data not lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	4120.397
95% Chebyshev (MVUE) UCL	5043.417
97.5% Chebyshev (MVUE) UCL	6116.809
99% Chebyshev (MVUE) UCL	8225.281

95% Non-parametric UCLs

CLT UCL	3414.593
Adj-CLT UCL (Adjusted for skewness)	3494.581
Mod-t UCL (Adjusted for skewness)	3435.882
Jackknife UCL	3423.405
Standard Bootstrap UCL	3421.02
Bootstrap-t UCL	3504.164
Hall's Bootstrap UCL	3508.368
Percentile Bootstrap UCL	3469.733
BCA Bootstrap UCL	3458.265
95% Chebyshev (Mean, Sd) UCL	4624.337
97.5% Chebyshev (Mean, Sd) UCL	**5465.037**
99% Chebyshev (Mean, Sd) UCL	7116.428

R2-0009499

Attachment 3

Type	ERA
Medium	Fish
Chemical	DDx - Sum
Units	µg/kg

Data File

Raw Statistics

Number of Valid Samples	77
Number of Unique Samples	75
Minimum	22.68
Maximum	2466.39
Mean	423.3305
Median	343.15
Standard Deviation	364.932
Variance	133175.4
Coefficient of Variation	0.86205
Skewness	2.857989

Gamma Statistics

k hat	1.909522
k star (bias corrected)	1.843783
Theta hat	221.6945
Theta star	229.5989
nu hat	294.0663
nu star	283.9425
Approx.Chi Square Value (.05)	245.9069
Adjusted Level of Significance	0.046883
Adjusted Chi Square Value	245.2363

Log-transformed Statistics

Minimum of log data	3.121483
Maximum of log data	7.810511
Mean of log data	5.764014
Standard Deviation of log data	0.780489
Variance of log data	0.609163

RECOMMENDATION

Data are lognormal (0.05)

Use H-UCL

Variable: DDx sum WP AE

Normal Distribution Test

Lilliefors Test Statisitic	0.213033
Lilliefors 5% Critical Value	0.100969

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	492.5805

Gamma Distribution Test

A-D Test Statistic	0.835753
A-D 5% Critical Value	0.764419
K-S Test Statistic	0.113413
K-S 5% Critical Value	0.103179

Data do not follow gamma distribution at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	488.8091
Adjusted Gamma UCL	490.1458

Lognormal Distribution Test

Lilliefors Test Statisitic	0.079892
Lilliefors 5% Critical Value	0.100969

Data are lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	**518.9032**
95% Chebyshev (MVUE) UCL	617.1879
97.5% Chebyshev (MVUE) UCL	698.2385
99% Chebyshev (MVUE) UCL	857.4468

95% Non-parametric UCLs

CLT UCL	491.7364
Adj-CLT UCL (Adjusted for skewness)	506.2095
Mod-t UCL (Adjusted for skewness)	494.838
Jackknife UCL	492.5805
Standard Bootstrap UCL	493.0449
Bootstrap-t UCL	519.3554
Hall's Bootstrap UCL	532.4099
Percentile Bootstrap UCL	494.3802
BCA Bootstrap UCL	498.8046
95% Chebyshev (Mean, Sd) UCL	604.6077
97.5% Chebyshev (Mean, Sd) UCL	683.0466
99% Chebyshev (Mean, Sd) UCL	837.1245

R2-0009500

Attachment 3

Type	ERA
Medium	Fish (American eel/White perch)
Chemical	Copper
Units	µg/kg

Data File

Variable: Copper

Raw Statistics

Number of Valid Samples	38
Number of Unique Samples	32
Minimum	310
Maximum	36700
Mean	8814.73684
Median	4700
Standard Deviation	9917.44647
Variance	98355744.5
Coefficient of Variation	1.12509842
Skewness	1.37153707

Gamma Statistics

k hat	0.75789298
k star (bias corrected)	0.71560318
Theta hat	11630.5825
Theta star	12317.9118
nu hat	57.5998664
nu star	54.3858418
Approx.Chi Square Value (.05)	38.4379356
Adjusted Level of Significance	0.0434
Adjusted Chi Square Value	37.8818903

Log-transformed Statistics

Minimum of log data	5.7365723
Maximum of log data	10.510532
Mean of log data	8.29543188
Standard Deviation of log data	1.41087694
Variance of log data	1.99057373

RECOMMENDATION

Data are Non-parametric (0.05)

Use 99% Chebyshev (Mean, Sd) UCL

Normal Distribution Test

Shapiro-Wilk Test Statisitic	0.792928
Shapiro-Wilk 5% Critical Value	0.938

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	11528.97

Gamma Distribution Test

A-D Test Statistic	1.158951
A-D 5% Critical Value	0.788184
K-S Test Statistic	0.189909
K-S 5% Critical Value	0.148741

Data do not follow gamma distribution at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	12471.97
Adjusted Gamma UCL	12655.04

Lognormal Distribution Test

Shapiro-Wilk Test Statisitic	0.920006
Shapiro-Wilk 5% Critical Value	0.938

Data not lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	21180.18
95% Chebyshev (MVUE) UCL	23417.75
97.5% Chebyshev (MVUE) UCL	29085.12
99% Chebyshev (MVUE) UCL	40217.58

95% Non-parametric UCLs

CLT UCL	11461.01
Adj-CLT UCL (Adjusted for skewness)	11843.49
Mod-t UCL (Adjusted for skewness)	11588.63
Jackknife UCL	11528.97
Standard Bootstrap UCL	11473.25
Bootstrap-t UCL	12187.16
Hall's Bootstrap UCL	11782.32
Percentile Bootstrap UCL	11473.42
BCA Bootstrap UCL	11763.42
95% Chebyshev (Mean, Sd) UCL	15827.43
97.5% Chebyshev (Mean, Sd) UCL	18861.83
99% Chebyshev (Mean, Sd) UCL	**24822.32**

R2-0009501

Attachment 3

Type	ERA
Medium	Fish (American eel/White perch)
Chemical	Lead
Units	µg/kg

Data File

Variable: Lead

Raw Statistics

Number of Valid Samples	29
Number of Unique Samples	19
Minimum	55
Maximum	1600
Mean	396.2069
Median	400
Standard Deviation	293.6338
Variance	86220.81
Coefficient of Variation	0.741112
Skewness	2.455774

Gamma Statistics

k hat	1.903402
k star (bias corrected)	1.729486
Theta hat	208.1573
Theta star	229.0893
nu hat	110.3973
nu star	100.3102
Approx.Chi Square Value (.05)	78.19927
Adjusted Level of Significance	0.0407
Adjusted Chi Square Value	77.03331

Log-transformed Statistics

Minimum of log data	4.007333
Maximum of log data	7.377759
Mean of log data	5.696816
Standard Deviation of log data	0.869528
Variance of log data	0.756078

Normal Distribution Test

Shapiro-Wilk Test Statisitic	0.756591
Shapiro-Wilk 5% Critical Value	0.926

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	488.9635

Gamma Distribution Test

A-D Test Statistic	1.725932
A-D 5% Critical Value	0.758309
K-S Test Statistic	0.190593
K-S 5% Critical Value	0.164889

Data do not follow gamma distribution
at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	508.2349
Adjusted Gamma UCL	515.9274

Lognormal Distribution Test

Shapiro-Wilk Test Statisitic	0.813044
Shapiro-Wilk 5% Critical Value	0.926

Data not lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	634.435
95% Chebyshev (MVUE) UCL	763.2342
97.5% Chebyshev (MVUE) UCL	908.5892
99% Chebyshev (MVUE) UCL	1194.111

95% Non-parametric UCLs

CLT UCL	485.8949
Adj-CLT UCL (Adjusted for skewness)	512.464
Mod-t UCL (Adjusted for skewness)	493.1077
Jackknife UCL	488.9635
Standard Bootstrap UCL	482.6225
Bootstrap-t UCL	522.9014
Hall's Bootstrap UCL	971.1481
Percentile Bootstrap UCL	491.3793
BCA Bootstrap UCL	516.3793
95% Chebyshev (Mean, Sd) UCL	**633.8821**
97.5% Chebyshev (Mean, Sd) UCL	736.7243
99% Chebyshev (Mean, Sd) UCL	938.738

RECOMMENDATION

Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

R2-0009502

Attachment 3

Type	ERA
Medium	Fish (American eel/White perch)
Chemical	LPAH
Units	µg/kg

Data File

Variable: LPAH

Raw Statistics

Number of Valid Samples	64
Number of Unique Samples	64
Minimum	22.649
Maximum	804.5
Mean	151.4141
Median	121.805
Standard Deviation	109.2235
Variance	11929.76
Coefficient of Variation	0.721356
Skewness	3.541971

Gamma Statistics

k hat	2.948661
k star (bias corrected)	2.820859
Theta hat	51.35013
Theta star	53.6766
nu hat	377.4286
nu star	361.07
Approx.Chi Square Value (.05)	318.0254
Adjusted Level of Significance	0.04625
Adjusted Chi Square Value	317.1003

Log-transformed Statistics

Minimum of log data	3.120116
Maximum of log data	6.690221
Mean of log data	4.84097
Standard Deviation of log data	0.594129
Variance of log data	0.352989

RECOMMENDATION

Data follow gamma distribution (0.05)

Use Approximate Gamma UCL

Normal Distribution Test

Lilliefors Test Statisitic	0.150804
Lilliefors 5% Critical Value	0.11075

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	174.2064

Gamma Distribution Test

A-D Test Statistic	0.58709
A-D 5% Critical Value	0.758077
K-S Test Statistic	0.090109
K-S 5% Critical Value	0.112228

Data follow gamma distribution
at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	**171.9079**
Adjusted Gamma UCL	172.4095

Lognormal Distribution Test

Lilliefors Test Statisitic	0.077295
Lilliefors 5% Critical Value	0.11075

Data are lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	174.3826
95% Chebyshev (MVUE) UCL	202.824
97.5% Chebyshev (MVUE) UCL	225.4462
99% Chebyshev (MVUE) UCL	269.8832

95% Non-parametric UCLs

CLT UCL	173.8712
Adj-CLT UCL (Adjusted for skewness)	180.3301
Mod-t UCL (Adjusted for skewness)	175.2138
Jackknife UCL	174.2064
Standard Bootstrap UCL	174.4526
Bootstrap-t UCL	183.6947
Hall's Bootstrap UCL	223.4092
Percentile Bootstrap UCL	176.1945
BCA Bootstrap UCL	180.1218
95% Chebyshev (Mean, Sd) UCL	210.9259
97.5% Chebyshev (Mean, Sd) UCL	236.6767
99% Chebyshev (Mean, Sd) UCL	287.2591

R2-0009503

Attachment 3

Type	ERA
Medium	Fish (American eel/White perch)
Chemical	HPAH - Bird
Units	µg/kg

Data File

Variable: HPAH

Raw Statistics

Number of Valid Samples	64
Number of Unique Samples	64
Minimum	11.17
Maximum	352.7
Mean	86.789
Median	65.135
Standard Deviation	65.226
Variance	4254.4
Coefficient of Variation	0.7515
Skewness	1.6841

Gamma Statistics

k hat	2.1217
k star (bias corrected)	2.0326
Theta hat	40.906
Theta star	42.698
nu hat	271.57
nu star	260.18
Approx.Chi Square Value (.05)	223.82
Adjusted Level of Significance	0.0463
Adjusted Chi Square Value	223.05

Log-transformed Statistics

Minimum of log data	2.4132
Maximum of log data	5.8656
Mean of log data	4.2097
Standard Deviation of log data	0.7371
Variance of log data	0.5433

RECOMMENDATION

Data follow gamma distribution (0.05)

Use Approximate Gamma UCL

Normal Distribution Test

Lilliefors Test Statisitic	0.1701
Lilliefors 5% Critical Value	0.1108

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	100.4

Gamma Distribution Test

A-D Test Statistic	0.5226
A-D 5% Critical Value	0.7624
K-S Test Statistic	0.0841
K-S 5% Critical Value	0.1127

Data follow gamma distribution
at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	100.89
Adjusted Gamma UCL	101.24

Lognormal Distribution Test

Lilliefors Test Statisitic	0.058
Lilliefors 5% Critical Value	0.1108

Data are lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	106.68
95% Chebyshev (MVUE) UCL	127
97.5% Chebyshev (MVUE) UCL	143.93
99% Chebyshev (MVUE) UCL	177.19

95% Non-parametric UCLs

CLT UCL	100.2
Adj-CLT UCL (Adjusted for skewness)	102.03
Mod-t UCL (Adjusted for skewness)	100.69
Jackknife UCL	100.4
Standard Bootstrap UCL	100.36
Bootstrap-t UCL	102.99
Hall's Bootstrap UCL	103.18
Percentile Bootstrap UCL	100.25
BCA Bootstrap UCL	100.92
95% Chebyshev (Mean, Sd) UCL	122.33
97.5% Chebyshev (Mean, Sd) UCL	137.71
99% Chebyshev (Mean, Sd) UCL	167.91

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Attachment 3

Type	ERA
Medium	Fish (American eel/White perch)
Chemical	TCDD TEQ (D/F) - Bird
Units	µg/kg

Data File		Variable:	WP/AE Dioxin TEQ
Raw Statistics		Normal Distribution Test	
Number of Valid Samples	66	Lilliefors Test Statisitic	0.126118
Number of Unique Samples	66	Lilliefors 5% Critical Value	0.109059
Minimum	0.005144	Data not normal at 5% significance level	
Maximum	0.515196		
Mean	0.174619	95% UCL (Assuming Normal Distribution)	
Median	0.169099	Student's-t UCL	0.202749
Standard Deviation	0.136953		
Variance	0.018756	Gamma Distribution Test	
Coefficient of Variation	0.784292	A-D Test Statistic	1.589533
Skewness	0.441079	A-D 5% Critical Value	0.778043
		K-S Test Statistic	0.136476
Gamma Statistics		K-S 5% Critical Value	0.112717
k hat	1.085958	Data do not follow gamma distribution	
k star (bias corrected)	1.046697	at 5% significance level	
Theta hat	0.160798		
Theta star	0.166829	95% UCLs (Assuming Gamma Distribution)	
nu hat	143.3464	Approximate Gamma UCL	0.215413
nu star	138.164	Adjusted Gamma UCL	0.216425
Approx.Chi Square Value (.05)	111.9996		
Adjusted Level of Significance	0.046364	Lognormal Distribution Test	
Adjusted Chi Square Value	111.4756	Lilliefors Test Statisitic	0.171495
		Lilliefors 5% Critical Value	0.109059
Log-transformed Statistics		Data not lognormal at 5% significance level	
Minimum of log data	-5.27002		
Maximum of log data	-0.66321	95% UCLs (Assuming Lognormal Distribution)	
Mean of log data	-2.27168	95% H-UCL	0.328187
Standard Deviation of log data	1.241406	95% Chebyshev (MVUE) UCL	0.402785
Variance of log data	1.541088	97.5% Chebyshev (MVUE) UCL	0.482544
		99% Chebyshev (MVUE) UCL	0.639214
		95% Non-parametric UCLs	
		CLT UCL	0.202348
		Adj-CLT UCL (Adjusted for skewness)	0.203326
		Mod-t UCL (Adjusted for skewness)	0.202901
		Jackknife UCL	0.202749
		Standard Bootstrap UCL	0.201879
		Bootstrap-t UCL	0.20315
RECOMMENDATION		Hall's Bootstrap UCL	0.204106
Data are Non-parametric (0.05)		Percentile Bootstrap UCL	0.203457
		BCA Bootstrap UCL	0.204342
Use 97.5% Chebyshev (Mean, Sd) UCL		95% Chebyshev (Mean, Sd) UCL	0.248101
		97.5% Chebyshev (Mean, Sd) UCL	**0.279896**
		99% Chebyshev (Mean, Sd) UCL	0.342352

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Attachment 3

Type	ERA
Medium	Fish (American eel/White perch)
Chemical	TCDD TEQ (D/F) - Fish
Units	µg/kg

Data File

Variable: WP AE Dioxin TEQ - fish

Raw Statistics	
Number of Valid Samples	66
Number of Unique Samples	66
Minimum	0.005119
Maximum	0.481149
Mean	0.155368
Median	0.145646
Standard Deviation	0.123952
Variance	0.015364
Coefficient of Variation	0.797793
Skewness	0.532118

Gamma Statistics	
k hat	1.106887
k star (bias corrected)	1.066675
Theta hat	0.140365
Theta star	0.145657
nu hat	146.1091
nu star	140.8011
Approx.Chi Square Value (.05)	114.3764
Adjusted Level of Significance	0.046364
Adjusted Chi Square Value	113.8467

Log-transformed Statistics	
Minimum of log data	-5.27481
Maximum of log data	-0.73158
Mean of log data	-2.37744
Standard Deviation of log data	1.210756
Variance of log data	1.465931

RECOMMENDATION

Data are Non-parametric (0.05)

Use 97.5% Chebyshev (Mean, Sd) UCL

Normal Distribution Test	
Lilliefors Test Statisitic	0.142716
Lilliefors 5% Critical Value	0.109059
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	0.180827

Gamma Distribution Test	
A-D Test Statistic	1.408087
A-D 5% Critical Value	0.777581
K-S Test Statistic	0.132953
K-S 5% Critical Value	0.11267
Data do not follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	0.191263
Adjusted Gamma UCL	0.192153

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.163015
Lilliefors 5% Critical Value	0.109059
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	0.280253
95% Chebyshev (MVUE) UCL	0.344247
97.5% Chebyshev (MVUE) UCL	0.411188
99% Chebyshev (MVUE) UCL	0.542681

95% Non-parametric UCLs	
CLT UCL	0.180464
Adj-CLT UCL (Adjusted for skewness)	0.181532
Mod-t UCL (Adjusted for skewness)	0.180994
Jackknife UCL	0.180827
Standard Bootstrap UCL	0.179948
Bootstrap-t UCL	0.183853
Hall's Bootstrap UCL	0.181358
Percentile Bootstrap UCL	0.180311
BCA Bootstrap UCL	0.181371
95% Chebyshev (Mean, Sd) UCL	0.221874
97.5% Chebyshev (Mean, Sd) UCL	**0.250651**
99% Chebyshev (Mean, Sd) UCL	0.307177

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Attachment 3

Type	ERA and HHRA
Medium	Fish (American eel/White perch)
Chemical	TCDD TEQ (D/F) - Mammal
Units	µg/kg

Data File		Variable:	Mammal - WP AE Dioxin TEQ
Raw Statistics		Normal Distribution Test	
Number of Valid Samples	66	Lilliefors Test Statisitic	0.140753
Number of Unique Samples	66	Lilliefors 5% Critical Value	0.109059
Minimum	0.005169	Data not normal at 5% significance level	
Maximum	0.482614		
Mean	0.156011	95% UCL (Assuming Normal Distribution)	
Median	0.146547	Student's-t UCL	0.18158
Standard Deviation	0.124489		
Variance	0.015498	Gamma Distribution Test	
Coefficient of Variation	0.797954	A-D Test Statistic	1.410214
Skewness	0.529935	A-D 5% Critical Value	0.777634
		K-S Test Statistic	0.133856
Gamma Statistics		K-S 5% Critical Value	0.112675
k hat	1.104473	Data do not follow gamma distribution	
k star (bias corrected)	1.064371	at 5% significance level	
Theta hat	0.141254		
Theta star	0.146576	95% UCLs (Assuming Gamma Distribution)	
nu hat	145.7905	Approximate Gamma UCL	0.1921
nu star	140.497	Adjusted Gamma UCL	0.192995
Approx.Chi Square Value (.05)	114.1022		
Adjusted Level of Significance	0.046364	Lognormal Distribution Test	
Adjusted Chi Square Value	113.5732	Lilliefors Test Statisitic	0.163708
		Lilliefors 5% Critical Value	0.109059
Log-transformed Statistics		Data not lognormal at 5% significance level	
Minimum of log data	-5.26512		
Maximum of log data	-0.72854	95% UCLs (Assuming Lognormal Distribution)	
Mean of log data	-2.37456	95% H-UCL	0.281962
Standard Deviation of log data	1.212663	95% Chebyshev (MVUE) UCL	0.346333
Variance of log data	1.470552	97.5% Chebyshev (MVUE) UCL	0.413757
		99% Chebyshev (MVUE) UCL	0.546198
		95% Non-parametric UCLs	
		CLT UCL	0.181216
		Adj-CLT UCL (Adjusted for skewness)	0.182284
		Mod-t UCL (Adjusted for skewness)	0.181747
		Jackknife UCL	0.18158
		Standard Bootstrap UCL	0.181661
		Bootstrap-t UCL	0.184577
RECOMMENDATION		Hall's Bootstrap UCL	0.182329
Data are Non-parametric (0.05)		Percentile Bootstrap UCL	0.182293
		BCA Bootstrap UCL	0.182339
Use 97.5% Chebyshev (Mean, Sd) UCL		95% Chebyshev (Mean, Sd) UCL	0.222805
		97.5% Chebyshev (Mean, Sd) UCL	**0.251707**
		99% Chebyshev (Mean, Sd) UCL	0.308479

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Attachment 3

Type	ERA and HHRA
Medium	Fish (American eel/White perch)
Chemical	TCDD TEQ (PCB) - Mammal
Units	µg/kg

Data File		Variable:	mammal-WP AE
Raw Statistics		Normal Distribution Test	
Number of Valid Samples	77	Lilliefors Test Statisitic	0.158545
Number of Unique Samples	77	Lilliefors 5% Critical Value	0.100969
Minimum	0.012503	Data not normal at 5% significance level	
Maximum	0.219331		
Mean	0.064516	95% UCL (Assuming Normal Distribution)	
Median	0.047801	Student's-t UCL	0.073632
Standard Deviation	0.04804		
Variance	0.002308	Gamma Distribution Test	
Coefficient of Variation	0.744624	A-D Test Statistic	1.487189
Skewness	1.370958	A-D 5% Critical Value	0.762309
		K-S Test Statistic	0.115692
Gamma Statistics		K-S 5% Critical Value	0.10297
k hat	2.188654	Data do not follow gamma distribution	
k star (bias corrected)	2.11204	at 5% significance level	
Theta hat	0.029478		
Theta star	0.030547	95% UCLs (Assuming Gamma Distribution)	
nu hat	337.0528	Approximate Gamma UCL	0.073768
nu star	325.2542	Adjusted Gamma UCL	0.073956
Approx.Chi Square Value (.05)	284.4612		
Adjusted Level of Significance	0.046883	Lognormal Distribution Test	
Adjusted Chi Square Value	283.7386	Lilliefors Test Statisitic	0.098245
		Lilliefors 5% Critical Value	0.100969
Log-transformed Statistics		Data are lognormal at 5% significance level	
Minimum of log data	-4.38182		
Maximum of log data	-1.51717	95% UCLs (Assuming Lognormal Distribution)	
Mean of log data	-2.98635	**95% H-UCL**	**0.075528**
Standard Deviation of log data	0.698956	95% Chebyshev (MVUE) UCL	0.088725
Variance of log data	0.48854	97.5% Chebyshev (MVUE) UCL	0.099344
		99% Chebyshev (MVUE) UCL	0.120203
		95% Non-parametric UCLs	
		CLT UCL	0.073521
		Adj-CLT UCL (Adjusted for skewness)	0.074435
		Mod-t UCL (Adjusted for skewness)	0.073775
		Jackknife UCL	0.073632
		Standard Bootstrap UCL	0.073426
		Bootstrap-t UCL	0.074824
RECOMMENDATION		Hall's Bootstrap UCL	0.074459
Data are lognormal (0.05)		Percentile Bootstrap UCL	0.073461
		BCA Bootstrap UCL	0.07428
Use H-UCL		95% Chebyshev (Mean, Sd) UCL	0.08838
		97.5% Chebyshev (Mean, Sd) UCL	0.098706
		99% Chebyshev (Mean, Sd) UCL	0.118989

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Attachment 3

Type	ERA
Medium	Fish (American eel/White perch)
Chemical	TCDD TEQ (PCB) - Bird
Units	µg/kg

Data File		Variable:	SumOfBird_TEF - WP AE PCB TEQ
Raw Statistics		Normal Distribution Test	
Number of Valid Samples	77	Lilliefors Test Statisitic	0.122376
Number of Unique Samples	77	Lilliefors 5% Critical Value	0.100969
Minimum	0.030044	Data not normal at 5% significance level	
Maximum	1.512824		
Mean	0.578114	95% UCL (Assuming Normal Distribution)	
Median	0.558286	Student's-t UCL	0.653852
Standard Deviation	0.399125		
Variance	0.159301	Gamma Distribution Test	
Coefficient of Variation	0.690391	A-D Test Statistic	2.534641
Skewness	0.241728	A-D 5% Critical Value	0.773708
		K-S Test Statistic	0.134872
Gamma Statistics		K-S 5% Critical Value	0.103989
k hat	1.336031	Data do not follow gamma distribution	
k star (bias corrected)	1.292636	at 5% significance level	
Theta hat	0.43271		
Theta star	0.447237	95% UCLs (Assuming Gamma Distribution)	
nu hat	205.7488	Approximate Gamma UCL	0.68741
nu star	199.0659	Adjusted Gamma UCL	0.689677
Approx.Chi Square Value (.05)	167.4151		
Adjusted Level of Significance	0.046883	Lognormal Distribution Test	
Adjusted Chi Square Value	166.8647	Lilliefors Test Statisitic	0.178631
		Lilliefors 5% Critical Value	0.100969
Log-transformed Statistics		Data not lognormal at 5% significance level	
Minimum of log data	-3.50509		
Maximum of log data	0.413978	95% UCLs (Assuming Lognormal Distribution)	
Mean of log data	-0.96677	95% H-UCL	0.940142
Standard Deviation of log data	1.103457	95% Chebyshev (MVUE) UCL	1.154793
Variance of log data	1.217618	97.5% Chebyshev (MVUE) UCL	1.355712
		99% Chebyshev (MVUE) UCL	1.750381
		95% Non-parametric UCLs	
		CLT UCL	0.652929
		Adj-CLT UCL (Adjusted for skewness)	0.654268
		Mod-t UCL (Adjusted for skewness)	0.654061
		Jackknife UCL	0.653852
		Standard Bootstrap UCL	0.652392
		Bootstrap-t UCL	0.654836
RECOMMENDATION		Hall's Bootstrap UCL	0.652871
Data are Non-parametric (0.05)		Percentile Bootstrap UCL	0.650435
		BCA Bootstrap UCL	0.647554
Use 97.5% Chebyshev (Mean, Sd) UCL		95% Chebyshev (Mean, Sd) UCL	0.776376
		97.5% Chebyshev (Mean, Sd) UCL	**0.862164**
		99% Chebyshev (Mean, Sd) UCL	1.030679

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Attachment 3

Type	ERA
Medium	Fish (American eel/White perch)
Chemical	TCDD TEQ (PCB) - Fish
Units	µg/kg

Data File		Variable:	SumOfFish_TEF - WP AE PCB TEQ
Raw Statistics		Normal Distribution Test	
Number of Valid Samples	77	Lilliefors Test Statisitic	0.133623
Number of Unique Samples	77	Lilliefors 5% Critical Value	0.100969
Minimum	0.000809	Data not normal at 5% significance level	
Maximum	0.016414		
Mean	0.004516	95% UCL (Assuming Normal Distribution)	
Median	0.003637	Student's-t UCL	0.005068
Standard Deviation	0.002907		
Variance	8.45E-06	Gamma Distribution Test	
Coefficient of Variation	0.643742	A-D Test Statistic	0.299785
Skewness	1.420229	A-D 5% Critical Value	0.760331
		K-S Test Statistic	0.06088
Gamma Statistics		K-S 5% Critical Value	0.102721
k hat	2.603678	Data follow gamma distribution	
k star (bias corrected)	2.510894	at 5% significance level	
Theta hat	0.001735		
Theta star	0.001799	95% UCLs (Assuming Gamma Distribution)	
nu hat	400.9664	**Approximate Gamma UCL**	**0.005105**
nu star	386.6777	Adjusted Gamma UCL	0.005117
Approx.Chi Square Value (.05)	342.0912		
Adjusted Level of Significance	0.046883	Lognormal Distribution Test	
Adjusted Chi Square Value	341.2973	Lilliefors Test Statisitic	0.067048
		Lilliefors 5% Critical Value	0.100969
Log-transformed Statistics		Data are lognormal at 5% significance level	
Minimum of log data	-7.1197		
Maximum of log data	-4.1096	95% UCLs (Assuming Lognormal Distribution)	
Mean of log data	-5.60418	95% H-UCL	0.00536
Standard Deviation of log data	0.670438	95% Chebyshev (MVUE) UCL	0.006267
Variance of log data	0.449488	97.5% Chebyshev (MVUE) UCL	0.006992
		99% Chebyshev (MVUE) UCL	0.008414
		95% Non-parametric UCLs	
		CLT UCL	0.005061
		Adj-CLT UCL (Adjusted for skewness)	0.005119
		Mod-t UCL (Adjusted for skewness)	0.005077
		Jackknife UCL	0.005068
		Standard Bootstrap UCL	0.005051
		Bootstrap-t UCL	0.005129
RECOMMENDATION		Hall's Bootstrap UCL	0.00516
Data follow gamma distribution (0.05)		Percentile Bootstrap UCL	0.005064
		BCA Bootstrap UCL	0.00513
Use Approximate Gamma UCL		95% Chebyshev (Mean, Sd) UCL	0.005961
		97.5% Chebyshev (Mean, Sd) UCL	0.006586
		99% Chebyshev (Mean, Sd) UCL	0.007813

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Attachment 3

Type	ERA
Medium	Fish (American eel/White perch)
Chemical	Total TEQ - Fish
Units	µg/kg

Data File		Variable:	SumOfFish_TEF - WP AE Total TEQ
Raw Statistics		Normal Distribution Test	
Number of Valid Samples	83	Lilliefors Test Statisitic	0.171418
Number of Unique Samples	83	Lilliefors 5% Critical Value	0.097251
Minimum	0.000841	Data not normal at 5% significance level	
Maximum	0.892268		
Mean	0.175061	95% UCL (Assuming Normal Distribution)	
Median	0.151681	Student's-t UCL	0.2086
Standard Deviation	0.183665		
Variance	0.033733	Gamma Distribution Test	
Coefficient of Variation	1.049148	A-D Test Statistic	1.527582
Skewness	1.642034	A-D 5% Critical Value	0.803972
		K-S Test Statistic	0.128126
Gamma Statistics		K-S 5% Critical Value	0.102711
k hat	0.645057	Data do not follow gamma distribution	
k star (bias corrected)	0.629774	at 5% significance level	
Theta hat	0.271389		
Theta star	0.277975	95% UCLs (Assuming Gamma Distribution)	
nu hat	107.0794	Approximate Gamma UCL	0.22334
nu star	104.5424	Adjusted Gamma UCL	0.224304
Approx.Chi Square Value (.05)	81.94388		
Adjusted Level of Significance	0.047108	Lognormal Distribution Test	
Adjusted Chi Square Value	81.59179	Lilliefors Test Statisitic	0.17862
		Lilliefors 5% Critical Value	0.097251
Log-transformed Statistics		Data not lognormal at 5% significance level	
Minimum of log data	-7.08139		
Maximum of log data	-0.11399	95% UCLs (Assuming Lognormal Distribution)	
Mean of log data	-2.69043	95% H-UCL	0.634721
Standard Deviation of log data	1.799296	95% Chebyshev (MVUE) UCL	0.742233
Variance of log data	3.237466	97.5% Chebyshev (MVUE) UCL	0.922248
		99% Chebyshev (MVUE) UCL	1.275853
		95% Non-parametric UCLs	
		CLT UCL	0.208221
		Adj-CLT UCL (Adjusted for skewness)	0.212104
		Mod-t UCL (Adjusted for skewness)	0.209206
		Jackknife UCL	0.2086
		Standard Bootstrap UCL	0.207941
		Bootstrap-t UCL	0.211832
RECOMMENDATION		Hall's Bootstrap UCL	0.213341
Data are Non-parametric (0.05)		Percentile Bootstrap UCL	0.209767
		BCA Bootstrap UCL	0.210565
Use 97.5% Chebyshev (Mean, Sd) UCL		95% Chebyshev (Mean, Sd) UCL	0.262936
		97.5% Chebyshev (Mean, Sd) UCL	**0.30096**
		99% Chebyshev (Mean, Sd) UCL	0.375649

R2-0009511

Attachment 3

Type	ERA
Medium	Fish (American eel/White perch)
Chemical	Total TEQ - Bird
Units	µg/kg

Data File		Variable:	SumOfBird_TEF - WP AE TOTAL TEQ
Raw Statistics		Normal Distribution Test	
Number of Valid Samples	83	Lilliefors Test Statisitic	0.152392
Number of Unique Samples	83	Lilliefors 5% Critical Value	0.097251
Minimum	0.002277	Data not normal at 5% significance level	
Maximum	1.983476		
Mean	0.627851	95% UCL (Assuming Normal Distribution)	
Median	0.560639	Student's-t UCL	0.722744
Standard Deviation	0.519649		
Variance	0.270035	Gamma Distribution Test	
Coefficient of Variation	0.827663	A-D Test Statistic	1.993275
Skewness	0.470899	A-D 5% Critical Value	0.787481
		K-S Test Statistic	0.125539
Gamma Statistics		K-S 5% Critical Value	0.101468
k hat	0.88075	Data do not follow gamma distribution	
k star (bias corrected)	0.856947	at 5% significance level	
Theta hat	0.71286		
Theta star	0.73266	95% UCLs (Assuming Gamma Distribution)	
nu hat	146.2044	Approximate Gamma UCL	0.772034
nu star	142.2533	Adjusted Gamma UCL	0.774855
Approx.Chi Square Value (.05)	115.6864		
Adjusted Level of Significance	0.047108	Lognormal Distribution Test	
Adjusted Chi Square Value	115.2652	Lilliefors Test Statisitic	0.160734
		Lilliefors 5% Critical Value	0.097251
Log-transformed Statistics		Data not lognormal at 5% significance level	
Minimum of log data	-6.08472		
Maximum of log data	0.684851	95% UCLs (Assuming Lognormal Distribution)	
Mean of log data	-1.13101	95% H-UCL	1.566348
Standard Deviation of log data	1.499322	95% Chebyshev (MVUE) UCL	1.9172
Variance of log data	2.247967	97.5% Chebyshev (MVUE) UCL	2.328859
		99% Chebyshev (MVUE) UCL	3.137482
		95% Non-parametric UCLs	
		CLT UCL	0.721672
		Adj-CLT UCL (Adjusted for skewness)	0.724822
		Mod-t UCL (Adjusted for skewness)	0.723235
		Jackknife UCL	0.722744
		Standard Bootstrap UCL	0.720211
		Bootstrap-t UCL	0.72388
RECOMMENDATION		Hall's Bootstrap UCL	0.72503
Data are Non-parametric (0.05)		Percentile Bootstrap UCL	0.726101
		BCA Bootstrap UCL	0.721317
Use 97.5% Chebyshev (Mean, Sd) UCL		95% Chebyshev (Mean, Sd) UCL	0.876478
		97.5% Chebyshev (Mean, Sd) UCL	**0.984059**
		99% Chebyshev (Mean, Sd) UCL	1.195381

R2-0009512

Attachment 3

Type	ERA and HHRA
Medium	Fish (American eel/White perch)
Chemical	Total TEQ - Mammal
Units	µg/kg

Data File	
Raw Statistics	
Number of Valid Samples	83
Number of Unique Samples	83
Minimum	0.012503
Maximum	0.561028
Mean	0.183909
Median	0.136946
Standard Deviation	0.146876
Variance	0.021573
Coefficient of Variation	0.798633
Skewness	0.738949
Gamma Statistics	
k hat	1.349681
k star (bias corrected)	1.30893
Theta hat	0.136261
Theta star	0.140503
nu hat	224.0471
nu star	217.2823
Approx.Chi Square Value (.05)	184.1608
Adjusted Level of Significance	0.047108
Adjusted Chi Square Value	183.6254
Log-transformed Statistics	
Minimum of log data	-4.38182
Maximum of log data	-0.57798
Mean of log data	-2.10745
Standard Deviation of log data	1.011276
Variance of log data	1.022679

RECOMMENDATION

Assuming gamma distribution (0.05)

Use Approximate Gamma UCL

Variable:	SumOfMammal_TEF - WP AE TOTAL TEQ
Normal Distribution Test	
Lilliefors Test Statisitic	0.160552
Lilliefors 5% Critical Value	0.097251
Data not normal at 5% significance level	
95% UCL (Assuming Normal Distribution)	
Student's-t UCL	0.21073
Gamma Distribution Test	
A-D Test Statistic	0.976542
A-D 5% Critical Value	0.774146
K-S Test Statistic	0.083876
K-S 5% Critical Value	0.10021
Data follow approximate gamma distibution	
at 5% significance level	
95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	**0.216985**
Adjusted Gamma UCL	0.217618
Lognormal Distribution Test	
Lilliefors Test Statisitic	0.126589
Lilliefors 5% Critical Value	0.097251
Data not lognormal at 5% significance level	
95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	0.260286
95% Chebyshev (MVUE) UCL	0.317258
97.5% Chebyshev (MVUE) UCL	0.367634
99% Chebyshev (MVUE) UCL	0.466587
95% Non-parametric UCLs	
CLT UCL	0.210427
Adj-CLT UCL (Adjusted for skewness)	0.211824
Mod-t UCL (Adjusted for skewness)	0.210948
Jackknife UCL	0.21073
Standard Bootstrap UCL	0.210337
Bootstrap-t UCL	0.21224
Hall's Bootstrap UCL	0.211192
Percentile Bootstrap UCL	0.208298
BCA Bootstrap UCL	0.212483
95% Chebyshev (Mean, Sd) UCL	0.254182
97.5% Chebyshev (Mean, Sd) UCL	0.284589
99% Chebyshev (Mean, Sd) UCL	0.344318

Attachment 3

Type	ERA
Medium	Sediment
Chemical	Chlordane
Units	µg/kg

Data File

Variable: Chlordane

Raw Statistics

Number of Valid Samples	227
Number of Unique Samples	200
Minimum	1.595
Maximum	332.25
Mean	37.17414
Median	27
Standard Deviation	37.88185
Variance	1435.035
Coefficient of Variation	1.019038
Skewness	3.222988

Gamma Statistics

k hat	1.267464
k star (bias corrected)	1.25365
Theta hat	29.32954
Theta star	29.65272
nu hat	575.4288
nu star	569.1573
Approx.Chi Square Value (.05)	514.8105
Adjusted Level of Significance	0.048943
Adjusted Chi Square Value	514.4843

Log-transformed Statistics

Minimum of log data	0.466874
Maximum of log data	5.805888
Mean of log data	3.171852
Standard Deviation of log data	1.017539
Variance of log data	1.035385

RECOMMENDATION

Data follow gamma distribution (0.05)

Use Approximate Gamma UCL

Normal Distribution Test

Lilliefors Test Statisitic	0.173811
Lilliefors 5% Critical Value	0.058806

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	41.32683

Gamma Distribution Test

A-D Test Statistic	0.432581
A-D 5% Critical Value	0.777311
K-S Test Statistic	0.036746
K-S 5% Critical Value	0.061956

Data follow gamma distribution at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	**41.09849**
Adjusted Gamma UCL	41.12455

Lognormal Distribution Test

Lilliefors Test Statisitic	0.072353
Lilliefors 5% Critical Value	0.058806

Data not lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	46.29554
95% Chebyshev (MVUE) UCL	54.2133
97.5% Chebyshev (MVUE) UCL	60.41135
99% Chebyshev (MVUE) UCL	72.58621

95% Non-parametric UCLs

CLT UCL	41.30981
Adj-CLT UCL (Adjusted for skewness)	41.88451
Mod-t UCL (Adjusted for skewness)	41.41647
Jackknife UCL	41.32683
Standard Bootstrap UCL	41.36496
Bootstrap-t UCL	42.19656
Hall's Bootstrap UCL	42.34805
Percentile Bootstrap UCL	41.34022
BCA Bootstrap UCL	41.68573
95% Chebyshev (Mean, Sd) UCL	48.13375
97.5% Chebyshev (Mean, Sd) UCL	52.87598
99% Chebyshev (Mean, Sd) UCL	62.19118

R2-0009514

Attachment 3

Type	ERA
Medium	Sediment
Chemical	Copper
Units	µg/kg

Data File

Variable: Copper

Raw Statistics

Number of Valid Samples	234
Number of Unique Samples	152
Minimum	11500
Maximum	2470000
Mean	217265
Median	195500
Standard Deviation	169088.8
Variance	2.86E+10
Coefficient of Variation	0.778261
Skewness	10.40631

Gamma Statistics

k hat	4.351721
k star (bias corrected)	4.298778
Theta hat	49926.22
Theta star	50541.09
nu hat	2036.605
nu star	2011.828
Approx.Chi Square Value (.05)	1908.619
Adjusted Level of Significance	0.048974
Adjusted Chi Square Value	1908.005

Log-transformed Statistics

Minimum of log data	9.350102
Maximum of log data	14.71973
Mean of log data	12.1696
Standard Deviation of log data	0.487203
Variance of log data	0.237367

RECOMMENDATION

Data are Non-parametric (0.05)

Use Student's-t UCL
or Modified-t UCL

Normal Distribution Test

Lilliefors Test Statisitic	0.241762
Lilliefors 5% Critical Value	0.05792

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	**235519.2**

Gamma Distribution Test

A-D Test Statistic	1.8E+308
A-D 5% Critical Value	0.756897
K-S Test Statistic	0.14947
K-S 5% Critical Value	0.059945

Data do not follow gamma distribution
at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	229013.7
Adjusted Gamma UCL	229087.4

Lognormal Distribution Test

Lilliefors Test Statisitic	0.170834
Lilliefors 5% Critical Value	0.05792

Data not lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	229910.4
95% Chebyshev (MVUE) UCL	248813.2
97.5% Chebyshev (MVUE) UCL	262573
99% Chebyshev (MVUE) UCL	289601.4

95% Non-parametric UCLs

CLT UCL	235446.6
Adj-CLT UCL (Adjusted for skewness)	243481.5
Mod-t UCL (Adjusted for skewness)	**236772.5**
Jackknife UCL	235519.2
Standard Bootstrap UCL	235747.9
Bootstrap-t UCL	251293.5
Hall's Bootstrap UCL	316671.9
Percentile Bootstrap UCL	238529.5
BCA Bootstrap UCL	245688
95% Chebyshev (Mean, Sd) UCL	265446.8
97.5% Chebyshev (Mean, Sd) UCL	286295.2
99% Chebyshev (Mean, Sd) UCL	327247.7

R2-0009515

Type	ERA
Medium	Sediment
Chemical	DDD

Data File 4-10-07

Variable: DDD

Raw Statistics

Number of Valid Samples	233
Number of Unique Samples	193
Minimum	2.035
Maximum	5980
Mean	96.38414
Median	47.3
Standard Deviation	399.8312
Variance	159865
Coefficient of Variation	4.148309
Skewness	13.91201

Gamma Statistics

k hat	0.80174
k star (bias corrected)	0.794279
Theta hat	120.2187
Theta star	121.348
nu hat	373.6109
nu star	370.1338
Approx.Chi Square Value (.05)	326.5374
Adjusted Level of Significance	0.04897
Adjusted Chi Square Value	326.2854

Log-transformed Statistics

Minimum of log data	0.710496
Maximum of log data	8.696176
Mean of log data	3.828299
Standard Deviation of log data	0.96922
Variance of log data	0.939388

Normal Distribution Test

Lilliefors Test Statisitic	0.406727
Lilliefors 5% Critical Value	0.058044
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)

Student's-t UCL	139.6419

Gamma Distribution Test

A-D Test Statistic	1.8E+308
A-D 5% Critical Value	0.793853
K-S Test Statistic	0.211417
K-S 5% Critical Value	0.06211
Data do not follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	109.2525
Adjusted Gamma UCL	109.3369

Lognormal Distribution Test

Lilliefors Test Statisitic	0.081374
Lilliefors 5% Critical Value	0.058044
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	84.11136
95% Chebyshev (MVUE) UCL	97.72933
97.5% Chebyshev (MVUE) UCL	108.2845
99% Chebyshev (MVUE) UCL	129.0181

95% Non-parametric UCLs

CLT UCL	139.4691
Adj-CLT UCL (Adjusted for skewness)	164.978
Mod-t UCL (Adjusted for skewness)	143.6207
Jackknife UCL	139.6419
Standard Bootstrap UCL	140.3512
Bootstrap-t UCL	258.5963
Hall's Bootstrap UCL	289.7358
Percentile Bootstrap UCL	146.9846
BCA Bootstrap UCL	178.0051
95% Chebyshev (Mean, Sd) UCL	**210.5603**
97.5% Chebyshev (Mean, Sd) UCL	259.9645
99% Chebyshev (Mean, Sd) UCL	357.0093

RECOMMENDATION

Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

R2-0009516

Type	HHRA
Medium	Sediment
Chemical	DDE
Units	µg/kg

Data File 4-10-07

Variable: DDE

Raw Statistics	
Number of Valid Samples	234
Number of Unique Samples	195
Minimum	2.035
Maximum	1010
Mean	58.44669
Median	40.75
Standard Deviation	90.12724
Variance	8122.919
Coefficient of Variation	1.542042
Skewness	7.379838

Gamma Statistics	
k hat	1.340952
k star (bias corrected)	1.32661
Theta hat	43.58595
Theta star	44.05718
nu hat	627.5658
nu star	620.8534
Approx.Chi Square Value (.05)	564.0395
Adjusted Level of Significance	0.048974
Adjusted Chi Square Value	563.7081

Log-transformed Statistics	
Minimum of log data	0.710496
Maximum of log data	6.917706
Mean of log data	3.651016
Standard Deviation of log data	0.88708
Variance of log data	0.78691

RECOMMENDATION

Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

Normal Distribution Test	
Lilliefors Test Statisitic	0.271283
Lilliefors 5% Critical Value	0.05792
Data not normal at 5% significance level	
95% UCL (Assuming Normal Distribution)	
Student's-t UCL	68.17652

Gamma Distribution Test	
A-D Test Statistic	5.757971
A-D 5% Critical Value	0.775518
K-S Test Statistic	0.124722
K-S 5% Critical Value	0.061039
Data do not follow gamma distribution	
at 5% significance level	
95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	64.33383
Adjusted Gamma UCL	64.37166

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.094995
Lilliefors 5% Critical Value	0.05792
Data not lognormal at 5% significance level	
95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	64.27917
95% Chebyshev (MVUE) UCL	73.8192
97.5% Chebyshev (MVUE) UCL	81.11935
99% Chebyshev (MVUE) UCL	95.45909
95% Non-parametric UCLs	
CLT UCL	68.13784
Adj-CLT UCL (Adjusted for skewness)	71.175
Mod-t UCL (Adjusted for skewness)	68.65026
Jackknife UCL	68.17652
Standard Bootstrap UCL	68.19334
Bootstrap-t UCL	74.68715
Hall's Bootstrap UCL	111.0965
Percentile Bootstrap UCL	68.68829
BCA Bootstrap UCL	72.25355
95% Chebyshev (Mean, Sd) UCL	**84.12846**
97.5% Chebyshev (Mean, Sd) UCL	95.24098
99% Chebyshev (Mean, Sd) UCL	117.0694

R2-0009517

Attachment 3

Type	HHRA
Medium	Sediment
Chemical	DDT
Units	µg/kg

Data File 4-10-07

Variable: DDT

Raw Statistics	
Number of Valid Samples	231
Number of Unique Samples	200
Minimum	1.5
Maximum	2470
Mean	90.25517
Median	24
Standard Deviation	270.3807
Variance	73105.72
Coefficient of Variation	2.995736
Skewness	6.273821

Gamma Statistics	
k hat	0.508099
k star (bias corrected)	0.504386
Theta hat	177.633
Theta star	178.9405
nu hat	234.7418
nu star	233.0265
Approx.Chi Square Value (.05)	198.6829
Adjusted Level of Significance	0.048961
Adjusted Chi Square Value	198.4858

Log-transformed Statistics	
Minimum of log data	0.405465
Maximum of log data	7.811973
Mean of log data	3.255634
Standard Deviation of log data	1.383405
Variance of log data	1.913809

RECOMMENDATION

Data are lognormal (0.05)

Use H-UCL

Normal Distribution Test	
Lilliefors Test Statisitic	0.371358
Lilliefors 5% Critical Value	0.058295
Data not normal at 5% significance level	
95% UCL (Assuming Normal Distribution)	
Student's-t UCL	119.635

Gamma Distribution Test	
A-D Test Statistic	15.92044
A-D 5% Critical Value	0.820354
K-S Test Statistic	0.197715
K-S 5% Critical Value	0.063495
Data do not follow gamma distribution	
at 5% significance level	
95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	105.8564
Adjusted Gamma UCL	105.9615

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.054296
Lilliefors 5% Critical Value	0.058295
Data are lognormal at 5% significance level	
95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	**84.65568**
95% Chebyshev (MVUE) UCL	103.4703
97.5% Chebyshev (MVUE) UCL	119.2558
99% Chebyshev (MVUE) UCL	150.2636
95% Non-parametric UCLs	
CLT UCL	119.5167
Adj-CLT UCL (Adjusted for skewness)	127.3632
Mod-t UCL (Adjusted for skewness)	120.8589
Jackknife UCL	119.635
Standard Bootstrap UCL	119.3921
Bootstrap-t UCL	135.0838
Hall's Bootstrap UCL	131.8052
Percentile Bootstrap UCL	121.1472
BCA Bootstrap UCL	126.9552
95% Chebyshev (Mean, Sd) UCL	167.7989
97.5% Chebyshev (Mean, Sd) UCL	201.3521
99% Chebyshev (Mean, Sd) UCL	267.2609

R2-0009518

Attachment 3

Type	ERA
Medium	Sediment
Chemical	DDx - Sum
Units	µg/kg

Data File

Variable: Total DDx

Raw Statistics

Number of Valid Samples	245
Number of Unique Samples	233
Minimum	6.105
Maximum	5984.52
Mean	232.5836
Median	123
Standard Deviation	521.5207
Variance	271983.8
Coefficient of Variation	2.242294
Skewness	7.550755

Gamma Statistics

k hat	0.949494
k star (bias corrected)	0.940588
Theta hat	244.9554
Theta star	247.2746
nu hat	465.2519
nu star	460.8883
Approx.Chi Square Value (.05)	412.1018
Adjusted Level of Significance	0.04902
Adjusted Chi Square Value	411.832

Log-transformed Statistics

Minimum of log data	1.809108
Maximum of log data	8.696931
Mean of log data	4.837568
Standard Deviation of log data	0.951846
Variance of log data	0.906011

Normal Distribution Test

Lilliefors Test Statisitic	0.332048
Lilliefors 5% Critical Value	0.056604

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	287.5969

Gamma Distribution Test

A-D Test Statistic	14.48874
A-D 5% Critical Value	0.786506
K-S Test Statistic	0.182076
K-S 5% Critical Value	0.060298

Data do not follow gamma distribution at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	260.1179
Adjusted Gamma UCL	260.2883

Lognormal Distribution Test

Lilliefors Test Statisitic	0.082525
Lilliefors 5% Critical Value	0.056604

Data not lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	225.4239
95% Chebyshev (MVUE) UCL	260.6675
97.5% Chebyshev (MVUE) UCL	287.8152
99% Chebyshev (MVUE) UCL	341.1415

95% Non-parametric UCLs

CLT UCL	287.388
Adj-CLT UCL (Adjusted for skewness)	304.5622
Mod-t UCL (Adjusted for skewness)	290.2757
Jackknife UCL	287.5969
Standard Bootstrap UCL	286.6447
Bootstrap-t UCL	321.7829
Hall's Bootstrap UCL	329.4934
Percentile Bootstrap UCL	292.434
BCA Bootstrap UCL	304.2273
95% Chebyshev (Mean, Sd) UCL	**377.8166**
97.5% Chebyshev (Mean, Sd) UCL	440.659
99% Chebyshev (Mean, Sd) UCL	564.1008

RECOMMENDATION

Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

R2-0009519

Attachment 3

Type	ERA
Medium	Sediment
Chemical	Dieldrin
Units	µg/kg

Data File

Variable: Dieldrin

Raw Statistics

Number of Valid Samples	236
Number of Unique Samples	165
Minimum	1.38
Maximum	141
Mean	13.74949
Median	8
Standard Deviation	17.497
Variance	306.1449
Coefficient of Variation	1.272556
Skewness	4.267641

Gamma Statistics

k hat	1.258406
k star (bias corrected)	1.245235
Theta hat	10.92611
Theta star	11.04169
nu hat	593.9678
nu star	587.7507
Approx.Chi Square Value (.05)	532.5042
Adjusted Level of Significance	0.048983
Adjusted Chi Square Value	532.185

Log-transformed Statistics

Minimum of log data	0.322083
Maximum of log data	4.94876
Mean of log data	2.173721
Standard Deviation of log data	0.896949
Variance of log data	0.804518

Normal Distribution Test

Lilliefors Test Statisitic	0.239799
Lilliefors 5% Critical Value	0.057674

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	15.63032

Gamma Distribution Test

A-D Test Statistic	6.535495
A-D 5% Critical Value	0.77757
K-S Test Statistic	0.127507
K-S 5% Critical Value	0.060907

Data do not follow gamma distribution
at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	15.17598
Adjusted Gamma UCL	15.18508

Lognormal Distribution Test

Lilliefors Test Statisitic	0.1046
Lilliefors 5% Critical Value	0.057674

Data not lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	14.81974
95% Chebyshev (MVUE) UCL	17.03619
97.5% Chebyshev (MVUE) UCL	18.73378
99% Chebyshev (MVUE) UCL	22.06835

95% Non-parametric UCLs

CLT UCL	15.62291
Adj-CLT UCL (Adjusted for skewness)	15.96099
Mod-t UCL (Adjusted for skewness)	15.68306
Jackknife UCL	15.63032
Standard Bootstrap UCL	15.63521
Bootstrap-t UCL	16.03974
Hall's Bootstrap UCL	16.22045
Percentile Bootstrap UCL	15.69025
BCA Bootstrap UCL	15.90769
95% Chebyshev (Mean, Sd) UCL	**18.71409**
97.5% Chebyshev (Mean, Sd) UCL	20.86228
99% Chebyshev (Mean, Sd) UCL	25.08198

RECOMMENDATION
Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

R2-0009520

Attachment 3

Type	ERA
Medium	Sediment
Chemical	Lead
Units	µg/kg

Data File

Variable: Lead

Raw Statistics

Number of Valid Samples	225
Number of Unique Samples	157
Minimum	4400
Maximum	1550000
Mean	328047.1
Median	287000
Standard Deviation	160309
Variance	2.57E+10
Coefficient of Variation	0.488677
Skewness	2.663771

Gamma Statistics

k hat	4.272078
k star (bias corrected)	4.21808
Theta hat	76788.65
Theta star	77771.66
nu hat	1922.435
nu star	1898.136
Approx.Chi Square Value (.05)	1797.919
Adjusted Level of Significance	0.048933
Adjusted Chi Square Value	1797.299

Log-transformed Statistics

Minimum of log data	8.38936
Maximum of log data	14.25377
Mean of log data	12.57933
Standard Deviation of log data	0.587178
Variance of log data	0.344778

Normal Distribution Test

Lilliefors Test Statisitic	0.165669
Lilliefors 5% Critical Value	0.059067

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	345699.1

Gamma Distribution Test

A-D Test Statistic	6.654842
A-D 5% Critical Value	0.756791
K-S Test Statistic	0.133404
K-S 5% Critical Value	0.060997

Data do not follow gamma distribution
at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	346332.7
Adjusted Gamma UCL	346452.2

Lognormal Distribution Test

Lilliefors Test Statisitic	0.178599
Lilliefors 5% Critical Value	0.059067

Data not lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	371065.2
95% Chebyshev (MVUE) UCL	408345.3
97.5% Chebyshev (MVUE) UCL	435825.8
99% Chebyshev (MVUE) UCL	489805.9

95% Non-parametric UCLs

CLT UCL	345626.1
Adj-CLT UCL (Adjusted for skewness)	347654
Mod-t UCL (Adjusted for skewness)	346015.4
Jackknife UCL	345699.1
Standard Bootstrap UCL	345859.2
Bootstrap-t UCL	347701.7
Hall's Bootstrap UCL	349747.6
Percentile Bootstrap UCL	346230.2
BCA Bootstrap UCL	347004.9
95% Chebyshev (Mean, Sd) UCL	**374631.8**
97.5% Chebyshev (Mean, Sd) UCL	394789.1
99% Chebyshev (Mean, Sd) UCL	434384.1

RECOMMENDATION

Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

R2-0009521

Attachment 3

Type	ERA
Medium	Sediment
Chemical	Mercury
Units	µg/kg

Data File

Variable: Mercury

Raw Statistics

Number of Valid Samples	232
Number of Unique Samples	77
Minimum	50
Maximum	10700
Mean	3128.448
Median	2800
Standard Deviation	1807.957
Variance	3268710
Coefficient of Variation	0.577909
Skewness	1.490197

Gamma Statistics

k hat	2.788324
k star (bias corrected)	2.755141
Theta hat	1121.982
Theta star	1135.495
nu hat	1293.782
nu star	1278.386
Approx.Chi Square Value (.05)	1196.35
Adjusted Level of Significance	0.048966
Adjusted Chi Square Value	1195.86

Log-transformed Statistics

Minimum of log data	3.912023
Maximum of log data	9.277999
Mean of log data	7.858385
Standard Deviation of log data	0.716282
Variance of log data	0.513061

Normal Distribution Test

Lilliefors Test Statisitic	0.164357
Lilliefors 5% Critical Value	0.058169
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)

Student's-t UCL	3324.476

Gamma Distribution Test

A-D Test Statistic	3.532914
A-D 5% Critical Value	0.761369
K-S Test Statistic	0.109185
K-S 5% Critical Value	0.060424
Data do not follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	3342.972
Adjusted Gamma UCL	3344.34

Lognormal Distribution Test

Lilliefors Test Statisitic	0.156132
Lilliefors 5% Critical Value	0.058169
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	3661.247
95% Chebyshev (MVUE) UCL	4103.117
97.5% Chebyshev (MVUE) UCL	4433.601
99% Chebyshev (MVUE) UCL	5082.772

95% Non-parametric UCLs

CLT UCL	3323.689
Adj-CLT UCL (Adjusted for skewness)	3336.098
Mod-t UCL (Adjusted for skewness)	3326.411
Jackknife UCL	3324.476
Standard Bootstrap UCL	3320.235
Bootstrap-t UCL	3349.824
Hall's Bootstrap UCL	3333.813
Percentile Bootstrap UCL	3331.897
BCA Bootstrap UCL	3330.733
95% Chebyshev (Mean, Sd) UCL	**3645.842**
97.5% Chebyshev (Mean, Sd) UCL	3869.718
99% Chebyshev (Mean, Sd) UCL	4309.481

RECOMMENDATION

Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

R2-0009522

Attachment 3

Type	ERA
Medium	Sediment
Chemical	LPAH
Units	µg/kg

Data File

Variable: LPAH

Raw Statistics

Number of Valid Samples	232
Number of Unique Samples	213
Minimum	7.1
Maximum	1410750
Mean	13709.5
Median	4781.8
Standard Deviation	94750.83
Variance	8.98E+09
Coefficient of Variation	6.911327
Skewness	14.13738

Gamma Statistics

k hat	0.616504
k star (bias corrected)	0.611406
Theta hat	22237.47
Theta star	22422.91
nu hat	286.058
nu star	283.6923
Approx.Chi Square Value (.05)	245.6739
Adjusted Level of Significance	0.048966
Adjusted Chi Square Value	245.4551

Log-transformed Statistics

Minimum of log data	1.960095
Maximum of log data	14.15963
Mean of log data	8.527606
Standard Deviation of log data	0.851424
Variance of log data	0.724922

RECOMMENDATION

Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

Normal Distribution Test

Lilliefors Test Statisitic	0.457075
Lilliefors 5% Critical Value	0.058169
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)

Student's-t UCL	23982.83

Gamma Distribution Test

A-D Test Statistic	1.8E+308
A-D 5% Critical Value	0.809636
K-S Test Statistic	0.359833
K-S 5% Critical Value	0.062922
Data do not follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	15831.06
Adjusted Gamma UCL	15845.17

Lognormal Distribution Test

Lilliefors Test Statisitic	0.161668
Lilliefors 5% Critical Value	0.058169
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	8128.173
95% Chebyshev (MVUE) UCL	9290.814
97.5% Chebyshev (MVUE) UCL	10176.41
99% Chebyshev (MVUE) UCL	11916

95% Non-parametric UCLs

CLT UCL	23941.63
Adj-CLT UCL (Adjusted for skewness)	30111.05
Mod-t UCL (Adjusted for skewness)	24945.14
Jackknife UCL	23982.83
Standard Bootstrap UCL	24131.47
Bootstrap-t UCL	122338.4
Hall's Bootstrap UCL	77529.73
Percentile Bootstrap UCL	25366.41
BCA Bootstrap UCL	34540.61
95% Chebyshev (Mean, Sd) UCL	**40824.89**
97.5% Chebyshev (Mean, Sd) UCL	52557.74
99% Chebyshev (Mean, Sd) UCL	75604.65

R2-0009523

Attachment 3

Type	ERA
Medium	Sediment
Chemical	HPAH
Units	µg/kg

Data File

Variable: HPAH

Raw Statistics

Number of Valid Samples	231
Number of Unique Samples	222
Minimum	1845
Maximum	1373000
Mean	34372.12
Median	23530
Standard Deviation	93097.23
Variance	8.67E+09
Coefficient of Variation	2.70851
Skewness	13.2524

Gamma Statistics

k hat	1.333327
k star (bias corrected)	1.318897
Theta hat	25779.22
Theta star	26061.27
nu hat	615.997
nu star	609.3303
Approx.Chi Square Value (.05)	553.0572
Adjusted Level of Significance	0.048961
Adjusted Chi Square Value	552.7248

Log-transformed Statistics

Minimum of log data	7.520235
Maximum of log data	14.13251
Mean of log data	10.02528
Standard Deviation of log data	0.760085
Variance of log data	0.57773

RECOMMENDATION

Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

Normal Distribution Test

Lilliefors Test Statisitic	0.363399
Lilliefors 5% Critical Value	0.058295

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	44488.17

Gamma Distribution Test

A-D Test Statistic	1.8E+308
A-D 5% Critical Value	0.775693
K-S Test Statistic	0.162462
K-S 5% Critical Value	0.061402

Data do not follow gamma distribution at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	37869.46
Adjusted Gamma UCL	37892.23

Lognormal Distribution Test

Lilliefors Test Statisitic	0.074775
Lilliefors 5% Critical Value	0.058295

Data not lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	33257.12
95% Chebyshev (MVUE) UCL	37519.95
97.5% Chebyshev (MVUE) UCL	40727.16
99% Chebyshev (MVUE) UCL	47027.11

95% Non-parametric UCLs

CLT UCL	44447.42
Adj-CLT UCL (Adjusted for skewness)	50154.31
Mod-t UCL (Adjusted for skewness)	45378.33
Jackknife UCL	44488.17
Standard Bootstrap UCL	44642.65
Bootstrap-t UCL	76289.83
Hall's Bootstrap UCL	86690.05
Percentile Bootstrap UCL	46076.44
BCA Bootstrap UCL	55530.05
95% Chebyshev (Mean, Sd) UCL	**61071.9**
97.5% Chebyshev (Mean, Sd) UCL	72624.91
99% Chebyshev (Mean, Sd) UCL	95318.57

R2-0009524

Attachment 3

Type	ERA
Medium	Sediment
Chemical	Total PCB
Units	µg/kg

Data File

Variable: Total Aroclor

Raw Statistics

Number of Valid Samples	238
Number of Unique Samples	230
Minimum	56.1
Maximum	17353.25
Mean	1318
Median	1026
Standard Deviation	1713.726
Variance	2936855
Coefficient of Variation	1.300247
Skewness	5.707205

Gamma Statistics

k hat	1.406906
k star (bias corrected)	1.391973
Theta hat	936.8077
Theta star	946.8577
nu hat	669.6871
nu star	662.579
Approx.Chi Square Value (.05)	603.848
Adjusted Level of Significance	0.048992
Adjusted Chi Square Value	603.5107

Log-transformed Statistics

Minimum of log data	4.027136
Maximum of log data	9.761535
Mean of log data	6.788151
Standard Deviation of log data	0.869717
Variance of log data	0.756408

Normal Distribution Test

Lilliefors Test Statisitic	0.24695
Lilliefors 5% Critical Value	0.057431

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	1501.434

Gamma Distribution Test

A-D Test Statistic	3.676559
A-D 5% Critical Value	0.773906
K-S Test Statistic	0.118218
K-S 5% Critical Value	0.060484

Data do not follow gamma distribution
at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	1446.19
Adjusted Gamma UCL	1446.999

Lognormal Distribution Test

Lilliefors Test Statisitic	0.07512
Lilliefors 5% Critical Value	0.057431

Data not lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	1452.462
95% Chebyshev (MVUE) UCL	1662.591
97.5% Chebyshev (MVUE) UCL	1822.819
99% Chebyshev (MVUE) UCL	2137.554

95% Non-parametric UCLs

CLT UCL	1500.717
Adj-CLT UCL (Adjusted for skewness)	1544.628
Mod-t UCL (Adjusted for skewness)	1508.284
Jackknife UCL	1501.434
Standard Bootstrap UCL	1504.92
Bootstrap-t UCL	1564.752
Hall's Bootstrap UCL	1609.707
Percentile Bootstrap UCL	1518.767
BCA Bootstrap UCL	1554.841
95% Chebyshev (Mean, Sd) UCL	**1802.205**
97.5% Chebyshev (Mean, Sd) UCL	2011.721
99% Chebyshev (Mean, Sd) UCL	2423.275

RECOMMENDATION
Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

R2-0009525

Attachment 3

Type	ERA
Medium	Sediment
Chemical	TCDD TEQ (D/F)- Bird
Units	µg/kg

Data File

Variable: D/F TEQ Bird

Raw Statistics

Number of Valid Samples	232
Number of Unique Samples	232
Minimum	0.00158
Maximum	24.54737
Mean	0.86964
Median	0.418419
Standard Deviation	2.182494
Variance	4.763282
Coefficient of Variation	2.509653
Skewness	7.348661

Gamma Statistics

k hat	0.749603
k star (bias corrected)	0.742783
Theta hat	1.160134
Theta star	1.170785
nu hat	347.8158
nu star	344.6515
Approx.Chi Square Value (.05)	302.6245
Adjusted Level of Significance	0.048966
Adjusted Chi Square Value	302.3811

Log-transformed Statistics

Minimum of log data	-6.45033
Maximum of log data	3.200605
Mean of log data	-0.93834
Standard Deviation of log data	1.23686
Variance of log data	1.529822

Normal Distribution Test

Lilliefors Test Statisitic	0.371733
Lilliefors 5% Critical Value	0.058169

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	1.106276

Gamma Distribution Test

A-D Test Statistic	18.83666
A-D 5% Critical Value	0.796467
K-S Test Statistic	0.229911
K-S 5% Critical Value	0.062368

Data do not follow gamma distribution at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	0.990411
Adjusted Gamma UCL	0.991208

Lognormal Distribution Test

Lilliefors Test Statisitic	0.207303
Lilliefors 5% Critical Value	0.058169

Data not lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	1.017107
95% Chebyshev (MVUE) UCL	1.223278
97.5% Chebyshev (MVUE) UCL	1.390877
99% Chebyshev (MVUE) UCL	1.720091

95% Non-parametric UCLs

CLT UCL	1.105327
Adj-CLT UCL (Adjusted for skewness)	1.179195
Mod-t UCL (Adjusted for skewness)	1.117798
Jackknife UCL	1.106276
Standard Bootstrap UCL	1.110866
Bootstrap-t UCL	1.23323
Hall's Bootstrap UCL	1.316972
Percentile Bootstrap UCL	1.116332
BCA Bootstrap UCL	1.17822
95% Chebyshev (Mean, Sd) UCL	1.494217
97.5% Chebyshev (Mean, Sd) UCL	**1.764472**
99% Chebyshev (Mean, Sd) UCL	2.295335

RECOMMENDATION

Data are Non-parametric (0.05)

Use 97.5% Chebyshev (Mean, Sd) UCL

R2-0009526

Attachment 3

Type	ERA
Medium	Sediment
Chemical	TCDD TEQ (D/F) - Fish
Units	µg/kg

Data File

Variable: D/F TEQ FISH

Raw Statistics

Number of Valid Samples	232
Number of Unique Samples	232
Minimum	0.00158
Maximum	19.92561
Mean	0.777074
Median	0.373605
Standard Deviation	1.92869
Variance	3.719844
Coefficient of Variation	2.481988
Skewness	6.674086

Gamma Statistics

k hat	0.722273
k star (bias corrected)	0.715807
Theta hat	1.075873
Theta star	1.085592
nu hat	335.1347
nu star	332.1344
Approx.Chi Square Value (.05)	290.8996
Adjusted Level of Significance	0.048966
Adjusted Chi Square Value	290.661

Log-transformed Statistics

Minimum of log data	-6.45033
Maximum of log data	2.992006
Mean of log data	-1.08532
Standard Deviation of log data	1.279938
Variance of log data	1.638241

Normal Distribution Test

Lilliefors Test Statisitic	0.375805
Lilliefors 5% Critical Value	0.058169

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	0.986192

Gamma Distribution Test

A-D Test Statistic	18.25974
A-D 5% Critical Value	0.799171
K-S Test Statistic	0.225111
K-S 5% Critical Value	0.062482

Data do not follow gamma distribution
at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	0.887224
Adjusted Gamma UCL	0.887952

Lognormal Distribution Test

Lilliefors Test Statisitic	0.21693
Lilliefors 5% Critical Value	0.058169

Data not lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	0.936293
95% Chebyshev (MVUE) UCL	1.131661
97.5% Chebyshev (MVUE) UCL	1.29186
99% Chebyshev (MVUE) UCL	1.60654

95% Non-parametric UCLs

CLT UCL	0.985353
Adj-CLT UCL (Adjusted for skewness)	1.044639
Mod-t UCL (Adjusted for skewness)	0.995439
Jackknife UCL	0.986192
Standard Bootstrap UCL	0.992188
Bootstrap-t UCL	1.080374
Hall's Bootstrap UCL	1.116874
Percentile Bootstrap UCL	1.003401
BCA Bootstrap UCL	1.056041
95% Chebyshev (Mean, Sd) UCL	1.329019
97.5% Chebyshev (Mean, Sd) UCL	**1.567845**
99% Chebyshev (Mean, Sd) UCL	2.036974

RECOMMENDATION

Data are Non-parametric (0.05)

Use 97.5% Chebyshev (Mean, Sd) UCL

R2-0009527

Type	ERA
Medium	Sediment
Chemical	TCDD TEQ (D/F) - Mammal
Units	µg/kg

Data File

Variable: D/F TEQ MAMMAL

Raw Statistics

Number of Valid Samples	232
Number of Unique Samples	232
Minimum	0.003621
Maximum	20.1618
Mean	0.779584
Median	0.372
Standard Deviation	1.937958
Variance	3.755682
Coefficient of Variation	2.485886
Skewness	6.725411

Gamma Statistics

k hat	0.724505
k star (bias corrected)	0.71801
Theta hat	1.076023
Theta star	1.085757
nu hat	336.1704
nu star	333.1567
Approx.Chi Square Value (.05)	291.8566
Adjusted Level of Significance	0.048966
Adjusted Chi Square Value	291.6176

Log-transformed Statistics

Minimum of log data	-5.6209
Maximum of log data	3.00379
Mean of log data	-1.07917
Standard Deviation of log data	1.266248
Variance of log data	1.603383

Normal Distribution Test

Lilliefors Test Statisitic	0.377
Lilliefors 5% Critical Value	0.058169

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	0.989707

Gamma Distribution Test

A-D Test Statistic	18.1581
A-D 5% Critical Value	0.79895
K-S Test Statistic	0.221427
K-S 5% Critical Value	0.062473

Data do not follow gamma distribution
at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	0.889902
Adjusted Gamma UCL	0.890631

Lognormal Distribution Test

Lilliefors Test Statisitic	0.211779
Lilliefors 5% Critical Value	0.058169

Data not lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	0.922826
95% Chebyshev (MVUE) UCL	1.113657
97.5% Chebyshev (MVUE) UCL	1.269699
99% Chebyshev (MVUE) UCL	1.576215

95% Non-parametric UCLs

CLT UCL	0.988864
Adj-CLT UCL (Adjusted for skewness)	1.048893
Mod-t UCL (Adjusted for skewness)	0.99907
Jackknife UCL	0.989707
Standard Bootstrap UCL	0.983773
Bootstrap-t UCL	1.110095
Hall's Bootstrap UCL	1.129555
Percentile Bootstrap UCL	0.999381
BCA Bootstrap UCL	1.060535
95% Chebyshev (Mean, Sd) UCL	1.334181
97.5% Chebyshev (Mean, Sd) UCL	**1.574155**
99% Chebyshev (Mean, Sd) UCL	2.045539

RECOMMENDATION
Data are Non-parametric (0.05)

Use 97.5% Chebyshev (Mean, Sd) UCL

R2-0009528

Attachment 3

Type	ERA
Medium	Sediment
Chemical	TCDD TEQ (PCB) - Bird
Units	µg/kg

Data File

Variable: PCB TEQ BIRD

Raw Statistics

Number of Valid Samples	230
Number of Unique Samples	230
Minimum	0.000271
Maximum	3.639277
Mean	0.536318
Median	0.443117
Standard Deviation	0.519076
Variance	0.269439
Coefficient of Variation	0.96785
Skewness	3.461421

Gamma Statistics

k hat	1.284005
k star (bias corrected)	1.270156
Theta hat	0.417691
Theta star	0.422246
nu hat	590.6423
nu star	584.2716
Approx.Chi Square Value (.05)	529.1924
Adjusted Level of Significance	0.048957
Adjusted Chi Square Value	528.8659

Log-transformed Statistics

Minimum of log data	-8.21339
Maximum of log data	1.291785
Mean of log data	-1.0605
Standard Deviation of log data	1.245806
Variance of log data	1.552032

RECOMMENDATION

Data are Non-parametric (0.05)

Use 97.5% Chebyshev (Mean, Sd) UCL

Normal Distribution Test

Lilliefors Test Statisitic	0.238504
Lilliefors 5% Critical Value	0.058421

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	0.592845

Gamma Distribution Test

A-D Test Statistic	8.82919
A-D 5% Critical Value	0.776912
K-S Test Statistic	0.153745
K-S 5% Critical Value	0.061582

Data do not follow gamma distribution at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	0.592139
Adjusted Gamma UCL	0.592504

Lognormal Distribution Test

Lilliefors Test Statisitic	0.221722
Lilliefors 5% Critical Value	0.058421

Data not lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	0.912888
95% Chebyshev (MVUE) UCL	1.099502
97.5% Chebyshev (MVUE) UCL	1.251619
99% Chebyshev (MVUE) UCL	1.550424

95% Non-parametric UCLs

CLT UCL	0.592616
Adj-CLT UCL (Adjusted for skewness)	0.600963
Mod-t UCL (Adjusted for skewness)	0.594147
Jackknife UCL	0.592845
Standard Bootstrap UCL	0.592156
Bootstrap-t UCL	0.604682
Hall's Bootstrap UCL	0.605042
Percentile Bootstrap UCL	0.593136
BCA Bootstrap UCL	0.606958
95% Chebyshev (Mean, Sd) UCL	0.685509
97.5% Chebyshev (Mean, Sd) UCL	**0.750064**
99% Chebyshev (Mean, Sd) UCL	0.876871

R2-0009529

Attachment 3

Type	ERA
Medium	Sediment
Chemical	TCDD TEQ (PCB) - Fish
Units	µg/kg

Data File

Variable: PCB TEQ FISH

Raw Statistics

Number of Valid Samples	230
Number of Unique Samples	230
Minimum	0.000136
Maximum	0.016773
Mean	0.003083
Median	0.002578
Standard Deviation	0.002536
Variance	6.43E-06
Coefficient of Variation	0.822675
Skewness	2.729145

Gamma Statistics

k hat	2.011127
k star (bias corrected)	1.987794
Theta hat	0.001533
Theta star	0.001551
nu hat	925.1186
nu star	914.3852
Approx.Chi Square Value (.05)	845.1852
Adjusted Level of Significance	0.048957
Adjusted Chi Square Value	844.7711

Log-transformed Statistics

Minimum of log data	-8.90654
Maximum of log data	-4.08797
Mean of log data	-6.05068
Standard Deviation of log data	0.781335
Variance of log data	0.610484

RECOMMENDATION

Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

Normal Distribution Test

Lilliefors Test Statisitic	0.223257
Lilliefors 5% Critical Value	0.058421

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	0.003359

Gamma Distribution Test

A-D Test Statistic	4.904809
A-D 5% Critical Value	0.766176
K-S Test Statistic	0.126251
K-S 5% Critical Value	0.06096

Data do not follow gamma distribution at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	0.003335
Adjusted Gamma UCL	0.003337

Lognormal Distribution Test

Lilliefors Test Statisitic	0.138851
Lilliefors 5% Critical Value	0.058421

Data not lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	0.003539
95% Chebyshev (MVUE) UCL	0.004006
97.5% Chebyshev (MVUE) UCL	0.004359
99% Chebyshev (MVUE) UCL	0.005051

95% Non-parametric UCLs

CLT UCL	0.003358
Adj-CLT UCL (Adjusted for skewness)	0.00339
Mod-t UCL (Adjusted for skewness)	0.003364
Jackknife UCL	0.003359
Standard Bootstrap UCL	0.003356
Bootstrap-t UCL	0.003401
Hall's Bootstrap UCL	0.003399
Percentile Bootstrap UCL	0.003357
BCA Bootstrap UCL	0.003376
95% Chebyshev (Mean, Sd) UCL	**0.003812**
97.5% Chebyshev (Mean, Sd) UCL	0.004127
99% Chebyshev (Mean, Sd) UCL	0.004747

R2-0009530

Attachment 3

Type	ERA
Medium	Sediment
Chemical	TCDD TEQ (PCB) - Mammal
Units	µg/kg

Data File

Variable: PCB TEQ MAMMAL

Raw Statistics

Number of Valid Samples	230
Number of Unique Samples	230
Minimum	0.000813
Maximum	0.169053
Mean	0.036352
Median	0.033603
Standard Deviation	0.03008
Variance	0.000905
Coefficient of Variation	0.827479
Skewness	2.625943

Gamma Statistics

k hat	1.949818
k star (bias corrected)	1.927284
Theta hat	0.018644
Theta star	0.018862
nu hat	896.9163
nu star	886.5507
Approx.Chi Square Value (.05)	818.4301
Adjusted Level of Significance	0.048957
Adjusted Chi Square Value	818.0227

Log-transformed Statistics

Minimum of log data	-7.11478
Maximum of log data	-1.77754
Mean of log data	-3.59235
Standard Deviation of log data	0.815678
Variance of log data	0.66533

Normal Distribution Test

Lilliefors Test Statisitic	0.232768
Lilliefors 5% Critical Value	0.058421

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	0.039627

Gamma Distribution Test

A-D Test Statistic	6.208409
A-D 5% Critical Value	0.766778
K-S Test Statistic	0.136736
K-S 5% Critical Value	0.060999

Data do not follow gamma distribution
at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	0.039377
Adjusted Gamma UCL	0.039397

Lognormal Distribution Test

Lilliefors Test Statisitic	0.142258
Lilliefors 5% Critical Value	0.058421

Data not lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	0.042753
95% Chebyshev (MVUE) UCL	0.048636
97.5% Chebyshev (MVUE) UCL	0.053097
99% Chebyshev (MVUE) UCL	0.06186

95% Non-parametric UCLs

CLT UCL	0.039614
Adj-CLT UCL (Adjusted for skewness)	0.039981
Mod-t UCL (Adjusted for skewness)	0.039685
Jackknife UCL	0.039627
Standard Bootstrap UCL	0.039653
Bootstrap-t UCL	0.040103
Hall's Bootstrap UCL	0.039926
Percentile Bootstrap UCL	0.039886
BCA Bootstrap UCL	0.040033
95% Chebyshev (Mean, Sd) UCL	**0.044997**
97.5% Chebyshev (Mean, Sd) UCL	0.048738
99% Chebyshev (Mean, Sd) UCL	0.056086

RECOMMENDATION
Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

R2-0009531

Attachment 3

Type	ERA
Medium	Sediment
Chemical	Total TEQ - Bird
Units	µg/kg

Data File

Variable: Total TEQ Bird

Raw Statistics

Number of Valid Samples	235
Number of Unique Samples	235
Minimum	0.000271
Maximum	25.97012
Mean	1.383445
Median	0.898256
Standard Deviation	2.482584
Variance	6.163224
Coefficient of Variation	1.794494
Skewness	6.208038

Gamma Statistics

k hat	0.881062
k star (bias corrected)	0.872651
Theta hat	1.570202
Theta star	1.585336
nu hat	414.0991
nu star	410.146
Approx.Chi Square Value (.05)	364.1909
Adjusted Level of Significance	0.048979
Adjusted Chi Square Value	363.9267

Log-transformed Statistics

Minimum of log data	-8.21339
Maximum of log data	3.256947
Mean of log data	-0.34072
Standard Deviation of log data	1.430486
Variance of log data	2.046291

Normal Distribution Test

Lilliefors Test Statisitic	0.340867
Lilliefors 5% Critical Value	0.057796

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	1.650881

Gamma Distribution Test

A-D Test Statistic	14.53473
A-D 5% Critical Value	0.789904
K-S Test Statistic	0.188813
K-S 5% Critical Value	0.061662

Data do not follow gamma distribution at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	1.558014
Adjusted Gamma UCL	1.559145

Lognormal Distribution Test

Lilliefors Test Statisitic	0.252788
Lilliefors 5% Critical Value	0.057796

Data not lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	2.505049
95% Chebyshev (MVUE) UCL	3.073811
97.5% Chebyshev (MVUE) UCL	3.555096
99% Chebyshev (MVUE) UCL	4.500486

95% Non-parametric UCLs

CLT UCL	1.649822
Adj-CLT UCL (Adjusted for skewness)	1.719899
Mod-t UCL (Adjusted for skewness)	1.661811
Jackknife UCL	1.650881
Standard Bootstrap UCL	1.636676
Bootstrap-t UCL	1.794995
Hall's Bootstrap UCL	1.798697
Percentile Bootstrap UCL	1.676747
BCA Bootstrap UCL	1.722898
95% Chebyshev (Mean, Sd) UCL	2.089351
97.5% Chebyshev (Mean, Sd) UCL	**2.394797**
99% Chebyshev (Mean, Sd) UCL	2.994787

RECOMMENDATION

Data are Non-parametric (0.05)

Use 97.5% Chebyshev (Mean, Sd) UCL

R2-0009532

Attachment 3

Type	ERA
Medium	Sediment
Chemical	Total TEQ - Fish
Units	µg/kg

Data File

Variable: Total TEQ Fish

Raw Statistics

Number of Valid Samples	235
Number of Unique Samples	235
Minimum	0.000136
Maximum	19.93251
Mean	0.770172
Median	0.374163
Standard Deviation	1.919463
Variance	3.684337
Coefficient of Variation	2.492253
Skewness	6.70569

Gamma Statistics

k hat	0.667784
k star (bias corrected)	0.662096
Theta hat	1.153324
Theta star	1.163232
nu hat	313.8585
nu star	311.1852
Approx.Chi Square Value (.05)	271.3104
Adjusted Level of Significance	0.048979
Adjusted Chi Square Value	271.0831

Log-transformed Statistics

Minimum of log data	-8.90654
Maximum of log data	2.992352
Mean of log data	-1.17217
Standard Deviation of log data	1.524581
Variance of log data	2.324347

Normal Distribution Test

Lilliefors Test Statisitic	0.373071
Lilliefors 5% Critical Value	0.057796

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	0.976945

Gamma Distribution Test

A-D Test Statistic	17.4285
A-D 5% Critical Value	0.804583
K-S Test Statistic	0.215853
K-S 5% Critical Value	0.062346

Data do not follow gamma distribution at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	0.883365
Adjusted Gamma UCL	0.884105

Lognormal Distribution Test

Lilliefors Test Statisitic	0.247321
Lilliefors 5% Critical Value	0.057796

Data not lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	1.285057
95% Chebyshev (MVUE) UCL	1.589861
97.5% Chebyshev (MVUE) UCL	1.853892
99% Chebyshev (MVUE) UCL	2.37253

95% Non-parametric UCLs

CLT UCL	0.976127
Adj-CLT UCL (Adjusted for skewness)	1.034651
Mod-t UCL (Adjusted for skewness)	0.986074
Jackknife UCL	0.976945
Standard Bootstrap UCL	0.979387
Bootstrap-t UCL	1.086925
Hall's Bootstrap UCL	1.128922
Percentile Bootstrap UCL	0.991961
BCA Bootstrap UCL	1.046193
95% Chebyshev (Mean, Sd) UCL	1.315958
97.5% Chebyshev (Mean, Sd) UCL	**1.55212**
99% Chebyshev (Mean, Sd) UCL	2.016015

RECOMMENDATION

Data are Non-parametric (0.05)

Use 97.5% Chebyshev (Mean, Sd) UCL

R2-0009533

Attachment 3

Type	ERA
Medium	Sediment
Chemical	Total TEQ - Mammal
Units	µg/kg

Data File

Variable: Total TEQ Mammal

Raw Statistics

Number of Valid Samples	235
Number of Unique Samples	235
Minimum	0.000813
Maximum	20.22292
Mean	0.80521
Median	0.412016
Standard Deviation	1.936447
Variance	3.749828
Coefficient of Variation	2.404896
Skewness	6.722162

Gamma Statistics

k hat	0.734201
k star (bias corrected)	0.727665
Theta hat	1.096716
Theta star	1.106567
nu hat	345.0746
nu star	342.0027
Approx.Chi Square Value (.05)	300.1421
Adjusted Level of Significance	0.048979
Adjusted Chi Square Value	299.9028

Log-transformed Statistics

Minimum of log data	-7.11478
Maximum of log data	3.006817
Mean of log data	-1.03437
Standard Deviation of log data	1.33297
Variance of log data	1.77681

Normal Distribution Test

Lilliefors Test Statisitic	0.373182
Lilliefors 5% Critical Value	0.057796

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	1.013814

Gamma Distribution Test

A-D Test Statistic	17.30526
A-D 5% Critical Value	0.798011
K-S Test Statistic	0.216747
K-S 5% Critical Value	0.062072

Data do not follow gamma distribution at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	0.917513
Adjusted Gamma UCL	0.918245

Lognormal Distribution Test

Lilliefors Test Statisitic	0.212584
Lilliefors 5% Critical Value	0.057796

Data not lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	1.067797
95% Chebyshev (MVUE) UCL	1.297429
97.5% Chebyshev (MVUE) UCL	1.487527
99% Chebyshev (MVUE) UCL	1.860937

95% Non-parametric UCLs

CLT UCL	1.012988
Adj-CLT UCL (Adjusted for skewness)	1.072175
Mod-t UCL (Adjusted for skewness)	1.023046
Jackknife UCL	1.013814
Standard Bootstrap UCL	1.016282
Bootstrap-t UCL	1.105282
Hall's Bootstrap UCL	1.146396
Percentile Bootstrap UCL	1.024532
BCA Bootstrap UCL	1.108996
95% Chebyshev (Mean, Sd) UCL	1.355826
97.5% Chebyshev (Mean, Sd) UCL	**1.594078**
99% Chebyshev (Mean, Sd) UCL	2.062078

RECOMMENDATION

Data are Non-parametric (0.05)

Use 97.5% Chebyshev (Mean, Sd) UCL

R2-0009534

Attachment 3

Type	ERA
Medium	American eel/WhitePerch
Chemical	1,2,3,4,6,7,8-HpCDD
Units	µg/kg

Data File

Raw Statistics

Number of Valid Samples	67
Number of Unique Samples	62
Minimum	0.000367
Maximum	0.00769
Mean	0.001505776
Median	0.00129
Standard Deviation	0.001051992
Variance	1.10669E-06
Coefficient of Variation	0.698637621
Skewness	3.246494823

Gamma Statistics

k hat	2.966484685
k star (bias corrected)	2.843607261
Theta hat	0.000507596
Theta star	0.00052953
nu hat	397.5089477
nu star	381.043373
Approx.Chi Square Value (.05)	336.7917093
Adjusted Level of Significance	0.04641791
Adjusted Chi Square Value	335.8830059

Log-transformed Statistics

Minimum of log data	-7.91014871
Maximum of log data	-4.867834495
Mean of log data	-6.676363778
Standard Deviation of log data	0.595776428
Variance of log data	0.354949552

RECOMMENDATION

Data follow gamma distribution (0.05)

Use Approximate Gamma UCL

Variable: 1,2,3,4,6,7,8-HpCDD American eel/Perch

Normal Distribution Test

Lilliefors Test Statisitic	0.139516
Lilliefors 5% Critical Value	0.108242

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	0.00172

Gamma Distribution Test

A-D Test Statistic	0.503965
A-D 5% Critical Value	0.757826
K-S Test Statistic	0.077178
K-S 5% Critical Value	0.109675

Data follow gamma distribution at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	**0.001704**
Adjusted Gamma UCL	0.001708

Lognormal Distribution Test

Lilliefors Test Statisitic	0.071589
Lilliefors 5% Critical Value	0.108242

Data are lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	0.001732
95% Chebyshev (MVUE) UCL	0.002012
97.5% Chebyshev (MVUE) UCL	0.002233
99% Chebyshev (MVUE) UCL	0.002667

95% Non-parametric UCLs

CLT UCL	0.001717
Adj-CLT UCL (Adjusted for skewness)	0.001772
Mod-t UCL (Adjusted for skewness)	0.001729
Jackknife UCL	0.00172
Standard Bootstrap UCL	0.001722
Bootstrap-t UCL	0.001797
Hall's Bootstrap UCL	0.001962
Percentile Bootstrap UCL	0.001731
BCA Bootstrap UCL	0.001799
95% Chebyshev (Mean, Sd) UCL	0.002066
97.5% Chebyshev (Mean, Sd) UCL	0.002308
99% Chebyshev (Mean, Sd) UCL	0.002785

R2-0009535

Attachment 3

Type	ERA
Medium	American eel/WhitePerch
Chemical	1,2,3,4,6,7,8-HpCDF
Units	µg/kg

Data File

Variable: 1,2,3,4,6,7,8-HpCDF AE/WP

Raw Statistics	
Number of Valid Samples	39
Number of Unique Samples	35
Minimum	0.0001
Maximum	0.0345
Mean	0.003556
Median	0.00175
Standard Deviation	0.005664
Variance	3.21E-05
Coefficient of Variation	1.592596
Skewness	4.539822

Gamma Statistics	
k hat	0.940857
k star (bias corrected)	0.885578
Theta hat	0.00378
Theta star	0.004016
nu hat	73.38686
nu star	69.07505
Approx.Chi Square Value (.05)	50.94035
Adjusted Level of Significance	0.0437
Adjusted Chi Square Value	50.32576

Log-transformed Statistics	
Minimum of log data	-9.21034
Maximum of log data	-3.3668
Mean of log data	-6.25703
Standard Deviation of log data	1.097799
Variance of log data	1.205163

RECOMMENDATION

Assuming gamma distribution (0.05)

Use Approximate Gamma UCL

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.517392
Shapiro-Wilk 5% Critical Value	0.939
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	0.005085

Gamma Distribution Test	
A-D Test Statistic	1.130883
A-D 5% Critical Value	0.780653
K-S Test Statistic	0.122532
K-S 5% Critical Value	0.145882
Data follow approximate gamma distibution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	**0.004822**
Adjusted Gamma UCL	0.004881

Lognormal Distribution Test	
Shapiro-Wilk Test Statisitic	0.975227
Shapiro-Wilk 5% Critical Value	0.939
Data are lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	0.005454
95% Chebyshev (MVUE) UCL	0.00654
97.5% Chebyshev (MVUE) UCL	0.00789
99% Chebyshev (MVUE) UCL	0.010541

95% Non-parametric UCLs	
CLT UCL	0.005048
Adj-CLT UCL (Adjusted for skewness)	0.005752
Mod-t UCL (Adjusted for skewness)	0.005195
Jackknife UCL	0.005085
Standard Bootstrap UCL	0.005024
Bootstrap-t UCL	0.006887
Hall's Bootstrap UCL	0.011008
Percentile Bootstrap UCL	0.005113
BCA Bootstrap UCL	0.005853
95% Chebyshev (Mean, Sd) UCL	0.007509
97.5% Chebyshev (Mean, Sd) UCL	0.00922
99% Chebyshev (Mean, Sd) UCL	0.01258

R2-0009536

Attachment 3

Type	ERA
Medium	American eel/WhitePerch
Chemical	1,2,3,4,7,8,9-HpCDF
Units	µg/kg

Data File

Variable: 1,2,3,4,7,8,9-HpCDF AE/WP

Raw Statistics	
Number of Valid Samples	62
Number of Unique Samples	59
Minimum	1.63E-05
Maximum	0.0126
Mean	0.001749
Median	0.000148
Standard Deviation	0.002812
Variance	7.91E-06
Coefficient of Variation	1.607732
Skewness	2.171023

Gamma Statistics	
k hat	0.375373
k star (bias corrected)	0.367963
Theta hat	0.00466
Theta star	0.004754
nu hat	46.5463
nu star	45.6274
Approx.Chi Square Value (.05)	31.12814
Adjusted Level of Significance	0.046129
Adjusted Chi Square Value	30.84292

Log-transformed Statistics	
Minimum of log data	-11.0274
Maximum of log data	-4.37406
Mean of log data	-8.11972
Standard Deviation of log data	2.130689
Variance of log data	4.539836

Normal Distribution Test	
Lilliefors Test Statisitic	0.305061
Lilliefors 5% Critical Value	0.112522
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	0.002346

Gamma Distribution Test	
A-D Test Statistic	3.713906
A-D 5% Critical Value	0.845803
K-S Test Statistic	0.262699
K-S 5% Critical Value	0.121528
Data do not follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	0.002564
Adjusted Gamma UCL	0.002588

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.189692
Lilliefors 5% Critical Value	0.112522
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	0.007738
95% Chebyshev (MVUE) UCL	0.00726
97.5% Chebyshev (MVUE) UCL	0.009284
99% Chebyshev (MVUE) UCL	0.01326

95% Non-parametric UCLs	
CLT UCL	0.002337
Adj-CLT UCL (Adjusted for skewness)	0.002442
Mod-t UCL (Adjusted for skewness)	0.002362
Jackknife UCL	0.002346
Standard Bootstrap UCL	0.002326
Bootstrap-t UCL	0.002505
Hall's Bootstrap UCL	0.002505
Percentile Bootstrap UCL	0.002385
BCA Bootstrap UCL	0.002472
95% Chebyshev (Mean, Sd) UCL	0.003306
97.5% Chebyshev (Mean, Sd) UCL	0.00398
99% Chebyshev (Mean, Sd) UCL	**0.005303**

RECOMMENDATION

Data are Non-parametric (0.05)

Use 99% Chebyshev (Mean, Sd) UCL

R2-0009537

Attachment 3

Type	ERA
Medium	American eel/WhitePerch
Chemical	1,2,3,4,7,8-HxCDD
Units	µg/kg

Data File

Variable: 1,2,3,4,7,8-HxCDD AE/WP

Raw Statistics	
Number of Valid Samples	64
Number of Unique Samples	62
Minimum	0.00015
Maximum	0.0122
Mean	0.001116
Median	0.000432
Standard Deviation	0.001855
Variance	3.44E-06
Coefficient of Variation	1.661642
Skewness	4.420321

Gamma Statistics	
k hat	0.991676
k star (bias corrected)	0.955608
Theta hat	0.001125
Theta star	0.001168
nu hat	126.9345
nu star	122.3178
Approx.Chi Square Value (.05)	97.77225
Adjusted Level of Significance	0.04625
Adjusted Chi Square Value	97.26825

Log-transformed Statistics	
Minimum of log data	-8.80488
Maximum of log data	-4.40632
Mean of log data	-7.38057
Standard Deviation of log data	0.965101
Variance of log data	0.93142

RECOMMENDATION

Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

Normal Distribution Test	
Lilliefors Test Statisitic	0.301207
Lilliefors 5% Critical Value	0.11075
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	0.001503

Gamma Distribution Test	
A-D Test Statistic	3.423429
A-D 5% Critical Value	0.780095
K-S Test Statistic	0.195069
K-S 5% Critical Value	0.11465
Data do not follow gamma distribution at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	0.001396
Adjusted Gamma UCL	0.001404

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.163567
Lilliefors 5% Critical Value	0.11075
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	0.001303
95% Chebyshev (MVUE) UCL	0.00159
97.5% Chebyshev (MVUE) UCL	0.001852
99% Chebyshev (MVUE) UCL	0.002368

95% Non-parametric UCLs	
CLT UCL	0.001497
Adj-CLT UCL (Adjusted for skewness)	0.001634
Mod-t UCL (Adjusted for skewness)	0.001524
Jackknife UCL	0.001503
Standard Bootstrap UCL	0.001493
Bootstrap-t UCL	0.001926
Hall's Bootstrap UCL	0.003392
Percentile Bootstrap UCL	0.001535
BCA Bootstrap UCL	0.001693
95% Chebyshev (Mean, Sd) UCL	**0.002127**
97.5% Chebyshev (Mean, Sd) UCL	0.002564
99% Chebyshev (Mean, Sd) UCL	0.003423

R2-0009538

Attachment 3

Type	ERA
Medium	American eel/WhitePerch
Chemical	1,2,3,4,7,8-HxCDF
Units	µg/kg

Data File

Raw Statistics

Number of Valid Samples	67
Number of Unique Samples	63
Minimum	0.00005
Maximum	0.0434
Mean	0.007924925
Median	0.00674
Standard Deviation	0.007227889
Variance	5.22424E-05
Coefficient of Variation	0.912045007
Skewness	2.688639424

Gamma Statistics

k hat	1.51189283
k star (bias corrected)	1.454146385
Theta hat	0.005241724
Theta star	0.005449881
nu hat	202.5936392
nu star	194.8556156
Approx.Chi Square Value (.05)	163.5542325
Adjusted Level of Significance	0.04641791
Adjusted Chi Square Value	162.9268452

Log-transformed Statistics

Minimum of log data	-9.903487553
Maximum of log data	-3.137295838
Mean of log data	-5.203555574
Standard Deviation of log data	0.992196754
Variance of log data	0.984454398

RECOMMENDATION

Data follow gamma distribution (0.05)

Use Approximate Gamma UCL

Variable: 1,2,3,4,7,8-HxCDF AE/WP

Normal Distribution Test

Lilliefors Test Statisitic	0.186332
Lilliefors 5% Critical Value	0.108242

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	0.009398

Gamma Distribution Test

A-D Test Statistic	0.590652
A-D 5% Critical Value	0.768752
K-S Test Statistic	0.091735
K-S 5% Critical Value	0.110931

Data follow gamma distribution

at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	**0.009442**
Adjusted Gamma UCL	0.009478

Lognormal Distribution Test

Lilliefors Test Statisitic	0.108626
Lilliefors 5% Critical Value	0.108242

Data not lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	0.011841
95% Chebyshev (MVUE) UCL	0.014468
97.5% Chebyshev (MVUE) UCL	0.016878
99% Chebyshev (MVUE) UCL	0.021613

95% Non-parametric UCLs

CLT UCL	0.009377
Adj-CLT UCL (Adjusted for skewness)	0.009687
Mod-t UCL (Adjusted for skewness)	0.009446
Jackknife UCL	0.009398
Standard Bootstrap UCL	0.009357
Bootstrap-t UCL	0.009778
Hall's Bootstrap UCL	0.010339
Percentile Bootstrap UCL	0.00955
BCA Bootstrap UCL	0.009696
95% Chebyshev (Mean, Sd) UCL	0.011774
97.5% Chebyshev (Mean, Sd) UCL	0.013439
99% Chebyshev (Mean, Sd) UCL	0.016711

R2-0009539

Attachment 3

Type	ERA
Medium	American eel/WhitePerch
Chemical	1,2,3,6,7,8-HxCDD
Units	µg/kg

Data File

Raw Statistics

Number of Valid Samples	67
Number of Unique Samples	62
Minimum	0.00052
Maximum	0.00492
Mean	0.002031119
Median	0.00174
Standard Deviation	0.001084888
Variance	1.17698E-06
Coefficient of Variation	0.534133224
Skewness	0.904568618

Gamma Statistics

k hat	3.741274983
k star (bias corrected)	3.583705456
Theta hat	0.000542895
Theta star	0.000566765
nu hat	501.3308477
nu star	480.2165311
Approx.Chi Square Value (.05)	430.392897
Adjusted Level of Significance	0.04641791
Adjusted Chi Square Value	429.3630983

Log-transformed Statistics

Minimum of log data	-7.561681746
Maximum of log data	-5.314446748
Mean of log data	-6.338724901
Standard Deviation of log data	0.540024569
Variance of log data	0.291626535

RECOMMENDATION

Data follow gamma distribution (0.05)

Use Approximate Gamma UCL

Variable: 1,2,3,6,7,8-HxCDD AE/WP

Normal Distribution Test

Lilliefors Test Statisitic	0.123822
Lilliefors 5% Critical Value	0.108242

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	0.002252

Gamma Distribution Test

A-D Test Statistic	0.48666
A-D 5% Critical Value	0.755697
K-S Test Statistic	0.090663
K-S 5% Critical Value	0.109415

Data follow gamma distribution at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	**0.002266**
Adjusted Gamma UCL	0.002272

Lognormal Distribution Test

Lilliefors Test Statisitic	0.092799
Lilliefors 5% Critical Value	0.108242

Data are lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	0.002316
95% Chebyshev (MVUE) UCL	0.002661
97.5% Chebyshev (MVUE) UCL	0.00293
99% Chebyshev (MVUE) UCL	0.003459

95% Non-parametric UCLs

CLT UCL	0.002249
Adj-CLT UCL (Adjusted for skewness)	0.002265
Mod-t UCL (Adjusted for skewness)	0.002255
Jackknife UCL	0.002252
Standard Bootstrap UCL	0.002244
Bootstrap-t UCL	0.00226
Hall's Bootstrap UCL	0.002267
Percentile Bootstrap UCL	0.002245
BCA Bootstrap UCL	0.002266
95% Chebyshev (Mean, Sd) UCL	0.002609
97.5% Chebyshev (Mean, Sd) UCL	0.002859
99% Chebyshev (Mean, Sd) UCL	0.00335

R2-0009540

Attachment 3

Type	ERA
Medium	American eel/WhitePerch
Chemical	1,2,3,6,7,8-HxCDF
Units	µg/kg

Data File

Raw Statistics

Number of Valid Samples	67
Number of Unique Samples	64
Minimum	0.00005
Maximum	0.0141
Mean	0.002815179
Median	0.002425
Standard Deviation	0.002240273
Variance	5.01882E-06
Coefficient of Variation	0.795783407
Skewness	2.450098365

Gamma Statistics

k hat	1.927023801
k star (bias corrected)	1.850689402
Theta hat	0.001460895
Theta star	0.001521152
nu hat	258.2211894
nu star	247.9923799
Approx.Chi Square Value (.05)	212.5248816
Adjusted Level of Significance	0.04641791
Adjusted Chi Square Value	211.807023

Log-transformed Statistics

Minimum of log data	-9.903487553
Maximum of log data	-4.261580482
Mean of log data	-6.154095774
Standard Deviation of log data	0.83443523
Variance of log data	0.696282154

RECOMMENDATION

Data follow gamma distribution (0.05)

Use Approximate Gamma UCL

Variable: 1,2,3,6,7,8-HxCDF AE/WP

Normal Distribution Test

Lilliefors Test Statisitic	0.186391
Lilliefors 5% Critical Value	0.108242

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	0.003272

Gamma Distribution Test

A-D Test Statistic	0.411342
A-D 5% Critical Value	0.764061
K-S Test Statistic	0.090003
K-S 5% Critical Value	0.110379

Data follow gamma distribution at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	**0.003285**
Adjusted Gamma UCL	0.003296

Lognormal Distribution Test

Lilliefors Test Statisitic	0.098743
Lilliefors 5% Critical Value	0.108242

Data are lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	0.003737
95% Chebyshev (MVUE) UCL	0.004499
97.5% Chebyshev (MVUE) UCL	0.005152
99% Chebyshev (MVUE) UCL	0.006435

95% Non-parametric UCLs

CLT UCL	0.003265
Adj-CLT UCL (Adjusted for skewness)	0.003353
Mod-t UCL (Adjusted for skewness)	0.003285
Jackknife UCL	0.003272
Standard Bootstrap UCL	0.003265
Bootstrap-t UCL	0.003376
Hall's Bootstrap UCL	0.00349
Percentile Bootstrap UCL	0.003289
BCA Bootstrap UCL	0.00337
95% Chebyshev (Mean, Sd) UCL	0.004008
97.5% Chebyshev (Mean, Sd) UCL	0.004524
99% Chebyshev (Mean, Sd) UCL	0.005538

R2-0009541

Attachment 3

Type	ERA
Medium	American eel/WhitePerch
Chemical	1,2,3,7,8,9-HxCDD
Units	µg/kg

Data File

Variable: 1,2,3,7,8,9-HxCDD AE/WP

Raw Statistics	
Number of Valid Samples	62
Number of Unique Samples	59
Minimum	0.000056
Maximum	0.0122
Mean	0.001098
Median	0.00028
Standard Deviation	0.002089
Variance	4.36E-06
Coefficient of Variation	1.902112
Skewness	3.468641

Gamma Statistics	
k hat	0.636696
k star (bias corrected)	0.616641
Theta hat	0.001725
Theta star	0.001781
nu hat	78.95035
nu star	76.46351
Approx.Chi Square Value (.05)	57.31777
Adjusted Level of Significance	0.046129
Adjusted Chi Square Value	56.92376

Log-transformed Statistics	
Minimum of log data	-9.79016
Maximum of log data	-4.40632
Mean of log data	-7.77619
Standard Deviation of log data	1.24905
Variance of log data	1.560126

RECOMMENDATION

Data are Non-parametric (0.05)

Use 97.5% Chebyshev (Mean, Sd) UCL

Normal Distribution Test	
Lilliefors Test Statisitic	0.340381
Lilliefors 5% Critical Value	0.112522
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	0.001541

Gamma Distribution Test	
A-D Test Statistic	5.568827
A-D 5% Critical Value	0.803028
K-S Test Statistic	0.269233
K-S 5% Critical Value	0.11847
Data do not follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	0.001465
Adjusted Gamma UCL	0.001475

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.191255
Lilliefors 5% Critical Value	0.112522
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	0.001373
95% Chebyshev (MVUE) UCL	0.00168
97.5% Chebyshev (MVUE) UCL	0.002019
99% Chebyshev (MVUE) UCL	0.002685

95% Non-parametric UCLs	
CLT UCL	0.001534
Adj-CLT UCL (Adjusted for skewness)	0.001659
Mod-t UCL (Adjusted for skewness)	0.001561
Jackknife UCL	0.001541
Standard Bootstrap UCL	0.001535
Bootstrap-t UCL	0.0018
Hall's Bootstrap UCL	0.00177
Percentile Bootstrap UCL	0.001574
BCA Bootstrap UCL	0.001708
95% Chebyshev (Mean, Sd) UCL	0.002254
97.5% Chebyshev (Mean, Sd) UCL	**0.002755**
99% Chebyshev (Mean, Sd) UCL	0.003738

R2-0009542

Attachment 3

Type	ERA
Medium	American eel/WhitePerch
Chemical	1,2,3,7,8,9-HxCDF
Units	µg/kg

Data File

Variable: 1,2,3,7,8,9-HxCDF AE/WP

Raw Statistics	
Number of Valid Samples	62
Number of Unique Samples	60
Minimum	1.38E-05
Maximum	0.0126
Mean	0.001698
Median	0.000123
Standard Deviation	0.002826
Variance	7.98E-06
Coefficient of Variation	1.664193
Skewness	2.188965

Gamma Statistics	
k hat	0.359301
k star (bias corrected)	0.352668
Theta hat	0.004725
Theta star	0.004814
nu hat	44.55331
nu star	43.73084
Approx.Chi Square Value (.05)	29.56332
Adjusted Level of Significance	0.046129
Adjusted Chi Square Value	29.28584

Log-transformed Statistics	
Minimum of log data	-11.1945
Maximum of log data	-4.37406
Mean of log data	-8.24193
Standard Deviation of log data	2.146667
Variance of log data	4.608178

RECOMMENDATION

Data are Non-parametric (0.05)

Use 99% Chebyshev (Mean, Sd) UCL

Normal Distribution Test	
Lilliefors Test Statisitic	0.345608
Lilliefors 5% Critical Value	0.112522
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	0.002297

Gamma Distribution Test	
A-D Test Statistic	4.381872
A-D 5% Critical Value	0.84963
K-S Test Statistic	0.28095
K-S 5% Critical Value	0.121776
Data do not follow gamma distribution at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	0.002512
Adjusted Gamma UCL	0.002535

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.184984
Lilliefors 5% Critical Value	0.112522
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	0.00718
95% Chebyshev (MVUE) UCL	0.006673
97.5% Chebyshev (MVUE) UCL	0.008541
99% Chebyshev (MVUE) UCL	0.012208

95% Non-parametric UCLs	
CLT UCL	0.002288
Adj-CLT UCL (Adjusted for skewness)	0.002395
Mod-t UCL (Adjusted for skewness)	0.002314
Jackknife UCL	0.002297
Standard Bootstrap UCL	0.002278
Bootstrap-t UCL	0.002413
Hall's Bootstrap UCL	0.002443
Percentile Bootstrap UCL	0.002331
BCA Bootstrap UCL	0.002416
95% Chebyshev (Mean, Sd) UCL	0.003262
97.5% Chebyshev (Mean, Sd) UCL	0.003939
99% Chebyshev (Mean, Sd) UCL	**0.005268**

R2-0009543

Attachment 3

Type	ERA
Medium	American eel/WhitePerch
Chemical	1,2,3,7,8-PeCDD
Units	µg/kg

Data File

Raw Statistics

Number of Valid Samples	67
Number of Unique Samples	64
Minimum	0.000229
Maximum	0.00772
Mean	0.002178806
Median	0.002
Standard Deviation	0.001498377
Variance	2.24513E-06
Coefficient of Variation	0.68770552
Skewness	1.306747393

Gamma Statistics

k hat	2.104038593
k star (bias corrected)	2.019778159
Theta hat	0.001035535
Theta star	0.001078735
nu hat	281.9411715
nu star	270.6502733
Approx.Chi Square Value (.05)	233.5440775
Adjusted Level of Significance	0.04641791
Adjusted Chi Square Value	232.7906242

Log-transformed Statistics

Minimum of log data	-8.381788554
Maximum of log data	-4.863940915
Mean of log data	-6.385053031
Standard Deviation of log data	0.77915446
Variance of log data	0.607081673

RECOMMENDATION

Data follow gamma distribution (0.05)

Use Approximate Gamma UCL

Variable: 1,2,3,7,8-PeCDD AE/WP

Normal Distribution Test

Lilliefors Test Statisitic	0.120532
Lilliefors 5% Critical Value	0.108242

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	0.002484

Gamma Distribution Test

A-D Test Statistic	0.340717
A-D 5% Critical Value	0.762654
K-S Test Statistic	0.092102
K-S 5% Critical Value	0.110217

Data follow gamma distribution
at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	**0.002525**
Adjusted Gamma UCL	0.002533

Lognormal Distribution Test

Lilliefors Test Statisitic	0.128205
Lilliefors 5% Critical Value	0.108242

Data not lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	0.002784
95% Chebyshev (MVUE) UCL	0.003328
97.5% Chebyshev (MVUE) UCL	0.003785
99% Chebyshev (MVUE) UCL	0.004683

95% Non-parametric UCLs

CLT UCL	0.00248
Adj-CLT UCL (Adjusted for skewness)	0.002511
Mod-t UCL (Adjusted for skewness)	0.002489
Jackknife UCL	0.002484
Standard Bootstrap UCL	0.002474
Bootstrap-t UCL	0.002518
Hall's Bootstrap UCL	0.002506
Percentile Bootstrap UCL	0.002478
BCA Bootstrap UCL	0.002515
95% Chebyshev (Mean, Sd) UCL	0.002977
97.5% Chebyshev (Mean, Sd) UCL	0.003322
99% Chebyshev (Mean, Sd) UCL	0.004

R2-0009544

Attachment 3

Type	ERA
Medium	American eel/WhitePerch
Chemical	1,2,3,7,8-PeCDF
Units	µg/kg

Data File

Raw Statistics

Number of Valid Samples	67
Number of Unique Samples	65
Minimum	0.0000245
Maximum	0.00894
Mean	0.00290891
Median	0.002475
Standard Deviation	0.002042828
Variance	4.17315E-06
Coefficient of Variation	0.702265719
Skewness	0.69315213

Gamma Statistics

k hat	1.357500085
k star (bias corrected)	1.306666748
Theta hat	0.002142844
Theta star	0.002226207
nu hat	181.9050114
nu star	175.0933442
Approx.Chi Square Value (.05)	145.4850651
Adjusted Level of Significance	0.04641791
Adjusted Chi Square Value	144.8944337

Log-transformed Statistics

Minimum of log data	-10.61683744
Maximum of log data	-4.71721969
Mean of log data	-6.251500902
Standard Deviation of log data	1.166662604
Variance of log data	1.361101633

RECOMMENDATION

Data are normal (0.05)

Use Student's-t UCL

Variable: 1,2,3,7,8-PeCDF AE/WP

Normal Distribution Test

Lilliefors Test Statisitic	0.104583
Lilliefors 5% Critical Value	0.108242

Data are normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	**0.003325**

Gamma Distribution Test

A-D Test Statistic	1.006772
A-D 5% Critical Value	0.772076
K-S Test Statistic	0.10602
K-S 5% Critical Value	0.111264

Data follow approximate gamma distibution at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	0.003501
Adjusted Gamma UCL	0.003515

Lognormal Distribution Test

Lilliefors Test Statisitic	0.173795
Lilliefors 5% Critical Value	0.108242

Data not lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	0.005396
95% Chebyshev (MVUE) UCL	0.006634
97.5% Chebyshev (MVUE) UCL	0.007885
99% Chebyshev (MVUE) UCL	0.010341

95% Non-parametric UCLs

CLT UCL	0.003319
Adj-CLT UCL (Adjusted for skewness)	0.003342
Mod-t UCL (Adjusted for skewness)	0.003329
Jackknife UCL	0.003325
Standard Bootstrap UCL	0.00332
Bootstrap-t UCL	0.003359
Hall's Bootstrap UCL	0.003351
Percentile Bootstrap UCL	0.003329
BCA Bootstrap UCL	0.003338
95% Chebyshev (Mean, Sd) UCL	0.003997
97.5% Chebyshev (Mean, Sd) UCL	0.004467
99% Chebyshev (Mean, Sd) UCL	0.005392

Attachment 3

Type	ERA
Medium	American eel/WhitePerch
Chemical	2,3,4,6,7,8-HxCDF
Units	µg/kg

Data File

Variable: 2,3,4,6,7,8-HxCDF AE/WP

Raw Statistics	
Number of Valid Samples	65
Number of Unique Samples	63
Minimum	0.000087
Maximum	0.0156
Mean	0.001669
Median	0.000586
Standard Deviation	0.003165
Variance	1E-05
Coefficient of Variation	1.896407
Skewness	3.388584

Gamma Statistics	
k hat	0.73607
k star (bias corrected)	0.712354
Theta hat	0.002267
Theta star	0.002343
nu hat	95.68907
nu star	92.60599
Approx.Chi Square Value (.05)	71.40994
Adjusted Level of Significance	0.046308
Adjusted Chi Square Value	70.98884

Log-transformed Statistics	
Minimum of log data	-9.3496
Maximum of log data	-4.16048
Mean of log data	-7.21096
Standard Deviation of log data	1.132143
Variance of log data	1.281748

RECOMMENDATION

Data are lognormal (0.05)

Use H-UCL

Normal Distribution Test	
Lilliefors Test Statisitic	0.313121
Lilliefors 5% Critical Value	0.109895
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	0.002324

Gamma Distribution Test	
A-D Test Statistic	4.44897
A-D 5% Critical Value	0.793664
K-S Test Statistic	0.187882
K-S 5% Critical Value	0.115063
Data do not follow gamma distribution at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	0.002164
Adjusted Gamma UCL	0.002177

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.096942
Lilliefors 5% Critical Value	0.109895
Data are lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	**0.001968**
95% Chebyshev (MVUE) UCL	0.002418
97.5% Chebyshev (MVUE) UCL	0.002867
99% Chebyshev (MVUE) UCL	0.00375

95% Non-parametric UCLs	
CLT UCL	0.002315
Adj-CLT UCL (Adjusted for skewness)	0.002491
Mod-t UCL (Adjusted for skewness)	0.002352
Jackknife UCL	0.002324
Standard Bootstrap UCL	0.002306
Bootstrap-t UCL	0.002688
Hall's Bootstrap UCL	0.002348
Percentile Bootstrap UCL	0.002343
BCA Bootstrap UCL	0.002511
95% Chebyshev (Mean, Sd) UCL	0.00338
97.5% Chebyshev (Mean, Sd) UCL	0.00412
99% Chebyshev (Mean, Sd) UCL	0.005575

R2-0009546

Attachment 3

Type	ERA
Medium	American eel/WhitePerch
Chemical	2,3,4,7,8-PeCDF
Units	µg/kg

Data File

Raw Statistics

Number of Valid Samples	67
Number of Unique Samples	62
Minimum	0.000136
Maximum	0.0423
Mean	0.009111791
Median	0.0076
Standard Deviation	0.00842561
Variance	7.09909E-05
Coefficient of Variation	0.92469304
Skewness	1.609948794

Gamma Statistics

k hat	0.95759148
k star (bias corrected)	0.924664498
Theta hat	0.009515322
Theta star	0.009854159
nu hat	128.3172583
nu star	123.9050428
Approx.Chi Square Value (.05)	99.19276809
Adjusted Level of Significance	0.04641791
Adjusted Chi Square Value	98.70837092

Log-transformed Statistics

Minimum of log data	-8.902855672
Maximum of log data	-3.162968193
Mean of log data	-5.304074775
Standard Deviation of log data	1.353261333
Variance of log data	1.831316236

RECOMMENDATION

Data are Non-parametric (0.05)

Use 97.5% Chebyshev (Mean, Sd) UCL

Variable: 2,3,4,7,8-PeCDF AE/WP

Normal Distribution Test

Lilliefors Test Statisitic	0.154141
Lilliefors 5% Critical Value	0.108242

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	0.010829

Gamma Distribution Test

A-D Test Statistic	1.235992
A-D 5% Critical Value	0.782173
K-S Test Statistic	0.15137
K-S 5% Critical Value	0.112258

Data do not follow gamma distribution at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	0.011382
Adjusted Gamma UCL	0.011438

Lognormal Distribution Test

Lilliefors Test Statisitic	0.220578
Lilliefors 5% Critical Value	0.108242

Data not lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	0.019261
95% Chebyshev (MVUE) UCL	0.023508
97.5% Chebyshev (MVUE) UCL	0.028439
99% Chebyshev (MVUE) UCL	0.038126

95% Non-parametric UCLs

CLT UCL	0.010805
Adj-CLT UCL (Adjusted for skewness)	0.011021
Mod-t UCL (Adjusted for skewness)	0.010863
Jackknife UCL	0.010829
Standard Bootstrap UCL	0.010748
Bootstrap-t UCL	0.011105
Hall's Bootstrap UCL	0.011146
Percentile Bootstrap UCL	0.010879
BCA Bootstrap UCL	0.010931
95% Chebyshev (Mean, Sd) UCL	0.013599
97.5% Chebyshev (Mean, Sd) UCL	**0.01554**
99% Chebyshev (Mean, Sd) UCL	0.019354

R2-0009547

Attachment 3

Type	ERA
Medium	American eel/WhitePerch
Chemical	2,3,7,8-TCDD
Units	µg/kg

Data File

Raw Statistics

Number of Valid Samples	67
Number of Unique Samples	64
Minimum	0.0018
Maximum	0.467
Mean	0.143448
Median	0.127
Standard Deviation	0.119719
Variance	0.014333
Coefficient of Variation	0.834584
Skewness	0.595266

Gamma Statistics

k hat	0.975749
k star (bias corrected)	0.942009
Theta hat	0.147013
Theta star	0.152279
nu hat	130.7504
nu star	126.2292
Approx.Chi Square Value (.05)	101.2747
Adjusted Level of Significance	0.046418
Adjusted Chi Square Value	100.7851

Log-transformed Statistics

Minimum of log data	-6.31997
Maximum of log data	-0.76143
Mean of log data	-2.53506
Standard Deviation of log data	1.334568
Variance of log data	1.781073

RECOMMENDATION

Data are Non-parametric (0.05)

Use 97.5% Chebyshev (Mean, Sd) UCL

Variable: 2,3,7,8-TCDD AE/WP

Normal Distribution Test

Lilliefors Test Statisitic	0.153034
Lilliefors 5% Critical Value	0.108242

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	0.167848

Gamma Distribution Test

A-D Test Statistic	1.35278
A-D 5% Critical Value	0.781276
K-S Test Statistic	0.137031
K-S 5% Critical Value	0.112173

Data do not follow gamma distribution at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	0.178794
Adjusted Gamma UCL	0.179663

Lognormal Distribution Test

Lilliefors Test Statisitic	0.168276
Lilliefors 5% Critical Value	0.108242

Data not lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	0.296615
95% Chebyshev (MVUE) UCL	0.362538
97.5% Chebyshev (MVUE) UCL	0.437854
99% Chebyshev (MVUE) UCL	0.585798

95% Non-parametric UCLs

CLT UCL	0.167506
Adj-CLT UCL (Adjusted for skewness)	0.168642
Mod-t UCL (Adjusted for skewness)	0.168026
Jackknife UCL	0.167848
Standard Bootstrap UCL	0.167797
Bootstrap-t UCL	0.168987
Hall's Bootstrap UCL	0.167492
Percentile Bootstrap UCL	0.166587
BCA Bootstrap UCL	0.167228
95% Chebyshev (Mean, Sd) UCL	0.207202
97.5% Chebyshev (Mean, Sd) UCL	**0.234788**
99% Chebyshev (Mean, Sd) UCL	0.288976

R2-0009548

Attachment 3

Type	ERA
Medium	American eel/WhitePerch
Chemical	2,3,7,8-TCDF
Units	µg/kg

Data File

Variable: 2,3,7,8-TCDF AE/WP

Raw Statistics	
Number of Valid Samples	89
Number of Unique Samples	82
Minimum	1.25E-05
Maximum	0.0443
Mean	0.016301
Median	0.0173
Standard Deviation	0.011403
Variance	0.00013
Coefficient of Variation	0.699569
Skewness	0.042394

Gamma Statistics	
k hat	0.614243
k star (bias corrected)	0.601029
Theta hat	0.026538
Theta star	0.027121
nu hat	109.3353
nu star	106.9831
Approx.Chi Square Value (.05)	84.1079
Adjusted Level of Significance	0.047303
Adjusted Chi Square Value	83.77557

Log-transformed Statistics	
Minimum of log data	-11.2898
Maximum of log data	-3.11677
Mean of log data	-5.11901
Standard Deviation of log data	2.300748
Variance of log data	5.293442

Normal Distribution Test	
Lilliefors Test Statisitic	0.141826
Lilliefors 5% Critical Value	0.093916
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	0.01831

Gamma Distribution Test	
A-D Test Statistic	8.76985
A-D 5% Critical Value	0.807078
K-S Test Statistic	0.259395
K-S 5% Critical Value	0.099426
Data do not follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	0.020734
Adjusted Gamma UCL	0.020816

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.314933
Lilliefors 5% Critical Value	0.093916
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	0.209714
95% Chebyshev (MVUE) UCL	0.210674
97.5% Chebyshev (MVUE) UCL	0.268812
99% Chebyshev (MVUE) UCL	0.383011

95% Non-parametric UCLs	
CLT UCL	0.018289
Adj-CLT UCL (Adjusted for skewness)	0.018295
Mod-t UCL (Adjusted for skewness)	0.018311
Jackknife UCL	0.01831
Standard Bootstrap UCL	0.018312
Bootstrap-t UCL	0.018311
Hall's Bootstrap UCL	0.018318
Percentile Bootstrap UCL	0.018204
BCA Bootstrap UCL	0.018312
95% Chebyshev (Mean, Sd) UCL	0.021569
97.5% Chebyshev (Mean, Sd) UCL	0.023849
99% Chebyshev (Mean, Sd) UCL	**0.028328**

RECOMMENDATION

Data are Non-parametric (0.05)

Use 99% Chebyshev (Mean, Sd) UCL

R2-0009549

Attachment 3

Type	ERA
Medium	American eel/WhitePerch
Chemical	OCDD
Units	µg/kg

Data File

Raw Statistics

Number of Valid Samples	67
Number of Unique Samples	61
Minimum	0.000548
Maximum	0.0163
Mean	0.003717672
Median	0.00251
Standard Deviation	0.003396247
Variance	1.15345E-05
Coefficient of Variation	0.913541342
Skewness	2.206311737

Gamma Statistics

k hat	1.771210455
k star (bias corrected)	1.701852773
Theta hat	0.002098944
Theta star	0.002184485
nu hat	237.342201
nu star	228.0482716
Approx.Chi Square Value (.05)	194.0864501
Adjusted Level of Significance	0.04641791
Adjusted Chi Square Value	193.4012928

Log-transformed Statistics

Minimum of log data	-7.509235271
Maximum of log data	-4.116590171
Mean of log data	-5.902766627
Standard Deviation of log data	0.781169654
Variance of log data	0.610226028

RECOMMENDATION

Data are lognormal (0.05)

Use H-UCL

Variable: OCDD AE/WP

Normal Distribution Test

Lilliefors Test Statisitic	0.213456
Lilliefors 5% Critical Value	0.108242

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	0.00441

Gamma Distribution Test

A-D Test Statistic	1.48498
A-D 5% Critical Value	0.765822
K-S Test Statistic	0.111497
K-S 5% Critical Value	0.110586

Data do not follow gamma distribution at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	0.004368
Adjusted Gamma UCL	0.004384

Lognormal Distribution Test

Lilliefors Test Statisitic	0.081425
Lilliefors 5% Critical Value	0.108242

Data are lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	**0.004519**
95% Chebyshev (MVUE) UCL	0.005404
97.5% Chebyshev (MVUE) UCL	0.006148
99% Chebyshev (MVUE) UCL	0.007609

95% Non-parametric UCLs

CLT UCL	0.0044
Adj-CLT UCL (Adjusted for skewness)	0.00452
Mod-t UCL (Adjusted for skewness)	0.004429
Jackknife UCL	0.00441
Standard Bootstrap UCL	0.004404
Bootstrap-t UCL	0.004576
Hall's Bootstrap UCL	0.004572
Percentile Bootstrap UCL	0.004454
BCA Bootstrap UCL	0.004466
95% Chebyshev (Mean, Sd) UCL	0.005526
97.5% Chebyshev (Mean, Sd) UCL	0.006309
99% Chebyshev (Mean, Sd) UCL	0.007846

R2-0009550

Attachment 3

Type	ERA
Medium	American eel/WhitePerch
Chemical	OCDF
Units	µg/kg

Data File

Variable: OCDF AE/WP

Raw Statistics	
Number of Valid Samples	65
Number of Unique Samples	61
Minimum	0.00012
Maximum	0.01575
Mean	0.001349
Median	0.000405
Standard Deviation	0.002462
Variance	6.06E-06
Coefficient of Variation	1.825398
Skewness	4.060358

Gamma Statistics	
k hat	0.72817
k star (bias corrected)	0.704819
Theta hat	0.001852
Theta star	0.001914
nu hat	94.66212
nu star	91.62644
Approx.Chi Square Value (.05)	70.54941
Adjusted Level of Significance	0.046308
Adjusted Chi Square Value	70.13097

Log-transformed Statistics	
Minimum of log data	-9.03219
Maximum of log data	-4.15091
Mean of log data	-7.43391
Standard Deviation of log data	1.168103
Variance of log data	1.364464

RECOMMENDATION

Data are Non-parametric (0.05)

Use 97.5% Chebyshev (Mean, Sd) UCL

Normal Distribution Test	
Lilliefors Test Statisitic	0.308786
Lilliefors 5% Critical Value	0.109895
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	0.001859

Gamma Distribution Test	
A-D Test Statistic	4.549468
A-D 5% Critical Value	0.794424
K-S Test Statistic	0.248779
K-S 5% Critical Value	0.115126
Data do not follow gamma distribution at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	0.001752
Adjusted Gamma UCL	0.001762

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.163259
Lilliefors 5% Critical Value	0.109895
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	0.001669
95% Chebyshev (MVUE) UCL	0.00205
97.5% Chebyshev (MVUE) UCL	0.00244
99% Chebyshev (MVUE) UCL	0.003205

95% Non-parametric UCLs	
CLT UCL	0.001851
Adj-CLT UCL (Adjusted for skewness)	0.002016
Mod-t UCL (Adjusted for skewness)	0.001884
Jackknife UCL	0.001859
Standard Bootstrap UCL	0.001855
Bootstrap-t UCL	0.002294
Hall's Bootstrap UCL	0.004126
Percentile Bootstrap UCL	0.001854
BCA Bootstrap UCL	0.002076
95% Chebyshev (Mean, Sd) UCL	0.00268
97.5% Chebyshev (Mean, Sd) UCL	**0.003256**
99% Chebyshev (Mean, Sd) UCL	0.004388

R2-0009551

Attachment 3

Type	ERA
Medium	American eel/WhitePerch
Chemical	Lipids
Units	µg/kg

Data File

Variable: Lipids AE/WP

Raw Statistics	
Number of Valid Samples	42
Number of Unique Samples	41
Minimum	1.78
Maximum	13.74
Mean	6.798786
Median	6.801
Standard Deviation	2.888525
Variance	8.343578
Coefficient of Variation	0.424859
Skewness	0.06061

Gamma Statistics	
k hat	4.771992
k star (bias corrected)	4.447009
Theta hat	1.424727
Theta star	1.528845
nu hat	400.8473
nu star	373.5487
Approx.Chi Square Value (.05)	329.7462
Adjusted Level of Significance	0.044286
Adjusted Chi Square Value	328.2863

Log-transformed Statistics	
Minimum of log data	0.576613
Maximum of log data	2.620311
Mean of log data	1.808322
Standard Deviation of log data	0.502567
Variance of log data	0.252573

RECOMMENDATION

Assuming gamma distribution (0.05)

Use Approximate Gamma UCL

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.909605
Shapiro-Wilk 5% Critical Value	0.942
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	7.54886

Gamma Distribution Test	
A-D Test Statistic	0.820989
A-D 5% Critical Value	0.752288
K-S Test Statistic	0.109068
K-S 5% Critical Value	0.136842
Data follow approximate gamma distibution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	**7.701916**
Adjusted Gamma UCL	7.736168

Lognormal Distribution Test	
Shapiro-Wilk Test Statisitic	0.877941
Shapiro-Wilk 5% Critical Value	0.942
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	8.035203
95% Chebyshev (MVUE) UCL	9.343986
97.5% Chebyshev (MVUE) UCL	10.40231
99% Chebyshev (MVUE) UCL	12.48117

95% Non-parametric UCLs	
CLT UCL	7.531912
Adj-CLT UCL (Adjusted for skewness)	7.536366
Mod-t UCL (Adjusted for skewness)	7.549554
Jackknife UCL	7.54886
Standard Bootstrap UCL	7.516042
Bootstrap-t UCL	7.542587
Hall's Bootstrap UCL	7.503309
Percentile Bootstrap UCL	7.573024
BCA Bootstrap UCL	7.496762
95% Chebyshev (Mean, Sd) UCL	8.741587
97.5% Chebyshev (Mean, Sd) UCL	9.582238
99% Chebyshev (Mean, Sd) UCL	11.23354

R2-0009552

Attachment 3

Type	ERA
Medium	American eel/WhitePerch
Chemical	2,3,3',4,4',5,5'-Heptachlorobiphenyl (189)
Units	µg/kg

Data File

Variable: 2,3,3',4,4',5,5'-Heptachlorobiphenyl (189) AE/WP

Raw Statistics	
Number of Valid Samples	77
Number of Unique Samples	58
Minimum	0.1
Maximum	18.27
Mean	1.973579
Median	1.36
Standard Deviation	2.683098
Variance	7.199015
Coefficient of Variation	1.359509
Skewness	4.089245

Gamma Statistics	
k hat	0.920851
k star (bias corrected)	0.893632
Theta hat	2.143211
Theta star	2.208491
nu hat	141.8111
nu star	137.6193
Approx.Chi Square Value (.05)	111.5089
Adjusted Level of Significance	0.046883
Adjusted Chi Square Value	111.0627

Log-transformed Statistics	
Minimum of log data	-2.30259
Maximum of log data	2.90526
Mean of log data	0.046784
Standard Deviation of log data	1.252316
Variance of log data	1.568294

RECOMMENDATION

Assuming gamma distribution (0.05)

Use Approximate Gamma UCL

Normal Distribution Test	
Lilliefors Test Statisitic	0.242498
Lilliefors 5% Critical Value	0.100969
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	2.482727

Gamma Distribution Test	
A-D Test Statistic	1.224139
A-D 5% Critical Value	0.785135
K-S Test Statistic	0.09583
K-S 5% Critical Value	0.105087
Data follow approximate gamma distibution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	**2.435702**
Adjusted Gamma UCL	2.445488

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.131251
Lilliefors 5% Critical Value	0.100969
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	3.284937
95% Chebyshev (MVUE) UCL	4.049517
97.5% Chebyshev (MVUE) UCL	4.825899
99% Chebyshev (MVUE) UCL	6.350952

95% Non-parametric UCLs	
CLT UCL	2.476521
Adj-CLT UCL (Adjusted for skewness)	2.628775
Mod-t UCL (Adjusted for skewness)	2.506476
Jackknife UCL	2.482727
Standard Bootstrap UCL	2.472494
Bootstrap-t UCL	2.822731
Hall's Bootstrap UCL	4.958555
Percentile Bootstrap UCL	2.524825
BCA Bootstrap UCL	2.687078
95% Chebyshev (Mean, Sd) UCL	3.306388
97.5% Chebyshev (Mean, Sd) UCL	3.883095
99% Chebyshev (Mean, Sd) UCL	5.015926

R2-0009553

Attachment 3

Type	ERA
Medium	American eel/WhitePerch
Chemical	2,3,3',4,4',5'-hexachlorobiphenyl (157)
Units	µg/kg

Data File		Variable:	2,3,3',4,4',5'-hexachlorobiphenyl	AE/WP
Raw Statistics		Normal Distribution Test		
Number of Valid Samples	77	Lilliefors Test Statisitic		0.357666
Number of Unique Samples	71	Lilliefors 5% Critical Value		0.100969
Minimum	0.1	Data not normal at 5% significance level		
Maximum	68.2			
Mean	3.613739	95% UCL (Assuming Normal Distribution)		
Median	2.44	Student's-t UCL		5.130134
Standard Deviation	7.991052			
Variance	63.85691	Gamma Distribution Test		
Coefficient of Variation	2.211297	A-D Test Statistic		6.215715
Skewness	7.363333	A-D 5% Critical Value		0.777159
		K-S Test Statistic		0.246426
Gamma Statistics		K-S 5% Critical Value		0.104329
k hat	1.187407	Data do not follow gamma distribution		
k star (bias corrected)	1.149802	at 5% significance level		
Theta hat	3.043388			
Theta star	3.142923	95% UCLs (Assuming Gamma Distribution)		
nu hat	182.8606	Approximate Gamma UCL		4.344441
nu star	177.0695	Adjusted Gamma UCL		4.359693
Approx.Chi Square Value (.05)	147.2877			
Adjusted Level of Significance	0.046883	Lognormal Distribution Test		
Adjusted Chi Square Value	146.7725	Lilliefors Test Statisitic		0.149589
		Lilliefors 5% Critical Value		0.100969
Log-transformed Statistics		Data not lognormal at 5% significance level		
Minimum of log data	-2.30259			
Maximum of log data	4.222445	95% UCLs (Assuming Lognormal Distribution)		
Mean of log data	0.807853	95% H-UCL		3.807455
Standard Deviation of log data	0.817733	95% Chebyshev (MVUE) UCL		4.551987
Variance of log data	0.668687	97.5% Chebyshev (MVUE) UCL		5.173444
		99% Chebyshev (MVUE) UCL		6.394175
		95% Non-parametric UCLs		
		CLT UCL		5.111649
		Adj-CLT UCL (Adjusted for skewness)		5.928172
		Mod-t UCL (Adjusted for skewness)		5.257495
		Jackknife UCL		5.130134
		Standard Bootstrap UCL		5.109379
		Bootstrap-t UCL		10.33849
RECOMMENDATION		Hall's Bootstrap UCL		11.51752
Data are Non-parametric (0.05)		Percentile Bootstrap UCL		5.341766
		BCA Bootstrap UCL		6.513555
Use 95% Chebyshev (Mean, Sd) UCL		**95% Chebyshev (Mean, Sd) UCL**		**7.583235**
		97.5% Chebyshev (Mean, Sd) UCL		9.300839
		99% Chebyshev (Mean, Sd) UCL		12.67474

R2-0009554

Attachment 3

Type	ERA
Medium	American eel/WhitePerch
Chemical	2,3,3',4,4',5-Hexachlorobiphenyl (156)
Units	µg/kg

Data File		Variable: 2,3,3',4,4',5-Hexachlorobiphenyl (156)	AE/WP
Raw Statistics		Normal Distribution Test	
Number of Valid Samples	77	Lilliefors Test Statisitic	0.176005
Number of Unique Samples	74	Lilliefors 5% Critical Value	0.100969
Minimum	1.27	Data not normal at 5% significance level	
Maximum	100.55		
Mean	15.87545	95% UCL (Assuming Normal Distribution)	
Median	12	Student's-t UCL	18.36442
Standard Deviation	13.11629		
Variance	172.0371	Gamma Distribution Test	
Coefficient of Variation	0.826199	A-D Test Statistic	0.930171
Skewness	3.907207	A-D 5% Critical Value	0.761074
		K-S Test Statistic	0.088727
Gamma Statistics		K-S 5% Critical Value	0.102814
k hat	2.447842	Data follow approximate gamma distibution	
k star (bias corrected)	2.36113	at 5% significance level	
Theta hat	6.485489		
Theta star	6.723668	95% UCLs (Assuming Gamma Distribution)	
nu hat	376.9677	**Approximate Gamma UCL**	**18.01588**
nu star	363.614	Adjusted Gamma UCL	18.05916
Approx.Chi Square Value (.05)	320.4139		
Adjusted Level of Significance	0.046883	Lognormal Distribution Test	
Adjusted Chi Square Value	319.646	Lilliefors Test Statisitic	0.075159
		Lilliefors 5% Critical Value	0.100969
Log-transformed Statistics		Data are lognormal at 5% significance level	
Minimum of log data	0.239017		
Maximum of log data	4.610655	95% UCLs (Assuming Lognormal Distribution)	
Mean of log data	2.546821	95% H-UCL	18.36431
Standard Deviation of log data	0.657859	95% Chebyshev (MVUE) UCL	21.42624
Variance of log data	0.432779	97.5% Chebyshev (MVUE) UCL	23.86201
		99% Chebyshev (MVUE) UCL	28.64663
		95% Non-parametric UCLs	
		CLT UCL	18.33408
		Adj-CLT UCL (Adjusted for skewness)	19.04524
		Mod-t UCL (Adjusted for skewness)	18.47535
		Jackknife UCL	18.36442
		Standard Bootstrap UCL	18.22317
		Bootstrap-t UCL	19.59828
RECOMMENDATION		Hall's Bootstrap UCL	23.4168
Assuming gamma distribution (0.05)		Percentile Bootstrap UCL	18.39013
		BCA Bootstrap UCL	19.17571
Use Approximate Gamma UCL		95% Chebyshev (Mean, Sd) UCL	22.39087
		97.5% Chebyshev (Mean, Sd) UCL	25.2101
		99% Chebyshev (Mean, Sd) UCL	30.74793

R2-0009555

Attachment 3

Type	ERA
Medium	American eel/WhitePerch
Chemical	2,3,3',4,4'-Pentachlorobiphenyl (105)
Units	µg/kg

Data File		Variable: 2,3,3',4,4'-Pentachlorobiphenyl (105)	AE/WP
Raw Statistics		Normal Distribution Test	
Number of Valid Samples	77	Lilliefors Test Statisitic	0.152089
Number of Unique Samples	76	Lilliefors 5% Critical Value	0.100969
Minimum	4.03	Data not normal at 5% significance level	
Maximum	145.32		
Mean	44.5887	95% UCL (Assuming Normal Distribution)	
Median	36.94	Student's-t UCL	48.83949
Standard Deviation	22.40068		
Variance	501.7903	Gamma Distribution Test	
Coefficient of Variation	0.502385	A-D Test Statistic	0.508624
Skewness	1.469695	A-D 5% Critical Value	0.75577
		K-S Test Statistic	0.100612
Gamma Statistics		K-S 5% Critical Value	0.102164
k hat	4.197081	Data follow gamma distribution	
k star (bias corrected)	4.042217	at 5% significance level	
Theta hat	10.62374		
Theta star	11.03075	95% UCLs (Assuming Gamma Distribution)	
nu hat	646.3505	**Approximate Gamma UCL**	**49.07356**
nu star	622.5014	Adjusted Gamma UCL	49.16272
Approx.Chi Square Value (.05)	565.6106		
Adjusted Level of Significance	0.046883	Lognormal Distribution Test	
Adjusted Chi Square Value	564.5848	Lilliefors Test Statisitic	0.084451
		Lilliefors 5% Critical Value	0.100969
Log-transformed Statistics		Data are lognormal at 5% significance level	
Minimum of log data	1.393766		
Maximum of log data	4.978938	95% UCLs (Assuming Lognormal Distribution)	
Mean of log data	3.673646	95% H-UCL	50.74843
Standard Deviation of log data	0.529311	95% Chebyshev (MVUE) UCL	57.83075
Variance of log data	0.280171	97.5% Chebyshev (MVUE) UCL	63.28492
		99% Chebyshev (MVUE) UCL	73.99859
		95% Non-parametric UCLs	
		CLT UCL	48.78767
		Adj-CLT UCL (Adjusted for skewness)	49.24453
		Mod-t UCL (Adjusted for skewness)	48.91075
		Jackknife UCL	48.83949
		Standard Bootstrap UCL	48.66643
		Bootstrap-t UCL	49.3006
RECOMMENDATION		Hall's Bootstrap UCL	49.87321
Data follow gamma distribution (0.05)		Percentile Bootstrap UCL	48.83117
		BCA Bootstrap UCL	48.73052
Use Approximate Gamma UCL		95% Chebyshev (Mean, Sd) UCL	55.71607
		97.5% Chebyshev (Mean, Sd) UCL	60.53089
		99% Chebyshev (Mean, Sd) UCL	69.98868

R2-0009556

Attachment 3

Type	ERA
Medium	American eel/WhitePerch
Chemical	2,3',4,4',5,5'-Hexachlorobiphenyl (167)
Units	µg/kg

Data File		Variable: 2,3',4,4',5,5'-Hexachlorobiphenyl (167)	AE/WP
Raw Statistics		Normal Distribution Test	
Number of Valid Samples	77	Lilliefors Test Statisitic	0.212247
Number of Unique Samples	76	Lilliefors 5% Critical Value	0.100969
Minimum	0.66	Data not normal at 5% significance level	
Maximum	44.59		
Mean	7.694156	95% UCL (Assuming Normal Distribution)	
Median	6.39	Student's-t UCL	8.86898
Standard Deviation	6.191056		
Variance	38.32917	Gamma Distribution Test	
Coefficient of Variation	0.804644	A-D Test Statistic	1.018307
Skewness	3.419189	A-D 5% Critical Value	0.760935
		K-S Test Statistic	0.117586
Gamma Statistics		K-S 5% Critical Value	0.102797
k hat	2.476999	Data do not follow gamma distribution	
k star (bias corrected)	2.38915	at 5% significance level	
Theta hat	3.106241		
Theta star	3.220457	95% UCLs (Assuming Gamma Distribution)	
nu hat	381.4578	Approximate Gamma UCL	8.7248
nu star	367.9291	Adjusted Gamma UCL	8.74563
Approx.Chi Square Value (.05)	324.4664		
Adjusted Level of Significance	0.046883	Lognormal Distribution Test	
Adjusted Chi Square Value	323.6935	Lilliefors Test Statisitic	0.087337
		Lilliefors 5% Critical Value	0.100969
Log-transformed Statistics		Data are lognormal at 5% significance level	
Minimum of log data	-0.41552		
Maximum of log data	3.79751	95% UCLs (Assuming Lognormal Distribution)	
Mean of log data	1.825228	**95% H-UCL**	**8.890855**
Standard Deviation of log data	0.653797	95% Chebyshev (MVUE) UCL	10.36604
Variance of log data	0.427451	97.5% Chebyshev (MVUE) UCL	11.53828
		99% Chebyshev (MVUE) UCL	13.8409
		95% Non-parametric UCLs	
		CLT UCL	8.85466
		Adj-CLT UCL (Adjusted for skewness)	9.148409
		Mod-t UCL (Adjusted for skewness)	8.914799
		Jackknife UCL	8.86898
		Standard Bootstrap UCL	8.88412
		Bootstrap-t UCL	9.344409
RECOMMENDATION		Hall's Bootstrap UCL	9.82844
Data are lognormal (0.05)		Percentile Bootstrap UCL	8.832727
		BCA Bootstrap UCL	9.314675
Use H-UCL		95% Chebyshev (Mean, Sd) UCL	10.76952
		97.5% Chebyshev (Mean, Sd) UCL	12.10023
		99% Chebyshev (Mean, Sd) UCL	14.71415

R2-0009557

Attachment 3

Type	ERA
Medium	American eel/WhitePerch
Chemical	2',3,4,4',5-pentachlorobiphenyl (123)
Units	µg/kg

Data File		Variable:	2',3,4,4',5-pentachlorobiphenyl AE/WP
Raw Statistics		Normal Distribution Test	
Number of Valid Samples	77	Lilliefors Test Statisitic	0.199229
Number of Unique Samples	57	Lilliefors 5% Critical Value	0.100969
Minimum	0.1	Data not normal at 5% significance level	
Maximum	14.6		
Mean	2.195273	95% UCL (Assuming Normal Distribution)	
Median	1.71	Student's-t UCL	2.666155
Standard Deviation	2.481439		
Variance	6.157539	Gamma Distribution Test	
Coefficient of Variation	1.130355	A-D Test Statistic	1.885983
Skewness	3.030227	A-D 5% Critical Value	0.78606
		K-S Test Statistic	0.137356
Gamma Statistics		K-S 5% Critical Value	0.105171
k hat	0.900642	Data do not follow gamma distribution	
k star (bias corrected)	0.87421	at 5% significance level	
Theta hat	2.437453		
Theta star	2.51115	95% UCLs (Assuming Gamma Distribution)	
nu hat	138.6989	Approximate Gamma UCL	2.715999
nu star	134.6284	Adjusted Gamma UCL	2.727041
Approx.Chi Square Value (.05)	108.8167		
Adjusted Level of Significance	0.046883	Lognormal Distribution Test	
Adjusted Chi Square Value	108.3761	Lilliefors Test Statisitic	0.179092
		Lilliefors 5% Critical Value	0.100969
Log-transformed Statistics		Data not lognormal at 5% significance level	
Minimum of log data	-2.30259		
Maximum of log data	2.681022	95% UCLs (Assuming Lognormal Distribution)	
Mean of log data	0.137261	95% H-UCL	4.376506
Standard Deviation of log data	1.363677	95% Chebyshev (MVUE) UCL	5.380723
Variance of log data	1.859615	97.5% Chebyshev (MVUE) UCL	6.479226
		99% Chebyshev (MVUE) UCL	8.637021
		95% Non-parametric UCLs	
		CLT UCL	2.660415
		Adj-CLT UCL (Adjusted for skewness)	2.76476
		Mod-t UCL (Adjusted for skewness)	2.682431
		Jackknife UCL	2.666155
		Standard Bootstrap UCL	2.670449
		Bootstrap-t UCL	2.885208
RECOMMENDATION		Hall's Bootstrap UCL	2.945512
Data are Non-parametric (0.05)		Percentile Bootstrap UCL	2.688505
		BCA Bootstrap UCL	2.798278
Use 97.5% Chebyshev (Mean, Sd) UCL		95% Chebyshev (Mean, Sd) UCL	3.42791
		97.5% Chebyshev (Mean, Sd) UCL	**3.961273**
		99% Chebyshev (Mean, Sd) UCL	5.008961

R2-0009558

Attachment 3

Type	ERA
Medium	American eel/WhitePerch
Chemical	2,3,4,4',5-Pentachlorobiphenyl (114)
Units	µg/kg

Data File	
Variable:	2,3,4,4',5-Pentachlorobiphenyl (114) AE/WP

Raw Statistics	
Number of Valid Samples	77
Number of Unique Samples	57
Minimum	0.1
Maximum	12.07
Mean	2.244869
Median	2.02
Standard Deviation	1.94993
Variance	3.802226
Coefficient of Variation	0.868616
Skewness	1.8123

Gamma Statistics	
k hat	0.915307
k star (bias corrected)	0.888304
Theta hat	2.452586
Theta star	2.527141
nu hat	140.9573
nu star	136.7988
Approx.Chi Square Value (.05)	110.77
Adjusted Level of Significance	0.046883
Adjusted Chi Square Value	110.3254

Log-transformed Statistics	
Minimum of log data	-2.30259
Maximum of log data	2.490723
Mean of log data	0.171275
Standard Deviation of log data	1.438625
Variance of log data	2.069643

RECOMMENDATION

Data are Non-parametric (0.05)

Use 97.5% Chebyshev (Mean, Sd) UCL

Normal Distribution Test	
Lilliefors Test Statisitic	0.135672
Lilliefors 5% Critical Value	0.100969
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	2.614891

Gamma Distribution Test	
A-D Test Statistic	3.723986
A-D 5% Critical Value	0.785389
K-S Test Statistic	0.166559
K-S 5% Critical Value	0.10511
Data do not follow gamma distribution at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	2.77237
Adjusted Gamma UCL	2.783544

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.237182
Lilliefors 5% Critical Value	0.100969
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	5.215522
95% Chebyshev (MVUE) UCL	6.381981
97.5% Chebyshev (MVUE) UCL	7.735696
99% Chebyshev (MVUE) UCL	10.39481

95% Non-parametric UCLs	
CLT UCL	2.610381
Adj-CLT UCL (Adjusted for skewness)	2.65942
Mod-t UCL (Adjusted for skewness)	2.62254
Jackknife UCL	2.614891
Standard Bootstrap UCL	2.603351
Bootstrap-t UCL	2.668167
Hall's Bootstrap UCL	2.750048
Percentile Bootstrap UCL	2.620582
BCA Bootstrap UCL	2.657309
95% Chebyshev (Mean, Sd) UCL	3.213483
97.5% Chebyshev (Mean, Sd) UCL	**3.632603**
99% Chebyshev (Mean, Sd) UCL	4.455882

R2-0009559

Attachment 3

Type	ERA
Medium	American eel/WhitePerch
Chemical	2,3',4,4',5-Pentachlorobiphenyl (118)
Units	µg/kg

Data File		Variable:	2,3',4,4',5-Pentachlorobiphenyl (118) AE/WP
Raw Statistics		Normal Distribution Test	
Number of Valid Samples	38	Shapiro-Wilk Test Statisitic	0.93325
Number of Unique Samples	33	Shapiro-Wilk 5% Critical Value	0.938
Minimum	48.5	Data not normal at 5% significance level	
Maximum	262		
Mean	140.0421	95% UCL (Assuming Normal Distribution)	
Median	138.5	Student's-t UCL	155.9617
Standard Deviation	58.16805		
Variance	3383.522	Gamma Distribution Test	
Coefficient of Variation	0.415361	A-D Test Statistic	0.667045
Skewness	0.412386	A-D 5% Critical Value	0.750376
		K-S Test Statistic	0.162128
Gamma Statistics		K-S 5% Critical Value	0.143475
k hat	5.773096	Data follow approximate gamma distibution	
k star (bias corrected)	5.334869	at 5% significance level	
Theta hat	24.25771		
Theta star	26.25033	95% UCLs (Assuming Gamma Distribution)	
nu hat	438.7553	**Approximate Gamma UCL**	**157.8252**
nu star	405.4501	Adjusted Gamma UCL	158.6084
Approx.Chi Square Value (.05)	359.7656		
Adjusted Level of Significance	0.0434	Lognormal Distribution Test	
Adjusted Chi Square Value	357.989	Shapiro-Wilk Test Statisitic	0.949938
		Shapiro-Wilk 5% Critical Value	0.938
Log-transformed Statistics		Data are lognormal at 5% significance level	
Minimum of log data	3.881564		
Maximum of log data	5.568345	95% UCLs (Assuming Lognormal Distribution)	
Mean of log data	4.852842	95% H-UCL	161.2009
Standard Deviation of log data	0.437401	95% Chebyshev (MVUE) UCL	185.6503
Variance of log data	0.19132	97.5% Chebyshev (MVUE) UCL	205.1531
		99% Chebyshev (MVUE) UCL	243.4626
		95% Non-parametric UCLs	
		CLT UCL	155.5631
		Adj-CLT UCL (Adjusted for skewness)	156.2376
		Mod-t UCL (Adjusted for skewness)	156.0669
		Jackknife UCL	155.9617
		Standard Bootstrap UCL	155.2971
		Bootstrap-t UCL	156.8041
RECOMMENDATION		Hall's Bootstrap UCL	156.1827
Assuming gamma distribution (0.05)		Percentile Bootstrap UCL	154.8132
		BCA Bootstrap UCL	155.9342
Use Approximate Gamma UCL		95% Chebyshev (Mean, Sd) UCL	181.1731
		97.5% Chebyshev (Mean, Sd) UCL	198.9706
		99% Chebyshev (Mean, Sd) UCL	233.9302

R2-0009560

Attachment 3

Type	ERA
Medium	American eel/WhitePerch
Chemical	3,3',4,4',5,5'-Hexachlorobiphenyl (169)
Units	µg/kg

Data File		Variable:	3,3',4,4',5,5'-Hexachlorobiphenyl (169)	AE/WP
Raw Statistics		Normal Distribution Test		
Number of Valid Samples	76	Lilliefors Test Statisitic		0.281703
Number of Unique Samples	56	Lilliefors 5% Critical Value		0.101631
Minimum	0.00965	Data not normal at 5% significance level		
Maximum	4.59			
Mean	0.484905	95% UCL (Assuming Normal Distribution)		
Median	0.295	Student's-t UCL		0.64204
Standard Deviation	0.822539			
Variance	0.676571	Gamma Distribution Test		
Coefficient of Variation	1.696291	A-D Test Statistic		1.771892
Skewness	3.52503	A-D 5% Critical Value		0.812244
		K-S Test Statistic		0.120541
Gamma Statistics		K-S 5% Critical Value		0.107897
k hat	0.557812	Data do not follow gamma distribution		
k star (bias corrected)	0.544565	at 5% significance level		
Theta hat	0.869298			
Theta star	0.890444	95% UCLs (Assuming Gamma Distribution)		
nu hat	84.78737	Approximate Gamma UCL		0.639101
nu star	82.77383	Adjusted Gamma UCL		0.642532
Approx.Chi Square Value (.05)	62.80288			
Adjusted Level of Significance	0.046842	Lognormal Distribution Test		
Adjusted Chi Square Value	62.46756	Lilliefors Test Statisitic		0.182762
		Lilliefors 5% Critical Value		0.101631
Log-transformed Statistics		Data not lognormal at 5% significance level		
Minimum of log data	-4.6408			
Maximum of log data	1.52388	95% UCLs (Assuming Lognormal Distribution)		
Mean of log data	-1.8436	95% H-UCL		1.18662
Standard Deviation of log data	1.69075	95% Chebyshev (MVUE) UCL		1.399559
Variance of log data	2.858637	97.5% Chebyshev (MVUE) UCL		1.731383
		99% Chebyshev (MVUE) UCL		2.383186
		95% Non-parametric UCLs		
		CLT UCL		0.640099
		Adj-CLT UCL (Adjusted for skewness)		0.680864
		Mod-t UCL (Adjusted for skewness)		0.648399
		Jackknife UCL		0.64204
		Standard Bootstrap UCL		0.636887
		Bootstrap-t UCL		0.721006
RECOMMENDATION		Hall's Bootstrap UCL		0.737058
Data are Non-parametric (0.05)		Percentile Bootstrap UCL		0.653524
		BCA Bootstrap UCL		0.691853
Use 97.5% Chebyshev (Mean, Sd) UCL		95% Chebyshev (Mean, Sd) UCL		0.896174
		97.5% Chebyshev (Mean, Sd) UCL		**1.074131**
		99% Chebyshev (Mean, Sd) UCL		1.423693

R2-0009561

Attachment 3

Type	ERA
Medium	American eel/WhitePerch
Chemical	3,3',4,4',5-Pentachlorobiphenyl (126)
Units	µg/kg

Data File

Variable: 3,3',4,4',5-Pentachlorobiphenyl (126) AE/WP

Raw Statistics	
Number of Valid Samples	77
Number of Unique Samples	45
Minimum	0.0385
Maximum	2.08
Mean	0.366436
Median	0.119
Standard Deviation	0.430772
Variance	0.185565
Coefficient of Variation	1.175573
Skewness	2.122198

Gamma Statistics	
k hat	1.0693
k star (bias corrected)	1.036297
Theta hat	0.342688
Theta star	0.353601
nu hat	164.6721
nu star	159.5897
Approx.Chi Square Value (.05)	131.3779
Adjusted Level of Significance	0.046883
Adjusted Chi Square Value	130.8922

Log-transformed Statistics	
Minimum of log data	-3.2571
Maximum of log data	0.732368
Mean of log data	-1.53959
Standard Deviation of log data	1.005411
Variance of log data	1.010852

RECOMMENDATION

Data are Non-parametric (0.05)

Use 97.5% Chebyshev (Mean, Sd) UCL

Normal Distribution Test	
Lilliefors Test Statisitic	0.24647
Lilliefors 5% Critical Value	0.100969
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	0.44818

Gamma Distribution Test	
A-D Test Statistic	5.068556
A-D 5% Critical Value	0.7799
K-S Test Statistic	0.261754
K-S 5% Critical Value	0.104599
Data do not follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	0.445123
Adjusted Gamma UCL	0.446775

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.256559
Lilliefors 5% Critical Value	0.100969
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	0.460572
95% Chebyshev (MVUE) UCL	0.562024
97.5% Chebyshev (MVUE) UCL	0.652863
99% Chebyshev (MVUE) UCL	0.831298

95% Non-parametric UCLs	
CLT UCL	0.447183
Adj-CLT UCL (Adjusted for skewness)	0.459869
Mod-t UCL (Adjusted for skewness)	0.450158
Jackknife UCL	0.44818
Standard Bootstrap UCL	0.445184
Bootstrap-t UCL	0.467899
Hall's Bootstrap UCL	0.462122
Percentile Bootstrap UCL	0.448829
BCA Bootstrap UCL	0.456794
95% Chebyshev (Mean, Sd) UCL	0.580419
97.5% Chebyshev (Mean, Sd) UCL	**0.673009**
99% Chebyshev (Mean, Sd) UCL	0.854885

R2-0009562

Attachment 3

Type	ERA
Medium	American eel/WhitePerch
Chemical	3,3',4,4'-Tetrachlorobiphenyl (77)
Units	µg/kg

Data File		Variable:	3,3',4,4'-Tetrachlorobiphenyl (77)	AE/WP
Raw Statistics		Normal Distribution Test		
Number of Valid Samples	77	Lilliefors Test Statisitic		0.147124
Number of Unique Samples	65	Lilliefors 5% Critical Value		0.100969
Minimum	0.1	Data not normal at 5% significance level		
Maximum	16.3			
Mean	4.824247	95% UCL (Assuming Normal Distribution)		
Median	3.45	Student's-t UCL		5.678976
Standard Deviation	4.504222			
Variance	20.28802	Gamma Distribution Test		
Coefficient of Variation	0.933663	A-D Test Statistic		1.98404
Skewness	0.718951	A-D 5% Critical Value		0.795692
		K-S Test Statistic		0.121978
Gamma Statistics		K-S 5% Critical Value		0.105994
k hat	0.723034	Data do not follow gamma distribution		
k star (bias corrected)	0.703522	at 5% significance level		
Theta hat	6.672229			
Theta star	6.857283	95% UCLs (Assuming Gamma Distribution)		
nu hat	111.3472	Approximate Gamma UCL		6.126401
nu star	108.3423	Adjusted Gamma UCL		6.15441
Approx.Chi Square Value (.05)	85.3144			
Adjusted Level of Significance	0.046883	Lognormal Distribution Test		
Adjusted Chi Square Value	84.92613	Lilliefors Test Statisitic		0.180439
		Lilliefors 5% Critical Value		0.100969
Log-transformed Statistics		Data not lognormal at 5% significance level		
Minimum of log data	-2.30259			
Maximum of log data	2.791165	95% UCLs (Assuming Lognormal Distribution)		
Mean of log data	0.741553	95% H-UCL		13.49215
Standard Deviation of log data	1.623462	95% Chebyshev (MVUE) UCL		16.14283
Variance of log data	2.635628	97.5% Chebyshev (MVUE) UCL		19.86126
		99% Chebyshev (MVUE) UCL		27.16542
		95% Non-parametric UCLs		
		CLT UCL		5.668557
		Adj-CLT UCL (Adjusted for skewness)		5.713494
		Mod-t UCL (Adjusted for skewness)		5.685985
		Jackknife UCL		5.678976
		Standard Bootstrap UCL		5.66467
		Bootstrap-t UCL		5.724953
RECOMMENDATION		Hall's Bootstrap UCL		5.726234
Data are Non-parametric (0.05)		Percentile Bootstrap UCL		5.68611
		BCA Bootstrap UCL		5.754353
Use 97.5% Chebyshev (Mean, Sd) UCL		95% Chebyshev (Mean, Sd) UCL		7.061686
		97.5% Chebyshev (Mean, Sd) UCL		**8.029828**
		99% Chebyshev (Mean, Sd) UCL		9.931555

R2-0009563

Attachment 3

Type	ERA
Medium	American eel/WhitePerch
Chemical	3,4,4',5-Tetrachlorobiphenyl (81)
Units	µg/kg

Data File	
Raw Statistics	
Number of Valid Samples	77
Number of Unique Samples	74
Minimum	0.1
Maximum	13.12
Mean	2.924819
Median	2.06
Standard Deviation	2.855918
Variance	8.156265
Coefficient of Variation	0.976443
Skewness	1.311843
Gamma Statistics	
k hat	0.934175
k star (bias corrected)	0.906436
Theta hat	3.130912
Theta star	3.226723
nu hat	143.8629
nu star	139.5912
Approx.Chi Square Value (.05)	113.2856
Adjusted Level of Significance	0.046883
Adjusted Chi Square Value	112.8357
Log-transformed Statistics	
Minimum of log data	-2.30259
Maximum of log data	2.574138
Mean of log data	0.450292
Standard Deviation of log data	1.289795
Variance of log data	1.663571

RECOMMENDATION

Data follow gamma distribution (0.05)

Use Approximate Gamma UCL

Variable:	3,4,4',5-Tetrachlorobiphenyl (81) AE/WP
Normal Distribution Test	
Lilliefors Test Statisitic	0.177811
Lilliefors 5% Critical Value	0.100969
Data not normal at 5% significance level	
95% UCL (Assuming Normal Distribution)	
Student's-t UCL	3.466762
Gamma Distribution Test	
A-D Test Statistic	0.569022
A-D 5% Critical Value	0.784524
K-S Test Statistic	0.069054
K-S 5% Critical Value	0.105031
Data follow gamma distribution	
at 5% significance level	
95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	**3.603979**
Adjusted Gamma UCL	3.618348
Lognormal Distribution Test	
Lilliefors Test Statisitic	0.119945
Lilliefors 5% Critical Value	0.100969
Data not lognormal at 5% significance level	
95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	5.244364
95% Chebyshev (MVUE) UCL	6.462766
97.5% Chebyshev (MVUE) UCL	7.729384
99% Chebyshev (MVUE) UCL	10.21741
95% Non-parametric UCLs	
CLT UCL	3.460156
Adj-CLT UCL (Adjusted for skewness)	3.512146
Mod-t UCL (Adjusted for skewness)	3.474872
Jackknife UCL	3.466762
Standard Bootstrap UCL	3.449944
Bootstrap-t UCL	3.49756
Hall's Bootstrap UCL	3.506854
Percentile Bootstrap UCL	3.472432
BCA Bootstrap UCL	3.571392
95% Chebyshev (Mean, Sd) UCL	4.343475
97.5% Chebyshev (Mean, Sd) UCL	4.957328
99% Chebyshev (Mean, Sd) UCL	6.163125

R2-0009564

Attachment 3

Type	ERA
Medium	American eel/WhitePerch
Chemical	Lipids
Units	µg/kg

Data File

Variable: Lipids AE/WP

Raw Statistics	
Number of Valid Samples	81
Number of Unique Samples	80
Minimum	0
Maximum	21.38
Mean	6.988877
Median	6.4
Standard Deviation	3.698366
Variance	13.67791
Coefficient of Variation	0.529179
Skewness	1.28806

Normal Distribution Test	
Lilliefors Test Statisitic	0.128329
Lilliefors 5% Critical Value	0.098444
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	7.672714

Gamma Statistics Not Available

Lognormal Statistics Not Available

95% Non-parametric UCLs	
CLT UCL	7.664795
Adj-CLT UCL (Adjusted for skewness)	7.727636
Mod-t UCL (Adjusted for skewness)	7.682516
Jackknife UCL	7.672714
Standard Bootstrap UCL	7.645853
Bootstrap-t UCL	7.756842
Hall's Bootstrap UCL	7.804641
Percentile Bootstrap UCL	7.692444
BCA Bootstrap UCL	7.69537
95% Chebyshev (Mean, Sd) UCL	**8.780077**
97.5% Chebyshev (Mean, Sd) UCL	9.555131
99% Chebyshev (Mean, Sd) UCL	11.07757

RECOMMENDATION

Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

R2-0009565

Attachment 3

Type	ERA
Medium	American eel/WhitePerch
Chemical	Lipids - eel
Units	µg/kg

Data File

Variable: Lipids - (eel)

Raw Statistics	
Number of Valid Samples	22
Number of Unique Samples	22
Minimum	0
Maximum	21.38
Mean	8.837182
Median	7.106
Standard Deviation	5.523116
Variance	30.50481
Coefficient of Variation	0.624986
Skewness	0.697989

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.935268
Shapiro-Wilk 5% Critical Value	0.911
Data are normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	**10.86341**

Gamma Statistics Not Available

Lognormal Statistics Not Available

95% Non-parametric UCLs	
CLT UCL	10.77405
Adj-CLT UCL (Adjusted for skewness)	10.96129
Mod-t UCL (Adjusted for skewness)	10.89262
Jackknife UCL	10.86341
Standard Bootstrap UCL	10.69169
Bootstrap-t UCL	11.04556
Hall's Bootstrap UCL	10.96917
Percentile Bootstrap UCL	10.83464
BCA Bootstrap UCL	11.01241
95% Chebyshev (Mean, Sd) UCL	13.96993
97.5% Chebyshev (Mean, Sd) UCL	16.19087
99% Chebyshev (Mean, Sd) UCL	20.55348

RECOMMENDATION

Data are normal (0.05)

Use Student's-t UCL

R2-0009566

Attachment 3

Type	ERA
Medium	American eel/WhitePerch
Chemical	Lipids - perch
Units	µg/kg

Data File

Variable: Lipid - (perch)

Raw Statistics	
Number of Valid Samples	59
Number of Unique Samples	59
Minimum	0.94
Maximum	10.4
Mean	6.299678
Median	6.21
Standard Deviation	2.458097
Variance	6.04224
Coefficient of Variation	0.390194
Skewness	-0.13006

Gamma Statistics	
k hat	5.207663
k star (bias corrected)	4.954166
Theta hat	1.209694
Theta star	1.271592
nu hat	614.5042
nu star	584.5915
Approx.Chi Square Value (.05)	529.4969
Adjusted Level of Significance	0.045932
Adjusted Chi Square Value	528.192

Log-transformed Statistics	
Minimum of log data	-0.06188
Maximum of log data	2.341806
Mean of log data	1.741424
Standard Deviation of log data	0.493995
Variance of log data	0.244031

RECOMMENDATION

Data are normal (0.05)

Use Student's-t UCL

Normal Distribution Test	
Lilliefors Test Statisitic	0.08257
Lilliefors 5% Critical Value	0.115347
Data are normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	**6.834603**

Gamma Distribution Test	
A-D Test Statistic	0.99666
A-D 5% Critical Value	0.753275
K-S Test Statistic	0.109309
K-S 5% Critical Value	0.116061
Data follow approximate gamma distibution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	6.955166
Adjusted Gamma UCL	6.972347

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.143611
Lilliefors 5% Critical Value	0.115347
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	7.272483
95% Chebyshev (MVUE) UCL	8.325144
97.5% Chebyshev (MVUE) UCL	9.144732
99% Chebyshev (MVUE) UCL	10.75465

95% Non-parametric UCLs	
CLT UCL	6.826059
Adj-CLT UCL (Adjusted for skewness)	6.820269
Mod-t UCL (Adjusted for skewness)	6.8337
Jackknife UCL	6.834603
Standard Bootstrap UCL	6.821924
Bootstrap-t UCL	6.811692
Hall's Bootstrap UCL	6.821607
Percentile Bootstrap UCL	6.819492
BCA Bootstrap UCL	6.834915
95% Chebyshev (Mean, Sd) UCL	7.6946
97.5% Chebyshev (Mean, Sd) UCL	8.298183
99% Chebyshev (Mean, Sd) UCL	9.483806

R2-0009567

Attachment 3

Type	ERA
Medium	Mummichog
Chemical	1,2,3,4,6,7,8-HpCDD
Units	µg/kg

Data File

Variable: 1,2,3,4,6,7,8-HpCDD Mummichog

Raw Statistics	
Number of Valid Samples	62
Number of Unique Samples	57
Minimum	0.00029
Maximum	0.01
Mean	0.001052
Median	0.000775
Standard Deviation	0.001329
Variance	1.77E-06
Coefficient of Variation	1.263513
Skewness	5.416917

Gamma Statistics	
k hat	1.901096
k star (bias corrected)	1.819861
Theta hat	0.000553
Theta star	0.000578
nu hat	235.736
nu star	225.6627
Approx.Chi Square Value (.05)	191.8853
Adjusted Level of Significance	0.046129
Adjusted Chi Square Value	191.1475

Log-transformed Statistics	
Minimum of log data	-8.14736
Maximum of log data	-4.60517
Mean of log data	-7.14262
Standard Deviation of log data	0.650703
Variance of log data	0.423415

Normal Distribution Test	
Lilliefors Test Statisitic	0.317681
Lilliefors 5% Critical Value	0.112522
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	0.001334

Gamma Distribution Test	
A-D Test Statistic	3.131526
A-D 5% Critical Value	0.764152
K-S Test Statistic	0.19382
K-S 5% Critical Value	0.114588
Data do not follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	0.001237
Adjusted Gamma UCL	0.001242

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.119754
Lilliefors 5% Critical Value	0.112522
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	0.001151
95% Chebyshev (MVUE) UCL	0.001354
97.5% Chebyshev (MVUE) UCL	0.001518
99% Chebyshev (MVUE) UCL	0.001842

95% Non-parametric UCLs	
CLT UCL	0.00133
Adj-CLT UCL (Adjusted for skewness)	0.001454
Mod-t UCL (Adjusted for skewness)	0.001353
Jackknife UCL	0.001334
Standard Bootstrap UCL	0.001327
Bootstrap-t UCL	0.001671
Hall's Bootstrap UCL	0.002404
Percentile Bootstrap UCL	0.001342
BCA Bootstrap UCL	0.00154
95% Chebyshev (Mean, Sd) UCL	**0.001788**
97.5% Chebyshev (Mean, Sd) UCL	0.002106
99% Chebyshev (Mean, Sd) UCL	0.002731

RECOMMENDATION

Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

R2-0009568

Attachment 3

Type	ERA
Medium	Mummichog
Chemical	1,2,3,4,6,7,8-HpCDF
Units	µg/kg

Data File

Variable: 1,2,3,4,6,7,8-HpCDF Mummichog

Raw Statistics	
Number of Valid Samples	14
Number of Unique Samples	14
Minimum	0.00024
Maximum	0.01
Mean	0.003649
Median	0.002835
Standard Deviation	0.002587
Variance	6.69E-06
Coefficient of Variation	0.709019
Skewness	1.221765

Gamma Statistics	
k hat	1.807148
k star (bias corrected)	1.467521
Theta hat	0.002019
Theta star	0.002486
nu hat	50.60015
nu star	41.09059
Approx.Chi Square Value (.05)	27.39721
Adjusted Level of Significance	0.03122
Adjusted Chi Square Value	25.91982

Log-transformed Statistics	
Minimum of log data	-8.33487
Maximum of log data	-4.60517
Mean of log data	-5.91494
Standard Deviation of log data	0.944011
Variance of log data	0.891157

RECOMMENDATION

Data are normal (0.05)

Use Student's-t UCL

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.878649
Shapiro-Wilk 5% Critical Value	0.874
Data are normal at 5% significance level	
95% UCL (Assuming Normal Distribution)	
Student's-t UCL	**0.004873**

Gamma Distribution Test	
A-D Test Statistic	0.587242
A-D 5% Critical Value	0.747751
K-S Test Statistic	0.243757
K-S 5% Critical Value	0.23206
Data follow approximate gamma distibution	
at 5% significance level	
95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	0.005472
Adjusted Gamma UCL	0.005784

Lognormal Distribution Test	
Shapiro-Wilk Test Statisitic	0.855713
Shapiro-Wilk 5% Critical Value	0.874
Data not lognormal at 5% significance level	
95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	0.008565
95% Chebyshev (MVUE) UCL	0.008832
97.5% Chebyshev (MVUE) UCL	0.010906
99% Chebyshev (MVUE) UCL	0.01498

95% Non-parametric UCLs	
CLT UCL	0.004786
Adj-CLT UCL (Adjusted for skewness)	0.005027
Mod-t UCL (Adjusted for skewness)	0.00491
Jackknife UCL	0.004873
Standard Bootstrap UCL	0.004754
Bootstrap-t UCL	0.005265
Hall's Bootstrap UCL	0.005603
Percentile Bootstrap UCL	0.004823
BCA Bootstrap UCL	0.005062
95% Chebyshev (Mean, Sd) UCL	0.006662
97.5% Chebyshev (Mean, Sd) UCL	0.007966
99% Chebyshev (Mean, Sd) UCL	0.010528

R2-0009569

Attachment 3

Type	ERA
Medium	Mummichog
Chemical	1,2,3,4,7,8,9-HpCDF
Units	µg/kg

Data File

Variable: 1,2,3,4,7,8,9-HpCDF Mummichog

Raw Statistics	
Number of Valid Samples	62
Number of Unique Samples	60
Minimum	2.45E-05
Maximum	0.01
Mean	0.00041
Median	0.000135
Standard Deviation	0.001415
Variance	2E-06
Coefficient of Variation	3.447715
Skewness	5.897713

Gamma Statistics	
k hat	0.559069
k star (bias corrected)	0.54277
Theta hat	0.000734
Theta star	0.000756
nu hat	69.32453
nu star	67.30345
Approx.Chi Square Value (.05)	49.41916
Adjusted Level of Significance	0.046129
Adjusted Chi Square Value	49.05472

Log-transformed Statistics	
Minimum of log data	-10.6168
Maximum of log data	-4.60517
Mean of log data	-8.91558
Standard Deviation of log data	1.03688
Variance of log data	1.075119

RECOMMENDATION

Data are Non-parametric (0.05)

Use 97.5% Chebyshev (Mean, Sd) UCL

Normal Distribution Test	
Lilliefors Test Statisitic	0.450284
Lilliefors 5% Critical Value	0.112522
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	0.00071

Gamma Distribution Test	
A-D Test Statistic	10.25915
A-D 5% Critical Value	0.810469
K-S Test Statistic	0.35068
K-S 5% Critical Value	0.119114
Data do not follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	0.000559
Adjusted Gamma UCL	0.000563

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.174133
Lilliefors 5% Critical Value	0.112522
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	0.000312
95% Chebyshev (MVUE) UCL	0.000383
97.5% Chebyshev (MVUE) UCL	0.00045
99% Chebyshev (MVUE) UCL	0.000583

95% Non-parametric UCLs	
CLT UCL	0.000706
Adj-CLT UCL (Adjusted for skewness)	0.00085
Mod-t UCL (Adjusted for skewness)	0.000733
Jackknife UCL	0.00071
Standard Bootstrap UCL	0.000709
Bootstrap-t UCL	0.001597
Hall's Bootstrap UCL	0.001747
Percentile Bootstrap UCL	0.000746
BCA Bootstrap UCL	0.00093
95% Chebyshev (Mean, Sd) UCL	0.001193
97.5% Chebyshev (Mean, Sd) UCL	**0.001532**
99% Chebyshev (Mean, Sd) UCL	0.002198

R2-0009570

Type	ERA
Medium	Mummichog
Chemical	1,2,3,4,7,8-HxCDD
Units	µg/kg

Data File

Variable: 1,2,3,4,7,8-HxCDD Mummichog

Raw Statistics	
Number of Valid Samples	62
Number of Unique Samples	62
Minimum	0.000083
Maximum	0.01
Mean	0.000566
Median	0.000236
Standard Deviation	0.001411
Variance	1.99E-06
Coefficient of Variation	2.493913
Skewness	5.648218

Gamma Statistics	
k hat	0.841772
k star (bias corrected)	0.811793
Theta hat	0.000672
Theta star	0.000697
nu hat	104.3797
nu star	100.6624
Approx.Chi Square Value (.05)	78.51048
Adjusted Level of Significance	0.046129
Adjusted Chi Square Value	78.04593

Log-transformed Statistics	
Minimum of log data	-9.39667
Maximum of log data	-4.60517
Mean of log data	-8.17788
Standard Deviation of log data	0.876983
Variance of log data	0.7691

RECOMMENDATION

Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

Normal Distribution Test	
Lilliefors Test Statisitic	0.423788
Lilliefors 5% Critical Value	0.112522
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	0.000865

Gamma Distribution Test	
A-D Test Statistic	8.132559
A-D 5% Critical Value	0.787483
K-S Test Statistic	0.295868
K-S 5% Critical Value	0.117082
Data do not follow gamma distribution at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	0.000725
Adjusted Gamma UCL	0.00073

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.157741
Lilliefors 5% Critical Value	0.112522
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	0.000525
95% Chebyshev (MVUE) UCL	0.000637
97.5% Chebyshev (MVUE) UCL	0.000735
99% Chebyshev (MVUE) UCL	0.000929

95% Non-parametric UCLs	
CLT UCL	0.00086
Adj-CLT UCL (Adjusted for skewness)	0.000998
Mod-t UCL (Adjusted for skewness)	0.000886
Jackknife UCL	0.000865
Standard Bootstrap UCL	0.000852
Bootstrap-t UCL	0.001723
Hall's Bootstrap UCL	0.001828
Percentile Bootstrap UCL	0.00089
BCA Bootstrap UCL	0.001058
95% Chebyshev (Mean, Sd) UCL	**0.001347**
97.5% Chebyshev (Mean, Sd) UCL	0.001685
99% Chebyshev (Mean, Sd) UCL	0.002348

Type	ERA
Medium	Mummichog
Chemical	1,2,3,4,7,8-HxCDF
Units	µg/kg

Data File

Variable: 1,2,3,4,7,8-HxCDF Mummichog

Raw Statistics	
Number of Valid Samples	62
Number of Unique Samples	57
Minimum	0.000147
Maximum	0.01
Mean	0.00117
Median	0.000823
Standard Deviation	0.001408
Variance	1.98E-06
Coefficient of Variation	1.203117
Skewness	4.591071

Gamma Statistics	
k hat	1.599497
k star (bias corrected)	1.532854
Theta hat	0.000731
Theta star	0.000763
nu hat	198.3376
nu star	190.0739
Approx.Chi Square Value (.05)	159.174
Adjusted Level of Significance	0.046129
Adjusted Chi Square Value	158.5039

Log-transformed Statistics	
Minimum of log data	-8.82508
Maximum of log data	-4.60517
Mean of log data	-7.09487
Standard Deviation of log data	0.786597
Variance of log data	0.618735

RECOMMENDATION

Data are lognormal (0.05)

Use H-UCL

Normal Distribution Test	
Lilliefors Test Statisitic	0.276138
Lilliefors 5% Critical Value	0.112522
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	0.001469

Gamma Distribution Test	
A-D Test Statistic	1.731724
A-D 5% Critical Value	0.767719
K-S Test Statistic	0.169712
K-S 5% Critical Value	0.115005
Data do not follow gamma distribution at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	0.001397
Adjusted Gamma UCL	0.001403

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.105129
Lilliefors 5% Critical Value	0.112522
Data are lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	**0.001393**
95% Chebyshev (MVUE) UCL	0.001671
97.5% Chebyshev (MVUE) UCL	0.001908
99% Chebyshev (MVUE) UCL	0.002374

95% Non-parametric UCLs	
CLT UCL	0.001464
Adj-CLT UCL (Adjusted for skewness)	0.001575
Mod-t UCL (Adjusted for skewness)	0.001486
Jackknife UCL	0.001469
Standard Bootstrap UCL	0.001457
Bootstrap-t UCL	0.001718
Hall's Bootstrap UCL	0.002763
Percentile Bootstrap UCL	0.001487
BCA Bootstrap UCL	0.001625
95% Chebyshev (Mean, Sd) UCL	0.001949
97.5% Chebyshev (Mean, Sd) UCL	0.002286
99% Chebyshev (Mean, Sd) UCL	0.002949

R2-0009572

Type	ERA
Medium	Mummichog
Chemical	1,2,3,6,7,8-HxCDD
Units	µg/kg

Data File

Variable: 1,2,3,6,7,8-HxCDD Mummichog

Raw Statistics	
Number of Valid Samples	62
Number of Unique Samples	59
Minimum	0.000108
Maximum	0.01
Mean	0.000487
Median	0.000232
Standard Deviation	0.001372
Variance	1.88E-06
Coefficient of Variation	2.816
Skewness	6.240581

Gamma Statistics	
k hat	0.922673
k star (bias corrected)	0.88878
Theta hat	0.000528
Theta star	0.000548
nu hat	114.4115
nu star	110.2088
Approx.Chi Square Value (.05)	86.97267
Adjusted Level of Significance	0.046129
Adjusted Chi Square Value	86.48267

Log-transformed Statistics	
Minimum of log data	-9.13802
Maximum of log data	-4.60517
Mean of log data	-8.25843
Standard Deviation of log data	0.740467
Variance of log data	0.548292

RECOMMENDATION

Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

Normal Distribution Test	
Lilliefors Test Statisitic	0.451241
Lilliefors 5% Critical Value	0.112522
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	0.000778

Gamma Distribution Test	
A-D Test Statistic	10.22325
A-D 5% Critical Value	0.783354
K-S Test Statistic	0.319086
K-S 5% Critical Value	0.116687
Data do not follow gamma distribution at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	0.000617
Adjusted Gamma UCL	0.000621

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.160258
Lilliefors 5% Critical Value	0.112522
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	0.000413
95% Chebyshev (MVUE) UCL	0.000493
97.5% Chebyshev (MVUE) UCL	0.00056
99% Chebyshev (MVUE) UCL	0.00069

95% Non-parametric UCLs	
CLT UCL	0.000774
Adj-CLT UCL (Adjusted for skewness)	0.000921
Mod-t UCL (Adjusted for skewness)	0.000801
Jackknife UCL	0.000778
Standard Bootstrap UCL	0.000773
Bootstrap-t UCL	0.003538
Hall's Bootstrap UCL	0.002435
Percentile Bootstrap UCL	0.000798
BCA Bootstrap UCL	0.001034
95% Chebyshev (Mean, Sd) UCL	**0.001247**
97.5% Chebyshev (Mean, Sd) UCL	0.001575
99% Chebyshev (Mean, Sd) UCL	0.002221

R2-0009573

Type	ERA
Medium	Mummichog
Chemical	1,2,3,6,7,8-HxCDF
Units	µg/kg

Data File

Variable: 1,2,3,6,7,8-HxCDF Mummichog

Raw Statistics	
Number of Valid Samples	62
Number of Unique Samples	59
Minimum	0.000056
Maximum	0.01
Mean	0.001173
Median	0.00084
Standard Deviation	0.001568
Variance	2.46E-06
Coefficient of Variation	1.336084
Skewness	3.489036

Gamma Statistics	
k hat	0.853701
k star (bias corrected)	0.823146
Theta hat	0.001374
Theta star	0.001425
nu hat	105.859
nu star	102.0701
Approx.Chi Square Value (.05)	79.75518
Adjusted Level of Significance	0.046129
Adjusted Chi Square Value	79.2868

Log-transformed Statistics	
Minimum of log data	-9.79016
Maximum of log data	-4.60517
Mean of log data	-7.4373
Standard Deviation of log data	1.250967
Variance of log data	1.564919

RECOMMENDATION

Data are Non-parametric (0.05)

Use 97.5% Chebyshev (Mean, Sd) UCL

Normal Distribution Test	
Lilliefors Test Statisitic	0.238005
Lilliefors 5% Critical Value	0.112522
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	0.001506

Gamma Distribution Test	
A-D Test Statistic	1.226077
A-D 5% Critical Value	0.786874
K-S Test Statistic	0.139725
K-S 5% Critical Value	0.117024
Data do not follow gamma distribution at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	0.001502
Adjusted Gamma UCL	0.00151

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.165114
Lilliefors 5% Critical Value	0.112522
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	0.001933
95% Chebyshev (MVUE) UCL	0.002365
97.5% Chebyshev (MVUE) UCL	0.002843
99% Chebyshev (MVUE) UCL	0.003782

95% Non-parametric UCLs	
CLT UCL	0.001501
Adj-CLT UCL (Adjusted for skewness)	0.001595
Mod-t UCL (Adjusted for skewness)	0.001521
Jackknife UCL	0.001506
Standard Bootstrap UCL	0.001491
Bootstrap-t UCL	0.001701
Hall's Bootstrap UCL	0.002077
Percentile Bootstrap UCL	0.00153
BCA Bootstrap UCL	0.001638
95% Chebyshev (Mean, Sd) UCL	0.002041
97.5% Chebyshev (Mean, Sd) UCL	**0.002417**
99% Chebyshev (Mean, Sd) UCL	0.003154

R2-0009574

Attachment 3

Type	ERA
Medium	Mummichog
Chemical	1,2,3,7,8,9-HxCDD
Units	µg/kg

Data File

Raw Statistics

Number of Valid Samples	62
Number of Unique Samples	59
Minimum	0.000036
Maximum	0.01
Mean	0.000456863
Median	0.00018325
Standard Deviation	0.001377434
Variance	1.89733E-06
Coefficient of Variation	3.014984085
Skewness	6.233272778

Gamma Statistics

k hat	0.811576095
k star (bias corrected)	0.783058972
Theta hat	0.000562933
Theta star	0.000583434
nu hat	100.6354358
nu star	97.09931255
Approx.Chi Square Value (.05)	75.36522341
Adjusted Level of Significance	0.046129032
Adjusted Chi Square Value	74.91048731

Log-transformed Statistics

Minimum of log data	-10.23199162
Maximum of log data	-4.605170186
Mean of log data	-8.421032627
Standard Deviation of log data	0.818660931
Variance of log data	0.670205721

RECOMMENDATION

Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

Variable: 1,2,3,7,8,9-HxCDD Mummichog

Normal Distribution Test

Lilliefors Test Statisitic	0.454382
Lilliefors 5% Critical Value	0.112522

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	0.000749

Gamma Distribution Test

A-D Test Statistic	9.681287
A-D 5% Critical Value	0.789024
K-S Test Statistic	0.307324
K-S 5% Critical Value	0.11723

Data do not follow gamma distribution at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	0.000589
Adjusted Gamma UCL	0.000592

Lognormal Distribution Test

Lilliefors Test Statisitic	0.142181
Lilliefors 5% Critical Value	0.112522

Data not lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	0.000384
95% Chebyshev (MVUE) UCL	0.000462
97.5% Chebyshev (MVUE) UCL	0.00053
99% Chebyshev (MVUE) UCL	0.000663

95% Non-parametric UCLs

CLT UCL	0.000745
Adj-CLT UCL (Adjusted for skewness)	0.000893
Mod-t UCL (Adjusted for skewness)	0.000772
Jackknife UCL	0.000749
Standard Bootstrap UCL	0.000738
Bootstrap-t UCL	0.003591
Hall's Bootstrap UCL	0.002383
Percentile Bootstrap UCL	0.000788
BCA Bootstrap UCL	0.000926
95% Chebyshev (Mean, Sd) UCL	**0.001219**
97.5% Chebyshev (Mean, Sd) UCL	0.001549
99% Chebyshev (Mean, Sd) UCL	0.002197

R2-0009575

Type	ERA
Medium	Mummichog
Chemical	1,2,3,7,8,9-HxCDF
Units	µg/kg

Data File

Variable: 1,2,3,7,8,9-HxCDF Mummichog

Raw Statistics	
Number of Valid Samples	62
Number of Unique Samples	59
Minimum	0.000015
Maximum	0.01
Mean	0.00039
Median	7.03E-05
Standard Deviation	0.00142
Variance	2.01E-06
Coefficient of Variation	3.643769
Skewness	5.878392

Gamma Statistics	
k hat	0.471688
k star (bias corrected)	0.459617
Theta hat	0.000826
Theta star	0.000848
nu hat	58.48927
nu star	56.99247
Approx.Chi Square Value (.05)	40.63656
Adjusted Level of Significance	0.046129
Adjusted Chi Square Value	40.30792

Log-transformed Statistics	
Minimum of log data	-11.1075
Maximum of log data	-4.60517
Mean of log data	-9.20939
Standard Deviation of log data	1.190088
Variance of log data	1.41631

RECOMMENDATION

Data are Non-parametric (0.05)

Use 97.5% Chebyshev (Mean, Sd) UCL

Normal Distribution Test	
Lilliefors Test Statisitic	0.429742
Lilliefors 5% Critical Value	0.112522
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	0.000691

Gamma Distribution Test	
A-D Test Statistic	9.25507
A-D 5% Critical Value	0.822873
K-S Test Statistic	0.295846
K-S 5% Critical Value	0.120041
Data do not follow gamma distribution at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	0.000546
Adjusted Gamma UCL	0.000551

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.143333
Lilliefors 5% Critical Value	0.112522
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	0.000296
95% Chebyshev (MVUE) UCL	0.000363
97.5% Chebyshev (MVUE) UCL	0.000434
99% Chebyshev (MVUE) UCL	0.000573

95% Non-parametric UCLs	
CLT UCL	0.000686
Adj-CLT UCL (Adjusted for skewness)	0.00083
Mod-t UCL (Adjusted for skewness)	0.000713
Jackknife UCL	0.000691
Standard Bootstrap UCL	0.000679
Bootstrap-t UCL	0.001609
Hall's Bootstrap UCL	0.001716
Percentile Bootstrap UCL	0.00071
BCA Bootstrap UCL	0.000942
95% Chebyshev (Mean, Sd) UCL	0.001175
97.5% Chebyshev (Mean, Sd) UCL	**0.001515**
99% Chebyshev (Mean, Sd) UCL	0.002183

R2-0009576

Attachment 3

Type	ERA
Medium	Mummichog
Chemical	1,2,3,7,8-PeCDD
Units	µg/kg

Data File

Variable: 1,2,3,7,8-PeCDD Mummichog

Raw Statistics	
Number of Valid Samples	54
Number of Unique Samples	52
Minimum	0.000145
Maximum	0.01
Mean	0.000854
Median	0.000459
Standard Deviation	0.001661
Variance	2.76E-06
Coefficient of Variation	1.945201
Skewness	4.291753

Gamma Statistics	
k hat	1.028239
k star (bias corrected)	0.983461
Theta hat	0.00083
Theta star	0.000868
nu hat	111.0499
nu star	106.2138
Approx.Chi Square Value (.05)	83.4254
Adjusted Level of Significance	0.045556
Adjusted Chi Square Value	82.87233

Log-transformed Statistics	
Minimum of log data	-8.83878
Maximum of log data	-4.60517
Mean of log data	-7.62519
Standard Deviation of log data	0.802878
Variance of log data	0.644614

RECOMMENDATION

Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

Normal Distribution Test	
Lilliefors Test Statisitic	0.450301
Lilliefors 5% Critical Value	0.120569
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	0.001232

Gamma Distribution Test	
A-D Test Statistic	9.061953
A-D 5% Critical Value	0.778969
K-S Test Statistic	0.386172
K-S 5% Critical Value	0.124486
Data do not follow gamma distribution at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	0.001087
Adjusted Gamma UCL	0.001094

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.284953
Lilliefors 5% Critical Value	0.120569
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	0.00085
95% Chebyshev (MVUE) UCL	0.001026
97.5% Chebyshev (MVUE) UCL	0.00118
99% Chebyshev (MVUE) UCL	0.001484

95% Non-parametric UCLs	
CLT UCL	0.001226
Adj-CLT UCL (Adjusted for skewness)	0.001367
Mod-t UCL (Adjusted for skewness)	0.001254
Jackknife UCL	0.001232
Standard Bootstrap UCL	0.00122
Bootstrap-t UCL	0.001711
Hall's Bootstrap UCL	0.001346
Percentile Bootstrap UCL	0.001291
BCA Bootstrap UCL	0.001456
95% Chebyshev (Mean, Sd) UCL	**0.001839**
97.5% Chebyshev (Mean, Sd) UCL	0.002266
99% Chebyshev (Mean, Sd) UCL	0.003103

R2-0009577

Attachment 3

Type	ERA
Medium	Mummichog
Chemical	1,2,3,7,8-PeCDF
Units	µg/kg

Data File

Variable: 1,2,3,7,8-PeCDF Mummichog

Raw Statistics	
Number of Valid Samples	62
Number of Unique Samples	57
Minimum	0.000089
Maximum	0.01
Mean	0.000552
Median	0.000314
Standard Deviation	0.001366
Variance	1.87E-06
Coefficient of Variation	2.475433
Skewness	6.180652

Gamma Statistics	
k hat	1.023533
k star (bias corrected)	0.98476
Theta hat	0.000539
Theta star	0.00056
nu hat	126.9181
nu star	122.1102
Approx.Chi Square Value (.05)	97.58653
Adjusted Level of Significance	0.046129
Adjusted Chi Square Value	97.06628

Log-transformed Statistics	
Minimum of log data	-9.32687
Maximum of log data	-4.60517
Mean of log data	-8.06472
Standard Deviation of log data	0.764599
Variance of log data	0.584612

RECOMMENDATION

Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

Normal Distribution Test	
Lilliefors Test Statisitic	0.408061
Lilliefors 5% Critical Value	0.112522
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	0.000842

Gamma Distribution Test	
A-D Test Statistic	8.185274
A-D 5% Critical Value	0.778913
K-S Test Statistic	0.311249
K-S 5% Critical Value	0.116255
Data do not follow gamma distribution at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	0.00069
Adjusted Gamma UCL	0.000694

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.189355
Lilliefors 5% Critical Value	0.112522
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	0.000515
95% Chebyshev (MVUE) UCL	0.000616
97.5% Chebyshev (MVUE) UCL	0.000702
99% Chebyshev (MVUE) UCL	0.00087

95% Non-parametric UCLs	
CLT UCL	0.000837
Adj-CLT UCL (Adjusted for skewness)	0.000983
Mod-t UCL (Adjusted for skewness)	0.000864
Jackknife UCL	0.000842
Standard Bootstrap UCL	0.000837
Bootstrap-t UCL	0.002715
Hall's Bootstrap UCL	0.002252
Percentile Bootstrap UCL	0.000869
BCA Bootstrap UCL	0.001041
95% Chebyshev (Mean, Sd) UCL	**0.001308**
97.5% Chebyshev (Mean, Sd) UCL	0.001635
99% Chebyshev (Mean, Sd) UCL	0.002278

R2-0009578

Attachment 3

Type	ERA
Medium	Mummichog
Chemical	2,3,4,6,7,8-HxCDF
Units	µg/kg

Data File

Raw Statistics

Number of Valid Samples	62
Number of Unique Samples	57
Minimum	3.58E-05
Maximum	0.01
Mean	0.000361
Median	0.000105
Standard Deviation	0.001393
Variance	1.94E-06
Coefficient of Variation	3.853053
Skewness	6.232351

Gamma Statistics

k hat	0.55375
k star (bias corrected)	0.537709
Theta hat	0.000653
Theta star	0.000672
nu hat	68.66504
nu star	66.67587
Approx.Chi Square Value (.05)	48.88108
Adjusted Level of Significance	0.046129
Adjusted Chi Square Value	48.51874

Log-transformed Statistics

Minimum of log data	-10.239
Maximum of log data	-4.60517
Mean of log data	-9.05451
Standard Deviation of log data	0.955953
Variance of log data	0.913847

RECOMMENDATION

Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

Variable: 2,3,4,6,7,8-HxCDF Mummichog

Normal Distribution Test

Lilliefors Test Statisitic	0.45411
Lilliefors 5% Critical Value	0.112522

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	0.000657

Gamma Distribution Test

A-D Test Statistic	11.64117
A-D 5% Critical Value	0.810979
K-S Test Statistic	0.349117
K-S 5% Critical Value	0.119158

Data do not follow gamma distribution at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	0.000493
Adjusted Gamma UCL	0.000497

Lognormal Distribution Test

Lilliefors Test Statisitic	0.174669
Lilliefors 5% Critical Value	0.112522

Data not lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	0.000242
95% Chebyshev (MVUE) UCL	0.000296
97.5% Chebyshev (MVUE) UCL	0.000345
99% Chebyshev (MVUE) UCL	0.000441

95% Non-parametric UCLs

CLT UCL	0.000652
Adj-CLT UCL (Adjusted for skewness)	0.000802
Mod-t UCL (Adjusted for skewness)	0.00068
Jackknife UCL	0.000657
Standard Bootstrap UCL	0.000641
Bootstrap-t UCL	0.004481
Hall's Bootstrap UCL	0.002317
Percentile Bootstrap UCL	0.000683
BCA Bootstrap UCL	0.000916
95% Chebyshev (Mean, Sd) UCL	**0.001133**
97.5% Chebyshev (Mean, Sd) UCL	0.001466
99% Chebyshev (Mean, Sd) UCL	0.002122

R2-0009579

Attachment 3

Type	ERA
Medium	Mummichog
Chemical	2,3,4,7,8-PeCDF
Units	µg/kg

Data File

Variable: 2,3,4,7,8-PeCDF Mummichog

Raw Statistics	
Number of Valid Samples	62
Number of Unique Samples	53
Minimum	0.00024
Maximum	0.0088
Mean	0.001984
Median	0.001705
Standard Deviation	0.001233
Variance	1.52E-06
Coefficient of Variation	0.621616
Skewness	3.356071

Gamma Statistics	
k hat	3.955847
k star (bias corrected)	3.775188
Theta hat	0.000502
Theta star	0.000526
nu hat	490.5251
nu star	468.1233
Approx.Chi Square Value (.05)	418.9461
Adjusted Level of Significance	0.046129
Adjusted Chi Square Value	417.8458

Log-transformed Statistics	
Minimum of log data	-8.33487
Maximum of log data	-4.733
Mean of log data	-6.35425
Standard Deviation of log data	0.517039
Variance of log data	0.267329

RECOMMENDATION

Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

Normal Distribution Test	
Lilliefors Test Statisitic	0.269909
Lilliefors 5% Critical Value	0.112522
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	0.002246

Gamma Distribution Test	
A-D Test Statistic	2.796578
A-D 5% Critical Value	0.754144
K-S Test Statistic	0.191283
K-S 5% Critical Value	0.113472
Data do not follow gamma distribution at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	0.002217
Adjusted Gamma UCL	0.002223

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.185823
Lilliefors 5% Critical Value	0.112522
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	0.00225
95% Chebyshev (MVUE) UCL	0.002583
97.5% Chebyshev (MVUE) UCL	0.002842
99% Chebyshev (MVUE) UCL	0.003351

95% Non-parametric UCLs	
CLT UCL	0.002242
Adj-CLT UCL (Adjusted for skewness)	0.002313
Mod-t UCL (Adjusted for skewness)	0.002257
Jackknife UCL	0.002246
Standard Bootstrap UCL	0.002243
Bootstrap-t UCL	0.002369
Hall's Bootstrap UCL	0.002645
Percentile Bootstrap UCL	0.002258
BCA Bootstrap UCL	0.002335
95% Chebyshev (Mean, Sd) UCL	**0.002667**
97.5% Chebyshev (Mean, Sd) UCL	0.002962
99% Chebyshev (Mean, Sd) UCL	0.003543

R2-0009580

Attachment 3

Type	ERA
Medium	Mummichog
Chemical	2,3,7,8-TCDD
Units	µg/kg

Data File

Variable: 2,3,7,8-TCDD Mummichog

Raw Statistics	
Number of Valid Samples	62
Number of Unique Samples	59
Minimum	0.002
Maximum	0.828
Mean	0.075567
Median	0.0563
Standard Deviation	0.119223
Variance	0.014214
Coefficient of Variation	1.577718
Skewness	5.123373

Gamma Statistics	
k hat	1.440652
k star (bias corrected)	1.381695
Theta hat	0.052453
Theta star	0.054691
nu hat	178.6408
nu star	171.3302
Approx.Chi Square Value (.05)	142.055
Adjusted Level of Significance	0.046129
Adjusted Chi Square Value	141.4231

Log-transformed Statistics	
Minimum of log data	-6.21461
Maximum of log data	-0.18874
Mean of log data	-2.96834
Standard Deviation of log data	0.79773
Variance of log data	0.636373

RECOMMENDATION

Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

Normal Distribution Test	
Lilliefors Test Statisitic	0.438119
Lilliefors 5% Critical Value	0.112522
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	0.100856

Gamma Distribution Test	
A-D Test Statistic	7.307331
A-D 5% Critical Value	0.770144
K-S Test Statistic	0.317558
K-S 5% Critical Value	0.115281
Data do not follow gamma distribution at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	0.09114
Adjusted Gamma UCL	0.091547

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.24327
Lilliefors 5% Critical Value	0.112522
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	0.087399
95% Chebyshev (MVUE) UCL	0.105019
97.5% Chebyshev (MVUE) UCL	0.120098
99% Chebyshev (MVUE) UCL	0.149717

95% Non-parametric UCLs	
CLT UCL	0.100472
Adj-CLT UCL (Adjusted for skewness)	0.110999
Mod-t UCL (Adjusted for skewness)	0.102498
Jackknife UCL	0.100856
Standard Bootstrap UCL	0.099776
Bootstrap-t UCL	0.215731
Hall's Bootstrap UCL	0.112883
Percentile Bootstrap UCL	0.102023
BCA Bootstrap UCL	0.112747
95% Chebyshev (Mean, Sd) UCL	**0.141566**
97.5% Chebyshev (Mean, Sd) UCL	0.170124
99% Chebyshev (Mean, Sd) UCL	0.226221

R2-0009581

Attachment 3

Type	ERA
Medium	Mummichog
Chemical	2,3,7,8-TCDF
Units	µg/kg

Data File

Variable: 2,3,7,8-TCDF Mummichog

Raw Statistics	
Number of Valid Samples	66
Number of Unique Samples	54
Minimum	0.000773
Maximum	0.00373
Mean	0.001965
Median	0.001945
Standard Deviation	0.000703
Variance	4.95E-07
Coefficient of Variation	0.357998
Skewness	0.503989

Gamma Statistics	
k hat	7.740678
k star (bias corrected)	7.39893
Theta hat	0.000254
Theta star	0.000266
nu hat	1021.769
nu star	976.6587
Approx.Chi Square Value (.05)	905.1018
Adjusted Level of Significance	0.046364
Adjusted Chi Square Value	903.5761

Log-transformed Statistics	
Minimum of log data	-7.16523
Maximum of log data	-5.59135
Mean of log data	-6.29835
Standard Deviation of log data	0.374571
Variance of log data	0.140303

RECOMMENDATION

Data are normal (0.05)

Use Student's-t UCL

Normal Distribution Test	
Lilliefors Test Statisitic	0.094658
Lilliefors 5% Critical Value	0.109059
Data are normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	**0.002109**

Gamma Distribution Test	
A-D Test Statistic	0.322447
A-D 5% Critical Value	0.752222
K-S Test Statistic	0.078777
K-S 5% Critical Value	0.109838
Data follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	0.00212
Adjusted Gamma UCL	0.002124

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.102809
Lilliefors 5% Critical Value	0.109059
Data are lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	0.002144
95% Chebyshev (MVUE) UCL	0.002379
97.5% Chebyshev (MVUE) UCL	0.002555
99% Chebyshev (MVUE) UCL	0.002902

95% Non-parametric UCLs	
CLT UCL	0.002107
Adj-CLT UCL (Adjusted for skewness)	0.002113
Mod-t UCL (Adjusted for skewness)	0.00211
Jackknife UCL	0.002109
Standard Bootstrap UCL	0.002105
Bootstrap-t UCL	0.002123
Hall's Bootstrap UCL	0.002116
Percentile Bootstrap UCL	0.002109
BCA Bootstrap UCL	0.002114
95% Chebyshev (Mean, Sd) UCL	0.002342
97.5% Chebyshev (Mean, Sd) UCL	0.002505
99% Chebyshev (Mean, Sd) UCL	0.002826

R2-0009582

Attachment 3

Type	ERA
Medium	Mummichog
Chemical	OCDD
Units	µg/kg

Data File

Variable: OCDD Mummichog

Raw Statistics	
Number of Valid Samples	62
Number of Unique Samples	59
Minimum	0.00198
Maximum	0.028
Mean	0.006464
Median	0.00483
Standard Deviation	0.005181
Variance	2.68E-05
Coefficient of Variation	0.801624
Skewness	2.77389

Gamma Statistics	
k hat	2.794898
k star (bias corrected)	2.670414
Theta hat	0.002313
Theta star	0.00242
nu hat	346.5674
nu star	331.1313
Approx.Chi Square Value (.05)	289.9606
Adjusted Level of Significance	0.046129
Adjusted Chi Square Value	289.0488

Log-transformed Statistics	
Minimum of log data	-6.22466
Maximum of log data	-3.57555
Mean of log data	-5.23101
Standard Deviation of log data	0.562957
Variance of log data	0.31692

RECOMMENDATION

Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

Normal Distribution Test	
Lilliefors Test Statisitic	0.224161
Lilliefors 5% Critical Value	0.112522
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	0.007563

Gamma Distribution Test	
A-D Test Statistic	2.840114
A-D 5% Critical Value	0.758957
K-S Test Statistic	0.140558
K-S 5% Critical Value	0.114008
Data do not follow gamma distribution at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	0.007381
Adjusted Gamma UCL	0.007405

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.116406
Lilliefors 5% Critical Value	0.112522
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	0.007187
95% Chebyshev (MVUE) UCL	0.008323
97.5% Chebyshev (MVUE) UCL	0.00922
99% Chebyshev (MVUE) UCL	0.010984

95% Non-parametric UCLs	
CLT UCL	0.007546
Adj-CLT UCL (Adjusted for skewness)	0.007794
Mod-t UCL (Adjusted for skewness)	0.007601
Jackknife UCL	0.007563
Standard Bootstrap UCL	0.007515
Bootstrap-t UCL	0.007816
Hall's Bootstrap UCL	0.007763
Percentile Bootstrap UCL	0.007592
BCA Bootstrap UCL	0.007728
95% Chebyshev (Mean, Sd) UCL	**0.009332**
97.5% Chebyshev (Mean, Sd) UCL	0.010573
99% Chebyshev (Mean, Sd) UCL	0.013011

R2-0009583

Type	ERA
Medium	Mummichog
Chemical	OCDF
Units	µg/kg

Data File

Variable: OCDF Mummichog

Raw Statistics	
Number of Valid Samples	62
Number of Unique Samples	61
Minimum	0.000216
Maximum	0.01995
Mean	0.001454
Median	0.00062
Standard Deviation	0.00287
Variance	8.24E-06
Coefficient of Variation	1.973901
Skewness	4.968825

Gamma Statistics	
k hat	0.890768
k star (bias corrected)	0.858419
Theta hat	0.001632
Theta star	0.001694
nu hat	110.4553
nu star	106.444
Approx.Chi Square Value (.05)	83.6296
Adjusted Level of Significance	0.046129
Adjusted Chi Square Value	83.1495

Log-transformed Statistics	
Minimum of log data	-8.44255
Maximum of log data	-3.91453
Mean of log data	-7.19056
Standard Deviation of log data	0.951349
Variance of log data	0.905065

RECOMMENDATION

Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

Normal Distribution Test	
Lilliefors Test Statisitic	0.33788
Lilliefors 5% Critical Value	0.112522
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	0.002063

Gamma Distribution Test	
A-D Test Statistic	5.47327
A-D 5% Critical Value	0.784982
K-S Test Statistic	0.218386
K-S 5% Critical Value	0.116843
Data do not follow gamma distribution at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	0.001851
Adjusted Gamma UCL	0.001861

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.143312
Lilliefors 5% Critical Value	0.112522
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	0.001554
95% Chebyshev (MVUE) UCL	0.001895
97.5% Chebyshev (MVUE) UCL	0.002208
99% Chebyshev (MVUE) UCL	0.002822

95% Non-parametric UCLs	
CLT UCL	0.002054
Adj-CLT UCL (Adjusted for skewness)	0.002299
Mod-t UCL (Adjusted for skewness)	0.002101
Jackknife UCL	0.002063
Standard Bootstrap UCL	0.002034
Bootstrap-t UCL	0.002677
Hall's Bootstrap UCL	0.00413
Percentile Bootstrap UCL	0.002081
BCA Bootstrap UCL	0.002407
95% Chebyshev (Mean, Sd) UCL	**0.003043**
97.5% Chebyshev (Mean, Sd) UCL	0.00373
99% Chebyshev (Mean, Sd) UCL	0.005081

R2-0009584

Attachment 3

Type	ERA
Medium	Mummichog
Chemical	Lipids
Units	µg/kg

Data File

Variable: Lipids Mummichog

Raw Statistics	
Number of Valid Samples	57
Number of Unique Samples	50
Minimum	0.75
Maximum	4.87
Mean	3.195439
Median	3.15
Standard Deviation	0.71386
Variance	0.509597
Coefficient of Variation	0.2234
Skewness	-0.128

Gamma Statistics	
k hat	16.71098
k star (bias corrected)	15.84315
Theta hat	0.191218
Theta star	0.201692
nu hat	1905.052
nu star	1806.119
Approx.Chi Square Value (.05)	1708.39
Adjusted Level of Significance	0.045789
Adjusted Chi Square Value	1705.942

Log-transformed Statistics	
Minimum of log data	-0.28768
Maximum of log data	1.583094
Mean of log data	1.131506
Standard Deviation of log data	0.270372
Variance of log data	0.073101

RECOMMENDATION

Data are normal (0.05)

Use Student's-t UCL

Normal Distribution Test	
Lilliefors Test Statisitic	0.085215
Lilliefors 5% Critical Value	0.117354
Data are normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	**3.353581**

Gamma Distribution Test	
A-D Test Statistic	0.854061
A-D 5% Critical Value	0.749351
K-S Test Statistic	0.11356
K-S 5% Critical Value	0.11766
Data follow approximate gamma distibution at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	3.378236
Adjusted Gamma UCL	3.383083

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.138623
Lilliefors 5% Critical Value	0.117354
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	3.424669
95% Chebyshev (MVUE) UCL	3.723055
97.5% Chebyshev (MVUE) UCL	3.943496
99% Chebyshev (MVUE) UCL	4.376508

95% Non-parametric UCLs	
CLT UCL	3.350965
Adj-CLT UCL (Adjusted for skewness)	3.349252
Mod-t UCL (Adjusted for skewness)	3.353314
Jackknife UCL	3.353581
Standard Bootstrap UCL	3.346315
Bootstrap-t UCL	3.354213
Hall's Bootstrap UCL	3.355052
Percentile Bootstrap UCL	3.345439
BCA Bootstrap UCL	3.343158
95% Chebyshev (Mean, Sd) UCL	3.607586
97.5% Chebyshev (Mean, Sd) UCL	3.785923
99% Chebyshev (Mean, Sd) UCL	4.13623

R2-0009585

Attachment 3

Type	ERA
Medium	Mummichog
Chemical	2,3,3',4,4',5,5'-Heptachlorobiphenyl (189)
Units	µg/kg

Data File

Variable: 2,3,3',4,4',5,5'-Heptachlorobiphenyl (189) Mummichog

Raw Statistics	
Number of Valid Samples	61
Number of Unique Samples	54
Minimum	0.0166
Maximum	0.781
Mean	0.391953
Median	0.369
Standard Deviation	0.154388
Variance	0.023836
Coefficient of Variation	0.393895
Skewness	0.266902

Gamma Statistics	
k hat	4.712275
k star (bias corrected)	4.491453
Theta hat	0.083177
Theta star	0.087266
nu hat	574.8975
nu star	547.9572
Approx.Chi Square Value (.05)	494.6544
Adjusted Level of Significance	0.046066
Adjusted Chi Square Value	493.4367

Log-transformed Statistics	
Minimum of log data	-4.09835
Maximum of log data	-0.24718
Mean of log data	-1.04645
Standard Deviation of log data	0.568272
Variance of log data	0.322934

RECOMMENDATION

Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

Normal Distribution Test	
Lilliefors Test Statisitic	0.141808
Lilliefors 5% Critical Value	0.113441
Data not normal at 5% significance level	
95% UCL (Assuming Normal Distribution)	
Student's-t UCL	0.424978

Gamma Distribution Test	
A-D Test Statistic	1.207775
A-D 5% Critical Value	0.753521
K-S Test Statistic	0.13497
K-S 5% Critical Value	0.114212
Data do not follow gamma distribution at 5% significance level	
95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	0.434189
Adjusted Gamma UCL	0.435261

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.183665
Lilliefors 5% Critical Value	0.113441
Data not lognormal at 5% significance level	
95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	0.474676
95% Chebyshev (MVUE) UCL	0.550629
97.5% Chebyshev (MVUE) UCL	0.610847
99% Chebyshev (MVUE) UCL	0.729133
95% Non-parametric UCLs	
CLT UCL	0.424468
Adj-CLT UCL (Adjusted for skewness)	0.42519
Mod-t UCL (Adjusted for skewness)	0.42509
Jackknife UCL	0.424978
Standard Bootstrap UCL	0.425042
Bootstrap-t UCL	0.4272
Hall's Bootstrap UCL	0.427244
Percentile Bootstrap UCL	0.423502
BCA Bootstrap UCL	0.423436
95% Chebyshev (Mean, Sd) UCL	**0.478117**
97.5% Chebyshev (Mean, Sd) UCL	0.515401
99% Chebyshev (Mean, Sd) UCL	0.588637

R2-0009586

Attachment 3

Type	ERA
Medium	Mummichog
Chemical	2,3,3',4,4',5'-hexachlorobiphenyl
Units	µg/kg

Data File	
Raw Statistics	
Number of Valid Samples	61
Number of Unique Samples	53
Minimum	0.0166
Maximum	4.84
Mean	1.050478
Median	0.91
Standard Deviation	0.839396
Variance	0.704585
Coefficient of Variation	0.799061
Skewness	3.535054
Gamma Statistics	
k hat	2.425463
k star (bias corrected)	2.317107
Theta hat	0.433104
Theta star	0.453357
nu hat	295.9065
nu star	282.6871
Approx.Chi Square Value (.05)	244.7383
Adjusted Level of Significance	0.046066
Adjusted Chi Square Value	243.8881
Log-transformed Statistics	
Minimum of log data	-4.09835
Maximum of log data	1.576915
Mean of log data	-0.17084
Standard Deviation of log data	0.770104
Variance of log data	0.59306

RECOMMENDATION

Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

Variable:	2,3,3',4,4',5'-hexachlorobiphenyl Mummichog
Normal Distribution Test	
Lilliefors Test Statisitic	0.309883
Lilliefors 5% Critical Value	0.113441
Data not normal at 5% significance level	
95% UCL (Assuming Normal Distribution)	
Student's-t UCL	1.230029
Gamma Distribution Test	
A-D Test Statistic	5.602145
A-D 5% Critical Value	0.760822
K-S Test Statistic	0.248423
K-S 5% Critical Value	0.115055
Data do not follow gamma distribution at 5% significance level	
95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	1.213364
Adjusted Gamma UCL	1.217593
Lognormal Distribution Test	
Lilliefors Test Statisitic	0.295804
Lilliefors 5% Critical Value	0.113441
Data not lognormal at 5% significance level	
95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	1.391993
95% Chebyshev (MVUE) UCL	1.667694
97.5% Chebyshev (MVUE) UCL	1.901695
99% Chebyshev (MVUE) UCL	2.361347
95% Non-parametric UCLs	
CLT UCL	1.227256
Adj-CLT UCL (Adjusted for skewness)	1.279234
Mod-t UCL (Adjusted for skewness)	1.238136
Jackknife UCL	1.230029
Standard Bootstrap UCL	1.225016
Bootstrap-t UCL	1.321645
Hall's Bootstrap UCL	2.366344
Percentile Bootstrap UCL	1.244455
BCA Bootstrap UCL	1.291897
95% Chebyshev (Mean, Sd) UCL	**1.518945**
97.5% Chebyshev (Mean, Sd) UCL	1.72165
99% Chebyshev (Mean, Sd) UCL	2.119827

R2-0009587

Attachment 3

Type	ERA
Medium	Mummichog
Chemical	2,3,3',4,4',5-Hexachlorobiphenyl (156)
Units	µg/kg

Data File

Variable: 2,3,3',4,4',5-Hexachlorobiphenyl (156) Mummichog

Raw Statistics	
Number of Valid Samples	61
Number of Unique Samples	55
Minimum	0.0166
Maximum	7.16
Mean	4.626338
Median	4.5
Standard Deviation	1.196553
Variance	1.431739
Coefficient of Variation	0.258639
Skewness	-1.06222

Gamma Statistics	
k hat	4.737167
k star (bias corrected)	4.515121
Theta hat	0.976604
Theta star	1.024632
nu hat	577.9344
nu star	550.8448
Approx.Chi Square Value (.05)	497.3986
Adjusted Level of Significance	0.046066
Adjusted Chi Square Value	496.1775

Log-transformed Statistics	
Minimum of log data	-4.09835
Maximum of log data	1.96851
Mean of log data	1.42252
Standard Deviation of log data	0.777834
Variance of log data	0.605026

Normal Distribution Test	
Lilliefors Test Statisitic	0.116365
Lilliefors 5% Critical Value	0.113441
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	4.882286

Gamma Distribution Test	
A-D Test Statistic	7.05145
A-D 5% Critical Value	0.753513
K-S Test Statistic	0.268697
K-S 5% Critical Value	0.11421
Data do not follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	5.123444
Adjusted Gamma UCL	5.136053

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.345658
Lilliefors 5% Critical Value	0.113441
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	6.908809
95% Chebyshev (MVUE) UCL	8.285464
97.5% Chebyshev (MVUE) UCL	9.457389
99% Chebyshev (MVUE) UCL	11.75941

95% Non-parametric UCLs	
CLT UCL	4.878334
Adj-CLT UCL (Adjusted for skewness)	4.85607
Mod-t UCL (Adjusted for skewness)	4.878813
Jackknife UCL	4.882286
Standard Bootstrap UCL	4.881795
Bootstrap-t UCL	4.860342
Hall's Bootstrap UCL	4.877051
Percentile Bootstrap UCL	4.868689
BCA Bootstrap UCL	4.836557
95% Chebyshev (Mean, Sd) UCL	**5.294134**
97.5% Chebyshev (Mean, Sd) UCL	5.58309
99% Chebyshev (Mean, Sd) UCL	6.150687

RECOMMENDATION

Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

R2-0009588

Attachment 3

Type	ERA
Medium	Mummichog
Chemical	2,3,3',4,4'-Pentachlorobiphenyl (105)
Units	µg/kg

Data File	
Raw Statistics	
Number of Valid Samples	61
Number of Unique Samples	49
Minimum	0.0166
Maximum	27.7
Mean	17.06781
Median	16.8
Standard Deviation	4.98162
Variance	24.81654
Coefficient of Variation	0.291872
Skewness	-0.78876
Gamma Statistics	
k hat	3.5178
k star (bias corrected)	3.355723
Theta hat	4.851842
Theta star	5.086181
nu hat	429.1717
nu star	409.3982
Approx.Chi Square Value (.05)	363.486
Adjusted Level of Significance	0.046066
Adjusted Chi Square Value	362.4453
Log-transformed Statistics	
Minimum of log data	-4.09835
Maximum of log data	3.321432
Mean of log data	2.688379
Standard Deviation of log data	0.967465
Variance of log data	0.935989

RECOMMENDATION

Data are normal (0.05)

Use Student's-t UCL

Variable:	2,3,3',4,4'-Pentachlorobiphenyl (105) Mummichog
Normal Distribution Test	
Lilliefors Test Statisitic	0.108804
Lilliefors 5% Critical Value	0.113441
Data are normal at 5% significance level	
95% UCL (Assuming Normal Distribution)	
Student's-t UCL	**18.1334**
Gamma Distribution Test	
A-D Test Statistic	6.806756
A-D 5% Critical Value	0.755792
K-S Test Statistic	0.284201
K-S 5% Critical Value	0.114501
Data do not follow gamma distribution at 5% significance level	
95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	19.22366
Adjusted Gamma UCL	19.27886
Lognormal Distribution Test	
Lilliefors Test Statisitic	0.364407
Lilliefors 5% Critical Value	0.113441
Data not lognormal at 5% significance level	
95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	31.0774
95% Chebyshev (MVUE) UCL	37.95359
97.5% Chebyshev (MVUE) UCL	44.32548
99% Chebyshev (MVUE) UCL	56.84183
95% Non-parametric UCLs	
CLT UCL	18.11695
Adj-CLT UCL (Adjusted for skewness)	18.04812
Mod-t UCL (Adjusted for skewness)	18.12267
Jackknife UCL	18.1334
Standard Bootstrap UCL	18.08723
Bootstrap-t UCL	18.08411
Hall's Bootstrap UCL	18.05582
Percentile Bootstrap UCL	18.04945
BCA Bootstrap UCL	17.99749
95% Chebyshev (Mean, Sd) UCL	19.84805
97.5% Chebyshev (Mean, Sd) UCL	21.05107
99% Chebyshev (Mean, Sd) UCL	23.41415

R2-0009589

Attachment 3

Type	ERA
Medium	Mummichog
Chemical	2,3',4,4',5,5'-Hexachlorobiphenyl (167)
Units	µg/kg

Data File		Variable:	2,3',4,4',5,5'-Hexachlorobiphenyl (167)	Mummichog
Raw Statistics		Normal Distribution Test		
Number of Valid Samples	61	Lilliefors Test Statisitic		0.235997
Number of Unique Samples	56	Lilliefors 5% Critical Value		0.113441
Minimum	0.0166	Data not normal at 5% significance level		
Maximum	9.8			
Mean	3.135354	95% UCL (Assuming Normal Distribution)		
Median	2.51	Student's-t UCL		3.542299
Standard Deviation	1.90246			
Variance	3.619355	Gamma Distribution Test		
Coefficient of Variation	0.606777	A-D Test Statistic		3.538804
Skewness	2.058462	A-D 5% Critical Value		0.759115
		K-S Test Statistic		0.199771
Gamma Statistics		K-S 5% Critical Value		0.114867
k hat	2.7699	Data do not follow gamma distribution		
k star (bias corrected)	2.644605	at 5% significance level		
Theta hat	1.131938			
Theta star	1.185566	95% UCLs (Assuming Gamma Distribution)		
nu hat	337.9278	Approximate Gamma UCL		3.586995
nu star	322.6418	Adjusted Gamma UCL		3.59866
Approx.Chi Square Value (.05)	282.0177			
Adjusted Level of Significance	0.046066	Lognormal Distribution Test		
Adjusted Chi Square Value	281.1035	Lilliefors Test Statisitic		0.264405
		Lilliefors 5% Critical Value		0.113441
Log-transformed Statistics		Data not lognormal at 5% significance level		
Minimum of log data	-4.09835			
Maximum of log data	2.282382	95% UCLs (Assuming Lognormal Distribution)		
Mean of log data	0.951502	95% H-UCL		4.490041
Standard Deviation of log data	0.812606	95% Chebyshev (MVUE) UCL		5.407738
Variance of log data	0.660328	97.5% Chebyshev (MVUE) UCL		6.199821
		99% Chebyshev (MVUE) UCL		7.755715
		95% Non-parametric UCLs		
		CLT UCL		3.536016
		Adj-CLT UCL (Adjusted for skewness)		3.604614
		Mod-t UCL (Adjusted for skewness)		3.552999
		Jackknife UCL		3.542299
		Standard Bootstrap UCL		3.524928
		Bootstrap-t UCL		3.688565
RECOMMENDATION		Hall's Bootstrap UCL		3.622905
Data are Non-parametric (0.05)		Percentile Bootstrap UCL		3.556502
		BCA Bootstrap UCL		3.604039
Use 95% Chebyshev (Mean, Sd) UCL		**95% Chebyshev (Mean, Sd) UCL**		**4.197117**
		97.5% Chebyshev (Mean, Sd) UCL		4.656542
		99% Chebyshev (Mean, Sd) UCL		5.558995

R2-0009590

Attachment 3

Type	ERA
Medium	Mummichog
Chemical	2',3,4,4',5-pentachlorobiphenyl
Units	µg/kg

Data File	
Raw Statistics	
Number of Valid Samples	61
Number of Unique Samples	52
Minimum	0.0166
Maximum	2.8
Mean	1.095059
Median	1.02
Standard Deviation	0.431483
Variance	0.186177
Coefficient of Variation	0.394027
Skewness	1.351526
Gamma Statistics	
k hat	4.749149
k star (bias corrected)	4.526513
Theta hat	0.23058
Theta star	0.241921
nu hat	579.3962
nu star	552.2346
Approx.Chi Square Value (.05)	498.7196
Adjusted Level of Significance	0.046066
Adjusted Chi Square Value	497.4968
Log-transformed Statistics	
Minimum of log data	-4.09835
Maximum of log data	1.029619
Mean of log data	-0.01815
Standard Deviation of log data	0.626225
Variance of log data	0.392158

RECOMMENDATION

Data are normal (0.05)

Use Student's-t UCL

Variable: 2',3,4,4',5-pentachlorobiphenyl Mummichog

Normal Distribution Test	
Lilliefors Test Statisitic	0.108839
Lilliefors 5% Critical Value	0.113441
Data are normal at 5% significance level	
95% UCL (Assuming Normal Distribution)	
Student's-t UCL	**1.187355**
Gamma Distribution Test	
A-D Test Statistic	2.150884
A-D 5% Critical Value	0.753509
K-S Test Statistic	0.149368
K-S 5% Critical Value	0.114209
Data do not follow gamma distribution	
at 5% significance level	
95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	1.212564
Adjusted Gamma UCL	1.215544
Lognormal Distribution Test	
Lilliefors Test Statisitic	0.217015
Lilliefors 5% Critical Value	0.113441
Data not lognormal at 5% significance level	
95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	1.398536
95% Chebyshev (MVUE) UCL	1.639327
97.5% Chebyshev (MVUE) UCL	1.833667
99% Chebyshev (MVUE) UCL	2.215411
95% Non-parametric UCLs	
CLT UCL	1.18593
Adj-CLT UCL (Adjusted for skewness)	1.196145
Mod-t UCL (Adjusted for skewness)	1.188948
Jackknife UCL	1.187355
Standard Bootstrap UCL	1.185558
Bootstrap-t UCL	1.198608
Hall's Bootstrap UCL	1.208668
Percentile Bootstrap UCL	1.187846
BCA Bootstrap UCL	1.19377
95% Chebyshev (Mean, Sd) UCL	1.335869
97.5% Chebyshev (Mean, Sd) UCL	1.440068
99% Chebyshev (Mean, Sd) UCL	1.644747

R2-0009591

Attachment 3

Type	ERA
Medium	Mummichog
Chemical	2,3,4,4',5-Pentachlorobiphenyl (114)
Units	µg/kg

Data File		Variable: 2,3,4,4',5-Pentachlorobiphenyl (114)	Mummichog
Raw Statistics		Normal Distribution Test	
Number of Valid Samples	61	Lilliefors Test Statisitic	0.155233
Number of Unique Samples	53	Lilliefors 5% Critical Value	0.113441
Minimum	0.0166	Data not normal at 5% significance level	
Maximum	2.5		
Mean	1.175452	95% UCL (Assuming Normal Distribution)	
Median	1.08	Student's-t UCL	1.269067
Standard Deviation	0.437648		
Variance	0.191536	Gamma Distribution Test	
Coefficient of Variation	0.372323	A-D Test Statistic	2.435757
Skewness	0.87117	A-D 5% Critical Value	0.753452
		K-S Test Statistic	0.165252
Gamma Statistics		K-S 5% Critical Value	0.114193
k hat	4.918122	Data do not follow gamma distribution	
k star (bias corrected)	4.687176	at 5% significance level	
Theta hat	0.239004		
Theta star	0.250781	95% UCLs (Assuming Gamma Distribution)	
nu hat	600.0109	Approximate Gamma UCL	1.299226
nu star	571.8355	Adjusted Gamma UCL	1.302363
Approx.Chi Square Value (.05)	517.3582		
Adjusted Level of Significance	0.046066	Lognormal Distribution Test	
Adjusted Chi Square Value	516.1124	Lilliefors Test Statisitic	0.236634
		Lilliefors 5% Critical Value	0.113441
Log-transformed Statistics		Data not lognormal at 5% significance level	
Minimum of log data	-4.09835		
Maximum of log data	0.916291	95% UCLs (Assuming Lognormal Distribution)	
Mean of log data	0.056557	95% H-UCL	1.507494
Standard Deviation of log data	0.626559	95% Chebyshev (MVUE) UCL	1.767147
Variance of log data	0.392577	97.5% Chebyshev (MVUE) UCL	1.976733
		99% Chebyshev (MVUE) UCL	2.388423
		95% Non-parametric UCLs	
		CLT UCL	1.267622
		Adj-CLT UCL (Adjusted for skewness)	1.274301
		Mod-t UCL (Adjusted for skewness)	1.270109
		Jackknife UCL	1.269067
		Standard Bootstrap UCL	1.268752
		Bootstrap-t UCL	1.277061
RECOMMENDATION		Hall's Bootstrap UCL	1.276744
Data are Non-parametric (0.05)		Percentile Bootstrap UCL	1.27041
		BCA Bootstrap UCL	1.268174
Use 95% Chebyshev (Mean, Sd) UCL		**95% Chebyshev (Mean, Sd) UCL**	**1.419704**
		97.5% Chebyshev (Mean, Sd) UCL	1.525392
		99% Chebyshev (Mean, Sd) UCL	1.732995

R2-0009592

Attachment 3

Type	ERE
Medium	Mummichog
Chemical	2,3',4,4',5-Pentachlorobiphenyl (118)
Units	µg/kg

Data File

Variable: 2,3',4,4',5-Pentachlorobiphenyl (118) Mummichog

Raw Statistics	
Number of Valid Samples	58
Number of Unique Samples	53
Minimum	0.0166
Maximum	78
Mean	52.31925
Median	51.35
Standard Deviation	12.7595
Variance	162.8048
Coefficient of Variation	0.243878
Skewness	-0.95488

Gamma Statistics	
k hat	3.683297
k star (bias corrected)	3.504276
Theta hat	14.20446
Theta star	14.93012
nu hat	427.2625
nu star	406.496
Approx.Chi Square Value (.05)	360.7511
Adjusted Level of Significance	0.045862
Adjusted Chi Square Value	359.6589

Log-transformed Statistics	
Minimum of log data	-4.09835
Maximum of log data	4.356709
Mean of log data	3.815518
Standard Deviation of log data	1.076721
Variance of log data	1.159328

RECOMMENDATION

Data are normal (0.05)

Use Student's-t UCL

Normal Distribution Test	
Lilliefors Test Statisitic	0.071065
Lilliefors 5% Critical Value	0.116337
Data are normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	**55.12058**

Gamma Distribution Test	
A-D Test Statistic	7.666302
A-D 5% Critical Value	0.754894
K-S Test Statistic	0.27553
K-S 5% Critical Value	0.117379
Data do not follow gamma distribution at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	58.95358
Adjusted Gamma UCL	59.13261

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.372922
Lilliefors 5% Critical Value	0.116337
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	113.5389
95% Chebyshev (MVUE) UCL	139.1611
97.5% Chebyshev (MVUE) UCL	164.8365
99% Chebyshev (MVUE) UCL	215.2708

95% Non-parametric UCLs	
CLT UCL	55.07505
Adj-CLT UCL (Adjusted for skewness)	54.85059
Mod-t UCL (Adjusted for skewness)	55.08556
Jackknife UCL	55.12058
Standard Bootstrap UCL	55.01902
Bootstrap-t UCL	55.01626
Hall's Bootstrap UCL	55.05963
Percentile Bootstrap UCL	54.95
BCA Bootstrap UCL	54.62759
95% Chebyshev (Mean, Sd) UCL	59.62217
97.5% Chebyshev (Mean, Sd) UCL	62.78215
99% Chebyshev (Mean, Sd) UCL	68.98931

R2-0009593

Attachment 3

Type	ERE
Medium	Mummichog
Chemical	3,3',4,4',5,5'-Hexachlorobiphenyl (169)
Units	µg/kg

Data File		Variable: 3,3',4,4',5,5'-Hexachlorobiphenyl (169)	Mummichog
Raw Statistics		Normal Distribution Test	
Number of Valid Samples	61	Lilliefors Test Statisitic	0.374373
Number of Unique Samples	29	Lilliefors 5% Critical Value	0.113441
Minimum	0.00175	Data not normal at 5% significance level	
Maximum	0.6		
Mean	0.04223	95% UCL (Assuming Normal Distribution)	
Median	0.0165	Student's-t UCL	0.0601
Standard Deviation	0.083541		
Variance	0.006979	Gamma Distribution Test	
Coefficient of Variation	1.978219	A-D Test Statistic	8.360181
Skewness	5.387241	A-D 5% Critical Value	0.786227
		K-S Test Statistic	0.397943
Gamma Statistics		K-S 5% Critical Value	0.117826
k hat	0.864603	Data do not follow gamma distribution	
k star (bias corrected)	0.833011	at 5% significance level	
Theta hat	0.048844		
Theta star	0.050696	95% UCLs (Assuming Gamma Distribution)	
nu hat	105.4816	Approximate Gamma UCL	0.054077
nu star	101.6273	Adjusted Gamma UCL	0.054403
Approx.Chi Square Value (.05)	79.36353		
Adjusted Level of Significance	0.046066	Lognormal Distribution Test	
Adjusted Chi Square Value	78.88846	Lilliefors Test Statisitic	0.348557
		Lilliefors 5% Critical Value	0.113441
Log-transformed Statistics		Data not lognormal at 5% significance level	
Minimum of log data	-6.34814		
Maximum of log data	-0.51083	95% UCLs (Assuming Lognormal Distribution)	
Mean of log data	-3.84419	95% H-UCL	0.050962
Standard Deviation of log data	1.050723	95% Chebyshev (MVUE) UCL	0.062473
Variance of log data	1.104019	97.5% Chebyshev (MVUE) UCL	0.07364
		99% Chebyshev (MVUE) UCL	0.095574
		95% Non-parametric UCLs	
		CLT UCL	0.059824
		Adj-CLT UCL (Adjusted for skewness)	0.067708
		Mod-t UCL (Adjusted for skewness)	0.06133
		Jackknife UCL	0.0601
		Standard Bootstrap UCL	0.059861
		Bootstrap-t UCL	0.081418
RECOMMENDATION		Hall's Bootstrap UCL	0.130024
Data are Non-parametric (0.05)		Percentile Bootstrap UCL	0.061807
		BCA Bootstrap UCL	0.07055
Use 97.5% Chebyshev (Mean, Sd) UCL		95% Chebyshev (Mean, Sd) UCL	0.088854
		97.5% Chebyshev (Mean, Sd) UCL	**0.109029**
		99% Chebyshev (Mean, Sd) UCL	0.148657

R2-0009594

Attachment 3

Type	ERE
Medium	Mummichog
Chemical	3,3',4,4',5-Pentachlorobiphenyl (126)
Units	µg/kg

Data File

Variable: 3,3',4,4',5-Pentachlorobiphenyl (126) Mummichog

Raw Statistics	
Number of Valid Samples	61
Number of Unique Samples	52
Minimum	0.0166
Maximum	0.295
Mean	0.149119
Median	0.136
Standard Deviation	0.051783
Variance	0.002682
Coefficient of Variation	0.347263
Skewness	0.481791

Gamma Statistics	
k hat	7.187364
k star (bias corrected)	6.844816
Theta hat	0.020747
Theta star	0.021786
nu hat	876.8584
nu star	835.0675
Approx.Chi Square Value (.05)	768.9891
Adjusted Level of Significance	0.046066
Adjusted Chi Square Value	767.4654

Log-transformed Statistics	
Minimum of log data	-4.09835
Maximum of log data	-1.22078
Mean of log data	-1.97419
Standard Deviation of log data	0.421459
Variance of log data	0.177628

RECOMMENDATION

Data are normal (0.05)

Use Student's-t UCL

Normal Distribution Test	
Lilliefors Test Statisitic	0.110874
Lilliefors 5% Critical Value	0.113441
Data are normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	**0.160196**

Gamma Distribution Test	
A-D Test Statistic	0.68883
A-D 5% Critical Value	0.752421
K-S Test Statistic	0.103638
K-S 5% Critical Value	0.114042
Data follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	0.161932
Adjusted Gamma UCL	0.162254

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.135201
Lilliefors 5% Critical Value	0.113441
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	0.167515
95% Chebyshev (MVUE) UCL	0.188512
97.5% Chebyshev (MVUE) UCL	0.204514
99% Chebyshev (MVUE) UCL	0.235945

95% Non-parametric UCLs	
CLT UCL	0.160025
Adj-CLT UCL (Adjusted for skewness)	0.160462
Mod-t UCL (Adjusted for skewness)	0.160264
Jackknife UCL	0.160196
Standard Bootstrap UCL	0.159765
Bootstrap-t UCL	0.160783
Hall's Bootstrap UCL	0.160559
Percentile Bootstrap UCL	0.160385
BCA Bootstrap UCL	0.160236
95% Chebyshev (Mean, Sd) UCL	0.178019
97.5% Chebyshev (Mean, Sd) UCL	0.190524
99% Chebyshev (Mean, Sd) UCL	0.215088

R2-0009595

Attachment 3

Type	ERE
Medium	Mummichog
Chemical	3,3',4,4'-Tetrachlorobiphenyl (77)
Units	µg/kg

Data File

Variable: 3,3',4,4'-Tetrachlorobiphenyl (77) Mummichog

Raw Statistics	
Number of Valid Samples	61
Number of Unique Samples	51
Minimum	0.0166
Maximum	8.06
Mean	1.537022
Median	1.3
Standard Deviation	1.116131
Variance	1.245747
Coefficient of Variation	0.726164
Skewness	3.657435

Gamma Statistics	
k hat	2.23598
k star (bias corrected)	2.136943
Theta hat	0.687404
Theta star	0.719262
nu hat	272.7896
nu star	260.7071
Approx.Chi Square Value (.05)	224.3112
Adjusted Level of Significance	0.046066
Adjusted Chi Square Value	223.4982

Log-transformed Statistics	
Minimum of log data	-4.09835
Maximum of log data	2.086914
Mean of log data	0.18987
Standard Deviation of log data	0.867648
Variance of log data	0.752814

Normal Distribution Test	
Lilliefors Test Statisitic	0.227396
Lilliefors 5% Critical Value	0.113441
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	1.775768

Gamma Distribution Test	
A-D Test Statistic	3.498219
A-D 5% Critical Value	0.761761
K-S Test Statistic	0.23209
K-S 5% Critical Value	0.115158
Data do not follow gamma distribution at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	1.786413
Adjusted Gamma UCL	1.792911

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.291058
Lilliefors 5% Critical Value	0.113441
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	2.240937
95% Chebyshev (MVUE) UCL	2.715004
97.5% Chebyshev (MVUE) UCL	3.133838
99% Chebyshev (MVUE) UCL	3.956556

95% Non-parametric UCLs	
CLT UCL	1.772081
Adj-CLT UCL (Adjusted for skewness)	1.843587
Mod-t UCL (Adjusted for skewness)	1.786921
Jackknife UCL	1.775768
Standard Bootstrap UCL	1.768639
Bootstrap-t UCL	1.905929
Hall's Bootstrap UCL	2.763699
Percentile Bootstrap UCL	1.784561
BCA Bootstrap UCL	1.861302
95% Chebyshev (Mean, Sd) UCL	**2.159934**
97.5% Chebyshev (Mean, Sd) UCL	2.429469
99% Chebyshev (Mean, Sd) UCL	2.958918

RECOMMENDATION

Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

R2-0009596

Attachment 3

Type	ERE
Medium	Mummichog
Chemical	3,4,4',5-Tetrachlorobiphenyl (81)
Units	µg/kg

Data File

Variable: 3,4,4',5-Tetrachlorobiphenyl (81) Mummichog

Raw Statistics	
Number of Valid Samples	56
Number of Unique Samples	51
Minimum	0.0166
Maximum	2.97
Mean	0.674529
Median	0.572
Standard Deviation	0.390383
Variance	0.152399
Coefficient of Variation	0.57875
Skewness	3.961548

Gamma Statistics	
k hat	3.982907
k star (bias corrected)	3.781442
Theta hat	0.169356
Theta star	0.178379
nu hat	446.0856
nu star	423.5215
Approx.Chi Square Value (.05)	376.8037
Adjusted Level of Significance	0.045714
Adjusted Chi Square Value	375.6456

Log-transformed Statistics	
Minimum of log data	-4.09835
Maximum of log data	1.088562
Mean of log data	-0.5245
Standard Deviation of log data	0.607378
Variance of log data	0.368908

RECOMMENDATION

Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

Normal Distribution Test	
Lilliefors Test Statisitic	0.235293
Lilliefors 5% Critical Value	0.118397
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	0.761806

Gamma Distribution Test	
A-D Test Statistic	3.680815
A-D 5% Critical Value	0.753607
K-S Test Statistic	0.227839
K-S 5% Critical Value	0.11936
Data do not follow gamma distribution at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	0.75816
Adjusted Gamma UCL	0.760497

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.274201
Lilliefors 5% Critical Value	0.118397
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	0.834501
95% Chebyshev (MVUE) UCL	0.978438
97.5% Chebyshev (MVUE) UCL	1.095027
99% Chebyshev (MVUE) UCL	1.324044

95% Non-parametric UCLs	
CLT UCL	0.760336
Adj-CLT UCL (Adjusted for skewness)	0.789845
Mod-t UCL (Adjusted for skewness)	0.766409
Jackknife UCL	0.761806
Standard Bootstrap UCL	0.761739
Bootstrap-t UCL	0.814411
Hall's Bootstrap UCL	1.178363
Percentile Bootstrap UCL	0.765964
BCA Bootstrap UCL	0.795779
95% Chebyshev (Mean, Sd) UCL	**0.90192**
97.5% Chebyshev (Mean, Sd) UCL	1.000313
99% Chebyshev (Mean, Sd) UCL	1.193586

R2-0009597

Attachment 3

Type	ERE
Medium	Mummichog
Chemical	Lipids
Units	µg/kg

Data File

Variable: Lipids Mummichog

Raw Statistics	
Number of Valid Samples	60
Number of Unique Samples	52
Minimum	0.75
Maximum	4.87
Mean	3.1555
Median	3.12
Standard Deviation	0.730705
Variance	0.53393
Coefficient of Variation	0.231566
Skewness	-0.14027

Gamma Statistics	
k hat	15.63857
k star (bias corrected)	14.86776
Theta hat	0.201777
Theta star	0.212238
nu hat	1876.629
nu star	1784.131
Approx.Chi Square Value (.05)	1687.005
Adjusted Level of Significance	0.046
Adjusted Chi Square Value	1684.699

Log-transformed Statistics	
Minimum of log data	-0.28768
Maximum of log data	1.583094
Mean of log data	1.116834
Standard Deviation of log data	0.27812
Variance of log data	0.077351

RECOMMENDATION

Data are normal (0.05)

Use Student's-t UCL

Normal Distribution Test	
Lilliefors Test Statisitic	0.078151
Lilliefors 5% Critical Value	0.114382
Data are normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	**3.31314**

Gamma Distribution Test	
A-D Test Statistic	0.878142
A-D 5% Critical Value	0.7499
K-S Test Statistic	0.10894
K-S 5% Critical Value	0.114532
Data follow approximate gamma distibution at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	3.337171
Adjusted Gamma UCL	3.34174

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.133711
Lilliefors 5% Critical Value	0.114382
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	3.382532
95% Chebyshev (MVUE) UCL	3.678438
97.5% Chebyshev (MVUE) UCL	3.896916
99% Chebyshev (MVUE) UCL	4.326075

95% Non-parametric UCLs	
CLT UCL	3.310665
Adj-CLT UCL (Adjusted for skewness)	3.30884
Mod-t UCL (Adjusted for skewness)	3.312856
Jackknife UCL	3.31314
Standard Bootstrap UCL	3.307784
Bootstrap-t UCL	3.302542
Hall's Bootstrap UCL	3.307685
Percentile Bootstrap UCL	3.304833
BCA Bootstrap UCL	3.309
95% Chebyshev (Mean, Sd) UCL	3.566691
97.5% Chebyshev (Mean, Sd) UCL	3.744613
99% Chebyshev (Mean, Sd) UCL	4.094108

R2-0009598

Attachment 3

Type	ERE
Medium	Sediment
Chemical	1,2,3,4,6,7,8-HpCDD
Units	µg/kg

Data File

Raw Statistics

Number of Valid Samples	214
Number of Unique Samples	181
Minimum	0.0012
Maximum	14.2
Mean	0.611057
Median	0.547
Standard Deviation	0.975185
Variance	0.950985
Coefficient of Variation	1.595898
Skewness	12.83435

Gamma Statistics

k hat	1.806597
k star (bias corrected)	1.784386
Theta hat	0.338237
Theta star	0.342447
nu hat	773.2235
nu star	763.7173
Approx.Chi Square Value (.05)	700.5762
Adjusted Level of Significance	0.048879
Adjusted Chi Square Value	700.1713

Log-transformed Statistics

Minimum of log data	-6.725434
Maximum of log data	2.653242
Mean of log data	-0.794168
Standard Deviation of log data	0.876432
Variance of log data	0.768134

RECOMMENDATION

Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

Variable: 1,2,3,4,6,7,8-HpCDD Sediment

Normal Distribution Test

Lilliefors Test Statisitic	0.313736
Lilliefors 5% Critical Value	0.060566

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	0.721186

Gamma Distribution Test

A-D Test Statistic	1.8E+308
A-D 5% Critical Value	0.76831
K-S Test Statistic	0.15872
K-S 5% Critical Value	0.062976

Data do not follow gamma distribution at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	0.66613
Adjusted Gamma UCL	0.666515

Lognormal Distribution Test

Lilliefors Test Statisitic	0.2112
Lilliefors 5% Critical Value	0.060566

Data not lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	0.7501
95% Chebyshev (MVUE) UCL	0.863771
97.5% Chebyshev (MVUE) UCL	0.951101
99% Chebyshev (MVUE) UCL	1.122645

95% Non-parametric UCLs

CLT UCL	0.720707
Adj-CLT UCL (Adjusted for skewness)	0.783199
Mod-t UCL (Adjusted for skewness)	0.730933
Jackknife UCL	0.721186
Standard Bootstrap UCL	0.720453
Bootstrap-t UCL	0.927245
Hall's Bootstrap UCL	1.160097
Percentile Bootstrap UCL	0.739409
BCA Bootstrap UCL	0.826046
95% Chebyshev (Mean, Sd) UCL	**0.901631**
97.5% Chebyshev (Mean, Sd) UCL	1.027363
99% Chebyshev (Mean, Sd) UCL	1.274338

R2-0009599

Attachment 3

Type	ERE
Medium	Sediment
Chemical	1,2,3,4,6,7,8-HpCDF
Units	µg/kg

Data File

Raw Statistics

Number of Valid Samples	214
Number of Unique Samples	185
Minimum	0.0011
Maximum	21.3
Mean	0.915292
Median	0.766
Standard Deviation	1.522966
Variance	2.319425
Coefficient of Variation	1.663913
Skewness	11.5232

Gamma Statistics

k hat	1.353654
k star (bias corrected)	1.337793
Theta hat	0.676164
Theta star	0.68418
nu hat	579.3639
nu star	572.5753
Approx.Chi Square Value (.05)	518.062
Adjusted Level of Significance	0.048879
Adjusted Chi Square Value	517.7147

Log-transformed Statistics

Minimum of log data	-6.81245
Maximum of log data	3.058707
Mean of log data	-0.50132
Standard Deviation of log data	1.060505
Variance of log data	1.124672

RECOMMENDATION

Data are Non-parametric (0.05)

Use 97.5% Chebyshev (Mean, Sd) UCL

Variable: 1,2,3,4,6,7,8-HpCDF Sediment

Normal Distribution Test

Lilliefors Test Statisitic	0.27891
Lilliefors 5% Critical Value	0.060566

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	1.087282

Gamma Distribution Test

A-D Test Statistic	6.384862
A-D 5% Critical Value	0.775104
K-S Test Statistic	0.130582
K-S 5% Critical Value	0.063378

Data do not follow gamma distribution at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	1.011604
Adjusted Gamma UCL	1.012282

Lognormal Distribution Test

Lilliefors Test Statisitic	0.188542
Lilliefors 5% Critical Value	0.060566

Data not lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	1.246252
95% Chebyshev (MVUE) UCL	1.471953
97.5% Chebyshev (MVUE) UCL	1.650814
99% Chebyshev (MVUE) UCL	2.002151

95% Non-parametric UCLs

CLT UCL	1.086534
Adj-CLT UCL (Adjusted for skewness)	1.174159
Mod-t UCL (Adjusted for skewness)	1.100949
Jackknife UCL	1.087282
Standard Bootstrap UCL	1.083837
Bootstrap-t UCL	1.344723
Hall's Bootstrap UCL	1.789638
Percentile Bootstrap UCL	1.111892
BCA Bootstrap UCL	1.255351
95% Chebyshev (Mean, Sd) UCL	1.369087
97.5% Chebyshev (Mean, Sd) UCL	**1.565445**
99% Chebyshev (Mean, Sd) UCL	1.951151

Attachment 3

Type	ERE
Medium	Sediment
Chemical	1,2,3,4,7,8,9-HpCDF
Units	µg/kg

Data File

Raw Statistics

Number of Valid Samples	214
Number of Unique Samples	167
Minimum	0.0008
Maximum	0.666
Mean	0.028015
Median	0.02405
Standard Deviation	0.046204
Variance	0.002135
Coefficient of Variation	1.649285
Skewness	12.5222

Gamma Statistics

k hat	1.757013
k star (bias corrected)	1.735497
Theta hat	0.015945
Theta star	0.016142
nu hat	752.0015
nu star	742.7927
Approx.Chi Square Value (.05)	680.5389
Adjusted Level of Significance	0.048879
Adjusted Chi Square Value	680.1399

Log-transformed Statistics

Minimum of log data	-7.130899
Maximum of log data	-0.406466
Mean of log data	-3.88582
Standard Deviation of log data	0.812585
Variance of log data	0.660295

RECOMMENDATION

Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

Variable: 1,2,3,4,7,8,9-HpCDF Sediment

Normal Distribution Test

Lilliefors Test Statisitic	0.32392
Lilliefors 5% Critical Value	0.060566

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	0.033233

Gamma Distribution Test

A-D Test Statistic	1.8E+308
A-D 5% Critical Value	0.768817
K-S Test Statistic	0.150824
K-S 5% Critical Value	0.063011

Data do not follow gamma distribution at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	0.030578
Adjusted Gamma UCL	0.030595

Lognormal Distribution Test

Lilliefors Test Statisitic	0.183873
Lilliefors 5% Critical Value	0.060566

Data not lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	0.031916
95% Chebyshev (MVUE) UCL	0.036412
97.5% Chebyshev (MVUE) UCL	0.039834
99% Chebyshev (MVUE) UCL	0.046555

95% Non-parametric UCLs

CLT UCL	0.03321
Adj-CLT UCL (Adjusted for skewness)	0.036099
Mod-t UCL (Adjusted for skewness)	0.033683
Jackknife UCL	0.033233
Standard Bootstrap UCL	0.03327
Bootstrap-t UCL	0.042345
Hall's Bootstrap UCL	0.053896
Percentile Bootstrap UCL	0.03367
BCA Bootstrap UCL	0.038637
95% Chebyshev (Mean, Sd) UCL	**0.041782**
97.5% Chebyshev (Mean, Sd) UCL	0.047739
99% Chebyshev (Mean, Sd) UCL	0.059441

R2-0009601

Attachment 3

Type	ERE
Medium	Sediment
Chemical	1,2,3,4,7,8-HxCDD
Units	µg/kg

Data File

Raw Statistics

Number of Valid Samples	214
Number of Unique Samples	169
Minimum	0.00031
Maximum	0.12
Mean	0.010218
Median	0.00887
Standard Deviation	0.012972
Variance	0.000168
Coefficient of Variation	1.269557
Skewness	7.153076

Gamma Statistics

k hat	1.914554
k star (bias corrected)	1.89083
Theta hat	0.005337
Theta star	0.005404
nu hat	819.4292
nu star	809.2752
Approx.Chi Square Value (.05)	744.2435
Adjusted Level of Significance	0.048879
Adjusted Chi Square Value	743.8261

Log-transformed Statistics

Minimum of log data	-8.07894
Maximum of log data	-2.12026
Mean of log data	-4.86696
Standard Deviation of log data	0.753179
Variance of log data	0.567278

RECOMMENDATION

Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

Variable: 1,2,3,4,7,8-HxCDD Sediment

Normal Distribution Test

Lilliefors Test Statisitic	0.310956
Lilliefors 5% Critical Value	0.060566

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	0.011683

Gamma Distribution Test

A-D Test Statistic	9.674837
A-D 5% Critical Value	0.767206
K-S Test Statistic	0.17339
K-S 5% Critical Value	0.0629

Data do not follow gamma distribution at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	0.011111
Adjusted Gamma UCL	0.011117

Lognormal Distribution Test

Lilliefors Test Statisitic	0.157306
Lilliefors 5% Critical Value	0.060566

Data not lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	0.011304
95% Chebyshev (MVUE) UCL	0.012784
97.5% Chebyshev (MVUE) UCL	0.0139
99% Chebyshev (MVUE) UCL	0.016093

95% Non-parametric UCLs

CLT UCL	0.011676
Adj-CLT UCL (Adjusted for skewness)	0.01214
Mod-t UCL (Adjusted for skewness)	0.011755
Jackknife UCL	0.011683
Standard Bootstrap UCL	0.011664
Bootstrap-t UCL	0.013725
Hall's Bootstrap UCL	0.020394
Percentile Bootstrap UCL	0.011797
BCA Bootstrap UCL	0.012151
95% Chebyshev (Mean, Sd) UCL	**0.014083**
97.5% Chebyshev (Mean, Sd) UCL	0.015756
99% Chebyshev (Mean, Sd) UCL	0.019041

R2-0009602

Attachment 3

Type	ERE
Medium	Sediment
Chemical	1,2,3,4,7,8-HxCDF
Units	µg/kg

Data File

Raw Statistics

Number of Valid Samples	214
Number of Unique Samples	167
Minimum	0.000245
Maximum	6.8
Mean	0.206689
Median	0.16
Standard Deviation	0.47412
Variance	0.224789
Coefficient of Variation	2.293882
Skewness	12.82178

Gamma Statistics

k hat	1.190369
k star (bias corrected)	1.176797
Theta hat	0.173634
Theta star	0.175637
nu hat	509.4781
nu star	503.6692
Approx.Chi Square Value (.05)	452.6148
Adjusted Level of Significance	0.048879
Adjusted Chi Square Value	452.2905

Log-transformed Statistics

Minimum of log data	-8.314252
Maximum of log data	1.916923
Mean of log data	-2.052119
Standard Deviation of log data	1.058058
Variance of log data	1.119486

RECOMMENDATION

Data are Non-parametric (0.05)

Use 97.5% Chebyshev (Mean, Sd) UCL

Variable: 1,2,3,4,7,8-HxCDF Sediment

Normal Distribution Test

Lilliefors Test Statisitic	0.331627
Lilliefors 5% Critical Value	0.060566

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	0.260232

Gamma Distribution Test

A-D Test Statistic	1.8E+308
A-D 5% Critical Value	0.779188
K-S Test Statistic	0.133634
K-S 5% Critical Value	0.063586

Data do not follow gamma distribution at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	0.230003
Adjusted Gamma UCL	0.230168

Lognormal Distribution Test

Lilliefors Test Statisitic	0.179025
Lilliefors 5% Critical Value	0.060566

Data not lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	0.263482
95% Chebyshev (MVUE) UCL	0.3111
97.5% Chebyshev (MVUE) UCL	0.348818
99% Chebyshev (MVUE) UCL	0.422909

95% Non-parametric UCLs

CLT UCL	0.259999
Adj-CLT UCL (Adjusted for skewness)	0.290352
Mod-t UCL (Adjusted for skewness)	0.264966
Jackknife UCL	0.260232
Standard Bootstrap UCL	0.2597
Bootstrap-t UCL	0.374196
Hall's Bootstrap UCL	0.470425
Percentile Bootstrap UCL	0.268713
BCA Bootstrap UCL	0.321481
95% Chebyshev (Mean, Sd) UCL	0.347961
97.5% Chebyshev (Mean, Sd) UCL	**0.40909**
99% Chebyshev (Mean, Sd) UCL	0.529166

R2-0009603

Attachment 3

Type	ERE
Medium	Sediment
Chemical	1,2,3,6,7,8-HxCDD
Units	µg/kg

Data File

Raw Statistics

Number of Valid Samples	214
Number of Unique Samples	165
Minimum	0.0006
Maximum	1.73
Mean	0.043178
Median	0.0314
Standard Deviation	0.119814
Variance	0.014355
Coefficient of Variation	2.774846
Skewness	13.33009

Gamma Statistics

k hat	1.317651
k star (bias corrected)	1.302295
Theta hat	0.032769
Theta star	0.033156
nu hat	563.9548
nu star	557.3823
Approx.Chi Square Value (.05)	503.6129
Adjusted Level of Significance	0.048879
Adjusted Chi Square Value	503.2705

Log-transformed Statistics

Minimum of log data	-7.418581
Maximum of log data	0.548121
Mean of log data	-3.567619
Standard Deviation of log data	0.84401
Variance of log data	0.712353

RECOMMENDATION

Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

Variable: 1,2,3,6,7,8-HxCDD Sediment

Normal Distribution Test

Lilliefors Test Statisitic	0.380236
Lilliefors 5% Critical Value	0.060566

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	0.056709

Gamma Distribution Test

A-D Test Statistic	1.8E+308
A-D 5% Critical Value	0.776005
K-S Test Statistic	0.206017
K-S 5% Critical Value	0.063424

Data do not follow gamma distribution at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	0.047789
Adjusted Gamma UCL	0.047821

Lognormal Distribution Test

Lilliefors Test Statisitic	0.198015
Lilliefors 5% Critical Value	0.060566

Data not lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	0.045283
95% Chebyshev (MVUE) UCL	0.051901
97.5% Chebyshev (MVUE) UCL	0.056961
99% Chebyshev (MVUE) UCL	0.066899

95% Non-parametric UCLs

CLT UCL	0.05665
Adj-CLT UCL (Adjusted for skewness)	0.064625
Mod-t UCL (Adjusted for skewness)	0.057953
Jackknife UCL	0.056709
Standard Bootstrap UCL	0.05646
Bootstrap-t UCL	0.107468
Hall's Bootstrap UCL	0.113885
Percentile Bootstrap UCL	0.058591
BCA Bootstrap UCL	0.074324
95% Chebyshev (Mean, Sd) UCL	**0.078879**
97.5% Chebyshev (Mean, Sd) UCL	0.094327
99% Chebyshev (Mean, Sd) UCL	0.124671

R2-0009604

Attachment 3

Type	ERE
Medium	Sediment
Chemical	1,2,3,6,7,8-HxCDF
Units	µg/kg

Data File

Raw Statistics

Number of Valid Samples	214
Number of Unique Samples	184
Minimum	0.00024
Maximum	1.2
Mean	0.051584
Median	0.04515
Standard Deviation	0.084057
Variance	0.007066
Coefficient of Variation	1.629524
Skewness	12.16591

Gamma Statistics

k hat	1.57944
k star (bias corrected)	1.560414
Theta hat	0.032659
Theta star	0.033058
nu hat	676.0004
nu star	667.8571
Approx.Chi Square Value (.05)	608.8879
Adjusted Level of Significance	0.048879
Adjusted Chi Square Value	608.5109

Log-transformed Statistics

Minimum of log data	-8.33487
Maximum of log data	0.182322
Mean of log data	-3.31338
Standard Deviation of log data	0.921702
Variance of log data	0.849535

RECOMMENDATION

Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

Variable: 1,2,3,6,7,8-HxCDF Sediment

Normal Distribution Test

Lilliefors Test Statisitic	0.299018
Lilliefors 5% Critical Value	0.060566

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	0.061076

Gamma Distribution Test

A-D Test Statistic	8.361219
A-D 5% Critical Value	0.770632
K-S Test Statistic	0.142358
K-S 5% Critical Value	0.063136

Data do not follow gamma distribution at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	0.056579
Adjusted Gamma UCL	0.056614

Lognormal Distribution Test

Lilliefors Test Statisitic	0.196836
Lilliefors 5% Critical Value	0.060566

Data not lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	0.063448
95% Chebyshev (MVUE) UCL	0.073537
97.5% Chebyshev (MVUE) UCL	0.081342
99% Chebyshev (MVUE) UCL	0.096675

95% Non-parametric UCLs

CLT UCL	0.061035
Adj-CLT UCL (Adjusted for skewness)	0.066141
Mod-t UCL (Adjusted for skewness)	0.061873
Jackknife UCL	0.061076
Standard Bootstrap UCL	0.060863
Bootstrap-t UCL	0.076668
Hall's Bootstrap UCL	0.099947
Percentile Bootstrap UCL	0.062546
BCA Bootstrap UCL	0.070137
95% Chebyshev (Mean, Sd) UCL	**0.07663**
97.5% Chebyshev (Mean, Sd) UCL	0.087467
99% Chebyshev (Mean, Sd) UCL	0.108755

R2-0009605

Attachment 3

Type	ERE
Medium	Sediment
Chemical	1,2,3,7,8,9-HxCDD
Units	µg/kg

Data File

Raw Statistics

Number of Valid Samples	214
Number of Unique Samples	144
Minimum	0.0005
Maximum	0.547
Mean	0.019949
Median	0.0176
Standard Deviation	0.037407
Variance	0.001399
Coefficient of Variation	1.875154
Skewness	13.26356

Gamma Statistics

k hat	1.746081
k star (bias corrected)	1.724719
Theta hat	0.011425
Theta star	0.011566
nu hat	747.3228
nu star	738.1796
Approx.Chi Square Value (.05)	676.123
Adjusted Level of Significance	0.048879
Adjusted Chi Square Value	675.7254

Log-transformed Statistics

Minimum of log data	-7.600902
Maximum of log data	-0.603306
Mean of log data	-4.22748
Standard Deviation of log data	0.792986
Variance of log data	0.628827

RECOMMENDATION

Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

Variable: 1,2,3,7,8,9-HxCDD Sediment

Normal Distribution Test

Lilliefors Test Statisitic	0.343658
Lilliefors 5% Critical Value	0.060566

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	0.024173

Gamma Distribution Test

A-D Test Statistic	1.8E+308
A-D 5% Critical Value	0.768928
K-S Test Statistic	0.172049
K-S 5% Critical Value	0.063018

Data do not follow gamma distribution at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	0.02178
Adjusted Gamma UCL	0.021793

Lognormal Distribution Test

Lilliefors Test Statisitic	0.185329
Lilliefors 5% Critical Value	0.060566

Data not lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	0.022248
95% Chebyshev (MVUE) UCL	0.025309
97.5% Chebyshev (MVUE) UCL	0.027632
99% Chebyshev (MVUE) UCL	0.032195

95% Non-parametric UCLs

CLT UCL	0.024155
Adj-CLT UCL (Adjusted for skewness)	0.026632
Mod-t UCL (Adjusted for skewness)	0.02456
Jackknife UCL	0.024173
Standard Bootstrap UCL	0.024045
Bootstrap-t UCL	0.033006
Hall's Bootstrap UCL	0.041144
Percentile Bootstrap UCL	0.024778
BCA Bootstrap UCL	0.028666
95% Chebyshev (Mean, Sd) UCL	**0.031095**
97.5% Chebyshev (Mean, Sd) UCL	0.035918
99% Chebyshev (Mean, Sd) UCL	0.045392

R2-0009606

Attachment 3

Type	ERE
Medium	Sediment
Chemical	1,2,3,7,8,9-HxCDF
Units	µg/kg

Data File

Raw Statistics

Number of Valid Samples	214
Number of Unique Samples	187
Minimum	0.00027
Maximum	0.123
Mean	0.008106238
Median	0.00711
Standard Deviation	0.009105423
Variance	8.29087E-05
Coefficient of Variation	1.123261254
Skewness	9.696064468

Gamma Statistics

k hat	1.992088707
k star (bias corrected)	1.967277495
Theta hat	0.004069216
Theta star	0.004120536
nu hat	852.6139666
nu star	841.9947676
Approx.Chi Square Value (.05)	775.6379338
Adjusted Level of Significance	0.048878505
Adjusted Chi Square Value	775.2116191

Log-transformed Statistics

Minimum of log data	-8.217088599
Maximum of log data	-2.095570924
Mean of log data	-5.086635656
Standard Deviation of log data	0.792702476
Variance of log data	0.628377216

RECOMMENDATION

Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

Variable: 1,2,3,7,8,9-HxCDF Sediment

Normal Distribution Test

Lilliefors Test Statistic	0.226983
Lilliefors 5% Critical Value	0.060566

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	0.009135

Gamma Distribution Test

A-D Test Statistic	4.807469
A-D 5% Critical Value	0.766414
K-S Test Statistic	0.108656
K-S 5% Critical Value	0.062845

Data do not follow gamma distribution at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	0.0088
Adjusted Gamma UCL	0.008805

Lognormal Distribution Test

Lilliefors Test Statisitic	0.153824
Lilliefors 5% Critical Value	0.060566

Data not lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	0.00942
95% Chebyshev (MVUE) UCL	0.010716
97.5% Chebyshev (MVUE) UCL	0.011699
99% Chebyshev (MVUE) UCL	0.01363

95% Non-parametric UCLs

CLT UCL	0.00913
Adj-CLT UCL (Adjusted for skewness)	0.009571
Mod-t UCL (Adjusted for skewness)	0.009203
Jackknife UCL	0.009135
Standard Bootstrap UCL	0.009107
Bootstrap-t UCL	0.009989
Hall's Bootstrap UCL	0.013662
Percentile Bootstrap UCL	0.009243
BCA Bootstrap UCL	0.009818
95% Chebyshev (Mean, Sd) UCL	**0.010819**
97.5% Chebyshev (Mean, Sd) UCL	0.011993
99% Chebyshev (Mean, Sd) UCL	0.014299

R2-0009607

Attachment 3

Type	ERE
Medium	Sediment
Chemical	1,2,3,7,8-PeCDD
Units	µg/kg

Data File

Raw Statistics

Number of Valid Samples	213
Number of Unique Samples	171
Minimum	0.000335
Maximum	0.76
Mean	0.011777
Median	0.00723
Standard Deviation	0.051959
Variance	0.0027
Coefficient of Variation	4.41177
Skewness	14.22711

Gamma Statistics

k hat	0.992162
k star (bias corrected)	0.981317
Theta hat	0.01187
Theta star	0.012002
nu hat	422.6609
nu star	418.0412
Approx.Chi Square Value (.05)	371.6345
Adjusted Level of Significance	0.048873
Adjusted Chi Square Value	371.3398

Log-transformed Statistics

Minimum of log data	-8.00138
Maximum of log data	-0.274437
Mean of log data	-5.023885
Standard Deviation of log data	0.840846
Variance of log data	0.707022

RECOMMENDATION

Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

Variable: 1,2,3,7,8-PeCDD Sediment

Normal Distribution Test

Lilliefors Test Statisitic	0.41285
Lilliefors 5% Critical Value	0.060708

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	0.017659

Gamma Distribution Test

A-D Test Statistic	1.8E+308
A-D 5% Critical Value	0.784336
K-S Test Statistic	0.234579
K-S 5% Critical Value	0.063968

Data do not follow gamma distribution at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	0.013248
Adjusted Gamma UCL	0.013259

Lognormal Distribution Test

Lilliefors Test Statisitic	0.145038
Lilliefors 5% Critical Value	0.060708

Data not lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	0.010525
95% Chebyshev (MVUE) UCL	0.01206
97.5% Chebyshev (MVUE) UCL	0.013233
99% Chebyshev (MVUE) UCL	0.015539

95% Non-parametric UCLs

CLT UCL	0.017633
Adj-CLT UCL (Adjusted for skewness)	0.021342
Mod-t UCL (Adjusted for skewness)	0.018238
Jackknife UCL	0.017659
Standard Bootstrap UCL	0.017581
Bootstrap-t UCL	0.054809
Hall's Bootstrap UCL	0.043225
Percentile Bootstrap UCL	0.01884
BCA Bootstrap UCL	0.023302
95% Chebyshev (Mean, Sd) UCL	**0.027296**
97.5% Chebyshev (Mean, Sd) UCL	0.034011
99% Chebyshev (Mean, Sd) UCL	0.047201

R2-0009608

Attachment 3

Type	ERE
Medium	Sediment
Chemical	1,2,3,7,8-PeCDF
Units	µg/kg

Data File

Raw Statistics

Number of Valid Samples	200
Number of Unique Samples	135
Minimum	0.000345
Maximum	0.139
Mean	0.015712
Median	0.015
Standard Deviation	0.012027
Variance	0.000145
Coefficient of Variation	0.765456
Skewness	5.87819

Gamma Statistics

k hat	2.328251
k star (bias corrected)	2.296661
Theta hat	0.006748
Theta star	0.006841
nu hat	931.3004
nu star	918.6642
Approx.Chi Square Value (.05)	849.2998
Adjusted Level of Significance	0.0488
Adjusted Chi Square Value	848.8219

Log-transformed Statistics

Minimum of log data	-7.97197
Maximum of log data	-1.97328
Mean of log data	-4.38319
Standard Deviation of log data	0.780769
Variance of log data	0.609601

RECOMMENDATION

Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

Variable: 1,2,3,7,8-PeCDF Sediment

Normal Distribution Test

Lilliefors Test Statisitic	0.180549
Lilliefors 5% Critical Value	0.06265

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	0.017117

Gamma Distribution Test

A-D Test Statistic	6.501311
A-D 5% Critical Value	0.764427
K-S Test Statistic	0.15881
K-S 5% Critical Value	0.064342

Data do not follow gamma distribution at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	0.016995
Adjusted Gamma UCL	0.017005

Lognormal Distribution Test

Lilliefors Test Statisitic	0.206173
Lilliefors 5% Critical Value	0.06265

Data not lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	0.01889
95% Chebyshev (MVUE) UCL	0.021518
97.5% Chebyshev (MVUE) UCL	0.023515
99% Chebyshev (MVUE) UCL	0.027439

95% Non-parametric UCLs

CLT UCL	0.017111
Adj-CLT UCL (Adjusted for skewness)	0.017489
Mod-t UCL (Adjusted for skewness)	0.017176
Jackknife UCL	0.017117
Standard Bootstrap UCL	0.017128
Bootstrap-t UCL	0.017652
Hall's Bootstrap UCL	0.019128
Percentile Bootstrap UCL	0.017157
BCA Bootstrap UCL	0.017694
95% Chebyshev (Mean, Sd) UCL	**0.019419**
97.5% Chebyshev (Mean, Sd) UCL	0.021023
99% Chebyshev (Mean, Sd) UCL	0.024174

R2-0009609

Type	ERE
Medium	Sediment
Chemical	2,3,4,6,7,8-HxCDF
Units	µg/kg

Data File

Raw Statistics

Number of Valid Samples	214
Number of Unique Samples	169
Minimum	0.001
Maximum	0.43
Mean	0.029688
Median	0.02485
Standard Deviation	0.032497
Variance	0.001056
Coefficient of Variation	1.09464
Skewness	9.3115

Gamma Statistics

k hat	2.291926
k star (bias corrected)	2.262912
Theta hat	0.012953
Theta star	0.013119
nu hat	980.9444
nu star	968.5262
Approx.Chi Square Value (.05)	897.2727
Adjusted Level of Significance	0.048879
Adjusted Chi Square Value	896.8138

Log-transformed Statistics

Minimum of log data	-6.90776
Maximum of log data	-0.84397
Mean of log data	-3.75076
Standard Deviation of log data	0.697501
Variance of log data	0.486507

RECOMMENDATION

Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

Variable: 2,3,4,6,7,8-HxCDF Sediment

Normal Distribution Test

Lilliefors Test Statisitic	0.228369
Lilliefors 5% Critical Value	0.060566

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	0.033358

Gamma Distribution Test

A-D Test Statistic	4.436831
A-D 5% Critical Value	0.764553
K-S Test Statistic	0.111199
K-S 5% Critical Value	0.062721

Data do not follow gamma distribution at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	0.032045
Adjusted Gamma UCL	0.032062

Lognormal Distribution Test

Lilliefors Test Statisitic	0.142574
Lilliefors 5% Critical Value	0.060566

Data not lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	0.032844
95% Chebyshev (MVUE) UCL	0.036832
97.5% Chebyshev (MVUE) UCL	0.039819
99% Chebyshev (MVUE) UCL	0.045686

95% Non-parametric UCLs

CLT UCL	0.033342
Adj-CLT UCL (Adjusted for skewness)	0.034853
Mod-t UCL (Adjusted for skewness)	0.033593
Jackknife UCL	0.033358
Standard Bootstrap UCL	0.033433
Bootstrap-t UCL	0.037028
Hall's Bootstrap UCL	0.050449
Percentile Bootstrap UCL	0.033784
BCA Bootstrap UCL	0.035341
95% Chebyshev (Mean, Sd) UCL	**0.039371**
97.5% Chebyshev (Mean, Sd) UCL	0.043561
99% Chebyshev (Mean, Sd) UCL	0.051791

R2-0009610

Type	ERE
Medium	Sediment
Chemical	2,3,4,7,8-PeCDF
Units	µg/kg

Data File

Raw Statistics

Number of Valid Samples	200
Number of Unique Samples	170
Minimum	0.0007
Maximum	0.856
Mean	0.050411
Median	0.0412
Standard Deviation	0.065649
Variance	0.00431
Coefficient of Variation	1.302266
Skewness	9.7507

Gamma Statistics

k hat	1.751944
k star (bias corrected)	1.728998
Theta hat	0.028775
Theta star	0.029156
nu hat	700.7774
nu star	691.5991
Approx.Chi Square Value (.05)	631.5701
Adjusted Level of Significance	0.0488
Adjusted Chi Square Value	631.1589

Log-transformed Statistics

Minimum of log data	-7.26443
Maximum of log data	-0.15548
Mean of log data	-3.29931
Standard Deviation of log data	0.864342
Variance of log data	0.747087

RECOMMENDATION

Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

Variable: 2,3,4,7,8-PeCDF Sediment

Normal Distribution Test

Lilliefors Test Statisitic	0.255615
Lilliefors 5% Critical Value	0.06265

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	0.058083

Gamma Distribution Test

A-D Test Statistic	6.00532
A-D 5% Critical Value	0.768861
K-S Test Statistic	0.146356
K-S 5% Critical Value	0.064659

Data do not follow gamma distribution at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	0.055203
Adjusted Gamma UCL	0.055239

Lognormal Distribution Test

Lilliefors Test Statisitic	0.194698
Lilliefors 5% Critical Value	0.06265

Data not lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	0.060746
95% Chebyshev (MVUE) UCL	0.070055
97.5% Chebyshev (MVUE) UCL	0.077225
99% Chebyshev (MVUE) UCL	0.091307

95% Non-parametric UCLs

CLT UCL	0.058047
Adj-CLT UCL (Adjusted for skewness)	0.061467
Mod-t UCL (Adjusted for skewness)	0.058616
Jackknife UCL	0.058083
Standard Bootstrap UCL	0.058001
Bootstrap-t UCL	0.065724
Hall's Bootstrap UCL	0.092106
Percentile Bootstrap UCL	0.058211
BCA Bootstrap UCL	0.064284
95% Chebyshev (Mean, Sd) UCL	**0.070646**
97.5% Chebyshev (Mean, Sd) UCL	0.079401
99% Chebyshev (Mean, Sd) UCL	0.0966

Attachment 3

Type	ERE
Medium	Sediment
Chemical	2,3,7,8-TCDD
Units	µg/kg

Data File

Raw Statistics

Number of Valid Samples	214
Number of Unique Samples	187
Minimum	0
Maximum	13.5
Mean	0.582449
Median	0.292
Standard Deviation	1.40583
Variance	1.976359
Coefficient of Variation	2.413653
Skewness	6.31258

Variable: 2,3,7,8-TCDD Sediment

Normal Distribution Test

Lilliefors Test Statisitic	0.364863
Lilliefors 5% Critical Value	0.060566

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	0.741211

Gamma Statistics Not Available

Lognormal Statistics Not Available

95% Non-parametric UCLs

CLT UCL	0.740521
Adj-CLT UCL (Adjusted for skewness)	0.784831
Mod-t UCL (Adjusted for skewness)	0.748123
Jackknife UCL	0.741211
Standard Bootstrap UCL	0.739131
Bootstrap-t UCL	0.833257
Hall's Bootstrap UCL	0.81305
Percentile Bootstrap UCL	0.755399
BCA Bootstrap UCL	0.799257
95% Chebyshev (Mean, Sd) UCL	**1.001342**
97.5% Chebyshev (Mean, Sd) UCL	1.182597
99% Chebyshev (Mean, Sd) UCL	1.538638

RECOMMENDATION

Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

R2-0009612

Type	ERE
Medium	Sediment
Chemical	2,3,7,8-TCDF
Units	µg/kg

Data File

Raw Statistics

Number of Valid Samples	214
Number of Unique Samples	169
Minimum	0.00031
Maximum	0.134
Mean	0.031817
Median	0.0307
Standard Deviation	0.018157
Variance	0.00033
Coefficient of Variation	0.570684
Skewness	1.537628

Gamma Statistics

k hat	2.27147
k star (bias corrected)	2.242742
Theta hat	0.014007
Theta star	0.014186
nu hat	972.1892
nu star	959.8937
Approx.Chi Square Value (.05)	888.9637
Adjusted Level of Significance	0.048879
Adjusted Chi Square Value	888.5069

Log-transformed Statistics

Minimum of log data	-8.07894
Maximum of log data	-2.00992
Mean of log data	-3.68375
Standard Deviation of log data	0.868793
Variance of log data	0.7548

RECOMMENDATION

Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

Variable: 2,3,7,8-TCDF Sediment

Normal Distribution Test

Lilliefors Test Statisitic	0.140582
Lilliefors 5% Critical Value	0.060566

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	0.033867

Gamma Distribution Test

A-D Test Statistic	8.192642
A-D 5% Critical Value	0.764678
K-S Test Statistic	0.168504
K-S 5% Critical Value	0.062729

Data do not follow gamma distribution at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	0.034355
Adjusted Gamma UCL	0.034373

Lognormal Distribution Test

Lilliefors Test Statisitic	0.221111
Lilliefors 5% Critical Value	0.060566

Data not lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	0.04137
95% Chebyshev (MVUE) UCL	0.047586
97.5% Chebyshev (MVUE) UCL	0.052357
99% Chebyshev (MVUE) UCL	0.061728

95% Non-parametric UCLs

CLT UCL	0.033858
Adj-CLT UCL (Adjusted for skewness)	0.033998
Mod-t UCL (Adjusted for skewness)	0.033889
Jackknife UCL	0.033867
Standard Bootstrap UCL	0.033827
Bootstrap-t UCL	0.034006
Hall's Bootstrap UCL	0.034084
Percentile Bootstrap UCL	0.033869
BCA Bootstrap UCL	0.03397
95% Chebyshev (Mean, Sd) UCL	**0.037227**
97.5% Chebyshev (Mean, Sd) UCL	0.039568
99% Chebyshev (Mean, Sd) UCL	0.044166

Attachment 3

Type	ERE
Medium	Sediment
Chemical	OCDD
Units	µg/kg

Data File

Raw Statistics

Number of Valid Samples	218
Number of Unique Samples	190
Minimum	0.0065
Maximum	22.6
Mean	6.329937
Median	6.05
Standard Deviation	3.502239
Variance	12.26568
Coefficient of Variation	0.553282
Skewness	1.334446

Gamma Statistics

k hat	2.334767
k star (bias corrected)	2.305695
Theta hat	2.711164
Theta star	2.745348
nu hat	1017.958
nu star	1005.283
Approx.Chi Square Value (.05)	932.6681
Adjusted Level of Significance	0.048899
Adjusted Chi Square Value	932.2087

Log-transformed Statistics

Minimum of log data	-5.03595
Maximum of log data	3.11795
Mean of log data	1.616108
Standard Deviation of log data	0.900965
Variance of log data	0.811738

RECOMMENDATION

Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

Variable: OCDD Sediment

Normal Distribution Test

Lilliefors Test Statisitic	0.106472
Lilliefors 5% Critical Value	0.060007

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	6.721771

Gamma Distribution Test

A-D Test Statistic	7.508441
A-D 5% Critical Value	0.764264
K-S Test Statistic	0.167063
K-S 5% Critical Value	0.062236

Data do not follow gamma distribution at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	6.822768
Adjusted Gamma UCL	6.826131

Lognormal Distribution Test

Lilliefors Test Statisitic	0.225658
Lilliefors 5% Critical Value	0.060007

Data not lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	8.56657
95% Chebyshev (MVUE) UCL	9.890737
97.5% Chebyshev (MVUE) UCL	10.91067
99% Chebyshev (MVUE) UCL	12.91413

95% Non-parametric UCLs

CLT UCL	6.720099
Adj-CLT UCL (Adjusted for skewness)	6.743006
Mod-t UCL (Adjusted for skewness)	6.725344
Jackknife UCL	6.721771
Standard Bootstrap UCL	6.72202
Bootstrap-t UCL	6.764805
Hall's Bootstrap UCL	6.776581
Percentile Bootstrap UCL	6.723198
BCA Bootstrap UCL	6.731377
95% Chebyshev (Mean, Sd) UCL	**7.363874**
97.5% Chebyshev (Mean, Sd) UCL	7.81126
99% Chebyshev (Mean, Sd) UCL	8.690062

R2-0009614

Attachment 3

Type	ERE
Medium	Sediment
Chemical	OCDF
Units	µg/kg

Data File

Raw Statistics

Number of Valid Samples	222
Number of Unique Samples	168
Minimum	0.0019
Maximum	25.2
Mean	1.292741
Median	1.075
Standard Deviation	1.85583
Variance	3.444104
Coefficient of Variation	1.435577
Skewness	10.09536

Gamma Statistics

k hat	1.361275
k star (bias corrected)	1.345882
Theta hat	0.949655
Theta star	0.960516
nu hat	604.4059
nu star	597.5716
Approx.Chi Square Value (.05)	541.8556
Adjusted Level of Significance	0.048919
Adjusted Chi Square Value	541.5131

Log-transformed Statistics

Minimum of log data	-6.2659
Maximum of log data	3.226844
Mean of log data	-0.15351
Standard Deviation of log data	1.082089
Variance of log data	1.170916

RECOMMENDATION

Data are Non-parametric (0.05)

Use 97.5% Chebyshev (Mean, Sd) UCL

Variable: OCDF Sediment

Normal Distribution Test

Lilliefors Test Statisitic	0.267025
Lilliefors 5% Critical Value	0.059464

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	1.498479

Gamma Distribution Test

A-D Test Statistic	6.849868
A-D 5% Critical Value	0.774954
K-S Test Statistic	0.141293
K-S 5% Critical Value	0.062426

Data do not follow gamma distribution at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	1.425667
Adjusted Gamma UCL	1.426568

Lognormal Distribution Test

Lilliefors Test Statisitic	0.203499
Lilliefors 5% Critical Value	0.059464

Data not lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	1.808501
95% Chebyshev (MVUE) UCL	2.138276
97.5% Chebyshev (MVUE) UCL	2.399799
99% Chebyshev (MVUE) UCL	2.913511

95% Non-parametric UCLs

CLT UCL	1.497616
Adj-CLT UCL (Adjusted for skewness)	1.587791
Mod-t UCL (Adjusted for skewness)	1.512544
Jackknife UCL	1.498479
Standard Bootstrap UCL	1.492739
Bootstrap-t UCL	1.707127
Hall's Bootstrap UCL	2.375127
Percentile Bootstrap UCL	1.531269
BCA Bootstrap UCL	1.615287
95% Chebyshev (Mean, Sd) UCL	1.835664
97.5% Chebyshev (Mean, Sd) UCL	**2.070588**
99% Chebyshev (Mean, Sd) UCL	2.532049

R2-0009615

Attachment 3

Type	ERE
Medium	Sediment
Chemical	Total Organic Carbon
Units	µg/kg

Data File

Raw Statistics

Number of Valid Samples	220
Number of Unique Samples	186
Minimum	922000
Maximum	409000000
Mean	76080781.82
Median	59950000
Standard Deviation	57029385.93
Variance	3.25235E+15
Coefficient of Variation	0.749589904
Skewness	1.669158292

Gamma Statistics

k hat	1.869943022
k star (bias corrected)	1.847474102
Theta hat	40686149.74
Theta star	41180973.37
nu hat	822.7749298
nu star	812.888605
Approx.Chi Square Value (.05)	747.7092768
Adjusted Level of Significance	0.048909091
Adjusted Chi Square Value	747.3023267

Log-transformed Statistics

Minimum of log data	13.7343005
Maximum of log data	19.82922571
Mean of log data	17.85669434
Standard Deviation of log data	0.839622821
Variance of log data	0.704966481

RECOMMENDATION

Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

Variable: TOC Sediment

Normal Distribution Test

Lilliefors Test Statisitic	0.140746435
Lilliefors 5% Critical Value	0.059734108

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)

Student's-t UCL	82431978.29

Gamma Distribution Test

A-D Test Statistic	1.81292859
A-D 5% Critical Value	0.767648431
K-S Test Statistic	0.092082049
K-S 5% Critical Value	0.06222704

Data do not follow gamma distribution
at 5% significance level

95% UCLs (Assuming Gamma Distribution)

Approximate Gamma UCL	82712897.28
Adjusted Gamma UCL	82757939.32

Lognormal Distribution Test

Lilliefors Test Statisitic	0.090620185
Lilliefors 5% Critical Value	0.059734108

Data not lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)

95% H-UCL	90723723.17
95% Chebyshev (MVUE) UCL	103780942.4
97.5% Chebyshev (MVUE) UCL	113741134.9
99% Chebyshev (MVUE) UCL	133306004.5

95% Non-parametric UCLs

CLT UCL	82405113.11
Adj-CLT UCL (Adjusted for skewness)	82867445.11
Mod-t UCL (Adjusted for skewness)	82504092.74
Jackknife UCL	82431978.29
Standard Bootstrap UCL	82748038.1
Bootstrap-t UCL	83161513.83
Hall's Bootstrap UCL	82969230.33
Percentile Bootstrap UCL	82413600
BCA Bootstrap UCL	83211090.91
95% Chebyshev (Mean, Sd) UCL	**92840401.35**
97.5% Chebyshev (Mean, Sd) UCL	100092302.1
99% Chebyshev (Mean, Sd) UCL	114337256.9

R2-0009616

Attachment 3

Type	ERE
Medium	Sediment
Chemical	2,3,3',4,4',5,5'-heptachlorobiphenyl
Units	µg/kg

Data File	
Raw Statistics	
Number of Valid Samples	212
Number of Unique Samples	139
Minimum	0.076
Maximum	12
Mean	0.969561
Median	0.7175
Standard Deviation	1.087085
Variance	1.181754
Coefficient of Variation	1.121213
Skewness	5.750554
Gamma Statistics	
k hat	1.626328
k star (bias corrected)	1.606459
Theta hat	0.596166
Theta star	0.603539
nu hat	689.5632
nu star	681.1385
Approx.Chi Square Value (.05)	621.5742
Adjusted Level of Significance	0.048868
Adjusted Chi Square Value	621.1896
Log-transformed Statistics	
Minimum of log data	-2.57702
Maximum of log data	2.484907
Mean of log data	-0.36883
Standard Deviation of log data	0.819163
Variance of log data	0.671028

RECOMMENDATION

Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

Variable:	2,3,3',4,4',5,5'-heptachlorobiphenyl Sediment
Normal Distribution Test	
Lilliefors Test Statisitic	0.23988
Lilliefors 5% Critical Value	0.060851
Data not normal at 5% significance level	
95% UCL (Assuming Normal Distribution)	
Student's-t UCL	1.09291
Gamma Distribution Test	
A-D Test Statistic	3.904354
A-D 5% Critical Value	0.770145
K-S Test Statistic	0.130829
K-S 5% Critical Value	0.063338
Data do not follow gamma distribution	
at 5% significance level	
95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	1.062473
Adjusted Gamma UCL	1.06313
Lognormal Distribution Test	
Lilliefors Test Statisitic	0.127736
Lilliefors 5% Critical Value	0.060851
Data not lognormal at 5% significance level	
95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	1.082661
95% Chebyshev (MVUE) UCL	1.236922
97.5% Chebyshev (MVUE) UCL	1.354496
99% Chebyshev (MVUE) UCL	1.585447
95% Non-parametric UCLs	
CLT UCL	1.092368
Adj-CLT UCL (Adjusted for skewness)	1.123876
Mod-t UCL (Adjusted for skewness)	1.097824
Jackknife UCL	1.09291
Standard Bootstrap UCL	1.089483
Bootstrap-t UCL	1.13695
Hall's Bootstrap UCL	1.196095
Percentile Bootstrap UCL	1.094526
BCA Bootstrap UCL	1.13812
95% Chebyshev (Mean, Sd) UCL	**1.295002**
97.5% Chebyshev (Mean, Sd) UCL	1.435821
99% Chebyshev (Mean, Sd) UCL	1.712432

R2-0009617

Attachment 3

Type	ERE
Medium	Sediment
Chemical	2,3,3',4,4',5'-hexachlorobiphenyl
Units	µg/kg

Data File	
Raw Statistics	
Number of Valid Samples	212
Number of Unique Samples	110
Minimum	0.096
Maximum	6.9
Mean	1.335085
Median	1.2
Standard Deviation	0.922129
Variance	0.850322
Coefficient of Variation	0.690689
Skewness	2.797582
Gamma Statistics	
k hat	2.449735
k star (bias corrected)	2.418213
Theta hat	0.544992
Theta star	0.552096
nu hat	1038.688
nu star	1025.322
Approx.Chi Square Value (.05)	951.9757
Adjusted Level of Significance	0.048868
Adjusted Chi Square Value	951.4982
Log-transformed Statistics	
Minimum of log data	-2.34341
Maximum of log data	1.931521
Mean of log data	0.071221
Standard Deviation of log data	0.733663
Variance of log data	0.538262

RECOMMENDATION

Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

Variable:	2,3,3',4,4',5'-hexachlorobiphenyl	Sediment
Normal Distribution Test		
Lilliefors Test Statisitic		0.203079
Lilliefors 5% Critical Value		0.060851
Data not normal at 5% significance level		
95% UCL (Assuming Normal Distribution)		
Student's-t UCL		1.439716
Gamma Distribution Test		
A-D Test Statistic		6.521033
A-D 5% Critical Value		0.763605
K-S Test Statistic		0.135947
K-S 5% Critical Value		0.06289
Data do not follow gamma distribution		
at 5% significance level		
95% UCLs (Assuming Gamma Distribution)		
Approximate Gamma UCL		1.437949
Adjusted Gamma UCL		1.438671
Lognormal Distribution Test		
Lilliefors Test Statisitic		0.179013
Lilliefors 5% Critical Value		0.060851
Data not lognormal at 5% significance level		
95% UCLs (Assuming Lognormal Distribution)		
95% H-UCL		1.550055
95% Chebyshev (MVUE) UCL		1.748548
97.5% Chebyshev (MVUE) UCL		1.897986
99% Chebyshev (MVUE) UCL		2.191529
95% Non-parametric UCLs		
CLT UCL		1.439257
Adj-CLT UCL (Adjusted for skewness)		1.452259
Mod-t UCL (Adjusted for skewness)		1.441744
Jackknife UCL		1.439716
Standard Bootstrap UCL		1.437754
Bootstrap-t UCL		1.458879
Hall's Bootstrap UCL		1.458288
Percentile Bootstrap UCL		1.437528
BCA Bootstrap UCL		1.458703
95% Chebyshev (Mean, Sd) UCL		**1.611143**
97.5% Chebyshev (Mean, Sd) UCL		1.730594
99% Chebyshev (Mean, Sd) UCL		1.965231

R2-0009618

Attachment 3

Type	ERE
Medium	Sediment
Chemical	2,3,3',4,4',5-hexachlorobiphenyl
Units	µg/kg

Data File		Variable:	2,3,3',4,4',5-hexachlorobiphenyl	Sediment
Raw Statistics		Normal Distribution Test		
Number of Valid Samples	212	Lilliefors Test Statisitic		0.268641
Number of Unique Samples	135	Lilliefors 5% Critical Value		0.060851
Minimum	0.125	Data not normal at 5% significance level		
Maximum	72			
Mean	6.633488	95% UCL (Assuming Normal Distribution)		
Median	5.5	Student's-t UCL		7.417543
Standard Deviation	6.90997			
Variance	47.74768	Gamma Distribution Test		
Coefficient of Variation	1.04168	A-D Test Statistic		9.539495
Skewness	5.630647	A-D 5% Critical Value		0.768979
		K-S Test Statistic		0.162568
Gamma Statistics		K-S 5% Critical Value		0.063257
k hat	1.740994	Data do not follow gamma distribution		
k star (bias corrected)	1.719502	at 5% significance level		
Theta hat	3.810173			
Theta star	3.857797	95% UCLs (Assuming Gamma Distribution)		
nu hat	738.1814	Approximate Gamma UCL		7.246393
nu star	729.0687	Adjusted Gamma UCL		7.250726
Approx.Chi Square Value (.05)	667.4036			
Adjusted Level of Significance	0.048868	Lognormal Distribution Test		
Adjusted Chi Square Value	667.0048	Lilliefors Test Statisitic		0.209709
		Lilliefors 5% Critical Value		0.060851
Log-transformed Statistics		Data not lognormal at 5% significance level		
Minimum of log data	-2.07944			
Maximum of log data	4.276666	95% UCLs (Assuming Lognormal Distribution)		
Mean of log data	1.578243	95% H-UCL		8.098241
Standard Deviation of log data	0.882227	95% Chebyshev (MVUE) UCL		9.337441
Variance of log data	0.778324	97.5% Chebyshev (MVUE) UCL		10.29088
		99% Chebyshev (MVUE) UCL		12.16374
		95% Non-parametric UCLs		
		CLT UCL		7.414101
		Adj-CLT UCL (Adjusted for skewness)		7.610201
		Mod-t UCL (Adjusted for skewness)		7.448131
		Jackknife UCL		7.417543
		Standard Bootstrap UCL		7.40528
		Bootstrap-t UCL		7.752787
RECOMMENDATION		Hall's Bootstrap UCL		7.965247
Data are Non-parametric (0.05)		Percentile Bootstrap UCL		7.489783
		BCA Bootstrap UCL		7.809458
Use 95% Chebyshev (Mean, Sd) UCL		**95% Chebyshev (Mean, Sd) UCL**		**8.702129**
		97.5% Chebyshev (Mean, Sd) UCL		9.597231
		99% Chebyshev (Mean, Sd) UCL		11.35549

R2-0009619

Attachment 3

Type	ERE
Medium	Sediment
Chemical	2,3,3',4,4'-Pentachlorobiphenyl
Units	µg/kg

Data File

Variable: 2,3,3',4,4'-Pentachlorobiphenyl Sediment

Raw Statistics	
Number of Valid Samples	212
Number of Unique Samples	115
Minimum	0.125
Maximum	140
Mean	20.62732
Median	17.45
Standard Deviation	17.3904
Variance	302.4262
Coefficient of Variation	0.843076
Skewness	3.815893

Gamma Statistics	
k hat	1.794171
k star (bias corrected)	1.771926
Theta hat	11.49685
Theta star	11.64118
nu hat	760.7285
nu star	751.2968
Approx.Chi Square Value (.05)	688.6808
Adjusted Level of Significance	0.048868
Adjusted Chi Square Value	688.2757

Log-transformed Statistics	
Minimum of log data	-2.07944
Maximum of log data	4.941642
Mean of log data	2.72276
Standard Deviation of log data	0.950538
Variance of log data	0.903523

Normal Distribution Test	
Lilliefors Test Statisitic	0.237172
Lilliefors 5% Critical Value	0.060851
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	22.60056

Gamma Distribution Test	
A-D Test Statistic	10.0457
A-D 5% Critical Value	0.768438
K-S Test Statistic	0.182975
K-S 5% Critical Value	0.063219
Data do not follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	22.50278
Adjusted Gamma UCL	22.51603

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.240673
Lilliefors 5% Critical Value	0.060851
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	27.43653
95% Chebyshev (MVUE) UCL	31.94216
97.5% Chebyshev (MVUE) UCL	35.44714
99% Chebyshev (MVUE) UCL	42.33198

95% Non-parametric UCLs	
CLT UCL	22.59189
Adj-CLT UCL (Adjusted for skewness)	22.92636
Mod-t UCL (Adjusted for skewness)	22.65273
Jackknife UCL	22.60056
Standard Bootstrap UCL	22.60734
Bootstrap-t UCL	22.9442
Hall's Bootstrap UCL	23.15041
Percentile Bootstrap UCL	22.72755
BCA Bootstrap UCL	22.72446
95% Chebyshev (Mean, Sd) UCL	**25.83349**
97.5% Chebyshev (Mean, Sd) UCL	28.0862
99% Chebyshev (Mean, Sd) UCL	32.51123

RECOMMENDATION

Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

R2-0009620

Attachment 3

Type	ERE
Medium	Sediment
Chemical	2,3',4,4',5,5'-hexachlorobiphenyl
Units	µg/kg

Data File

Variable: 2,3',4,4',5,5'-hexachlorobiphenyl Sediment

Raw Statistics	
Number of Valid Samples	212
Number of Unique Samples	136
Minimum	0.125
Maximum	62
Mean	7.451472
Median	5.5
Standard Deviation	8.008045
Variance	64.12879
Coefficient of Variation	1.074693
Skewness	3.149483

Gamma Statistics	
k hat	1.209521
k star (bias corrected)	1.19555
Theta hat	6.160678
Theta star	6.232672
nu hat	512.8371
nu star	506.9133
Approx.Chi Square Value (.05)	455.6909
Adjusted Level of Significance	0.048868
Adjusted Chi Square Value	455.3624

Log-transformed Statistics	
Minimum of log data	-2.07944
Maximum of log data	4.127134
Mean of log data	1.541148
Standard Deviation of log data	1.033851
Variance of log data	1.068848

RECOMMENDATION

Data are Non-parametric (0.05)

Use 97.5% Chebyshev (Mean, Sd) UCL

Normal Distribution Test	
Lilliefors Test Statisitic	0.185788
Lilliefors 5% Critical Value	0.060851
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	8.360122

Gamma Distribution Test	
A-D Test Statistic	2.69362
A-D 5% Critical Value	0.778703
K-S Test Statistic	0.109154
K-S 5% Critical Value	0.063797
Data do not follow gamma distribution at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	8.289062
Adjusted Gamma UCL	8.295041

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.109079
Lilliefors 5% Critical Value	0.060851
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	9.298658
95% Chebyshev (MVUE) UCL	10.94899
97.5% Chebyshev (MVUE) UCL	12.25161
99% Chebyshev (MVUE) UCL	14.81036

95% Non-parametric UCLs	
CLT UCL	8.356133
Adj-CLT UCL (Adjusted for skewness)	8.483252
Mod-t UCL (Adjusted for skewness)	8.37995
Jackknife UCL	8.360122
Standard Bootstrap UCL	8.365441
Bootstrap-t UCL	8.441282
Hall's Bootstrap UCL	8.531603
Percentile Bootstrap UCL	8.346943
BCA Bootstrap UCL	8.46475
95% Chebyshev (Mean, Sd) UCL	9.848843
97.5% Chebyshev (Mean, Sd) UCL	**10.88619**
99% Chebyshev (Mean, Sd) UCL	12.92385

R2-0009621

Attachment 3

Type	ERE
Medium	Sediment
Chemical	2,3,4,4',5-pentachlorobiphenyl
Units	µg/kg

Data File		Variable:	2,3,4,4',5-pentachlorobiphenyl	Sediment
Raw Statistics		Normal Distribution Test		
Number of Valid Samples	212	Lilliefors Test Statisitic		0.25788
Number of Unique Samples	122	Lilliefors 5% Critical Value		0.060851
Minimum	0.11	Data not normal at 5% significance level		
Maximum	13			
Mean	1.710321	95% UCL (Assuming Normal Distribution)		
Median	1.4	Student's-t UCL		1.903388
Standard Deviation	1.701527			
Variance	2.895194	Gamma Distribution Test		
Coefficient of Variation	0.994858	A-D Test Statistic		7.028027
Skewness	4.174961	A-D 5% Critical Value		0.76823
		K-S Test Statistic		0.147099
Gamma Statistics		K-S 5% Critical Value		0.063205
k hat	1.814586	Data do not follow gamma distribution		
k star (bias corrected)	1.792052	at 5% significance level		
Theta hat	0.942541			
Theta star	0.954392	95% UCLs (Assuming Gamma Distribution)		
nu hat	769.3843	Approximate Gamma UCL		1.864889
nu star	759.8301	Adjusted Gamma UCL		1.86598
Approx.Chi Square Value (.05)	696.8529			
Adjusted Level of Significance	0.048868	Lognormal Distribution Test		
Adjusted Chi Square Value	696.4453	Lilliefors Test Statisitic		0.131067
		Lilliefors 5% Critical Value		0.060851
Log-transformed Statistics		Data not lognormal at 5% significance level		
Minimum of log data	-2.20727			
Maximum of log data	2.564949	95% UCLs (Assuming Lognormal Distribution)		
Mean of log data	0.236509	95% H-UCL		1.969361
Standard Deviation of log data	0.812067	95% Chebyshev (MVUE) UCL		2.247614
Variance of log data	0.659453	97.5% Chebyshev (MVUE) UCL		2.459471
		99% Chebyshev (MVUE) UCL		2.875622
		95% Non-parametric UCLs		
		CLT UCL		1.902541
		Adj-CLT UCL (Adjusted for skewness)		1.938345
		Mod-t UCL (Adjusted for skewness)		1.908973
		Jackknife UCL		1.903388
		Standard Bootstrap UCL		1.902602
		Bootstrap-t UCL		1.946197
RECOMMENDATION		Hall's Bootstrap UCL		1.968965
Data are Non-parametric (0.05)		Percentile Bootstrap UCL		1.900014
		BCA Bootstrap UCL		1.947741
Use 95% Chebyshev (Mean, Sd) UCL		**95% Chebyshev (Mean, Sd) UCL**		**2.219708**
		97.5% Chebyshev (Mean, Sd) UCL		2.44012
		99% Chebyshev (Mean, Sd) UCL		2.873077

R2-0009622

Attachment 3

Type	ERE
Medium	Sediment
Chemical	2',3,4,4',5-pentachlorobiphenyl
Units	µg/kg

Data File

Variable: 2',3,4,4',5-pentachlorobiphenyl Sediment

Raw Statistics	
Number of Valid Samples	211
Number of Unique Samples	127
Minimum	0.125
Maximum	18
Mean	2.181668
Median	1.4
Standard Deviation	2.365509
Variance	5.595634
Coefficient of Variation	1.084266
Skewness	3.232235

Gamma Statistics	
k hat	1.345501
k star (bias corrected)	1.32953
Theta hat	1.621454
Theta star	1.640932
nu hat	567.8014
nu star	561.0617
Approx.Chi Square Value (.05)	507.1112
Adjusted Level of Significance	0.048863
Adjusted Chi Square Value	506.7627

Log-transformed Statistics	
Minimum of log data	-2.07944
Maximum of log data	2.890372
Mean of log data	0.364538
Standard Deviation of log data	0.940299
Variance of log data	0.884162

RECOMMENDATION

Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

Normal Distribution Test	
Lilliefors Test Statisitic	0.20517
Lilliefors 5% Critical Value	0.060995

Data not normal at 5% significance level

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	2.450717

Gamma Distribution Test	
A-D Test Statistic	2.764166
A-D 5% Critical Value	0.775294
K-S Test Statistic	0.087808
K-S 5% Critical Value	0.063742

Data do not follow gamma distribution at 5% significance level

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	2.413771
Adjusted Gamma UCL	2.415431

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.071322
Lilliefors 5% Critical Value	0.060995

Data not lognormal at 5% significance level

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	2.56588
95% Chebyshev (MVUE) UCL	2.983676
97.5% Chebyshev (MVUE) UCL	3.308234
99% Chebyshev (MVUE) UCL	3.945764

95% Non-parametric UCLs	
CLT UCL	2.44953
Adj-CLT UCL (Adjusted for skewness)	2.488249
Mod-t UCL (Adjusted for skewness)	2.456756
Jackknife UCL	2.450717
Standard Bootstrap UCL	2.453306
Bootstrap-t UCL	2.510981
Hall's Bootstrap UCL	2.493735
Percentile Bootstrap UCL	2.470299
BCA Bootstrap UCL	2.478538
95% Chebyshev (Mean, Sd) UCL	**2.891508**
97.5% Chebyshev (Mean, Sd) UCL	3.198656
99% Chebyshev (Mean, Sd) UCL	3.801989

R2-0009623

Attachment 3

Type	ERE
Medium	Sediment
Chemical	2,3',4,4',5-Pentachlorobiphenyl
Units	µg/kg

Data File

Variable: 2,3',4,4',5-Pentachlorobiphenyl Sediment

Raw Statistics	
Number of Valid Samples	290
Number of Unique Samples	206
Minimum	0.35
Maximum	846
Mean	59.32776
Median	45.1
Standard Deviation	72.49059
Variance	5254.885
Coefficient of Variation	1.221866
Skewness	6.344994

Gamma Statistics	
k hat	1.510326
k star (bias corrected)	1.497001
Theta hat	39.28142
Theta star	39.63107
nu hat	875.9893
nu star	868.2607
Approx.Chi Square Value (.05)	800.8586
Adjusted Level of Significance	0.049172
Adjusted Chi Square Value	800.5396

Log-transformed Statistics	
Minimum of log data	-1.04982
Maximum of log data	6.740519
Mean of log data	3.716851
Standard Deviation of log data	0.934407
Variance of log data	0.873116

RECOMMENDATION

Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

Normal Distribution Test	
Lilliefors Test Statisitic	0.280867
Lilliefors 5% Critical Value	0.052028
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	66.35208

Gamma Distribution Test	
A-D Test Statistic	11.3987
A-D 5% Critical Value	0.771828
K-S Test Statistic	0.154132
K-S 5% Critical Value	0.05424
Data do not follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	64.32092
Adjusted Gamma UCL	64.34655

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.186491
Lilliefors 5% Critical Value	0.052028
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	71.31298
95% Chebyshev (MVUE) UCL	81.60326
97.5% Chebyshev (MVUE) UCL	89.43063
99% Chebyshev (MVUE) UCL	104.806

95% Non-parametric UCLs	
CLT UCL	66.32956
Adj-CLT UCL (Adjusted for skewness)	68.02427
Mod-t UCL (Adjusted for skewness)	66.61642
Jackknife UCL	66.35208
Standard Bootstrap UCL	66.22621
Bootstrap-t UCL	69.20151
Hall's Bootstrap UCL	71.44357
Percentile Bootstrap UCL	67.02341
BCA Bootstrap UCL	69.18855
95% Chebyshev (Mean, Sd) UCL	**77.88269**
97.5% Chebyshev (Mean, Sd) UCL	85.91143
99% Chebyshev (Mean, Sd) UCL	101.6823

R2-0009624

Attachment 3

Type	ERE
Medium	Sediment
Chemical	3,3',4,4',5,5'-hexachlorobiphenyl
Units	µg/kg

Data File

Variable: 3,3',4,4',5,5'-hexachlorobiphenyl Sediment

Raw Statistics	
Number of Valid Samples	207
Number of Unique Samples	65
Minimum	0.0017
Maximum	1.26
Mean	0.162997
Median	0.125
Standard Deviation	0.18834
Variance	0.035472
Coefficient of Variation	1.155482
Skewness	4.245217

Gamma Statistics	
k hat	1.083923
k star (bias corrected)	1.071435
Theta hat	0.150377
Theta star	0.15213
nu hat	448.7442
nu star	443.574
Approx.Chi Square Value (.05)	395.7352
Adjusted Level of Significance	0.048841
Adjusted Chi Square Value	395.422

Log-transformed Statistics	
Minimum of log data	-6.37713
Maximum of log data	0.231112
Mean of log data	-2.34165
Standard Deviation of log data	1.209702
Variance of log data	1.463379

RECOMMENDATION

Data are Non-parametric (0.05)

Use 97.5% Chebyshev (Mean, Sd) UCL

Normal Distribution Test	
Lilliefors Test Statisitic	0.2835
Lilliefors 5% Critical Value	0.061581
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	0.184627

Gamma Distribution Test	
A-D Test Statistic	11.74675
A-D 5% Critical Value	0.781839
K-S Test Statistic	0.279621
K-S 5% Critical Value	0.064547
Data do not follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	0.182701
Adjusted Gamma UCL	0.182846

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.339423
Lilliefors 5% Critical Value	0.061581
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	0.243154
95% Chebyshev (MVUE) UCL	0.293018
97.5% Chebyshev (MVUE) UCL	0.333835
99% Chebyshev (MVUE) UCL	0.414011

95% Non-parametric UCLs	
CLT UCL	0.184529
Adj-CLT UCL (Adjusted for skewness)	0.188657
Mod-t UCL (Adjusted for skewness)	0.18527
Jackknife UCL	0.184627
Standard Bootstrap UCL	0.184735
Bootstrap-t UCL	0.190854
Hall's Bootstrap UCL	0.189538
Percentile Bootstrap UCL	0.184211
BCA Bootstrap UCL	0.191339
95% Chebyshev (Mean, Sd) UCL	0.220058
97.5% Chebyshev (Mean, Sd) UCL	**0.244748**
99% Chebyshev (Mean, Sd) UCL	0.293247

R2-0009625

Attachment 3

Type	ERE
Medium	Sediment
Chemical	3,3',4,4',5-pentachlorobiphenyl
Units	µg/kg

Data File		Variable:	3,3',4,4',5-pentachlorobiphenyl	Sediment
Raw Statistics		Normal Distribution Test		
Number of Valid Samples	208	Lilliefors Test Statisitic		0.248735
Number of Unique Samples	81	Lilliefors 5% Critical Value		0.061433
Minimum	0.026	Data not normal at 5% significance level		
Maximum	1.5			
Mean	0.277781	95% UCL (Assuming Normal Distribution)		
Median	0.238	Student's-t UCL		0.305016
Standard Deviation	0.23773			
Variance	0.056515	Gamma Distribution Test		
Coefficient of Variation	0.855816	A-D Test Statistic		6.983629
Skewness	2.879346	A-D 5% Critical Value		0.764752
		K-S Test Statistic		0.157052
Gamma Statistics		K-S 5% Critical Value		0.063433
k hat	2.26579	Data do not follow gamma distribution		
k star (bias corrected)	2.236316	at 5% significance level		
Theta hat	0.122598			
Theta star	0.124214	95% UCLs (Assuming Gamma Distribution)		
nu hat	942.5688	Approximate Gamma UCL		0.300317
nu star	930.3074	Adjusted Gamma UCL		0.300478
Approx.Chi Square Value (.05)	860.4973			
Adjusted Level of Significance	0.048846	Lognormal Distribution Test		
Adjusted Chi Square Value	860.0349	Lilliefors Test Statisitic		0.118081
		Lilliefors 5% Critical Value		0.061433
Log-transformed Statistics		Data not lognormal at 5% significance level		
Minimum of log data	-3.64966			
Maximum of log data	0.405465	95% UCLs (Assuming Lognormal Distribution)		
Mean of log data	-1.51754	95% H-UCL		0.29907
Standard Deviation of log data	0.667114	95% Chebyshev (MVUE) UCL		0.334247
Variance of log data	0.44504	97.5% Chebyshev (MVUE) UCL		0.360517
		99% Chebyshev (MVUE) UCL		0.412118
		95% Non-parametric UCLs		
		CLT UCL		0.304894
		Adj-CLT UCL (Adjusted for skewness)		0.308411
		Mod-t UCL (Adjusted for skewness)		0.305565
		Jackknife UCL		0.305016
		Standard Bootstrap UCL		0.304319
		Bootstrap-t UCL		0.307582
RECOMMENDATION		Hall's Bootstrap UCL		0.310237
Data are Non-parametric (0.05)		Percentile Bootstrap UCL		0.306135
		BCA Bootstrap UCL		0.30987
Use 95% Chebyshev (Mean, Sd) UCL		**95% Chebyshev (Mean, Sd) UCL**		**0.349632**
		97.5% Chebyshev (Mean, Sd) UCL		0.380721
		99% Chebyshev (Mean, Sd) UCL		0.441791

R2-0009626

Attachment 3

Type	ERE
Medium	Sediment
Chemical	3,3',4,4'-tetrachlorobiphenyl
Units	µg/kg

Data File

Variable: 3,3',4,4'-tetrachlorobiphenyl Sediment

Raw Statistics	
Number of Valid Samples	212
Number of Unique Samples	148
Minimum	0.125
Maximum	71
Mean	9.228403
Median	7.67
Standard Deviation	9.447273
Variance	89.25098
Coefficient of Variation	1.023717
Skewness	4.23822

Gamma Statistics	
k hat	1.4081
k star (bias corrected)	1.391319
Theta hat	6.553797
Theta star	6.632845
nu hat	597.0345
nu star	589.9192
Approx.Chi Square Value (.05)	534.5687
Adjusted Level of Significance	0.048868
Adjusted Chi Square Value	534.2124

Log-transformed Statistics	
Minimum of log data	-2.07944
Maximum of log data	4.26268
Mean of log data	1.826933
Standard Deviation of log data	1.059119
Variance of log data	1.121732

RECOMMENDATION

Data are Non-parametric (0.05)

Use 97.5% Chebyshev (Mean, Sd) UCL

Normal Distribution Test	
Lilliefors Test Statisitic	0.252542
Lilliefors 5% Critical Value	0.060851
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	10.30036

Gamma Distribution Test	
A-D Test Statistic	9.136944
A-D 5% Critical Value	0.773731
K-S Test Statistic	0.158699
K-S 5% Critical Value	0.063545
Data do not follow gamma distribution at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	10.18393
Adjusted Gamma UCL	10.19073

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.219282
Lilliefors 5% Critical Value	0.060851
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	12.77421
95% Chebyshev (MVUE) UCL	15.09176
97.5% Chebyshev (MVUE) UCL	16.92935
99% Chebyshev (MVUE) UCL	20.53893

95% Non-parametric UCLs	
CLT UCL	10.29565
Adj-CLT UCL (Adjusted for skewness)	10.49746
Mod-t UCL (Adjusted for skewness)	10.33184
Jackknife UCL	10.30036
Standard Bootstrap UCL	10.28711
Bootstrap-t UCL	10.6984
Hall's Bootstrap UCL	10.65052
Percentile Bootstrap UCL	10.39202
BCA Bootstrap UCL	10.46351
95% Chebyshev (Mean, Sd) UCL	12.05664
97.5% Chebyshev (Mean, Sd) UCL	**13.28042**
99% Chebyshev (Mean, Sd) UCL	15.68429

R2-0009627

Attachment 3

Type	ERE
Medium	Sediment
Chemical	3,4,4',5-tetrachlorobiphenyl
Units	µg/kg

Data File

Variable: 3,4,4',5-tetrachlorobiphenyl Sediment

Raw Statistics	
Number of Valid Samples	76
Number of Unique Samples	70
Minimum	0.18
Maximum	4.23
Mean	0.90925
Median	0.8035
Standard Deviation	0.524601
Variance	0.275206
Coefficient of Variation	0.57696
Skewness	3.616275

Gamma Statistics	
k hat	4.320728
k star (bias corrected)	4.158945
Theta hat	0.210439
Theta star	0.218625
nu hat	656.7507
nu star	632.1597
Approx.Chi Square Value (.05)	574.8202
Adjusted Level of Significance	0.046842
Adjusted Chi Square Value	573.772

Log-transformed Statistics	
Minimum of log data	-1.7148
Maximum of log data	1.442202
Mean of log data	-0.2153
Standard Deviation of log data	0.495182
Variance of log data	0.245205

RECOMMENDATION

Data are Non-parametric (0.05)

Use Student's-t UCL
or Modified-t UCL

Normal Distribution Test	
Lilliefors Test Statisitic	0.166449
Lilliefors 5% Critical Value	0.101631
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	**1.009468**

Gamma Distribution Test	
A-D Test Statistic	1.496306
A-D 5% Critical Value	0.755503
K-S Test Statistic	0.116909
K-S 5% Critical Value	0.102801
Data do not follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	0.99995
Adjusted Gamma UCL	1.001776

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.118942
Lilliefors 5% Critical Value	0.101631
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	1.012802
95% Chebyshev (MVUE) UCL	1.146977
97.5% Chebyshev (MVUE) UCL	1.249591
99% Chebyshev (MVUE) UCL	1.451155

95% Non-parametric UCLs	
CLT UCL	1.00823
Adj-CLT UCL (Adjusted for skewness)	1.034903
Mod-t UCL (Adjusted for skewness)	1.013629
Jackknife UCL	1.009468
Standard Bootstrap UCL	1.008442
Bootstrap-t UCL	1.048933
Hall's Bootstrap UCL	1.171236
Percentile Bootstrap UCL	1.014908
BCA Bootstrap UCL	1.034592
95% Chebyshev (Mean, Sd) UCL	1.17155
97.5% Chebyshev (Mean, Sd) UCL	1.285048
99% Chebyshev (Mean, Sd) UCL	1.507992

R2-0009628

Type	ERE
Medium	Sediment
Chemical	TOC
Units	µg/kg

Data File

Variable: TOC Sediment

Raw Statistics	
Number of Valid Samples	220
Number of Unique Samples	186
Minimum	922000
Maximum	4.09E+08
Mean	76080782
Median	59950000
Standard Deviation	57029386
Variance	3.25E+15
Coefficient of Variation	0.74959
Skewness	1.669158

Gamma Statistics	
k hat	1.869943
k star (bias corrected)	1.847474
Theta hat	40686150
Theta star	41180973
nu hat	822.7749
nu star	812.8886
Approx.Chi Square Value (.05)	747.7093
Adjusted Level of Significance	0.048909
Adjusted Chi Square Value	747.3023

Log-transformed Statistics	
Minimum of log data	13.7343
Maximum of log data	19.82923
Mean of log data	17.85669
Standard Deviation of log data	0.839623
Variance of log data	0.704966

RECOMMENDATION

Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

Normal Distribution Test	
Lilliefors Test Statisitic	0.140746
Lilliefors 5% Critical Value	0.059734
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	82431978

Gamma Distribution Test	
A-D Test Statistic	1.812929
A-D 5% Critical Value	0.767648
K-S Test Statistic	0.092082
K-S 5% Critical Value	0.062227
Data do not follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	82712897
Adjusted Gamma UCL	82757939

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.09062
Lilliefors 5% Critical Value	0.059734
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	90723723
95% Chebyshev (MVUE) UCL	1.04E+08
97.5% Chebyshev (MVUE) UCL	1.14E+08
99% Chebyshev (MVUE) UCL	1.33E+08

95% Non-parametric UCLs	
CLT UCL	82405113
Adj-CLT UCL (Adjusted for skewness)	82867445
Mod-t UCL (Adjusted for skewness)	82504093
Jackknife UCL	82431978
Standard Bootstrap UCL	82287937
Bootstrap-t UCL	82951917
Hall's Bootstrap UCL	82921605
Percentile Bootstrap UCL	82614636
BCA Bootstrap UCL	82459427
95% Chebyshev (Mean, Sd) UCL	**92840401**
97.5% Chebyshev (Mean, Sd) UCL	1E+08
99% Chebyshev (Mean, Sd) UCL	1.14E+08

R2-0009629

ATTACHMENT 4
HUMAN HEALTH RISK – CURRENT CONDITIONS

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TABLE 4-1 (RAGS PT. D TABLE 3.1 RME)
EXPOSURE POINT CONCENTRATION SUMMARY
REASONABLE MAXIMUM EXPOSURE
Lower Passaic River

Scenario Timeframe: Current
Medium: Fish
Exposure Medium: Fish

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL (Distribution) (1)	Maximum Concentration (Qualifier)	Exposure Point Concentration			
						Value	Units	Statistic	Rationale
Fish	TCDD-TEQ (D/F)	mg/kg	0.000200	NA	0.0005000	0.00025	mg/kg	97.5% Chebyshev	Nonparametric
	TCDD-TEQ (PCBs)	mg/kg	0.000060	Log	0.0002200	0.00008	m/gkg	H-UCL	Lognormal
	Total PCBs	mg/kg	2.85	Gamma	13.99	3.42	mg/kg	Approximate Gamma	Gamma Distribution
	4,4'-DDD	mg/kg	0.12	Log	0.68	0.15	mg/kg	H-UCL	Lognormal
	4,4'-DDE	mg/kg	0.25	Log	1.69	0.303	mg/kg	H-UCL	Lognormal
	4,4'-DDT	mg/kg	0.06	Gamma	0.38	0.076	mg/kg	Approximate Gamma	Gamma Distribution
	Total Chlordane	mg/kg	0.73	NA	3.77	1.8	mg/kg	99% Chebyshev	Nonparametric
	Dieldrin	mg/kg	0.02	Gamma	0.14	0.027	mg/kg	Approximate Gamma	Gamma Distribution
	Methyl mercury	mg/kg	0.32	Gamma	0.93	0.347	mg/kg	Approximate Gamma	Gamma Distribution

(1) NA - distribution not determined; Log - lognormal distribution; Gamma - gamma distribution.

TABLE 4-2 (RAGS PT. D TABLE 3.1 RME)
EXPOSURE POINT CONCENTRATION SUMMARY
REASONABLE MAXIMUM EXPOSURE
Lower Passaic River

Scenario Timeframe: Current
Medium: Crab
Exposure Medium: Crab

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL (Distribution) (1)	Maximum Concentration (Qualifier)	Exposure Point Concentration			
						Value	Units	Statistic	Rationale
Crab	TCDD TEQ (D/F)	mg/kg	0.0001	NA	0.000750	0.0002	mg/kg	97.5% Chebyshev	Nonparametric
	TCDD TEQ (PCBs)	mg/kg	0.00009	NA	0.004000	0.0004	mg/kg	97.5% Chebyshev	Nonparametric
	Total PCBs	mg/kg	2.4	NA	14	5.2	mg/kg	97.5% Chebyshev	Nonparametric
	4,4'-DDD	mg/kg	0.053	NA	0.82	0.138	mg/kg	97.5% Chebyshev	Nonparametric
	4,4'-DDE	mg/kg	0.137	NA	1.74	0.317	mg/kg	97.5% Chebyshev	Nonparametric
	4,4'-DDT	mg/kg	0.078	NA	0.48	0.235	mg/kg	99% Chebyshev	Nonparametric
	Total Chlordane	mg/kg	0.019	NA	0.20	0.037	mg/kg	97.5% Chebyshev	Nonparametric
	Dieldrin	mg/kg	0.009	NA	0.03	0.018	mg/kg	97.5% Chebyshev	Nonparametric
	Methyl mercury	mg/kg	0.087	Log	0.28	0.097	mg/kg	H-UCL	Lognormal

(1) NA - distribution not determined; Log - lognormal.

TABLE 4-3 (RAGS PT. D TABLE 3.1 CT)
EXPOSURE POINT CONCENTRATION SUMMARY
CENTRAL TENDENCY
Lower Passaic River

Scenario Timeframe: Current
Medium: Fish
Exposure Medium: Fish

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL (Distribution) (1)	Maximum Concentration (Qualifier)	Exposure Point Concentration			
						Value	Units	Statistic	Rationale
Fish	TCDD-TEQ (D/F)	mg/kg	0.000200	NA	0.0005000	0.00025	mg/kg	97.5% Chebyshev	Nonparametric
	TCDD-TEQ (PCBs)	mg/kg	0.000060	Log	0.0002200	0.00008	m/gkg	H-UCL	Lognormal
	Total PCBs	mg/kg	2.85	Gamma	13.99	3.42	mg/kg	Approximate Gamma	Gamma Distribution
	4,4'-DDD	mg/kg	0.12	Log	0.68	0.15	mg/kg	H-UCL	Lognormal
	4,4'-DDE	mg/kg	0.25	Log	1.69	0.303	mg/kg	H-UCL	Lognormal
	4,4'-DDT	mg/kg	0.06	Gamma	0.38	0.076	mg/kg	Approximate Gamma	Gamma Distribution
	Total Chlordane	mg/kg	0.73	NA	3.77	1.8	mg/kg	99% Chebyshev	Nonparametric
	Dieldrin	mg/kg	0.02	Gamma	0.14	0.027	mg/kg	Approximate Gamma	Gamma Distribution
	Methyl mercury	mg/kg	0.32	Gamma	0.93	0.347	mg/kg	Approximate Gamma	Gamma Distribution

(1) log - lognormal; N - normal; NA - not normal or lognormal

TABLE 4-4 (RAGS PT. D TABLE 3.1 CT)
EXPOSURE POINT CONCENTRATION SUMMARY
CENTRAL TENDENCY
Lower Passaic River

Scenario Timeframe: Current
Medium: Crab
Exposure Medium: Crab

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL (Distribution) (1)	Maximum Concentration (Qualifier)	Exposure Point Concentration			
						Value	Units	Statistic (2)	Rationale
Crab	TCDD TEQ (D/F)	mg/kg	0.0001	NA	0.000750	0.0002	mg/kg	97.5% Chebyshev	Nonparametric
	TCDD TEQ (PCBs)	mg/kg	0.00009	NA	0.004000	0.0004	mg/kg	97.5% Chebyshev	Nonparametric
	Total PCBs	mg/kg	2.4	NA	14	5.2	mg/kg	97.5% Chebyshev	Nonparametric
	4,4'-DDD	mg/kg	0.053	NA	0.82	0.138	mg/kg	97.5% Chebyshev	Nonparametric
	4,4'-DDE	mg/kg	0.137	NA	1.74	0.317	mg/kg	97.5% Chebyshev	Nonparametric
	4,4'-DDT	mg/kg	0.078	NA	0.48	0.235	mg/kg	99% Chebyshev	Nonparametric
	Total Chlordane	mg/kg	0.019	NA	0.20	0.037	mg/kg	97.5% Chebyshev	Nonparametric
	Dieldrin	mg/kg	0.009	NA	0.03	0.018	mg/kg	97.5% Chebyshev	Nonparametric
	Methyl mercury	mg/kg	0.087	Log	0.28	0.097	mg/kg	H-UCL	Lognormal

(1) log - lognormal; N - normal; NA - not normal or lognormal

TABLE 4-5 (RAGS PT.D TABLE 4.1)
VALUES USED FOR DAILY INTAKE CALCULATIONS
Lower Passaic River

Scenario Timeframe: Current/Future
Medium: Fish
Exposure Medium: Fish
Receptor Population: Angler (Adult)
Receptor Age: >18 Years

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	CT Value	CT Rationale/ Reference	Intake Equation/ Model Name
Ingestion	C_f	Chemical Concentration in Fish	mg/kg wet weight	Site-specific		Site-specific		$Intake = \frac{C_f \times IR_f \times EF \times FI \times (1-Loss) \times ED \times CF}{BW \times AT}$
	IR_f	Ingestion rate of Fish	g/day	25	USEPA, 1997	8	USEPA, 1997	
	FI	Fraction from Source	unitless	1	Assumes 100% exposure is from Passaic River	1	Assumes 100% exposure is from Passaic River	
	EF	Exposure Frequency	days/year	365	USEPA, 1989	365	Assumed to be one-half RME	
	ED	Exposure Duration [(2)]	years	24	USEPA, 1989	9	USEPA, 1989	
	Loss	Cooking Loss	g/g	0	Assumes 100% chemical remains in fish	Chemical-specific	--	
	CF	Conversion Factor	kg/g	1.00E-03	--	1.00E-03	--	
	BW	Body Weight	kg	70	Mean adult body weight, males and females (USEPA, 1989)	70	Mean adult body weight, makes and females (USEPA, 1989)	
	AT-C	Averaging Time (Cancer)	days	25550	70-year lifetime exposure x 365 days/year (USEPA, 1989)	25550	70-year lifetime exposure x 365 days/year (USEPA, 1989)	
	AT-NC	Averaging Time (Noncancer)	days	8760	ED (years) x 365 days/year	3285	ED (years) x 365 days/year	

TABLE 4-6 (RAGS PT.D TABLE 4.1)
VALUES FOR DAILY INTAKE CALCULATIONS
Lower Passaic River

Scenario Timeframe: Current/Future
Medium: Fish
Exposure Medium: Fish
Receptor Population: Angler (Adolescent)
Receptor Age: 10- 18 Years

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	CT Value	CT Rationale/ Reference	Intake Equation/ Model Name
Ingestion	C_f	Chemical Concentration in Fish	mg/kg wet weight	Site-specific		Site-specific		$Intake = \frac{C_f \times IR_f \times EF \times FI \times (1-Loss) \times ED \times CF}{BW \times AT}$
	IR_f	Ingestion rate of Fish	g/day	17	2/3 the adult ingestion rate (USEPA, 1997)	5	2/3 the adult ingestion rate (USEPA, 1997)	
	FI	Fraction from Source	unitless	1	Assumes 100% exposure is from Passaic River	1	Assumes 100% exposure is from Passaic River	
	EF	Exposure Frequency	days/year	365	USEPA, 1989	365	Based on an annualized ingestion rate	
	ED	Exposure Duration	years	9	Assumed	6	EPA default (USEPA, 1991)	
	Loss	Cooking Loss	g/g	0	Assumes 100% chemical remains in fish	Chemical-specific	--	
	CF	Conversion Factor	kg/g	1.00E-03	--	1.00E-03	--	
	BW	Body Weight	kg	54.5	Mean weight, males and females age 10-17 (USEPA, 2002c)	54.5	Mean weight, males and females age 10-17 (USEPA, 2002c)	
	AT-C	Averaging Time (Cancer)	days	25550	70-year lifetime exposure x 365 days/year (USEPA, 1989)	25550	70-year lifetime exposure x 365 days/year (USEPA, 1989)	
	AT-NC	Averaging Time (Noncancer)	days	3285	ED (years) x 365 days/year	1825	ED (years) x 365 days/year	

TABLE 4-7 (RAGS PT. D TABLE 4.1)
VALUES FOR DAILY INTAKE CALCULATIONS
Lower Passaic River

Scenario Timeframe: Current/Future
Medium: Fish
Exposure Medium: Fish
Receptor Population: Angler (Child)
Receptor Age: 0 - 6 Years

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	CT Value	CT Rationale/ Reference	Intake Equation/ Model Name
Ingestion	C_f	Chemical Concentration in Fish	mg/kg wet weight	Site-specific		Site-specific		$Intake = \frac{C_f \times IR_f \times EF \times FI \times (1-Loss) \times ED \times CF}{BW \times AT}$
	IR_f	Ingestion rate of Fish	g/day	8	1/3 of the adult ingestion rate (USEPA, 1997)	3	1/3 of the adult ingestion rate (USEPA, 1997)	
	FI	Fraction from Source	unitless	1	Assumes 100% exposure is from Passaic River	1	Assumes 100% exposure is from Passaic River	
	EF	Exposure Frequency	days/year	365	USEPA, 1989	365	Based on an annualized ingestion rate	
	ED	Exposure Duration	years	6	EPA default (USEPA, 1991)	3	Assumed	
	Loss	Cooking Loss	g/g	0	Assumes 100% chemical remains in fish	Chemical-specific	--	
	CF	Conversion Factor	kg/g	1.00E-03	--	1.00E-03	--	
	BW	Body Weight	kg	15	Mean child weight (USEPA, 1989)	15	Mean child weight (USEPA, 1989)	
	AT-C	Averaging Time (Cancer)	days	25550	70-year lifetime exposure x 365 days/year (USEPA, 1989)	25550	70-year lifetime exposure x 365 days/year (USEPA, 1989)	
	AT-NC	Averaging Time (Noncancer)	days	2190	ED (years) x 365 days/year	1095	ED (years) x 365 days/year	

TABLE 4-8 (RAGS PT. D TABLE 4.1)
VALUES USED FOR DAILY INTAKE CALCULATIONS
Lower Passaic River

Scenario Timeframe: Current/Future
Medium: Crab
Exposure Medium: Crab
Receptor Population: Angler (Adult)
Receptor Age: >18 Years

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	CT Value	CT Rationale/ Reference	Intake Equation/ Model Name
Ingestion	C_b	Chemical Concentration in Crab	mg/kg wet weight	Site-specific		Site-specific		$Intake = \frac{C_b \times IR_b \times EF \times FI \times (1-Loss) \times ED \times CF}{BW \times AT}$
	IR_b	Ingestion rate of Crab	g/day	23	Burger, 2002	16	Burger, 2002	
	FI	Fraction from Source	unitless	1	Assumes 100% exposure is from Passaic River	1	Assumes 100% exposure is from Passaic River	
	EF	Exposure Frequency	days/year	365	USEPA, 1989	365	Based on an annualized ingestion rate	
	ED	Exposure Duration [(2)]	years	24	USEPA, 1989	9	USEPA, 1989	
	Loss	Cooking Loss	g/g	0	Assumes 100% chemical remains in crab	0	No data available	
	CF	Conversion Factor	kg/g	1.00E-03	--	1.00E-03	--	
	BW	Body Weight	kg	70	Mean adult body weight, males and females (USEPA, 1989)	70	Mean adult body weight, males and females (USEPA, 1989)	
	AT-C	Averaging Time (Cancer)	days	25550	70-year lifetime exposure x 365 days/year (USEPA, 1989)	25550	70-year lifetime exposure x 365 days/year (USEPA, 1989)	
	AT-NC	Averaging Time (Noncancer)	days	8760	ED (years) x 365 days/year	3285	ED (years) x 365 days/year	

TABLE 4-9 (RAGS PT. D TABLE 4.1)
VALUES FOR DAILY INTAKE CALCULATIONS
Lower Passaic River

Scenario Timeframe: Current/Future
Medium: Crab
Exposure Medium: Crab
Receptor Population: Angler (Adolescent)
Receptor Age: 10 - 18 Years

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	CT Value	CT Rationale/ Reference	Intake Equation/ Model Name
Ingestion	C_b	Chemical Concentration in Crab	mg/kg wet weight	Site-specific		Site-specific		$\text{Intake} = \frac{C_b \times IR_b \times EF \times FI \times (1-Loss) \times ED \times CF}{BW \times AT}$
	IR_b	Ingestion rate of Crab	g/day	15	2/3 the adult ingestion rate (USEPA, 1997)	11	2/3 the adult ingestion rate (USEPA, 1997)	
	FI	Fraction from Source	unitless	1	Assumes 100% exposure is from Passaic River	1	Assumes 100% exposure is from Passaic River	
	EF	Exposure Frequency	days/year	365	USEPA, 1989	365	Based on an annualized ingestion rate	
	ED	Exposure Duration	years	9	Assumed (from age 10 through 18)	6	Standard EPA default (USEPA, 1991)	
	Loss	Cooking Loss	g/g	0	Assumes 100% chemical remains in fish	Chemical-specific	--	
	CF	Conversion Factor	kg/g	1.00E-03	--	1.00E-03	--	
	BW	Body Weight	kg	54.5	Mean weight, males and females age 10-17 (USEPA, 2002c)	54.5	Mean weight, males and females age 10-17 (USEPA, 2002c)	
	AT-C	Averaging Time (Cancer)	days	25550	70-year lifetime exposure x 365 days/year (USEPA, 1989)	25550	70-year lifetime exposure x 365 days/year (USEPA, 1989)	
	AT-NC	Averaging Time (Noncancer)	days	3285	ED (years) x 365 days/year	1825	ED (years) x 365 days/year	

TABLE 4-10 (RAGS PT. D TABLE 4.1)
VALUES FOR DAILY INTAKE CALCULATIONS
Lower Passaic River

Scenario Timeframe: Current/Future
Medium: Crab
Exposure Medium: Crab
Receptor Population: Angler (Child)
Receptor Age: 0 - 6 Years

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	CT Value	CT Rationale/ Reference	Intake Equation/ Model Name
Ingestion	C_b	Chemical Concentration in Crab	mg/kg wet weight	Site-specific		Site-specific		$Intake = \frac{C_b \times IR_b \times EF \times FI \times (1-Loss) \times ED \times CF}{BW \times AT}$
	IR_b	Ingestion rate of Crab	g/day	8	1/3 of the adult ingestion rate (USEPA, 1997)	5	1/3 of the adult ingestion rate (USEPA, 1997)	
	FI	Fraction from Source	unitless	1	Assumes 100% exposure is from Passaic River	1	Assumes 100% exposure is from Passaic River	
	EF	Exposure Frequency	days/year	365	USEPA, 1989	365	Based on an annualized ingestion rate	
	ED	Exposure Duration	years	6	Standard EPA default (USEPA, 1991)	3	Assumed	
	Loss	Cooking Loss	g/g	0	Assumes 100% chemical remains in crab	0	No data available	
	CF	Conversion Factor	kg/g	1.00E-03	--	1.00E-03	--	
	BW	Body Weight	kg	15	Standard EPA default (USEPA, 1991)	15	Standard EPA default (USEPA, 1991)	
	AT-C	Averaging Time (Cancer)	days	25550	70-year lifetime exposure x 365 days/year (USEPA, 1989)	25550	70-year lifetime exposure x 365 days/year (USEPA, 1989)	
	AT-NC	Averaging Time (Noncancer)	days	2190	ED (years) x 365 days/year	1095	ED (years) x 365 days/year	

TABLE 4-11 (RAGS PT. D TABLE 5.1)
NON-CANCER TOXICITY DATA -- ORAL/DERMAL
Lower Passaic River

Chemical of Potential Concern	Chronic/ Subchronic	Oral RfD		Oral Absorption Efficiency for Dermal (1)	Absorbed RfD for Dermal		Primary Target Organ(s)	Combined Uncertainty/Modifying Factors	RfD:Target Organ(s)	
		Value	Units		Value	Units			Source(s)	Date(s) (MM/DD/YYYY)
TCDD TEQ	--	--	--	--	--	--	--	--	IRIS	8/23/2006
Total PCBs (2)	Chronic	2.0E-05	mg/kg-day	1.0E+00	2.0E-05	mg/kg-day	Immune System, eye	300	IRIS	8/23/2006
4,4'-DDD	--	--	--	--	--	--	--	--	IRIS	8/23/2006
4,4'-DDE	--	--	--	--	--	--	--	--	IRIS	8/23/2006
4,4'-DDT	Chronic	5.0E-04	mg/kg-day	1.0E+00	5.0E-04	mg/kg-day	liver	100	IRIS	8/23/2006
Chlordane	Chronic	5.0E-04	mg/kg-day	1.0E+00	5.0E-04	mg/kg-day	liver	300	IRIS	8/23/2006
Dieldrin	Chronic	5.0E-05	mg/kg-day	1.0E+00	5.0E-05	mg/kg-day	liver	100	IRIS	8/23/2006
Methylmercury	Chronic	1.0E-04	mg/kg-day	1.0E+00	1.0E-04	mg/kg-day	central nervous system	10	IRIS	8/23/2006

Footnote Instructions:

(1) Per USEPA's Dermal Guidance Document (USEPA, 2004), Exhibit 4-1,

(2) Based on the noncancer toxicity values for Aroclor 1254.

TABLE 4-12 (RAGS PT D TABLE 6.1)
CANCER TOXICITY DATA -- ORAL/DERMAL
Lower Passaic River

Chemical of Potential Concern	Oral Cancer Slope Factor		Oral Absorption Efficiency for Dermal	Absorbed Cancer Slope Factor for Dermal		Weight of Evidence/ Cancer Guideline Description	Oral CSF	
	Value	Units	(1)	Value	Units	(2)	Source(s)	Date(s) (MM/DD/YYYY)
TCDD TEQ	1.50E+05	$(mg/kg\text{-}day)^{-1}$	100%	1.50E+05	$(mg/kg\text{-}day)^{-1}$	B2	HEAST	07/31/97
Total PCBs	2.00E+00	$(mg/kg\text{-}day)^{-1}$	100%	2.00E+00	$(mg/kg\text{-}day)^{-1}$	B2	IRIS	8/23/2006
Total PCBs (3)	1.00E+00	$(mg/kg\text{-}day)^{-1}$	100%	1.00E+00	$(mg/kg\text{-}day)^{-1}$	B2	IRIS	8/23/2006
4,4'-DDD	2.40E-01	$(mg/kg\text{-}day)^{-1}$	100%	2.40E-01	$(mg/kg\text{-}day)^{-1}$	B2	IRIS	8/23/2006
4,4'-DDE	3.40E-01	$(mg/kg\text{-}day)^{-1}$	100%	3.40E-01	$(mg/kg\text{-}day)^{-1}$	B2	IRIS	8/23/2006
4,4'-DDT	3.40E-01	$(mg/kg\text{-}day)^{-1}$	100%	3.40E-01	$(mg/kg\text{-}day)^{-1}$	B2	IRIS	8/23/2006
Chlordane	3.50E-01	$(mg/kg\text{-}day)^{-1}$	100%	3.50E-01	$(mg/kg\text{-}day)^{-1}$	B2	IRIS	8/23/2006
Dieldrin	1.60E+01	$(mg/kg\text{-}day)^{-1}$	100%	1.60E+01	$(mg/kg\text{-}day)^{-1}$	B2	IRIS	8/23/2006
Methylmercury	--	--	100%	--	--	C	IRIS	8/23/2006

(1) Per USEPA's Dermal Guidance Document (USEPA, 2004a), Exhibit 4-1.

(2) Weight of eveidence: B2 - probable human carcinogen; C- possible human carcinogen

(3) Central estimate slope factor for exposures to PCBs via ingestion of fish

IRIS - Integrated Risk Information System

HEAST - Health Effects Assessment Summary Tables

Attachment 4

TABLE 4-13 (RAGS PT D TABLE 7a.1 RME)
CALCULATION OF CHEMICAL CANCER RISKS
REASONABLE MAXIMUM EXPOSURE
Lower Passaic River

Scenario Timeframe: Current/Future
Receptor Population: Angler (Adult)
Receptor Age: >18 Years

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk
							Value	Units	Value	Units	
Fish			Ingestion	TCDD TEQ (D/F)	3E-04	mg/kg	3.1E-08	mg/kg-day	1.5E+05	(mg/kg-day)-1	5.E-03
				TCDD TEQ (PCBs)	8E-05	mg/kg	9.8E-09	mg/kg-day	1.5E+05	(mg/kg-day)-1	1.E-03
				Total PCBs	3E+00	mg/kg	4.2E-04	mg/kg-day	2.0E+00	(mg/kg-day)-1	8.E-04
				4,4'-DDD	2E-01	mg/kg	1.8E-05	mg/kg-day	2.4E-01	(mg/kg-day)-1	4.E-06
				4,4'-DDE	3E-01	mg/kg	3.7E-05	mg/kg-day	3.4E-01	(mg/kg-day)-1	1.E-05
				4,4'-DDT	8E-02	mg/kg	9.3E-06	mg/kg-day	3.4E-01	(mg/kg-day)-1	3.E-06
				Total Chlordane	2E+00	mg/kg	2.2E-04	mg/kg-day	3.5E-01	(mg/kg-day)-1	8.E-05
				Dieldrin	3E-02	mg/kg	3.3E-06	mg/kg-day	1.6E+01	(mg/kg-day)-1	5.E-05
				Methyl mercury	3E-01	mg/kg	4.2E-05	mg/kg-day	--	--	ND
			Exp. Route Total								7.E-03
		Exposure Point Total									7.E-03
	Exposure Medium Total										7.E-03
Medium Total											
Crab				TCDD TEQ (D/F)	2E-04	mg/kg	2.3E-08	mg/kg-day	1.5E+05	(mg/kg-day)-1	3.E-03
				TCDD TEQ (PCBs)	4E-04	mg/kg	4.5E-08	mg/kg-day	1.5E+05	(mg/kg-day)-1	7.E-03
				Total PCBs	5E+00	mg/kg	5.9E-04	mg/kg-day	2.0E+00	(mg/kg-day)-1	1.E-03
				4,4'-DDD	1E-01	mg/kg	1.6E-05	mg/kg-day	2.4E-01	(mg/kg-day)-1	4.E-06
				4,4'-DDE	3E-01	mg/kg	3.6E-05	mg/kg-day	3.4E-01	(mg/kg-day)-1	1.E-05
				4,4'-DDT	2E-01	mg/kg	2.6E-05	mg/kg-day	3.4E-01	(mg/kg-day)-1	9.E-06
				Total Chlordane	4E-02	mg/kg	4.2E-06	mg/kg-day	3.5E-01	(mg/kg-day)-1	1.E-06
				Dieldrin	2E-02	mg/kg	2.0E-06	mg/kg-day	1.6E+01	(mg/kg-day)-1	3.E-05
				Methyl mercury	1E-01	mg/kg	1.1E-05	mg/kg-day	--	--	ND
			Exp. Route Total								1.E-02
		Exposure Point Total									1.E-02
	Exposure Medium Total										1.E-02
Medium Total											

ND - not determined because toxicity values are not available for this exposure route.
mg/kg - milligram per kilogram

TABLE 4-14 (RAGS PT D TABLE 7a.1 RME)
CALCULATION OF CHEMICAL CANCER RISKS
REASONABLE MAXIMUM EXPOSURE
Lower Passaic River

Scenario Timeframe: Current/Future
Receptor Population: Angler (Adolescent)
Receptor Age: 10 - 18 Years

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk
							Value	Units	Value	Units	
Fish			Ingestion	TCDD TEQ (D/F)	3E-04	mg/kg	9.8E-09	mg/kg-day	1.5E+05	(mg/kg-day)-1	1.E-03
				TCDD TEQ (PCBs)	8E-05	mg/kg	3.1E-09	mg/kg-day	1.5E+05	(mg/kg-day)-1	5.E-04
				Total PCBs	3E+00	mg/kg	1.3E-04	mg/kg-day	2.0E+00	(mg/kg-day)-1	3.E-04
				4,4'-DDD	2E-01	mg/kg	5.9E-06	mg/kg-day	2.4E-01	(mg/kg-day)-1	1.E-06
				4,4'-DDE	3E-01	mg/kg	1.2E-05	mg/kg-day	3.4E-01	(mg/kg-day)-1	4.E-06
				4,4'-DDT	8E-02	mg/kg	3.0E-06	mg/kg-day	3.4E-01	(mg/kg-day)-1	1.E-06
				Total Chlordane	2E+00	mg/kg	7.1E-05	mg/kg-day	3.5E-01	(mg/kg-day)-1	2.E-05
				Dieldrin	3E-02	mg/kg	1.1E-06	mg/kg-day	1.6E+01	(mg/kg-day)-1	2.E-05
				Methyl mercury	3E-01	mg/kg	1.4E-05	mg/kg-day	--	--	ND
			Exp. Route Total								2.E-03
		Exposure Point Total									2.E-03
	Exposure Medium Total										2.E-03
Medium Total											
Crab				TCDD TEQ	2E-04	mg/kg	7.1E-09	mg/kg-day	1.5E+05	(mg/kg-day)-1	1.E-03
					4E-04	mg/kg	1.4E-08	mg/kg-day	1.5E+05	(mg/kg-day)-1	2.E-03
				Total PCBs	5E+00	mg/kg	1.8E-04	mg/kg-day	2.0E+00	(mg/kg-day)-1	4.E-04
				4,4'-DDD	1E-01	mg/kg	4.9E-06	mg/kg-day	2.4E-01	(mg/kg-day)-1	1.E-06
				4,4'-DDE	3E-01	mg/kg	1.1E-05	mg/kg-day	3.4E-01	(mg/kg-day)-1	4.E-06
				4,4'-DDT	2E-01	mg/kg	8.3E-06	mg/kg-day	3.4E-01	(mg/kg-day)-1	3.E-06
				Total Chlordane	4E-02	mg/kg	1.3E-06	mg/kg-day	3.5E-01	(mg/kg-day)-1	5.E-07
				Dieldrin	2E-02	mg/kg	6.4E-07	mg/kg-day	1.6E+01	(mg/kg-day)-1	1.E-05
				Methyl mercury	1E-01	mg/kg	3.4E-06	mg/kg-day	--	--	ND
			Exp. Route Total								4.E-03
		Exposure Point Total									4.E-03
	Exposure Medium Total										4.E-03
Medium Total											

ND - not determined because a toxicity value is not available for this exposure route.
mg/kg - milligram per kilogram

Attachment 4

TABLE 4-15 (RAGS PT D TABLE 7a.1 RME)
CALCULATION OF CHEMICAL CANCER RISKS
REASONABLE MAXIMUM EXPOSURE
Lower Passaic River

Scenario Timeframe: Current/Future
Receptor Population: Angler (Child)
Receptor Age: 0 - 6 Years

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk
							Value	Units	Value	Units	
Fish			Ingestion	TCDD TEQ (D/F)	3E-04	mg/kg	1.2E-08	mg/kg-day	1.5E+05	(mg/kg-day)-1	2.E-03
				TCDD TEQ (PCBs)	8E-05	mg/kg	3.8E-09	mg/kg-day	1.5E+05	(mg/kg-day)-1	6.E-04
				Total PCBs	3E+00	mg/kg	1.6E-04	mg/kg-day	2.0E+00	(mg/kg-day)-1	3.E-04
				4,4'-DDD	2E-01	mg/kg	7.1E-06	mg/kg-day	2.4E-01	(mg/kg-day)-1	2.E-06
				4,4'-DDE	3E-01	mg/kg	1.4E-05	mg/kg-day	3.4E-01	(mg/kg-day)-1	5.E-06
				4,4'-DDT	8E-02	mg/kg	3.6E-06	mg/kg-day	3.4E-01	(mg/kg-day)-1	1.E-06
				Total Chlordane	2E+00	mg/kg	8.6E-05	mg/kg-day	3.5E-01	(mg/kg-day)-1	3.E-05
				Dieldrin	3E-02	mg/kg	1.3E-06	mg/kg-day	1.6E+01	(mg/kg-day)-1	2.E-05
				Methyl mercury	3E-01	mg/kg	1.7E-05	mg/kg-day	--	--	ND
			Exp. Route Total								3.E-03
		Exposure Point Total									3.E-03
	Exposure Medium Total										3.E-03
Medium Total											
Crab				TCDD TEQ (D/F)	2E-04	mg/kg	9.1E-09	mg/kg-day	1.5E+05	(mg/kg-day)-1	1.E-03
				TCDD TEQ (PCBs)	4E-04	mg/kg	1.8E-08	mg/kg-day	1.5E+05	(mg/kg-day)-1	3.E-03
				Total PCBs	5E+00	mg/kg	2.4E-04	mg/kg-day	2.0E+00	(mg/kg-day)-1	5.E-04
				4,4'-DDD	1E-01	mg/kg	6.3E-06	mg/kg-day	2.4E-01	(mg/kg-day)-1	2.E-06
				4,4'-DDE	3E-01	mg/kg	1.4E-05	mg/kg-day	3.4E-01	(mg/kg-day)-1	5.E-06
				4,4'-DDT	2E-01	mg/kg	1.1E-05	mg/kg-day	3.4E-01	(mg/kg-day)-1	4.E-06
				Total Chlordane	4E-02	mg/kg	1.7E-06	mg/kg-day	3.5E-01	(mg/kg-day)-1	6.E-07
				Dieldrin	2E-02	mg/kg	8.2E-07	mg/kg-day	1.6E+01	(mg/kg-day)-1	1.E-05
				Methyl mercury	1E-01	mg/kg	4.4E-06	mg/kg-day	--	--	ND
			Exp. Route Total								5.E-03
		Exposure Point Total									5.E-03
	Exposure Medium Total										5.E-03
Medium Total											

ND - not determined because a toxicity value is unavailable for this exposure route.
mg/kg - milligram per kilogram

TABLE 4-16 (RAGS PT D TABLE 7b.1 RME)
CALCULATION OF CHEMICAL NON-CANCER HAZARDS
REASONABLE MAXIMUM EXPOSURE
Lower Passaic River

Scenario Timeframe: Current/Future
Receptor Population: Angler (Adult)
Receptor Age: >18 Years

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units	
Fish			Ingestion	TCDD TEQ (D/F)	3E-04	mg/kg	8.93E-08	mg/kg-day	--	--	ND
				TCDD TEQ (PCBs)	8E-05	mg/kg	2.86E-08	mg/kg-day	--	--	ND
				Total PCBs	3E+00	mg/kg	1.22E-03	mg/kg-day	2.0E-05	mg/kg-day	61
				4,4'-DDD	2E-01	mg/kg	5.36E-05	mg/kg-day	--	--	ND
				4,4'-DDE	3E-01	mg/kg	1.08E-04	mg/kg-day	--	--	ND
				4,4'-DDT	8E-02	mg/kg	2.71E-05	mg/kg-day	5.0E-04	mg/kg-day	0.05
				Total Chlordane	2E+00	mg/kg	6.43E-04	mg/kg-day	5.0E-04	mg/kg-day	1
				Dieldrin	3E-02	mg/kg	9.64E-06	mg/kg-day	5.0E-05	mg/kg-day	0.2
				Methyl mercury	3E-01	mg/kg	1.24E-04	mg/kg-day	1.0E-04	mg/kg-day	1
			Exp. Route Total								64
		Exposure Point Total									64
	Exposure Medium Total										64
Medium Total											
Crab				TCDD TEQ (D/F)	2E-04	mg/kg	6.6E-08	mg/kg-day	--	--	ND
				TCDD TEQ (PCBs)	4E-04	mg/kg	4.5E-08	mg/kg-day	--	--	ND
				Total PCBs	5E+00	mg/kg	1.7E-03	mg/kg-day	2.0E-05	mg/kg-day	85
				4,4'-DDD	1E-01	mg/kg	4.5E-05	mg/kg-day	--	--	ND
				4,4'-DDE	3E-01	mg/kg	1.0E-04	mg/kg-day	--	--	ND
				4,4'-DDT	2E-01	mg/kg	7.7E-05	mg/kg-day	5.0E-04	mg/kg-day	0.2
				Total Chlordane	4E-02	mg/kg	1.2E-05	mg/kg-day	5.0E-04	mg/kg-day	0.02
				Dieldrin	2E-02	mg/kg	5.9E-06	mg/kg-day	5.0E-05	mg/kg-day	0.1
				Methyl mercury	1E-01	mg/kg	3.2E-05	mg/kg-day	1.0E-04	mg/kg-day	0.3
			Exp. Route Total								86
		Exposure Point Total									86
	Exposure Medium Total										86
Medium Total											

ND - not determined because toxicity values are not available for this exposure route.
mg/kg - milligram per kilogram

TABLE 4-17 (RAGS PT D TABLE 7b.1 RME)
CALCULATION OF CHEMICAL NON-CANCER HAZARDS
REASONABLE MAXIMUM EXPOSURE
Lower Passaic River

Scenario Timeframe: Current/Future
Receptor Population: Angler (Adolescent)
Receptor Age: 10 - 18 Years

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units	
Fish			Ingestion	TCDD TEQ (D/F)	3E-04	mg/kg	7.65E-08	mg/kg-day	--	--	ND
				TCDD TEQ (PCBs)	8E-05	mg/kg	2.45E-08	mg/kg-day	--	--	ND
				Total PCBs	3E+00	mg/kg	1.05E-03	mg/kg-day	2.0E-05	mg/kg-day	52
				4,4'-DDD	2E-01	mg/kg	4.59E-05	mg/kg-day	--	--	ND
				4,4'-DDE	3E-01	mg/kg	9.27E-05	mg/kg-day	--	--	ND
				4,4'-DDT	8E-02	mg/kg	2.32E-05	mg/kg-day	5.0E-04	mg/kg-day	0.05
				Total Chlordane	2E+00	mg/kg	5.50E-04	mg/kg-day	5.0E-04	mg/kg-day	1
				Dieldrin	3E-02	mg/kg	8.26E-06	mg/kg-day	5.0E-05	mg/kg-day	0.2
				Methyl mercury	3E-01	mg/kg	1.06E-04	mg/kg-day	1.0E-04	mg/kg-day	1
			Exp. Route Total								55
		Exposure Point Total									55
	Exposure Medium Total										55
Medium Total											
Crab				TCDD TEQ (D/F)	2E-04	mg/kg	5.5E-08	mg/kg-day	--	--	ND
				TCDD TEQ (PCBs)	4E-04	mg/kg	1.1E-07	mg/kg-day	--	--	ND
				Total PCBs	5E+00	mg/kg	1.4E-03	mg/kg-day	2.0E-05	mg/kg-day	72
				4,4'-DDD	1E-01	mg/kg	3.8E-05	mg/kg-day	--	--	ND
				4,4'-DDE	3E-01	mg/kg	8.7E-05	mg/kg-day	--	--	ND
				4,4'-DDT	2E-01	mg/kg	6.5E-05	mg/kg-day	5.0E-04	mg/kg-day	0.1
				Total Chlordane	4E-02	mg/kg	1.0E-05	mg/kg-day	5.0E-04	mg/kg-day	0.02
				Dieldrin	2E-02	mg/kg	5.0E-06	mg/kg-day	5.0E-05	mg/kg-day	0.1
				Methyl mercury	1E-01	mg/kg	2.7E-05	mg/kg-day	1.0E-04	mg/kg-day	0.3
			Exp. Route Total								72
		Exposure Point Total									72
	Exposure Medium Total										72
Medium Total											

ND - not determined because a toxicity value is not available for this exposure route.
mg/kg - milligram per kilogram

TABLE 4-18 (RAGS PT D TABLE 7.b.1 RME)
CALCULATION OF CHEMICAL NON-CANCER HAZARDS
REASONABLE MAXIMUM EXPOSURE
Lower Passaic River

Scenario Timeframe: Current/Future
Receptor Population: Angler (Child)
Receptor Age: 0 - 6 Years

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units	
Fish			Ingestion	TCDD TEQ (D/F)	3E-04	mg/kg	1.39E-07	mg/kg-day	--	--	ND
				TCDD TEQ (PCBs)	8E-05	mg/kg	4.44E-08	mg/kg-day	--	--	ND
				Total PCBs	3E+00	mg/kg	1.90E-03	mg/kg-day	2.0E-05	mg/kg-day	95
				4,4'-DDD	2E-01	mg/kg	8.33E-05	mg/kg-day	--	--	ND
				4,4'-DDE	3E-01	mg/kg	1.68E-04	mg/kg-day	--	--	ND
				4,4'-DDT	8E-02	mg/kg	4.22E-05	mg/kg-day	5.0E-04	mg/kg-day	0.1
				Total Chlordane	2E+00	mg/kg	1.00E-03	mg/kg-day	5.0E-04	mg/kg-day	2
				Dieldrin	3E-02	mg/kg	1.50E-05	mg/kg-day	5.0E-05	mg/kg-day	0.3
				Methyl mercury	3E-01	mg/kg	1.93E-04	mg/kg-day	1.0E-04	mg/kg-day	2
			Exp. Route Total								99
		Exposure Point Total									99
	Exposure Medium Total										99
Medium Total											
Crab				TCDD TEQ (D/F)	2E-04	mg/kg	1.1E-07	mg/kg-day	--	--	ND
				TCDD TEQ (PCBs)	4E-04	mg/kg	2.1E-07	mg/kg-day	--	--	ND
				Total PCBs	5E+00	mg/kg	2.8E-03	mg/kg-day	2.0E-05	mg/kg-day	139
				4,4'-DDD	1E-01	mg/kg	7.4E-05	mg/kg-day	--	--	ND
				4,4'-DDE	3E-01	mg/kg	1.7E-04	mg/kg-day	--	--	ND
				4,4'-DDT	2E-01	mg/kg	1.3E-04	mg/kg-day	5.0E-04	mg/kg-day	0.3
				Total Chlordane	4E-02	mg/kg	2.0E-05	mg/kg-day	5.0E-04	mg/kg-day	0.04
				Dieldrin	2E-02	mg/kg	9.6E-06	mg/kg-day	5.0E-05	mg/kg-day	0.2
				Methyl mercury	1E-01	mg/kg	5.2E-05	mg/kg-day	1.0E-04	mg/kg-day	0.5
			Exp. Route Total								140
		Exposure Point Total									140
	Exposure Medium Total										140
Medium Total											

ND - not determined because a toxicity value is unavailable for this exposure route.
mg/kg - milligram per kilogram

TABLE 4-19 (RAGS PT D TABLE 7a.1 CT)
CALCULATION OF CHEMICAL CANCER RISKS
CENTRAL TENDENCY
Lower Passaic River

Scenario Timeframe: Current/Future
Receptor Population: Angler (Adult)
Receptor Age: >18 Years

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk
							Value	Units	Value	Units	
Fish			Ingestion	TCDD TEQ (D/F)	3E-04	mg/kg	1.9E-09	mg/kg-day	1.5E+05	(mg/kg-day)-1	3.E-04
				TCDD TEQ (PCBs)	8E-05	mg/kg	6.0E-10	mg/kg-day	1.5E+05	(mg/kg-day)-1	9.E-05
				Total PCBs	3E+00	mg/kg	4.0E-05	mg/kg-day	1.0E+00	(mg/kg-day)-1	4.E-05
				4,4'-DDD	2E-01	mg/kg	1.5E-06	mg/kg-day	2.4E-01	(mg/kg-day)-1	4.E-07
				4,4'-DDE	3E-01	mg/kg	2.9E-06	mg/kg-day	3.4E-01	(mg/kg-day)-1	1.E-06
				4,4'-DDT	8E-02	mg/kg	7.8E-07	mg/kg-day	3.4E-01	(mg/kg-day)-1	3.E-07
				Total Chlordane	2E+00	mg/kg	1.8E-05	mg/kg-day	3.5E-01	(mg/kg-day)-1	6.E-06
				Dieldrin	3E-02	mg/kg	2.8E-07	mg/kg-day	1.6E+01	(mg/kg-day)-1	4.E-06
				Methyl mercury	3E-01	mg/kg	5.1E-06	mg/kg-day	--	--	ND
			Exp. Route Total								4.E-04
		Exposure Point Total									4.E-04
	Exposure Medium Total										4.E-04
Medium Total											
Crab				TCDD TEQ (D/F)	2E-04	mg/kg	5.9E-09	mg/kg-day	1.5E+05	(mg/kg-day)-1	9.E-04
				TCDD TEQ (PCBs)	4E-04	mg/kg	1.2E-08	mg/kg-day	1.5E+05	(mg/kg-day)-1	2.E-03
				Total PCBs	5E+00	mg/kg	1.5E-04	mg/kg-day	1.0E+00	(mg/kg-day)-1	2.E-04
				4,4'-DDD	1E-01	mg/kg	4.1E-06	mg/kg-day	2.4E-01	(mg/kg-day)-1	1.E-06
				4,4'-DDE	3E-01	mg/kg	9.3E-06	mg/kg-day	3.4E-01	(mg/kg-day)-1	3.E-06
				4,4'-DDT	2E-01	mg/kg	6.9E-06	mg/kg-day	3.4E-01	(mg/kg-day)-1	2.E-06
				Total Chlordane	4E-02	mg/kg	1.1E-06	mg/kg-day	3.5E-01	(mg/kg-day)-1	4.E-07
				Dieldrin	2E-02	mg/kg	5.3E-07	mg/kg-day	1.6E+01	(mg/kg-day)-1	8.E-06
				Methyl mercury	1E-01	mg/kg	2.9E-06	mg/kg-day	--	--	ND
			Exp. Route Total								3.E-03
		Exposure Point Total									3.E-03
	Exposure Medium Total										3.E-03
Medium Total											

ND - not determined because a toxicity value is not available for this exposure route.
mg/kg - milligram per kilogram

TABLE 4-20 (RAGS PT D TABLE 7a.1 CT)
CALCULATION OF CHEMICAL CANCER RISKS
CENTRAL TENDENCY
Lower Passaic River

Scenario Timeframe: Current/Future
Receptor Population: Angler (Adolescent)
Receptor Age: 10 - 18 Years

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk
							Value	Units	Value	Units	
Fish			Ingestion	TCDD TEQ (D/F)	3E-04	mg/kg	1.1E-09	mg/kg-day	1.5E+05	(mg/kg-day)-1	2.E-04
				TCDD TEQ (PCBs)	8E-05	mg/kg	3.4E-10	mg/kg-day	1.5E+05	(mg/kg-day)-1	5.E-05
				Total PCBs	3E+00	mg/kg	2.3E-05	mg/kg-day	1.0E+00	(mg/kg-day)-1	2.E-05
				4,4'-DDD	2E-01	mg/kg	8.8E-07	mg/kg-day	2.4E-01	(mg/kg-day)-1	2.E-07
				4,4'-DDE	3E-01	mg/kg	1.7E-06	mg/kg-day	3.4E-01	(mg/kg-day)-1	6.E-07
				4,4'-DDT	8E-02	mg/kg	4.5E-07	mg/kg-day	3.4E-01	(mg/kg-day)-1	2.E-07
				Total Chlordane	2E+00	mg/kg	1.0E-05	mg/kg-day	3.5E-01	(mg/kg-day)-1	4.E-06
				Dieldrin	3E-02	mg/kg	1.6E-07	mg/kg-day	1.6E+01	(mg/kg-day)-1	3.E-06
				Methyl mercury	3E-01	mg/kg	2.9E-06	mg/kg-day	--	(mg/kg-day)-1	ND
			Exp. Route Total								2.E-04
		Exposure Point Total									2.E-04
	Exposure Medium Total										2.E-04
Medium Total											
Crab				TCDD TEQ (D/F)	2E-04	mg/kg	3.5E-09	mg/kg-day	1.5E+05	(mg/kg-day)-1	5.E-04
				TCDD TEQ (PCBs)	4E-04	mg/kg	6.9E-09	mg/kg-day	1.5E+05	(mg/kg-day)-1	1.E-03
				Total PCBs	5E+00	mg/kg	9.0E-05	mg/kg-day	1.0E+00	(mg/kg-day)-1	9.E-05
				4,4'-DDD	1E-01	mg/kg	2.4E-06	mg/kg-day	2.4E-01	(mg/kg-day)-1	6.E-07
				4,4'-DDE	3E-01	mg/kg	5.5E-06	mg/kg-day	3.4E-01	(mg/kg-day)-1	2.E-06
				4,4'-DDT	2E-01	mg/kg	4.1E-06	mg/kg-day	3.4E-01	(mg/kg-day)-1	1.E-06
				Total Chlordane	4E-02	mg/kg	6.4E-07	mg/kg-day	3.5E-01	(mg/kg-day)-1	2.E-07
				Dieldrin	2E-02	mg/kg	3.1E-07	mg/kg-day	1.6E+01	(mg/kg-day)-1	5.E-06
				Methyl mercury	1E-01	mg/kg	1.7E-06	mg/kg-day	--	(mg/kg-day)-1	ND
			Exp. Route Total								2.E-03
		Exposure Point Total									2.E-03
	Exposure Medium Total										2.E-03
Medium Total											

ND - not determined because a toxicity value is not available for this exposure route.
mg/kg - milligram per kilogram

TABLE 4-21 (RAGS PT D TABLE 7a.1 CT)
CALCULATION OF CHEMICAL CANCER RISKS
CENTRAL TENDENCY
Lower Passaic River

Scenario Timeframe: Current/Future
Receptor Population: Angler (Child)
Receptor Age: 0 - 6 Years

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk
							Value	Units	Value	Units	
Fish			Ingestion	TCDD TEQ (D/F)	3E-04	mg/kg	9.7E-10	mg/kg-day	1.5E+05	(mg/kg-day)-1	1.E-04
				TCDD TEQ (PCBs)	8E-05	mg/kg	3.1E-10	mg/kg-day	1.5E+05	(mg/kg-day)-1	5.E-05
				Total PCBs	3E+00	mg/kg	2.1E-05	mg/kg-day	1.0E+00	(mg/kg-day)-1	2.E-05
				4,4'-DDD	2E-01	mg/kg	8.0E-07	mg/kg-day	2.4E-01	(mg/kg-day)-1	2.E-07
				4,4'-DDE	3E-01	mg/kg	1.5E-06	mg/kg-day	3.4E-01	(mg/kg-day)-1	5.E-07
				4,4'-DDT	8E-02	mg/kg	4.1E-07	mg/kg-day	3.4E-01	(mg/kg-day)-1	1.E-07
				Total Chlordane	2E+00	mg/kg	9.2E-06	mg/kg-day	3.5E-01	(mg/kg-day)-1	3.E-06
				Dieldrin	3E-02	mg/kg	1.4E-07	mg/kg-day	1.6E+01	(mg/kg-day)-1	2.E-06
				Methyl mercury	3E-01	mg/kg	2.6E-06	mg/kg-day	--	(mg/kg-day)-1	ND
			Exp. Route Total								2.E-04
		Exposure Point Total									2.E-04
	Exposure Medium Total										2.E-04
Medium Total											
Crab				TCDD TEQ (D/F)	2E-04	mg/kg	2.9E-09	mg/kg-day	1.5E+05	(mg/kg-day)-1	4.E-04
				TCDD TEQ (PCBs)	4E-04	mg/kg	5.7E-09	mg/kg-day	1.5E+05	(mg/kg-day)-1	9.E-04
				Total PCBs	5E+00	mg/kg	7.4E-05	mg/kg-day	1.0E+00	(mg/kg-day)-1	7.E-05
				4,4'-DDD	1E-01	mg/kg	2.0E-06	mg/kg-day	2.4E-01	(mg/kg-day)-1	5.E-07
				4,4'-DDE	3E-01	mg/kg	4.5E-06	mg/kg-day	3.4E-01	(mg/kg-day)-1	2.E-06
				4,4'-DDT	2E-01	mg/kg	3.4E-06	mg/kg-day	3.4E-01	(mg/kg-day)-1	1.E-06
				Total Chlordane	4E-02	mg/kg	5.3E-07	mg/kg-day	3.5E-01	(mg/kg-day)-1	2.E-07
				Dieldrin	2E-02	mg/kg	2.6E-07	mg/kg-day	1.6E+01	(mg/kg-day)-1	4.E-06
				Methyl mercury	1E-01	mg/kg	1.4E-06	mg/kg-day	--	(mg/kg-day)-1	ND
			Exp. Route Total								1.E-03
		Exposure Point Total									1.E-03
	Exposure Medium Total										1.E-03
Medium Total											

ND - not determined because a toxicity value is not available for this exposure route.
mg/kg - milligram per kilogram

TABLE 4-22 (RAGS PT D TABLE 7b.1 CT)
CALCULATION OF CHEMICAL NON-CANCER HAZARDS
CENTRAL TENDENCY
Lower Passaic River

Scenario Timeframe: Current/Future
Receptor Population: Angler (Adult)
Receptor Age: >18 Years

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units	
Fish			Ingestion	TCDD TEQ (D/F)	3E-04	mg/kg	1.46E-08	mg/kg-day	--	--	ND
				TCDD TEQ (PCBs)	8E-05	mg/kg	4.66E-09	mg/kg-day	--	--	ND
				Total PCBs	3E+00	mg/kg	3.13E-04	mg/kg-day	2.0E-05	mg/kg-day	16
				4,4'-DDD	2E-01	mg/kg	1.20E-05	mg/kg-day	--	--	ND
				4,4'-DDE	3E-01	mg/kg	2.25E-05	mg/kg-day	--	--	ND
				4,4'-DDT	8E-02	mg/kg	6.08E-06	mg/kg-day	5.0E-04	mg/kg-day	0.01
				Total Chlordane	2E+00	mg/kg	1.38E-04	mg/kg-day	5.0E-04	mg/kg-day	0.3
				Dieldrin	3E-02	mg/kg	2.16E-06	mg/kg-day	5.0E-05	mg/kg-day	0.04
				Methyl mercury	3E-01	mg/kg	3.97E-05	mg/kg-day	1.0E-04	mg/kg-day	0.4
			Exp. Route Total								16
		Exposure Point Total									16
	Exposure Medium Total										16
Medium Total											
Crab				TCDD TEQ (D/F)	2E-04	mg/kg	4.6E-08	mg/kg-day	--	--	ND
				TCDD TEQ (PCBs)	4E-04	mg/kg	9.1E-08	mg/kg-day	--	--	ND
				Total PCBs	5E+00	mg/kg	1.2E-03	mg/kg-day	2.0E-05	mg/kg-day	59
				4,4'-DDD	1E-01	mg/kg	3.2E-05	mg/kg-day	--	--	ND
				4,4'-DDE	3E-01	mg/kg	7.2E-05	mg/kg-day	--	--	ND
				4,4'-DDT	2E-01	mg/kg	5.4E-05	mg/kg-day	5.0E-04	mg/kg-day	0.1
				Total Chlordane	4E-02	mg/kg	8.5E-06	mg/kg-day	5.0E-04	mg/kg-day	0.02
				Dieldrin	2E-02	mg/kg	4.1E-06	mg/kg-day	5.0E-05	mg/kg-day	0.1
				Methyl mercury	1E-01	mg/kg	2.2E-05	mg/kg-day	1.0E-04	mg/kg-day	0.2
			Exp. Route Total								60
		Exposure Point Total									60
	Exposure Medium Total										60
Medium Total											

ND - not determined because a toxicity value is not available for this exposure route.
mg/kg - milligram per kilogram

TABLE 4-23 (RAGS PT D TABLE 7b.1 CT)
CALCULATION OF CHEMICAL NON-CANCER HAZARDS
CENTRAL TENDENCY
Lower Passaic River

Scenario Timeframe: Current/Future
Receptor Population: Angler (Adolescent)
Receptor Age: 10 - 18 Years

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units	
Fish			Ingestion	TCDD TEQ (D/F)	3E-04	mg/kg	1.2E-08	mg/kg-day	--	--	ND
				TCDD TEQ (PCBs)	8E-05	mg/kg	4.0E-09	mg/kg-day	--	--	ND
				Total PCBs	3E+00	mg/kg	2.7E-04	mg/kg-day	2.0E-05	mg/kg-day	13
				4,4'-DDD	2E-01	mg/kg	1.0E-05	mg/kg-day	--	--	ND
				4,4'-DDE	3E-01	mg/kg	1.9E-05	mg/kg-day	--	--	ND
				4,4'-DDT	8E-02	mg/kg	5.2E-06	mg/kg-day	5.0E-04	mg/kg-day	0.01
				Total Chlordane	2E+00	mg/kg	1.2E-04	mg/kg-day	5.0E-04	mg/kg-day	0.2
				Dieldrin	3E-02	mg/kg	1.8E-06	mg/kg-day	5.0E-05	mg/kg-day	0.04
				Methyl mercury	3E-01	mg/kg	3.4E-05	mg/kg-day	1.0E-04	mg/kg-day	0.3
			Exp. Route Total								14
		Exposure Point Total									14
	Exposure Medium Total										14
Medium Total											
Crab				TCDD TEQ (D/F)	2E-04	mg/kg	4.0E-08	mg/kg-day	--	--	ND
				TCDD TEQ (PCBs)	4E-04	mg/kg	8.1E-08	mg/kg-day	--	--	ND
				Total PCBs	5E+00	mg/kg	1.0E-03	mg/kg-day	2.0E-05	mg/kg-day	52
				4,4'-DDD	1E-01	mg/kg	2.8E-05	mg/kg-day	--	--	ND
				4,4'-DDE	3E-01	mg/kg	6.4E-05	mg/kg-day	--	--	ND
				4,4'-DDT	2E-01	mg/kg	4.7E-05	mg/kg-day	5.0E-04	mg/kg-day	0.1
				Total Chlordane	4E-02	mg/kg	7.5E-06	mg/kg-day	5.0E-04	mg/kg-day	0.01
				Dieldrin	2E-02	mg/kg	3.6E-06	mg/kg-day	5.0E-05	mg/kg-day	0.1
				Methyl mercury	1E-01	mg/kg	2.0E-05	mg/kg-day	1.0E-04	mg/kg-day	0.2
			Exp. Route Total								53
		Exposure Point Total									53
	Exposure Medium Total										53
Medium Total											

ND - not determined because a toxicity value is not available for this exposure route.
mg/kg - milligram per kilogram

TABLE 4-24 (RAGS PT D TABLE 7b.1 CT)
CALCULATION OF CHEMICAL NON-CANCER HAZARDS
CENTRAL TENDENCY
Lower Passaic River

Scenario Timeframe: Current/Future
Receptor Population: Angler (Child)
Receptor Age: 0 - 6 Years

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units	
Fish			Ingestion	TCDD TEQ (D/F)	3E-04	mg/kg	2.27E-08	mg/kg-day	--	--	ND
				TCDD TEQ (PCBs)	8E-05	mg/kg	7.25E-09	mg/kg-day	--	--	ND
				Total PCBs	3E+00	mg/kg	4.86E-04	mg/kg-day	2.0E-05	mg/kg-day	24
				4,4'-DDD	2E-01	mg/kg	1.87E-05	mg/kg-day	--	--	ND
				4,4'-DDE	3E-01	mg/kg	3.50E-05	mg/kg-day	--	--	ND
				4,4'-DDT	8E-02	mg/kg	9.46E-06	mg/kg-day	5.0E-04	mg/kg-day	0.02
				Total Chlordane	2E+00	mg/kg	2.14E-04	mg/kg-day	5.0E-04	mg/kg-day	0.4
				Dieldrin	3E-02	mg/kg	3.36E-06	mg/kg-day	5.0E-05	mg/kg-day	0.1
				Methyl mercury	3E-01	mg/kg	6.17E-05	mg/kg-day	1.0E-04	mg/kg-day	0.6
			Exp. Route Total								25
		Exposure Point Total									25
	Exposure Medium Total										25
Medium Total											
Crab				TCDD TEQ (D/F)	2E-04	mg/kg	6.7E-08	mg/kg-day	--	--	ND
				TCDD TEQ (PCBs)	4E-04	mg/kg	1.3E-07	mg/kg-day	--	--	ND
				Total PCBs	5E+00	mg/kg	1.7E-03	mg/kg-day	2.0E-05	mg/kg-day	87
				4,4'-DDD	1E-01	mg/kg	4.6E-05	mg/kg-day	--	--	ND
				4,4'-DDE	3E-01	mg/kg	1.1E-04	mg/kg-day	--	--	ND
				4,4'-DDT	2E-01	mg/kg	7.8E-05	mg/kg-day	5.0E-04	mg/kg-day	0.2
				Total Chlordane	4E-02	mg/kg	1.2E-05	mg/kg-day	5.0E-04	mg/kg-day	0.02
				Dieldrin	2E-02	mg/kg	6.0E-06	mg/kg-day	5.0E-05	mg/kg-day	0.1
				Methyl mercury	1E-01	mg/kg	3.2E-05	mg/kg-day	1.0E-04	mg/kg-day	0.3
			Exp. Route Total								87
		Exposure Point Total									87
	Exposure Medium Total										87
Medium Total											

ND - not determined because a toxicity value is not available for this exposure route.
mg/kg - milligram per kilogram

PCB ENHANCEMENT ASSESSMENT

R2-0009656

Attachment 4

Potential for Enhancement of Risk from Dioxin-Like PCBs in Fish

As described in USEPA's 1996 document "PCBs: Cancer Dose Response Assessment and Application to Environmental Mixtures" (USEPA, 1996) the potential exists that the relative concentrations of dioxin-like PCBs may be enhanced in environmental mixtures, particularly in fish due to bioaccumulation of more persistent congeners. In the risk assessment, where congener data are available it is possible to determine the fraction that each dioxin-like congener represents of the total PCB concentration and whether the dioxin-like PCB congeners (non-ortho substituted PCBs and mono-ortho substituted PCBs) (Van den Berg *et al.*, 2005) enhance the overall risk. In application, the analysis of potential PCB congeners requires special consideration regarding the dioxin-like and non-dioxin like congeners and their relative percentage in the total PCB concentration.

Risk Assessment.
To evaluate the percentage of dioxin-like congeners in the total PCB concentration PCB data from White perch and crab from the USEPA 1999 Late Summer/Early Fall Ecological Sampling Plan Program were reviewed to:

- Determine the likelihood of enhancement of the risk from dioxin-like congeners in the total PCB concentration and the potential overestimation of risks from dioxin-like and total PCBs are combined
- Understand the PCB composition of the samples, and from that estimate the proportion of the total PCB that may include dioxin-like PCBs in the risk assessment

Data Comparisons. The data used for these comparisons are a subset of the historical dataset that were collected by Chemical Land Holdings (CLH), Inc. in 1999/2000 in accordance with an USEPA-approved Ecological Sampling Plan (CLH, 1999). The CLH data were chosen since these data offer a more complete set of data from which to evaluate the potential PCB enhancement. The CLH sample analyses were conducted for Aroclors (Aroclor 1260, Aroclor 1254, Aroclor 1221, Aroclor 1232, Aroclor 1248, Aroclor 1016, and Aroclor 1242) and 33 PCB congeners, including the World Health Organization (WHO) list of 12 dioxin-like congeners (Van den Berg *et al.*, 2005). As explained in Section 3.0 of the risk assessment, Aroclor data were combined and used to represent the total PCB concentration in the risk assessment, whereas the 12 dioxin-like congeners were used to determine the concentration for the dioxin-like TCDD TEQ (PCBs).

Human Health Risk Assessment. The human heath risk estimated risks for adult anglers consuming fish and crab. Risks to young children and adolescent fish consumers were also evaluated but the results for the adult are only present for this analysis. The PCB-related risk was estimated based on concentrations of both the WHO list of 12 dioxin-like PCB congeners and, separately, based on the total PCB (as the sum of Aroclors) concentration. Theoretically, it is possible to have a total of 209 different PCB congeners (individual PCB congeners), but more than 95% of the PCB in Aroclor formulations and in environmental PCB contamination is typically comprised of a little more that 100 PCB congeners; close to 100 PCB congeners were never found in any commercial Aroclor formulations or are not detected in environmental samples at all or to any notable degree (need reference). As described in PCB cancer toxicity reassessment (USEPA, 1996), in the environment, PCBs occur as mixtures of congeners where their composition differs from commercial mixtures. The differences in environmental mixtures from commercial mixtures changes through partitioning, chemical transformation, and preferential bioaccumulation.

The Aroclor-based total PCB analysis is intended to capture all the PCB congeners in the sample based on the individual Aroclors and provides one method for determining potential risk from PCB exposure. The 12 dioxin-like WHO PCB congeners are a subset of congeners in the total PCB mixture and are of interest

and concern for assessing risk since the presence of a higher percentage of these congeners may significantly increase the risks when compared to total PCBs. These two methods provided individual estimates of PCB risk that were then combined for an overall measure of total PCB risk. The total PCB calculated risk including the sum of the Aroclors and the 12 WHO congeners did not account for the fact that the 12 WHO congeners are a subset of the Total PCB calculated by summing the Aroclors.

PCB Composition

To determine the degree to which the WHO dioxin-like congeners are present in the total PCB mixtures the following analysis was performed.

Background In general, most environmental PCB contamination typically consists of a little more than 100 PCB congeners. This includes the PCB congeners that comprise the various commercial Aroclor formulations, and a relatively small set of additional congeners that are formed through environmental abiotic and biotic processes (*e.g*., dechlorination of some congeners under anaerobic conditions).

A literature review found studies where some of the 12 WHO PCB congeners are present at relatively high proportions in some Aroclors and environmental PCB contamination (*e.g*., PCB105, PCB118, and PCB156), while other congeners are less abundant. Table 1 presents the concentrations of the 12 WHO PCB congeners in the nine different Aroclor formulations, as determined by high-resolution gas chromatography/high-resolution mass spectrometry (HRGC/HRMS) using EPA Method 1668a (Rushneck *et al.*, 2004). Method 1668a is currently the most accurate standard method for PCB congener analysis. Table 1 also includes data for three Aroclors from an earlier gas chromatography/electron capture detection (GC/ECD) based study conducted by Frame *et al.* (1996). The data for both analytical approaches and by both investigators are presented for Aroclor 1242, 1254, and 1260. This analysis indicates that there is very good agreement between these two studies, which were conducted using different techniques and almost 10 years apart. For instance, Rushneck *et al.* (2004) determined the sum of the 12 WHO dioxin-like PCB congeners comprise 13% of the PCB in Aroclor 1254 and 1.45% in Aroclor 1260, while Frame *et al.* (1996) determined the concentrations to comprise 12% and 1.53%, respectively. This excellent agreement lends credibility to and confidence in the data in Table 1.

Analysis of PCB Enhancement Based on White Perch and Crab Data. In the absence of data on all congeners in the white perch and crab ESP data, we evaluated the literature reported percentages of dioxin-like PCBs in the commercial Aroclor mixtures. Based on a literature review, it was found that the 12 WHO dioxin-like PCB congeners comprise from 0.02% to 13% of the total PCB in the individual unweathered commercial Aroclor formulations (Table 1). These dioxin-like congeners are least abundant in Aroclors 1221 (0.02%), 1016 (0.02%), 1268 (0.03%), and 1262 (0.46%). The dioxin-like congeners comprise between 1% and 2% of the total PCB in Aroclors 1232, 1242, and 1260, and are most abundant in Aroclors 1248 (4.9%) and 1254 (12%). As shown on Table 1, the 12 WHO dioxin-like congeners comprise between 1.5% and 13% of the total PCB in Aroclors 1248, 1254, and 1260, and a 1:2:1 mixture of Aroclors 1248:1254:1260 has a PCB composition that is comprised of about 8% of the 12 WHO dioxin-like PCB congeners. This 1:2:1 mixture of Aroclors 1248:1254:1260 appears to be the approximate PCB composition in the white perch and crab samples analyzed from the USEPA 1999 Late Summer/Early fall ESP Sampling Program, based on the percentage of the specific Aroclors with dioxin-like PCBs found from the data analyses of the fish samples.

Table 2 presents the total PCB (as Aroclor) and the sum of the dioxin-like (WHO) PCB congener data from the analysis of white perch samples from the USEPA 1999 Late Summer/Early fall ESP Sampling Program. Table 2 also includes the relationship between the total PCB (as Aroclor) concentration and the sum of the dioxin-like PCB congener concentrations for the white perch samples. The sum of the dioxin-like congener concentrations averaged 3.5% (range from 3.1% to 3.9%) of the total PCB concentration.

The PCB concentration and composition data were more variable for the crab samples than for white perch; the total PCB (as Aroclor) concentrations ranged from less than 1,000 to more than 10,000 ppb. The dioxin-like PCB congeners comprised an average of 9.8% of total PCB concentration in the data reported for the crab samples, and it ranged from 3.1 to 93%. However, most of the available crab data for the site indicated that the contribution of dioxin-like PCB congeners were within the 3% to 13% range. Aroclors 1248, 1254, and 1260 were, as with white perch, the widely detected Aroclors in the crab samples, and Aroclor 1254 was again consistently the most abundant Aroclor.

Potential Double-Counting of Dioxin-Like Congeners in Total PCB Risk.
To evaluate the potential for double-counting the PCB concentrations when the two risk determinations (*i.e*., total PCBs and dioxin-like PCBs individually) are combined we performed additional calculations. The calculation involved subtracting the concentrations of the 12 dioxin-like WHO PCB congeners from the initially determined total PCB concentration, and then using the "corrected" total PCB value for the total PCB-based risk determination. The calculation provides a mechanism by which the TCDD TEQ PCB risk would be based on the concentrations of the 12 dioxin-like congeners, and the total PCB risk would be based on the concentration of all other PCBs.

Table 3 provides example risk calculations for total PCB-adjusted concentrations following this method. In order to provide a risk range, the total PCB concentration was reduced by the lower and upper percentages approximated by Rushneck *et al*. (2004) for the contribution of the 12 dioxin-like PCB congeners (*i.e*., 1.5% and 13% for the three most abundant Aroclors: 1248, 1254, and 1260 in the samples), even though the approximate contribution is more likely closer to some average of the 1248, 1254, and 1260 composition of these congeners (*e.g*., 8%). The first set of risk calculations presented in Table 3 are those presented in the risk assessment for the adult angler ingesting fish and are provided for comparison purposes. The second set of risk calculations assumes that the total PCB concentration is reduced by 1.5% (*i.e*., the approximate contribution of the 12 dioxin-like PCB congeners to the total PCB) and the third set of calculations assumes that the total PCB concentration is reduced by 13%. The adjusted total PCB concentrations result in relative reductions of total risk by 0.2% and 1.5% for the second and third set of calculations, respectively. As shown on Table 3, the total cancer risk values for both sets of calculations using an adjusted total PCB concentration would still be reported as 7.0E-03 which exceeds the risk range of 10^{-4} to 10^{-6} identified in the National Contingency Plan (USEPA, 1990). Risks estimated for consumption of crab in the risk assessment are similar to those for consumption of fish; therefore, a separate evaluation to determine the potential for double-counting for crab ingestion was not performed. It is expected that the results observed for the example calculations for ingestion of fish with regard to the overall total cancer risk would be similar for ingestion of crab, and that the total risk would still exceed the NCP risk range of 10^{-4} to 10^{-6}.

Based on the evaluation of the site-specific white perch and crab data that determined the sums of the dioxin-like congener concentrations ranged from 3.1% to 3.9% for the fish and were mostly 3% to 13% for the crab, current total PCB risks estimated for ingestion of fish and crab in the risk assessment may be over estimated by 3 to 13%; however, the overall total cancer risk for ingestion of fish and crab is not expected to be significantly impacted by the total PCB risk over-estimation as demonstrated in the example calculations for fish ingestion provided in Table 3.

Conclusion.

Based on an application of data from the literature on the relative percentages of dioxin-like PCBs in specific Aroclor mixtures, combined with results from the 1999 ESP samples and risk calculations, additional calculations of the risks from ingestion of white perch and crabs were conducted. The evaluation included an assessment of the relative difference in calculated risks when dioxin-like congeners were evaluated and compared to non-dioxin like congeners. The results of this analysis found

that the resulting risks calculated using different methods remain above the risk range of 10^{-4} to 10^{-6}. The results of this PCB enhancement assessment indicate that double counting the dioxin-like PCB congeners does not notably impact the conclusions from this risk assessment.

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Table 1. WHO Congener Concentrations in Aroclor Formulations
(Rushneck *et al.* 2004, unless otherwise specified)

			Aroclor Formulation												
			1221	**1232**	**1016**	**1242**	**1242**	**1248**	**1254**	**1254**	**1260**	**1260**	**1262**	**1268**	**1248:1254:1260**
							(Frame et al.)			(Frame et al.)		(Frame et al.)			(1:2:1)
			Congener Concentration (ppm)												
PCB Congener	**IUPAC #**	**WHO TEF**													
3,3',4,4' - TeCB	77	0.0001	12.6	2,150	40.9	2,590	3,100	4,440	174	283	33.8	0.00	84.6	36.1	1,205
3,4,4',5 - TeCB	81	0.0001	0.51	111	1.96	156	108	221	16.4	0.00	3.33	0.00	4.63	1.35	64.3
2,3,3',4,4' - PeCB	105	0.0001	55.9	3,030	69.5	4,840	4,700	17,300	33,800	29,900	434	2,200	764	107	21,334
2,3,4,4',5 - PeCB	114	0.0005	4.04	248	6.03	443	401	1,320	1,930	1,830	17.0	0.00	46.0	5.86	1,299
2,3',4,4',5 - PeCB	118	0.0001	88.1	4,460	110	6,980	6,620	24,200	78,900	73,800	5,610	4,840	1,980	101	46,903
2',3,4,4',5 - PeCB	123	0.0001	3.33	164	4.72	277	267	806	1,150	1,500	5.02	0.00	27.8	3.24	778
3,3',4,4',5 - PeCB	126	0.1	0.28	21.0	0.56	33.6	0.00	98.0	37.3	17.0	2.13	0.00	2.28	1.76	43.7
2,3,3',4,4',5 - HxCB	156	0.0005	7.49	90.7	3.72	255	72.3	6.54	8,440	8,180	4,860	5,200	946	17.6	5,437
2,3,3',4,4',5' - HxCB	157	0.0005	1.46	22.0	1.03	70.9	0.00	171	1,870	1,910	252	190	63.8	7.92	1,041
2,3',4,4',5,5' - HxCB	167	0.00001	2.52	32.4	1.10	80.7	0.00	207	3,100	2,720	1,990	1,880	278	4.96	2,099
3,3',4,4',5,5' - HxCB	169	0.01	0.08	0.17	0.13	0.11	0.00	0.21	0.81	0.00	0.82	0.00	0.40	0.32	0.66
2,3,3',4,4',5,5' - HpCB	189	0.0001	1.17	4.36	0.12	4.53	0.00	11.0	246	106	1,290	1,020	451	4.40	448
		Sum (ppm)	177	10,334	240	15,731	15,268	48,781	129,665	120,246	14,498	15,330	4,649	292	80,652
		Sum (% of Total PCB)	0.02	1.03	0.02	1.57	1.53	4.88	13.0	12.0	1.45	1.53	0.46	0.03	8.07
		TOTAL TEQ	**0.051**	**3.27**	**0.085**	**5.23**		**15.5**	**21.3**		**3.54**		**1.09**	**0.21**	

Attachment 4

Table 2. Total Aroclor and Sum of WHO Congener Concentrations (ppb) in White Perch Tissue Samples (USEPA 1999 Late Summer/Early Fall ESP Sampling Program)

Sample ID	Total Aroclors	Sum of Dioxin-like (WHO) PCB Congeners	Dioxin-like (WHO) Congeners % of Total Aroclors
PR9904TIFW2	6,920	256	3.7
PR9911TIFW13	7,940	275	3.5
PR9911TIFW14	8,390	324	3.9
PR9911TIFW21	8,220	263	3.2
PR9911TIFW22	6,970	258	3.7
PR9911TIFW3	8,600	294	3.4
PR997/15TIFW6	8,200	281	3.4
PR997/15TIFW7	7,820	268	3.4
PR997/15TIFW9	13,990	427	3.1
		Average	3.5

Table 3: Example Calculations of Chemical Cancer Risk for Adjusted Total PCB Concentrations

Scenario Timeframe: Current/Future
Receptor Population: Angler (Adult)
Receptor Age: >18 Years

Medium	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations				
			Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk
					Value	Units	Value	Units	
Fish	Ingestion	TCDD TEQ (D/F)	2.50E-04	mg/kg	3.1E-08	mg/kg-day	1.5E+05	(mg/kg-day)-1	4.59E-03
		TCDD TEQ (PCBs)	8.00E-05	mg/kg	9.8E-09	mg/kg-day	1.5E+05	(mg/kg-day)-1	1.47E-03
		Total PCBs (unadjusted)	3.42E+00	mg/kg	4.2E-04	mg/kg-day	2.0E+00	(mg/kg-day)-1	8.38E-04
		4,4'-DDD	1.50E-01	mg/kg	1.8E-05	mg/kg-day	2.4E-01	(mg/kg-day)-1	4.41E-06
		4,4'-DDE	3.03E-01	mg/kg	3.7E-05	mg/kg-day	3.4E-01	(mg/kg-day)-1	1.26E-05
		4,4'-DDT	7.60E-02	mg/kg	9.3E-06	mg/kg-day	3.4E-01	(mg/kg-day)-1	3.16E-06
		Total Chlordane	1.80E+00	mg/kg	2.2E-04	mg/kg-day	3.5E-01	(mg/kg-day)-1	7.71E-05
		Dieldrin	2.70E-02	mg/kg	3.3E-06	mg/kg-day	1.6E+01	(mg/kg-day)-1	5.29E-05
		Methyl mercury	3.47E-01	mg/kg	4.2E-05	mg/kg-day	--	--	ND
	Exp. Route Total								7.05E-03

Medium	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations				
			Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk
					Value	Units	Value	Units	
Fish	Ingestion	TCDD TEQ (D/F)	2.50E-04	mg/kg	3.1E-08	mg/kg-day	1.5E+05	(mg/kg-day)-1	4.59E-03
		TCDD TEQ (PCBs)	8.00E-05	mg/kg	9.8E-09	mg/kg-day	1.5E+05	(mg/kg-day)-1	1.47E-03
		Total PCBs (adusted 1.5%)	3.37E+00	mg/kg	4.1E-04	mg/kg-day	2.0E+00	(mg/kg-day)-1	8.25E-04
		4,4'-DDD	1.50E-01	mg/kg	1.8E-05	mg/kg-day	2.4E-01	(mg/kg-day)-1	4.41E-06
		4,4'-DDE	3.03E-01	mg/kg	3.7E-05	mg/kg-day	3.4E-01	(mg/kg-day)-1	1.26E-05
		4,4'-DDT	7.60E-02	mg/kg	9.3E-06	mg/kg-day	3.4E-01	(mg/kg-day)-1	3.16E-06
		Total Chlordane	1.80E+00	mg/kg	2.2E-04	mg/kg-day	3.5E-01	(mg/kg-day)-1	7.71E-05
		Dieldrin	2.70E-02	mg/kg	3.3E-06	mg/kg-day	1.6E+01	(mg/kg-day)-1	5.29E-05
		Methyl mercury	3.47E-01	mg/kg	4.2E-05	mg/kg-day	--	--	ND
	Exp. Route Total								7.04E-03

Medium	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations				
			Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk
					Value	Units	Value	Units	
Fish	Ingestion	TCDD TEQ (D/F)	2.50E-04	mg/kg	3.1E-08	mg/kg-day	1.5E+05	(mg/kg-day)-1	4.59E-03
		TCDD TEQ (PCBs)	8.00E-05	mg/kg	9.8E-09	mg/kg-day	1.5E+05	(mg/kg-day)-1	1.47E-03
		Total PCBs (adusted 13%)	2.98E+00	mg/kg	3.6E-04	mg/kg-day	2.0E+00	(mg/kg-day)-1	7.29E-04
		4,4'-DDD	1.50E-01	mg/kg	1.8E-05	mg/kg-day	2.4E-01	(mg/kg-day)-1	4.41E-06
		4,4'-DDE	3.03E-01	mg/kg	3.7E-05	mg/kg-day	3.4E-01	(mg/kg-day)-1	1.26E-05
		4,4'-DDT	7.60E-02	mg/kg	9.3E-06	mg/kg-day	3.4E-01	(mg/kg-day)-1	3.16E-06
		Total Chlordane	1.80E+00	mg/kg	2.2E-04	mg/kg-day	3.5E-01	(mg/kg-day)-1	7.71E-05
		Dieldrin	2.70E-02	mg/kg	3.3E-06	mg/kg-day	1.6E+01	(mg/kg-day)-1	5.29E-05
		Methyl mercury	3.47E-01	mg/kg	4.2E-05	mg/kg-day	--	--	ND
	Exp. Route Total								6.94E-03

ND - not determined because toxicity values are not available for this exposure route.
mg/kg - milligram per kilogram
Intake/Exposure Concentration = 0.00012245 x EPC Value
Cancer Risk = Intake/Exposure Concentration x CSF/Unit Risk Value

ATTACHMENT 5
CRITICAL BODY RESIDUES
FOR INVERTEBRATES AND FISH

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Figure 5-1
Summary of Copper Concentrations in Freshwater and Saltwater Fish Tissue Associated with Toxicity

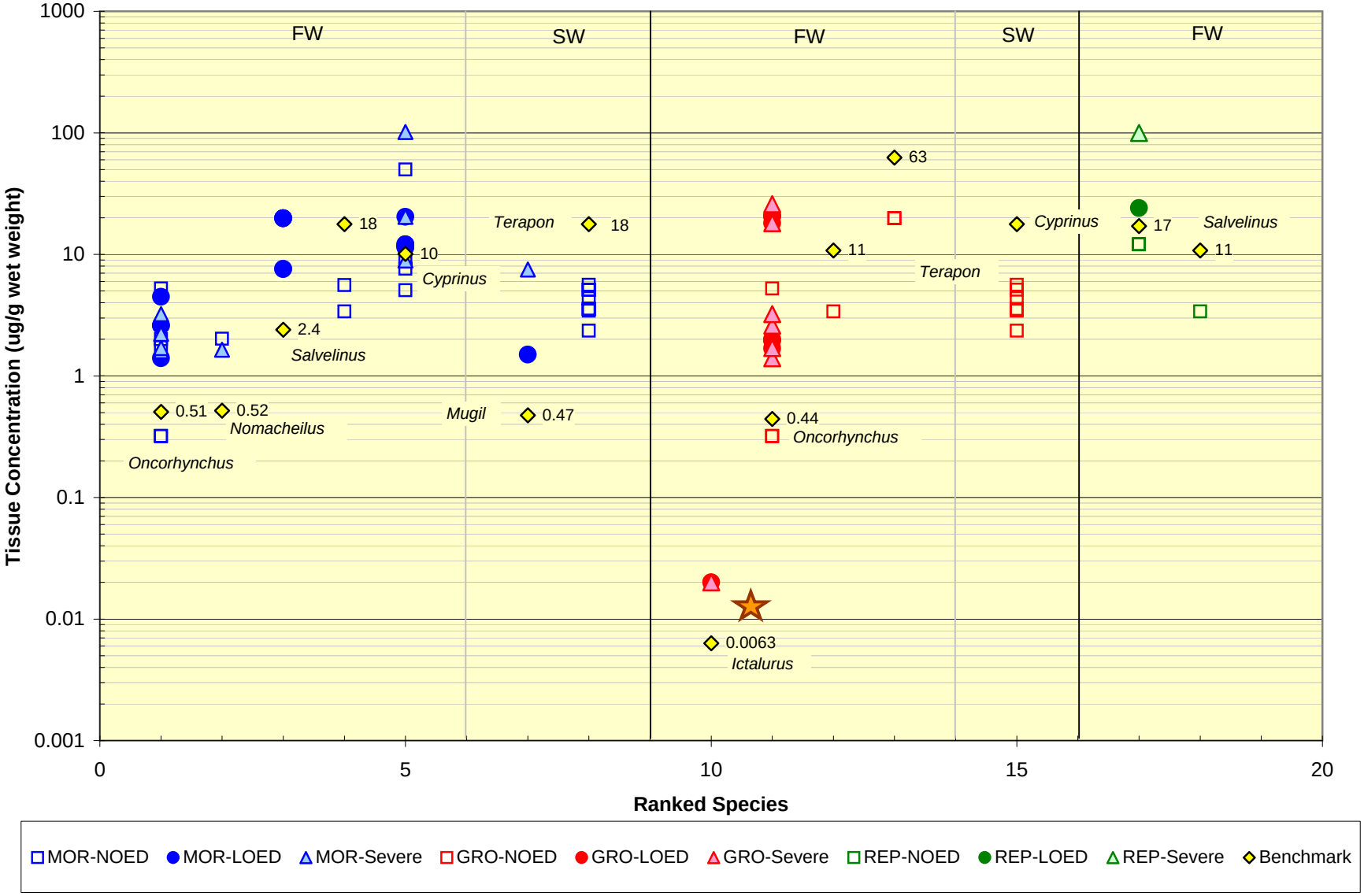

Figure 5-2
Summary of Lead Concentrations in Freshwater Fish Tissue Associated with Toxicity

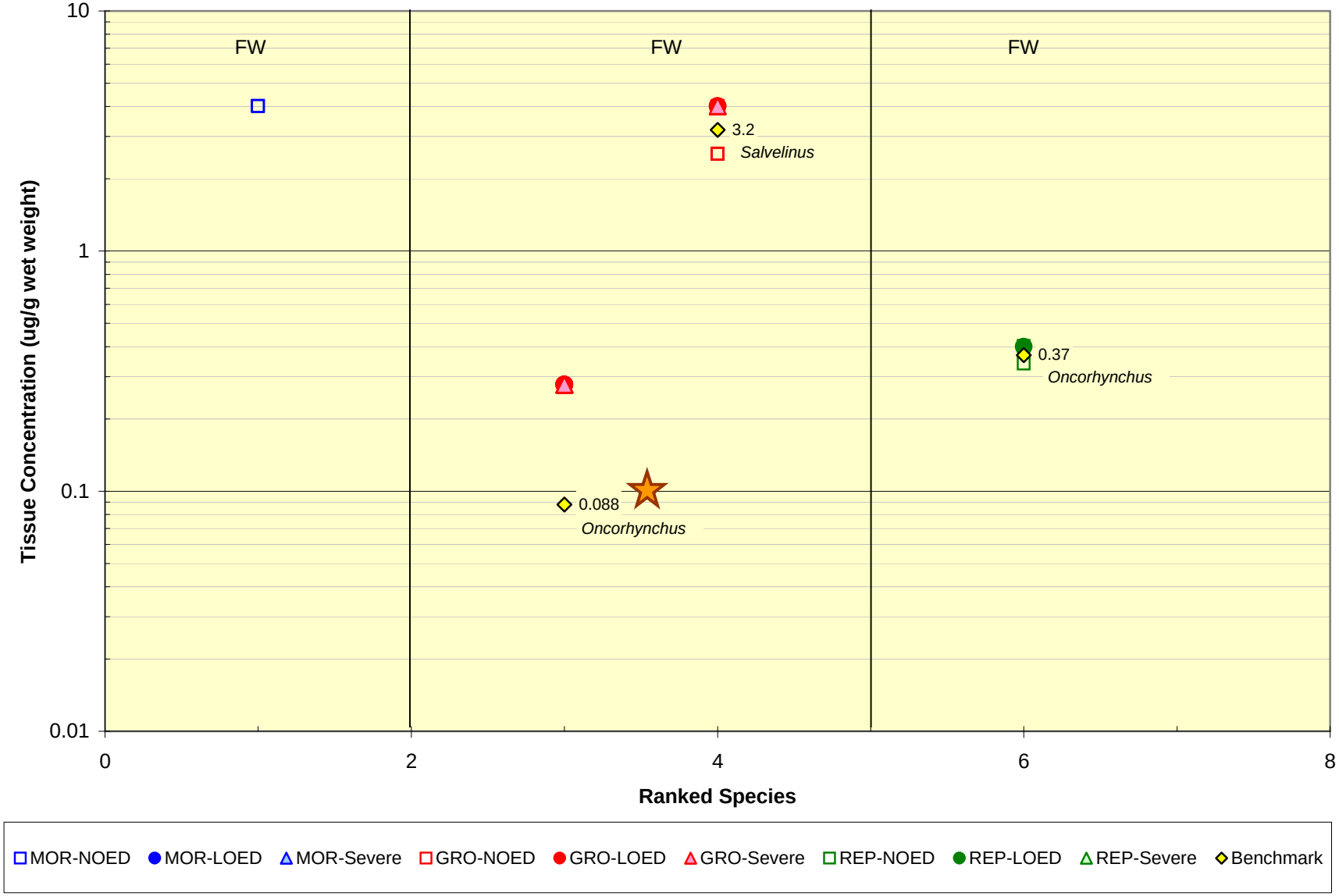

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Figure 5-3
Summary of Mercury Concentrations in Freshwater and Saltwater Fish Tissue Associated with Toxicity

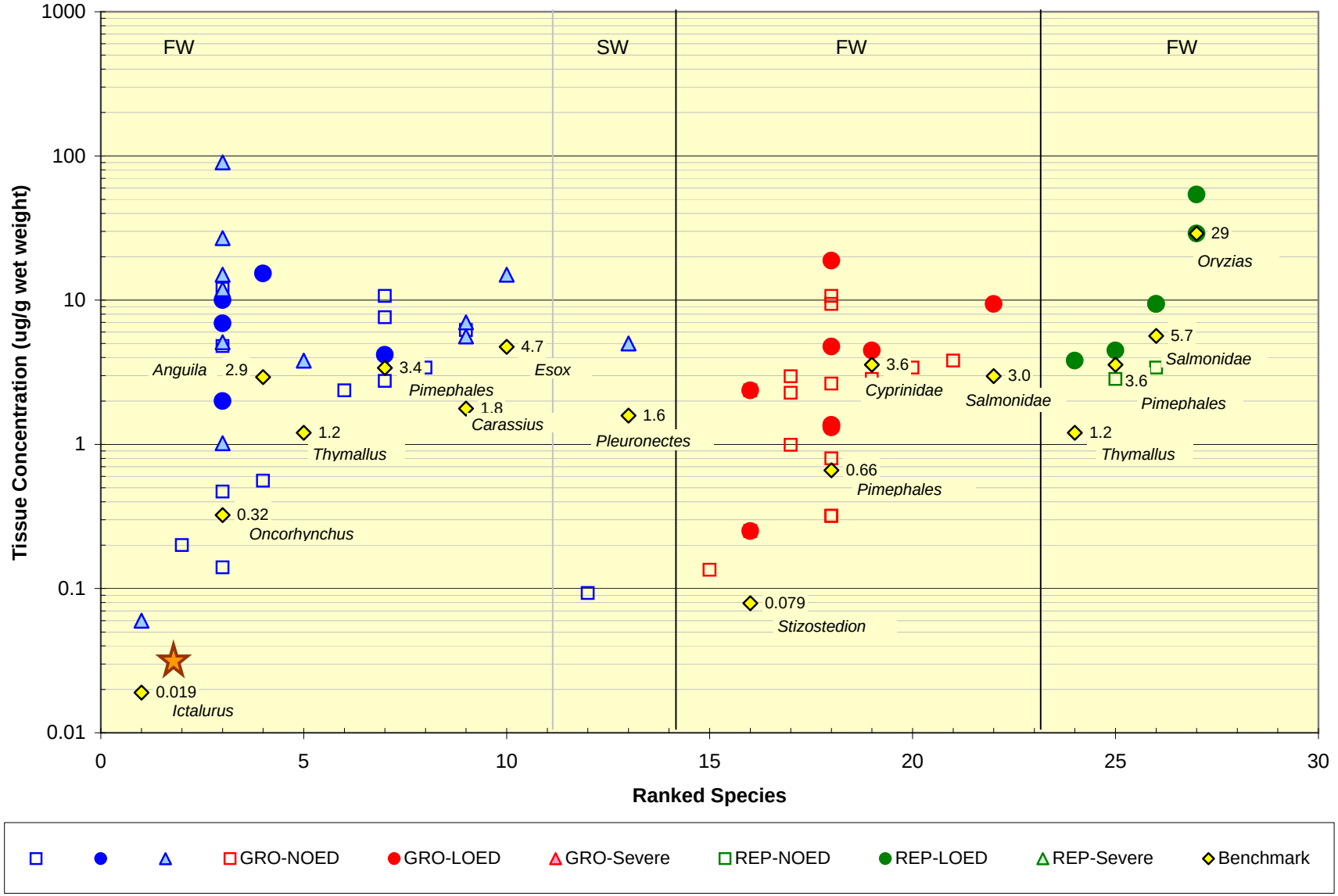

Figure 5-4
Summary of Methylmercury Concentrations in Freshwater and Saltwater Fish Tissue Associated with Toxicity

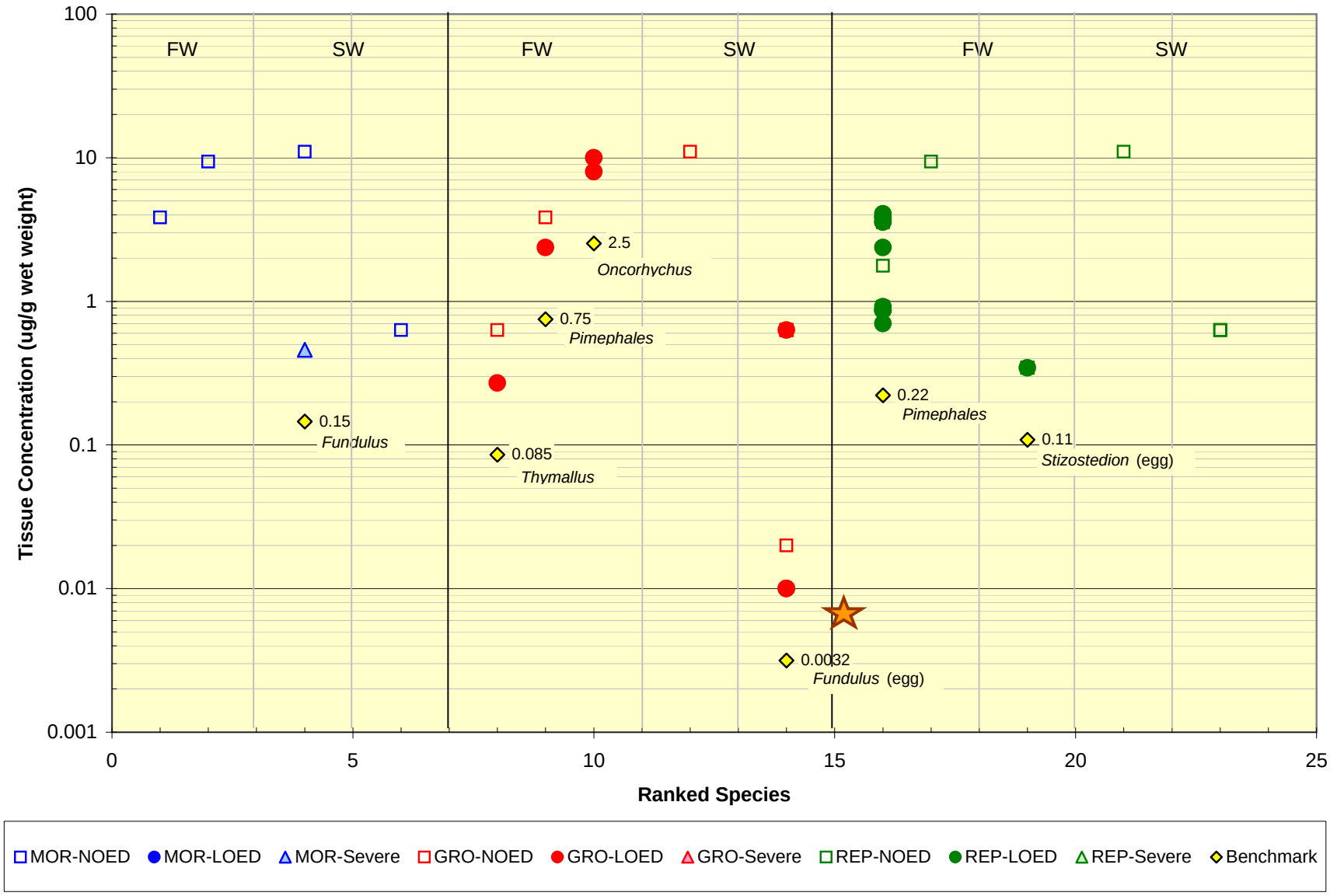

Figure 5-5
Summary of PAH Concentrations in Freshwater and Saltwater Fish Tissue Associated with Toxicity

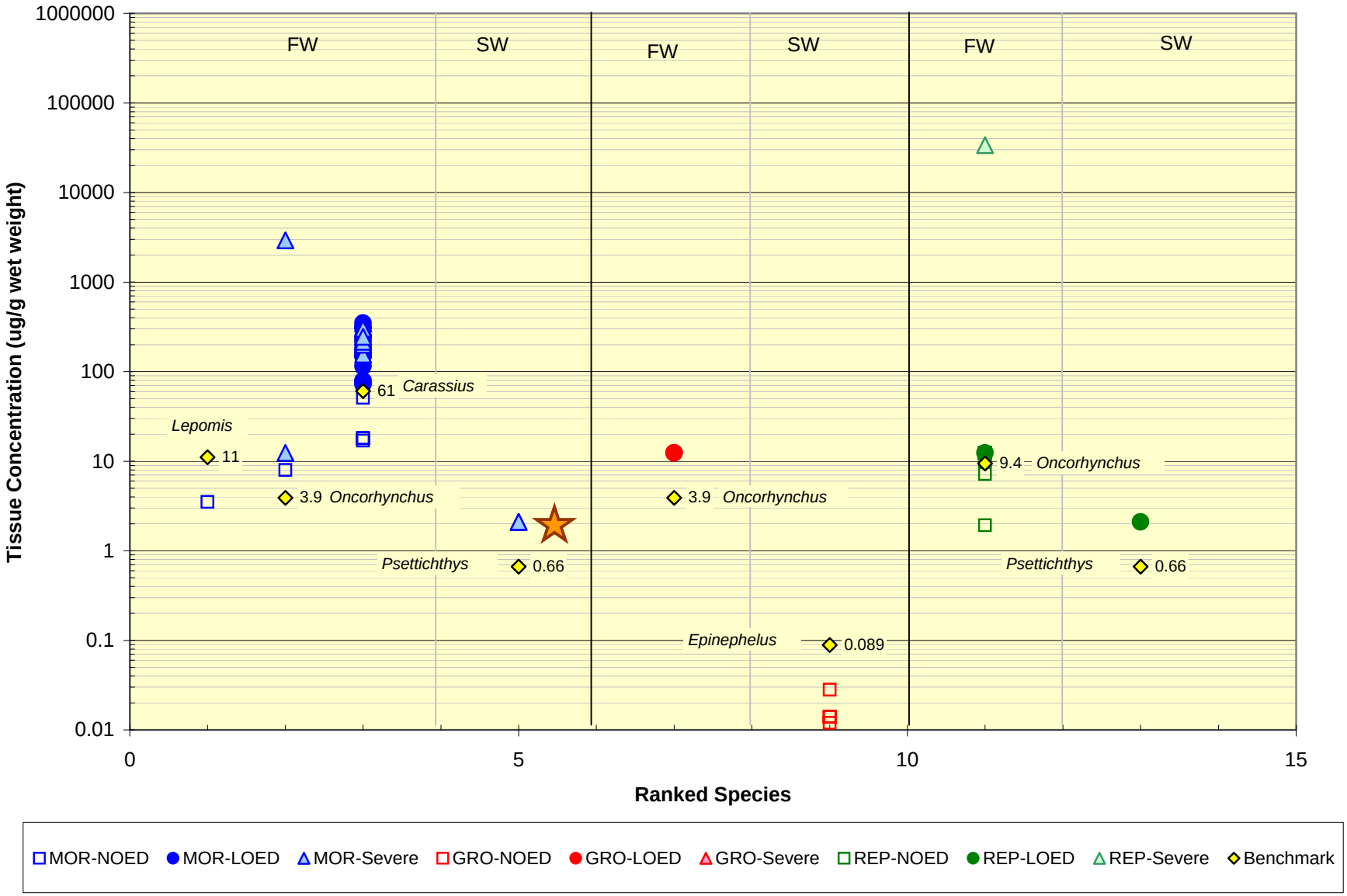

Figure 5-6
Summary of PCB Concentrations in Freshwater and Saltwater Fish Early Life Stage Tissue Associated with Toxicity

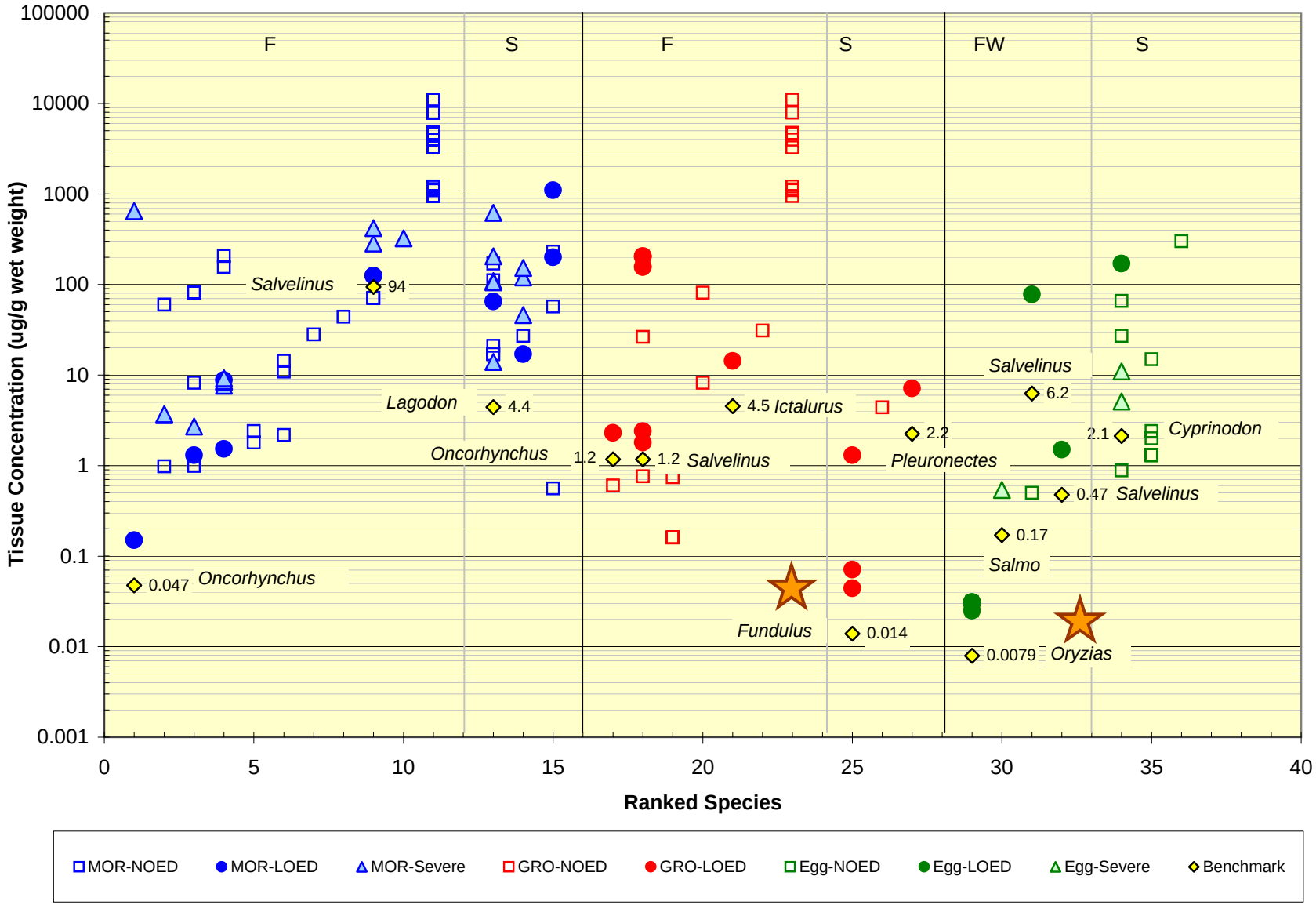

Figure 5-7
Summary of Dieldrin/Aldrin Concentrations in Freshwater and Saltwater Fish Tissue Associated with Toxicity

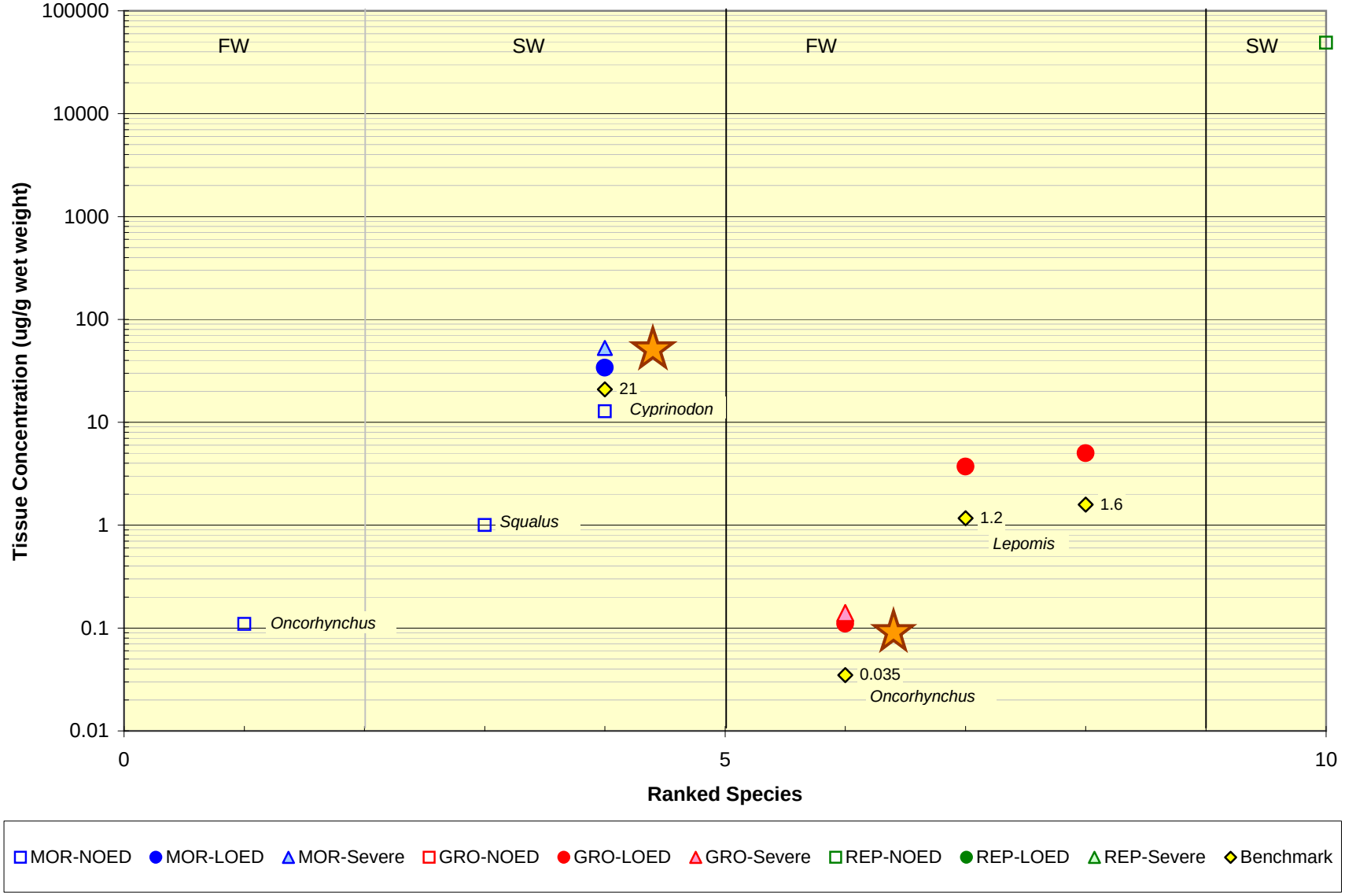

Figure 5-8
Summary of DDT, DDE, and DDD Concentrations in Freshwater and Saltwater Fish Tissue Associated with Toxicity

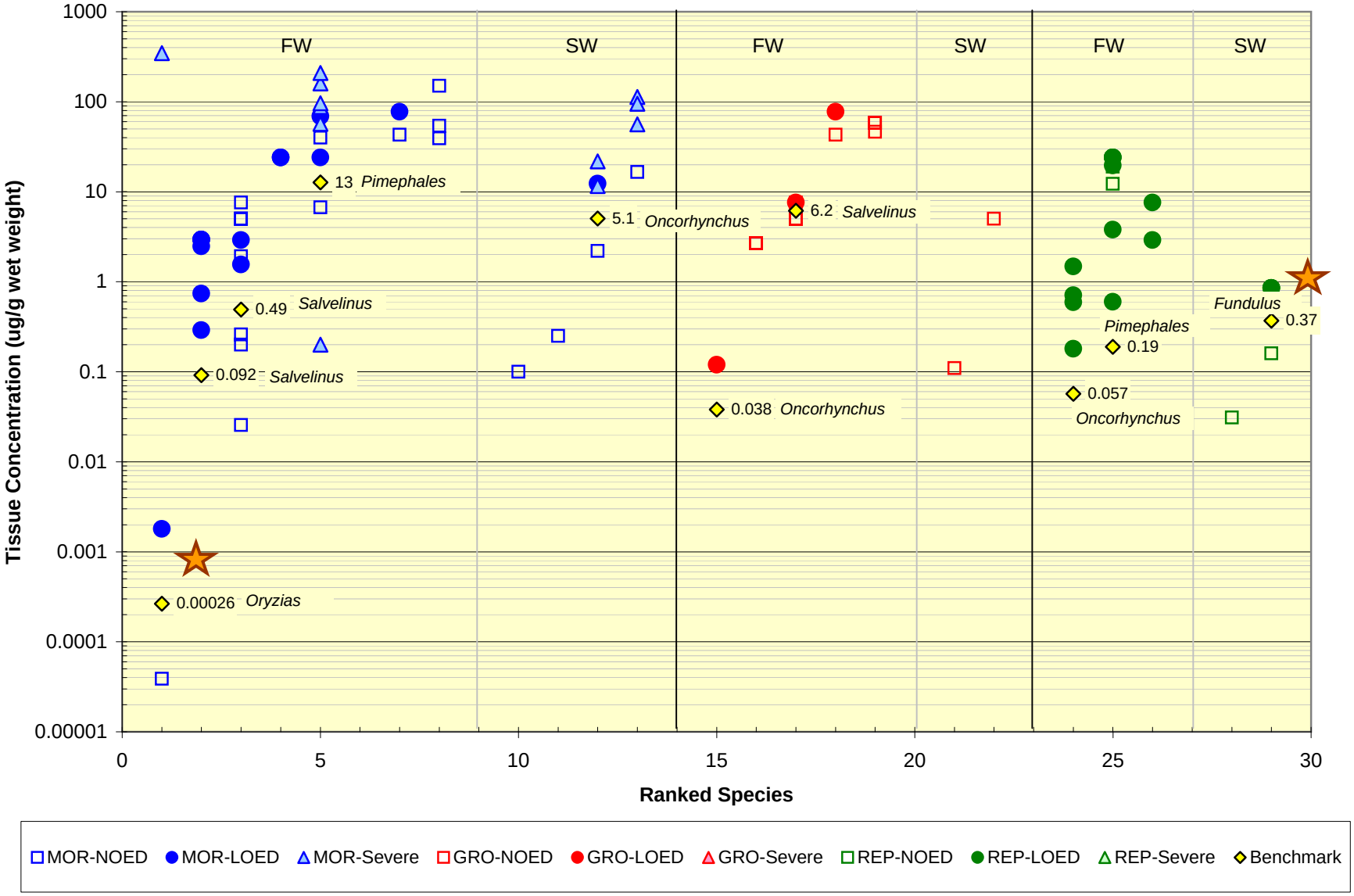

Figure 5-9
Summary of 2,3,7,8-TCDD Concentrations in Freshwater and Saltwater Fish Egg Tissue Associated with Toxicity

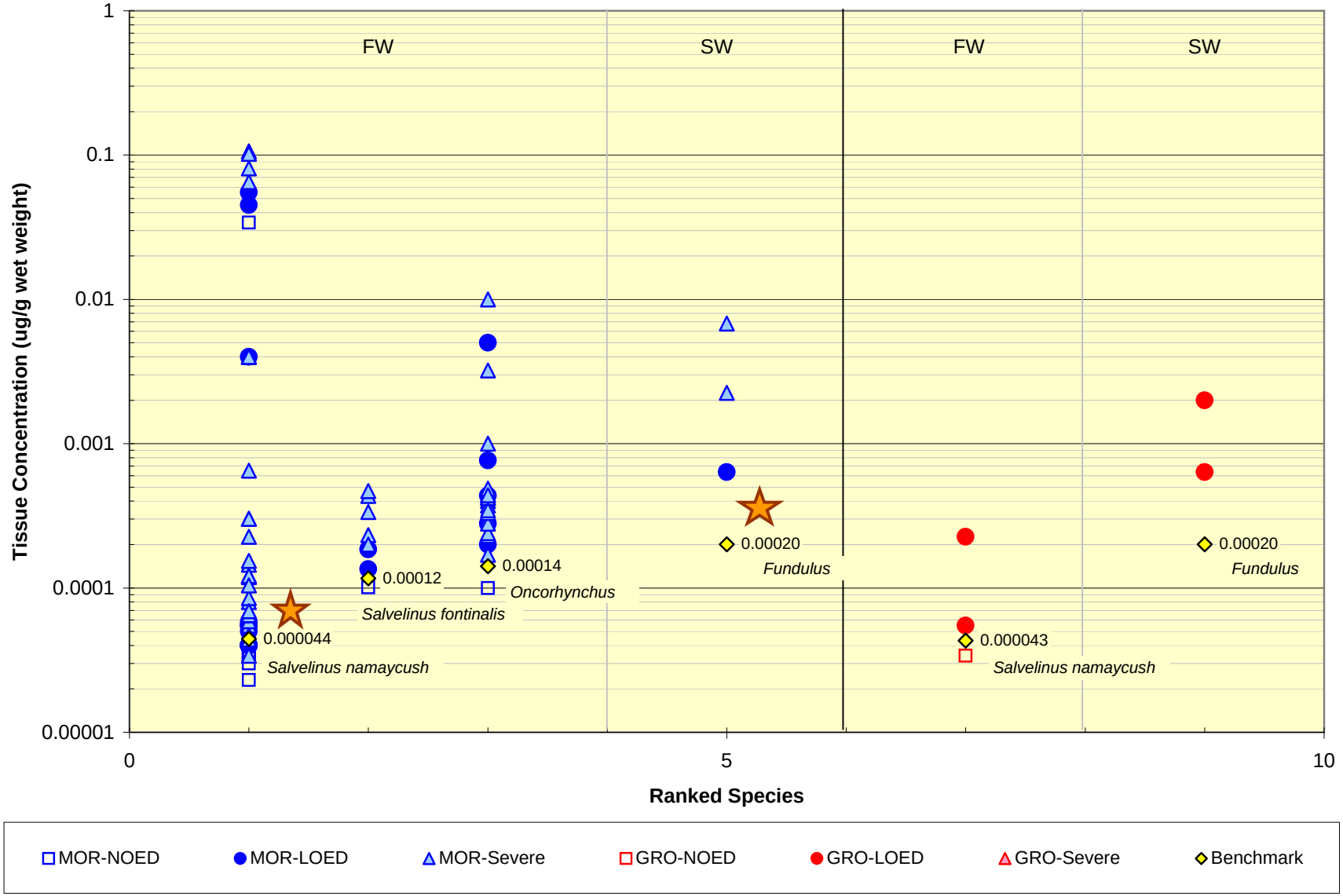

Figure 5-10
Summary of Copper Concentrations in Freshwater and Saltwater Invertebrate Tissue Associated with Toxicity

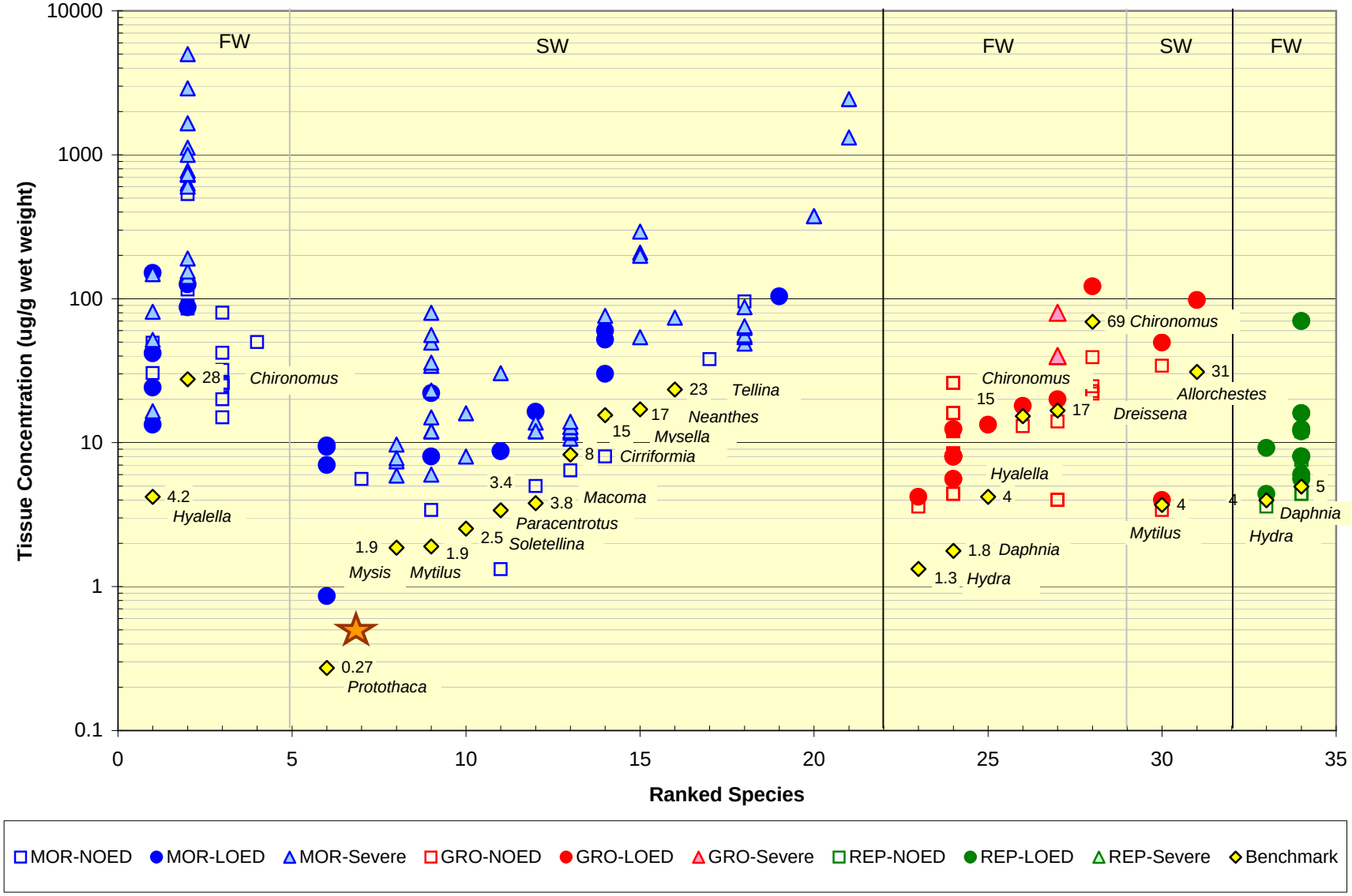

Figure 5-11
Summary of Lead Concentrations in Freshwater and Saltwater Invertebrate Tissue Associated with Toxicity

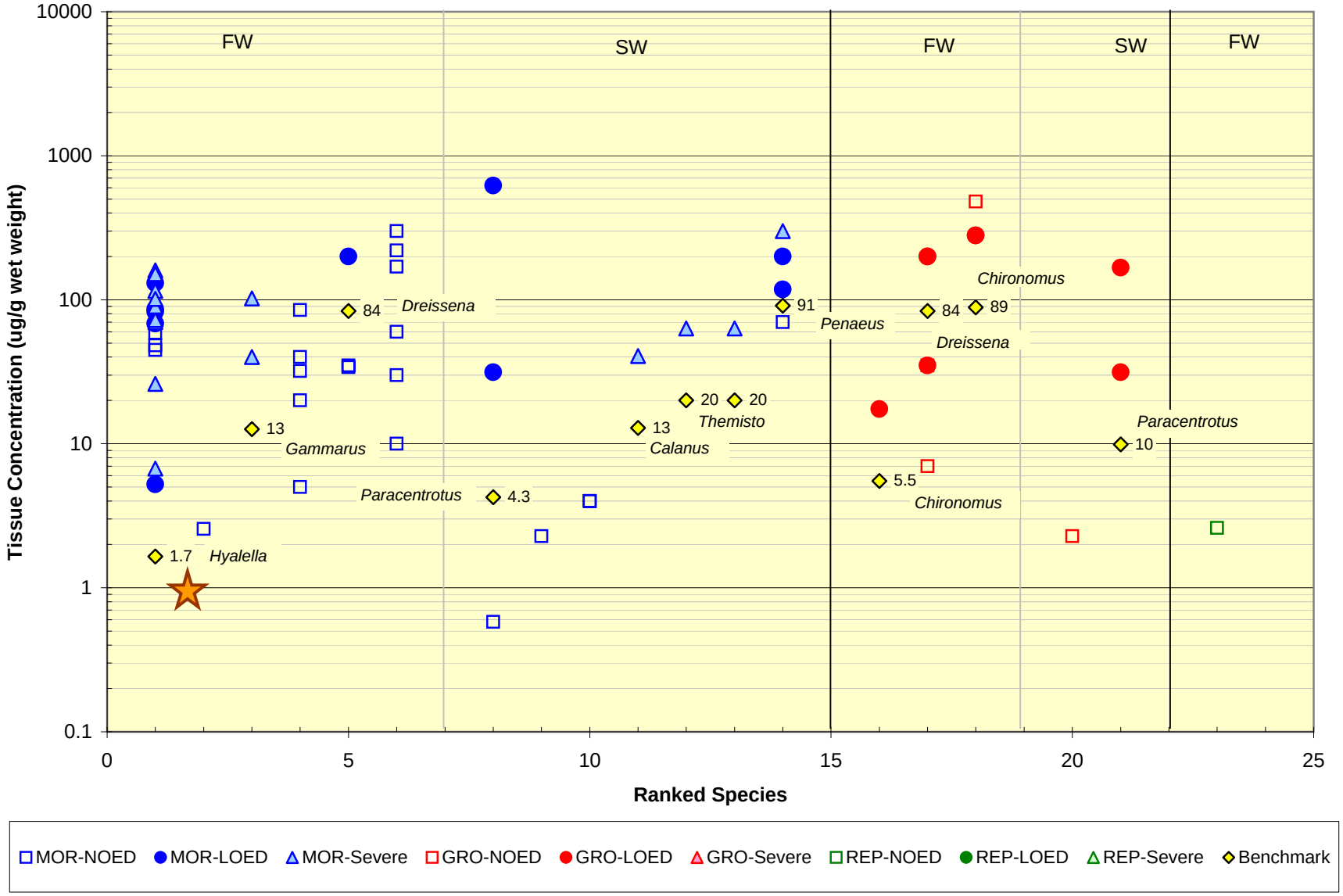

Figure 5-12
Summary of Mercury Concentrations in Freshwater and Saltwater Invertebrate Tissue Associated with Toxicity

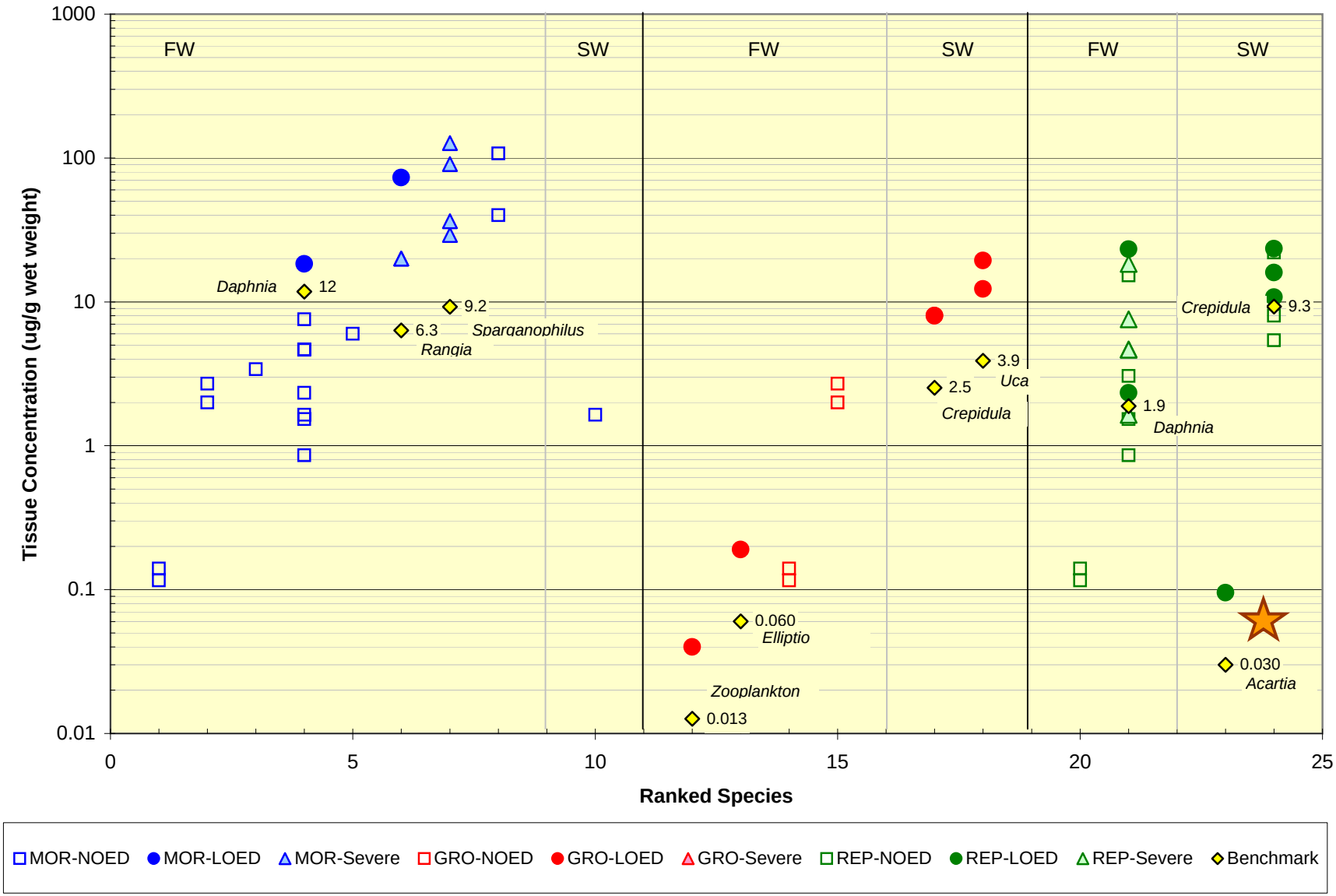

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Figure 5-13
Summary of PAH Concentrations in Freshwater and Saltwater Aquatic Invertebrate Tissue Associated with Toxicity

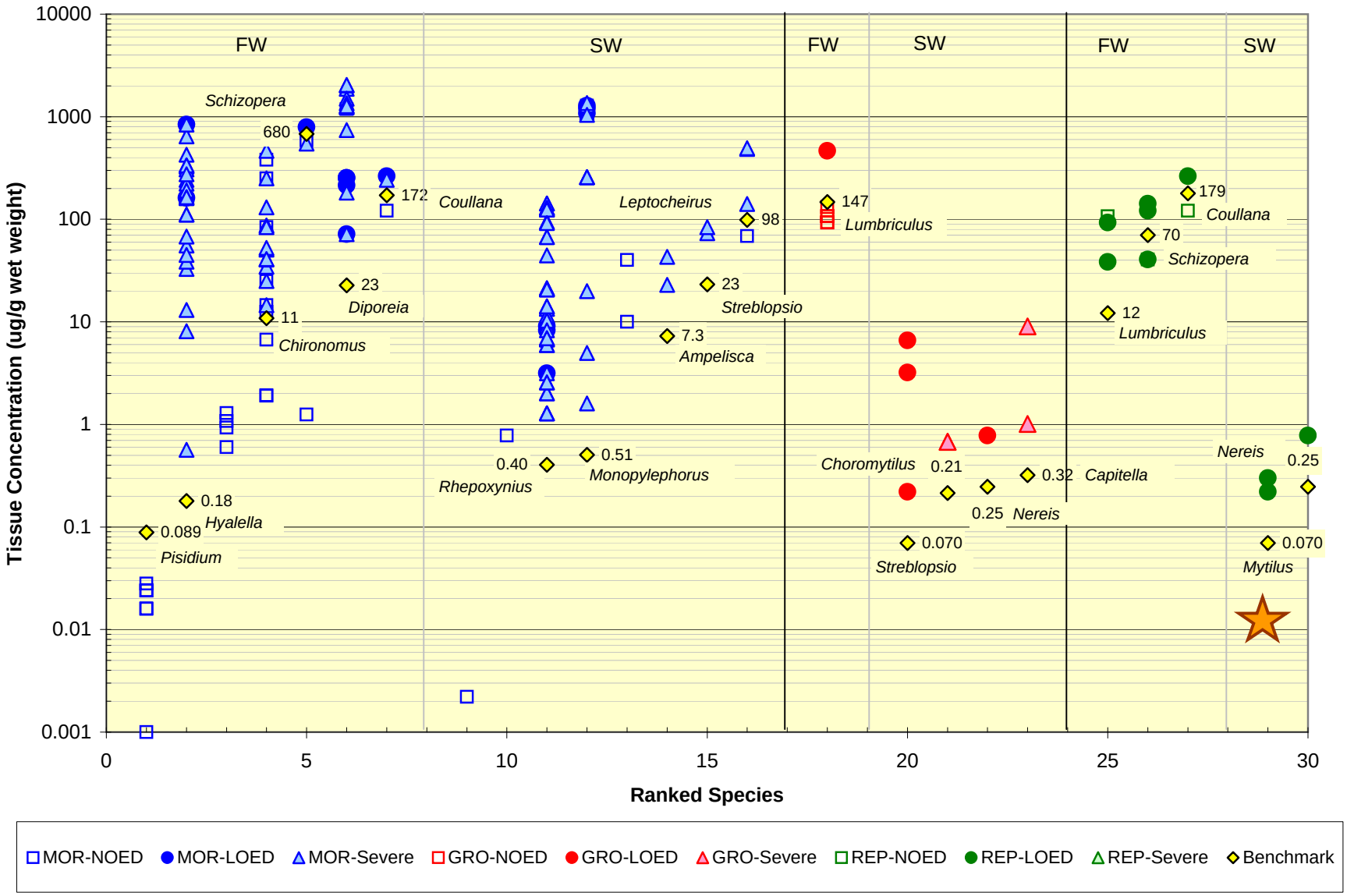

Figure 5-14
Summary of PCB Concentrations in Freshwater and Saltwater Aquatic Invertebrate Tissue Associated with Toxicity

Figure 5-15
Summary of Dieldrin/Aldrin Concentrations in Freshwater and Saltwater Invertebrate Tissue Associated with Toxicity

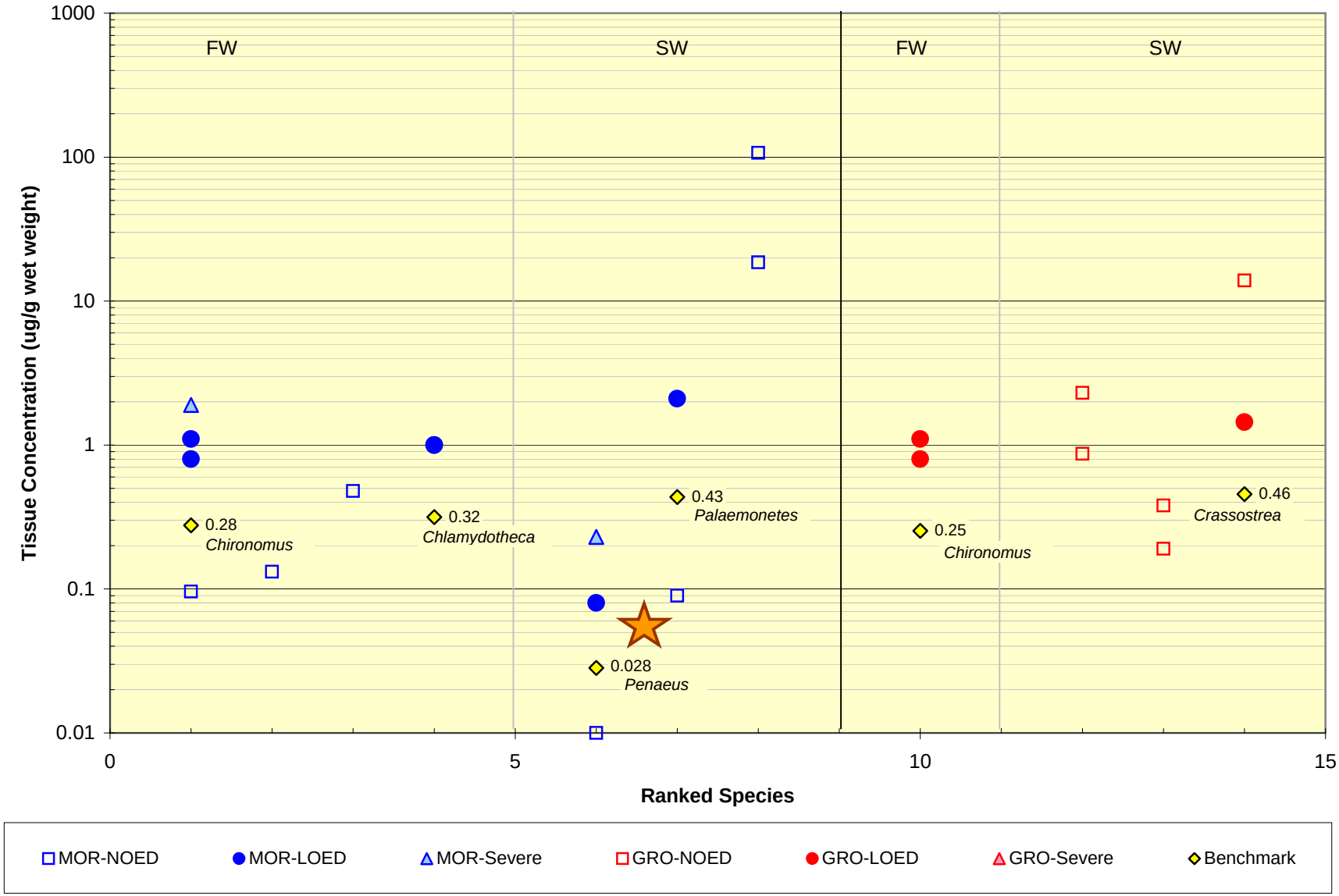

Figure 5-16
Summary of DDT, DDE, and DDD Concentrations in Freshwater and Saltwater Invertebrate Tissue Associated with Toxicity

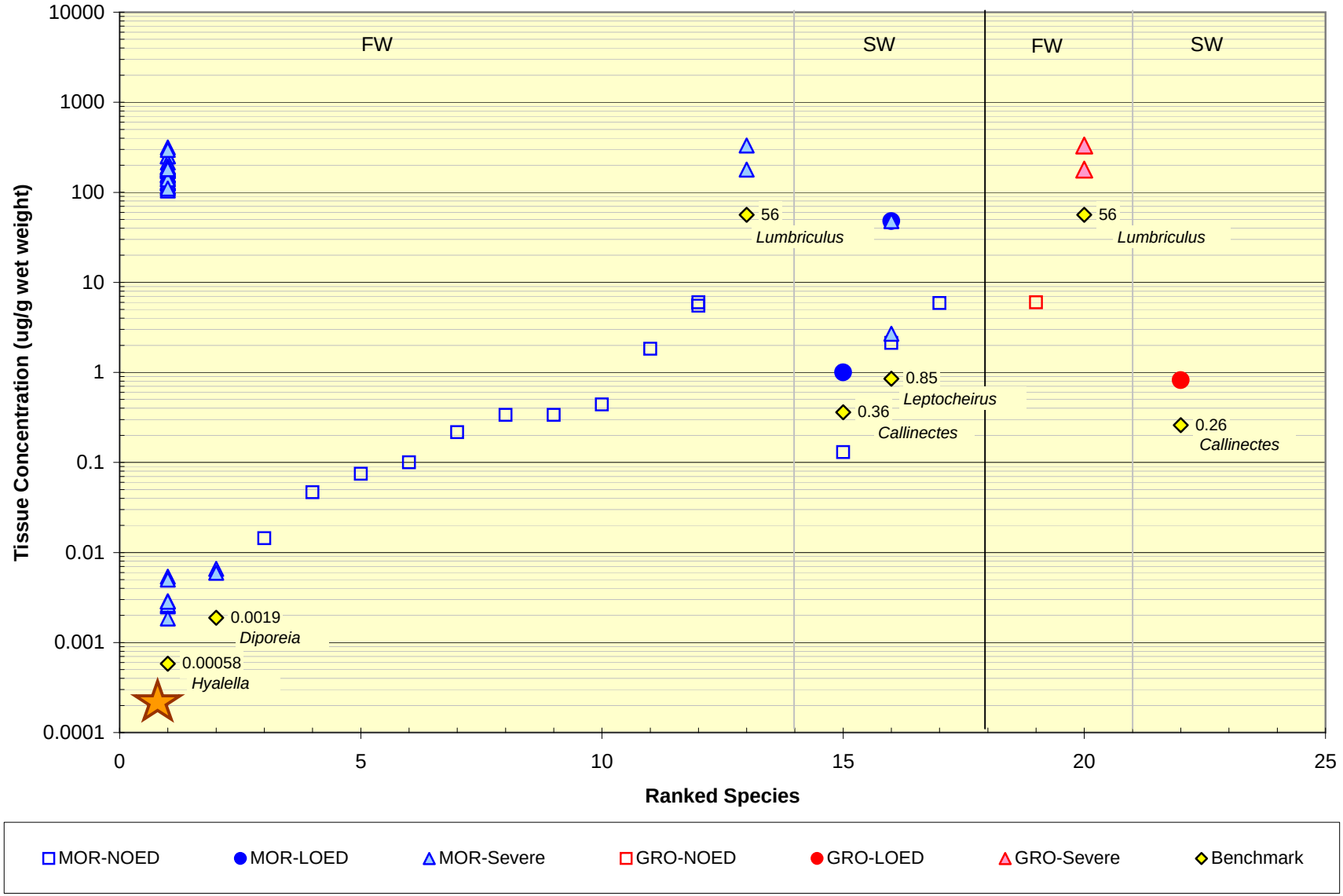

TABLE 5-1
SUMMARY OF SELECTED STUDIES OBTAINED FROM ENVIRONMENTAL RESIDUE EFFECTS DATABASE QUERY

Species Scientific Name	Species Common Name	FW/ SW	Analyte Name	CAS No	Conc (mg/kg)	Effect Class	Toxicity Measure	Exposure Route	Body Part Analyzed	Age of Species Studied	Comments	Year	Author	Species Habitat	Species Feeding Behavior	Ref ID	Publication Source
Ictalurus punctatus	Catfish-Channel	FW	Copper	7440-50-8	0.02	Growth	LOED	Ingestion	Muscle	Juvenile		1981	Murai T, JW Andrews, RG Smith Jr.	Rapid water streams	Omnivore	JA317	Aquaculture 22:353-357
Protothaca staminea	Pacific littleneck clam	SW	Copper	7440-50-8	0.86	Mortality	LD11	Water	Muscle	Adult		1980	Roesijadi G	Not Specified	Not Specified	JA377	Biol. Bull 158:233-247
Oncorhynchus mykiss	Trout - Rainbow	FW	Lead	7439-92-1	0.278	Growth	ED11	Ingestion	Whole Body	Fry	growth=length Fed trout oligochaetes reared in contaminated sediments. Exposed to As and/or Pb. Concluded As was primarily responsible for the toxicity exhibited. Histopathic measurements were taken but were not quantified.	2004	Hansen JA; J Lipton; PG Welsh; D Cacela; B MacConnell	Cool streams	Carnivore-juv fish, inverts	Weston05-031	Environ Tox & Chem 23:1902-1911
Hyalella azteca	Amphipod - Freshwater	FW	Lead	7439-92-1	5.22	Mortality	LD25	Absorption	Whole Body	Immature	Field-collected sediment	1999	Borgmann U, WP Norwood	Widely distributed in North America in permanent bodies of water with submerged vegetation	Detritivore	MEC04-063	Can J Fish Aquat Sci 56:1494-1503
Ictalurus punctatus	Catfish-Channel	FW	Mercury	7439-97-6	0.06	Mortality	LD50	Water	Whole Body	Embryo	Duration = 4d posthatch	1979	Birge WJ, JA Black, AG Westerman, JE Hudson	Rapid water streams	Omnivore	JA33	The Biogeochemistry of Mercury, pg 629-655
Acartia tonsa		#N/A	Mercury	7439-97-6	0.095	Reproduction	ED50	Combined	Whole Body	Adult	Used the kinetic modeling concentration of metal. Modeled concentration was approximately 1.4 fold higher than measured for the few measured values. Effect was 50% reduction in egg production 1 week after exposure. Food concentration=6.8 ug/g dry.	2002	Hook, Sharon and Nicholas Fisher	NS	NS	MEC03-211	Mar Environ Res 53: 161-174
Fundulus heteroclitus	Mummichog	SW	Methyl Mercury	22967-92-6	0.01	Growth	ED146	NA	Eggs	Egg	Resd measurement basis not given, assumed to be wet weight, Exposure in food of P1 generation, tissue concentration in F1 eggs, effect is juvenile weight	2001	Matta MB, J Linse, C Cairncross, L Francendese, RM Kocan	Sheltered shores, tidal creeks, brackish water at mouths of streams and estuaries	Omnivore-diatoms, small crustaceans, mollusks, sometimes small fish	MEC03-135	Environ Tox & Chem 20(2):327-335
Psettichthys melanostictus	Sand Sole	SW	Benzo[a]pyrene	50-32-8	2.1	Mortality	LD51	Water	Whole Body	Egg	Hatching mortality	1982	Hose JE, JB Hannah, D DiJulio, ML Landholt, BS miller, WT Iwaoka, SP Felton	Northern California to Bering Sea in sandy bottoms	Feeds on crustaceans, worms, small mollusks	JA212	Arch Environ Contam Toxicol 11:167-171
Mytilus edulis	Mussel	SW	Fluoranthene	206-44-0	0.22	Reproduction	LOED	Absorption	Whole Body	NA	Abnormal Gametogenesis	1995	Eertman, R.H.M., C.L. Groenink, B. Sandee and H. Hummel	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	URS75	Mar. Environ. Res. 39:169-173.
Oryzias latipes	Japanese medaka	FW	PCBs	1336-36-3	0.025	Reproduction	ED11	Ingestion	Eggs	Adult	1ug/g TBT + 25ug/g PCB % decrease in swimup	2005	Nakayama, K; Y Oshima; K Nagafuchi; T Hano; Y Shimasaki; T Honjo	Not Specified	Not Specified	Weston05-046	Environ Tox & Chem 24:591-596
Fundulus heteroclitus	Mummichog	SW	Aroclor 1268	11100-14-4	0.044	Growth	ED149	Ingestion	Eggs	Egg	Resd measurement basis not given, assumed to be wet weight, Exposure in food of F0 generation, effects on F1 generation, tissue concentration for F1 eggs, effect is juvenile weight	2001	Matta MB, J Linse, C Cairncross, L Francendese, RM Kocan	Sheltered shores, tidal creeks, brackish water at mouths of streams and estuaries	Omnivore-diatoms, small crustaceans, mollusks, sometimes small fish	MEC03-135	Environ Tox & Chem 20(2):327-335
Palaemonetes pugio	Shrimp - Grass	SW	PCBs	1336-36-3	1.1	Mortality	LOED	Absorption	Whole Body	Adult	33% Mortality In 96 Hours	1974	Hansen, D.J., P.R. Parrish and J. Forester	Nova Scotia south to Corpus Christi, TX; estuaries on beds of submerged vegetation	Detritus with associated bacteria, diatoms	URS102	Environ. Res. 7:363-373.

TABLE 5-1
SUMMARY OF SELECTED STUDIES OBTAINED FROM ENVIRONMENTAL RESIDUE EFFECTS DATABASE QUERY

Species Scientific Name	Species Common Name	FW/ SW	Analyte Name	CAS No	Conc (mg/kg)	Effect Class	Toxicity Measure	Exposure Route	Body Part Analyzed	Age of Species Studied	Comments	Year	Author	Species Habitat	Species Feeding Behavior	Ref ID	Publication Source
Palaemonetes pugio	Shrimp - Grass	SW	Aroclor 1254	11097-69-1	0.42	Mortality	NOED	Absorption	Whole Body	NA	No significant increase in mortality in 90 days in field	1974	Nimmo, D.R., J. Forester, P.T. Heitmuller, and G.H. Cook.	Nova Scotia south to Corpus Christi, TX; estuaries on beds of submerged vegetation	Detritus with associated bacteria, diatoms	JA329	Bull. Environ. Contam. Toxicol. 11(4):303-308.
Oncorhynchus mykiss	Trout - Rainbow	FW	Dieldrin	60-57-1	0.11	Growth	LOED				Poels et al., 1980, Rhine River Water	1984	Dillon TM	Cool streams	Carnivore-juv fish, inverts	MEC04-070	Army Corps of Engineers Report Technical Report, D-84-2
Cyprinodon variegatus	Sheepshead minnow	SW	Dieldrin	60-57-1	34	Mortality	LOED	Combined	Whole Body	Immature	Estimated Noed - No Statistical Summary In Text	NS	Parrish, P.P., J.A. Couch, J. Forester, J.M. Patrick, and G.H. Cook	Shallow brackish waters, Cape Cod to Mexico	Wide variety of small aquatic animals and plants	SEQ97-2	Contribution No. 178, Gulf Breeze Environmental Research Laboratory, Sabine Island, Gulf Breeze, FL. 32561
Cyprinodon variegatus	Sheepshead minnow	SW	Dieldrin	60-57-1	12.8	Mortality	NOED	Combined	Whole Body	Immature	Estimated Noed - No Statistical Summary In Text	NS	Parrish, P.P., J.A. Couch, J. Forester, J.M. Patrick, and G.H. Cook	Shallow brackish waters, Cape Cod to Mexico	Wide variety of small aquatic animals and plants	SEQ97-2	Contribution No. 178, Gulf Breeze Environmental Research Laboratory, Sabine Island, Gulf Breeze, FL. 32561
Penaeus duorarum	Shrimp - Pink	SW	Dieldrin	60-57-1	0.08	Mortality	LOED	Combined	Whole Body	Adult	Estimated Loed - No Statistical Summary In Text	NS	Parrish, P.P., J.A. Couch, J. Forester, J.M. Patrick, and G.H. Cook	Lower Chesapeake through Florida Straits, around to Yucatan; estuaries and inner oceanic, to 35 m, on sand, shell-sand, coral mud	Opportunistic omnivore; small invertebrates, benthic diatoms, vascular plant material	SEQ97-2	Contribution No. 178, Gulf Breeze Environmental Research Laboratory, Sabine Island, Gulf Breeze, FL. 32561
Penaeus duorarum	Shrimp - Pink	SW	Dieldrin	60-57-1	0.01	Mortality	NOED	Combined	Whole Body	Adult	Estimated Noed - No Statistical Summary In Text	NS	Parrish, P.P., J.A. Couch, J. Forester, J.M. Patrick, and G.H. Cook	Lower Chesapeake through Florida Straits, around to Yucatan; estuaries and inner oceanic, to 35 m, on sand, shell-sand, coral mud	Opportunistic omnivore; small invertebrates, benthic diatoms, vascular plant material	SEQ97-2	Contribution No. 178, Gulf Breeze Environmental Research Laboratory, Sabine Island, Gulf Breeze, FL. 32561
Oryzias latipes	Japanese medaka	FW	4,4`-DDE	72-55-9	0.0018	Mortality	LOED	Injection	Eggs	Egg		2003	Villalobos SA, DM papoulias, SD Pastva, AL Blankenship, J Meadow, DE Tillitt JP Giesy	Not Specified	Not Specified	MEC04-293	Chemosphere 53 819-826
Oryzias latipes	Japanese medaka	FW	4,4`-DDE	72-55-9	3.88E-05	Mortality	NOED	Injection	Eggs	Egg		2003	Villalobos SA, DM papoulias, SD Pastva, AL Blankenship, J Meadow, DE Tillitt JP Giesy	Not Specified	Not Specified	MEC04-293	Chemosphere 53 819-826

TABLE 5-1
SUMMARY OF SELECTED STUDIES OBTAINED FROM ENVIRONMENTAL RESIDUE EFFECTS DATABASE QUERY

Species Scientific Name	Species Common Name	FW/ SW	Analyte Name	CAS No	Conc (mg/kg)	Effect Class	Toxicity Measure	Exposure Route	Body Part Analyzed	Age of Species Studied	Comments	Year	Author	Species Habitat	Species Feeding Behavior	Ref ID	Publication Source
Fundulus heteroclitus	Mummichog	SW	4,4`-DDT	50-29-3	0.85	Reproduction	ED20	Water	Eggs	Adult	% Fertilization	1976	Crawford RB, AM Guarino	Sheltered shores, tidal creeks, brackish water at mouths of streams and estuaries	Omnivore-diatoms, small crustaceans, mollusks, sometimes small fish	JA96	Arch Environ Contam Toxicol 4:334-348
Fundulus heteroclitus	Mummichog	SW	4,4`-DDT	50-29-3	0.16	Reproduction	NOED	Water	Eggs	Adult	% Fertilization 2 doses to maternal fish at @0.1 mg/l Some delay to late stages of organogenesis; development normal through hatching	1976	Crawford RB, AM Guarino	Sheltered shores, tidal creeks, brackish water at mouths of streams and estuaries	Omnivore-diatoms, small crustaceans, mollusks, sometimes small fish	JA96	Arch Environ Contam Toxicol 4:334-348
Hyalella azteca	Amphipod - Freshwater	FW	4,4`-DDT	50-29-3	0.0018	Mortality	LD50	Combined	Whole Body	Juvenile		2001	Lotufo GR, PF Landrum, ML Gedeon	Widely distributed in North America in permanent bodies of water with submerged vegetation	Detritivore	MEC03-102	Environ Tox & Chem 20(4):810-825
Salvelinus namaycush	Trout -Lake	FW	2,3,7,8-TCDD	1746-01-6	5.50E-05	Growth	LOED	Water	Whole Body	Egg	Significant increase in sac fry weight at this TCDD concentration	1991	Walker MK, JM Spitsbergen, JR Olson, RE Peterson	Deep waters of cold northern lakes	Carnivore-adults piscivorous	JA474	Can. J. Fish. Aquat. Sci.
Salvelinus namaycush	Trout -Lake	FW	2,3,7,8-TCDD	1746-01-6	3.40E-05	Growth	NOED	Water	Whole Body	Egg	No significant sac fry wet weight change at this TCDD concentration.	1991	Walker MK, JM Spitsbergen, JR Olson, RE Peterson	Deep waters of cold northern lakes	Carnivore-adults piscivorous	JA474	Can. J. Fish. Aquat. Sci.
Fundulus heteroclitus	Mummichog	SW	TCDD	1746-01-6	0.000635	Mortality	LOED	Absorption	Whole Body	Embryo	28% Decrease in hatchability.	1995	Prince, R. and K.R. Cooper	Sheltered shores, tidal creeks, brackish water at mouths of streams and estuaries	Omnivore-diatoms, small crustaceans, mollusks, sometimes small fish	JA368	Environmental Toxicology and Chemistry, 14(4):579-587.

Data extracted from the U.S. Army Corps of Engineers Environmental Residue-Effects Database; queried on 10 January 2006. Database available at the following link:
http://el.erdc.usace.army.mil/ered/

TABLE 5-2
SUMMARY OF BIOMAGNIFICATION FACTORS FOR AVIAN RECEPTORS (Gull Eggs)

Analyte	log K_{ow}[a]	Gull (Adult Whole Body)[b]		Gulls (Liver)[b]		Gulls (Egg)[b]		Alewife[b]		Gull BMF (Whole Body:Alewife) (ww)[c]		Gull BMF (Whole Body:Alewife) (lipid basis)[c]		Gull Egg/Whole Body (lipid basis)[c]		Gull Egg/Alewife (lipid basis)[c]
Total DDT[d]	6.76	14	3.2	3.5	1.5	5.4	1.5	0.16		88	20	24		0.56	0.25	**13.3**
Dieldrin	5.30	0.28	0.09	0.12	0.04	0.12	0.04	0.017		16	5.1	4.5		0.63	0.24	**2.8**
Aroclor, Total	7.10	47	8.7	12	5.6	16	3.7	0.505		93	17	25		0.47	0.19	**11.9**
2,3,7,8-TCDD	7.02	127	37	72	30	83	19	4		32	9.2	8.6		0.81	0.33	**7.0**
1,2,3,4,6,7,8-HpCDD	8.20	6.8	4.9	25	20	6	0	nd		nc	nc	nc		1.60	0.43	
1,2,3,4,7,8-HxCDF	7.50	6.3	2.2	26	9.9	4.2	1.9	nd		nc	nc	nc		0.88	0.47	
1,2,3,6,7,8-HxCDD	7.80	20	2.5	40	15	16	5.8	1		20	2.5	5.4		1.10	0.68	**6.0**
1,2,3,6,7,8-HxCDF	7.50	6.3	2.3	22	9.9	4	1.2	nd		nc	nc	nc		0.84	0.4	
1,2,3,7,8-PeCDD	7.50	14	3.4	14	4.5	9.7	2.9	1		14	3.4	3.8		0.88	0.38	**3.3**
2,3,4,7,8-PeCDF	7.00	13	5.4	26	10	8.9	5.1	2		7	2.7	1.8		0.89	0.52	**1.6**
2,3,7,8-TCDF	6.53	2.6	1.3	2.4	1.3	nd		2		1	0.6	0.35		-	nc	
OCDD	8.60	7.6	4.8	40	27	8	4	nd		nc	nc	nc		1.60	0.92	
2,3,3',4,4',5,5'-Heptachlorobiphenyl (189)	7.71	1.7		0.42		0.50		0.012		121		33		0.46		**15.0**
2,3,3',4,4',5-Hexachlorobiphenyl (156)	7.18	3.3		0.85		1.2		0.029		98		27		0.51		**13.6**
2,3,3',4,4',5'-Hexachlorobiphenyl (157)	7.23	1.3	0.22	0.37	0.16	0.39	0.09	0.01		130	41	35		0.22	0.09	**7.8**
2,3,3',4,4'-Pentachlorobiphenyl (105)	6.65	0.51	0.08	0.22	0.12	0.1	0.04	0.005		102	16	28		0.22	0.08	**6.1**
2,3',4,4',5,5'-Hexachlorobiphenyl (167)	7.27	3.3		0.85		1.2		0.029		98		27		0.51		**13.6**
2,3,4,4',5-Pentachlorobiphenyl (114)	6.98	1.5		0.41		0.576		0.029		57		15		0.51		**7.8**
2,3',4,4',5-Pentachlorobiphenyl (118)	6.74	3.4	0.67	0.91	0.41	1.3	0.33	0.042		81	16	22		0.51	0.19	**11.2**
2,3',4,4',5'-Pentachlorobiphenyl (123)	6.98	1.5		0.41		0.576		0.029		57		15		0.51		**7.8**
3,3',4,4',5,5'-Hexachlorobiphenyl (169)	7.41	3.3		0.85		1.2		0.029		98		27		0.51		**13.6**
3,3',4,4',5-Pentachlorobiphenyl (126)	6.89	1.5		0.41		0.58		0.029		57		15		0.51		**7.8**
3,3',4,4'-Tetrachlorobiphenyl (77)	6.36	0.5		0.15		0.17		0.014		42		12		0.46		**5.3**
3,4,4',5-Tetrachlorobiphenyl (81)	6.36	0.5		0.15		0.17		0.014		42		12		0.46		**5.3**
Lipids (%)		10.3	2.2	4.2	0.9	7.7	0.8	2.8								

Notes:

a. Octanol-water partition coefficients as provided in USEPA, 1998 and supplemented by a query of the SRS Interactive LogKow database, 2003 (www.esc.syrres.com/interkow/kowdemo.htm).

b. Average wet-weight tissue concentrations (and standard deviations) measured in herring gulls (Lake Ontario) (Braune and Norstrom, 1989). All units in mg/kg except dioxins/furan congeners which are reported in ng/kg. nd - not detected, nc - not calculated.

c. Biomagnification Factors (BMFs) estimated as the ratio of the concentration (wet weight or lipid-normalized) in gull tissue divided by fish (or secondary tissue) concentration (wet weight or lipid-normalized).

d. Value for 4,4'-DDE.

TABLE 5-3
SUMMARY OF ANALYTICAL DATA USED IN THE AVIAN EGG ANALYSIS

	Media[a]						BAFs[b]		
	Sediment		American Eel/White Perch		Mummichog				
Analyte	Average	95% UCL	Average	95% UCL	Average	95% UCL		Mummichog	BMFs[c]
Pesticide/Aroclors									
Dieldrin	1.4E-02	1.9E-02	2.2E-02	2.7E-02	3.1E-03	4.3E-03	1.6E+00	2.2E-01	2.8E+00
Total DDx	2.3E-01	3.8E-01	4.2E-01	5.2E-01	7.4E-02	8.8E-02	1.8E+00	3.2E-01	1.3E+01
Aroclor, Total	1.3E+00	1.8E+00	2.9E+00	3.4E+00	6.7E-01	7.2E-01	2.2E+00	5.1E-01	1.2E+01
Dioxin/Furan Congeners									
2,3,7,8-TCDD	5.8E-04	1.0E-03	1.4E-04	2.3E-04	7.6E-05	1.4E-04	2.5E-01	1.3E-01	7.0E+00
1,2,3,7,8-PeCDD	1.2E-05	2.7E-05	2.2E-06	2.5E-06	8.5E-07	1.8E-06	1.9E-01	7.3E-02	3.3E+00
1,2,3,7,8-PeCDF	1.6E-05	1.9E-05	2.9E-06	3.3E-06	5.5E-07	1.3E-06	1.9E-01	3.5E-02	#N/A
2,3,4,7,8-PeCDF	5.0E-05	7.1E-05	9.1E-06	1.6E-05	2.0E-06	2.7E-06	1.8E-01	3.9E-02	1.6E+00
1,2,3,6,7,8-HxCDD	4.3E-05	7.9E-05	2.0E-06	2.3E-06	4.9E-07	1.2E-06	4.7E-02	1.1E-02	6.0E+00
1,2,3,4,6,7,8-HpCDD	6.1E-04	9.0E-04	1.5E-06	1.7E-06	1.1E-06	1.8E-06	2.5E-03	1.7E-03	NC
OCDD	6.3E-03	7.4E-03	3.7E-06	4.5E-06	6.5E-06	9.3E-06	5.9E-04	1.0E-03	NC
1,2,3,4,7,8-HxCDF	2.1E-04	4.1E-04	7.9E-06	9.4E-06	1.2E-06	1.4E-06	3.8E-02	5.7E-03	NC
1,2,3,6,7,8-HxCDF	5.2E-05	7.7E-05	2.8E-06	3.3E-06	1.2E-06	2.4E-06	5.5E-02	2.3E-02	NC
2,3,7,8-TCDF	3.2E-05	3.7E-05	1.6E-05	2.8E-05	2.0E-06	2.1E-06	5.1E-01	6.2E-02	NC
1,2,3,4,7,8-HxCDD	1.0E-05	1.4E-05	1.1E-06	2.1E-06	5.7E-07	1.3E-06	1.1E-01	5.5E-02	#N/A
1,2,3,7,8,9-HxCDD	2.0E-05	3.1E-05	1.1E-06	2.8E-06	4.6E-07	1.2E-06	5.5E-02	2.3E-02	#N/A
1,2,3,7,8,9-HxCDF	8.1E-06	1.1E-05	1.7E-06	5.3E-06	3.9E-07	1.5E-06	2.1E-01	4.8E-02	#N/A
2,3,4,6,7,8-HxCDF	3.0E-05	3.9E-05	1.7E-06	2.0E-06	3.6E-07	1.1E-06	5.6E-02	1.2E-02	#N/A
1,2,3,4,6,7,8-HpCDF	9.2E-04	1.6E-03	3.6E-06	4.8E-06	3.6E-06	4.9E-06	3.9E-03	4.0E-03	#N/A
1,2,3,4,7,8,9-HpCDF	2.8E-05	4.2E-05	1.7E-06	5.3E-06	4.1E-07	1.5E-06	6.2E-02	1.5E-02	#N/A
OCDF	1.3E-03	2.1E-03	1.3E-06	3.3E-06	1.5E-06	3.0E-06	1.0E-03	1.1E-03	#N/A
PCB Congeners									
2,3,3',4,4',5,5'-Heptachlorobiphenyl (189)	9.7E-04	1.3E-03	2.0E-03	2.4E-03	3.9E-04	4.8E-04	2.0E+00	4.0E-01	1.5E+01
2,3,3',4,4',5'-Hexachlorobiphenyl (157)	1.3E-03	1.6E-03	3.6E-03	7.6E-03	1.1E-03	1.5E-03	2.7E+00	7.9E-01	7.8E+00
2,3,3',4,4',5-Hexachlorobiphenyl (156)	6.6E-03	8.7E-03	1.6E-02	1.8E-02	4.6E-03	5.3E-03	2.4E+00	7.0E-01	1.4E+01
2,3,3',4,4'-Pentachlorobiphenyl (105)	2.1E-02	2.6E-02	4.5E-02	4.9E-02	1.7E-02	1.8E-02	2.2E+00	8.3E-01	6.1E+00
2,3',4,4',5,5'-Hexachlorobiphenyl (167)	7.5E-03	1.1E-02	7.7E-03	8.9E-03	3.1E-03	4.2E-03	1.0E+00	4.2E-01	1.4E+01
2',3,4,4',5-Pentachlorobiphenyl (123)	2.2E-03	2.9E-03	2.2E-03	4.0E-03	1.1E-03	1.2E-03	1.0E+00	5.0E-01	7.8E+00
2,3,4,4',5-Pentachlorobiphenyl (114)	1.7E-03	2.2E-03	2.2E-03	3.6E-03	1.2E-03	1.4E-03	1.3E+00	6.9E-01	7.8E+00
2,3',4,4',5-Pentachlorobiphenyl (118)	5.9E-02	7.8E-02	1.4E-01	1.6E-01	5.2E-02	5.5E-02	2.4E+00	8.8E-01	1.1E+01
3,3',4,4',5,5'-Hexachlorobiphenyl (169)	1.6E-04	2.4E-04	4.8E-04	1.1E-03	4.2E-05	1.1E-04	3.0E+00	2.6E-01	1.4E+01
3,3',4,4',5-Pentachlorobiphenyl (126)	2.8E-04	3.5E-04	3.7E-04	6.7E-04	1.5E-04	1.6E-04	1.3E+00	5.4E-01	7.8E+00
3,3',4,4'-Tetrachlorobiphenyl (77)	9.2E-03	1.3E-02	4.8E-03	8.0E-03	1.5E-03	2.2E-03	5.2E-01	1.7E-01	5.3E+00
3,4,4',5-Tetrachlorobiphenyl (81)	9.1E-04	1.0E-03	2.9E-03	3.6E-03	6.7E-04	9.0E-04	3.2E+00	7.4E-01	5.3E+00

TABLE 5-3
SUMMARY OF ANALYTICAL DATA USED IN THE AVIAN EGG ANALYSIS

	Media[a]						BAFs[b]	
	Sediment		American Eel/White Perch		Mummichog			
Analyte	Average	95% UCL	Average	95% UCL	Average	95% UCL	Mummichog	BMFs[c]

Notes

a. Data summarized using ProUCL software; outputs provided in Attachment 3.

b. Bioaccumulation Factors (BAFs) calculated as the ratio of the average biotic (i.e., either American eel/White perch or mummichog) tissue concentration to the average sediment concentration; unitless.

c. Biomagnification Factors (BMFs) estimated as the ratio of the gull egg tissue concentration divided by maternal prey (i.e., fish) tissue concentration, both lipid-normalized. BMFs are expressed in units of g (lipid % fish)/g (lipid % gull egg) .

TABLE 5-4
CBR-BASED HAZARD QUOTIENTS FOR ESTIMATED PISCIVOROUS BIRD EGG TISSUE - American eel/White Perch Diet

COPEC	American eel/ White perch EPC[a]	Units	Avian BMF[b]	TEF	Estimated Egg Tissue Concentration[c]	CBR[d]		Hazard Quotients[e]	
						NOAEL	LOAEL	NOAEL	LOAEL
Pesticides/Aroclors									
Dieldrin	0.027	MG/KG	2.8	na	8.4E-02		0.059		**1.4E+00**
Total DDx	0.52	MG/KG	13.3	na	7.6E+00		0.1		**7.6E+01**
Aroclor, Total	3.4	MG/KG	11.9	na	4.5E+01				
							Total Pesticides/PCBs	0.0E+00	**7.8E+01**
Dioxins					**TEQ**				
2,3,7,8-TCDD	2.3E-04	MG/KG	7.0	1	1.8E-03				
1,2,3,7,8-PeCDD	2.5E-06	MG/KG	3.3	1	9.3E-06				
1,2,3,7,8-PeCDF	3.3E-06	MG/KG	#N/A	0.1					
2,3,4,7,8-PeCDF	1.6E-05	MG/KG	1.6	1	2.7E-05				
1,2,3,6,7,8-HxCDD	2.3E-06	MG/KG	6.0	0.01	1.5E-07				
1,2,3,4,6,7,8-HpCDD	1.7E-06	MG/KG		0.001					
OCDD	4.5E-06	MG/KG		0.0001					
1,2,3,4,7,8-HxCDF	9.4E-06	MG/KG		0.1					
1,2,3,6,7,8-HxCDF	3.3E-06	MG/KG		0.1					
2,3,7,8-TCDF	2.8E-05	MG/KG		1					
1,2,3,4,7,8-HxCDD	2.1E-06	MG/KG	#N/A	0.05					
1,2,3,7,8,9-HxCDD	2.8E-06	MG/KG	#N/A	0.1					
1,2,3,7,8,9-HxCDF	5.27E-06	MG/KG	#N/A	0.1					
2,3,4,6,7,8-HxCDF	2.0E-06	MG/KG	#N/A	0.1					
1,2,3,4,6,7,8-HpCDF	4.8E-06	MG/KG	#N/A	0.01					
1,2,3,4,7,8,9-HpCDF	5.3E-06	MG/KG	#N/A	0.01					
OCDF	3.3E-06	MG/KG	#N/A	0.0001					
Total Dioxin/Furan Congeners					1.8E-03	5.9E-05	1.5E-04	**3.1E+01**	**1.2E+01**
							TEQ (D/F)	**3.1E+01**	**1.2E+01**

TABLE 5-4
CBR-BASED HAZARD QUOTIENTS FOR ESTIMATED PISCIVOROUS BIRD EGG TISSUE - American eel/White Perch Diet

COPEC	American eel/ White perch EPC[a]	Units	Avian BMF[b]	TEF	Estimated Egg Tissue Concentration[c]	CBR[d]		Hazard Quotients[e]	
						NOAEL	LOAEL	NOAEL	LOAEL
PCBs					**TEQ**				
2,3,3',4,4',5,5'-Heptachlorobiphenyl (189)	2.4E-03	MG/KG	15.0	0.00001	4.0E-07				
2,3,3',4,4',5'-Hexachlorobiphenyl (157)	7.6E-03	MG/KG	7.8	0.0001	6.5E-06				
2,3,3',4,4',5-Hexachlorobiphenyl (156)	1.8E-02	MG/KG	13.6	0.0001	2.7E-05				
2,3,3',4,4'-Pentachlorobiphenyl (105)	4.9E-02	MG/KG	6.1	0.0001	3.3E-05				
2,3',4,4',5,5'-Hexachlorobiphenyl (167)	8.9E-03	MG/KG	13.6	0.00001	1.3E-06				
2',3,4,4',5-Pentachlorobiphenyl (123)	4.0E-03	MG/KG	7.8	0.00001	3.4E-07				
2,3,4,4',5-Pentachlorobiphenyl (114)	3.6E-03	MG/KG	7.8	0.0001	3.1E-06				
2,3',4,4',5-Pentachlorobiphenyl (118)	1.6E-01	MG/KG	11.2	0.00001	2.0E-05				
3,3',4,4',5,5'-Hexachlorobiphenyl (169)	1.1E-03	MG/KG	13.6	0.001	1.6E-05				
3,3',4,4',5-Pentachlorobiphenyl (126)	6.7E-04	MG/KG	7.8	0.1	5.8E-04				
3,3',4,4'-Tetrachlorobiphenyl (77)	8.0E-03	MG/KG	5.3	0.05	2.3E-03				
3,4,4',5-Tetrachlorobiphenyl (81)	3.6E-03	MG/KG	5.3	0.1	2.1E-03				
Total PCB Congeners					5.1E-03	5.9E-05	1.5E-04	**8.7E+01**	**3.4E+01**
							TEQ (PCBs)	**8.7E+01**	**3.4E+01**
							Total TCDD TEQ	**1.2E+02**	**4.6E+01**
							Total	**1.2E+02**	**1.2E+02**

Notes:
[a] EPCs for American eel/white perch tissue (see Table 4.1).
[b] Biomagnification Factors (BMFs - expressed in units of g (lipid % fish)/g (lipid % gull egg) presented in Table 5-2 (Attachment 5).
[c] Egg concentration for avian insectivore receptor (mg/kg wet weight) estimated by multiplying the Fish tissue concentration by the BMF and the ratio of the egg to fish percent lipid. The following lipid contents were assumed:
7.0 Average American eel/white perch lipid percent in Lower Passaic River samples.
7.7 Average gull egg lipid percentage (Braune and Norstrom, 1989).
[d] Critical Body Residues (CBRs) are obtained from summary of tissue effects data discussed in Section 6.2.
[e] Hazard Quotient is the ratio of the estimated tissue concentration to the NOAEL or LOAEL CBR.
HQs for shaded analytes not included in the HI totals.
#N/A, na - Not available/applicable.

TABLE 5-5
CBR-BASED HAZARD QUOTIENTS FOR ESTIMATED PISCIVOROUS FISH EGG TISSUE - American eel/White perch

COPEC	American eel/ White perch EPC[a]	Units	Trout Female/Egg BMF[b]	Fish TEF	Estimated Egg Tissue Concentration[c]	CBR[d]		Hazard Quotients[e]	
						LCL	UCL	LCL	UCL
Dioxins					**TEQ**				
2,3,7,8-TCDD	2.3E-04	MG/KG	0.69	1	1.9E-04				
1,2,3,7,8-PeCDD	2.5E-06	MG/KG	0.67	1	2.0E-06				
1,2,3,7,8-PeCDF	3.3E-06	MG/KG	-	0.05					
2,3,4,7,8-PeCDF	1.6E-05	MG/KG	0.60	0.5	5.5E-06				
1,2,3,6,7,8-HxCDD	2.3E-06	MG/KG	-	0.01					
1,2,3,4,6,7,8-HpCDD	1.7E-06	MG/KG	-	0.001					
OCDD	4.5E-06	MG/KG	-	0.0001					
1,2,3,4,7,8-HxCDF	9.4E-06	MG/KG	-	0.1					
1,2,3,6,7,8-HxCDF	3.3E-06	MG/KG	-	0.1					
2,3,7,8-TCDF	2.8E-05	MG/KG	0.71	0.05	1.2E-06				
1,2,3,4,7,8-HxCDD	2.1E-06	MG/KG	-	0.5					
1,2,3,7,8,9-HxCDD	2.8E-06	MG/KG	-	0.01					
1,2,3,7,8,9-HxCDF	5.27E-06	MG/KG	-	0.1					
2,3,4,6,7,8-HxCDF	2.0E-06	MG/KG	-	0.1					
1,2,3,4,6,7,8-HpCDF	4.8E-06	MG/KG	-	0.01					
1,2,3,4,7,8,9-HpCDF	5.3E-06	MG/KG	-	0.01					
OCDF	3.3E-06	MG/KG	-	0.0001					
Total Dioxin/Furan Congeners					2.0E-04	7.2E-06	8.6E-05	**2.8E+01**	**2.3E+00**
							TEQ (D/F)	**2.8E+01**	**2.3E+00**

TABLE 5-5
CBR-BASED HAZARD QUOTIENTS FOR ESTIMATED PISCIVOROUS FISH EGG TISSUE - American eel/White perch

COPEC	American eel/ White perch EPC[a]	Units	Trout Female/Egg BMF[b]	Fish TEF	Estimated Egg Tissue Concentration[c]	CBR[d]		Hazard Quotients[e]	
						LCL	UCL	LCL	UCL
PCBs					**TEQ**				
2,3,3',4,4',5,5'-Heptachlorobiphenyl (189)	2.4E-03	MG/KG	-	0.000005					
2,3,3',4,4',5'-Hexachlorobiphenyl (157)	7.6E-03	MG/KG	-	0.000005					
2,3,3',4,4',5-Hexachlorobiphenyl (156)	1.8E-02	MG/KG	-	0.000005					
2,3,3',4,4'-Pentachlorobiphenyl (105)	4.9E-02	MG/KG	0.67	0.000005	1.9E-07				
2,3',4,4',5,5'-Hexachlorobiphenyl (167)	8.9E-03	MG/KG	-	0.000005					
2',3,4,4',5-Pentachlorobiphenyl (123)	4.0E-03	MG/KG	-	0.000005					
2,3,4,4',5-Pentachlorobiphenyl (114)	3.6E-03	MG/KG	-	0.000005					
2,3',4,4',5-Pentachlorobiphenyl (118)	1.6E-01	MG/KG	0.67	0.000005	6.2E-07				
3,3',4,4',5,5'-Hexachlorobiphenyl (169)	1.1E-03	MG/KG	0.43	0.00005	2.7E-08				
3,3',4,4',5-Pentachlorobiphenyl (126)	6.7E-04	MG/KG	0.61	0.005	2.4E-06				
3,3',4,4'-Tetrachlorobiphenyl (77)	8.0E-03	MG/KG	0.71	0.0001	6.7E-07				
3,4,4',5-Tetrachlorobiphenyl (81)	3.6E-03	MG/KG	0.65	0.0005	1.4E-06				
Total PCB Congeners					5.3E-06	7.2E-06	8.6E-05	7.3E-01	6.1E-02
							TEQ (PCBs)	7.3E-01	6.1E-02
							Total TCDD TEQ	**2.8E+01**	**2.4E+00**

Notes:
[a] EPCs for American eel/white perch tissue (see Table 5-3, Attachment 5).
[b] Biomagnification Factors (BMFs - expressed in units of g (lipid % fish)/g (lipid % egg) from Cook *et al.* , 2003.
[c] Fish egg concentrations (mg/kg wet weight) estimated by multiplying the adult fish tissue concentration by the BMF and the ratio of the egg to female fish percent lipid and congener-specific TEF. The following lipid contents were assumed:
7.0 Average American eel/white perch lipid percent in Lower Passaic River samples.
8.2 Average Lake trout egg lipid percentage (Cook *et al.* , 2003).
[d] Critical Body Residues (CBRs) thresholds derived as the Lower and Upper 95% Confidence Levels derived by Steevens *et al.* , 2005 (0.088 and 1.05 ngTCDD/g_{lipid}, respectiv
[e] Hazard Quotient is the ratio of the estimated tissue concentration to the LCL or UCL CBR.
HQs for shaded analytes not included in the HI totals.
#N/A, na - Not available/applicable.

TABLE 5-6
CBR-BASED HAZARD QUOTIENTS FOR ESTIMATED PISCIVOROUS FISH EGG TISSUE - Mummichog

COPEC	Mummichog EPC[a]	Units	Trout Female/Egg BMF[b]	Fish TEF	Estimated Egg Tissue Concentration[c]	CBR[d]		Hazard Quotients[e]	
						LCL	UCL	LCL	UCL
Dioxins					**TEQ**				
2,3,7,8-TCDD	1.4E-04	MG/KG	0.69	1	2.5E-04				
1,2,3,7,8-PeCDD	1.8E-06	MG/KG	0.67	1	3.2E-06				
1,2,3,7,8-PeCDF	1.3E-06	MG/KG	-	0.05					
2,3,4,7,8-PeCDF	2.7E-06	MG/KG	0.60	0.5	2.1E-06				
1,2,3,6,7,8-HxCDD	1.2E-06	MG/KG	-	0.01					
1,2,3,4,6,7,8-HpCDD	1.8E-06	MG/KG	-	0.001					
OCDD	9.3E-06	MG/KG	-	0.0001					
1,2,3,4,7,8-HxCDF	1.4E-06	MG/KG	-	0.1					
1,2,3,6,7,8-HxCDF	2.4E-06	MG/KG	-	0.1					
2,3,7,8-TCDF	2.1E-06	MG/KG	0.71	0.05	1.9E-07				
1,2,3,4,7,8-HxCDD	1.3E-06	MG/KG	-	0.5					
1,2,3,7,8,9-HxCDD	1.2E-06	MG/KG	-	0.01					
1,2,3,7,8,9-HxCDF	1.52E-06	MG/KG	-	0.1					
2,3,4,6,7,8-HxCDF	1.1E-06	MG/KG	-	0.1					
1,2,3,4,6,7,8-HpCDF	4.9E-06	MG/KG	-	0.01					
1,2,3,4,7,8,9-HpCDF	1.5E-06	MG/KG	-	0.01					
OCDF	3.0E-06	MG/KG	-	0.0001					
Total Dioxin/Furan Congeners					2.6E-04	7.2E-06	8.6E-05	**3.6E+01**	**3.0E+00**
							TEQ (D/F)	**3.6E+01**	**3.0E+00**

TABLE 5-6
CBR-BASED HAZARD QUOTIENTS FOR ESTIMATED PISCIVOROUS FISH EGG TISSUE - Mummichog

COPEC	Mummichog EPC[a]	Units	Trout Female/Egg BMF[b]	Fish TEF	Estimated Egg Tissue Concentration[c]	CBR[d]		Hazard Quotients[e]	
						LCL	UCL	LCL	UCL
PCBs					**TEQ**				
2,3,3',4,4',5,5'-Heptachlorobiphenyl (189)	4.8E-04	MG/KG	-	0.000005					
2,3,3',4,4',5'-Hexachlorobiphenyl (157)	1.5E-03	MG/KG	-	0.000005					
2,3,3',4,4',5-Hexachlorobiphenyl (156)	5.3E-03	MG/KG	-	0.000005					
2,3,3',4,4'-Pentachlorobiphenyl (105)	1.8E-02	MG/KG	0.67	0.000005	1.6E-07				
2,3',4,4',5,5'-Hexachlorobiphenyl (167)	4.2E-03	MG/KG	-	0.000005					
2',3,4,4',5-Pentachlorobiphenyl (123)	1.2E-03	MG/KG	-	0.000005					
2,3,4,4',5-Pentachlorobiphenyl (114)	1.4E-03	MG/KG	-	0.000005					
2,3',4,4',5-Pentachlorobiphenyl (118)	5.5E-02	MG/KG	0.67	0.000005	4.8E-07				
3,3',4,4',5,5'-Hexachlorobiphenyl (169)	1.1E-04	MG/KG	0.43	0.00005	6.1E-09				
3,3',4,4',5-Pentachlorobiphenyl (126)	1.6E-04	MG/KG	0.61	0.005	1.3E-06				
3,3',4,4'-Tetrachlorobiphenyl (77)	2.2E-03	MG/KG	0.71	0.0001	4.0E-07				
3,4,4',5-Tetrachlorobiphenyl (81)	9.0E-04	MG/KG	0.65	0.0005	7.6E-07				
Total PCB Congeners					3.1E-06	7.2E-06	8.6E-05	4.3E-01	3.6E-02
							TEQ (PCBs)	4.3E-01	3.6E-02
							Total TCDD TEQ	**3.6E+01**	**3.0E+00**

Notes:
[a] EPCs for mummichog tissue (see Table 5-3, Attachment 5).
[b] Biomagnification Factors (BMFs - expressed in units of g (lipid % fish)/g (lipid % egg) from Cook *et al.* , 2003.
[c] Fish egg concentrations (mg/kg wet weight) estimated by multiplying the adult fish tissue concentration by the BMF and the ratio of the egg to female fish percent lipid and congener-specific TEF. The following lipid contents were assumed:
3.2 Average American eel/white perch lipid percent in Lower Passaic River samples.
8.2 Average Lake trout egg lipid percentage (Cook *et al.* , 2003).
[d] Critical Body Residues (CBRs) thresholds derived as the Lower and Upper 95% Confidence Levels derived by Steevens *et al.* , 2005 (0.088 and 1.05 ngTCDD/g_{lipid}, respective
[e] Hazard Quotient is the ratio of the estimated tissue concentration to the LCL or UCL CBR.
HQs for shaded analytes not included in the HI totals.
#N/A, na - Not available/applicable.

ATTACHMENT 6
ECOLOGICAL RISK – CURRENT CONDITIONS

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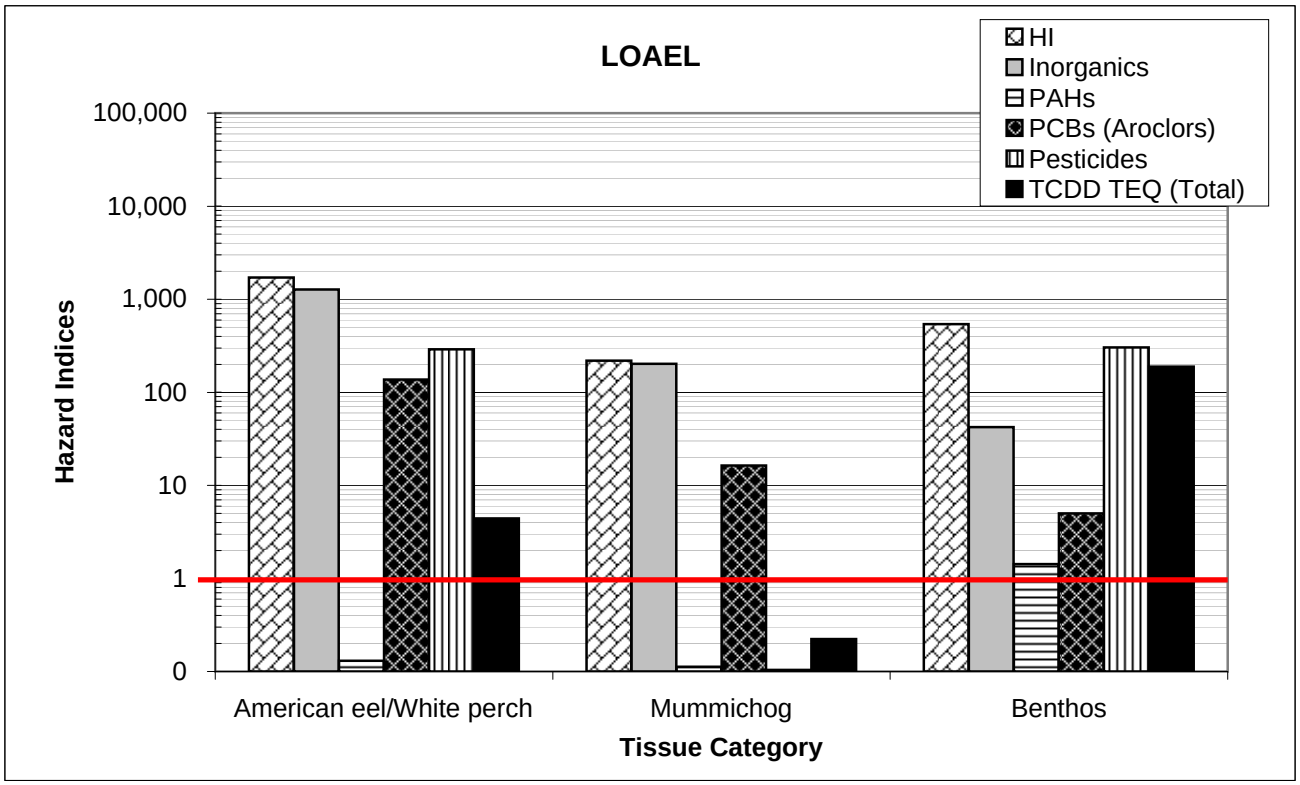
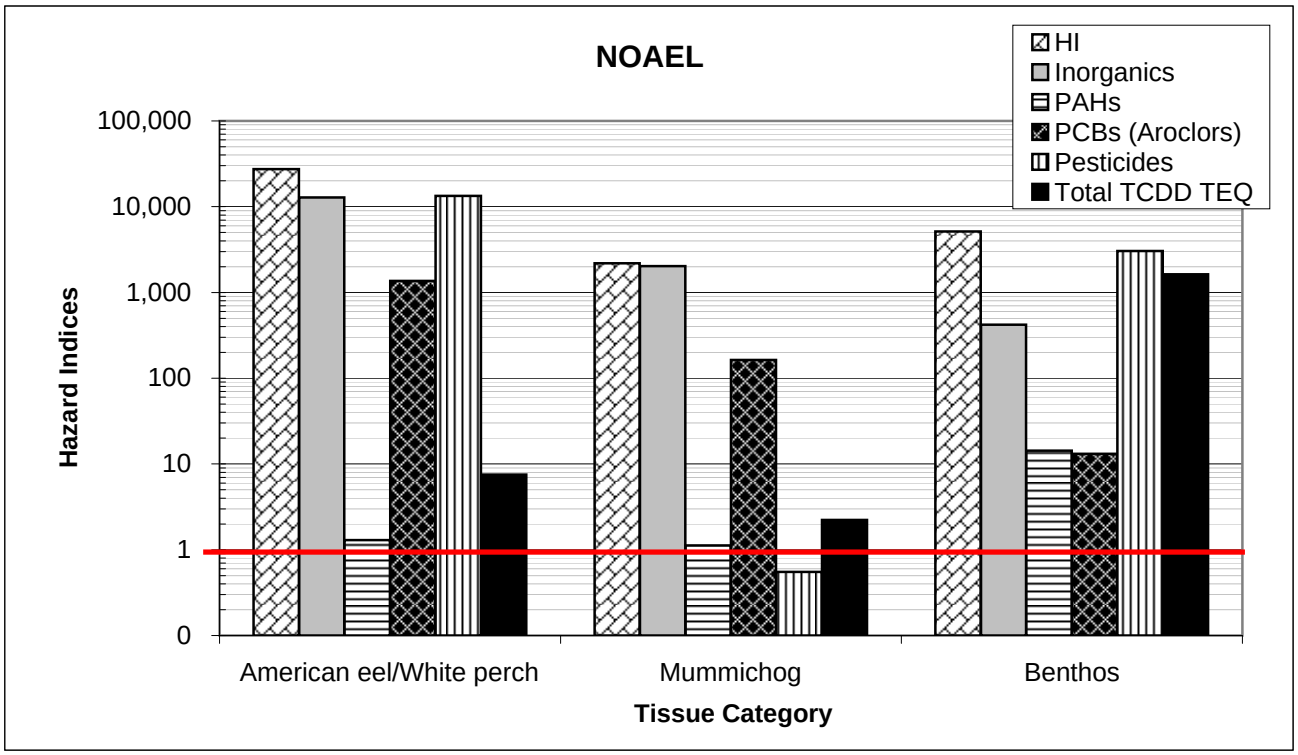
Attachment 6

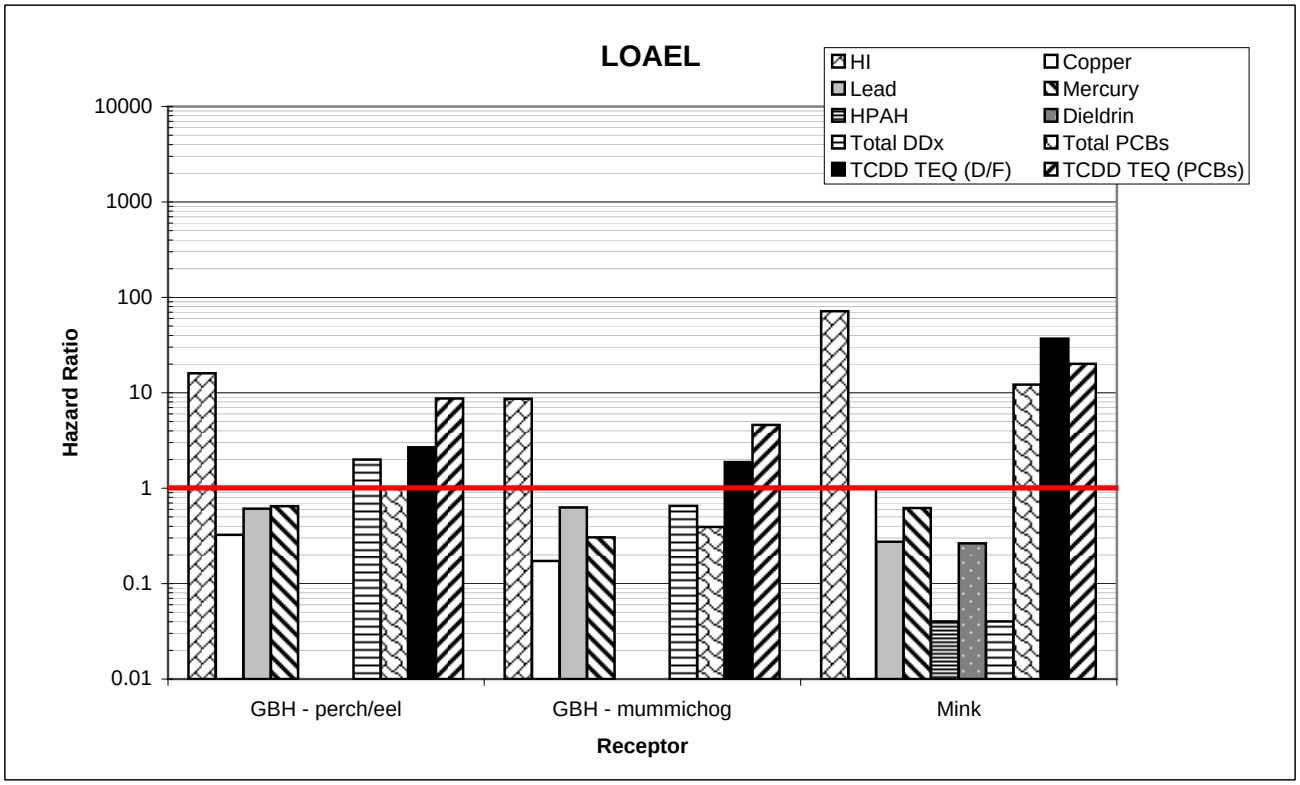
FIGURE 6-1
CBR-BASED HAZARD RATIOS FOR BIOLOGICAL TISSUE SAMPLES
Current Conditions

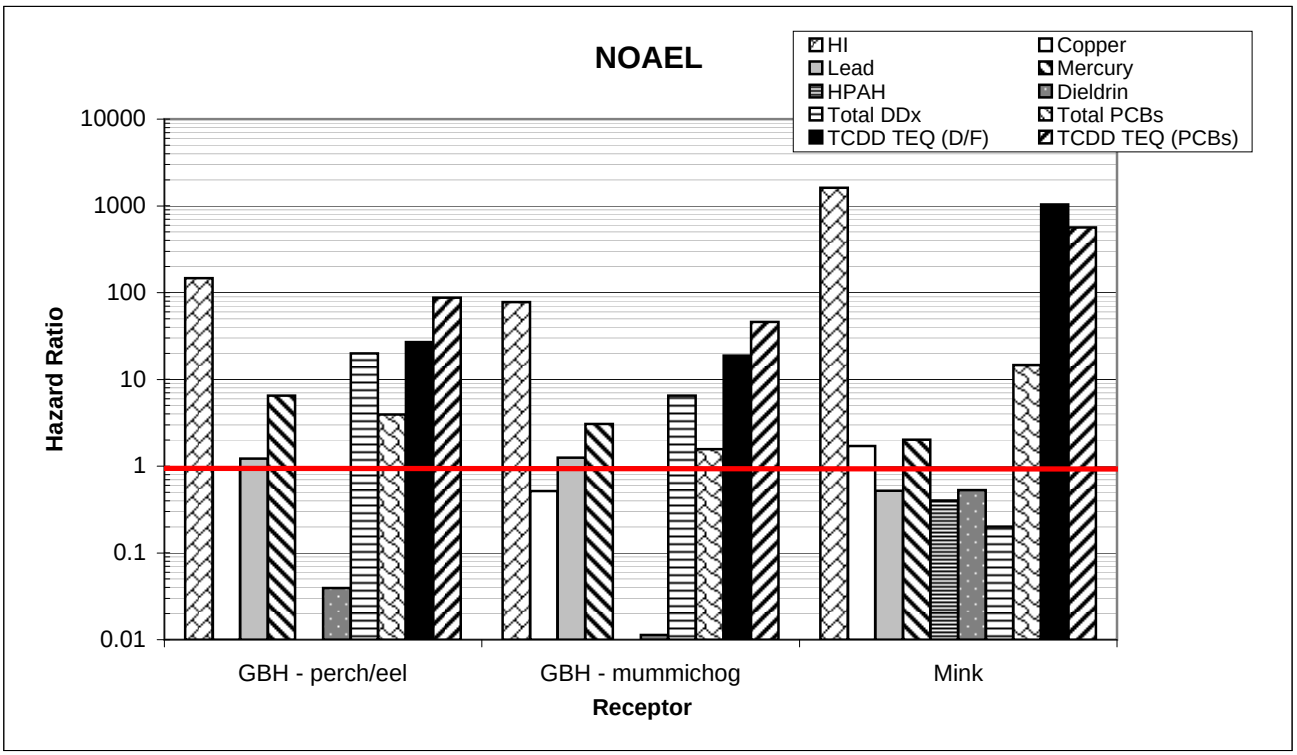




Attachment 6

FIGURE 6-2
SUMMARY OF WILDLIFE EXPOSURE DOSE MODELING
Current Conditions





Attachment 6

TABLE 6-1
CBR-BASED HAZARD QUOTIENTS FOR COPECS IN WHITE PERCH/AMERICAN EEL TISSUE
Current Conditions

Chemical	Units	EPC [a]	CBR [b]		Species	Endpoint	Reference	Hazard Quotients [c]	
			NOAEL	LOAEL				NOAEL	LOAEL
Inorganics/Metals									
Copper	µg/g	25	0.002	**0.02**	*Ictalurus punctatus*	Growth - LOED	1	**1.2E+04**	**1.2E+03**
Lead	µg/g	0.63	0.028	**0.28**	*Oncorhynchus mykiss*	Growth - ED_{11}	2	**2.3E+01**	**2.3E+00**
Mercury[1]	µg/g	0.35	0.006	**0.06**	*Ictalurus punctatus*	Mortality - LD_{50}	3	**5.8E+01**	**5.8E+00**
Mercury (methyl)	µg/g	0.35	0.001	**0.01**	*Fundulus heteroclitus*	Growth - ED_{146}	4	**3.5E+02**	**3.5E+01**
						Total Inorganics/Metals		**1.3E+04**	**1.3E+03**
Semivolatile Organics (PAHs)									
Low Weight PAHs	µg/g	0.17	0.21	**2.1**	*Psettichthys melanostictus*	Mortality - LD_{51}	5	8.2E-01	8.2E-02
High Weight PAHs	µg/g	0.10	0.21	**2.1**	*Psettichthys melanostictus*	Mortality - LD_{51}	5	4.8E-01	4.8E-02
						Total PAHs		**1.3E+00**	1.3E-01
PCBs (Aroclors)									
Aroclor, Total	µg/g	3.4	0.0025	**0.025**	*Oryzias latipes*	Reproduction - ED_{11}	6	**1.4E+03**	**1.4E+02**
						Total PCBs		**1.4E+03**	**1.4E+02**
Pesticides									
Dieldrin	µg/g	0.027	0.011	**0.11**	*Oncorhynchus mykiss*	Growth - LOED	7	**2.5E+00**	2.5E-01
Total DDx	µg/g	0.52	**0.000039**	**0.0018**	*Oryzias latipes*	Mortality - LOED	8	**1.3E+04**	**2.9E+02**
						Total Pesticides		**1.3E+04**	**2.9E+02**
Dioxin-like Compounds									
TCDD TEQ (D/F)	µg/g	0.00025	**0.000034**	**0.00006**	*Salvelinus namaycush*	Growth - LOED	9	**7.4E+00**	**4.3E+00**
TCDD TEQ (PCBs)	µg/g	0.0000051	**0.000034**	**0.00006**	*Salvelinus namaycush*	Growth - LOED	9	1.5E-01	8.8E-02
						Total TCDD TEQ		**7.5E+00**	**4.4E+00**
						Total		**2.8E+04**	**1.7E+03**

Notes:

[a] Exposure Point Concentration (95% UCLs) presented in Table 4-1. TCDD Toxic Equivalencies based on fish TEF values, EPCs based on white perch and American eel tissue data.

[b] Critical Body Residues (CBRs) are obtained from summary of tissue effects data presented in CSM Technical Memorandum #3 (Battelle, 2006).

[c] Hazard Quotient is the ratio of the EPC to the NOAEL or LOAEL CBR.

[1]Analyte is not included in the HI totals.

Non-bolded CBR values were estimated using a 10-fold extrapolation factor.

Attachment 6

TABLE 6-1
CBR-BASED HAZARD QUOTIENTS FOR COPECS IN WHITE PERCH/AMERICAN EEL TISSUE
Current Conditions

Chemical	Units	EPC [a]	CBR [b]		Species	Endpoint	Reference	Hazard Quotients [c]	
			NOAEL	LOAEL				NOAEL	LOAEL

References:

1. Murai, T., J.W. Andrews, and R.G. Smith, Jr., 1981. Aquaculture 22:353-357; ERED Ref ID JA317.
2. Hansen, J.A., J. Lipton, P.G., Welsh, D. Cacela, and B. MacConnell, 2004. Environ. Tox. & Chem. 23:1902-1911; ERED Ref ID Weston05-031.
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TABLE 6-2
CBR-BASED HAZARD QUOTIENTS FOR COPECS IN MUMMICHOG TISSUE
Current Conditions

Chemical	Units	EPC [a]	CBR [b]		Species	Endpoint	Reference	Hazard Quotients [c]	
			NOAEL	LOAEL				NOAEL	LOAEL
Inorganics/Metals									
Copper	µg/g	3.9	0.002	**0.02**	*Ictalurus punctatus*	Growth - LOED	1	**1.9E+03**	**1.9E+02**
Lead	µg/g	1.2	0.028	**0.28**	*Oncorhynchus mykiss*	Growth - ED_{11}	2	**4.5E+01**	**4.5E+00**
Mercury[1]	µg/g	0.041	0.006	**0.06**	*Ictalurus punctatus*	Mortality - LD_{50}	3	**6.8E+00**	6.8E-01
Mercury (methyl)	µg/g	0.041	0.001	**0.01**	*Fundulus heteroclitus*	Growth - ED_{146}	4	**4.1E+01**	**4.1E+00**
						Total Inorganics/Metals		**2.0E+03**	**2.0E+02**
Semivolatile Organics (PAHs)									
Low Weight PAHs	µg/g	0.17	0.21	**2.1**	*Psettichthys melanostictus*	Mortality - LD_{51}	5	8.2E-01	8.2E-02
High Weight PAHs	µg/g	0.065	0.21	**2.1**	*Psettichthys melanostictus*	Mortality - LD_{51}	5	3.1E-01	3.1E-02
						Total PAHs		**1.1E+00**	1.1E-01
PCBs (Aroclors)									
Aroclor, Total	µg/g	0.72	0.0044	**0.044**	*Fundulus heteroclitus*	Growth - ED_{149}	4	**1.6E+02**	**1.6E+01**
						Total PCBs		**1.6E+02**	**1.6E+01**
Pesticides									
Dieldrin	µg/g	0.0042	**12.8**	**34**	*Cyprinodon variegatus*	Mortality - LOED	6	3.3E-04	1.2E-04
Total DDx	µg/g	0.088	**0.16**	**0.85**	*Fundulus heteroclitus*	Reproduction - ED_{20}	7	5.5E-01	1.0E-01
						Total Pesticides		5.5E-01	1.0E-01
Dioxin-like Compounds									
TCDD TEQ (D/F)	µg/g	0.00014	0.000064	**0.00064**	*Fundulus heteroclitus*	Mortality - LOED	8	**2.2E+00**	2.2E-01
TCDD TEQ (PCBs)	µg/g	0.0000017	0.000064	**0.00064**	*Fundulus heteroclitus*	Mortality - LOED	8	2.7E-02	2.7E-03
						Total TCDD TEQ		**2.2E+00**	2.2E-01
						Total		**2.2E+03**	**2.2E+02**

Notes:

[a] Exposure Point Concentration (95% UCLs) presented in Table 4-1. TCDD Toxic Equivalencies based on fish TEF values, EPCs based on mummichog tissue data.

[b] Critical Body Residues (CBRs) are obtained from summary of tissue effects data presented in CSM Technical Memorandum #3 (Battelle, 2006).

[c] Hazard Quotient is the ratio of the EPC to the NOAEL or LOAEL CBR.

[1]Analyte is not included in the HI totals.

Non-bolded CBR values were estimated using a 10-fold extrapolation factor.

TABLE 6-2
CBR-BASED HAZARD QUOTIENTS FOR COPECS IN MUMMICHOG TISSUE
Current Conditions

Chemical	Units	EPC [a]	CBR [b]		Species	Endpoint	Reference	Hazard Quotients [c]	
			NOAEL	LOAEL				NOAEL	LOAEL

References:

1. Murai, T., J.W. Andrews, and R.G. Smith, Jr., 1981. Aquaculture 22:353-357; ERED Ref ID JA317.
2. Hansen, J.A., J. Lipton, P.G., Welsh, D. Cacela, and B. MacConnell, 2004. Environ. Tox. & Chem. 23:1902-1911; ERED Ref ID Weston05-031.
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Attachment 6

TABLE 6-3
CBR-BASED HAZARD QUOTIENTS FOR COPECS IN BLUE CRAB TISSUE
Current Conditions

Chemical	Units	EPC [a]	CBR [b]		Species	Endpoint	Reference	Hazard Quotients [c]	
			NOAEL	LOAEL				NOAEL	LOAEL
Inorganics/Metals									
Copper	µg/g	35	0.086	**0.86**	*Protothaca staminea*	Mortality - LD_{11}	1	**4.1E+02**	**4.1E+01**
Lead	µg/g	0.55	0.52	**5.2**	*Hyalella azteca*	Mortality - LD_{25}	2	**1.0E+00**	1.0E-01
Mercury[1]	µg/g	0.10	0.0095	**0.095**	*Acartia tonsa*	Reproduction - ED_{50}	3	**1.0E+01**	**1.0E+00**
Mercury (methyl)	µg/g	0.10	0.0095	**0.095**	*Acartia tonsa*	Reproduction - ED_{50}	3	**1.0E+01**	**1.0E+00**
						Total Inorganics/Metals		**4.2E+02**	**4.2E+01**
Semivolatile Organics (PAHs)									
Low Weight PAHs	µg/g	0.15	0.022	**0.22**	*Mytilus edulis*	Reproduction - LOED	4	**6.9E+00**	6.9E-01
High Weight PAHs	µg/g	0.16	0.022	**0.22**	*Mytilus edulis*	Reproduction - LOED	4	**7.4E+00**	7.4E-01
						Total PAHs		**1.4E+01**	**1.4E+00**
PCBs (Aroclors)									
Aroclor, Total	µg/g	5.5	**0.42**	**1.1**	*Palaemonetes pugio*	Mortality - LOED	5	**1.3E+01**	**5.0E+00**
						Total PCBs		**1.3E+01**	**5.0E+00**
Pesticides									
Dieldrin	µg/g	0.022	**0.01**	**0.08**	*Penaeus duorarum*	Mortality - LOED	6	**2.2E+00**	2.8E-01
Total DDx	µg/g	0.56	0.00018	**0.0018**	*Hyalella azteca*	Mortality - LD_{50}	7	**3.0E+03**	**3.0E+02**
						Total Pesticides		**3.0E+03**	**3.0E+02**
Dioxin-like Compounds									
TCDD TEQ (D/F)	µg/g	0.00022	**0.00000015**	**0.0000013**	*Crassostrea virginica*	Reproduction - LOED	8	**1.5E+03**	**1.7E+02**
TCDD TEQ (PCBs)	µg/g	0.000025	**0.00000015**	**0.0000013**	*Crassostrea virginica*	Reproduction - LOED	8	**1.7E+02**	**1.9E+01**
						Total TCDD TEQ		**1.6E+03**	**1.9E+02**
						Total		**5.1E+03**	**5.4E+02**

Notes:

[a] Exposure Point Concentrations (95% UCLs) presented in Table 4-1. TCDD Toxic Equivalencies based on fish TEF values, EPCs based on blue crab tissue data.

[b] Critical Body Residues (CBRs) are obtained from summary of tissue effects data presented in CSM Technical Memorandum #3 (Battelle, 2006).

[c] Hazard Quotient is the ratio of the EPC to the NOAEL or LOAEL CBR.

[1]Analyte is not included in the HI totals.

Non-bolded CBR values were estimated using a 10-fold extrapolation factor.

References:

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TABLE 6-3
CBR-BASED HAZARD QUOTIENTS FOR COPECS IN BLUE CRAB TISSUE
Current Conditions

Chemical	Units	EPC [a]	CBR [b]		Species	Endpoint	Reference	Hazard Quotients [c]	
			NOAEL	LOAEL				NOAEL	LOAEL

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(LOAEL) Hansen, D.J., P.R. Parrish, and J. Forester, 1974. Environ. Res. 7:363-373; ERED Ref ID URS102.
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Attachment 6

TABLE 6-4
SUMMARY OF TOXICITY REFERENCE VALUES FOR AQUATIC WILDLIFE RECEPTORS

Chemical Name	Large Bird		Large Mammal		Reference
	NOAEL	LOAEL	NOAEL	LOAEL	
TCDD TEQ (D/F) - bird	1.4E-06	1.4E-05			Nosek *et al.* , 1992a, b
TCDD TEQ (D/F) - mammal			8.0E-08	2.2E-06	Tillet *et al.* , 1996
TCDD TEQ (PCBs) - bird	1.4E-06	1.4E-05			Nosek *et al.* , 1992a, b
TCDD TEQ (PCBs) - mammal			8.0E-08	2.2E-06	Tillet *et al.* , 1996
Total TCDD TEQ - bird	1.4E-06	1.4E-05			Nosek *et al.* , 1992a, b
Total TCDD TEQ - mammal			8.0E-08	2.2E-06	Tillet *et al.* , 1996
Total PCBs (Aroclors) -birds	1.0E-01	4.0E-01			Chapman, 2003
Total PCBs (Aroclors) -mammals			8.0E-02	9.6E-02	Chapman, 2003
Total DDT-birds	2.8E-03	2.8E-02			Anderson *et al.* , 1975
Total DDT-mammals			8.0E-01	4.0E+00	Sample *et al.* , 1996
Dieldrin-birds	7.1E-02	3.8E+00			Nebeker *et al.* , 1992
Dieldrin-mammals			1.5E-02	3.0E-02	Harr *et al.* , 1970
LPAH-birds	-	-			Not necessary
LPAH-mammals			-	-	Not necessary
HPAH-birds	-	-			Not available
HPAH-mammals			1.0E+00	1.0E+01	Sample *et al.* , 1996
Copper-birds	4.1E+00	1.2E+01			USEPA, 2007
Copper-mammals			5.6E+00	9.3E+00	USEPA, 2007
Lead-birds	1.6E+00	3.3E+00			USEPA, 2005
Lead-mammals			4.7E+00	8.9E+00	USEPA, 2005
Mercury-birds	7.8E-03	7.8E-02			Heinz, 1979
Mercury-mammals			5.5E-02	1.8E-01	Wobeser *et al.,* 1976a,b

Notes:
Units in ug/g-day
The TRV selection process and review of relevant toxicological data are discussed in the document text.

References:
Sample, B.E., D.M. Opresko, and G.W. Suter II. 1996. Toxicological Benchmarks for Wildlife: 1996 Revision. Prepared for the U.S. Department of Energy. ES/ER/TM-86/R3. June.
USEPA. 2005. Ecological Screening Levels for Lead: Interim Final. OSWER Directive 9285.7-70. March.
USEPA. 2007. Ecological Screening Levels for Copper: Interim Final. OSWER Directive 9285.7-68. February.

TABLE 6-5
PARAMETER VALUES USED TO CALCULATE ESTIMATED DAILY INTAKE : Surficial sediment / MINK

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: CURRENT/FUTURE
MEDIUM: SEDIMENT
EXPOSURE MEDIUM: Surficial sediment
EXPOSURE POINT: RME
RECEPTOR: MINK

EXPOSURE ROUTE	PARAMETER SYMBOL	PARAMETER DEFINITION	UNITS	RME VALUE	RME RATIONALE/ REFERENCE	INTAKE EQUATION/ MODEL NAME
INGESTION	EDI_{sed}	ESTIMATED DAILY INTAKE VIA SEDIMENT INGESTION	mg/kg-d	calculated		SEDIMENT INTAKE-INGESTION
	C_{sed}	CHEMICAL CONCENTRATION IN SEDIMENT	mg/kg	chemical-specific		$EDI_{sed} = C_{sed} * IR_{sed} * SFF * EF * 1/BW$
	IR_{sed}	INGESTION RATE OF SEDIMENT	kg/day	0.0034	assumption	
	SFF	SITE FORAGING FREQUENCY	unitless	100%	Mitchell, 1961	
	EF	EXPOSURE FREQUENCY	unitless	100%	USEPA, 1993	
	BW	BODY WEIGHT	kg	0.57	Mitchell, 1961	

References:
Mitchell, J.L., 1961. Mink movements and populations on a Montana river; J. Wildl. Manage. 25:48-54.
USEPA, 1993. Wildlife Exposure Factors Handbook; United States Environmental Protection Agency, Office of Research and Development; EPA/600/R-93/187a; December 1993; Washington, D.C.

TABLE 6-6
CALCULATION OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS : Surficial sediment / MINK

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: CURRENT/FUTURE
MEDIUM: SEDIMENT
EXPOSURE MEDIUM: Surficial sediment
EXPOSURE POINT: RME
RECEPTOR: MINK

Analyte	Medium EPC	Medium EPC Units	Estimated Daily Intake[a]	Daily Intake Units	Reference Dose (NOAEL)[b]	Reference Dose (LOAEL)[b]	Reference Dose Units	Hazard Quotient (NOAEL)[c]	Hazard Quotient (LOAEL)[c]
Copper	2.4E+02	mg/kg	1.4E+00	mg/kg-d	5.6E+00	9.3E+00	mg/kg-d	2.5E-01	1.5E-01
Lead	3.7E+02	mg/kg	2.3E+00	mg/kg-d	4.7E+00	8.9E+00	mg/kg-d	4.8E-01	2.5E-01
Mercury	3.6E+00	mg/kg	2.2E-02	mg/kg-d	5.5E-02	1.8E-01	mg/kg-d	4.0E-01	1.2E-01
LPAH	4.1E+01	mg/kg	2.5E-01	mg/kg-d	-	-			
HPAH	6.1E+01	mg/kg	3.7E-01	mg/kg-d	1.0E+00	1.0E+01	mg/kg-d	3.7E-01	3.7E-02
Total PCBs	1.8E+00	mg/kg	1.1E-02	mg/kg-d	8.0E-02	9.6E-02	mg/kg-d	1.4E-01	1.1E-01
Dieldrin	1.9E-02	mg/kg	1.1E-04	mg/kg-d	1.5E-02	3.0E-02	mg/kg-d	7.5E-03	3.8E-03
Total DDx	3.8E-01	mg/kg	2.3E-03	mg/kg-d	8.0E-01	4.0E+00	mg/kg-d	2.8E-03	5.7E-04
TCDD TEQ (D/F)	1.6E-03	mg/kg	9.5E-06	mg/kg-d	8.0E-08	2.2E-06	mg/kg-d	**1.2E+02**	**4.2E+00**
TCDD TEQ (PCBs)	4.5E-05	mg/kg	2.7E-07	mg/kg-d	8.0E-08	2.2E-06	mg/kg-d	**3.4E+00**	1.2E-01
							HAZARD INDICES:	**1.2E+02**	**5.0E+00**

Notes:
a. Estimated Daily Intake (EDI) calculated using parameters presented in Table 6-5.
b. Reference Dose Values presented in Table 6-4. A dash indicates that no value is available.
c. Hazard Quotients (HQs) calculated by dividing the Estimated Daily Intake dose by either the NOAEL- or LOAEL-based Reference Dose.

TABLE 6-7
PARAMETER VALUES USED TO CALCULATE ESTIMATED DAILY INTAKE : Blue crab / MINK

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: CURRENT/FUTURE
MEDIUM: AQUATIC INVERTEBRATES
EXPOSURE MEDIUM: Blue crab
EXPOSURE POINT: RME
RECEPTOR: MINK

EXPOSURE ROUTE	PARAMETER SYMBOL	PARAMETER DEFINITION	UNITS	RME VALUE	RME RATIONALE/ REFERENCE	INTAKE EQUATION/ MODEL NAME
INGESTION	EDI_{invert}	ESTIMATED DAILY INTAKE VIA INVERTEBRATE INGESTION	mg/kg-d	calculated		INVERTEBRATE INTAKE-INGESTION $EDI_{invert} = C_{invert} * IR_{food} * P_{invert} * SFF * EF * 1/BW$
	C_{invert}	CHEMICAL CONCENTRATION IN INVERTEBRATES	mg/kg	chemical-specific		
	IR_{food}	INGESTION RATE OF FOOD	kg/day	0.17	USEPA, 1993	
	P_{invert}	PERCENT INVERTEBRATES IN DIET	unitless	20%	assumption	Where C_{invert} is estimated using site-specific tissue data or calculated using the following equation: $C_{invert} = C_{sed} * BAF_{invert}$
	SFF	SITE FORAGING FREQUENCY	unitless	100%	Mitchell, 1961	
	EF	EXPOSURE FREQUENCY	unitless	100%	USEPA, 1993	Bioaccumulation Factors [mg(ww tissue)/ kg(dw sediment)] provided separately.
	BW	BODY WEIGHT	kg	0.57	Mitchell, 1961	

References:
Mitchell, J.L., 1961. Mink movements and populations on a Montana river; J. Wildl. Manage. 25:48-54.
USEPA, 1993. Wildlife Exposure Factors Handbook; United States Environmental Protection Agency, Office of Research and Development; EPA/600/R-93/187a; December 1993; Washington, D.C.

TABLE 6-8
CALCULATION OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS : Blue crab / MINK

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: CURRENT/FUTURE
MEDIUM: AQUATIC INVERTEBRATES
EXPOSURE MEDIUM: Blue crab
EXPOSURE POINT: RME
RECEPTOR: MINK

Analyte	Medium EPC	Medium EPC Units	Estimated Daily Intake[a]	Daily Intake Units	Reference Dose (NOAEL)[b]	Reference Dose (LOAEL)[b]	Reference Dose Units	Hazard Quotient (NOAEL)[c]	Hazard Quotient (LOAEL)[c]
Copper	3.5E+01	mg/kg	2.1E+00	mg/kg-d	5.6E+00	9.3E+00	mg/kg-d	3.8E-01	2.3E-01
Lead	5.5E-01	mg/kg	3.3E-02	mg/kg-d	4.7E+00	8.9E+00	mg/kg-d	7.0E-03	3.7E-03
Mercury	9.7E-02	mg/kg	5.8E-03	mg/kg-d	5.5E-02	1.8E-01	mg/kg-d	1.1E-01	3.2E-02
LPAH	1.5E-01	mg/kg	9.1E-03	mg/kg-d	-	-			
HPAH	1.6E-01	mg/kg	9.8E-03	mg/kg-d	1.0E+00	1.0E+01	mg/kg-d	9.8E-03	9.8E-04
Total PCBs	5.5E+00	mg/kg	3.3E-01	mg/kg-d	8.0E-02	9.6E-02	mg/kg-d	**4.1E+00**	**3.5E+00**
Dieldrin	2.2E-02	mg/kg	1.3E-03	mg/kg-d	1.5E-02	3.0E-02	mg/kg-d	8.8E-02	4.4E-02
Total DDx	5.6E-01	mg/kg	3.4E-02	mg/kg-d	8.0E-01	4.0E+00	mg/kg-d	4.2E-02	8.4E-03
TCDD TEQ (D/F)	2.2E-04	mg/kg	1.3E-05	mg/kg-d	8.0E-08	2.2E-06	mg/kg-d	**1.7E+02**	**5.9E+00**
TCDD TEQ (PCBs)	4.4E-04	mg/kg	2.7E-05	mg/kg-d	8.0E-08	2.2E-06	mg/kg-d	**3.3E+02**	**1.2E+01**
							HAZARD INDICES:	**5.0E+02**	**2.2E+01**

Notes:
a. Estimated Daily Intake (EDI) calculated using parameters presented in Table 6-7.
b. Reference Dose Values presented in Table 6-4. A dash indicates that no value is available.
c. Hazard Quotients (HQs) calculated by dividing the Estimated Daily Intake dose by either the NOAEL- or LOAEL-based Reference Dose.

TABLE 6-9
PARAMETER VALUES USED TO CALCULATE ESTIMATED DAILY INTAKE : White perch/American eel / MINK

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: CURRENT/FUTURE
MEDIUM: FISH
EXPOSURE MEDIUM: White perch/American eel
EXPOSURE POINT: RME
RECEPTOR: MINK

EXPOSURE ROUTE	PARAMETER SYMBOL	PARAMETER DEFINITION	UNITS	RME VALUE	RME RATIONALE/ REFERENCE	INTAKE EQUATION/ MODEL NAME
INGESTION	EDI_{fish}	ESTIMATED DAILY INTAKE VIA FISH INGESTION	mg/kg-d	calculated		FISH INTAKE-INGESTION
	C_{fish}	CHEMICAL CONCENTRATION IN FISH	mg/kg	chemical-specific		$EDI_{fish} = C_{fish} * IR_{food} * P_{fish} * SFF * EF * 1/BW$
	IR_{food}	INGESTION RATE OF FOOD	kg/day	0.17	USEPA, 1993	
	P_{fish}	PERCENT FISH IN DIET	unitless	80%	assumption	Where C_{fish} is estimated using site-specific tissue data or estimated using the following equation:
	SFF	SITE FORAGING FREQUENCY	unitless	100%	Mitchell, 1961	$C_{fish} = C_{sed} * BAF_{fish}$
	EF	EXPOSURE FREQUENCY	unitless	100%	USEPA, 1993	Bioaccumulation Factors [mg(ww tissue)/ kg(dw sediment)] provided separately.
	BW	BODY WEIGHT	kg	0.57	Mitchell, 1961	

References:
Mitchell, J.L., 1961. Mink movements and populations on a Montana river; J. Wildl. Manage. 25:48-54.
USEPA, 1993. Wildlife Exposure Factors Handbook; United States Environmental Protection Agency, Office of Research and Development; EPA/600/R-93/187a; December 1993; Washington, D.C.

TABLE 6-10
CALCULATION OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS : White perch/American eel / MINK

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: CURRENT/FUTURE
MEDIUM: FISH
EXPOSURE MEDIUM: White perch/American eel
EXPOSURE POINT: RME
RECEPTOR: MINK

Analyte	Medium EPC	Medium EPC Units	Estimated Daily Intake[a]	Daily Intake Units	Reference Dose (NOAEL)[b]	Reference Dose (LOAEL)[b]	Reference Dose Units	Hazard Quotient (NOAEL)[c]	Hazard Quotient (LOAEL)[c]
Copper	2.5E+01	mg/kg	6.0E+00	mg/kg-d	5.6E+00	9.3E+00	mg/kg-d	**1.1E+00**	6.4E-01
Lead	6.3E-01	mg/kg	1.5E-01	mg/kg-d	4.7E+00	8.9E+00	mg/kg-d	3.2E-02	1.7E-02
Mercury	3.5E-01	mg/kg	8.4E-02	mg/kg-d	5.5E-02	1.8E-01	mg/kg-d	**1.5E+00**	4.6E-01
LPAH	1.7E-01	mg/kg	4.1E-02	mg/kg-d	-	-			
HPAH	1.0E-01	mg/kg	2.4E-02	mg/kg-d	1.0E+00	1.0E+01	mg/kg-d	2.4E-02	2.4E-03
Total PCBs	3.4E+00	mg/kg	8.2E-01	mg/kg-d	8.0E-02	9.6E-02	mg/kg-d	**1.0E+01**	**8.6E+00**
Dieldrin	2.7E-02	mg/kg	6.5E-03	mg/kg-d	1.5E-02	3.0E-02	mg/kg-d	4.3E-01	2.2E-01
Total DDx	5.2E-01	mg/kg	1.3E-01	mg/kg-d	8.0E-01	4.0E+00	mg/kg-d	1.6E-01	3.1E-02
TCDD TEQ (D/F)	2.5E-04	mg/kg	6.0E-05	mg/kg-d	8.0E-08	2.2E-06	mg/kg-d	**7.5E+02**	**2.7E+01**
TCDD TEQ (PCBs)	7.6E-05	mg/kg	1.8E-05	mg/kg-d	8.0E-08	2.2E-06	mg/kg-d	**2.3E+02**	**8.2E+00**
							HAZARD INDICES:	**1.0E+03**	**4.5E+01**

Notes:
a. Estimated Daily Intake (EDI) calculated using parameters presented in Table 6-9.
b. Reference Dose Values presented in Table 6-4. A dash indicates that no value is available.
c. Hazard Quotients (HQs) calculated by dividing the Estimated Daily Intake dose by either the NOAEL- or LOAEL-based Reference Dose.

TABLE 6-11
SUMMARY OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS USING NOAEL-BASED TRVs : MINK

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: CURRENT/FUTURE
EXPOSURE POINT: RME
RECEPTOR: MINK
TOTAL RISK (HI): 1.6E+03

Analyte	Exposure Medium[a]					Combined HQs[b]	Percent Contribution[c]
	Surface Water	Sediment	Aquatic Plants	Aquatic Invertebrates	Fish		
TCDD TEQ (D/F)		1.2E+02		1.7E+02	7.5E+02	***1.0E+03***	***64%***
TCDD TEQ (PCBs)		3.4E+00		3.3E+02	2.3E+02	***5.6E+02***	***35%***
Total PCBs		1.4E-01		4.1E+00	1.0E+01	***1.5E+01***	1%
Mercury		4.0E-01		1.1E-01	1.5E+00	***2.0E+00***	0%
Copper		2.5E-01		3.8E-01	1.1E+00	***1.7E+00***	0%
Dieldrin		7.5E-03		8.8E-02	4.3E-01	5.3E-01	0%
Lead		4.8E-01		7.0E-03	3.2E-02	5.2E-01	0%
HPAH		3.7E-01		9.8E-03	2.4E-02	4.0E-01	0%
Total DDx		2.8E-03		4.2E-02	1.6E-01	2.0E-01	0%
LPAH							
TOTAL MEDIUM-SPECIFIC RISK	**-**	**1.2E+02**	**-**	**5.0E+02**	**1.0E+03**	**1.6E+03**	
PERCENTAGE OF TOTAL RISK		**8%**		**31%**	**61%**	**100%**	

Notes:
a. Hazard Quotients presented by exposure medium; a blank cell indicates that the analyte was not a COPC for that medium; a dash entry indicates that there was no assumed exposure to that medium.
b. Combined risk across all media exposures.
c. Relative contribution of COPC to total risk associated with the ingestion exposure pathway.

TABLE 6-12
SUMMARY OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS USING LOAEL-BASED TRVs : MINK

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: CURRENT/FUTURE
EXPOSURE POINT: RME
RECEPTOR: MINK
TOTAL RISK (HI): 7.2E+01

Analyte	Exposure Medium[a]					Combined HQs[b]	Percent Contribution[c]
	Surface Water	Sediment	Aquatic Plants	Aquatic Invertebrates	Fish		
TCDD TEQ (D/F)		4.2E+00		5.9E+00	2.7E+01	***3.7E+01***	***52%***
TCDD TEQ (PCBs)		1.2E-01		1.2E+01	8.2E+00	***2.0E+01***	***28%***
Total PCBs		1.1E-01		3.5E+00	8.6E+00	***1.2E+01***	***17%***
Copper		1.5E-01		2.3E-01	6.4E-01	***1.0E+00***	1%
Mercury		1.2E-01		3.2E-02	4.6E-01	6.2E-01	1%
Lead		2.5E-01		3.7E-03	1.7E-02	2.7E-01	0%
Dieldrin		3.8E-03		4.4E-02	2.2E-01	2.6E-01	0%
Total DDx		5.7E-04		8.4E-03	3.1E-02	4.0E-02	0%
HPAH		3.7E-02		9.8E-04	2.4E-03	4.0E-02	0%
LPAH							
TOTAL MEDIUM-SPECIFIC RISK	**-**	**5.0E+00**	**-**	**2.2E+01**	**4.5E+01**	**7.2E+01**	
PERCENTAGE OF TOTAL RISK		**7%**		**30%**	**63%**	**100%**	

Notes:
a. Hazard Quotients presented by exposure medium; a blank cell indicates that the analyte was not a COPC for that medium; a dash entry indicates that there was no assumed exposure to that medium.
b. Combined risk across all media exposures.
c. Relative contribution of COPC to total risk associated with the ingestion exposure pathway.

TABLE 6-13
PARAMETER VALUES USED TO CALCULATE ESTIMATED DAILY INTAKE : Surficial sediment / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: CURRENT/FUTURE
MEDIUM: SEDIMENT
EXPOSURE MEDIUM: Surficial sediment
EXPOSURE POINT: RME (with WP/AE diet)
RECEPTOR: HERON

EXPOSURE ROUTE	PARAMETER SYMBOL	PARAMETER DEFINITION	UNITS	RME VALUE	RME RATIONALE/ REFERENCE	INTAKE EQUATION/ MODEL NAME
INGESTION	EDI_{sed}	ESTIMATED DAILY INTAKE VIA SEDIMENT INGESTION	mg/kg-d	calculated		SEDIMENT INTAKE-INGESTION
	C_{sed}	CHEMICAL CONCENTRATION IN SEDIMENT	mg/kg	chemical-specific		$EDI_{sed} = C_{sed} * IR_{sed} * SFF * EF * 1/BW$
	IR_{sed}	INGESTION RATE OF SEDIMENT	kg/day	0.019	assumption	
	SFF	SITE FORAGING FREQUENCY	unitless	100%	Bayer, 1978	
	EF	EXPOSURE FREQUENCY	unitless	58%	USEPA, 1993	
	BW	BODY WEIGHT	kg	2.2	USEPA, 1993	

References:

Bayer,R.D., 1978. Aspects of an Oregon estuarine great blue heron population; In: Sprunt, A., J. Ogden, S. Winkler, eds. Wading Birds; Natl. Audubon Soc. Res. Rep. 7:213-217.

USEPA, 1993. Wildlife Exposure Factors Handbook; United States Environmental Protection Agency, Office of Research and Development; EPA/600/R-93/187a; December 1993; Washington, D.C.

TABLE 6-14
CALCULATION OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS : Surficial sediment / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: CURRENT/FUTURE
MEDIUM: SEDIMENT
EXPOSURE MEDIUM: Surficial sediment
EXPOSURE POINT: RME (with WP/AE diet)
RECEPTOR: HERON

Analyte	Medium EPC	Medium EPC Units	Estimated Daily Intake[a]	Daily Intake Units	Reference Dose (NOAEL)[b]	Reference Dose (LOAEL)[b]	Reference Dose Units	Hazard Quotient (NOAEL)[c]	Hazard Quotient (LOAEL)[c]
Copper	2.4E+02	mg/kg	1.2E+00	mg/kg-d	4.1E+00	1.2E+01	mg/kg-d	3.0E-01	1.0E-01
Lead	3.7E+02	mg/kg	1.9E+00	mg/kg-d	1.6E+00	3.3E+00	mg/kg-d	**1.2E+00**	5.9E-01
Mercury	3.6E+00	mg/kg	1.9E-02	mg/kg-d	7.8E-03	7.8E-02	mg/kg-d	**2.4E+00**	2.4E-01
LPAH	4.1E+01	mg/kg	2.1E-01	mg/kg-d	-	-			
HPAH	6.1E+01	mg/kg	3.1E-01	mg/kg-d	-	-			
Total PCBs	1.8E+00	mg/kg	9.3E-03	mg/kg-d	1.0E-01	4.0E-01	mg/kg-d	9.3E-02	2.3E-02
Dieldrin	1.9E-02	mg/kg	9.6E-05	mg/kg-d	7.1E-02	3.8E+00	mg/kg-d	1.4E-03	2.5E-05
Total DDx	3.8E-01	mg/kg	1.9E-03	mg/kg-d	2.8E-03	2.8E-02	mg/kg-d	6.9E-01	6.9E-02
TCDD TEQ (D/F)	1.8E-03	mg/kg	9.1E-06	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	**6.5E+00**	6.5E-01
TCDD TEQ (PCBs)	7.5E-04	mg/kg	3.9E-06	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	**2.8E+00**	2.8E-01
							HAZARD INDICES:	**1.4E+01**	**1.9E+00**

Notes:
a. Estimated Daily Intake (EDI) calculated using parameters presented in Table 6-13.
b. Reference Dose Values presented in Table 6-4. A dash indicates that no value is available.
c. Hazard Quotients (HQs) calculated by dividing the Estimated Daily Intake dose by either the NOAEL- or LOAEL-based Reference Dose.

TABLE 6-15
PARAMETER VALUES USED TO CALCULATE ESTIMATED DAILY INTAKE : Blue crab / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: CURRENT/FUTURE
MEDIUM: AQUATIC INVERTEBRATES
EXPOSURE MEDIUM: Blue crab
EXPOSURE POINT: RME (with WP/AE diet)
RECEPTOR: HERON

EXPOSURE ROUTE	PARAMETER SYMBOL	PARAMETER DEFINITION	UNITS	RME VALUE	RME RATIONALE/ REFERENCE	INTAKE EQUATION/ MODEL NAME
INGESTION	EDI_{invert}	ESTIMATED DAILY INTAKE VIA INVERTEBRATE INGESTION	mg/kg-d	calculated		INVERTEBRATE INTAKE-INGESTION $EDI_{invert} = C_{invert} * IR_{food} * P_{invert} * SFF * EF * 1/BW$
	C_{invert}	CHEMICAL CONCENTRATION IN INVERTEBRATES	mg/kg	chemical-specific		
	IR_{food}	INGESTION RATE OF FOOD	kg/day	0.39	Kushlan, 1978	
	P_{invert}	PERCENT INVERTEBRATES IN DIET	unitless	15%	assumption	Where C_{invert} is estimated using site-specific tissue data or calculated using the following equation: $C_{invert} = C_{sed} * BAF_{invert}$
	SFF	SITE FORAGING FREQUENCY	unitless	100%	Bayer, 1978	
	EF	EXPOSURE FREQUENCY	unitless	58%	USEPA, 1993	Bioaccumulation Factors [mg(ww tissue)/ kg(dw sediment)] provided separately.
	BW	BODY WEIGHT	kg	2.2	USEPA, 1993	

References:

Bayer,R.D., 1978. Aspects of an Oregon estuarine great blue heron population; In: Sprunt, A., J. Ogden, S. Winkler, eds. Wading Birds; Natl. Audubon Soc. Res. Rep. 7:213-217.

Kushlan, J.A., 1978. Feeding ecology of wading birds; In: Sprunt, A., J. Ogden, S. Winkler, eds. Wading Birds; Natl. Audubon Soc. Res. Rep. 7:213-217.

USEPA, 1993. Wildlife Exposure Factors Handbook; United States Environmental Protection Agency, Office of Research and Development; EPA/600/R-93/187a; December 1993; Washington, D.C.

TABLE 6-16
CALCULATION OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS : Blue crab / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: CURRENT/FUTURE
MEDIUM: AQUATIC INVERTEBRATES
EXPOSURE MEDIUM: Blue crab
EXPOSURE POINT: RME (with WP/AE diet)
RECEPTOR: HERON

Analyte	Medium EPC	Medium EPC Units	Estimated Daily Intake[a]	Daily Intake Units	Reference Dose (NOAEL)[b]	Reference Dose (LOAEL)[b]	Reference Dose Units	Hazard Quotient (NOAEL)[c]	Hazard Quotient (LOAEL)[c]
Copper	3.5E+01	mg/kg	5.4E-01	mg/kg-d	4.1E+00	1.2E+01	mg/kg-d	1.3E-01	4.5E-02
Lead	5.5E-01	mg/kg	8.4E-03	mg/kg-d	1.6E+00	3.3E+00	mg/kg-d	5.2E-03	2.6E-03
Mercury	9.7E-02	mg/kg	1.5E-03	mg/kg-d	7.8E-03	7.8E-02	mg/kg-d	1.9E-01	1.9E-02
LPAH	1.5E-01	mg/kg	2.3E-03	mg/kg-d	-	-			
HPAH	1.6E-01	mg/kg	2.5E-03	mg/kg-d	-	-			
Total PCBs	5.5E+00	mg/kg	8.5E-02	mg/kg-d	1.0E-01	4.0E-01	mg/kg-d	8.5E-01	2.1E-01
Dieldrin	2.2E-02	mg/kg	3.4E-04	mg/kg-d	7.1E-02	3.8E+00	mg/kg-d	4.8E-03	8.9E-05
Total DDx	5.6E-01	mg/kg	8.6E-03	mg/kg-d	2.8E-03	2.8E-02	mg/kg-d	**3.1E+00**	3.1E-01
TCDD TEQ (D/F)	2.7E-04	mg/kg	4.2E-06	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	**3.0E+00**	3.0E-01
TCDD TEQ (PCBs)	2.8E-03	mg/kg	4.3E-05	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	**3.1E+01**	**3.1E+00**
							HAZARD INDICES:	**3.8E+01**	**4.0E+00**

Notes:
a. Estimated Daily Intake (EDI) calculated using parameters presented in Table 6-15.
b. Reference Dose Values presented in Table 6-4. A dash indicates that no value is available.
c. Hazard Quotients (HQs) calculated by dividing the Estimated Daily Intake dose by either the NOAEL- or LOAEL-based Reference Dose.

TABLE 6-17
PARAMETER VALUES USED TO CALCULATE ESTIMATED DAILY INTAKE : White perch/American eel / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: CURRENT/FUTURE
MEDIUM: FISH
EXPOSURE MEDIUM: White perch/American eel
EXPOSURE POINT: RME (with WP/AE diet)
RECEPTOR: HERON

EXPOSURE ROUTE	PARAMETER SYMBOL	PARAMETER DEFINITION	UNITS	RME VALUE	RME RATIONALE/ REFERENCE	INTAKE EQUATION/ MODEL NAME
INGESTION	EDI_{fish}	ESTIMATED DAILY INTAKE VIA FISH INGESTION	mg/kg-d	calculated		FISH INTAKE-INGESTION
	C_{fish}	CHEMICAL CONCENTRATION IN FISH	mg/kg	chemical-specific		$EDI_{fish} = C_{fish} * IR_{food} * P_{fish} *$ SFF * EF * 1/BW
	IR_{food}	INGESTION RATE OF FOOD	kg/day	0.39	Kushlan, 1978	
	P_{fish}	PERCENT FISH IN DIET	unitless	85%	assumption	Where C_{fish} is estimated using site-specific tissue data or estimated using the following equation:
	SFF	SITE FORAGING FREQUENCY	unitless	100%	Bayer, 1978	$C_{fish} = C_{sed} * BAF_{fish}$
	EF	EXPOSURE FREQUENCY	unitless	58%	USEPA, 1993	Bioaccumulation Factors [mg(ww tissue)/ kg(dw sediment)] provided separately.
	BW	BODY WEIGHT	kg	2.2	USEPA, 1993	

References:

Bayer,R.D., 1978. Aspects of an Oregon estuarine great blue heron population; In: Sprunt, A., J. Ogden, S. Winkler, eds. Wading Birds; Natl. Audubon Soc. Res. Rep. 7:213-217.

Kushlan, J.A., 1978. Feeding ecology of wading birds; In: Sprunt, A., J. Ogden, S. Winkler, eds. Wading Birds; Natl. Audubon Soc. Res. Rep. 7:213-217.

USEPA, 1993. Wildlife Exposure Factors Handbook; United States Environmental Protection Agency, Office of Research and Development; EPA/600/R-93/187a; December 1993; Washington, D.C.

TABLE 6-18
CALCULATION OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS : White perch/American eel / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: CURRENT/FUTURE
MEDIUM: FISH
EXPOSURE MEDIUM: White perch/American eel
EXPOSURE POINT: RME (with WP/AE diet)
RECEPTOR: HERON

Analyte	Medium EPC	Medium EPC Units	Estimated Daily Intake[a]	Daily Intake Units	Reference Dose (NOAEL)[b]	Reference Dose (LOAEL)[b]	Reference Dose Units	Hazard Quotient (NOAEL)[c]	Hazard Quotient (LOAEL)[c]
Copper	2.5E+01	mg/kg	2.2E+00	mg/kg-d	4.1E+00	1.2E+01	mg/kg-d	5.4E-01	1.8E-01
Lead	6.3E-01	mg/kg	5.5E-02	mg/kg-d	1.6E+00	3.3E+00	mg/kg-d	3.4E-02	1.7E-02
Mercury	3.5E-01	mg/kg	3.0E-02	mg/kg-d	7.8E-03	7.8E-02	mg/kg-d	**3.9E+00**	3.9E-01
LPAH	1.7E-01	mg/kg	1.5E-02	mg/kg-d	-	-			
HPAH	1.0E-01	mg/kg	8.8E-03	mg/kg-d	-	-			
Total PCBs	3.4E+00	mg/kg	3.0E-01	mg/kg-d	1.0E-01	4.0E-01	mg/kg-d	**3.0E+00**	7.5E-01
Dieldrin	2.7E-02	mg/kg	2.4E-03	mg/kg-d	7.1E-02	3.8E+00	mg/kg-d	3.3E-02	6.2E-04
Total DDx	5.2E-01	mg/kg	4.5E-02	mg/kg-d	2.8E-03	2.8E-02	mg/kg-d	**1.6E+01**	**1.6E+00**
TCDD TEQ (D/F)	2.8E-04	mg/kg	2.4E-05	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	**1.7E+01**	**1.7E+00**
TCDD TEQ (PCBs)	8.6E-04	mg/kg	7.5E-05	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	**5.4E+01**	**5.4E+00**
							HAZARD INDICES:	**9.5E+01**	**1.0E+01**

Notes:
a. Estimated Daily Intake (EDI) calculated using parameters presented in Table 6-17.
b. Reference Dose Values presented in Table 6-4. A dash indicates that no value is available.
c. Hazard Quotients (HQs) calculated by dividing the Estimated Daily Intake dose by either the NOAEL- or LOAEL-based Reference Dose.

TABLE 6-19
SUMMARY OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS USING NOAEL-BASED TRVs : HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: CURRENT/FUTURE
EXPOSURE POINT: RME (with WP/AE diet)
RECEPTOR: HERON
TOTAL RISK (HI): 1.5E+02

Analyte	Exposure Medium[a]					Combined HQs[b]	Percent Contribution[c]
	Surface Water	Sediment	Aquatic Plants	Aquatic Invertebrates	Fish		
TCDD TEQ (PCBs)		2.8E+00		3.1E+01	5.4E+01	***8.7E+01***	***59%***
TCDD TEQ (D/F)		6.5E+00		3.0E+00	1.7E+01	***2.7E+01***	***18%***
Total DDx		6.9E-01		3.1E+00	1.6E+01	***2.0E+01***	***14%***
Mercury		2.4E+00	-	1.9E-01	3.9E+00	***6.5E+00***	4%
Total PCBs		9.3E-02	-	8.5E-01	3.0E+00	***3.9E+00***	3%
Lead		1.2E+00	-	5.2E-03	3.4E-02	***1.2E+00***	1%
Copper		3.0E-01	-	1.3E-01	5.4E-01	9.7E-01	1%
Dieldrin		1.4E-03		4.8E-03	3.3E-02	3.9E-02	0%
LPAH							
HPAH							
TOTAL MEDIUM-SPECIFIC RISK	**-**	**1.4E+01**	**-**	**3.8E+01**	**9.5E+01**	**1.5E+02**	
PERCENTAGE OF TOTAL RISK		**9%**		**26%**	**65%**	**100%**	

Notes:
a. Hazard Quotients presented by exposure medium; a blank cell indicates that the analyte was not a COPC for that medium; a dash entry indicates that there was no assumed exposure to that medium.
b. Combined risk across all media exposures.
c. Relative contribution of COPC to total risk associated with the ingestion exposure pathway.

TABLE 6-20
SUMMARY OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS USING LOAEL-BASED TRVs : HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: CURRENT/FUTURE
EXPOSURE POINT: RME (with WP/AE diet)
RECEPTOR: HERON
TOTAL RISK (HI): 1.6E+01

Analyte	Exposure Medium[a]					Combined HQs[b]	Percent Contribution[c]
	Surface Water	Sediment	Aquatic Plants	Aquatic Invertebrates	Fish		
TCDD TEQ (PCBs)		2.8E-01		3.1E+00	5.4E+00	***8.7E+00***	***55%***
TCDD TEQ (D/F)		6.5E-01		3.0E-01	1.7E+00	***2.7E+00***	***17%***
Total DDx		6.9E-02		3.1E-01	1.6E+00	***2.0E+00***	***12%***
Total PCBs		2.3E-02	-	2.1E-01	7.5E-01	9.8E-01	6%
Mercury		2.4E-01	-	1.9E-02	3.9E-01	6.5E-01	4%
Lead		5.9E-01	-	2.6E-03	1.7E-02	6.1E-01	4%
Copper		1.0E-01	-	4.5E-02	1.8E-01	3.2E-01	2%
Dieldrin		2.5E-05		8.9E-05	6.2E-04	7.4E-04	0%
LPAH							
HPAH							
TOTAL MEDIUM-SPECIFIC RISK	**-**	**1.9E+00**	**-**	**4.0E+00**	**1.0E+01**	**1.6E+01**	
PERCENTAGE OF TOTAL RISK		**12%**		**25%**	**63%**	**100%**	

Notes:
a. Hazard Quotients presented by exposure medium; a blank cell indicates that the analyte was not a COPC for that medium; a dash entry indicates that there was no assumed exposure to that medium.
b. Combined risk across all media exposures.
c. Relative contribution of COPC to total risk associated with the ingestion exposure pathway.

Attachment 6

TABLE 6-21
PARAMETER VALUES USED TO CALCULATE ESTIMATED DAILY INTAKE : Surficial sediment / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: CURRENT/FUTURE
MEDIUM: SEDIMENT
EXPOSURE MEDIUM: Surficial sediment
EXPOSURE POINT: RME (with mummichog diet)
RECEPTOR: HERON

EXPOSURE ROUTE	PARAMETER SYMBOL	PARAMETER DEFINITION	UNITS	RME VALUE	RME RATIONALE/ REFERENCE	INTAKE EQUATION/ MODEL NAME
INGESTION	EDI_{sed}	ESTIMATED DAILY INTAKE VIA SEDIMENT INGESTION	mg/kg-d	calculated		SEDIMENT INTAKE-INGESTION
	C_{sed}	CHEMICAL CONCENTRATION IN SEDIMENT	mg/kg	chemical-specific		$EDI_{sed} = C_{sed} * IR_{sed} * SFF * EF * 1/BW$
	IR_{sed}	INGESTION RATE OF SEDIMENT	kg/day	0.019	assumption	
	SFF	SITE FORAGING FREQUENCY	unitless	100%	Bayer, 1978	
	EF	EXPOSURE FREQUENCY	unitless	58%	USEPA, 1993	
	BW	BODY WEIGHT	kg	2.2	USEPA, 1993	

References:

Bayer,R.D., 1978. Aspects of an Oregon estuarine great blue heron population; In: Sprunt, A., J. Ogden, S. Winkler, eds. Wading Birds; Natl. Audubon Soc. Res. Rep. 7:213-217.

USEPA, 1993. Wildlife Exposure Factors Handbook; United States Environmental Protection Agency, Office of Research and Development; EPA/600/R-93/187a; December 1993; Washington, D.C.

Attachment 6

TABLE 6-22
CALCULATION OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS : Surficial sediment / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: CURRENT/FUTURE
MEDIUM: SEDIMENT
EXPOSURE MEDIUM: Surficial sediment
EXPOSURE POINT: RME (with mummichog diet)
RECEPTOR: HERON

Analyte	Medium EPC	Medium EPC Units	Estimated Daily Intake[a]	Daily Intake Units	Reference Dose (NOAEL)[b]	Reference Dose (LOAEL)[b]	Reference Dose Units	Hazard Quotient (NOAEL)[c]	Hazard Quotient (LOAEL)[c]
Copper	2.4E+02	mg/kg	1.2E+00	mg/kg-d	4.1E+00	1.2E+01	mg/kg-d	3.0E-01	1.0E-01
Lead	3.7E+02	mg/kg	1.9E+00	mg/kg-d	1.6E+00	3.3E+00	mg/kg-d	**1.2E+00**	5.9E-01
Mercury	3.6E+00	mg/kg	1.9E-02	mg/kg-d	7.8E-03	7.8E-02	mg/kg-d	**2.4E+00**	2.4E-01
LPAH	4.1E+01	mg/kg	2.1E-01	mg/kg-d	-	-			
HPAH	6.1E+01	mg/kg	3.1E-01	mg/kg-d	-	-			
Total PCBs	1.8E+00	mg/kg	9.3E-03	mg/kg-d	1.0E-01	4.0E-01	mg/kg-d	9.3E-02	2.3E-02
Dieldrin	1.9E-02	mg/kg	9.6E-05	mg/kg-d	7.1E-02	3.8E+00	mg/kg-d	1.4E-03	2.5E-05
Total DDx	3.8E-01	mg/kg	1.9E-03	mg/kg-d	2.8E-03	2.8E-02	mg/kg-d	6.9E-01	6.9E-02
TCDD TEQ (D/F)	1.8E-03	mg/kg	9.1E-06	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	**6.5E+00**	6.5E-01
TCDD TEQ (PCBs)	7.5E-04	mg/kg	3.9E-06	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	**2.8E+00**	2.8E-01
							HAZARD INDICES:	**1.4E+01**	**1.9E+00**

Notes:
a. Estimated Daily Intake (EDI) calculated using parameters presented in Table 6-21.
b. Reference Dose Values presented in Table 6-4. A dash indicates that no value is available.
c. Hazard Quotients (HQs) calculated by dividing the Estimated Daily Intake dose by either the NOAEL- or LOAEL-based Reference Dose.

Attachment 6

TABLE 6-23
PARAMETER VALUES USED TO CALCULATE ESTIMATED DAILY INTAKE : Blue crab / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: CURRENT/FUTURE
MEDIUM: AQUATIC INVERTEBRATES
EXPOSURE MEDIUM: Blue crab
EXPOSURE POINT: RME (with mummichog diet)
RECEPTOR: HERON

EXPOSURE ROUTE	PARAMETER SYMBOL	PARAMETER DEFINITION	UNITS	RME VALUE	RME RATIONALE/ REFERENCE	INTAKE EQUATION/ MODEL NAME
INGESTION	EDI_{invert}	ESTIMATED DAILY INTAKE VIA INVERTEBRATE INGESTION	mg/kg-d	calculated		INVERTEBRATE INTAKE-INGESTION $EDI_{invert} = C_{invert} * IR_{food} * P_{invert} * SFF * EF * 1/BW$
	C_{invert}	CHEMICAL CONCENTRATION IN INVERTEBRATES	mg/kg	chemical-specific		
	IR_{food}	INGESTION RATE OF FOOD	kg/day	0.39	Kushlan, 1978	
	P_{invert}	PERCENT INVERTEBRATES IN DIET	unitless	15%	assumption	Where C_{invert} is estimated using site-specific tissue data or calculated using the following equation: $C_{invert} = C_{sed} * BAF_{invert}$
	SFF	SITE FORAGING FREQUENCY	unitless	100%	Bayer, 1978	
	EF	EXPOSURE FREQUENCY	unitless	58%	USEPA, 1993	Bioaccumulation Factors [mg(ww tissue)/ kg(dw sediment)] provided separately.
	BW	BODY WEIGHT	kg	2.2	USEPA, 1993	

References:

Bayer,R.D., 1978. Aspects of an Oregon estuarine great blue heron population; In: Sprunt, A., J. Ogden, S. Winkler, eds. Wading Birds; Natl. Audubon Soc. Res. Rep. 7:213-217.

Kushlan, J.A., 1978. Feeding ecology of wading birds; In: Sprunt, A., J. Ogden, S. Winkler, eds. Wading Birds; Natl. Audubon Soc. Res. Rep. 7:213-217.

USEPA, 1993. Wildlife Exposure Factors Handbook; United States Environmental Protection Agency, Office of Research and Development; EPA/600/R-93/187a; December 1993; Washington, D.C.

Attachment 6

TABLE 6-24
CALCULATION OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS : Blue crab / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: CURRENT/FUTURE
MEDIUM: AQUATIC INVERTEBRATES
EXPOSURE MEDIUM: Blue crab
EXPOSURE POINT: RME (with mummichog diet)
RECEPTOR: HERON

Analyte	Medium EPC	Medium EPC Units	Estimated Daily Intake[a]	Daily Intake Units	Reference Dose (NOAEL)[b]	Reference Dose (LOAEL)[b]	Reference Dose Units	Hazard Quotient (NOAEL)[c]	Hazard Quotient (LOAEL)[c]
Copper	3.5E+01	mg/kg	5.4E-01	mg/kg-d	4.1E+00	1.2E+01	mg/kg-d	1.3E-01	4.5E-02
Lead	5.5E-01	mg/kg	8.4E-03	mg/kg-d	1.6E+00	3.3E+00	mg/kg-d	5.2E-03	2.6E-03
Mercury	9.7E-02	mg/kg	1.5E-03	mg/kg-d	7.8E-03	7.8E-02	mg/kg-d	1.9E-01	1.9E-02
LPAH	1.5E-01	mg/kg	2.3E-03	mg/kg-d	-	-			
HPAH	1.6E-01	mg/kg	2.5E-03	mg/kg-d	-	-			
Total PCBs	5.5E+00	mg/kg	8.5E-02	mg/kg-d	1.0E-01	4.0E-01	mg/kg-d	8.5E-01	2.1E-01
Dieldrin	2.2E-02	mg/kg	3.4E-04	mg/kg-d	7.1E-02	3.8E+00	mg/kg-d	4.8E-03	8.9E-05
Total DDx	5.6E-01	mg/kg	8.6E-03	mg/kg-d	2.8E-03	2.8E-02	mg/kg-d	**3.1E+00**	3.1E-01
TCDD TEQ (D/F)	2.7E-04	mg/kg	4.2E-06	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	**3.0E+00**	3.0E-01
TCDD TEQ (PCBs)	2.8E-03	mg/kg	4.3E-05	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	**3.1E+01**	**3.1E+00**
							HAZARD INDICES:	**3.8E+01**	**4.0E+00**

Notes:
a. Estimated Daily Intake (EDI) calculated using parameters presented in Table 6-23.
b. Reference Dose Values presented in Table 6-4. A dash indicates that no value is available.
c. Hazard Quotients (HQs) calculated by dividing the Estimated Daily Intake dose by either the NOAEL- or LOAEL-based Reference Dose.

Attachment 6

TABLE 6-25
PARAMETER VALUES USED TO CALCULATE ESTIMATED DAILY INTAKE : Mummichog / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: CURRENT/FUTURE
MEDIUM: FISH
EXPOSURE MEDIUM: Mummichog
EXPOSURE POINT: RME (with mummichog diet)
RECEPTOR: HERON

EXPOSURE ROUTE	PARAMETER SYMBOL	PARAMETER DEFINITION	UNITS	RME VALUE	RME RATIONALE/ REFERENCE	INTAKE EQUATION/ MODEL NAME
INGESTION	EDI_{fish}	ESTIMATED DAILY INTAKE VIA FISH INGESTION	mg/kg-d	calculated		FISH INTAKE-INGESTION
	C_{fish}	CHEMICAL CONCENTRATION IN FISH	mg/kg	chemical-specific		$EDI_{fish} = C_{fish} * IR_{food} * P_{fish} * SFF * EF * 1/BW$
	IR_{food}	INGESTION RATE OF FOOD	kg/day	0.39	Kushlan, 1978	
	P_{fish}	PERCENT FISH IN DIET	unitless	85%	assumption	Where C_{fish} is estimated using site-specific tissue data or estimated using the following equation:
	SFF	SITE FORAGING FREQUENCY	unitless	100%	Bayer, 1978	$C_{fish} = C_{sed} * BAF_{fish}$
	EF	EXPOSURE FREQUENCY	unitless	58%	USEPA, 1993	Bioaccumulation Factors [mg(ww tissue)/ kg(dw sediment)] provided separately.
	BW	BODY WEIGHT	kg	2.2	USEPA, 1993	

References:

Bayer,R.D., 1978. Aspects of an Oregon estuarine great blue heron population; In: Sprunt, A., J. Ogden, S. Winkler, eds. Wading Birds; Natl. Audubon Soc. Res. Rep. 7:213-217.

Kushlan, J.A., 1978. Feeding ecology of wading birds; In: Sprunt, A., J. Ogden, S. Winkler, eds. Wading Birds; Natl. Audubon Soc. Res. Rep. 7:213-217.

USEPA, 1993. Wildlife Exposure Factors Handbook; United States Environmental Protection Agency, Office of Research and Development; EPA/600/R-93/187a; December 1993; Washington, D.C.

Attachment 6

TABLE 6-26
CALCULATION OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS : Mummichog / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: CURRENT/FUTURE
MEDIUM: FISH
EXPOSURE MEDIUM: Mummichog
EXPOSURE POINT: RME (with mummichog diet)
RECEPTOR: HERON

Analyte	Medium EPC	Medium EPC Units	Estimated Daily Intake[a]	Daily Intake Units	Reference Dose (NOAEL)[b]	Reference Dose (LOAEL)[b]	Reference Dose Units	Hazard Quotient (NOAEL)[c]	Hazard Quotient (LOAEL)[c]
Copper	3.9E+00	mg/kg	3.4E-01	mg/kg-d	4.1E+00	1.2E+01	mg/kg-d	8.4E-02	2.8E-02
Lead	1.2E+00	mg/kg	1.1E-01	mg/kg-d	1.6E+00	3.3E+00	mg/kg-d	6.7E-02	3.3E-02
Mercury	4.1E-02	mg/kg	3.6E-03	mg/kg-d	7.8E-03	7.8E-02	mg/kg-d	4.6E-01	4.6E-02
LPAH	1.7E-01	mg/kg	1.5E-02	mg/kg-d	-	-			
HPAH	6.5E-02	mg/kg	5.7E-03	mg/kg-d	-	-			
Total PCBs	7.2E-01	mg/kg	6.3E-02	mg/kg-d	1.0E-01	4.0E-01	mg/kg-d	6.3E-01	1.6E-01
Dieldrin	4.2E-03	mg/kg	3.7E-04	mg/kg-d	7.1E-02	3.8E+00	mg/kg-d	5.2E-03	9.7E-05
Total DDx	8.8E-02	mg/kg	7.7E-03	mg/kg-d	2.8E-03	2.8E-02	mg/kg-d	**2.7E+00**	2.7E-01
TCDD TEQ (D/F)	1.5E-04	mg/kg	1.3E-05	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	**9.4E+00**	9.4E-01
TCDD TEQ (PCBs)	2.0E-04	mg/kg	1.7E-05	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	**1.2E+01**	**1.2E+00**
							HAZARD INDICES:	**2.6E+01**	**2.7E+00**

Notes:
a. Estimated Daily Intake (EDI) calculated using parameters presented in Table 6-25.
b. Reference Dose Values presented in Table 6-4. A dash indicates that no value is available.
c. Hazard Quotients (HQs) calculated by dividing the Estimated Daily Intake dose by either the NOAEL- or LOAEL-based Reference Dose.

Attachment 6

TABLE 6-27
SUMMARY OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS USING NOAEL-BASED TRVs : HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: CURRENT/FUTURE
EXPOSURE POINT: RME (with mummichog diet)
RECEPTOR: HERON
TOTAL RISK (HI): 7.8E+01

Analyte	Exposure Medium[a]					Combined HQs[b]	Percent Contribution[c]
	Surface Water	Sediment	Aquatic Plants	Aquatic Invertebrates	Fish		
TCDD TEQ (PCBs)		2.8E+00		3.1E+01	1.2E+01	***4.6E+01***	***59%***
TCDD TEQ (D/F)		6.5E+00		3.0E+00	9.4E+00	***1.9E+01***	***24%***
Total DDx		6.9E-01		3.1E+00	2.7E+00	***6.5E+00***	8%
Mercury		2.4E+00		1.9E-01	4.6E-01	***3.1E+00***	4%
Total PCBs		9.3E-02		8.5E-01	6.3E-01	***1.6E+00***	2%
Lead		1.2E+00		5.2E-03	6.7E-02	***1.3E+00***	2%
Copper		3.0E-01		1.3E-01	8.4E-02	5.2E-01	1%
Dieldrin		1.4E-03		4.8E-03	5.2E-03	1.1E-02	0%
LPAH							
HPAH							
TOTAL MEDIUM-SPECIFIC RISK	**-**	**1.4E+01**	**-**	**3.8E+01**	**2.6E+01**	**7.8E+01**	
PERCENTAGE OF TOTAL RISK		**18%**		**49%**	**33%**	**100%**	

Notes:
a. Hazard Quotients presented by exposure medium; a blank cell indicates that the analyte was not a COPC for that medium; a dash entry indicates that there was no assumed exposure to that medium.
b. Combined risk across all media exposures.
c. Relative contribution of COPC to total risk associated with the ingestion exposure pathway.

Attachment 6

TABLE 6-28
SUMMARY OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS USING LOAEL-BASED TRVs : HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: CURRENT/FUTURE
EXPOSURE POINT: RME (with mummichog diet)
RECEPTOR: HERON
TOTAL RISK (HI): 8.6E+00

Analyte	Exposure Medium[a]					Combined HQs[b]	Percent Contribution[c]
	Surface Water	Sediment	Aquatic Plants	Aquatic Invertebrates	Fish		
TCDD TEQ (PCBs)		2.8E-01		3.1E+00	1.2E+00	***4.6E+00***	***53%***
TCDD TEQ (D/F)		6.5E-01		3.0E-01	9.4E-01	***1.9E+00***	***22%***
Total DDx		6.9E-02		3.1E-01	2.7E-01	6.5E-01	8%
Lead		5.9E-01		2.6E-03	3.3E-02	6.3E-01	7%
Total PCBs		2.3E-02		2.1E-01	1.6E-01	3.9E-01	5%
Mercury		2.4E-01		1.9E-02	4.6E-02	3.1E-01	4%
Copper		1.0E-01		4.5E-02	2.8E-02	1.7E-01	2%
Dieldrin		2.5E-05		8.9E-05	9.7E-05	2.1E-04	0%
LPAH							
HPAH							
TOTAL MEDIUM-SPECIFIC RISK	**-**	**1.9E+00**	**-**	**4.0E+00**	**2.7E+00**	**8.6E+00**	
PERCENTAGE OF TOTAL RISK		**23%**		**46%**	**32%**	**100%**	

Notes:
a. Hazard Quotients presented by exposure medium; a blank cell indicates that the analyte was not a COPC for that medium; a dash entry indicates that there was no assumed exposure to that medium.
b. Combined risk across all media exposures.
c. Relative contribution of COPC to total risk associated with the ingestion exposure pathway.

ATTACHMENT 7
HUMAN HEALTH RISK – FUTURE CONDITIONS

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TABLE 7-1
CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS
MONITORED NATURAL RECOVERY - YEAR=2018
Lower Passaic River

Scenario Timeframe: Future
Receptor Population: Angler (Adult)
Receptor Age: >18 Years

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Fish			Ingestion	TCDD TEQ (D/F)	2.E-04	mg/kg	2.3E-08	mg/kg-day	1.5E+05	(mg/kg-day)-1	3.E-03	6.70E-08	mg/kg-day	--	--	ND
				TCDD TEQ (PCBs)	2.E-05	mg/kg	2.0E-09	mg/kg-day	1.5E+05	(mg/kg-day)-1	3.E-04	5.81E-09	mg/kg-day	--	--	ND
				Total PCBs	1.E+00	mg/kg	1.5E-04	mg/kg-day	2.0E+00	(mg/kg-day)-1	3.E-04	4.39E-04	mg/kg-day	2.0E-05	mg/kg-day	22
				4,4'-DDD	2.E-01	mg/kg	2.0E-05	mg/kg-day	2.4E-01	(mg/kg-day)-1	5.E-06	5.95E-05	mg/kg-day	--	--	ND
				4,4'-DDE	3.E-01	mg/kg	3.2E-05	mg/kg-day	3.4E-01	(mg/kg-day)-1	1.E-05	9.40E-05	mg/kg-day	--	--	ND
				4,4'-DDT	8.E-03	mg/kg	1.0E-06	mg/kg-day	3.4E-01	(mg/kg-day)-1	3.E-07	3.00E-06	mg/kg-day	5.0E-04	mg/kg-day	0.01
				Total Chlordane	1.E+00	mg/kg	1.4E-04	mg/kg-day	3.5E-01	(mg/kg-day)-1	5.E-05	4.18E-04	mg/kg-day	5.0E-04	mg/kg-day	0.84
				Dieldrin	3.E-02	mg/kg	4.0E-06	mg/kg-day	1.6E+01	(mg/kg-day)-1	6.E-05	1.16E-05	mg/kg-day	5.0E-05	mg/kg-day	0.23
				Methyl mercury	2.E-01	mg/kg	1.9E-05	mg/kg-day	--	--	ND	5.61E-05	mg/kg-day	1.0E-04	mg/kg-day	0.6
			Exp. Route Total								4.E-03					24
		Exposure Point Total									4.E-03					24
	Exposure Medium Total										4.E-03					24
Medium Total																
Crab				TCDD TEQ (D/F)	1E-04	mg/kg	1.6E-08	mg/kg-day	1.5E+05	(mg/kg-day)-1	2.E-03	4.7E-08	mg/kg-day	--	--	ND
				TCDD TEQ (PCBs)	2E-05	mg/kg	2.6E-09	mg/kg-day	1.5E+05	(mg/kg-day)-1	4.E-04	7.7E-09	mg/kg-day	--	--	ND
				Total PCBs	1E+00	mg/kg	1.3E-04	mg/kg-day	2.0E+00	(mg/kg-day)-1	3.E-04	3.8E-04	mg/kg-day	2.0E-05	mg/kg-day	19
				4,4'-DDD	8E-02	mg/kg	8.6E-06	mg/kg-day	2.4E-01	(mg/kg-day)-1	2.E-06	2.5E-05	mg/kg-day	--	--	ND
				4,4'-DDE	1E-01	mg/kg	1.6E-05	mg/kg-day	3.4E-01	(mg/kg-day)-1	6.E-06	4.8E-05	mg/kg-day	--	--	ND
				4,4'-DDT	1E-02	mg/kg	1.2E-06	mg/kg-day	3.4E-01	(mg/kg-day)-1	4.E-07	3.6E-06	mg/kg-day	5.0E-04	mg/kg-day	0.01
				Total Chlordane	3E-02	mg/kg	3.6E-06	mg/kg-day	3.5E-01	(mg/kg-day)-1	1.E-06	1.0E-05	mg/kg-day	5.0E-04	mg/kg-day	0.02
				Dieldrin	1E-02	mg/kg	1.5E-06	mg/kg-day	1.6E+01	(mg/kg-day)-1	2.E-05	4.5E-06	mg/kg-day	5.0E-05	mg/kg-day	0.09
				Methyl mercury	4E-02	mg/kg	4.9E-06	mg/kg-day	--	--	ND	1.4E-05	mg/kg-day	1.0E-04	mg/kg-day	0.1
			Exp. Route Total								3.E-03					19
		Exposure Point Total									3.E-03					19
	Exposure Medium Total										3.E-03					19
Medium Total																

ND - not determined because toxicity values are not available for this exposure route.
mg/kg - milligram per kilogram

TABLE 7-2
CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS
MONITORED NATURAL RECOVERY - YEAR=2048
Lower Passaic River Restoration Project

Scenario Timeframe: Future
Receptor Population: Angler (Adult)
Receptor Age: >18 Years

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration (a)		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Fish			Ingestion	TCDD TEQ (D/F)	9.E-05	mg/kg	1.1E-08	mg/kg-day	1.5E+05	(mg/kg-day)-1	2.E-03	5.44E-08	mg/kg-day	--	--	ND
				TCDD TEQ (PCBs)	7.E-06	mg/kg	8.1E-10	mg/kg-day	1.5E+05	(mg/kg-day)-1	1.E-04	7.85E-09	mg/kg-day	--	--	ND
				Total PCBs	5.E-01	mg/kg	6.4E-05	mg/kg-day	2.0E+00	(mg/kg-day)-1	1.E-04	3.62E-04	mg/kg-day	2.0E-05	mg/kg-day	18
				4,4'-DDD	9.E-02	mg/kg	1.1E-05	mg/kg-day	2.4E-01	(mg/kg-day)-1	3.E-06	5.15E-05	mg/kg-day	--	--	ND
				4,4'-DDE	1.E-01	mg/kg	1.7E-05	mg/kg-day	3.4E-01	(mg/kg-day)-1	6.E-06	8.31E-05	mg/kg-day	--	--	ND
				4,4'-DDT	4.E-03	mg/kg	5.5E-07	mg/kg-day	3.4E-01	(mg/kg-day)-1	2.E-07	2.62E-06	mg/kg-day	5.0E-04	mg/kg-day	0.005
				Total Chlordane	9.E-01	mg/kg	1.1E-04	mg/kg-day	3.5E-01	(mg/kg-day)-1	4.E-05	3.96E-04	mg/kg-day	5.0E-04	mg/kg-day	0.79
				Dieldrin	3.E-02	mg/kg	4.0E-06	mg/kg-day	1.6E+01	(mg/kg-day)-1	6.E-05	1.15E-05	mg/kg-day	5.0E-05	mg/kg-day	0.23
				Methyl mercury	8.E-02	mg/kg	9.8E-06	mg/kg-day	--	--	ND	4.84E-05	mg/kg-day	1.0E-04	mg/kg-day	0.5
			Exp. Route Total								2.E-03					20
		Exposure Point Total									2.E-03					20
	Exposure Medium Total										2.E-03					20
Medium Total																
Crab				TCDD TEQ (D/F)	7E-05	mg/kg	8.1E-09	mg/kg-day	1.5E+05	(mg/kg-day)-1	1.E-03	3.8E-08	mg/kg-day	--	--	ND
				TCDD TEQ (PCBs)	1E-05	mg/kg	1.1E-09	mg/kg-day	1.5E+05	(mg/kg-day)-1	2.E-04	1.0E-08	mg/kg-day	--	--	ND
				Total PCBs	5E-01	mg/kg	5.6E-05	mg/kg-day	2.0E+00	(mg/kg-day)-1	1.E-04	3.1E-04	mg/kg-day	2.0E-05	mg/kg-day	16
				4,4'-DDD	4E-02	mg/kg	4.6E-06	mg/kg-day	2.4E-01	(mg/kg-day)-1	1.E-06	2.2E-05	mg/kg-day	--	--	ND
				4,4'-DDE	8E-02	mg/kg	8.8E-06	mg/kg-day	3.4E-01	(mg/kg-day)-1	3.E-06	4.2E-05	mg/kg-day	--	--	ND
				4,4'-DDT	6E-03	mg/kg	6.6E-07	mg/kg-day	3.4E-01	(mg/kg-day)-1	2.E-07	3.2E-06	mg/kg-day	5.0E-04	mg/kg-day	0.01
				Total Chlordane	2E-02	mg/kg	2.8E-06	mg/kg-day	3.5E-01	(mg/kg-day)-1	1.E-06	9.9E-06	mg/kg-day	5.0E-04	mg/kg-day	0.02
				Dieldrin	1E-02	mg/kg	1.5E-06	mg/kg-day	1.6E+01	(mg/kg-day)-1	2.E-05	4.5E-06	mg/kg-day	5.0E-05	mg/kg-day	0.09
				Methyl mercury	2E-02	mg/kg	2.5E-06	mg/kg-day	--	--	ND	1.2E-05	mg/kg-day	1.0E-04	mg/kg-day	0.1
			Exp. Route Total								2.E-03					16
		Exposure Point Total									2.E-03					16
	Exposure Medium Total										2.E-03					16
Medium Total																

ND - not determined because toxicity values are not available for this exposure route.
mg/kg - milligram per kilogram
(a) Intake/Exposure concentration based on the EPC value derived from the 7-year average sediment concentration and an average daily dose for ingestion of fish of 3.57E-04 and 3.29E-04 for crab.

TABLE 7-3
CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS
MONITORED NATURAL RECOVERY - YEAR=2018
Lower Passaic River Restoration Project

Scenario Timeframe: Future
Receptor Population: Angler (Child)
Receptor Age: 0 - 6 Years

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Fish			Ingestion	TCDD TEQ (D/F)	2E-04	mg/kg	8.9E-09	mg/kg-day	1.5E+05	(mg/kg-day)-1	1.E-03	1.04E-07	mg/kg-day	--	--	ND
				TCDD TEQ (PCBs)	2E-05	mg/kg	7.7E-10	mg/kg-day	1.5E+05	(mg/kg-day)-1	1.E-04	9.03E-09	mg/kg-day	--	--	ND
				Total PCBs	1E+00	mg/kg	5.9E-05	mg/kg-day	2.0E+00	(mg/kg-day)-1	1.E-04	6.83E-04	mg/kg-day	2.0E-05	mg/kg-day	34
				4,4'-DDD	2E-01	mg/kg	7.9E-06	mg/kg-day	2.4E-01	(mg/kg-day)-1	2.E-06	9.26E-05	mg/kg-day	--	--	ND
				4,4'-DDE	3E-01	mg/kg	1.3E-05	mg/kg-day	3.4E-01	(mg/kg-day)-1	4.E-06	1.46E-04	mg/kg-day	--	--	ND
				4,4'-DDT	8E-03	mg/kg	4.0E-07	mg/kg-day	3.4E-01	(mg/kg-day)-1	1.E-07	4.66E-06	mg/kg-day	5.0E-04	mg/kg-day	0.01
				Total Chlordane	1E+00	mg/kg	5.6E-05	mg/kg-day	3.5E-01	(mg/kg-day)-1	2.E-05	6.50E-04	mg/kg-day	5.0E-04	mg/kg-day	1
				Dieldrin	3E-02	mg/kg	1.5E-06	mg/kg-day	1.6E+01	(mg/kg-day)-1	2.E-05	1.80E-05	mg/kg-day	5.0E-05	mg/kg-day	0
				Methyl mercury	2E-01	mg/kg	7.5E-06	mg/kg-day	--	--	ND	8.73E-05	mg/kg-day	1.0E-04	mg/kg-day	1
			Exp. Route Total								2.E-03					37
		Exposure Point Total									2.E-03					37
	Exposure Medium Total										2.E-03					37
Medium Total																
Crab				TCDD TEQ (D/F)	1E-04	mg/kg	6.5E-09	mg/kg-day	1.5E+05	(mg/kg-day)-1	1.E-03	7.6E-08	mg/kg-day	--	--	ND
				TCDD TEQ (PCBs)	2E-05	mg/kg	1.1E-09	mg/kg-day	1.5E+05	(mg/kg-day)-1	2.E-04	1.3E-08	mg/kg-day	--	--	ND
				Total PCBs	1E+00	mg/kg	5.3E-05	mg/kg-day	2.0E+00	(mg/kg-day)-1	1.E-04	6.2E-04	mg/kg-day	2.0E-05	mg/kg-day	31
				4,4'-DDD	8E-02	mg/kg	3.5E-06	mg/kg-day	2.4E-01	(mg/kg-day)-1	8.E-07	4.1E-05	mg/kg-day	--	--	ND
				4,4'-DDE	1E-01	mg/kg	6.6E-06	mg/kg-day	3.4E-01	(mg/kg-day)-1	2.E-06	7.8E-05	mg/kg-day	--	--	ND
				4,4'-DDT	1E-02	mg/kg	5.1E-07	mg/kg-day	3.4E-01	(mg/kg-day)-1	2.E-07	5.9E-06	mg/kg-day	5.0E-04	mg/kg-day	0.01
				Total Chlordane	3E-02	mg/kg	1.5E-06	mg/kg-day	3.5E-01	(mg/kg-day)-1	5.E-07	1.7E-05	mg/kg-day	5.0E-04	mg/kg-day	0.03
				Dieldrin	1E-02	mg/kg	6.3E-07	mg/kg-day	1.6E+01	(mg/kg-day)-1	1.E-05	7.3E-06	mg/kg-day	5.0E-05	mg/kg-day	0.15
				Methyl mercury	4E-02	mg/kg	2.0E-06	mg/kg-day	--	--	ND	2.3E-05	mg/kg-day	1.0E-04	mg/kg-day	0.23
			Exp. Route Total								1.E-03					31
		Exposure Point Total									1.E-03					31
	Exposure Medium Total										1.E-03					31
Medium Total																

ND - not determined because a toxicity value is unavailable for this exposure route.
mg/kg - milligram per kilogram

TABLE 7-4
CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS
MONITORED NATURAL RECOVERY - YEAR=2048
Lower Passaic River Restoration Project

Scenario Timeframe: Future
Receptor Population: Angler (Child)
Receptor Age: 0 - 6 Years

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Fish			Ingestion	TCDD TEQ (D/F)	2E-04	mg/kg	7.8E-09	mg/kg-day	1.5E+05	(mg/kg-day)-1	1.E-03	9.11E-08	mg/kg-day	--	--	ND
				TCDD TEQ (PCBs)	2E-05	mg/kg	1.0E-09	mg/kg-day	1.5E+05	(mg/kg-day)-1	2.E-04	1.22E-08	mg/kg-day	--	--	ND
				Total PCBs	1E+00	mg/kg	4.9E-05	mg/kg-day	2.0E+00	(mg/kg-day)-1	1.E-04	5.76E-04	mg/kg-day	2.0E-05	mg/kg-day	29
				4,4'-DDD	1E-01	mg/kg	7.0E-06	mg/kg-day	2.4E-01	(mg/kg-day)-1	2.E-06	8.13E-05	mg/kg-day	--	--	ND
				4,4'-DDE	2E-01	mg/kg	1.1E-05	mg/kg-day	3.4E-01	(mg/kg-day)-1	4.E-06	1.29E-04	mg/kg-day	--	--	ND
				4,4'-DDT	7E-03	mg/kg	3.5E-07	mg/kg-day	3.4E-01	(mg/kg-day)-1	1.E-07	4.05E-06	mg/kg-day	5.0E-04	mg/kg-day	0.01
				Total Chlordane	1E+00	mg/kg	5.3E-05	mg/kg-day	3.5E-01	(mg/kg-day)-1	2.E-05	6.14E-04	mg/kg-day	5.0E-04	mg/kg-day	1
				Dieldrin	3E-02	mg/kg	1.5E-06	mg/kg-day	1.6E+01	(mg/kg-day)-1	2.E-05	1.79E-05	mg/kg-day	5.0E-05	mg/kg-day	0
				Methyl mercury	1E-01	mg/kg	6.6E-06	mg/kg-day	--	--	ND	7.67E-05	mg/kg-day	1.0E-04	mg/kg-day	1
			Exp. Route Total								1.E-03					31
		Exposure Point Total									1.E-03					31
	Exposure Medium Total										1.E-03					31
Medium Total																
Crab				TCDD TEQ (D/F)	1E-04	mg/kg	5.7E-09	mg/kg-day	1.5E+05	(mg/kg-day)-1	9.E-04	6.7E-08	mg/kg-day	--	--	ND
				TCDD TEQ (PCBs)	3E-05	mg/kg	1.4E-09	mg/kg-day	1.5E+05	(mg/kg-day)-1	2.E-04	1.7E-08	mg/kg-day	--	--	ND
				Total PCBs	1E+00	mg/kg	4.5E-05	mg/kg-day	2.0E+00	(mg/kg-day)-1	9.E-05	5.2E-04	mg/kg-day	2.0E-05	mg/kg-day	26
				4,4'-DDD	7E-02	mg/kg	3.1E-06	mg/kg-day	2.4E-01	(mg/kg-day)-1	7.E-07	3.6E-05	mg/kg-day	--	--	ND
				4,4'-DDE	1E-01	mg/kg	5.9E-06	mg/kg-day	3.4E-01	(mg/kg-day)-1	2.E-06	6.9E-05	mg/kg-day	--	--	ND
				4,4'-DDT	1E-02	mg/kg	4.4E-07	mg/kg-day	3.4E-01	(mg/kg-day)-1	1.E-07	5.1E-06	mg/kg-day	5.0E-04	mg/kg-day	0.01
				Total Chlordane	3E-02	mg/kg	1.4E-06	mg/kg-day	3.5E-01	(mg/kg-day)-1	5.E-07	1.6E-05	mg/kg-day	5.0E-04	mg/kg-day	0.03
				Dieldrin	1E-02	mg/kg	6.2E-07	mg/kg-day	1.6E+01	(mg/kg-day)-1	1.E-05	7.3E-06	mg/kg-day	5.0E-05	mg/kg-day	0.15
				Methyl mercury	4E-02	mg/kg	1.7E-06	mg/kg-day	--	--	ND	2.0E-05	mg/kg-day	1.0E-04	mg/kg-day	0.20
			Exp. Route Total								1.E-03					27
		Exposure Point Total									1.E-03					27
	Exposure Medium Total										1.E-03					27
Medium Total																

ND - not determined because a toxicity value is unavailable for this exposure route.
mg/kg - milligram per kilogram

TABLE 7-5
CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS
PRIMARY EROSIONAL ZONE/PRIMARY INVENTORY ZONE - YEAR=2018
Lower Passaic River Restoration Project

Scenario Timeframe: Future
Receptor Population: Angler (Adult)
Receptor Age: >18 Years

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Fish			Ingestion	TCDD TEQ (D/F)	1.E-04	mg/kg	1.6E-08	mg/kg-day	1.5E+05	(mg/kg-day)-1	2.E-03	4.60E-08	mg/kg-day	--	--	ND
				TCDD TEQ (PCBs)	2.E-05	mg/kg	1.9E-09	mg/kg-day	1.5E+05	(mg/kg-day)-1	3.E-04	5.49E-09	mg/kg-day	--	--	ND
				Total PCBs	1.E+00	mg/kg	1.3E-04	mg/kg-day	2.0E+00	(mg/kg-day)-1	3.E-04	3.90E-04	mg/kg-day	2.0E-05	mg/kg-day	20
				4,4'-DDD	1.E-01	mg/kg	1.8E-05	mg/kg-day	2.4E-01	(mg/kg-day)-1	4.E-06	5.15E-05	mg/kg-day	--	--	ND
				4,4'-DDE	2.E-01	mg/kg	2.8E-05	mg/kg-day	3.4E-01	(mg/kg-day)-1	1.E-05	8.31E-05	mg/kg-day	--	--	ND
				4,4'-DDT	7.E-03	mg/kg	9.0E-07	mg/kg-day	3.4E-01	(mg/kg-day)-1	3.E-07	2.62E-06	mg/kg-day	5.0E-04	mg/kg-day	0.005
				Total Chlordane	1.E+00	mg/kg	1.4E-04	mg/kg-day	3.5E-01	(mg/kg-day)-1	5.E-05	4.18E-04	mg/kg-day	5.0E-04	mg/kg-day	0.84
				Dieldrin	3.E-02	mg/kg	3.7E-06	mg/kg-day	1.6E+01	(mg/kg-day)-1	6.E-05	1.07E-05	mg/kg-day	5.0E-05	mg/kg-day	0.21
				Methyl mercury	1.E-01	mg/kg	1.7E-05	mg/kg-day	--	--	ND	4.96E-05	mg/kg-day	1.0E-04	mg/kg-day	0.5
			Exp. Route Total								3.E-03					21
		Exposure Point Total									3.E-03					21
	Exposure Medium Total										3.E-03					21
Medium Total																
Crab				TCDD TEQ (D/F)	1E-04	mg/kg	1.1E-08	mg/kg-day	1.5E+05	(mg/kg-day)-1	2.E-03	3.2E-08	mg/kg-day	--	--	ND
				TCDD TEQ (PCBs)	2E-05	mg/kg	2.5E-09	mg/kg-day	1.5E+05	(mg/kg-day)-1	4.E-04	7.3E-09	mg/kg-day	--	--	ND
				Total PCBs	1E+00	mg/kg	1.2E-04	mg/kg-day	2.0E+00	(mg/kg-day)-1	2.E-04	3.4E-04	mg/kg-day	2.0E-05	mg/kg-day	17
				4,4'-DDD	7E-02	mg/kg	7.4E-06	mg/kg-day	2.4E-01	(mg/kg-day)-1	2.E-06	2.2E-05	mg/kg-day	--	--	ND
				4,4'-DDE	1E-01	mg/kg	1.4E-05	mg/kg-day	3.4E-01	(mg/kg-day)-1	5.E-06	4.2E-05	mg/kg-day	--	--	ND
				4,4'-DDT	1E-02	mg/kg	1.1E-06	mg/kg-day	3.4E-01	(mg/kg-day)-1	4.E-07	3.2E-06	mg/kg-day	5.0E-04	mg/kg-day	0.01
				Total Chlordane	3E-02	mg/kg	3.6E-06	mg/kg-day	3.5E-01	(mg/kg-day)-1	1.E-06	1.0E-05	mg/kg-day	5.0E-04	mg/kg-day	0.02
				Dieldrin	1E-02	mg/kg	1.4E-06	mg/kg-day	1.6E+01	(mg/kg-day)-1	2.E-05	4.2E-06	mg/kg-day	5.0E-05	mg/kg-day	0.08
				Methyl mercury	4E-02	mg/kg	4.3E-06	mg/kg-day	--	--	ND	1.3E-05	mg/kg-day	1.0E-04	mg/kg-day	0.1
			Exp. Route Total								2.E-03					17
		Exposure Point Total									2.E-03					17
	Exposure Medium Total										2.E-03					17
Medium Total																

ND - not determined because toxicity values are not available for this exposure route.
mg/kg - milligram per kilogram

TABLE 7-6
CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS
PRIMARY EROSIONAL ZONE/PRIMARY INVENTORY ZONE - YEAR=2048
Lower Passaic River Restoration Project

Scenario Timeframe: Future
Receptor Population: Angler (Adult)
Receptor Age: >18 Years

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration (a		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Fish			Ingestion	TCDD TEQ (D/F)	6.E-05	mg/kg	7.2E-09	mg/kg-day	1.5E+05	(mg/kg-day)-1	1.E-03	4.18E-08	mg/kg-day	--	--	ND
				TCDD TEQ (PCBs)	7.E-06	mg/kg	8.1E-10	mg/kg-day	1.5E+05	(mg/kg-day)-1	1.E-04	4.71E-09	mg/kg-day	--	--	ND
				Total PCBs	5.E-01	mg/kg	5.7E-05	mg/kg-day	2.0E+00	(mg/kg-day)-1	1.E-04	3.27E-04	mg/kg-day	2.0E-05	mg/kg-day	16
				4,4'-DDD	8.E-02	mg/kg	9.4E-06	mg/kg-day	2.4E-01	(mg/kg-day)-1	2.E-06	4.51E-05	mg/kg-day	--	--	ND
				4,4'-DDE	1.E-01	mg/kg	1.5E-05	mg/kg-day	3.4E-01	(mg/kg-day)-1	5.E-06	7.23E-05	mg/kg-day	--	--	ND
				4,4'-DDT	4.E-03	mg/kg	5.1E-07	mg/kg-day	3.4E-01	(mg/kg-day)-1	2.E-07	2.25E-06	mg/kg-day	5.0E-04	mg/kg-day	0.004
				Total Chlordane	9.E-01	mg/kg	1.1E-04	mg/kg-day	3.5E-01	(mg/kg-day)-1	4.E-05	4.02E-04	mg/kg-day	5.0E-04	mg/kg-day	0.80
				Dieldrin	3.E-02	mg/kg	3.7E-06	mg/kg-day	1.6E+01	(mg/kg-day)-1	6.E-05	1.07E-05	mg/kg-day	5.0E-05	mg/kg-day	0.21
				Methyl mercury	7.E-02	mg/kg	8.7E-06	mg/kg-day	--	--	ND	4.41E-05	mg/kg-day	1.0E-04	mg/kg-day	0.4
			Exp. Route Total								1.E-03					18
		Exposure Point Total									1.E-03					18
	Exposure Medium Total										1.E-03					18
Medium Total																
Crab				TCDD TEQ (D/F)	4E-05	mg/kg	5.0E-09	mg/kg-day	1.5E+05	(mg/kg-day)-1	8.E-04	2.9E-08	mg/kg-day	--	--	ND
				TCDD TEQ (PCBs)	1E-05	mg/kg	1.1E-09	mg/kg-day	1.5E+05	(mg/kg-day)-1	2.E-04	6.2E-09	mg/kg-day	--	--	ND
				Total PCBs	4E-01	mg/kg	5.0E-05	mg/kg-day	2.0E+00	(mg/kg-day)-1	1.E-04	2.8E-04	mg/kg-day	2.0E-05	mg/kg-day	14
				4,4'-DDD	3E-02	mg/kg	3.9E-06	mg/kg-day	2.4E-01	(mg/kg-day)-1	9.E-07	1.9E-05	mg/kg-day	--	--	ND
				4,4'-DDE	7E-02	mg/kg	7.6E-06	mg/kg-day	3.4E-01	(mg/kg-day)-1	3.E-06	3.7E-05	mg/kg-day	--	--	ND
				4,4'-DDT	6E-03	mg/kg	6.2E-07	mg/kg-day	3.4E-01	(mg/kg-day)-1	2.E-07	2.7E-06	mg/kg-day	5.0E-04	mg/kg-day	0.005
				Total Chlordane	2E-02	mg/kg	2.8E-06	mg/kg-day	3.5E-01	(mg/kg-day)-1	1.E-06	1.0E-05	mg/kg-day	5.0E-04	mg/kg-day	0.02
				Dieldrin	1E-02	mg/kg	1.4E-06	mg/kg-day	1.6E+01	(mg/kg-day)-1	2.E-05	4.2E-06	mg/kg-day	5.0E-05	mg/kg-day	0.08
				Methyl mercury	2E-02	mg/kg	2.2E-06	mg/kg-day	--	--	ND	1.1E-05	mg/kg-day	1.0E-04	mg/kg-day	0.1
			Exp. Route Total								1.E-03					14
		Exposure Point Total									1.E-03					14
	Exposure Medium Total										1.E-03					14
Medium Total																

ND - not determined because toxicity values are not available for this exposure route.
mg/kg - milligram per kilogram
(a) Intake/Exposure concentration based on the EPC value derived from the 7-year average sediment concentration and an average daily dose for ingestion of fish of 3.57E-04 and 3.29E-04 for crab.

TABLE 7-7
CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS
PRIMARY EROSIONAL ZONE/PRIMARY INVENTORY ZONE - YEAR=2018
Lower Passaic River Restoration Project

Scenario Timeframe: Future
Receptor Population: Angler (Child)
Receptor Age: 0 - 6 Years

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Fish			Ingestion	TCDD TEQ (D/F)	1E-04	mg/kg	6.1E-09	mg/kg-day	1.5E+05	(mg/kg-day)-1	9.E-04	7.16E-08	mg/kg-day	--	--	ND
				TCDD TEQ (PCBs)	2E-05	mg/kg	7.3E-10	mg/kg-day	1.5E+05	(mg/kg-day)-1	1.E-04	8.54E-09	mg/kg-day	--	--	ND
				Total PCBs	1E+00	mg/kg	5.2E-05	mg/kg-day	2.0E+00	(mg/kg-day)-1	1.E-04	6.07E-04	mg/kg-day	2.0E-05	mg/kg-day	30
				4,4'-DDD	1E-01	mg/kg	6.9E-06	mg/kg-day	2.4E-01	(mg/kg-day)-1	2.E-06	8.01E-05	mg/kg-day	--	--	ND
				4,4'-DDE	2E-01	mg/kg	1.1E-05	mg/kg-day	3.4E-01	(mg/kg-day)-1	4.E-06	1.29E-04	mg/kg-day	--	--	ND
				4,4'-DDT	7E-03	mg/kg	3.5E-07	mg/kg-day	3.4E-01	(mg/kg-day)-1	1.E-07	4.08E-06	mg/kg-day	5.0E-04	mg/kg-day	0.01
				Total Chlordane	1E+00	mg/kg	5.6E-05	mg/kg-day	3.5E-01	(mg/kg-day)-1	2.E-05	6.50E-04	mg/kg-day	5.0E-04	mg/kg-day	1
				Dieldrin	3E-02	mg/kg	1.4E-06	mg/kg-day	1.6E+01	(mg/kg-day)-1	2.E-05	1.67E-05	mg/kg-day	5.0E-05	mg/kg-day	0.3
				Methyl mercury	1E-01	mg/kg	6.6E-06	mg/kg-day	--	--	ND	7.72E-05	mg/kg-day	1.0E-04	mg/kg-day	0.8
			Exp. Route Total								1.E-03					33
		Exposure Point Total									1.E-03					33
	Exposure Medium Total										1.E-03					33
Medium Total																
Crab				TCDD TEQ (D/F)	1E-04	mg/kg	4.5E-09	mg/kg-day	1.5E+05	(mg/kg-day)-1	7.E-04	5.2E-08	mg/kg-day	--	--	ND
				TCDD TEQ (PCBs)	2E-05	mg/kg	1.0E-09	mg/kg-day	1.5E+05	(mg/kg-day)-1	2.E-04	1.2E-08	mg/kg-day	--	--	ND
				Total PCBs	1E+00	mg/kg	4.7E-05	mg/kg-day	2.0E+00	(mg/kg-day)-1	9.E-05	5.5E-04	mg/kg-day	2.0E-05	mg/kg-day	28
				4,4'-DDD	7E-02	mg/kg	3.0E-06	mg/kg-day	2.4E-01	(mg/kg-day)-1	7.E-07	3.5E-05	mg/kg-day	--	--	ND
				4,4'-DDE	1E-01	mg/kg	5.9E-06	mg/kg-day	3.4E-01	(mg/kg-day)-1	2.E-06	6.9E-05	mg/kg-day	--	--	ND
				4,4'-DDT	1E-02	mg/kg	4.4E-07	mg/kg-day	3.4E-01	(mg/kg-day)-1	2.E-07	5.2E-06	mg/kg-day	5.0E-04	mg/kg-day	0.01
				Total Chlordane	3E-02	mg/kg	1.5E-06	mg/kg-day	3.5E-01	(mg/kg-day)-1	5.E-07	1.7E-05	mg/kg-day	5.0E-04	mg/kg-day	0.03
				Dieldrin	1E-02	mg/kg	5.8E-07	mg/kg-day	1.6E+01	(mg/kg-day)-1	9.E-06	6.8E-06	mg/kg-day	5.0E-05	mg/kg-day	0.14
				Methyl mercury	4E-02	mg/kg	1.7E-06	mg/kg-day	--	--	ND	2.0E-05	mg/kg-day	1.0E-04	mg/kg-day	0.20
			Exp. Route Total								9.E-04					28
		Exposure Point Total									9.E-04					28
	Exposure Medium Total										9.E-04					28
Medium Total																

ND - not determined because a toxicity value is unavailable for this exposure route.
mg/kg - milligram per kilogram

TABLE 7-8
CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS
PRIMARY EROSIONAL ZONE/PRIMARY INVENTORY ZONE - YEAR=2048
Lower Passaic River Restoration Project

Scenario Timeframe: Future
Receptor Population: Angler (Child)
Receptor Age: 0 - 6 Years

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Fish			Ingestion	TCDD TEQ (D/F)	1E-04	mg/kg	5.6E-09	mg/kg-day	1.5E+05	(mg/kg-day)-1	8.E-04	6.51E-08	mg/kg-day	--	--	ND
				TCDD TEQ (PCBs)	1E-05	mg/kg	6.3E-10	mg/kg-day	1.5E+05	(mg/kg-day)-1	9.E-05	7.32E-09	mg/kg-day	--	--	ND
				Total PCBs	1E+00	mg/kg	4.5E-05	mg/kg-day	2.0E+00	(mg/kg-day)-1	9.E-05	5.30E-04	mg/kg-day	2.0E-05	mg/kg-day	26
				4,4'-DDD	1E-01	mg/kg	6.2E-06	mg/kg-day	2.4E-01	(mg/kg-day)-1	1.E-06	7.26E-05	mg/kg-day	--	--	ND
				4,4'-DDE	2E-01	mg/kg	9.9E-06	mg/kg-day	3.4E-01	(mg/kg-day)-1	3.E-06	1.15E-04	mg/kg-day	--	--	ND
				4,4'-DDT	7E-03	mg/kg	3.1E-07	mg/kg-day	3.4E-01	(mg/kg-day)-1	1.E-07	3.61E-06	mg/kg-day	5.0E-04	mg/kg-day	0.01
				Total Chlordane	1E+00	mg/kg	5.4E-05	mg/kg-day	3.5E-01	(mg/kg-day)-1	2.E-05	6.26E-04	mg/kg-day	5.0E-04	mg/kg-day	1
				Dieldrin	3E-02	mg/kg	1.4E-06	mg/kg-day	1.6E+01	(mg/kg-day)-1	2.E-05	1.67E-05	mg/kg-day	5.0E-05	mg/kg-day	0.3
				Methyl mercury	1E-01	mg/kg	6.0E-06	mg/kg-day	--	--	ND	6.97E-05	mg/kg-day	1.0E-04	mg/kg-day	0.7
			Exp. Route Total								1.E-03					29
		Exposure Point Total									1.E-03					29
	Exposure Medium Total										1.E-03					29
Medium Total																
Crab				TCDD TEQ (D/F)	9E-05	mg/kg	4.1E-09	mg/kg-day	1.5E+05	(mg/kg-day)-1	6.E-04	4.8E-08	mg/kg-day	--	--	ND
				TCDD TEQ (PCBs)	2E-05	mg/kg	8.7E-10	mg/kg-day	1.5E+05	(mg/kg-day)-1	1.E-04	1.0E-08	mg/kg-day	--	--	ND
				Total PCBs	9E-01	mg/kg	4.1E-05	mg/kg-day	2.0E+00	(mg/kg-day)-1	8.E-05	4.8E-04	mg/kg-day	2.0E-05	mg/kg-day	24
				4,4'-DDD	6E-02	mg/kg	2.7E-06	mg/kg-day	2.4E-01	(mg/kg-day)-1	7.E-07	3.2E-05	mg/kg-day	--	--	ND
				4,4'-DDE	1E-01	mg/kg	5.2E-06	mg/kg-day	3.4E-01	(mg/kg-day)-1	2.E-06	6.1E-05	mg/kg-day	--	--	ND
				4,4'-DDT	9E-03	mg/kg	3.9E-07	mg/kg-day	3.4E-01	(mg/kg-day)-1	1.E-07	4.6E-06	mg/kg-day	5.0E-04	mg/kg-day	0.01
				Total Chlordane	3E-02	mg/kg	1.4E-06	mg/kg-day	3.5E-01	(mg/kg-day)-1	5.E-07	1.6E-05	mg/kg-day	5.0E-04	mg/kg-day	0.03
				Dieldrin	1E-02	mg/kg	5.8E-07	mg/kg-day	1.6E+01	(mg/kg-day)-1	9.E-06	6.8E-06	mg/kg-day	5.0E-05	mg/kg-day	0.14
				Methyl mercury	3E-02	mg/kg	1.6E-06	mg/kg-day	--	--	ND	1.8E-05	mg/kg-day	1.0E-04	mg/kg-day	0.18
			Exp. Route Total								8.E-04					24
		Exposure Point Total									8.E-04					24
	Exposure Medium Total										8.E-04					24
Medium Total																

ND - not determined because a toxicity value is unavailable for this exposure route.
mg/kg - milligram per kilogram

TABLE 7-9
CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS
AREA OF FOCUS - YEAR=2018
Lower Passaic River Restoration Project

Scenario Timeframe: Future
Receptor Population: Angler (Adult)
Receptor Age: >18 Years

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Fish			Ingestion	TCDD TEQ (D/F)	9.E-06	mg/kg	1.1E-09	mg/kg-day	1.5E+05	(mg/kg-day)-1	2.E-04	3.17E-09	mg/kg-day	--	--	ND
				TCDD TEQ (PCBs)	1.E-05	mg/kg	1.3E-09	mg/kg-day	1.5E+05	(mg/kg-day)-1	2.E-04	3.92E-09	mg/kg-day	--	--	ND
				Total PCBs	8.E-01	mg/kg	1.0E-04	mg/kg-day	2.0E+00	(mg/kg-day)-1	2.E-04	2.99E-04	mg/kg-day	2.0E-05	mg/kg-day	15
				4,4'-DDD	6.E-02	mg/kg	7.1E-06	mg/kg-day	2.4E-01	(mg/kg-day)-1	2.E-06	2.08E-05	mg/kg-day	--	--	ND
				4,4'-DDE	1.E-01	mg/kg	1.2E-05	mg/kg-day	3.4E-01	(mg/kg-day)-1	4.E-06	3.40E-05	mg/kg-day	--	--	ND
				4,4'-DDT	3.E-03	mg/kg	3.8E-07	mg/kg-day	3.4E-01	(mg/kg-day)-1	1.E-07	1.10E-06	mg/kg-day	5.0E-04	mg/kg-day	0.002
				Total Chlordane	1.E+00	mg/kg	1.4E-04	mg/kg-day	3.5E-01	(mg/kg-day)-1	5.E-05	4.18E-04	mg/kg-day	5.0E-04	mg/kg-day	0.84
				Dieldrin	7.E-03	mg/kg	9.2E-07	mg/kg-day	1.6E+01	(mg/kg-day)-1	1.E-05	2.67E-06	mg/kg-day	5.0E-05	mg/kg-day	0.05
				Methyl mercury	6.E-02	mg/kg	7.7E-06	mg/kg-day	--	--	ND	2.24E-05	mg/kg-day	1.0E-04	mg/kg-day	0.2
			Exp. Route Total								6.E-04					16
		Exposure Point Total									6.E-04					16
	Exposure Medium Total										6.E-04					16
Medium Total																
Crab				TCDD TEQ (D/F)	7E-06	mg/kg	7.6E-10	mg/kg-day	1.5E+05	(mg/kg-day)-1	1.E-04	2.2E-09	mg/kg-day	--	--	ND
				TCDD TEQ (PCBs)	2E-05	mg/kg	1.8E-09	mg/kg-day	1.5E+05	(mg/kg-day)-1	3.E-04	5.2E-09	mg/kg-day	--	--	ND
				Total PCBs	8E-01	mg/kg	8.9E-05	mg/kg-day	2.0E+00	(mg/kg-day)-1	2.E-04	2.6E-04	mg/kg-day	2.0E-05	mg/kg-day	13
				4,4'-DDD	3E-02	mg/kg	3.0E-06	mg/kg-day	2.4E-01	(mg/kg-day)-1	7.E-07	8.8E-06	mg/kg-day	--	--	ND
				4,4'-DDE	5E-02	mg/kg	5.9E-06	mg/kg-day	3.4E-01	(mg/kg-day)-1	2.E-06	1.7E-05	mg/kg-day	--	--	ND
				4,4'-DDT	4E-03	mg/kg	4.6E-07	mg/kg-day	3.4E-01	(mg/kg-day)-1	2.E-07	1.3E-06	mg/kg-day	5.0E-04	mg/kg-day	0.003
				Total Chlordane	3E-02	mg/kg	3.6E-06	mg/kg-day	3.5E-01	(mg/kg-day)-1	1.E-06	1.0E-05	mg/kg-day	5.0E-04	mg/kg-day	0.02
				Dieldrin	3E-03	mg/kg	3.6E-07	mg/kg-day	1.6E+01	(mg/kg-day)-1	6.E-06	1.0E-06	mg/kg-day	5.0E-05	mg/kg-day	0.02
				Methyl mercury	2E-02	mg/kg	1.9E-06	mg/kg-day	--	--	ND	5.7E-06	mg/kg-day	1.0E-04	mg/kg-day	0.1
			Exp. Route Total								6.E-04					13
		Exposure Point Total									6.E-04					13
	Exposure Medium Total										6.E-04					13
Medium Total																

ND - not determined because toxicity values are not available for this exposure route.
mg/kg - milligram per kilogram

TABLE 7-10
CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS
AREA OF FOCUS - YEAR=2048
Lower Passaic River Restoration Project

Scenario Timeframe: Future
Receptor Population: Angler (Adult)
Receptor Age: >18 Years

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration(a)		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Fish			Ingestion	TCDD TEQ (D/F)	4.E-06	mg/kg	4.9E-10	mg/kg-day	1.5E+05	(mg/kg-day)-1	7.E-05	2.89E-09	mg/kg-day	--	--	ND
				TCDD TEQ (PCBs)	4.E-06	mg/kg	5.4E-10	mg/kg-day	1.5E+05	(mg/kg-day)-1	8.E-05	3.14E-09	mg/kg-day	--	--	ND
				Total PCBs	4.E-01	mg/kg	4.4E-05	mg/kg-day	2.0E+00	(mg/kg-day)-1	9.E-05	2.51E-04	mg/kg-day	2.0E-05	mg/kg-day	13
				4,4'-DDD	3.E-02	mg/kg	3.9E-06	mg/kg-day	2.4E-01	(mg/kg-day)-1	9.E-07	1.86E-05	mg/kg-day	--	--	ND
				4,4'-DDE	5.E-02	mg/kg	6.6E-06	mg/kg-day	3.4E-01	(mg/kg-day)-1	2.E-06	2.98E-05	mg/kg-day	--	--	ND
				4,4'-DDT	2.E-03	mg/kg	2.0E-07	mg/kg-day	3.4E-01	(mg/kg-day)-1	7.E-08	8.81E-07	mg/kg-day	5.0E-04	mg/kg-day	0.002
				Total Chlordane	9.E-01	mg/kg	1.1E-04	mg/kg-day	3.5E-01	(mg/kg-day)-1	4.E-05	4.02E-04	mg/kg-day	5.0E-04	mg/kg-day	0.80
				Dieldrin	7.E-03	mg/kg	9.0E-07	mg/kg-day	1.6E+01	(mg/kg-day)-1	1.E-05	2.67E-06	mg/kg-day	5.0E-05	mg/kg-day	0.05
				Methyl mercury	3.E-02	mg/kg	3.9E-06	mg/kg-day	--	--	ND	1.96E-05	mg/kg-day	1.0E-04	mg/kg-day	0.2
			Exp. Route Total								3.E-04					14
		Exposure Point Total									3.E-04					14
	Exposure Medium Total										3.E-04					14
Medium Total																
Crab				TCDD TEQ (D/F)	3E-06	mg/kg	3.5E-10	mg/kg-day	1.5E+05	(mg/kg-day)-1	5.E-05	2.0E-09	mg/kg-day	--	--	ND
				TCDD TEQ (PCBs)	6E-06	mg/kg	7.1E-10	mg/kg-day	1.5E+05	(mg/kg-day)-1	1.E-04	4.2E-09	mg/kg-day	--	--	ND
				Total PCBs	3E-01	mg/kg	3.8E-05	mg/kg-day	2.0E+00	(mg/kg-day)-1	8.E-05	2.2E-04	mg/kg-day	2.0E-05	mg/kg-day	11
				4,4'-DDD	1E-02	mg/kg	1.6E-06	mg/kg-day	2.4E-01	(mg/kg-day)-1	4.E-07	7.8E-06	mg/kg-day	--	--	ND
				4,4'-DDE	3E-02	mg/kg	3.3E-06	mg/kg-day	3.4E-01	(mg/kg-day)-1	1.E-06	1.5E-05	mg/kg-day	--	--	ND
				4,4'-DDT	2E-03	mg/kg	2.4E-07	mg/kg-day	3.4E-01	(mg/kg-day)-1	8.E-08	1.1E-06	mg/kg-day	5.0E-04	mg/kg-day	0.002
				Total Chlordane	2E-02	mg/kg	2.8E-06	mg/kg-day	3.5E-01	(mg/kg-day)-1	1.E-06	1.0E-05	mg/kg-day	5.0E-04	mg/kg-day	0.02
				Dieldrin	3E-03	mg/kg	3.5E-07	mg/kg-day	1.6E+01	(mg/kg-day)-1	6.E-06	1.0E-06	mg/kg-day	5.0E-05	mg/kg-day	0.02
				Methyl mercury	9E-03	mg/kg	9.8E-07	mg/kg-day	--	--	ND	5.0E-06	mg/kg-day	1.0E-04	mg/kg-day	0.05
			Exp. Route Total								2.E-04					11
		Exposure Point Total									2.E-04					11
	Exposure Medium Total										2.E-04					11

ND - not determined because toxicity values are not available for this exposure route.
mg/kg - milligram per kilogram
(a) Intake/Exposure concentration based on the EPC value derived from the 7-year average sediment concentration and an average daily dose for ingestion of fish of 3.57E-04 and 3.29E-04 for crab.

TABLE 7-11
CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS
AREA OF FOCUS - YEAR=2018
Lower Passaic River Restoration Project

Scenario Timeframe: Future
Receptor Population: Angler (Child)
Receptor Age: 0 - 6 Years

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Fish			Ingestion	TCDD TEQ (D/F)	9E-06	mg/kg	4.2E-10	mg/kg-day	1.5E+05	(mg/kg-day)-1	6.E-05	4.94E-09	mg/kg-day	--	--	ND
				TCDD TEQ (PCBs)	1E-05	mg/kg	5.2E-10	mg/kg-day	1.5E+05	(mg/kg-day)-1	8.E-05	6.10E-09	mg/kg-day	--	--	ND
				Total PCBs	8E-01	mg/kg	4.0E-05	mg/kg-day	2.0E+00	(mg/kg-day)-1	8.E-05	4.66E-04	mg/kg-day	2.0E-05	mg/kg-day	23
				4,4'-DDD	6E-02	mg/kg	2.8E-06	mg/kg-day	2.4E-01	(mg/kg-day)-1	7.E-07	3.24E-05	mg/kg-day	--	--	ND
				4,4'-DDE	1E-01	mg/kg	4.5E-06	mg/kg-day	3.4E-01	(mg/kg-day)-1	2.E-06	5.29E-05	mg/kg-day	--	--	ND
				4,4'-DDT	3E-03	mg/kg	1.5E-07	mg/kg-day	3.4E-01	(mg/kg-day)-1	5.E-08	1.71E-06	mg/kg-day	5.0E-04	mg/kg-day	0.003
				Total Chlordane	1E+00	mg/kg	5.6E-05	mg/kg-day	3.5E-01	(mg/kg-day)-1	2.E-05	6.50E-04	mg/kg-day	5.0E-04	mg/kg-day	1
				Dieldrin	7E-03	mg/kg	3.6E-07	mg/kg-day	1.6E+01	(mg/kg-day)-1	6.E-06	4.16E-06	mg/kg-day	5.0E-05	mg/kg-day	0.1
				Methyl mercury	6E-02	mg/kg	3.0E-06	mg/kg-day	--	--	ND	3.49E-05	mg/kg-day	1.0E-04	mg/kg-day	0.3
			Exp. Route Total								2.E-04					25
		Exposure Point Total									2.E-04					25
	Exposure Medium Total										2.E-04					25
Medium Total																
Crab				TCDD TEQ (D/F)	7E-06	mg/kg	3.1E-10	mg/kg-day	1.5E+05	(mg/kg-day)-1	5.E-05	3.6E-09	mg/kg-day	--	--	ND
				TCDD TEQ (PCBs)	2E-05	mg/kg	7.2E-10	mg/kg-day	1.5E+05	(mg/kg-day)-1	1.E-04	8.4E-09	mg/kg-day	--	--	ND
				Total PCBs	8E-01	mg/kg	3.6E-05	mg/kg-day	2.0E+00	(mg/kg-day)-1	7.E-05	4.2E-04	mg/kg-day	2.0E-05	mg/kg-day	21
				4,4'-DDD	3E-02	mg/kg	1.2E-06	mg/kg-day	2.4E-01	(mg/kg-day)-1	3.E-07	1.4E-05	mg/kg-day	--	--	ND
				4,4'-DDE	5E-02	mg/kg	2.4E-06	mg/kg-day	3.4E-01	(mg/kg-day)-1	8.E-07	2.8E-05	mg/kg-day	--	--	ND
				4,4'-DDT	4E-03	mg/kg	1.9E-07	mg/kg-day	3.4E-01	(mg/kg-day)-1	6.E-08	2.2E-06	mg/kg-day	5.0E-04	mg/kg-day	0.004
				Total Chlordane	3E-02	mg/kg	1.5E-06	mg/kg-day	3.5E-01	(mg/kg-day)-1	5.E-07	1.7E-05	mg/kg-day	5.0E-04	mg/kg-day	0.03
				Dieldrin	3E-03	mg/kg	1.4E-07	mg/kg-day	1.6E+01	(mg/kg-day)-1	2.E-06	1.7E-06	mg/kg-day	5.0E-05	mg/kg-day	0.03
				Methyl mercury	2E-02	mg/kg	7.9E-07	mg/kg-day	--	--	ND	9.2E-06	mg/kg-day	1.0E-04	mg/kg-day	0.09
			Exp. Route Total								2.E-04					21
		Exposure Point Total									2.E-04					21
	Exposure Medium Total										2.E-04					21
Medium Total																

ND - not determined because a toxicity value is unavailable for this exposure route.
mg/kg - milligram per kilogram

TABLE 7-12
CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS
AREA OF FOCUS - YEAR=2048
Lower Passaic River Restoration Project

Scenario Timeframe: Future
Receptor Population: Angler (Child)
Receptor Age: 0 - 6 Years

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Fish			Ingestion	TCDD TEQ (D/F)	8E-06	mg/kg	3.8E-10	mg/kg-day	1.5E+05	(mg/kg-day)-1	6.E-05	4.49E-09	mg/kg-day	--	--	ND
				TCDD TEQ (PCBs)	9E-06	mg/kg	4.2E-10	mg/kg-day	1.5E+05	(mg/kg-day)-1	6.E-05	4.88E-09	mg/kg-day	--	--	ND
				Total PCBs	7E-01	mg/kg	3.5E-05	mg/kg-day	2.0E+00	(mg/kg-day)-1	7.E-05	4.05E-04	mg/kg-day	2.0E-05	mg/kg-day	20
				4,4'-DDD	5E-02	mg/kg	2.5E-06	mg/kg-day	2.4E-01	(mg/kg-day)-1	6.E-07	2.94E-05	mg/kg-day	--	--	ND
				4,4'-DDE	8E-02	mg/kg	4.0E-06	mg/kg-day	3.4E-01	(mg/kg-day)-1	1.E-06	4.63E-05	mg/kg-day	--	--	ND
				4,4'-DDT	2E-03	mg/kg	1.2E-07	mg/kg-day	3.4E-01	(mg/kg-day)-1	4.E-08	1.37E-06	mg/kg-day	5.0E-04	mg/kg-day	0.003
				Total Chlordane	1E+00	mg/kg	5.4E-05	mg/kg-day	3.5E-01	(mg/kg-day)-1	2.E-05	6.26E-04	mg/kg-day	5.0E-04	mg/kg-day	1
				Dieldrin	7E-03	mg/kg	3.5E-07	mg/kg-day	1.6E+01	(mg/kg-day)-1	6.E-06	4.11E-06	mg/kg-day	5.0E-05	mg/kg-day	0.1
				Methyl mercury	6E-02	mg/kg	2.7E-06	mg/kg-day	--	--	ND	3.11E-05	mg/kg-day	1.0E-04	mg/kg-day	0.3
			Exp. Route Total								2.E-04					22
		Exposure Point Total									2.E-04					22
	Exposure Medium Total										2.E-04					22
Medium Total																
Crab				TCDD TEQ (D/F)	6E-06	mg/kg	2.8E-10	mg/kg-day	1.5E+05	(mg/kg-day)-1	4.E-05	3.3E-09	mg/kg-day	--	--	ND
				TCDD TEQ (PCBs)	1E-05	mg/kg	5.8E-10	mg/kg-day	1.5E+05	(mg/kg-day)-1	9.E-05	6.8E-09	mg/kg-day	--	--	ND
				Total PCBs	7E-01	mg/kg	3.2E-05	mg/kg-day	2.0E+00	(mg/kg-day)-1	6.E-05	3.7E-04	mg/kg-day	2.0E-05	mg/kg-day	18
				4,4'-DDD	2E-02	mg/kg	1.1E-06	mg/kg-day	2.4E-01	(mg/kg-day)-1	3.E-07	1.3E-05	mg/kg-day	--	--	ND
				4,4'-DDE	5E-02	mg/kg	2.1E-06	mg/kg-day	3.4E-01	(mg/kg-day)-1	7.E-07	2.5E-05	mg/kg-day	--	--	ND
				4,4'-DDT	3E-03	mg/kg	1.5E-07	mg/kg-day	3.4E-01	(mg/kg-day)-1	5.E-08	1.7E-06	mg/kg-day	5.0E-04	mg/kg-day	0.003
				Total Chlordane	3E-02	mg/kg	1.4E-06	mg/kg-day	3.5E-01	(mg/kg-day)-1	5.E-07	1.6E-05	mg/kg-day	5.0E-04	mg/kg-day	0.03
				Dieldrin	3E-03	mg/kg	1.4E-07	mg/kg-day	1.6E+01	(mg/kg-day)-1	2.E-06	1.7E-06	mg/kg-day	5.0E-05	mg/kg-day	0.03
				Methyl mercury	2E-02	mg/kg	7.0E-07	mg/kg-day	--	--	ND	8.2E-06	mg/kg-day	1.0E-04	mg/kg-day	0.08
			Exp. Route Total								2.E-04					19
		Exposure Point Total									2.E-04					19
	Exposure Medium Total										2.E-04					19
Medium Total																

ND - not determined because a toxicity value is unavailable for this exposure route.
mg/kg - milligram per kilogram

TABLE 7-13
CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS
MONITORED NATURAL RECOVERY - YEARS=2042-2048
Lower Passaic River

Scenario Timeframe: Future
Receptor Population: Angler (Adult)
Receptor Age: >18 Years

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Fish			Ingestion	TCDD TEQ (D/F)	6.E-05	mg/kg	7.2E-09	mg/kg-day	1.5E+05	(mg/kg-day)-1	1.E-03	2.09E-08	mg/kg-day	--	--	ND
				TCDD TEQ (PCBs)	4.E-06	mg/kg	5.4E-10	mg/kg-day	1.5E+05	(mg/kg-day)-1	8.E-05	1.57E-09	mg/kg-day	--	--	ND
				Total PCBs	3.E-01	mg/kg	4.0E-05	mg/kg-day	2.0E+00	(mg/kg-day)-1	8.E-05	1.16E-04	mg/kg-day	2.0E-05	mg/kg-day	6
				4,4'-DDD	6.E-02	mg/kg	7.9E-06	mg/kg-day	2.4E-01	(mg/kg-day)-1	2.E-06	2.32E-05	mg/kg-day	--	--	ND
				4,4'-DDE	1.E-01	mg/kg	1.3E-05	mg/kg-day	3.4E-01	(mg/kg-day)-1	4.E-06	3.82E-05	mg/kg-day	--	--	ND
				4,4'-DDT	3.E-03	mg/kg	4.0E-07	mg/kg-day	3.4E-01	(mg/kg-day)-1	1.E-07	1.16E-06	mg/kg-day	5.0E-04	mg/kg-day	0.002
				Total Chlordane	8.E-01	mg/kg	9.9E-05	mg/kg-day	3.5E-01	(mg/kg-day)-1	3.E-05	2.88E-04	mg/kg-day	5.0E-04	mg/kg-day	0.58
				Dieldrin	3.E-02	mg/kg	4.0E-06	mg/kg-day	1.6E+01	(mg/kg-day)-1	6.E-05	1.16E-05	mg/kg-day	5.0E-05	mg/kg-day	0.23
				Methyl mercury	6.E-02	mg/kg	6.9E-06	mg/kg-day	--	--	ND	2.00E-05	mg/kg-day	1.0E-04	mg/kg-day	0.2
			Exp. Route Total								1.E-03					7
		Exposure Point Total									1.E-03					7
	Exposure Medium Total										1.E-03					7
Medium Total																
Crab				TCDD TEQ (D/F)	4E-05	mg/kg	5.0E-09	mg/kg-day	1.5E+05	(mg/kg-day)-1	8.E-04	1.5E-08	mg/kg-day	--	--	ND
				TCDD TEQ (PCBs)	6E-06	mg/kg	7.1E-10	mg/kg-day	1.5E+05	(mg/kg-day)-1	1.E-04	2.1E-09	mg/kg-day	--	--	ND
				Total PCBs	3E-01	mg/kg	3.5E-05	mg/kg-day	2.0E+00	(mg/kg-day)-1	7.E-05	1.0E-04	mg/kg-day	2.0E-05	mg/kg-day	5
				4,4'-DDD	3E-02	mg/kg	3.3E-06	mg/kg-day	2.4E-01	(mg/kg-day)-1	8.E-07	9.7E-06	mg/kg-day	--	--	ND
				4,4'-DDE	6E-02	mg/kg	6.7E-06	mg/kg-day	3.4E-01	(mg/kg-day)-1	2.E-06	1.9E-05	mg/kg-day	--	--	ND
				4,4'-DDT	4E-03	mg/kg	4.8E-07	mg/kg-day	3.4E-01	(mg/kg-day)-1	2.E-07	1.4E-06	mg/kg-day	5.0E-04	mg/kg-day	0.003
				Total Chlordane	2E-02	mg/kg	2.5E-06	mg/kg-day	3.5E-01	(mg/kg-day)-1	9.E-07	7.2E-06	mg/kg-day	5.0E-04	mg/kg-day	0.01
				Dieldrin	1E-02	mg/kg	1.5E-06	mg/kg-day	1.6E+01	(mg/kg-day)-1	2.E-05	4.5E-06	mg/kg-day	5.0E-05	mg/kg-day	0.09
				Methyl mercury	2E-02	mg/kg	1.7E-06	mg/kg-day	--	--	ND	5.1E-06	mg/kg-day	1.0E-04	mg/kg-day	0.1
			Exp. Route Total								1.E-03					5
		Exposure Point Total									1.E-03					5
	Exposure Medium Total										1.E-03					5
Medium Total																

ND - not determined because toxicity values are not available for this exposure route.
mg/kg - milligram per kilogram

TABLE 7-14
CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS
PRIMARY EROSIONAL ZONE/PRIMARY INVENTORY ZONE - YEARS=2042-2048
Lower Passaic River

Scenario Timeframe: Future
Receptor Population: Angler (Adult)
Receptor Age: >18 Years

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Fish			Ingestion	TCDD TEQ (D/F)	5.E-05	mg/kg	5.7E-09	mg/kg-day	1.5E+05	(mg/kg-day)-1	9.E-04	1.67E-08	mg/kg-day	--	--	ND
				TCDD TEQ (PCBs)	4.E-06	mg/kg	5.4E-10	mg/kg-day	1.5E+05	(mg/kg-day)-1	8.E-05	1.57E-09	mg/kg-day	--	--	ND
				Total PCBs	3.E-01	mg/kg	3.6E-05	mg/kg-day	2.0E+00	(mg/kg-day)-1	7.E-05	1.04E-04	mg/kg-day	2.0E-05	mg/kg-day	5
				4,4'-DDD	5.E-02	mg/kg	6.6E-06	mg/kg-day	2.4E-01	(mg/kg-day)-1	2.E-06	1.93E-05	mg/kg-day	--	--	ND
				4,4'-DDE	9.E-02	mg/kg	1.1E-05	mg/kg-day	3.4E-01	(mg/kg-day)-1	4.E-06	3.34E-05	mg/kg-day	--	--	ND
				4,4'-DDT	3.E-03	mg/kg	3.9E-07	mg/kg-day	3.4E-01	(mg/kg-day)-1	1.E-07	1.12E-06	mg/kg-day	5.0E-04	mg/kg-day	0.002
				Total Chlordane	8.E-01	mg/kg	9.8E-05	mg/kg-day	3.5E-01	(mg/kg-day)-1	3.E-05	2.86E-04	mg/kg-day	5.0E-04	mg/kg-day	0.57
				Dieldrin	3.E-02	mg/kg	3.7E-06	mg/kg-day	1.6E+01	(mg/kg-day)-1	6.E-05	1.07E-05	mg/kg-day	5.0E-05	mg/kg-day	0.21
				Methyl mercury	5.E-02	mg/kg	6.1E-06	mg/kg-day	--	--	ND	1.77E-05	mg/kg-day	1.0E-04	mg/kg-day	0.2
			Exp. Route Total								1.E-03					6
		Exposure Point Total									1.E-03					6
	Exposure Medium Total										1.E-03					6
Medium Total																
Crab				TCDD TEQ (D/F)	4E-05	mg/kg	4.0E-09	mg/kg-day	1.5E+05	(mg/kg-day)-1	6.E-04	1.2E-08	mg/kg-day	--	--	ND
				TCDD TEQ (PCBs)	6E-06	mg/kg	7.1E-10	mg/kg-day	1.5E+05	(mg/kg-day)-1	1.E-04	2.1E-09	mg/kg-day	--	--	ND
				Total PCBs	3E-01	mg/kg	3.1E-05	mg/kg-day	2.0E+00	(mg/kg-day)-1	6.E-05	9.0E-05	mg/kg-day	2.0E-05	mg/kg-day	5
				4,4'-DDD	2E-02	mg/kg	2.8E-06	mg/kg-day	2.4E-01	(mg/kg-day)-1	7.E-07	8.1E-06	mg/kg-day	--	--	ND
				4,4'-DDE	5E-02	mg/kg	5.8E-06	mg/kg-day	3.4E-01	(mg/kg-day)-1	2.E-06	1.7E-05	mg/kg-day	--	--	ND
				4,4'-DDT	4E-03	mg/kg	4.7E-07	mg/kg-day	3.4E-01	(mg/kg-day)-1	2.E-07	1.4E-06	mg/kg-day	5.0E-04	mg/kg-day	0.003
				Total Chlordane	2E-02	mg/kg	2.5E-06	mg/kg-day	3.5E-01	(mg/kg-day)-1	9.E-07	7.2E-06	mg/kg-day	5.0E-04	mg/kg-day	0.01
				Dieldrin	1E-02	mg/kg	1.4E-06	mg/kg-day	1.6E+01	(mg/kg-day)-1	2.E-05	4.2E-06	mg/kg-day	5.0E-05	mg/kg-day	0.08
				Methyl mercury	1E-02	mg/kg	1.5E-06	mg/kg-day	--	--	ND	4.5E-06	mg/kg-day	1.0E-04	mg/kg-day	0.045
			Exp. Route Total								8.E-04					5
		Exposure Point Total									8.E-04					5
	Exposure Medium Total										8.E-04					5
Medium Total																

ND - not determined because toxicity values are not available for this exposure route.
mg/kg - milligram per kilogram

TABLE 7-15
CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS
AREA OF FOCUS - YEARS=2042-2048
Lower Passaic River

Scenario Timeframe: Future
Receptor Population: Angler (Adult)
Receptor Age: >18 Years

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Fish			Ingestion	TCDD TEQ (D/F)	4.E-06	mg/kg	4.9E-10	mg/kg-day	1.5E+05	(mg/kg-day)-1	7.E-05	1.44E-09	mg/kg-day	--	--	ND
				TCDD TEQ (PCBs)	2.E-06	mg/kg	2.7E-10	mg/kg-day	1.5E+05	(mg/kg-day)-1	4.E-05	7.85E-10	mg/kg-day	--	--	ND
				Total PCBs	2.E-01	mg/kg	2.7E-05	mg/kg-day	2.0E+00	(mg/kg-day)-1	5.E-05	7.93E-05	mg/kg-day	2.0E-05	mg/kg-day	4
				4,4'-DDD	2.E-02	mg/kg	2.9E-06	mg/kg-day	2.4E-01	(mg/kg-day)-1	7.E-07	8.52E-06	mg/kg-day	--	--	ND
				4,4'-DDE	4.E-02	mg/kg	4.5E-06	mg/kg-day	3.4E-01	(mg/kg-day)-1	2.E-06	1.31E-05	mg/kg-day	--	--	ND
				4,4'-DDT	1.E-03	mg/kg	1.5E-07	mg/kg-day	3.4E-01	(mg/kg-day)-1	5.E-08	4.41E-07	mg/kg-day	5.0E-04	mg/kg-day	0.001
				Total Chlordane	8.E-01	mg/kg	9.8E-05	mg/kg-day	3.5E-01	(mg/kg-day)-1	3.E-05	2.86E-04	mg/kg-day	5.0E-04	mg/kg-day	0.57
				Dieldrin	7.E-03	mg/kg	9.2E-07	mg/kg-day	1.6E+01	(mg/kg-day)-1	1.E-05	2.67E-06	mg/kg-day	5.0E-05	mg/kg-day	0.05
				Methyl mercury	2.E-02	mg/kg	2.7E-06	mg/kg-day	--	--	ND	7.87E-06	mg/kg-day	1.0E-04	mg/kg-day	0.1
			Exp. Route Total								2.E-04					5
		Exposure Point Total									2.E-04					5
	Exposure Medium Total										2.E-04					5
Medium Total																
Crab				TCDD TEQ (D/F)	3E-06	mg/kg	3.5E-10	mg/kg-day	1.5E+05	(mg/kg-day)-1	5.E-05	1.0E-09	mg/kg-day	--	--	ND
				TCDD TEQ (PCBs)	3E-06	mg/kg	3.6E-10	mg/kg-day	1.5E+05	(mg/kg-day)-1	5.E-05	1.0E-09	mg/kg-day	--	--	ND
				Total PCBs	2E-01	mg/kg	2.4E-05	mg/kg-day	2.0E+00	(mg/kg-day)-1	5.E-05	6.9E-05	mg/kg-day	2.0E-05	mg/kg-day	3
				4,4'-DDD	1E-02	mg/kg	1.2E-06	mg/kg-day	2.4E-01	(mg/kg-day)-1	3.E-07	3.6E-06	mg/kg-day	--	--	ND
				4,4'-DDE	2E-02	mg/kg	2.3E-06	mg/kg-day	3.4E-01	(mg/kg-day)-1	8.E-07	6.7E-06	mg/kg-day	--	--	ND
				4,4'-DDT	2E-03	mg/kg	1.8E-07	mg/kg-day	3.4E-01	(mg/kg-day)-1	6.E-08	5.3E-07	mg/kg-day	5.0E-04	mg/kg-day	0.001
				Total Chlordane	2E-02	mg/kg	2.5E-06	mg/kg-day	3.5E-01	(mg/kg-day)-1	9.E-07	7.2E-06	mg/kg-day	5.0E-04	mg/kg-day	0.01
				Dieldrin	3E-03	mg/kg	3.6E-07	mg/kg-day	1.6E+01	(mg/kg-day)-1	6.E-06	1.0E-06	mg/kg-day	5.0E-05	mg/kg-day	0.02
				Methyl mercury	6E-03	mg/kg	6.8E-07	mg/kg-day	--	--	ND	2.0E-06	mg/kg-day	1.0E-04	mg/kg-day	0.02
			Exp. Route Total								2.E-04					4
		Exposure Point Total									2.E-04					4
	Exposure Medium Total										2.E-04					4
Medium Total																

ND - not determined because toxicity values are not available for this exposure route.
mg/kg - milligram per kilogram

ATTACHMENT 8
ECOLOGICAL RISK – FUTURE CONDITIONS

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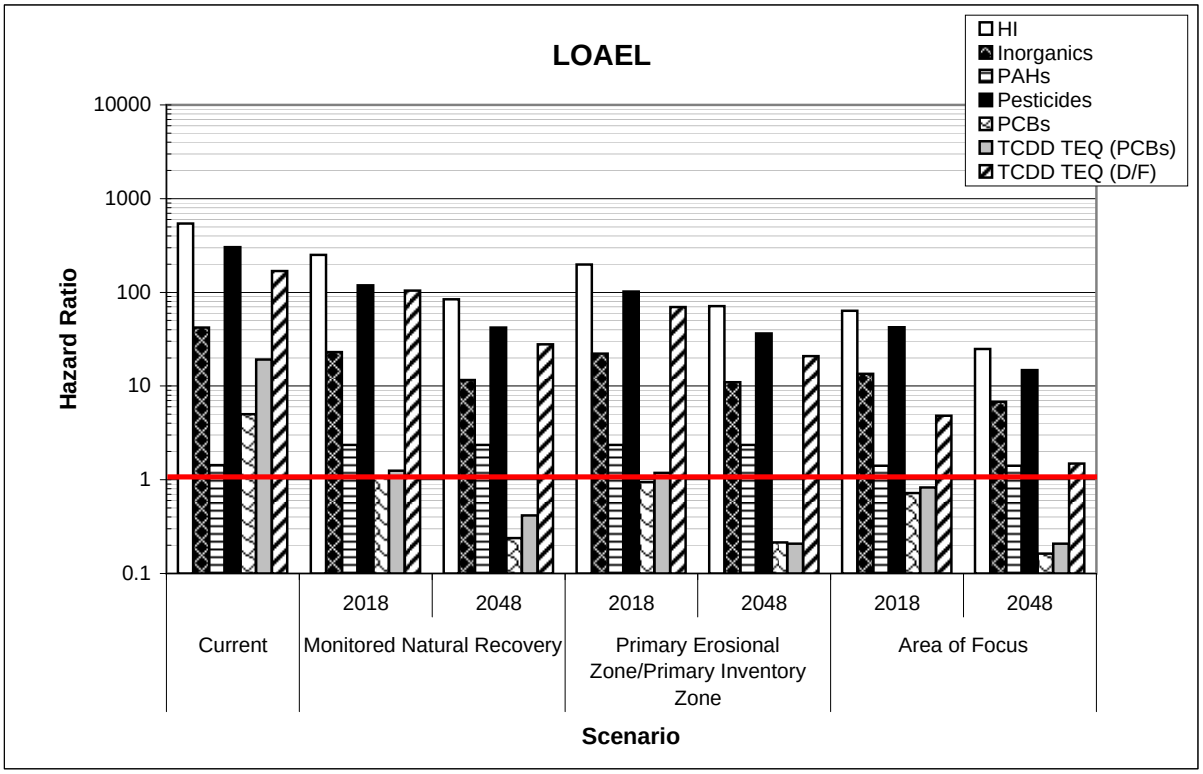
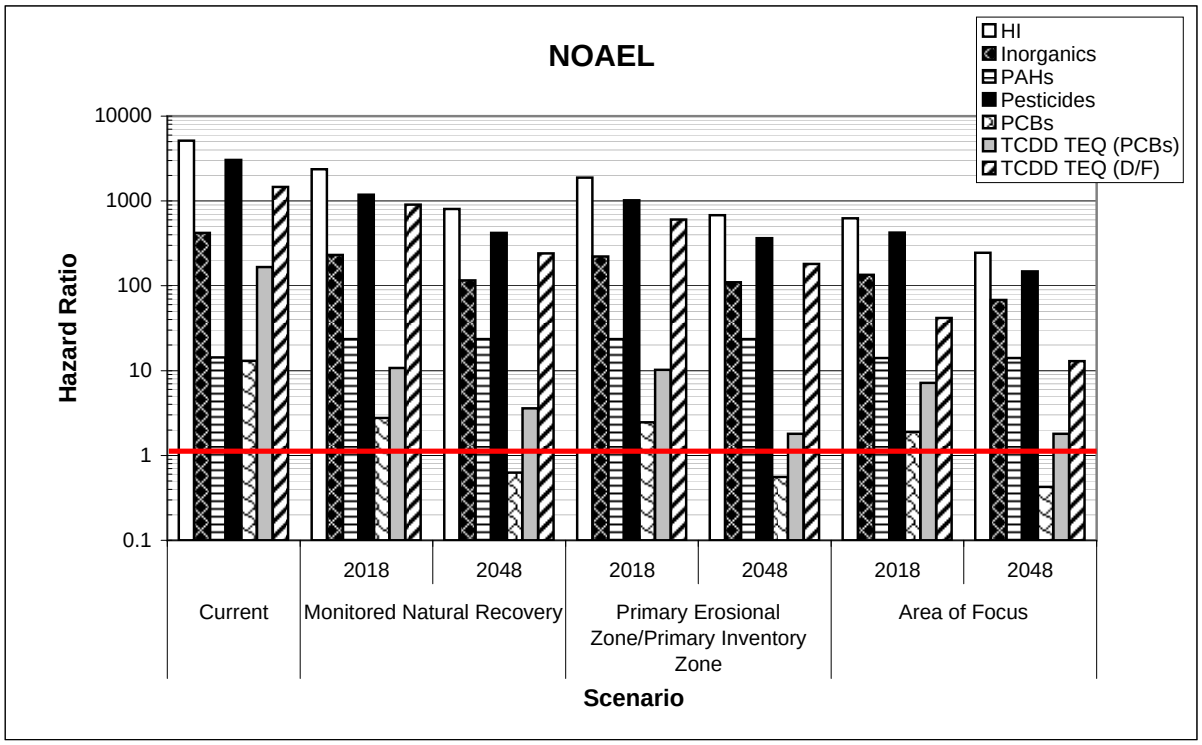
Attachment 8

FIGURE 8-1
SUMMARY OF TISSUE RESIDUE ASSESSMENT UNDER DIFFERENT REMEDIAL SCENARIOS - Benthos

Focused Feasibility Study - Ecological Risk Assessment

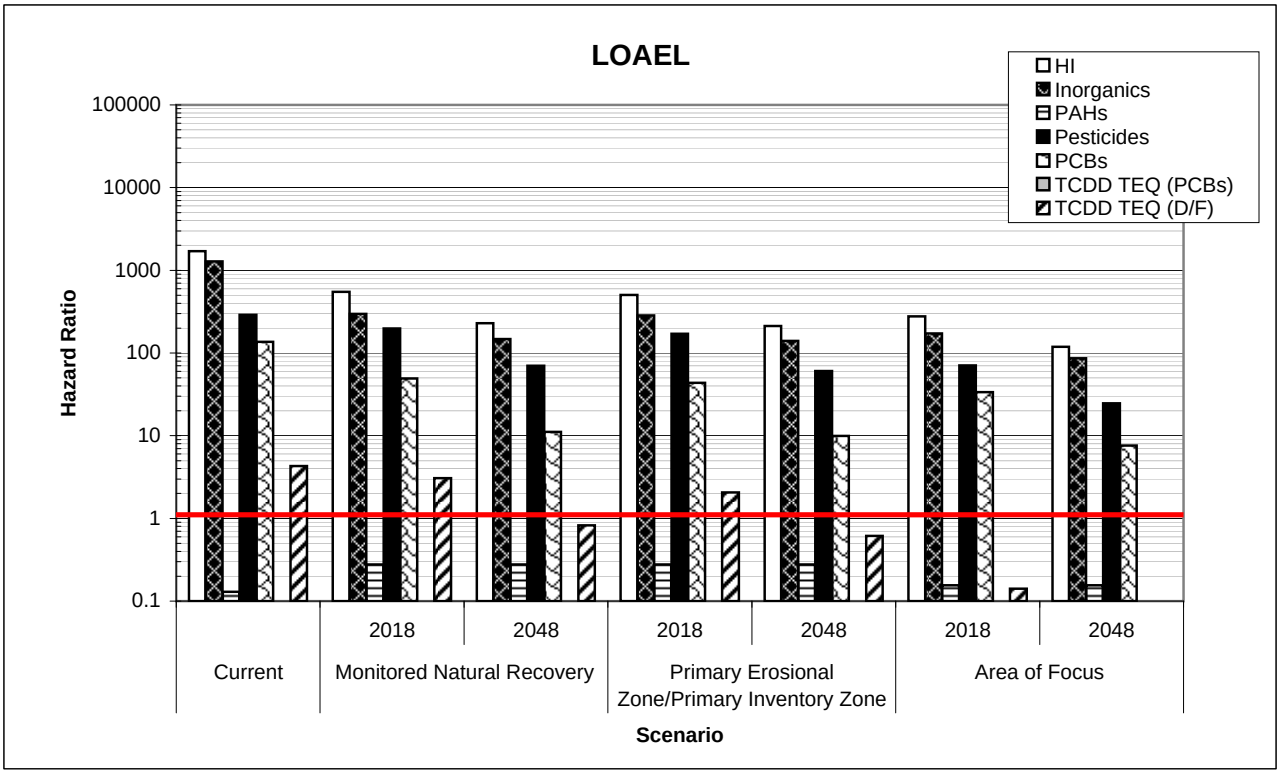




R2-0009748

FIGURE 8-2
SUMMARY OF TISSUE RESIDUE ASSESSMENT UNDER DIFFERENT REMEDIAL SCENARIOS - White Perch/American Eel

Focused Feasibility Study - Ecological Risk Assessment



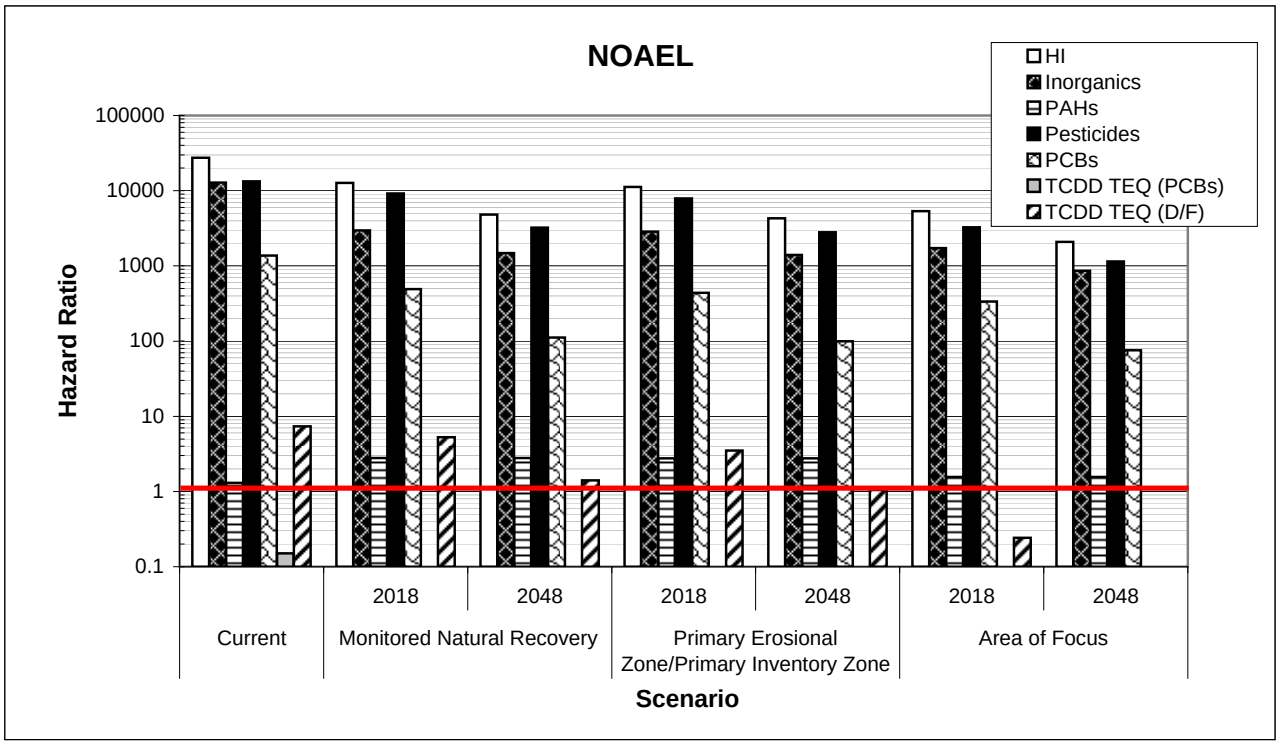
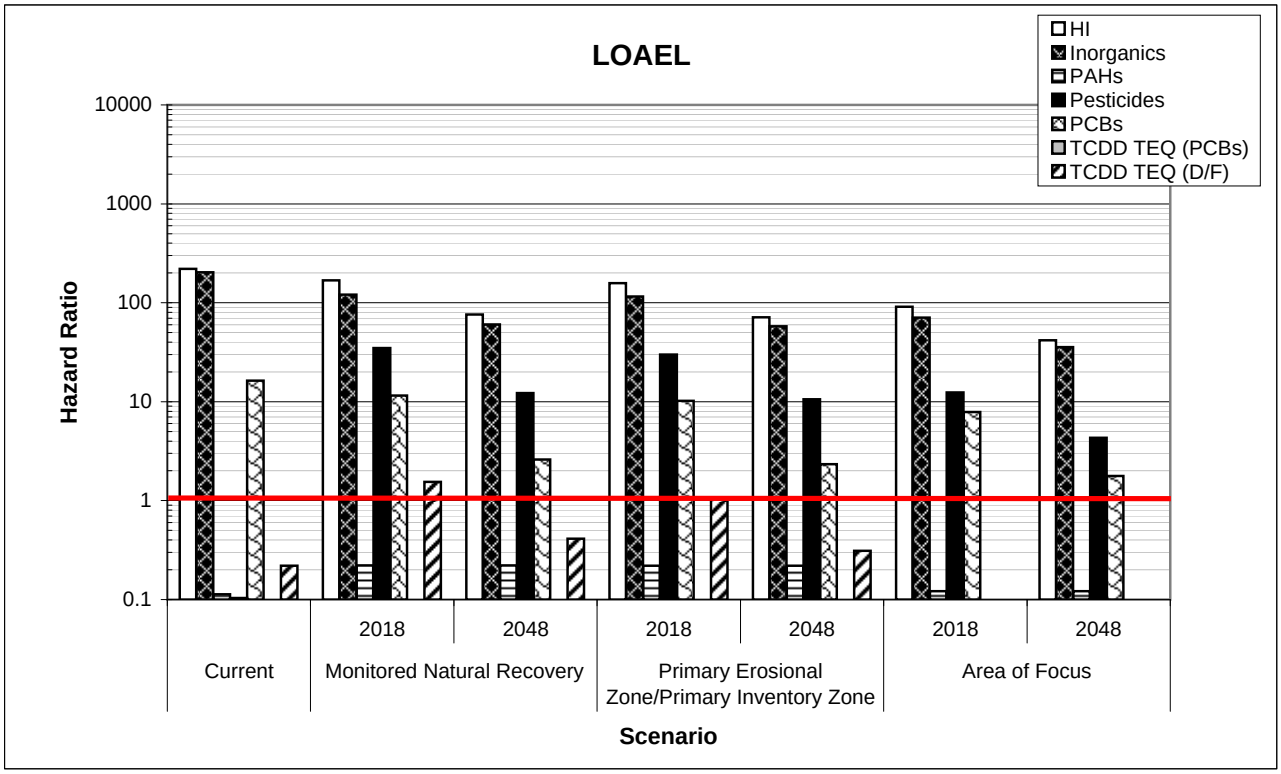


FIGURE 8-3
SUMMARY OF TISSUE RESIDUE ASSESSMENT UNDER DIFFERENT REMEDIAL SCENARIOS - Mummichog

Focused Feasibility Study - Ecological Risk Assessment



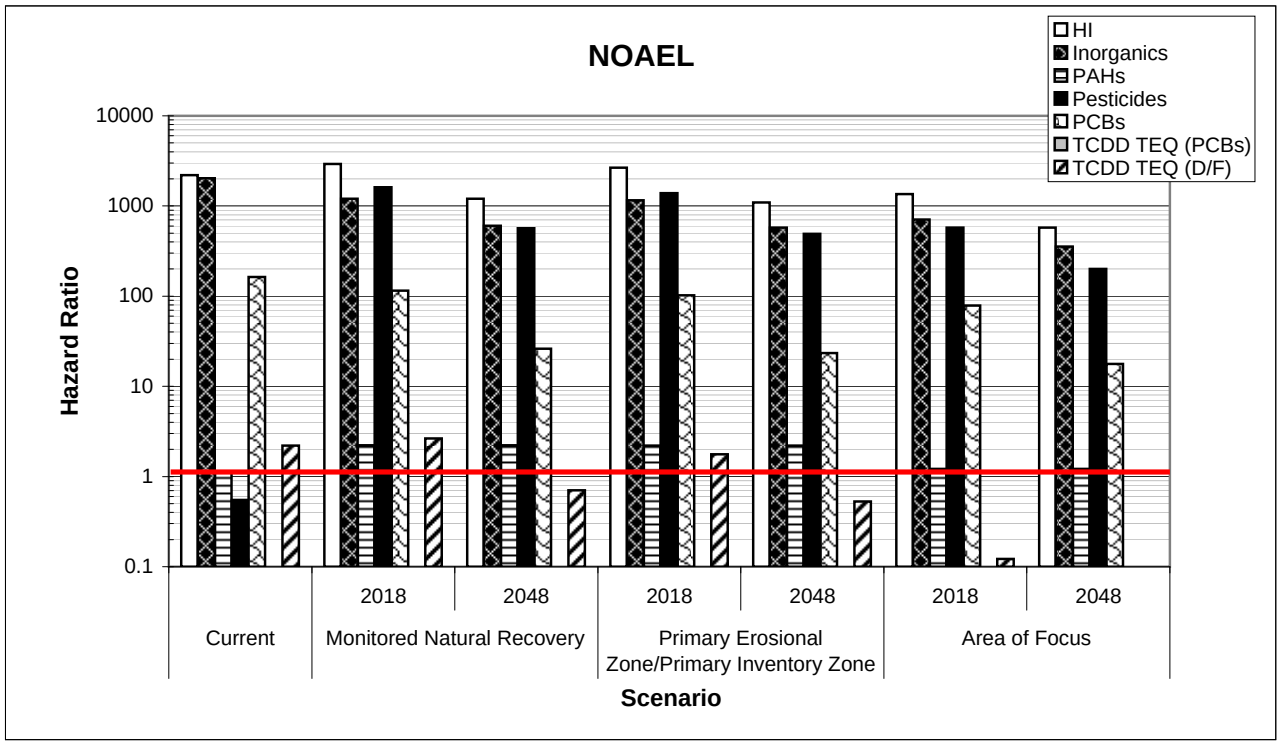
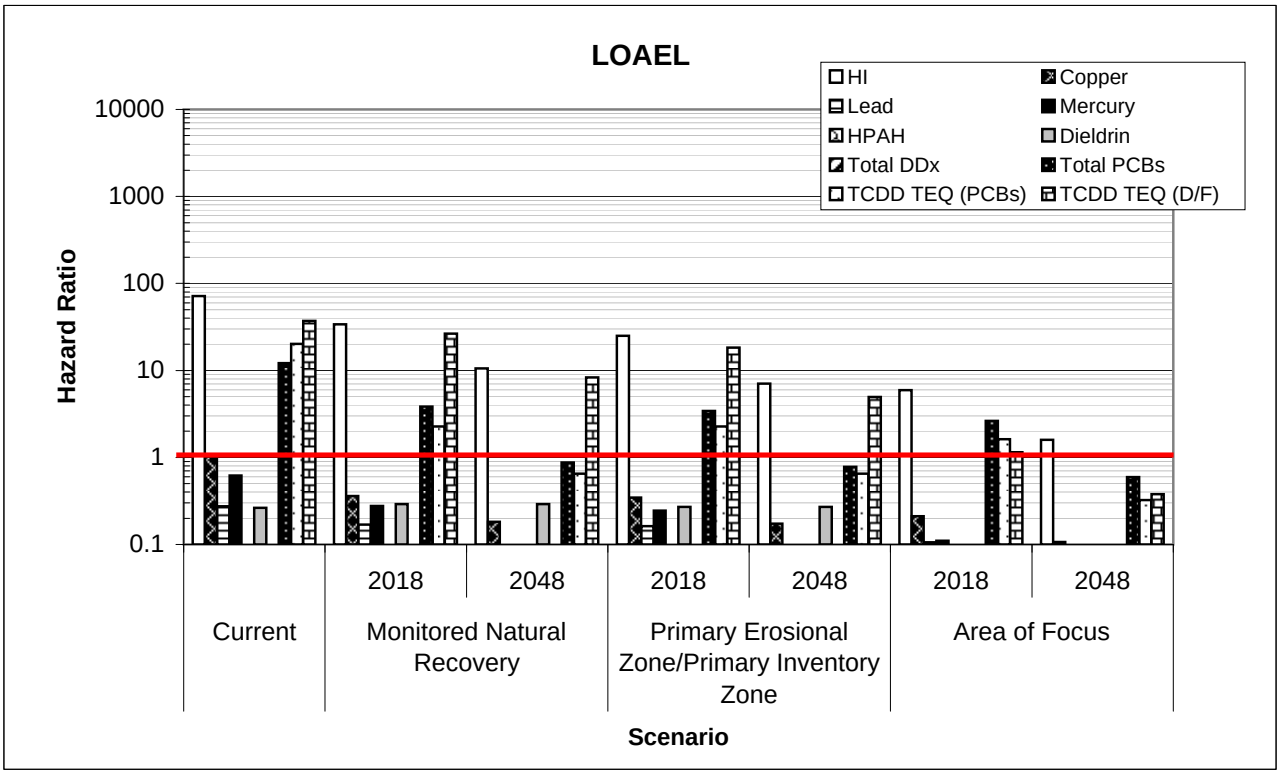


FIGURE 8-4
SUMMARY OF WILDLIFE RISK ASSESSMENT UNDER DIFFERENT REMEDIAL SCENARIOS - Mink

Focused Feasibility Study - Ecological Risk Assessment



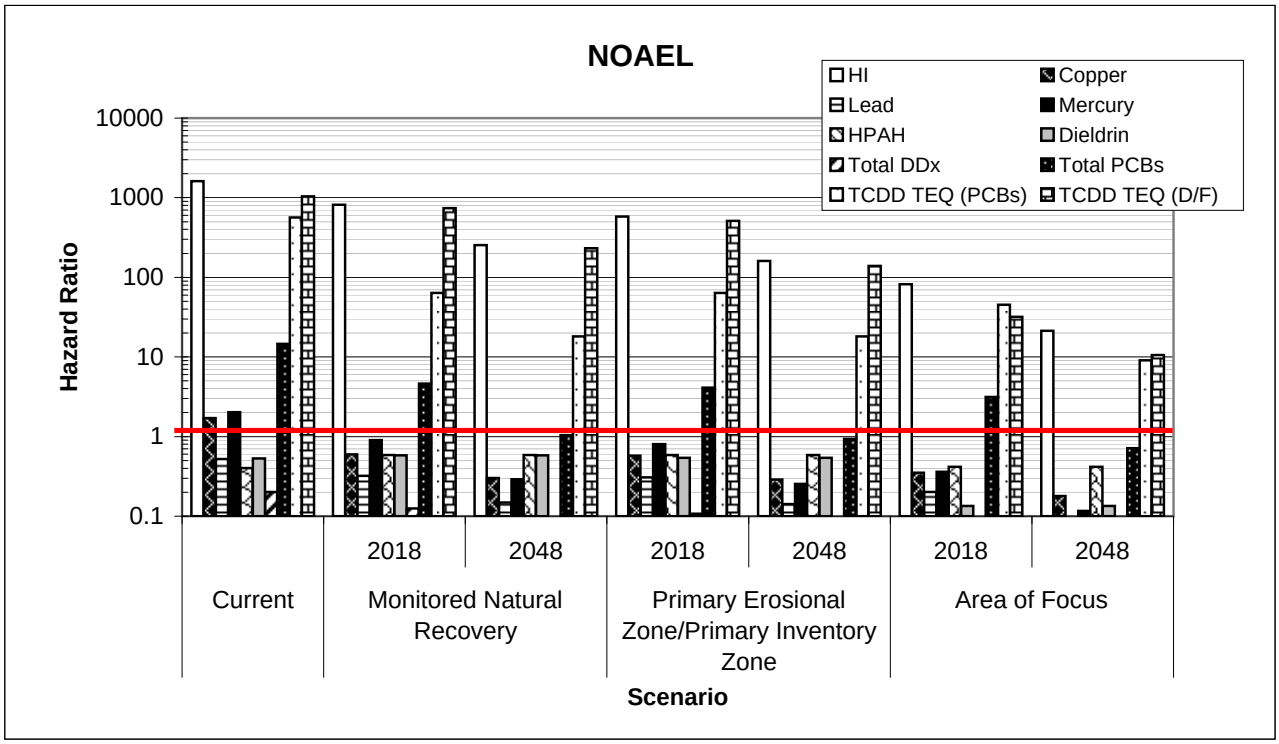
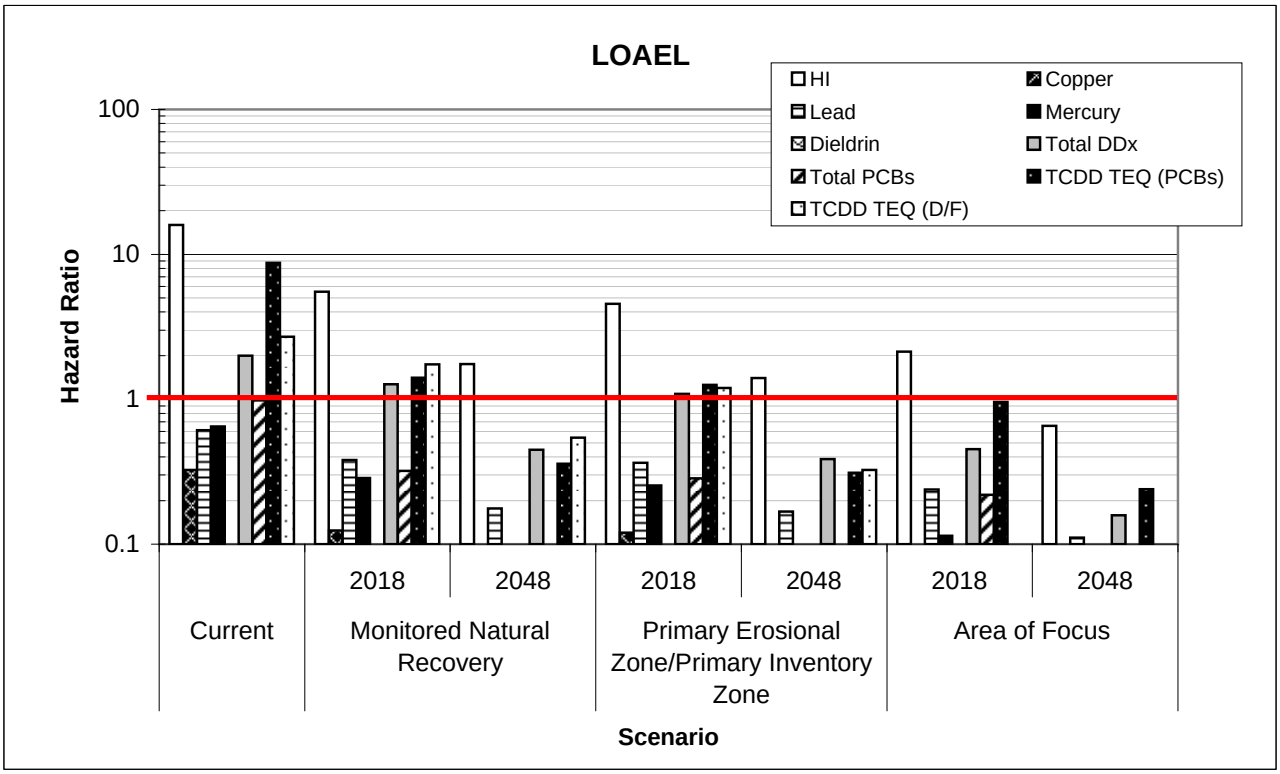
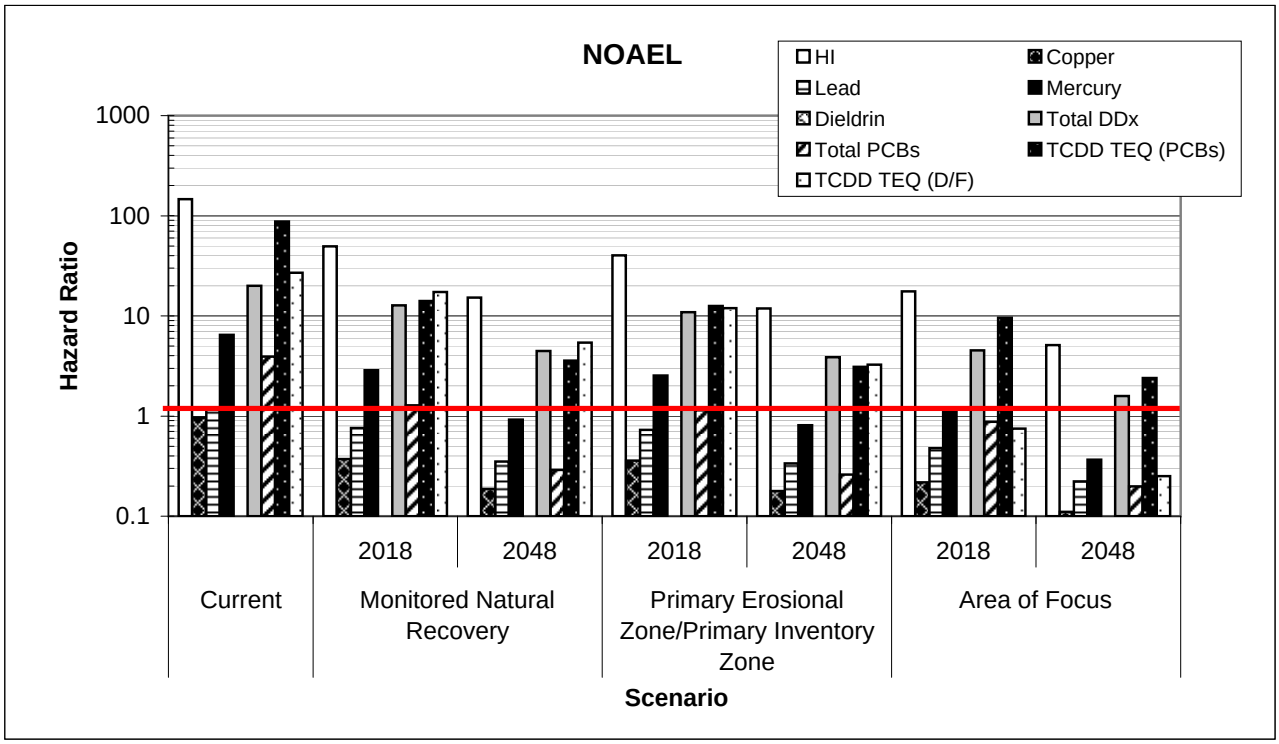


FIGURE 8-5
SUMMARY OF WILDLIFE RISK ASSESSMENT UNDER DIFFERENT REMEDIAL SCENARIOS - Great Blue Heron

Focused Feasibility Study - Ecological Risk Assessment





Attachment 8
TABLE 8-1
SUMMARY OF SEDIMENT BENCHMARK COMPARISONS
Future Conditions (2018) - Monitored Natural Recovery

Focused Feasibility Study - Ecological Risk Assessment

CASRN	Units	Chemical Parameter	*Marine/ Estuarine Values* NOAA ER-L[a]		NJDEP[b]		Lowest Sediment Benchmark[c]	Sediment EPC[d]	Hazard Quotient[e]	Relative Magnitude[f]
Inorganics/Metals										
7440-50-8	µg/g	Copper	34		34		34	138	**4.1**	**0.3%**
7439-92-1	µg/g	Lead	47		47		47	235	**5.0**	**0.3%**
7439-97-6	µg/g	Mercury	0.15		0.15		0.15	1.5	**10**	**0.7%**
								Total Inorganics/Metals	**19**	**1.2%**
Semivolatile Organics (PAHs)										
SUM_LOW_PAH	µg/g	Low Molecular Weight PAHs	0.55		-		0.55	33	**60**	**3.8%**
SUM_HIGH_PAH	µg/g	High Molecular Weight PAHs	1.7		-		1.7	86	**50**	**3.2%**
								Total PAHs	**111**	**7.0%**
PCBs (Aroclors)										
SUM_PCB	µg/g	Total PCBs	0.023		0.023		0.023	0.57	**25.0**	**1.6%**
								Total PCBs	**25**	**1.6%**
Pesticides										
60-57-1	µg/g	Dieldrin	0.000020		-		0.000020	0.020	**1,016**	**64%**
SUM_DDT	µg/g	DDx	0.0016		0.0016		0.0016	0.20	**124**	**8%**
								Total Pesticides	**1,140**	**72%**
Dioxin-like Compounds										
TCDD TEQ (D/F)	µg/g	TCDD TEQ (D/F)	0.0000032	g	-		0.0000032	0.00090	**282**	**18%**
TCDD TEQ (PCBs)	µg/g	TCDD TEQ (PCBs)	0.0000032	g	-		0.0000032	0.00000078	**0.2**	**0.0%**
								Total TCDD TEQ	**282**	**18%**
								Total	**1,577**	100%

a. ER-L = Effects Range-Low from Long *et al.* , 1995; except where noted.
b. NJDEP Guidance For Sediment Quality Evaluations, November 1998. References Long et al, 1995.
c. Minimum of the ER-L and the NJ sediment benchmark values.
d. Exposure Point Concentration (EPC) is based on the 95% Upper Confidence Level on the arithmetic mean of the values in the assessment data set as discussed in the text. TEQs calculated using fish TEFs.
e. Hazard Quotient (HQ) is the ratio of the EPC to the benchmark value.
f. Percentage of the COPEC HQ to the sum of all Hazard Quotients (excluding the TCDD TEQ value).
g. Derived by USFWS using sediment chemistry for Newark Bay and oyster effect data presented in Wintermyer and Cooper, 2003.

Attachment 8
TABLE 8-2
SUMMARY OF SEDIMENT BENCHMARK COMPARISONS
Future Conditions (2048) - Monitored Natural Recovery

Focused Feasibility Study - Ecological Risk Assessment

CASRN	Units	Chemical Parameter	*Marine/ Estuarine Values* NOAA ER-L[a]		NJDEP[b]		Lowest Sediment Benchmark[c]	Sediment EPC[d]	Hazard Quotient[e]	Relative Magnitude[f]
Inorganics/Metals										
7440-50-8	µg/g	Copper	34		34		34	70	**2.1**	**0.2%**
7439-92-1	µg/g	Lead	47		47		47	109	**2.3**	**0.2%**
7439-97-6	µg/g	Mercury	0.15		0.15		0.15	0.50	**3**	**0.3%**
								Total Inorganics/Metals	**8**	**0.6%**
Semivolatile Organics (PAHs)										
SUM_LOW_PAH	µg/g	Low Molecular Weight PAHs	0.55		-		0.55	33	**60**	**4.8%**
SUM_HIGH_PAH	µg/g	High Molecular Weight PAHs	1.7		-		1.7	86	**50**	**4.0%**
								Total PAHs	**111**	**8.8%**
PCBs (Aroclors)										
SUM_PCB	µg/g	Total PCBs	0.023		0.023		0.023	0.13	**5.7**	**0.4%**
								Total PCBs	**6**	**0.4%**
Pesticides										
60-57-1	µg/g	Dieldrin	0.000020		-		0.000020	0.020	**1,016**	**81%**
SUM_DDT	µg/g	DDx	0.0016		0.0016		0.0016	0.069	**44**	**3%**
								Total Pesticides	**1,059**	**84%**
Dioxin-like Compounds										
TCDD TEQ (D/F)	µg/g	TCDD TEQ (D/F)	0.0000032	g	-		0.0000032	0.00024	**75**	**6%**
TCDD TEQ (PCBs)	µg/g	TCDD TEQ (PCBs)	0.0000032	g	-		0.0000032	0.00000026	**0.1**	**0.01%**
								Total TCDD TEQ	**75**	**6%**
								Total	**1,259**	100%

a. ER-L = Effects Range-Low from Long *et al.* , 1995; except where noted.
b. NJDEP Guidance For Sediment Quality Evaluations, November 1998. References Long et al, 1995.
c. Minimum of the ER-L and the NJ sediment benchmark values.
d. Exposure Point Concentration (EPC) is based on the 95% Upper Confidence Level on the arithmetic mean of the values in the assessment data set as discussed in the text. TEQs calculated using fish TEFs.
e. Hazard Quotient (HQ) is the ratio of the EPC to the benchmark value.
f. Percentage of the COPEC HQ to the sum of all Hazard Quotients (excluding the TCDD TEQ value).
g. Derived by USFWS using sediment chemistry for Newark Bay and oyster effect data presented in Wintermyer and Cooper, 2003.

Attachment 8
TABLE 8-3
SUMMARY OF SEDIMENT BENCHMARK COMPARISONS
Future Conditions (2018) - Primary Erosional Zone/Primary Inventory Zone

Focused Feasibility Study - Ecological Risk Assessment

CASRN	Units	Chemical Parameter	*Marine/ Estuarine Values* NOAA ER-L[a]		NJDEP[b]		Lowest Sediment Benchmark[c]	Sediment EPC[d]	Hazard Quotient[e]	Relative Magnitude[f]
Inorganics/Metals										
7440-50-8	µg/g	Copper	34		34		34	134	**3.9**	**0.3%**
7439-92-1	µg/g	Lead	47		47		47	226	**4.8**	**0.3%**
7439-97-6	µg/g	Mercury	0.15		0.15		0.15	1.4	**9**	**0.7%**
								Total Inorganics/Metals	**18**	**1.3%**
Semivolatile Organics (PAHs)										
SUM_LOW_PAH	µg/g	Low Molecular Weight PAHs	0.55		-		0.55	33	**60**	**4.3%**
SUM_HIGH_PAH	µg/g	High Molecular Weight PAHs	1.7		-		1.7	86	**50**	**3.6%**
								Total PAHs	**110**	**7.9%**
PCBs (Aroclors)										
SUM_PCB	µg/g	Total PCBs	0.023		0.023		0.023	0.5	**22.2**	**1.6%**
								Total PCBs	**22**	**1.6%**
Pesticides										
60-57-1	µg/g	Dieldrin	0.000020		-		0.000020	0.019	**943**	**68%**
SUM_DDT	µg/g	DDx	0.0016		0.0016		0.0016	0.17	**107**	**8%**
								Total Pesticides	**1,050**	**76%**
Dioxin-like Compounds										
TCDD TEQ (D/F)	µg/g	TCDD TEQ (D/F)	0.0000032	g	-		0.0000032	0.00060	**188**	**14%**
TCDD TEQ (PCBs)	µg/g	TCDD TEQ (PCBs)	0.0000032	g	-		0.0000032	0.0000007	**0.2**	**0.0%**
								Total TCDD TEQ	**188**	**14%**
								Total	**1,388**	100%

a. ER-L = Effects Range-Low from Long *et al.* , 1995; except where noted.
b. NJDEP Guidance For Sediment Quality Evaluations, November 1998. References Long et al, 1995.
c. Minimum of the ER-L and the NJ sediment benchmark values.
d. Exposure Point Concentration (EPC) is based on the 95% Upper Confidence Level on the arithmetic mean of the values in the assessment data set as discussed in the text. TEQs calculated using fish TEFs.
e. Hazard Quotient (HQ) is the ratio of the EPC to the benchmark value.
f. Percentage of the COPEC HQ to the sum of all Hazard Quotients (excluding the TCDD TEQ value).
g. Derived by USFWS using sediment chemistry for Newark Bay and oyster effect data presented in Wintermyer and Cooper, 2003.

Attachment 8
TABLE 8-4
SUMMARY OF SEDIMENT BENCHMARK COMPARISONS
Future Conditions (2048) - Primary Erosional Zone/Primary Inventory Zone

Focused Feasibility Study - Ecological Risk Assessment

CASRN	Units	Chemical Parameter	*Marine/ Estuarine Values* NOAA ER-L[a]		NJDEP[b]		Lowest Sediment Benchmark[c]	Sediment EPC[d]	Hazard Quotient[e]	Relative Magnitude[f]
Inorganics/Metals										
7440-50-8	µg/g	Copper	34		34		34	67	**2.0**	**0.2%**
7439-92-1	µg/g	Lead	47		47		47	104	**2.2**	**0.2%**
7439-97-6	µg/g	Mercury	0.15		0.15		0.15	0.44	**3**	**0.3%**
								Total Inorganics/Metals	**7**	**0.6%**
Semivolatile Organics (PAHs)										
SUM_LOW_PAH	µg/g	Low Molecular Weight PAHs	0.55		-		0.55	33	**60**	**5.2%**
SUM_HIGH_PAH	µg/g	High Molecular Weight PAHs	1.7		-		1.7	86	**50**	**4.3%**
								Total PAHs	**110**	**9.5%**
PCBs (Aroclors)										
SUM_PCB	µg/g	Total PCBs	0.023		0.023		0.023	0.11	**5.1**	**0.4%**
								Total PCBs	**5**	**0.4%**
Pesticides										
60-57-1	µg/g	Dieldrin	0.000020		-		0.000020	0.019	**943**	**81%**
SUM_DDT	µg/g	DDx	0.0016		0.0016		0.0016	0.060	**38**	**3%**
								Total Pesticides	**981**	**85%**
Dioxin-like Compounds										
TCDD TEQ (D/F)	µg/g	TCDD TEQ (D/F)	0.0000032	g	-		0.0000032	0.00018	**56**	**5%**
TCDD TEQ (PCBs)	µg/g	TCDD TEQ (PCBs)	0.0000032	g	-		0.0000032	0.00000013	**0.041**	**0.004%**
								Total TCDD TEQ	**56**	**5%**
								Total	**1,160**	100%

a. ER-L = Effects Range-Low from Long *et al.* , 1995; except where noted.
b. NJDEP Guidance For Sediment Quality Evaluations, November 1998. References Long et al, 1995.
c. Minimum of the ER-L and the NJ sediment benchmark values.
d. Exposure Point Concentration (EPC) is based on the 95% Upper Confidence Level on the arithmetic mean of the values in the assessment data set as discussed in the text. TEQs calculated using fish TEFs.
e. Hazard Quotient (HQ) is the ratio of the EPC to the benchmark value.
f. Percentage of the COPEC HQ to the sum of all Hazard Quotients (excluding the TCDD TEQ value).
g. Derived by USFWS using sediment chemistry for Newark Bay and oyster effect data presented in Wintermyer and Cooper, 2003.

Attachment 8
TABLE 8-5
SUMMARY OF SEDIMENT BENCHMARK COMPARISONS
Future Conditions (2018) - Area of Focus

Focused Feasibility Study - Ecological Risk Assessment

CASRN	Units	Chemical Parameter	*Marine/ Estuarine Values* NOAA ER-L[a]		NJDEP[b]		Lowest Sediment Benchmark[c]	Sediment EPC[d]	Hazard Quotient[e]	Relative Magnitude[f]
Inorganics/Metals										
7440-50-8	µg/g	Copper	34		34		34	81	**2.4**	**0.6%**
7439-92-1	µg/g	Lead	47		47		47	147	**3.2**	**0.8%**
7439-97-6	µg/g	Mercury	0.15		0.15		0.15	0.62	**4**	**1.1%**
								Total Inorganics/Metals	**10**	**2.5%**
Semivolatile Organics (PAHs)										
SUM_LOW_PAH	µg/g	Low Molecular Weight PAHs	0.55		-		0.55	16	**28**	**7.4%**
SUM_HIGH_PAH	µg/g	High Molecular Weight PAHs	1.7		-		1.7	61	**36**	**9.4%**
								Total PAHs	**64**	**16.8%**
PCBs (Aroclors)										
SUM_PCB	µg/g	Total PCBs	0.023		0.023		0.023	0.39	**17.0**	**4.4%**
								Total PCBs	**17**	**4.4%**
Pesticides										
60-57-1	µg/g	Dieldrin	0.000020		-		0.000020	0.0047	**235**	**61%**
SUM_DDT	µg/g	DDx	0.0016		0.0016		0.0016	0.070	**44**	**12%**
								Total Pesticides	**279**	**73%**
Dioxin-like Compounds										
TCDD TEQ (D/F)	µg/g	TCDD TEQ (D/F)	0.0000032	g	-		0.0000032	0.000041	**13**	**3%**
TCDD TEQ (PCBs)	µg/g	TCDD TEQ (PCBs)	0.0000032	g	-		0.0000032	0.00000052	**0.2**	**0.0%**
								Total TCDD TEQ	**13**	**3%**
								Total	**383**	100%

a. ER-L = Effects Range-Low from Long *et al.* , 1995; except where noted.
b. NJDEP Guidance For Sediment Quality Evaluations, November 1998. References Long et al, 1995.
c. Minimum of the ER-L and the NJ sediment benchmark values.
d. Exposure Point Concentration (EPC) is based on the 95% Upper Confidence Level on the arithmetic mean of the values in the assessment data set as discussed in the text. TEQs calculated using fish TEFs.
e. Hazard Quotient (HQ) is the ratio of the EPC to the benchmark value.
f. Percentage of the COPEC HQ to the sum of all Hazard Quotients (excluding the TCDD TEQ value).
g. Derived by USFWS using sediment chemistry for Newark Bay and oyster effect data presented in Wintermyer and Cooper, 2003.

Attachment 8
TABLE 8-6
SUMMARY OF SEDIMENT BENCHMARK COMPARISONS
Future Conditions (2048) - Area of Focus

Focused Feasibility Study - Ecological Risk Assessment

CASRN	Units	Chemical Parameter	*Marine/ Estuarine Values* NOAA ER-L[a]		NJDEP[b]		Lowest Sediment Benchmark[c]	Sediment EPC[d]	Hazard Quotient[e]	Relative Magnitude[f]
Inorganics/Metals										
7440-50-8	µg/g	Copper	34		34		34	41	**1.2**	**0.4%**
7439-92-1	µg/g	Lead	47		47		47	69	**1.5**	**0.4%**
7439-97-6	µg/g	Mercury	0.15		0.15		0.15	0.20	**1.3**	**0.4%**
								Total Inorganics/Metals	**4.0**	**1.2%**
Semivolatile Organics (PAHs)										
SUM_LOW_PAH	µg/g	Low Molecular Weight PAHs	0.55		-		0.55	16	**28**	**8.6%**
SUM_HIGH_PAH	µg/g	High Molecular Weight PAHs	1.7		-		1.7	61	**36**	**11.0%**
								Total PAHs	**64**	**19.7%**
PCBs (Aroclors)										
SUM_PCB	µg/g	Total PCBs	0.023		0.023		0.023	0.088	**4**	**1.2%**
								Total PCBs	**4**	**1.2%**
Pesticides										
60-57-1	µg/g	Dieldrin	0.000020		-		0.000020	0.0047	**235**	**72%**
SUM_DDT	µg/g	DDx	0.0016		0.0016		0.0016	0.024	**15.4**	**5%**
								Total Pesticides	**250**	**77%**
Dioxin-like Compounds										
TCDD TEQ (D/F)	µg/g	TCDD TEQ (D/F)	0.0000032	g	-		0.0000032	0.000013	**4.0**	**1%**
TCDD TEQ (PCBs)	µg/g	TCDD TEQ (PCBs)	0.0000032	g	-		0.0000032	0.00000013	**0.04**	**0.0%**
								Total TCDD TEQ	**4.1**	**1%**
								Total	**326**	**100%**

a. ER-L = Effects Range-Low from Long *et al.* , 1995; except where noted.
b. NJDEP Guidance For Sediment Quality Evaluations, November 1998. References Long et al, 1995.
c. Minimum of the ER-L and the NJ sediment benchmark values.
d. Exposure Point Concentration (EPC) is based on the 95% Upper Confidence Level on the arithmetic mean of the values in the assessment data set as discussed in the text. TEQs calculated using fish TEFs.
e. Hazard Quotient (HQ) is the ratio of the EPC to the benchmark value.
f. Percentage of the COPEC HQ to the sum of all Hazard Quotients (excluding the TCDD TEQ value).
g. Derived by USFWS using sediment chemistry for Newark Bay and oyster effect data presented in Wintermyer and Cooper, 2003.

TABLE 8-7
CBR-BASED HAZARD QUOTIENTS FOR COPCs IN BLUE CRAB TISSUE
Future Conditions (2018) - Monitored Natural Recovery

Focused Feasibility Study - Ecological Risk Assessment

Chemical	Units	EPC [a]	CBR [b]		Species	Endpoint	Reference	Hazard Quotients [c]	
			NOAEL	LOAEL				NOAEL	LOAEL
Inorganics/Metals									
Copper	µg/g	19	0.086	**0.86**	*Protothaca staminea*	Mortality - LD_{11}	1	**2.3E+02**	**2.3E+01**
Lead	µg/g	0.33	0.52	**5.2**	*Hyalella azteca*	Mortality - LD_{25}	2	6.4E-01	6.4E-02
Mercury[1]	µg/g	0.043	0.0095	**0.095**	*Acartia tonsa*	Reproduction - ED_{50}	3	**4.6E+00**	4.6E-01
Mercury (methyl)	µg/g	0.043	0.0095	**0.095**	*Acartia tonsa*	Reproduction - ED_{50}	3	**4.6E+00**	4.6E-01
						Total Inorganics/Metals		**2.3E+02**	**2.3E+01**
Semivolatile Organics (PAHs)									
Low Weight PAHs	µg/g	0.25	0.022	**0.22**	*Mytilus edulis*	Reproduction - LOED	4	**1.1E+01**	**1.1E+00**
High Weight PAHs	µg/g	0.27	0.022	**0.22**	*Mytilus edulis*	Reproduction - LOED	4	**1.2E+01**	**1.2E+00**
						Total PAHs		**2.4E+01**	**2.4E+00**
PCBs (Aroclors)									
Aroclor, Total	µg/g	1.2	**0.42**	**1.1**	*Palaemonetes pugio*	Mortality - LOED	5	**2.8E+00**	**1.1E+00**
						Total PCBs		**2.8E+00**	**1.1E+00**
Pesticides									
Dieldrin	µg/g	0.014	**0.01**	**0.08**	*Penaeus duorarum*	Mortality - LOED	6	**1.4E+00**	1.7E-01
Total DDx	µg/g	0.22	0.00018	**0.0018**	*Hyalella azteca*	Mortality - LD_{50}	7	**1.2E+03**	**1.2E+02**
						Total Pesticides		**1.2E+03**	**1.2E+02**
Dioxin-like Compounds									
TCDD TEQ (D/F)	µg/g	0.00014	**0.00000015**	**0.0000013**	*Crassostrea virginica*	Reproduction - LOED	8	**9.1E+02**	**1.0E+02**
TCDD TEQ (PCBs)	µg/g	0.0000016	**0.00000015**	**0.0000013**	*Crassostrea virginica*	Reproduction - LOED	8	**1.1E+01**	**1.2E+00**
						Total TCDD TEQ		**9.2E+02**	**1.1E+02**
						Total		**2.4E+03**	**2.5E+02**

Notes:

[a] Exposure Point Concentrations (95% UCLs) presented in Table 7-6. TCDD Toxic Equivalencies based on fish TEF values, EPCs based on blue crab tissue data.

[b] Critical Body Residues (CBRs) are obtained from summary of tissue effects data presented in CSM Technical Memorandum #3 (Battelle, 2006).

[c] Hazard Quotient is the ratio of the EPC to the NOAEL or LOAEL CBR.

[1]Analyte is not included in the HI totals.

Non-bolded CBR values were estimated using a 10-fold extrapolation factor.

TABLE 8-7
CBR-BASED HAZARD QUOTIENTS FOR COPCs IN BLUE CRAB TISSUE
Future Conditions (2018) - Monitored Natural Recovery

Focused Feasibility Study - Ecological Risk Assessment

Chemical	Units	EPC [a]	CBR [b]		Species	Endpoint	Reference	Hazard Quotients [c]	
			NOAEL	LOAEL				NOAEL	LOAEL

References:

1. Roesijadi, G., 1980. Biol.Bull. 158:233-247; ERED Ref ID JA377.
2. Borgmann, U., and W.P. Norwood, 1999. Can. J. Fish. Aquat. Sci. 56; ERED Ref ID MEC04-063.
3. Hook, S., and N. Fisher, 2002. Marine Environ. Res. 53: 161-174; ERED Ref ID MEC03-211.
4. Eertman, R.H.M., C.L. Groenink, B. Sandee, and H. Hummel, 1995; ERED Ref ID URS75.
5. (NOAEL) Nimmo, D.R., J. Forester, P.T. Heitmuller, and G.H. Cook, 1974. Bull. Environ. Contam. Toxicol. 11(4):303-308; ERED Ref ID JA329
(LOAEL) Hansen, D.J., P.R. Parrish, and J. Forester, 1974. Environ. Res. 7:363-373; ERED Ref ID URS102.
6. Parrish, P.P., J.A. Couch, J. Forester, J.M. Patrick, and G.H. Cook, NS. Contribution No. 178, Gulf Breeze Environmental Research Laboratory, Sabine Island, Gulf Breeze, FL 32561; ERED Ref ID SEQ97-2.
7. Lotufo, G.R., P.F. Landrum, and M.L. Gedeon, 2001. Environ. Tox. Chem. 20(4):810-825; ERED Ref ID MEC03-102.
8. Wintermyer, M.L., and K.R. Cooper, 2003. Dioxin/Furan and Polychlorinated Biphenyl Concentrations in Eastern Oyster (Crassostrea virginica, Gmelin) Tissues and the Effects on Egg-Fertilization and Development; J. Shellfish Res. 22(3):737-746.

TABLE 8-8
CBR-BASED HAZARD QUOTIENTS FOR COPCs IN BLUE CRAB TISSUE
Future Conditions (2048) - Monitored Natural Recovery

Focused Feasibility Study - Ecological Risk Assessment

Chemical	Units	EPC [a]	CBR [b]		Species	Endpoint	Reference	Hazard Quotients [c]	
			NOAEL	LOAEL				NOAEL	LOAEL
Inorganics/Metals									
Copper	µg/g	9.8	0.086	**0.86**	*Protothaca staminea*	Mortality - LD_{11}	1	**1.1E+02**	**1.1E+01**
Lead	µg/g	0.15	0.52	**5.2**	*Hyalella azteca*	Mortality - LD_{25}	2	3.0E-01	3.0E-02
Mercury[1]	µg/g	0.014	0.0095	**0.095**	*Acartia tonsa*	Reproduction - ED_{50}	3	**1.5E+00**	1.5E-01
Mercury (methyl)	µg/g	0.014	0.0095	**0.095**	*Acartia tonsa*	Reproduction - ED_{50}	3	**1.5E+00**	1.5E-01
						Total Inorganics/Metals		**1.2E+02**	**1.2E+01**
Semivolatile Organics (PAHs)									
Low Weight PAHs	µg/g	0.25	0.022	**0.22**	*Mytilus edulis*	Reproduction - LOED	4	**1.1E+01**	**1.1E+00**
High Weight PAHs	µg/g	0.27	0.022	**0.22**	*Mytilus edulis*	Reproduction - LOED	4	**1.2E+01**	**1.2E+00**
						Total PAHs		**2.4E+01**	**2.4E+00**
PCBs (Aroclors)									
Aroclor, Total	µg/g	0.26	**0.42**	**1.1**	*Palaemonetes pugio*	Mortality - LOED	5	6.3E-01	2.4E-01
						Total PCBs		6.3E-01	2.4E-01
Pesticides									
Dieldrin	µg/g	0.014	**0.01**	**0.08**	*Penaeus duorarum*	Mortality - LOED	6	**1.4E+00**	1.7E-01
Total DDx	µg/g	0.077	0.00018	**0.0018**	*Hyalella azteca*	Mortality - LD_{50}	7	**4.2E+02**	**4.2E+01**
						Total Pesticides		**4.2E+02**	**4.2E+01**
Dioxin-like Compounds									
TCDD TEQ (D/F)	µg/g	0.000036	**0.00000015**	**0.0000013**	*Crassostrea virginica*	Reproduction - LOED	8	**2.4E+02**	**2.8E+01**
TCDD TEQ (PCBs)	µg/g	0.00000054	**0.00000015**	**0.0000013**	*Crassostrea virginica*	Reproduction - LOED	8	**3.6E+00**	4.2E-01
						Total TCDD TEQ		**2.5E+02**	**2.8E+01**
						Total		**8.1E+02**	**8.4E+01**

Notes:

[a] Exposure Point Concentrations (95% UCLs) presented in Table 7-6. TCDD Toxic Equivalencies based on fish TEF values, EPCs based on blue crab tissue data.

[b] Critical Body Residues (CBRs) are obtained from summary of tissue effects data presented in CSM Technical Memorandum #3 (Battelle, 2006).

[c] Hazard Quotient is the ratio of the EPC to the NOAEL or LOAEL CBR.

[1]Analyte is not included in the HI totals.

Non-bolded CBR values were estimated using a 10-fold extrapolation factor.

TABLE 8-8
CBR-BASED HAZARD QUOTIENTS FOR COPCs IN BLUE CRAB TISSUE
Future Conditions (2048) - Monitored Natural Recovery

Focused Feasibility Study - Ecological Risk Assessment

Chemical	Units	EPC [a]	CBR [b]		Species	Endpoint	Reference	Hazard Quotients [c]	
			NOAEL	LOAEL				NOAEL	LOAEL

References:

1. Roesijadi, G., 1980. Biol.Bull. 158:233-247; ERED Ref ID JA377.
2. Borgmann, U., and W.P. Norwood, 1999. Can. J. Fish. Aquat. Sci. 56; ERED Ref ID MEC04-063.
3. Hook, S., and N. Fisher, 2002. Marine Environ. Res. 53: 161-174; ERED Ref ID MEC03-211.
4. Eertman, R.H.M., C.L. Groenink, B. Sandee, and H. Hummel, 1995; ERED Ref ID URS75.
5. (NOAEL) Nimmo, D.R., J. Forester, P.T. Heitmuller, and G.H. Cook, 1974. Bull. Environ. Contam. Toxicol. 11(4):303-308; ERED Ref ID JA329
(LOAEL) Hansen, D.J., P.R. Parrish, and J. Forester, 1974. Environ. Res. 7:363-373; ERED Ref ID URS102.
6. Parrish, P.P., J.A. Couch, J. Forester, J.M. Patrick, and G.H. Cook, NS. Contribution No. 178, Gulf Breeze Environmental Research Laboratory, Sabine Island, Gulf Breeze, FL 32561; ERED Ref ID SEQ97-2.
7. Lotufo, G.R., P.F. Landrum, and M.L. Gedeon, 2001. Environ. Tox. Chem. 20(4):810-825; ERED Ref ID MEC03-102.
8. Wintermyer, M.L., and K.R. Cooper, 2003. Dioxin/Furan and Polychlorinated Biphenyl Concentrations in Eastern Oyster (Crassostrea virginica, Gmelin) Tissues and the Effects on Egg-Fertilization and Development; J. Shellfish Res. 22(3):737-746.

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TABLE 8-9

CBR-BASED HAZARD QUOTIENTS FOR COPCs IN BLUE CRAB TISSUE

Future Conditions (2018) - Primary Erosional Zone/Primary Inventory Zone

Focused Feasibility Study - Ecological Risk Assessment

Chemical	Units	EPC [a]	CBR [b]		Species	Endpoint	Reference	Hazard Quotients [c]	
			NOAEL	LOAEL				NOAEL	LOAEL
Inorganics/Metals									
Copper	µg/g	19	0.086	**0.86**	*Protothaca staminea*	Mortality - LD_{11}	1	**2.2E+02**	**2.2E+01**
Lead	µg/g	0.32	0.52	**5.2**	*Hyalella azteca*	Mortality - LD_{25}	2	6.1E-01	6.1E-02
Mercury[1]	µg/g	0.038	0.0095	**0.095**	*Acartia tonsa*	Reproduction - ED_{50}	3	**4.0E+00**	4.0E-01
Mercury (methyl)	µg/g	0.038	0.0095	**0.095**	*Acartia tonsa*	Reproduction - ED_{50}	3	**4.0E+00**	4.0E-01
						Total Inorganics/Metals		**2.2E+02**	**2.2E+01**
Semivolatile Organics (PAHs)									
Low Weight PAHs	µg/g	0.25	0.022	**0.22**	*Mytilus edulis*	Reproduction - LOED	4	**1.1E+01**	**1.1E+00**
High Weight PAHs	µg/g	0.27	0.022	**0.22**	*Mytilus edulis*	Reproduction - LOED	4	**1.2E+01**	**1.2E+00**
						Total PAHs		**2.4E+01**	**2.4E+00**
PCBs (Aroclors)									
Aroclor, Total	µg/g	1.0	**0.42**	**1.1**	*Palaemonetes pugio*	Mortality - LOED	5	**2.5E+00**	9.4E-01
						Total PCBs		**2.5E+00**	9.4E-01
Pesticides									
Dieldrin	µg/g	0.013	**0.01**	**0.08**	*Penaeus duorarum*	Mortality - LOED	6	**1.3E+00**	1.6E-01
Total DDx	µg/g	0.19	0.00018	**0.0018**	*Hyalella azteca*	Mortality - LD_{50}	7	**1.0E+03**	**1.0E+02**
						Total Pesticides		**1.0E+03**	**1.0E+02**
Dioxin-like Compounds									
TCDD TEQ (D/F)	µg/g	0.000091	**0.00000015**	**0.0000013**	*Crassostrea virginica*	Reproduction - LOED	8	**6.0E+02**	**7.0E+01**
TCDD TEQ (PCBs)	µg/g	0.0000015	**0.00000015**	**0.0000013**	*Crassostrea virginica*	Reproduction - LOED	8	**1.0E+01**	**1.2E+00**
						Total TCDD TEQ		**6.1E+02**	**7.1E+01**
						Total		**1.9E+03**	**2.0E+02**

Notes:

[a] Exposure Point Concentrations (95% UCLs) presented in Table 7-7. TCDD Toxic Equivalencies based on fish TEF values, EPCs based on blue crab tissue data.

[b] Critical Body Residues (CBRs) are obtained from summary of tissue effects data presented in CSM Technical Memorandum #3 (Battelle, 2006).

[c] Hazard Quotient is the ratio of the EPC to the NOAEL or LOAEL CBR.

[1]Analyte is not included in the HI totals.

Non-bolded CBR values were estimated using a 10-fold extrapolation factor.

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TABLE 8-9

CBR-BASED HAZARD QUOTIENTS FOR COPCs IN BLUE CRAB TISSUE

Future Conditions (2018) - Primary Erosional Zone/Primary Inventory Zone

Focused Feasibility Study - Ecological Risk Assessment

Chemical	Units	EPC [a]	CBR [b]		Species	Endpoint	Reference	Hazard Quotients [c]	
			NOAEL	LOAEL				NOAEL	LOAEL

References:

1. Roesijadi, G., 1980. Biol.Bull. 158:233-247; ERED Ref ID JA377.
2. Borgmann, U., and W.P. Norwood, 1999. Can. J. Fish. Aquat. Sci. 56; ERED Ref ID MEC04-063.
3. Hook, S., and N. Fisher, 2002. Marine Environ. Res. 53: 161-174; ERED Ref ID MEC03-211.
4. Eertman, R.H.M., C.L. Groenink, B. Sandee, and H. Hummel, 1995; ERED Ref ID URS75.
5. (NOAEL) Nimmo, D.R., J. Forester, P.T. Heitmuller, and G.H. Cook, 1974. Bull. Environ. Contam. Toxicol. 11(4):303-308; ERED Ref ID JA329
(LOAEL) Hansen, D.J., P.R. Parrish, and J. Forester, 1974. Environ. Res. 7:363-373; ERED Ref ID URS102.
6. Parrish, P.P., J.A. Couch, J. Forester, J.M. Patrick, and G.H. Cook, NS. Contribution No. 178, Gulf Breeze Environmental Research Laboratory, Sabine Island, Gulf Breeze, FL 32561; ERED Ref ID SEQ97-2.
7. Lotufo, G.R., P.F. Landrum, and M.L. Gedeon, 2001. Environ. Tox. Chem. 20(4):810-825; ERED Ref ID MEC03-102.
8. Wintermyer, M.L., and K.R. Cooper, 2003. Dioxin/Furan and Polychlorinated Biphenyl Concentrations in Eastern Oyster (Crassostrea virginica, Gmelin) Tissues and the Effects on Egg-Fertilization and Development; J. Shellfish Res. 22(3):737-746.

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TABLE 8-10
CBR-BASED HAZARD QUOTIENTS FOR COPCs IN BLUE CRAB TISSUE
Future Conditions (2048) - Primary Erosional Zone/Primary Inventory Zone

Focused Feasibility Study - Ecological Risk Assessment

Chemical	Units	EPC [a]	CBR [b]		Species	Endpoint	Reference	Hazard Quotients [c]	
			NOAEL	LOAEL				NOAEL	LOAEL
Inorganics/Metals									
Copper	µg/g	9.3	0.086	**0.86**	*Protothaca staminea*	Mortality - LD_{11}	1	**1.1E+02**	**1.1E+01**
Lead	µg/g	0.15	0.52	**5.2**	*Hyalella azteca*	Mortality - LD_{25}	2	2.8E-01	2.8E-02
Mercury[1]	µg/g	0.012	0.0095	**0.095**	*Acartia tonsa*	Reproduction - ED_{50}	3	**1.3E+00**	1.3E-01
Mercury (methyl)	µg/g	0.012	0.0095	**0.095**	*Acartia tonsa*	Reproduction - ED_{50}	3	**1.3E+00**	1.3E-01
						Total Inorganics/Metals		**1.1E+02**	**1.1E+01**
Semivolatile Organics (PAHs)									
Low Weight PAHs	µg/g	0.25	0.022	**0.22**	*Mytilus edulis*	Reproduction - LOED	4	**1.1E+01**	**1.1E+00**
High Weight PAHs	µg/g	0.27	0.022	**0.22**	*Mytilus edulis*	Reproduction - LOED	4	**1.2E+01**	**1.2E+00**
						Total PAHs		**2.4E+01**	**2.4E+00**
PCBs (Aroclors)									
Aroclor, Total	µg/g	0.24	**0.42**	**1.1**	*Palaemonetes pugio*	Mortality - LOED	5	5.6E-01	2.1E-01
						Total PCBs		5.6E-01	2.1E-01
Pesticides									
Dieldrin	µg/g	0.013	**0.01**	**0.08**	*Penaeus duorarum*	Mortality - LOED	6	**1.3E+00**	1.6E-01
Total DDx	µg/g	0.067	0.00018	**0.0018**	*Hyalella azteca*	Mortality - LD_{50}	7	**3.6E+02**	**3.6E+01**
						Total Pesticides		**3.6E+02**	**3.6E+01**
Dioxin-like Compounds									
TCDD TEQ (D/F)	µg/g	0.000027	**0.00000015**	**0.0000013**	*Crassostrea virginica*	Reproduction - LOED	8	**1.8E+02**	**2.1E+01**
TCDD TEQ (PCBs)	µg/g	0.00000027	**0.00000015**	**0.0000013**	*Crassostrea virginica*	Reproduction - LOED	8	**1.8E+00**	2.1E-01
						Total TCDD TEQ		**1.8E+02**	**2.1E+01**
						Total		**6.8E+02**	**7.1E+01**

Notes:

[a] Exposure Point Concentrations (95% UCLs) presented in Table 7-7. TCDD Toxic Equivalencies based on fish TEF values, EPCs based on blue crab tissue data.

[b] Critical Body Residues (CBRs) are obtained from summary of tissue effects data presented in CSM Technical Memorandum #3 (Battelle, 2006).

[c] Hazard Quotient is the ratio of the EPC to the NOAEL or LOAEL CBR.

[1]Analyte is not included in the HI totals.

Non-bolded CBR values were estimated using a 10-fold extrapolation factor.

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TABLE 8-10
CBR-BASED HAZARD QUOTIENTS FOR COPCs IN BLUE CRAB TISSUE
Future Conditions (2048) - Primary Erosional Zone/Primary Inventory Zone

Focused Feasibility Study - Ecological Risk Assessment

Chemical	Units	EPC [a]	CBR [b]		Species	Endpoint	Reference	Hazard Quotients [c]	
			NOAEL	LOAEL				NOAEL	LOAEL

References:

1. Roesijadi, G., 1980. Biol.Bull. 158:233-247; ERED Ref ID JA377.
2. Borgmann, U., and W.P. Norwood, 1999. Can. J. Fish. Aquat. Sci. 56; ERED Ref ID MEC04-063.
3. Hook, S., and N. Fisher, 2002. Marine Environ. Res. 53: 161-174; ERED Ref ID MEC03-211.
4. Eertman, R.H.M., C.L. Groenink, B. Sandee, and H. Hummel, 1995; ERED Ref ID URS75.
5. (NOAEL) Nimmo, D.R., J. Forester, P.T. Heitmuller, and G.H. Cook, 1974. Bull. Environ. Contam. Toxicol. 11(4):303-308; ERED Ref ID JA329
(LOAEL) Hansen, D.J., P.R. Parrish, and J. Forester, 1974. Environ. Res. 7:363-373; ERED Ref ID URS102.
6. Parrish, P.P., J.A. Couch, J. Forester, J.M. Patrick, and G.H. Cook, NS. Contribution No. 178, Gulf Breeze Environmental Research Laboratory, Sabine Island, Gulf Breeze, FL 32561; ERED Ref ID SEQ97-2.
7. Lotufo, G.R., P.F. Landrum, and M.L. Gedeon, 2001. Environ. Tox. Chem. 20(4):810-825; ERED Ref ID MEC03-102.
8. Wintermyer, M.L., and K.R. Cooper, 2003. Dioxin/Furan and Polychlorinated Biphenyl Concentrations in Eastern Oyster (Crassostrea virginica, Gmelin) Tissues and the Effects on Egg-Fertilization and Development; J. Shellfish Res. 22(3):737-746.

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TABLE 8-11
CBR-BASED HAZARD QUOTIENTS FOR COPCs IN BLUE CRAB TISSUE
Future Conditions (2018) - Area of Focus

Focused Feasibility Study - Ecological Risk Assessment

Chemical	Units	EPC [a]	CBR [b]		Species	Endpoint	Reference	Hazard Quotients [c]	
			NOAEL	LOAEL				NOAEL	LOAEL
Inorganics/Metals									
Copper	µg/g	11	0.086	**0.86**	*Protothaca staminea*	Mortality - LD_{11}	1	**1.3E+02**	**1.3E+01**
Lead	µg/g	0.21	0.52	**5.2**	*Hyalella azteca*	Mortality - LD_{25}	2	4.0E-01	4.0E-02
Mercury[1]	µg/g	0.017	0.0095	**0.095**	*Acartia tonsa*	Reproduction - ED_{50}	3	**1.8E+00**	1.8E-01
Mercury (methyl)	µg/g	0.017	0.0095	**0.095**	*Acartia tonsa*	Reproduction - ED_{50}	3	**1.8E+00**	1.8E-01
						Total Inorganics/Metals		**1.3E+02**	**1.3E+01**
Semivolatile Organics (PAHs)									
Low Weight PAHs	µg/g	0.12	0.022	**0.22**	*Mytilus edulis*	Reproduction - LOED	4	**5.3E+00**	5.3E-01
High Weight PAHs	µg/g	0.19	0.022	**0.22**	*Mytilus edulis*	Reproduction - LOED	4	**8.8E+00**	8.8E-01
						Total PAHs		**1.4E+01**	**1.4E+00**
PCBs (Aroclors)									
Aroclor, Total	µg/g	0.79	**0.42**	**1.1**	*Palaemonetes pugio*	Mortality - LOED	5	**1.9E+00**	7.2E-01
						Total PCBs		**1.9E+00**	7.2E-01
Pesticides									
Dieldrin	µg/g	0.0032	**0.01**	**0.08**	*Penaeus duorarum*	Mortality - LOED	6	3.2E-01	4.0E-02
Total DDx	µg/g	0.078	0.00018	**0.0018**	*Hyalella azteca*	Mortality - LD_{50}	7	**4.2E+02**	**4.2E+01**
						Total Pesticides		**4.2E+02**	**4.2E+01**
Dioxin-like Compounds									
TCDD TEQ (D/F)	µg/g	0.0000062	**0.00000015**	**0.0000013**	*Crassostrea virginica*	Reproduction - LOED	8	**4.2E+01**	**4.8E+00**
TCDD TEQ (PCBs)	µg/g	0.0000011	**0.00000015**	**0.0000013**	*Crassostrea virginica*	Reproduction - LOED	8	**7.2E+00**	8.3E-01
						Total TCDD TEQ		**4.9E+01**	**5.6E+00**
						Total		**6.2E+02**	**6.4E+01**

Notes:

[a] Exposure Point Concentrations (95% UCLs) presented in Table 7-8. TCDD Toxic Equivalencies based on fish TEF values, EPCs based on blue crab tissue data.

[b] Critical Body Residues (CBRs) are obtained from summary of tissue effects data presented in CSM Technical Memorandum #3 (Battelle, 2006).

[c] Hazard Quotient is the ratio of the EPC to the NOAEL or LOAEL CBR.

[1]Analyte is not included in the HI totals.

Non-bolded CBR values were estimated using a 10-fold extrapolation factor.

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TABLE 8-11
CBR-BASED HAZARD QUOTIENTS FOR COPCs IN BLUE CRAB TISSUE
Future Conditions (2018) - Area of Focus

Focused Feasibility Study - Ecological Risk Assessment

Chemical	Units	EPC [a]	CBR [b]		Species	Endpoint	Reference	Hazard Quotients [c]	
			NOAEL	LOAEL				NOAEL	LOAEL

References:

1. Roesijadi, G., 1980. Biol.Bull. 158:233-247; ERED Ref ID JA377.
2. Borgmann, U., and W.P. Norwood, 1999. Can. J. Fish. Aquat. Sci. 56; ERED Ref ID MEC04-063.
3. Hook, S., and N. Fisher, 2002. Marine Environ. Res. 53: 161-174; ERED Ref ID MEC03-211.
4. Eertman, R.H.M., C.L. Groenink, B. Sandee, and H. Hummel, 1995; ERED Ref ID URS75.
5. (NOAEL) Nimmo, D.R., J. Forester, P.T. Heitmuller, and G.H. Cook, 1974. Bull. Environ. Contam. Toxicol. 11(4):303-308; ERED Ref ID JA329
(LOAEL) Hansen, D.J., P.R. Parrish, and J. Forester, 1974. Environ. Res. 7:363-373; ERED Ref ID URS102.
6. Parrish, P.P., J.A. Couch, J. Forester, J.M. Patrick, and G.H. Cook, NS. Contribution No. 178, Gulf Breeze Environmental Research Laboratory, Sabine Island, Gulf Breeze, FL 32561; ERED Ref ID SEQ97-2.
7. Lotufo, G.R., P.F. Landrum, and M.L. Gedeon, 2001. Environ. Tox. Chem. 20(4):810-825; ERED Ref ID MEC03-102.
8. Wintermyer, M.L., and K.R. Cooper, 2003. Dioxin/Furan and Polychlorinated Biphenyl Concentrations in Eastern Oyster (Crassostrea virginica, Gmelin) Tissues and the Effects on Egg-Fertilization and Development; J. Shellfish Res. 22(3):737-746.

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TABLE 8-12
CBR-BASED HAZARD QUOTIENTS FOR COPCs IN BLUE CRAB TISSUE
Future Conditions (2048) - Area of Focus

Focused Feasibility Study - Ecological Risk Assessment

Chemical	Units	EPC [a]	CBR [b]		Species	Endpoint	Reference	Hazard Quotients [c]	
			NOAEL	LOAEL				NOAEL	LOAEL
Inorganics/Metals									
Copper	µg/g	5.8	0.086	**0.86**	*Protothaca staminea*	Mortality - LD_{11}	1	**6.7E+01**	**6.7E+00**
Lead	µg/g	0.097	0.52	**5.2**	*Hyalella azteca*	Mortality - LD_{25}	2	1.9E-01	1.9E-02
Mercury[1]	µg/g	0.0055	0.0095	**0.095**	*Acartia tonsa*	Reproduction - ED_{50}	3	5.8E-01	5.8E-02
Mercury (methyl)	µg/g	0.0055	0.0095	**0.095**	*Acartia tonsa*	Reproduction - ED_{50}	3	5.8E-01	5.8E-02
						Total Inorganics/Metals		**6.8E+01**	**6.8E+00**
Semivolatile Organics (PAHs)									
Low Weight PAHs	µg/g	0.12	0.022	**0.22**	*Mytilus edulis*	Reproduction - LOED	4	**5.3E+00**	5.3E-01
High Weight PAHs	µg/g	0.19	0.022	**0.22**	*Mytilus edulis*	Reproduction - LOED	4	**8.8E+00**	8.8E-01
						Total PAHs		**1.4E+01**	**1.4E+00**
PCBs (Aroclors)									
Aroclor, Total	µg/g	0.18	**0.42**	**1.1**	*Palaemonetes pugio*	Mortality - LOED	5	4.3E-01	1.6E-01
						Total PCBs		4.3E-01	1.6E-01
Pesticides									
Dieldrin	µg/g	0.0032	**0.01**	**0.08**	*Penaeus duorarum*	Mortality - LOED	6	3.2E-01	4.0E-02
Total DDx	µg/g	0.027	0.00018	**0.0018**	*Hyalella azteca*	Mortality - LD_{50}	7	**1.5E+02**	**1.5E+01**
						Total Pesticides		**1.5E+02**	**1.5E+01**
Dioxin-like Compounds									
TCDD TEQ (D/F)	µg/g	0.0000019	**0.00000015**	**0.0000013**	*Crassostrea virginica*	Reproduction - LOED	8	**1.3E+01**	**1.5E+00**
TCDD TEQ (PCBs)	µg/g	0.00000027	**0.00000015**	**0.0000013**	*Crassostrea virginica*	Reproduction - LOED	8	**1.8E+00**	2.1E-01
						Total TCDD TEQ		**1.5E+01**	**1.7E+00**
						Total		**2.5E+02**	**2.5E+01**

Notes:

[a] Exposure Point Concentrations (95% UCLs) presented in Table 7-8. TCDD Toxic Equivalencies based on fish TEF values, EPCs based on blue crab tissue data.

[b] Critical Body Residues (CBRs) are obtained from summary of tissue effects data presented in CSM Technical Memorandum #3 (Battelle, 2006).

[c] Hazard Quotient is the ratio of the EPC to the NOAEL or LOAEL CBR.

[1]Analyte is not included in the HI totals.

Non-bolded CBR values were estimated using a 10-fold extrapolation factor.

Attachment 8

TABLE 8-12
CBR-BASED HAZARD QUOTIENTS FOR COPCs IN BLUE CRAB TISSUE
Future Conditions (2048) - Area of Focus

Focused Feasibility Study - Ecological Risk Assessment

Chemical	Units	EPC [a]	CBR [b]		Species	Endpoint	Reference	Hazard Quotients [c]	
			NOAEL	LOAEL				NOAEL	LOAEL

References:

1. Roesijadi, G., 1980. Biol.Bull. 158:233-247; ERED Ref ID JA377.
2. Borgmann, U., and W.P. Norwood, 1999. Can. J. Fish. Aquat. Sci. 56; ERED Ref ID MEC04-063.
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4. Eertman, R.H.M., C.L. Groenink, B. Sandee, and H. Hummel, 1995; ERED Ref ID URS75.
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(LOAEL) Hansen, D.J., P.R. Parrish, and J. Forester, 1974. Environ. Res. 7:363-373; ERED Ref ID URS102.
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7. Lotufo, G.R., P.F. Landrum, and M.L. Gedeon, 2001. Environ. Tox. Chem. 20(4):810-825; ERED Ref ID MEC03-102.
8. Wintermyer, M.L., and K.R. Cooper, 2003. Dioxin/Furan and Polychlorinated Biphenyl Concentrations in Eastern Oyster (Crassostrea virginica, Gmelin) Tissues and the Effects on Egg-Fertilization and Development; J. Shellfish Res. 22(3):737-746.

Attachment 8
TABLE 8-13
CBR-BASED HAZARD QUOTIENTS FOR COPECS IN WHITE PERCH/AMERICAN EEL TISSUE
Future Conditions (2018) - Monitored Natural Recovery

Focused Feasibility Study - Ecological Risk Assessment

Chemical	Units	EPC [a]	CBR [b]		Species	Endpoint	Reference	Hazard Quotients [c]	
			NOAEL	LOAEL				NOAEL	LOAEL
Inorganics/Metals									
Copper	µg/g	5.6	0.002	**0.02**	*Ictalurus punctatus*	Growth - LOED	1	**2.8E+03**	**2.8E+02**
Lead	µg/g	0.28	0.028	**0.28**	*Oncorhynchus mykiss*	Growth - ED_{11}	2	**1.0E+01**	**1.0E+00**
Mercury[1]	µg/g	0.16	0.006	**0.06**	*Ictalurus punctatus*	Mortality - LD_{50}	3	**2.6E+01**	**2.6E+00**
Mercury (methyl)	µg/g	0.16	0.001	**0.01**	*Fundulus heteroclitus*	Growth - ED_{146}	4	**1.6E+02**	**1.6E+01**
						Total Inorganics/Metals		**3.0E+03**	**3.0E+02**
Semivolatile Organics (PAHs)									
Low Weight PAHs	µg/g	0.37	0.21	**2.1**	*Psettichthys melanostictus*	Mortality - LD_{51}	5	**1.8E+00**	1.8E-01
High Weight PAHs	µg/g	0.22	0.21	**2.1**	*Psettichthys melanostictus*	Mortality - LD_{51}	5	**1.0E+00**	1.0E-01
						Total PAHs		**2.8E+00**	2.8E-01
PCBs (Aroclors)									
Aroclor, Total	µg/g	1.2	0.0025	**0.025**	*Oryzias latipes*	Reproduction - ED_{11}	6	**4.9E+02**	**4.9E+01**
						Total PCBs		**4.9E+02**	**4.9E+01**
Pesticides									
Dieldrin	µg/g	0.032	0.011	**0.11**	*Oncorhynchus mykiss*	Growth - LOED	7	**2.9E+00**	2.9E-01
Total DDx	µg/g	0.36	**0.000039**	**0.0018**	*Oryzias latipes*	Mortality - LOED	8	**9.2E+03**	**2.0E+02**
						Total Pesticides		**9.2E+03**	**2.0E+02**
Dioxin-like Compounds									
TCDD TEQ (D/F)	µg/g	0.00018	**0.000034**	**0.00006**	*Salvelinus namaycush*	Growth - LOED	9	**5.3E+00**	**3.1E+00**
TCDD TEQ (PCBs)	µg/g	0.0000011	**0.000034**	**0.00006**	*Salvelinus namaycush*	Growth - LOED	9	3.4E-02	2.0E-02
						Total TCDD TEQ		**5.3E+00**	**3.1E+00**
						Total		**1.3E+04**	**5.5E+02**

Notes:

[a] Exposure Point Concentration (95% UCLs) presented in Table 7-6. TCDD Toxic Equivalencies based on fish TEF values, EPCs based on white perch and American eel tissue data.

[b] Critical Body Residues (CBRs) are obtained from summary of tissue effects data presented in CSM Technical Memorandum #3 (Battelle, 2006).

[c] Hazard Quotient is the ratio of the EPC to the NOAEL or LOAEL CBR.

[1]Analyte is not included in the HI totals.

Non-bolded CBR values were estimated using a 10-fold extrapolation factor.

Attachment 8
TABLE 8-13
CBR-BASED HAZARD QUOTIENTS FOR COPECS IN WHITE PERCH/AMERICAN EEL TISSUE
Future Conditions (2018) - Monitored Natural Recovery

Focused Feasibility Study - Ecological Risk Assessment

Chemical	Units	EPC [a]	CBR [b]		Species	Endpoint	Reference	Hazard Quotients [c]	
			NOAEL	LOAEL				NOAEL	LOAEL

References:

1. Murai, T., J.W. Andrews, and R.G. Smith, Jr., 1981. Aquaculture 22:353-357; ERED Ref ID JA317.
2. Hansen, J.A., J. Lipton, P.G., Welsh, D. Cacela, and B. MacConnell, 2004. Environ. Tox. & Chem. 23:1902-1911; ERED Ref ID Weston05-031.
3. Birge, W.J., J.A. Black, A.G. Westerman, and J.E. Hudson, 1979. The Biogeochemistry of Mercury, pg. 629-655; ERED Ref ID JA33.
4. Matta, M.B., J. Linse, C. Cairncross, L. Francendese, and R.M. Kocan, 2001. Environ. Tox. & Chem. 20(2)L327-335; ERED Ref ID MECO3-135.
5. Hose, J.E., J.B. Hannah, D. DiJulio, M.L. Landholt, B.S. Miller, W.T. Iwaoka, and S.P. Felton, 1982. Arch. Environ. Contam. Toxicol. 11:167-171; ERED Ref ID JA212
6. Nakayama, K., Y. Oshima, K. Nagafuchi, T. Hano, Y. Shimasaki, and T. Honjo, 2005. Environ. Tox. Chem. 24:591-596; ERED Ref ID Weston05-046.
7. Dillon, T.M., 1984. Army Corps of Engineers Technical Report, D-84-2; ERED Ref ID MEC04-070.
8. Villalobos, S.B., D.M. Papoulias, S.D. Pastva, A.L. Blankenship, J. Meadow, D.E. Tillitt, and J.P. Giesy, 2003. Chemosphere 53:819-826; ERED Ref ID MEC04-293.
9. Walker, M.K., J.M. Spitsbergen, J.R. Olson, and R.E. Peterson, 1991. Can. J. Fish. Aquat. Sci.; ERED Ref ID JA474.

Attachment 8
TABLE 8-14
CBR-BASED HAZARD QUOTIENTS FOR COPECS IN WHITE PERCH/AMERICAN EEL TISSUE
Future Conditions (2048) - Monitored Natural Recovery

Focused Feasibility Study - Ecological Risk Assessment

Chemical	Units	EPC [a]	CBR [b]		Species	Endpoint	Reference	Hazard Quotients [c]	
			NOAEL	LOAEL				NOAEL	LOAEL
Inorganics/Metals									
Copper	µg/g	2.8	0.002	**0.02**	*Ictalurus punctatus*	Growth - LOED	1	**1.4E+03**	**1.4E+02**
Lead	µg/g	0.13	0.028	**0.28**	*Oncorhynchus mykiss*	Growth - ED_{11}	2	**4.7E+00**	4.7E-01
Mercury[1]	µg/g	0.050	0.006	**0.06**	*Ictalurus punctatus*	Mortality - LD_{50}	3	**8.4E+00**	8.4E-01
Mercury (methyl)	µg/g	0.050	0.001	**0.01**	*Fundulus heteroclitus*	Growth - ED_{146}	4	**5.0E+01**	**5.0E+00**
						Total Inorganics/Metals		**1.5E+03**	**1.5E+02**
Semivolatile Organics (PAHs)									
Low Weight PAHs	µg/g	0.37	0.21	**2.1**	*Psettichthys melanostictus*	Mortality - LD_{51}	5	**1.8E+00**	1.8E-01
High Weight PAHs	µg/g	0.22	0.21	**2.1**	*Psettichthys melanostictus*	Mortality - LD_{51}	5	**1.0E+00**	1.0E-01
						Total PAHs		**2.8E+00**	2.8E-01
PCBs (Aroclors)									
Aroclor, Total	µg/g	0.28	0.0025	**0.025**	*Oryzias latipes*	Reproduction - ED_{11}	6	**1.1E+02**	**1.1E+01**
						Total PCBs		**1.1E+02**	**1.1E+01**
Pesticides									
Dieldrin	µg/g	0.032	0.011	**0.11**	*Oncorhynchus mykiss*	Growth - LOED	7	**2.9E+00**	2.9E-01
Total DDx	µg/g	0.13	**0.000039**	**0.0018**	*Oryzias latipes*	Mortality - LOED	8	**3.2E+03**	**7.0E+01**
						Total Pesticides		**3.2E+03**	**7.0E+01**
Dioxin-like Compounds									
TCDD TEQ (D/F)	µg/g	0.000048	**0.000034**	**0.00006**	*Salvelinus namaycush*	Growth - LOED	9	**1.4E+00**	8.2E-01
TCDD TEQ (PCBs)	µg/g	0.00000038	**0.000034**	**0.00006**	*Salvelinus namaycush*	Growth - LOED	9	1.1E-02	6.6E-03
						Total TCDD TEQ		**1.4E+00**	8.3E-01
						Total		**4.8E+03**	**2.3E+02**

Notes:

[a] Exposure Point Concentration (95% UCLs) presented in Table 7-6. TCDD Toxic Equivalencies based on fish TEF values, EPCs based on white perch and American eel tissue data.

[b] Critical Body Residues (CBRs) are obtained from summary of tissue effects data presented in CSM Technical Memorandum #3 (Battelle, 2006).

[c] Hazard Quotient is the ratio of the EPC to the NOAEL or LOAEL CBR.

[1]Analyte is not included in the HI totals.

Non-bolded CBR values were estimated using a 10-fold extrapolation factor.

Attachment 8
TABLE 8-14
CBR-BASED HAZARD QUOTIENTS FOR COPECS IN WHITE PERCH/AMERICAN EEL TISSUE
Future Conditions (2048) - Monitored Natural Recovery

Focused Feasibility Study - Ecological Risk Assessment

Chemical	Units	EPC [a]	CBR [b]		Species	Endpoint	Reference	Hazard Quotients [c]	
			NOAEL	LOAEL				NOAEL	LOAEL

References:

1. Murai, T., J.W. Andrews, and R.G. Smith, Jr., 1981. Aquaculture 22:353-357; ERED Ref ID JA317.
2. Hansen, J.A., J. Lipton, P.G., Welsh, D. Cacela, and B. MacConnell, 2004. Environ. Tox. & Chem. 23:1902-1911; ERED Ref ID Weston05-031.
3. Birge, W.J., J.A. Black, A.G. Westerman, and J.E. Hudson, 1979. The Biogeochemistry of Mercury, pg. 629-655; ERED Ref ID JA33.
4. Matta, M.B., J. Linse, C. Cairncross, L. Francendese, and R.M. Kocan, 2001. Environ. Tox. & Chem. 20(2)L327-335; ERED Ref ID MECO3-135.
5. Hose, J.E., J.B. Hannah, D. DiJulio, M.L. Landholt, B.S. Miller, W.T. Iwaoka, and S.P. Felton, 1982. Arch. Environ. Contam. Toxicol. 11:167-171; ERED Ref ID JA212
6. Nakayama, K., Y. Oshima, K. Nagafuchi, T. Hano, Y. Shimasaki, and T. Honjo, 2005. Environ. Tox. Chem. 24:591-596; ERED Ref ID Weston05-046.
7. Dillon, T.M., 1984. Army Corps of Engineers Technical Report, D-84-2; ERED Ref ID MEC04-070.
8. Villalobos, S.B., D.M. Papoulias, S.D. Pastva, A.L. Blankenship, J. Meadow, D.E. Tillitt, and J.P. Giesy, 2003. Chemosphere 53:819-826; ERED Ref ID MEC04-293.
9. Walker, M.K., J.M. Spitsbergen, J.R. Olson, and R.E. Peterson, 1991. Can. J. Fish. Aquat. Sci.; ERED Ref ID JA474.

Attachment 8
TABLE 8-15
CBR-BASED HAZARD QUOTIENTS FOR COPECS IN WHITE PERCH/AMERICAN EEL TISSUE
Future Conditions (2018) - Primary Erosional Zone/Primary Inventory Zone

Focused Feasibility Study - Ecological Risk Assessment

Chemical	Units	EPC [a]	CBR [b]		Species	Endpoint	Reference	Hazard Quotients [c]	
			NOAEL	LOAEL				NOAEL	LOAEL
Inorganics/Metals									
Copper	µg/g	5.4	0.002	**0.02**	*Ictalurus punctatus*	Growth - LOED	1	**2.7E+03**	**2.7E+02**
Lead	µg/g	0.27	0.028	**0.28**	*Oncorhynchus mykiss*	Growth - ED_{11}	2	**9.8E+00**	9.8E-01
Mercury[1]	µg/g	0.14	0.006	**0.06**	*Ictalurus punctatus*	Mortality - LD_{50}	3	**2.3E+01**	**2.3E+00**
Mercury (methyl)	µg/g	0.14	0.001	**0.01**	*Fundulus heteroclitus*	Growth - ED_{146}	4	**1.4E+02**	**1.4E+01**
						Total Inorganics/Metals		**2.9E+03**	**2.9E+02**
Semivolatile Organics (PAHs)									
Low Weight PAHs	µg/g	0.36	0.21	**2.1**	*Psettichthys melanostictus*	Mortality - LD_{51}	5	**1.7E+00**	1.7E-01
High Weight PAHs	µg/g	0.22	0.21	**2.1**	*Psettichthys melanostictus*	Mortality - LD_{51}	5	**1.0E+00**	1.0E-01
						Total PAHs		**2.8E+00**	2.8E-01
PCBs (Aroclors)									
Aroclor, Total	µg/g	1.1	0.0025	**0.025**	*Oryzias latipes*	Reproduction - ED_{11}	6	**4.4E+02**	**4.4E+01**
						Total PCBs		**4.4E+02**	**4.4E+01**
Pesticides									
Dieldrin	µg/g	0.030	0.011	**0.11**	*Oncorhynchus mykiss*	Growth - LOED	7	**2.7E+00**	2.7E-01
Total DDx	µg/g	0.31	**0.000039**	**0.0018**	*Oryzias latipes*	Mortality - LOED	8	**7.9E+03**	**1.7E+02**
						Total Pesticides		**7.9E+03**	**1.7E+02**
Dioxin-like Compounds									
TCDD TEQ (D/F)	µg/g	0.00012	**0.000034**	**0.00006**	*Salvelinus namaycush*	Growth - LOED	9	**3.5E+00**	**2.1E+00**
TCDD TEQ (PCBs)	µg/g	0.0000011	**0.000034**	**0.00006**	*Salvelinus namaycush*	Growth - LOED	9	3.2E-02	1.9E-02
						Total TCDD TEQ		**3.5E+00**	**2.1E+00**
						Total		**1.1E+04**	**5.0E+02**

Notes:

[a] Exposure Point Concentration (95% UCLs) presented in Table 7-7. TCDD Toxic Equivalencies based on fish TEF values, EPCs based on white perch and American eel tissue data.

[b] Critical Body Residues (CBRs) are obtained from summary of tissue effects data presented in CSM Technical Memorandum #3 (Battelle, 2006).

[c] Hazard Quotient is the ratio of the EPC to the NOAEL or LOAEL CBR.

[1]Analyte is not included in the HI totals.

Non-bolded CBR values were estimated using a 10-fold extrapolation factor.

TABLE 8-15
CBR-BASED HAZARD QUOTIENTS FOR COPECS IN WHITE PERCH/AMERICAN EEL TISSUE
Future Conditions (2018) - Primary Erosional Zone/Primary Inventory Zone

Focused Feasibility Study - Ecological Risk Assessment

Chemical	Units	EPC [a]	CBR [b]		Species	Endpoint	Reference	Hazard Quotients [c]	
			NOAEL	LOAEL				NOAEL	LOAEL

References:

1. Murai, T., J.W. Andrews, and R.G. Smith, Jr., 1981. Aquaculture 22:353-357; ERED Ref ID JA317.
2. Hansen, J.A., J. Lipton, P.G., Welsh, D. Cacela, and B. MacConnell, 2004. Environ. Tox. & Chem. 23:1902-1911; ERED Ref ID Weston05-031.
3. Birge, W.J., J.A. Black, A.G. Westerman, and J.E. Hudson, 1979. The Biogeochemistry of Mercury, pg. 629-655; ERED Ref ID JA33.
4. Matta, M.B., J. Linse, C. Cairncross, L. Francendese, and R.M. Kocan, 2001. Environ. Tox. & Chem. 20(2)L327-335; ERED Ref ID MECO3-135.
5. Hose, J.E., J.B. Hannah, D. DiJulio, M.L. Landholt, B.S. Miller, W.T. Iwaoka, and S.P. Felton, 1982. Arch. Environ. Contam. Toxicol. 11:167-171; ERED Ref ID JA212
6. Nakayama, K., Y. Oshima, K. Nagafuchi, T. Hano, Y. Shimasaki, and T. Honjo, 2005. Environ. Tox. Chem. 24:591-596; ERED Ref ID Weston05-046.
7. Dillon, T.M., 1984. Army Corps of Engineers Technical Report, D-84-2; ERED Ref ID MEC04-070.
8. Villalobos, S.B., D.M. Papoulias, S.D. Pastva, A.L. Blankenship, J. Meadow, D.E. Tillitt, and J.P. Giesy, 2003. Chemosphere 53:819-826; ERED Ref ID MEC04-293.
9. Walker, M.K., J.M. Spitsbergen, J.R. Olson, and R.E. Peterson, 1991. Can. J. Fish. Aquat. Sci.; ERED Ref ID JA474.

Attachment 8
TABLE 8-16
CBR-BASED HAZARD QUOTIENTS FOR COPECS IN WHITE PERCH/AMERICAN EEL TISSUE
Future Conditions (2048) - Primary Erosional Zone/Primary Inventory Zone

Focused Feasibility Study - Ecological Risk Assessment

Chemical	Units	EPC [a]	CBR [b]		Species	Endpoint	Reference	Hazard Quotients [c]	
			NOAEL	LOAEL				NOAEL	LOAEL
Inorganics/Metals									
Copper	µg/g	2.7	0.002	**0.02**	*Ictalurus punctatus*	Growth - LOED	1	**1.4E+03**	**1.4E+02**
Lead	µg/g	0.13	0.028	**0.28**	*Oncorhynchus mykiss*	Growth - ED_{11}	2	**4.5E+00**	4.5E-01
Mercury[1]	µg/g	0.044	0.006	**0.06**	*Ictalurus punctatus*	Mortality - LD_{50}	3	**7.4E+00**	7.4E-01
Mercury (methyl)	µg/g	0.044	0.001	**0.01**	*Fundulus heteroclitus*	Growth - ED_{146}	4	**4.4E+01**	**4.4E+00**
						Total Inorganics/Metals		**1.4E+03**	**1.4E+02**
Semivolatile Organics (PAHs)									
Low Weight PAHs	µg/g	0.36	0.21	**2.1**	*Psettichthys melanostictus*	Mortality - LD_{51}	5	**1.7E+00**	1.7E-01
High Weight PAHs	µg/g	0.22	0.21	**2.1**	*Psettichthys melanostictus*	Mortality - LD_{51}	5	**1.0E+00**	1.0E-01
						Total PAHs		**2.8E+00**	2.8E-01
PCBs (Aroclors)									
Aroclor, Total	µg/g	0.25	0.0025	**0.025**	*Oryzias latipes*	Reproduction - ED_{11}	6	**9.9E+01**	**9.9E+00**
						Total PCBs		**9.9E+01**	**9.9E+00**
Pesticides									
Dieldrin	µg/g	0.030	0.011	**0.11**	*Oncorhynchus mykiss*	Growth - LOED	7	**2.7E+00**	2.7E-01
Total DDx	µg/g	0.11	**0.000039**	**0.0018**	*Oryzias latipes*	Mortality - LOED	8	**2.8E+03**	**6.0E+01**
						Total Pesticides		**2.8E+03**	**6.1E+01**
Dioxin-like Compounds									
TCDD TEQ (D/F)	µg/g	0.000036	**0.000034**	**0.00006**	*Salvelinus namaycush*	Growth - LOED	9	**1.1E+00**	6.2E-01
TCDD TEQ (PCBs)	µg/g	0.00000019	**0.000034**	**0.00006**	*Salvelinus namaycush*	Growth - LOED	9	5.6E-03	3.3E-03
						Total TCDD TEQ		**1.1E+00**	6.2E-01
						Total		**4.3E+03**	**2.1E+02**

Notes:

[a] Exposure Point Concentration (95% UCLs) presented in Table 7-7. TCDD Toxic Equivalencies based on fish TEF values, EPCs based on white perch and American eel tissue data.

[b] Critical Body Residues (CBRs) are obtained from summary of tissue effects data presented in CSM Technical Memorandum #3 (Battelle, 2006).

[c] Hazard Quotient is the ratio of the EPC to the NOAEL or LOAEL CBR.

[1]Analyte is not included in the HI totals.

Non-bolded CBR values were estimated using a 10-fold extrapolation factor.

Attachment 8
TABLE 8-16
CBR-BASED HAZARD QUOTIENTS FOR COPECS IN WHITE PERCH/AMERICAN EEL TISSUE
Future Conditions (2048) - Primary Erosional Zone/Primary Inventory Zone

Focused Feasibility Study - Ecological Risk Assessment

Chemical	Units	EPC [a]	CBR [b]		Species	Endpoint	Reference	Hazard Quotients [c]	
			NOAEL	LOAEL				NOAEL	LOAEL

References:

1. Murai, T., J.W. Andrews, and R.G. Smith, Jr., 1981. Aquaculture 22:353-357; ERED Ref ID JA317.
2. Hansen, J.A., J. Lipton, P.G., Welsh, D. Cacela, and B. MacConnell, 2004. Environ. Tox. & Chem. 23:1902-1911; ERED Ref ID Weston05-031.
3. Birge, W.J., J.A. Black, A.G. Westerman, and J.E. Hudson, 1979. The Biogeochemistry of Mercury, pg. 629-655; ERED Ref ID JA33.
4. Matta, M.B., J. Linse, C. Cairncross, L. Francendese, and R.M. Kocan, 2001. Environ. Tox. & Chem. 20(2)L327-335; ERED Ref ID MECO3-135.
5. Hose, J.E., J.B. Hannah, D. DiJulio, M.L. Landholt, B.S. Miller, W.T. Iwaoka, and S.P. Felton, 1982. Arch. Environ. Contam. Toxicol. 11:167-171; ERED Ref ID JA212
6. Nakayama, K., Y. Oshima, K. Nagafuchi, T. Hano, Y. Shimasaki, and T. Honjo, 2005. Environ. Tox. Chem. 24:591-596; ERED Ref ID Weston05-046.
7. Dillon, T.M., 1984. Army Corps of Engineers Technical Report, D-84-2; ERED Ref ID MEC04-070.
8. Villalobos, S.B., D.M. Papoulias, S.D. Pastva, A.L. Blankenship, J. Meadow, D.E. Tillitt, and J.P. Giesy, 2003. Chemosphere 53:819-826; ERED Ref ID MEC04-293.
9. Walker, M.K., J.M. Spitsbergen, J.R. Olson, and R.E. Peterson, 1991. Can. J. Fish. Aquat. Sci.; ERED Ref ID JA474.

Attachment 8
TABLE 8-17
CBR-BASED HAZARD QUOTIENTS FOR COPECS IN WHITE PERCH/AMERICAN EEL TISSUE
Future Conditions (2018) - Area of Focus

Focused Feasibility Study - Ecological Risk Assessment

Chemical	Units	EPC [a]	CBR [b]		Species	Endpoint	Reference	Hazard Quotients [c]	
			NOAEL	LOAEL				NOAEL	LOAEL
Inorganics/Metals									
Copper	µg/g	3.3	0.002	**0.02**	*Ictalurus punctatus*	Growth - LOED	1	**1.7E+03**	**1.7E+02**
Lead	µg/g	0.18	0.028	**0.28**	*Oncorhynchus mykiss*	Growth - ED_{11}	2	**6.4E+00**	6.4E-01
Mercury[1]	µg/g	0.063	0.006	**0.06**	*Ictalurus punctatus*	Mortality - LD_{50}	3	**1.0E+01**	**1.0E+00**
Mercury (methyl)	µg/g	0.063	0.001	**0.01**	*Fundulus heteroclitus*	Growth - ED_{146}	4	**6.3E+01**	**6.3E+00**
						Total Inorganics/Metals		**1.7E+03**	**1.7E+02**
Semivolatile Organics (PAHs)									
Low Weight PAHs	µg/g	0.17	0.21	**2.1**	*Psettichthys melanostictus*	Mortality - LD_{51}	5	8.2E-01	8.2E-02
High Weight PAHs	µg/g	0.15	0.21	**2.1**	*Psettichthys melanostictus*	Mortality - LD_{51}	5	7.4E-01	7.4E-02
						Total PAHs		**1.6E+00**	1.6E-01
PCBs (Aroclors)									
Aroclor, Total	µg/g	0.84	0.0025	**0.025**	*Oryzias latipes*	Reproduction - ED_{11}	6	**3.4E+02**	**3.4E+01**
						Total PCBs		**3.4E+02**	**3.4E+01**
Pesticides									
Dieldrin	µg/g	0.0075	0.011	**0.11**	*Oncorhynchus mykiss*	Growth - LOED	7	6.8E-01	6.8E-02
Total DDx	µg/g	0.13	**0.000039**	**0.0018**	*Oryzias latipes*	Mortality - LOED	8	**3.3E+03**	**7.1E+01**
						Total Pesticides		**3.3E+03**	**7.1E+01**
Dioxin-like Compounds									
TCDD TEQ (D/F)	µg/g	0.0000082	**0.000034**	**0.00006**	*Salvelinus namaycush*	Growth - LOED	9	2.4E-01	1.4E-01
TCDD TEQ (PCBs)	µg/g	0.00000076	**0.000034**	**0.00006**	*Salvelinus namaycush*	Growth - LOED	9	2.2E-02	1.3E-02
						Total TCDD TEQ		2.6E-01	1.5E-01
						Total		**5.3E+03**	**2.8E+02**

Notes:

[a] Exposure Point Concentration (95% UCLs) presented in Table 7-8. TCDD Toxic Equivalencies based on fish TEF values, EPCs based on white perch and American eel tissue data.

[b] Critical Body Residues (CBRs) are obtained from summary of tissue effects data presented in CSM Technical Memorandum #3 (Battelle, 2006).

[c] Hazard Quotient is the ratio of the EPC to the NOAEL or LOAEL CBR.

[1]Analyte is not included in the HI totals.

Non-bolded CBR values were estimated using a 10-fold extrapolation factor.

Attachment 8
TABLE 8-17
CBR-BASED HAZARD QUOTIENTS FOR COPECS IN WHITE PERCH/AMERICAN EEL TISSUE
Future Conditions (2018) - Area of Focus

Focused Feasibility Study - Ecological Risk Assessment

Chemical	Units	EPC [a]	CBR [b]		Species	Endpoint	Reference	Hazard Quotients [c]	
			NOAEL	LOAEL				NOAEL	LOAEL

References:

1. Murai, T., J.W. Andrews, and R.G. Smith, Jr., 1981. Aquaculture 22:353-357; ERED Ref ID JA317.
2. Hansen, J.A., J. Lipton, P.G., Welsh, D. Cacela, and B. MacConnell, 2004. Environ. Tox. & Chem. 23:1902-1911; ERED Ref ID Weston05-031.
3. Birge, W.J., J.A. Black, A.G. Westerman, and J.E. Hudson, 1979. The Biogeochemistry of Mercury, pg. 629-655; ERED Ref ID JA33.
4. Matta, M.B., J. Linse, C. Cairncross, L. Francendese, and R.M. Kocan, 2001. Environ. Tox. & Chem. 20(2)L327-335; ERED Ref ID MECO3-135.
5. Hose, J.E., J.B. Hannah, D. DiJulio, M.L. Landholt, B.S. Miller, W.T. Iwaoka, and S.P. Felton, 1982. Arch. Environ. Contam. Toxicol. 11:167-171; ERED Ref ID JA212
6. Nakayama, K., Y. Oshima, K. Nagafuchi, T. Hano, Y. Shimasaki, and T. Honjo, 2005. Environ. Tox. Chem. 24:591-596; ERED Ref ID Weston05-046.
7. Dillon, T.M., 1984. Army Corps of Engineers Technical Report, D-84-2; ERED Ref ID MEC04-070.
8. Villalobos, S.B., D.M. Papoulias, S.D. Pastva, A.L. Blankenship, J. Meadow, D.E. Tillitt, and J.P. Giesy, 2003. Chemosphere 53:819-826; ERED Ref ID MEC04-293.
9. Walker, M.K., J.M. Spitsbergen, J.R. Olson, and R.E. Peterson, 1991. Can. J. Fish. Aquat. Sci.; ERED Ref ID JA474.

Attachment 8
TABLE 8-18
CBR-BASED HAZARD QUOTIENTS FOR COPECS IN WHITE PERCH/AMERICAN EEL TISSUE
Future Conditions (2048) - Area of Focus

Focused Feasibility Study - Ecological Risk Assessment

Chemical	Units	EPC [a]	CBR [b]		Species	Endpoint	Reference	Hazard Quotients [c]	
			NOAEL	LOAEL				NOAEL	LOAEL
Inorganics/Metals									
Copper	µg/g	1.7	0.002	**0.02**	*Ictalurus punctatus*	Growth - LOED	1	**8.4E+02**	**8.4E+01**
Lead	µg/g	0.083	0.028	**0.28**	*Oncorhynchus mykiss*	Growth - ED_{11}	2	**3.0E+00**	3.0E-01
Mercury[1]	µg/g	0.020	0.006	**0.06**	*Ictalurus punctatus*	Mortality - LD_{50}	3	**3.4E+00**	3.4E-01
Mercury (methyl)	µg/g	0.020	0.001	**0.01**	*Fundulus heteroclitus*	Growth - ED_{146}	4	**2.0E+01**	**2.0E+00**
						Total Inorganics/Metals		**8.6E+02**	**8.6E+01**
Semivolatile Organics (PAHs)									
Low Weight PAHs	µg/g	0.17	0.21	**2.1**	*Psettichthys melanostictus*	Mortality - LD_{51}	5	8.2E-01	8.2E-02
High Weight PAHs	µg/g	0.15	0.21	**2.1**	*Psettichthys melanostictus*	Mortality - LD_{51}	5	7.4E-01	7.4E-02
						Total PAHs		**1.6E+00**	1.6E-01
PCBs (Aroclors)									
Aroclor, Total	µg/g	0.19	0.0025	**0.025**	*Oryzias latipes*	Reproduction - ED_{11}	6	**7.6E+01**	**7.6E+00**
						Total PCBs		**7.6E+01**	**7.6E+00**
Pesticides									
Dieldrin	µg/g	0.0075	0.011	**0.11**	*Oncorhynchus mykiss*	Growth - LOED	7	6.8E-01	6.8E-02
Total DDx	µg/g	0.044	**0.000039**	**0.0018**	*Oryzias latipes*	Mortality - LOED	8	**1.1E+03**	**2.5E+01**
						Total Pesticides		**1.1E+03**	**2.5E+01**
Dioxin-like Compounds									
TCDD TEQ (D/F)	µg/g	0.0000025	**0.000034**	**0.00006**	*Salvelinus namaycush*	Growth - LOED	9	7.5E-02	4.4E-02
TCDD TEQ (PCBs)	µg/g	0.00000019	**0.000034**	**0.00006**	*Salvelinus namaycush*	Growth - LOED	9	5.6E-03	3.3E-03
						Total TCDD TEQ		8.1E-02	4.7E-02
						Total		**2.1E+03**	**1.2E+02**

Notes:

[a] Exposure Point Concentration (95% UCLs) presented in Table 7-8. TCDD Toxic Equivalencies based on fish TEF values, EPCs based on white perch and American eel tissue data.

[b] Critical Body Residues (CBRs) are obtained from summary of tissue effects data presented in CSM Technical Memorandum #3 (Battelle, 2006).

[c] Hazard Quotient is the ratio of the EPC to the NOAEL or LOAEL CBR.

[1]Analyte is not included in the HI totals.

Non-bolded CBR values were estimated using a 10-fold extrapolation factor.

Attachment 8
TABLE 8-18
CBR-BASED HAZARD QUOTIENTS FOR COPECS IN WHITE PERCH/AMERICAN EEL TISSUE
Future Conditions (2048) - Area of Focus

Focused Feasibility Study - Ecological Risk Assessment

Chemical	Units	EPC [a]	CBR [b]		Species	Endpoint	Reference	Hazard Quotients [c]	
			NOAEL	LOAEL				NOAEL	LOAEL

References:

1. Murai, T., J.W. Andrews, and R.G. Smith, Jr., 1981. Aquaculture 22:353-357; ERED Ref ID JA317.
2. Hansen, J.A., J. Lipton, P.G., Welsh, D. Cacela, and B. MacConnell, 2004. Environ. Tox. & Chem. 23:1902-1911; ERED Ref ID Weston05-031.
3. Birge, W.J., J.A. Black, A.G. Westerman, and J.E. Hudson, 1979. The Biogeochemistry of Mercury, pg. 629-655; ERED Ref ID JA33.
4. Matta, M.B., J. Linse, C. Cairncross, L. Francendese, and R.M. Kocan, 2001. Environ. Tox. & Chem. 20(2)L327-335; ERED Ref ID MECO3-135.
5. Hose, J.E., J.B. Hannah, D. DiJulio, M.L. Landholt, B.S. Miller, W.T. Iwaoka, and S.P. Felton, 1982. Arch. Environ. Contam. Toxicol. 11:167-171; ERED Ref ID JA212
6. Nakayama, K., Y. Oshima, K. Nagafuchi, T. Hano, Y. Shimasaki, and T. Honjo, 2005. Environ. Tox. Chem. 24:591-596; ERED Ref ID Weston05-046.
7. Dillon, T.M., 1984. Army Corps of Engineers Technical Report, D-84-2; ERED Ref ID MEC04-070.
8. Villalobos, S.B., D.M. Papoulias, S.D. Pastva, A.L. Blankenship, J. Meadow, D.E. Tillitt, and J.P. Giesy, 2003. Chemosphere 53:819-826; ERED Ref ID MEC04-293.
9. Walker, M.K., J.M. Spitsbergen, J.R. Olson, and R.E. Peterson, 1991. Can. J. Fish. Aquat. Sci.; ERED Ref ID JA474.

TABLE 8-19
CBR-BASED HAZARD QUOTIENTS FOR COPECS IN MUMMICHOG TISSUE
Future Conditions (2018) - Monitored Natural Recovery

Focused Feasibility Study - Ecological Risk Assessment

Chemical	Units	EPC [a]	CBR [b]		Species	Endpoint	Reference	Hazard Quotients [c]	
			NOAEL	LOAEL				NOAEL	LOAEL
Inorganics/Metals									
Copper	µg/g	2.3	0.002	**0.02**	*Ictalurus punctatus*	Growth - LOED	1	**1.2E+03**	**1.2E+02**
Lead	µg/g	0.51	0.028	**0.28**	*Oncorhynchus mykiss*	Growth - ED_{11}	2	**1.8E+01**	**1.8E+00**
Mercury[1]	µg/g	0.019	0.006	**0.06**	*Ictalurus punctatus*	Mortality - LD_{50}	3	**3.2E+00**	3.2E-01
Mercury (methyl)	µg/g	0.019	0.001	**0.01**	*Fundulus heteroclitus*	Growth - ED_{146}	4	**1.9E+01**	**1.9E+00**
						Total Inorganics/Metals		**1.2E+03**	**1.2E+02**
Semivolatile Organics (PAHs)									
Low Weight PAHs	µg/g	0.31	0.21	**2.1**	*Psettichthys melanostictus*	Mortality - LD_{51}	5	**1.5E+00**	1.5E-01
High Weight PAHs	µg/g	0.15	0.21	**2.1**	*Psettichthys melanostictus*	Mortality - LD_{51}	5	7.3E-01	7.3E-02
						Total PAHs		**2.2E+00**	2.2E-01
PCBs (Aroclors)									
Aroclor, Total	µg/g	0.29	0.0025	**0.025**	*Oryzias latipes*	Reproduction - ED_{11}	6	**1.2E+02**	**1.2E+01**
						Total PCBs		**1.2E+02**	**1.2E+01**
Pesticides									
Dieldrin	µg/g	0.0045	0.011	**0.11**	*Oncorhynchus mykiss*	Growth - LOED	7	4.1E-01	4.1E-02
Total DDx	µg/g	0.062	**0.000039**	**0.0018**	*Oryzias latipes*	Mortality - LOED	8	**1.6E+03**	**3.5E+01**
						Total Pesticides		**1.6E+03**	**3.5E+01**
Dioxin-like Compounds									
TCDD TEQ (D/F)	µg/g	0.000090	**0.000034**	**0.00006**	*Salvelinus namaycush*	Growth - LOED	9	**2.6E+00**	**1.6E+00**
TCDD TEQ (PCBs)	µg/g	0.00000040	**0.000034**	**0.00006**	*Salvelinus namaycush*	Growth - LOED	9	1.2E-02	6.9E-03
						Total TCDD TEQ		**2.7E+00**	**1.6E+00**
						Total		**2.9E+03**	**1.7E+02**

Notes:

[a] Exposure Point Concentration (95% UCLs) presented in Table 7-6. TCDD Toxic Equivalencies based on fish TEF values, EPCs based on mummichog tissue data.

[b] Critical Body Residues (CBRs) are obtained from summary of tissue effects data presented in CSM Technical Memorandum #3 (Battelle, 2006).

[c] Hazard Quotient is the ratio of the EPC to the NOAEL or LOAEL CBR.

[1]Analyte is not included in the HI totals.

Non-bolded CBR values were estimated using a 10-fold extrapolation factor.

TABLE 8-19
CBR-BASED HAZARD QUOTIENTS FOR COPECS IN MUMMICHOG TISSUE
Future Conditions (2018) - Monitored Natural Recovery

Focused Feasibility Study - Ecological Risk Assessment

Chemical	Units	EPC [a]	CBR [b]		Species	Endpoint	Reference	Hazard Quotients [c]	
			NOAEL	LOAEL				NOAEL	LOAEL

References:

1. Murai, T., J.W. Andrews, and R.G. Smith, Jr., 1981. Aquaculture 22:353-357; ERED Ref ID JA317.
2. Hansen, J.A., J. Lipton, P.G., Welsh, D. Cacela, and B. MacConnell, 2004. Environ. Tox. & Chem. 23:1902-1911; ERED Ref ID Weston05-031.
3. Birge, W.J., J.A. Black, A.G. Westerman, and J.E. Hudson, 1979. The Biogeochemistry of Mercury, pg. 629-655; ERED Ref ID JA33.
4. Matta, M.B., J. Linse, C. Cairncross, L. Francendese, and R.M. Kocan, 2001. Environ. Tox. & Chem. 20(2)L327-335; ERED Ref ID MECO3-135.
5. Hose, J.E., J.B. Hannah, D. DiJulio, M.L. Landholt, B.S. Miller, W.T. Iwaoka, and S.P. Felton, 1982. Arch. Environ. Contam. Toxicol. 11:167-171; ERED Ref ID JA212
6. Nakayama, K., Y. Oshima, K. Nagafuchi, T. Hano, Y. Shimasaki, and T. Honjo, 2005. Environ. Tox. Chem. 24:591-596; ERED Ref ID Weston05-046.
7. Dillon, T.M., 1984. Army Corps of Engineers Technical Report, D-84-2; ERED Ref ID MEC04-070.
8. Villalobos, S.B., D.M. Papoulias, S.D. Pastva, A.L. Blankenship, J. Meadow, D.E. Tillitt, and J.P. Giesy, 2003. Chemosphere 53:819-826; ERED Ref ID MEC04-293.
9. Walker, M.K., J.M. Spitsbergen, J.R. Olson, and R.E. Peterson, 1991. Can. J. Fish. Aquat. Sci.; ERED Ref ID JA474.

TABLE 8-20
CBR-BASED HAZARD QUOTIENTS FOR COPCs IN MUMMICHOG TISSUE
Future Conditions (2048) - Monitored Natural Recovery

Focused Feasibility Study - Ecological Risk Assessment

Chemical	Units	EPC [a]	CBR [b]		Species	Endpoint	Reference	Hazard Quotients [c]	
			NOAEL	LOAEL				NOAEL	LOAEL
Inorganics/Metals									
Copper	µg/g	1.2	0.002	**0.02**	*Ictalurus punctatus*	Growth - LOED	1	**5.9E+02**	**5.9E+01**
Lead	µg/g	0.23	0.028	**0.28**	*Oncorhynchus mykiss*	Growth - ED_{11}	2	**8.5E+00**	8.5E-01
Mercury[1]	µg/g	0.0061	0.006	**0.06**	*Ictalurus punctatus*	Mortality - LD_{50}	3	**1.0E+00**	1.0E-01
Mercury (methyl)	µg/g	0.0061	0.001	**0.01**	*Fundulus heteroclitus*	Growth - ED_{146}	4	**6.1E+00**	6.1E-01
						Total Inorganics/Metals		**6.1E+02**	**6.1E+01**
Semivolatile Organics (PAHs)									
Low Weight PAHs	µg/g	0.31	0.21	**2.1**	*Psettichthys melanostictus*	Mortality - LD_{51}	5	**1.5E+00**	1.5E-01
High Weight PAHs	µg/g	0.15	0.21	**2.1**	*Psettichthys melanostictus*	Mortality - LD_{51}	5	7.3E-01	7.3E-02
						Total PAHs		**2.2E+00**	2.2E-01
PCBs (Aroclors)									
Aroclor, Total	µg/g	0.065	0.0025	**0.025**	*Oryzias latipes*	Reproduction - ED_{11}	6	**2.6E+01**	**2.6E+00**
						Total PCBs		**2.6E+01**	**2.6E+00**
Pesticides									
Dieldrin	µg/g	0.0045	0.011	**0.11**	*Oncorhynchus mykiss*	Growth - LOED	7	4.1E-01	4.1E-02
Total DDx	µg/g	0.022	**0.000039**	**0.0018**	*Oryzias latipes*	Mortality - LOED	8	**5.7E+02**	**1.2E+01**
						Total Pesticides		**5.7E+02**	**1.2E+01**
Dioxin-like Compounds									
TCDD TEQ (D/F)	µg/g	0.000024	**0.000034**	**0.00006**	*Salvelinus namaycush*	Growth - LOED	9	7.1E-01	4.1E-01
TCDD TEQ (PCBs)	µg/g	0.00000013	**0.000034**	**0.00006**	*Salvelinus namaycush*	Growth - LOED	9	3.9E-03	2.3E-03
						Total TCDD TEQ		7.1E-01	4.2E-01
						Total		**1.2E+03**	**7.6E+01**

Notes:

[a] Exposure Point Concentration (95% UCLs) presented in Table 7-6. TCDD Toxic Equivalencies based on fish TEF values, EPCs based on mummichog tissue data.

[b] Critical Body Residues (CBRs) are obtained from summary of tissue effects data presented in CSM Technical Memorandum #3 (Battelle, 2006).

[c] Hazard Quotient is the ratio of the EPC to the NOAEL or LOAEL CBR.

[1]Analyte is not included in the HI totals.

Non-bolded CBR values were estimated using a 10-fold extrapolation factor.

TABLE 8-20
CBR-BASED HAZARD QUOTIENTS FOR COPCs IN MUMMICHOG TISSUE
Future Conditions (2048) - Monitored Natural Recovery

Focused Feasibility Study - Ecological Risk Assessment

Chemical	Units	EPC [a]	CBR [b]		Species	Endpoint	Reference	Hazard Quotients [c]	
			NOAEL	LOAEL				NOAEL	LOAEL

References:

1. Murai, T., J.W. Andrews, and R.G. Smith, Jr., 1981. Aquaculture 22:353-357; ERED Ref ID JA317.
2. Hansen, J.A., J. Lipton, P.G., Welsh, D. Cacela, and B. MacConnell, 2004. Environ. Tox. & Chem. 23:1902-1911; ERED Ref ID Weston05-031.
3. Birge, W.J., J.A. Black, A.G. Westerman, and J.E. Hudson, 1979. The Biogeochemistry of Mercury, pg. 629-655; ERED Ref ID JA33.
4. Matta, M.B., J. Linse, C. Cairncross, L. Francendese, and R.M. Kocan, 2001. Environ. Tox. & Chem. 20(2)L327-335; ERED Ref ID MECO3-135.
5. Hose, J.E., J.B. Hannah, D. DiJulio, M.L. Landholt, B.S. Miller, W.T. Iwaoka, and S.P. Felton, 1982. Arch. Environ. Contam. Toxicol. 11:167-171; ERED Ref ID JA212
6. Nakayama, K., Y. Oshima, K. Nagafuchi, T. Hano, Y. Shimasaki, and T. Honjo, 2005. Environ. Tox. Chem. 24:591-596; ERED Ref ID Weston05-046.
7. Dillon, T.M., 1984. Army Corps of Engineers Technical Report, D-84-2; ERED Ref ID MEC04-070.
8. Villalobos, S.B., D.M. Papoulias, S.D. Pastva, A.L. Blankenship, J. Meadow, D.E. Tillitt, and J.P. Giesy, 2003. Chemosphere 53:819-826; ERED Ref ID MEC04-293.
9. Walker, M.K., J.M. Spitsbergen, J.R. Olson, and R.E. Peterson, 1991. Can. J. Fish. Aquat. Sci.; ERED Ref ID JA474.

Attachment 8
TABLE 8-21
CBR-BASED HAZARD QUOTIENTS FOR COPCs IN MUMMICHOG TISSUE
Future Conditions (2018) - Primary Erosional Zone/Primary Inventory Zone

Focused Feasibility Study - Ecological Risk Assessment

Chemical	Units	EPC [a]	CBR [b]		Species	Endpoint	Reference	Hazard Quotients [c]	
			NOAEL	LOAEL				NOAEL	LOAEL
Inorganics/Metals									
Copper	µg/g	2.3	0.002	**0.02**	*Ictalurus punctatus*	Growth - LOED	1	**1.1E+03**	**1.1E+02**
Lead	µg/g	0.49	0.028	**0.28**	*Oncorhynchus mykiss*	Growth - ED_{11}	2	**1.8E+01**	**1.8E+00**
Mercury[1]	µg/g	0.017	0.006	**0.06**	*Ictalurus punctatus*	Mortality - LD_{50}	3	**2.8E+00**	2.8E-01
Mercury (methyl)	µg/g	0.017	0.001	**0.01**	*Fundulus heteroclitus*	Growth - ED_{146}	4	**1.7E+01**	**1.7E+00**
						Total Inorganics/Metals		**1.2E+03**	**1.2E+02**
Semivolatile Organics (PAHs)									
Low Weight PAHs	µg/g	0.31	0.21	**2.1**	*Psettichthys melanostictus*	Mortality - LD_{51}	5	**1.5E+00**	1.5E-01
High Weight PAHs	µg/g	0.15	0.21	**2.1**	*Psettichthys melanostictus*	Mortality - LD_{51}	5	7.3E-01	7.3E-02
						Total PAHs		**2.2E+00**	2.2E-01
PCBs (Aroclors)									
Aroclor, Total	µg/g	0.26	0.0025	**0.025**	*Oryzias latipes*	Reproduction - ED_{11}	6	**1.0E+02**	**1.0E+01**
						Total PCBs		**1.0E+02**	**1.0E+01**
Pesticides									
Dieldrin	µg/g	0.0042	0.011	**0.11**	*Oncorhynchus mykiss*	Growth - LOED	7	3.8E-01	3.8E-02
Total DDx	µg/g	0.054	**0.000039**	**0.0018**	*Oryzias latipes*	Mortality - LOED	8	**1.4E+03**	**3.0E+01**
						Total Pesticides		**1.4E+03**	**3.0E+01**
Dioxin-like Compounds									
TCDD TEQ (D/F)	µg/g	0.000060	**0.000034**	**0.00006**	*Salvelinus namaycush*	Growth - LOED	9	**1.8E+00**	**1.0E+00**
TCDD TEQ (PCBs)	µg/g	0.00000038	**0.000034**	**0.00006**	*Salvelinus namaycush*	Growth - LOED	9	1.1E-02	6.6E-03
						Total TCDD TEQ		**1.8E+00**	**1.0E+00**
						Total		**2.7E+03**	**1.6E+02**

Notes:

[a] Exposure Point Concentration (95% UCLs) presented in Table 7-7. TCDD Toxic Equivalencies based on fish TEF values, EPCs based on mummichog tissue data.

[b] Critical Body Residues (CBRs) are obtained from summary of tissue effects data presented in CSM Technical Memorandum #3 (Battelle, 2006).

[c] Hazard Quotient is the ratio of the EPC to the NOAEL or LOAEL CBR.

[1]Analyte is not included in the HI totals.

Non-bolded CBR values were estimated using a 10-fold extrapolation factor.

Attachment 8
TABLE 8-21
CBR-BASED HAZARD QUOTIENTS FOR COPCs IN MUMMICHOG TISSUE
Future Conditions (2018) - Primary Erosional Zone/Primary Inventory Zone

Focused Feasibility Study - Ecological Risk Assessment

Chemical	Units	EPC [a]	CBR [b]		Species	Endpoint	Reference	Hazard Quotients [c]	
			NOAEL	LOAEL				NOAEL	LOAEL

References:

1. Murai, T., J.W. Andrews, and R.G. Smith, Jr., 1981. Aquaculture 22:353-357; ERED Ref ID JA317.
2. Hansen, J.A., J. Lipton, P.G., Welsh, D. Cacela, and B. MacConnell, 2004. Environ. Tox. & Chem. 23:1902-1911; ERED Ref ID Weston05-031.
3. Birge, W.J., J.A. Black, A.G. Westerman, and J.E. Hudson, 1979. The Biogeochemistry of Mercury, pg. 629-655; ERED Ref ID JA33.
4. Matta, M.B., J. Linse, C. Cairncross, L. Francendese, and R.M. Kocan, 2001. Environ. Tox. & Chem. 20(2)L327-335; ERED Ref ID MECO3-135.
5. Hose, J.E., J.B. Hannah, D. DiJulio, M.L. Landholt, B.S. Miller, W.T. Iwaoka, and S.P. Felton, 1982. Arch. Environ. Contam. Toxicol. 11:167-171; ERED Ref ID JA212
6. Nakayama, K., Y. Oshima, K. Nagafuchi, T. Hano, Y. Shimasaki, and T. Honjo, 2005. Environ. Tox. Chem. 24:591-596; ERED Ref ID Weston05-046.
7. Dillon, T.M., 1984. Army Corps of Engineers Technical Report, D-84-2; ERED Ref ID MEC04-070.
8. Villalobos, S.B., D.M. Papoulias, S.D. Pastva, A.L. Blankenship, J. Meadow, D.E. Tillitt, and J.P. Giesy, 2003. Chemosphere 53:819-826; ERED Ref ID MEC04-293.
9. Walker, M.K., J.M. Spitsbergen, J.R. Olson, and R.E. Peterson, 1991. Can. J. Fish. Aquat. Sci.; ERED Ref ID JA474.

Attachment 8
TABLE 8-22
CBR-BASED HAZARD QUOTIENTS FOR COPCs IN MUMMICHOG TISSUE
Future Conditions (2048) - Primary Erosional Zone/Primary Inventory Zone

Focused Feasibility Study - Ecological Risk Assessment

Chemical	Units	EPC [a]	CBR [b]		Species	Endpoint	Reference	Hazard Quotients [c]	
			NOAEL	LOAEL				NOAEL	LOAEL
Inorganics/Metals									
Copper	µg/g	1.1	0.002	**0.02**	*Ictalurus punctatus*	Growth - LOED	1	**5.6E+02**	**5.6E+01**
Lead	µg/g	0.22	0.028	**0.28**	*Oncorhynchus mykiss*	Growth - ED_{11}	2	**8.1E+00**	8.1E-01
Mercury[1]	µg/g	0.0054	0.006	**0.06**	*Ictalurus punctatus*	Mortality - LD_{50}	3	9.0E-01	9.0E-02
Mercury (methyl)	µg/g	0.0054	0.001	**0.01**	*Fundulus heteroclitus*	Growth - ED_{146}	4	**5.4E+00**	5.4E-01
						Total Inorganics/Metals		**5.8E+02**	**5.8E+01**
Semivolatile Organics (PAHs)									
Low Weight PAHs	µg/g	0.31	0.21	**2.1**	*Psettichthys melanostictus*	Mortality - LD_{51}	5	**1.5E+00**	1.5E-01
High Weight PAHs	µg/g	0.15	0.21	**2.1**	*Psettichthys melanostictus*	Mortality - LD_{51}	5	7.3E-01	7.3E-02
						Total PAHs		**2.2E+00**	2.2E-01
PCBs (Aroclors)									
Aroclor, Total	µg/g	0.058	0.0025	**0.025**	*Oryzias latipes*	Reproduction - ED_{11}	6	**2.3E+01**	**2.3E+00**
						Total PCBs		**2.3E+01**	**2.3E+00**
Pesticides									
Dieldrin	µg/g	0.0042	0.011	**0.11**	*Oncorhynchus mykiss*	Growth - LOED	7	3.8E-01	3.8E-02
Total DDx	µg/g	0.019	**0.000039**	**0.0018**	*Oryzias latipes*	Mortality - LOED	8	**4.9E+02**	**1.1E+01**
						Total Pesticides		**4.9E+02**	**1.1E+01**
Dioxin-like Compounds									
TCDD TEQ (D/F)	µg/g	0.000018	**0.000034**	**0.00006**	*Salvelinus namaycush*	Growth - LOED	9	5.3E-01	3.1E-01
TCDD TEQ (PCBs)	µg/g	0.000000067	**0.000034**	**0.00006**	*Salvelinus namaycush*	Growth - LOED	9	2.0E-03	1.2E-03
						Total TCDD TEQ		5.3E-01	3.1E-01
						Total		**1.1E+03**	**7.1E+01**

Notes:

[a] Exposure Point Concentration (95% UCLs) presented in Table 7-7. TCDD Toxic Equivalencies based on fish TEF values, EPCs based on mummichog tissue data.

[b] Critical Body Residues (CBRs) are obtained from summary of tissue effects data presented in CSM Technical Memorandum #3 (Battelle, 2006).

[c] Hazard Quotient is the ratio of the EPC to the NOAEL or LOAEL CBR.

[1]Analyte is not included in the HI totals.

Non-bolded CBR values were estimated using a 10-fold extrapolation factor.

Attachment 8
TABLE 8-22
CBR-BASED HAZARD QUOTIENTS FOR COPCs IN MUMMICHOG TISSUE
Future Conditions (2048) - Primary Erosional Zone/Primary Inventory Zone

Focused Feasibility Study - Ecological Risk Assessment

Chemical	Units	EPC [a]	CBR [b]		Species	Endpoint	Reference	Hazard Quotients [c]	
			NOAEL	LOAEL				NOAEL	LOAEL

References:

1. Murai, T., J.W. Andrews, and R.G. Smith, Jr., 1981. Aquaculture 22:353-357; ERED Ref ID JA317.
2. Hansen, J.A., J. Lipton, P.G., Welsh, D. Cacela, and B. MacConnell, 2004. Environ. Tox. & Chem. 23:1902-1911; ERED Ref ID Weston05-031.
3. Birge, W.J., J.A. Black, A.G. Westerman, and J.E. Hudson, 1979. The Biogeochemistry of Mercury, pg. 629-655; ERED Ref ID JA33.
4. Matta, M.B., J. Linse, C. Cairncross, L. Francendese, and R.M. Kocan, 2001. Environ. Tox. & Chem. 20(2)L327-335; ERED Ref ID MECO3-135.
5. Hose, J.E., J.B. Hannah, D. DiJulio, M.L. Landholt, B.S. Miller, W.T. Iwaoka, and S.P. Felton, 1982. Arch. Environ. Contam. Toxicol. 11:167-171; ERED Ref ID JA212
6. Nakayama, K., Y. Oshima, K. Nagafuchi, T. Hano, Y. Shimasaki, and T. Honjo, 2005. Environ. Tox. Chem. 24:591-596; ERED Ref ID Weston05-046.
7. Dillon, T.M., 1984. Army Corps of Engineers Technical Report, D-84-2; ERED Ref ID MEC04-070.
8. Villalobos, S.B., D.M. Papoulias, S.D. Pastva, A.L. Blankenship, J. Meadow, D.E. Tillitt, and J.P. Giesy, 2003. Chemosphere 53:819-826; ERED Ref ID MEC04-293.
9. Walker, M.K., J.M. Spitsbergen, J.R. Olson, and R.E. Peterson, 1991. Can. J. Fish. Aquat. Sci.; ERED Ref ID JA474.

Attachment 8
TABLE 8-23
CBR-BASED HAZARD QUOTIENTS FOR COPCs IN MUMMICHOG TISSUE
Future Conditions (2018) - Area of Focus

Focused Feasibility Study - Ecological Risk Assessment

Chemical	Units	EPC [a]	CBR [b]		Species	Endpoint	Reference	Hazard Quotients [c]	
			NOAEL	LOAEL				NOAEL	LOAEL
Inorganics/Metals									
Copper	µg/g	1.4	0.002	**0.02**	*Ictalurus punctatus*	Growth - LOED	1	**6.9E+02**	**6.9E+01**
Lead	µg/g	0.32	0.028	**0.28**	*Oncorhynchus mykiss*	Growth - ED_{11}	2	**1.1E+01**	**1.1E+00**
Mercury[1]	µg/g	0.0076	0.006	**0.06**	*Ictalurus punctatus*	Mortality - LD_{50}	3	**1.3E+00**	1.3E-01
Mercury (methyl)	µg/g	0.0076	0.001	**0.01**	*Fundulus heteroclitus*	Growth - ED_{146}	4	**7.6E+00**	7.6E-01
						Total Inorganics/Metals		**7.1E+02**	**7.1E+01**
Semivolatile Organics (PAHs)									
Low Weight PAHs	µg/g	0.15	0.21	**2.1**	*Psettichthys melanostictus*	Mortality - LD_{51}	5	6.9E-01	6.9E-02
High Weight PAHs	µg/g	0.11	0.21	**2.1**	*Psettichthys melanostictus*	Mortality - LD_{51}	5	5.2E-01	5.2E-02
						Total PAHs		**1.2E+00**	1.2E-01
PCBs (Aroclors)									
Aroclor, Total	µg/g	0.2	0.0025	**0.025**	*Oryzias latipes*	Reproduction - ED_{11}	6	**7.9E+01**	**7.9E+00**
						Total PCBs		**7.9E+01**	**7.9E+00**
Pesticides									
Dieldrin	µg/g	0.0010	0.011	**0.11**	*Oncorhynchus mykiss*	Growth - LOED	7	9.5E-02	9.5E-03
Total DDx	µg/g	0.022	**0.000039**	**0.0018**	*Oryzias latipes*	Mortality - LOED	8	**5.7E+02**	**1.2E+01**
						Total Pesticides		**5.7E+02**	**1.2E+01**
Dioxin-like Compounds									
TCDD TEQ (D/F)	µg/g	0.0000041	**0.000034**	**0.00006**	*Salvelinus namaycush*	Growth - LOED	9	1.2E-01	7.1E-02
TCDD TEQ (PCBs)	µg/g	0.00000027	**0.000034**	**0.00006**	*Salvelinus namaycush*	Growth - LOED	9	7.9E-03	4.6E-03
						Total TCDD TEQ		1.3E-01	7.6E-02
						Total		**1.4E+03**	**9.1E+01**

Notes:

[a] Exposure Point Concentration (95% UCLs) presented in Table 7-8. TCDD Toxic Equivalencies based on fish TEF values, EPCs based on mummichog tissue data.

[b] Critical Body Residues (CBRs) are obtained from summary of tissue effects data presented in CSM Technical Memorandum #3 (Battelle, 2006).

[c] Hazard Quotient is the ratio of the EPC to the NOAEL or LOAEL CBR.

[1]Analyte is not included in the HI totals.

Non-bolded CBR values were estimated using a 10-fold extrapolation factor.

Attachment 8
TABLE 8-23
CBR-BASED HAZARD QUOTIENTS FOR COPCs IN MUMMICHOG TISSUE
Future Conditions (2018) - Area of Focus

Focused Feasibility Study - Ecological Risk Assessment

Chemical	Units	EPC [a]	CBR [b]		Species	Endpoint	Reference	Hazard Quotients [c]	
			NOAEL	LOAEL				NOAEL	LOAEL

References:

1. Murai, T., J.W. Andrews, and R.G. Smith, Jr., 1981. Aquaculture 22:353-357; ERED Ref ID JA317.
2. Hansen, J.A., J. Lipton, P.G., Welsh, D. Cacela, and B. MacConnell, 2004. Environ. Tox. & Chem. 23:1902-1911; ERED Ref ID Weston05-031.
3. Birge, W.J., J.A. Black, A.G. Westerman, and J.E. Hudson, 1979. The Biogeochemistry of Mercury, pg. 629-655; ERED Ref ID JA33.
4. Matta, M.B., J. Linse, C. Cairncross, L. Francendese, and R.M. Kocan, 2001. Environ. Tox. & Chem. 20(2)L327-335; ERED Ref ID MECO3-135.
5. Hose, J.E., J.B. Hannah, D. DiJulio, M.L. Landholt, B.S. Miller, W.T. Iwaoka, and S.P. Felton, 1982. Arch. Environ. Contam. Toxicol. 11:167-171; ERED Ref ID JA212
6. Nakayama, K., Y. Oshima, K. Nagafuchi, T. Hano, Y. Shimasaki, and T. Honjo, 2005. Environ. Tox. Chem. 24:591-596; ERED Ref ID Weston05-046.
7. Dillon, T.M., 1984. Army Corps of Engineers Technical Report, D-84-2; ERED Ref ID MEC04-070.
8. Villalobos, S.B., D.M. Papoulias, S.D. Pastva, A.L. Blankenship, J. Meadow, D.E. Tillitt, and J.P. Giesy, 2003. Chemosphere 53:819-826; ERED Ref ID MEC04-293.
9. Walker, M.K., J.M. Spitsbergen, J.R. Olson, and R.E. Peterson, 1991. Can. J. Fish. Aquat. Sci.; ERED Ref ID JA474.

Attachment 8
TABLE 8-24
CBR-BASED HAZARD QUOTIENTS FOR COPCs IN MUMMICHOG TISSUE
Future Conditions (2048) - Area of Focus

Focused Feasibility Study - Ecological Risk Assessment

Chemical	Units	EPC [a]	CBR [b]		Species	Endpoint	Reference	Hazard Quotients [c]	
			NOAEL	LOAEL				NOAEL	LOAEL
Inorganics/Metals									
Copper	µg/g	0.70	0.002	**0.02**	*Ictalurus punctatus*	Growth - LOED	1	**3.5E+02**	**3.5E+01**
Lead	µg/g	0.15	0.028	**0.28**	*Oncorhynchus mykiss*	Growth - ED_{11}	2	**5.3E+00**	5.3E-01
Mercury[1]	µg/g	0.0024	0.006	**0.06**	*Ictalurus punctatus*	Mortality - LD_{50}	3	4.1E-01	4.1E-02
Mercury (methyl)	µg/g	0.0024	0.001	**0.01**	*Fundulus heteroclitus*	Growth - ED_{146}	4	**2.4E+00**	2.4E-01
						Total Inorganics/Metals		**3.6E+02**	**3.6E+01**
Semivolatile Organics (PAHs)									
Low Weight PAHs	µg/g	0.15	0.21	**2.1**	*Psettichthys melanostictus*	Mortality - LD_{51}	5	6.9E-01	6.9E-02
High Weight PAHs	µg/g	0.11	0.21	**2.1**	*Psettichthys melanostictus*	Mortality - LD_{51}	5	5.2E-01	5.2E-02
						Total PAHs		**1.2E+00**	1.2E-01
PCBs (Aroclors)									
Aroclor, Total	µg/g	0.044	0.0025	**0.025**	*Oryzias latipes*	Reproduction - ED_{11}	6	**1.8E+01**	**1.8E+00**
						Total PCBs		**1.8E+01**	**1.8E+00**
Pesticides									
Dieldrin	µg/g	0.0010	0.011	**0.11**	*Oncorhynchus mykiss*	Growth - LOED	7	9.5E-02	9.5E-03
Total DDx	µg/g	0.0078	**0.000039**	**0.0018**	*Oryzias latipes*	Mortality - LOED	8	**2.0E+02**	**4.3E+00**
						Total Pesticides		**2.0E+02**	**4.3E+00**
Dioxin-like Compounds									
TCDD TEQ (D/F)	µg/g	0.0000013	**0.000034**	**0.00006**	*Salvelinus namaycush*	Growth - LOED	9	3.8E-02	2.2E-02
TCDD TEQ (PCBs)	µg/g	0.000000067	**0.000034**	**0.00006**	*Salvelinus namaycush*	Growth - LOED	9	2.0E-03	1.2E-03
						Total TCDD TEQ		4.0E-02	2.3E-02
						Total		**5.7E+02**	**4.2E+01**

Notes:

[a] Exposure Point Concentration (95% UCLs) presented in Table 7-8. TCDD Toxic Equivalencies based on fish TEF values, EPCs based on mummichog tissue data.

[b] Critical Body Residues (CBRs) are obtained from summary of tissue effects data presented in CSM Technical Memorandum #3 (Battelle, 2006).

[c] Hazard Quotient is the ratio of the EPC to the NOAEL or LOAEL CBR.

[1]Analyte is not included in the HI totals.

Non-bolded CBR values were estimated using a 10-fold extrapolation factor.

TABLE 8-24
CBR-BASED HAZARD QUOTIENTS FOR COPCs IN MUMMICHOG TISSUE
Future Conditions (2048) - Area of Focus

Focused Feasibility Study - Ecological Risk Assessment

Chemical	Units	EPC [a]	CBR [b]		Species	Endpoint	Reference	Hazard Quotients [c]	
			NOAEL	LOAEL				NOAEL	LOAEL

References:

1. Murai, T., J.W. Andrews, and R.G. Smith, Jr., 1981. Aquaculture 22:353-357; ERED Ref ID JA317.
2. Hansen, J.A., J. Lipton, P.G., Welsh, D. Cacela, and B. MacConnell, 2004. Environ. Tox. & Chem. 23:1902-1911; ERED Ref ID Weston05-031.
3. Birge, W.J., J.A. Black, A.G. Westerman, and J.E. Hudson, 1979. The Biogeochemistry of Mercury, pg. 629-655; ERED Ref ID JA33.
4. Matta, M.B., J. Linse, C. Cairncross, L. Francendese, and R.M. Kocan, 2001. Environ. Tox. & Chem. 20(2)L327-335; ERED Ref ID MECO3-135.
5. Hose, J.E., J.B. Hannah, D. DiJulio, M.L. Landholt, B.S. Miller, W.T. Iwaoka, and S.P. Felton, 1982. Arch. Environ. Contam. Toxicol. 11:167-171; ERED Ref ID JA212
6. Nakayama, K., Y. Oshima, K. Nagafuchi, T. Hano, Y. Shimasaki, and T. Honjo, 2005. Environ. Tox. Chem. 24:591-596; ERED Ref ID Weston05-046.
7. Dillon, T.M., 1984. Army Corps of Engineers Technical Report, D-84-2; ERED Ref ID MEC04-070.
8. Villalobos, S.B., D.M. Papoulias, S.D. Pastva, A.L. Blankenship, J. Meadow, D.E. Tillitt, and J.P. Giesy, 2003. Chemosphere 53:819-826; ERED Ref ID MEC04-293.
9. Walker, M.K., J.M. Spitsbergen, J.R. Olson, and R.E. Peterson, 1991. Can. J. Fish. Aquat. Sci.; ERED Ref ID JA474.

Attachment 8

TABLE 8-25

PARAMETER VALUES USED TO CALCULATE ESTIMATED DAILY INTAKE : Surficial sediment / MINK

Focused Feasiblity Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2018)
MEDIUM: SEDIMENT
EXPOSURE MEDIUM: Surficial sediment
EXPOSURE POINT: RME - Monitored Natural Recovery
RECEPTOR: MINK

EXPOSURE ROUTE	PARAMETER SYMBOL	PARAMETER DEFINITION	UNITS	RME VALUE	RME RATIONALE/ REFERENCE	INTAKE EQUATION/ MODEL NAME
INGESTION	EDI_{sed}	ESTIMATED DAILY INTAKE VIA SEDIMENT INGESTION	mg/kg-d	calculated		SEDIMENT INTAKE-INGESTION
	C_{sed}	CHEMICAL CONCENTRATION IN SEDIMENT	mg/kg	chemical-specific		$EDI_{sed} = C_{sed} * IR_{sed} * SFF * EF * 1/BW$
	IR_{sed}	INGESTION RATE OF SEDIMENT	kg/day	0.0034	assumption	
	SFF	SITE FORAGING FREQUENCY	unitless	100%	Mitchell, 1961	
	EF	EXPOSURE FREQUENCY	unitless	100%	USEPA, 1993	
	BW	BODY WEIGHT	kg	0.57	Mitchell, 1961	

References:

Mitchell, J.L., 1961. Mink movements and populations on a Montana river; J. Wildl. Manage. 25:48-54.

USEPA, 1993. Wildlife Exposure Factors Handbook; United States Environmental Protection Agency, Office of Research and Development; EPA/600/R-93/187a; December 1993; Washington, D.C.

Attachment 8

TABLE 8-26

CALCULATION OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS : Surficial sediment / MINK

Focused Feasiblity Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2018)
MEDIUM: SEDIMENT
EXPOSURE MEDIUM: Surficial sediment
EXPOSURE POINT: RME - Monitored Natural Recovery
RECEPTOR: MINK

Analyte	Medium EPC	Medium EPC Units	Estimated Daily Intake[a]	Daily Intake Units	Reference Dose (NOAEL)[b]	Reference Dose (LOAEL)[b]	Reference Dose Units	Hazard Quotient (NOAEL)[c]	Hazard Quotient (LOAEL)[c]
Copper	1.4E+02	mg/kg	8.3E-01	mg/kg-d	5.6E+00	9.3E+00	mg/kg-d	1.5E-01	8.9E-02
Lead	2.4E+02	mg/kg	1.4E+00	mg/kg-d	4.7E+00	8.9E+00	mg/kg-d	3.0E-01	1.6E-01
Methyl Mercury	1.5E+00	mg/kg	9.3E-03	mg/kg-d	5.5E-02	1.8E-01	mg/kg-d	1.7E-01	5.2E-02
LPAH	3.3E+01	mg/kg	2.0E-01	mg/kg-d	-	-			
HPAH	8.6E+01	mg/kg	5.2E-01	mg/kg-d	1.0E+00	1.0E+01	mg/kg-d	5.2E-01	5.2E-02
Dieldrin	2.0E-02	mg/kg	1.2E-04	mg/kg-d	1.5E-02	3.0E-02	mg/kg-d	8.2E-03	4.1E-03
Total DDx	2.0E-01	mg/kg	1.2E-03	mg/kg-d	8.0E-01	4.0E+00	mg/kg-d	1.5E-03	3.0E-04
Total PCBs	5.7E-01	mg/kg	3.4E-03	mg/kg-d	8.0E-02	9.6E-02	mg/kg-d	4.3E-02	3.6E-02
TEQ PCB-mammals	8.7E-06	mg/kg	5.2E-08	mg/kg-d	8.0E-08	2.2E-06	mg/kg-d	6.5E-01	2.3E-02
TEQ D/F-mammals	9.4E-04	mg/kg	5.6E-06	mg/kg-d	8.0E-08	2.2E-06	mg/kg-d	**7.1E+01**	**2.5E+00**
							HAZARD INDICES:	**7.2E+01**	**2.9E+00**

Notes:
a. Estimated Daily Intake (EDI) calculated using parameters presented in Table 8-25.
b. Reference Dose Values presented in Table 6-4. A dash indicates that no value is available.
c. Hazard Quotients (HQs) calculated by dividing the Estimated Daily Intake dose by either the NOAEL- or LOAEL-based Reference Dose.

Attachment 8

TABLE 8-27

PARAMETER VALUES USED TO CALCULATE ESTIMATED DAILY INTAKE : Blue crab / MINK

Focused Feasiblity Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2018)
MEDIUM: AQUATIC INVERTEBRATES
EXPOSURE MEDIUM: Blue crab
EXPOSURE POINT: RME - Monitored Natural Recovery
RECEPTOR: MINK

EXPOSURE ROUTE	PARAMETER SYMBOL	PARAMETER DEFINITION	UNITS	RME VALUE	RME RATIONALE/ REFERENCE	INTAKE EQUATION/ MODEL NAME
INGESTION	EDI_{invert}	ESTIMATED DAILY INTAKE VIA INVERTEBRATE INGESTION	mg/kg-d	calculated		INVERTEBRATE INTAKE-INGESTION $EDI_{invert} = C_{invert} * IR_{food} * P_{invert} * SFF * EF * 1/BW$
	C_{invert}	CHEMICAL CONCENTRATION IN INVERTEBRATES	mg/kg	chemical-specific		
	IR_{food}	INGESTION RATE OF FOOD	kg/day	0.17	USEPA, 1993	
	P_{invert}	PERCENT INVERTEBRATES IN DIET	unitless	20%	assumption	Where C_{invert} is estimated using site-specific tissue data or calculated using the following equation: $C_{invert} = C_{sed} * BAF_{invert}$
	SFF	SITE FORAGING FREQUENCY	unitless	100%	Mitchell, 1961	
	EF	EXPOSURE FREQUENCY	unitless	100%	USEPA, 1993	Bioaccumulation Factors [mg(ww tissue)/ kg(dw sediment)] provided separately.
	BW	BODY WEIGHT	kg	0.57	Mitchell, 1961	

References:
Mitchell, J.L., 1961. Mink movements and populations on a Montana river; J. Wildl. Manage. 25:48-54.
USEPA, 1993. Wildlife Exposure Factors Handbook; United States Environmental Protection Agency, Office of Research and Development; EPA/600/R-93/187a; December 1993; Washington, D.C.

Attachment 8

TABLE 8-28

CALCULATION OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS : Blue crab / MINK

Focused Feasiblity Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2018)
MEDIUM: AQUATIC INVERTEBRATES
EXPOSURE MEDIUM: Blue crab
EXPOSURE POINT: RME - Monitored Natural Recovery
RECEPTOR: MINK

Analyte	Medium EPC	Medium EPC Units	Estimated Daily Intake[a]	Daily Intake Units	Reference Dose (NOAEL)[b]	Reference Dose (LOAEL)[b]	Reference Dose Units	Hazard Quotient (NOAEL)[c]	Hazard Quotient (LOAEL)[c]
Copper	1.9E+01	mg/kg	1.2E+00	mg/kg-d	5.6E+00	9.3E+00	mg/kg-d	2.1E-01	1.2E-01
Lead	3.3E-01	mg/kg	2.0E-02	mg/kg-d	4.7E+00	8.9E+00	mg/kg-d	4.3E-03	2.3E-03
Methyl Mercury	4.3E-02	mg/kg	2.6E-03	mg/kg-d	5.5E-02	1.8E-01	mg/kg-d	4.7E-02	1.4E-02
LPAH	2.5E-01	mg/kg	1.5E-02	mg/kg-d	-	-			
HPAH	2.7E-01	mg/kg	1.6E-02	mg/kg-d	1.0E+00	1.0E+01	mg/kg-d	1.6E-02	1.6E-03
Dieldrin	1.4E-02	mg/kg	8.2E-04	mg/kg-d	1.5E-02	3.0E-02	mg/kg-d	5.5E-02	2.7E-02
Total DDx	2.2E-01	mg/kg	1.3E-02	mg/kg-d	8.0E-01	4.0E+00	mg/kg-d	1.7E-02	3.3E-03
Total PCBs	1.2E+00	mg/kg	7.0E-02	mg/kg-d	8.0E-02	9.6E-02	mg/kg-d	8.8E-01	7.3E-01
TEQ PCB-mammals	2.2E-05	mg/kg	1.3E-06	mg/kg-d	8.0E-08	2.2E-06	mg/kg-d	**1.7E+01**	6.0E-01
TEQ D/F-mammals	1.4E-04	mg/kg	8.6E-06	mg/kg-d	8.0E-08	2.2E-06	mg/kg-d	**1.1E+02**	**3.8E+00**
							HAZARD INDICES:	**1.3E+02**	**5.3E+00**

Notes:
a. Estimated Daily Intake (EDI) calculated using parameters presented in Table 8-27.
b. Reference Dose Values presented in Table 6-4. A dash indicates that no value is available.
c. Hazard Quotients (HQs) calculated by dividing the Estimated Daily Intake dose by either the NOAEL- or LOAEL-based Reference Dose.

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TABLE 8-29

PARAMETER VALUES USED TO CALCULATE ESTIMATED DAILY INTAKE : White perch/American eel / MINK

Focused Feasiblity Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2018)
MEDIUM: FISH
EXPOSURE MEDIUM: White perch/American eel
EXPOSURE POINT: RME - Monitored Natural Recovery
RECEPTOR: MINK

EXPOSURE ROUTE	PARAMETER SYMBOL	PARAMETER DEFINITION	UNITS	RME VALUE	RME RATIONALE/ REFERENCE	INTAKE EQUATION/ MODEL NAME
INGESTION	EDI_{fish}	ESTIMATED DAILY INTAKE VIA FISH INGESTION	mg/kg-d	calculated		FISH INTAKE-INGESTION
	C_{fish}	CHEMICAL CONCENTRATION IN FISH	mg/kg	chemical-specific		$EDI_{fish} = C_{fish} * IR_{food} * P_{fish} * SFF * EF * 1/BW$
	IR_{food}	INGESTION RATE OF FOOD	kg/day	0.17	USEPA, 1993	
	P_{fish}	PERCENT FISH IN DIET	unitless	80%	assumption	Where C_{fish} is estimated using site-specific tissue data or estimated using the following equation:
	SFF	SITE FORAGING FREQUENCY	unitless	100%	Mitchell, 1961	$C_{fish} = C_{sed} * BAF_{fish}$
	EF	EXPOSURE FREQUENCY	unitless	100%	USEPA, 1993	Bioaccumulation Factors [mg(ww tissue)/ kg(dw sediment)] provided separately.
	BW	BODY WEIGHT	kg	0.57	Mitchell, 1961	

References:
Mitchell, J.L., 1961. Mink movements and populations on a Montana river; J. Wildl. Manage. 25:48-54.
USEPA, 1993. Wildlife Exposure Factors Handbook; United States Environmental Protection Agency, Office of Research and Development; EPA/600/R-93/187a; December 1993; Washington, D.C.

Attachment 8

TABLE 8-30

CALCULATION OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS : White perch/American eel / MINK

Focused Feasiblity Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2018)
MEDIUM: FISH
EXPOSURE MEDIUM: White perch/American eel
EXPOSURE POINT: RME - Monitored Natural Recovery
RECEPTOR: MINK

Analyte	Medium EPC	Medium EPC Units	Estimated Daily Intake[a]	Daily Intake Units	Reference Dose (NOAEL)[b]	Reference Dose (LOAEL)[b]	Reference Dose Units	Hazard Quotient (NOAEL)[c]	Hazard Quotient (LOAEL)[c]
Copper	5.6E+00	mg/kg	1.4E+00	mg/kg-d	5.6E+00	9.3E+00	mg/kg-d	2.4E-01	1.4E-01
Lead	2.8E-01	mg/kg	6.8E-02	mg/kg-d	4.7E+00	8.9E+00	mg/kg-d	1.5E-02	7.7E-03
Methyl Mercury	1.6E-01	mg/kg	3.8E-02	mg/kg-d	5.5E-02	1.8E-01	mg/kg-d	6.9E-01	2.1E-01
LPAH	3.7E-01	mg/kg	8.9E-02	mg/kg-d	-	-			
HPAH	2.2E-01	mg/kg	5.2E-02	mg/kg-d	1.0E+00	1.0E+01	mg/kg-d	5.2E-02	5.2E-03
Dieldrin	3.2E-02	mg/kg	7.8E-03	mg/kg-d	1.5E-02	3.0E-02	mg/kg-d	5.2E-01	2.6E-01
Total DDx	3.6E-01	mg/kg	8.6E-02	mg/kg-d	8.0E-01	4.0E+00	mg/kg-d	1.1E-01	2.1E-02
Total PCBs	1.2E+00	mg/kg	3.0E-01	mg/kg-d	8.0E-02	9.6E-02	mg/kg-d	**3.7E+00**	**3.1E+00**
TEQ PCB-mammals	1.5E-05	mg/kg	3.7E-06	mg/kg-d	8.0E-08	2.2E-06	mg/kg-d	**4.6E+01**	**1.7E+00**
TEQ D/F-mammals	1.9E-04	mg/kg	4.5E-05	mg/kg-d	8.0E-08	2.2E-06	mg/kg-d	**5.6E+02**	**2.0E+01**
							HAZARD INDICES:	**6.2E+02**	**2.6E+01**

Notes:
a. Estimated Daily Intake (EDI) calculated using parameters presented in Table 8-29.
b. Reference Dose Values presented in Table 6-4. A dash indicates that no value is available.
c. Hazard Quotients (HQs) calculated by dividing the Estimated Daily Intake dose by either the NOAEL- or LOAEL-based Reference Dose.

Attachment 8

TABLE 8-31

SUMMARY OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS USING NOAEL-BASED TRVs : MINK

Focused Feasiblity Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2018)
EXPOSURE POINT: RME - Monitored Natural Recovery
RECEPTOR: MINK
TOTAL RISK (HI): 8.1E+02

	Exposure Medium[a]						
Analyte	Surface Water	Sediment	Aquatic Plants	Aquatic Invertebrates	Fish	Combined HQs[b]	Percent Contribution[c]
TCDD TEQ (D/F)		7.1E+01		1.1E+02	5.6E+02	***7.4E+02***	***91%***
TCDD TEQ (PCBs)		6.5E-01		1.7E+01	4.6E+01	***6.4E+01***	8%
Total PCBs		4.3E-02		8.8E-01	3.7E+00	***4.6E+00***	1%
Mercury		1.7E-01		4.7E-02	6.9E-01	9.0E-01	0%
Copper		1.5E-01		2.1E-01	2.4E-01	6.0E-01	0%
HPAH		5.2E-01		1.6E-02	5.2E-02	5.8E-01	0%
Dieldrin		8.2E-03		5.5E-02	5.2E-01	5.8E-01	0%
Lead		3.0E-01		4.3E-03	1.5E-02	3.2E-01	0%
Total DDx		1.5E-03		1.7E-02	1.1E-01	1.3E-01	0%
LPAH							
TOTAL MEDIUM-SPECIFIC RISK	**-**	**7.2E+01**	**-**	**1.3E+02**	**6.2E+02**	**8.1E+02**	
PERCENTAGE OF TOTAL RISK		**9%**		**15%**	**76%**	**100%**	

Notes:

a. Hazard Quotients presented by exposure medium; a blank cell indicates that the analyte was not a COPC for that medium; a dash entry indicates that there was no assumed exposure to that medium.

b. Combined risk across all media exposures.

c. Relative contribution of COPC to total risk associated with the ingestion exposure pathway.

Attachment 8

TABLE 8-32

SUMMARY OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS USING LOAEL-BASED TRVs : MINK

Focused Feasiblity Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2018)
EXPOSURE POINT: RME - Monitored Natural Recovery
RECEPTOR: MINK
TOTAL RISK (HI): 3.4E+01

Analyte	Exposure Medium[a]					Combined HQs[b]	Percent Contribution[c]
	Surface Water	Sediment	Aquatic Plants	Aquatic Invertebrates	Fish		
TCDD TEQ (D/F)		2.5E+00		3.8E+00	2.0E+01	***2.7E+01***	***78%***
Total PCBs		3.6E-02		7.3E-01	3.1E+00	***3.8E+00***	***11%***
TCDD TEQ (PCBs)		2.3E-02		6.0E-01	1.7E+00	***2.3E+00***	7%
Copper		8.9E-02		1.2E-01	1.4E-01	3.6E-01	1%
Dieldrin		4.1E-03		2.7E-02	2.6E-01	2.9E-01	1%
Mercury		5.2E-02		1.4E-02	2.1E-01	2.8E-01	1%
Lead		1.6E-01		2.3E-03	7.7E-03	1.7E-01	1%
HPAH		5.2E-02		1.6E-03	5.2E-03	5.8E-02	0%
Total DDx		3.0E-04		3.3E-03	2.1E-02	2.5E-02	0%
LPAH							
TOTAL MEDIUM-SPECIFIC RISK	**-**	**2.9E+00**	**-**	**5.3E+00**	**2.6E+01**	**3.4E+01**	
PERCENTAGE OF TOTAL RISK		**9%**		**16%**	**76%**	**100%**	

Notes:

a. Hazard Quotients presented by exposure medium; a blank cell indicates that the analyte was not a COPC for that medium; a dash entry indicates that there was no assumed exposure to that medium.

b. Combined risk across all media exposures.

c. Relative contribution of COPC to total risk associated with the ingestion exposure pathway.

Attachment 8

TABLE 8-33

PARAMETER VALUES USED TO CALCULATE ESTIMATED DAILY INTAKE : Surficial sediment / MINK

Focused Feasiblity Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2048)
MEDIUM: SEDIMENT
EXPOSURE MEDIUM: Surficial sediment
EXPOSURE POINT: RME - Monitored Natural Recovery
RECEPTOR: MINK

EXPOSURE ROUTE	PARAMETER SYMBOL	PARAMETER DEFINITION	UNITS	RME VALUE	RME RATIONALE/ REFERENCE	INTAKE EQUATION/ MODEL NAME
INGESTION	EDI_{sed}	ESTIMATED DAILY INTAKE VIA SEDIMENT INGESTION	mg/kg-d	calculated		SEDIMENT INTAKE-INGESTION
	C_{sed}	CHEMICAL CONCENTRATION IN SEDIMENT	mg/kg	chemical-specific		$EDI_{sed} = C_{sed} * IR_{sed} * SFF * EF * 1/BW$
	IR_{sed}	INGESTION RATE OF SEDIMENT	kg/day	0.0034	assumption	
	SFF	SITE FORAGING FREQUENCY	unitless	100%	Mitchell, 1961	
	EF	EXPOSURE FREQUENCY	unitless	100%	USEPA, 1993	
	BW	BODY WEIGHT	kg	0.57	Mitchell, 1961	

References:

Mitchell, J.L., 1961. Mink movements and populations on a Montana river; J. Wildl. Manage. 25:48-54.

USEPA, 1993. Wildlife Exposure Factors Handbook; United States Environmental Protection Agency, Office of Research and Development; EPA/600/R-93/187a; December 1993; Washington, D.C.

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TABLE 8-34

CALCULATION OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS : Surficial sediment / MINK

Focused Feasiblity Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2048)
MEDIUM: SEDIMENT
EXPOSURE MEDIUM: Surficial sediment
EXPOSURE POINT: RME - Monitored Natural Recovery
RECEPTOR: MINK

Analyte	Medium EPC	Medium EPC Units	Estimated Daily Intake[a]	Daily Intake Units	Reference Dose (NOAEL)[b]	Reference Dose (LOAEL)[b]	Reference Dose Units	Hazard Quotient (NOAEL)[c]	Hazard Quotient (LOAEL)[c]
Copper	7.0E+01	mg/kg	4.2E-01	mg/kg-d	5.6E+00	9.3E+00	mg/kg-d	7.5E-02	4.5E-02
Lead	1.1E+02	mg/kg	6.6E-01	mg/kg-d	4.7E+00	8.9E+00	mg/kg-d	1.4E-01	7.4E-02
Methyl Mercury	5.0E-01	mg/kg	3.0E-03	mg/kg-d	5.5E-02	1.8E-01	mg/kg-d	5.4E-02	1.7E-02
LPAH	3.3E+01	mg/kg	2.0E-01	mg/kg-d	-	-			
HPAH	8.6E+01	mg/kg	5.2E-01	mg/kg-d	1.0E+00	1.0E+01	mg/kg-d	5.2E-01	5.2E-02
Dieldrin	2.0E-02	mg/kg	1.2E-04	mg/kg-d	1.5E-02	3.0E-02	mg/kg-d	8.2E-03	4.1E-03
Total DDx	6.9E-02	mg/kg	4.2E-04	mg/kg-d	8.0E-01	4.0E+00	mg/kg-d	5.2E-04	1.0E-04
Total PCBs	1.3E-01	mg/kg	7.7E-04	mg/kg-d	8.0E-02	9.6E-02	mg/kg-d	9.7E-03	8.1E-03
TEQ PCB-mammals	2.5E-06	mg/kg	1.5E-08	mg/kg-d	8.0E-08	2.2E-06	mg/kg-d	1.9E-01	6.7E-03
TEQ D/F-mammals	2.9E-04	mg/kg	1.8E-06	mg/kg-d	8.0E-08	2.2E-06	mg/kg-d	**2.2E+01**	7.9E-01
							HAZARD INDICES:	**2.3E+01**	9.9E-01

Notes:
a. Estimated Daily Intake (EDI) calculated using parameters presented in Table 8-33.
b. Reference Dose Values presented in Table 6-4. A dash indicates that no value is available.
c. Hazard Quotients (HQs) calculated by dividing the Estimated Daily Intake dose by either the NOAEL- or LOAEL-based Reference Dose.

Attachment 8

TABLE 8-35

PARAMETER VALUES USED TO CALCULATE ESTIMATED DAILY INTAKE : Blue crab / MINK

Focused Feasiblity Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2048)
MEDIUM: AQUATIC INVERTEBRATES
EXPOSURE MEDIUM: Blue crab
EXPOSURE POINT: RME - Monitored Natural Recovery
RECEPTOR: MINK

EXPOSURE ROUTE	PARAMETER SYMBOL	PARAMETER DEFINITION	UNITS	RME VALUE	RME RATIONALE/ REFERENCE	INTAKE EQUATION/ MODEL NAME
INGESTION	EDI_{invert}	ESTIMATED DAILY INTAKE VIA INVERTEBRATE INGESTION	mg/kg-d	calculated		INVERTEBRATE INTAKE-INGESTION $EDI_{invert} = C_{invert} * IR_{food} * P_{invert} * SFF * EF * 1/BW$
	C_{invert}	CHEMICAL CONCENTRATION IN INVERTEBRATES	mg/kg	chemical-specific		
	IR_{food}	INGESTION RATE OF FOOD	kg/day	0.17	USEPA, 1993	
	P_{invert}	PERCENT INVERTEBRATES IN DIET	unitless	20%	assumption	Where C_{invert} is estimated using site-specific tissue data or calculated using the following equation: $C_{invert} = C_{sed} * BAF_{invert}$
	SFF	SITE FORAGING FREQUENCY	unitless	100%	Mitchell, 1961	
	EF	EXPOSURE FREQUENCY	unitless	100%	USEPA, 1993	Bioaccumulation Factors [mg(ww tissue)/ kg(dw sediment)] provided separately.
	BW	BODY WEIGHT	kg	0.57	Mitchell, 1961	

References:
Mitchell, J.L., 1961. Mink movements and populations on a Montana river; J. Wildl. Manage. 25:48-54.
USEPA, 1993. Wildlife Exposure Factors Handbook; United States Environmental Protection Agency, Office of Research and Development; EPA/600/R-93/187a; December 1993; Washington, D.C.

Attachment 8

TABLE 8-36

CALCULATION OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS : Blue crab / MINK

Focused Feasiblity Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2048)
MEDIUM: AQUATIC INVERTEBRATES
EXPOSURE MEDIUM: Blue crab
EXPOSURE POINT: RME - Monitored Natural Recovery
RECEPTOR: MINK

Analyte	Medium EPC	Medium EPC Units	Estimated Daily Intake[a]	Daily Intake Units	Reference Dose (NOAEL)[b]	Reference Dose (LOAEL)[b]	Reference Dose Units	Hazard Quotient (NOAEL)[c]	Hazard Quotient (LOAEL)[c]
Copper	9.8E+00	mg/kg	5.9E-01	mg/kg-d	5.6E+00	9.3E+00	mg/kg-d	1.1E-01	6.3E-02
Lead	1.5E-01	mg/kg	9.3E-03	mg/kg-d	4.7E+00	8.9E+00	mg/kg-d	2.0E-03	1.0E-03
Methyl Mercury	1.4E-02	mg/kg	8.3E-04	mg/kg-d	5.5E-02	1.8E-01	mg/kg-d	1.5E-02	4.6E-03
LPAH	2.5E-01	mg/kg	1.5E-02	mg/kg-d	-	-			
HPAH	2.7E-01	mg/kg	1.6E-02	mg/kg-d	1.0E+00	1.0E+01	mg/kg-d	1.6E-02	1.6E-03
Dieldrin	1.4E-02	mg/kg	8.2E-04	mg/kg-d	1.5E-02	3.0E-02	mg/kg-d	5.5E-02	2.7E-02
Total DDx	7.7E-02	mg/kg	4.6E-03	mg/kg-d	8.0E-01	4.0E+00	mg/kg-d	5.8E-03	1.2E-03
Total PCBs	2.6E-01	mg/kg	1.6E-02	mg/kg-d	8.0E-02	9.6E-02	mg/kg-d	2.0E-01	1.7E-01
TEQ PCB-mammals	6.3E-06	mg/kg	3.8E-07	mg/kg-d	8.0E-08	2.2E-06	mg/kg-d	**4.8E+00**	1.7E-01
TEQ D/F-mammals	4.5E-05	mg/kg	2.7E-06	mg/kg-d	8.0E-08	2.2E-06	mg/kg-d	**3.4E+01**	**1.2E+00**
							HAZARD INDICES:	**3.9E+01**	**1.6E+00**

Notes:
a. Estimated Daily Intake (EDI) calculated using parameters presented in Table 8-35.
b. Reference Dose Values presented in Table 6-4. A dash indicates that no value is available.
c. Hazard Quotients (HQs) calculated by dividing the Estimated Daily Intake dose by either the NOAEL- or LOAEL-based Reference Dose.

Attachment 8

TABLE 8-37

PARAMETER VALUES USED TO CALCULATE ESTIMATED DAILY INTAKE : White perch/American eel / MINK

Focused Feasiblity Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2048)
MEDIUM: FISH
EXPOSURE MEDIUM: White perch/American eel
EXPOSURE POINT: RME - Monitored Natural Recovery
RECEPTOR: MINK

EXPOSURE ROUTE	PARAMETER SYMBOL	PARAMETER DEFINITION	UNITS	RME VALUE	RME RATIONALE/ REFERENCE	INTAKE EQUATION/ MODEL NAME
INGESTION	EDI_{fish}	ESTIMATED DAILY INTAKE VIA FISH INGESTION	mg/kg-d	calculated		FISH INTAKE-INGESTION
	C_{fish}	CHEMICAL CONCENTRATION IN FISH	mg/kg	chemical-specific		$EDI_{fish} = C_{fish} * IR_{food} * P_{fish} * SFF * EF * 1/BW$
	IR_{food}	INGESTION RATE OF FOOD	kg/day	0.17	USEPA, 1993	
	P_{fish}	PERCENT FISH IN DIET	unitless	80%	assumption	Where C_{fish} is estimated using site-specific tissue data or estimated using the following equation:
	SFF	SITE FORAGING FREQUENCY	unitless	100%	Mitchell, 1961	$C_{fish} = C_{sed} * BAF_{fish}$
	EF	EXPOSURE FREQUENCY	unitless	100%	USEPA, 1993	Bioaccumulation Factors [mg(ww tissue)/ kg(dw sediment)] provided separately.
	BW	BODY WEIGHT	kg	0.57	Mitchell, 1961	

References:
Mitchell, J.L., 1961. Mink movements and populations on a Montana river; J. Wildl. Manage. 25:48-54.
USEPA, 1993. Wildlife Exposure Factors Handbook; United States Environmental Protection Agency, Office of Research and Development; EPA/600/R-93/187a; December 1993; Washington, D.C.

Attachment 8

TABLE 8-38

CALCULATION OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS : White perch/American eel / MINK

Focused Feasiblity Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2048)
MEDIUM: FISH
EXPOSURE MEDIUM: White perch/American eel
EXPOSURE POINT: RME - Monitored Natural Recovery
RECEPTOR: MINK

Analyte	Medium EPC	Medium EPC Units	Estimated Daily Intake[a]	Daily Intake Units	Reference Dose (NOAEL)[b]	Reference Dose (LOAEL)[b]	Reference Dose Units	Hazard Quotient (NOAEL)[c]	Hazard Quotient (LOAEL)[c]
Copper	2.8E+00	mg/kg	6.8E-01	mg/kg-d	5.6E+00	9.3E+00	mg/kg-d	1.2E-01	7.3E-02
Lead	1.3E-01	mg/kg	3.2E-02	mg/kg-d	4.7E+00	8.9E+00	mg/kg-d	6.7E-03	3.6E-03
Methyl Mercury	5.0E-02	mg/kg	1.2E-02	mg/kg-d	5.5E-02	1.8E-01	mg/kg-d	2.2E-01	6.7E-02
LPAH	3.7E-01	mg/kg	8.9E-02	mg/kg-d	-	-			
HPAH	2.2E-01	mg/kg	5.2E-02	mg/kg-d	1.0E+00	1.0E+01	mg/kg-d	5.2E-02	5.2E-03
Dieldrin	3.2E-02	mg/kg	7.8E-03	mg/kg-d	1.5E-02	3.0E-02	mg/kg-d	5.2E-01	2.6E-01
Total DDx	1.3E-01	mg/kg	3.0E-02	mg/kg-d	8.0E-01	4.0E+00	mg/kg-d	3.8E-02	7.6E-03
Total PCBs	2.8E-01	mg/kg	6.7E-02	mg/kg-d	8.0E-02	9.6E-02	mg/kg-d	8.4E-01	7.0E-01
TEQ PCB-mammals	4.4E-06	mg/kg	1.1E-06	mg/kg-d	8.0E-08	2.2E-06	mg/kg-d	**1.3E+01**	4.7E-01
TEQ D/F-mammals	5.9E-05	mg/kg	1.4E-05	mg/kg-d	8.0E-08	2.2E-06	mg/kg-d	**1.8E+02**	**6.3E+00**
							HAZARD INDICES:	**1.9E+02**	**7.9E+00**

Notes:
a. Estimated Daily Intake (EDI) calculated using parameters presented in Table 8-37.
b. Reference Dose Values presented in Table 6-4. A dash indicates that no value is available.
c. Hazard Quotients (HQs) calculated by dividing the Estimated Daily Intake dose by either the NOAEL- or LOAEL-based Reference Dose.

Attachment 8

TABLE 8-39

SUMMARY OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS USING NOAEL-BASED TRVs : MINK

Focused Feasiblity Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2048)
EXPOSURE POINT: RME - Monitored Natural Recovery
RECEPTOR: MINK
TOTAL RISK (HI): 2.5E+02

	Exposure Medium[a]						
Analyte	Surface Water	Sediment	Aquatic Plants	Aquatic Invertebrates	Fish	Combined HQs[b]	Percent Contribution[c]
TCDD TEQ (D/F)		2.2E+01		3.4E+01	1.8E+02	***2.3E+02***	***92%***
TCDD TEQ (PCBs)		1.9E-01		4.8E+00	1.3E+01	***1.8E+01***	7%
Total PCBs		9.7E-03		2.0E-01	8.4E-01	***1.0E+00***	0%
Dieldrin		8.2E-03		5.5E-02	5.2E-01	5.8E-01	0%
Copper		7.5E-02		1.1E-01	1.2E-01	3.0E-01	0%
Mercury		5.4E-02		1.5E-02	2.2E-01	2.9E-01	0%
HPAH		5.2E-01		1.6E-02	5.2E-02	5.8E-01	0%
Lead		1.4E-01		2.0E-03	6.7E-03	1.5E-01	0%
Total DDx		5.2E-04		5.8E-03	3.8E-02	4.4E-02	0%
LPAH							
TOTAL MEDIUM-SPECIFIC RISK	**-**	**2.3E+01**	**-**	**3.9E+01**	**1.9E+02**	**2.5E+02**	
PERCENTAGE OF TOTAL RISK		**9%**		**15%**	**76%**	**100%**	

Notes:
a. Hazard Quotients presented by exposure medium; a blank cell indicates that the analyte was not a COPC for that medium; a dash entry indicates that there was no assumed exposure to that medium.
b. Combined risk across all media exposures.
c. Relative contribution of COPC to total risk associated with the ingestion exposure pathway.

Attachment 8

TABLE 8-40

SUMMARY OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS USING LOAEL-BASED TRVs : MINK

Focused Feasiblity Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2048)
EXPOSURE POINT: RME - Monitored Natural Recovery
RECEPTOR: MINK
TOTAL RISK (HI): 1.1E+01

Analyte	Exposure Medium[a]					Combined HQs[b]	Percent Contribution[c]
	Surface Water	Sediment	Aquatic Plants	Aquatic Invertebrates	Fish		
TCDD TEQ (D/F)		7.9E-01		1.2E+00	6.3E+00	***8.3E+00***	***79%***
Total PCBs		8.1E-03		1.7E-01	7.0E-01	8.7E-01	8%
TCDD TEQ (PCBs)		6.7E-03		1.7E-01	4.7E-01	6.5E-01	6%
Dieldrin		4.1E-03		2.7E-02	2.6E-01	2.9E-01	3%
Copper		4.5E-02		6.3E-02	7.3E-02	1.8E-01	2%
Mercury		1.7E-02		4.6E-03	6.7E-02	8.9E-02	1%
Lead		7.4E-02		1.0E-03	3.6E-03	7.8E-02	1%
HPAH		5.2E-02		1.6E-03	5.2E-03	5.8E-02	1%
Total DDx		1.0E-04		1.2E-03	7.6E-03	8.8E-03	0%
LPAH							
TOTAL MEDIUM-SPECIFIC RISK	**-**	**9.9E-01**	**-**	**1.6E+00**	**7.9E+00**	**1.1E+01**	
PERCENTAGE OF TOTAL RISK		**9%**		**16%**	**75%**	**100%**	

Notes:

a. Hazard Quotients presented by exposure medium; a blank cell indicates that the analyte was not a COPC for that medium; a dash entry indicates that there was no assumed exposure to that medium.

b. Combined risk across all media exposures.

c. Relative contribution of COPC to total risk associated with the ingestion exposure pathway.

TABLE 8-41
PARAMETER VALUES USED TO CALCULATE ESTIMATED DAILY INTAKE : Surficial sediment / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2018)
MEDIUM: SEDIMENT
EXPOSURE MEDIUM: Surficial sediment
EXPOSURE POINT: RME - Monitored Natural Recovery
RECEPTOR: HERON

EXPOSURE ROUTE	PARAMETER SYMBOL	PARAMETER DEFINITION	UNITS	RME VALUE	RME RATIONALE/ REFERENCE	INTAKE EQUATION/ MODEL NAME
INGESTION	EDI_{sed}	ESTIMATED DAILY INTAKE VIA SEDIMENT INGESTION	mg/kg-d	calculated		SEDIMENT INTAKE-INGESTION
	C_{sed}	CHEMICAL CONCENTRATION IN SEDIMENT	mg/kg	chemical-specific		$EDI_{sed} = C_{sed} * IR_{sed} * SFF * EF * 1/BW$
	IR_{sed}	INGESTION RATE OF SEDIMENT	kg/day	0.019	assumption	
	SFF	SITE FORAGING FREQUENCY	unitless	100%	Bayer, 1978	
	EF	EXPOSURE FREQUENCY	unitless	58%	USEPA, 1993	
	BW	BODY WEIGHT	kg	2.2	USEPA, 1993	

References:

Bayer,R.D., 1978. Aspects of an Oregon estuarine great blue heron population; In: Sprunt, A., J. Ogden, S. Winkler, eds. Wading Birds; Natl. Audubon Soc. Res. Rep. 7:213-217.

USEPA, 1993. Wildlife Exposure Factors Handbook; United States Environmental Protection Agency, Office of Research and Development; EPA/600/R-93/187a; December 1993; Washington, D.C.

TABLE 8-42
CALCULATION OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS : Surficial sediment / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2018)
MEDIUM: SEDIMENT
EXPOSURE MEDIUM: Surficial sediment
EXPOSURE POINT: RME - Monitored Natural Recovery
RECEPTOR: HERON

Analyte	Medium EPC	Medium EPC Units	Estimated Daily Intake[a]	Daily Intake Units	Reference Dose (NOAEL)[b]	Reference Dose (LOAEL)[b]	Reference Dose Units	Hazard Quotient (NOAEL)[c]	Hazard Quotient (LOAEL)[c]
Copper	1.4E+02	mg/kg	7.1E-01	mg/kg-d	4.1E+00	1.2E+01	mg/kg-d	1.8E-01	5.9E-02
Lead	2.4E+02	mg/kg	1.2E+00	mg/kg-d	1.6E+00	3.3E+00	mg/kg-d	7.4E-01	3.7E-01
Methyl Mercury	1.5E+00	mg/kg	7.9E-03	mg/kg-d	7.8E-03	7.8E-02	mg/kg-d	**1.0E+00**	1.0E-01
LPAH	3.3E+01	mg/kg	1.7E-01	mg/kg-d	-	-			
HPAH	8.6E+01	mg/kg	4.4E-01	mg/kg-d	-	-			
Dieldrin	2.0E-02	mg/kg	1.0E-04	mg/kg-d	7.1E-02	3.8E+00	mg/kg-d	1.5E-03	2.7E-05
Total DDx	2.0E-01	mg/kg	1.0E-03	mg/kg-d	2.8E-03	2.8E-02	mg/kg-d	3.6E-01	3.6E-02
Total PCBs	5.7E-01	mg/kg	2.9E-03	mg/kg-d	1.0E-01	4.0E-01	mg/kg-d	2.9E-02	7.3E-03
TEQ PCB-birds	1.7E-04	mg/kg	8.5E-07	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	6.1E-01	6.1E-02
TEQ D/F-birds	9.6E-04	mg/kg	4.9E-06	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	**3.5E+00**	3.5E-01
							HAZARD INDICES:	**6.5E+00**	9.9E-01

Notes:
a. Estimated Daily Intake (EDI) calculated using parameters presented in Table 8-41.
b. Reference Dose Values presented in Table 6-4. A dash indicates that no value is available.
c. Hazard Quotients (HQs) calculated by dividing the Estimated Daily Intake dose by either the NOAEL- or LOAEL-based Reference Dose.

TABLE 8-43
PARAMETER VALUES USED TO CALCULATE ESTIMATED DAILY INTAKE : Blue crab / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2018)
MEDIUM: AQUATIC INVERTEBRATES
EXPOSURE MEDIUM: Blue crab
EXPOSURE POINT: RME - Monitored Natural Recovery
RECEPTOR: HERON

EXPOSURE ROUTE	PARAMETER SYMBOL	PARAMETER DEFINITION	UNITS	RME VALUE	RME RATIONALE/ REFERENCE	INTAKE EQUATION/ MODEL NAME
INGESTION	EDI_{invert}	ESTIMATED DAILY INTAKE VIA INVERTEBRATE INGESTION	mg/kg-d	calculated		INVERTEBRATE INTAKE-INGESTION $EDI_{invert} = C_{invert} * IR_{food} * P_{invert} * SFF * EF * 1/BW$
	C_{invert}	CHEMICAL CONCENTRATION IN INVERTEBRATES	mg/kg	chemical-specific		
	IR_{food}	INGESTION RATE OF FOOD	kg/day	0.39	Kushlan, 1978	
	P_{invert}	PERCENT INVERTEBRATES IN DIET	unitless	15%	assumption	Where C_{invert} is estimated using site-specific tissue data or calculated using the following equation: $C_{invert} = C_{sed} * BAF_{invert}$
	SFF	SITE FORAGING FREQUENCY	unitless	100%	Bayer, 1978	
	EF	EXPOSURE FREQUENCY	unitless	58%	USEPA, 1993	Bioaccumulation Factors [mg(ww tissue)/ kg(dw sediment)] provided separately.
	BW	BODY WEIGHT	kg	2.2	USEPA, 1993	

References:

Bayer,R.D., 1978. Aspects of an Oregon estuarine great blue heron population; In: Sprunt, A., J. Ogden, S. Winkler, eds. Wading Birds; Natl. Audubon Soc. Res. Rep. 7:213-217.

Kushlan, J.A., 1978. Feeding ecology of wading birds; In: Sprunt, A., J. Ogden, S. Winkler, eds. Wading Birds; Natl. Audubon Soc. Res. Rep. 7:213-217.

USEPA, 1993. Wildlife Exposure Factors Handbook; United States Environmental Protection Agency, Office of Research and Development; EPA/600/R-93/187a; December 1993; Washington, D.C.

TABLE 8-44
CALCULATION OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS : Blue crab / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2018)
MEDIUM: AQUATIC INVERTEBRATES
EXPOSURE MEDIUM: Blue crab
EXPOSURE POINT: RME - Monitored Natural Recovery
RECEPTOR: HERON

Analyte	Medium EPC	Medium EPC Units	Estimated Daily Intake[a]	Daily Intake Units	Reference Dose (NOAEL)[b]	Reference Dose (LOAEL)[b]	Reference Dose Units	Hazard Quotient (NOAEL)[c]	Hazard Quotient (LOAEL)[c]
Copper	1.9E+01	mg/kg	3.0E-01	mg/kg-d	4.1E+00	1.2E+01	mg/kg-d	7.4E-02	2.5E-02
Lead	3.3E-01	mg/kg	5.1E-03	mg/kg-d	1.6E+00	3.3E+00	mg/kg-d	3.2E-03	1.6E-03
Methyl Mercury	4.3E-02	mg/kg	6.7E-04	mg/kg-d	7.8E-03	7.8E-02	mg/kg-d	8.6E-02	8.6E-03
LPAH	2.5E-01	mg/kg	3.8E-03	mg/kg-d	-	-			
HPAH	2.7E-01	mg/kg	4.2E-03	mg/kg-d	-	-			
Dieldrin	1.4E-02	mg/kg	2.1E-04	mg/kg-d	7.1E-02	3.8E+00	mg/kg-d	3.0E-03	5.6E-05
Total DDx	2.2E-01	mg/kg	3.4E-03	mg/kg-d	2.8E-03	2.8E-02	mg/kg-d	**1.2E+00**	1.2E-01
Total PCBs	1.2E+00	mg/kg	1.8E-02	mg/kg-d	1.0E-01	4.0E-01	mg/kg-d	1.8E-01	4.5E-02
TEQ PCB-birds	2.2E-04	mg/kg	3.3E-06	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	**2.4E+00**	2.4E-01
TEQ D/F-birds	1.6E-04	mg/kg	2.5E-06	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	**1.8E+00**	1.8E-01
							HAZARD INDICES:	**5.7E+00**	6.2E-01

Notes:
a. Estimated Daily Intake (EDI) calculated using parameters presented in Table 8-43.
b. Reference Dose Values presented in Table 6-4. A dash indicates that no value is available.
c. Hazard Quotients (HQs) calculated by dividing the Estimated Daily Intake dose by either the NOAEL- or LOAEL-based Reference Dose.

TABLE 8-45
PARAMETER VALUES USED TO CALCULATE ESTIMATED DAILY INTAKE : White perch/American eel / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2018)
MEDIUM: FISH
EXPOSURE MEDIUM: White perch/American eel
EXPOSURE POINT: RME - Monitored Natural Recovery
RECEPTOR: HERON

EXPOSURE ROUTE	PARAMETER SYMBOL	PARAMETER DEFINITION	UNITS	RME VALUE	RME RATIONALE/ REFERENCE	INTAKE EQUATION/ MODEL NAME
INGESTION	EDI_{fish}	ESTIMATED DAILY INTAKE VIA FISH INGESTION	mg/kg-d	calculated		FISH INTAKE-INGESTION
	C_{fish}	CHEMICAL CONCENTRATION IN FISH	mg/kg	chemical-specific		$EDI_{fish} = C_{fish} * IR_{food} * P_{fish} * SFF * EF * 1/BW$
	IR_{food}	INGESTION RATE OF FOOD	kg/day	0.39	Kushlan, 1978	
	P_{fish}	PERCENT FISH IN DIET	unitless	85%	assumption	Where C_{fish} is estimated using site-specific tissue data or estimated using the following equation:
	SFF	SITE FORAGING FREQUENCY	unitless	100%	Bayer, 1978	$C_{fish} = C_{sed} * BAF_{fish}$
	EF	EXPOSURE FREQUENCY	unitless	58%	USEPA, 1993	Bioaccumulation Factors [mg(ww tissue)/ kg(dw sediment)] provided separately.
	BW	BODY WEIGHT	kg	2.2	USEPA, 1993	

References:
Bayer,R.D., 1978. Aspects of an Oregon estuarine great blue heron population; In: Sprunt, A., J. Ogden, S. Winkler, eds. Wading Birds; Natl. Audubon Soc. Res. Rep. 7:213-217.
Kushlan, J.A., 1978. Feeding ecology of wading birds; In: Sprunt, A., J. Ogden, S. Winkler, eds. Wading Birds; Natl. Audubon Soc. Res. Rep. 7:213-217.
USEPA, 1993. Wildlife Exposure Factors Handbook; United States Environmental Protection Agency, Office of Research and Development; EPA/600/R-93/187a; December 1993; Washington, D.C.

TABLE 8-46
CALCULATION OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS : White perch/American eel / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2018)
MEDIUM: FISH
EXPOSURE MEDIUM: White perch/American eel
EXPOSURE POINT: RME - Monitored Natural Recovery
RECEPTOR: HERON

Analyte	Medium EPC	Medium EPC Units	Estimated Daily Intake[a]	Daily Intake Units	Reference Dose (NOAEL)[b]	Reference Dose (LOAEL)[b]	Reference Dose Units	Hazard Quotient (NOAEL)[c]	Hazard Quotient (LOAEL)[c]
Copper	5.6E+00	mg/kg	4.9E-01	mg/kg-d	4.1E+00	1.2E+01	mg/kg-d	1.2E-01	4.1E-02
Lead	2.8E-01	mg/kg	2.5E-02	mg/kg-d	1.6E+00	3.3E+00	mg/kg-d	1.5E-02	7.6E-03
Methyl Mercury	1.6E-01	mg/kg	1.4E-02	mg/kg-d	7.8E-03	7.8E-02	mg/kg-d	**1.8E+00**	1.8E-01
LPAH	3.7E-01	mg/kg	3.2E-02	mg/kg-d	-	-			
HPAH	2.2E-01	mg/kg	1.9E-02	mg/kg-d	-	-			
Dieldrin	3.2E-02	mg/kg	2.8E-03	mg/kg-d	7.1E-02	3.8E+00	mg/kg-d	4.0E-02	7.4E-04
Total DDx	3.6E-01	mg/kg	3.1E-02	mg/kg-d	2.8E-03	2.8E-02	mg/kg-d	**1.1E+01**	**1.1E+00**
Total PCBs	1.2E+00	mg/kg	1.1E-01	mg/kg-d	1.0E-01	4.0E-01	mg/kg-d	**1.1E+00**	2.7E-01
TEQ PCB-birds	1.8E-04	mg/kg	1.6E-05	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	**1.1E+01**	**1.1E+00**
TEQ D/F-birds	1.9E-04	mg/kg	1.7E-05	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	**1.2E+01**	**1.2E+00**
							HAZARD INDICES:	**3.7E+01**	**3.9E+00**

Notes:
a. Estimated Daily Intake (EDI) calculated using parameters presented in Table 8-45.
b. Reference Dose Values presented in Table 6-4. A dash indicates that no value is available.
c. Hazard Quotients (HQs) calculated by dividing the Estimated Daily Intake dose by either the NOAEL- or LOAEL-based Reference Dose.

TABLE 8-47
SUMMARY OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS USING NOAEL-BASED TRVs : HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2018)
EXPOSURE POINT: RME - Monitored Natural Recovery
RECEPTOR: HERON
TOTAL RISK (HI): 5.0E+01

	Exposure Medium[a]						
Analyte	Surface Water	Sediment	Aquatic Plants	Aquatic Invertebrates	Fish	Combined HQs[b]	Percent Contribution[c]
TCDD TEQ (D/F)		3.5E+00		1.8E+00	1.2E+01	***1.7E+01***	***35%***
Total DDx		3.6E-01		1.2E+00	1.1E+01	***1.3E+01***	***26%***
Total PCBs		2.9E-02		1.8E-01	1.1E+00	***1.3E+00***	3%
Mercury		1.0E+00	-	8.6E-02	1.8E+00	***2.9E+00***	6%
TCDD TEQ (PCBs)		6.1E-01		2.4E+00	1.1E+01	***1.4E+01***	***28%***
Lead		7.4E-01	-	3.2E-03	1.5E-02	7.6E-01	2%
Copper		1.8E-01	-	7.4E-02	1.2E-01	3.7E-01	1%
Dieldrin		1.5E-03	-	3.0E-03	4.0E-02	4.4E-02	0%
LPAH							
HPAH							
TOTAL MEDIUM-SPECIFIC RISK	**-**	**6.5E+00**	**-**	**5.7E+00**	**3.7E+01**	**5.0E+01**	
PERCENTAGE OF TOTAL RISK		**13%**		**12%**	**75%**	**100%**	

Notes:
a. Hazard Quotients presented by exposure medium; a blank cell indicates that the analyte was not a COPC for that medium; a dash entry indicates that there was no assumed exposure to that medium.
b. Combined risk across all media exposures.
c. Relative contribution of COPC to total risk associated with the ingestion exposure pathway.

TABLE 8-48
SUMMARY OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS USING LOAEL-BASED TRVs : HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2018)
EXPOSURE POINT: RME - Monitored Natural Recovery
RECEPTOR: HERON
TOTAL RISK (HI): 5.5E+00

Analyte	Exposure Medium[a]					Combined HQs[b]	Percent Contribution[c]
	Surface Water	Sediment	Aquatic Plants	Aquatic Invertebrates	Fish		
TCDD TEQ (D/F)		3.5E-01		1.8E-01	1.2E+00	***1.7E+00***	***31%***
Total DDx		3.6E-02		1.2E-01	1.1E+00	***1.3E+00***	***23%***
Total PCBs		7.3E-03		4.5E-02	2.7E-01	3.2E-01	6%
Lead		3.7E-01	-	1.6E-03	7.6E-03	3.8E-01	7%
Mercury		1.0E-01	-	8.6E-03	1.8E-01	2.9E-01	5%
Copper		5.9E-02	-	2.5E-02	4.1E-02	1.2E-01	2%
TCDD TEQ (PCBs)		6.1E-02		2.4E-01	1.1E+00	***1.4E+00***	***26%***
Dieldrin		2.7E-05	-	5.6E-05	7.4E-04	8.3E-04	0%
LPAH							
HPAH							
TOTAL MEDIUM-SPECIFIC RISK	**-**	**9.9E-01**	**-**	**6.2E-01**	**3.9E+00**	**5.5E+00**	
PERCENTAGE OF TOTAL RISK		**18%**		**11%**	**71%**	**100%**	

Notes:
a. Hazard Quotients presented by exposure medium; a blank cell indicates that the analyte was not a COPC for that medium; a dash entry indicates that there was no assumed exposure to that medium.
b. Combined risk across all media exposures.
c. Relative contribution of COPC to total risk associated with the ingestion exposure pathway.

TABLE 8-49
PARAMETER VALUES USED TO CALCULATE ESTIMATED DAILY INTAKE : Surficial sediment / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2048)
MEDIUM: SEDIMENT
EXPOSURE MEDIUM: Surficial sediment
EXPOSURE POINT: RME - Monitored Natural Recovery
RECEPTOR: HERON

EXPOSURE ROUTE	PARAMETER SYMBOL	PARAMETER DEFINITION	UNITS	RME VALUE	RME RATIONALE/ REFERENCE	INTAKE EQUATION/ MODEL NAME
INGESTION	EDI_{sed}	ESTIMATED DAILY INTAKE VIA SEDIMENT INGESTION	mg/kg-d	calculated		SEDIMENT INTAKE-INGESTION
	C_{sed}	CHEMICAL CONCENTRATION IN SEDIMENT	mg/kg	chemical-specific		$EDI_{sed} = C_{sed} * IR_{sed} * SFF * EF * 1/BW$
	IR_{sed}	INGESTION RATE OF SEDIMENT	kg/day	0.019	assumption	
	SFF	SITE FORAGING FREQUENCY	unitless	100%	Bayer, 1978	
	EF	EXPOSURE FREQUENCY	unitless	58%	USEPA, 1993	
	BW	BODY WEIGHT	kg	2.2	USEPA, 1993	

References:

Bayer,R.D., 1978. Aspects of an Oregon estuarine great blue heron population; In: Sprunt, A., J. Ogden, S. Winkler, eds. Wading Birds; Natl. Audubon Soc. Res. Rep. 7:213-217.

USEPA, 1993. Wildlife Exposure Factors Handbook; United States Environmental Protection Agency, Office of Research and Development; EPA/600/R-93/187a; December 1993; Washington, D.C.

TABLE 8-50
CALCULATION OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS : Surficial sediment / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2048)
MEDIUM: SEDIMENT
EXPOSURE MEDIUM: Surficial sediment
EXPOSURE POINT: RME - Monitored Natural Recovery
RECEPTOR: HERON

Analyte	Medium EPC	Medium EPC Units	Estimated Daily Intake[a]	Daily Intake Units	Reference Dose (NOAEL)[b]	Reference Dose (LOAEL)[b]	Reference Dose Units	Hazard Quotient (NOAEL)[c]	Hazard Quotient (LOAEL)[c]
Copper	7.0E+01	mg/kg	3.6E-01	mg/kg-d	4.1E+00	1.2E+01	mg/kg-d	8.9E-02	3.0E-02
Lead	1.1E+02	mg/kg	5.6E-01	mg/kg-d	1.6E+00	3.3E+00	mg/kg-d	3.4E-01	1.7E-01
Methyl Mercury	5.0E-01	mg/kg	2.5E-03	mg/kg-d	7.8E-03	7.8E-02	mg/kg-d	3.3E-01	3.3E-02
LPAH	3.3E+01	mg/kg	1.7E-01	mg/kg-d	-	-			
HPAH	8.6E+01	mg/kg	4.4E-01	mg/kg-d	-	-			
Dieldrin	2.0E-02	mg/kg	1.0E-04	mg/kg-d	7.1E-02	3.8E+00	mg/kg-d	1.5E-03	2.7E-05
Total DDx	6.9E-02	mg/kg	3.6E-04	mg/kg-d	2.8E-03	2.8E-02	mg/kg-d	1.3E-01	1.3E-02
Total PCBs	1.3E-01	mg/kg	6.6E-04	mg/kg-d	1.0E-01	4.0E-01	mg/kg-d	6.6E-03	1.7E-03
TEQ PCB-birds	4.2E-05	mg/kg	2.2E-07	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	1.5E-01	1.5E-02
TEQ D/F-birds	3.0E-04	mg/kg	1.5E-06	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	**1.1E+00**	1.1E-01
							HAZARD INDICES:	**2.2E+00**	3.7E-01

Notes:
a. Estimated Daily Intake (EDI) calculated using parameters presented in Table 8-49.
b. Reference Dose Values presented in Table 6-4. A dash indicates that no value is available.
c. Hazard Quotients (HQs) calculated by dividing the Estimated Daily Intake dose by either the NOAEL- or LOAEL-based Reference Dose.

TABLE 8-51
PARAMETER VALUES USED TO CALCULATE ESTIMATED DAILY INTAKE : Blue crab / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2048)
MEDIUM: AQUATIC INVERTEBRATES
EXPOSURE MEDIUM: Blue crab
EXPOSURE POINT: RME - Monitored Natural Recovery
RECEPTOR: HERON

EXPOSURE ROUTE	PARAMETER SYMBOL	PARAMETER DEFINITION	UNITS	RME VALUE	RME RATIONALE/ REFERENCE	INTAKE EQUATION/ MODEL NAME
INGESTION	EDI_{invert}	ESTIMATED DAILY INTAKE VIA INVERTEBRATE INGESTION	mg/kg-d	calculated		INVERTEBRATE INTAKE-INGESTION $EDI_{invert} = C_{invert} * IR_{food} * P_{invert} * SFF * EF * 1/BW$
	C_{invert}	CHEMICAL CONCENTRATION IN INVERTEBRATES	mg/kg	chemical-specific		
	IR_{food}	INGESTION RATE OF FOOD	kg/day	0.39	Kushlan, 1978	
	P_{invert}	PERCENT INVERTEBRATES IN DIET	unitless	15%	assumption	Where C_{invert} is estimated using site-specific tissue data or calculated using the following equation: $C_{invert} = C_{sed} * BAF_{invert}$
	SFF	SITE FORAGING FREQUENCY	unitless	100%	Bayer, 1978	
	EF	EXPOSURE FREQUENCY	unitless	58%	USEPA, 1993	Bioaccumulation Factors [mg(ww tissue)/ kg(dw sediment)] provided separately.
	BW	BODY WEIGHT	kg	2.2	USEPA, 1993	

References:

Bayer,R.D., 1978. Aspects of an Oregon estuarine great blue heron population; In: Sprunt, A., J. Ogden, S. Winkler, eds. Wading Birds; Natl. Audubon Soc. Res. Rep. 7:213-217.

Kushlan, J.A., 1978. Feeding ecology of wading birds; In: Sprunt, A., J. Ogden, S. Winkler, eds. Wading Birds; Natl. Audubon Soc. Res. Rep. 7:213-217.

USEPA, 1993. Wildlife Exposure Factors Handbook; United States Environmental Protection Agency, Office of Research and Development; EPA/600/R-93/187a; December 1993; Washington, D.C.

TABLE 8-52
CALCULATION OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS : Blue crab / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2048)
MEDIUM: AQUATIC INVERTEBRATES
EXPOSURE MEDIUM: Blue crab
EXPOSURE POINT: RME - Monitored Natural Recovery
RECEPTOR: HERON

Analyte	Medium EPC	Medium EPC Units	Estimated Daily Intake[a]	Daily Intake Units	Reference Dose (NOAEL)[b]	Reference Dose (LOAEL)[b]	Reference Dose Units	Hazard Quotient (NOAEL)[c]	Hazard Quotient (LOAEL)[c]
Copper	9.8E+00	mg/kg	1.5E-01	mg/kg-d	4.1E+00	1.2E+01	mg/kg-d	3.7E-02	1.2E-02
Lead	1.5E-01	mg/kg	2.4E-03	mg/kg-d	1.6E+00	3.3E+00	mg/kg-d	1.5E-03	7.3E-04
Methyl Mercury	1.4E-02	mg/kg	2.1E-04	mg/kg-d	7.8E-03	7.8E-02	mg/kg-d	2.7E-02	2.7E-03
LPAH	2.5E-01	mg/kg	3.8E-03	mg/kg-d	-	-			
HPAH	2.7E-01	mg/kg	4.2E-03	mg/kg-d	-	-			
Dieldrin	1.4E-02	mg/kg	2.1E-04	mg/kg-d	7.1E-02	3.8E+00	mg/kg-d	3.0E-03	5.6E-05
Total DDx	7.7E-02	mg/kg	1.2E-03	mg/kg-d	2.8E-03	2.8E-02	mg/kg-d	4.3E-01	4.3E-02
Total PCBs	2.6E-01	mg/kg	4.1E-03	mg/kg-d	1.0E-01	4.0E-01	mg/kg-d	4.1E-02	1.0E-02
TEQ PCB-birds	5.5E-05	mg/kg	8.5E-07	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	6.0E-01	6.0E-02
TEQ D/F-birds	5.1E-05	mg/kg	7.9E-07	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	5.6E-01	5.6E-02
							HAZARD INDICES:	**1.7E+00**	1.9E-01

Notes:
a. Estimated Daily Intake (EDI) calculated using parameters presented in Table 8-51.
b. Reference Dose Values presented in Table 6-4. A dash indicates that no value is available.
c. Hazard Quotients (HQs) calculated by dividing the Estimated Daily Intake dose by either the NOAEL- or LOAEL-based Reference Dose.

TABLE 8-53
PARAMETER VALUES USED TO CALCULATE ESTIMATED DAILY INTAKE : White perch/American eel / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2048)
MEDIUM: FISH
EXPOSURE MEDIUM: White perch/American eel
EXPOSURE POINT: RME - Monitored Natural Recovery
RECEPTOR: HERON

EXPOSURE ROUTE	PARAMETER SYMBOL	PARAMETER DEFINITION	UNITS	RME VALUE	RME RATIONALE/ REFERENCE	INTAKE EQUATION/ MODEL NAME
INGESTION	EDI_{fish}	ESTIMATED DAILY INTAKE VIA FISH INGESTION	mg/kg-d	calculated		FISH INTAKE-INGESTION
	C_{fish}	CHEMICAL CONCENTRATION IN FISH	mg/kg	chemical-specific		$EDI_{fish} = C_{fish} * IR_{food} * P_{fish} * SFF * EF * 1/BW$
	IR_{food}	INGESTION RATE OF FOOD	kg/day	0.39	Kushlan, 1978	
	P_{fish}	PERCENT FISH IN DIET	unitless	85%	assumption	Where C_{fish} is estimated using site-specific tissue data or estimated using the following equation:
	SFF	SITE FORAGING FREQUENCY	unitless	100%	Bayer, 1978	$C_{fish} = C_{sed} * BAF_{fish}$
	EF	EXPOSURE FREQUENCY	unitless	58%	USEPA, 1993	Bioaccumulation Factors [mg(ww tissue)/ kg(dw sediment)] provided separately.
	BW	BODY WEIGHT	kg	2.2	USEPA, 1993	

References:
Bayer,R.D., 1978. Aspects of an Oregon estuarine great blue heron population; In: Sprunt, A., J. Ogden, S. Winkler, eds. Wading Birds; Natl. Audubon Soc. Res. Rep. 7:213-217.
Kushlan, J.A., 1978. Feeding ecology of wading birds; In: Sprunt, A., J. Ogden, S. Winkler, eds. Wading Birds; Natl. Audubon Soc. Res. Rep. 7:213-217.
USEPA, 1993. Wildlife Exposure Factors Handbook; United States Environmental Protection Agency, Office of Research and Development; EPA/600/R-93/187a; December 1993; Washington, D.C.

TABLE 8-54
CALCULATION OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS : White perch/American eel / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2048)
MEDIUM: FISH
EXPOSURE MEDIUM: White perch/American eel
EXPOSURE POINT: RME - Monitored Natural Recovery
RECEPTOR: HERON

Analyte	Medium EPC	Medium EPC Units	Estimated Daily Intake[a]	Daily Intake Units	Reference Dose (NOAEL)[b]	Reference Dose (LOAEL)[b]	Reference Dose Units	Hazard Quotient (NOAEL)[c]	Hazard Quotient (LOAEL)[c]
Copper	2.8E+00	mg/kg	2.5E-01	mg/kg-d	4.1E+00	1.2E+01	mg/kg-d	6.1E-02	2.1E-02
Lead	1.3E-01	mg/kg	1.1E-02	mg/kg-d	1.6E+00	3.3E+00	mg/kg-d	7.1E-03	3.5E-03
Methyl Mercury	5.0E-02	mg/kg	4.4E-03	mg/kg-d	7.8E-03	7.8E-02	mg/kg-d	5.6E-01	5.6E-02
LPAH	3.7E-01	mg/kg	3.2E-02	mg/kg-d	-	-			
HPAH	2.2E-01	mg/kg	1.9E-02	mg/kg-d	-	-			
Dieldrin	3.2E-02	mg/kg	2.8E-03	mg/kg-d	7.1E-02	3.8E+00	mg/kg-d	4.0E-02	7.4E-04
Total DDx	1.3E-01	mg/kg	1.1E-02	mg/kg-d	2.8E-03	2.8E-02	mg/kg-d	**3.9E+00**	3.9E-01
Total PCBs	2.8E-01	mg/kg	2.4E-02	mg/kg-d	1.0E-01	4.0E-01	mg/kg-d	2.4E-01	6.1E-02
TEQ PCB-birds	4.5E-05	mg/kg	4.0E-06	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	**2.8E+00**	2.8E-01
TEQ D/F-birds	6.0E-05	mg/kg	5.3E-06	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	**3.8E+00**	3.8E-01
							HAZARD INDICES:	**1.1E+01**	**1.2E+00**

Notes:
a. Estimated Daily Intake (EDI) calculated using parameters presented in Table 8-53.
b. Reference Dose Values presented in Table 6-4. A dash indicates that no value is available.
c. Hazard Quotients (HQs) calculated by dividing the Estimated Daily Intake dose by either the NOAEL- or LOAEL-based Reference Dose.

TABLE 8-55
SUMMARY OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS USING NOAEL-BASED TRVs : HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2048)
EXPOSURE POINT: RME - Monitored Natural Recovery
RECEPTOR: HERON
TOTAL RISK (HI): 1.5E+01

	Exposure Medium[a]						
Analyte	Surface Water	Sediment	Aquatic Plants	Aquatic Invertebrates	Fish	Combined HQs[b]	Percent Contribution[c]
TCDD TEQ (D/F)		1.1E+00		5.6E-01	3.8E+00	***5.4E+00***	***36%***
Total DDx		1.3E-01		4.3E-01	3.9E+00	***4.5E+00***	***29%***
Mercury		3.3E-01	-	2.7E-02	5.6E-01	9.2E-01	6%
Total PCBs		6.6E-03		4.1E-02	2.4E-01	2.9E-01	2%
Lead		3.4E-01	-	1.5E-03	7.1E-03	3.5E-01	2%
TCDD TEQ (PCBs)		1.5E-01		6.0E-01	2.8E+00	***3.6E+00***	***23%***
Copper		8.9E-02	-	3.7E-02	6.1E-02	1.9E-01	1%
Dieldrin		1.5E-03	-	3.0E-03	4.0E-02	4.4E-02	0%
LPAH							
HPAH							
TOTAL MEDIUM-SPECIFIC RISK	**-**	**2.2E+00**	**-**	**1.7E+00**	**1.1E+01**	**1.5E+01**	
PERCENTAGE OF TOTAL RISK		**14%**		**11%**	**75%**	**100%**	

Notes:
a. Hazard Quotients presented by exposure medium; a blank cell indicates that the analyte was not a COPC for that medium; a dash entry indicates that there was no assumed exposure to that medium.
b. Combined risk across all media exposures.
c. Relative contribution of COPC to total risk associated with the ingestion exposure pathway.

TABLE 8-56
SUMMARY OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS USING LOAEL-BASED TRVs : HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2048)
EXPOSURE POINT: RME - Monitored Natural Recovery
RECEPTOR: HERON
TOTAL RISK (HI): 1.8E+00

Analyte	Exposure Medium[a]					Combined HQs[b]	Percent Contribution[c]
	Surface Water	Sediment	Aquatic Plants	Aquatic Invertebrates	Fish		
TCDD TEQ (D/F)		1.1E-01		5.6E-02	3.8E-01	5.4E-01	***31%***
Total DDx		1.3E-02		4.3E-02	3.9E-01	4.5E-01	***26%***
Total PCBs		1.7E-03		1.0E-02	6.1E-02	7.3E-02	4%
Lead		1.7E-01	-	7.3E-04	3.5E-03	1.8E-01	***10%***
Mercury		3.3E-02	-	2.7E-03	5.6E-02	9.2E-02	5%
Copper		3.0E-02	-	1.2E-02	2.1E-02	6.3E-02	4%
TCDD TEQ (PCBs)		1.5E-02		6.0E-02	2.8E-01	3.6E-01	***20%***
Dieldrin		2.7E-05	-	5.6E-05	7.4E-04	8.3E-04	0%
LPAH							
HPAH							
TOTAL MEDIUM-SPECIFIC RISK	**-**	**3.7E-01**	**-**	**1.9E-01**	**1.2E+00**	**1.8E+00**	
PERCENTAGE OF TOTAL RISK		**21%**		**11%**	**68%**	**100%**	

Notes:
a. Hazard Quotients presented by exposure medium; a blank cell indicates that the analyte was not a COPC for that medium; a dash entry indicates that there was no assumed exposure to that medium.
b. Combined risk across all media exposures.
c. Relative contribution of COPC to total risk associated with the ingestion exposure pathway.

Attachment 8

TABLE 8-57

PARAMETER VALUES USED TO CALCULATE ESTIMATED DAILY INTAKE : Surficial sediment / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2018)
MEDIUM: SEDIMENT
EXPOSURE MEDIUM: Surficial sediment
EXPOSURE POINT: RME - Monitored Natural Recovery
RECEPTOR: HERON

EXPOSURE ROUTE	PARAMETER SYMBOL	PARAMETER DEFINITION	UNITS	RME VALUE	RME RATIONALE/ REFERENCE	INTAKE EQUATION/ MODEL NAME
INGESTION	EDI_{sed}	ESTIMATED DAILY INTAKE VIA SEDIMENT INGESTION	mg/kg-d	calculated		SEDIMENT INTAKE-INGESTION
	C_{sed}	CHEMICAL CONCENTRATION IN SEDIMENT	mg/kg	chemical-specific		$EDI_{sed} = C_{sed} * IR_{sed} * SFF * EF * 1/BW$
	IR_{sed}	INGESTION RATE OF SEDIMENT	kg/day	0.019	assumption	
	SFF	SITE FORAGING FREQUENCY	unitless	100%	Bayer, 1978	
	EF	EXPOSURE FREQUENCY	unitless	58%	USEPA, 1993	
	BW	BODY WEIGHT	kg	2.2	USEPA, 1993	

References:

Bayer,R.D., 1978. Aspects of an Oregon estuarine great blue heron population; In: Sprunt, A., J. Ogden, S. Winkler, eds. Wading Birds; Natl. Audubon Soc. Res. Rep. 7:213-217.

USEPA, 1993. Wildlife Exposure Factors Handbook; United States Environmental Protection Agency, Office of Research and Development; EPA/600/R-93/187a; December 1993; Washington, D.C.

Attachment 8

TABLE 8-58

CALCULATION OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS : Surficial sediment / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2018)
MEDIUM: SEDIMENT
EXPOSURE MEDIUM: Surficial sediment
EXPOSURE POINT: RME - Monitored Natural Recovery
RECEPTOR: HERON

Analyte	Medium EPC	Medium EPC Units	Estimated Daily Intake[a]	Daily Intake Units	Reference Dose (NOAEL)[b]	Reference Dose (LOAEL)[b]	Reference Dose Units	Hazard Quotient (NOAEL)[c]	Hazard Quotient (LOAEL)[c]
Copper	1.4E+02	mg/kg	7.1E-01	mg/kg-d	4.1E+00	1.2E+01	mg/kg-d	1.8E-01	5.9E-02
Lead	2.4E+02	mg/kg	1.2E+00	mg/kg-d	1.6E+00	3.3E+00	mg/kg-d	7.4E-01	3.7E-01
Methyl Mercury	1.5E+00	mg/kg	7.9E-03	mg/kg-d	7.8E-03	7.8E-02	mg/kg-d	**1.0E+00**	1.0E-01
LPAH	3.3E+01	mg/kg	1.7E-01	mg/kg-d	-	-			
HPAH	8.6E+01	mg/kg	4.4E-01	mg/kg-d	-	-			
Dieldrin	2.0E-02	mg/kg	1.0E-04	mg/kg-d	7.1E-02	3.8E+00	mg/kg-d	1.5E-03	2.7E-05
Total DDx	2.0E-01	mg/kg	1.0E-03	mg/kg-d	2.8E-03	2.8E-02	mg/kg-d	3.6E-01	3.6E-02
Total PCBs	5.7E-01	mg/kg	2.9E-03	mg/kg-d	1.0E-01	4.0E-01	mg/kg-d	2.9E-02	7.3E-03
TEQ PCB-birds	1.7E-04	mg/kg	8.5E-07	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	6.1E-01	6.1E-02
TEQ D/F-birds	9.6E-04	mg/kg	4.9E-06	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	**3.5E+00**	3.5E-01
							HAZARD INDICES:	**6.5E+00**	9.9E-01

Notes:
a. Estimated Daily Intake (EDI) calculated using parameters presented in Table 8-57.
b. Reference Dose Values presented in Table 6-4. A dash indicates that no value is available.
c. Hazard Quotients (HQs) calculated by dividing the Estimated Daily Intake dose by either the NOAEL- or LOAEL-based Reference Dose.

Attachment 8

TABLE 8-59

PARAMETER VALUES USED TO CALCULATE ESTIMATED DAILY INTAKE : Blue crab / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2018)
MEDIUM: AQUATIC INVERTEBRATES
EXPOSURE MEDIUM: Blue crab
EXPOSURE POINT: RME - Monitored Natural Recovery
RECEPTOR: HERON

EXPOSURE ROUTE	PARAMETER SYMBOL	PARAMETER DEFINITION	UNITS	RME VALUE	RME RATIONALE/ REFERENCE	INTAKE EQUATION/ MODEL NAME
INGESTION	EDI_{invert}	ESTIMATED DAILY INTAKE VIA INVERTEBRATE INGESTION	mg/kg-d	calculated		INVERTEBRATE INTAKE-INGESTION $EDI_{invert} = C_{invert} * IR_{food} * P_{invert} * SFF * EF * 1/BW$
	C_{invert}	CHEMICAL CONCENTRATION IN INVERTEBRATES	mg/kg	chemical-specific		
	IR_{food}	INGESTION RATE OF FOOD	kg/day	0.39	Kushlan, 1978	
	P_{invert}	PERCENT INVERTEBRATES IN DIET	unitless	15%	assumption	Where C_{invert} is estimated using site-specific tissue data or calculated using the following equation: $C_{invert} = C_{sed} * BAF_{invert}$
	SFF	SITE FORAGING FREQUENCY	unitless	100%	Bayer, 1978	
	EF	EXPOSURE FREQUENCY	unitless	58%	USEPA, 1993	Bioaccumulation Factors [mg(ww tissue)/ kg(dw sediment)] provided separately.
	BW	BODY WEIGHT	kg	2.2	USEPA, 1993	

References:

Bayer,R.D., 1978. Aspects of an Oregon estuarine great blue heron population; In: Sprunt, A., J. Ogden, S. Winkler, eds. Wading Birds; Natl. Audubon Soc. Res. Rep. 7:213-217.

Kushlan, J.A., 1978. Feeding ecology of wading birds; In: Sprunt, A., J. Ogden, S. Winkler, eds. Wading Birds; Natl. Audubon Soc. Res. Rep. 7:213-217.

USEPA, 1993. Wildlife Exposure Factors Handbook; United States Environmental Protection Agency, Office of Research and Development; EPA/600/R-93/187a; December 1993; Washington, D.C.

R2-0009829

Attachment 8

TABLE 8-60

CALCULATION OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS : Blue crab / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2018)
MEDIUM: AQUATIC INVERTEBRATES
EXPOSURE MEDIUM: Blue crab
EXPOSURE POINT: RME - Monitored Natural Recovery
RECEPTOR: HERON

Analyte	Medium EPC	Medium EPC Units	Estimated Daily Intake[a]	Daily Intake Units	Reference Dose (NOAEL)[b]	Reference Dose (LOAEL)[b]	Reference Dose Units	Hazard Quotient (NOAEL)[c]	Hazard Quotient (LOAEL)[c]
Copper	1.9E+01	mg/kg	3.0E-01	mg/kg-d	4.1E+00	1.2E+01	mg/kg-d	7.4E-02	2.5E-02
Lead	3.3E-01	mg/kg	5.1E-03	mg/kg-d	1.6E+00	3.3E+00	mg/kg-d	3.2E-03	1.6E-03
Methyl Mercury	4.3E-02	mg/kg	6.7E-04	mg/kg-d	7.8E-03	7.8E-02	mg/kg-d	8.6E-02	8.6E-03
LPAH	2.5E-01	mg/kg	3.8E-03	mg/kg-d	-	-			
HPAH	2.7E-01	mg/kg	4.2E-03	mg/kg-d	-	-			
Dieldrin	1.4E-02	mg/kg	2.1E-04	mg/kg-d	7.1E-02	3.8E+00	mg/kg-d	3.0E-03	5.6E-05
Total DDx	2.2E-01	mg/kg	3.4E-03	mg/kg-d	2.8E-03	2.8E-02	mg/kg-d	**1.2E+00**	1.2E-01
Total PCBs	1.2E+00	mg/kg	1.8E-02	mg/kg-d	1.0E-01	4.0E-01	mg/kg-d	1.8E-01	4.5E-02
TEQ PCB-birds	2.2E-04	mg/kg	3.3E-06	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	**2.4E+00**	2.4E-01
TEQ D/F-birds	1.6E-04	mg/kg	2.5E-06	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	**1.8E+00**	1.8E-01
							HAZARD INDICES:	**5.7E+00**	6.2E-01

Notes:
a. Estimated Daily Intake (EDI) calculated using parameters presented in Table 8-59.
b. Reference Dose Values presented in Table 6-4. A dash indicates that no value is available.
c. Hazard Quotients (HQs) calculated by dividing the Estimated Daily Intake dose by either the NOAEL- or LOAEL-based Reference Dose.

Attachment 8

TABLE 8-61

PARAMETER VALUES USED TO CALCULATE ESTIMATED DAILY INTAKE : Mummichog / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2018)
MEDIUM: FISH
EXPOSURE MEDIUM: Mummichog
EXPOSURE POINT: RME - Monitored Natural Recovery
RECEPTOR: HERON

EXPOSURE ROUTE	PARAMETER SYMBOL	PARAMETER DEFINITION	UNITS	RME VALUE	RME RATIONALE/ REFERENCE	INTAKE EQUATION/ MODEL NAME
INGESTION	EDI_{fish}	ESTIMATED DAILY INTAKE VIA FISH INGESTION	mg/kg-d	calculated		FISH INTAKE-INGESTION
	C_{fish}	CHEMICAL CONCENTRATION IN FISH	mg/kg	chemical-specific		$EDI_{fish} = C_{fish} * IR_{food} * P_{fish} * SFF * EF * 1/BW$
	IR_{food}	INGESTION RATE OF FOOD	kg/day	0.39	Kushlan, 1978	
	P_{fish}	PERCENT FISH IN DIET	unitless	85%	assumption	Where C_{fish} is estimated using site-specific tissue data or estimated using the following equation:
	SFF	SITE FORAGING FREQUENCY	unitless	100%	Bayer, 1978	$C_{fish} = C_{sed} * BAF_{fish}$
	EF	EXPOSURE FREQUENCY	unitless	58%	USEPA, 1993	Bioaccumulation Factors [mg(ww tissue)/ kg(dw sediment)] provided separately.
	BW	BODY WEIGHT	kg	2.2	USEPA, 1993	

References:

Bayer,R.D., 1978. Aspects of an Oregon estuarine great blue heron population; In: Sprunt, A., J. Ogden, S. Winkler, eds. Wading Birds; Natl. Audubon Soc. Res. Rep. 7:213-217.

Kushlan, J.A., 1978. Feeding ecology of wading birds; In: Sprunt, A., J. Ogden, S. Winkler, eds. Wading Birds; Natl. Audubon Soc. Res. Rep. 7:213-217.

USEPA, 1993. Wildlife Exposure Factors Handbook; United States Environmental Protection Agency, Office of Research and Development; EPA/600/R-93/187a; December 1993; Washington, D.C.

Attachment 8

TABLE 8-62

CALCULATION OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS : Mummichog / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2018)
MEDIUM: FISH
EXPOSURE MEDIUM: Mummichog
EXPOSURE POINT: RME - Monitored Natural Recovery
RECEPTOR: HERON

Analyte	Medium EPC	Medium EPC Units	Estimated Daily Intake[a]	Daily Intake Units	Reference Dose (NOAEL)[b]	Reference Dose (LOAEL)[b]	Reference Dose Units	Hazard Quotient (NOAEL)[c]	Hazard Quotient (LOAEL)[c]
Copper	2.3E+00	mg/kg	2.0E-01	mg/kg-d	4.1E+00	1.2E+01	mg/kg-d	5.0E-02	1.7E-02
Lead	5.1E-01	mg/kg	4.4E-02	mg/kg-d	1.6E+00	3.3E+00	mg/kg-d	2.7E-02	1.4E-02
Methyl Mercury	1.9E-02	mg/kg	1.7E-03	mg/kg-d	7.8E-03	7.8E-02	mg/kg-d	2.1E-01	2.1E-02
LPAH	3.1E-01	mg/kg	2.7E-02	mg/kg-d	-	-			
HPAH	1.5E-01	mg/kg	1.3E-02	mg/kg-d	-	-			
Dieldrin	4.5E-03	mg/kg	4.0E-04	mg/kg-d	7.1E-02	3.8E+00	mg/kg-d	5.6E-03	1.0E-04
Total DDx	6.2E-02	mg/kg	5.5E-03	mg/kg-d	2.8E-03	2.8E-02	mg/kg-d	**2.0E+00**	2.0E-01
Total PCBs	2.9E-01	mg/kg	2.5E-02	mg/kg-d	1.0E-01	4.0E-01	mg/kg-d	2.5E-01	6.3E-02
TEQ PCB-birds	4.8E-05	mg/kg	4.2E-06	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	**3.0E+00**	3.0E-01
TEQ D/F-birds	8.9E-05	mg/kg	7.8E-06	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	**5.6E+00**	5.6E-01
							HAZARD INDICES:	**1.1E+01**	**1.2E+00**

Notes:
a. Estimated Daily Intake (EDI) calculated using parameters presented in Table 8-61.
b. Reference Dose Values presented in Table 6-4. A dash indicates that no value is available.
c. Hazard Quotients (HQs) calculated by dividing the Estimated Daily Intake dose by either the NOAEL- or LOAEL-based Reference Dose.

Attachment 8

TABLE 8-63

SUMMARY OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS USING NOAEL-BASED TRVs : HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2018)
EXPOSURE POINT: RME - Monitored Natural Recovery
RECEPTOR: HERON
TOTAL RISK (HI): 2.3E+01

Analyte	Exposure Medium[a]					Combined HQs[b]	Percent Contribution[c]
	Surface Water	Sediment	Aquatic Plants	Aquatic Invertebrates	Fish		
TCDD TEQ (D/F)		3.5E+00		1.8E+00	5.6E+00	***1.1E+01***	***47%***
Total DDx		3.6E-01		1.2E+00	2.0E+00	***3.5E+00***	***15%***
Mercury		1.0E+00		8.6E-02	2.1E-01	***1.3E+00***	6%
Total PCBs		2.9E-02		1.8E-01	2.5E-01	4.6E-01	2%
Lead		7.4E-01		3.2E-03	2.7E-02	7.7E-01	3%
TCDD TEQ (PCBs)		6.1E-01		2.4E+00	3.0E+00	***6.0E+00***	***26%***
Copper		1.8E-01		7.4E-02	5.0E-02	3.0E-01	1%
Dieldrin		1.5E-03		3.0E-03	5.6E-03	1.0E-02	0%
LPAH							
HPAH							
TOTAL MEDIUM-SPECIFIC RISK	**-**	**6.5E+00**	**-**	**5.7E+00**	**1.1E+01**	**2.3E+01**	
PERCENTAGE OF TOTAL RISK		**28%**		**25%**	**48%**	**100%**	

Notes:

a. Hazard Quotients presented by exposure medium; a blank cell indicates that the analyte was not a COPC for that medium; a dash entry indicates that there was no assumed exposure to that medium.

b. Combined risk across all media exposures.

c. Relative contribution of COPC to total risk associated with the ingestion exposure pathway.

Attachment 8

TABLE 8-64

SUMMARY OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS USING LOAEL-BASED TRVs : HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2018)
EXPOSURE POINT: RME - Monitored Natural Recovery
RECEPTOR: HERON
TOTAL RISK (HI): 2.8E+00

Analyte	Exposure Medium[a]					Combined HQs[b]	Percent Contribution[c]
	Surface Water	Sediment	Aquatic Plants	Aquatic Invertebrates	Fish		
TCDD TEQ (D/F)		3.5E-01		1.8E-01	5.6E-01	***1.1E+00***	***39%***
Lead		3.7E-01		1.6E-03	1.4E-02	3.9E-01	***14%***
Total DDx		3.6E-02		1.2E-01	2.0E-01	3.5E-01	***13%***
Total PCBs		7.3E-03		4.5E-02	6.3E-02	1.2E-01	4%
Mercury		1.0E-01		8.6E-03	2.1E-02	1.3E-01	5%
Copper		5.9E-02		2.5E-02	1.7E-02	1.0E-01	4%
TCDD TEQ (PCBs)		6.1E-02		2.4E-01	3.0E-01	6.0E-01	***22%***
Dieldrin		2.7E-05		5.6E-05	1.0E-04	1.9E-04	0%
LPAH							
HPAH							
TOTAL MEDIUM-SPECIFIC RISK	**-**	**9.9E-01**	**-**	**6.2E-01**	**1.2E+00**	**2.8E+00**	
PERCENTAGE OF TOTAL RISK		**36%**		**22%**	**42%**	**100%**	

Notes:
a. Hazard Quotients presented by exposure medium; a blank cell indicates that the analyte was not a COPC for that medium; a dash entry indicates that there was no assumed exposure to that medium.
b. Combined risk across all media exposures.
c. Relative contribution of COPC to total risk associated with the ingestion exposure pathway.

Attachment 8

TABLE 8-65

PARAMETER VALUES USED TO CALCULATE ESTIMATED DAILY INTAKE : Surficial sediment / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2048)
MEDIUM: SEDIMENT
EXPOSURE MEDIUM: Surficial sediment
EXPOSURE POINT: RME - Monitored Natural Recovery
RECEPTOR: HERON

EXPOSURE ROUTE	PARAMETER SYMBOL	PARAMETER DEFINITION	UNITS	RME VALUE	RME RATIONALE/ REFERENCE	INTAKE EQUATION/ MODEL NAME
INGESTION	EDI_{sed}	ESTIMATED DAILY INTAKE VIA SEDIMENT INGESTION	mg/kg-d	calculated		SEDIMENT INTAKE-INGESTION
	C_{sed}	CHEMICAL CONCENTRATION IN SEDIMENT	mg/kg	chemical-specific		$EDI_{sed} = C_{sed} * IR_{sed} * SFF * EF * 1/BW$
	IR_{sed}	INGESTION RATE OF SEDIMENT	kg/day	0.019	assumption	
	SFF	SITE FORAGING FREQUENCY	unitless	100%	Bayer, 1978	
	EF	EXPOSURE FREQUENCY	unitless	58%	USEPA, 1993	
	BW	BODY WEIGHT	kg	2.2	USEPA, 1993	

References:

Bayer,R.D., 1978. Aspects of an Oregon estuarine great blue heron population; In: Sprunt, A., J. Ogden, S. Winkler, eds. Wading Birds; Natl. Audubon Soc. Res. Rep. 7:213-217.

USEPA, 1993. Wildlife Exposure Factors Handbook; United States Environmental Protection Agency, Office of Research and Development; EPA/600/R-93/187a; December 1993; Washington, D.C.

Attachment 8

TABLE 8-66

CALCULATION OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS : Surficial sediment / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2048)
MEDIUM: SEDIMENT
EXPOSURE MEDIUM: Surficial sediment
EXPOSURE POINT: RME - Monitored Natural Recovery
RECEPTOR: HERON

Analyte	Medium EPC	Medium EPC Units	Estimated Daily Intake[a]	Daily Intake Units	Reference Dose (NOAEL)[b]	Reference Dose (LOAEL)[b]	Reference Dose Units	Hazard Quotient (NOAEL)[c]	Hazard Quotient (LOAEL)[c]
Copper	7.0E+01	mg/kg	3.6E-01	mg/kg-d	4.1E+00	1.2E+01	mg/kg-d	8.9E-02	3.0E-02
Lead	1.1E+02	mg/kg	5.6E-01	mg/kg-d	1.6E+00	3.3E+00	mg/kg-d	3.4E-01	1.7E-01
Methyl Mercury	5.0E-01	mg/kg	2.5E-03	mg/kg-d	7.8E-03	7.8E-02	mg/kg-d	3.3E-01	3.3E-02
LPAH	3.3E+01	mg/kg	1.7E-01	mg/kg-d	-	-			
HPAH	8.6E+01	mg/kg	4.4E-01	mg/kg-d	-	-			
Dieldrin	2.0E-02	mg/kg	1.0E-04	mg/kg-d	7.1E-02	3.8E+00	mg/kg-d	1.5E-03	2.7E-05
Total DDx	6.9E-02	mg/kg	3.6E-04	mg/kg-d	2.8E-03	2.8E-02	mg/kg-d	1.3E-01	1.3E-02
Total PCBs	1.3E-01	mg/kg	6.6E-04	mg/kg-d	1.0E-01	4.0E-01	mg/kg-d	6.6E-03	1.7E-03
TEQ PCB-birds	4.2E-05	mg/kg	2.2E-07	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	1.5E-01	1.5E-02
TEQ D/F-birds	3.0E-04	mg/kg	1.5E-06	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	**1.1E+00**	1.1E-01
							HAZARD INDICES:	**2.2E+00**	3.7E-01

Notes:
a. Estimated Daily Intake (EDI) calculated using parameters presented in Table 8-65.
b. Reference Dose Values presented in Table 6-4. A dash indicates that no value is available.
c. Hazard Quotients (HQs) calculated by dividing the Estimated Daily Intake dose by either the NOAEL- or LOAEL-based Reference Dose.

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TABLE 8-67

PARAMETER VALUES USED TO CALCULATE ESTIMATED DAILY INTAKE : Blue crab / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2048)
MEDIUM: AQUATIC INVERTEBRATES
EXPOSURE MEDIUM: Blue crab
EXPOSURE POINT: RME - Monitored Natural Recovery
RECEPTOR: HERON

EXPOSURE ROUTE	PARAMETER SYMBOL	PARAMETER DEFINITION	UNITS	RME VALUE	RME RATIONALE/ REFERENCE	INTAKE EQUATION/ MODEL NAME
INGESTION	EDI_{invert}	ESTIMATED DAILY INTAKE VIA INVERTEBRATE INGESTION	mg/kg-d	calculated		INVERTEBRATE INTAKE-INGESTION $EDI_{invert} = C_{invert} * IR_{food} * P_{invert} * SFF * EF * 1/BW$
	C_{invert}	CHEMICAL CONCENTRATION IN INVERTEBRATES	mg/kg	chemical-specific		
	IR_{food}	INGESTION RATE OF FOOD	kg/day	0.39	Kushlan, 1978	
	P_{invert}	PERCENT INVERTEBRATES IN DIET	unitless	15%	assumption	Where C_{invert} is estimated using site-specific tissue data or calculated using the following equation: $C_{invert} = C_{sed} * BAF_{invert}$
	SFF	SITE FORAGING FREQUENCY	unitless	100%	Bayer, 1978	
	EF	EXPOSURE FREQUENCY	unitless	58%	USEPA, 1993	Bioaccumulation Factors [mg(ww tissue)/ kg(dw sediment)] provided separately.
	BW	BODY WEIGHT	kg	2.2	USEPA, 1993	

References:

Bayer,R.D., 1978. Aspects of an Oregon estuarine great blue heron population; In: Sprunt, A., J. Ogden, S. Winkler, eds. Wading Birds; Natl. Audubon Soc. Res. Rep. 7:213-217.

Kushlan, J.A., 1978. Feeding ecology of wading birds; In: Sprunt, A., J. Ogden, S. Winkler, eds. Wading Birds; Natl. Audubon Soc. Res. Rep. 7:213-217.

USEPA, 1993. Wildlife Exposure Factors Handbook; United States Environmental Protection Agency, Office of Research and Development; EPA/600/R-93/187a; December 1993; Washington, D.C.

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TABLE 8-68

CALCULATION OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS : Blue crab / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2048)
MEDIUM: AQUATIC INVERTEBRATES
EXPOSURE MEDIUM: Blue crab
EXPOSURE POINT: RME - Monitored Natural Recovery
RECEPTOR: HERON

Analyte	Medium EPC	Medium EPC Units	Estimated Daily Intake[a]	Daily Intake Units	Reference Dose (NOAEL)[b]	Reference Dose (LOAEL)[b]	Reference Dose Units	Hazard Quotient (NOAEL)[c]	Hazard Quotient (LOAEL)[c]
Copper	9.8E+00	mg/kg	1.5E-01	mg/kg-d	4.1E+00	1.2E+01	mg/kg-d	3.7E-02	1.2E-02
Lead	1.5E-01	mg/kg	2.4E-03	mg/kg-d	1.6E+00	3.3E+00	mg/kg-d	1.5E-03	7.3E-04
Methyl Mercury	1.4E-02	mg/kg	2.1E-04	mg/kg-d	7.8E-03	7.8E-02	mg/kg-d	2.7E-02	2.7E-03
LPAH	2.5E-01	mg/kg	3.8E-03	mg/kg-d	-	-			
HPAH	2.7E-01	mg/kg	4.2E-03	mg/kg-d	-	-			
Dieldrin	1.4E-02	mg/kg	2.1E-04	mg/kg-d	7.1E-02	3.8E+00	mg/kg-d	3.0E-03	5.6E-05
Total DDx	7.7E-02	mg/kg	1.2E-03	mg/kg-d	2.8E-03	2.8E-02	mg/kg-d	4.3E-01	4.3E-02
Total PCBs	2.6E-01	mg/kg	4.1E-03	mg/kg-d	1.0E-01	4.0E-01	mg/kg-d	4.1E-02	1.0E-02
TEQ PCB-birds	5.5E-05	mg/kg	8.5E-07	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	6.0E-01	6.0E-02
TEQ D/F-birds	5.1E-05	mg/kg	7.9E-07	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	5.6E-01	5.6E-02
							HAZARD INDICES:	**1.7E+00**	1.9E-01

Notes:
a. Estimated Daily Intake (EDI) calculated using parameters presented in Table 8-67.
b. Reference Dose Values presented in Table 6-4. A dash indicates that no value is available.
c. Hazard Quotients (HQs) calculated by dividing the Estimated Daily Intake dose by either the NOAEL- or LOAEL-based Reference Dose.

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TABLE 8-69

PARAMETER VALUES USED TO CALCULATE ESTIMATED DAILY INTAKE : Mummichog / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2048)
MEDIUM: FISH
EXPOSURE MEDIUM: Mummichog
EXPOSURE POINT: RME - Monitored Natural Recovery
RECEPTOR: HERON

EXPOSURE ROUTE	PARAMETER SYMBOL	PARAMETER DEFINITION	UNITS	RME VALUE	RME RATIONALE/ REFERENCE	INTAKE EQUATION/ MODEL NAME
INGESTION	EDI_{fish}	ESTIMATED DAILY INTAKE VIA FISH INGESTION	mg/kg-d	calculated		FISH INTAKE-INGESTION
	C_{fish}	CHEMICAL CONCENTRATION IN FISH	mg/kg	chemical-specific		$EDI_{fish} = C_{fish} * IR_{food} * P_{fish} * SFF * EF * 1/BW$
	IR_{food}	INGESTION RATE OF FOOD	kg/day	0.39	Kushlan, 1978	
	P_{fish}	PERCENT FISH IN DIET	unitless	85%	assumption	Where C_{fish} is estimated using site-specific tissue data or estimated using the following equation:
	SFF	SITE FORAGING FREQUENCY	unitless	100%	Bayer, 1978	$C_{fish} = C_{sed} * BAF_{fish}$
	EF	EXPOSURE FREQUENCY	unitless	58%	USEPA, 1993	Bioaccumulation Factors [mg(ww tissue)/ kg(dw sediment)] provided separately.
	BW	BODY WEIGHT	kg	2.2	USEPA, 1993	

References:

Bayer,R.D., 1978. Aspects of an Oregon estuarine great blue heron population; In: Sprunt, A., J. Ogden, S. Winkler, eds. Wading Birds; Natl. Audubon Soc. Res. Rep. 7:213-217.

Kushlan, J.A., 1978. Feeding ecology of wading birds; In: Sprunt, A., J. Ogden, S. Winkler, eds. Wading Birds; Natl. Audubon Soc. Res. Rep. 7:213-217.

USEPA, 1993. Wildlife Exposure Factors Handbook; United States Environmental Protection Agency, Office of Research and Development; EPA/600/R-93/187a; December 1993; Washington, D.C.

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TABLE 8-70

CALCULATION OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS : Mummichog / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2048)
MEDIUM: FISH
EXPOSURE MEDIUM: Mummichog
EXPOSURE POINT: RME - Monitored Natural Recovery
RECEPTOR: HERON

Analyte	Medium EPC	Medium EPC Units	Estimated Daily Intake[a]	Daily Intake Units	Reference Dose (NOAEL)[b]	Reference Dose (LOAEL)[b]	Reference Dose Units	Hazard Quotient (NOAEL)[c]	Hazard Quotient (LOAEL)[c]
Copper	1.2E+00	mg/kg	1.0E-01	mg/kg-d	4.1E+00	1.2E+01	mg/kg-d	2.5E-02	8.5E-03
Lead	2.3E-01	mg/kg	2.1E-02	mg/kg-d	1.6E+00	3.3E+00	mg/kg-d	1.3E-02	6.3E-03
Methyl Mercury	6.1E-03	mg/kg	5.3E-04	mg/kg-d	7.8E-03	7.8E-02	mg/kg-d	6.8E-02	6.8E-03
LPAH	3.1E-01	mg/kg	2.7E-02	mg/kg-d	-	-			
HPAH	1.5E-01	mg/kg	1.3E-02	mg/kg-d	-	-			
Dieldrin	4.5E-03	mg/kg	4.0E-04	mg/kg-d	7.1E-02	3.8E+00	mg/kg-d	5.6E-03	1.0E-04
Total DDx	2.2E-02	mg/kg	1.9E-03	mg/kg-d	2.8E-03	2.8E-02	mg/kg-d	6.9E-01	6.9E-02
Total PCBs	6.5E-02	mg/kg	5.7E-03	mg/kg-d	1.0E-01	4.0E-01	mg/kg-d	5.7E-02	1.4E-02
TEQ PCB-birds	1.2E-05	mg/kg	1.1E-06	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	7.6E-01	7.6E-02
TEQ D/F-birds	2.8E-05	mg/kg	2.4E-06	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	**1.7E+00**	1.7E-01
							HAZARD INDICES:	**3.4E+00**	3.5E-01

Notes:
a. Estimated Daily Intake (EDI) calculated using parameters presented in Table 8-69.
b. Reference Dose Values presented in Table 6-4. A dash indicates that no value is available.
c. Hazard Quotients (HQs) calculated by dividing the Estimated Daily Intake dose by either the NOAEL- or LOAEL-based Reference Dose.

Attachment 8

TABLE 8-71

SUMMARY OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS USING NOAEL-BASED TRVs : HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2048)
EXPOSURE POINT: RME - Monitored Natural Recovery
RECEPTOR: HERON
TOTAL RISK (HI): 7.2E+00

Analyte	Exposure Medium[a]					Combined HQs[b]	Percent Contribution[c]
	Surface Water	Sediment	Aquatic Plants	Aquatic Invertebrates	Fish		
TCDD TEQ (D/F)		1.1E+00		5.6E-01	1.7E+00	***3.4E+00***	***47%***
Total DDx		1.3E-01		4.3E-01	6.9E-01	***1.2E+00***	***17%***
Mercury		3.3E-01		2.7E-02	6.8E-02	4.2E-01	6%
Lead		3.4E-01		1.5E-03	1.3E-02	3.6E-01	5%
Total PCBs		6.6E-03		4.1E-02	5.7E-02	1.0E-01	1%
Copper		8.9E-02		3.7E-02	2.5E-02	1.5E-01	2%
TCDD TEQ (PCBs)		1.5E-01		6.0E-01	7.6E-01	***1.5E+00***	***21%***
Dieldrin		1.5E-03		3.0E-03	5.6E-03	1.0E-02	0%
LPAH							
HPAH							
TOTAL MEDIUM-SPECIFIC RISK	**-**	**2.2E+00**	**-**	**1.7E+00**	**3.4E+00**	**7.2E+00**	
PERCENTAGE OF TOTAL RISK		**30%**		**24%**	**47%**	**100%**	

Notes:
a. Hazard Quotients presented by exposure medium; a blank cell indicates that the analyte was not a COPC for that medium; a dash entry indicates that there was no assumed exposure to that medium.
b. Combined risk across all media exposures.
c. Relative contribution of COPC to total risk associated with the ingestion exposure pathway.

Attachment 8

TABLE 8-72

SUMMARY OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS USING LOAEL-BASED TRVs : HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2048)
EXPOSURE POINT: RME - Monitored Natural Recovery
RECEPTOR: HERON
TOTAL RISK (HI): 9.1E-01

Analyte	Exposure Medium[a]					Combined HQs[b]	Percent Contribution[c]
	Surface Water	Sediment	Aquatic Plants	Aquatic Invertebrates	Fish		
TCDD TEQ (D/F)		1.1E-01		5.6E-02	1.7E-01	3.4E-01	***37%***
Lead		1.7E-01		7.3E-04	6.3E-03	1.8E-01	***20%***
Total DDx		1.3E-02		4.3E-02	6.9E-02	1.2E-01	***14%***
Total PCBs		1.7E-03		1.0E-02	1.4E-02	2.6E-02	3%
Copper		3.0E-02		1.2E-02	8.5E-03	5.1E-02	6%
Mercury		3.3E-02		2.7E-03	6.8E-03	4.2E-02	5%
TCDD TEQ (PCBs)		1.5E-02		6.0E-02	7.6E-02	1.5E-01	***17%***
Dieldrin		2.7E-05		5.6E-05	1.0E-04	1.9E-04	0%
LPAH							
HPAH							
TOTAL MEDIUM-SPECIFIC RISK	**-**	**3.7E-01**	**-**	**1.9E-01**	**3.5E-01**	**9.1E-01**	
PERCENTAGE OF TOTAL RISK		**41%**		**20%**	**39%**	**100%**	

Notes:
a. Hazard Quotients presented by exposure medium; a blank cell indicates that the analyte was not a COPC for that medium; a dash entry indicates that there was no assumed exposure to that medium.
b. Combined risk across all media exposures.
c. Relative contribution of COPC to total risk associated with the ingestion exposure pathway.

Attachment 8

TABLE 8-73

PARAMETER VALUES USED TO CALCULATE ESTIMATED DAILY INTAKE : Surficial sediment / MINK

Focused Feasiblity Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2018)
MEDIUM: SEDIMENT
EXPOSURE MEDIUM: Surficial sediment
EXPOSURE POINT: RME - Primary Erosional Zone/Primary Inventory Zone
RECEPTOR: MINK

EXPOSURE ROUTE	PARAMETER SYMBOL	PARAMETER DEFINITION	UNITS	RME VALUE	RME RATIONALE/ REFERENCE	INTAKE EQUATION/ MODEL NAME
INGESTION	EDI_{sed}	ESTIMATED DAILY INTAKE VIA SEDIMENT INGESTION	mg/kg-d	calculated		SEDIMENT INTAKE-INGESTION
	C_{sed}	CHEMICAL CONCENTRATION IN SEDIMENT	mg/kg	chemical-specific		$EDI_{sed} = C_{sed} * IR_{sed} * SFF * EF * 1/BW$
	IR_{sed}	INGESTION RATE OF SEDIMENT	kg/day	0.0034	assumption	
	SFF	SITE FORAGING FREQUENCY	unitless	100%	Mitchell, 1961	
	EF	EXPOSURE FREQUENCY	unitless	100%	USEPA, 1993	
	BW	BODY WEIGHT	kg	0.57	Mitchell, 1961	

References:

Mitchell, J.L., 1961. Mink movements and populations on a Montana river; J. Wildl. Manage. 25:48-54.

USEPA, 1993. Wildlife Exposure Factors Handbook; United States Environmental Protection Agency, Office of Research and Development; EPA/600/R-93/187a; December 1993; Washington, D.C.

Attachment 8

TABLE 8-74

CALCULATION OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS : Surficial sediment / MINK

Focused Feasiblity Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2018)
MEDIUM: SEDIMENT
EXPOSURE MEDIUM: Surficial sediment
EXPOSURE POINT: RME - Primary Erosional Zone/Primary Inventory Zone
RECEPTOR: MINK

Analyte	Medium EPC	Medium EPC Units	Estimated Daily Intake[a]	Daily Intake Units	Reference Dose (NOAEL)[b]	Reference Dose (LOAEL)[b]	Reference Dose Units	Hazard Quotient (NOAEL)[c]	Hazard Quotient (LOAEL)[c]
Copper	1.3E+02	mg/kg	8.0E-01	mg/kg-d	5.6E+00	9.3E+00	mg/kg-d	1.4E-01	8.6E-02
Lead	2.3E+02	mg/kg	1.4E+00	mg/kg-d	4.7E+00	8.9E+00	mg/kg-d	2.9E-01	1.5E-01
Methyl Mercury	1.4E+00	mg/kg	8.2E-03	mg/kg-d	5.5E-02	1.8E-01	mg/kg-d	1.5E-01	4.6E-02
LPAH	3.3E+01	mg/kg	2.0E-01	mg/kg-d	-	-			
HPAH	8.6E+01	mg/kg	5.2E-01	mg/kg-d	1.0E+00	1.0E+01	mg/kg-d	5.2E-01	5.2E-02
Dieldrin	1.9E-02	mg/kg	1.1E-04	mg/kg-d	1.5E-02	3.0E-02	mg/kg-d	7.6E-03	3.8E-03
Total DDx	1.7E-01	mg/kg	1.0E-03	mg/kg-d	8.0E-01	4.0E+00	mg/kg-d	1.3E-03	2.5E-04
Total PCBs	5.0E-01	mg/kg	3.0E-03	mg/kg-d	8.0E-02	9.6E-02	mg/kg-d	3.8E-02	3.2E-02
TEQ PCB-mammals	8.7E-06	mg/kg	5.2E-08	mg/kg-d	8.0E-08	2.2E-06	mg/kg-d	6.5E-01	2.3E-02
TEQ D/F-mammals	6.4E-04	mg/kg	3.9E-06	mg/kg-d	8.0E-08	2.2E-06	mg/kg-d	**4.8E+01**	**1.7E+00**
							HAZARD INDICES:	**5.0E+01**	**2.1E+00**

Notes:
a. Estimated Daily Intake (EDI) calculated using parameters presented in Table 8-73.
b. Reference Dose Values presented in Table 6-4. A dash indicates that no value is available.
c. Hazard Quotients (HQs) calculated by dividing the Estimated Daily Intake dose by either the NOAEL- or LOAEL-based Reference Dose.

Attachment 8

TABLE 8-75

PARAMETER VALUES USED TO CALCULATE ESTIMATED DAILY INTAKE : Blue crab / MINK

Focused Feasiblity Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2018)
MEDIUM: AQUATIC INVERTEBRATES
EXPOSURE MEDIUM: Blue crab
EXPOSURE POINT: RME - Primary Erosional Zone/Primary Inventory Zone
RECEPTOR: MINK

EXPOSURE ROUTE	PARAMETER SYMBOL	PARAMETER DEFINITION	UNITS	RME VALUE	RME RATIONALE/ REFERENCE	INTAKE EQUATION/ MODEL NAME
INGESTION	EDI_{invert}	ESTIMATED DAILY INTAKE VIA INVERTEBRATE INGESTION	mg/kg-d	calculated		INVERTEBRATE INTAKE-INGESTION $EDI_{invert} = C_{invert} * IR_{food} * P_{invert} * SFF * EF * 1/BW$
	C_{invert}	CHEMICAL CONCENTRATION IN INVERTEBRATES	mg/kg	chemical-specific		
	IR_{food}	INGESTION RATE OF FOOD	kg/day	0.17	USEPA, 1993	
	P_{invert}	PERCENT INVERTEBRATES IN DIET	unitless	20%	assumption	Where C_{invert} is estimated using site-specific tissue data or calculated using the following equation: $C_{invert} = C_{sed} * BAF_{invert}$
	SFF	SITE FORAGING FREQUENCY	unitless	100%	Mitchell, 1961	
	EF	EXPOSURE FREQUENCY	unitless	100%	USEPA, 1993	Bioaccumulation Factors [mg(ww tissue)/ kg(dw sediment)] provided separately.
	BW	BODY WEIGHT	kg	0.57	Mitchell, 1961	

References:
Mitchell, J.L., 1961. Mink movements and populations on a Montana river; J. Wildl. Manage. 25:48-54.
USEPA, 1993. Wildlife Exposure Factors Handbook; United States Environmental Protection Agency, Office of Research and Development; EPA/600/R-93/187a; December 1993; Washington, D.C.

Attachment 8

TABLE 8-76

CALCULATION OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS : Blue crab / MINK

Focused Feasiblity Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2018)
MEDIUM: AQUATIC INVERTEBRATES
EXPOSURE MEDIUM: Blue crab
EXPOSURE POINT: RME - Primary Erosional Zone/Primary Inventory Zone
RECEPTOR: MINK

Analyte	Medium EPC	Medium EPC Units	Estimated Daily Intake[a]	Daily Intake Units	Reference Dose (NOAEL)[b]	Reference Dose (LOAEL)[b]	Reference Dose Units	Hazard Quotient (NOAEL)[c]	Hazard Quotient (LOAEL)[c]
Copper	1.9E+01	mg/kg	1.1E+00	mg/kg-d	5.6E+00	9.3E+00	mg/kg-d	2.0E-01	1.2E-01
Lead	3.2E-01	mg/kg	1.9E-02	mg/kg-d	4.7E+00	8.9E+00	mg/kg-d	4.1E-03	2.2E-03
Methyl Mercury	3.8E-02	mg/kg	2.3E-03	mg/kg-d	5.5E-02	1.8E-01	mg/kg-d	4.2E-02	1.3E-02
LPAH	2.5E-01	mg/kg	1.5E-02	mg/kg-d	-	-			
HPAH	2.7E-01	mg/kg	1.6E-02	mg/kg-d	1.0E+00	1.0E+01	mg/kg-d	1.6E-02	1.6E-03
Dieldrin	1.3E-02	mg/kg	7.7E-04	mg/kg-d	1.5E-02	3.0E-02	mg/kg-d	5.1E-02	2.6E-02
Total DDx	1.9E-01	mg/kg	1.1E-02	mg/kg-d	8.0E-01	4.0E+00	mg/kg-d	1.4E-02	2.8E-03
Total PCBs	1.0E+00	mg/kg	6.2E-02	mg/kg-d	8.0E-02	9.6E-02	mg/kg-d	7.8E-01	6.5E-01
TEQ PCB-mammals	2.2E-05	mg/kg	1.3E-06	mg/kg-d	8.0E-08	2.2E-06	mg/kg-d	**1.7E+01**	6.0E-01
TEQ D/F-mammals	9.8E-05	mg/kg	5.9E-06	mg/kg-d	8.0E-08	2.2E-06	mg/kg-d	**7.4E+01**	**2.6E+00**
							HAZARD INDICES:	**9.2E+01**	**4.1E+00**

Notes:
a. Estimated Daily Intake (EDI) calculated using parameters presented in Table 8-75.
b. Reference Dose Values presented in Table 6-4. A dash indicates that no value is available.
c. Hazard Quotients (HQs) calculated by dividing the Estimated Daily Intake dose by either the NOAEL- or LOAEL-based Reference Dose.

Attachment 8

TABLE 8-77

PARAMETER VALUES USED TO CALCULATE ESTIMATED DAILY INTAKE : White perch/American eel / MINK

Focused Feasiblity Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2018)
MEDIUM: FISH
EXPOSURE MEDIUM: White perch/American eel
EXPOSURE POINT: RME - Primary Erosional Zone/Primary Inventory Zone
RECEPTOR: MINK

EXPOSURE ROUTE	PARAMETER SYMBOL	PARAMETER DEFINITION	UNITS	RME VALUE	RME RATIONALE/ REFERENCE	INTAKE EQUATION/ MODEL NAME
INGESTION	EDI_{fish}	ESTIMATED DAILY INTAKE VIA FISH INGESTION	mg/kg-d	calculated		FISH INTAKE-INGESTION
	C_{fish}	CHEMICAL CONCENTRATION IN FISH	mg/kg	chemical-specific		$EDI_{fish} = C_{fish} * IR_{food} * P_{fish} * SFF * EF * 1/BW$
	IR_{food}	INGESTION RATE OF FOOD	kg/day	0.17	USEPA, 1993	
	P_{fish}	PERCENT FISH IN DIET	unitless	80%	assumption	Where C_{fish} is estimated using site-specific tissue data or estimated using the following equation:
	SFF	SITE FORAGING FREQUENCY	unitless	100%	Mitchell, 1961	$C_{fish} = C_{sed} * BAF_{fish}$
	EF	EXPOSURE FREQUENCY	unitless	100%	USEPA, 1993	Bioaccumulation Factors [mg(ww tissue)/ kg(dw sediment)] provided separately.
	BW	BODY WEIGHT	kg	0.57	Mitchell, 1961	

References:
Mitchell, J.L., 1961. Mink movements and populations on a Montana river; J. Wildl. Manage. 25:48-54.
USEPA, 1993. Wildlife Exposure Factors Handbook; United States Environmental Protection Agency, Office of Research and Development; EPA/600/R-93/187a; December 1993; Washington, D.C.

Attachment 8

TABLE 8-78

CALCULATION OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS : White perch/American eel / MINK

Focused Feasiblity Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2018)
MEDIUM: FISH
EXPOSURE MEDIUM: White perch/American eel
EXPOSURE POINT: RME - Primary Erosional Zone/Primary Inventory Zone
RECEPTOR: MINK

Analyte	Medium EPC	Medium EPC Units	Estimated Daily Intake[a]	Daily Intake Units	Reference Dose (NOAEL)[b]	Reference Dose (LOAEL)[b]	Reference Dose Units	Hazard Quotient (NOAEL)[c]	Hazard Quotient (LOAEL)[c]
Copper	5.4E+00	mg/kg	1.3E+00	mg/kg-d	5.6E+00	9.3E+00	mg/kg-d	2.3E-01	1.4E-01
Lead	2.7E-01	mg/kg	6.6E-02	mg/kg-d	4.7E+00	8.9E+00	mg/kg-d	1.4E-02	7.4E-03
Methyl Mercury	1.4E-01	mg/kg	3.3E-02	mg/kg-d	5.5E-02	1.8E-01	mg/kg-d	6.1E-01	1.9E-01
LPAH	3.6E-01	mg/kg	8.8E-02	mg/kg-d	-	-			
HPAH	2.2E-01	mg/kg	5.2E-02	mg/kg-d	1.0E+00	1.0E+01	mg/kg-d	5.2E-02	5.2E-03
Dieldrin	3.0E-02	mg/kg	7.2E-03	mg/kg-d	1.5E-02	3.0E-02	mg/kg-d	4.8E-01	2.4E-01
Total DDx	3.1E-01	mg/kg	7.4E-02	mg/kg-d	8.0E-01	4.0E+00	mg/kg-d	9.2E-02	1.8E-02
Total PCBs	1.1E+00	mg/kg	2.6E-01	mg/kg-d	8.0E-02	9.6E-02	mg/kg-d	**3.3E+00**	**2.7E+00**
TEQ PCB-mammals	1.5E-05	mg/kg	3.7E-06	mg/kg-d	8.0E-08	2.2E-06	mg/kg-d	**4.6E+01**	**1.7E+00**
TEQ D/F-mammals	1.3E-04	mg/kg	3.1E-05	mg/kg-d	8.0E-08	2.2E-06	mg/kg-d	**3.9E+02**	**1.4E+01**
							HAZARD INDICES:	**4.4E+02**	**1.9E+01**

Notes:
a. Estimated Daily Intake (EDI) calculated using parameters presented in Table 8-77.
b. Reference Dose Values presented in Table 6-4. A dash indicates that no value is available.
c. Hazard Quotients (HQs) calculated by dividing the Estimated Daily Intake dose by either the NOAEL- or LOAEL-based Reference Dose.

Attachment 8

TABLE 8-79

SUMMARY OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS USING NOAEL-BASED TRVs : MINK

Focused Feasiblity Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2018)
EXPOSURE POINT: RME - Primary Erosional Zone/Primary Inventory Zone
RECEPTOR: MINK
TOTAL RISK (HI): 5.8E+02

Analyte	Exposure Medium[a]					Combined HQs[b]	Percent Contribution[c]
	Surface Water	Sediment	Aquatic Plants	Aquatic Invertebrates	Fish		
TCDD TEQ (D/F)		4.8E+01		7.4E+01	3.9E+02	***5.1E+02***	***88%***
TCDD TEQ (PCBs)		6.5E-01		1.7E+01	4.6E+01	***6.4E+01***	***11%***
Total PCBs		3.8E-02		7.8E-01	3.3E+00	***4.1E+00***	1%
Mercury		1.5E-01		4.2E-02	6.1E-01	8.0E-01	0%
HPAH		5.2E-01		1.6E-02	5.2E-02	5.8E-01	0%
Copper		1.4E-01		2.0E-01	2.3E-01	5.8E-01	0%
Dieldrin		7.6E-03		5.1E-02	4.8E-01	5.4E-01	0%
Lead		2.9E-01		4.1E-03	1.4E-02	3.1E-01	0%
Total DDx		1.3E-03		1.4E-02	9.2E-02	1.1E-01	0%
LPAH							
TOTAL MEDIUM-SPECIFIC RISK	**-**	**5.0E+01**	**-**	**9.2E+01**	**4.4E+02**	**5.8E+02**	
PERCENTAGE OF TOTAL RISK		**9%**		**16%**	**76%**	**100%**	

Notes:

a. Hazard Quotients presented by exposure medium; a blank cell indicates that the analyte was not a COPC for that medium; a dash entry indicates that there was no assumed exposure to that medium.

b. Combined risk across all media exposures.

c. Relative contribution of COPC to total risk associated with the ingestion exposure pathway.

Attachment 8

TABLE 8-80

SUMMARY OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS USING LOAEL-BASED TRVs : MINK

Focused Feasiblity Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2018)
EXPOSURE POINT: RME - Primary Erosional Zone/Primary Inventory Zone
RECEPTOR: MINK
TOTAL RISK (HI): 2.5E+01

	Exposure Medium[a]						
Analyte	Surface Water	Sediment	Aquatic Plants	Aquatic Invertebrates	Fish	Combined HQs[b]	Percent Contribution[c]
TCDD TEQ (D/F)		1.7E+00		2.6E+00	1.4E+01	***1.8E+01***	***73%***
Total PCBs		3.2E-02		6.5E-01	2.7E+00	***3.4E+00***	***14%***
TCDD TEQ (PCBs)		2.3E-02		6.0E-01	1.7E+00	***2.3E+00***	9%
Copper		8.6E-02		1.2E-01	1.4E-01	3.5E-01	1%
Dieldrin		3.8E-03		2.6E-02	2.4E-01	2.7E-01	1%
Mercury		4.6E-02		1.3E-02	1.9E-01	2.4E-01	1%
Lead		1.5E-01		2.2E-03	7.4E-03	1.6E-01	1%
HPAH		5.2E-02		1.6E-03	5.2E-03	5.8E-02	0%
Total DDx		2.5E-04		2.8E-03	1.8E-02	2.2E-02	0%
LPAH							
TOTAL MEDIUM-SPECIFIC RISK	**-**	**2.1E+00**	**-**	**4.1E+00**	**1.9E+01**	**2.5E+01**	
PERCENTAGE OF TOTAL RISK		**8%**		**16%**	**75%**	**100%**	

Notes:

a. Hazard Quotients presented by exposure medium; a blank cell indicates that the analyte was not a COPC for that medium; a dash entry indicates that there was no assumed exposure to that medium.

b. Combined risk across all media exposures.

c. Relative contribution of COPC to total risk associated with the ingestion exposure pathway.

Attachment 8

TABLE 8-81

PARAMETER VALUES USED TO CALCULATE ESTIMATED DAILY INTAKE : Surficial sediment / MINK

Focused Feasiblity Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2048)
MEDIUM: SEDIMENT
EXPOSURE MEDIUM: Surficial sediment
EXPOSURE POINT: RME - Primary Erosional Zone/Primary Inventory Zone
RECEPTOR: MINK

EXPOSURE ROUTE	PARAMETER SYMBOL	PARAMETER DEFINITION	UNITS	RME VALUE	RME RATIONALE/ REFERENCE	INTAKE EQUATION/ MODEL NAME
INGESTION	EDI_{sed}	ESTIMATED DAILY INTAKE VIA SEDIMENT INGESTION	mg/kg-d	calculated		SEDIMENT INTAKE-INGESTION
	C_{sed}	CHEMICAL CONCENTRATION IN SEDIMENT	mg/kg	chemical-specific		$EDI_{sed} = C_{sed} * IR_{sed} * SFF * EF * 1/BW$
	IR_{sed}	INGESTION RATE OF SEDIMENT	kg/day	0.0034	assumption	
	SFF	SITE FORAGING FREQUENCY	unitless	100%	Mitchell, 1961	
	EF	EXPOSURE FREQUENCY	unitless	100%	USEPA, 1993	
	BW	BODY WEIGHT	kg	0.57	Mitchell, 1961	

References:

Mitchell, J.L., 1961. Mink movements and populations on a Montana river; J. Wildl. Manage. 25:48-54.

USEPA, 1993. Wildlife Exposure Factors Handbook; United States Environmental Protection Agency, Office of Research and Development; EPA/600/R-93/187a; December 1993; Washington, D.C.

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TABLE 8-82

CALCULATION OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS : Surficial sediment / MINK

Focused Feasiblity Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2048)
MEDIUM: SEDIMENT
EXPOSURE MEDIUM: Surficial sediment
EXPOSURE POINT: RME - Primary Erosional Zone/Primary Inventory Zone
RECEPTOR: MINK

Analyte	Medium EPC	Medium EPC Units	Estimated Daily Intake[a]	Daily Intake Units	Reference Dose (NOAEL)[b]	Reference Dose (LOAEL)[b]	Reference Dose Units	Hazard Quotient (NOAEL)[c]	Hazard Quotient (LOAEL)[c]
Copper	6.7E+01	mg/kg	4.0E-01	mg/kg-d	5.6E+00	9.3E+00	mg/kg-d	7.2E-02	4.3E-02
Lead	1.0E+02	mg/kg	6.3E-01	mg/kg-d	4.7E+00	8.9E+00	mg/kg-d	1.3E-01	7.0E-02
Methyl Mercury	4.4E-01	mg/kg	2.6E-03	mg/kg-d	5.5E-02	1.8E-01	mg/kg-d	4.8E-02	1.5E-02
LPAH	3.3E+01	mg/kg	2.0E-01	mg/kg-d	-	-			
HPAH	8.6E+01	mg/kg	5.2E-01	mg/kg-d	1.0E+00	1.0E+01	mg/kg-d	5.2E-01	5.2E-02
Dieldrin	1.9E-02	mg/kg	1.1E-04	mg/kg-d	1.5E-02	3.0E-02	mg/kg-d	7.6E-03	3.8E-03
Total DDx	6.0E-02	mg/kg	3.6E-04	mg/kg-d	8.0E-01	4.0E+00	mg/kg-d	4.5E-04	9.0E-05
Total PCBs	1.1E-01	mg/kg	6.9E-04	mg/kg-d	8.0E-02	9.6E-02	mg/kg-d	8.6E-03	7.2E-03
TEQ PCB-mammals	2.5E-06	mg/kg	1.5E-08	mg/kg-d	8.0E-08	2.2E-06	mg/kg-d	1.9E-01	6.7E-03
TEQ D/F-mammals	1.8E-04	mg/kg	1.1E-06	mg/kg-d	8.0E-08	2.2E-06	mg/kg-d	**1.3E+01**	4.7E-01
							HAZARD INDICES:	**1.4E+01**	6.7E-01

Notes:
a. Estimated Daily Intake (EDI) calculated using parameters presented in Table 8-81.
b. Reference Dose Values presented in Table 6-4. A dash indicates that no value is available.
c. Hazard Quotients (HQs) calculated by dividing the Estimated Daily Intake dose by either the NOAEL- or LOAEL-based Reference Dose.

Attachment 8

TABLE 8-83

PARAMETER VALUES USED TO CALCULATE ESTIMATED DAILY INTAKE : Blue crab / MINK

Focused Feasiblity Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2048)
MEDIUM: AQUATIC INVERTEBRATES
EXPOSURE MEDIUM: Blue crab
EXPOSURE POINT: RME - Primary Erosional Zone/Primary Inventory Zone
RECEPTOR: MINK

EXPOSURE ROUTE	PARAMETER SYMBOL	PARAMETER DEFINITION	UNITS	RME VALUE	RME RATIONALE/ REFERENCE	INTAKE EQUATION/ MODEL NAME
INGESTION	EDI_{invert}	ESTIMATED DAILY INTAKE VIA INVERTEBRATE INGESTION	mg/kg-d	calculated		INVERTEBRATE INTAKE-INGESTION $EDI_{invert} = C_{invert} * IR_{food} * P_{invert} * SFF * EF * 1/BW$
	C_{invert}	CHEMICAL CONCENTRATION IN INVERTEBRATES	mg/kg	chemical-specific		
	IR_{food}	INGESTION RATE OF FOOD	kg/day	0.17	USEPA, 1993	
	P_{invert}	PERCENT INVERTEBRATES IN DIET	unitless	20%	assumption	Where C_{invert} is estimated using site-specific tissue data or calculated using the following equation: $C_{invert} = C_{sed} * BAF_{invert}$
	SFF	SITE FORAGING FREQUENCY	unitless	100%	Mitchell, 1961	
	EF	EXPOSURE FREQUENCY	unitless	100%	USEPA, 1993	Bioaccumulation Factors [mg(ww tissue)/ kg(dw sediment)] provided separately.
	BW	BODY WEIGHT	kg	0.57	Mitchell, 1961	

References:
Mitchell, J.L., 1961. Mink movements and populations on a Montana river; J. Wildl. Manage. 25:48-54.
USEPA, 1993. Wildlife Exposure Factors Handbook; United States Environmental Protection Agency, Office of Research and Development; EPA/600/R-93/187a; December 1993; Washington, D.C.

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TABLE 8-84

CALCULATION OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS : Blue crab / MINK

Focused Feasiblity Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2048)
MEDIUM: AQUATIC INVERTEBRATES
EXPOSURE MEDIUM: Blue crab
EXPOSURE POINT: RME - Primary Erosional Zone/Primary Inventory Zone
RECEPTOR: MINK

Analyte	Medium EPC	Medium EPC Units	Estimated Daily Intake[a]	Daily Intake Units	Reference Dose (NOAEL)[b]	Reference Dose (LOAEL)[b]	Reference Dose Units	Hazard Quotient (NOAEL)[c]	Hazard Quotient (LOAEL)[c]
Copper	9.3E+00	mg/kg	5.6E-01	mg/kg-d	5.6E+00	9.3E+00	mg/kg-d	1.0E-01	6.0E-02
Lead	1.5E-01	mg/kg	8.9E-03	mg/kg-d	4.7E+00	8.9E+00	mg/kg-d	1.9E-03	1.0E-03
Methyl Mercury	1.2E-02	mg/kg	7.3E-04	mg/kg-d	5.5E-02	1.8E-01	mg/kg-d	1.3E-02	4.1E-03
LPAH	2.5E-01	mg/kg	1.5E-02	mg/kg-d	-	-			
HPAH	2.7E-01	mg/kg	1.6E-02	mg/kg-d	1.0E+00	1.0E+01	mg/kg-d	1.6E-02	1.6E-03
Dieldrin	1.3E-02	mg/kg	7.7E-04	mg/kg-d	1.5E-02	3.0E-02	mg/kg-d	5.1E-02	2.6E-02
Total DDx	6.7E-02	mg/kg	4.0E-03	mg/kg-d	8.0E-01	4.0E+00	mg/kg-d	5.0E-03	1.0E-03
Total PCBs	2.4E-01	mg/kg	1.4E-02	mg/kg-d	8.0E-02	9.6E-02	mg/kg-d	1.8E-01	1.5E-01
TEQ PCB-mammals	6.3E-06	mg/kg	3.8E-07	mg/kg-d	8.0E-08	2.2E-06	mg/kg-d	**4.8E+00**	1.7E-01
TEQ D/F-mammals	2.7E-05	mg/kg	1.6E-06	mg/kg-d	8.0E-08	2.2E-06	mg/kg-d	**2.0E+01**	7.2E-01
							HAZARD INDICES:	**2.5E+01**	**1.1E+00**

Notes:
a. Estimated Daily Intake (EDI) calculated using parameters presented in Table 8-83.
b. Reference Dose Values presented in Table 6-4. A dash indicates that no value is available.
c. Hazard Quotients (HQs) calculated by dividing the Estimated Daily Intake dose by either the NOAEL- or LOAEL-based Reference Dose.

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TABLE 8-85

PARAMETER VALUES USED TO CALCULATE ESTIMATED DAILY INTAKE : White perch/American eel / MINK

Focused Feasiblity Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2048)
MEDIUM: FISH
EXPOSURE MEDIUM: White perch/American eel
EXPOSURE POINT: RME - Primary Erosional Zone/Primary Inventory Zone
RECEPTOR: MINK

EXPOSURE ROUTE	PARAMETER SYMBOL	PARAMETER DEFINITION	UNITS	RME VALUE	RME RATIONALE/ REFERENCE	INTAKE EQUATION/ MODEL NAME
INGESTION	EDI_{fish}	ESTIMATED DAILY INTAKE VIA FISH INGESTION	mg/kg-d	calculated		FISH INTAKE-INGESTION
	C_{fish}	CHEMICAL CONCENTRATION IN FISH	mg/kg	chemical-specific		$EDI_{fish} = C_{fish} * IR_{food} * P_{fish} * SFF * EF * 1/BW$
	IR_{food}	INGESTION RATE OF FOOD	kg/day	0.17	USEPA, 1993	
	P_{fish}	PERCENT FISH IN DIET	unitless	80%	assumption	Where C_{fish} is estimated using site-specific tissue data or estimated using the following equation:
	SFF	SITE FORAGING FREQUENCY	unitless	100%	Mitchell, 1961	$C_{fish} = C_{sed} * BAF_{fish}$
	EF	EXPOSURE FREQUENCY	unitless	100%	USEPA, 1993	Bioaccumulation Factors [mg(ww tissue)/ kg(dw sediment)] provided separately.
	BW	BODY WEIGHT	kg	0.57	Mitchell, 1961	

References:
Mitchell, J.L., 1961. Mink movements and populations on a Montana river; J. Wildl. Manage. 25:48-54.
USEPA, 1993. Wildlife Exposure Factors Handbook; United States Environmental Protection Agency, Office of Research and Development; EPA/600/R-93/187a; December 1993; Washington, D.C.

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TABLE 8-86

CALCULATION OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS : White perch/American eel / MINK

Focused Feasiblity Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2048)
MEDIUM: FISH
EXPOSURE MEDIUM: White perch/American eel
EXPOSURE POINT: RME - Primary Erosional Zone/Primary Inventory Zone
RECEPTOR: MINK

Analyte	Medium EPC	Medium EPC Units	Estimated Daily Intake[a]	Daily Intake Units	Reference Dose (NOAEL)[b]	Reference Dose (LOAEL)[b]	Reference Dose Units	Hazard Quotient (NOAEL)[c]	Hazard Quotient (LOAEL)[c]
Copper	2.7E+00	mg/kg	6.5E-01	mg/kg-d	5.6E+00	9.3E+00	mg/kg-d	1.2E-01	7.0E-02
Lead	1.3E-01	mg/kg	3.0E-02	mg/kg-d	4.7E+00	8.9E+00	mg/kg-d	6.4E-03	3.4E-03
Methyl Mercury	4.4E-02	mg/kg	1.1E-02	mg/kg-d	5.5E-02	1.8E-01	mg/kg-d	1.9E-01	5.9E-02
LPAH	3.6E-01	mg/kg	8.8E-02	mg/kg-d	-	-			
HPAH	2.2E-01	mg/kg	5.2E-02	mg/kg-d	1.0E+00	1.0E+01	mg/kg-d	5.2E-02	5.2E-03
Dieldrin	3.0E-02	mg/kg	7.2E-03	mg/kg-d	1.5E-02	3.0E-02	mg/kg-d	4.8E-01	2.4E-01
Total DDx	1.1E-01	mg/kg	2.6E-02	mg/kg-d	8.0E-01	4.0E+00	mg/kg-d	3.3E-02	6.5E-03
Total PCBs	2.5E-01	mg/kg	6.0E-02	mg/kg-d	8.0E-02	9.6E-02	mg/kg-d	7.5E-01	6.2E-01
TEQ PCB-mammals	4.4E-06	mg/kg	1.1E-06	mg/kg-d	8.0E-08	2.2E-06	mg/kg-d	**1.3E+01**	4.7E-01
TEQ D/F-mammals	3.5E-05	mg/kg	8.5E-06	mg/kg-d	8.0E-08	2.2E-06	mg/kg-d	**1.1E+02**	**3.8E+00**
							HAZARD INDICES:	**1.2E+02**	**5.3E+00**

Notes:
a. Estimated Daily Intake (EDI) calculated using parameters presented in Table 8-85.
b. Reference Dose Values presented in Table 6-4. A dash indicates that no value is available.
c. Hazard Quotients (HQs) calculated by dividing the Estimated Daily Intake dose by either the NOAEL- or LOAEL-based Reference Dose.

Attachment 8

TABLE 8-87

SUMMARY OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS USING NOAEL-BASED TRVs : MINK

Focused Feasiblity Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2048)
EXPOSURE POINT: RME - Primary Erosional Zone/Primary Inventory Zone
RECEPTOR: MINK
TOTAL RISK (HI): 1.6E+02

	Exposure Medium[a]						
Analyte	Surface Water	Sediment	Aquatic Plants	Aquatic Invertebrates	Fish	Combined HQs[b]	Percent Contribution[c]
TCDD TEQ (D/F)		1.3E+01		2.0E+01	1.1E+02	***1.4E+02***	***87%***
TCDD TEQ (PCBs)		1.9E-01		4.8E+00	1.3E+01	***1.8E+01***	***11%***
Total PCBs		8.6E-03		1.8E-01	7.5E-01	9.3E-01	1%
HPAH		5.2E-01		1.6E-02	5.2E-02	5.8E-01	0%
Dieldrin		7.6E-03		5.1E-02	4.8E-01	5.4E-01	0%
Copper		7.2E-02		1.0E-01	1.2E-01	2.9E-01	0%
Mercury		4.8E-02		1.3E-02	1.9E-01	2.6E-01	0%
Lead		1.3E-01		1.9E-03	6.4E-03	1.4E-01	0%
Total DDx		4.5E-04		5.0E-03	3.3E-02	3.8E-02	0%
LPAH							
TOTAL MEDIUM-SPECIFIC RISK	**-**	**1.4E+01**	**-**	**2.5E+01**	**1.2E+02**	**1.6E+02**	
PERCENTAGE OF TOTAL RISK		**9%**		**16%**	**75%**	**100%**	

Notes:
a. Hazard Quotients presented by exposure medium; a blank cell indicates that the analyte was not a COPC for that medium; a dash entry indicates that there was no assumed exposure to that medium.
b. Combined risk across all media exposures.
c. Relative contribution of COPC to total risk associated with the ingestion exposure pathway.

Attachment 8

TABLE 8-88

SUMMARY OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS USING LOAEL-BASED TRVs : MINK

Focused Feasiblity Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2048)
EXPOSURE POINT: RME - Primary Erosional Zone/Primary Inventory Zone
RECEPTOR: MINK
TOTAL RISK (HI): 7.1E+00

Analyte	Exposure Medium[a]					Combined HQs[b]	Percent Contribution[c]
	Surface Water	Sediment	Aquatic Plants	Aquatic Invertebrates	Fish		
TCDD TEQ (D/F)		4.7E-01		7.2E-01	3.8E+00	***5.0E+00***	***70%***
Total PCBs		7.2E-03		1.5E-01	6.2E-01	7.8E-01	***11%***
Dieldrin		3.8E-03		2.6E-02	2.4E-01	2.7E-01	4%
TCDD TEQ (PCBs)		6.7E-03		1.7E-01	4.7E-01	6.5E-01	9%
Copper		4.3E-02		6.0E-02	7.0E-02	1.7E-01	2%
Mercury		1.5E-02		4.1E-03	5.9E-02	7.8E-02	1%
Lead		7.0E-02		1.0E-03	3.4E-03	7.5E-02	1%
HPAH		5.2E-02		1.6E-03	5.2E-03	5.8E-02	1%
Total DDx		9.0E-05		1.0E-03	6.5E-03	7.6E-03	0%
LPAH							
TOTAL MEDIUM-SPECIFIC RISK	**-**	**6.7E-01**	**-**	**1.1E+00**	**5.3E+00**	**7.1E+00**	
PERCENTAGE OF TOTAL RISK		**9%**		**16%**	**74%**	**100%**	

Notes:

a. Hazard Quotients presented by exposure medium; a blank cell indicates that the analyte was not a COPC for that medium; a dash entry indicates that there was no assumed exposure to that medium.

b. Combined risk across all media exposures.

c. Relative contribution of COPC to total risk associated with the ingestion exposure pathway.

TABLE 8-89
PARAMETER VALUES USED TO CALCULATE ESTIMATED DAILY INTAKE : Surficial sediment / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2018)
MEDIUM: SEDIMENT
EXPOSURE MEDIUM: Surficial sediment
EXPOSURE POINT: RME - Primary Erosional Zone/Primary Inventory Zone
RECEPTOR: HERON

EXPOSURE ROUTE	PARAMETER SYMBOL	PARAMETER DEFINITION	UNITS	RME VALUE	RME RATIONALE/ REFERENCE	INTAKE EQUATION/ MODEL NAME
INGESTION	EDI_{sed}	ESTIMATED DAILY INTAKE VIA SEDIMENT INGESTION	mg/kg-d	calculated		SEDIMENT INTAKE-INGESTION
	C_{sed}	CHEMICAL CONCENTRATION IN SEDIMENT	mg/kg	chemical-specific		$EDI_{sed} = C_{sed} * IR_{sed} * SFF * EF * 1/BW$
	IR_{sed}	INGESTION RATE OF SEDIMENT	kg/day	0.019	assumption	
	SFF	SITE FORAGING FREQUENCY	unitless	100%	Bayer, 1978	
	EF	EXPOSURE FREQUENCY	unitless	58%	USEPA, 1993	
	BW	BODY WEIGHT	kg	2.2	USEPA, 1993	

References:

Bayer,R.D., 1978. Aspects of an Oregon estuarine great blue heron population; In: Sprunt, A., J. Ogden, S. Winkler, eds. Wading Birds; Natl. Audubon Soc. Res. Rep. 7:213-217.

USEPA, 1993. Wildlife Exposure Factors Handbook; United States Environmental Protection Agency, Office of Research and Development; EPA/600/R-93/187a; December 1993; Washington, D.C.

TABLE 8-90
CALCULATION OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS : Surficial sediment / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2018)
MEDIUM: SEDIMENT
EXPOSURE MEDIUM: Surficial sediment
EXPOSURE POINT: RME - Primary Erosional Zone/Primary Inventory Zone
RECEPTOR: HERON

Analyte	Medium EPC	Medium EPC Units	Estimated Daily Intake[a]	Daily Intake Units	Reference Dose (NOAEL)[b]	Reference Dose (LOAEL)[b]	Reference Dose Units	Hazard Quotient (NOAEL)[c]	Hazard Quotient (LOAEL)[c]
Copper	1.3E+02	mg/kg	6.9E-01	mg/kg-d	4.1E+00	1.2E+01	mg/kg-d	1.7E-01	5.7E-02
Lead	2.3E+02	mg/kg	1.2E+00	mg/kg-d	1.6E+00	3.3E+00	mg/kg-d	7.1E-01	3.6E-01
Methyl Mercury	1.4E+00	mg/kg	7.0E-03	mg/kg-d	7.8E-03	7.8E-02	mg/kg-d	9.0E-01	9.0E-02
LPAH	3.3E+01	mg/kg	1.7E-01	mg/kg-d	-	-			
HPAH	8.6E+01	mg/kg	4.4E-01	mg/kg-d	-	-			
Dieldrin	1.9E-02	mg/kg	9.7E-05	mg/kg-d	7.1E-02	3.8E+00	mg/kg-d	1.4E-03	2.6E-05
Total DDx	1.7E-01	mg/kg	8.7E-04	mg/kg-d	2.8E-03	2.8E-02	mg/kg-d	3.1E-01	3.1E-02
Total PCBs	5.0E-01	mg/kg	2.6E-03	mg/kg-d	1.0E-01	4.0E-01	mg/kg-d	2.6E-02	6.5E-03
TEQ PCB-birds	1.5E-04	mg/kg	7.6E-07	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	5.4E-01	5.4E-02
TEQ D/F-birds	6.6E-04	mg/kg	3.4E-06	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	**2.4E+00**	2.4E-01
							HAZARD INDICES:	**5.1E+00**	8.4E-01

Notes:
a. Estimated Daily Intake (EDI) calculated using parameters presented in Table 8-89.
b. Reference Dose Values presented in Table 6-4. A dash indicates that no value is available.
c. Hazard Quotients (HQs) calculated by dividing the Estimated Daily Intake dose by either the NOAEL- or LOAEL-based Reference Dose.

TABLE 8-91
PARAMETER VALUES USED TO CALCULATE ESTIMATED DAILY INTAKE : Blue crab / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2018)
MEDIUM: AQUATIC INVERTEBRATES
EXPOSURE MEDIUM: Blue crab
EXPOSURE POINT: RME - Primary Erosional Zone/Primary Inventory Zone
RECEPTOR: HERON

EXPOSURE ROUTE	PARAMETER SYMBOL	PARAMETER DEFINITION	UNITS	RME VALUE	RME RATIONALE/ REFERENCE	INTAKE EQUATION/ MODEL NAME
INGESTION	EDI_{invert}	ESTIMATED DAILY INTAKE VIA INVERTEBRATE INGESTION	mg/kg-d	calculated		INVERTEBRATE INTAKE-INGESTION $EDI_{invert} = C_{invert} * IR_{food} * P_{invert} * SFF * EF * 1/BW$
	C_{invert}	CHEMICAL CONCENTRATION IN INVERTEBRATES	mg/kg	chemical-specific		
	IR_{food}	INGESTION RATE OF FOOD	kg/day	0.39	Kushlan, 1978	
	P_{invert}	PERCENT INVERTEBRATES IN DIET	unitless	15%	assumption	Where C_{invert} is estimated using site-specific tissue data or calculated using the following equation: $C_{invert} = C_{sed} * BAF_{invert}$
	SFF	SITE FORAGING FREQUENCY	unitless	100%	Bayer, 1978	
	EF	EXPOSURE FREQUENCY	unitless	58%	USEPA, 1993	Bioaccumulation Factors [mg(ww tissue)/ kg(dw sediment)] provided separately.
	BW	BODY WEIGHT	kg	2.2	USEPA, 1993	

References:

Bayer,R.D., 1978. Aspects of an Oregon estuarine great blue heron population; In: Sprunt, A., J. Ogden, S. Winkler, eds. Wading Birds; Natl. Audubon Soc. Res. Rep. 7:213-217.

Kushlan, J.A., 1978. Feeding ecology of wading birds; In: Sprunt, A., J. Ogden, S. Winkler, eds. Wading Birds; Natl. Audubon Soc. Res. Rep. 7:213-217.

USEPA, 1993. Wildlife Exposure Factors Handbook; United States Environmental Protection Agency, Office of Research and Development; EPA/600/R-93/187a; December 1993; Washington, D.C.

TABLE 8-92
CALCULATION OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS : Blue crab / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2018)
MEDIUM: AQUATIC INVERTEBRATES
EXPOSURE MEDIUM: Blue crab
EXPOSURE POINT: RME - Primary Erosional Zone/Primary Inventory Zone
RECEPTOR: HERON

Analyte	Medium EPC	Medium EPC Units	Estimated Daily Intake[a]	Daily Intake Units	Reference Dose (NOAEL)[b]	Reference Dose (LOAEL)[b]	Reference Dose Units	Hazard Quotient (NOAEL)[c]	Hazard Quotient (LOAEL)[c]
Copper	1.9E+01	mg/kg	2.9E-01	mg/kg-d	4.1E+00	1.2E+01	mg/kg-d	7.1E-02	2.4E-02
Lead	3.2E-01	mg/kg	4.9E-03	mg/kg-d	1.6E+00	3.3E+00	mg/kg-d	3.0E-03	1.5E-03
Methyl Mercury	3.8E-02	mg/kg	5.9E-04	mg/kg-d	7.8E-03	7.8E-02	mg/kg-d	7.6E-02	7.6E-03
LPAH	2.5E-01	mg/kg	3.8E-03	mg/kg-d	-	-			
HPAH	2.7E-01	mg/kg	4.2E-03	mg/kg-d	-	-			
Dieldrin	1.3E-02	mg/kg	2.0E-04	mg/kg-d	7.1E-02	3.8E+00	mg/kg-d	2.8E-03	5.2E-05
Total DDx	1.9E-01	mg/kg	2.9E-03	mg/kg-d	2.8E-03	2.8E-02	mg/kg-d	**1.0E+00**	1.0E-01
Total PCBs	1.0E+00	mg/kg	1.6E-02	mg/kg-d	1.0E-01	4.0E-01	mg/kg-d	1.6E-01	4.0E-02
TEQ PCB-birds	1.9E-04	mg/kg	3.0E-06	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	**2.1E+00**	2.1E-01
TEQ D/F-birds	1.1E-04	mg/kg	1.7E-06	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	**1.2E+00**	1.2E-01
							HAZARD INDICES:	**4.7E+00**	5.1E-01

Notes:
a. Estimated Daily Intake (EDI) calculated using parameters presented in Table 8-91.
b. Reference Dose Values presented in Table 6-4. A dash indicates that no value is available.
c. Hazard Quotients (HQs) calculated by dividing the Estimated Daily Intake dose by either the NOAEL- or LOAEL-based Reference Dose.

TABLE 8-93
PARAMETER VALUES USED TO CALCULATE ESTIMATED DAILY INTAKE : White perch/American eel / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2018)
MEDIUM: FISH
EXPOSURE MEDIUM: White perch/American eel
EXPOSURE POINT: RME - Primary Erosional Zone/Primary Inventory Zone
RECEPTOR: HERON

EXPOSURE ROUTE	PARAMETER SYMBOL	PARAMETER DEFINITION	UNITS	RME VALUE	RME RATIONALE/ REFERENCE	INTAKE EQUATION/ MODEL NAME
INGESTION	EDI_{fish}	ESTIMATED DAILY INTAKE VIA FISH INGESTION	mg/kg-d	calculated		FISH INTAKE-INGESTION
	C_{fish}	CHEMICAL CONCENTRATION IN FISH	mg/kg	chemical-specific		$EDI_{fish} = C_{fish} * IR_{food} * P_{fish} * SFF * EF * 1/BW$
	IR_{food}	INGESTION RATE OF FOOD	kg/day	0.39	Kushlan, 1978	
	P_{fish}	PERCENT FISH IN DIET	unitless	85%	assumption	Where C_{fish} is estimated using site-specific tissue data or estimated using the following equation:
	SFF	SITE FORAGING FREQUENCY	unitless	100%	Bayer, 1978	$C_{fish} = C_{sed} * BAF_{fish}$
	EF	EXPOSURE FREQUENCY	unitless	58%	USEPA, 1993	Bioaccumulation Factors [mg(ww tissue)/ kg(dw sediment)] provided separately.
	BW	BODY WEIGHT	kg	2.2	USEPA, 1993	

References:

Bayer,R.D., 1978. Aspects of an Oregon estuarine great blue heron population; In: Sprunt, A., J. Ogden, S. Winkler, eds. Wading Birds; Natl. Audubon Soc. Res. Rep. 7:213-217.

Kushlan, J.A., 1978. Feeding ecology of wading birds; In: Sprunt, A., J. Ogden, S. Winkler, eds. Wading Birds; Natl. Audubon Soc. Res. Rep. 7:213-217.

USEPA, 1993. Wildlife Exposure Factors Handbook; United States Environmental Protection Agency, Office of Research and Development; EPA/600/R-93/187a; December 1993; Washington, D.C.

TABLE 8-94
CALCULATION OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS : White perch/American eel / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2018)
MEDIUM: FISH
EXPOSURE MEDIUM: White perch/American eel
EXPOSURE POINT: RME - Primary Erosional Zone/Primary Inventory Zone
RECEPTOR: HERON

Analyte	Medium EPC	Medium EPC Units	Estimated Daily Intake[a]	Daily Intake Units	Reference Dose (NOAEL)[b]	Reference Dose (LOAEL)[b]	Reference Dose Units	Hazard Quotient (NOAEL)[c]	Hazard Quotient (LOAEL)[c]
Copper	5.4E+00	mg/kg	4.7E-01	mg/kg-d	4.1E+00	1.2E+01	mg/kg-d	1.2E-01	3.9E-02
Lead	2.7E-01	mg/kg	2.4E-02	mg/kg-d	1.6E+00	3.3E+00	mg/kg-d	1.5E-02	7.3E-03
Methyl Mercury	1.4E-01	mg/kg	1.2E-02	mg/kg-d	7.8E-03	7.8E-02	mg/kg-d	**1.6E+00**	1.6E-01
LPAH	3.6E-01	mg/kg	3.2E-02	mg/kg-d	-	-			
HPAH	2.2E-01	mg/kg	1.9E-02	mg/kg-d	-	-			
Dieldrin	3.0E-02	mg/kg	2.6E-03	mg/kg-d	7.1E-02	3.8E+00	mg/kg-d	3.7E-02	6.9E-04
Total DDx	3.1E-01	mg/kg	2.7E-02	mg/kg-d	2.8E-03	2.8E-02	mg/kg-d	**9.6E+00**	9.6E-01
Total PCBs	1.1E+00	mg/kg	9.6E-02	mg/kg-d	1.0E-01	4.0E-01	mg/kg-d	9.6E-01	2.4E-01
TEQ PCB-birds	1.6E-04	mg/kg	1.4E-05	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	**9.9E+00**	9.9E-01
TEQ D/F-birds	1.3E-04	mg/kg	1.2E-05	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	**8.3E+00**	8.3E-01
							HAZARD INDICES:	**3.0E+01**	**3.2E+00**

Notes:
a. Estimated Daily Intake (EDI) calculated using parameters presented in Table 8-93.
b. Reference Dose Values presented in Table 6-4. A dash indicates that no value is available.
c. Hazard Quotients (HQs) calculated by dividing the Estimated Daily Intake dose by either the NOAEL- or LOAEL-based Reference Dose.

TABLE 8-95
SUMMARY OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS USING NOAEL-BASED TRVs : HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2018)
EXPOSURE POINT: RME - Primary Erosional Zone/Primary Inventory Zone
RECEPTOR: HERON
TOTAL RISK (HI): 4.0E+01

	Exposure Medium[a]						
Analyte	Surface Water	Sediment	Aquatic Plants	Aquatic Invertebrates	Fish	Combined HQs[b]	Percent Contribution[c]
TCDD TEQ (D/F)		2.4E+00		1.2E+00	8.3E+00	***1.2E+01***	***30%***
Total DDx		3.1E-01		1.0E+00	9.6E+00	***1.1E+01***	***27%***
Total PCBs		2.6E-02		1.6E-01	9.6E-01	***1.1E+00***	3%
Mercury		9.0E-01	-	7.6E-02	1.6E+00	***2.5E+00***	6%
TCDD TEQ (PCBs)		5.4E-01		2.1E+00	9.9E+00	***1.3E+01***	***31%***
Lead		7.1E-01	-	3.0E-03	1.5E-02	7.3E-01	2%
Copper		1.7E-01	-	7.1E-02	1.2E-01	3.6E-01	1%
Dieldrin		1.4E-03	-	2.8E-03	3.7E-02	4.1E-02	0%
LPAH							
HPAH							
TOTAL MEDIUM-SPECIFIC RISK	**-**	**5.1E+00**	**-**	**4.7E+00**	**3.0E+01**	**4.0E+01**	
PERCENTAGE OF TOTAL RISK		**13%**		**12%**	**76%**	**100%**	

Notes:
a. Hazard Quotients presented by exposure medium; a blank cell indicates that the analyte was not a COPC for that medium; a dash entry indicates that there was no assumed exposure to that medium.
b. Combined risk across all media exposures.
c. Relative contribution of COPC to total risk associated with the ingestion exposure pathway.

TABLE 8-96
SUMMARY OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS USING LOAEL-BASED TRVs : HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2018)
EXPOSURE POINT: RME - Primary Erosional Zone/Primary Inventory Zone
RECEPTOR: HERON
TOTAL RISK (HI): 4.6E+00

Analyte	Exposure Medium[a]					Combined HQs[b]	Percent Contribution[c]
	Surface Water	Sediment	Aquatic Plants	Aquatic Invertebrates	Fish		
TCDD TEQ (D/F)		2.4E-01		1.2E-01	8.3E-01	***1.2E+00***	***26%***
Total DDx		3.1E-02		1.0E-01	9.6E-01	***1.1E+00***	***24%***
Total PCBs		6.5E-03		4.0E-02	2.4E-01	2.9E-01	6%
Lead		3.6E-01	-	1.5E-03	7.3E-03	3.6E-01	8%
Mercury		9.0E-02	-	7.6E-03	1.6E-01	2.5E-01	6%
Copper		5.7E-02	-	2.4E-02	3.9E-02	1.2E-01	3%
TCDD TEQ (PCBs)		5.4E-02		2.1E-01	9.9E-01	***1.3E+00***	***27%***
Dieldrin		2.6E-05	-	5.2E-05	6.9E-04	7.7E-04	0%
LPAH							
HPAH							
TOTAL MEDIUM-SPECIFIC RISK	**-**	**8.4E-01**	**-**	**5.1E-01**	**3.2E+00**	**4.6E+00**	
PERCENTAGE OF TOTAL RISK		**18%**		**11%**	**70%**	**100%**	

Notes:
a. Hazard Quotients presented by exposure medium; a blank cell indicates that the analyte was not a COPC for that medium; a dash entry indicates that there was no assumed exposure to that medium.
b. Combined risk across all media exposures.
c. Relative contribution of COPC to total risk associated with the ingestion exposure pathway.

TABLE 8-97
PARAMETER VALUES USED TO CALCULATE ESTIMATED DAILY INTAKE : Surficial sediment / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2048)
MEDIUM: SEDIMENT
EXPOSURE MEDIUM: Surficial sediment
EXPOSURE POINT: RME - Primary Erosional Zone/Primary Inventory Zone
RECEPTOR: HERON

EXPOSURE ROUTE	PARAMETER SYMBOL	PARAMETER DEFINITION	UNITS	RME VALUE	RME RATIONALE/ REFERENCE	INTAKE EQUATION/ MODEL NAME
INGESTION	EDI_{sed}	ESTIMATED DAILY INTAKE VIA SEDIMENT INGESTION	mg/kg-d	calculated		SEDIMENT INTAKE-INGESTION
	C_{sed}	CHEMICAL CONCENTRATION IN SEDIMENT	mg/kg	chemical-specific		$EDI_{sed} = C_{sed} * IR_{sed} * SFF * EF * 1/BW$
	IR_{sed}	INGESTION RATE OF SEDIMENT	kg/day	0.019	assumption	
	SFF	SITE FORAGING FREQUENCY	unitless	100%	Bayer, 1978	
	EF	EXPOSURE FREQUENCY	unitless	58%	USEPA, 1993	
	BW	BODY WEIGHT	kg	2.2	USEPA, 1993	

References:

Bayer,R.D., 1978. Aspects of an Oregon estuarine great blue heron population; In: Sprunt, A., J. Ogden, S. Winkler, eds. Wading Birds; Natl. Audubon Soc. Res. Rep. 7:213-217.

USEPA, 1993. Wildlife Exposure Factors Handbook; United States Environmental Protection Agency, Office of Research and Development; EPA/600/R-93/187a; December 1993; Washington, D.C.

TABLE 8-97
PARAMETER VALUES USED TO CALCULATE ESTIMATED DAILY INTAKE : Surficial sediment / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2048)
MEDIUM: SEDIMENT
EXPOSURE MEDIUM: Surficial sediment
EXPOSURE POINT: RME - Primary Erosional Zone/Primary Inventory Zone
RECEPTOR: HERON

EXPOSURE ROUTE	PARAMETER SYMBOL	PARAMETER DEFINITION	UNITS	RME VALUE	RME RATIONALE/ REFERENCE	INTAKE EQUATION/ MODEL NAME
INGESTION	EDI_{sed}	ESTIMATED DAILY INTAKE VIA SEDIMENT INGESTION	mg/kg-d	calculated		SEDIMENT INTAKE-INGESTION
	C_{sed}	CHEMICAL CONCENTRATION IN SEDIMENT	mg/kg	chemical-specific		$EDI_{sed} = C_{sed} * IR_{sed} * SFF * EF * 1/BW$
	IR_{sed}	INGESTION RATE OF SEDIMENT	kg/day	0.019	assumption	
	SFF	SITE FORAGING FREQUENCY	unitless	100%	Bayer, 1978	
	EF	EXPOSURE FREQUENCY	unitless	58%	USEPA, 1993	
	BW	BODY WEIGHT	kg	2.2	USEPA, 1993	

References:

Bayer,R.D., 1978. Aspects of an Oregon estuarine great blue heron population; In: Sprunt, A., J. Ogden, S. Winkler, eds. Wading Birds; Natl. Audubon Soc. Res. Rep. 7:213-217.

USEPA, 1993. Wildlife Exposure Factors Handbook; United States Environmental Protection Agency, Office of Research and Development; EPA/600/R-93/187a; December 1993; Washington, D.C.

TABLE 8-99
PARAMETER VALUES USED TO CALCULATE ESTIMATED DAILY INTAKE : Blue crab / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2048)
MEDIUM: AQUATIC INVERTEBRATES
EXPOSURE MEDIUM: Blue crab
EXPOSURE POINT: RME - Primary Erosional Zone/Primary Inventory Zone
RECEPTOR: HERON

EXPOSURE ROUTE	PARAMETER SYMBOL	PARAMETER DEFINITION	UNITS	RME VALUE	RME RATIONALE/ REFERENCE	INTAKE EQUATION/ MODEL NAME
INGESTION	EDI_{invert}	ESTIMATED DAILY INTAKE VIA INVERTEBRATE INGESTION	mg/kg-d	calculated		INVERTEBRATE INTAKE-INGESTION $EDI_{invert} = C_{invert} * IR_{food} * P_{invert} * SFF * EF * 1/BW$
	C_{invert}	CHEMICAL CONCENTRATION IN INVERTEBRATES	mg/kg	chemical-specific		
	IR_{food}	INGESTION RATE OF FOOD	kg/day	0.39	Kushlan, 1978	
	P_{invert}	PERCENT INVERTEBRATES IN DIET	unitless	15%	assumption	Where C_{invert} is estimated using site-specific tissue data or calculated using the following equation: $C_{invert} = C_{sed} * BAF_{invert}$
	SFF	SITE FORAGING FREQUENCY	unitless	100%	Bayer, 1978	
	EF	EXPOSURE FREQUENCY	unitless	58%	USEPA, 1993	Bioaccumulation Factors [mg(ww tissue)/ kg(dw sediment)] provided separately.
	BW	BODY WEIGHT	kg	2.2	USEPA, 1993	

References:

Bayer,R.D., 1978. Aspects of an Oregon estuarine great blue heron population; In: Sprunt, A., J. Ogden, S. Winkler, eds. Wading Birds; Natl. Audubon Soc. Res. Rep. 7:213-217.

Kushlan, J.A., 1978. Feeding ecology of wading birds; In: Sprunt, A., J. Ogden, S. Winkler, eds. Wading Birds; Natl. Audubon Soc. Res. Rep. 7:213-217.

USEPA, 1993. Wildlife Exposure Factors Handbook; United States Environmental Protection Agency, Office of Research and Development; EPA/600/R-93/187a; December 1993; Washington, D.C.

TABLE 8-100
CALCULATION OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS : Blue crab / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2048)
MEDIUM: AQUATIC INVERTEBRATES
EXPOSURE MEDIUM: Blue crab
EXPOSURE POINT: RME - Primary Erosional Zone/Primary Inventory Zone
RECEPTOR: HERON

Analyte	Medium EPC	Medium EPC Units	Estimated Daily Intake[a]	Daily Intake Units	Reference Dose (NOAEL)[b]	Reference Dose (LOAEL)[b]	Reference Dose Units	Hazard Quotient (NOAEL)[c]	Hazard Quotient (LOAEL)[c]
Copper	9.3E+00	mg/kg	1.4E-01	mg/kg-d	4.1E+00	1.2E+01	mg/kg-d	3.6E-02	1.2E-02
Lead	1.5E-01	mg/kg	2.3E-03	mg/kg-d	1.6E+00	3.3E+00	mg/kg-d	1.4E-03	7.0E-04
Methyl Mercury	1.2E-02	mg/kg	1.9E-04	mg/kg-d	7.8E-03	7.8E-02	mg/kg-d	2.4E-02	2.4E-03
LPAH	2.5E-01	mg/kg	3.8E-03	mg/kg-d	-	-			
HPAH	2.7E-01	mg/kg	4.2E-03	mg/kg-d	-	-			
Dieldrin	1.3E-02	mg/kg	2.0E-04	mg/kg-d	7.1E-02	3.8E+00	mg/kg-d	2.8E-03	5.2E-05
Total DDx	6.7E-02	mg/kg	1.0E-03	mg/kg-d	2.8E-03	2.8E-02	mg/kg-d	3.7E-01	3.7E-02
Total PCBs	2.4E-01	mg/kg	3.6E-03	mg/kg-d	1.0E-01	4.0E-01	mg/kg-d	3.6E-02	9.1E-03
TEQ PCB-birds	4.8E-05	mg/kg	7.3E-07	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	5.2E-01	5.2E-02
TEQ D/F-birds	3.1E-05	mg/kg	4.7E-07	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	3.4E-01	3.4E-02
							HAZARD INDICES:	**1.3E+00**	1.5E-01

Notes:
a. Estimated Daily Intake (EDI) calculated using parameters presented in Table 8-99.
b. Reference Dose Values presented in Table 6-4. A dash indicates that no value is available.
c. Hazard Quotients (HQs) calculated by dividing the Estimated Daily Intake dose by either the NOAEL- or LOAEL-based Reference Dose.

TABLE 8-101
PARAMETER VALUES USED TO CALCULATE ESTIMATED DAILY INTAKE : White perch/American eel / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2048)
MEDIUM: FISH
EXPOSURE MEDIUM: White perch/American eel
EXPOSURE POINT: RME - Primary Erosional Zone/Primary Inventory Zone
RECEPTOR: HERON

EXPOSURE ROUTE	PARAMETER SYMBOL	PARAMETER DEFINITION	UNITS	RME VALUE	RME RATIONALE/ REFERENCE	INTAKE EQUATION/ MODEL NAME
INGESTION	EDI_{fish}	ESTIMATED DAILY INTAKE VIA FISH INGESTION	mg/kg-d	calculated		FISH INTAKE-INGESTION
	C_{fish}	CHEMICAL CONCENTRATION IN FISH	mg/kg	chemical-specific		$EDI_{fish} = C_{fish} * IR_{food} * P_{fish} * SFF * EF * 1/BW$
	IR_{food}	INGESTION RATE OF FOOD	kg/day	0.39	Kushlan, 1978	
	P_{fish}	PERCENT FISH IN DIET	unitless	85%	assumption	Where C_{fish} is estimated using site-specific tissue data or estimated using the following equation:
	SFF	SITE FORAGING FREQUENCY	unitless	100%	Bayer, 1978	$C_{fish} = C_{sed} * BAF_{fish}$
	EF	EXPOSURE FREQUENCY	unitless	58%	USEPA, 1993	Bioaccumulation Factors [mg(ww tissue)/ kg(dw sediment)] provided separately.
	BW	BODY WEIGHT	kg	2.2	USEPA, 1993	

References:

Bayer,R.D., 1978. Aspects of an Oregon estuarine great blue heron population; In: Sprunt, A., J. Ogden, S. Winkler, eds. Wading Birds; Natl. Audubon Soc. Res. Rep. 7:213-217.

Kushlan, J.A., 1978. Feeding ecology of wading birds; In: Sprunt, A., J. Ogden, S. Winkler, eds. Wading Birds; Natl. Audubon Soc. Res. Rep. 7:213-217.

USEPA, 1993. Wildlife Exposure Factors Handbook; United States Environmental Protection Agency, Office of Research and Development; EPA/600/R-93/187a; December 1993; Washington, D.C.

TABLE 8-102
CALCULATION OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS : White perch/American eel / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2048)
MEDIUM: FISH
EXPOSURE MEDIUM: White perch/American eel
EXPOSURE POINT: RME - Primary Erosional Zone/Primary Inventory Zone
RECEPTOR: HERON

Analyte	Medium EPC	Medium EPC Units	Estimated Daily Intake[a]	Daily Intake Units	Reference Dose (NOAEL)[b]	Reference Dose (LOAEL)[b]	Reference Dose Units	Hazard Quotient (NOAEL)[c]	Hazard Quotient (LOAEL)[c]
Copper	2.7E+00	mg/kg	2.4E-01	mg/kg-d	4.1E+00	1.2E+01	mg/kg-d	5.9E-02	2.0E-02
Lead	1.3E-01	mg/kg	1.1E-02	mg/kg-d	1.6E+00	3.3E+00	mg/kg-d	6.7E-03	3.4E-03
Methyl Mercury	4.4E-02	mg/kg	3.9E-03	mg/kg-d	7.8E-03	7.8E-02	mg/kg-d	5.0E-01	5.0E-02
LPAH	3.6E-01	mg/kg	3.2E-02	mg/kg-d	-	-			
HPAH	2.2E-01	mg/kg	1.9E-02	mg/kg-d	-	-			
Dieldrin	3.0E-02	mg/kg	2.6E-03	mg/kg-d	7.1E-02	3.8E+00	mg/kg-d	3.7E-02	6.9E-04
Total DDx	1.1E-01	mg/kg	9.5E-03	mg/kg-d	2.8E-03	2.8E-02	mg/kg-d	**3.4E+00**	3.4E-01
Total PCBs	2.5E-01	mg/kg	2.2E-02	mg/kg-d	1.0E-01	4.0E-01	mg/kg-d	2.2E-01	5.4E-02
TEQ PCB-birds	3.9E-05	mg/kg	3.4E-06	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	**2.5E+00**	2.5E-01
TEQ D/F-birds	3.6E-05	mg/kg	3.2E-06	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	**2.3E+00**	2.3E-01
							HAZARD INDICES:	**8.9E+00**	9.4E-01

Notes:
a. Estimated Daily Intake (EDI) calculated using parameters presented in Table 8-101.
b. Reference Dose Values presented in Table 6-4. A dash indicates that no value is available.
c. Hazard Quotients (HQs) calculated by dividing the Estimated Daily Intake dose by either the NOAEL- or LOAEL-based Reference Dose.

TABLE 8-103
SUMMARY OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS USING NOAEL-BASED TRVs : HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2048)
EXPOSURE POINT: RME - Primary Erosional Zone/Primary Inventory Zone
RECEPTOR: HERON
TOTAL RISK (HI): 1.2E+01

Analyte	Exposure Medium[a]					Combined HQs[b]	Percent Contribution[c]
	Surface Water	Sediment	Aquatic Plants	Aquatic Invertebrates	Fish		
Total DDx		1.1E-01		3.7E-01	3.4E+00	***3.9E+00***	***33%***
TCDD TEQ (D/F)		6.6E-01		3.4E-01	2.3E+00	***3.3E+00***	***27%***
Mercury		2.9E-01	-	2.4E-02	5.0E-01	8.1E-01	7%
Total PCBs		5.9E-03		3.6E-02	2.2E-01	2.6E-01	2%
Lead		3.3E-01	-	1.4E-03	6.7E-03	3.4E-01	3%
TCDD TEQ (PCBs)		1.3E-01		5.2E-01	2.5E+00	***3.1E+00***	***26%***
Copper		8.5E-02	-	3.6E-02	5.9E-02	1.8E-01	2%
Dieldrin		1.4E-03	-	2.8E-03	3.7E-02	4.1E-02	0%
LPAH							
HPAH							
TOTAL MEDIUM-SPECIFIC RISK	**-**	**1.6E+00**	**-**	**1.3E+00**	**8.9E+00**	**1.2E+01**	
PERCENTAGE OF TOTAL RISK		**14%**		**11%**	**75%**	**100%**	

Notes:
a. Hazard Quotients presented by exposure medium; a blank cell indicates that the analyte was not a COPC for that medium; a dash entry indicates that there was no assumed exposure to that medium.
b. Combined risk across all media exposures.
c. Relative contribution of COPC to total risk associated with the ingestion exposure pathway.

TABLE 8-104
SUMMARY OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS USING LOAEL-BASED TRVs : HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2048)
EXPOSURE POINT: RME - Primary Erosional Zone/Primary Inventory Zone
RECEPTOR: HERON
TOTAL RISK (HI): 1.4E+00

Analyte	Exposure Medium[a]					Combined HQs[b]	Percent Contribution[c]
	Surface Water	Sediment	Aquatic Plants	Aquatic Invertebrates	Fish		
Total DDx		1.1E-02		3.7E-02	3.4E-01	3.9E-01	***28%***
TCDD TEQ (D/F)		6.6E-02		3.4E-02	2.3E-01	3.3E-01	***23%***
Lead		1.6E-01	-	7.0E-04	3.4E-03	1.7E-01	***12%***
Total PCBs		1.5E-03		9.1E-03	5.4E-02	6.5E-02	5%
Mercury		2.9E-02	-	2.4E-03	5.0E-02	8.1E-02	6%
Copper		2.8E-02	-	1.2E-02	2.0E-02	6.0E-02	4%
TCDD TEQ (PCBs)		1.3E-02		5.2E-02	2.5E-01	3.1E-01	***22%***
Dieldrin		2.6E-05	-	5.2E-05	6.9E-04	7.7E-04	0%
LPAH							
HPAH							
TOTAL MEDIUM-SPECIFIC RISK	**-**	**3.1E-01**	**-**	**1.5E-01**	**9.4E-01**	**1.4E+00**	
PERCENTAGE OF TOTAL RISK		**22%**		**11%**	**67%**	**100%**	

Notes:
a. Hazard Quotients presented by exposure medium; a blank cell indicates that the analyte was not a COPC for that medium; a dash entry indicates that there was no assumed exposure to that medium.
b. Combined risk across all media exposures.
c. Relative contribution of COPC to total risk associated with the ingestion exposure pathway.

Attachment 8

TABLE 8-105

PARAMETER VALUES USED TO CALCULATE ESTIMATED DAILY INTAKE : Surficial sediment / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2018)
MEDIUM: SEDIMENT
EXPOSURE MEDIUM: Surficial sediment
EXPOSURE POINT: RME - Primary Erosional Zone/Primary Inventory Zone
RECEPTOR: HERON

EXPOSURE ROUTE	PARAMETER SYMBOL	PARAMETER DEFINITION	UNITS	RME VALUE	RME RATIONALE/ REFERENCE	INTAKE EQUATION/ MODEL NAME
INGESTION	EDI_{sed}	ESTIMATED DAILY INTAKE VIA SEDIMENT INGESTION	mg/kg-d	calculated		SEDIMENT INTAKE-INGESTION
	C_{sed}	CHEMICAL CONCENTRATION IN SEDIMENT	mg/kg	chemical-specific		$EDI_{sed} = C_{sed} * IR_{sed} * SFF * EF * 1/BW$
	IR_{sed}	INGESTION RATE OF SEDIMENT	kg/day	0.019	assumption	
	SFF	SITE FORAGING FREQUENCY	unitless	100%	Bayer, 1978	
	EF	EXPOSURE FREQUENCY	unitless	58%	USEPA, 1993	
	BW	BODY WEIGHT	kg	2.2	USEPA, 1993	

References:

Bayer,R.D., 1978. Aspects of an Oregon estuarine great blue heron population; In: Sprunt, A., J. Ogden, S. Winkler, eds. Wading Birds; Natl. Audubon Soc. Res. Rep. 7:213-217.

USEPA, 1993. Wildlife Exposure Factors Handbook; United States Environmental Protection Agency, Office of Research and Development; EPA/600/R-93/187a; December 1993; Washington, D.C.

Attachment 8

TABLE 8-106

CALCULATION OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS : Surficial sediment / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2018)
MEDIUM: SEDIMENT
EXPOSURE MEDIUM: Surficial sediment
EXPOSURE POINT: RME - Primary Erosional Zone/Primary Inventory Zone
RECEPTOR: HERON

Analyte	Medium EPC	Medium EPC Units	Estimated Daily Intake[a]	Daily Intake Units	Reference Dose (NOAEL)[b]	Reference Dose (LOAEL)[b]	Reference Dose Units	Hazard Quotient (NOAEL)[c]	Hazard Quotient (LOAEL)[c]
Copper	1.3E+02	mg/kg	6.9E-01	mg/kg-d	4.1E+00	1.2E+01	mg/kg-d	1.7E-01	5.7E-02
Lead	2.3E+02	mg/kg	1.2E+00	mg/kg-d	1.6E+00	3.3E+00	mg/kg-d	7.1E-01	3.6E-01
Methyl Mercury	1.4E+00	mg/kg	7.0E-03	mg/kg-d	7.8E-03	7.8E-02	mg/kg-d	9.0E-01	9.0E-02
LPAH	3.3E+01	mg/kg	1.7E-01	mg/kg-d	-	-			
HPAH	8.6E+01	mg/kg	4.4E-01	mg/kg-d	-	-			
Dieldrin	1.9E-02	mg/kg	9.7E-05	mg/kg-d	7.1E-02	3.8E+00	mg/kg-d	1.4E-03	2.6E-05
Total DDx	1.7E-01	mg/kg	8.7E-04	mg/kg-d	2.8E-03	2.8E-02	mg/kg-d	3.1E-01	3.1E-02
Total PCBs	5.0E-01	mg/kg	2.6E-03	mg/kg-d	1.0E-01	4.0E-01	mg/kg-d	2.6E-02	6.5E-03
TEQ PCB-birds	1.5E-04	mg/kg	7.6E-07	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	5.4E-01	5.4E-02
TEQ D/F-birds	6.6E-04	mg/kg	3.4E-06	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	**2.4E+00**	2.4E-01
							HAZARD INDICES:	**5.1E+00**	8.4E-01

Notes:
a. Estimated Daily Intake (EDI) calculated using parameters presented in Table 8-105.
b. Reference Dose Values presented in Table 6-4. A dash indicates that no value is available.
c. Hazard Quotients (HQs) calculated by dividing the Estimated Daily Intake dose by either the NOAEL- or LOAEL-based Reference Dose.

Attachment 8

TABLE 8-107

PARAMETER VALUES USED TO CALCULATE ESTIMATED DAILY INTAKE : Blue crab / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2018)
MEDIUM: AQUATIC INVERTEBRATES
EXPOSURE MEDIUM: Blue crab
EXPOSURE POINT: RME - Primary Erosional Zone/Primary Inventory Zone
RECEPTOR: HERON

EXPOSURE ROUTE	PARAMETER SYMBOL	PARAMETER DEFINITION	UNITS	RME VALUE	RME RATIONALE/ REFERENCE	INTAKE EQUATION/ MODEL NAME
INGESTION	EDI_{invert}	ESTIMATED DAILY INTAKE VIA INVERTEBRATE INGESTION	mg/kg-d	calculated		INVERTEBRATE INTAKE-INGESTION $EDI_{invert} = C_{invert} * IR_{food} * P_{invert} * SFF * EF * 1/BW$
	C_{invert}	CHEMICAL CONCENTRATION IN INVERTEBRATES	mg/kg	chemical-specific		
	IR_{food}	INGESTION RATE OF FOOD	kg/day	0.39	Kushlan, 1978	
	P_{invert}	PERCENT INVERTEBRATES IN DIET	unitless	15%	assumption	Where C_{invert} is estimated using site-specific tissue data or calculated using the following equation: $C_{invert} = C_{sed} * BAF_{invert}$
	SFF	SITE FORAGING FREQUENCY	unitless	100%	Bayer, 1978	
	EF	EXPOSURE FREQUENCY	unitless	58%	USEPA, 1993	Bioaccumulation Factors [mg(ww tissue)/ kg(dw sediment)] provided separately.
	BW	BODY WEIGHT	kg	2.2	USEPA, 1993	

References:

Bayer,R.D., 1978. Aspects of an Oregon estuarine great blue heron population; In: Sprunt, A., J. Ogden, S. Winkler, eds. Wading Birds; Natl. Audubon Soc. Res. Rep. 7:213-217.

Kushlan, J.A., 1978. Feeding ecology of wading birds; In: Sprunt, A., J. Ogden, S. Winkler, eds. Wading Birds; Natl. Audubon Soc. Res. Rep. 7:213-217.

USEPA, 1993. Wildlife Exposure Factors Handbook; United States Environmental Protection Agency, Office of Research and Development; EPA/600/R-93/187a; December 1993; Washington, D.C.

Attachment 8

TABLE 8-108

CALCULATION OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS : Blue crab / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2018)
MEDIUM: AQUATIC INVERTEBRATES
EXPOSURE MEDIUM: Blue crab
EXPOSURE POINT: RME - Primary Erosional Zone/Primary Inventory Zone
RECEPTOR: HERON

Analyte	Medium EPC	Medium EPC Units	Estimated Daily Intake[a]	Daily Intake Units	Reference Dose (NOAEL)[b]	Reference Dose (LOAEL)[b]	Reference Dose Units	Hazard Quotient (NOAEL)[c]	Hazard Quotient (LOAEL)[c]
Copper	1.9E+01	mg/kg	2.9E-01	mg/kg-d	4.1E+00	1.2E+01	mg/kg-d	7.1E-02	2.4E-02
Lead	3.2E-01	mg/kg	4.9E-03	mg/kg-d	1.6E+00	3.3E+00	mg/kg-d	3.0E-03	1.5E-03
Methyl Mercury	3.8E-02	mg/kg	5.9E-04	mg/kg-d	7.8E-03	7.8E-02	mg/kg-d	7.6E-02	7.6E-03
LPAH	2.5E-01	mg/kg	3.8E-03	mg/kg-d	-	-			
HPAH	2.7E-01	mg/kg	4.2E-03	mg/kg-d	-	-			
Dieldrin	1.3E-02	mg/kg	2.0E-04	mg/kg-d	7.1E-02	3.8E+00	mg/kg-d	2.8E-03	5.2E-05
Total DDx	1.9E-01	mg/kg	2.9E-03	mg/kg-d	2.8E-03	2.8E-02	mg/kg-d	**1.0E+00**	1.0E-01
Total PCBs	1.0E+00	mg/kg	1.6E-02	mg/kg-d	1.0E-01	4.0E-01	mg/kg-d	1.6E-01	4.0E-02
TEQ PCB-birds	1.9E-04	mg/kg	3.0E-06	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	**2.1E+00**	2.1E-01
TEQ D/F-birds	1.1E-04	mg/kg	1.7E-06	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	**1.2E+00**	1.2E-01
							HAZARD INDICES:	**4.7E+00**	5.1E-01

Notes:
a. Estimated Daily Intake (EDI) calculated using parameters presented in Table 8-107.
b. Reference Dose Values presented in Table 6-4. A dash indicates that no value is available.
c. Hazard Quotients (HQs) calculated by dividing the Estimated Daily Intake dose by either the NOAEL- or LOAEL-based Reference Dose.

Attachment 8

TABLE 8-109

PARAMETER VALUES USED TO CALCULATE ESTIMATED DAILY INTAKE : Mummichog / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2018)
MEDIUM: FISH
EXPOSURE MEDIUM: Mummichog
EXPOSURE POINT: RME - Primary Erosional Zone/Primary Inventory Zone
RECEPTOR: HERON

EXPOSURE ROUTE	PARAMETER SYMBOL	PARAMETER DEFINITION	UNITS	RME VALUE	RME RATIONALE/ REFERENCE	INTAKE EQUATION/ MODEL NAME
INGESTION	EDI_{fish}	ESTIMATED DAILY INTAKE VIA FISH INGESTION	mg/kg-d	calculated		FISH INTAKE-INGESTION
	C_{fish}	CHEMICAL CONCENTRATION IN FISH	mg/kg	chemical-specific		$EDI_{fish} = C_{fish} * IR_{food} * P_{fish} * SFF * EF * 1/BW$
	IR_{food}	INGESTION RATE OF FOOD	kg/day	0.39	Kushlan, 1978	
	P_{fish}	PERCENT FISH IN DIET	unitless	85%	assumption	Where C_{fish} is estimated using site-specific tissue data or estimated using the following equation:
	SFF	SITE FORAGING FREQUENCY	unitless	100%	Bayer, 1978	$C_{fish} = C_{sed} * BAF_{fish}$
	EF	EXPOSURE FREQUENCY	unitless	58%	USEPA, 1993	Bioaccumulation Factors [mg(ww tissue)/ kg(dw sediment)] provided separately.
	BW	BODY WEIGHT	kg	2.2	USEPA, 1993	

References:

Bayer,R.D., 1978. Aspects of an Oregon estuarine great blue heron population; In: Sprunt, A., J. Ogden, S. Winkler, eds. Wading Birds; Natl. Audubon Soc. Res. Rep. 7:213-217.

Kushlan, J.A., 1978. Feeding ecology of wading birds; In: Sprunt, A., J. Ogden, S. Winkler, eds. Wading Birds; Natl. Audubon Soc. Res. Rep. 7:213-217.

USEPA, 1993. Wildlife Exposure Factors Handbook; United States Environmental Protection Agency, Office of Research and Development; EPA/600/R-93/187a; December 1993; Washington, D.C.

Attachment 8

TABLE 8-110

CALCULATION OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS : Mummichog / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2018)
MEDIUM: FISH
EXPOSURE MEDIUM: Mummichog
EXPOSURE POINT: RME - Primary Erosional Zone/Primary Inventory Zone
RECEPTOR: HERON

Analyte	Medium EPC	Medium EPC Units	Estimated Daily Intake[a]	Daily Intake Units	Reference Dose (NOAEL)[b]	Reference Dose (LOAEL)[b]	Reference Dose Units	Hazard Quotient (NOAEL)[c]	Hazard Quotient (LOAEL)[c]
Copper	2.3E+00	mg/kg	2.0E-01	mg/kg-d	4.1E+00	1.2E+01	mg/kg-d	4.9E-02	1.6E-02
Lead	4.9E-01	mg/kg	4.3E-02	mg/kg-d	1.6E+00	3.3E+00	mg/kg-d	2.6E-02	1.3E-02
Methyl Mercury	1.7E-02	mg/kg	1.5E-03	mg/kg-d	7.8E-03	7.8E-02	mg/kg-d	1.9E-01	1.9E-02
LPAH	3.1E-01	mg/kg	2.7E-02	mg/kg-d	-	-			
HPAH	1.5E-01	mg/kg	1.3E-02	mg/kg-d	-	-			
Dieldrin	4.2E-03	mg/kg	3.7E-04	mg/kg-d	7.1E-02	3.8E+00	mg/kg-d	5.2E-03	9.7E-05
Total DDx	5.4E-02	mg/kg	4.7E-03	mg/kg-d	2.8E-03	2.8E-02	mg/kg-d	**1.7E+00**	1.7E-01
Total PCBs	2.6E-01	mg/kg	2.2E-02	mg/kg-d	1.0E-01	4.0E-01	mg/kg-d	2.2E-01	5.6E-02
TEQ PCB-birds	4.3E-05	mg/kg	3.7E-06	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	**2.7E+00**	2.7E-01
TEQ D/F-birds	6.1E-05	mg/kg	5.4E-06	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	**3.8E+00**	3.8E-01
							HAZARD INDICES:	**8.7E+00**	9.2E-01

Notes:
a. Estimated Daily Intake (EDI) calculated using parameters presented in Table 8-109.
b. Reference Dose Values presented in Table 6-4. A dash indicates that no value is available.
c. Hazard Quotients (HQs) calculated by dividing the Estimated Daily Intake dose by either the NOAEL- or LOAEL-based Reference Dose.

Attachment 8

TABLE 8-111

SUMMARY OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS USING NOAEL-BASED TRVs : HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2018)
EXPOSURE POINT: RME - Primary Erosional Zone/Primary Inventory Zone
RECEPTOR: HERON
TOTAL RISK (HI): 1.8E+01

	Exposure Medium[a]						
Analyte	Surface Water	Sediment	Aquatic Plants	Aquatic Invertebrates	Fish	Combined HQs[b]	Percent Contribution[c]
TCDD TEQ (D/F)		2.4E+00		1.2E+00	3.8E+00	***7.5E+00***	***41%***
Total DDx		3.1E-01		1.0E+00	1.7E+00	***3.0E+00***	***16%***
Mercury		9.0E-01		7.6E-02	1.9E-01	***1.2E+00***	6%
Total PCBs		2.6E-02		1.6E-01	2.2E-01	4.1E-01	2%
Lead		7.1E-01		3.0E-03	2.6E-02	7.4E-01	4%
TCDD TEQ (PCBs)		5.4E-01		2.1E+00	2.7E+00	***5.3E+00***	***29%***
Copper		1.7E-01		7.1E-02	4.9E-02	2.9E-01	2%
Dieldrin		1.4E-03		2.8E-03	5.2E-03	9.3E-03	0%
LPAH							
HPAH							
TOTAL MEDIUM-SPECIFIC RISK	**-**	**5.1E+00**	**-**	**4.7E+00**	**8.7E+00**	**1.8E+01**	
PERCENTAGE OF TOTAL RISK		**28%**		**25%**	**47%**	**100%**	

Notes:
a. Hazard Quotients presented by exposure medium; a blank cell indicates that the analyte was not a COPC for that medium; a dash entry indicates that there was no assumed exposure to that medium.
b. Combined risk across all media exposures.
c. Relative contribution of COPC to total risk associated with the ingestion exposure pathway.

Attachment 8

TABLE 8-112

SUMMARY OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS USING LOAEL-BASED TRVs : HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2018)
EXPOSURE POINT: RME - Primary Erosional Zone/Primary Inventory Zone
RECEPTOR: HERON
TOTAL RISK (HI): 2.3E+00

Analyte	Exposure Medium[a]					Combined HQs[b]	Percent Contribution[c]
	Surface Water	Sediment	Aquatic Plants	Aquatic Invertebrates	Fish		
TCDD TEQ (D/F)		2.4E-01		1.2E-01	3.8E-01	7.5E-01	***33%***
Lead		3.6E-01		1.5E-03	1.3E-02	3.7E-01	***16%***
Total DDx		3.1E-02		1.0E-01	1.7E-01	3.0E-01	***13%***
Total PCBs		6.5E-03		4.0E-02	5.6E-02	1.0E-01	5%
Mercury		9.0E-02		7.6E-03	1.9E-02	1.2E-01	5%
Copper		5.7E-02		2.4E-02	1.6E-02	9.7E-02	4%
TCDD TEQ (PCBs)		5.4E-02		2.1E-01	2.7E-01	5.3E-01	***23%***
Dieldrin		2.6E-05		5.2E-05	9.7E-05	1.7E-04	0%
LPAH							
HPAH							
TOTAL MEDIUM-SPECIFIC RISK	**-**	**8.4E-01**	**-**	**5.1E-01**	**9.2E-01**	**2.3E+00**	
PERCENTAGE OF TOTAL RISK		**37%**		**23%**	**41%**	**100%**	

Notes:

a. Hazard Quotients presented by exposure medium; a blank cell indicates that the analyte was not a COPC for that medium; a dash entry indicates that there was no assumed exposure to that medium.

b. Combined risk across all media exposures.

c. Relative contribution of COPC to total risk associated with the ingestion exposure pathway.

Attachment 8

TABLE 8-113

PARAMETER VALUES USED TO CALCULATE ESTIMATED DAILY INTAKE : Surficial sediment / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2048)
MEDIUM: SEDIMENT
EXPOSURE MEDIUM: Surficial sediment
EXPOSURE POINT: RME - Primary Erosional Zone/Primary Inventory Zone
RECEPTOR: HERON

EXPOSURE ROUTE	PARAMETER SYMBOL	PARAMETER DEFINITION	UNITS	RME VALUE	RME RATIONALE/ REFERENCE	INTAKE EQUATION/ MODEL NAME
INGESTION	EDI_{sed}	ESTIMATED DAILY INTAKE VIA SEDIMENT INGESTION	mg/kg-d	calculated		SEDIMENT INTAKE-INGESTION
	C_{sed}	CHEMICAL CONCENTRATION IN SEDIMENT	mg/kg	chemical-specific		$EDI_{sed} = C_{sed} * IR_{sed} * SFF * EF * 1/BW$
	IR_{sed}	INGESTION RATE OF SEDIMENT	kg/day	0.019	assumption	
	SFF	SITE FORAGING FREQUENCY	unitless	100%	Bayer, 1978	
	EF	EXPOSURE FREQUENCY	unitless	58%	USEPA, 1993	
	BW	BODY WEIGHT	kg	2.2	USEPA, 1993	

References:

Bayer,R.D., 1978. Aspects of an Oregon estuarine great blue heron population; In: Sprunt, A., J. Ogden, S. Winkler, eds. Wading Birds; Natl. Audubon Soc. Res. Rep. 7:213-217.

USEPA, 1993. Wildlife Exposure Factors Handbook; United States Environmental Protection Agency, Office of Research and Development; EPA/600/R-93/187a; December 1993; Washington, D.C.

Attachment 8

TABLE 8-114

CALCULATION OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS : Surficial sediment / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2048)
MEDIUM: SEDIMENT
EXPOSURE MEDIUM: Surficial sediment
EXPOSURE POINT: RME - Primary Erosional Zone/Primary Inventory Zone
RECEPTOR: HERON

Analyte	Medium EPC	Medium EPC Units	Estimated Daily Intake[a]	Daily Intake Units	Reference Dose (NOAEL)[b]	Reference Dose (LOAEL)[b]	Reference Dose Units	Hazard Quotient (NOAEL)[c]	Hazard Quotient (LOAEL)[c]
Copper	6.7E+01	mg/kg	3.4E-01	mg/kg-d	4.1E+00	1.2E+01	mg/kg-d	8.5E-02	2.8E-02
Lead	1.0E+02	mg/kg	5.4E-01	mg/kg-d	1.6E+00	3.3E+00	mg/kg-d	3.3E-01	1.6E-01
Methyl Mercury	4.4E-01	mg/kg	2.2E-03	mg/kg-d	7.8E-03	7.8E-02	mg/kg-d	2.9E-01	2.9E-02
LPAH	3.3E+01	mg/kg	1.7E-01	mg/kg-d	-	-			
HPAH	8.6E+01	mg/kg	4.4E-01	mg/kg-d	-	-			
Dieldrin	1.9E-02	mg/kg	9.7E-05	mg/kg-d	7.1E-02	3.8E+00	mg/kg-d	1.4E-03	2.6E-05
Total DDx	6.0E-02	mg/kg	3.1E-04	mg/kg-d	2.8E-03	2.8E-02	mg/kg-d	1.1E-01	1.1E-02
Total PCBs	1.1E-01	mg/kg	5.9E-04	mg/kg-d	1.0E-01	4.0E-01	mg/kg-d	5.9E-03	1.5E-03
TEQ PCB-birds	3.6E-05	mg/kg	1.9E-07	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	1.3E-01	1.3E-02
TEQ D/F-birds	1.8E-04	mg/kg	9.3E-07	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	6.6E-01	6.6E-02
							HAZARD INDICES:	**1.6E+00**	3.1E-01

Notes:
a. Estimated Daily Intake (EDI) calculated using parameters presented in Table 8-113.
b. Reference Dose Values presented in Table 6-4. A dash indicates that no value is available.
c. Hazard Quotients (HQs) calculated by dividing the Estimated Daily Intake dose by either the NOAEL- or LOAEL-based Reference Dose.

Attachment 8

TABLE 8-115

PARAMETER VALUES USED TO CALCULATE ESTIMATED DAILY INTAKE : Blue crab / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2048)
MEDIUM: AQUATIC INVERTEBRATES
EXPOSURE MEDIUM: Blue crab
EXPOSURE POINT: RME - Primary Erosional Zone/Primary Inventory Zone
RECEPTOR: HERON

EXPOSURE ROUTE	PARAMETER SYMBOL	PARAMETER DEFINITION	UNITS	RME VALUE	RME RATIONALE/ REFERENCE	INTAKE EQUATION/ MODEL NAME
INGESTION	EDI_{invert}	ESTIMATED DAILY INTAKE VIA INVERTEBRATE INGESTION	mg/kg-d	calculated		INVERTEBRATE INTAKE-INGESTION $EDI_{invert} = C_{invert} * IR_{food} * P_{invert} * SFF * EF * 1/BW$
	C_{invert}	CHEMICAL CONCENTRATION IN INVERTEBRATES	mg/kg	chemical-specific		
	IR_{food}	INGESTION RATE OF FOOD	kg/day	0.39	Kushlan, 1978	
	P_{invert}	PERCENT INVERTEBRATES IN DIET	unitless	15%	assumption	Where C_{invert} is estimated using site-specific tissue data or calculated using the following equation: $C_{invert} = C_{sed} * BAF_{invert}$
	SFF	SITE FORAGING FREQUENCY	unitless	100%	Bayer, 1978	
	EF	EXPOSURE FREQUENCY	unitless	58%	USEPA, 1993	Bioaccumulation Factors [mg(ww tissue)/ kg(dw sediment)] provided separately.
	BW	BODY WEIGHT	kg	2.2	USEPA, 1993	

References:

Bayer,R.D., 1978. Aspects of an Oregon estuarine great blue heron population; In: Sprunt, A., J. Ogden, S. Winkler, eds. Wading Birds; Natl. Audubon Soc. Res. Rep. 7:213-217.

Kushlan, J.A., 1978. Feeding ecology of wading birds; In: Sprunt, A., J. Ogden, S. Winkler, eds. Wading Birds; Natl. Audubon Soc. Res. Rep. 7:213-217.

USEPA, 1993. Wildlife Exposure Factors Handbook; United States Environmental Protection Agency, Office of Research and Development; EPA/600/R-93/187a; December 1993; Washington, D.C.

Attachment 8

TABLE 8-116

CALCULATION OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS : Blue crab / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2048)
MEDIUM: AQUATIC INVERTEBRATES
EXPOSURE MEDIUM: Blue crab
EXPOSURE POINT: RME - Primary Erosional Zone/Primary Inventory Zone
RECEPTOR: HERON

Analyte	Medium EPC	Medium EPC Units	Estimated Daily Intake[a]	Daily Intake Units	Reference Dose (NOAEL)[b]	Reference Dose (LOAEL)[b]	Reference Dose Units	Hazard Quotient (NOAEL)[c]	Hazard Quotient (LOAEL)[c]
Copper	9.3E+00	mg/kg	1.4E-01	mg/kg-d	4.1E+00	1.2E+01	mg/kg-d	3.6E-02	1.2E-02
Lead	1.5E-01	mg/kg	2.3E-03	mg/kg-d	1.6E+00	3.3E+00	mg/kg-d	1.4E-03	7.0E-04
Methyl Mercury	1.2E-02	mg/kg	1.9E-04	mg/kg-d	7.8E-03	7.8E-02	mg/kg-d	2.4E-02	2.4E-03
LPAH	2.5E-01	mg/kg	3.8E-03	mg/kg-d	-	-			
HPAH	2.7E-01	mg/kg	4.2E-03	mg/kg-d	-	-			
Dieldrin	1.3E-02	mg/kg	2.0E-04	mg/kg-d	7.1E-02	3.8E+00	mg/kg-d	2.8E-03	5.2E-05
Total DDx	6.7E-02	mg/kg	1.0E-03	mg/kg-d	2.8E-03	2.8E-02	mg/kg-d	3.7E-01	3.7E-02
Total PCBs	2.4E-01	mg/kg	3.6E-03	mg/kg-d	1.0E-01	4.0E-01	mg/kg-d	3.6E-02	9.1E-03
TEQ PCB-birds	4.8E-05	mg/kg	7.3E-07	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	5.2E-01	5.2E-02
TEQ D/F-birds	3.1E-05	mg/kg	4.7E-07	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	3.4E-01	3.4E-02
							HAZARD INDICES:	**1.3E+00**	1.5E-01

Notes:
a. Estimated Daily Intake (EDI) calculated using parameters presented in Table 8-115.
b. Reference Dose Values presented in Table 6-4. A dash indicates that no value is available.
c. Hazard Quotients (HQs) calculated by dividing the Estimated Daily Intake dose by either the NOAEL- or LOAEL-based Reference Dose.

Attachment 8

TABLE 8-117

PARAMETER VALUES USED TO CALCULATE ESTIMATED DAILY INTAKE : Mummichog / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2048)
MEDIUM: FISH
EXPOSURE MEDIUM: Mummichog
EXPOSURE POINT: RME - Primary Erosional Zone/Primary Inventory Zone
RECEPTOR: HERON

EXPOSURE ROUTE	PARAMETER SYMBOL	PARAMETER DEFINITION	UNITS	RME VALUE	RME RATIONALE/ REFERENCE	INTAKE EQUATION/ MODEL NAME
INGESTION	EDI_{fish}	ESTIMATED DAILY INTAKE VIA FISH INGESTION	mg/kg-d	calculated		FISH INTAKE-INGESTION
	C_{fish}	CHEMICAL CONCENTRATION IN FISH	mg/kg	chemical-specific		$EDI_{fish} = C_{fish} * IR_{food} * P_{fish} * SFF * EF * 1/BW$
	IR_{food}	INGESTION RATE OF FOOD	kg/day	0.39	Kushlan, 1978	
	P_{fish}	PERCENT FISH IN DIET	unitless	85%	assumption	Where C_{fish} is estimated using site-specific tissue data or estimated using the following equation:
	SFF	SITE FORAGING FREQUENCY	unitless	100%	Bayer, 1978	$C_{fish} = C_{sed} * BAF_{fish}$
	EF	EXPOSURE FREQUENCY	unitless	58%	USEPA, 1993	Bioaccumulation Factors [mg(ww tissue)/ kg(dw sediment)] provided separately.
	BW	BODY WEIGHT	kg	2.2	USEPA, 1993	

References:

Bayer,R.D., 1978. Aspects of an Oregon estuarine great blue heron population; In: Sprunt, A., J. Ogden, S. Winkler, eds. Wading Birds; Natl. Audubon Soc. Res. Rep. 7:213-217.

Kushlan, J.A., 1978. Feeding ecology of wading birds; In: Sprunt, A., J. Ogden, S. Winkler, eds. Wading Birds; Natl. Audubon Soc. Res. Rep. 7:213-217.

USEPA, 1993. Wildlife Exposure Factors Handbook; United States Environmental Protection Agency, Office of Research and Development; EPA/600/R-93/187a; December 1993; Washington, D.C.

Attachment 8

TABLE 8-118

CALCULATION OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS : Mummichog / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2048)
MEDIUM: FISH
EXPOSURE MEDIUM: Mummichog
EXPOSURE POINT: RME - Primary Erosional Zone/Primary Inventory Zone
RECEPTOR: HERON

Analyte	Medium EPC	Medium EPC Units	Estimated Daily Intake[a]	Daily Intake Units	Reference Dose (NOAEL)[b]	Reference Dose (LOAEL)[b]	Reference Dose Units	Hazard Quotient (NOAEL)[c]	Hazard Quotient (LOAEL)[c]
Copper	1.1E+00	mg/kg	9.8E-02	mg/kg-d	4.1E+00	1.2E+01	mg/kg-d	2.4E-02	8.1E-03
Lead	2.2E-01	mg/kg	2.0E-02	mg/kg-d	1.6E+00	3.3E+00	mg/kg-d	1.2E-02	6.0E-03
Methyl Mercury	5.4E-03	mg/kg	4.7E-04	mg/kg-d	7.8E-03	7.8E-02	mg/kg-d	6.0E-02	6.0E-03
LPAH	3.1E-01	mg/kg	2.7E-02	mg/kg-d	-	-			
HPAH	1.5E-01	mg/kg	1.3E-02	mg/kg-d	-	-			
Dieldrin	4.2E-03	mg/kg	3.7E-04	mg/kg-d	7.1E-02	3.8E+00	mg/kg-d	5.2E-03	9.7E-05
Total DDx	1.9E-02	mg/kg	1.7E-03	mg/kg-d	2.8E-03	2.8E-02	mg/kg-d	5.9E-01	5.9E-02
Total PCBs	5.8E-02	mg/kg	5.1E-03	mg/kg-d	1.0E-01	4.0E-01	mg/kg-d	5.1E-02	1.3E-02
TEQ PCB-birds	1.1E-05	mg/kg	9.3E-07	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	6.6E-01	6.6E-02
TEQ D/F-birds	1.7E-05	mg/kg	1.5E-06	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	**1.0E+00**	1.0E-01
							HAZARD INDICES:	**2.5E+00**	2.6E-01

Notes:
a. Estimated Daily Intake (EDI) calculated using parameters presented in Table 8-117.
b. Reference Dose Values presented in Table 6-4. A dash indicates that no value is available.
c. Hazard Quotients (HQs) calculated by dividing the Estimated Daily Intake dose by either the NOAEL- or LOAEL-based Reference Dose.

Attachment 8

TABLE 8-119

SUMMARY OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS USING NOAEL-BASED TRVs : HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2048)
EXPOSURE POINT: RME - Primary Erosional Zone/Primary Inventory Zone
RECEPTOR: HERON
TOTAL RISK (HI): 5.4E+00

	Exposure Medium[a]						
Analyte	Surface Water	Sediment	Aquatic Plants	Aquatic Invertebrates	Fish	Combined HQs[b]	Percent Contribution[c]
TCDD TEQ (D/F)		6.6E-01		3.4E-01	1.0E+00	***2.0E+00***	***38%***
Total DDx		1.1E-01		3.7E-01	5.9E-01	***1.1E+00***	***20%***
Mercury		2.9E-01		2.4E-02	6.0E-02	3.7E-01	7%
Lead		3.3E-01		1.4E-03	1.2E-02	3.4E-01	6%
Total PCBs		5.9E-03		3.6E-02	5.1E-02	9.3E-02	2%
Copper		8.5E-02		3.6E-02	2.4E-02	1.4E-01	3%
TCDD TEQ (PCBs)		1.3E-01		5.2E-01	6.6E-01	***1.3E+00***	***24%***
Dieldrin		1.4E-03		2.8E-03	5.2E-03	9.3E-03	0%
LPAH							
HPAH							
TOTAL MEDIUM-SPECIFIC RISK	**-**	**1.6E+00**	**-**	**1.3E+00**	**2.5E+00**	**5.4E+00**	
PERCENTAGE OF TOTAL RISK		**30%**		**25%**	**45%**	**100%**	

Notes:
a. Hazard Quotients presented by exposure medium; a blank cell indicates that the analyte was not a COPC for that medium; a dash entry indicates that there was no assumed exposure to that medium.
b. Combined risk across all media exposures.
c. Relative contribution of COPC to total risk associated with the ingestion exposure pathway.

Attachment 8

TABLE 8-120

SUMMARY OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS USING LOAEL-BASED TRVs : HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2048)
EXPOSURE POINT: RME - Primary Erosional Zone/Primary Inventory Zone
RECEPTOR: HERON
TOTAL RISK (HI): 7.2E-01

Analyte	Exposure Medium[a]					Combined HQs[b]	Percent Contribution[c]
	Surface Water	Sediment	Aquatic Plants	Aquatic Invertebrates	Fish		
TCDD TEQ (D/F)		6.6E-02		3.4E-02	1.0E-01	2.0E-01	***28%***
Lead		1.6E-01		7.0E-04	6.0E-03	1.7E-01	***24%***
Total DDx		1.1E-02		3.7E-02	5.9E-02	1.1E-01	***15%***
Total PCBs		1.5E-03		9.1E-03	1.3E-02	2.3E-02	3%
Copper		2.8E-02		1.2E-02	8.1E-03	4.8E-02	7%
Mercury		2.9E-02		2.4E-03	6.0E-03	3.7E-02	5%
TCDD TEQ (PCBs)		1.3E-02		5.2E-02	6.6E-02	1.3E-01	***18%***
Dieldrin		2.6E-05		5.2E-05	9.7E-05	1.7E-04	0%
LPAH							
HPAH							
TOTAL MEDIUM-SPECIFIC RISK	**-**	**3.1E-01**	**-**	**1.5E-01**	**2.6E-01**	**7.2E-01**	
PERCENTAGE OF TOTAL RISK		**43%**		**20%**	**36%**	**100%**	

Notes:
a. Hazard Quotients presented by exposure medium; a blank cell indicates that the analyte was not a COPC for that medium; a dash entry indicates that there was no assumed exposure to that medium.
b. Combined risk across all media exposures.
c. Relative contribution of COPC to total risk associated with the ingestion exposure pathway.

Attachment 8

TABLE 8-121

PARAMETER VALUES USED TO CALCULATE ESTIMATED DAILY INTAKE : Surficial sediment / MINK

Focused Feasiblity Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2018)
MEDIUM: SEDIMENT
EXPOSURE MEDIUM: Surficial sediment
EXPOSURE POINT: RME - Area of Focus
RECEPTOR: MINK

EXPOSURE ROUTE	PARAMETER SYMBOL	PARAMETER DEFINITION	UNITS	RME VALUE	RME RATIONALE/ REFERENCE	INTAKE EQUATION/ MODEL NAME
INGESTION	EDI_{sed}	ESTIMATED DAILY INTAKE VIA SEDIMENT INGESTION	mg/kg-d	calculated		SEDIMENT INTAKE-INGESTION
	C_{sed}	CHEMICAL CONCENTRATION IN SEDIMENT	mg/kg	chemical-specific		$EDI_{sed} = C_{sed} * IR_{sed} * SFF * EF * 1/BW$
	IR_{sed}	INGESTION RATE OF SEDIMENT	kg/day	0.0034	assumption	
	SFF	SITE FORAGING FREQUENCY	unitless	100%	Mitchell, 1961	
	EF	EXPOSURE FREQUENCY	unitless	100%	USEPA, 1993	
	BW	BODY WEIGHT	kg	0.57	Mitchell, 1961	

References:

Mitchell, J.L., 1961. Mink movements and populations on a Montana river; J. Wildl. Manage. 25:48-54.

USEPA, 1993. Wildlife Exposure Factors Handbook; United States Environmental Protection Agency, Office of Research and Development; EPA/600/R-93/187a; December 1993; Washington, D.C.

Attachment 8

TABLE 8-122

CALCULATION OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS : Surficial sediment / MINK

Focused Feasiblity Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2018)
MEDIUM: SEDIMENT
EXPOSURE MEDIUM: Surficial sediment
EXPOSURE POINT: RME - Area of Focus
RECEPTOR: MINK

Analyte	Medium EPC	Medium EPC Units	Estimated Daily Intake[a]	Daily Intake Units	Reference Dose (NOAEL)[b]	Reference Dose (LOAEL)[b]	Reference Dose Units	Hazard Quotient (NOAEL)[c]	Hazard Quotient (LOAEL)[c]
Copper	8.1E+01	mg/kg	4.9E-01	mg/kg-d	5.6E+00	9.3E+00	mg/kg-d	8.8E-02	5.3E-02
Lead	1.5E+02	mg/kg	8.9E-01	mg/kg-d	4.7E+00	8.9E+00	mg/kg-d	1.9E-01	1.0E-01
Methyl Mercury	6.2E-01	mg/kg	3.7E-03	mg/kg-d	5.5E-02	1.8E-01	mg/kg-d	6.8E-02	2.1E-02
LPAH	1.6E+01	mg/kg	9.4E-02	mg/kg-d	-	-			
HPAH	6.1E+01	mg/kg	3.7E-01	mg/kg-d	1.0E+00	1.0E+01	mg/kg-d	3.7E-01	3.7E-02
Dieldrin	4.7E-03	mg/kg	2.8E-05	mg/kg-d	1.5E-02	3.0E-02	mg/kg-d	1.9E-03	9.4E-04
Total DDx	7.0E-02	mg/kg	4.2E-04	mg/kg-d	8.0E-01	4.0E+00	mg/kg-d	5.3E-04	1.1E-04
Total PCBs	3.9E-01	mg/kg	2.3E-03	mg/kg-d	8.0E-02	9.6E-02	mg/kg-d	2.9E-02	2.4E-02
TEQ PCB-mammals	6.2E-06	mg/kg	3.7E-08	mg/kg-d	8.0E-08	2.2E-06	mg/kg-d	4.7E-01	1.7E-02
TEQ D/F-mammals	4.0E-05	mg/kg	2.4E-07	mg/kg-d	8.0E-08	2.2E-06	mg/kg-d	**3.0E+00**	1.1E-01
							HAZARD INDICES:	**4.3E+00**	3.6E-01

Notes:
a. Estimated Daily Intake (EDI) calculated using parameters presented in Table 8-121.
b. Reference Dose Values presented in Table 6-4. A dash indicates that no value is available.
c. Hazard Quotients (HQs) calculated by dividing the Estimated Daily Intake dose by either the NOAEL- or LOAEL-based Reference Dose.

Attachment 8

TABLE 8-123

PARAMETER VALUES USED TO CALCULATE ESTIMATED DAILY INTAKE : Blue crab / MINK

Focused Feasiblity Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2018)
MEDIUM: AQUATIC INVERTEBRATES
EXPOSURE MEDIUM: Blue crab
EXPOSURE POINT: RME - Area of Focus
RECEPTOR: MINK

EXPOSURE ROUTE	PARAMETER SYMBOL	PARAMETER DEFINITION	UNITS	RME VALUE	RME RATIONALE/ REFERENCE	INTAKE EQUATION/ MODEL NAME
INGESTION	EDI_{invert}	ESTIMATED DAILY INTAKE VIA INVERTEBRATE INGESTION	mg/kg-d	calculated		INVERTEBRATE INTAKE-INGESTION $EDI_{invert} = C_{invert} * IR_{food} * P_{invert} * SFF * EF * 1/BW$
	C_{invert}	CHEMICAL CONCENTRATION IN INVERTEBRATES	mg/kg	chemical-specific		
	IR_{food}	INGESTION RATE OF FOOD	kg/day	0.17	USEPA, 1993	
	P_{invert}	PERCENT INVERTEBRATES IN DIET	unitless	20%	assumption	Where C_{invert} is estimated using site-specific tissue data or calculated using the following equation: $C_{invert} = C_{sed} * BAF_{invert}$
	SFF	SITE FORAGING FREQUENCY	unitless	100%	Mitchell, 1961	
	EF	EXPOSURE FREQUENCY	unitless	100%	USEPA, 1993	Bioaccumulation Factors [mg(ww tissue)/ kg(dw sediment)] provided separately.
	BW	BODY WEIGHT	kg	0.57	Mitchell, 1961	

References:

Mitchell, J.L., 1961. Mink movements and populations on a Montana river; J. Wildl. Manage. 25:48-54.

USEPA, 1993. Wildlife Exposure Factors Handbook; United States Environmental Protection Agency, Office of Research and Development; EPA/600/R-93/187a; December 1993; Washington, D.C.

Attachment 8

TABLE 8-124

CALCULATION OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS : Blue crab / MINK

Focused Feasiblity Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2018)
MEDIUM: AQUATIC INVERTEBRATES
EXPOSURE MEDIUM: Blue crab
EXPOSURE POINT: RME - Area of Focus
RECEPTOR: MINK

Analyte	Medium EPC	Medium EPC Units	Estimated Daily Intake[a]	Daily Intake Units	Reference Dose (NOAEL)[b]	Reference Dose (LOAEL)[b]	Reference Dose Units	Hazard Quotient (NOAEL)[c]	Hazard Quotient (LOAEL)[c]
Copper	1.1E+01	mg/kg	6.9E-01	mg/kg-d	5.6E+00	9.3E+00	mg/kg-d	1.2E-01	7.3E-02
Lead	2.1E-01	mg/kg	1.3E-02	mg/kg-d	4.7E+00	8.9E+00	mg/kg-d	2.7E-03	1.4E-03
Methyl Mercury	1.7E-02	mg/kg	1.0E-03	mg/kg-d	5.5E-02	1.8E-01	mg/kg-d	1.9E-02	5.8E-03
LPAH	1.2E-01	mg/kg	7.0E-03	mg/kg-d	-	-			
HPAH	1.9E-01	mg/kg	1.2E-02	mg/kg-d	1.0E+00	1.0E+01	mg/kg-d	1.2E-02	1.2E-03
Dieldrin	3.2E-03	mg/kg	1.9E-04	mg/kg-d	1.5E-02	3.0E-02	mg/kg-d	1.3E-02	6.4E-03
Total DDx	7.8E-02	mg/kg	4.7E-03	mg/kg-d	8.0E-01	4.0E+00	mg/kg-d	5.9E-03	1.2E-03
Total PCBs	7.9E-01	mg/kg	4.8E-02	mg/kg-d	8.0E-02	9.6E-02	mg/kg-d	6.0E-01	5.0E-01
TEQ PCB-mammals	1.6E-05	mg/kg	9.5E-07	mg/kg-d	8.0E-08	2.2E-06	mg/kg-d	**1.2E+01**	4.3E-01
TEQ D/F-mammals	6.2E-06	mg/kg	3.7E-07	mg/kg-d	8.0E-08	2.2E-06	mg/kg-d	**4.6E+00**	1.7E-01
							HAZARD INDICES:	**1.7E+01**	**1.2E+00**

Notes:
a. Estimated Daily Intake (EDI) calculated using parameters presented in Table 8-123.
b. Reference Dose Values presented in Table 6-4. A dash indicates that no value is available.
c. Hazard Quotients (HQs) calculated by dividing the Estimated Daily Intake dose by either the NOAEL- or LOAEL-based Reference Dose.

Attachment 8

TABLE 8-125

PARAMETER VALUES USED TO CALCULATE ESTIMATED DAILY INTAKE : White perch/American eel / MINK

Focused Feasiblity Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2018)
MEDIUM: FISH
EXPOSURE MEDIUM: White perch/American eel
EXPOSURE POINT: RME - Area of Focus
RECEPTOR: MINK

EXPOSURE ROUTE	PARAMETER SYMBOL	PARAMETER DEFINITION	UNITS	RME VALUE	RME RATIONALE/ REFERENCE	INTAKE EQUATION/ MODEL NAME
INGESTION	EDI_{fish}	ESTIMATED DAILY INTAKE VIA FISH INGESTION	mg/kg-d	calculated		FISH INTAKE-INGESTION
	C_{fish}	CHEMICAL CONCENTRATION IN FISH	mg/kg	chemical-specific		$EDI_{fish} = C_{fish} * IR_{food} * P_{fish} * SFF * EF * 1/BW$
	IR_{food}	INGESTION RATE OF FOOD	kg/day	0.17	USEPA, 1993	
	P_{fish}	PERCENT FISH IN DIET	unitless	80%	assumption	Where C_{fish} is estimated using site-specific tissue data or estimated using the following equation:
	SFF	SITE FORAGING FREQUENCY	unitless	100%	Mitchell, 1961	$C_{fish} = C_{sed} * BAF_{fish}$
	EF	EXPOSURE FREQUENCY	unitless	100%	USEPA, 1993	Bioaccumulation Factors [mg(ww tissue)/ kg(dw sediment)] provided separately.
	BW	BODY WEIGHT	kg	0.57	Mitchell, 1961	

References:
Mitchell, J.L., 1961. Mink movements and populations on a Montana river; J. Wildl. Manage. 25:48-54.
USEPA, 1993. Wildlife Exposure Factors Handbook; United States Environmental Protection Agency, Office of Research and Development; EPA/600/R-93/187a; December 1993; Washington, D.C.

Attachment 8

TABLE 8-126

CALCULATION OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS : White perch/American eel / MINK

Focused Feasiblity Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2018)
MEDIUM: FISH
EXPOSURE MEDIUM: White perch/American eel
EXPOSURE POINT: RME - Area of Focus
RECEPTOR: MINK

Analyte	Medium EPC	Medium EPC Units	Estimated Daily Intake[a]	Daily Intake Units	Reference Dose (NOAEL)[b]	Reference Dose (LOAEL)[b]	Reference Dose Units	Hazard Quotient (NOAEL)[c]	Hazard Quotient (LOAEL)[c]
Copper	3.3E+00	mg/kg	8.0E-01	mg/kg-d	5.6E+00	9.3E+00	mg/kg-d	1.4E-01	8.5E-02
Lead	1.8E-01	mg/kg	4.3E-02	mg/kg-d	4.7E+00	8.9E+00	mg/kg-d	9.1E-03	4.8E-03
Methyl Mercury	6.3E-02	mg/kg	1.5E-02	mg/kg-d	5.5E-02	1.8E-01	mg/kg-d	2.8E-01	8.4E-02
LPAH	1.7E-01	mg/kg	4.1E-02	mg/kg-d	-	-			
HPAH	1.5E-01	mg/kg	3.7E-02	mg/kg-d	1.0E+00	1.0E+01	mg/kg-d	3.7E-02	3.7E-03
Dieldrin	7.5E-03	mg/kg	1.8E-03	mg/kg-d	1.5E-02	3.0E-02	mg/kg-d	1.2E-01	6.0E-02
Total DDx	1.3E-01	mg/kg	3.1E-02	mg/kg-d	8.0E-01	4.0E+00	mg/kg-d	3.8E-02	7.7E-03
Total PCBs	8.4E-01	mg/kg	2.0E-01	mg/kg-d	8.0E-02	9.6E-02	mg/kg-d	**2.5E+00**	**2.1E+00**
TEQ PCB-mammals	1.1E-05	mg/kg	2.6E-06	mg/kg-d	8.0E-08	2.2E-06	mg/kg-d	**3.3E+01**	**1.2E+00**
TEQ D/F-mammals	8.1E-06	mg/kg	1.9E-06	mg/kg-d	8.0E-08	2.2E-06	mg/kg-d	**2.4E+01**	8.7E-01
							HAZARD INDICES:	**6.1E+01**	**4.4E+00**

Notes:
a. Estimated Daily Intake (EDI) calculated using parameters presented in Table 8-125.
b. Reference Dose Values presented in Table 6-4. A dash indicates that no value is available.
c. Hazard Quotients (HQs) calculated by dividing the Estimated Daily Intake dose by either the NOAEL- or LOAEL-based Reference Dose.

Attachment 8

TABLE 8-127

SUMMARY OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS USING NOAEL-BASED TRVs : MINK

Focused Feasiblity Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2018)
EXPOSURE POINT: RME - Area of Focus
RECEPTOR: MINK
TOTAL RISK (HI): 8.2E+01

Analyte	Exposure Medium[a]					Combined HQs[b]	Percent Contribution[c]
	Surface Water	Sediment	Aquatic Plants	Aquatic Invertebrates	Fish		
TCDD TEQ (PCBs)		4.7E-01		1.2E+01	3.3E+01	***4.5E+01***	***55%***
TCDD TEQ (D/F)		3.0E+00		4.6E+00	2.4E+01	***3.2E+01***	***39%***
Total PCBs		2.9E-02		6.0E-01	2.5E+00	***3.1E+00***	4%
HPAH		3.7E-01		1.2E-02	3.7E-02	4.2E-01	1%
Mercury		6.8E-02		1.9E-02	2.8E-01	3.6E-01	0%
Copper		8.8E-02		1.2E-01	1.4E-01	3.5E-01	0%
Lead		1.9E-01		2.7E-03	9.1E-03	2.0E-01	0%
Dieldrin		1.9E-03		1.3E-02	1.2E-01	1.3E-01	0%
Total DDx		5.3E-04		5.9E-03	3.8E-02	4.5E-02	0%
LPAH							
TOTAL MEDIUM-SPECIFIC RISK	**-**	**4.3E+00**	**-**	**1.7E+01**	**6.1E+01**	**8.2E+01**	
PERCENTAGE OF TOTAL RISK		**5%**		**21%**	**74%**	**100%**	

Notes:

a. Hazard Quotients presented by exposure medium; a blank cell indicates that the analyte was not a COPC for that medium; a dash entry indicates that there was no assumed exposure to that medium.

b. Combined risk across all media exposures.

c. Relative contribution of COPC to total risk associated with the ingestion exposure pathway.

Attachment 8

TABLE 8-128

SUMMARY OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS USING LOAEL-BASED TRVs : MINK

Focused Feasiblity Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2018)
EXPOSURE POINT: RME - Area of Focus
RECEPTOR: MINK
TOTAL RISK (HI): 5.9E+00

Analyte	Exposure Medium[a]					Combined HQs[b]	Percent Contribution[c]
	Surface Water	Sediment	Aquatic Plants	Aquatic Invertebrates	Fish		
Total PCBs		2.4E-02		5.0E-01	2.1E+00	***2.6E+00***	***44%***
TCDD TEQ (PCBs)		1.7E-02		4.3E-01	1.2E+00	***1.6E+00***	***27%***
TCDD TEQ (D/F)		1.1E-01		1.7E-01	8.7E-01	***1.1E+00***	***19%***
Copper		5.3E-02		7.3E-02	8.5E-02	2.1E-01	4%
Mercury		2.1E-02		5.8E-03	8.4E-02	1.1E-01	2%
Lead		1.0E-01		1.4E-03	4.8E-03	1.1E-01	2%
Dieldrin		9.4E-04		6.4E-03	6.0E-02	6.7E-02	1%
HPAH		3.7E-02		1.2E-03	3.7E-03	4.2E-02	1%
Total DDx		1.1E-04		1.2E-03	7.7E-03	8.9E-03	0%
LPAH							
TOTAL MEDIUM-SPECIFIC RISK	**-**	**3.6E-01**	**-**	**1.2E+00**	**4.4E+00**	**5.9E+00**	
PERCENTAGE OF TOTAL RISK		**6%**		**20%**	**74%**	**100%**	

Notes:
a. Hazard Quotients presented by exposure medium; a blank cell indicates that the analyte was not a COPC for that medium; a dash entry indicates that there was no assumed exposure to that medium.
b. Combined risk across all media exposures.
c. Relative contribution of COPC to total risk associated with the ingestion exposure pathway.

Attachment 8

TABLE 8-129

PARAMETER VALUES USED TO CALCULATE ESTIMATED DAILY INTAKE : Surficial sediment / MINK

Focused Feasiblity Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2048)
MEDIUM: SEDIMENT
EXPOSURE MEDIUM: Surficial sediment
EXPOSURE POINT: RME - Area of Focus
RECEPTOR: MINK

EXPOSURE ROUTE	PARAMETER SYMBOL	PARAMETER DEFINITION	UNITS	RME VALUE	RME RATIONALE/ REFERENCE	INTAKE EQUATION/ MODEL NAME
INGESTION	EDI_{sed}	ESTIMATED DAILY INTAKE VIA SEDIMENT INGESTION	mg/kg-d	calculated		SEDIMENT INTAKE-INGESTION
	C_{sed}	CHEMICAL CONCENTRATION IN SEDIMENT	mg/kg	chemical-specific		$EDI_{sed} = C_{sed} * IR_{sed} * SFF * EF * 1/BW$
	IR_{sed}	INGESTION RATE OF SEDIMENT	kg/day	0.0034	assumption	
	SFF	SITE FORAGING FREQUENCY	unitless	100%	Mitchell, 1961	
	EF	EXPOSURE FREQUENCY	unitless	100%	USEPA, 1993	
	BW	BODY WEIGHT	kg	0.57	Mitchell, 1961	

References:

Mitchell, J.L., 1961. Mink movements and populations on a Montana river; J. Wildl. Manage. 25:48-54.

USEPA, 1993. Wildlife Exposure Factors Handbook; United States Environmental Protection Agency, Office of Research and Development; EPA/600/R-93/187a; December 1993; Washington, D.C.

Attachment 8

TABLE 8-130

CALCULATION OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS : Surficial sediment / MINK

Focused Feasiblity Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2048)
MEDIUM: SEDIMENT
EXPOSURE MEDIUM: Surficial sediment
EXPOSURE POINT: RME - Area of Focus
RECEPTOR: MINK

Analyte	Medium EPC	Medium EPC Units	Estimated Daily Intake[a]	Daily Intake Units	Reference Dose (NOAEL)[b]	Reference Dose (LOAEL)[b]	Reference Dose Units	Hazard Quotient (NOAEL)[c]	Hazard Quotient (LOAEL)[c]
Copper	4.1E+01	mg/kg	2.5E-01	mg/kg-d	5.6E+00	9.3E+00	mg/kg-d	4.4E-02	2.7E-02
Lead	6.9E+01	mg/kg	4.1E-01	mg/kg-d	4.7E+00	8.9E+00	mg/kg-d	8.8E-02	4.6E-02
Methyl Mercury	2.0E-01	mg/kg	1.2E-03	mg/kg-d	5.5E-02	1.8E-01	mg/kg-d	2.2E-02	6.6E-03
LPAH	1.6E+01	mg/kg	9.4E-02	mg/kg-d	-	-			
HPAH	6.1E+01	mg/kg	3.7E-01	mg/kg-d	1.0E+00	1.0E+01	mg/kg-d	3.7E-01	3.7E-02
Dieldrin	4.7E-03	mg/kg	2.8E-05	mg/kg-d	1.5E-02	3.0E-02	mg/kg-d	1.9E-03	9.4E-04
Total DDx	2.4E-02	mg/kg	1.5E-04	mg/kg-d	8.0E-01	4.0E+00	mg/kg-d	1.8E-04	3.7E-05
Total PCBs	8.8E-02	mg/kg	5.3E-04	mg/kg-d	8.0E-02	9.6E-02	mg/kg-d	6.6E-03	5.5E-03
TEQ PCB-mammals	1.2E-06	mg/kg	7.5E-09	mg/kg-d	8.0E-08	2.2E-06	mg/kg-d	9.3E-02	3.3E-03
TEQ D/F-mammals	1.3E-05	mg/kg	8.0E-08	mg/kg-d	8.0E-08	2.2E-06	mg/kg-d	**1.0E+00**	3.6E-02
							HAZARD INDICES:	**1.6E+00**	1.6E-01

Notes:
a. Estimated Daily Intake (EDI) calculated using parameters presented in Table 8-129.
b. Reference Dose Values presented in Table 6-4. A dash indicates that no value is available.
c. Hazard Quotients (HQs) calculated by dividing the Estimated Daily Intake dose by either the NOAEL- or LOAEL-based Reference Dose.

Attachment 8

TABLE 8-131

PARAMETER VALUES USED TO CALCULATE ESTIMATED DAILY INTAKE : Blue crab / MINK

Focused Feasiblity Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2048)
MEDIUM: AQUATIC INVERTEBRATES
EXPOSURE MEDIUM: Blue crab
EXPOSURE POINT: RME - Area of Focus
RECEPTOR: MINK

EXPOSURE ROUTE	PARAMETER SYMBOL	PARAMETER DEFINITION	UNITS	RME VALUE	RME RATIONALE/ REFERENCE	INTAKE EQUATION/ MODEL NAME
INGESTION	EDI_{invert}	ESTIMATED DAILY INTAKE VIA INVERTEBRATE INGESTION	mg/kg-d	calculated		INVERTEBRATE INTAKE-INGESTION $EDI_{invert} = C_{invert} * IR_{food} * P_{invert} * SFF * EF * 1/BW$
	C_{invert}	CHEMICAL CONCENTRATION IN INVERTEBRATES	mg/kg	chemical-specific		
	IR_{food}	INGESTION RATE OF FOOD	kg/day	0.17	USEPA, 1993	
	P_{invert}	PERCENT INVERTEBRATES IN DIET	unitless	20%	assumption	Where C_{invert} is estimated using site-specific tissue data or calculated using the following equation: $C_{invert} = C_{sed} * BAF_{invert}$
	SFF	SITE FORAGING FREQUENCY	unitless	100%	Mitchell, 1961	
	EF	EXPOSURE FREQUENCY	unitless	100%	USEPA, 1993	Bioaccumulation Factors [mg(ww tissue)/ kg(dw sediment)] provided separately.
	BW	BODY WEIGHT	kg	0.57	Mitchell, 1961	

References:
Mitchell, J.L., 1961. Mink movements and populations on a Montana river; J. Wildl. Manage. 25:48-54.
USEPA, 1993. Wildlife Exposure Factors Handbook; United States Environmental Protection Agency, Office of Research and Development; EPA/600/R-93/187a; December 1993; Washington, D.C.

Attachment 8

TABLE 8-132

CALCULATION OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS : Blue crab / MINK

Focused Feasiblity Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2048)
MEDIUM: AQUATIC INVERTEBRATES
EXPOSURE MEDIUM: Blue crab
EXPOSURE POINT: RME - Area of Focus
RECEPTOR: MINK

Analyte	Medium EPC	Medium EPC Units	Estimated Daily Intake[a]	Daily Intake Units	Reference Dose (NOAEL)[b]	Reference Dose (LOAEL)[b]	Reference Dose Units	Hazard Quotient (NOAEL)[c]	Hazard Quotient (LOAEL)[c]
Copper	5.8E+00	mg/kg	3.5E-01	mg/kg-d	5.6E+00	9.3E+00	mg/kg-d	6.2E-02	3.7E-02
Lead	9.7E-02	mg/kg	5.9E-03	mg/kg-d	4.7E+00	8.9E+00	mg/kg-d	1.2E-03	6.6E-04
Methyl Mercury	5.5E-03	mg/kg	3.3E-04	mg/kg-d	5.5E-02	1.8E-01	mg/kg-d	6.1E-03	1.9E-03
LPAH	1.2E-01	mg/kg	7.0E-03	mg/kg-d	-	-			
HPAH	1.9E-01	mg/kg	1.2E-02	mg/kg-d	1.0E+00	1.0E+01	mg/kg-d	1.2E-02	1.2E-03
Dieldrin	3.2E-03	mg/kg	1.9E-04	mg/kg-d	1.5E-02	3.0E-02	mg/kg-d	1.3E-02	6.4E-03
Total DDx	2.7E-02	mg/kg	1.6E-03	mg/kg-d	8.0E-01	4.0E+00	mg/kg-d	2.1E-03	4.1E-04
Total PCBs	1.8E-01	mg/kg	1.1E-02	mg/kg-d	8.0E-02	9.6E-02	mg/kg-d	1.3E-01	1.1E-01
TEQ PCB-mammals	3.2E-06	mg/kg	1.9E-07	mg/kg-d	8.0E-08	2.2E-06	mg/kg-d	**2.4E+00**	8.5E-02
TEQ D/F-mammals	2.0E-06	mg/kg	1.2E-07	mg/kg-d	8.0E-08	2.2E-06	mg/kg-d	**1.5E+00**	5.5E-02
							HAZARD INDICES:	**4.1E+00**	3.0E-01

Notes:
a. Estimated Daily Intake (EDI) calculated using parameters presented in Table 8-131.
b. Reference Dose Values presented in Table 6-4. A dash indicates that no value is available.
c. Hazard Quotients (HQs) calculated by dividing the Estimated Daily Intake dose by either the NOAEL- or LOAEL-based Reference Dose.

Attachment 8

TABLE 8-133

PARAMETER VALUES USED TO CALCULATE ESTIMATED DAILY INTAKE : White perch/American eel / MINK

Focused Feasiblity Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2048)
MEDIUM: FISH
EXPOSURE MEDIUM: White perch/American eel
EXPOSURE POINT: RME - Area of Focus
RECEPTOR: MINK

EXPOSURE ROUTE	PARAMETER SYMBOL	PARAMETER DEFINITION	UNITS	RME VALUE	RME RATIONALE/ REFERENCE	INTAKE EQUATION/ MODEL NAME
INGESTION	EDI_{fish}	ESTIMATED DAILY INTAKE VIA FISH INGESTION	mg/kg-d	calculated		FISH INTAKE-INGESTION
	C_{fish}	CHEMICAL CONCENTRATION IN FISH	mg/kg	chemical-specific		$EDI_{fish} = C_{fish} * IR_{food} * P_{fish} * SFF * EF * 1/BW$
	IR_{food}	INGESTION RATE OF FOOD	kg/day	0.17	USEPA, 1993	
	P_{fish}	PERCENT FISH IN DIET	unitless	80%	assumption	Where C_{fish} is estimated using site-specific tissue data or estimated using the following equation:
	SFF	SITE FORAGING FREQUENCY	unitless	100%	Mitchell, 1961	$C_{fish} = C_{sed} * BAF_{fish}$
	EF	EXPOSURE FREQUENCY	unitless	100%	USEPA, 1993	Bioaccumulation Factors [mg(ww tissue)/ kg(dw sediment)] provided separately.
	BW	BODY WEIGHT	kg	0.57	Mitchell, 1961	

References:
Mitchell, J.L., 1961. Mink movements and populations on a Montana river; J. Wildl. Manage. 25:48-54.
USEPA, 1993. Wildlife Exposure Factors Handbook; United States Environmental Protection Agency, Office of Research and Development; EPA/600/R-93/187a; December 1993; Washington, D.C.

Attachment 8

TABLE 8-134

CALCULATION OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS : White perch/American eel / MINK

Focused Feasiblity Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2048)
MEDIUM: FISH
EXPOSURE MEDIUM: White perch/American eel
EXPOSURE POINT: RME - Area of Focus
RECEPTOR: MINK

Analyte	Medium EPC	Medium EPC Units	Estimated Daily Intake[a]	Daily Intake Units	Reference Dose (NOAEL)[b]	Reference Dose (LOAEL)[b]	Reference Dose Units	Hazard Quotient (NOAEL)[c]	Hazard Quotient (LOAEL)[c]
Copper	1.7E+00	mg/kg	4.0E-01	mg/kg-d	5.6E+00	9.3E+00	mg/kg-d	7.2E-02	4.3E-02
Lead	8.3E-02	mg/kg	2.0E-02	mg/kg-d	4.7E+00	8.9E+00	mg/kg-d	4.2E-03	2.2E-03
Methyl Mercury	2.0E-02	mg/kg	4.9E-03	mg/kg-d	5.5E-02	1.8E-01	mg/kg-d	8.8E-02	2.7E-02
LPAH	1.7E-01	mg/kg	4.1E-02	mg/kg-d	-	-			
HPAH	1.5E-01	mg/kg	3.7E-02	mg/kg-d	1.0E+00	1.0E+01	mg/kg-d	3.7E-02	3.7E-03
Dieldrin	7.5E-03	mg/kg	1.8E-03	mg/kg-d	1.5E-02	3.0E-02	mg/kg-d	1.2E-01	6.0E-02
Total DDx	4.4E-02	mg/kg	1.1E-02	mg/kg-d	8.0E-01	4.0E+00	mg/kg-d	1.3E-02	2.7E-03
Total PCBs	1.9E-01	mg/kg	4.6E-02	mg/kg-d	8.0E-02	9.6E-02	mg/kg-d	5.7E-01	4.8E-01
TEQ PCB-mammals	2.2E-06	mg/kg	5.3E-07	mg/kg-d	8.0E-08	2.2E-06	mg/kg-d	**6.6E+00**	2.4E-01
TEQ D/F-mammals	2.7E-06	mg/kg	6.4E-07	mg/kg-d	8.0E-08	2.2E-06	mg/kg-d	**8.0E+00**	2.9E-01
							HAZARD INDICES:	**1.6E+01**	**1.1E+00**

Notes:
a. Estimated Daily Intake (EDI) calculated using parameters presented in Table 8-133.
b. Reference Dose Values presented in Table 6-4. A dash indicates that no value is available.
c. Hazard Quotients (HQs) calculated by dividing the Estimated Daily Intake dose by either the NOAEL- or LOAEL-based Reference Dose.

Attachment 8

TABLE 8-135

SUMMARY OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS USING NOAEL-BASED TRVs : MINK

Focused Feasiblity Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2048)
EXPOSURE POINT: RME - Area of Focus
RECEPTOR: MINK
TOTAL RISK (HI): 2.1E+01

	Exposure Medium[a]						
Analyte	Surface Water	Sediment	Aquatic Plants	Aquatic Invertebrates	Fish	Combined HQs[b]	Percent Contribution[c]
TCDD TEQ (D/F)		1.0E+00		1.5E+00	8.0E+00	***1.1E+01***	***50%***
TCDD TEQ (PCBs)		9.3E-02		2.4E+00	6.6E+00	***9.1E+00***	***43%***
Total PCBs		6.6E-03		1.3E-01	5.7E-01	7.1E-01	3%
HPAH		3.7E-01		1.2E-02	3.7E-02	4.2E-01	2%
Copper		4.4E-02		6.2E-02	7.2E-02	1.8E-01	1%
Dieldrin		1.9E-03		1.3E-02	1.2E-01	1.3E-01	1%
Mercury		2.2E-02		6.1E-03	8.8E-02	1.2E-01	1%
Lead		8.8E-02		1.2E-03	4.2E-03	9.3E-02	0%
Total DDx		1.8E-04		2.1E-03	1.3E-02	1.6E-02	0%
LPAH							
TOTAL MEDIUM-SPECIFIC RISK	**-**	**1.6E+00**	**-**	**4.1E+00**	**1.6E+01**	**2.1E+01**	
PERCENTAGE OF TOTAL RISK		**8%**		**19%**	**73%**	**100%**	

Notes:

a. Hazard Quotients presented by exposure medium; a blank cell indicates that the analyte was not a COPC for that medium; a dash entry indicates that there was no assumed exposure to that medium.

b. Combined risk across all media exposures.

c. Relative contribution of COPC to total risk associated with the ingestion exposure pathway.

Attachment 8

TABLE 8-136

SUMMARY OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS USING LOAEL-BASED TRVs : MINK

Focused Feasiblity Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2048)
EXPOSURE POINT: RME - Area of Focus
RECEPTOR: MINK
TOTAL RISK (HI): 1.6E+00

Analyte	Exposure Medium[a]					Combined HQs[b]	Percent Contribution[c]
	Surface Water	Sediment	Aquatic Plants	Aquatic Invertebrates	Fish		
Total PCBs		5.5E-03		1.1E-01	4.8E-01	5.9E-01	***37%***
TCDD TEQ (D/F)		3.6E-02		5.5E-02	2.9E-01	3.8E-01	***24%***
Copper		2.7E-02		3.7E-02	4.3E-02	1.1E-01	7%
Dieldrin		9.4E-04		6.4E-03	6.0E-02	6.7E-02	4%
Lead		4.6E-02		6.6E-04	2.2E-03	4.9E-02	3%
HPAH		3.7E-02		1.2E-03	3.7E-03	4.2E-02	3%
Mercury		6.6E-03		1.9E-03	2.7E-02	3.5E-02	2%
TCDD TEQ (PCBs)		3.3E-03		8.5E-02	2.4E-01	3.2E-01	***20%***
Total DDx		3.7E-05		4.1E-04	2.7E-03	3.1E-03	0%
LPAH							
TOTAL MEDIUM-SPECIFIC RISK	**-**	**1.6E-01**	**-**	**3.0E-01**	**1.1E+00**	**1.6E+00**	
PERCENTAGE OF TOTAL RISK		**10%**		**19%**	**71%**	**100%**	

Notes:

a. Hazard Quotients presented by exposure medium; a blank cell indicates that the analyte was not a COPC for that medium; a dash entry indicates that there was no assumed exposure to that medium.

b. Combined risk across all media exposures.

c. Relative contribution of COPC to total risk associated with the ingestion exposure pathway.

TABLE 8-137
PARAMETER VALUES USED TO CALCULATE ESTIMATED DAILY INTAKE : Surficial sediment / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2018)
MEDIUM: SEDIMENT
EXPOSURE MEDIUM: Surficial sediment
EXPOSURE POINT: RME - Area of Focus
RECEPTOR: HERON

EXPOSURE ROUTE	PARAMETER SYMBOL	PARAMETER DEFINITION	UNITS	RME VALUE	RME RATIONALE/ REFERENCE	INTAKE EQUATION/ MODEL NAME
INGESTION	EDI_{sed}	ESTIMATED DAILY INTAKE VIA SEDIMENT INGESTION	mg/kg-d	calculated		SEDIMENT INTAKE-INGESTION
	C_{sed}	CHEMICAL CONCENTRATION IN SEDIMENT	mg/kg	chemical-specific		$EDI_{sed} = C_{sed} * IR_{sed} * SFF * EF * 1/BW$
	IR_{sed}	INGESTION RATE OF SEDIMENT	kg/day	0.019	assumption	
	SFF	SITE FORAGING FREQUENCY	unitless	100%	Bayer, 1978	
	EF	EXPOSURE FREQUENCY	unitless	58%	USEPA, 1993	
	BW	BODY WEIGHT	kg	2.2	USEPA, 1993	

References:

Bayer,R.D., 1978. Aspects of an Oregon estuarine great blue heron population; In: Sprunt, A., J. Ogden, S. Winkler, eds. Wading Birds; Natl. Audubon Soc. Res. Rep. 7:213-217.

USEPA, 1993. Wildlife Exposure Factors Handbook; United States Environmental Protection Agency, Office of Research and Development; EPA/600/R-93/187a; December 1993; Washington, D.C.

TABLE 8-138
CALCULATION OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS : Surficial sediment / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2018)
MEDIUM: SEDIMENT
EXPOSURE MEDIUM: Surficial sediment
EXPOSURE POINT: RME - Area of Focus
RECEPTOR: HERON

Analyte	Medium EPC	Medium EPC Units	Estimated Daily Intake[a]	Daily Intake Units	Reference Dose (NOAEL)[b]	Reference Dose (LOAEL)[b]	Reference Dose Units	Hazard Quotient (NOAEL)[c]	Hazard Quotient (LOAEL)[c]
Copper	8.1E+01	mg/kg	4.2E-01	mg/kg-d	4.1E+00	1.2E+01	mg/kg-d	1.0E-01	3.5E-02
Lead	1.5E+02	mg/kg	7.6E-01	mg/kg-d	1.6E+00	3.3E+00	mg/kg-d	4.7E-01	2.3E-01
Methyl Mercury	6.2E-01	mg/kg	3.2E-03	mg/kg-d	7.8E-03	7.8E-02	mg/kg-d	4.1E-01	4.1E-02
LPAH	1.6E+01	mg/kg	8.0E-02	mg/kg-d	-	-			
HPAH	6.1E+01	mg/kg	3.1E-01	mg/kg-d	-	-			
Dieldrin	4.7E-03	mg/kg	2.4E-05	mg/kg-d	7.1E-02	3.8E+00	mg/kg-d	3.4E-04	6.4E-06
Total DDx	7.0E-02	mg/kg	3.6E-04	mg/kg-d	2.8E-03	2.8E-02	mg/kg-d	1.3E-01	1.3E-02
Total PCBs	3.9E-01	mg/kg	2.0E-03	mg/kg-d	1.0E-01	4.0E-01	mg/kg-d	2.0E-02	5.0E-03
TEQ PCB-birds	1.1E-04	mg/kg	5.8E-07	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	4.1E-01	4.1E-02
TEQ D/F-birds	4.1E-05	mg/kg	2.1E-07	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	1.5E-01	1.5E-02
							HAZARD INDICES:	**1.7E+00**	3.8E-01

Notes:
a. Estimated Daily Intake (EDI) calculated using parameters presented in Table 8-137.
b. Reference Dose Values presented in Table 6-4. A dash indicates that no value is available.
c. Hazard Quotients (HQs) calculated by dividing the Estimated Daily Intake dose by either the NOAEL- or LOAEL-based Reference Dose.

TABLE 8-139
PARAMETER VALUES USED TO CALCULATE ESTIMATED DAILY INTAKE : Blue crab / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2018)
MEDIUM: AQUATIC INVERTEBRATES
EXPOSURE MEDIUM: Blue crab
EXPOSURE POINT: RME - Area of Focus
RECEPTOR: HERON

EXPOSURE ROUTE	PARAMETER SYMBOL	PARAMETER DEFINITION	UNITS	RME VALUE	RME RATIONALE/ REFERENCE	INTAKE EQUATION/ MODEL NAME
INGESTION	EDI_{invert}	ESTIMATED DAILY INTAKE VIA INVERTEBRATE INGESTION	mg/kg-d	calculated		INVERTEBRATE INTAKE-INGESTION $EDI_{invert} = C_{invert} * IR_{food} * P_{invert} * SFF * EF * 1/BW$
	C_{invert}	CHEMICAL CONCENTRATION IN INVERTEBRATES	mg/kg	chemical-specific		
	IR_{food}	INGESTION RATE OF FOOD	kg/day	0.39	Kushlan, 1978	
	P_{invert}	PERCENT INVERTEBRATES IN DIET	unitless	15%	assumption	Where C_{invert} is estimated using site-specific tissue data or calculated using the following equation: $C_{invert} = C_{sed} * BAF_{invert}$
	SFF	SITE FORAGING FREQUENCY	unitless	100%	Bayer, 1978	
	EF	EXPOSURE FREQUENCY	unitless	58%	USEPA, 1993	Bioaccumulation Factors [mg(ww tissue)/ kg(dw sediment)] provided separately.
	BW	BODY WEIGHT	kg	2.2	USEPA, 1993	

References:

Bayer,R.D., 1978. Aspects of an Oregon estuarine great blue heron population; In: Sprunt, A., J. Ogden, S. Winkler, eds. Wading Birds; Natl. Audubon Soc. Res. Rep. 7:213-217.

Kushlan, J.A., 1978. Feeding ecology of wading birds; In: Sprunt, A., J. Ogden, S. Winkler, eds. Wading Birds; Natl. Audubon Soc. Res. Rep. 7:213-217.

USEPA, 1993. Wildlife Exposure Factors Handbook; United States Environmental Protection Agency, Office of Research and Development; EPA/600/R-93/187a; December 1993; Washington, D.C.

TABLE 8-140
CALCULATION OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS : Blue crab / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2018)
MEDIUM: AQUATIC INVERTEBRATES
EXPOSURE MEDIUM: Blue crab
EXPOSURE POINT: RME - Area of Focus
RECEPTOR: HERON

Analyte	Medium EPC	Medium EPC Units	Estimated Daily Intake[a]	Daily Intake Units	Reference Dose (NOAEL)[b]	Reference Dose (LOAEL)[b]	Reference Dose Units	Hazard Quotient (NOAEL)[c]	Hazard Quotient (LOAEL)[c]
Copper	1.1E+01	mg/kg	1.8E-01	mg/kg-d	4.1E+00	1.2E+01	mg/kg-d	4.3E-02	1.5E-02
Lead	2.1E-01	mg/kg	3.2E-03	mg/kg-d	1.6E+00	3.3E+00	mg/kg-d	2.0E-03	9.9E-04
Methyl Mercury	1.7E-02	mg/kg	2.7E-04	mg/kg-d	7.8E-03	7.8E-02	mg/kg-d	3.4E-02	3.4E-03
LPAH	1.2E-01	mg/kg	1.8E-03	mg/kg-d	-	-			
HPAH	1.9E-01	mg/kg	3.0E-03	mg/kg-d	-	-			
Dieldrin	3.2E-03	mg/kg	4.9E-05	mg/kg-d	7.1E-02	3.8E+00	mg/kg-d	6.9E-04	1.3E-05
Total DDx	7.8E-02	mg/kg	1.2E-03	mg/kg-d	2.8E-03	2.8E-02	mg/kg-d	4.3E-01	4.3E-02
Total PCBs	7.9E-01	mg/kg	1.2E-02	mg/kg-d	1.0E-01	4.0E-01	mg/kg-d	1.2E-01	3.1E-02
TEQ PCB-birds	1.5E-04	mg/kg	2.3E-06	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	**1.6E+00**	1.6E-01
TEQ D/F-birds	7.0E-06	mg/kg	1.1E-07	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	7.7E-02	7.7E-03
							HAZARD INDICES:	**2.3E+00**	2.6E-01

Notes:
a. Estimated Daily Intake (EDI) calculated using parameters presented in Table 8-139.
b. Reference Dose Values presented in Table 6-4. A dash indicates that no value is available.
c. Hazard Quotients (HQs) calculated by dividing the Estimated Daily Intake dose by either the NOAEL- or LOAEL-based Reference Dose.

TABLE 8-141
PARAMETER VALUES USED TO CALCULATE ESTIMATED DAILY INTAKE : White perch/American eel / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2018)
MEDIUM: FISH
EXPOSURE MEDIUM: White perch/American eel
EXPOSURE POINT: RME - Area of Focus
RECEPTOR: HERON

EXPOSURE ROUTE	PARAMETER SYMBOL	PARAMETER DEFINITION	UNITS	RME VALUE	RME RATIONALE/ REFERENCE	INTAKE EQUATION/ MODEL NAME
INGESTION	EDI_{fish}	ESTIMATED DAILY INTAKE VIA FISH INGESTION	mg/kg-d	calculated		FISH INTAKE-INGESTION
	C_{fish}	CHEMICAL CONCENTRATION IN FISH	mg/kg	chemical-specific		$EDI_{fish} = C_{fish} * IR_{food} * P_{fish} * SFF * EF * 1/BW$
	IR_{food}	INGESTION RATE OF FOOD	kg/day	0.39	Kushlan, 1978	
	P_{fish}	PERCENT FISH IN DIET	unitless	85%	assumption	Where C_{fish} is estimated using site-specific tissue data or estimated using the following equation:
	SFF	SITE FORAGING FREQUENCY	unitless	100%	Bayer, 1978	$C_{fish} = C_{sed} * BAF_{fish}$
	EF	EXPOSURE FREQUENCY	unitless	58%	USEPA, 1993	Bioaccumulation Factors [mg(ww tissue)/ kg(dw sediment)] provided separately.
	BW	BODY WEIGHT	kg	2.2	USEPA, 1993	

References:

Bayer,R.D., 1978. Aspects of an Oregon estuarine great blue heron population; In: Sprunt, A., J. Ogden, S. Winkler, eds. Wading Birds; Natl. Audubon Soc. Res. Rep. 7:213-217.

Kushlan, J.A., 1978. Feeding ecology of wading birds; In: Sprunt, A., J. Ogden, S. Winkler, eds. Wading Birds; Natl. Audubon Soc. Res. Rep. 7:213-217.

USEPA, 1993. Wildlife Exposure Factors Handbook; United States Environmental Protection Agency, Office of Research and Development; EPA/600/R-93/187a; December 1993; Washington, D.C.

TABLE 8-142
CALCULATION OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS : White perch/American eel / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2018)
MEDIUM: FISH
EXPOSURE MEDIUM: White perch/American eel
EXPOSURE POINT: RME - Area of Focus
RECEPTOR: HERON

Analyte	Medium EPC	Medium EPC Units	Estimated Daily Intake[a]	Daily Intake Units	Reference Dose (NOAEL)[b]	Reference Dose (LOAEL)[b]	Reference Dose Units	Hazard Quotient (NOAEL)[c]	Hazard Quotient (LOAEL)[c]
Copper	3.3E+00	mg/kg	2.9E-01	mg/kg-d	4.1E+00	1.2E+01	mg/kg-d	7.1E-02	2.4E-02
Lead	1.8E-01	mg/kg	1.6E-02	mg/kg-d	1.6E+00	3.3E+00	mg/kg-d	9.6E-03	4.8E-03
Methyl Mercury	6.3E-02	mg/kg	5.5E-03	mg/kg-d	7.8E-03	7.8E-02	mg/kg-d	7.0E-01	7.0E-02
LPAH	1.7E-01	mg/kg	1.5E-02	mg/kg-d	-	-			
HPAH	1.5E-01	mg/kg	1.4E-02	mg/kg-d	-	-			
Dieldrin	7.5E-03	mg/kg	6.5E-04	mg/kg-d	7.1E-02	3.8E+00	mg/kg-d	9.2E-03	1.7E-04
Total DDx	1.3E-01	mg/kg	1.1E-02	mg/kg-d	2.8E-03	2.8E-02	mg/kg-d	**4.0E+00**	4.0E-01
Total PCBs	8.4E-01	mg/kg	7.3E-02	mg/kg-d	1.0E-01	4.0E-01	mg/kg-d	7.3E-01	1.8E-01
TEQ PCB-birds	1.2E-04	mg/kg	1.1E-05	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	**7.5E+00**	7.5E-01
TEQ D/F-birds	8.3E-06	mg/kg	7.3E-07	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	5.2E-01	5.2E-02
							HAZARD INDICES:	**1.4E+01**	**1.5E+00**

Notes:
a. Estimated Daily Intake (EDI) calculated using parameters presented in Table 8-141.
b. Reference Dose Values presented in Table 6-4. A dash indicates that no value is available.
c. Hazard Quotients (HQs) calculated by dividing the Estimated Daily Intake dose by either the NOAEL- or LOAEL-based Reference Dose.

TABLE 8-143
SUMMARY OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS USING NOAEL-BASED TRVs : HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2018)
EXPOSURE POINT: RME - Area of Focus
RECEPTOR: HERON
TOTAL RISK (HI): 1.8E+01

Analyte	Exposure Medium[a]					Combined HQs[b]	Percent Contribution[c]
	Surface Water	Sediment	Aquatic Plants	Aquatic Invertebrates	Fish		
Total DDx		1.3E-01		4.3E-01	4.0E+00	***4.5E+00***	***26%***
Total PCBs		2.0E-02		1.2E-01	7.3E-01	8.7E-01	5%
Mercury		4.1E-01	-	3.4E-02	7.0E-01	***1.1E+00***	7%
TCDD TEQ (D/F)		1.5E-01		7.7E-02	5.2E-01	7.5E-01	4%
TCDD TEQ (PCBs)		4.1E-01		1.6E+00	7.5E+00	***9.6E+00***	***54%***
Lead		4.7E-01	-	2.0E-03	9.6E-03	4.8E-01	3%
Copper		1.0E-01	-	4.3E-02	7.1E-02	2.2E-01	1%
Dieldrin		3.4E-04	-	6.9E-04	9.2E-03	1.0E-02	0%
LPAH							
HPAH							
TOTAL MEDIUM-SPECIFIC RISK	**-**	**1.7E+00**	**-**	**2.3E+00**	**1.4E+01**	**1.8E+01**	
PERCENTAGE OF TOTAL RISK		**10%**		**13%**	**77%**	**100%**	

Notes:
a. Hazard Quotients presented by exposure medium; a blank cell indicates that the analyte was not a COPC for that medium; a dash entry indicates that there was no assumed exposure to that medium.
b. Combined risk across all media exposures.
c. Relative contribution of COPC to total risk associated with the ingestion exposure pathway.

TABLE 8-144
SUMMARY OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS USING LOAEL-BASED TRVs : HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2018)
EXPOSURE POINT: RME - Area of Focus
RECEPTOR: HERON
TOTAL RISK (HI): 2.1E+00

Analyte	Exposure Medium[a]					Combined HQs[b]	Percent Contribution[c]
	Surface Water	Sediment	Aquatic Plants	Aquatic Invertebrates	Fish		
Total PCBs		5.0E-03		3.1E-02	1.8E-01	2.2E-01	***10%***
Total DDx		1.3E-02		4.3E-02	4.0E-01	4.5E-01	***21%***
Lead		2.3E-01	-	9.9E-04	4.8E-03	2.4E-01	***11%***
Mercury		4.1E-02	-	3.4E-03	7.0E-02	1.1E-01	5%
TCDD TEQ (D/F)		1.5E-02		7.7E-03	5.2E-02	7.5E-02	4%
Copper		3.5E-02	-	1.5E-02	2.4E-02	7.3E-02	3%
TCDD TEQ (PCBs)		4.1E-02		1.6E-01	7.5E-01	9.6E-01	***45%***
Dieldrin		6.4E-06	-	1.3E-05	1.7E-04	1.9E-04	0%
LPAH							
HPAH							
TOTAL MEDIUM-SPECIFIC RISK	**-**	**3.8E-01**	**-**	**2.6E-01**	**1.5E+00**	**2.1E+00**	
PERCENTAGE OF TOTAL RISK		**18%**		**12%**	**70%**	**100%**	

Notes:
a. Hazard Quotients presented by exposure medium; a blank cell indicates that the analyte was not a COPC for that medium; a dash entry indicates that there was no assumed exposure to that medium.
b. Combined risk across all media exposures.
c. Relative contribution of COPC to total risk associated with the ingestion exposure pathway.

TABLE 8-145
PARAMETER VALUES USED TO CALCULATE ESTIMATED DAILY INTAKE : Surficial sediment / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2048)
MEDIUM: SEDIMENT
EXPOSURE MEDIUM: Surficial sediment
EXPOSURE POINT: RME - Area of Focus
RECEPTOR: HERON

EXPOSURE ROUTE	PARAMETER SYMBOL	PARAMETER DEFINITION	UNITS	RME VALUE	RME RATIONALE/ REFERENCE	INTAKE EQUATION/ MODEL NAME
INGESTION	EDI_{sed}	ESTIMATED DAILY INTAKE VIA SEDIMENT INGESTION	mg/kg-d	calculated		SEDIMENT INTAKE-INGESTION
	C_{sed}	CHEMICAL CONCENTRATION IN SEDIMENT	mg/kg	chemical-specific		$EDI_{sed} = C_{sed} * IR_{sed} * SFF * EF * 1/BW$
	IR_{sed}	INGESTION RATE OF SEDIMENT	kg/day	0.019	assumption	
	SFF	SITE FORAGING FREQUENCY	unitless	100%	Bayer, 1978	
	EF	EXPOSURE FREQUENCY	unitless	58%	USEPA, 1993	
	BW	BODY WEIGHT	kg	2.2	USEPA, 1993	

References:

Bayer,R.D., 1978. Aspects of an Oregon estuarine great blue heron population; In: Sprunt, A., J. Ogden, S. Winkler, eds. Wading Birds; Natl. Audubon Soc. Res. Rep. 7:213-217.

USEPA, 1993. Wildlife Exposure Factors Handbook; United States Environmental Protection Agency, Office of Research and Development; EPA/600/R-93/187a; December 1993; Washington, D.C.

TABLE 8-146
CALCULATION OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS : Surficial sediment / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2048)
MEDIUM: SEDIMENT
EXPOSURE MEDIUM: Surficial sediment
EXPOSURE POINT: RME - Area of Focus
RECEPTOR: HERON

Analyte	Medium EPC	Medium EPC Units	Estimated Daily Intake[a]	Daily Intake Units	Reference Dose (NOAEL)[b]	Reference Dose (LOAEL)[b]	Reference Dose Units	Hazard Quotient (NOAEL)[c]	Hazard Quotient (LOAEL)[c]
Copper	4.1E+01	mg/kg	2.1E-01	mg/kg-d	4.1E+00	1.2E+01	mg/kg-d	5.2E-02	1.8E-02
Lead	6.9E+01	mg/kg	3.5E-01	mg/kg-d	1.6E+00	3.3E+00	mg/kg-d	2.2E-01	1.1E-01
Methyl Mercury	2.0E-01	mg/kg	1.0E-03	mg/kg-d	7.8E-03	7.8E-02	mg/kg-d	1.3E-01	1.3E-02
LPAH	1.6E+01	mg/kg	8.0E-02	mg/kg-d	-	-			
HPAH	6.1E+01	mg/kg	3.1E-01	mg/kg-d	-	-			
Dieldrin	4.7E-03	mg/kg	2.4E-05	mg/kg-d	7.1E-02	3.8E+00	mg/kg-d	3.4E-04	6.4E-06
Total DDx	2.4E-02	mg/kg	1.3E-04	mg/kg-d	2.8E-03	2.8E-02	mg/kg-d	4.5E-02	4.5E-03
Total PCBs	8.8E-02	mg/kg	4.5E-04	mg/kg-d	1.0E-01	4.0E-01	mg/kg-d	4.5E-03	1.1E-03
TEQ PCB-birds	2.8E-05	mg/kg	1.4E-07	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	1.0E-01	1.0E-02
TEQ D/F-birds	1.4E-05	mg/kg	7.1E-08	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	5.1E-02	5.1E-03
							HAZARD INDICES:	6.0E-01	1.6E-01

Notes:
a. Estimated Daily Intake (EDI) calculated using parameters presented in Table 8-145.
b. Reference Dose Values presented in Table 6-4. A dash indicates that no value is available.
c. Hazard Quotients (HQs) calculated by dividing the Estimated Daily Intake dose by either the NOAEL- or LOAEL-based Reference Dose.

TABLE 8-147
PARAMETER VALUES USED TO CALCULATE ESTIMATED DAILY INTAKE : Blue crab / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2048)
MEDIUM: AQUATIC INVERTEBRATES
EXPOSURE MEDIUM: Blue crab
EXPOSURE POINT: RME - Area of Focus
RECEPTOR: HERON

EXPOSURE ROUTE	PARAMETER SYMBOL	PARAMETER DEFINITION	UNITS	RME VALUE	RME RATIONALE/ REFERENCE	INTAKE EQUATION/ MODEL NAME
INGESTION	EDI_{invert}	ESTIMATED DAILY INTAKE VIA INVERTEBRATE INGESTION	mg/kg-d	calculated		INVERTEBRATE INTAKE-INGESTION $EDI_{invert} = C_{invert} * IR_{food} * P_{invert} * SFF * EF * 1/BW$
	C_{invert}	CHEMICAL CONCENTRATION IN INVERTEBRATES	mg/kg	chemical-specific		
	IR_{food}	INGESTION RATE OF FOOD	kg/day	0.39	Kushlan, 1978	
	P_{invert}	PERCENT INVERTEBRATES IN DIET	unitless	15%	assumption	Where C_{invert} is estimated using site-specific tissue data or calculated using the following equation: $C_{invert} = C_{sed} * BAF_{invert}$
	SFF	SITE FORAGING FREQUENCY	unitless	100%	Bayer, 1978	
	EF	EXPOSURE FREQUENCY	unitless	58%	USEPA, 1993	Bioaccumulation Factors [mg(ww tissue)/ kg(dw sediment)] provided separately.
	BW	BODY WEIGHT	kg	2.2	USEPA, 1993	

References:

Bayer,R.D., 1978. Aspects of an Oregon estuarine great blue heron population; In: Sprunt, A., J. Ogden, S. Winkler, eds. Wading Birds; Natl. Audubon Soc. Res. Rep. 7:213-217.

Kushlan, J.A., 1978. Feeding ecology of wading birds; In: Sprunt, A., J. Ogden, S. Winkler, eds. Wading Birds; Natl. Audubon Soc. Res. Rep. 7:213-217.

USEPA, 1993. Wildlife Exposure Factors Handbook; United States Environmental Protection Agency, Office of Research and Development; EPA/600/R-93/187a; December 1993; Washington, D.C.

TABLE 8-148
CALCULATION OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS : Blue crab / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2048)
MEDIUM: AQUATIC INVERTEBRATES
EXPOSURE MEDIUM: Blue crab
EXPOSURE POINT: RME - Area of Focus
RECEPTOR: HERON

Analyte	Medium EPC	Medium EPC Units	Estimated Daily Intake[a]	Daily Intake Units	Reference Dose (NOAEL)[b]	Reference Dose (LOAEL)[b]	Reference Dose Units	Hazard Quotient (NOAEL)[c]	Hazard Quotient (LOAEL)[c]
Copper	5.8E+00	mg/kg	8.9E-02	mg/kg-d	4.1E+00	1.2E+01	mg/kg-d	2.2E-02	7.4E-03
Lead	9.7E-02	mg/kg	1.5E-03	mg/kg-d	1.6E+00	3.3E+00	mg/kg-d	9.2E-04	4.6E-04
Methyl Mercury	5.5E-03	mg/kg	8.6E-05	mg/kg-d	7.8E-03	7.8E-02	mg/kg-d	1.1E-02	1.1E-03
LPAH	1.2E-01	mg/kg	1.8E-03	mg/kg-d	-	-			
HPAH	1.9E-01	mg/kg	3.0E-03	mg/kg-d	-	-			
Dieldrin	3.2E-03	mg/kg	4.9E-05	mg/kg-d	7.1E-02	3.8E+00	mg/kg-d	6.9E-04	1.3E-05
Total DDx	2.7E-02	mg/kg	4.2E-04	mg/kg-d	2.8E-03	2.8E-02	mg/kg-d	1.5E-01	1.5E-02
Total PCBs	1.8E-01	mg/kg	2.8E-03	mg/kg-d	1.0E-01	4.0E-01	mg/kg-d	2.8E-02	6.9E-03
TEQ PCB-birds	3.7E-05	mg/kg	5.6E-07	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	4.0E-01	4.0E-02
TEQ D/F-birds	2.4E-06	mg/kg	3.6E-08	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	2.6E-02	2.6E-03
							HAZARD INDICES:	6.4E-01	7.4E-02

Notes:
a. Estimated Daily Intake (EDI) calculated using parameters presented in Table 8-147.
b. Reference Dose Values presented in Table 6-4. A dash indicates that no value is available.
c. Hazard Quotients (HQs) calculated by dividing the Estimated Daily Intake dose by either the NOAEL- or LOAEL-based Reference Dose.

TABLE 8-149
PARAMETER VALUES USED TO CALCULATE ESTIMATED DAILY INTAKE : White perch/American eel / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2048)
MEDIUM: FISH
EXPOSURE MEDIUM: White perch/American eel
EXPOSURE POINT: RME - Area of Focus
RECEPTOR: HERON

EXPOSURE ROUTE	PARAMETER SYMBOL	PARAMETER DEFINITION	UNITS	RME VALUE	RME RATIONALE/ REFERENCE	INTAKE EQUATION/ MODEL NAME
INGESTION	EDI_{fish}	ESTIMATED DAILY INTAKE VIA FISH INGESTION	mg/kg-d	calculated		FISH INTAKE-INGESTION
	C_{fish}	CHEMICAL CONCENTRATION IN FISH	mg/kg	chemical-specific		$EDI_{fish} = C_{fish} * IR_{food} * P_{fish} * SFF * EF * 1/BW$
	IR_{food}	INGESTION RATE OF FOOD	kg/day	0.39	Kushlan, 1978	
	P_{fish}	PERCENT FISH IN DIET	unitless	85%	assumption	Where C_{fish} is estimated using site-specific tissue data or estimated using the following equation:
	SFF	SITE FORAGING FREQUENCY	unitless	100%	Bayer, 1978	$C_{fish} = C_{sed} * BAF_{fish}$
	EF	EXPOSURE FREQUENCY	unitless	58%	USEPA, 1993	Bioaccumulation Factors [mg(ww tissue)/ kg(dw sediment)] provided separately.
	BW	BODY WEIGHT	kg	2.2	USEPA, 1993	

References:
Bayer,R.D., 1978. Aspects of an Oregon estuarine great blue heron population; In: Sprunt, A., J. Ogden, S. Winkler, eds. Wading Birds; Natl. Audubon Soc. Res. Rep. 7:213-217.
Kushlan, J.A., 1978. Feeding ecology of wading birds; In: Sprunt, A., J. Ogden, S. Winkler, eds. Wading Birds; Natl. Audubon Soc. Res. Rep. 7:213-217.
USEPA, 1993. Wildlife Exposure Factors Handbook; United States Environmental Protection Agency, Office of Research and Development; EPA/600/R-93/187a; December 1993; Washington, D.C.

TABLE 8-150
CALCULATION OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS : White perch/American eel / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2048)
MEDIUM: FISH
EXPOSURE MEDIUM: White perch/American eel
EXPOSURE POINT: RME - Area of Focus
RECEPTOR: HERON

Analyte	Medium EPC	Medium EPC Units	Estimated Daily Intake[a]	Daily Intake Units	Reference Dose (NOAEL)[b]	Reference Dose (LOAEL)[b]	Reference Dose Units	Hazard Quotient (NOAEL)[c]	Hazard Quotient (LOAEL)[c]
Copper	1.7E+00	mg/kg	1.5E-01	mg/kg-d	4.1E+00	1.2E+01	mg/kg-d	3.6E-02	1.2E-02
Lead	8.3E-02	mg/kg	7.2E-03	mg/kg-d	1.6E+00	3.3E+00	mg/kg-d	4.4E-03	2.2E-03
Methyl Mercury	2.0E-02	mg/kg	1.8E-03	mg/kg-d	7.8E-03	7.8E-02	mg/kg-d	2.3E-01	2.3E-02
LPAH	1.7E-01	mg/kg	1.5E-02	mg/kg-d	-	-			
HPAH	1.5E-01	mg/kg	1.4E-02	mg/kg-d	-	-			
Dieldrin	7.5E-03	mg/kg	6.5E-04	mg/kg-d	7.1E-02	3.8E+00	mg/kg-d	9.2E-03	1.7E-04
Total DDx	4.4E-02	mg/kg	3.9E-03	mg/kg-d	2.8E-03	2.8E-02	mg/kg-d	**1.4E+00**	1.4E-01
Total PCBs	1.9E-01	mg/kg	1.7E-02	mg/kg-d	1.0E-01	4.0E-01	mg/kg-d	1.7E-01	4.1E-02
TEQ PCB-birds	3.0E-05	mg/kg	2.6E-06	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	**1.9E+00**	1.9E-01
TEQ D/F-birds	2.8E-06	mg/kg	2.4E-07	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	1.7E-01	1.7E-02
							HAZARD INDICES:	**3.9E+00**	4.2E-01

Notes:
a. Estimated Daily Intake (EDI) calculated using parameters presented in Table 8-149.
b. Reference Dose Values presented in Table 6-4. A dash indicates that no value is available.
c. Hazard Quotients (HQs) calculated by dividing the Estimated Daily Intake dose by either the NOAEL- or LOAEL-based Reference Dose.

TABLE 8-151
SUMMARY OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS USING NOAEL-BASED TRVs : HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2048)
EXPOSURE POINT: RME - Area of Focus
RECEPTOR: HERON
TOTAL RISK (HI): 5.1E+00

	Exposure Medium[a]						
Analyte	Surface Water	Sediment	Aquatic Plants	Aquatic Invertebrates	Fish	Combined HQs[b]	Percent Contribution[c]
Total PCBs		4.5E-03		2.8E-02	1.7E-01	2.0E-01	4%
TCDD TEQ (D/F)		5.1E-02		2.6E-02	1.7E-01	2.5E-01	5%
Mercury		1.3E-01	-	1.1E-02	2.3E-01	3.7E-01	7%
Lead		2.2E-01	-	9.2E-04	4.4E-03	2.2E-01	4%
Total DDx		4.5E-02		1.5E-01	1.4E+00	***1.6E+00***	***31%***
TCDD TEQ (PCBs)		1.0E-01		4.0E-01	1.9E+00	***2.4E+00***	***47%***
Copper		5.2E-02	-	2.2E-02	3.6E-02	1.1E-01	2%
Dieldrin		3.4E-04	-	6.9E-04	9.2E-03	1.0E-02	0%
LPAH							
HPAH							
TOTAL MEDIUM-SPECIFIC RISK	**-**	**6.0E-01**	**-**	**6.4E-01**	**3.9E+00**	**5.1E+00**	
PERCENTAGE OF TOTAL RISK		**12%**		**13%**	**76%**	**100%**	

Notes:
a. Hazard Quotients presented by exposure medium; a blank cell indicates that the analyte was not a COPC for that medium; a dash entry indicates that there was no assumed exposure to that medium.
b. Combined risk across all media exposures.
c. Relative contribution of COPC to total risk associated with the ingestion exposure pathway.

TABLE 8-152
SUMMARY OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS USING LOAEL-BASED TRVs : HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2048)
EXPOSURE POINT: RME - Area of Focus
RECEPTOR: HERON
TOTAL RISK (HI): 6.6E-01

Analyte	Exposure Medium[a]					Combined HQs[b]	Percent Contribution[c]
	Surface Water	Sediment	Aquatic Plants	Aquatic Invertebrates	Fish		
Total PCBs		1.1E-03		6.9E-03	4.1E-02	4.9E-02	8%
Lead		1.1E-01	-	4.6E-04	2.2E-03	1.1E-01	***17%***
TCDD TEQ (D/F)		5.1E-03		2.6E-03	1.7E-02	2.5E-02	4%
Copper		1.8E-02	-	7.4E-03	1.2E-02	3.7E-02	6%
Mercury		1.3E-02	-	1.1E-03	2.3E-02	3.7E-02	6%
Total DDx		4.5E-03		1.5E-02	1.4E-01	1.6E-01	***24%***
TCDD TEQ (PCBs)		1.0E-02		4.0E-02	1.9E-01	2.4E-01	***36%***
Dieldrin		6.4E-06	-	1.3E-05	1.7E-04	1.9E-04	0%
LPAH							
HPAH							
TOTAL MEDIUM-SPECIFIC RISK	**-**	**1.6E-01**	**-**	**7.4E-02**	**4.2E-01**	**6.6E-01**	
PERCENTAGE OF TOTAL RISK		**24%**		**11%**	**64%**	**100%**	

Notes:
a. Hazard Quotients presented by exposure medium; a blank cell indicates that the analyte was not a COPC for that medium; a dash entry indicates that there was no assumed exposure to that medium.
b. Combined risk across all media exposures.
c. Relative contribution of COPC to total risk associated with the ingestion exposure pathway.

Attachment 8

TABLE 8-153

PARAMETER VALUES USED TO CALCULATE ESTIMATED DAILY INTAKE : Surficial sediment / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2018)
MEDIUM: SEDIMENT
EXPOSURE MEDIUM: Surficial sediment
EXPOSURE POINT: RME - Area of Focus
RECEPTOR: HERON

EXPOSURE ROUTE	PARAMETER SYMBOL	PARAMETER DEFINITION	UNITS	RME VALUE	RME RATIONALE/ REFERENCE	INTAKE EQUATION/ MODEL NAME
INGESTION	EDI_{sed}	ESTIMATED DAILY INTAKE VIA SEDIMENT INGESTION	mg/kg-d	calculated		SEDIMENT INTAKE-INGESTION
	C_{sed}	CHEMICAL CONCENTRATION IN SEDIMENT	mg/kg	chemical-specific		$EDI_{sed} = C_{sed} * IR_{sed} * SFF * EF * 1/BW$
	IR_{sed}	INGESTION RATE OF SEDIMENT	kg/day	0.019	assumption	
	SFF	SITE FORAGING FREQUENCY	unitless	100%	Bayer, 1978	
	EF	EXPOSURE FREQUENCY	unitless	58%	USEPA, 1993	
	BW	BODY WEIGHT	kg	2.2	USEPA, 1993	

References:

Bayer,R.D., 1978. Aspects of an Oregon estuarine great blue heron population; In: Sprunt, A., J. Ogden, S. Winkler, eds. Wading Birds; Natl. Audubon Soc. Res. Rep. 7:213-217.

USEPA, 1993. Wildlife Exposure Factors Handbook; United States Environmental Protection Agency, Office of Research and Development; EPA/600/R-93/187a; December 1993; Washington, D.C.

Attachment 8

TABLE 8-154

CALCULATION OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS : Surficial sediment / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2018)
MEDIUM: SEDIMENT
EXPOSURE MEDIUM: Surficial sediment
EXPOSURE POINT: RME - Area of Focus
RECEPTOR: HERON

Analyte	Medium EPC	Medium EPC Units	Estimated Daily Intake[a]	Daily Intake Units	Reference Dose (NOAEL)[b]	Reference Dose (LOAEL)[b]	Reference Dose Units	Hazard Quotient (NOAEL)[c]	Hazard Quotient (LOAEL)[c]
Copper	8.1E+01	mg/kg	4.2E-01	mg/kg-d	4.1E+00	1.2E+01	mg/kg-d	1.0E-01	3.5E-02
Lead	1.5E+02	mg/kg	7.6E-01	mg/kg-d	1.6E+00	3.3E+00	mg/kg-d	4.7E-01	2.3E-01
Methyl Mercury	6.2E-01	mg/kg	3.2E-03	mg/kg-d	7.8E-03	7.8E-02	mg/kg-d	4.1E-01	4.1E-02
LPAH	1.6E+01	mg/kg	8.0E-02	mg/kg-d	-	-			
HPAH	6.1E+01	mg/kg	3.1E-01	mg/kg-d	-	-			
Dieldrin	4.7E-03	mg/kg	2.4E-05	mg/kg-d	7.1E-02	3.8E+00	mg/kg-d	3.4E-04	6.4E-06
Total DDx	7.0E-02	mg/kg	3.6E-04	mg/kg-d	2.8E-03	2.8E-02	mg/kg-d	1.3E-01	1.3E-02
Total PCBs	3.9E-01	mg/kg	2.0E-03	mg/kg-d	1.0E-01	4.0E-01	mg/kg-d	2.0E-02	5.0E-03
TEQ PCB-birds	1.1E-04	mg/kg	5.8E-07	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	4.1E-01	4.1E-02
TEQ D/F-birds	4.1E-05	mg/kg	2.1E-07	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	1.5E-01	1.5E-02
							HAZARD INDICES:	**1.7E+00**	3.8E-01

Notes:
a. Estimated Daily Intake (EDI) calculated using parameters presented in Table 8-153.
b. Reference Dose Values presented in Table 6-4. A dash indicates that no value is available.
c. Hazard Quotients (HQs) calculated by dividing the Estimated Daily Intake dose by either the NOAEL- or LOAEL-based Reference Dose.

Attachment 8

TABLE 8-155

PARAMETER VALUES USED TO CALCULATE ESTIMATED DAILY INTAKE : Blue crab / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2018)
MEDIUM: AQUATIC INVERTEBRATES
EXPOSURE MEDIUM: Blue crab
EXPOSURE POINT: RME - Area of Focus
RECEPTOR: HERON

EXPOSURE ROUTE	PARAMETER SYMBOL	PARAMETER DEFINITION	UNITS	RME VALUE	RME RATIONALE/ REFERENCE	INTAKE EQUATION/ MODEL NAME
INGESTION	EDI_{invert}	ESTIMATED DAILY INTAKE VIA INVERTEBRATE INGESTION	mg/kg-d	calculated		INVERTEBRATE INTAKE-INGESTION $EDI_{invert} = C_{invert} * IR_{food} * P_{invert} * SFF * EF * 1/BW$
	C_{invert}	CHEMICAL CONCENTRATION IN INVERTEBRATES	mg/kg	chemical-specific		
	IR_{food}	INGESTION RATE OF FOOD	kg/day	0.39	Kushlan, 1978	
	P_{invert}	PERCENT INVERTEBRATES IN DIET	unitless	15%	assumption	Where C_{invert} is estimated using site-specific tissue data or calculated using the following equation: $C_{invert} = C_{sed} * BAF_{invert}$
	SFF	SITE FORAGING FREQUENCY	unitless	100%	Bayer, 1978	
	EF	EXPOSURE FREQUENCY	unitless	58%	USEPA, 1993	Bioaccumulation Factors [mg(ww tissue)/ kg(dw sediment)] provided separately.
	BW	BODY WEIGHT	kg	2.2	USEPA, 1993	

References:

Bayer,R.D., 1978. Aspects of an Oregon estuarine great blue heron population; In: Sprunt, A., J. Ogden, S. Winkler, eds. Wading Birds; Natl. Audubon Soc. Res. Rep. 7:213-217.

Kushlan, J.A., 1978. Feeding ecology of wading birds; In: Sprunt, A., J. Ogden, S. Winkler, eds. Wading Birds; Natl. Audubon Soc. Res. Rep. 7:213-217.

USEPA, 1993. Wildlife Exposure Factors Handbook; United States Environmental Protection Agency, Office of Research and Development; EPA/600/R-93/187a; December 1993; Washington, D.C.

Attachment 8

TABLE 8-156

CALCULATION OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS : Blue crab / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2018)
MEDIUM: AQUATIC INVERTEBRATES
EXPOSURE MEDIUM: Blue crab
EXPOSURE POINT: RME - Area of Focus
RECEPTOR: HERON

Analyte	Medium EPC	Medium EPC Units	Estimated Daily Intake[a]	Daily Intake Units	Reference Dose (NOAEL)[b]	Reference Dose (LOAEL)[b]	Reference Dose Units	Hazard Quotient (NOAEL)[c]	Hazard Quotient (LOAEL)[c]
Copper	1.1E+01	mg/kg	1.8E-01	mg/kg-d	4.1E+00	1.2E+01	mg/kg-d	4.3E-02	1.5E-02
Lead	2.1E-01	mg/kg	3.2E-03	mg/kg-d	1.6E+00	3.3E+00	mg/kg-d	2.0E-03	9.9E-04
Methyl Mercury	1.7E-02	mg/kg	2.7E-04	mg/kg-d	7.8E-03	7.8E-02	mg/kg-d	3.4E-02	3.4E-03
LPAH	1.2E-01	mg/kg	1.8E-03	mg/kg-d	-	-			
HPAH	1.9E-01	mg/kg	3.0E-03	mg/kg-d	-	-			
Dieldrin	3.2E-03	mg/kg	4.9E-05	mg/kg-d	7.1E-02	3.8E+00	mg/kg-d	6.9E-04	1.3E-05
Total DDx	7.8E-02	mg/kg	1.2E-03	mg/kg-d	2.8E-03	2.8E-02	mg/kg-d	4.3E-01	4.3E-02
Total PCBs	7.9E-01	mg/kg	1.2E-02	mg/kg-d	1.0E-01	4.0E-01	mg/kg-d	1.2E-01	3.1E-02
TEQ PCB-birds	1.5E-04	mg/kg	2.3E-06	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	**1.6E+00**	1.6E-01
TEQ D/F-birds	7.0E-06	mg/kg	1.1E-07	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	7.7E-02	7.7E-03
							HAZARD INDICES:	**2.3E+00**	2.6E-01

Notes:
a. Estimated Daily Intake (EDI) calculated using parameters presented in Table 8-155.
b. Reference Dose Values presented in Table 6-4. A dash indicates that no value is available.
c. Hazard Quotients (HQs) calculated by dividing the Estimated Daily Intake dose by either the NOAEL- or LOAEL-based Reference Dose.

Attachment 8

TABLE 8-157

PARAMETER VALUES USED TO CALCULATE ESTIMATED DAILY INTAKE : Mummichog / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2018)
MEDIUM: FISH
EXPOSURE MEDIUM: Mummichog
EXPOSURE POINT: RME - Area of Focus
RECEPTOR: HERON

EXPOSURE ROUTE	PARAMETER SYMBOL	PARAMETER DEFINITION	UNITS	RME VALUE	RME RATIONALE/ REFERENCE	INTAKE EQUATION/ MODEL NAME
INGESTION	EDI_{fish}	ESTIMATED DAILY INTAKE VIA FISH INGESTION	mg/kg-d	calculated		FISH INTAKE-INGESTION
	C_{fish}	CHEMICAL CONCENTRATION IN FISH	mg/kg	chemical-specific		$EDI_{fish} = C_{fish} * IR_{food} * P_{fish} * SFF * EF * 1/BW$
	IR_{food}	INGESTION RATE OF FOOD	kg/day	0.39	Kushlan, 1978	
	P_{fish}	PERCENT FISH IN DIET	unitless	85%	assumption	Where C_{fish} is estimated using site-specific tissue data or estimated using the following equation:
	SFF	SITE FORAGING FREQUENCY	unitless	100%	Bayer, 1978	$C_{fish} = C_{sed} * BAF_{fish}$
	EF	EXPOSURE FREQUENCY	unitless	58%	USEPA, 1993	Bioaccumulation Factors [mg(ww tissue)/ kg(dw sediment)] provided separately.
	BW	BODY WEIGHT	kg	2.2	USEPA, 1993	

References:

Bayer,R.D., 1978. Aspects of an Oregon estuarine great blue heron population; In: Sprunt, A., J. Ogden, S. Winkler, eds. Wading Birds; Natl. Audubon Soc. Res. Rep. 7:213-217.

Kushlan, J.A., 1978. Feeding ecology of wading birds; In: Sprunt, A., J. Ogden, S. Winkler, eds. Wading Birds; Natl. Audubon Soc. Res. Rep. 7:213-217.

USEPA, 1993. Wildlife Exposure Factors Handbook; United States Environmental Protection Agency, Office of Research and Development; EPA/600/R-93/187a; December 1993; Washington, D.C.

Attachment 8

TABLE 8-158

CALCULATION OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS : Mummichog / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2018)
MEDIUM: FISH
EXPOSURE MEDIUM: Mummichog
EXPOSURE POINT: RME - Area of Focus
RECEPTOR: HERON

Analyte	Medium EPC	Medium EPC Units	Estimated Daily Intake[a]	Daily Intake Units	Reference Dose (NOAEL)[b]	Reference Dose (LOAEL)[b]	Reference Dose Units	Hazard Quotient (NOAEL)[c]	Hazard Quotient (LOAEL)[c]
Copper	1.4E+00	mg/kg	1.2E-01	mg/kg-d	4.1E+00	1.2E+01	mg/kg-d	3.0E-02	9.9E-03
Lead	3.2E-01	mg/kg	2.8E-02	mg/kg-d	1.6E+00	3.3E+00	mg/kg-d	1.7E-02	8.5E-03
Methyl Mercury	7.6E-03	mg/kg	6.7E-04	mg/kg-d	7.8E-03	7.8E-02	mg/kg-d	8.5E-02	8.5E-03
LPAH	1.5E-01	mg/kg	1.3E-02	mg/kg-d	-	-			
HPAH	1.1E-01	mg/kg	9.6E-03	mg/kg-d	-	-			
Dieldrin	1.0E-03	mg/kg	9.2E-05	mg/kg-d	7.1E-02	3.8E+00	mg/kg-d	1.3E-03	2.4E-05
Total DDx	2.2E-02	mg/kg	1.9E-03	mg/kg-d	2.8E-03	2.8E-02	mg/kg-d	6.9E-01	6.9E-02
Total PCBs	2.0E-01	mg/kg	1.7E-02	mg/kg-d	1.0E-01	4.0E-01	mg/kg-d	1.7E-01	4.3E-02
TEQ PCB-birds	3.3E-05	mg/kg	2.8E-06	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	**2.0E+00**	2.0E-01
TEQ D/F-birds	3.8E-06	mg/kg	3.4E-07	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	2.4E-01	2.4E-02
							HAZARD INDICES:	**3.3E+00**	3.7E-01

Notes:
a. Estimated Daily Intake (EDI) calculated using parameters presented in Table 8-157.
b. Reference Dose Values presented in Table 6-4. A dash indicates that no value is available.
c. Hazard Quotients (HQs) calculated by dividing the Estimated Daily Intake dose by either the NOAEL- or LOAEL-based Reference Dose.

Attachment 8

TABLE 8-159

SUMMARY OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS USING NOAEL-BASED TRVs : HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2018)
EXPOSURE POINT: RME - Area of Focus
RECEPTOR: HERON
TOTAL RISK (HI): 7.3E+00

Analyte	Exposure Medium[a]					Combined HQs[b]	Percent Contribution[c]
	Surface Water	Sediment	Aquatic Plants	Aquatic Invertebrates	Fish		
Total DDx		1.3E-01		4.3E-01	6.9E-01	***1.3E+00***	***17%***
Total PCBs		2.0E-02		1.2E-01	1.7E-01	3.1E-01	4%
Mercury		4.1E-01		3.4E-02	8.5E-02	5.3E-01	7%
Lead		4.7E-01		2.0E-03	1.7E-02	4.8E-01	7%
TCDD TEQ (D/F)		1.5E-01		7.7E-02	2.4E-01	4.7E-01	6%
TCDD TEQ (PCBs)		4.1E-01		1.6E+00	2.0E+00	***4.1E+00***	***56%***
Copper		1.0E-01		4.3E-02	3.0E-02	1.8E-01	2%
Dieldrin		3.4E-04		6.9E-04	1.3E-03	2.3E-03	0%
LPAH							
HPAH							
TOTAL MEDIUM-SPECIFIC RISK	**-**	**1.7E+00**	**-**	**2.3E+00**	**3.3E+00**	**7.3E+00**	
PERCENTAGE OF TOTAL RISK		**23%**		**32%**	**45%**	**100%**	

Notes:
a. Hazard Quotients presented by exposure medium; a blank cell indicates that the analyte was not a COPC for that medium; a dash entry indicates that there was no assumed exposure to that medium.
b. Combined risk across all media exposures.
c. Relative contribution of COPC to total risk associated with the ingestion exposure pathway.

Attachment 8

TABLE 8-160

SUMMARY OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS USING LOAEL-BASED TRVs : HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2018)
EXPOSURE POINT: RME - Area of Focus
RECEPTOR: HERON
TOTAL RISK (HI): 1.0E+00

Analyte	Exposure Medium[a]					Combined HQs[b]	Percent Contribution[c]
	Surface Water	Sediment	Aquatic Plants	Aquatic Invertebrates	Fish		
Lead		2.3E-01		9.9E-04	8.5E-03	2.4E-01	***24%***
Total PCBs		5.0E-03		3.1E-02	4.3E-02	7.8E-02	8%
Total DDx		1.3E-02		4.3E-02	6.9E-02	1.3E-01	***12%***
Copper		3.5E-02		1.5E-02	9.9E-03	5.9E-02	6%
Mercury		4.1E-02		3.4E-03	8.5E-03	5.3E-02	5%
TCDD TEQ (D/F)		1.5E-02		7.7E-03	2.4E-02	4.7E-02	5%
TCDD TEQ (PCBs)		4.1E-02		1.6E-01	2.0E-01	4.1E-01	***40%***
Dieldrin		6.4E-06		1.3E-05	2.4E-05	4.3E-05	0%
LPAH							
HPAH							
TOTAL MEDIUM-SPECIFIC RISK	**-**	**3.8E-01**	**-**	**2.6E-01**	**3.7E-01**	**1.0E+00**	
PERCENTAGE OF TOTAL RISK		**38%**		**26%**	**36%**	**100%**	

Notes:
a. Hazard Quotients presented by exposure medium; a blank cell indicates that the analyte was not a COPC for that medium; a dash entry indicates that there was no assumed exposure to that medium.
b. Combined risk across all media exposures.
c. Relative contribution of COPC to total risk associated with the ingestion exposure pathway.

Attachment 8

TABLE 8-161

PARAMETER VALUES USED TO CALCULATE ESTIMATED DAILY INTAKE : Surficial sediment / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2048)
MEDIUM: SEDIMENT
EXPOSURE MEDIUM: Surficial sediment
EXPOSURE POINT: RME - Area of Focus
RECEPTOR: HERON

EXPOSURE ROUTE	PARAMETER SYMBOL	PARAMETER DEFINITION	UNITS	RME VALUE	RME RATIONALE/ REFERENCE	INTAKE EQUATION/ MODEL NAME
INGESTION	EDI_{sed}	ESTIMATED DAILY INTAKE VIA SEDIMENT INGESTION	mg/kg-d	calculated		SEDIMENT INTAKE-INGESTION
	C_{sed}	CHEMICAL CONCENTRATION IN SEDIMENT	mg/kg	chemical-specific		$EDI_{sed} = C_{sed} * IR_{sed} * SFF * EF * 1/BW$
	IR_{sed}	INGESTION RATE OF SEDIMENT	kg/day	0.019	assumption	
	SFF	SITE FORAGING FREQUENCY	unitless	100%	Bayer, 1978	
	EF	EXPOSURE FREQUENCY	unitless	58%	USEPA, 1993	
	BW	BODY WEIGHT	kg	2.2	USEPA, 1993	

References:

Bayer,R.D., 1978. Aspects of an Oregon estuarine great blue heron population; In: Sprunt, A., J. Ogden, S. Winkler, eds. Wading Birds; Natl. Audubon Soc. Res. Rep. 7:213-217.

USEPA, 1993. Wildlife Exposure Factors Handbook; United States Environmental Protection Agency, Office of Research and Development; EPA/600/R-93/187a; December 1993; Washington, D.C.

Attachment 8

TABLE 8-162

CALCULATION OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS : Surficial sediment / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2048)
MEDIUM: SEDIMENT
EXPOSURE MEDIUM: Surficial sediment
EXPOSURE POINT: RME - Area of Focus
RECEPTOR: HERON

Analyte	Medium EPC	Medium EPC Units	Estimated Daily Intake[a]	Daily Intake Units	Reference Dose (NOAEL)[b]	Reference Dose (LOAEL)[b]	Reference Dose Units	Hazard Quotient (NOAEL)[c]	Hazard Quotient (LOAEL)[c]
Copper	4.1E+01	mg/kg	2.1E-01	mg/kg-d	4.1E+00	1.2E+01	mg/kg-d	5.2E-02	1.8E-02
Lead	6.9E+01	mg/kg	3.5E-01	mg/kg-d	1.6E+00	3.3E+00	mg/kg-d	2.2E-01	1.1E-01
Methyl Mercury	2.0E-01	mg/kg	1.0E-03	mg/kg-d	7.8E-03	7.8E-02	mg/kg-d	1.3E-01	1.3E-02
LPAH	1.6E+01	mg/kg	8.0E-02	mg/kg-d	-	-			
HPAH	6.1E+01	mg/kg	3.1E-01	mg/kg-d	-	-			
Dieldrin	4.7E-03	mg/kg	2.4E-05	mg/kg-d	7.1E-02	3.8E+00	mg/kg-d	3.4E-04	6.4E-06
Total DDx	2.4E-02	mg/kg	1.3E-04	mg/kg-d	2.8E-03	2.8E-02	mg/kg-d	4.5E-02	4.5E-03
Total PCBs	8.8E-02	mg/kg	4.5E-04	mg/kg-d	1.0E-01	4.0E-01	mg/kg-d	4.5E-03	1.1E-03
TEQ PCB-birds	2.8E-05	mg/kg	1.4E-07	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	1.0E-01	1.0E-02
TEQ D/F-birds	1.4E-05	mg/kg	7.1E-08	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	5.1E-02	5.1E-03
							HAZARD INDICES:	6.0E-01	1.6E-01

Notes:
a. Estimated Daily Intake (EDI) calculated using parameters presented in Table 8-161.
b. Reference Dose Values presented in Table 6-4. A dash indicates that no value is available.
c. Hazard Quotients (HQs) calculated by dividing the Estimated Daily Intake dose by either the NOAEL- or LOAEL-based Reference Dose.

Attachment 8

TABLE 8-163

PARAMETER VALUES USED TO CALCULATE ESTIMATED DAILY INTAKE : Blue crab / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2048)
MEDIUM: AQUATIC INVERTEBRATES
EXPOSURE MEDIUM: Blue crab
EXPOSURE POINT: RME - Area of Focus
RECEPTOR: HERON

EXPOSURE ROUTE	PARAMETER SYMBOL	PARAMETER DEFINITION	UNITS	RME VALUE	RME RATIONALE/ REFERENCE	INTAKE EQUATION/ MODEL NAME
INGESTION	EDI_{invert}	ESTIMATED DAILY INTAKE VIA INVERTEBRATE INGESTION	mg/kg-d	calculated		INVERTEBRATE INTAKE-INGESTION $EDI_{invert} = C_{invert} * IR_{food} * P_{invert} * SFF * EF * 1/BW$
	C_{invert}	CHEMICAL CONCENTRATION IN INVERTEBRATES	mg/kg	chemical-specific		
	IR_{food}	INGESTION RATE OF FOOD	kg/day	0.39	Kushlan, 1978	
	P_{invert}	PERCENT INVERTEBRATES IN DIET	unitless	15%	assumption	Where C_{invert} is estimated using site-specific tissue data or calculated using the following equation: $C_{invert} = C_{sed} * BAF_{invert}$
	SFF	SITE FORAGING FREQUENCY	unitless	100%	Bayer, 1978	
	EF	EXPOSURE FREQUENCY	unitless	58%	USEPA, 1993	Bioaccumulation Factors [mg(ww tissue)/ kg(dw sediment)] provided separately.
	BW	BODY WEIGHT	kg	2.2	USEPA, 1993	

References:

Bayer,R.D., 1978. Aspects of an Oregon estuarine great blue heron population; In: Sprunt, A., J. Ogden, S. Winkler, eds. Wading Birds; Natl. Audubon Soc. Res. Rep. 7:213-217.

Kushlan, J.A., 1978. Feeding ecology of wading birds; In: Sprunt, A., J. Ogden, S. Winkler, eds. Wading Birds; Natl. Audubon Soc. Res. Rep. 7:213-217.

USEPA, 1993. Wildlife Exposure Factors Handbook; United States Environmental Protection Agency, Office of Research and Development; EPA/600/R-93/187a; December 1993; Washington, D.C.

Attachment 8

TABLE 8-164

CALCULATION OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS : Blue crab / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2048)
MEDIUM: AQUATIC INVERTEBRATES
EXPOSURE MEDIUM: Blue crab
EXPOSURE POINT: RME - Area of Focus
RECEPTOR: HERON

Analyte	Medium EPC	Medium EPC Units	Estimated Daily Intake[a]	Daily Intake Units	Reference Dose (NOAEL)[b]	Reference Dose (LOAEL)[b]	Reference Dose Units	Hazard Quotient (NOAEL)[c]	Hazard Quotient (LOAEL)[c]
Copper	5.8E+00	mg/kg	8.9E-02	mg/kg-d	4.1E+00	1.2E+01	mg/kg-d	2.2E-02	7.4E-03
Lead	9.7E-02	mg/kg	1.5E-03	mg/kg-d	1.6E+00	3.3E+00	mg/kg-d	9.2E-04	4.6E-04
Methyl Mercury	5.5E-03	mg/kg	8.6E-05	mg/kg-d	7.8E-03	7.8E-02	mg/kg-d	1.1E-02	1.1E-03
LPAH	1.2E-01	mg/kg	1.8E-03	mg/kg-d	-	-			
HPAH	1.9E-01	mg/kg	3.0E-03	mg/kg-d	-	-			
Dieldrin	3.2E-03	mg/kg	4.9E-05	mg/kg-d	7.1E-02	3.8E+00	mg/kg-d	6.9E-04	1.3E-05
Total DDx	2.7E-02	mg/kg	4.2E-04	mg/kg-d	2.8E-03	2.8E-02	mg/kg-d	1.5E-01	1.5E-02
Total PCBs	1.8E-01	mg/kg	2.8E-03	mg/kg-d	1.0E-01	4.0E-01	mg/kg-d	2.8E-02	6.9E-03
TEQ PCB-birds	3.7E-05	mg/kg	5.6E-07	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	4.0E-01	4.0E-02
TEQ D/F-birds	2.4E-06	mg/kg	3.6E-08	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	2.6E-02	2.6E-03
							HAZARD INDICES:	6.4E-01	7.4E-02

Notes:
a. Estimated Daily Intake (EDI) calculated using parameters presented in Table 8-163.
b. Reference Dose Values presented in Table 6-4. A dash indicates that no value is available.
c. Hazard Quotients (HQs) calculated by dividing the Estimated Daily Intake dose by either the NOAEL- or LOAEL-based Reference Dose.

Attachment 8

TABLE 8-165

PARAMETER VALUES USED TO CALCULATE ESTIMATED DAILY INTAKE : Mummichog / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2048)
MEDIUM: FISH
EXPOSURE MEDIUM: Mummichog
EXPOSURE POINT: RME - Area of Focus
RECEPTOR: HERON

EXPOSURE ROUTE	PARAMETER SYMBOL	PARAMETER DEFINITION	UNITS	RME VALUE	RME RATIONALE/ REFERENCE	INTAKE EQUATION/ MODEL NAME
INGESTION	EDI_{fish}	ESTIMATED DAILY INTAKE VIA FISH INGESTION	mg/kg-d	calculated		FISH INTAKE-INGESTION
	C_{fish}	CHEMICAL CONCENTRATION IN FISH	mg/kg	chemical-specific		$EDI_{fish} = C_{fish} * IR_{food} * P_{fish} * SFF * EF * 1/BW$
	IR_{food}	INGESTION RATE OF FOOD	kg/day	0.39	Kushlan, 1978	
	P_{fish}	PERCENT FISH IN DIET	unitless	85%	assumption	Where C_{fish} is estimated using site-specific tissue data or estimated using the following equation:
	SFF	SITE FORAGING FREQUENCY	unitless	100%	Bayer, 1978	$C_{fish} = C_{sed} * BAF_{fish}$
	EF	EXPOSURE FREQUENCY	unitless	58%	USEPA, 1993	Bioaccumulation Factors [mg(ww tissue)/ kg(dw sediment)] provided separately.
	BW	BODY WEIGHT	kg	2.2	USEPA, 1993	

References:

Bayer,R.D., 1978. Aspects of an Oregon estuarine great blue heron population; In: Sprunt, A., J. Ogden, S. Winkler, eds. Wading Birds; Natl. Audubon Soc. Res. Rep. 7:213-217.

Kushlan, J.A., 1978. Feeding ecology of wading birds; In: Sprunt, A., J. Ogden, S. Winkler, eds. Wading Birds; Natl. Audubon Soc. Res. Rep. 7:213-217.

USEPA, 1993. Wildlife Exposure Factors Handbook; United States Environmental Protection Agency, Office of Research and Development; EPA/600/R-93/187a; December 1993; Washington, D.C.

Attachment 8

TABLE 8-166

CALCULATION OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS : Mummichog / HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2048)
MEDIUM: FISH
EXPOSURE MEDIUM: Mummichog
EXPOSURE POINT: RME - Area of Focus
RECEPTOR: HERON

Analyte	Medium EPC	Medium EPC Units	Estimated Daily Intake[a]	Daily Intake Units	Reference Dose (NOAEL)[b]	Reference Dose (LOAEL)[b]	Reference Dose Units	Hazard Quotient (NOAEL)[c]	Hazard Quotient (LOAEL)[c]
Copper	7.0E-01	mg/kg	6.1E-02	mg/kg-d	4.1E+00	1.2E+01	mg/kg-d	1.5E-02	5.0E-03
Lead	1.5E-01	mg/kg	1.3E-02	mg/kg-d	1.6E+00	3.3E+00	mg/kg-d	7.9E-03	4.0E-03
Methyl Mercury	2.4E-03	mg/kg	2.1E-04	mg/kg-d	7.8E-03	7.8E-02	mg/kg-d	2.7E-02	2.7E-03
LPAH	1.5E-01	mg/kg	1.3E-02	mg/kg-d	-	-			
HPAH	1.1E-01	mg/kg	9.6E-03	mg/kg-d	-	-			
Dieldrin	1.0E-03	mg/kg	9.2E-05	mg/kg-d	7.1E-02	3.8E+00	mg/kg-d	1.3E-03	2.4E-05
Total DDx	7.8E-03	mg/kg	6.8E-04	mg/kg-d	2.8E-03	2.8E-02	mg/kg-d	2.4E-01	2.4E-02
Total PCBs	4.4E-02	mg/kg	3.9E-03	mg/kg-d	1.0E-01	4.0E-01	mg/kg-d	3.9E-02	9.7E-03
TEQ PCB-birds	8.1E-06	mg/kg	7.1E-07	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	5.1E-01	5.1E-02
TEQ D/F-birds	1.3E-06	mg/kg	1.1E-07	mg/kg-d	1.4E-06	1.4E-05	mg/kg-d	8.0E-02	8.0E-03
							HAZARD INDICES:	9.2E-01	1.0E-01

Notes:
a. Estimated Daily Intake (EDI) calculated using parameters presented in Table 8-165.
b. Reference Dose Values presented in Table 6-4. A dash indicates that no value is available.
c. Hazard Quotients (HQs) calculated by dividing the Estimated Daily Intake dose by either the NOAEL- or LOAEL-based Reference Dose.

Attachment 8

TABLE 8-167

SUMMARY OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS USING NOAEL-BASED TRVs : HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2048)
EXPOSURE POINT: RME - Area of Focus
RECEPTOR: HERON
TOTAL RISK (HI): 2.2E+00

Analyte	Exposure Medium[a]					Combined HQs[b]	Percent Contribution[c]
	Surface Water	Sediment	Aquatic Plants	Aquatic Invertebrates	Fish		
TCDD TEQ (D/F)		5.1E-02		2.6E-02	8.0E-02	1.6E-01	7%
Lead		2.2E-01		9.2E-04	7.9E-03	2.3E-01	***10%***
Total PCBs		4.5E-03		2.8E-02	3.9E-02	7.1E-02	3%
Mercury		1.3E-01		1.1E-02	2.7E-02	1.7E-01	8%
Copper		5.2E-02		2.2E-02	1.5E-02	8.9E-02	4%
Total DDx		4.5E-02		1.5E-01	2.4E-01	4.4E-01	***20%***
TCDD TEQ (PCBs)		1.0E-01		4.0E-01	5.1E-01	***1.0E+00***	***47%***
Dieldrin		3.4E-04		6.9E-04	1.3E-03	2.3E-03	0%
LPAH							
HPAH							
TOTAL MEDIUM-SPECIFIC RISK	**-**	**6.0E-01**	**-**	**6.4E-01**	**9.2E-01**	**2.2E+00**	
PERCENTAGE OF TOTAL RISK		**28%**		**30%**	**43%**	**100%**	

Notes:
a. Hazard Quotients presented by exposure medium; a blank cell indicates that the analyte was not a COPC for that medium; a dash entry indicates that there was no assumed exposure to that medium.
b. Combined risk across all media exposures.
c. Relative contribution of COPC to total risk associated with the ingestion exposure pathway.

Attachment 8

TABLE 8-168

SUMMARY OF EXPOSURE PATHWAY/MEDIUM-SPECIFIC HAZARD QUOTIENTS USING LOAEL-BASED TRVs : HERON

Focused Feasibility Study - Ecological Risk Assessment
LOWER PASSAIC RIVER RESTORATION PROJECT
New Jersey

SCENARIO TIMEFRAME: FUTURE (2048)
EXPOSURE POINT: RME - Area of Focus
RECEPTOR: HERON
TOTAL RISK (HI): 3.4E-01

Analyte	Exposure Medium[a]					Combined HQs[b]	Percent Contribution[c]
	Surface Water	Sediment	Aquatic Plants	Aquatic Invertebrates	Fish		
Lead		1.1E-01		4.6E-04	4.0E-03	1.1E-01	***33%***
Total PCBs		1.1E-03		6.9E-03	9.7E-03	1.8E-02	5%
Copper		1.8E-02		7.4E-03	5.0E-03	3.0E-02	9%
TCDD TEQ (D/F)		5.1E-03		2.6E-03	8.0E-03	1.6E-02	5%
Mercury		1.3E-02		1.1E-03	2.7E-03	1.7E-02	5%
Total DDx		4.5E-03		1.5E-02	2.4E-02	4.4E-02	***13%***
TCDD TEQ (PCBs)		1.0E-02		4.0E-02	5.1E-02	1.0E-01	***30%***
Dieldrin		6.4E-06		1.3E-05	2.4E-05	4.3E-05	0%
LPAH							
HPAH							
TOTAL MEDIUM-SPECIFIC RISK	**-**	**1.6E-01**	**-**	**7.4E-02**	**1.0E-01**	**3.4E-01**	
PERCENTAGE OF TOTAL RISK		**47%**		**22%**	**31%**	**100%**	

Notes:
a. Hazard Quotients presented by exposure medium; a blank cell indicates that the analyte was not a COPC for that medium; a dash entry indicates that there was no assumed exposure to that medium.
b. Combined risk across all media exposures.
c. Relative contribution of COPC to total risk associated with the ingestion exposure pathway.

Appendix D

Empirical Mass Balance Model

Draft Contractor Document: Subject to Continuing Agency Review

LOWER PASSAIC RIVER RESTORATION PROJECT
EMPIRICAL MASS BALANCE MODEL

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1.0 SUMMARY OF THE EMPIRICAL MASS BALANCE REPORT

An empirical mass balance model (EMBM) was developed to assist in the analysis of remedial alternatives for the Lower Passaic River FFS. The model quantifies the relative contaminant and solids contributions to the river's recently deposited surface sediments from various sources. These estimates are then used to evaluate the potential impacts of remediation on the lower eight miles of the Lower Passaic River, utilizing the dated sediment core records as a starting point. The major conclusions of the empirical mass balance model are summarized as follows:

- External contaminant sources (by themselves) cannot account for the observed chemical of potential concern (COPC) concentrations in the Lower Passaic River surface sediments, indicating that an internal source, or more specifically sediment resuspension, is contributing to the contaminant burden of recently deposited surface sediments in the river.
- Surface sediments that accumulate in the Lower Passaic River are comprised of solids that originated from the Upper Passaic River, Newark Bay, tributaries, CSO/SWOs, and river-bottom sediment resuspension.
- As a fraction of the total solids flux to the Lower Passaic River, resuspension of legacy sediments (*i.e.*, the historical inventory) comprises about 10 percent of the total annual deposition.
- The relative contributions from the Upper Passaic River and Newark Bay are roughly equal with respect to solids. In terms of the contaminant loads, however, the Upper Passaic River is clearly the more important of the two.
- For 2,3,7,8-tetrachlorodibenzodioxins (TCDD) and Total TCDD, no significant external contaminant source exists, while the resuspension of legacy sediments accounts for more than 95 percent of the dioxin burden in recently deposited sediments. Consequently, the mixing of contaminated, resuspended solids with relatively cleaner solids from external sources has resulted in a relatively gradual decline in surface concentrations over the past 25 years.

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- For Total Polychlorinated Biphenyls (PCB), which are primarily comprised of heavier PCB congeners, the Upper Passaic River and the resuspension of legacy sediments each contribute approximately 40 percent of the contaminant burden to the river. The source loading of the lighter PCB congeners is similar to that of dioxins, with resuspension of legacy sediments accounting for approximately 75 percent of the contaminant burden.
- The Upper Passaic River is the dominant source of polyaromatic hydrocarbon (PAH) compounds to the Lower Passaic River, accounting for at least 50 percent of the contaminant load and often much more.
- For dichlorodiphenyldichloroethylene (DDE, a DDT derivative) and mercury, the resuspension of historical inventory is a major component of the burden in recently deposited sediments. However, DDE has a secondary but important contribution from the Upper Passaic River while mercury has a substantive input from Newark Bay. In each case, resuspension is responsible for about half of the ongoing flux to the sediments while the secondary term represents about a quarter.
- The Upper Passaic River, tributaries, combined sewer overflows/stormwater overflows (CSO/SWOs), Newark Bay, and resuspension of historical inventory contributed equal portions of the lead contaminant burden in recently deposited sediments.
- CSO/SWOs and the tributaries play only minor roles for contaminants like dioxin, PCB, and DDT; however, taken together, their contributions can represent about a third of the total flux for contaminants like lead, copper, dieldrin, and chlordane.

The dated sediment record in the Lower Passaic River for the COPCs shows concentrations in sediments to be declining slowly, with the shortest ‘half lives” around 14 years. Several contaminants show no measurable rate of decline over the past 25 years and in fact a few suggest a gradual increase during this period. The major conclusions for the dated sediment core analysis are summarized as follows:

- None of the sediment concentrations of the COPCs have declined rapidly over the past 25 years. The COPC with the shortest half life is Total PCB,

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at about 14 years. Even at this rate, an order of magnitude decline in concentration requires about 45 years.

- The COPCs with the shorter half lives are those whose mass balance estimates are dominated by resuspension of legacy sediments. The COPCs with significant external sources appear to be declining much more slowly.
- Surface sediment concentrations of low molecular weight (LMW) PAHs, high molecular weight (HMW) PAHs, and dieldrin have not declined over the past 25 years and may be increasing slightly with time.
- In terms of toxic equivalency (TEQ), 2,3,7,8-TCDD is the most important constituent in the sum, with the dioxin-based fraction representing 80 percent or more of the Total TEQ for mammals and fish. For birds, the dioxin component is still the most important, but the PCB component is a significant contributor, representing about 40 percent of the Total TEQ.

Based on the relative contributions of the various sources considered in the EMBM and the historical trends in the dated sediment cores, post-remediation COPC concentrations were calculated for the various remedial alternatives, based on the fact that remediation will reduce the resuspension flux of legacy sediments. Sediment resuspension as a source will be controlled by active remediation because each active remedial alternative includes the placement of sand material from RM0 to RM8. This sand material will restrict the erosion and mixing of older, more contaminated sediments with the Lower Passaic River surface sediment. By controlling resuspension, future surface sediment concentrations can be calculated for the following three scenarios:

- Monitored Natural Recovery (MNR, no change in the resuspension source term).
- The placement of sand material from RM0 to RM8, which will control approximately 90 percent of the resuspension in the Lower Passaic River (referred to as “the containment alternative”).

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- A hypothetical remedial scenario for the remediation of individual target areas. The target areas of the river include the Primary Erosional Zone between RM3.5 and RM5.1 and the Primary Inventory Zone between RM2.4 and RM3.3. Remediation would control approximately one third of the erosional areas between RM0 and RM15 and presumably one third of the resuspension flux as well.

The forecasted 2048 concentrations showed that the active remediation of RM0 to RM8 substantively reduced surface sediment concentrations relative to MNR for 2,3,7,8-TCDD. The forecast concentrations for surface sediments are given in Table 1-1.

Table 1-1: Summary of Forecasted 2048 Surface Sediment Concentrations

Analyte	MNR Response	Containment Alternative	Primary Erosional Zone
Mercury (mg/kg)	0.25	0.17	0.22
Lead (mg/kg)	68	60	65
Copper (mg/kg)	43	38	41
Total Chlordane (µg/kg)	36	36	36
DDE (µg/kg)	9.2	5.7	8.0
DDD (µg/kg)	13	7.9	11
DDT (µg/kg)	2.8	1.7	2.4
Total DDT (µg/kg)	25	15	22
Dieldrin (µg/kg)	4.2	3.4	3.9
2,3,7,8-TCDD (ng/kg)	45	6.5	32
PCDD/F TEQ (µg/kg)	0.046	0.0066	0.032
Total PCB (µg/kg)	94	64	84
PCB TEQ Mammal (µg/kg)	0.0019	0.0013	0.0017
PCB TEQ Bird (µg/kg)	0.030	0.020	0.026
PCB TEQ Fish(µg/kg)	0.00016	0.00011	0.00014
LMW PAH (mg/kg)	5.3	5.2	5.3
HMW PAH (mg/kg)	35	35	35

Concentrations rounded to two significant figures.

Forecasted surface sediment concentrations did not significantly differ between the MNR scenario and the hypothetical remedial scenario of the Primary Erosional Zone only. However, the containment alternative did result in lower surface sediment concentrations for most contaminants. Another approach to comparing the MNR response and the containment alternative is to calculate the additional amount of time required for the MNR response to achieve the surface concentrations predicted in the containment alternative (Table 1-2). In this comparison, the largest time differences corresponded to

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2,3,7,8-TCDD and the associated TEQ values. The smallest time differences correspond to lead and copper. These time differences are expected to represent a minimum for any scenario involving deepening of the channel since this will enhance the settling of solids in the Lower Passaic River and probably increase the percentage of cleaner solids from Newark Bay in the solids mixture.

Table 1-2: Additional Time Required by the MNR Scenario Relative to the RM0 to RM8 Remediation to Achieve a Given Concentration

Analyte	Additional Time to Achieve the Same Reduction by MNR (yrs)
Mercury	10
Lead	5
Copper	5
Total Chlordane	-
DDE	15
DDD	15
DDT	15
Total DDT	15
Dieldrin	-
2,3,7,8-TCDD	40
PCDD/F TEQ	40
Total PCB	10
PCB TEQ Mammal	10
PCB TEQ Bird	10
PCB TEQ Fish	10
Total TEQ Mammal	40
Total TEQ Bird	25
Total TEQ Fish	40
LMW PAH	-
HMW PAH	-

The symbol (-) represents no time difference.

In summary, the EMBM successfully synthesized the COPC concentrations in recently deposited sediments based on the known levels of contamination in the external sources to the Lower Passaic plus a significant sediment resuspension flux. For the most part, the calculations bore out the hypotheses of the February 2007 update of the conceptual site model (CSM; Malcolm Pirnie, 2007a; provided in Appendix A of the FFS) in this regard, such as the importance of resuspension and the loads originating above Dundee Dam. The solids contribution to the Lower Passaic River from Newark Bay was larger than anticipated, but the associated contaminant transport was minor (15 percent or less for all contaminants except mercury), which confirmed the more important premise of the CSM,

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i.e., Newark Bay is not an important source of contamination to the Lower Passaic River. The EMBM results combined with the dated sediment core chronologies enabled the calculation of the impacts of two remedial scenarios relative to MNR and showed a substantial improvement in surface sediment concentrations of 2,3,7,8-TCDD as a result of remediating RM0 to RM8. Based on the analysis, MNR will require at least an additional 40 years to attain a concentration comparable to this remediation.

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2.0 INTRODUCTION

2.1 PURPOSE OF THE EMPIRICAL MASS BALANCE MODEL

The purpose of this document is to describe the results of an empirical mass balance model that was developed to assist in the analysis of remedial alternatives for the Lower Passaic River Focused Feasibility Study (FFS). The model quantifies the relative contributions of contaminants and solids to the Lower Passaic River by the various sources described in the conceptual site model (CSM) (Malcolm Pirnie, Inc., 2007a; provided as Appendix A to the FFS). In doing so, the EMBM serves to refine and extend the observations made as part of the development of the CSM, testing some of the original hypotheses and increasing the current understanding of the river and its contaminants. In particular, the empirical mass balance is intended to quantify the relative contaminant load due to river bottom sediment resuspension in comparison to those derived from external sources to the Lower Passaic River. The empirical mass balance also estimates the relative contributions of the external sources for each contaminant. By using the sediments and suspended solids as integrators of the entire suite of loads to the Lower Passaic River, the empirical mass balance can establish the relative contributions of each source. The estimated relative proportions are then used as a basis to forecast post-remediation concentrations in surface sediments. Forecasts are provided for fifteen chemicals of potential concern[1] (Table 2-1) chosen by the FFS risk assessment (see Appendix C of the FFS). The future concentrations of these COPCs are forecasted for three scenarios, including monitored natural recovery (MNR) or No Action;[2] remediation of the Area of Focus[3], river mile (RM) 0[4] to RM8; and remediation of the Primary

[1] The list of chemicals of potential concern includes both those derived from human health impacts (COPCs) and those derived for ecological impacts (COPECs). For the purposes of this report the combined list of chemicals is referred to as simply COPCs.

[2] Since the MNR and No Action responses are physically the same, these two responses are considered together in one scenario when assessing future sediment concentrations.

[3] The Area of Focus includes the entire Lower Passaic River from RM0 to RM8 and is further discussed in the main text of the FFS.

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Erosional Zone[5] in the river. These forecasted concentrations were then incorporated into the risk assessments to evaluate potential reduction in risks to human health and the ecosystem due to remedial action on the river. Notably, the empirical mass balance results are only required for the forecasts of the two remedial scenarios just listed, since these results establish the relative importance of resuspension, which is addressed under the remedial scenarios.

Table 2-1: COPCs in the Lower Passaic River

Chemical Class	Chemical Name
Metals	Copper
	Lead
	Mercury
Polycyclic Aromatic Hydrocarbons (PAH)	Low Molecular Weight (LMW PAH)[a]
	High Molecular Weight (HMW PAH)[b]
Polychlorinated Biphenyls (PCB)	Total PCB[c]
	Toxic Equivalency (TEQ) for PCB
Pesticides	Total Chlordane
	Dieldrin
	Dichlorodiphenyldichloroethane (DDD)[d]
	Dichlorodiphenyldichloroethylene (DDE)[d]
	Dichlorodiphenyltrichloroethane (DDT)[d]
	Total DDT[d]
Polychlorinated dibenzodioxins/furans (PCDD/F)	2,3,7,8-tetrachlorodibenzodioxin (2,3,7,8-TCDD)
	TEQ for PCDD/F

a: LMW PAH is defined as the sum of acenaphthene, acenaphthylene, anthracene, fluorene, naphthalene, and phenanthrene with samples flagged as not detected incorporated into the summation as zero.
b: HMW PAH is defined as the sum of benz[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, benzo[g,h,i]perylene, benzo[k]fluoranthene, chrysene, dibenz[a,h]anthracene, fluoranthene, indeno[1,2,3-c,d]pyrene, and pyrene with results flagged as not detected incorporated into the summation as zero. Total PAH is the sum of HMW PAH and LMW PAH.
c: Total PCB is defined as the sum of 209 PCB congeners with samples flagged as not detected incorporated into the summation as zero. See Section 4 on the treatment of PCB nondetect results.
d: DDD, DDE, and DDT refer only to the 4,4'-isomers. Total DDT is defined as the sum of DDD, DDE, and DDT.

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[4] RM0, which was established for this Study, is defined by an imaginary line between two marker lighthouses at the confluence of the Lower Passaic River and Newark Bay: one in Essex County, New Jersey just offshore of Newark and the other one in Hudson County, New Jersey just offshore of Kearny Point. River miles follow the centerline of the river from RM0 to RM17.4 at Dundee Dam.

[5] The Primary Erosional Zone is an area typified by above average persistent erosion located between RM 3.5 and RM5.1 and is further discussed in the main text of the FFS.

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2.2 ENVIRONMENTAL SETTING: LOWER PASSAIC RIVER

2.2.1 PHYSICAL FEATURES OF THE RIVER

The Lower Passaic River Restoration Project (herein referred to as the Study) is an interagency effort to remediate and restore the complex ecosystem of a portion of the Passaic River identified as the Lower Passaic River, which is the 17-mile, tidally-influenced portion of the river located in northeastern New Jersey. The Study Area (118 square miles) is defined as the Lower Passaic River and its basin, which comprises the tidally-influenced portion of the river from the Dundee Dam (RM17.4) to Newark Bay and the watershed of this river portion, including Saddle River, Second River, and Third River (Figure 2-1). The Upper Passaic River watershed (the area impacting the portion of the Passaic River located above the Dundee Dam) is represented as a point source with solids, water, and contaminants crossing over the dam into the Study Area.

As described in the CSM (Malcolm Pirnie, Inc., 2007a), the Lower Passaic River is bounded by the Dundee Dam and Newark Bay and is divided into three river sections. In general, freshwater and solids flow over the Dundee Dam, enter the Freshwater River Section and flow downriver to Newark Bay. Tidal exchange causes saline water from Newark Bay to move upriver beneath the freshwater flow. The mixing of fresh and saline waters creates the Brackish and Transitional River Sections (Figure 2-1). Solids originating above the dam, solids eroding along the length of the river, and those solids discharged from other sources (including CSO/SWOs and tributaries) are continuously mixed by tidal action, which causes the resuspension and redeposition of river-bottom sediments. These processes continuously re-work sediments on the surface of the river bed and expose deeper sediments that contain historical COPC inventories. The river bottom from RM0 to RM8 is classified as more than 80 percent silt and fine sand by area as interpreted from side-scan sonar images (Aqua Survey, Inc., 2006). Between RM8 and RM15, the river bottom transitions from primarily silt and fine sand to coarser sediments. From RM15 to the head-of-tide at RM17, river bottom sediments are classified as sand, gravel, and rock as interpreted by side-scan sonar images (Aqua Survey, Inc., 2006) and observed during field reconnaissance (Earth Tech, Inc. and Malcolm Pirnie, Inc., 2005).

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2.2.2 SOURCES TO THE RIVER

Much of the contamination found within the Lower Passaic River is associated with the solids that line the river bottom as well as those that enter from external sources and adjacent areas. While other contaminants may be present primarily in the water column, this empirical mass balance focuses on these solids-associated contaminants since they represent a more persistent problem, are the focus of the risk assessment, and can be used to trace solids sources to the river. Resuspension and reworking of the sediments constitute a major mechanism for the continued exposure to legacy contamination. Solids transported to the Lower Passaic River from the Upper Passaic River, from the tributaries, and from the CSO/SWOs all carry contaminants that become part of the mixture of contaminated sediments that line the river bottom. Tidal currents serve to blend the solids from the various sources as well as to transport these solids to Newark Bay.

As described in the CSM, the solids fluxes of the Lower Passaic River can be represented in a box model as presented in Figure 2-2. In this model, the river (or the "box") receives solids and contaminant inputs from the Upper Passaic River, tributaries, and CSO/SWOs. Additional solids and contaminant inputs are introduced to the surface sediments from the continuous eroding and mixing of older, more contaminated sediments. The exchange of solids and contaminant loads at the confluence of the Lower Passaic River with Newark Bay allows bay solids to enter the river while delivering solids from the river to the bay. While Newark Bay solids enter the river and become incorporated into the river's sediment beds, preliminary estimations as presented in the *Draft Geochemical Evaluation (Step 2)* (Malcolm Pirnie, Inc., 2006a) suggest that the Lower Passaic River is a net source of solids to Newark Bay. In the Lower Passaic River box model, contaminant loads of the COPCs from atmospheric deposition, groundwater, and New Jersey Pollutant Discharge Elimination System (NJPDES) permitted discharges are considered negligible.

2.2.3 CONTAMINANT HISTORY ON THE RIVER

As described in the CSM (Malcolm Pirnie, Inc., 2007a), a channel was constructed in the Lower Passaic River to provide commercial vessel access to the city of Newark and the

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surrounding industrial area. Several large dredging projects were undertaken at the beginning of the twentieth century to create a shipping channel from RM0 to RM15. These dredging projects created deep channels, in some areas 30 feet deep relative to mean low water (MLW). However, in the second half of the 20th century, maintenance dredging operations declined and solids accumulated in the channel at a relatively rapid rate.

Since the 1940s, the solids sources have delivered sufficient material to build up several feet of deposition in the channels, yielding an average rate of deposition substantially greater than what would normally occur in an estuary. Figure 2-3 portrays the existing elevation in the river bottom [elevations relative to the National Geodetic Vertical Datum of 1929 (NGVD29)[6]] compared to the authorized depth of the federal navigation channel. Between RM0 and RM2, approximately 15 to 20 feet of sediments have accumulated since the channel was last maintained, while between RM2 and RM8 approximately 5 to 10 feet of sediments have accumulated.

At the same time that sediments were accumulating in the unmaintained channels, industries in the watershed were discharging relatively untreated waste to the river (until these practices were restricted in the 1970s). The coincidence of chemical disposal in the river along with the construction and subsequent limited maintenance of the navigation channel created an ideal situation for the accumulation of thick beds of contaminated sediments. Because the authorized dimensions of the federal navigation channel were most extensive in the lower eight miles of the river, the thickest deposits of fine-grained sediments, and hence, the largest contaminant inventories are located between RM0 and RM8. Coincidentally, the natural and man-made widening of the river in the lower eight miles also causes river current velocities to decrease, which in turn further increased the rate of sediment deposition in this area. Volume calculations presented in the CSM

[6] Data source: 2004 bathymetric survey conducted by Rogers Surveying, Inc. for the U.S. Army Corps of Engineers (USACE).

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(Malcolm Pirnie Inc., 2007a) suggest that 85 to 90 percent of the contaminated sediment inventory resides between RM0 and RM8.

2.3 REMEDIAL ACTION AND IMPACTS ON THE RIVER

2.3.1 SUMMARY OF REMEDIAL ALTERNATIVES

As part of the comprehensive 17-mile Study, an FFS is being developed for sediments of the lower eight miles of the river. The FFS evaluates several remedial alternatives for the Lower Passaic River including MNR. The remedial alternatives involve a combination of dredging and capping activities in RM0 to RM8 to reduce surface sediment concentrations,[7] control the erosion and resuspension of contaminated sediment, and reduce contaminant inventory. These efforts are intended to reduce the potential risks to human health and the environment. While tidal action on the Lower Passaic River has resulted in contamination of fine-grained sediments throughout much of the tidal domain, the proposed remedial actions are focusing on RM0 to RM8, which is estimated to contain 80 to 90 percent of the contaminated fine-grained sediment (Malcolm Pirnie, Inc., 2007a). In brief, in addition to the No Action alternative, remedial actions under consideration include:

- Placing sand material on top of the existing river bottom from RM0 to RM8 (bank-to-bank) and reconstructing the mudflats.
- Dredging the fine-grained sediments in RM0 to RM8 (bank-to-bank), covering the residual surface with sand material, and reconstructing the mudflats.
- Limited dredging to reconstruct the federal navigational channel within the authorized dimensions, or dimensions that are suitable to the current uses of the river, or

[7] "Surface sediment concentration" is used in geochemical parlance to refer to the concentration of a contaminant or contaminants in the surface sediment (units of contaminant mass per mass of sediment). For purpose of discussion, surface sediments are typically described as the top 6 inches of sediments. However, for this mass balance report a subset of surface sediments is defined as recently-deposited surface sediments, specifically sediments that have accumulated on the river bed between 2003 and 2005. This is discussed further under sediment core dating in Section 4.2.

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dimensions that are suitable for anticipated future uses of the river, and then placing sand material from RM0 to RM8 (bank-to-bank).

- Limited dredging to reconstruct the federal navigational channel within dimensions that are suitable for anticipated future uses of the river, addressing the Primary Erosional Zone between RM3.5 and RM5.1 and/or the Primary Inventory Zone[8] between RM2.4 and RM3.3, and then placing sand material from RM0 to RM8 (bank-to-bank).
- Dredging only the Primary Erosional Zone between RM3.5 and RM5.1 and/or the Primary Inventory Zone between RM2.4 and RM3.3, and then placing sand material on the dredged areas only.

Implementation of an active remedial alternative will impact the Lower Passaic River by suppressing sediment resuspension from the river bottom. For all of the scenarios except the last one listed above, sediment resuspension is suppressed over the entire Area of Focus, (RM0 to RM8). As described later in this report, these scenarios are all approximated by reducing the sediment resuspension term in the model in proportion to the area of fine-grained area addressed by the specific alternative. Except for the limited Primary Erosional Zone/Primary Inventory Zone action, the amount of area addressed by the evaluated remediation alternatives is the same and so the model calculations are the same in all of these instances. Specifically, the remedial alternatives undertaken from RM0 to RM8 will address approximately 90 percent of the fine-grained sediment area in the Lower Passaic River and are assumed to equally reduce the rate of resuspension by the same amount. Since these scenarios are effectively the same with respect to the model and yield identical forecasts, they are collectively referred to as the "containment scenario" in the remainder of this report.

The last scenario listed above is handled differently. In this instance, the adjustment to the resuspension term is made based on the proportion of erosional area addressed by the

[8] The Primary Inventory Zone is an area of high inventory in the Harrison reach of the Lower Passaic River, between RM2.4 and RM3.3.

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scenario, instead of the total fine-grained area. The remediation of the Primary Inventory Zone alone is not addressed in this report due to its relatively small footprint and associated small impact on contaminant forecasts.

The MNR scenario assumes that the resuspension process as well as the other external solids loads will remain the same with respect to solids transport. The only changes anticipated are the gradual declines in contaminant concentrations determined from the dated sediment core analysis (Section 4.2). Hence, the MNR forecasts do not require any modification to the resuspension term and are based solely on the observed historical trends.

Because of the empirical nature of the model calculations, the model forecasts cannot differentiate among the various remedial scenarios with respect to their associated changes to the existing river bottom elevation, which will alter the existing sedimentation rate. For example, raising the bottom elevation will decrease sedimentation rates, increase erosion, and result in less contribution from Newark Bay, while deepening the river will increase sedimentation rates and the contribution of Newark Bay solids.

2.3.2 MODELING CURRENT CONDITIONS ON THE RIVER

While the remedial actions address resuspension of fine-grained sediments in RM0 to RM8 with the placement of sand material, they *do not* address or control the solids and contaminant inputs originating from other sources (Figure 2-2). For example, solids and contaminant inputs will continue to enter the river from tributaries, CSO/SWOs, Newark Bay, and by flowing over Dundee Dam. In addition, contaminated sediments upriver of RM8 are currently assumed to remain in place following remediation, although tidal action on the river will continue to resuspend and redeposit these sediments throughout the river. All of these sources will likely cause some recontamination of the Lower Passaic River surficial sediments in RM0 to RM8 following implementation of a remedy. Estimation of the magnitude of these other contaminant sources relative to the resuspension of historical inventory is the focus of this modeling effort.

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As part of the process to evaluate alternatives, the FFS requires an estimation of the post-remediation COPC concentrations for each alternative and a comparison of these future concentrations to the preliminary remedial goals (PRGs). The FFS also requires an estimation of the potential risk from exposure to these future COPC concentrations. However, before post-remediation surface sediment concentrations can be predicted, the current conditions in the river must be understood and the relative contaminant burden currently delivered from each source to the Lower Passaic River must be quantified. According to the CSM and the model presented in Figure 2-2, the current surface sediment concentrations in the Lower Passaic River are impacted by several sources, which can be represented with the following chemical mass balance equation (Equation 2-1):

$$C_{surface} = \frac{M_{Dam} + M_{Trib} + M_{CWO/SWO} + M_{NB} + M_{RSP}}{S_{Total}} \qquad \text{Equation 2-1}$$

Where

$C_{surface}$: COPC concentration in the Lower Passaic River surface sediments

M_{Dam}: contaminant mass derived from above Dundee Dam

M_{Trib}: contaminant mass derived from the tributaries

$M_{CSO/SWO}$: contaminant mass derived from CSO/SWOs

M_{NB}: contaminant mass derived from Newark Bay

M_{RSP}: contaminant mass derived from sediment resuspension

S_{Total}: total sediment mass load deposited in the Lower Passaic River

For the purposes of this analysis, the relative proportion of the contaminant mass deposited in the sediments from each source is assumed to be the same as the relative proportion of the total solids-borne mass load in the water column derived from each source. That is, if a source is responsible for 10 percent of the total contaminant mass load, that source is assumed to be responsible for 10 percent of the contaminant mass in the surface sediments. Equation 2-1 shows that the surface sediments of the Lower Passaic River are a combination of the solids and contaminant mass originating from various sources.

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Based on this chemical mass balance, a receptor[9]-type model was developed where the total contaminant mass present in the sediments of the receptor (*i.e.*, Lower Passaic River) is the sum of the mass contributions from the individual sources. For a fixed number of sources (p), the receptor observation of the ith chemical (i = 1, 2 …, j) is modeled as a linear combination of sources' chemical species as presented in Equation 2-2. (Equation 2-2 is an algebraic manipulation of Equation 2-1 where the contaminant mass from each source is represented by a concentration and a solids fraction.)

$$Y_i = \sum_{j=1}^{p} f_j X_{ij} \qquad \text{Equation 2-2}$$

Where

Y_i: receptor concentration for the ith chemical concentration

X_{ij}: the ith chemical concentration for the jth source

f_i: fraction of solids contribution of each jth source to the receptor

p: number of sources

The empirical mass balance model is designed to be solved simultaneously for the contaminant burden of the ith chemical species for each jth source, assuming that the model parameters are independent. The empirical mass balance modeling approach is, however, limited by the following assumptions:

- The number of sources is known and includes the Upper Passaic River (above Dundee Dam), the tributaries, CSO/SWOs, resuspension of historical inventories within the Lower Passaic River, and Newark Bay. Contaminant inputs from atmospheric deposition, groundwater, and NJPDES permitted discharges are assumed to be negligible.

[9] The term "receptor" is used throughout Sections 2 to 6 of this report to refer to the concentrations in sediments depositing on the river bottom (*i.e.*, recently deposited sediments). This receptor represents the integration of the various external and internal loads. This term is **NOT** the same as the risk assessment definition of the term which is used in Section 7 and elsewhere in the FFS.

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- The nature of the sources is known, and the available data represents the current average composition of all these sources. While this assumption is generally true, the source characteristics for resuspension of historical inventories were derived by considering various time horizons in dated cores as well as the entire integrated sediment column to obtain the best solution to the mass balance.
- The model focuses on the movement of solids; therefore, only chemical species that are associated exclusively with solids were evaluated. Dissolved-phase concentrations (and the processes impacting the dissolved-phase concentrations) are assumed to be negligible in the transport of the particle-reactive chemicals evaluated.
- The chemical species included in the mass balance do not react with each other and can be added linearly.
- The system is assumed to be over-determined, meaning that the number of sources is less than or equal to the number of chemical species. In this analysis, nine chemicals were considered as parameters for the model, compared to the five source terms. Note that these nine parameters overlap with the COPCs listed in Table 2-1 but are not inclusive.
- The source profiles (*i.e.*, the relative proportion of the 9 compounds in each source) are linearly independent of each other and any chemical transformations or losses that occur between the source and receptor are not included. Therefore, only chemicals that aid in differentiating among the sources (*i.e.*, make the sources independent) were selected for the modeling analysis.
- Uncertainties in the measurement of chemicals and spatial variability are addressed by statistical simulation.

Because of the empirical nature of the mass balance, feedback loops were not incorporated into the model formulation. Consequently, the model can describe the contaminant burden of the river under current conditions, but the model cannot describe surface sediment concentration in future conditions. Instead, the model output was used in combination with observed trends to forecast COPC concentrations.

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2.3.3 FORECASTING POST-REMEDIATION SURFACE SEDIMENT

The output of the empirical mass balance model is the proportion of the contaminant burden from each source to the Lower Passaic River. These burdens are solved simultaneously for several parameters, including solids and chemicals. Once the relative contaminant burden is determined, post-remediation COPC concentrations can be calculated for the various remedial alternatives, knowing that remediation will alter the relative contribution of these sources to the overall contaminant burden. Sediment resuspension as a source will be controlled by active remediation because each active remedial alternative includes the placement of sand material over some fraction of the river bottom from RM0 to RM8. This sand material will restrict the erosion and mixing of older, more contaminated sediments with the Lower Passaic River surface sediment. By controlling resuspension, future surface sediment concentrations can be calculated for the following three scenarios:

- MNR (no change in the resuspension source term).
- The placement of sand material from RM0 to RM8, which will control approximately 90 percent of the resuspension in the Lower Passaic River (*i.e.*, the containment scenario)River.
- A hypothetical remedial scenario for the remediation of the Primary Erosional Zone, between RM3.5 and RM 5.1. This remediation would control approximately one third of the erosional areas between RM0 and RM15 and is assumed to reduce the resuspension flux by the same amount.

As noted in Section 2.3.1, the empirical mass balance model cannot estimate the change in suspended solids transport and deposition due to changes in river bathymetry and hydrodynamics from dredging. Therefore, the potential changes in solids contribution to the Lower Passaic River from Newark Bay as a result of remediation were not incorporated into the forecasting of COPC concentrations. Refer to Section 5.5 for further evaluation of this issue relative to the modeling results.

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2.4 DOCUMENT CONTENT

This document is divided into the following sections to describe the EMBM and the forecasting of COPC concentrations in surface sediments.

Section 1.0, SUMMARY: provides a brief summary on the EMBM and the forecasting of COPC concentrations.

Section 2.0, INTRODUCTION: explains the CSM of the Lower Passaic River and introduces the EMBM.

Section 3.0, GENERAL APPROACH: explains the sequence of events involved in processing the data, creating the model, and forecasting COPC concentrations.

Section 4.0, DATA EVALUATION: provides detailed discussions on the sampling programs, data processing, and data evaluations used to characterize the receptor solids and source solids. However, the document is arranged so the reader can proceed to the subsequent report sections and refer back to this section if greater detail is desired.

Section 5.0, MODEL FORMULATION: provides an in-depth discussion on the formulation of the EMBM and the associated sensitivity tests.

Section 6.0, MODEL RESULTS: describes the fate and transport of the examined contaminants using the modeling results.

Section 7.0, FORECASTING COPC CONCENTRATIONS: describes the forecasting process used to predict post-remediation COPC concentrations in surface sediments.

Section 8.0, ACRONYMS: lists and defines the acronyms used in this document.

Section 9.0, REFERENCES: lists the references used in this document.

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3.0 GENERAL APPROACH

The following section provides an overview of the three major components of the EMBM: data evaluation and methodology to characterize sources, application and results of the model, and forecasting of COPC concentrations. The remaining sections of this document provide in-depth discussions on each component.

The flow chart presented in Figure 3-1 illustrates the connection of these components and is intended to accompany the following discussion. In brief, "source solids" were described by the chemical concentrations on suspended solids and sediments from the sources or source areas, and "receptor solids" were described by the chemical concentrations in recently deposited surficial sediments of the Lower Passaic River. These concentrations were used in the EMBM to calculate the contribution of each source to the contaminant burden in the Lower Passaic River. Meanwhile, dated sediment cores from the Lower Passaic River were examined to quantify the rate of change in contaminant concentration over the past 25 years (1980 to 2005) to estimate a "half life," or the amount of time estimated for the contaminant concentration to decrease by half. Finally, the contaminant burden fraction associated with resuspension and the contaminant-specific half-life were applied together to forecast post-remediation COPC concentrations in surface sediments (Figure 3-1).

3.1 OVERVIEW OF DATA EVALUATION TO CHARACTERIZE SOURCES

The objective of the data evaluation was to characterize the source solids and the surficial sediments of the Lower Passaic River (the receptor solids) by examining contaminant profiles, contaminant ratios, and concentration levels. One of the key assumptions in the EMBM is that the source profiles are independent. Consequently, to satisfy this assumption, only chemicals that distinguish the sources are characterized. The following sections provide an overview of the data evaluations completed for the EMBM. A detailed discussion on the sampling programs, methodology, and data manipulations is presented in Section 4.0 "Data Evaluation." The flow chart presented in Figure 3-2

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illustrates the sequence of events involved in the data evaluation; this figure is intended to accompany the following discussion.

3.1.1 LOWER PASSAIC RIVER (THE RECEPTOR SOLIDS) FLOW CHART

The sediments of the Lower Passaic River represent the integration of the contaminant loads to the river over time. Dated sediment cores (*i.e.*, high resolution cores[10]) collected on behalf of the U.S. Environmental Protection Agency (USEPA) provide a measure of the variation in the loads to the river over time, resolving current conditions from historical ones. The Lower Passaic River sediments were represented by five high resolution sediment cores that were collected from RM1.4 to RM12.6. These data were processed in several ways to characterize recently deposited solids as well as historical contaminant loads and the associated legacy sediment contamination. In Figure 3-2a, the high resolution sediment core dataset is marked as box #1, located in the lower left corner of the diagram. Once the laboratory qualifiers were examined, dated sediment core profiles were constructed to estimate historical loading (box #2) and surface sediment samples were used to characterize recently deposited sediments [*i.e.*, solids deposited between 2003 and 2005 (box #3)]. Historical loadings were estimated in two ways: calculating the average decadal concentrations from the 1940 to 2005 (box #4) and integrating the entire historical load from 1950 to 2005 using a length-weighed average (LWA) approach (box #5). Both decadal and LWA concentrations were used in the empirical mass balance model as alternative representations of the resuspension of historical inventory (box #6).

Several correlations and statistical evaluations were conducted to characterize the recently deposited sediments (*i.e.*, the receptor solids). First, the contaminant

[10] A high resolution sediment core is a finely-segmented core collected from a depositional area in the river. If continuously depositional, the core segments can be dated through comparison of radioisotope measurements to known radiochemical events and trends. When analyzed for specific contaminants, the individual dated segments can be used to infer contaminant loads historically borne by the river.

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concentrations were normalized[11] to examine patterns or contaminant ratios (box #7) and to determine correlations between sampling locations (box #8). As described in the CSM, surficial sediments are resuspended and redeposited due to tidal action; consequently, patterns exhibited in recently deposited sediments also should be observed in the suspended solids. To verify this assumption, suspended solids collected during two independent monitoring programs were evaluated in conjunction with the surface sediments (box #7). These programs were the USEPA Lower Passaic River Restoration Project Large Volume Water Column Program (box #9) and the U.S. Geological Survey (USGS) water quality data collected during the Environmental Dredging Pilot Study for the New Jersey DOT, Office of Maritime Resources (box #10).

In addition, the Lower Passaic River recently deposited surface sediment samples were standardized[12] to examine the similarities among the five coring locations [using a cluster analysis (box #11) and robust regression (box #12)]. Average contaminant concentrations were calculated for coring locations that were deemed similar by the cluster analysis and were then used in the empirical mass balance model to represent the receptor solids (box #13).

3.1.2 NEWARK BAY FLOW CHART

The Newark Bay sediments were represented by sixteen beryllium-7 bearing samples (0-6 inches) located in the federal navigation channels of the bay. In Figure 3-2a, the Newark Bay dataset is marked as box #14, in the upper left corner. Once the laboratory qualifiers were examined, the contaminant concentrations were normalized and the patterns (box #15) and correlations (box #16) among the locations for the given chemical class were examined. The samples were standardized to identify similarities among the

[11] Normalization refers to the division of multiple sets of data by a common variable to negate that variable's effect on the data, thus allowing underlying characteristics of the data sets to be compared.

[12] Standardization refers to a process where the mean of the sample population is subtracted from the individual values in a sample population and subsequently the individual remainders are divided by the standard deviation to allow for a comparison of normal distributions with similar absolute magnitudes. In the fashion, the process examines the variation equally and does not place undue emphasis on the constituent with the highest absolute concentration.

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sampling locations and to characterize the northern and southern regions of Newark Bay using a cluster analysis by location (box #18). To determine the contaminant concentration for the Newark Bay end members, the concentration gradients across the Bay were examined (box #17). Average contaminant concentrations for the northern and southern regions of Newark Bay were calculated and then used in the EMBM to represent the Newark Bay solids (box #19).

Because the Newark Bay sediments were analyzed by a different set of laboratories, the method detection limits and extraction procedures for the Newark Bay samples differed from the other sampling programs used in the model. Consequently, additional data evaluations were required for the Newark Bay dataset, including a comparison of PCB co-elutions and an approximation for the pesticide concentrations using literature values. These additional evaluations are further described in Section 4.0 "Data Evaluation."

3.1.3 DUNDEE DAM FLOW CHART

Solids entering the Study Area from above the Dundee Dam were represented by one recently deposited surface sediment sample collected in Dundee Lake at RM18.3 in January 2007. The Dundee Dam sample is represented by box #20, located to the upper left of center in Figure 3-2a. The surface sediment concentrations for this sample were used in the EMBM to represent Upper Passaic River solids (box #21), once laboratory qualifiers were examined. The Dundee Dam data were further examined to assess how the contaminant patterns (box #22) and correlations between contaminants (box #23) varied as solids flowed over the dam, across the Lower Passaic River and into Newark Bay. For this evaluation, normalized Dundee Dam data were combined with the normalized Newark Bay sediments and the normalized data for sediments in the Lower Passaic River. Cluster analysis was also performed with the Dundee Dam, Lower Passaic River, and Newark Bay data to identify independent and dependent parameters [*i.e.*, independent and dependent contaminants (box #24)].

3.1.4 TRIBUTARY FLOW CHART

The tributaries, including Saddle River, Second River, and Third River, were characterized with two datasets (Figure 3-2b): the USEPA Small Volume Water Column

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Program (box #25) and USEPA Semi-permeable Membrane Device (SPMD) Deployments (boxes #26 and #27, located in the upper left of the diagram). Two sampling programs were considered for the tributaries based on their focus on different analyte suites. Metals concentrations on the tributary solids were calculated by subtracting the dissolved-phase metals concentration from the total concentration and converting the value to a suspended solids concentration (box #28) using the measured total suspended solids (TSS) values from the Small Volume Grab Sampling Program. Organic contaminant concentrations on the tributary solids were estimated by converting measured concentrations in the SPMDs to dissolved-phase concentrations, and then calculating the solid-phase concentrations using site-specific, freshwater distribution coefficients (K_d). These K_d values (box #30) were calculated by dividing the measured contaminant concentration in Dundee Dam surface sediments (box #20) by the dissolved-phase concentrations reported at RM17 (box #29). The K_d values were then applied to the dissolved-phase concentrations from the tributary (measured in the SPMD) to estimate the sediment concentrations in the tributaries (box #31). Once contaminant concentrations were calculated for each tributary, a single watershed-area weighted value was calculated for each contaminant and used in the model to represent the tributary source (box #32). The concentrations from the three tributaries were combined into a single representation since an evaluation of patterns indicated that the distribution and concentration of contaminants on the tributary solids were similar (box #33; refer to Section 4.7 "Tributary and CSO/SWO Data Evaluation").

3.1.5 CSO/SWO FLOW CHART

CSO/SWOs were represented from the 2001-2004 Contaminant Assessment and Reduction Program (CARP) dataset. In Figure 3-2b, the CSO/SWO data are represented by box #34, located in the middle of the left edge of the figure. Because the CSO/SWO data were reported as whole water samples, the suspended solids concentrations were calculated using the measured TSS values (box #35), assuming all of the contaminant mass in the sample was borne by the suspended matter. An examination of conversion of the whole water concentration to the suspended solids concentrations using literature K_d values was also performed for PCB congeners, as a check on the approach of converting

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whole water to suspended solids concentrations using TSS directly. This analysis found that more than 90 percent of the mass for each PCB congener examined was associated with the suspended matter. Given the similar partitioning behavior among the various organic COPCs, this analysis supported our approach for these parameters. For the inorganics, this approach provides an upper bound estimate on the concentration on the suspended matter, thus providing an upper bound on the percentage of the inorganic concentration in the sediments derived from CSO and SWO discharges. Like the tributaries, the average CSO and SWO concentrations and contaminant patterns were found to be quite similar. As a result, the contaminant concentrations from the SWO and CSO data were then averaged to a single value and used in the model to represent a combined CSO/SWO source (box #36; refer to Section 4.7 "Tributary and CSO/SWO Data Evaluation").

3.2 OVERVIEW OF THE EMPIRICAL MASS BALANCE MODEL

Once the receptor solids and source solids were characterized, the values were used in the EMBM (Figure 3-1), which was initially presented in Section 2.3.2 "Modeling Current Conditions on the River." The output of the EMBM quantifies the relative contribution of the contaminant burden and solids load from each source to the Lower Passaic River sediment. These relative contributions were solved simultaneously for the nine contaminants plus solids. Based on the results, the fate and transport implications of the model results were then described qualitatively for each contaminant..

As discussed in Section 5.0 "Model Formulation," several scenarios were simulated during this evaluation to determine the following:

- The most likely characteristics of the resuspended sediment based on the various distributions found in the historical inventory.
- The average relative contribution of solids from the various sources.
- The relative magnitude of the fluxes of contaminants from the various sources.

To focus the discussion, only those iterations that replicated the concentrations in the recently deposited sediments of the Lower Passaic River to within a prescribed precision were described. One of the scenarios uses the average 1990s sediment concentrations to

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represent the resuspension source. The 1990s scenario simulates surface sediments resuspending and redepositing to form a thick mixed layer on the top of the sediment bed. Another scenario uses the LWA concentrations to describe the resuspension contaminant source. This scenario simulates a meandering river eroding its banks and resuspending sediments approximately equally from the entire thickness of the sediment bed.

3.3 OVERVIEW OF FORECASTING SEDIMENT CONCENTRATIONS

The forecasting of post-remediation COPC concentrations involves the incorporation of two values, the fraction of the contaminant burden associated with resuspension and the chemical-specific half life (Figure 3-1). As mentioned at the beginning of Section 3.0 "General Approach," the half life is the amount of time estimated for the contaminant concentration to decrease by half. These chemical-specific half lives were estimated by examining dated sediment cores from the Lower Passaic River and characterizing the historical sediment concentration trends from 1980 to 2005 with a first-order exponential decay equation.

For the purposes of the forecasts, it is assumed that the observed 1980-2005 concentration trends in the sediment cores will continue unaltered into the future until 2018, when the selected remedial alternative is assumed to be implemented. For the MNR scenario, this trajectory continues unaltered indefinitely into the future. However, for the remaining remedial alternatives, surface sediment concentrations were adjusted in 2018 to account for the two categories of remedial alternatives described previously, which will suppress some portion of the sediment resuspension flux. This adjustment is expressed as a single downward step in concentration at 2018 that reduces the concentration in the sediment based on the decreased relative contribution by resuspension. Following this adjustment, concentrations continue to decline exponentially from 2018 to 2048 with the same chemical-specific half life. A schematic of the trajectories is provided in Figure 3-3.

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4.0 DATA EVALUATION

The following section provides detailed discussions on the sampling programs, data processing, and data evaluations used to characterize the recently deposited sediments (*i.e.*, receptor solids) and source solids. However, the document is arranged so the reader can proceed to the subsequent report sections and refer back to this section if greater detail about a specific contaminant or source is desired. The associated sections, figures, and tables from Section 4.0 are referenced throughout the document.

The overall goal of this data evaluation is to determine the list of chemicals that distinguishes the various sources because a key model assumption is independence of source profiles. The selected chemical profiles of the different sources were compared, so that sources that were correlated could be combined. It is important to recognize that the results of many of the field efforts were not evaluated prior to the development of the empirical mass balance, and consequently, the data are not described in previous studies or reports. For this reason, it was necessary to evaluate data quality and relationships before using it in the empirical mass balance. The logic and sequence of events for evaluating the data are provided and discussed in Section 3.1 "Overview of Data Evaluation to Characterize Sources" and presented in Figure 3-2.

4.1 OVERVIEW OF SAMPLING PROGRAMS

Data from several field sampling programs were gathered and examined to characterize the source solids and the receptor solids used in the EMBM (Table 4-1). To focus the discussion, only those samples and locations from each program that were directly used in the analyses are presented. A map showing the locations of the pertinent samples is presented in Figure 4-1.

Table 4-1: Field Sampling Programs Considered in the Empirical Mass Balance

Source or Receptor	Field Sampling Program Considered
Lower Passaic River	2005 USEPA High Resolution Sediment Coring Program
	2005 USEPA Large Volume Water Column Program
	2005 USGS Water Monitoring Data (collected during the NJ DOT

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	Environmental Dredging Pilot Study)
Newark Bay	2005 Tierra Solutions, Inc. (TSI) Remedial Investigation Phase 1 dataset
Dundee Dam	2007 USEPA Sediment Coring Program
Tributaries	2005 USEPA SPMD Deployments
	2005 USEPA Small Volume Water Column Program
CSO/SWOs	2001-2004 CARP dataset

4.1.1 LOWER PASSAIC RIVER HIGH RESOLUTION CORE PROGRAM

As part of the 2005 USEPA sampling program, Malcolm Pirnie, Inc. collected high resolution sediment cores from several locations in the Lower Passaic River from September 19, 2005 to October 12, 2005 (Figure 4-1). These locations were previously identified as potential depositional sites during a field reconnaissance program (August 29, 2005 to September 8, 2005) because they contained beryllium-7 in surficial sediment (0-1 cm) and the sediment texture was classified as fine-grained material. Based on the results of the cesium-137 analysis, the cores from RM1.4, RM2.2, RM7.8, RM11, and RM12.6 were processed to generate approximately 40 sediment intervals per core with the top 8 intervals of each core being half the thickness of the deeper intervals.

Sediment samples were analyzed for cesium-137 by Outreach Laboratory (Broken Arrow, Okalahoma) to establish a chronology for the core and "qualify" it as useful for further chemical analysis. Samples from every interval of the cores were analyzed for target analyte list (TAL) metals including mercury through USEPA's contract laboratory program (CLP) by Sentinel, Inc. (Huntsville, Alabama). For organic compounds, including PAH compounds, PCB congeners, polychlorinated dibenzodioxins/furans PCDD/F, and pesticides, sediment samples were combined (every two intervals, consecutively) to yield approximately 20 samples per core. Organic analyses were conducted by Axys Analytical Services in British Columbia, Canada. This combination resulted in the first four segments in each core representing approximately 2-year time intervals (with the top interval representing the 2005-2003 time horizon), and the remainder of the segments each representing approximately a 4-year time interval. For more information on the high resolution sediment sampling program refer to the *Field Sampling Plan, Volume 1* (Malcolm Pirnie, Inc., 2006b).

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4.1.2 LOWER PASSAIC RIVER LARGE VOLUME WATER COLUMN PROGRAM

Malcolm Pirnie, Inc. collected large volume water column samples from RM2.5 on October 6, 2005 (Figure 4-1) to assess dissolved and suspended trace-level organic contaminants being transported by the river. An Infiltrex sampler and a Trace Organic Platform Sampler (TOPS) were used to collect large volume samples that could be analyzed for these trace-level organic contaminants. For the empirical mass balance, only the suspended solids were evaluated.

The Infiltrex Sampler is a high efficiency, high volume automatic water sampling system designed for the extraction of trace-level organic contaminants (manufactured by Axys Analytical Services). The Infiltrex consisted of three distinct components: (1) a 1 micrometer (µm) glass wound cartridge filter used to remove the majority of particulates from the influent whole river water; (2) a 0.7 µm Whatman glass fiber filter used as a polishing step for particulate removal; and (3) a solid phase extraction system used to measure trace quantities of dissolved-phase organic contaminants. A total of 83 liters of whole river water were filtered through the Infiltrex sampler in the field. The cartridge filter and the flat filters were combined into a single sample and were analyzed by Axys Analytical Services for PCB congeners, PCDD/F, and pesticides. Laboratory results were reported as contaminant mass per liter, based on the total volume of water that passed through the filters.

The TOPS Sampler is an automatic water sampling system that is similar in design and function to the Infiltrex (developed as part of CARP). For the Lower Passaic River sampling events, it consisted of two components: (1) a 0.5 µm glass wound cartridge filter used to remove the majority of particulates from the whole water; and (2) a 0.7 µm Whatman glass fiber filter used as a polishing filtration step. Since the TOPS sampler was not configured with a solid phase extraction system, the filtered water was shipped to Axys Analytical Services for analysis after field sample collection activities had concluded.

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A total of 79.6 liters of whole river water were filtered through the TOPS sampler in the field. Samples derived from this event are hereinafter referred to as field-filtered TOPS samples. Suspended solids from the cartridge filter were analyzed by Axys Analytical Services for PCB congeners, PCDD/F, and pesticides. Suspended solids from the flat filter were not analyzed. As a result, suspended solids data from the Infiltrex samples (which incorporated the cartridge and flat filters) and the field-filtered TOPS samples (which only incorporated the cartridge filter) are based on slightly different filtration procedures. However, it is assumed that mass of suspended solids collected on the flat filter is negligible relative to the mass of solids captured on the cartridge filter. Laboratory results were reported as contaminant mass per liter, based on the volume of water passed through the system.

As part of the quality assurance component of the program, 20 liters of whole river water were sent directly to the laboratory to be filtered and analyzed for comparison. Samples derived from this event are hereinafter referred to as laboratory-filtered TOPS samples. The laboratory used a 0.5 µm glass wound cartridge filter and a 0.7 µm Whatman glass fiber filter to replicate the TOPS sampler components. The cartridge filter and flat filter were combined into a single sample and analyzed for PCB congeners, PCDD/F, and pesticides. Laboratory results were reported as contaminant mass per liter, based on the sample volume of 20 liters. For more information on the large volume water column program refer to the *Field Sampling Plan, Volume 1* (Malcolm Pirnie, Inc., 2006b).

4.1.3 LOWER PASSAIC RIVER USGS WATER MONITORING PROGRAM

As part of the Environmental Dredging Pilot Study, the USGS monitored the water quality of the Lower Passaic River near RM3.2 during dredging pilot activities (Figure 4-1). The program was conducted from December 1, 2005 through December 12, 2005 and included collecting suspended and dissolved phase samples. These data were not used directly in the mass balance; however, contaminant patterns in the suspended solids obtained during this study were compared to the recently deposited surface sediments of the Lower Passaic River obtained from the high resolution sediment cores. The monitoring program was organized so that two boats, one located upriver and one located

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downriver of the dredging activities continuously traversed the river perpendicular to the flow. The boats used TOPS to collect composite samples over a 3-hour period at least once each day. The inlet ports were weighted by a sampling "fish" to keep the intakes at approximately 1 meter below the water surface during the outbound transect, and approximately 1 meter above the sediment surface on the inbound transect. A round-trip traverse lasted approximately 10-12 minutes. The residue on the cartridge filter and the glass fiber filters (0.7 µm filter) of the TOPS apparatus were used to measure suspended contaminants while a solid phase extraction system was used to measure dissolved contaminants. The suspended solids were analyzed for PCB congeners, PCDD/F, and pesticides by Axys Analytical Services. Chemical concentrations were converted to units of micrograms per kilogram of sediment (µg/kg) based on concurrently collected suspended solids samples. For more information on the water monitoring program refer to the *Environmental Dredging Pilot Study Report* (Malcolm Pirnie, Inc. and Earth Tech, Inc., 2006).

4.1.4 NEWARK BAY REMEDIAL INVESTIGATION PHASE 1 DATASET

TSI conducted a Phase 1 sampling effort from October to December 2005 as part of the Newark Bay Study Area Remedial Investigation/Feasibility Study (TSI, 2006). The Phase 1 sampling program included the collection of 69 low resolution sediment cores.[13] These cores were collected throughout the bay, with cores obtained from the shoals penetrating approximately 3 feet into the sediments and cores obtained in the channels penetrating greater than 5 feet. All cores were segmented into a top 6 inch segment and then 1-foot intervals. A 1-inch sediment sample was also collected from all coring locations and analyzed for beryllium-7. Radiological samples were analyzed by Paragon Analytics, Inc. (Fort Collins, Colorado); organic compounds including PCB, PCDD, and PCDF compounds were analyzed by Alta (El Dorado Hills, California). Lancaster Laboratory (Lancaster, Pennsylvania) analyzed sediments for pesticides and metals.

[13] A low resolution sediment core is a coarsely-segmented core that records the general chemistry of the river sediment. In some cases, the cores may provide data to approximate historical contaminant load (timescale of decades).

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Only cores that were located in depositional environments were evaluated for this empirical mass balance calculation. Since the sample detection limit for beryllium-7 in the TSI Phase 1 dataset ranges from approximately 0.1 to 0.5 picocuries per gram (pCi/g), only sampling locations with detectable beryllium-7 concentrations greater than 0.5 pCi/g were considered depositional. Based on this definition, only 35 of the 69 sampling locations in Newark Bay are classified as reliably depositional. The remaining 34 locations represent sites that were either minimally depositional or non-depositional. The beryllium-7 bearing sites were further subdivided to select locations from the main channels of Newark Bay. This was done to obtain samples that reflected the main tidal flows of the bay, and to remove the effects of any local influences or backwater areas. As noted in the CSM, there are strong concentration gradients in the bay, unlike the Lower Passaic River. The empirical modeling analysis needed to reflect the properties of the bulk of the suspended solids in Newark Bay, since the sediment transported to the Lower Passaic River would likely be similar to these materials.

As expected, the majority of these depositional sites are primarily located in the navigational and port channels (20 of the 35 depositional sites) where dredging activities have created deep, relatively quiescent conditions suitable for rapid sediment deposition. Of the 20 candidate sampling locations, four locations were removed because they were located in the port channels or appeared to be impacted by a local external source that influenced surface sediment concentrations. The remaining 16 sampling locations used in the EMBM are presented in Figure 4-1. For more information on the Newark Bay Remedial Investigation Phase 1 dataset refer to the *Newark Bay Study Area Remedial Investigation Work Plan Phase 2* (TSI, 2006).

4.1.5 DUNDEE DAM SEDIMENT CORING PROGRAM

Malcolm Pirnie, Inc. collected nine sediment cores on January 11, 2007 in Dundee Lake between the Dundee Dam and Interstate Route 80, in the Upper Passaic River. All locations were initially classified as potential depositional sites because they contained fine-grained sediment deposits (determined using a probing rod). At each sampling location, two sediment cores were collected: a 2-inch diameter core for physical

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examination of sediment characteristics and a 3-inch diameter sediment core for chemical analysis. The 2-inch diameter cores were split in half longitudinally to reveal the geological strata in the cores and to identify locations with thick, fine-grained sediment deposits. Of the nine original locations, four locations were selected as representing potentially depositional sites because the core top was silt and contained no organic debris. These cores also contained a distinct oil-bearing layer at depth, estimated to represent the 1850s to 1890s time period. The corresponding 3-inch diameter cores from the four selected sampling locations were segmented, and the samples were shipped to the laboratory for analysis. Organic analytes (including PCB congeners, PAH compounds, PCDD/F, and pesticides) were analyzed by Axys Analytical Services. Inorganic analytes (including TAL metals, mercury, cesium-137, and beryllium-7) were analyzed by Severn Trent Laboratories (STL) Burlington in Vermont and STL Richland in Washington.

At the time of preparation of this report, only the core top from the sediment core collected at RM18.3 (or field coring location #2) was found to contain detectable levels of beryllium-7. Consequently, only this core top sample was used in the empirical mass balance model because it represents recently deposited sediments in Dundee Dam Lake and therefore can be considered reflective of contaminant concentrations on suspended solids transported over Dundee Dam to the Lower Passaic River (Figure 4-1). A subsequent reanalysis of the beryllium-7 level in the top segment from core location 6 showed this segment to also be recently deposited, but the finding came too late for the results to be included in this analysis. Notably, the concentrations observed in the recently deposited sediments from core 6 were similar to those obtained from core 2 so that this exclusion is not expected to significantly affect the model results. For more information refer to the *Field Sampling Plan, Volume 1* (Malcolm Pirnie, Inc., 2006b) and the *Quality Assurance Project Plan (QAPP) Amendment* dated January 8, 2007 (Malcolm Pirnie, Inc., 2007b).

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4.1.6 TRIBUTARY SPMD DEPLOYMENTS

As part of the 2005 USEPA sampling program, Malcolm Pirnie, Inc. deployed SPMDs to measure the dissolved-phase concentration of trace-level organic contaminants in the water column. These devices are manufactured by Environmental Sampling Technologies (EST) Laboratory (Saint Joseph, Missouri) and are composed of lay flat, low density polyethylene tubing containing a thin film of a pure, high-molecular weight lipid (triolein). Two SPMD deployments were conducted, one each in the months of October and November 2005: the first deployment lasted 33 to 44 days and the second deployment lasted 24 to 28 days. Five SPMDs were deployed at each location. These five devices were subsequently combined to form one sample for the location. Each SPMD was attached to a concrete block placed over a 5-foot long steel bar driven into the river bed to maintain a position of 1-foot from the river bottom.

SPMDs were located at RM17 at the Ackermann Avenue Bridge, near but downstream of the head-of-tide on the Lower Passaic River, and on each of the three major tributaries, above the head-of-tide (Figure 4-1). The SPMDs deployed at RM17 are intended to represent water quality conditions coming over the Dundee Dam (RM17.4). The approximate location of each SPMD was measured with global positioning system (GPS); however, tree cover interfered with the GPS readings. Details of the positions were described in the field logs to assist in determining the actual locations.

Once retrieved, the SPMD devices were placed back into their original shipping cans and returned to EST Laboratories. Chemical residues in the SPMDs were recovered into an organic solvent using a dialytic extraction step. The solvent material containing the sequestered chemicals was shipped to Axys Analytical Services for analysis of PCB congeners, PAH compounds, PCDD/F, and pesticides. For more information on the SPMD deployments refer to the *Field Sampling Plan, Volume 1* (Malcolm Pirnie, Inc., 2006b).

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4.1.7 TRIBUTARY SMALL VOLUME WATER COLUMN PROGRAM

Malcolm Pirnie, Inc. collected small volume water column grab samples on November 10, 2005 on the Second River, Third River, and Saddle River to examine the inorganic analytes, which were not measured during the SPMD deployments. Small volume grab samples were collected at the SPMD sampling locations, which were located at or above the head-of-tide. At each location, grab samples were collected at the center of the water body. Water quality parameters, including TSS, were analyzed by STL Burlington. Total and dissolved TAL metals (field filtered through 0.45 µm filter) were analyzed by the CLP laboratory, Sentinel, Inc. Total and dissolved mercury were analyzed by Brooks Rand (Seattle, Washington). For more information on the small volume water column program refer to the *Field Sampling Plan, Volume 1* (Malcolm Pirnie, Inc., 2006b).

4.1.8 CSO/SWO CARP SAMPLING PROGRAM

Through discussions with the New Jersey Department of Environmental Protection (NJDEP), CARP data were provided to Malcolm Pirnie, Inc. to characterize the contaminant burden from CSO/SWOs. These point discharges were located throughout the Passaic and Hackensack sewer-sheds and were sampled during the CARP program between 2001 and 2004. While the original dataset included five SWO locations, only the three SWOs that discharge directly to the Lower Passaic River were used in the data evaluations (Table 4-2; Figure 4-1). Likewise, the original dataset provided by NJDEP contained nine CSO locations; however, only one CSO location discharges directly to the Lower Passaic River (Ivy Street). Four other CSO locations discharge to the Hackensack River. These additional CSO locations were incorporated into the evaluation to characterize CSO discharge to the Lower Passaic River under the assumption that CSO discharges to the Hackensack River would be similar to CSO discharges to the Lower Passaic River, since the drainage areas are characterized by similar levels of industrial, commercial, and residential development (Table 4-2; Figure 4-1).

Table 4-2: CARP CSO/SWO Sampling Locations and Dates

Selected Stations	Associated Sampling Dates	
CSO: Christie Street	October 16, 2002	April 11, 2003
CSO: Court Street	October 16, 2002	April 11, 2003
CSO: Elm Street		April 11, 2003

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CSO: Ivy Street		October 16, 2002	April 11, 2003	April 13, 2004
CSO: West Side Road		October 16, 2002		
SWO: Blanchard Street	September 25, 2001	October 16, 2002	April 11, 2003	
SWO: CCI		October 16, 2002	April 11, 2003	April 13, 2004
SWO: Smith Marina		October 16, 2002	April 11, 2003	April 13, 2004

Contaminant concentrations were reported in units of contaminant mass per liter; TSS samples were reported in units of solids mass per liter. Data were used as received from the NJDEP, which previously reviewed the data for field and laboratory QA/QC issues.

4.2 LOWER PASSAIC RIVER SEDIMENT PROFILE EVALUATION

4.2.1 DATA QUALITY OF SEDIMENT PROFILE DATA

Before manipulating the high resolution core dataset, the laboratory and validator qualifiers were examined. Due to the additional analytical cleanup methods employed in the Lower Passaic River sampling programs, method detection limits were relatively low, which resulted in few samples being reported as not detected (qualifiers containing a "U"). For the COPC and modeling parameters examined, analytes reported as not detected include two PCDD/F analytes, eleven pesticides, and five PCB congeners (excluding samples from the bottom of the cores, which included sand and were therefore not considered depositional material). No rejected data were reported in this dataset.

4.2.2 RADIOLOGICAL PROFILES

Cesium-137 profiles for the five high resolution cores are presented in Figure 4-2. These profiles can be used to construct the depositional histories for the COPCs because:

- The cores contained no discontinuities.
- The cesium-137 peak was greater than 1 picocurie per gram (pCi/g), which is used to identify the 1963 time horizon.
- The cores exhibited a general decline in cesium-137 concentrations from the peak to the sediment surface.
- For deeper cores, the initial appearance of cesium-137 could be observed near the bottom of the core. The bottom of the segment in which cesium-137 is first detectable is assigned to the 1954 time horizon.

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The average annual sedimentation rate for the period 1963 to 2005 (the year of core collection) was determined for each core based on the depth of the cesium-137 maximum in the core and the time elapsed, 42 years (Table 4-3). The sedimentation rate is assumed to be constant during this period. A second deposition rate was determined for the deeper cores, where the 1954 horizon could be discerned. For these cores, the deposition rate between 1954 and 1963 was determined by the difference in depth between the two horizons and the time elapsed (9 years). As shown in Table 4-3, the deposition rates from 1954 to 1963 were substantially greater than those occurring post-1963 within the same core. This observation has important implication for the half life assessment completed for each contaminant. Since the rate of sedimentation is likely to have declined over time, the estimated half life for the period 1980 to 2005 represents a minimum estimate. Because of this, river recovery may take longer than estimated under the MNR.

Table 4-3: Sedimentation Rates for High Resolution Cores

Sediment Core	Sedimentation Rate Based on 1963 (centimeter/year)	Sedimentation Rate Between 1954 and 1963 (centimeter/year)
RM1.4	5.2	13
RM2.2	10	16
RM7.8	2.0	NA
RM11	2.3	11
RM12.6	3.2	NA

NA = not applicable

Using these sedimentation rates, dated sediment core profiles were created for the parameters used in the EMBM and for the COPCs (Figure 4-3). Each profile was constructed following geochemical conventions with the approximate year of deposition on the vertical axis and concentration (units of µg/kg) on the horizontal axis.

4.2.3 CALCULATING AVERAGE DECADAL CONCENTRATIONS

Average decadal concentrations were calculated over the period 1940 to 2005 for each model parameter based on the dated sediment core profiles presented in Figure 4-3. In one modeling scenario, the concentrations from 2000 to 2005 were put together with the 1990s decade, and in another scenario, they were applied to the model as half a decade. For each core, the concentrations corresponding to each decade were summed and

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divided by the total number of core segments assigned to that interval. In this calculation, data associated with a laboratory or validator qualifier containing a "U" were considered to be not detected and were set to a value of zero. Values from duplicate samples were averaged prior to inclusion in the decadal mean calculation. Decadal averages for metals, PAH compounds, and pesticides involved five cores while the PCDD/F and PCB congener decadal averages involved three cores.[14]

Table 4-4: Average Decadal Concentrations from 1950 to 2005 for Select Contaminants

Analyte	1950s- 1960	1960s-1970	1970s-1980	1980s-1990	1990s -2005
Mercury (mg/kg)	6.4	9.2	7.4	3.2	1.9
Lead (mg/kg)	370	660	540	320	220
Cadmium (mg/kg)	10	20	14	6.3	3.8
Trans-Chlordane (µg/kg)	17	87	63	38	33
DDE (µg/kg)	140	290	260	110	59
2,3,7,8-TCDD (ng/kg)[a]	3,300	6,800	2,300	560	350
Total TCDD (ng/kg)[a]	3,700	7,800	2,500	750	500
BZ 31 (µg/kg)[a]	200	550	260	80	30
BZ 52 (µg/kg)[a]	200	550	240	95	41
BZ 61+66+70+74+76 (µg/kg)[a]	530	1,300	480	210	96
BZ 83+99 (µg/kg)[a]	74	210	91	51	25
BZ 90+101+113 (µg/kg)[a]	130	350	140	79	38
BZ 93+95+98+100+102 (µg/kg)[a]	110	300	130	68	34
BZ 110+111+115 (µg/kg)[a]	140	370	150	80	40
BZ 129+138+158+160+163+164 (µg/kg)[a]	120	330	180	99	51
BZ 139+140+147+149 (µg/kg)[a]	85	240	130	76	37
BZ 170 (µg/kg)[a]	22	59	39	24	13
BZ 180+193 (µg/kg)[a]	57	140	91	57	30
Benz[a]anthracene (mg/kg)	3.7	4.5	3.6	2.7	2.9
Benzo[a]pyrene (mg/kg)	3.2	4.6	3.5	2.9	3.4
Chrysene (mg/kg)	4.9	6.4	5.0	3.6	4.0
Fluoranthene (mg/kg)	7.8	11	8.5	5.5	6.2
Indeno[1,2,3-cd]pyrene (mg/kg)	2.0	3.4	2.6	2.2	2.6
Pyrene (mg/kg)	7.4	11	8.2	5.4	5.8

a: Average concentration for only three river locations (RM1.4, RM2.2, and RM11)
Concentrations rounded to two significant figures.

Note that the calculation of the average 1940 decadal concentration was restricted to the longer cores that penetrated into deep sediments. (Decadal concentrations and statistics

[14] Not all of the PCDD/F and PCB congener samples from the sediment cores collected at RM7.8 and RM12 were analyzed at the time that the empirical mass balance was completed, but are being held as archived extracts at Axys Analytical.

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on these values are provided in Attachment A.) Average decadal concentrations for the select contaminants are provided in Table 4-4 and represent the concentrations of contaminants on the resuspended material that would be generated by erosion of that time interval. Table 4-4 essentially summarizes the historical mean contaminant loading to the Lower Passaic River, with the greatest loading (or highest concentrations) for these select contaminants occurring in the 1960s. In general, metals concentrations in 1960 were approximately 3 to 5 times greater than those concentrations measured in 2005 surface sediments, while PCB congener and PCDD/F concentrations in 1960 were approximately 5 to 20 times greater than the 2005 surface concentrations. PAH compounds varied only by a factor of 2 or less, inferring that the PAH contaminant load has remained relatively constant over the past 50 years.

4.2.4 CALCULATING LENGTH-WEIGHTED AVERAGE CONCENTRATIONS

LWA concentrations were calculated for each model parameter in the dated sediment core profiles presented in Figure 4-3. LWA calculations focus on the sediment data from the 1950 time horizon through the 2005 time horizon. This interval represents the period when most discharges took place as well as the period when most of the dredging activities had ceased. Non-detect data were set to a value of zero so as to avoid variations in contaminant proportions (*i.e.*, contaminant ratios) that were not directly measured. Values from duplicate samples were averaged prior to inclusion in the LWA calculation. The LWA concentration was calculated for each core according to Equation 4-1, which represents the sum of the concentration in each core segment (deposited between 1950 and 2005) multiplied by the respective segment thickness. This sum is then divided by the total length of the core segments used.

$$\mathrm{LWA} = \frac{\sum_{i=1}^{p} C_i T_i}{\sum_{i=1}^{p} T_i} \qquad \text{Equation 4-1}$$

Where

C_i: sediment concentration in the ith segment of the core

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T_i: thickness of the ith segment of the core

p: segment in the core corresponding to the 1950 time horizon

The calculated LWA concentrations from each high resolution sediment core were averaged to obtain one LWA concentration for the EMBM. (LWA concentrations and statistics on these values are provided in Attachment B.) LWA concentrations for select contaminants are provided in Table 4-5 and represent a second method of describing concentrations potentially available for resuspension. Unlike the decadal concentrations, the LWA concentration integrates the entire thickness of contaminated sediments into one value for each contaminant, equivalent to the river eroding and resuspending sediment from all possible historical sediment layers on a roughly equal basis.

Table 4-5: LWA Concentrations for Select Contaminants

Analyte	LWA Concentration
Mercury (mg/kg)	5.7
Lead (mg/kg)	420
Cadmium (mg/kg)	11
Trans-Chlordane (µg/kg)	44
DDE (µg/kg)	200
2,3,7,8-TCDD (ng/kg)[a]	3,600
Total TCDD (ng/kg)[a]	4,100
BZ 31 (µg/kg)[a]	270
BZ 52 (µg/kg)[a]	270
BZ 61+66+70+74+76 (µg/kg)[a]	640
BZ 83+99 (µg/kg)[a]	110
BZ 90+101+113 (µg/kg)[a]	180
BZ 93+95+98+100+102 (µg/kg)[a]	150
BZ 110+111+115 (µg/kg)[a]	190
BZ 129+138+158+160+163+164 (µg/kg)[a]	170
BZ 139+140+147+149 (µg/kg)[a]	130
BZ 170 (µg/kg)[a]	33
BZ 180+193 (µg/kg)[a]	80
Benz[a]anthracene (mg/kg)	3.7
Benzo[a]pyrene (mg/kg)	3.7
Chrysene (mg/kg)	5.1
Fluoranthene (mg/kg)	8.2
Indeno[1,2,3-cd]pyrene (mg/kg)	2.6
Pyrene (mg/kg)	7.9

a: Average concentration for only three river locations (RM1.4, RM2.2, and RM11)
Concentrations rounded to two significant figures

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4.3 EVALUATION OF RECENTLY DEPOSITED SURFACE SEDIMENT CONCENTRATIONS IN THE LOWER PASSAIC RIVER

Recently deposited surface sediments for the Lower Passaic River were defined as those sediments deposited during the 2003-2005 time period. Due to the various sedimentation rates in the high resolution cores (Table 4-3), the thickness of the 2003-2005 surface sediment layer varies from core to core (Table 4-6). Note that for the core located at RM12.6, two consecutive segments (0-3 centimeters and 3-6 centimeters) are combined to represent this time horizon.

Table 4-6: Recently Deposited Surface Sediment Definition for the Dated Sediment Cores

Sediment Core	Time Horizon	Sediment Thickness (centimeters)
RM1.4	2005-2002	15
RM2.2	2005-2003	18
RM7.8	2005-2003	3
RM11	2005-2002	6
RM12.6	2005-2003	6

Recently deposited surface sediment concentrations for the Lower Passaic River and the corresponding statistics are presented in Attachment C. Average recently deposited surface sediment concentrations for select contaminants are provided in Table 4-7. These values represent the receptor concentrations for the EMBM.

Table 4-7: Average Lower Passaic River Surface Sediment Concentrations for Select Contaminants

Analyte	Average Concentration (RM1.4, RM2.2, RM7.8, RM11, and RM12.6)
Mercury (mg/kg)	1.8
Lead (mg/kg)	210
Cadmium (mg/kg)	3.6
Trans-Chlordane (µg/kg)	33
DDE (µg/kg)	54
2,3,7,8-TCDD (ng/kg) [a]	280[a]
Total TCDD (ng/kg) [a]	420[a]
BZ 31 (µg/kg)	26
BZ 52 (µg/kg)	35
BZ 61+66+70+74+76 (µg/kg)	85
BZ 83+99 (µg/kg)	21
BZ 90+101+113 (µg/kg)	34
BZ 93+95+98+100+102 (µg/kg)	28
BZ 110+111+115 (µg/kg)	35
BZ 129+138+158+160+163+164 (µg/kg)	45

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BZ 139+140+147+149 (µg/kg)	34
BZ 170 (µg/kg)	11
BZ 180+193 (µg/kg)	27
Benz[a]anthracene (mg/kg)	3.1
Benzo[a]pyrene (mg/kg)	3.6
Chrysene (mg/kg)	4.3
Fluoranthene (mg/kg)	6.5
Indeno[1,2,3-cd]pyrene (mg/kg)	2.9
Pyrene (mg/kg)	6.1

a: Average concentration for only three river locations (RM1.4, RM2.2, and RM11)
Concentrations rounded to two significant figures.

4.3.1 EVALUATION OF 2,3,7,8-TCDD AND TOTAL TCDD IN THE RIVER

As discussed in the CSM (Malcolm Pirnie, Inc., 2007a), tidal action causes the mixing and homogenizing of the surface sediments in the Lower Passaic River. Consequently, strong concentration gradients do not exist laterally in the river. For example, the 2,3,7,8-TCDD concentrations range from 190 to 740 nanograms per kilogram of sediment (ng/kg), which represents a factor of four variation from RM1.4 to RM12.6 (Figure 4-3a). By contrast, the 2,3,7,8-TCDD concentration varied by approximately four orders of magnitude over time. The lowest reported concentration was approximately 2 ng/kg, which corresponds to the 1950s time horizon, while the highest reported concentration was approximately 22,000 ng/kg, which corresponds to the 1960s time horizon (Figure 4-3a). On closer examination, 2,3,7,8-TCDD concentrations in the surface sediments from RM11 and RM12.6 were approximately 2 to 7 times higher than concentrations reported for the other three cores at RM1.4, RM2.2, and RM7.8 (Table 4-8). Likewise, the total tetrachlorodibenzodioxin (Total TCDD) concentration for these two cores was about 2 to 5 times higher than the reported concentration in the other cores (Figure 4-3b). A closer examination of the two upriver cores (RM11 and RM12.6) suggests the occurrence of a localized event occurring relatively recently, affecting only the upper portion of the Lower Passaic River. Prior to this event, the 2,3,7,8-TCDD concentrations tracked quite closely (less than a factor of two variation among the 5 cores) for the last 20 years.

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Table 4-8: 2,3,7,8-TCDD Surface Sediment Concentrations in the Lower Passaic River

Analyte	Surface Sediment at RM1.4	Surface Sediment at RM2.2	Surface Sediment at RM7.8	Surface Sediment at RM11	Surface Sediment at RM12.6[a]
2,3,7,8-TCDD	190	340	300	590	Average 740 1,300/170
Total TCDD	300	500	460	850	Average 830 1,400/260
2,3,7,8-TCDD / Total TCDD	0.63	0.67	0.66	0.69	Average 0.79 0.92/0.66

a: Two values are presented for RM12.6 for core segments at 0-3 centimeters and 3-6 centimeters, which together represent the 2003-2005 time horizon.
Values rounded to two significant figures

The increase in concentration along with the change in the 2,3,7,8-TCDD-to-Total TCDD ratio to a value observed historically (0.9) suggests that this increase is due to the resuspension of historical sediments characterized by this higher ratio. This increased ratio was observed in the surface layer at RM 12.6 and in the first layer below the surface at RM 11. The consistency of this observation in the two cores suggests a single event that affected both cores. A possible explanation is the erosion and redeposition of historical sediments by the high flow event that occurred in April 2005 (Figure 4-4). The April 2005 flood had measured flows of approximately 11,600 cubic feet per second (CFS), an event slightly larger than the 1999 Hurricane Floyd event and larger than any other event since 1984. As discussed in the CSM, fine-grained, net non-depositional areas are located between RM13 and RM14. This non-depositional area would likely be impacted by a high flow event, which would cause fine-grained sediments to move downriver and impact surface concentration at the coring locations at RM11 and RM12.6. Because of the elevated PCDD/F concentrations in the surface sediments of these upriver cores, the average of only the three lower river surface sediment samples were used in the mass balance model calculations. The average 2,3,7,8-TCDD concentration for RM1.4, RM2.2, and RM7.8 is approximately 280 ng/kg, which is only about 30 percent lower than the average for the five surface sediment samples. (Note that the incorporation of the average from all five cores does not impact the modeling results.) While the hypothesis provided above may explain the observed surface concentration increase, further exploration of these observations is beyond the scope of this effort and is recommended for future analysis.

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The ratio of 2,3,7,8-TCDD/Total TCDD ranged from 0.63 to 0.79 (Table 4-8) in the Lower Passaic River, which is consistent with the Chaky (2003) model. In this model, Passaic-contaminated solids have a ratio value of approximately 0.7, representing one end member, while sewage, atmospheric, and Upper Hudson River sources have a ratio of 0.06 or less, representing "other" end members. To further evaluate this ratio among the five river locations, a hierarchical cluster analysis utilizing Ward's minimum variance method was performed on the ratios. The result from this analysis showed clusters (*i.e.*, groups of samples) whose values were close to each other relative to other clusters. As part of the clustering procedure the ratio were first standardized to allow for the comparison of results from different normal distributions (Figure 4-5). Clustering is the partitioning of a dataset into subsets, or "clusters," where the data in each subset share some common trait. Typically, the relationship between data is expressed as a unitless distance; the closer the distance is, the more similar the elements are. Hierarchical clustering is a process that starts with each point in its own cluster. At each step, the two clusters that are closest together are combined into a single cluster to show closely related datasets. This process continues until there is only one cluster containing all the points.

The cluster analysis for the 2,3,7,8-TCDD/Total TCDD ratio showed that several similarities existed among the five river locations; however, the strongest similarity occurred when all five river locations were clustered into one group, suggesting that the ratio does not differ significantly from RM1.4 to 12.6. This break point to one cluster is evident in the cluster distances (noted in Figure 4-5) where the distances jump from a value of 0.041 to 0.195, indicating that the preferred grouping of the data is one cluster. However, it is noteworthy to mention that the ratio for RM12.6 is the last location to be incorporated into the cluster, suggesting that this location is slightly different from the other locations (Figure 4-5).

4.3.2 EVALUATION OF PCB CONGENERS IN THE RIVER

Similar to the fate and transport of 2,3,7,8-TCDD, Total PCB concentrations in the Lower Passaic River have been impacted by tidal mixing. For example, surface

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sediments are rather homogenous, varying by a factor of two from RM1.4 to RM12.6. Historical concentrations follow similar trends with Total PCB peaking in the 1960s for cores collected at RM1.4, RM2.2, and RM11 (Figure 4-3c). Individual PCB congeners followed similar trends to the Total PCB profile as shown in Figure 4-3d through Figure 4-3n.

While Total PCB concentrations are similar in the surface sediments, an evaluation was completed to determine if the PCB patterns at the five river locations were similar. If the patterns are well correlated, then one PCB source (or several sources with the same signature) is impacting the Lower Passaic River, and tidal action is likely mixing and homogenizing the surface sediments. For this evaluation, PCB congeners in the surface sediments at the five river locations were normalized to the PCB congener [Ballschmiter and Zell (BZ) Number] 52 and plotted with the lighter weight PCB compounds on the left and the heavier PCB compounds on the right (Figure 4-6). As anticipated, the congener pattern for all five river locations was similar, and the variations in the fraction were small. The normalized data for different river locations were then plotted against each other (Figure 4-7). The correlation matrix shows tightly correlated data among the different river miles [with correlation coefficients (R) equal to 0.99]; however, the data tend to cluster near the low fractions of the normalized data with some scatter of points at the high end of the fractions. To better fit the data, a robust regression was used. Unlike the least squares regression, the robust regression considers the data more equally and is not strongly affected by points far from the center of the data. The robust regression resulted in lower intercept values and higher coefficients of determination (R^2) for all cases (Figure 4-8).[15] Cluster analysis for the river locations was not performed for PCB congeners since the results from the correlation matrix and the robust regression showed that the PCB congener pattern was the same throughout the river from RM1.4 to RM12.6. Average PCB congener concentrations incorporated into the model to represent the Lower Passaic River are presented in Table 4-7.

[15] The statistical value, R^2, is defined as the proportion of variability in a data set that is accounted for by a statistical model.

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4.3.3 EVALUATION OF PAH COMPOUNDS IN THE RIVER

Total PAH concentrations vary by a factor of two from 1980 to 2005 (Figure 4-3o) but with no particular trend with time, suggesting that the Total PAH contaminant load to the Lower Passaic River has not changed significantly over this period. An increase in Total PAH concentration is observed in the 1960s with concentrations doubling from about 50 to 100 milligram per kilogram of sediment (mg/kg). HMW PAH accounts for approximately 80 percent of the Total PAH concentration (Figure 4-3p). Upon closer inspection of the HMW PAH profile and the LMW PAH profile (Figure 4-3q), a slight rise in concentration over the last 20 years is observed in the sediment cores collected at RM2.2 and RM12.6, whereas the concentrations at RM1.4, RM7.8, and RM11 have remained constant. This slight rise in concentration is geochemically different from the distinct short-term increase in concentration for 2,3,7,8-TCDD and Total TCDD, which may be attributed to the high flow event in April 2005 (Figure 4-3a and Figure 4-3b). While the PAH compounds likely experienced the same phenomenon, the mixing of older sediments with surface sediments had less of an impact on the Total PAH concentration than the PCDD/F concentrations because the PAH contaminant burden has been the same over the past 25 years. Thus, PAH compounds have less historic variability compared to PCDD/F. [Individual PAH compounds show similar trends to the Total PAH profile (Figure 4-3r to Figure 4-3x)].

Similar to the PCB congeners, an analysis was completed to examine the PAH patterns at each river location to determine if the PAH patterns were similar across the river. For the purpose of this evaluation, the PAH compounds were normalized to benz[a]antharacene, and the sampling locations were plotted against each other (Figure 4-9). As anticipated, the PAH compounds, like the PCB congeners, are tightly correlated for all five river locations with R values ranging from 0.98 to 0.99. Robust regression was also performed to assess the correlation among the different river miles (Figure 4-10); however, since the individual PAH compounds concentrations are relatively similar in magnitude and evenly distributed, the robust regression values are similar to the linear regression values. The intercept from the robust regression is slightly lower but is not considered significantly different.

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Cluster analysis was performed for the PAH compound concentrations (normalized and standardized) at the five river locations (Figure 4-11). Like the 2,3,7,8-TCDD/Total TCDD cluster results, the strongest similarity occurred when all five river locations were clustered into one group, suggesting that the PAH pattern does not differ from RM1.4 to 12.6. Average PAH concentrations incorporated into the model to represent the Lower Passaic River are presented in Table 4-7.

4.3.4 EVALUATION OF PESTICIDES IN THE RIVER

The evaluation of the Lower Passaic River pesticide data focuses on the following pesticide compounds: DDD, DDE, DDT, dieldrin, cis-chlordane, and trans-chlordane, which have been identified as COPCs (Table 2-1). However, for the EMBM, only DDE was considered because the pesticides in the Newark Bay dataset were frequently not detected (refer to Section 4.5.2 "Data Quality of Newark Bay Data"). Dated sediment core profiles for DDE, Total Chlordane, and dieldrin are provided in Figure 4-3y through Figure 4-3aa. DDE concentrations have slowly declined over the past 25 years with the range of annual concentrations varying by a factor of two or less (Figure 4-3y). Total chlordane concentrations represent the sum of the cis-chlordane and trans-chlordane, with each form representing roughly half of the total. Unlike DDE, Total Chlordane concentrations have not declined appreciably over the past 25 years, with peak concentrations observed in the 1960s and 1970s (Figure 4-3z). Dieldrin concentrations also peaked in the 1960s with notably higher concentrations at RM11 and RM12.6. Like total chlordane, dieldrin concentrations have been fairly constant over the past 25 years, although a slight rise in dieldrin concentrations may have occurred in the early 1980s (Figure 4-3aa).

To identify the similarity in the pesticides data along the river, the pesticide compounds were normalized to dieldrin, and scatter plots were constructed for the different river locations (Figure 4-12). Data from RM1.4, RM7.8, and RM11 are correlated with R values equal to 0.98 to 0.99. Because the sample size was limited and the concentrations were similar and relatively well distributed, robust regressions did not improve the fit of

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the data relative to the linear regressions. Robust regressions for three comparisons are provided in Figure 4-13. A cluster analysis was also performed on the standardized pesticide concentrations normalized to dieldrin (Figure 4-14). Like the PAH and 2,3,7,8-TCDD/Total TCDD cluster results, the strongest similarity occurred when all five river locations were clustered into one group, suggesting that the pesticide pattern does not differ from RM1.4 to 12.6. Average pesticide concentrations incorporated into the model to represent the Lower Passaic River are presented in Table 4-7

4.3.5 EVALUATION OF METALS IN THE RIVER

As discussed in Section 4.1.1, metals analyses were performed on every core segment in the five dated sediment cores. Consequently, reported metal concentrations were averaged to provide the same temporal resolution as the organic analyses. Dated sediment core profiles for mercury, cadmium, lead, and copper are presented in Figures 4-3bb through Figure 4-3ee. In general, metals concentrations varied approximately one order of magnitude or less over time with peak concentrations occurring in the 1960s. Average metals concentrations for these contaminants in the Lower Passaic River surface sediments are presented in Table 4-7.

The selection of metals for the EMBM was limited by the CSO/SWO dataset, which included only three metals: mercury, lead, and cadmium. (Copper was identified as a COPC for this analysis and is examined later in the report.) Because the sample size was limited, no correlation evaluation or cluster analyses were completed. However, a summary table of the ratios of mercury/lead, cadmium/lead, and copper/lead in the surface sediments is provided as Table 4-9.

Table 4-9: Metals Ratio in Surface Sediments of the Lower Passaic River

River Location	Mercury/Lead	Cadmium/Lead	Copper/Lead
RM1.4	0.011	0.017	0.73
RM2.2	0.007	0.016	0.63
RM7.8	0.010	0.017	0.73
RM11	0.009	0.019	0.76
RM12.6	0.005	0.015	0.67

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The ratio of cadmium/lead does not vary in the surface sediment from RM1.4 to RM12.6 and is similar to the cadmium/lead ratio (0.015) measured in the surface sediment above Dundee Dam. The copper/lead ratio is also fairly constant across the river; however, the ratio is greater than the corresponding ratio measured above Dundee Dam (0.56), suggesting a copper source in the Lower Passaic River. The ratio of mercury/lead varies by a factor of two from 0.005 to 0.011, with the lowest ratio reported at RM12.6 and the highest ratio reported at RM1.4, suggesting a slight mercury gradient in the river.

4.4 LOWER PASSAIC RIVER SUSPENDED SOLIDS EVALUATION

4.4.1 DATA QUALITY OF CONTAMINANT CONCENTRATIONS ON SUSPENDED SOLIDS

Data from the cartridge filter blank were used to evaluate the quality of the contaminant concentrations on the Infiltrex and TOPS suspended solids in the USEPA large volume water column program. (No cartridge filter blanks were available for the USGS Water Monitoring Program.) Contaminant concentrations from the blank (reported in mass per sample) were divided by the volume of water filtered through each sample (83 liters for Infiltrex and 20 liters for laboratory-filtered TOPS) to convert the data to mass per liter. The quality of the Infiltrex and TOPS data was then evaluated by calculating the ratio of the contaminant concentration in the blank to the contaminant concentration in each suspended solids sample. Ratios that were equal to or less than 1 percent were considered acceptable data quality. Only endosulphan sulphate and 1,2,3,4,7,8,9-heptachlorodibenzofuran exceeded this criterion.

Before the suspended solids data were incorporated in the analysis, the laboratory and validator qualifiers were evaluated. (Note that a portion of the PCDD/F and pesticides samples and all the PCB congener data from the USGS TOPS program were unvalidated at the time that the EMBM was completed; hence, data qualifiers were unavailable.) A limited number of samples were not detected (*e.g.*, flagged with a qualifier containing a "U"), including three pesticide samples, three PCDD/F samples, and one PCB congener. These sample concentrations were set equal to zero.

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Another qualifier of interest was "EMPC," which was associated with the suspended PCDD/F concentrations for the USGS TOPS dataset. This qualifier indicates that the reported values are biased high. Approximately 30 percent of the tetra-, penta-, and hexachlorodibenzodioxins/furans samples were marked with this qualifier. In addition, the results for total tetrachlorodibenzofuran for the USGS TOPS samples were rejected.

4.4.2 Comparison of Suspended Solids and Surface Sediment Concentrations

Suspended solids data from the Infiltrex and TOPS samples were converted from mass of contaminant per liter of water to mass of contaminant per mass of suspended solids by dividing the contaminant concentrations by the TSS concentration of the whole water sample. The USGS Water Monitoring Program data were used as reported to the NJ Department of Transportation as part of the Environmental Dredging Pilot Study. To compare the suspended solids to the surface sediments of the Lower Passaic River, the PCB congeners were normalized to BZ 52 and the 2,3,7,8-TCDD/Total TCDD ratio was examined.

As discussed in Section 2.2, daily tides resuspend and redeposit surface sediments, resulting in relatively homogeneous chemical concentrations in the recently deposited surface sediments across the Lower Passaic River (Malcolm Pirnie, Inc., 2007a). Accordingly, suspended solids should possess the same contaminant pattern as the recently deposited surface sediments since the solids resuspend and redeposit in the river. Figure 4-15 presents the PCB congener pattern for suspended solids measured during the USGS monitoring program and the USEPA large volume program. (For the USGS TOPS data, the PCB congener pattern presents the average of composite samples collected on December 5, 2005, December 6, 2005, and December 10, 2005.) For both programs, the same dominant PCB congeners are measured in the suspended solids (for simplicity, only the average USGS data are presented in Figure 4-15b). Moreover, the same dominant PCB congeners were identified in the surface sediment of the Lower Passaic River (Figure 4-6).

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The concentrations and ratio of 2,3,7,8-TCDD/Total TCDD in the suspended solids and the surface sediments were also examined. Similar to the PCB congener pattern, the same ratio observed in the surface sediments was reported in the suspended solids in two independent programs (Table 4-10). The average concentrations agreed within measurement error. Together, these results support the hypothesis that recently deposited surface sediment and suspended solids are derived from the same pool of solids, tidally mixed and distributed throughout the Lower Passaic River.

Table 4-10: Ratio of 2,3,7,8-TCDD/Total TCDD Measured on Suspended Solids

Analyte[a]	Average Surface Sediment	Average USGS TOPS	Infiltrex Program	TOPS Laboratory
2,3,7,8-TCDD (µg/kg)	0.28 ±0.079 (N = 3)	0.57 ±0.57 (N = 18)	0.22 (N = 1)	0.17 (N = 1)
Total TCDD (µg/kg)	0.42 ±0.11 (N = 3)	0.78 ±0.62 (N = 18)	0.32 (N = 1)	0.25 (N = 1)
Ratio 2,3,7,8-TCDD/Total TCDD	0.65 ±0.024 (N = 3)	0.72 ±0.15 (N = 18)	0.69 (N = 1)	0.68 (N = 1)

a: Arithmetic average and standard deviation (± 1 sigma) based on a normal distribution of sample size. .
N = sample size

4.5 NEWARK BAY DATA EVALUATION

4.5.1 NEWARK BAY CONCEPTUAL SITE MODEL

The following section briefly describes the Newark Bay CSM, which is presented here to accompany the Newark Bay data evaluation and provide rationale for dividing Newark Bay into a northern and southern area. Newark Bay is part of the Hudson-Raritan Estuary and is formed by the confluence of the Lower Passaic River and the Hackensack River at its northern end, and by the confluence of the Arthur Kill and the Kill van Kull at its southern end. Like the rest of the Hudson-Raritan Estuary, tidal currents cause the re-working of sediments, mixing suspended sediments from the bay with sediments derived from other areas. Consequently, contaminated sediments from Newark Bay have been, and continue to be, distributed throughout the Hudson-Raritan Estuary.

The mixing of relatively less contaminated solids from the Kill Van Kull with more contaminated solids from the Lower Passaic River has resulted in relatively strong

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concentration gradients longitudinally across Newark Bay from north to south, as contaminated sediments from the Lower Passaic River are blended with relatively less contaminated sediment entering Newark Bay from the Kills. These concentration gradients are most apparent in the navigation channels, where maintenance dredging has created deep, quiescent channels that provide an ideal environment for rapid sediment deposition and sediment concentrations are less affected by local inputs.

As discussed in Section 4.1.4 "Newark Bay Remedial Investigation Phase 1 Dataset," surface sediment samples were collected at depositional locations. Concentration scatter plots for select contaminants at these depositional locations illustrate three general concentration distributions in Newark Bay (Figure 4-16):

- Decreasing concentration gradients from north to south across Newark Bay (*e.g.*, for 2,3,7,8-TCDD and Total PAH), which are considered strongly indicative of the impacts of contamination emanating from the Lower Passaic River.
- Uniform concentrations across the main body of Newark Bay (*e.g.*, for lead), which indicates similar concentrations in the solids arriving at both ends of the bay.
- A distribution with local maxima near the intersection of the Port Newark Channel and the main channel of Newark Bay, as well as at the mouth of the Arthur Kill (*e.g.*, for mercury and Total PCB), which are indicative of a major source within the bay as well as the presence of sources external to the bay.

The presence of different concentration gradients occurring simultaneously in Newark Bay suggests that the bay is not an efficient "mixing bowl." In other words, the tidal currents are not sufficient to completely homogenize and distribute contaminated sediments evenly throughout the bay, unlike the conditions that exist in the Lower Passaic River. The external contaminant loads arising from source areas are sufficiently large relative to the tidal fluxes such that tidal circulation cannot dissipate the local gradients prior to sediment deposition. Ultimately, the fate of particle-reactive contaminants is linked to the movements of sediments in the bay. In this manner, particle-reactive contaminants are slowly buried in the shoals or removed from the

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channels by dredging. Although the bay is considered net depositional, some portion of the bay sediments escape via tidal exchange, adding to contamination elsewhere in the Hudson-Raritan Estuary.

The impacts of the Lower Passaic River on the bay must be understood to characterize Newark Bay sediments. The following discussion describes the methods and analyses used to distinguish a Newark Bay signature within the data.

4.5.2 QUALITY OF NEWARK BAY DATA

Before beginning the analysis of the Newark Bay samples, the laboratory and validator qualifiers were examined. For the contaminants examined, one rejected copper sample was reported. However, many samples were not detected (*e.g.*, flagged with a qualifier containing a "U"), especially in the pesticide class. Approximately 90 percent of the pesticides were not detected due to high method detection limits and matrix interference. The only pesticide regularly detected in Newark Bay during TSI's Phase 1 investigation was DDE. For the 16 sampling locations deemed to be reliably depositional, DDE was not detected in three of the sampling locations. The DDE concentrations at the three non-detected locations were assigned half the method detection limit.

Surface sediment concentrations for Newark Bay and the corresponding statistics are presented in Attachment D. Average surface sediment concentrations for select contaminants are provided in Table 4-11. Because of the strong concentration gradients in Newark Bay, average northern and southern concentrations were calculated separately. For this discussion, sampling locations are discussed in terms of distance from the mouth of the Lower Passaic River following the federal navigation channel. Hence, a negative river mile of RM-3 represents three miles from the mouth of the Lower Passaic River.

Table 4-11: Average Newark Bay Recently Deposited Surface Sediment Concentrations for Select Contaminants

Analyte	Average Northern Concentration [a]	Average Southern Concentration [b]
Mercury (mg/kg)	2.2	0.93
Lead (mg/kg)	110	77
Cadmium (mg/kg)	1.2	0.64
Trans-Chlordane (µg/kg)	NA	26
DDE (µg/kg)	32	18
2,3,7,8-TCDD (ng/kg)	77	16
Total TCDD (ng/kg)	160	54
BZ 31 (µg/kg)	21	12
BZ 52 (µg/kg)	20	7.4
BZ 61+66+70+74+76 (µg/kg)	46	19
BZ 83+99 (µg/kg)	10	4.3
BZ 90+101+113 (µg/kg)	19	7.8
BZ 93+95+98+100+102 (µg/kg)	16	5.8
BZ 110+111+115 (µg/kg)	22	9.3
BZ 129+138+158+160+163+164 (µg/kg)	18	7.4
BZ 139+140+147+149 (µg/kg)	16	6.0
BZ 170 (µg/kg)	3.8	1.5
BZ 180+193 (µg/kg)	11	4.2
Benz[a]anthracene (mg/kg) [c]	1.3	0.35
Benzo[a]pyrene (mg/kg) [c]	1.7	0.40
Chrysene (mg/kg) [c]	1.4	0.37
Fluoranthene (mg/kg) [c]	1.9	0.51
Indeno[1,2,3-cd]pyrene (mg/kg) [c]	0.92	0.31
Pyrene (mg/kg) [c]	2.4	0.58

a: Northern Newark Bay sampling locations represent recently deposited surface sediments between RM-0.45 and RM-1.9.
b: Southern Newark Bay sampling locations represent recently deposited surface sediments between RM-3.0 and RM-4.6.
c: One elevated PAH concentration at RM-4.1 was excluded from the average southern concentration.
Concentrations rounded to two significant figures.

4.5.3 EVALUATION OF 2,3,7,8-TCDD AND TOTAL TCDD IN THE BAY

The concentration scatter plot for 2,3,7,8-TCDD indicates a north-to-south concentration gradient in Newark Bay at depositional locations both in the channel and on the shoals (Figure 4-16a). A decreasing 2,3,7,8-TCDD concentration gradient was suggested by Bopp *et al*. (1991a), who also showed that this gradient continued through the Kill Van Kull, with the lowest levels of 2,3,7,8-TCDD measured in New York Harbor. Their data indicated that the likely source of the 2,3,7,8-TCDD contamination was the Lower Passaic River. The TSI 2005 data documents a decrease in the ratio across the Bay from approximately 0.6 in the northern end to 0.3 in the southern end, reflecting the mixing of

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highly-contaminated Lower Passaic River sediment with relatively cleaner sediments originating in Upper and Lower New York Bay (Figure 4-16b). These cleaner sediments have a 2,3,7,8-TCDD/Total TCDD ratio more consistent with sewage-based sources, and 2,3,7,8-TCDD concentration levels orders of magnitude below those concentrations observed in the Lower Passaic River (Malcolm Pirnie, Inc., 2007a; Chaky, 2003). Elevated concentrations observed at the head of the port channels for other contaminants (*e.g.*, Total PCB and metals) are not observed for 2,3,7,8-TCDD, showing that, unlike Total PCB and metals, no major 2,3,7,8-TCDD source exists to Newark Bay other than the Lower Passaic River.

Average 2,3,7,8-TCDD and Total TCDD concentrations for the northern and southern portions of Newark Bay are provided in Table 4-11. Multivariate and cluster analyses were not performed on the 2,3,7,8-TCDD dataset since it is likely that most of the 2,3,7,8-TCDD contamination in the bay originated from the Lower Passaic River.

4.5.4 EVALUATION OF PCB CONGENERS IN THE BAY

To identify a PCB pattern unique to Newark Bay (*e.g.*, not impacted by Lower Passaic River contributions), PCB congeners from the 16 selected depositional locations (beryllium-7 bearing and located within the federal navigation channel) were normalized to BZ 52 and were plotted against each other to identify a correlation among the bay locations. Sample locations that had a correlation of R less than 0.99 were eliminated, resulting in five locations that are tightly correlated (Figure 4-17). These five locations are located on the southern end of the bay from RM-3 to RM-4.6 (Figure 4-18). Note that the Newark Bay locations are discussed here with respect to distance from the Lower Passaic River; consequently RM-3 indicates a distance of 3 miles into the bay from the mouth of the river, which is located at RM0.

The results of the correlation evaluation suggest that the five identified sample locations are less affected by the Lower Passaic River PCB contamination than the other sampling locations in the bay. This conclusion is further supported by examining the PCB congener concentrations across the Bay (Figure 4-19). In Figure 4-19, the five sample

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locations identified from the correlation analysis were marked with an asterisk symbol. The PCB congener concentrations reported for these locations were lower than the concentrations reported closer to the mouth of the Lower Passaic River. Finally, the normalized PCB congener pattern for the five sampling locations was compared (Figure 4-20) to assess any variations among the locations. The small variation in the PCB congener pattern continues to support the hypothesis that these five locations adequately represent a Newark Bay PCB signature with minimal impacts from the Lower Passaic River. The PCB congener concentrations for surface sediments at these southern locations ranged from 0.90 to 22 µg/kg for the individual PCB congeners with average concentrations ranging from 1.5 to 19 µg/kg for the individual PCB congeners (Table 4-11).

Conversely, the northernmost samples that are located between RM-0.45 and RM-1.9 have PCB congener patterns more similar to those patterns observed in the Lower Passaic River. Similar to the evaluation presented above for the five southern samples, a correlation matrix was plotted for the five northernmost sampling locations (Figure 4-21). These northern samples were well correlated with R values ranged from 0.97 to 0.99. In general, the surface sediment concentrations for the northern samples were approximately three to four times higher than the concentration of the five southern samples. The surface sediment PCB congener concentrations for these northern locations ranged from 2.5 to 67 µg/kg for the individual PCB congeners, with average concentrations ranging from 3.8 to 46 µg/kg for the individual PCB congeners (Table 4-11).

4.5.5 EVALUATION OF PAH COMPOUNDS IN THE BAY

Similar to the PCB congener evaluation, the PAH compounds were evaluated to distinguish a Newark Bay signature. Following the procedure described above for the PCB congeners, the PAH compounds were normalized to benz[a]anthracene, and the data from the 16 depositional locations were plotted against each other. The correlation for the PAH compounds was poorer than the PCB congeners, with R values ranged from 0.6 to 0.99. Since the PAH compounds were not as well correlated, only the sample locations with R value less than 0.9 were eliminated in an effort to identify a Newark Bay

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source (Figure 4-22). The remaining 11 correlated locations for the PAH compounds were scattered throughout Newark Bay from RM-0.03 to RM-5. Consequently, the PAH pattern was assumed to be constant throughout the bay even though a Total PAH concentration gradient exists from north to south in the bay (Figure 4-23).

To be consistent with the PCB evaluation, the five southern locations that were previously identified as possessing a unique Newark Bay signature were further examined for the PAH compounds (marked with an asterisk symbol in Figure 4-23). Among these five southern locations, one location, RM-4.1 exhibited an elevated PAH concentration. This location was removed from the dataset and the remaining four southern locations were averaged to represent a Newark Bay PAH signature. The surface sediment concentrations for the individual PAH compounds ranged from 200 to 640 µg/kg with average concentrations ranging from 300 to 580 ug/kg for the individual PAH compounds (Table 4-11). Similar to PCB evaluation, the PAH compounds data from the northern most locations were also examined. On average, the concentrations of PAH compounds near the mouth of the Lower Passaic River were 3 to 4 times higher than the corresponding concentrations measured in the southern samples. The surface sediment concentrations for the northern locations ranged from 690 to 2,800 µg/kg for the individual PAH compounds with average concentrations ranging from 900 to 2,400 µg/kg among the PAH compounds (Table 4-11).

4.5.6 EVALUATION OF PESTICIDES IN THE BAY

Due to analytical problems and high detection limits, DDE was the only pesticide consistently detected during the Newark Bay Phase 1 Remedial Investigation. To substitute for the missing pesticide data, trans-chlordane concentrations reported by Bopp *et al.* (1991b) were evaluated since trans-chlordane was considered a potential modeling parameter (Table 4-12). These samples were beryllium-7 bearing surficial sediments (0-2 centimeters), representing Newark Bay conditions in 1985 when the samples were collected. (For comparison, the TSI Phase 1 dataset had a reported detection limit for trans-chlordane that ranged from 6.7 to 75 µg/kg.)

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Table 4-12: Trans-Chlordane Concentrations in 1985 Surficial Sediment

Bopp *et al*. (1991) Location Identification Number	Approximate River Mile (relative to mouth of river)[a]	Trans-Chlordane Concentration (µg/kg)
NB11	-0.5	15
NB12	-0.5	32
NB13	-1.4	15
NB16	-2.8	19
NB19	-3.5	52
NB10	-4.5	14
NB18	-5.0	32

a: River miles for the Newark Bay sampling locations are assigned with respect to the distance from the mouth of the Lower Passaic River (RM0.0) and follow the federal navigation channel.

DDE and trans-chlordane concentrations were then plotted across the bay (Figure 4-24). No concentration gradients were observed for the pesticides and no clustering of samples was observed. To be consistent with PCB evaluation, the average concentration for DDE was calculated for the previously identified southern and northern locations (Table 4-11). The average DDE for the southern locations was approximately 18 µg/kg, and the average concentration for the northern locations was approximately 32 µg/kg. For trans-chlordane, since the data originated from a separate study, all the samples were averaged to represent a Newark Bay signature (Table 4-12), yielding an average concentration of 26 µg/kg.

4.5.7 EVALUATION OF METALS IN THE BAY

As discussed in Section 4.3.5 "Evaluation of Metals in the River," the selection of metals for the mass balance was limited by the CSO/SWO dataset, which included only three metals: mercury, lead, and cadmium. The relative proportion of these metals to each other, or the metals pattern, was not as extensively examined as the organic analytes due to the limited number of parameters. No apparent concentration gradient was observed for the metals among the 16 depositional locations (Figure 4-25). Note that near RM-1.5, the metals concentrations were higher than other locations, which suggests a source originating in the port channels on the bay. To be consistent with PCB evaluation, average metals concentrations were determined for the five southern and five northern locations (Table 4-11).

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4.6 DUNDEE DAM DATA EVALUATION

4.6.1 QUALITY OF DUNDEE DAM DATA

The Dundee Dam dataset consists of a single recently deposited surface sediment sample (0-2 centimeters) from the core collected at RM18.3. At the time of the preparation of this report, the metals data were validated, but the organic data were unvalidated and undergoing review. For all of the contaminants examined, only a few of the PCB congener results were non-detect. Upper Passaic River surface sediment concentrations are summarized in Table 4-13. As discussed previously, a second sample of recently deposited sediments was also identified, but could not be incorporated in this report due to schedule constraints.

Table 4-13: Upper Passaic River Recently Deposited Surface Sediment Concentrations for Select Contaminants

Analyte	Upper Passaic River Concentrations
Mercury (mg/kg)	0.72
Lead (mg/kg)	140
Cadmium (mg/kg)	2.2
Trans-Chlordane (µg/kg)	47
DDE (µg/kg)	26
2,3,7,8-TCDD (ng/kg)	2.0
Total TCDD (ng/kg)	73
BZ 31 (µg/kg)	13
BZ 52 (µg/kg)	19
BZ 61+66+70+74+76 (µg/kg)	38
BZ 83+99 (µg/kg)	12
BZ 90+101+113 (µg/kg)	22
BZ 93+95+98+100+102 (µg/kg)	19
BZ 110+111+115 (µg/kg)	25
BZ 129+138+158+160+163+164 (µg/kg)	41
BZ 139+140+147+149 (µg/kg)	28
BZ 170 (µg/kg)	10
BZ 180+193 (µg/kg)	24
Benz[a]anthracene (mg/kg)	5.8
Benzo[a]pyrene (mg/kg)	7.1
Chrysene (mg/kg)	8.3
Fluoranthene (mg/kg)	10
Indeno[1,2,3-cd]pyrene (mg/kg)	4.5
Pyrene (mg/kg)	11

Concentrations rounded to two significant figures.

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4.6.2 EVALUATION OF PCB CONGENER PATTERNS

Preliminary evaluations presented in the *Draft Geochemical Evaluation (Step 2) (Malcolm Pirnie, Inc., 2006a)* suggest that the Upper Passaic River is an important source of Total PCB to the Lower Passaic River. To further evaluate this observation, the PCB congener pattern in the Dundee Dam surface sediments was compared to the corresponding PCB pattern in the Lower Passaic River. If the only source of PCB congeners to the Lower Passaic River was the Dundee Dam contaminant load, then the two PCB patterns would be similar. Figure 4-26 shows the normalized congener patterns for both the Dundee Dam surface sediment and the five Lower Passaic River surface sediment samples. The greater percentage of higher molecular weight congeners in the Dundee Dam sample suggests that the Dundee Dam sediments contain higher levels of Aroclors 1254 and 1260 than the sediments of the Lower Passaic River. The difference in pattern shift suggests that while the Dundee Dam solids are supplying a significant contaminant load of heavy PCB congeners to the Lower Passaic River, a second source exists on the river that is supplying or adding a significant source of lighter molecular weight PCB congeners to the river.

To further explore the PCB distribution in the Lower Passaic River, the PCB congener data from above Dundee Dam, the Lower Passaic River, and Newark Bay were compared. Because the PCB congeners for Newark Bay Phase 1 remedial investigation were analyzed by a different laboratory (relative to the Dundee Dam and Lower Passaic River samples), the reported PCB co-elutions differed between the datasets; consequently, a direct comparison of data as initially reported was not possible. To address this issue, single and co-eluting congeners were combined to form a series of co-elution groups common to both labs. The reported concentrations for all congeners placed in each group were then summed to produce a value for the group that could be directly compared. The list of the combined co-eluting congeners is provided in Attachment E along with the original congeners and co-elution groups from each laboratory.

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Once the co-eluting congeners were addressed, the concentrations for individual congeners and co-eluting groups were normalized to BZ 52 to enable a comparison of the relative proportions of each congener in the samples, rather than a comparison of the absolute concentrations. These normalized concentrations were then compared with a scatter plot to assess the correlations of PCB congeners among the different water bodies (Figure 4-27). The correlation matrix shows that Lower Passaic River samples are well correlated, which supports the CSM conclusions that tidal action has homogenized recently deposited surface sediments (Malcolm Pirnie, Inc., 2007a). Moreover, the correlation shows that the Dundee Dam PCB congener pattern is more closely correlated with the Lower Passaic River surface sediment congener pattern (with R values ranged from 0.93 to 0.96) than the Newark Bay congener pattern (with R values range from 0.75 to 0.8). These results combined with observed Total PCB concentration gradients from the Lower Passaic River to Newark Bay suggest that the Upper Passaic River has a stronger impact on the Lower Passaic River PCB concentrations than Newark Bay and that the Lower Passaic River is likely contributing some portion of the PCB contaminant burden to the bay.

4.6.3 IDENTIFYING INDEPENDENT CONTAMINANTS IN DUNDEE DAM AND THE LOWER PASSAIC RIVER

Solids and solid-bound contaminants flow over Dundee Dam, traverse the Lower Passaic River, and exchange with Newark Bay. During this course, different contaminants will experience different fate and transport processes. To identify those contaminants that can uniquely identify the various sources to the Lower Passaic River, a cluster analysis was performed on the Dundee Dam, Lower Passaic River, and Newark Bay datasets. To perform the cluster analysis, the PCB congener results for all three datasets were first normalized to BZ 52 and then standardized. The cluster analysis separated the PCB congeners into roughly 20 different clusters. Each analyte cluster represents a group of PCB congeners that are correlated, presumably having similar sources and/or having similar fate and transport processes. Out of these 20 clusters, eight congeners or co-eluting congener groups were selected as potential parameters for the EMBM (Figure 4-28). Since the eight selected congeners originate from different clusters, they represent

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PCB congeners with different sources or fate and transport processes and are considered to have the highest likelihood that they are independent of one another. Subsequently, two additional congeners/co-eluting congeners were selected from the same eight clusters (as well as the normalizing congener BZ 52) for redundancy in the event that later analysis might exclude one or more of the original eight identified (Table 4-14).

Table 4-14: Unique PCB Congeners in the Upper Passaic River, Lower Passaic River, and Newark Bay

Congeners/Co-eluting Congener Groups Identified by Cluster Analysis	Additional Congeners/Co-eluting Congener Groups
BZ 31	BZ 52
BZ 61+ 70+74+76+66	BZ 139+140+147+149
BZ 83+99	BZ 170
BZ 90+101+113	
BZ 93+95+98+100+102	
BZ 110+115+111	
BZ 129+138+158+160+163+164	
BZ 180+193	

A similar evaluation was completed for PAH compounds to identify independent contaminants in this suite of analytes. For the PAH compounds, the data were normalized to benz[a]anthracene. Then, scatter plots of the normalized PAH data were produced for Dundee Dam, Lower Passaic River, and Newark Bay. Like the PCB congeners, the PAH compound patterns for the Lower Passaic River samples were correlated, again supporting the CSM conclusions that the recently deposited surface sediments are tidally mixed. Unlike the PCB congener evaluation, the PAH correlation among the three major sample sets was not as good, yielding lower R values (Figure 4-29). These results indicate that the PAH sources to the Upper Passaic River, Lower Passaic River, and Newark Bay are different. An analyte cluster analysis was then performed on the PAH compounds, yielding four different clusters (Figure 4-30). Four PAH compounds were selected (one from each cluster) as chemicals with unique sources or fate and transport processes. One additional PAH compound was selected (as well as the normalizing PAH, benz[a]anthracene) for redundancy (Figure 4-30; Table 4-15).

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Table 4-15: Unique PAH Compounds in Upper Passaic River, Lower Passaic River, and Newark Bay

PAH Compounds from Cluster Analysis	Additional PAH Compounds
Benzo[a]pyrene	Benz[a]anthracene
Fluoranthene	Chrysene
Indeno[1,2,3-c,d]pyrene	
Pyrene	

4.7 TRIBUTARY AND CSO/SWO DATA EVALUATION

4.7.1 TRIBUTARY METALS DATA ANALYSIS

Dissolved metals concentrations (from the USEPA Small Volume Water Column Program) were subtracted from whole water metals concentrations to calculate the concentration of each metal on suspended solids in the tributaries. Suspended solids data [units of milligram per liter (mg/L)] were converted to mass of contaminant per mass of solids by dividing the concentrations by TSS.

For this analysis, samples that were not detected were carefully evaluated before they were used in the suspended solids calculation, especially since Sentinel, Inc. reported these values as the Contract Required Quantitation Limit (CRQL) and not the actual detection limit. For the lead data, Malcolm Pirnie, Inc. replaced the CRQL with the actual reported detection limit (as reported in the original data validation packages) before calculating suspended solids concentrations. For cadmium data, the original reported detection limit could not be found. Because whole water cadmium and dissolved cadmium were both reported at the CRQL, Malcolm Pirnie, Inc. calculated the suspended cadmium concentration as the whole water cadmium divided by TSS (as opposed to subtracting out the dissolved concentration first). The resulting suspended solids concentrations were considered to be maximum values for cadmium. Table 4-16 summarizes samples that were not detected and CRQL values used in small volume water column data evaluations.

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Table 4-16: Summary of Metals that Were Not Detected in the Small Volume Water Column

Chemical Name	Sample Location	Sample Type	Original Reported CRQL (mg/L)	Value Taken from Data Validation Packages and Used in Data Evaluations
Cadmium	Third River	Whole water	1 U	Used CRQL
	Third River	Dissolved	1 U	Used CRQL
	Saddle River	Whole water	1 U	Used CRQL
	Saddle River	Dissolved	1 U	Used CRQL
Lead	Saddle River	Dissolved	1 U	0.67 U

Table 4-17 presents a summary of calculated suspended solids concentrations (units of mg/kg) for the metals.

Table 4-17: Calculated Suspended Solids Metals Concentrations for the Tributaries

Chemical Name	Third River Suspended Solids (mg/kg)	Second River Suspended Solids (mg/kg)	Saddle River Suspended Solids (mg/kg)
Cadmium	<140 [a,b]	4.6	<200 [a,b]
Copper	430	1,400	290
Lead	490	410	160 [b]
Mercury	3.2	1.8	1.4

a: Value was calculated as whole water metal concentration divided by TSS concentration.
b: Concentrations were calculated using one or more values that were not detected.
Concentrations rounded to two significant figures.

Because of the uncertainty in incorporating suspended metals concentrations that were calculated using values that were not detected, the following assumptions were applied to the lead and cadmium concentrations. The lead concentration for Saddle River of 160 mg/kg was replaced with the value of 142 mg/kg, which corresponds to the lead concentration measured in the Dundee Dam core top at RM18.3. Cadmium concentrations for all three tributaries were replaced with 2.2 mg/kg, which corresponds to the cadmium concentration measured in the Dundee Dam core top. The cadmium concentration for Second River was also replaced with 2.2 mg/kg since the suspended cadmium calculation involved the subtraction of two values that were both detected but close to the method reporting limit.

4.7.2 TRIBUTARY SPMD EVALUATION

The laboratory data of the enriched SPMD dialysates provided a direct measure of the mass of chemical accumulated in the SPMDs during the deployment period. To convert

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these measurements to dissolved-phase chemical concentrations, an updated USGS "Water Calculator" spreadsheet program was used.[16] Each SPMD was spiked with five radio-labeled compounds called performance reference compounds. These compounds permit the estimation of *in-situ* SPMD sampling rates needed to determine ambient concentrations of chemicals from their respective levels in the SPMDs. The SPMD levels were inputted into the USGS spreadsheet and the dissolved-phase results were obtained. The dissolved-phase concentration measured at Ackermann Avenue Bridge (RM17) was combined with the Dundee Dam surface sediment concentrations (Table 4-13) to obtain a site-specific, freshwater K_d value. Given the close proximity, it was assumed that the water conditions at the Ackermann Avenue Bridge (RM17) were similar to the water conditions at Dundee Dam (RM17.4) and thus could be used in this calculation. These freshwater K_d values were applied to the other tributaries to determine the particulate concentration for organic analytes based on the dissolved phase concentrations derived from the SPMD samples.

Scatter plots of the suspended solids concentrations in Saddle River, Second River and Third River were then constructed to compare the contaminant load from each tributary (Figure 4-31). Because of the difference in the magnitude of the lead concentrations relative to the concentrations of the other parameters, the axes in the plots were presented in a logarithmic scale. The plots show a strong relationship among the three tributary sources, indicating that their contaminant patterns are not independent. Consequently, the three tributaries were combined into a single source to maintain the assumption of independence in the model. Area-weighted averages were calculated for each independent parameter using Equation 4-2.

$$C_{Tributary} = \frac{C_{Third} A_{Third} + C_{Second} A_{Second} + C_{Saddle} A_{Saddle}}{A_{Third} + A_{Second} + A_{Saddle}} \qquad \text{Equation 4-2}$$

[16] Personal communication between Solomon Gbondo-Tugbawa (Malcolm Pirnie, Inc.) and David Alvarez (USGS Columbia Environmental Research Center) on March 2, 2007.

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Where

$C_{Tributary}$: area-weighted average concentration in the three tributary sources

C_{Third}: concentration in Third River

A_{Third}: watershed area of Third River

C_{Second}: concentration in Second River

A_{Second}: watershed area of Second River

C_{Saddle}: concentration in Saddle River

A_{Saddle}: watershed area of Saddle River

The Third River watershed area of 12.5 square miles and Second River watershed area of 14.6 square miles were obtained from the NJDEP Hydrologic Unit Code (HUC) database. The Saddle River watershed area of 60.4 square miles was obtained from the USGS website (USGS, 2007). Watershed-area weighted tributary average concentrations are presented in Table 4-18, and statistics on these data are provided in Attachment F.

Table 4-18: Watershed Area-Weighted Tributary Average Concentrations for Select Contaminants

Analyte	Watershed Area-Weighted Tributary Average Concentrations
Mercury (mg/kg)	1.7
Lead (mg/kg)	240
Cadmium (mg/kg)	5.2
Trans-Chlordane (µg/kg)	210
DDE (µg/kg)	10
2,3,7,8-TCDD (ng/kg)	1.6
Total TCDD (ng/kg)	89
BZ 31 (µg/kg)	7.4
BZ 52 (µg/kg)	9.9
BZ 61+66+70+74+76 (µg/kg)	21
BZ 83+99 (µg/kg)	6.5
BZ 90+101+113 (µg/kg)	14
BZ 93+95+98+100+102 (µg/kg)	12
BZ 110+111+115 (µg/kg)	17
BZ 129+138+158+160+163+164 (µg/kg)	26
BZ 139+140+147+149 (µg/kg)	18
BZ 170 (µg/kg)	6.1
BZ 180+193 (µg/kg)	14
Benz[a]anthracene (mg/kg)	2.4
Benzo[a]pyrene (mg/kg)	3.1
Chrysene (mg/kg)	5.7
Fluoranthene (mg/kg)	10
Indeno[1,2,3-cd]pyrene (mg/kg)	2.7
Pyrene (mg/kg)	5.2

Concentrations rounded to two significant figures.

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4.7.3 CSO/SWO DATA ANALYSIS

Contaminant concentrations were received from NJDEP as contaminant mass per liter for whole water. Data associated with a laboratory qualifier containing a "U" were considered to be not detected and were set to zero. Duplicate values for each station and sampling date pair were averaged prior to inclusion in the calculation of mean values. Whole water samples were then converted to contaminant mass per suspended solids by dividing the whole water sample concentration by TSS. This conversion was considered adequate since preliminary evaluation using literature K_d values indicated that the majority of the contaminant mass was associated with the suspended solids; hence, the concentration in the whole water approximated the concentration in the suspended phase.

An inspection of the average CSO concentration and average SWO concentration showed that concentrations varied between 15 to 20 percent for the two discharge types. The close agreement suggests that both CSO and SWO discharges derive their contaminant concentrations from similar sources, most likely atmospheric fallout and solids from urban streets, common pathways between the two discharge types. Like the tributaries, the lack of independence between the two discharges types was evident in the scatter plots of the mean suspended solids concentrations measured in CSO and SWO samples (Figure 4-32). A logarithmic scale was used to represent the axes due to the range in concentrations between the organic and inorganic analytes. Since a strong relationship was evident between the CSO and SWO samples, the two sources were combined to a single CSO/SWO source and represented by the average chemical concentrations (Table 4-19). The averages were constructed as the simple average of the mean CSO and the mean SWO concentrations. Statistics on the CSO/SWO data are provided in Attachment G.

Table 4-19: Average CSO/SWO Concentrations for Select Contaminants

Analyte	Average CSO/SWO Concentrations
Mercury (mg/kg)	2.1
Lead (mg/kg)	790
Cadmium (mg/kg)	5.2

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Trans-Chlordane (µg/kg)	120
DDE (µg/kg)	64
2,3,7,8-TCDD (ng/kg)	27
Total TCDD (ng/kg)	540
BZ 31 (µg/kg)	7.4
BZ 52 (µg/kg)	22
BZ 61+66+70+74+76 (µg/kg)	41
BZ 83+99 (µg/kg)	13
BZ 90+101+113 (µg/kg)	29
BZ 93+95+98+100+102 (µg/kg)	22
BZ 110+111+115 (µg/kg)	39
BZ 129+138+158+160+163+164 (µg/kg)	47
BZ 139+140+147+149 (µg/kg)	27
BZ 170 (µg/kg)	10
BZ 180+193 (µg/kg)	24
Benz[a]anthracene (mg/kg)	6.7
Benzo[a]pyrene (mg/kg)	8.7
Chrysene (mg/kg)	12
Fluoranthene (mg/kg)	20
Indeno[1,2,3-cd]pyrene (mg/kg)	7.0
Pyrene (mg/kg)	18

Concentrations rounded to two significant figures.

Evaluation of the CARP dataset, represented in the mean values listed above, suggests that CSO/SWOs are not a significant source of 2,3,7,8-TCDD to the Lower Passaic River. This conclusion may appear to contradict the conclusions sited by Iannuzzi *et al*. (1997), who suggested that CSO/SWOs are a source of 2,3,7,8-TCDD in the river. This discrepancy in the CSO/SWOs is likely related to the sampling procedure used by Iannuzzi *et al*. (1997). In their study, three CSOs were sampled that discharged directly to the Lower Passaic River. A fourth, the Ivy Street CSO which discharges into a small creek in the Harrison reach above the head of tide, was also sampled. For the three CSOs that discharged directly to the river, the sampling program obtained Lower Passaic River sediments near the discharge points and not the CSO solids directly. Notably, the contaminant patterns from the three CSO sites were similar to the contaminant patterns observed in the sediments in the rest of the river. This observation is not unexpected, since the extensive tidal currents would be expected to disperse the relatively small solids loads and deposit average Lower Passaic River suspended solids in the area. Conversely, solids obtained in the creek near the Ivy Street CSO are not affected by the Lower Passaic River tides. In this instance, the contaminant concentrations reported by Iannuzzi *et al*. (1997) for the Ivy Street CSO were lower than those concentrations reported for this CSO

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in the CARP dataset. In light of these observations, the CARP data for the Ivy Street CSO was used as a conservative estimate of the contaminant load from this location.

4.8 EVALUATING INDEPENDENT CONTAMINANTS

The Lower Passaic River accumulates solids that originate from several sources. In order for the EMBM to decipher the contribution of these sources to the river sediments, independent parameters must be identified and applied in the model. Independent parameters are chemicals that have independent sources and/or different fate and transport processes. Essentially, the combination of contaminants selected for analysis must provide a relatively unique pattern for each of the various sources in order for a unique solution to be obtained by the model.

The data evaluations described above were used to identify a list of 24 chemicals that were considered unique (Table 4-20) for the sources and the recently deposited surface sediments of the Lower Passaic River (*i.e.*, the receptor). For metals, the selection was limited by data availability, since only three metals were measured in CSO/SWO dataset. For pesticides, the selected compounds were limited to data availability in the Newark Bay dataset, which had only DDE consistently detected in the sediments. For PCDD/F, the congener 2,3,7,8-TCDD and the Total TCDD were selected because previous data analysis identified the ratio of these two compounds as important end members in tracing Lower Passaic River solids throughout the Hudson-Raritan Estuary. For PCB congeners and PAH compounds, the individual chemical compounds were selected based on the results of cluster analysis for the Dundee Dam, Lower Passaic River, and Newark Bay datasets (refer to Section 4.6.3 “Identifying Unique Contaminants in Dundee Dam and the Lower Passaic River”).

Table 4-20: Unique Contaminants Considered for the Model

Analyte	Dundee Dam Concentrations
Metals	Mercury
	Lead
	Cadmium
Pesticides	Trans-Chlordane
	DDE
PCDD/F	2,3,7,8-TCDD
	Total TCDD

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PCB Congeners	BZ 31
	BZ 52
	BZ 61+66+70+74+76
	BZ 83+99
	BZ 90+101+113
	BZ 93+95+98+100+102
	BZ 110+111+115
	BZ 129+138+158+160+163+164
	BZ 139+140+147+149
	BZ 170
	BZ 180+193
PAH Compounds	Benz[a]anthracene
	Benzo[a]pyrene
	Chrysene
	Fluoranthene
	Indeno[1,2,3-cd]pyrene
	Pyrene

This list of 24 unique chemicals was then further evaluated to ensure that the independence assumption for the EMBM was satisfied and that the sources are not over-represented with a particular class of chemical. A final cluster analysis was conducted to ensure that only independent parameters were selected for model simulation. About seven clusters were identified from the cluster analysis (Figure 4-33). Based on these clusters, the following chemicals were selected as independent parameters: mercury, DDE, BZ 180+193, 2,3,7,8-TCDD, lead, benzo[a]pyrene, and fluoranthene. Total TCDD was added to the list because of its importance as a PCDD/F end member for the Hudson-Raritan Estuary, and BZ 52 was added because it was used throughout this analysis as a normalizing parameter. The final list of nine parameters that were used in the empirical mass balance model is provided in Table 4-21.

Table 4-21: Independent Parameters Used in the Receptor Model

Chemical Class	Chemical Name
Metals	Lead
	Mercury
PCDD/F	2,3,7,8-TCDD
	Total TCDD
Pesticides	DDE
PAH	Benzo[a]pyrene
	Fluoranthene
PCB Congeners and Co-Elutions	BZ 52
	BZ 180+193

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5.0 MODEL FORMULATION

The following section provides an in-depth discussion on the EMBM. This discussion builds on the principles and assumptions presented in Section 2.3.2 "Modeling Current Conditions on the River" and on Equations 2-1 and 2-2.

5.1 RECEPTOR MODELING BACKGROUND AND MODEL SELECTION

An important component of a chemical mass balance analysis is determining the relative significance of each contaminant source, which is typically modeled using either "source oriented" models or "receptor" models at contaminated sediment sites. "Source oriented" models include mathematical simulations of hydrodynamics, sediment transport, and chemical fate and transport processes [*e.g.*, Environmental Fluid Dynamics Code (EFDC)]. These models begin at the sources and estimate concentrations at the receptor. Conversely, "receptor" models are empirically based, and they focus on the behavior at the receptor site by inferring contributions from different sources from multivariate measurements taken at the receptor site. Consequently, receptor models are inferential rather than predictive of source contributions.

Receptor models have been widely used in the field of air pollution [*e.g.*, USEPA Chemical Mass Balance (CMB) Model (Watson *et al*., 2004)] as tools for identification of pollutant sources and evaluation of their relative contributions. Recently, receptor models have also been applied to sediment contamination sites that are contaminated with PCB, PCDD/F, and PAH compounds. Examples of these sediment contamination sites include: Fox River in Wisconsin (Su *et al*., 2000), San Francisco Bay in California (Johnson *et al*., 2000), Ashtabula River in Ohio (Imamoglu *et al*., 2002), Lake Calumet in Chicago (Bzdusek *et al*., 2004), and Tokyo Bay and Lake Shinji in Japan (Ogura *et al*., 2005). The objectives of the receptor model are to determine the number of end members or sources contributing to the system, the chemical composition of each source, and the relative contribution of each end member at the receptor site.

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In the mass balance context, there are two classes of solutions in receptor modeling problems, depending on whether the sources are known or unknown. When the source profiles are *unknown*, multivariate statistical techniques are used [*e.g.*, polytopic vector analysis (Johnson *et al*., 2000)]. These techniques are equivalent to a non-negative constrained factor analysis, which use the environmental data collected at the receptor site and express them as a linear sum of products of the profiles of potential sources and their contributions.[17] The model employs oblique rotations to obtain non-negative[18] elements in the factor loading matrix (representing source profiles) and the score matrix (representing source contributions). These techniques have been described in detail by Johnson *et al*. (2001).

In the case where the source compositions are *known*, the non-negative constrained chemical mass balance approach is used, which is similar to the application in air pollution modeling. This approach estimates source contributions to environmental pollution by comparing the profiles of known sources with those profiles from a receptor sample. A non-negative constrained chemical mass balance model is applied so that source contributions could be obtained without negative values. One significant problem associated with the application of these models to environmental data is that the source profiles have considerable variability and uncertainty. In the USEPA CMB model, the uncertainty and variability in both source profiles and receptor are used as weights in the mass balance formulation, yielding a solution called the effective variance weighted least-squares solution. However, this solution requires the hypothesis of normal distributions to represent the variability and uncertainty. Because environmental data usually display non-normal distributions (*e.g.*, log-normal), a recent application of the

[17] Factor analysis is a statistical technique used to examine the interrelations among a set of variables, or items, to identify an underlying structure to those items. It reduces large data sets to the smallest number of factors required to explain the pattern of relationships in the data.

[18] The term "non-negative" refers to the constraint in receptor modeling that each source can only add to the mixture of contaminants observed in the environment. It is not physically possible for a source to "subtract" from the environmental mixture, hence the non-negative requirement.

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USEPA CMB model has been combined with Monte Carlo techniques,[19] which accepts any type of distribution and even re-sampling from the observed data (Ogura *et al*., 2005).

The receptor modeling approach is the logical methodology to construct the mass balance for the Lower Passaic River. Because the objective of the mass balance was to express the observed patterns in the Lower Passaic River in relation to external and internal inputs to the river, the sources were selected as the input waters to the river as well as resuspension of historical contaminant inventory in the river. With the known sources, the non-negative chemical mass balance modeling approach was the best method to combine the historical and current data for the major classes of contaminants to construct the mass balance. Uncertainties in source and receptor compositions were accounted for through scenario analyses and Monte Carlo simulations.

5.2 MODEL FORMULATION

5.2.1 OBJECTIVE FUNCTION AND CONSTRAINTS

The receptor model was formulated following the principles described in Section 2.3.2 "Modeling Current Conditions on the River" and using Equations 2-1 and Equation 2-2. To reiterate, the model assumes that the total contaminant mass present in the sediments of the receptor (*i.e.*, Lower Passaic River) is the sum of the mass contributions from the individual sources. For a fixed number of sources (p), the receptor observation of the ith chemical (Table 4-21) is modeled as a linear combination of sources' chemical species as presented in Equation 2-2. The linear equations generated from Equation 2-2 were solved simultaneously using a least square solution to determine the fraction of the contaminant burden (*i.e.*, the contaminant flux) contributed by each source to the Lower

[19] Monte Carlo is an analytical technique where a large number of simulations are run using random quantities for uncertain variables and looking at the distribution of results to infer which values are most likely. In this Monte Carlo simulation, the concentrations of chemicals in the sources and receptor are generated randomly from defined distributions and the mass balance calculation is repeated many times with different randomly determined data to allow statistical conclusions to be drawn.

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Passaic River. This solution was achieved by establishing an objective function (Equation 5-1):

$$\chi^2 = \sum_{i=1}^{n} \left[\frac{1}{\sigma_i} \left(Y_i - \sum_{j=1}^{p} f_j X_{ij} \right) \right]^2 \qquad \text{Equation 5-1}$$

Where:

χ^2:	weighted sum of squares differences between predicted and observed receptor concentrations
Y_i:	concentration in Lower Passaic River surface sediment for the ith chemical
f_j:	fraction of solids contribution of each source to the Lower Passaic River
X_{ij}:	i^{th} chemical concentration from the jth source
p:	number of sources
n:	number of chemical species (assuming that $n > p$)
σ_i:	uncertainty and spatial variability in Y_i. (σ_i was replaced by Y_i).

The objective function (Equation 5-1) was limited by the following constraints:

- Total solids fraction (f_j) equals unity.
- Non-negativity constraint is applied to ensure that a source cannot have negative contribution: $f_j > 0$.
- A watershed delivery constraint is applied to avoid solids contribution results from the least square equation that are unrealistic with regard to the delivery capacity of the sources. These constraints were written for the tributaries (Saddle River, Second River, and Third River) and CSO/SWOs as limiting linear functions of contribution from the Upper Passaic River using a tolerance of ±50 percent of the watershed area ratios according to Equation 5-2. (Watershed areas are described in Section 5.2.2 "Solids and Watershed Areas."):

$$0.15 \le \frac{S_{Tributaries}}{S_{Upper\ Passaic\ River}} \ge 0.05 \qquad \text{Equation 5-2a}$$

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$$0.11 \leq \frac{S_{CSO/SWO}}{S_{Upper\ Passaic\ River}} \geq 0.02 \qquad \text{Equation 5-2b}$$

Where

$S_{Tributaries}$: solids load from the tributaries

$S_{CSO/SWO}$: solids load from CSO/SWOs

$S_{Upper\ Passaic\ River}$: solids load from the Upper Passaic River

The empirical mass balance calculations were performed using the Solver™ function in Microsoft Excel® (a tool typically used for solving optimization problems) using the model formulation described above and the average source and receptor concentrations provided in Section 4.0 "Data Evaluation." Several scenarios representing the different source profiles for resuspension and Newark Bay were simulated in the deterministic mode without consideration of source and receptor concentration uncertainties or spatial distribution. (For these scenarios, resuspension of historical inventory is described by average decadal concentrations or the LWA concentration. Since these average concentrations represent an averaging or an integration of several sediment samples, they are called "integrated sediments.") The solutions obtained for these scenarios were assessed using model performance criterion (described below) and the best scenarios were further explored using Monte Carlo simulations (5,000 iterations) conducted using Crystal Ball Pro for Windows 2007 (Decisioneering, Denver, CO, USA).

Based on the available data for the chemical species concentrations for the receptor and sources, the coefficients of variation[20] (CV) are less than 1.0, and except for the CSO/SWO source and Lower Passaic River integrated sediments, the CV was mostly less than 0.5 (refer to Appendices A through F for statistics). Therefore, normal distributions can be used to describe most of the data. In the Monte Carlo simulations, the calculations

[20] The CV is the standard deviation divided by the mean and is the simplest and least rigorous test of normality. If CV exceeds 0.5 and/or 1.0 there is strong evidence that the data are not normally distributed.

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were conducted assuming the chemical species concentrations were normally distributed. This assumption was implemented in Crystal Ball Pro by selecting the appropriate distribution and inputting the mean, standard deviation, maximum concentration, and minimum concentrations for each chemical species for each source and the receptor. The calculations were repeated assuming log-normal distributions, but since the relative solids contributions obtained from this assumption did not differ from the normality assumption, only the results from the normal distribution assumption are presented.

5.2.2 SOLIDS AND WATERSHED AREAS

The solids load and watershed area for each source to the Lower Passaic River were combined to form a watershed constraint to the objective function (Equation 5-2). The estimated solids load and watershed area for each source are summarized in Table 5-1 and discussed below. Note that the mass balance is not contingent on the magnitude of the solids load or watershed area but only on the relative proportion of each source to each other. Moreover, the watershed constraint in Equation 5-2 is designed to allow the relative proportion of each source to vary by ±50 percent.

Table 5-1: Estimated Solids Load and Watershed Area to the Lower Passaic River

Source to the Lower Passaic River	Solids Load [a] (cubic yards/year)	Watershed Area (square miles)
Dundee Dam	73,000	810
Saddle River	4,100	60
Third River	850	13
Second River	990	15
CSO/SWOs (ungauged)	2,800	43

a: Solids loads differ from the values reported in the CSM because adjustments were made here to consider the additional watershed area between the USGS gauging station and the confluence with the Lower Passaic River.
Values were rounded to two significant figures.

Saddle River is a major tributary of the Lower Passaic River with its confluence located at RM15.6. The Saddle River originates in New York and then flows south through the New Jersey municipalities of Lodi, Garfield, and Wallington. Lowe *et al*. (2005) estimated that the solids load on Saddle River at Lodi, New Jersey (USGS gauging station 01391500) was approximately 3,700 cubic yards. Since this gauging station only accounts for 90 percent of the Saddle River watershed, the solids load was adjusted for

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the additional watershed area (5.8 square miles) between Lodi, New Jersey and the Lower Passaic River, yielding a solids load of 4,100 cubic yards (USGS, 2007).

Third River is another major tributary of the Lower Passaic River with its confluence located at RM11.3. The Third River extends through the New Jersey municipalities of Nutley and Clifton. Since no active USGS gauging stations exist on Third River, the solids load was estimated assuming that the solids yield on Third River was similar to the solids yield on Saddle River (68 cubic yards of solids per square mile per year). The Third River watershed of 13 square miles was obtained from the NJDEP HUC watershed, yielding a solids load of 850 cubic yards.

Second River is a major tributary of the Lower Passaic River with its confluence located at RM8.1. The Second River flows through the New Jersey municipalities of Newark, Bloomfield, and Belleville. Like Third River, no active USGS gauging station is located on Second River; hence, the solids load for Second River was estimated considering the solids yield on Saddle River and the HUC watershed area of 15 square miles. This estimation yielded a solids load of 990 cubic yards.

Dundee Dam is located at RM17.4 between Garfield and Clifton, New Jersey and represents the upper boundary of the Lower Passaic River. The Dundee Dam, which was built in 1845, is the effective upriver limit of the tide for the Lower Passaic River under all known conditions. Consequently, the Upper Passaic River watershed (approximately 810 square miles) represents a point source with solids and freshwater crossing over the dam into the Study Area. Lowe *et al*. (2005) estimated that the solids load on the Upper Passaic River at Little Falls, New Jersey (USGS gauging station 01389500) was approximately 69,000 cubic yards. Since this gauging station only accounts for 95 percent of the Upper Passaic River watershed, the solids load was adjusted for the additional watershed area (43 square miles) between Little Falls and Dundee Dam, yielding a solids load of 73,000 cubic yards at the dam (USGS, 2007). Hence, for the watershed constraint (Equation 5-2a), the watershed areas from the three tributaries are

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approximately 10 percent of the Upper Passaic River watershed (similar but slightly lower results were calculated using the solids loads).

CSO/SWOs and the associated sewage infrastructure located in the Study Area are common in old, urban cities where surface waters are directed and released (untreated) to local rivers as a form of disposal. On the Lower Passaic River, active CSO/SWOs are located between RM1 and RM8 (Malcolm Pirnie, Inc., 2005). However, since data were not available to calculate the solids load from these sources, it was assumed that the CSO/SWO drainage area represented the remaining ungauged area for the Lower Passaic River watershed. In addition, it was assumed that the CSO/SWO solids yield was similar to the Saddle River (68 cubic yards of solids per square mile per year). The total Lower Passaic River watershed is 935 square miles; the Upper Passaic River and tributaries account for 95 percent of this watershed, yielding 43 square miles in the ungauged area or 2,800 cubic yards of solids. This estimation is reasonable since Lowe *et al*. (2005) estimated that the solids load from CSO/SWOs to Newark Bay was 5,000 cubic yards/year, and approximately half of these solids originated from the Lower Passaic River.

Hence, for the watershed constraint (Equation 5-2b), the CSO/SWO watershed is approximately 5 percent of the Upper Passaic River watershed (similar results were calculated using the solids loads). The upper limit of this watershed constraint was adjusted to 11 percent to account for the fact that the CSO/SWO watershed area is ungauged. This adjustment is based on the assumption that an additional area (approximately 2 percent) exists between the USGS gauging stations on the tributaries and the point where these tributaries discharge to the Lower Passaic River. This additional area could be attributed to the CSO/SWO watershed because these areas are highly developed.

5.2.3 DESCRIPTION OF SOURCES AND RECEPTOR

The sources and receptor used in the EMBM were described in Figure 3-1 and characterized in Section 4.0 “Data Evaluation.” For completeness, a brief description of

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each source and the receptor are provided here. Resuspension of Lower Passaic River integrated sediments was represented by average decadal concentrations (Table 4-4) or LWA concentrations (Table 4-5). Newark Bay was characterized into a northern and southern region (Table 4-11). The southern concentrations were used in all scenarios to represent Newark Bay; however, a scenario was completed considering the average concentration in the northern region as part of the sensitivity analysis. The Upper Passaic River was characterized by one beryllium-7 bearing surface sediment sample collected at RM18.3 (Table 4-13). Tributary concentrations were summarized into one watershed-average to reduce the effect of multi-collinearity (*i.e.*, correlated source patterns) on the solution (Table 4-18). The CSO/SWO solids were also combined into one source for similar reasons (Table 4-19). The Lower Passaic River surface sediments are the receptor in the model and are summarized in Table 4-7.

5.3 MODEL SCENARIOS AND EVALUATION

5.3.1 SCENARIOS AND PERFORMANCE MODEL TARGET

The performance of the model under the various scenarios was first evaluated by the fraction of mass explained by the model for each chemical species (Equation 5-3). A value approaching 100 percent is desirable. However, a criterion of 100 ±20 percent was used to assess the various scenarios representing the Lower Passaic River integrated sediment source (Figure 5-1).

$$Ratio_{m/m} = \frac{M_{Model}}{M_{Measured}} \qquad \text{Equation 5-3}$$

Where

$Ratio_{m/m}$: fraction of mass for each chemical accounted for in the mass balance

M_{model}: chemical-specific mass estimated by the model

$M_{Measured}$: chemical-specific mass measured in the Lower Passaic River

For the various modeling scenarios, the output generated a $Ratio_{m/m}$ results (Figure 5-1) and source contribution (Figure 5-2). These results were obtained from deterministic

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analyses based on average concentrations of source profiles using Solver™. The results of the modeling scenarios are summarized below. Note that except for the LWA scenario, the label for each scenario describes the time horizon within the sediment bed used by the model as the source of resuspended sediment. Thus the 1960 scenario uses sediment properties characteristic of the 1960s to represent the nature of the resuspended material in the scenario. This is equivalent to the resuspension process eroding sediments exclusively from an exposed layer of sediment from that time period.

- LWA Scenario: The $Ratio_{m/m}$ of all contaminants was within the model performance target (100 ±20 percent), except for BZ 52 with a $Ratio_{m/m}$ of 124 percent. The resuspension contribution to the total solids was ranged from 10 to 15 percent (Figure 5-1a, Figure 5-2a).
- 1940 Scenario: The $Ratio_{m/m}$ for almost all the chemicals was outside the model performance target; hence, the scenario was eliminated from further consideration (Figure 5-1a).
- 1950 Scenario: Except for BZ 180+193, the $Ratio_{m/m}$ was within the model performance target for other chemicals. Similar to the LWA scenario, resuspension contribution to the solids fraction was estimated between 10 and 15 percent (Figure 5-1a).
- 1960 Scenario: The $Ratio_{m/m}$ for DDE (69 percent) and BZ 180+193 (129 percent) were outside the model performance target; hence, the scenario was eliminated from further consideration (Figure 5-1a).
- 1970 Scenario: Total TCDD (76 percent) and BZ 180+193 (133 percent) were outside the model performance target. However, the resuspension contribution to total solids was consistent with the 1950s and LWA scenarios (Figure 5-1b).
- 1980 Scenario: DDE (121 percent), 2,3,7,8-TCDD (49 percent), Total TCDD (56 percent), and BZ 52 (123 percent) were outside the model performance target; hence, the scenario was eliminated from further consideration (Figure 5-1b).
- 1990 Scenario: This scenario, which corresponds to a 30 inch mixing layer, met the model performance target of all chemicals except for 2,3,7,8-TCDD (80 percent).

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This scenario resulted in the highest resuspension contribution at more than 95 percent of the total solids (Figure 5-1b and Figure 5-2b).

- 2000 Scenario: Except for BZ 180+190, the $Ratio_{m/m}$ was within the model performance target for other chemicals. The resuspension contribution to the total solids was over 90 percent of the total solids contributed. These results are consistent with the observation that average Lower Passaic River surface sediments deposited in 2000 are similar to the surface sediments specified in the receptor. Therefore, the simple resuspension of these sediments would be enough to explain the receptor averages (Figure 5-1b).

5.3.2 RESUSPENSION EVALUATION

The modeling effort yielded two unique solutions for the Lower Passaic River (Figure 5-2). The first solution suggests that resuspended solids account for approximately 10 percent of the total solids present in the Lower Passaic River surface sediment (Figure 5-2a). The second solution suggests that resuspended solids account for more than 95 percent of the total solids (Figure 5-2b). Both solutions could be valid and balance the sources and receptors; however, they present different conceptualizations of the solids transport in the Lower Passaic River. Yet, in each solution, solids from external sources cannot balance the chemical concentrations measured in the Lower Passaic River. Resuspended solids *must* contribute a fraction of the total solids.

The first solution to the model uses the LWA concentrations to characterize the resuspension of historical inventory. Conceptually, the application of this LWA value represents the integration of the entire historical inventory from 1950 to 2005, which would resemble the erosion of a sediment bed that caused solids from various time horizons to resuspend, mix, and deposit. Following this scenario, resuspended solids account for approximately 10 percent of the total solids deposited in the Lower Passaic River while Newark Bay solids plus Upper Passaic River solids account for approximately 80 percent of the solids, and tributaries and CSO/SWOs account for the remaining 10 percent (Table 5-2).

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Table 5-2: Solids Contribution to the Lower Passaic River Surface Sediment using LWA Concentration to Represent Resuspended Solids

Source	Solids Contribution as Percent
Resuspended Solids (represented by LWA)	≈ 10
Upper Passaic River	≈ 40
Newark Bay	≈ 40
Tributaries	≈ 5
CSO/SWOs	≈ 5

The second solution to the model uses the average decadal concentration from 1990 to characterize the resuspended sediments. Since the 1990 time horizon is located relatively close to the surface, the application of average 1990 concentrations in the model conceptually represents the resuspension of the top layers of the surface sediments in a "mixed layer" conceptualization. This mixed layer may correspond to a thickness of approximately 30 inches (using the half life values calculated in Section 7.3.1 "MNR Process Occurring in the Lower Passaic River"). Consequently, in this scenario resuspended solids account for more than 95 percent of the total solids deposited in the Lower Passaic River, or the solids in the surface sediment are comprised of a 33:1 ratio of resuspended solids to external source solids.

Since both scenarios provide mathematically plausible solutions to the model, they likely are both occurring to some degree in the Lower Passaic River in that the river is likely eroding sediment beds across all time horizons and surface sediments are likely mixing. Mathematically, it is important to note that the LWA scenario includes the 1990s solution whereas the 1990s scenario excludes the LWA solution. Moreover, while the 1990s solution provides the best fit to the model, the LWA solution follows the CSM closer. Consequently, in accordance with the CSM and to be conservative in estimating the extent of resuspension occurring, the LWA concentrations and the solids contributions listed in Table 5-2 were used to calculate the chemical-specific contaminant burdens associated with resuspension (Table 5-3). Moreover, this solution provides a tighter constraint on the external sources to the Lower Passaic River. Well-constrained external sources are an important input to the remedial scenario calculations where resuspension is greatly reduced.

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Table 5-3: Contaminant Burden Attributed to Resuspension

Analyte	Percent of Contaminant Burden in Recently Deposited Sediments Attributed to Resuspension
Mercury	≈ 45
Lead	≈ 25
DDE	≈ 50
2,3,7,8-TCDD	≈ 95
Total TCDD	≈ 90
BZ 52	≈ 70
BZ 180+193	≈ 45
Benzo[a]pyrene	≈ 10
Fluoranthene	≈ 15

5.4 MODELING SENSITIVITY TESTS

The original modeling results indicated that the Upper Passaic River and Newark Bay each contributed approximately 40 percent of the solids to the Lower Passaic River (Figure 5-2a and Table 5-3) when using the LWA concentration to represent the integrated sediment source. An analysis was then conducted to assess the sensitivity of this solids contribution using the average northern samples of Newark Bay opposed to the average southern samples (Figure 5-3 and Table 4-11). For this test, the estimated resuspension contribution ranged from 10 to 15 percent, which was consistent with the original results. Note that the Bay contribution did increase slightly relative to the Upper Passaic River contribution because the average northern concentrations were greater than the average southern concentrations (Figure 5-3).

Monte Carlo simulation was used to examine the range of solids contributions, based on 5,000 iterations and using the LWA concentration as the source signature for the Lower Passaic River integrated sediment source. The results from the assumption of normal distribution were similar to those obtained from the log-normal simulation. The average percent solids contribution from the simulation results are consistent with the results obtained from Solver™ based on the average LWA concentrations. In general, the resuspension varies from 5 to 15 percent, and the contribution from Upper Passaic River is similar to that from Newark Bay (Figure 5-4).

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5.5 LIMITATIONS OF THE EMPIRICAL MASS BALANCE TO MODEL NEWARK BAY

Receptor models are inferential in nature, implying that they infer the contributions from different sources from multivariate measurements collected at the receptor site. Because the models infer, rather than predict, they cannot be used directly to predict future changes in the system under certain conditions. While the model indicates that a fraction of the Lower Passaic River bottom sediments is composed of Newark Bay sediments, the model cannot predict how the Newark Bay contribution will change after remediation. For example, raising the river bottom elevation (in a containment scenario) will likely decrease sedimentation rates, increase erosion, and result in less contribution from Newark Bay. Alternatively, deepening the Lower Passaic River (in a dredging scenario) will likely increase sedimentation rates and the contribution of Newark Bay solids.

Because of the empirical nature of the model, COPC concentrations were *not* forecasted for the dredging alternatives based on the EMBM alone. Moreover, in the forecasts presented in Section 7.0 "Forecasting COPC Concentrations," the Newark Bay solids contribution was assumed to remain the same over time. However, for most of the COPCs examined, the Newark Bay contribution is not significant, so for any scenario involving a deepening of the Lower Passaic River channel, the forecast trajectories are not likely to be a major underestimation of the remedial action impacts (*i.e.*, The forecasted improvements in surface concentrations by remedial actions are probably upper bounds on the actual improvement in surface concentrations.).

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6.0 MODEL RESULTS

The modeling results present in Section 5.0 "Model Formulation" allow a further discussion of the fate and transport of contaminants in the Lower Passaic River, which build on the data and hypotheses originally presented in the *Draft Geochemical Evaluation (Step 2)* (Malcolm Pirnie, Inc., 2006a) and the CSM (Malcolm Pirnie, Inc., 2007a). The fate and transport discussions are based on the EMBM outputs showing the distribution of the contaminant flux among the sources and a comparison of average contaminant concentrations used to characterize each source (Section 4.0 "Data Evaluation"). Note that this section is divided into two sub-sections (1) fate and transport of contaminants examined in the EMBM and (2) inferred fate and transport of additional COPCs.

For these fate and transport scenarios, the resuspension of historical inventory is represented by the LWA concentration of the sediment core and is referred to as the Lower Passaic River integrated sediment source. This assumption provides a conservative (*i.e.*, minimum) estimate of the contaminant flux associated with resuspension of historical inventory.

6.1 FATE AND TRANSPORT MODEL FOR PARAMETERS

6.1.1 2,3,7,8-TCDD AND TOTAL TCDD MASS BALANCES

While the source of the Lower Passaic River 2,3,7,8-TCDD contamination has not been quantitatively identified, the primary candidate is the upland area at RM3.2 and the associated chemical manufacturing facility and Superfund sites (USEPA, 2007). It is unlikely that the source of 2,3,7,8-TCDD contamination to the Lower Passaic River originates above the Dundee Dam since the historical levels of 2,3,7,8-TCDD above the dam were approximately 40 times lower than those concentrations reported in the Lower Passaic River (Malcolm Pirnie, Inc, 2006a and Bopp *et al*., 1998).

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Similar results were reported with the EMBM and the accompanying data evaluation (Figure 6-1). The upper panel of Figure 6-1 presents the mean and range of the 2,3,7,8-TCDD concentration for each source, and the dotted line represents the measured 2,3,7,8-TCDD concentration in source sediments of the Lower Passaic River. The first striking feature is that external sources alone (Upper Passaic River, the tributaries, the CSO/SWOs, and Newark Bay) cannot explain the measured 2,3,7,8-TCDD concentration in the river. Note that the 2,3,7,8-TCDD concentrations from these external source are approximately two orders of magnitude less than the measured concentration in the surface sediments. Consequently, another source is necessary to achieve a chemical mass balance. Assuming that all the external sources have been accounted for in the model, the only other source is resuspension of historical inventory. Unlike the external source, the Lower Passaic River integrated sediment source has a 2,3,7,8-TCDD concentration that is approximately an order of magnitude greater than the river's surface sediment concentration. In this chemical mass balance, the integrated sediment source accounts for more than 95 percent of the 2,3,7,8-TCDD mass while external sources account for the remaining mass.

Similar results were reported for Total TCDD (Figure 6-2). However, for Total TCDD, the relative difference between the measured concentration in the river and the concentrations in the external sources is less than the corresponding difference observed for 2,3,7,8-TCDD. While the range of Total TCDD concentrations reported for CSO/SWOs overlaps with the measured Total TCDD in surface sediments, the solids load from the CSO/SWO source cannot account for the Total TCDD mass in the river. Consequently, the resuspension of historical inventory is necessary to achieve a chemical mass balance. While external sources account for 5 percent of the Total TCDD mass balance, the Lower Passaic River integrated sediment source accounts for more than 90 percent of the mass.

For both 2,3,7,8-TCDD and Total TCDD, the Newark Bay contribution to the Lower Passaic River contaminant burden is less than 5 percent. Moreover, the concentrations of these contaminants in the river surface sediments are greater than the reported

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concentrations observed in the Bay. These results infer that the Lower Passaic River is a source of contamination to the Bay, and they concur with the Newark Bay mass balance presented in the *Draft Geochemical Evaluation (Step 2)* (Malcolm Pirnie, Inc., 2006a) and the CSM (Malcolm Pirnie, Inc., 2007a). The Newark Bay mass balance estimated that the Lower Passaic River comprises approximately 10 percent of the total amount of solids accumulating in the Newark Bay and more than 80 percent of the 2,3,7,8-TCDD accumulating in the bay.

6.1.2 TOTAL PCB MASS BALANCE

The fate and transport of Total PCB in the Lower Passaic River represents the integration of the fate and transport of the individual PCB congeners that comprise the Total PCB concentration. Unlike 2,3,7,8-TCDD and Total TCDD, which exhibited similar fate and transport scenarios, the PCB congeners showed a sliding scale with the lighter PCB congeners more influenced by resuspension of historical inventory and the heavier PCB congeners impacted by solids originated from the Upper Passaic River. To illustrate this phenomenon, the two extremes are presented in Figure 6-3 with BZ 52 and Figure 6-4 with BZ 180+193.

The chemical mass balance for BZ 52 and the lighter PCB congeners is similar to the Total TCDD mass balance, where the external sources and the solids load cannot account for the measured PCB concentration in the river. Consequently, the Lower Passaic River integrated sediment source is necessary to achieve a chemical mass balance and accounts for about 70 percent of the mass (Figure 6-3). Alternatively, the concentration of BZ 180+193 in the external sources approaches the measured BZ 180+193 concentration in the river within a factor of two. However, to balance the solids and the chemical concentrations simultaneously, the mass balance requires some contribution from the Lower Passaic River integrated sediment source, but unlike the 2,3,7,8-TCDD mass balance and the BZ 52 mass balance, the Upper Passaic River source is comparable to the resuspension of historical inventory. In the BZ 180+193 mass balance, the Upper Passaic River and the integrated sediment source each contribute approximately 40 percent of the contaminant burden to the river (Figure 6-4).

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The fate and transport of Total PCB is then influenced by both resuspension of historical inventory and the Upper Passaic River source. As discussed in Section 7.0 "Forecasting COPC Concentrations" and the data presented in Table 7-7, Total PCB is more likely to be influenced by the fate and transport of the heavier PCB congeners than the lighter PCB congeners. Consequently, the Upper Passaic River and resuspension of historical inventory are both likely contributing to the Total PCB contaminant burden on the river. These results are consistent with the data presented in the *Draft Geochemical Evaluation (Step 2)* (Malcolm Pirnie, Inc., 2006a) and the CSM (Malcolm Pirnie, Inc., 2007a), which estimated that the Upper Passaic River was contributing approximately one-third of the PCB load to the Lower Passaic River.

Among the external BZ 180+193 sources, the concentration of BZ180+193 in Newark Bay is the lowest and contributes approximately 10 percent of the contaminant burden in the river. These results, compounded with the Total PCB concentration gradients observed in Newark Bay, suggest that the Lower Passaic River is likely impacting the Bay more than the Bay is impacting the river with respect to PCBs. As noted in Section 4.5.1 "Newark Bay Conceptual Site Model," the Total PCB contaminant load from the Lower Passaic River along with other sources from the port channels and the Arthur Kill are likely impacting the Bay (Figure 4-16c).

6.1.3 PAH MASS BALANCE

Like Total PCB, the fate and transport of Total PAH is dependent on the fate and transport of the individual PAH compounds. Unlike the PCB congeners the suite of PAH compounds exhibit the same general trends and are strongly impacted by the Upper Passaic River source. In the model, benzo[a]pyrene (Figure 6-5) and fluoranthene (Figure 6-6) represented the PAH chemical class. For both of these compounds, the average PAH concentration in the Upper Passaic River, the tributaries, and the CSO/SWOs were comparable to the measured PAH concentration in the Lower Passaic River. Moreover, unlike the PCB congeners and 2,3,7,8-TCDD, the PAH concentrations in the river's surface sediments were comparable to the integrated sediment source

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concentrations. These results are consistent with the dated sediment core PAH profiles (Figure 4-3o and Figure 4-3w) and the average decadal concentrations (Table 4-4), which indicate that the PAH contaminant load to the river has been relatively constant over the past 50 years. Thus, the PAH concentration in deeper, older sediments is comparable to shallower, recent sediment deposits.

Because the PAH concentration in the sources are similar and so much of the solids originate above the Dundee Dam, the external solids loads strongly influence the mass balance. The relatively large solids load from the Upper Passaic River, compounded with PAH concentrations that are greater than the measured river surface sediments, results in the Upper Passaic River contributing more than half of the contaminant load to the Lower Passaic River. Meanwhile, the resuspension of historical inventory accounts for 10 to 15 percent of the PAH contaminant burden, which is one of the smallest contributions observed during this modeling exercise.

Since the individual PAH compounds exhibit similar trends, Total PAH is also heavily impacted by the Upper Passaic River. Moreover, as presented in Figures 6-5 and 6-6, it is likely that the Lower Passaic River is a source of Total PAH to Newark Bay. This hypothesis is supported by the Total PAH concentration gradients presented for Newark Bay (Figure 4-16d), which shows a strong gradient from north to south, starting at the mouth of the Lower Passaic River.

6.1.4 DDE MASS BALANCE

The fate and transport of DDE appears similar to the PAH scenario wherein the DDE concentration from the external sources are comparable to the measured DDE concentration in the Lower Passaic River surface sediment; however, three conditions distinguish the DDE fate and transport from the PAH fate and transport:

- The DDE concentration in the Upper Passaic River is roughly half the measured concentration in the Lower Passaic River. This situation is different from the PAH

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scenario where the Upper Passaic River concentrations were greater than the Lower Passaic River.

- The DDE concentrations in Newark Bay are less than the Lower Passaic River but equal to the DDE concentration from the Upper Passaic River. This situation is different from the PAH scenario where the Newark Bay concentrations were an order of magnitude lower.
- The DDE concentration from the integrated sediment source is a factor of four greater than the concentration in the Lower Passaic River surface sediment, which is consistent with the historical production and contaminant loading of DDE to the Lower Passaic River (Figure 4-3y; Malcolm Pirnie, Inc., 2006a). This scenario is different from the PAH scenario where concentrations and contaminant loads have been relatively constant over the last 50 years.

These conditions require the Newark Bay source and the integrated sediment source to contribute more of the DDE contaminant burden to the Lower Passaic River relative to the PAH budget. Nonetheless, the Upper Passaic and the integrated sediment source still account for 75 percent of the DDE contaminant burden in the river (Figure 6-7).

6.1.5 MERCURY AND LEAD MASS BALANCES

Conditions that describe the DDE mass balance also impact the fate and transport of mercury and lead in the Lower Passaic River. Again, the Upper Passaic River and Newark Bay concentrations are relatively comparable to the Lower Passaic River but are not sufficient to achieve a mass balance. A significant contribution is needed from the integrated sediment source to raise the external solids concentrations to those observed in the recently deposited sediments of the Lower Passaic River. As a result, the chemical mass balance for mercury is similar to the DDE mass balance, where resuspension of historical inventory accounts for 50 percent of the contaminant burden and Newark Bay accounts for 25 percent of the burden (Figure 6-8). This is the largest contribution by Newark Bay to any of the contaminant mass balances examined. The potential importance of Newark Bay on the Lower Passaic River is suggested by the plot of mercury concentrations in the Bay (Figure 4-16f), which shows a strong concentration

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gradient from the middle of the Bay near Port Newark to the mouth of the Lower Passaic River.

Unlike the DDE and mercury mass balance, the lead concentrations from the CSO/SWO source were significantly greater than the measured concentrations in the Lower Passaic River. Unlike the other contaminants, the contribution from the CSO/SWO source for lead was substantial, resulting in roughly equal contaminant contributions from the five sources, approximately 20 percent each (Figure 6-9). Among the chemicals examined, the largest CSO/SWO contribution occurs in the lead mass balance. Note that the observed concentration gradient observed for mercury from the port channels to the mouth of the Lower Passaic River was not present in the lead concentration plot (Figure 4-16e).

6.2 INFERRED FATE AND TRANSPORT MODEL FOR COPCS

As discussed in Section 4.0 "Data Evaluation," Malcolm Pirnie, Inc. could not examine all of the COPCs in the EMBM due to data limitations. For example, pesticides were not detected in the Newark Bay dataset, and copper was not reported in the CSO/SWO dataset. To compensate, missing concentrations were approximated from the available data, and inferred mass balances were created for trans-chlordane, dieldrin, copper, and phenanthrene.

- To estimate trans-chlordane in Newark Bay, surficial sediment samples collected in 1985 by Bopp *et al*. (1991b) were used in the mass balance with an average trans-chlordane for Newark Bay equal to 26 µg/kg in the surface sediments.
- To estimated dieldrin in Newark Bay, the ratio of dieldrin/DDE in the Lower Passaic River was applied to the Bay, yielding 2 µg/kg in the surface sediments. (Note that the reported detection limit for dieldrin in the Newark Bay dataset ranged from 13 to 150 µg/kg.)
- To estimate copper in the CSO/SWOs, the average watershed-weighted concentration for the tributaries was applied to the CSO/SWO source.

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- Phenanthrene was characterized at each source (Upper Passaic River, tributaries, CSO/SWOs, Newark Bay, and the integrated sediment source) and was used as a surrogate to represent LMW PAH.

In these four inferred mass balances, the resuspension of historical inventory is represented by the LWA concentration and the solids fraction presented in Figure 5-2a.

6.2.1 INFERRED MASS BALANCE FOR TRANS-CHLORDANE

The trans-chlordane mass balance is based on the assumption that the trans-chlordane surface sediment concentration in 2005 is similar to the surface sediment concentration in 1985 [*e.g.*, the Bopp *et al*. (1991b) dataset]. This assumption was considered appropriate based on the Total Chlordane concentration in the Lower Passaic River, which showed sediment concentrations varying by a factor of two over the past 25 years. Even with this assumption, a chemical mass balance for trans-chlordane was not achieved because trans-chlordane concentrations for all the sources (Upper Passaic River, tributaries, CSO/SWOs, Newark Bay, and the integrated sediment source) were greater than or equal to the Lower Passaic River surface sediment concentrations. An inferred mass balance suggests that resuspension accounts for approximately 10 percent of the contaminant burden and that the Upper Passaic River, CSO/SWOs, and tributaries contribute equally to the contaminant burden (Figure 6-10).

6.2.2 INFERRED MASS BALANCE FOR DIELDRIN

The dieldrin mass balance is based on the assumption that the DDE/dieldrin ratio observed in the Lower Passaic River is similar to the corresponding ratio in the Bay. Following this assumption, the inferred dieldrin mass balance suggests that resuspension of historical inventory accounts for approximately 30 percent of the contaminant burden while the Upper Passaic River and the CSO/SWOs account approximately 40 percent of the burden (Figure 6-11).

6.2.3 INFERRED MASS BALANCE FOR COPPER

The copper mass balance is based on the assumption that the copper concentration in the CSO/SWOs is similar to the tributary watershed-weighed average. This assumption

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yields a relatively equal distribution of the contaminant burden among the five sources (Figure 6-12), which was similar to the fate and transport of lead (Figure 6-9). Resuspension of historical inventory accounts for approximately one quarter of the contaminant burden.

6.2.4 INFERRED MASS BALANCE FOR PHENANTHRENE

Unlike the other inferred mass balances, data were available to characterize phenanthrene from the five sources. As discussed in Section 4.8 "Evaluating Independent Contaminants," phenanthrene was initially considered a potential modeling parameter but was excluded during the final selection process. A mass balance was then estimated based on the available data and the solids fraction presented in Figure 5-2a. As expected, the phenanthrene mass balance (Figure 6-13) resembles the mass balances of the other PAH compounds, benzo[a]pyrene (Figure 6-5) and fluoranthene (Figure 6-6) with more than 50 percent of the contaminant burden originated above Dundee Dam and resuspension of historical inventory accounting for 10 to 15 percent of the burden.

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7.0 FORECASTING COPC CONCENTRATIONS

The modeling results show a distribution of the contaminant burden from each source to the Lower Passaic River. Once the contaminant burden is determined, post-remediation surface sediment concentrations can be calculated for the various remedial alternatives, knowing that remediation will alter the contaminant burden to the river. This section describes the process to forecast post-remediation COPC concentrations in surface sediments for the following three scenarios:

- MNR.
- The placement of sand material from RM0 to RM8, which will control approximately 90 percent of the resuspension in the Lower Passaic River (*i.e.*, containment scenario).
- Remediation of the Primary Erosional Zone between RM3.5 and RM 5.1 and the Primary Inventory Zone between RM2.4 and RM3.3, which will control approximately one third of the erosional areas between RM0 and RM15.

The post-remediation concentrations are then compared to the PRG concentrations and RAOs for the Study to assist in the evaluation of alternatives. The RAOs for the Study include:

- Reduce cancer risks and non-cancer health hazards for people eating fish and shellfish from the Lower Passaic River by reducing the concentration of COPCs in fish and shellfish.
- Reduce the risks to ecological receptors[21] by reducing the concentration of COPCs in fish and shellfish.

[21] For the remainder of this section, the term "receptor" will be used in the risk assessment context, referring to human or ecological exposures, and not in the modeling context used in Sections 2 through 6 of this report.

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- Reduce levels of COPCs/COPECs in sediments in order to reduce COPC/COPEC levels in river water that are above surface water quality standards.
- Reduce the inventory (mass) of COPCs/COPECs in sediments that are or may become bioavailable.
- Remediate the most significant mass of contaminated sediments that may be mobile to prevent it from acting as a source of contaminants to the Lower Passaic River or to Newark Bay and the New York-New Jersey Harbor Estuary.

Note that the forecasted COPC concentrations are compared to PRGs for completeness of the analysis. It is not the objective of the mass balance or the forecast to evaluate or to select a remedial alternative.

7.1 OVERVIEW OF REMEDIAL SCENARIOS

Post-remediation COPC concentrations in surface sediment were be forecasted for MNR, placement of sand material from RM0 to RM8, and remediation of select target areas in the river. To better understand the implications of the forecasts, a brief overview of the remedial alternatives that were evaluated is provided below.

7.1.1 MNR RESPONSE SCENARIO

For the purposes of assessing future concentrations, the MNR and No Action responses are physically the same with the following distinction in implementation: under MNR, naturally occurring remedial processes (*e.g.*, biodegradation and sorption) are monitored and the recovery rates are quantified to determine the impact on contaminant concentration. Alternatively, under the No Action response, the contamination concentrations are monitored only to determine the rates of change over time.

MNR has been identified as a potential response for managing contaminated sediments by the USEPA. In the guidance document, *Contaminated Sediment Remediation Guidance for Hazardous Waste Sites* (USEPA, 2005), MNR relies on naturally occurring processes to contain, destroy, or reduce the bioavailability or toxicity of contaminants in sediments. The naturally occurring processes may include physical processes (such as

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sedimentation, advection, diffusion, dilution, dispersion, bioturbation, or volatilization), biological processes (such as biodegradation, biotransformation, phytoremediation, or biological stabilization), and chemical processes (such as sorption or oxidation/reduction reactions). Multiple lines of evidence are generally needed to confirm that MNR processes are occurring to a significant degree at a site. Potential lines of evidence include:

- Decreasing trend in biota contaminant concentrations.
- Long-term decreasing trend in water column concentrations.
- Sediment core data demonstrating a decreasing trend in historical surface concentrations through time.
- Long-term decreasing trend in surface sediment contaminant concentration, sediment toxicity, or contaminant mass.
- The stability of the sediment bed in areas with high subsurface contaminant inventories.

MNR processes are occurring in the Lower Passaic River to some extent. For example, scour and transport affect recovery processes in high-energy environments while sedimentation and bioturbation affect natural recovery of contaminants in moderately depositional areas. Conversely, other processes, like resuspension and redeposition of older, more contaminated sediments, slow natural recovery.

7.1.2 CONTAINMENT SCENARIO

Containment entails the physical isolation or immobilization of contaminated sediments without treatment, for example, by an engineered cap. Assuming effective placement, containment isolates contaminated sediments, which in turn limits the potential exposure and mobility of contaminants in the sediments.

Each of the active remedial alternatives proposed for the Lower Passaic River involves placement of sand material as a cover, either as backfill or an engineered cap, which will cover approximately 650 acres from RM0 to RM8 (bank-to-bank). Because the area

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between RM0 and RM8 is predominantly classified as fine-grained material [as interpreted by side-scan sonar images (Aqua Surveys, Inc., 2006)], the placement of sand material will cover approximately 90 percent of the fine-grained, surface sediments in the Lower Passaic River. Consequently, the placement of sand material will control approximately 90 percent of the resuspension of historical contaminant inventory.

7.1.3 HYPOTHETICAL REMEDIATION OF PRIMARY EROSIONAL ZONE

For comparison purposes in the risk assessments, a hypothetical scenario is being considered for the remediation of individual target areas. (Note that remediation of target areas is not a proposed alternative in the FFS. Instead, target areas are being incorporated into other alternatives.) The target areas of the river include the Primary Erosional Zone between RM3.5 and RM 5.1 and the Primary Inventory Zone between RM2.4 and RM3.3.

A hypothetical remedial scenario that addresses the Primary Erosional Zone will control a certain percentage of the erosional areas in the Lower Passaic River from RM0 to RM15. To estimate this erosional area, the following calculations were considered. Erosional areas between RM1 and RM7 were identified in the CSM (Malcolm Pirnie, Inc., 2007a) and encompass approximately 29 acres. To expand this estimation from RM0 to RM8, the percent erosional area in RM1 to RM2 was calculated and applied to RM0 to RM1. Likewise, the percent erosional area in RM6 to RM7 was calculated and applied to RM7 to RM8. This estimation yielded an erosional area of approximately 40 acres, or 6 percent of the area between RM0 to RM8. Upriver of RM8, approximately 84 acres of fine-grained material exists. Assuming that 6 percent of this area is erosional then an additional 5 acres of erosional areas are located between RM8 and RM15. Consequently, hypothetically remediating the Primary Erosional Zone, which includes 15 erosional acres, will control about one third of the erosional areas in the Lower Passaic River. Note that remediating the Primary Erosional Zone and the Primary Inventory Zone together will have similar impacts in controlling erosional areas in the Lower Passaic River since the erosional area in the Primary Inventory Zone is estimated to be less than 1 acre.

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7.2 TOXIC EQUIVALENCY (TEQ)

For each scenario described above, post-remediation surface sediment concentrations were forecasted for the COPCs listed in Table 2-1, including the PCDD/F TEQ and PCB TEQ. The TEQ methodology was applied to the sediments of the Lower Passaic River since they are contaminated with a suite of toxic chemicals, each possessing a different level of potency and risk to humans and ecological receptors. To quantify the toxicity associated with PCDD/F and PCB congeners, a weighting system was developed where each congener is assigned a toxic equivalent factor (TEF), which relates the respective congener's toxicity to 2,3,7,8-TCDD (Table 7-1). In other words, the higher the TEF is for a congener, the more toxic the congener is relative to the other congeners. Note that a TEF for a given congener may vary for different receptors since some receptors are more sensitive to a particular congener than other receptors.

Table 7-1: Unitless TEF Values for Mammal, Fish and Bird Exposure

Analyte	1998 Mammal TEF	2005 Mammal TEF	Fish TEF	Bird TEF
PCDD/F TEF Values				
2,3,7,8- TCDD	1	1	1	1
1,2,3,7,8-PeCDD	1	1	1	1
1,2,3,4,7,8-HxCDD	0.1	0.1	0.5	0.05
1,2,3,6,7,8-HxCDD	0.1	0.1	0.01	0.01
1,2,3,7,8,9-HxCDD	0.1	0.1	0.01	0.1
1,2,3,4,6,7,8-HpCDD	0.01	0.01	0.001	0.001
OCDD	0.0001	0.0003	0.0001	0.0001
2,3,7,8-TCDF	0.1	0.1	0.05	1
1,2,3,7,8-PeCDF	0.05	0.03	0.05	0.1
2,3,4,7,8-PeCDF	0.5	0.3	0.5	1
1,2,3,4,7,8-HxCDF	0.1	0.1	0.1	0.1
1,2,3,6,7,8-HxCDF	0.1	0.1	0.1	0.1
1,2,3,7,8,9-HxCDF	0.1	0.1	0.1	0.1
2,3,4,6,7,8-HxCDF	0.1	0.1	0.1	0.1
1,2,3,4,6,7,8-HpCDF	0.01	0.01	0.01	0.01
1,2,3,4,7,8,9-HpCDF	0.01	0.01	0.01	0.01
OCDF	0.0001	0.0003	0.0001	0.0001
PCB TEF Values				
3,3',4,4'-Tetrachlorobiphenyl (77)	0.0001	0.0001	0.0001	0.05
3,4,4',5-Tetrachlorobiphenyl (81)	0.0001	0.0003	0.0005	0.1
3,3',4,4',5-Pentachlorobiphenyl (126)	0.1	0.1	0.005	0.1
3,3',4,4',5,5'-Hexachlorobiphenyl (169)	0.01	0.03	0.00005	0.001
2,3,3',4,4'-Pentachlorobiphenyl (105)	0.0001	0.00003	0.000005	0.0001
2,3,4,4',5-Pentachlorobiphenyl (114)	0.0005	0.00003	0.000005	0.0001
2,3',4,4',5-Pentachlorobiphenyl (118)	0.0001	0.00003	0.000005	0.00001
3,4,4',5-Pentachlorobiphenyl (123)	0.0001	0.00003	0.000005	0.00001

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2,3,3',4,4',5-Hexachlorobiphenyl (156)	0.0005	0.00003	0.000005	0.0001
2,3,3',4,4',5'-Hexachlorobiphenyl (157)	0.0005	0.00003	0.000005	0.0001
2,3',4,4',5,5'-Hexachlorobiphenyl (167)	0.00001	0.00003	0.000005	0.00001
2,3,3',4,4',5,5'-Heptachlorobiphenyl (189)	0.0001	0.00003	0.000005	0.00001

Data source: Van den Berg *et al*., 1998 and Van den Berg *et al.*, 2005.

The TEQ for a sediment sample is then the sum of TEF concentrations according to Equation 7-1.

$$TEQ = \sum_{i=1}^{p} TEF_i C_i \qquad \text{Equation 7-1}$$

Where

TEQ: calculated toxic equivalency for sample

TEF_i: reported toxic equivalent factor for the ith chemical

C_i: measured concentration for the ith chemical

To generate site-specific PCDD/F TEQ and PCB TEQ for the Lower Passaic River, sediment concentrations measured in the dated sediment core profiles at RM1.4, RM2.2, RM7.8, RM 11, and RM12.6 were converted to TEQ following Equation 7-1 (Figures 7-1 and 7-2). Concentrations that were not detected typically occurred in the bottom sand layer for the cores collected at RM1.4 and RM11. Two PCB congeners (BZ 156 and BZBZ 157) were reported as a co-elution; however, since BZ 156 and BZ 157 have the same TEF value, they were treated as one compound. BZ 169 and 1,2,3,7,8,9-hexachlorodibenzofuran were commonly reported as not detected.

For the five high resolution sediment cores, BZ 169 was only reported in two samples in the core at RM1.4 and was included in the calculation of PCB TEQ in these two instances. In an effort to include BZ 169 in the PCB TEQ for all five cores, the average ratio of BZ 169/BZ 77 was used to estimate BZ 169 concentrations for the remaining samples. However, the majority of these BZ 169 estimates were greater than the average BZ 169 method detection limit (0.019 µg/kg). These estimations indicate that BZ 169 should have been detected by the laboratory. Since it was only reported in two instances,

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the use of the BZ 169/BZ 77 ratio was rejected, and no estimates were used in the calculation of the PCB TEQ. Because the inclusion of estimated BZ 169 concentrations in the Total TEQ (PCDD/F TEQ plus PCB TEQ) resulted in an increase of less than 10 percent, the ultimate exclusion of estimated BZ 169 concentrations does not have a major effect on the Total TEQ.

Total TEQ was estimated by summing the PCDD/F TEQ and the PCB TEQ for each of the receptors (mammal, fish, and bird). Dated sediment core profiles of the Total TEQ are presented in Figure 7-3, which exhibit several notable features. First, for both PCDD/F TEQ and PCB TEQ, sediments deposited in the 1960s and 1970s are more toxic than the 2005 surface sediments. Second, the sediment toxicity has been relatively constant over the past 25 years for PCDD/F TEQ and PCB TEQ. Lastly, while the PCDD/F TEQ presents the same risk to mammals, birds, and fish receptors, the PCB TEQ varies among the receptors with birds being most sensitive. Average surface sediment TEQ concentrations are presented in Table 7-2.

Table 7-2: TEQ in Lower Passaic River Surface Sediment for Mammal, Fish and Bird Exposures

Analyte	1998 Mammal TEQ	2005 Mammal TEQ	Fish TEQ	Bird TEQ
Average PCDD/F TEQ (ug/kg)	0.37 ±0.16	0.37 ±0.16	0.36 ±0.16	0.39 ±0.17
Average PCB TEQ (ug/kg)	0.020 ±0.0048	0.015 ±0.0039	0.0014 ±0.00033	0.26 ±0.059

Between 1980 and 2005, the PCDD/F TEQ accounts for 95 percent of the mammal Total TEQ and 99 percent of the fish Total TEQ. Moreover, for both the mammal and fish receptors, 2,3,7,8-TCDD contributes approximately 80 percent of the PCDD/F TEQ, suggesting that mammal and fish receptors are sensitive to the presence of 2,3,7,8-TCDD in the surface sediment. Conversely, the PCDD/F TEQ accounts for approximately 60 percent of the bird Total TEQ, reflecting the greater contribution of PCBs to the bird TEQ in surface sediments. Similar to the surface sediments, the PCDD/F TEQ accounts for more than 95 percent of the Total TEQ in deep sediments for the mammal and fish receptor. For the bird receptor, the PCDD/F TEQ accounts for approximately 60 percent of the Total TEQ.

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7.3 CONCENTRATION FORECASTS FOR THE MNR RESPONSE

7.3.1 MNR PROCESS OCCURRING IN THE LOWER PASSAIC RIVER

MNR processes are likely occurring in the Lower Passaic River and impacting some contaminant concentrations over time. These trends are observed in the dated sediment core profiles in Figure 4-3 with concentrations declining from the 1980s to 2005 for some contaminants. Table 7-3 summarizes the average 1980s concentrations for some of the COPCs and compares these values to the average 2005 surface sediment concentration.

Table 7-3: Comparison on the Average 1980s Concentrations and 2005 Surface Sediment Concentrations for Select COPCs

Analyte	Average 1980s Decadal Concentration	Average 2005 Surface Sediment Concentration
Mercury (mg/kg)	3.3	1.8
Lead (mg/kg)	320	210
Copper (mg/kg)	180	150
Total Chlordane (µg/kg)	85	70
Dieldrin (µg/kg)	2.4	5.8
DDE (µg/kg)	110	54
2,3,7,8-TCDD (ng/kg)[a]	560	430
PCDD/F TEQ (µg/kg)[a, b]	0.67	0.49
Total PCB (µg/kg)[a]	2,500	1,000
PCB TEQ (µg/kg)[a, b]	0.16	0.083
LMW PAH (mg/kg)	10	10
HMW PAH (mg/kg)	25	28

a: Average decadal concentration for only three river locations (RM1.4, RM2.2, and RM11)
b: Mammal TEQ estimate
Concentrations rounded to two significant figures.

The mechanisms responsible for these observed declines in contaminant concentrations have not been identified or quantified. Moreover, these declines may be a combination of MNR processes and/or the implementation of source controls, which curtailed the contaminant load over time. Nevertheless, the observed decline in concentration from 1980 to 2005 can be captured or characterized with a first order exponential decay equation (Equation 7-2).

$$C_t = C_o \exp(-\lambda t) \qquad \text{Equation 7-2}$$

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Where

C_t: sediment concentration at a given time

C_o: sediment concentration at the initial time

λ: exponential decay parameter

t: time

Moreover, the exponential decay parameter (λ) is related to the half life (Equation 7-3), or the estimated time for the contaminant concentration to decrease by half:

$$t_{half} = \frac{\ln(2)}{\lambda} \qquad \text{Equation 7-3}$$

Where

t_{half}: time estimated for the 1980 concentration to decline by half

A contaminant-specific half life was estimated for each COPC by fitting Equation 7-2 through all five dated sediment cores from 1979-2005. The sensitivity of this calculated half life was then tested by calculating a similar half life from 1977-2005 and 1981-2005 (the difference of adding or subtracting a single core segment in the analysis; Table 7-4). Additional sensitivity tests were evaluated by including and excluding outliers in the dataset. Final contaminant-specific half lives that were selected to describe the observed concentration trends in the Lower Passaic River are listed in Table 7-4; note that these values are rounded to two significant figures.

Table 7-4: Half Life Sensitivity Test and Final Contaminant-Specific Half Life Values

Analyte	Sensitivity Test Half Life 1977-2005	Half Life 1979-2005	Sensitivity Test Half Life 1981-2005	Selected Half Life
Mercury (mg/kg)	16	18	22	18
Lead (mg/kg)	26	27	33	27
Copper (mg/kg)	29	30	38	30
Total Chlordane (µg/kg)	52	50	56	50
DDE (µg/kg)	19	21	22	20
Dieldrin (µg/kg)	-33	-23	-11	No decline
2,3,7,8-TCDD (ng/kg)[a]	16	17	19	17
PCDD/F TEQ (µg/kg)[a]	16-17	17	18-19	17

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Total PCB (µg/kg)[a]	13	14	16	14
PCB TEQ (µg/kg)[a]	14-15	15	15-16	15
LMW PAH (mg/kg)	41	50	85	No decline
HMW PAH (mg/kg)	-360	-170	-120	No decline

a: Half live calculated for only three river locations, based on available data (RM1.4, RM2.2, and RM11)

The metals half lives were not sensitive when considering the longer time period of 1971-2005; however, the half lives did vary by 6-8 years when considering the shorter time period of 1981-2005. The R^2 values for the 1979-2005 metals half life calculations were significant (greater than 0.4), indicating a statistical decline. Hence, for the metals, the selected half life values were equal to the 1979-2005 calculations. Similar results were observed for Total Chlordane; however, DDE appeared to be sensitive to the exclusion of outliers. Consequently, the DDE half life was rounded to 20 years. Half lives were not calculated for DDD or DDT due to analytical problems quantifying these contaminants.[22] The relatively large half lives for these contaminants indicate that the mechanisms for natural recovery are slow, or the source of these contaminants continues to impact the river.

Unlike most of the other COPCs examined, dieldrin exhibited a rising concentration from the 1980s to the present. Moreover, the rising half life was sensitive to the time period examined. To simplify the forecast calculations, the dieldrin half life was assumed to be zero, or no decline or increase. HMW PAH was also assigned a half life of zero, or no change with time, because of the observed rising trends and the half life values that were greater than 100 years. The LMW PAH was sensitive to the time period examined; however, the low R^2 values for the 1979-2005 PAH half life calculations were insignificant (less than 0.02), indicating no statistical trends in the half lives. A half life of zero indicates that no natural recovery for these contaminants is occurring on the river, and one or more sources of these contaminants may be continuing to impact the river.

[22] The high sulfur content and complex sediment matrix interfered with the recovery of the DDD and DDT surrogates, resulting in poor quantification of the DDD and DDT compounds in many samples. The DDE surrogate did not suffer as much from these interferences.

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The half lives for 2,3,7,8-TCDD, the PCDD/F TEQ, Total PCB, and the PCB TEQ were relatively consistent for the various sensitivity tests. (A range of half lives are presented for the TEQ values reflecting the different receptors.) Note that these COPCs represent some of the shortest half lives in the dataset. Assuming a sedimentation rate of 1.5 inches/year for the Lower Passaic River (Malcolm Pirnie, Inc., 2006a), these "short" half lives correspond to a mixed layer of approximately 30 inches. The fact that these half lives can be determined also indicates that natural recovery is occurring to some degree in the river and/or the external sources of these contaminants are largely controlled.

7.3.2 TRAJECTORY FOR THE MNR SCENARIO

Assuming that the concentration trends observed for the past 25 years will continue into the future, surface sediment concentrations from 2005 to 2048 were forecasted for each COPC following Equation 7-2 (Figure 7-4). These forecasts are appropriate for the MNR response since this alternative does not alter the river or the current solids load contributions. Consequently, the forecasts presented in Figure 7-4 assume only that the contaminant contributions by the various internal and external sources will continue the declines observed in the dated sediment cores for the next 40 years. Note that Figure 7-4 presents the forecasts for all of the contaminants listed in Table 7-5 as well as the summed TEQ trajectories for mammals, fish and birds. The figure also shows the trajectories for the remedial scenarios, which are discussed below. Table 7-5 summarizes the change in surface sediment concentrations for the MNR response. [Note that the DDD and DDT concentrations were estimated based on the DDE trajectory. A DDD/DDE ratio of 1.4 and a Total DDT/DDE ratio of 2.7 observed in the high resolution sediment cores (1980 to 2005) are consistent with ratios observed by Dr. Richard Bopp (personnel communication).[23]] Other surrogates were used by applying the half life determined for the surrogate to the 2005 recently deposited surface sediment concentration for the associated contaminant.

[23] Personnel communication between Dr. AmyMarie Accardi-Dey (Malcolm Pirnie, Inc.) and Dr. Richard Bopp (Rensselaer Polytechnic Institute) on April 5, 2007.

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Table 7-5: Forecasted Surface Sediment Concentrations for the MNR Response

Analyte	Forecasted 2048 Concentration	Percent Reduction from 2005 to 2048
Mercury (mg/kg)	0.25	81
Lead (mg/kg)	68	67
Copper (mg/kg)	43	63
Total Chlordane (µg/kg)	36	45
DDE (µg/kg)	9.2	77
DDD (µg/kg)	13	77
DDT (µg/kg)	2.8	77
Total DDT (µg/kg)	25	77
Dieldrin (µg/kg)	4.2	None predicted
2,3,7,8-TCDD (ng/kg)	45	83
PCDD/F TEQ (µg/kg)	0.046	83
Total PCB (µg/kg)	94	88
PCB TEQ Mammal (µg/kg)	0.0019	86
PCB TEQ Bird (µg/kg)	0.030	86
PCB TEQ Fish(µg/kg)	0.00016	86
LMW PAH (mg/kg)	5.3	None predicted
HMW PAH (mg/kg)	35	None predicted

Concentrations rounded to two significant figures.

In the MNR scenario, the surface sediment concentrations would decline by approximately 70 to 80 percent between 2005 and 2048 for most contaminants. While these reductions are substantive, the levels of reduction suggested by the risk assessment included in the FFS (Appendix C) suggest greater reductions are needed for some compounds. For these compounds given their current half lives, this would require as much as an additional 40 to 50 years. It is anticipated that the HMW PAH, LMW PAH, and dieldrin concentrations would remain constant over time since the measured trends from 1980-2005 showed no decline.

The declines in contaminant concentration that take place under this scenario represent the combination of a number of factors. For those contaminants controlled by resuspension of legacy sediments (*e.g.*, 2,3,7,8-TCDD), the decline in surface concentrations is the result of the dilution and dispersion of the contaminants throughout the environment, in particular through transport to Newark Bay and by delivery of cleaner solids from the Upper Passaic and Newark Bay. For contaminants controlled by external sources (*e.g.*, HMW PAH), these sources must decline first, followed by the dilution and dispersion of contaminated sediments as is the case for the contaminants controlled by resuspension of legacy sediments. For many of the contaminants of the

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Lower Passaic River, dilution and dispersion represent the only significant means to reduce concentrations under MNR, since they are highly resistant to degradation processes (*e.g.*, Total PCB and 2,3,7,8-TCDD) or they simply cannot be broken down (*e.g.*, mercury and lead).

The discussions above reflect certain refinements to the February 2007 update of the CSM (Malcolm Pirnie, Inc., 2007a; Appendix A) with regard to the change in sediment concentrations over time. As a result, some clarification of the conclusions of the CSM is appropriate. Specifically, on page 2-4 , the CSM notes that "while the original sources of some of these contaminants may have been discontinued, surface sediment contaminant concentrations have remained relatively constant over the past decade (1997-2006) over the distance of eight miles (RM0 to RM8)." For the contaminants LMW PAH, HMW PAH and dieldrin, the statement stands without qualification since, in fact, there is no observed change over the last 25 years. Clarification is appropriate for other contaminants. For Total Chlordane, copper and lead, the estimated half lives are so long that the anticipated amount of change over the ten year period is less than 25 percent, well within the observed year-to-year variability. For the contaminants with the shortest half-lives (14, 17, 18 and 20 years for Total PCB, 2,3,7,8-TCDD, mercury and DDE, respectively) the anticipated decline is still relatively small, ranging from a 39 to a 29 percent reduction, respectively.

A closer examination of these contaminant trends in the 1990 to 2005 period suggests that the actual rate of decline in concentration for several compounds may be slowing, that is, the concentrations in the more recent sediment core segments appear to be declining more slowly (note the data trends in Figure 7-4 for the period 1995-2005).[24] While this period was considered too short to yield a robust estimate of the rate of decline, the observations are consistent with those made in the CSM.

[24] As discussed previously, the sharp rise in 2,3,7,8-TCDD concentrations near the top of cores at RM11 and RM12.6 is considered the result of a localized event and does not represent an overall trend for the entire Lower Passaic River.

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7.4 CONCENTRATION FORECASTS FOR THE CONTAINMENT ALTERNATIVE

7.4.1 ASSUMPTIONS FOR THE CONTAINMENT SCENARIO

To forecast post-remediation COPC concentrations in surface sediments after the placement of sand material from RM0 to RM8 (bank-to-bank), several assumptions are necessary:

- The observed concentration trends for the COPCs will continue following the half life values provided in Table 7-4 from 2005 to the implementation of the remedy in 2018.
- The placement of sand material will control approximately 90 percent of the fine-grained resuspension and will impact surface sediment concentrations in 2018.
- The fraction of the contaminant burden associated with resuspension estimated from the EMBM is applicable to the COPC being examined.
- Following remediation, surface sediment concentrations will continue to decline with the same half life values provided in Table 7-4 from 2018 to 2048. No improvement in the half life is assumed as a result of the remediation.

The first assumption follows the logic described in Section 7.3 "Concentration Forecasts for the MNR Response" that mechanisms currently impacting the river and causing a concentration decline in surface sediments will continue unhindered in the future. In 2018, the remedy is assumed to be implemented, and sand material will cover approximately 90 percent of the fine-grained material in the Lower Passaic River, thus restricting approximately 90 percent of the contaminant flux associated with resuspension. The third assumption follows the logic presented in Section 6.0 "Modeling Results" where parameters used in the EMBM are used as surrogates to estimate the contaminant-specific flux associated with resuspension and the subsequent reduction due to the remediation (Table 7-6). Surrogates were necessary since COPC concentrations were not measured or reported for all the sources evaluated in the empirical mass balance. The half life for the surrogate is applied to the associated compound for the post-remediation period.

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Table 7-6: Resuspension Parameters Used in the Containment Scenario

Analyte	Surrogate Used in Empirical Mass Balance	Percent of Contaminant Flux from Resuspension
Mercury	Mercury	≈ 45
Lead	Lead	≈ 25
Copper	Copper	≈ 25
Total Chlordane	Trans-Chlordane	≈ 10
DDE	DDE	≈ 50
DDD	DDE	-
DDT	DDE	-
Total DDT	DDE	-
Dieldrin	Dieldrin	≈ 30
2,3,7,8-TCDD	2,3,7,8-TCDD	> 95
PCDD/F TEQ	2,3,7,8-TCDD	> 95
Total PCB	BZ180	≈ 45
PCB TEQ Mammal	BZ180	≈ 45
PCB TEQ Bird	BZ180	≈ 45
PCB TEQ Fish	BZ180	≈ 45
LMW PAH	Phenanthrene	≈ 15
HMW PAH	Benzo[a]pyrene	≈ 10

The surrogate for Total Chlordane was trans-chlordane since the cis-chlordane compound was not consistently reported for all the sources. As discussed in Section 7.3.2 "Trajectory for the MNR Response," due to analytical problems associated with quantifying DDT and DDD, these compounds were estimated from the DDE trajectory. For the PCDD/F TEQ, the 2,3,7,8-TCDD surrogate was applied since 2,3,7,8-TCDD accounted for 70 to 80 percent of the PCDD/F TEQ. For the PAH classes, phenanthrene was selected as a surrogate for the LMW PAH and benzo[a]pyrene was selected as the surrogate for the HMW PAH.

As discussed in Section 6.0 "Modeling Results," the PCB congeners exhibited a range of percentages to describe the resuspension contaminant burden. The mass balance for the lighter PCB congeners, like BZ 52, associated approximate 75 percent of the contaminant flux to resuspension (Figure 6-3). Conversely, resuspension accounted for approximately 40 percent of the contaminant flux for the heavier PCB congeners, like BZ 180, with the Upper Passaic River fraction increasing to account for the difference (Figure 6-4). To determine the appropriate resuspension flux to characterize Total PCB, the half lives for the individual PCB congeners were calculated (Table 7-7).

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Table 7-7: Half Life Comparison for Individual PCB Congeners

Analyte	Sensitivity Test Half Life 1977-2005	Half Life 1979-2005	Sensitivity Test Half Life 1981-2005
BZ 31	10	11	12
BZ 52	12	12	13
BZ 61+70+74+76+66	12	12	14
BZ 83+99	15	15	16
BZ 90+101+113	15	14	15
BZ 93+95+98+100+102	15	14	15
BZ 110+115+111	15	15	16
BZ 129+138+158+160+163+164	15	15	16
BZ 139+140+149+147	15	15	16
BZ 170	16	15	16
BZ 180+193	16	15	17

The results of this evaluation show that the half life for the lighter PCB congeners, like BZ 31, BZ 52, and BZ 61 with its co-eluting PCB congeners, ranges from 10 to 14 years. Conversely, the half lives for the heavier PCB congeners ranged from 14 to 17 years. Note that in Table 7-4, the half life for Total PCB ranged from 13 to 17 years with a selected half life of 15 years, indicating that the observed concentration trends for Total PCB are likely governed by the trends in the heavier PCB congeners. In other words, the Upper Passaic River is likely contributing a more significant fraction of the Total PCB contaminant burden than resuspension. Therefore, for the forecasting calculation, the surrogate BZ 180 was used to estimate the resuspension contaminant burden for Total PCB and the PCB TEQ.

7.4.2 TRAJECTORY FOR THE CONTAINMENT SCENARIO

Assuming that the concentration trends observed for the past 25 years will continue into the future, surface sediment concentrations from 2005 to 2018 were forecasted for each COPC following Equation 7-2. The placement of sand material completed as part of the remediation is assumed to restrict fine-grained sediment resuspension by approximately 90 percent. Given the many unknowns associated with remedial construction sequence for the various alternatives, no attempt has been made to predict short-term consequences of implementation. Rather, for purposes of long-term forecasts, it has been assumed that all benefits of remediation are realized in the final year of the typical remedial alternative

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construction period in 2018. Surface sediment concentrations will then decline according to the contaminant-specific resuspension fraction ($F_{resupsension}$) listed in Table 7-6, the fraction of solids in the river associated with resuspension (f_{solids}), and Equation 7-4.

$$C_{\mathrm{Re}m} = C_{MNR}\left(\frac{1-bF_{resuspension}}{1-bf_{solids}}\right) \qquad \text{Equation 7-4}$$

Where

C_{Rem}: new surface sediment concentration following remediation in 2018

C_{MNR}: surface sediment concentration under MNR in 2018

b: fraction of fine-grained sediment area impacted by placement of sand

$F_{resupsension}$: fraction of contaminant flux associated with resuspension

f_{solids}: fraction of solids associated with resuspension

Once the new concentration is calculated (C_{Rem}), surface sediment concentrations are allowed to decline again from 2018 to 2048 according to Equation 7-2 with the same contaminant-specific half lives listed in Table 7-2. The forecasted COPC concentrations for the containment scenario are presented in Figure 7-4 along with the MNR trajectories and summarized in Table 7-8. (As discussed in Section 7.3.2 "Trajectory for the MNR Response," the DDD and DDT concentrations were estimated based on the DDE trajectories.) Table 7-8 also includes the percent reduction due to remediation, assumed to be completed by 2018. The number reflects the amount of reduction in the concentration due to remediation alone and does not include any reduction due to natural recovery. The percent reduction from 2005 to 2048 is also shown in Table 7-8. The number was calculated based on the difference in the contaminant concentrations between 2005 and 2048.

Table 7-8: Forecasted Surface Sediment Concentrations for the Containment Alternative

Analyte	Forecasted 2048 Concentration	Percent Reduction in 2018 due to Remediation	Percent Reduction from 2005 to 2048
Mercury (mg/kg)	0.17	33	91
Lead (mg/kg)	60	12	71

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Copper (mg/kg)	38	12	75
Total Chlordane (µg/kg)	36	None predicted	43
DDE (µg/kg)	5.7	39	86
DDD (µg/kg)	7.9	39	86
DDT (µg/kg)	1.7	39	86
Total DDT (µg/kg)	15	39	86
Dieldrin (µg/kg)	3.4	20	20
2,3,7,8-TCDD (ng/kg)	6.5	86	98
PCDD/F TEQ (µg/kg)	0.0066	86	98
Total PCB (µg/kg)	64	32	92
PCB TEQ Mammal (µg/kg)	0.0013	32	91
PCB TEQ Bird (µg/kg)	0.020	32	91
PCB TEQ Fish(µg/kg)	0.00011	32	91
LMW PAH (mg/kg)	5.2	2	2
HMW PAH (mg/kg)	35	None predicted	None predicted

Concentrations rounded to two significant figures.

For most contaminants, remediation in 2018 via the containment alternative would result in approximately a 30 percent reduction in surface sediment concentrations. Lead, copper, and the PAH concentrations would change by less than 15 percent (or stay constant) due to continual contaminant inputs from other sources. Meanwhile, the 2,3,7,8-TCDD and PCDD/F TEQ concentrations would experience the largest percent reduction (more than 80 percent) in surface sediment concentrations due the control of the resuspension of historical inventory.

For Total Chlordane and the HMW PAH, the actual calculation yielded a less than1 percent increase in the surface sediment concentration following remediation. This concentration increase reflects the mixing of more contaminated solids from external sources with the Lower Passaic River sediments. Considering the uncertainty of the mass balance, the trajectory reflects no change in concentration due to remediation.

Most notably this scenario achieves a much greater degree of reduction for 2,3,7,8-TCDD, PCBs and the associated TEQs by the year 2048 than does the MNR scenario. The percent reductions are greater than 95 percent in each case. The DDT suite and

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mercury are also substantially reduced under this scenario, by roughly 90 percent relative to 2005 levels.

7.5 CONCENTRATION FORECASTS FOR THE PRIMARY EROSIONAL ZONE

7.5.1 ASSUMPTIONS FOR THE PRIMARY EROSIONAL ZONE FORECAST

The assumptions for the hypothetical remedial scenario for the Primary Erosional Zone are similar to the assumption for the containment scenario, which are:

- The observed concentration trends for the COPCs will continue following the half life values provided in Table 7-4 from 2005 to the implementation of the remedy in 2018.
- Remediation of the Primary Erosional Zone will control about one third of the erosional areas and will impact surface sediment concentrations in 2018 according to Equation 7-4.
- The fraction of the contaminant flux associated with resuspension estimated from the empirical mass balance is applicable to the COPC being examined (Table 7-6).
- Following remediation, surface sediment concentrations will continue to decline with the same half life values provided in Table 7-4 from 2018 to 2048.
- Remediation of the Primary Erosional Zone and the Primary Inventory Zone together will produce similar forecasted COPC concentrations.

7.5.2 TRAJECTORY FOR THE PRIMARY EROSIONAL ZONE

Assuming that the concentration trends observed for the past 25 years will continue into the future, surface sediment concentrations from 2005 to 2018 were forecasted for each COPC following Equation 7-2. In 2018, the remediation of the Primary Erosional Zone is assumed to be implemented, which controls about one third of the erosional areas in the Lower Passaic River. Surface sediment concentrations will then decline according to the contaminant-specific resuspension burden listed in Table 7-6, the fraction of solids in the river associated with resuspension (f_{solids}), and Equation 7-4. Once the new 2018 concentration is calculated, surface sediment concentrations are allowed to decline again from 2018 to 2048 according to Equation 7-2 with the same contaminant-specific half

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lives listed in Table 7-2. The forecasted COPC concentrations for the remediation of the Primary Erosional Zone are presented in Figure 7-4 along with the other scenario trajectories and summarized in Table 7-9. Table 7-9 shows the forecasted concentration for various chemicals in 2048. The percent reduction in 2018 due to remediation alone is also listed in the table. This value is calculated similarly to the value given in Table 7-8, again assuming all remediation benefits are realized in the final year of the construction period.

Table 7-9: Forecasted Surface Sediment Concentrations for the Remediation of the Primary Erosional Zone

Analyte	Forecasted 2048 Concentration	Percent Reduction in 2018 due to Remediation	Percent Reduction from 2005 to 2048
Mercury (mg/kg)	0.22	11	83
Lead (mg/kg)	65	4	68
Copper (mg/kg)	41	4	64
Total Chlordane (µg/kg)	36	None predicted	45
DDE (µg/kg)	8.0	13	80
DDD (µg/kg)	11	13	80
DDT (µg/kg)	2.4	13	80
Total DDT (µg/kg)	22	13	80
Dieldrin (µg/kg)	3.9	7	7
2,3,7,8-TCDD (ng/kg)	32	30	88
PCDD/F TEQ (µg/kg)	0.032	30	88
Total PCB (µg/kg)	84	11	89
PCB TEQ Mammal (µg/kg)	0.0017	11	88
PCB TEQ Bird (µg/kg)	0.026	11	88
PCB TEQ Fish(µg/kg)	0.00014	11	88
LMW PAH (mg/kg)	5.3	1	1
HMW PAH (mg/kg)	35	None predicted	None predicted

Concentrations rounded to two significant figures.

While remediating the Primary Erosional Zone would control surface sediment concentrations to some extent, the percent reduction in 2018 is less than 15 percent for most contaminants since resuspension of historical inventory would continue along much

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of the river. In this hypothetical remedial scenario, the 2,3,7,8-TCDD and PCDD/F TEQ concentrations would experience the largest percent reduction in surface sediment concentrations due the control of the resuspension of historical inventory; however, the reductions in surface sediment concentrations are not as significant as the containment scenario described in Section 7.4 "Concentration Forecasts for the Containment Alternative."

As discussed above, for Total Chlordane and the HMW PAH, the actual calculation yielded a less than 1 percent increase in the surface sediment concentration following remediation. This concentration increase reflects the mixing of more contaminated solids from external sources with the Lower Passaic River sediments. Considering the uncertainty of the mass balance, the trajectory reflects no change in concentration due to remediation.

The forecast results out to 2048 are most easily seen in Figure 7-4 for this scenario. In most cases this scenario does not make a large difference relative to the MNR forecasts. This is evident in comparing Table 7-9 to Tables 7-8 and 7-5 as well. The percent reduction for the primary erosion scenario is not much greater than that for the MNR scenario.

7.6 SUMMARY OF REMEDIAL ALTERNATIVES

All three scenarios show a decline over time for most contaminants, reflecting the historical declines observed in the sediments. Forecasted recently deposited surface sediment concentrations did not significantly differ between the MNR scenario and the hypothetical remedial scenario for the Primary Erosional Zone. By contrast, the containment alternative yielded the lowest surface sediment concentrations for all contaminants, in some cases nearly an order of magnitude below those forecast for the MNR scenario. Table 7-10 summarized the forecasted 2048 surface sediment concentrations for the COPCs.

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Table 7-10: Summary of Forecasted 2048 Surface Sediment Concentrations

Analyte	MNR Response	Containment Alternative	Primary Erosional Zone
Mercury (mg/kg)	0.25	0.17	0.22
Lead (mg/kg)	68	60	65
Copper (mg/kg)	43	38	41
Total Chlordane (µg/kg)	36	36	36
DDE (µg/kg)	9.2	5.7	8.0
DDD (µg/kg)	13	7.9	11
DDT (µg/kg)	2.8	1.7	2.4
Total DDT (µg/kg)	25	15	22
Dieldrin (µg/kg)	4.2	3.4	3.9
2,3,7,8-TCDD (ng/kg)	45	6.5	32
PCDD/F TEQ (µg/kg)	0.046	0.0066	0.032
Total PCB (µg/kg)	94	64	84
PCB TEQ Mammal (µg/kg)	0.0019	0.0013	0.0017
PCB TEQ Bird (µg/kg)	0.030	0.020	0.026
PCB TEQ Fish(µg/kg)	0.00016	0.00011	0.00014
LMW PAH (mg/kg)	5.3	5.2	5.3
HMW PAH (mg/kg)	35	35	35

Concentrations rounded to two significant figures.

Another approach to comparing the MNR response and the containment alternative is to calculate the additional amount of time required for the MNR response to achieve the surface concentrations predicted in the containment alternative (Table 7-11). In this comparison, the largest time differences corresponded to 2,3,7,8-TCDD and the associated TEQ values. The smallest time differences were observed for lead and copper. The amount of time between the scenarios for a given contaminant directly reflects the percent of the contaminant flux due to resuspension. The greater the importance of resuspension to the total flux, the larger the difference in time is to the same concentration.

Table 7-11: Additional Time Required by the MNR Scenario Relative to the Containment Scenario to Achieve a Given Concentration

Analyte	Additional Time to Achieve the Same Reduction by MNR (yrs)
Mercury	10
Lead	5
Copper	5
Total Chlordane	-
DDE	15
DDD	15
DDT	15
Total DDT	15
Dieldrin	-

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2,3,7,8-TCDD	40
PCDD/F TEQ	40
Total PCB	10
PCB TEQ Mammal	10
PCB TEQ Bird	10
PCB TEQ Fish	10
Total TEQ Mammal	40
Total TEQ Bird	25
Total TEQ Fish	40
LMW PAH	-
HMW PAH	-

The symbol (-) indicates no time difference.

7.7 RELATIONSHIP BETWEEN FORECASTED CONCENTRATIONS AND MEAN SURFACE SEDIMENT CONCENTRATIONS

As presented in the CSM (Malcolm Pirnie, Inc., 2007a), the Lower Passaic River is a dynamic system with erosional and depositional areas intertwined along the river bottom. Consequently, the forecasted sediment concentrations are needed to describe this environment, especially for the MNR response and the remediation of the Primary Erosional Zone. Note that the forecasts do not currently account for the various depositional/erosional environments since the forecasts were based on high resolution sediment cores which track the most recently deposited sediments, characteristic of depositional environments of the river. These cores by design do not reflect variability in surface concentrations due to erosion and variable deposition rates; however, it is anticipated that the mean surface concentration will track the trends observed in the depositional settings reflected in the dated sediment cores.

To accommodate for the lack of spatial representation in the high resolution sediment cores, the average 1990 decadal concentrations (excluding the 2000-2005 samples) were compared to the surface sediments collected by TSI in 1995 (Table 7-12). During the 1995 TSI sampling event, sediment cores were collected along transects that were spaced every quarter mile from RM1 to RM7, yielding 97 sampling locations. Consequently, samples were collected from both erosional and depositional environments. The ratio of the average TSI 1995 concentration to the average 1990s concentration for the high resolution cores was then calculated. Ratios greater than one imply that the actual

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surface sediment concentrations will likely be greater than the forecasted sediment concentrations. In instances, where the ratio was less than unity (*e.g.*, Total Chlordane), the ratio was replaced with 1 because of the observations of greater contamination at depth and the assumption that average surface concentrations are higher than or equal to the recently deposited materials recorded in the high resolution cores. These ratios are specifically intended to enable the calculation of average surface concentrations for risk assessment purposes based on the forecasts of recently deposited surface sediments described earlier in this section. The forecast concentrations can be simply multiplied by these values to obtain the corresponding average surface concentration.

Table 7-12: Relationship Between Recently Deposited Surface Sediment Concentrations and Mean Surface Concentrations for the Lower Passaic River

Analyte	Dated Sediment Core 1990s Decadal Concentration (mean ±standard error) [a]	1995 TSI Surface Concentration (mean ±standard error) [b]	Ratio of 1995 Surface Sediment to 1990 Decade (mean ±standard error)
Mercury (mg/kg)	2.0 ± 0.11	3.3 ±0.22	1.7 ±0.14
Lead (mg/kg)	240 ±11	330 ±15	1.4 ±0.09
Copper (mg/kg)	150 ±6.8	230 ±25	1.5 ±0.18
Total Chlordane (µg/kg)	85 ±4.2	47 ±4.0	1[c]
DDE (µg/kg)	59 ±2.9	66 ±6.4	1.7[d]
DDD (µg/kg)	94 ±23	150 ±70	1.7[d]
DDT (µg/kg)	36 ±10	120 ±40	1.7[d]
Total DDT (µg/kg)	180 ±31	300 ±78	1.7 ±0.53
Dieldrin (µg/kg)	7.2 ±1.9	25 ±2.5	3.5 ±0.98
2,3,7,8-TCDD (ng/kg)	0.29 ±0.03	0.82 ±0.21	2.9 ±0.79
Total PCB (µg/kg)	1,300 ±110	1,300 ±180	1.0 ±0.17
LMW PAH (mg/kg)	11,000 ±770	24,000 ±15,000	2.1 ±1.3
HMW PAH (mg/kg)	29,000 ±1,400	39,000 ±15,000	1.4 ±0.53

a: Average 1990 decadal concentration (excluding the 2000-2005 samples) and standard error on the average.
b: Average 1995 surface sediment concentration (0 to 6 inches) and standard error on the average.
c: Actual ratio is less than 1.
d: The ratio for Total DDT of 1.7 was assumed for DDE, DDD, and DDT.

These factors are intended for use in evaluating risks under the MNR and Primary Erosional Area scenarios. Since the containment scenario will address nearly all surface sediment contamination in RM0 to RM8, these factors should not be applied after remediation. Rather, the forecasted concentrations themselves should be used in this instance.

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8.0 ACRONYMS

2,3,7,8-TCDD	2,3,7,8-Tetrachlorodibenzodioxin
BZ	PCB naming convention based on the work by Ballschmiter and Zell
CARP	Contaminant Assessment and Reduction Program
cfs	cubic feet per second
CLP	Contract Laboratory Program
CMB	Chemical Mass Balance
COPC	Chemical of Potential Concern – Note this acronym is used to refer to both COPC and COPEC in this report.
COPEC	Chemical of Potential Ecological Concern
CRQL	Contract Required Quantitation Limit
CSM	Conceptual Site Model
CSO	Combined Sewer Overflow
CV	Coefficient of Variation
DDD	Dichlorodiphenyldichloroethane
DDE	Dichlorodiphenyldichloroethylene
DDT	Dichlorodiphenyltrichloroethane
EFDC	Environmental Fluid Dynamics Code
EMBM	Empirical Mass Balance Model
EST	Environmental Sampling Technologies
FFS	Focused Feasibility Study
GPS	Global Positioning System
HMW	High Molecular Weight
HUC	Hydrologic Unit Code
K_d	Distribution Coefficients
LMW	Low Molecular Weight
LWA	Length-Weighed Average
mg/kg	Milligram per kilogram of sediment

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mg/L	Milligram per liter
MLW	Mean Low Water
MNR	Monitored Natural Recovery
NA	Not applicable
ng/kg	Nanogram per kilogram of sediment
NGVD29	National Geodetic Vertical Datum of 1929
NJDEP	New Jersey Department of Environmental Protection
NJPDES	New Jersey Pollutant Discharge Elimination System
NYSDEC	New York State Department of Environmental Conservation
PAH	Polycyclic Aromatic Hydrocarbons
PCB	Polychlorinated Biphenyls
PCDD/F	Polychlorodibenzodioxins/furans
pCi/g	Picocurie per gram
PRGs	Preliminary Remedial Goals
QA/QC	Quality Assurance/Quality Control
R	Correlation Coefficient
R^2	Coefficient of Determination
RAO	Remedial Action Objective
RI/FS	Remedial Investigation/Feasibility Study
RM	River Mile
SPMD	Semi-permeable Membrane Device
STL	Severn Trent Laboratories
SWO	Storm Water Outfall
TAL	Target Analyte List
TEF	Toxic Equivalent Factor
TEQ	Toxic Equivalency
TOPS	Trace Organic Platform Sampler
Total TCDD	Total Tetrachlorodibenzodioxins
TSI	Tierra Solutions, Inc.
TSS	Total Suspended Solids
USACE	U.S. Army Corps of Engineers

R2-0010069

USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
µg/kg	Microgram per kilogram of sediment
µm	Micrometer

R2-0010070

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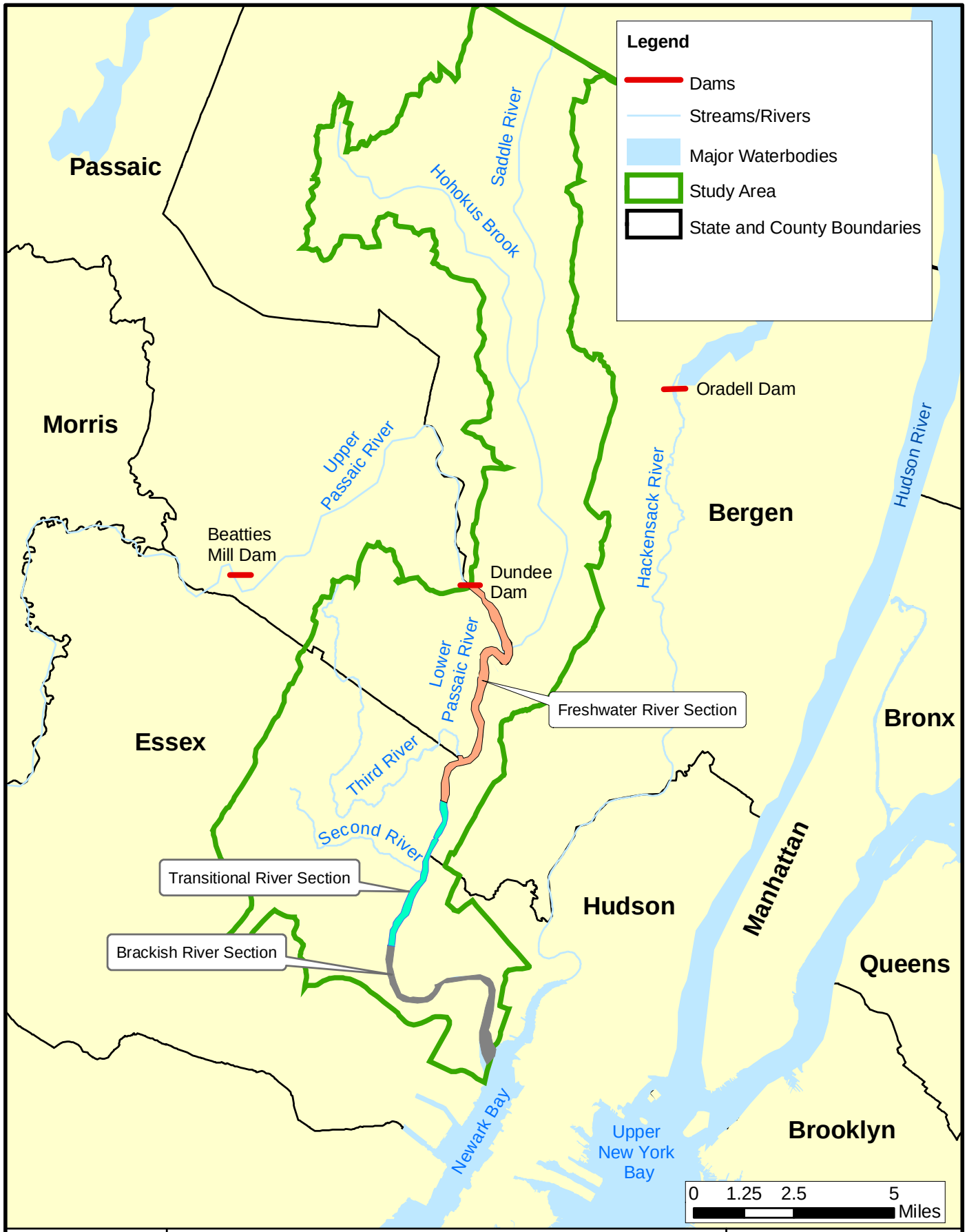
R2-0010074

Figures



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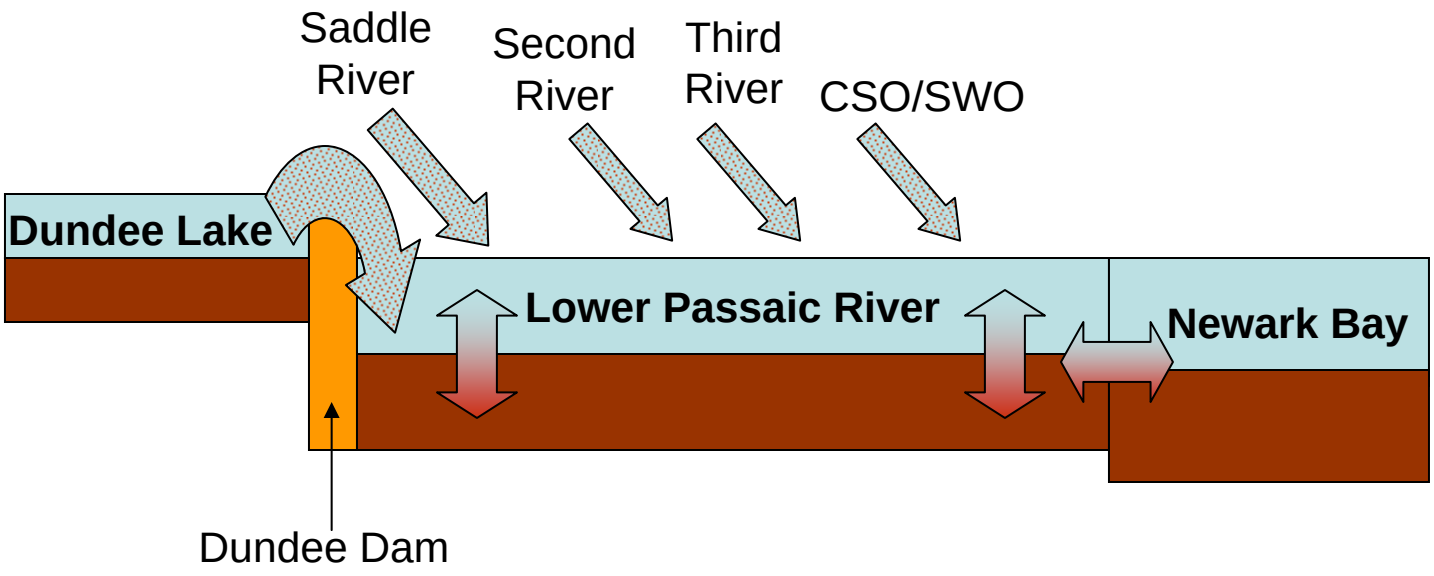
Study Area Location Map

Lower Passaic River Restoration Project

Figure 2-1

June 2007

R2-0010076



Legend

Water

Sediment

Notes

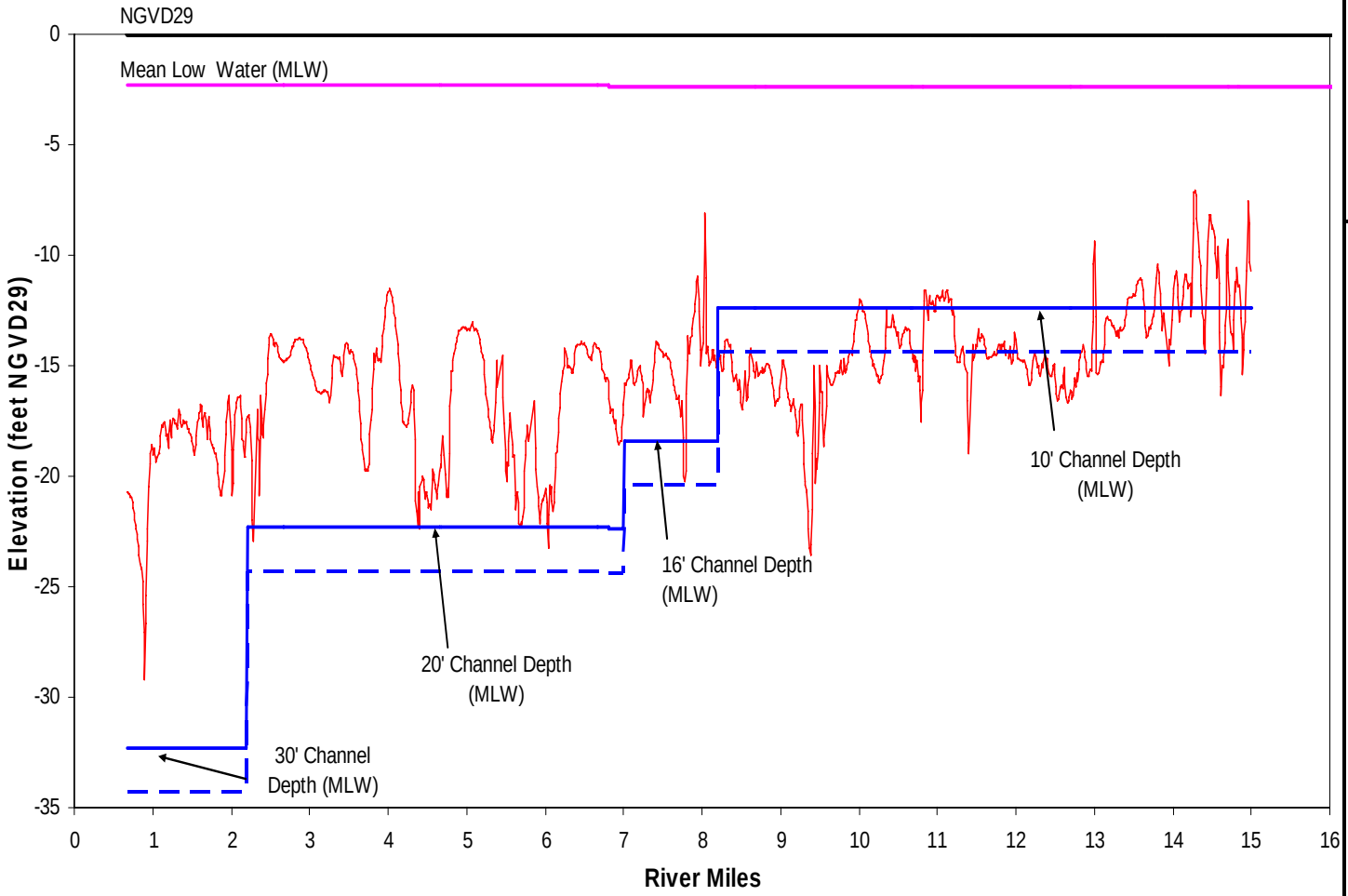
Schematic of Box Model for the Lower Passaic River Empirical Mass Balance

Lower Passaic River Restoration Project

Figure 2-2

June 2007

R2-0010077



Legend

- Navigational Channel Centerline Bathymetry
- Navigational Channel Depth
- Navigational Channel Depth + 2 feet

Notes

Channel depths were dredged relative to mean low water (MLW). The difference between NGVD29 and MLW is approximately 2.3 feet.

Solid blue line represents federally authorized channel depth.

Dashed blue line represents the channel depth +2 feet. This depth would have been the actual dredged depth in order to maintain the federally authorized channel depth.

Elevation data estimated from 2004 bathymetric data surveyed by Rogers Survey,Inc. for USACE.

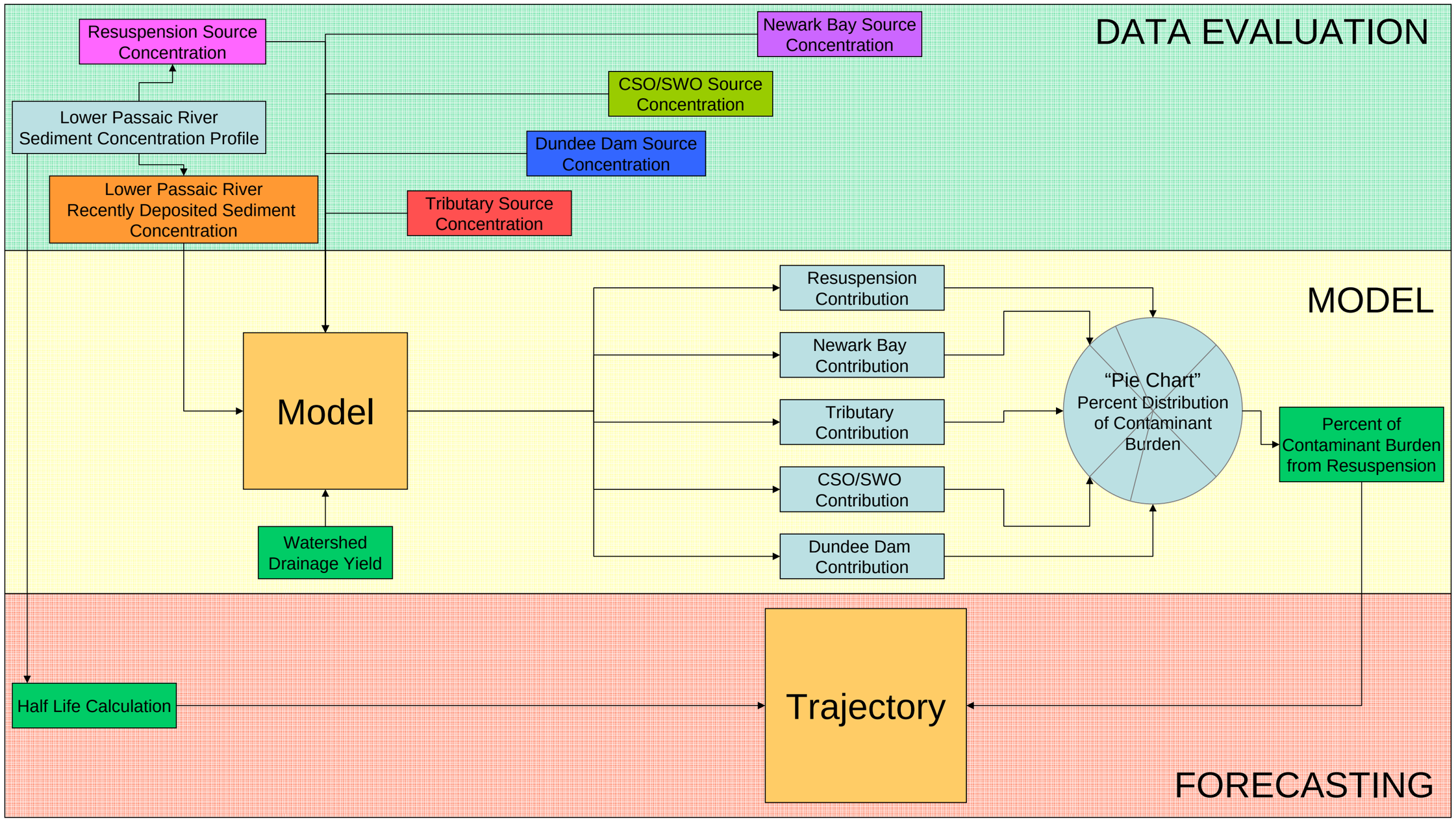
Elevation of River Bottom Compared to Federally Authorized Channel Depth

Lower Passaic River Restoration Project

Figure 2-3

June 2007

R2-0010078



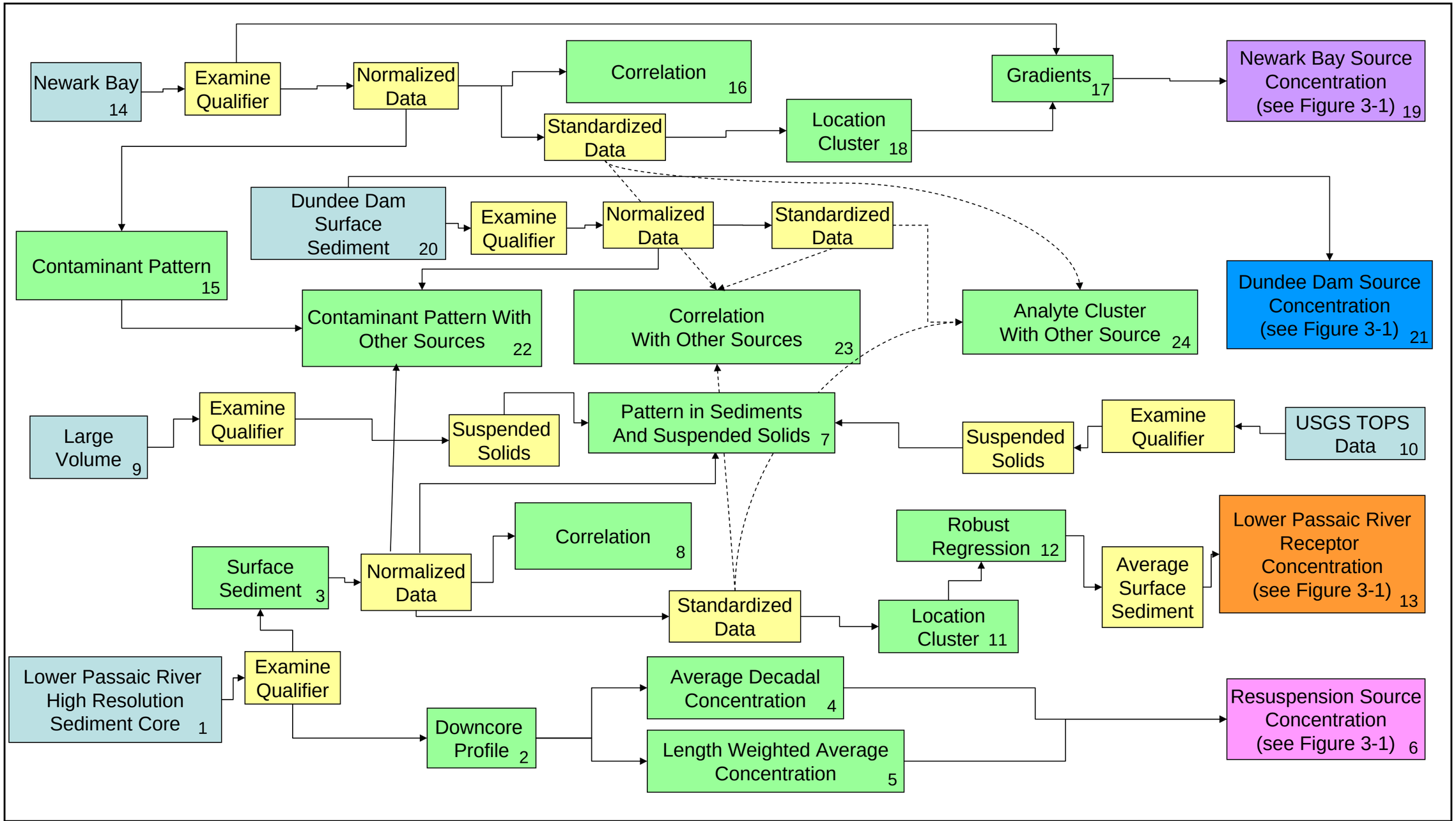
Flow Chart for the Empirical Mass Balance Model

Lower Passaic River Restoration Project

Figure 3-1

June 2007

R2-0010079



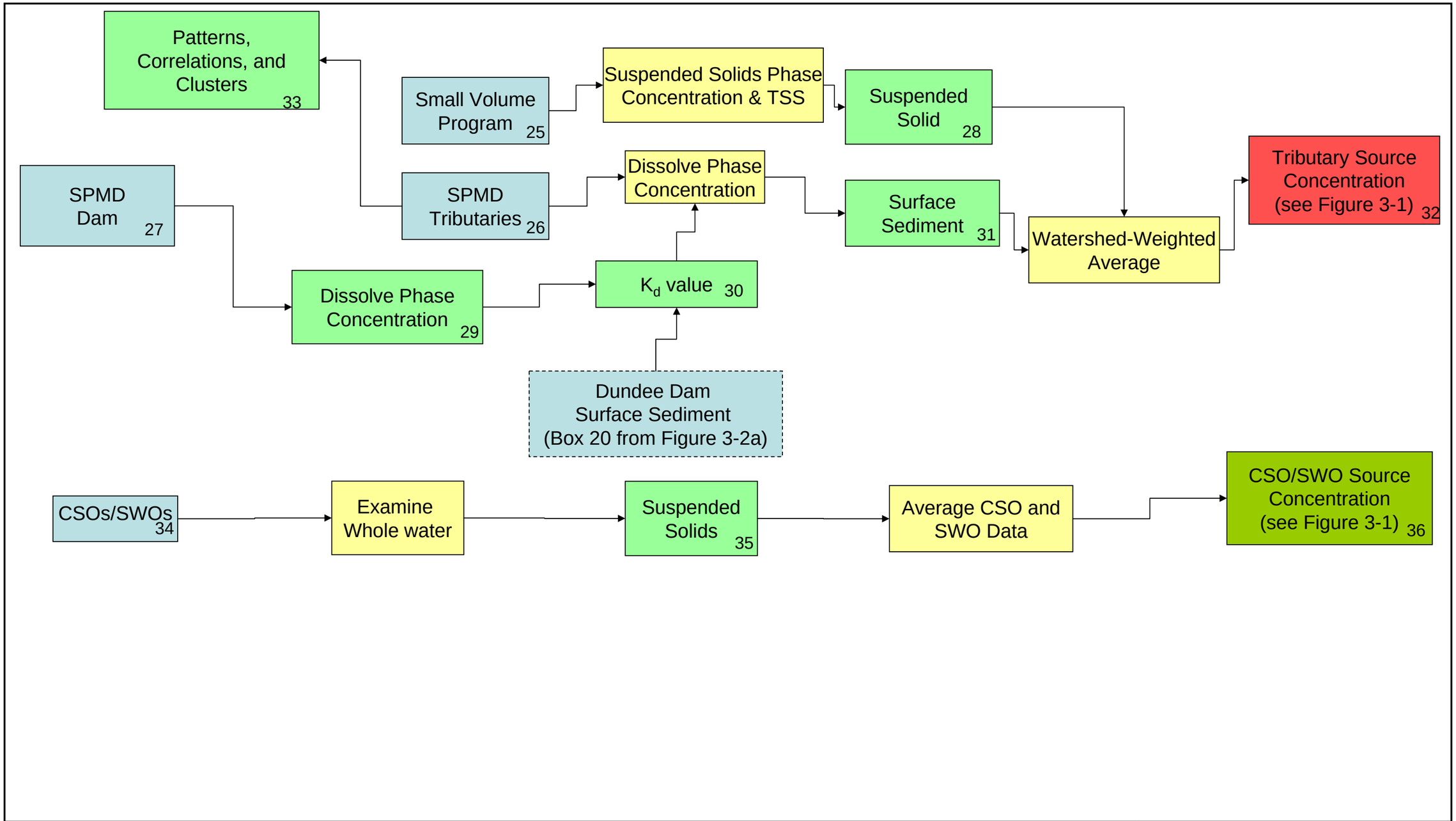
Flow Chart for the Data Evaluation Component of the Mass Balance Model for Newark Bay, Lower Passaic River and Dundee Dam

Lower Passaic River Restoration Project

Figure 3-2a

June 2007

R2-0010080

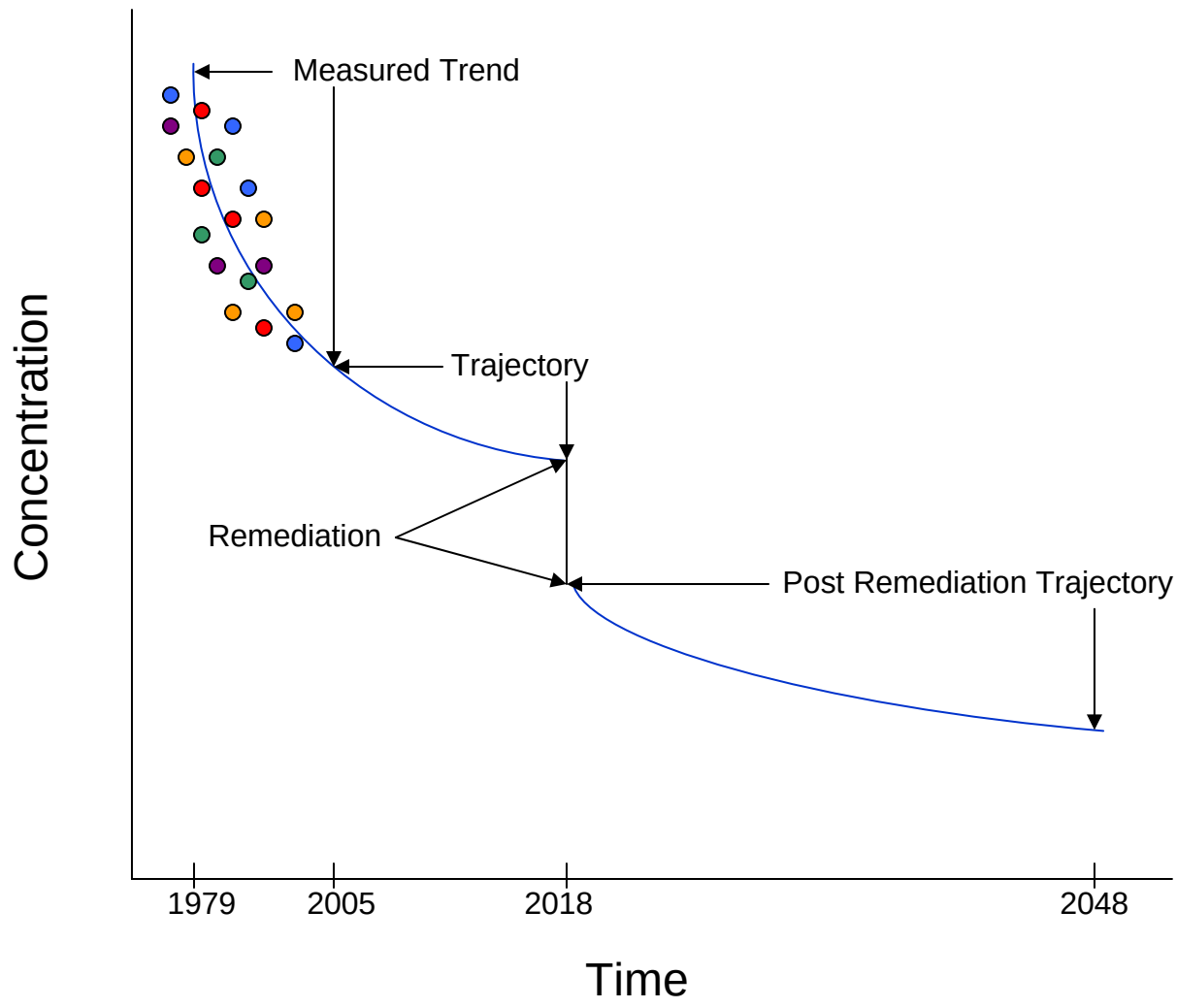


Flow Chart for the Data Evaluation Component of the Mass Balance Model for Tributaries and CSOs/SWOs

Lower Passaic River Restoration Project

Figure 3-2b

June 2007



Legend

Measured Concentrations

Notes

-Trajectory assumes implementation of remedy in 2018.

-Figure is not to scale

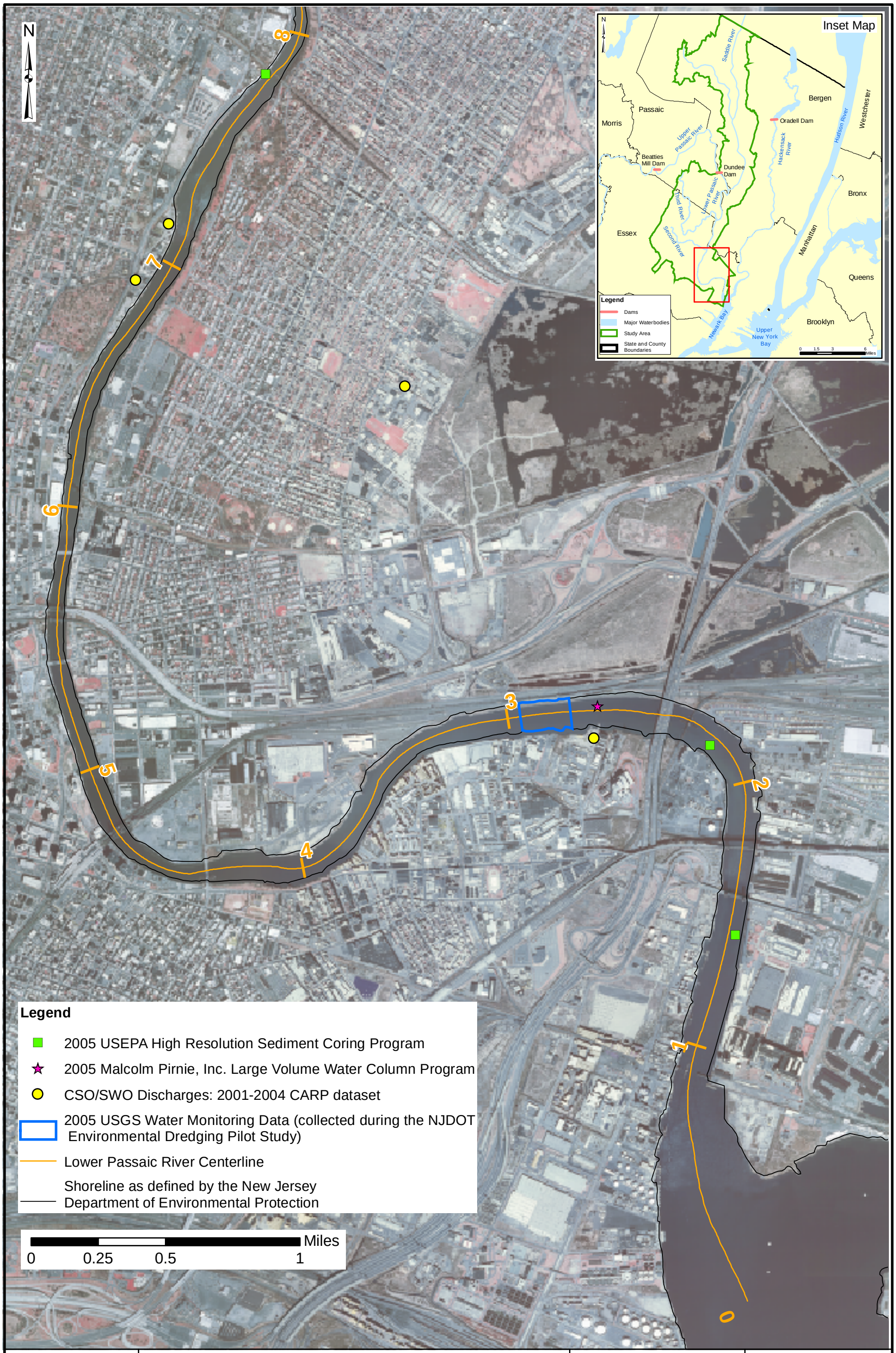
Schematic of Forecasted Surface Sediment Trajectory in the Lower Passaic River

Lower Passaic River Restoration Project

Figure 3-3

June 2007

R2-0010082



Locations of Passaic River Samples Used In the Mass Balance Model

Lower Passaic River Restoration Project

Data Source: 2002 Aerial photographs from the New Jersey State data clearing house (http://njgin.state.nj.us).

Figure 4-1a

June 2007

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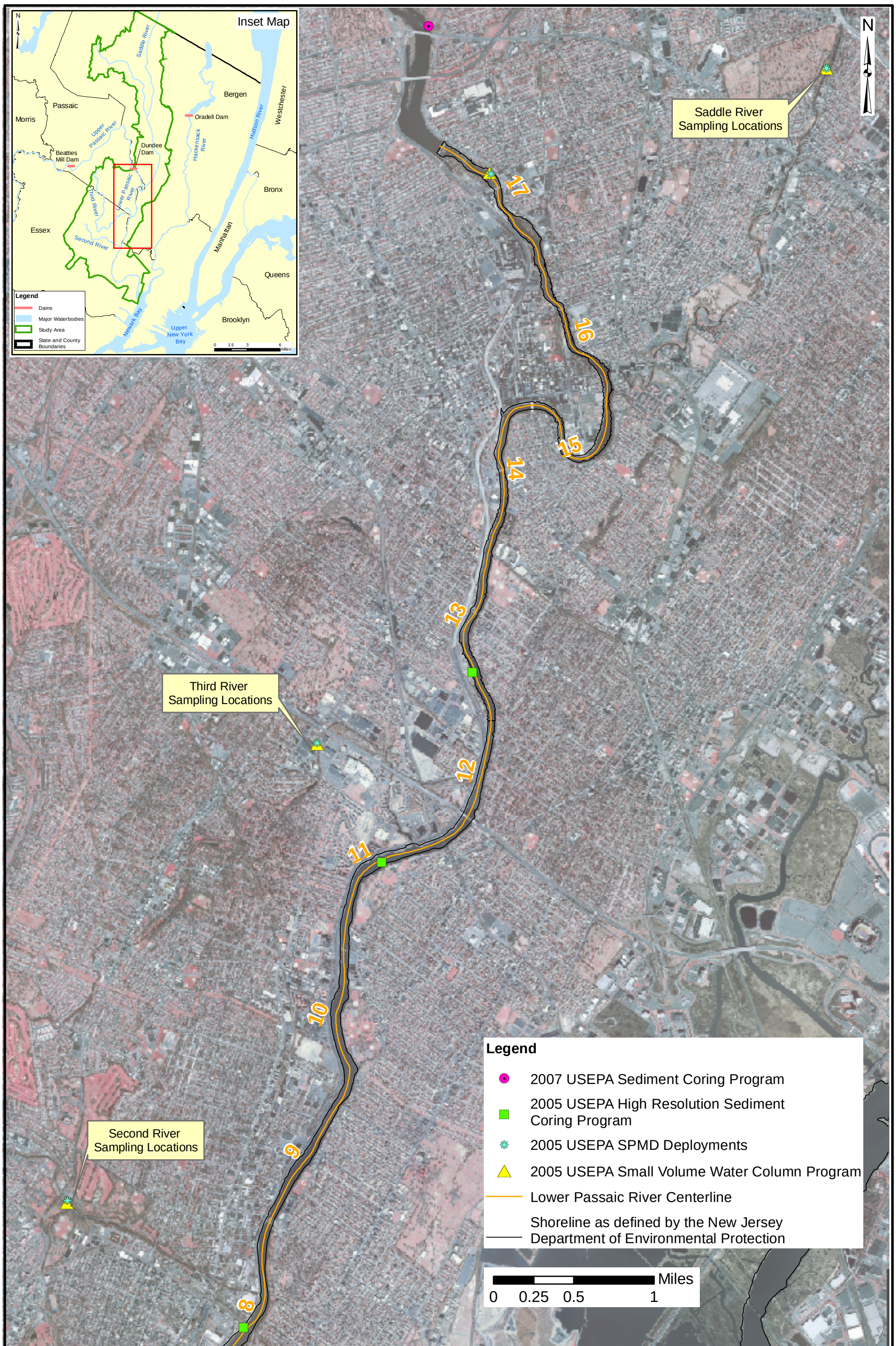

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US Army Corp of Engineers

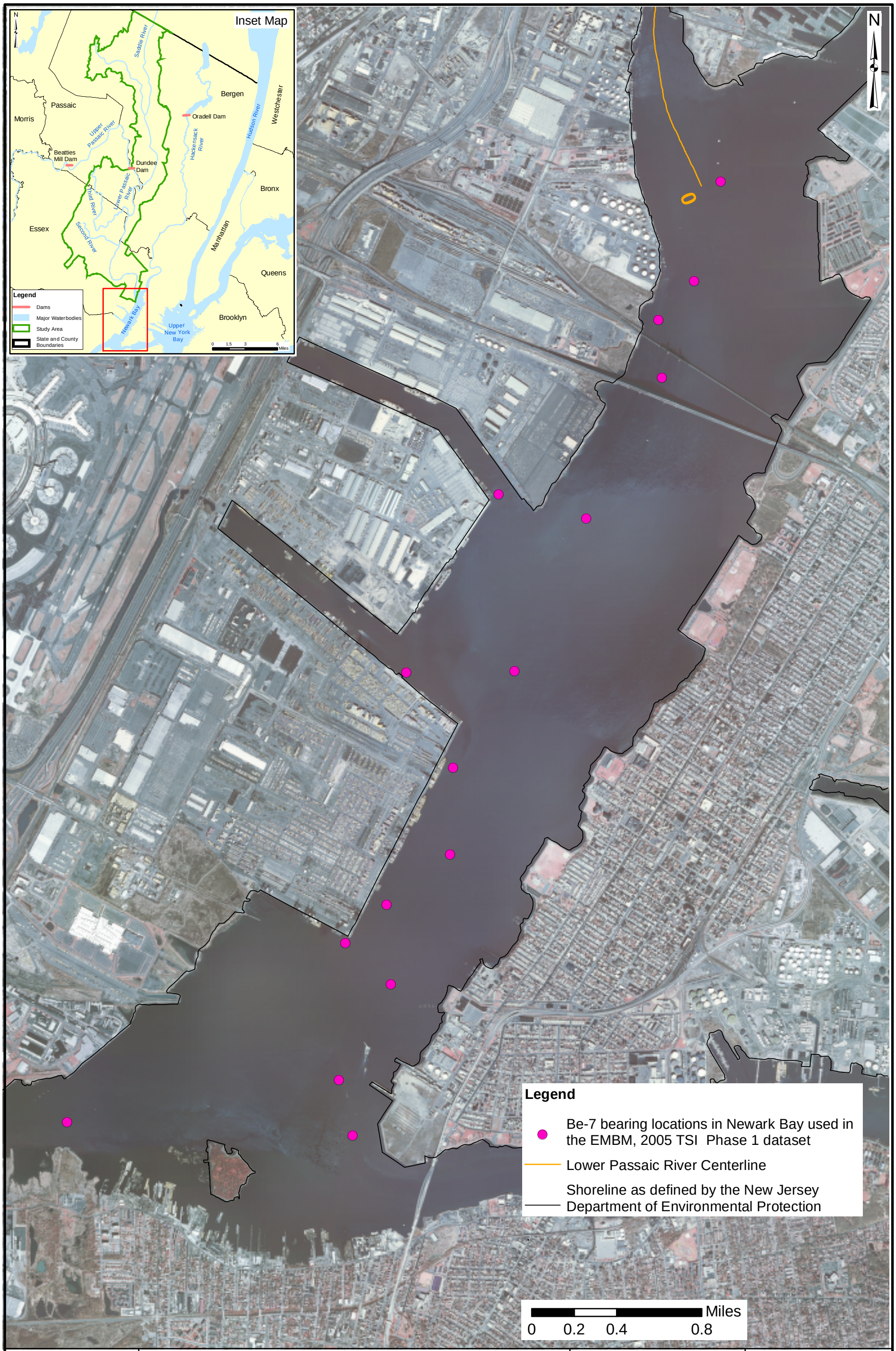
Locations of Passaic River Samples Used In the Mass Balance Model

Lower Passaic River Restoration Project

Data Source: 2002 Aerial photographs from the New Jersey State data clearing house (http://njgin.state.nj.us).

Figure 4-1b

June 2007



US Army Corp of Engineers

Locations of Newark Bay Samples Used In the Mass Balance Model

Lower Passaic River Restoration Project

Data Source: 2002 Aerial photographs from the New Jersey State data clearing house (http://njgin.state.nj.us).

Figure 4-1c

June 2007

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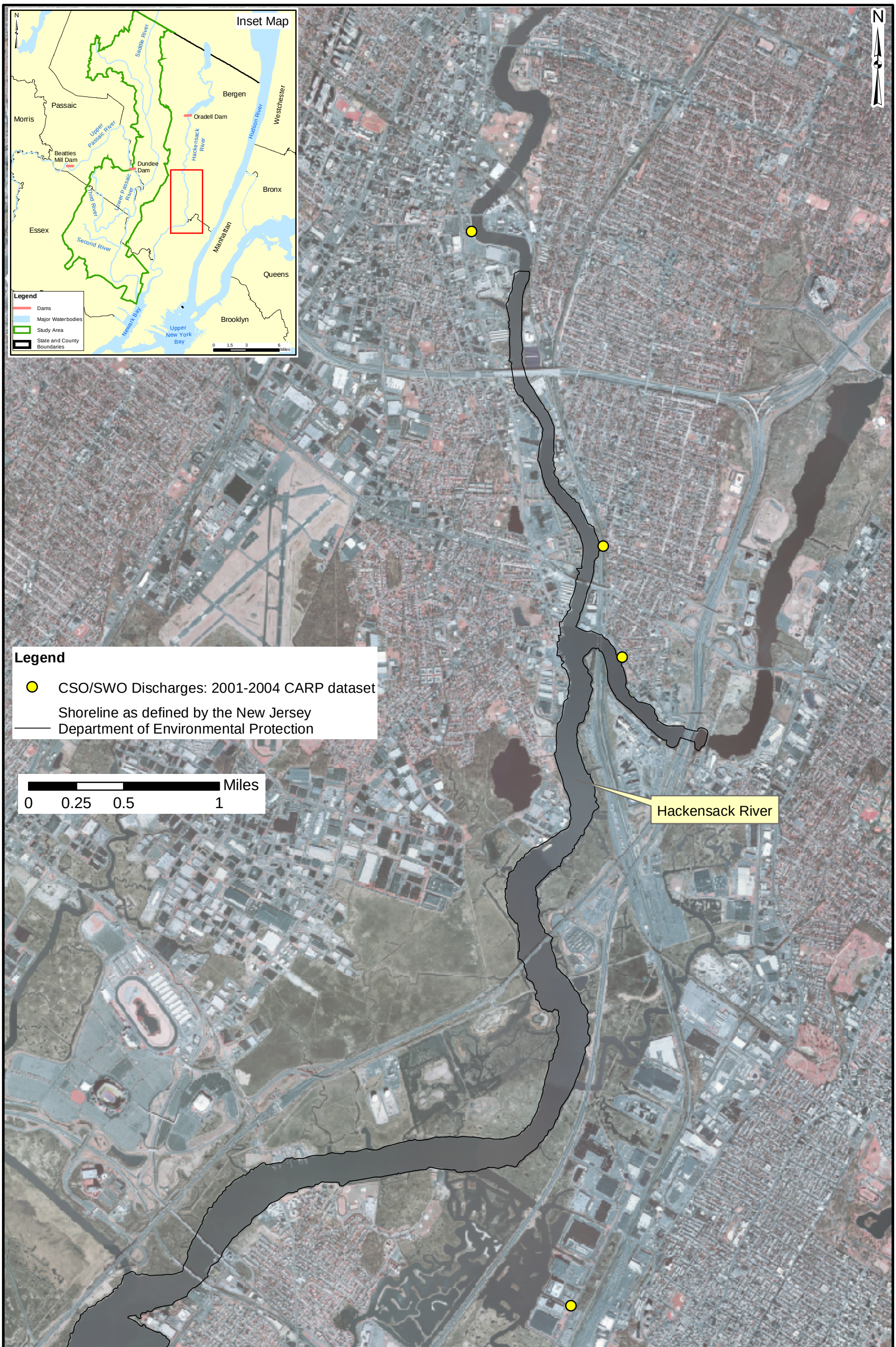

US Army Corp of Engineers

Locations of CSO/SWO Samples Used In the Mass Balance Model

Lower Passaic River Restoration Project

Data Source: 2002 Aerial photographs from the New Jersey State data clearing house (http://njgin.state.nj.us).

Figure 4-1d

June 2007

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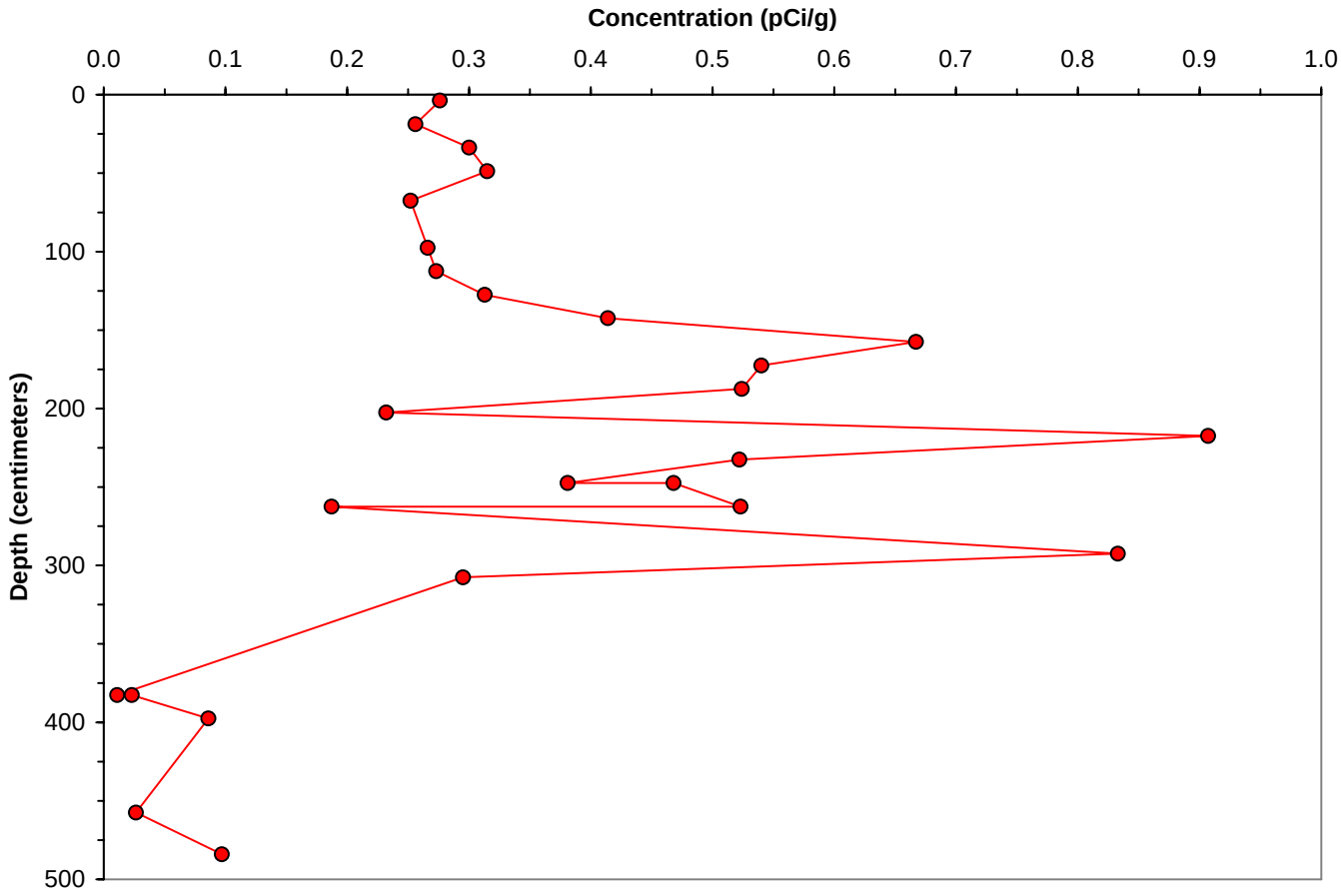


Legend

RM1.4

Notes

Nondetected values are plotted as half the reported detection limit.

pCi/g = picoCurie per gram of sediment

Data Source: USEPA 2005 High Resolution Sediment Core Program collected by Malcolm Pirnie, Inc.

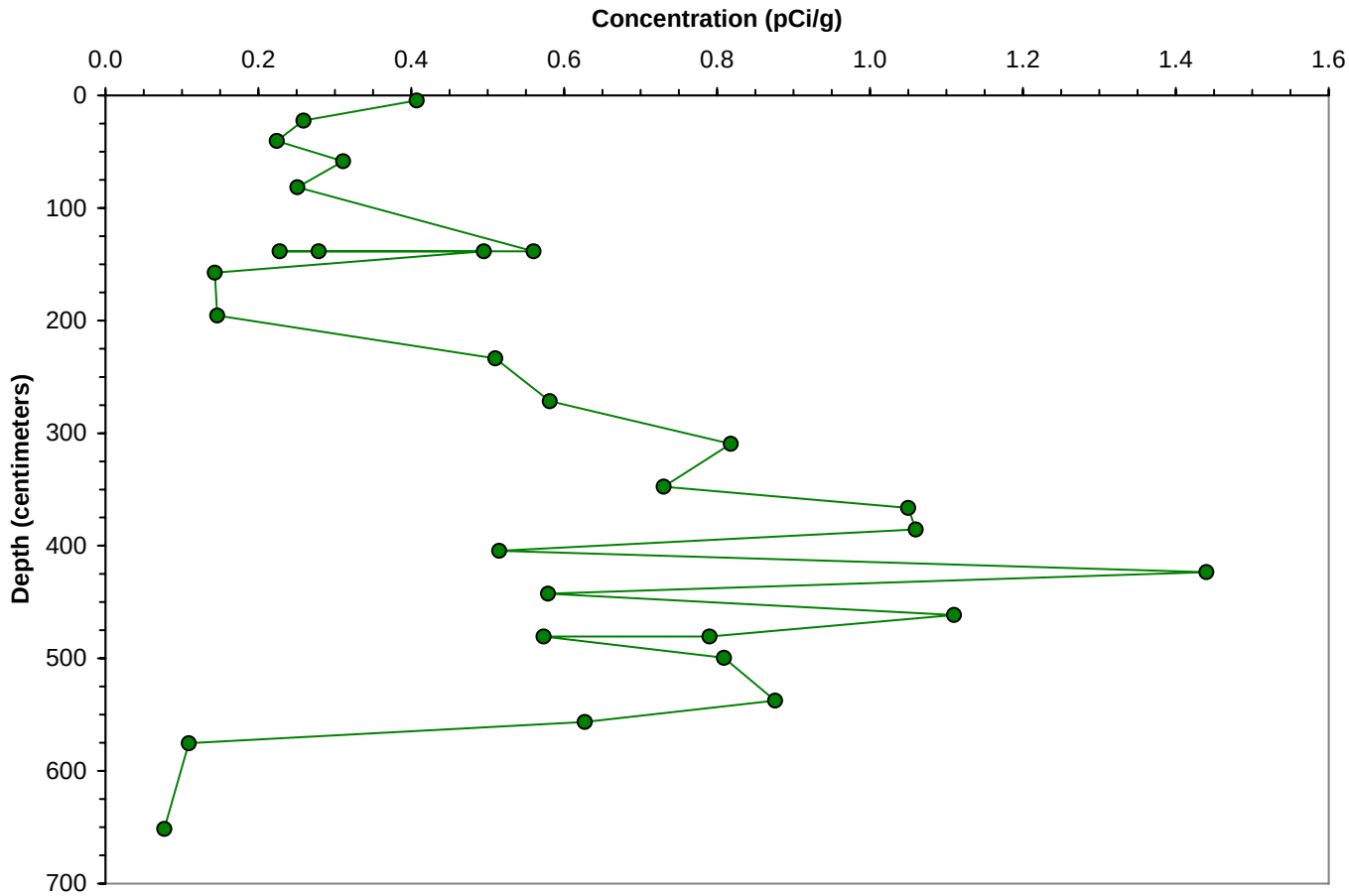
Downcore Profile for Cesium-137 Concentration:
Lower Passaic River High Resolution Sediment Core at RM1.4

Lower Passaic River Restoration Project

Figure 4-2a

June 2007

R2-0010087



Legend

RM2.2

Notes

Nondetected values are plotted as half the reported detection limit.

pCi/g = picoCurie per gram of sediment

Data Source: USEPA 2005 High Resolution Sediment Core Program collected by Malcolm Pirnie, Inc.

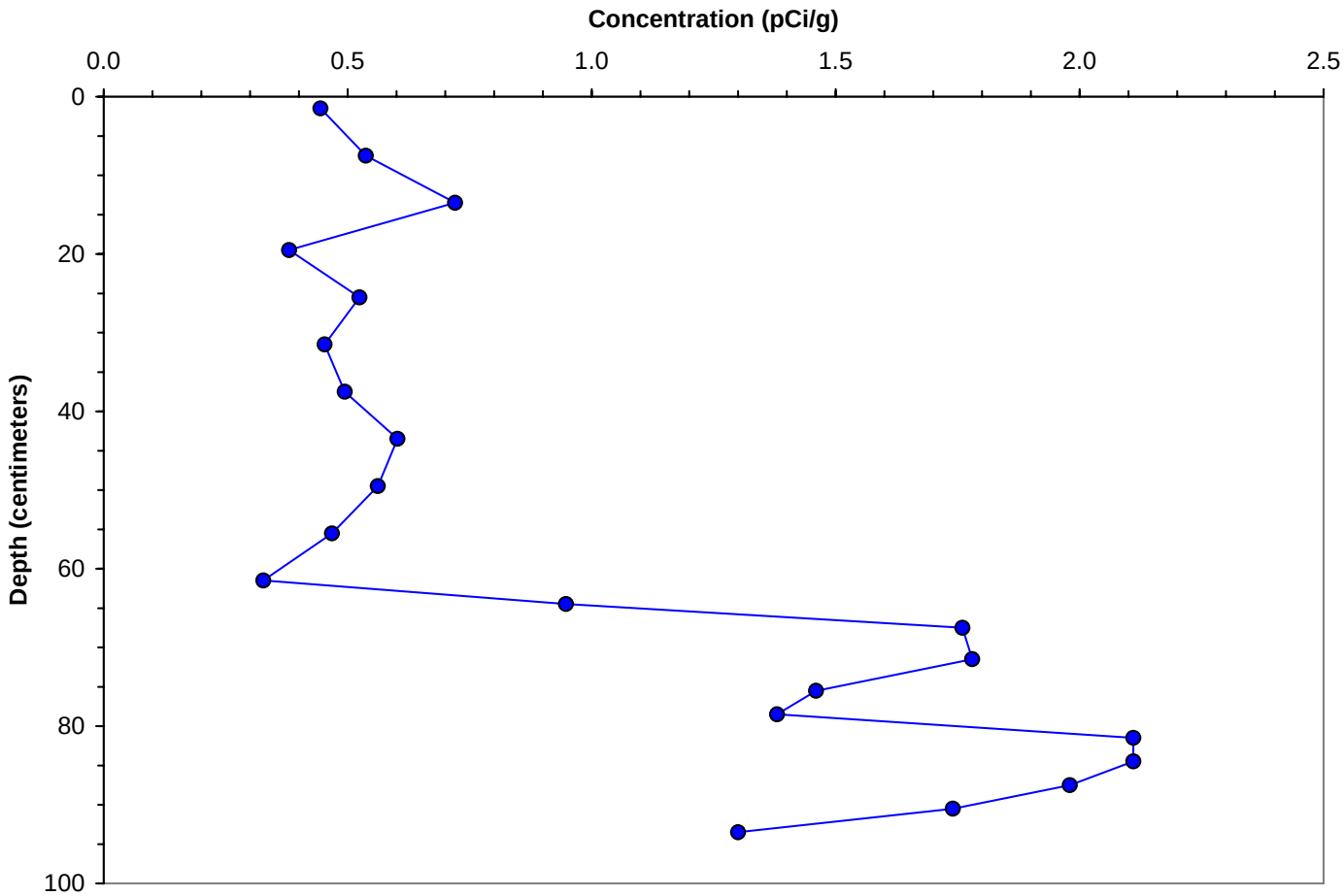
Downcore Profile for Cesium-137 Concentration:
Lower Passaic River High Resolution Sediment Core at RM2.2

Lower Passaic River Restoration Project

Figure 4-2b

June 2007

R2-0010088



Legend

RM7.8

Notes

Nondetected values are plotted as half the reported detection limit.

pCi/g = picoCurie per gram of sediment

Data Source: USEPA 2005 High Resolution Sediment Core Program collected by Malcolm Pirnie, Inc.

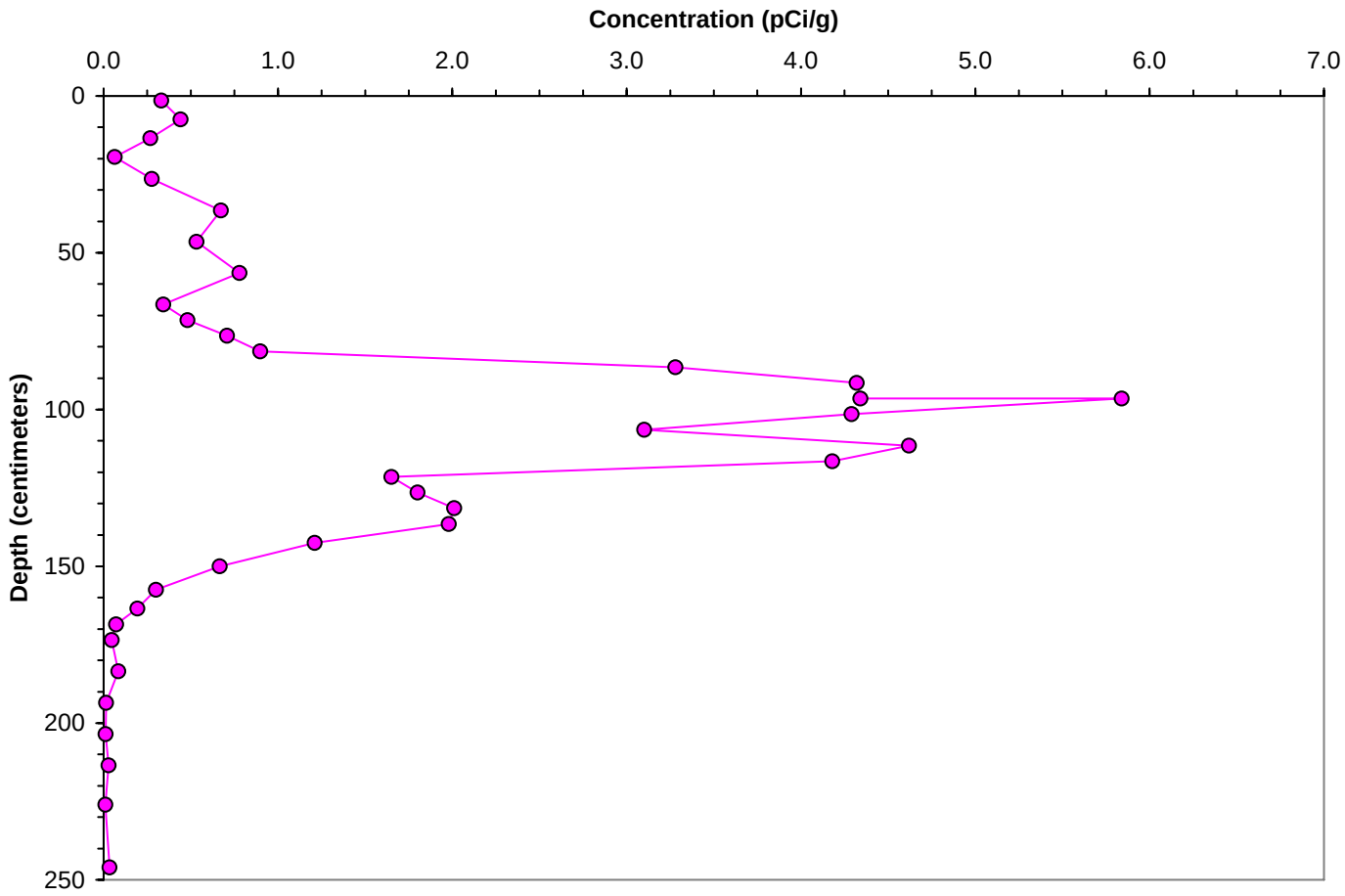
Downcore Profile for Cesium-137 Concentration:
Lower Passaic River High Resolution Sediment Core at RM7.8

Lower Passaic River Restoration Project

Figure 4-2c

June 2007

R2-0010089



Legend

RM11

Notes

Nondetected values are plotted as half the reported detection limit.

pCi/g = picoCurie per gram of sediment

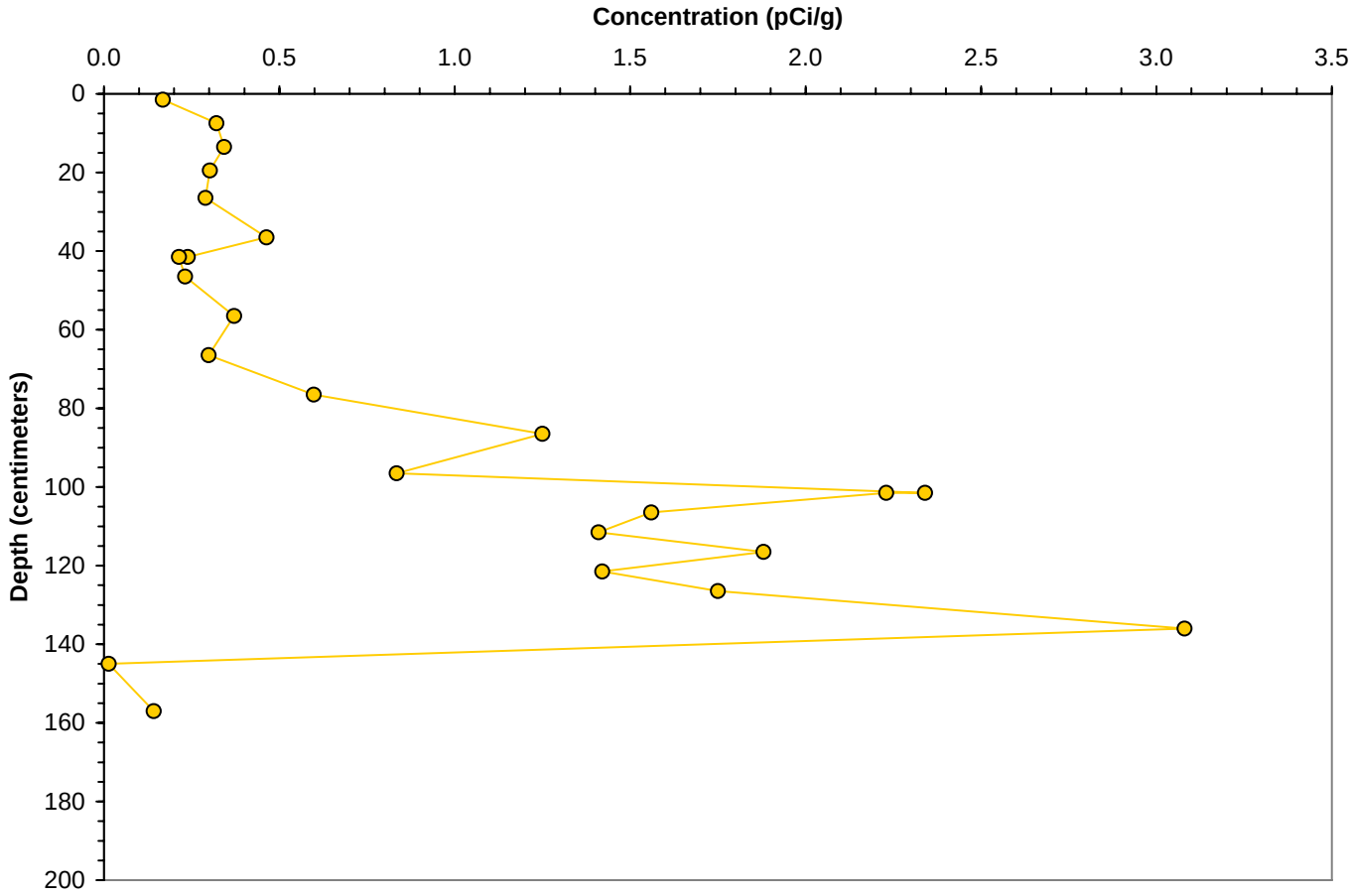
Data Source: USEPA 2005 High Resolution Sediment Core Program collected by Malcolm Pirnie, Inc.

Downcore Profile for Cesium-137 Concentration:
Lower Passaic River High Resolution Sediment Core at RM11

Lower Passaic River Restoration Project

Figure 4-2d

June 2007



Legend

RM12.6

Notes

Nondetected values are plotted as half the reported detection limit.

pCi/g = picoCurie per gram of sediment

Data Source: USEPA 2005 High Resolution Sediment Core Program collected by Malcolm Pirnie, Inc.

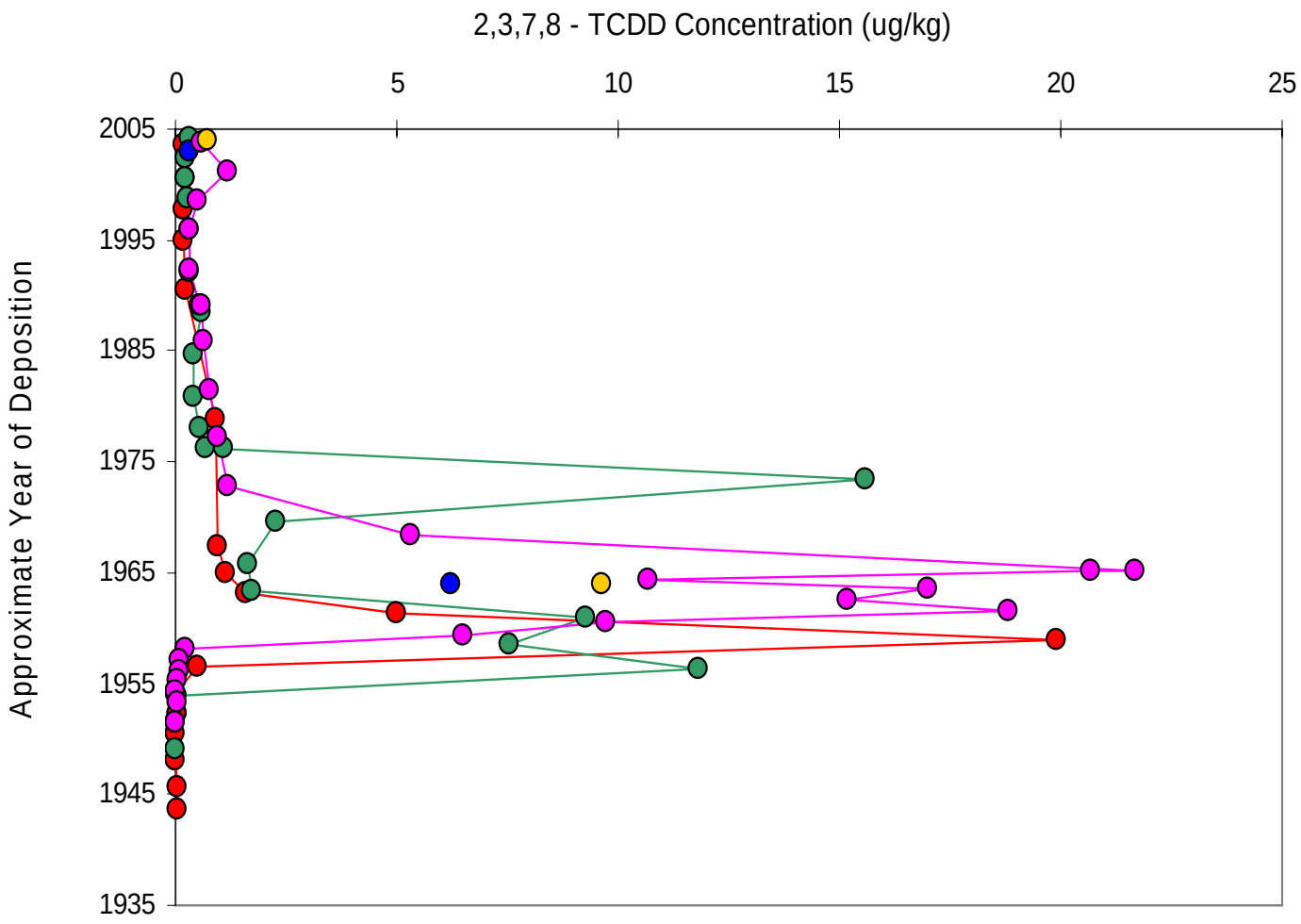
Downcore Profile for Cesium-137 Concentration:
Lower Passaic River High Resolution Sediment Core at RM12.6

Lower Passaic River Restoration Project

Figure 4-2e

June 2007

R2-0010091



Legend

- RM1.4
- RM2.2
- RM7.8
- RM11
- RM12.6

Notes

Nondetect concentrations plotted as zero.

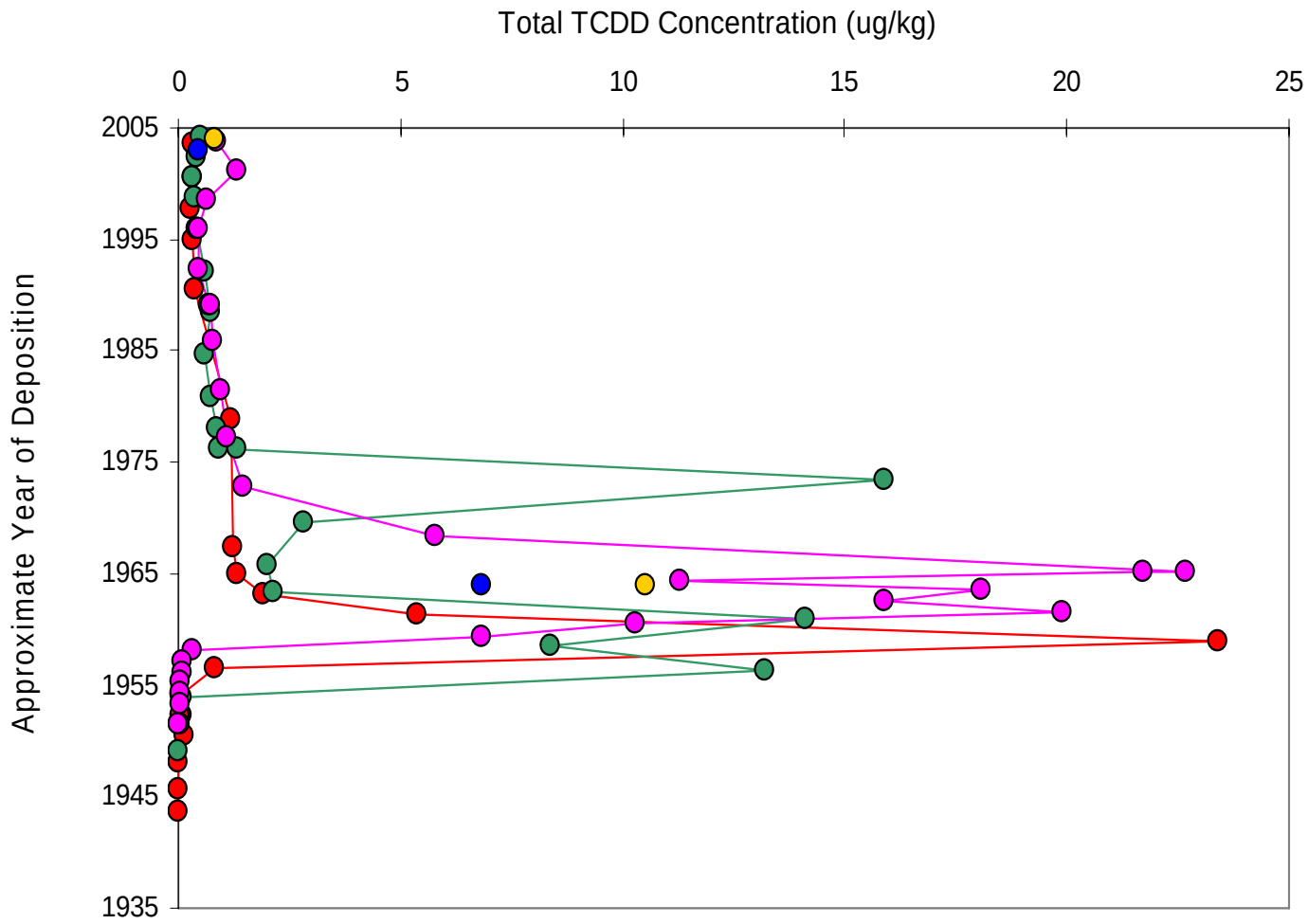
Data source: USEPA 2005 High Resolution Sediment Coring Program collected by Malcolm Pirnie, Inc.

Dated Sediment Core Profile for 2,3,7,8-TCDD Concentration of Lower Passaic River High Resolution Sediment Cores

Lower Passaic River Restoration Project

Figure 4-3a

June 2007



Legend

- RM1.4
- RM2.2
- RM7.8
- RM11
- RM12.6

Notes

Nondetect concentrations plotted as zero.

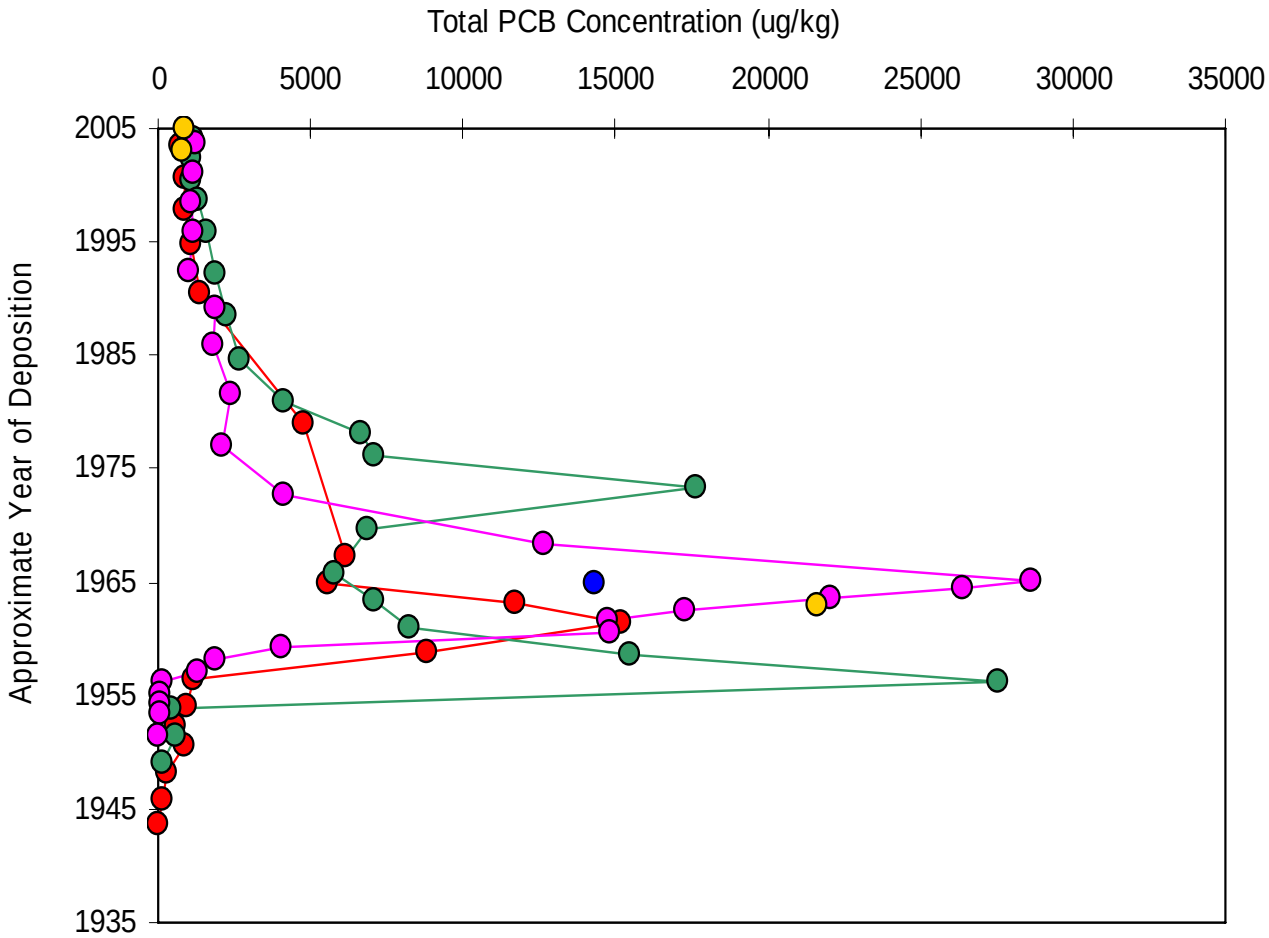
Data source: USEPA 2005 High Resolution Sediment Coring Program collected by Malcolm Pirnie, Inc.

Dated Sediment Core Profile for Total TCDD Concentration of Lower Passaic River High Resolution Sediment Cores

Lower Passaic River Restoration Project

Figure 4-3b

June 2007



Legend

- RM1.4
- RM2.2
- RM7.8
- RM11
- RM12.6

Notes

Total PCB equals sum of 209 congeners with nondetected PCB congener concentrations equal to zero.

Nondetect concentrations plotted as zero.

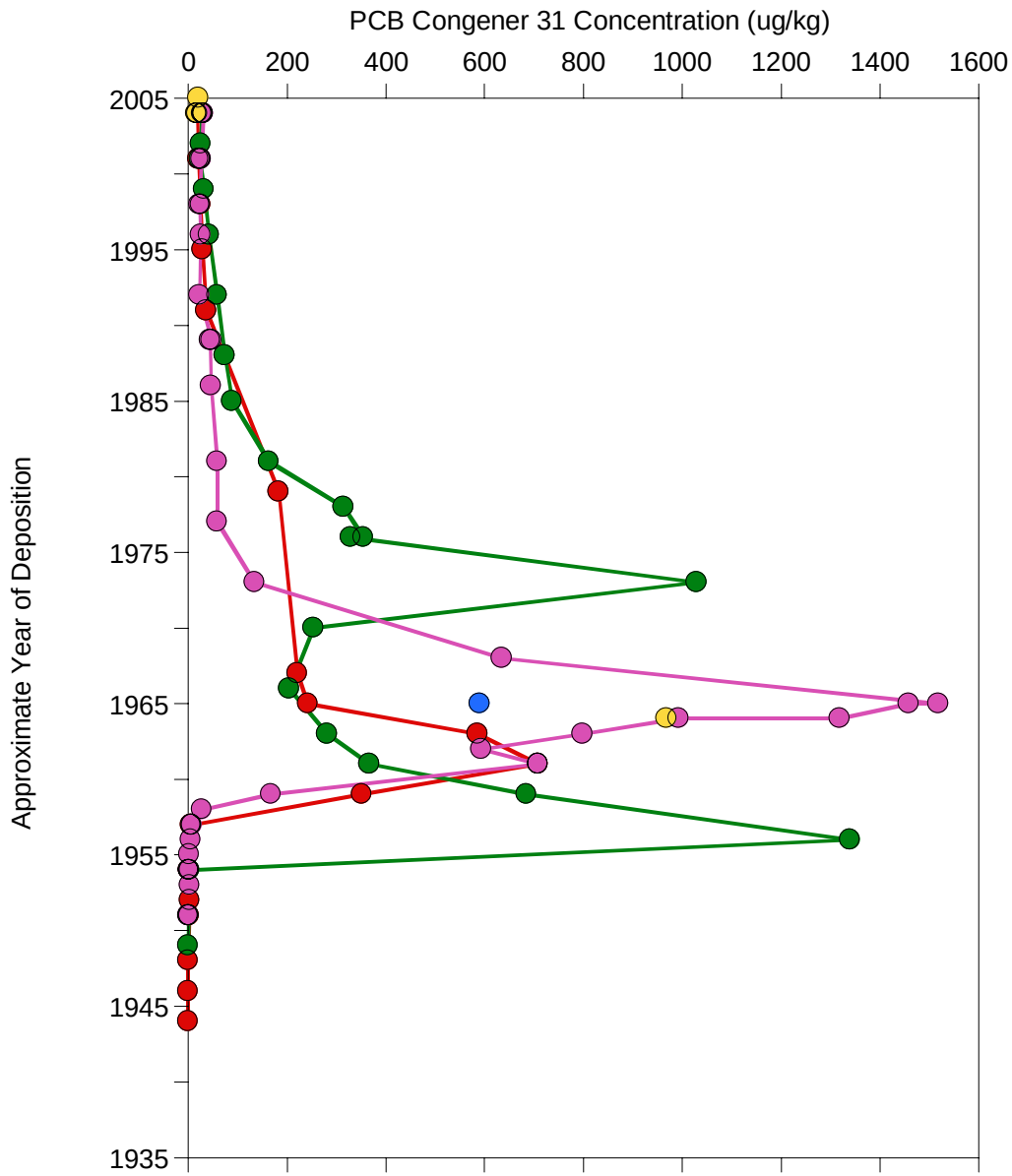
Data source: USEPA 2005 High Resolution Sediment Coring Program collected by Malcolm Pirnie, Inc.

Dated Sediment Core Profile for Total PCB Concentration of Lower Passaic River High Resolution Sediment Cores

Lower Passaic River Restoration Project

Figure 4-3c

June 2007



Legend

- RM1.4
- RM2.2
- RM7.8
- RM11
- RM12.6

Notes

Nondetect concentrations plotted as zero.

Data source: USEPA 2005 High Resolution Sediment Coring Program collected by Malcolm Pirnie, Inc.

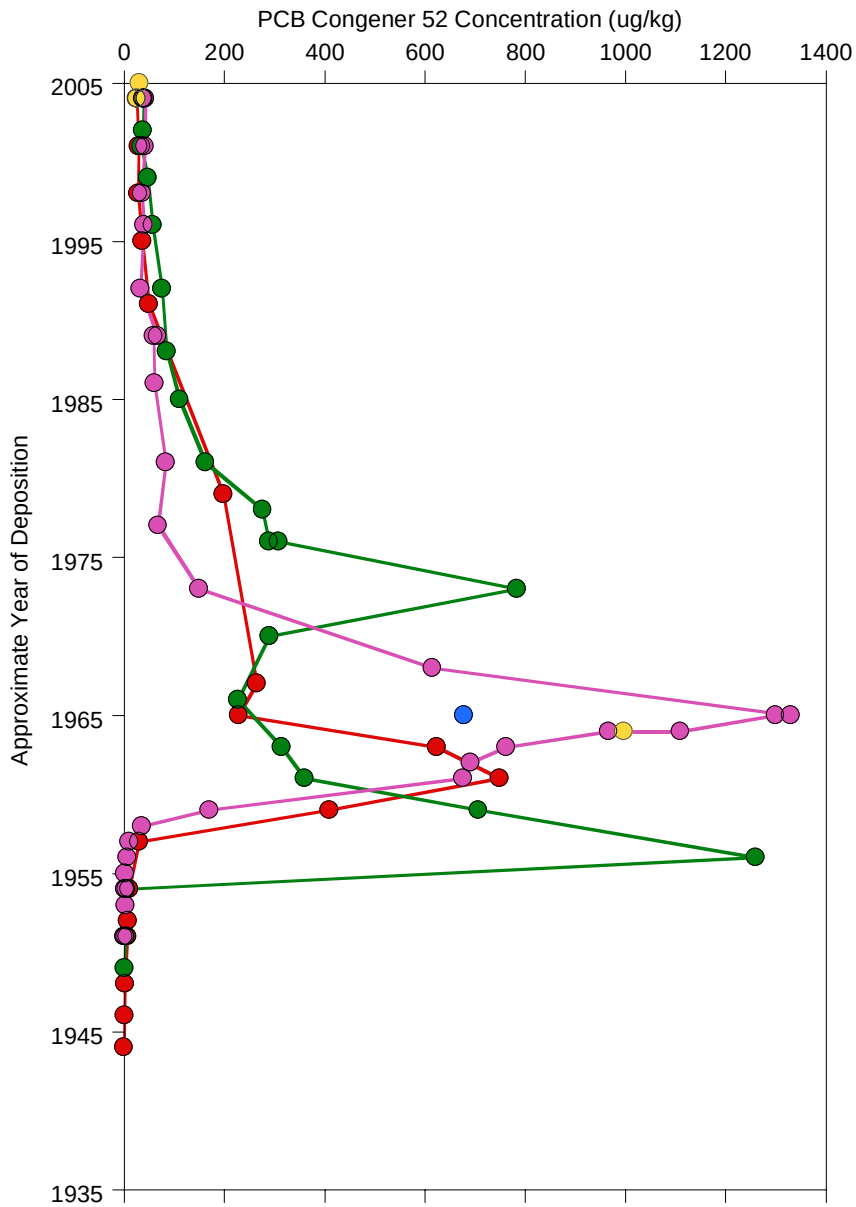
Dated Sediment Core Profile for PCB Congener 31 Concentration of Lower Passaic River High Resolution Sediment Cores

Lower Passaic River Restoration Project

Figure 4-3d

June 2007

R2-0010095



Legend

- RM1.4
- RM2.2
- RM7.8
- RM11
- RM12.6

Notes

Nondetect concentrations plotted as zero.

Data source: USEPA 2005 High Resolution Sediment Coring Program collected by Malcolm Pirnie, Inc.

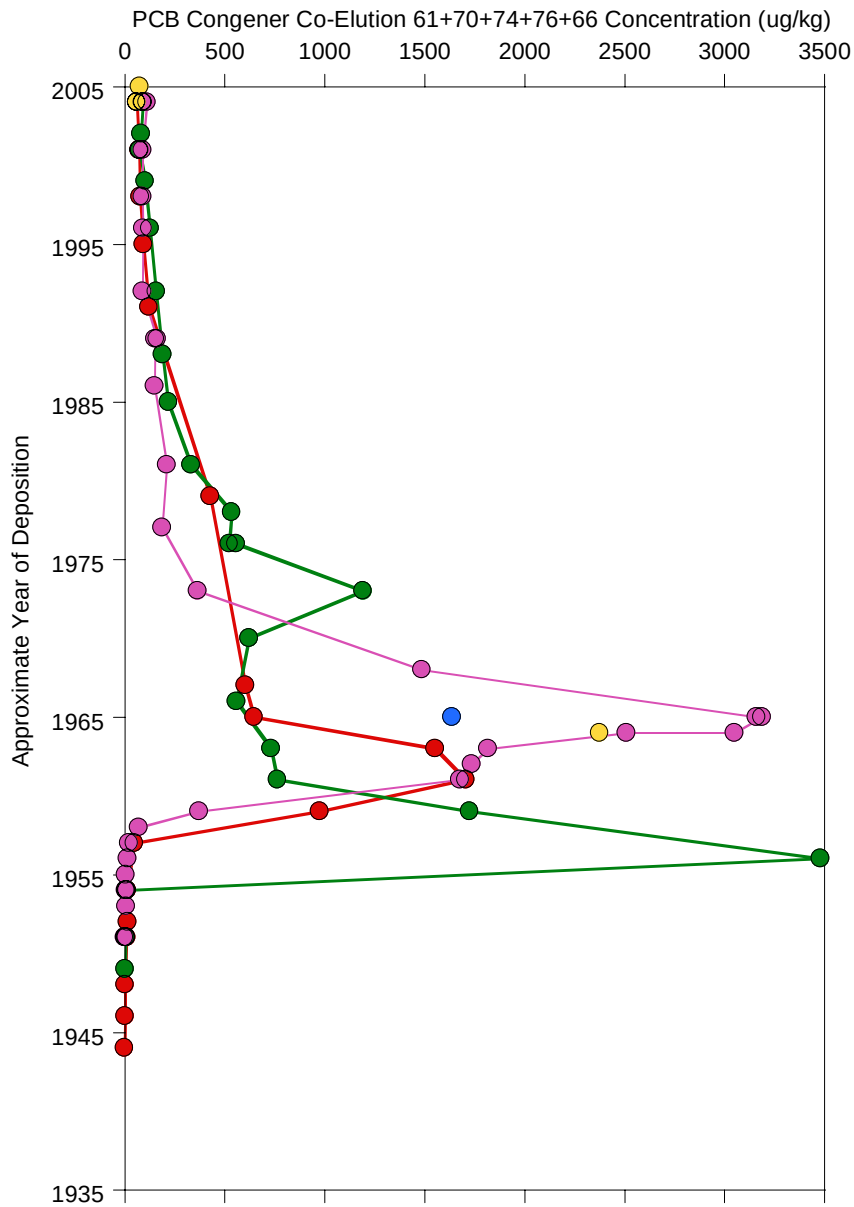
Dated Sediment Core Profile for PCB Congener 52 Concentration of Lower Passaic River High Resolution Sediment Cores

Lower Passaic River Restoration Project

Figure 4-3e

June 2007

R2-0010096



Legend

- RM1.4
- RM2.2
- RM7.8
- RM11
- RM12.6

Notes

Nondetect concentrations plotted as zero.

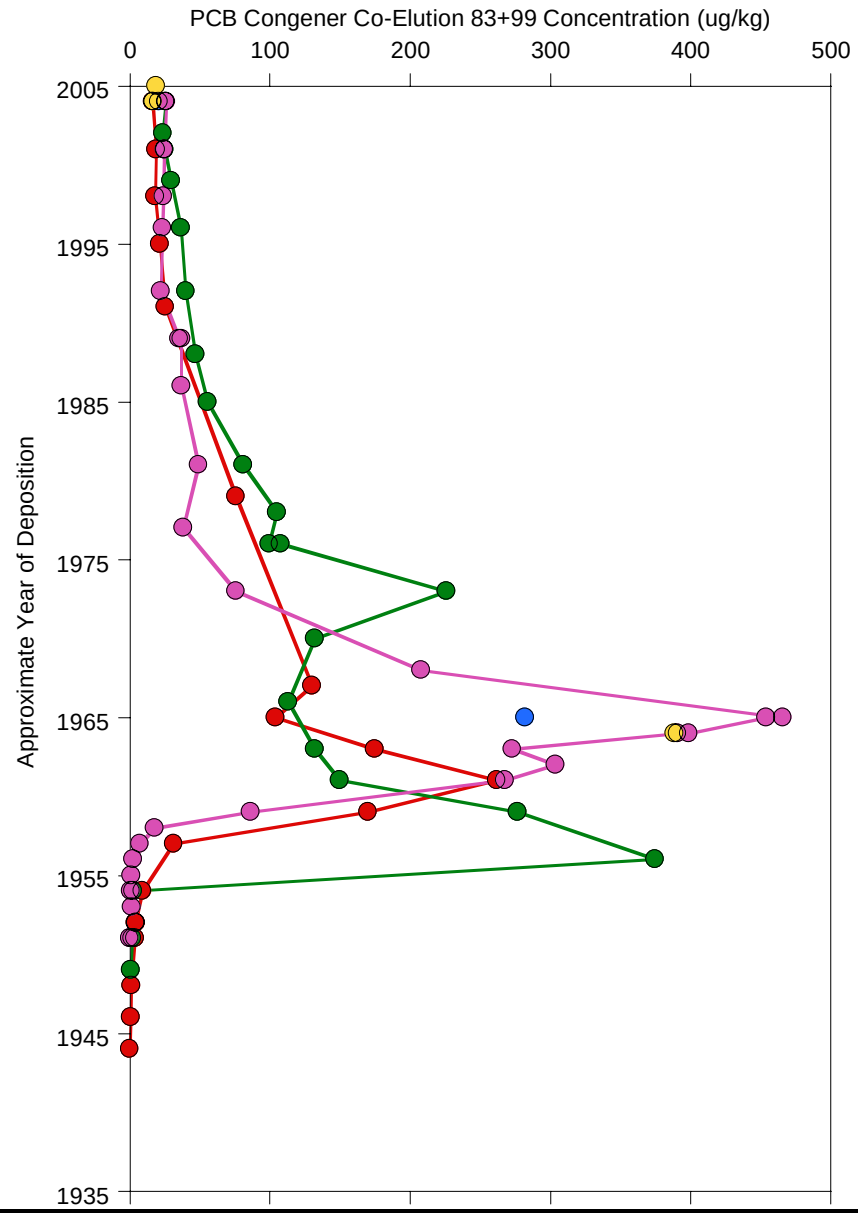
Data source: USEPA 2005 High Resolution Sediment Coring Program collected by Malcolm Pirnie, Inc.

Dated Sediment Core Profile for PCB Congener Co-elution 61+70+74+76+66 Concentration of Lower Passaic River High Resolution Sediment Cores

Lower Passaic River Restoration Project

Figure 4-3f

June 2007



Legend

- RM1.4
- RM2.2
- RM7.8
- RM11
- RM12.6

Notes

Nondetect concentrations plotted as zero.

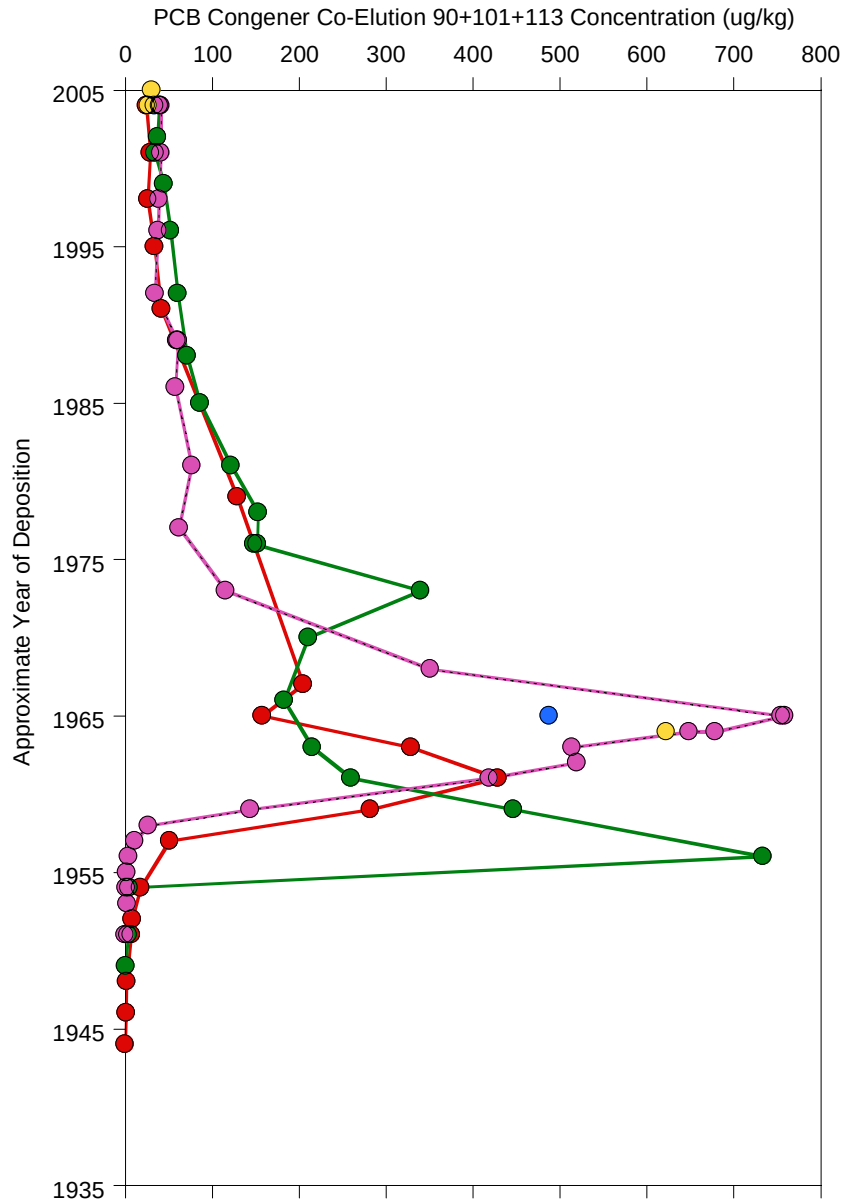
Data source: USEPA 2005 High Resolution Sediment Coring Program collected by Malcolm Pirnie, Inc.

Dated Sediment Core Profile for PCB Congener Co-elution 83+99 Concentration of Lower Passaic River High Resolution Sediment Cores

Lower Passaic River Restoration Project

Figure 4-3g

June 2007



Legend

- RM1.4
- RM2.2
- RM7.8
- RM11
- RM12.6

Notes

Nondetect concentrations plotted as zero.

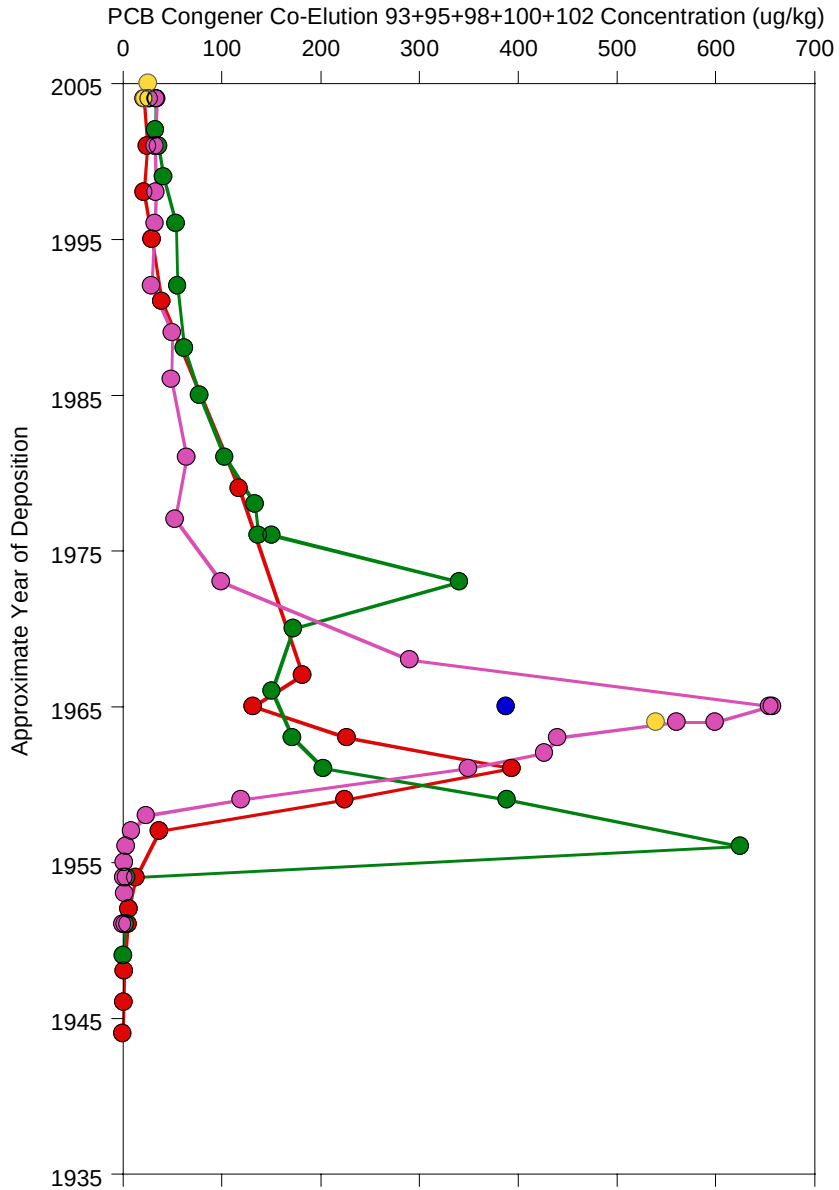
Data source: USEPA 2005 High Resolution Sediment Coring Program collected by Malcolm Pirnie, Inc.

Dated Sediment Core Profile for PCB Congener Co-elution 90+101+113 Concentration of Lower Passaic River High Resolution Sediment Cores

Lower Passaic River Restoration Project

Figure 4-3h

June 2007



Legend

- RM1.4
- RM2.2
- RM7.8
- RM11
- RM12.6

Notes

Nondetect concentrations plotted as zero.

Data source: USEPA 2005 High Resolution Sediment Coring Program collected by Malcolm Pirnie, Inc.

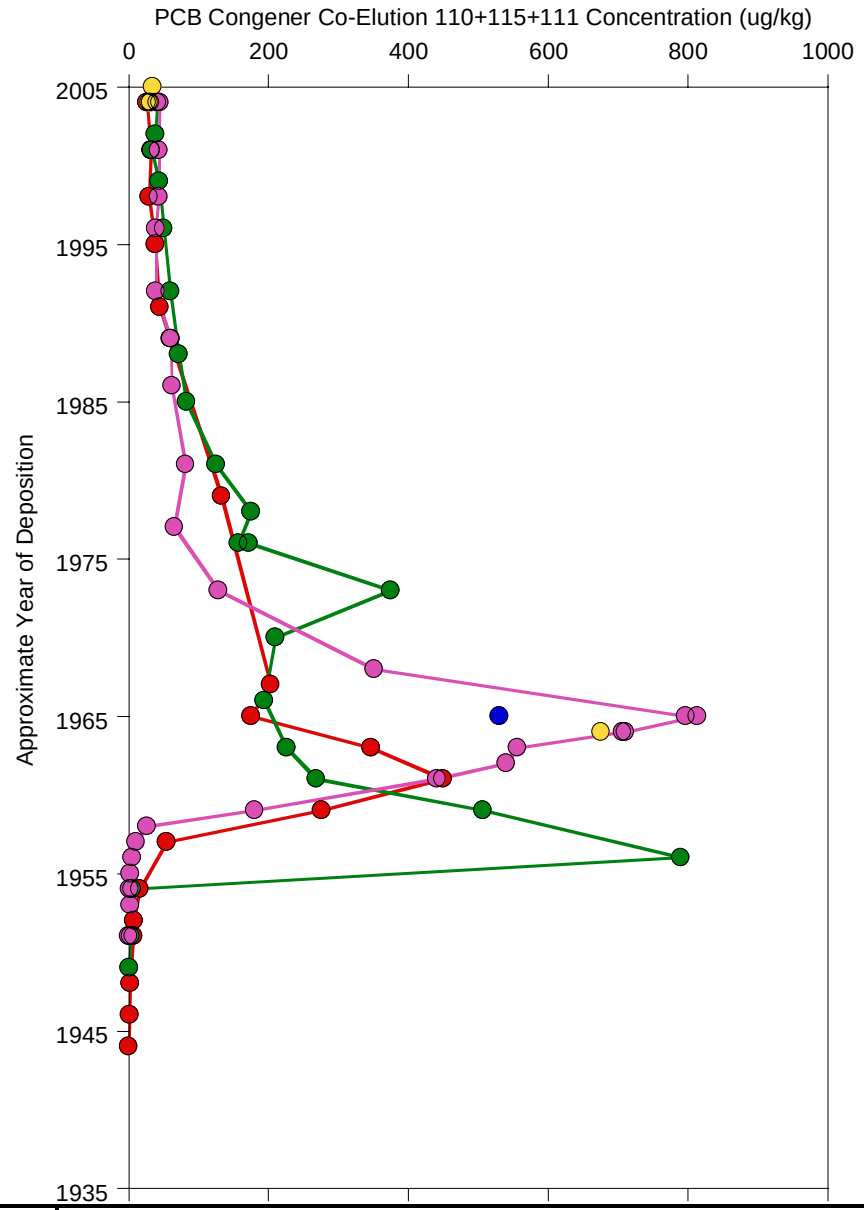
Dated Sediment Core Profile for PCB Congener Co-elution 93+95+98+100+102 Concentration of Lower Passaic River High Resolution Sediment Cores

Lower Passaic River Restoration Project

Figure 4-3i

June 2007

R2-0010100



Legend

- RM1.4
- RM2.2
- RM7.8
- RM11
- RM12.6

Notes

Nondetect concentrations plotted as zero.

Data source: USEPA 2005 High Resolution Sediment Coring Program collected by Malcolm Pirnie, Inc.

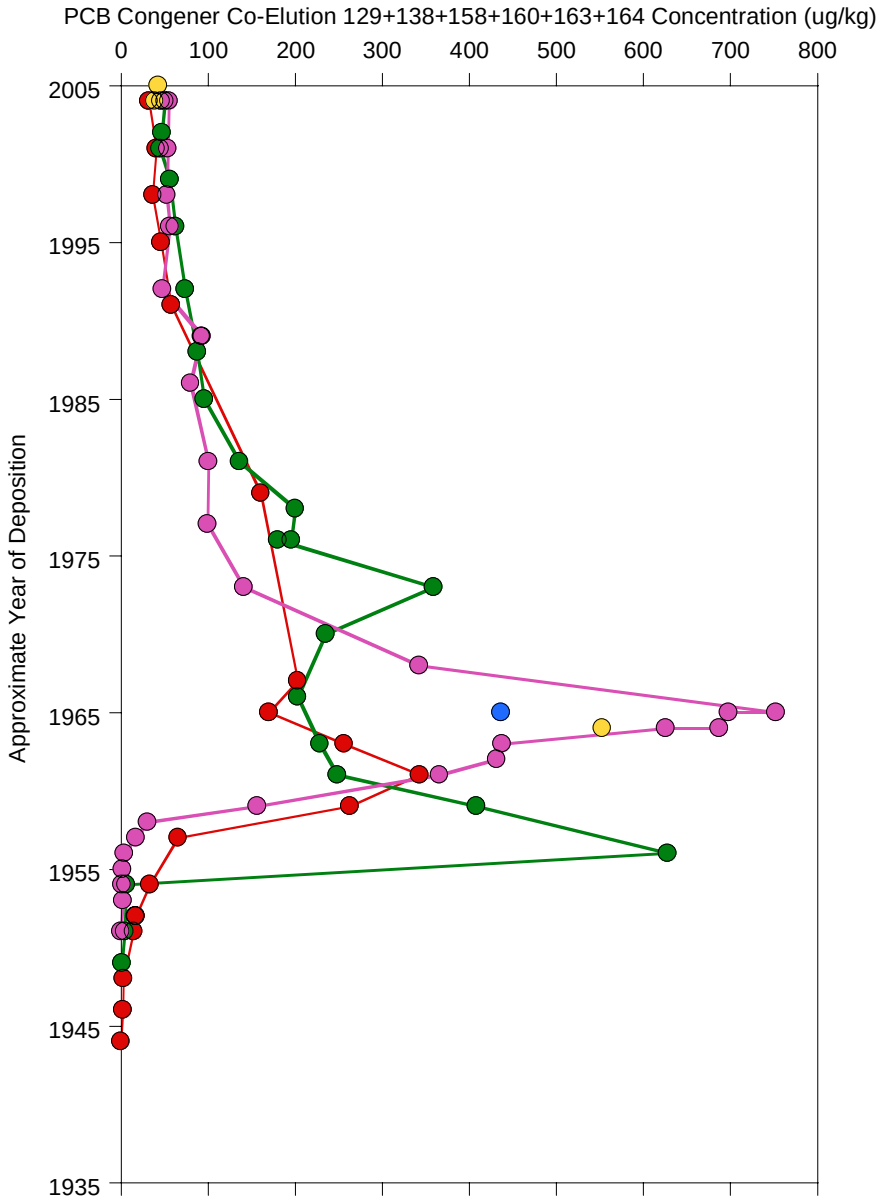
Dated Sediment Core Profile for PCB Congener Co-elution 110+115+111 Concentration of Lower Passaic River High Resolution Sediment Cores

Lower Passaic River Restoration Project

Figure 4-3j

June 2007

R2-0010101



Legend

- RM1.4
- RM2.2
- RM7.8
- RM11
- RM12.6

Notes

Nondetect concentrations plotted as zero.

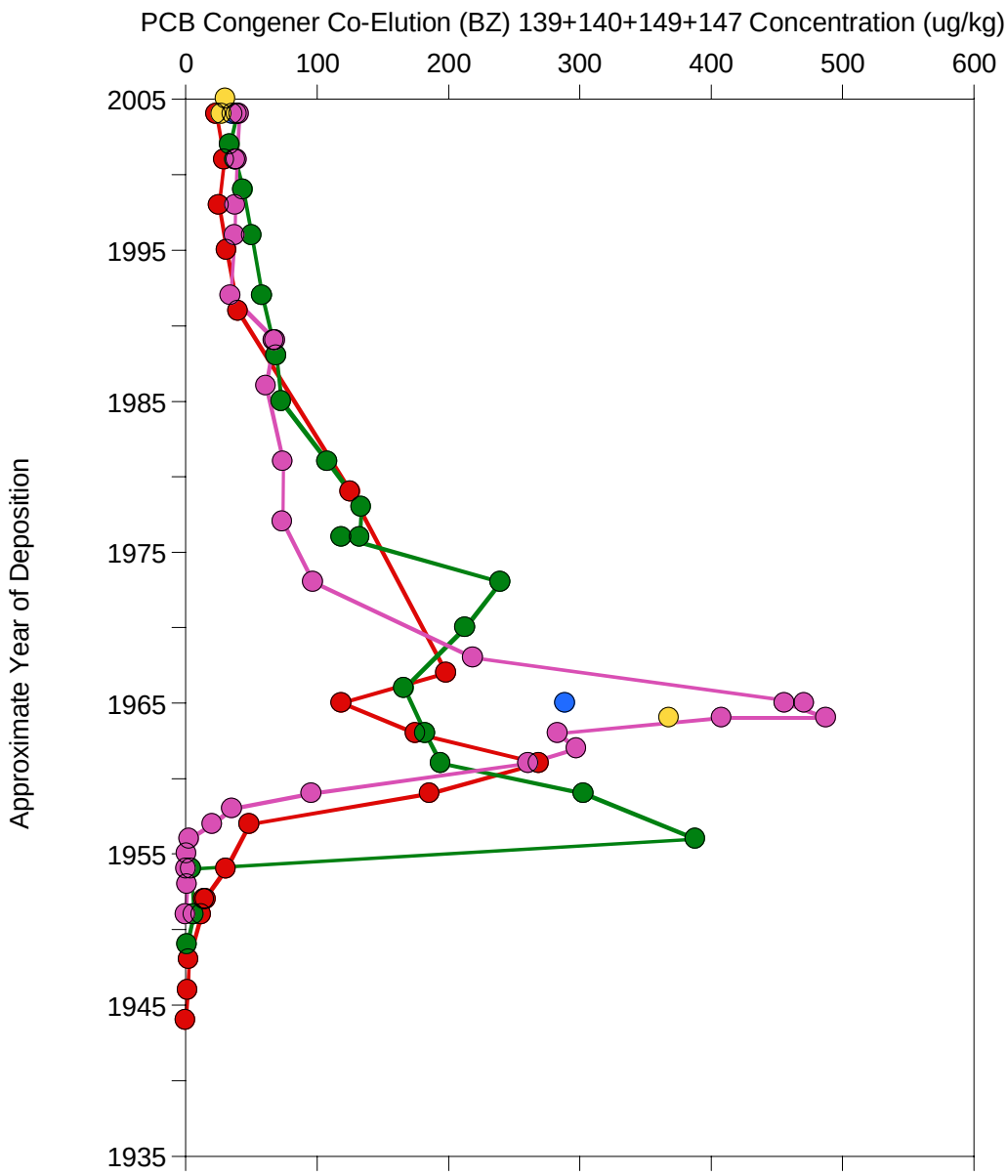
Data source: USEPA 2005 High Resolution Sediment Coring Program collected by Malcolm Pirnie, Inc.

Dated Sediment Core Profile for PCB Congener Co-elution 129+138+158+160+163+164 Concentration of Lower Passaic River High Resolution Sediment Cores

Lower Passaic River Restoration Project

Figure 4-3k

June 2007



Legend

- RM1.4
- RM2.2
- RM7.8
- RM11
- RM12.6

Notes

Nondetect concentrations plotted as zero.

Data source: USEPA 2005 High Resolution Sediment Coring Program collected by Malcolm Pirnie, Inc.

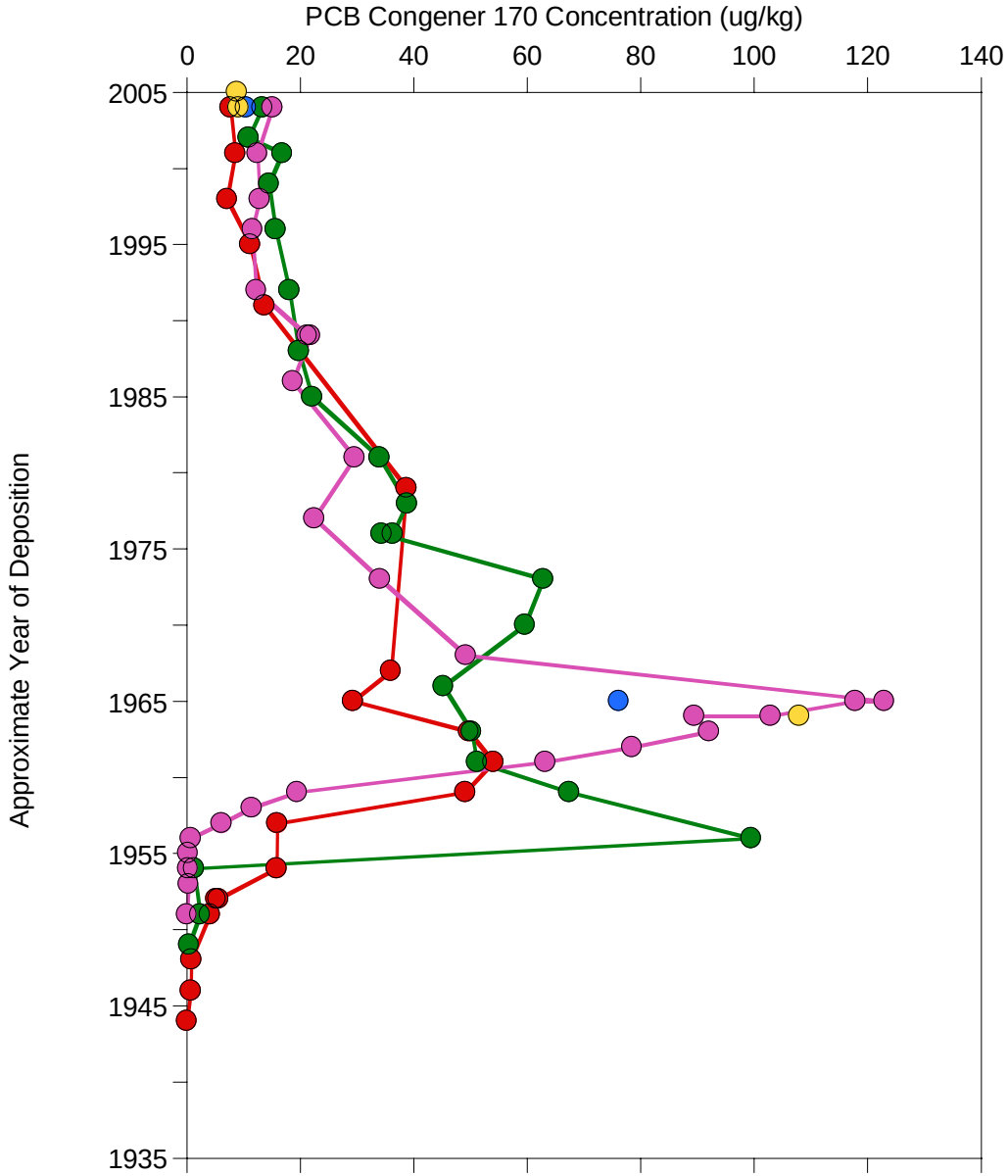
Dated Sediment Core Profile for PCB Congener Co-elution 139+140+149+147 Concentration of Lower Passaic River High Resolution Sediment Cores

Lower Passaic River Restoration Project

Figure 4-3l

June 2007

R2-0010103



Legend

- RM1.4
- RM2.2
- RM7.8
- RM11
- RM12.6

Notes

Nondetect concentrations plotted as zero.

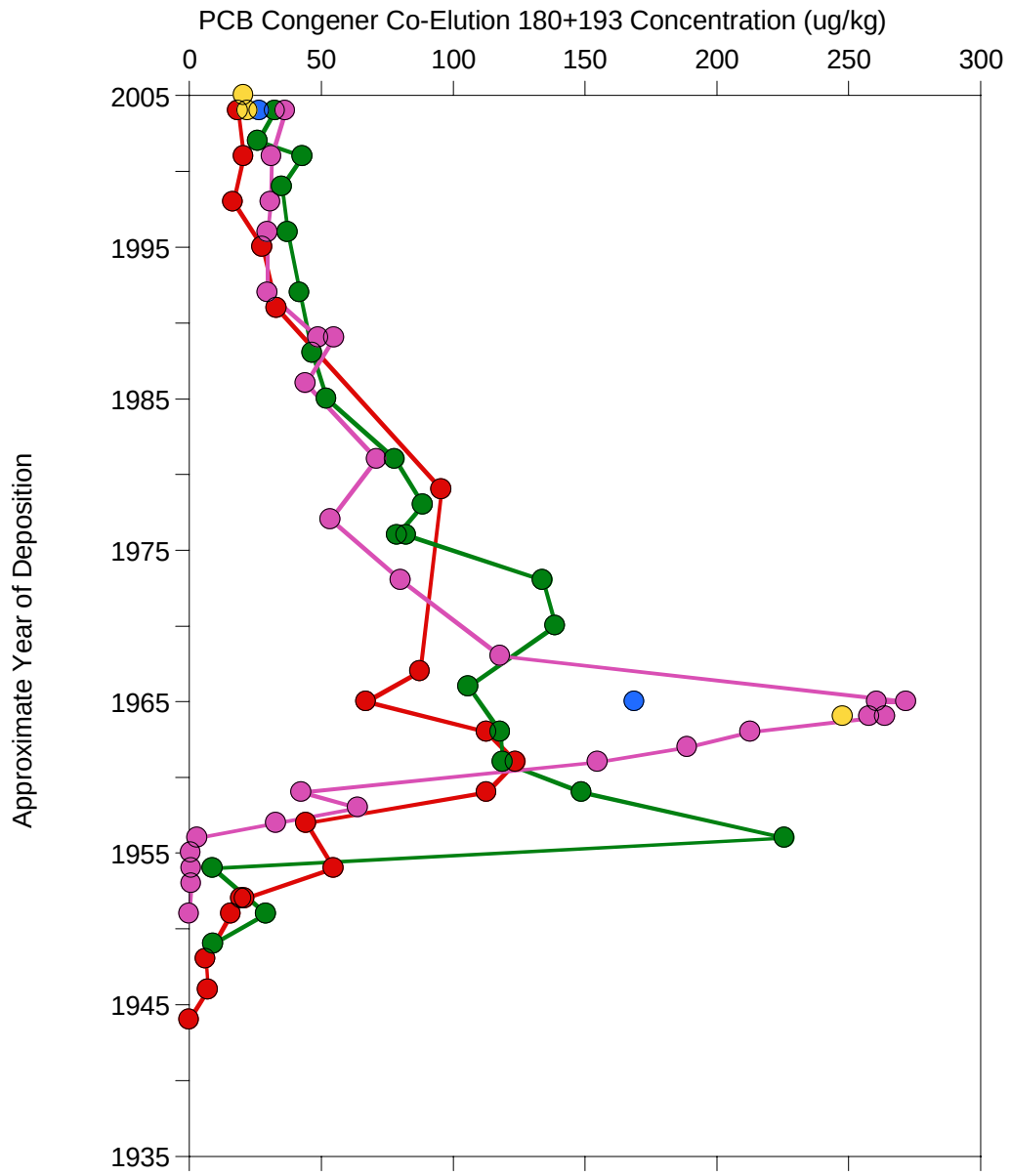
Data source: USEPA 2005 High Resolution Sediment Coring Program collected by Malcolm Pirnie, Inc.

Dated Sediment Core Profile for PCB Congener 170 Concentration of Lower Passaic River High Resolution Sediment Cores

Lower Passaic River Restoration Project

Figure 4-3m

June 2007



Legend

- RM1.4
- RM2.2
- RM7.8
- RM11
- RM12.6

Notes

Nondetect concentrations plotted as zero.

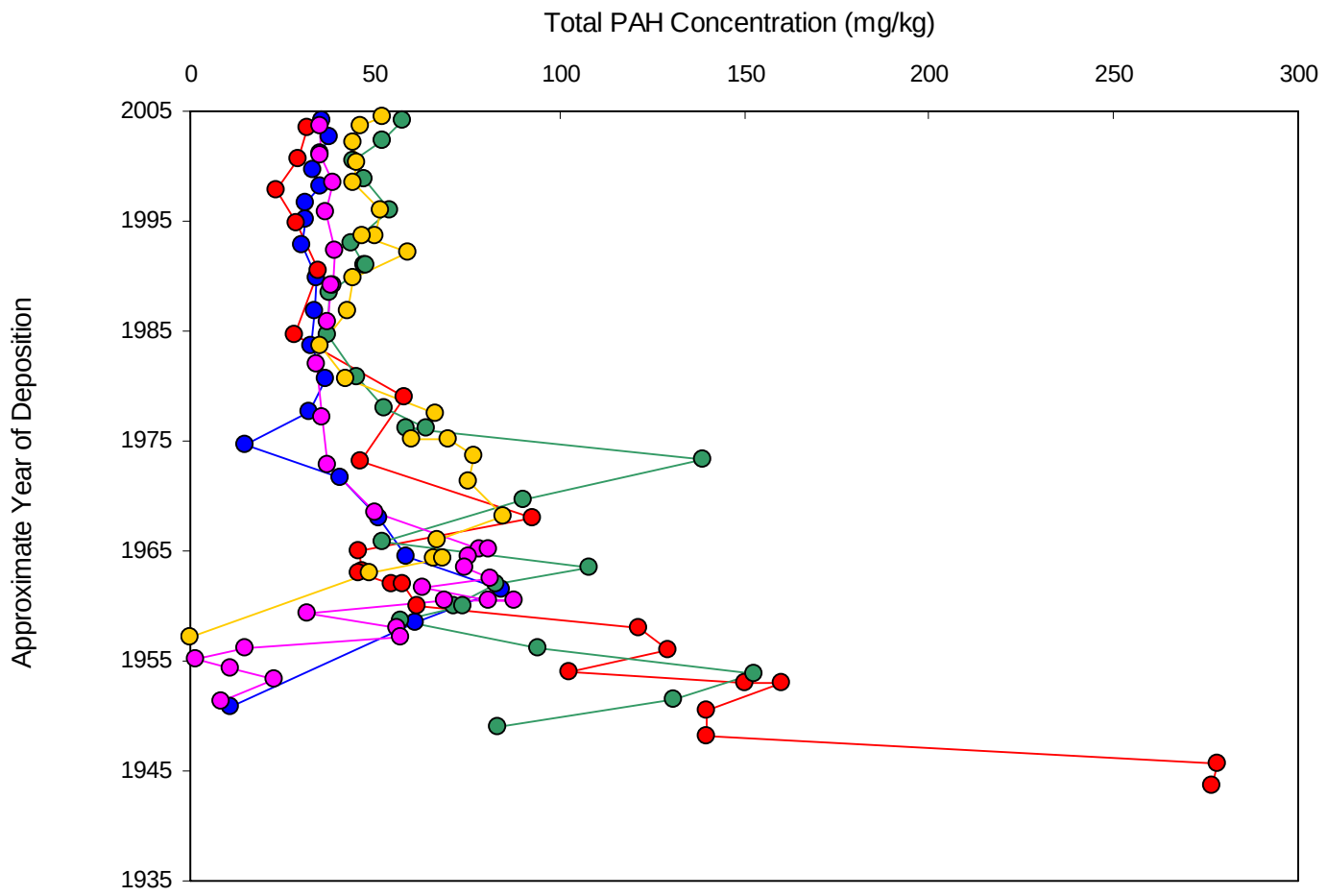
Data source: USEPA 2005 High Resolution Sediment Coring Program collected by Malcolm Pirnie, Inc.

Dated Sediment Core Profile for PCB Congener Co-elution 180+193 Concentration of Lower Passaic River High Resolution Sediment Cores

Lower Passaic River Restoration Project

Figure 4-3n

June 2007



Legend

- RM1.4
- RM2.2
- RM7.8
- RM11
- RM12.6

Notes

Total PAH equals the sum of 16 priority PAH compound with nondetect PAH compounds equal to zero.

Nondetect concentrations plotted as zero.

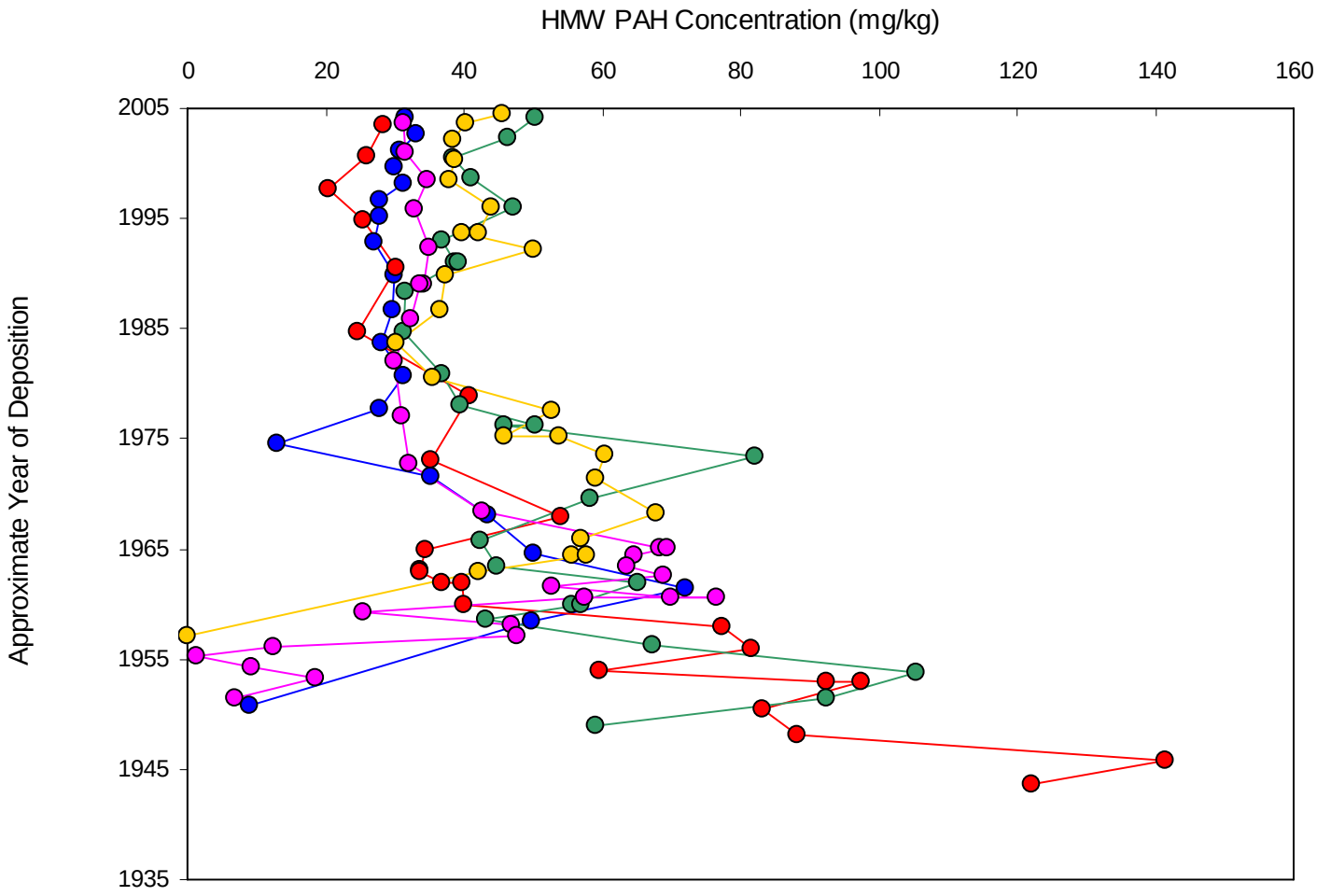
Data source: USEPA 2005 High Resolution Sediment Coring Program collected by Malcolm Pirnie, Inc.

Dated Sediment Core Profile for Total PAH Concentration of Lower Passaic River High Resolution Sediment Cores

Lower Passaic River Restoration Project

Figure 4-3o

June 2007



Legend

- RM1.4
- RM2.2
- RM7.8
- RM11
- RM12.6

Notes

HMW = High Molecular Weight

HMW PAH equals the sum of 4-ring, 5-ring, and 6-ring PAH compounds.

Nondetect concentrations plotted as zero.

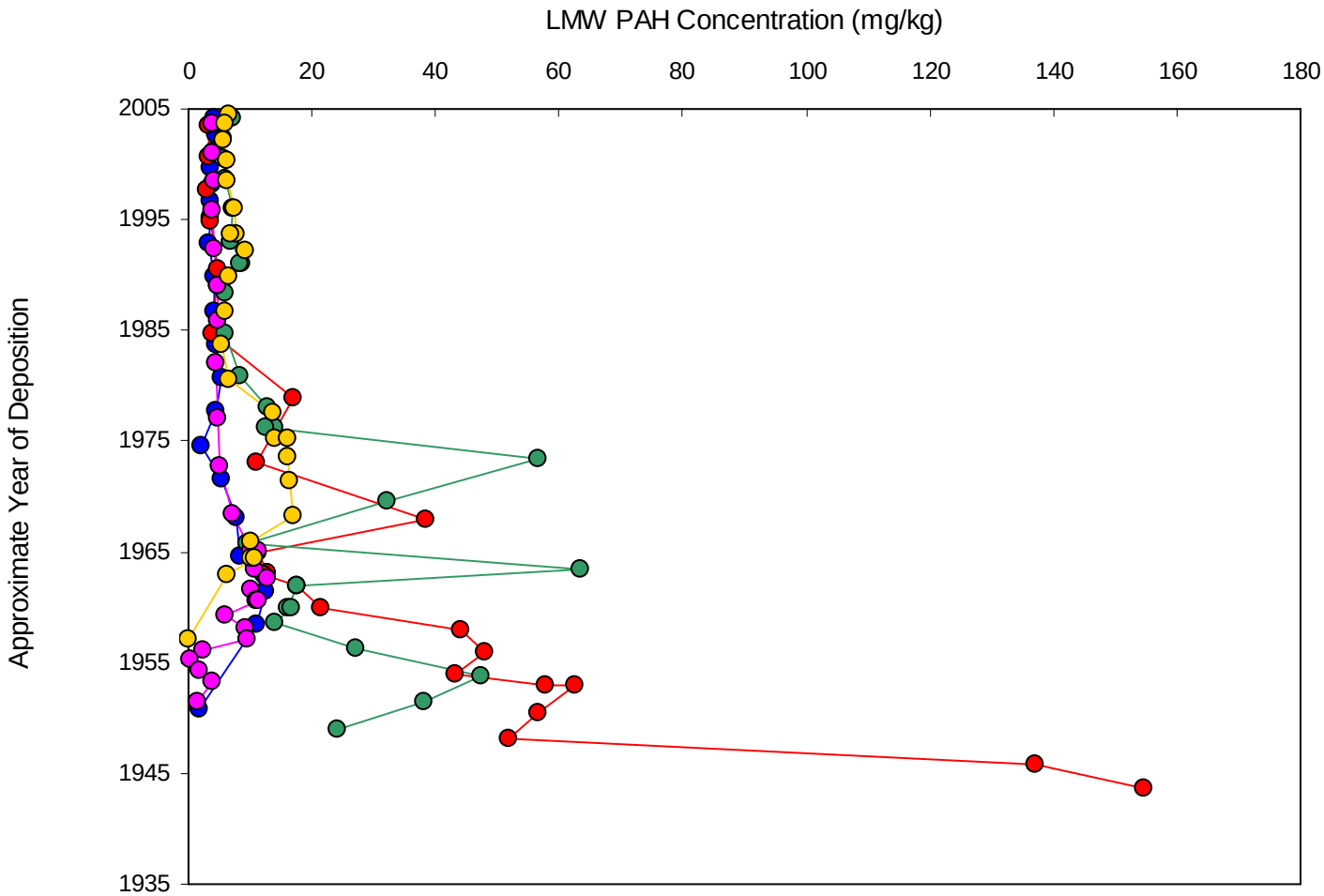
Data source: USEPA 2005 High Resolution Sediment Coring Program collected by Malcolm Pirnie, Inc.

Dated Sediment Core Profile for HMW PAH Concentration of Lower Passaic River High Resolution Sediment Cores

Lower Passaic River Restoration Project

Figure 4-3p

June 2007



Legend

- RM1.4
- RM2.2
- RM7.8
- RM11
- RM12.6

Notes

LMW = Low Molecular Weight

LMW PAH equals the sum of 2-ring and 3-ring PAH compounds.

Nondetect concentrations plotted as zero.

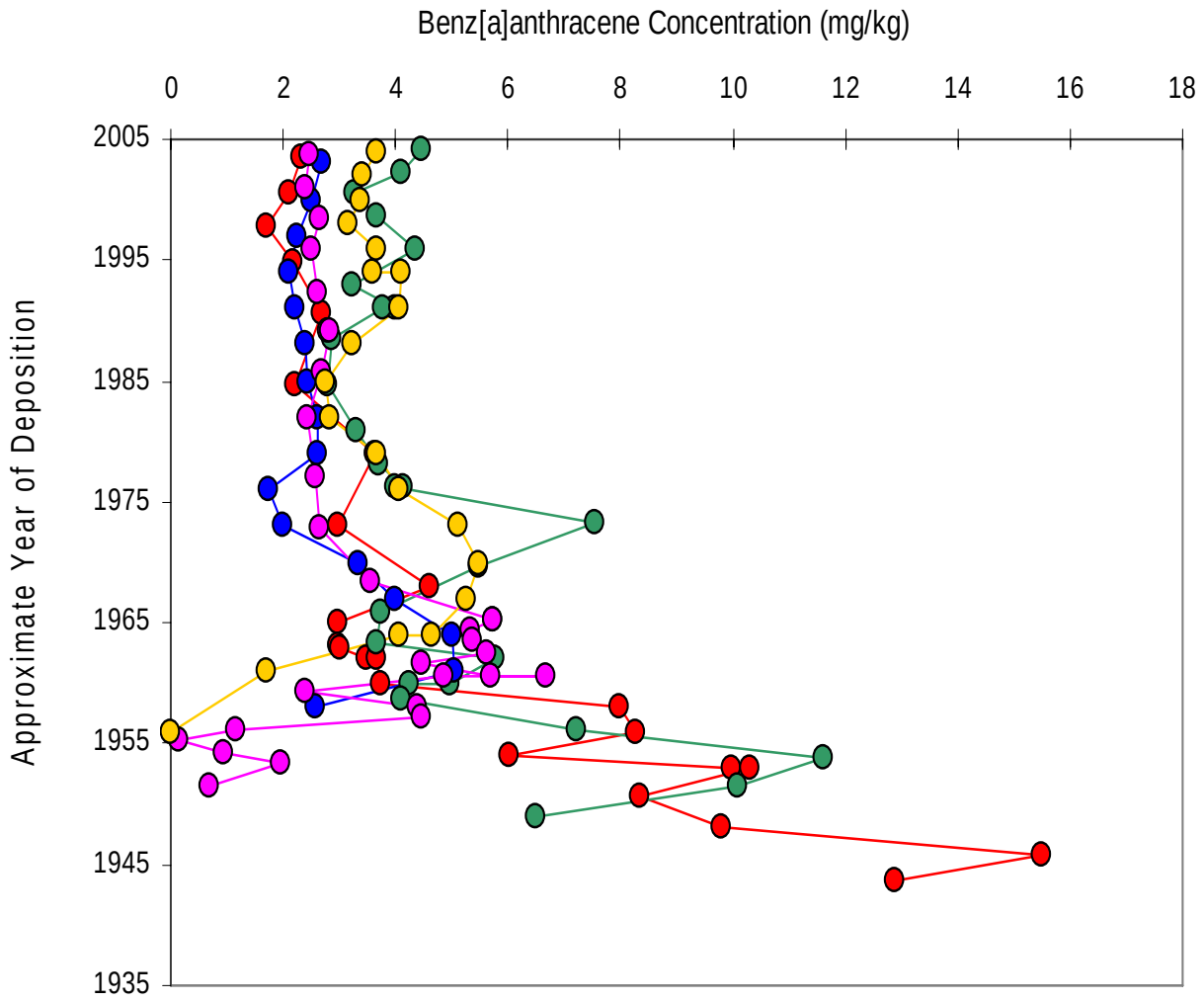
Data source: USEPA 2005 High Resolution Sediment Coring Program collected by Malcolm Pirnie, Inc.

Dated Sediment Core Profile for LMW PAH Concentration of Lower Passaic River High Resolution Sediment Cores

Lower Passaic River Restoration Project

Figure 4-3q

June 2007



Legend

- RM1.4
- RM2.2
- RM7.8
- RM11
- RM12.6

Notes

Nondetect concentrations plotted as zero.

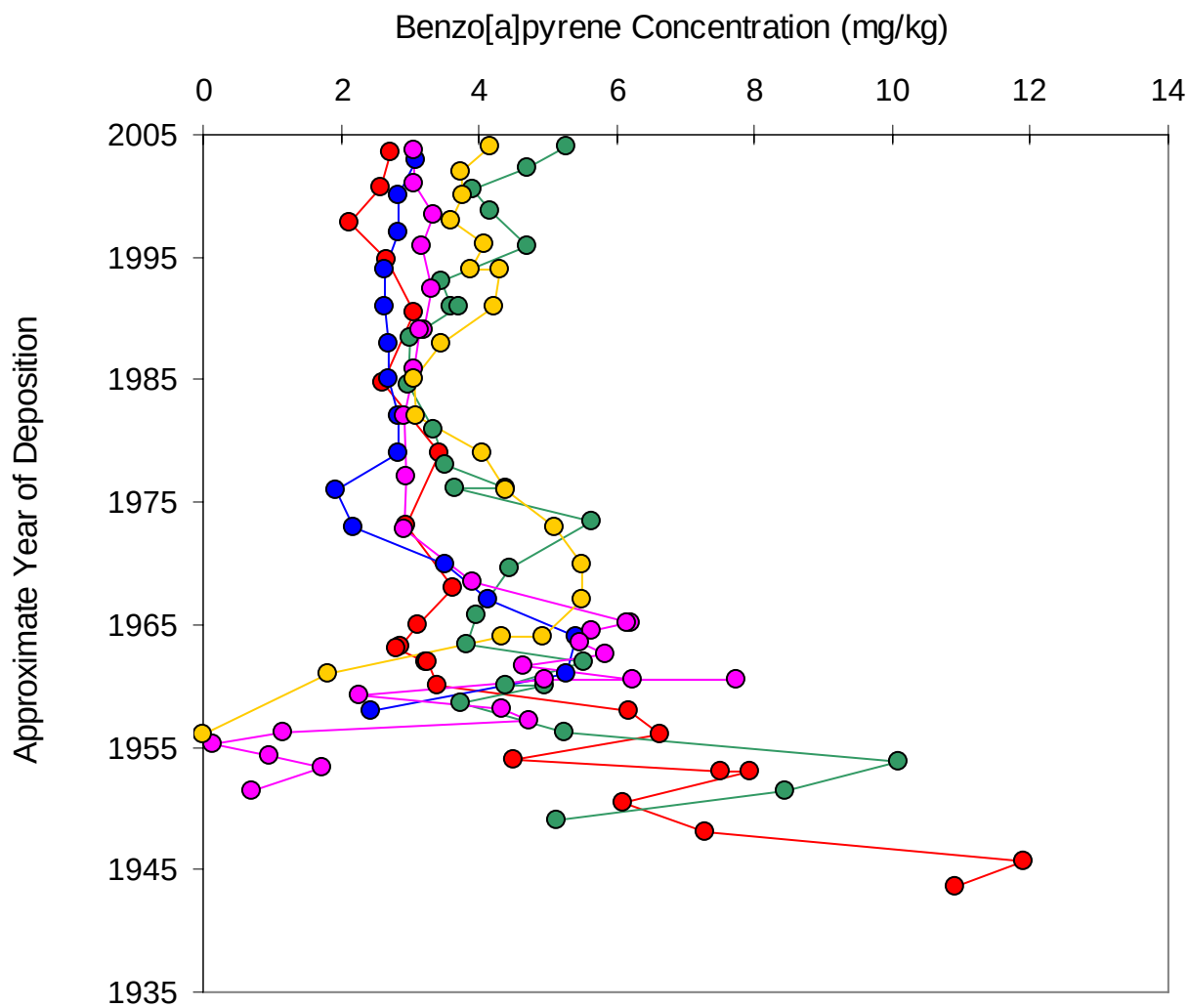
Data source: USEPA 2005 High Resolution Sediment Coring Program collected by Malcolm Pirnie, Inc.

Dated Sediment Core Profile for Benz[a]anthracene Concentration of Lower Passaic River High Resolution Sediment Cores

Lower Passaic River Restoration Project

Figure 4-3r

June 2007



Legend

- RM1.4
- RM2.2
- RM7.8
- RM11
- RM12.6

Notes

Nondetect concentrations plotted as zero.

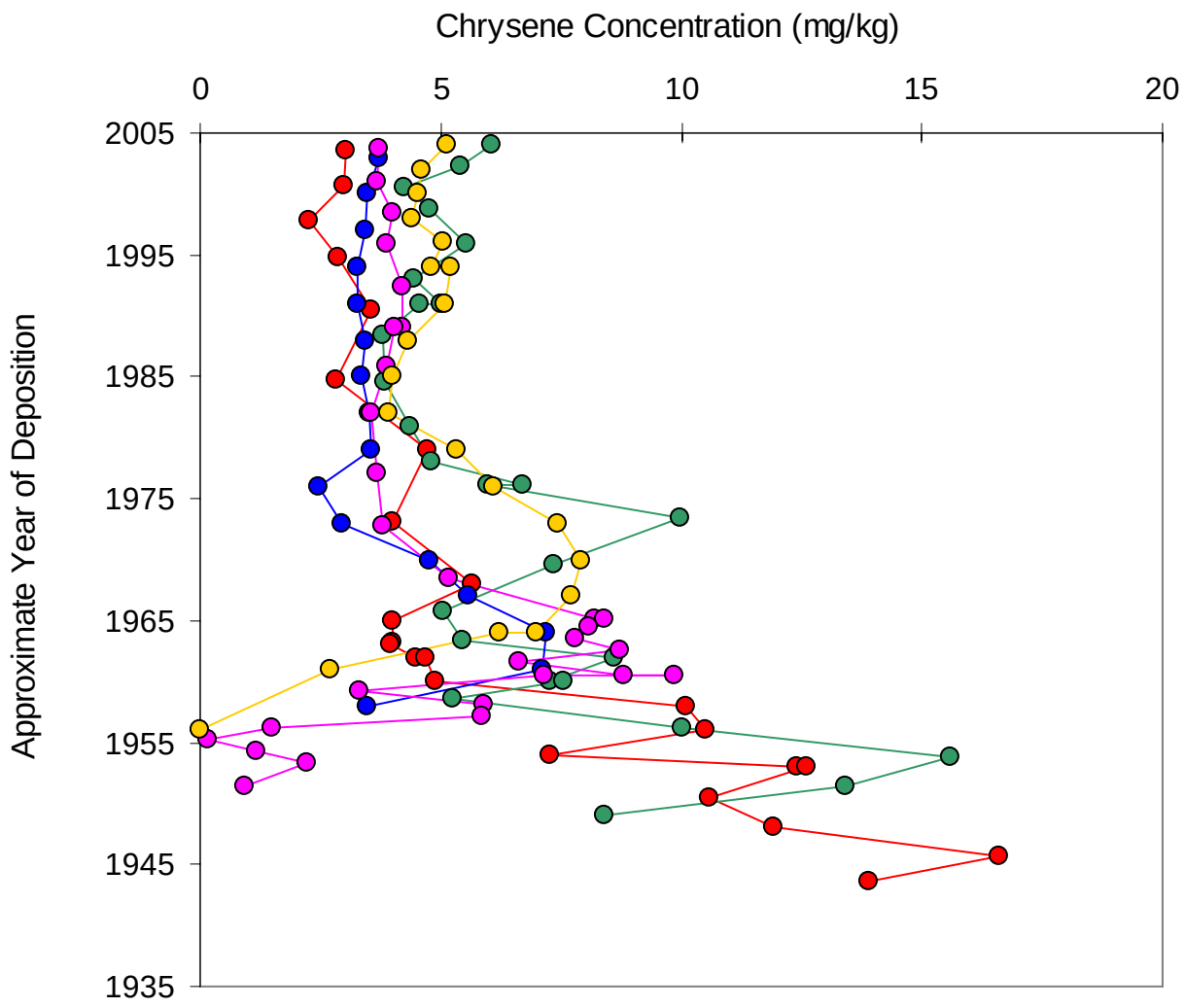
Data source: USEPA 2005 High Resolution Sediment Coring Program collected by Malcolm Pirnie, Inc.

Dated Sediment Core Profile for Benzo[a]pyrene Concentration of Lower Passaic River High Resolution Sediment Cores

Lower Passaic River Restoration Project

Figure 4-3s

June 2007



Legend

- RM1.4
- RM2.2
- RM7.8
- RM11
- RM12.6

Notes

Nondetect concentrations plotted as zero.

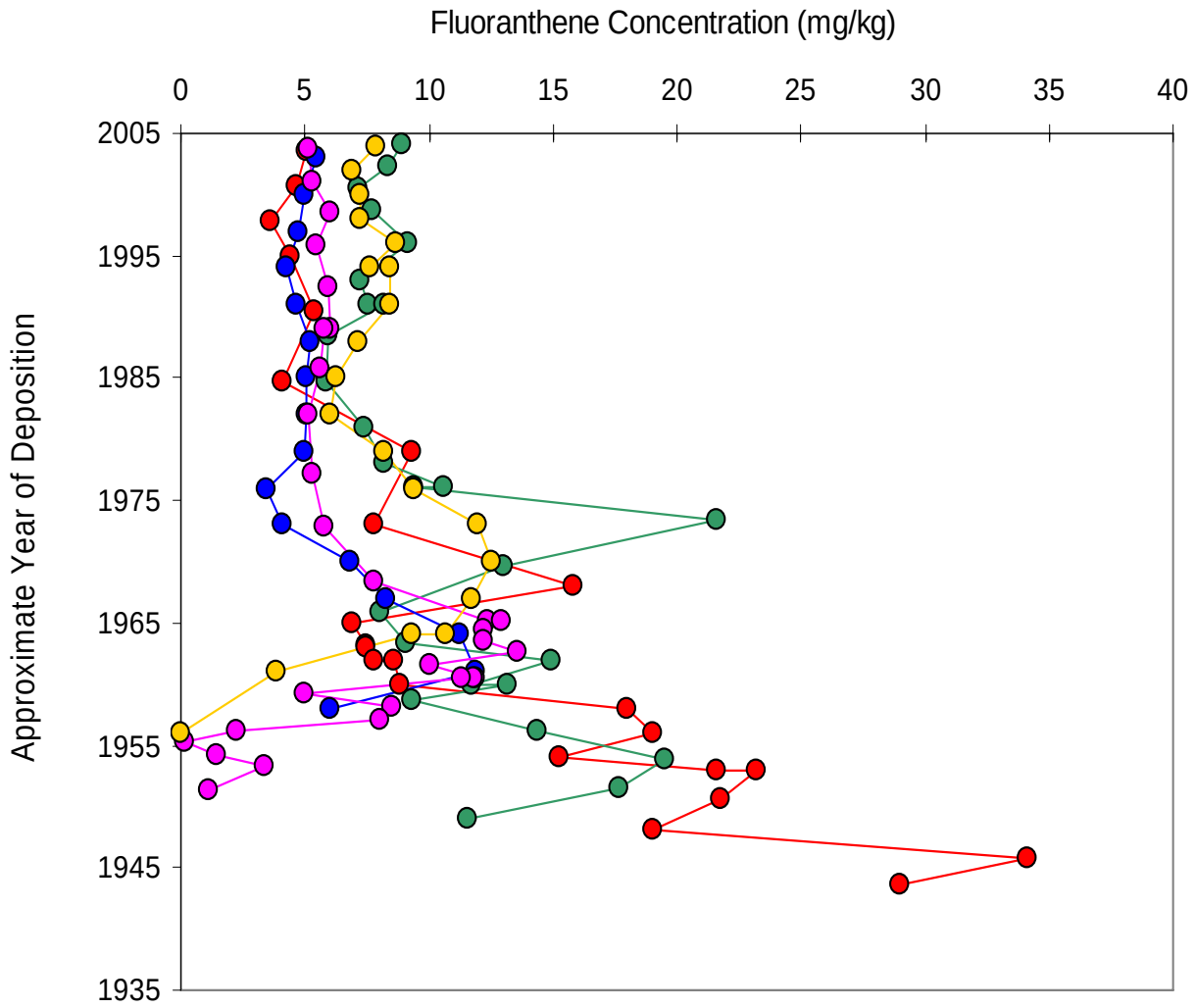
Data source: USEPA 2005 High Resolution Sediment Coring Program collected by Malcolm Pirnie, Inc.

Dated Sediment Core Profile for Chrysene Concentration of Lower Passaic River High Resolution Sediment Cores

Lower Passaic River Restoration Project

Figure 4-3t

June 2007



Legend

- RM1.4
- RM2.2
- RM7.8
- RM11
- RM12.6

Notes

Nondetect concentrations plotted as zero.

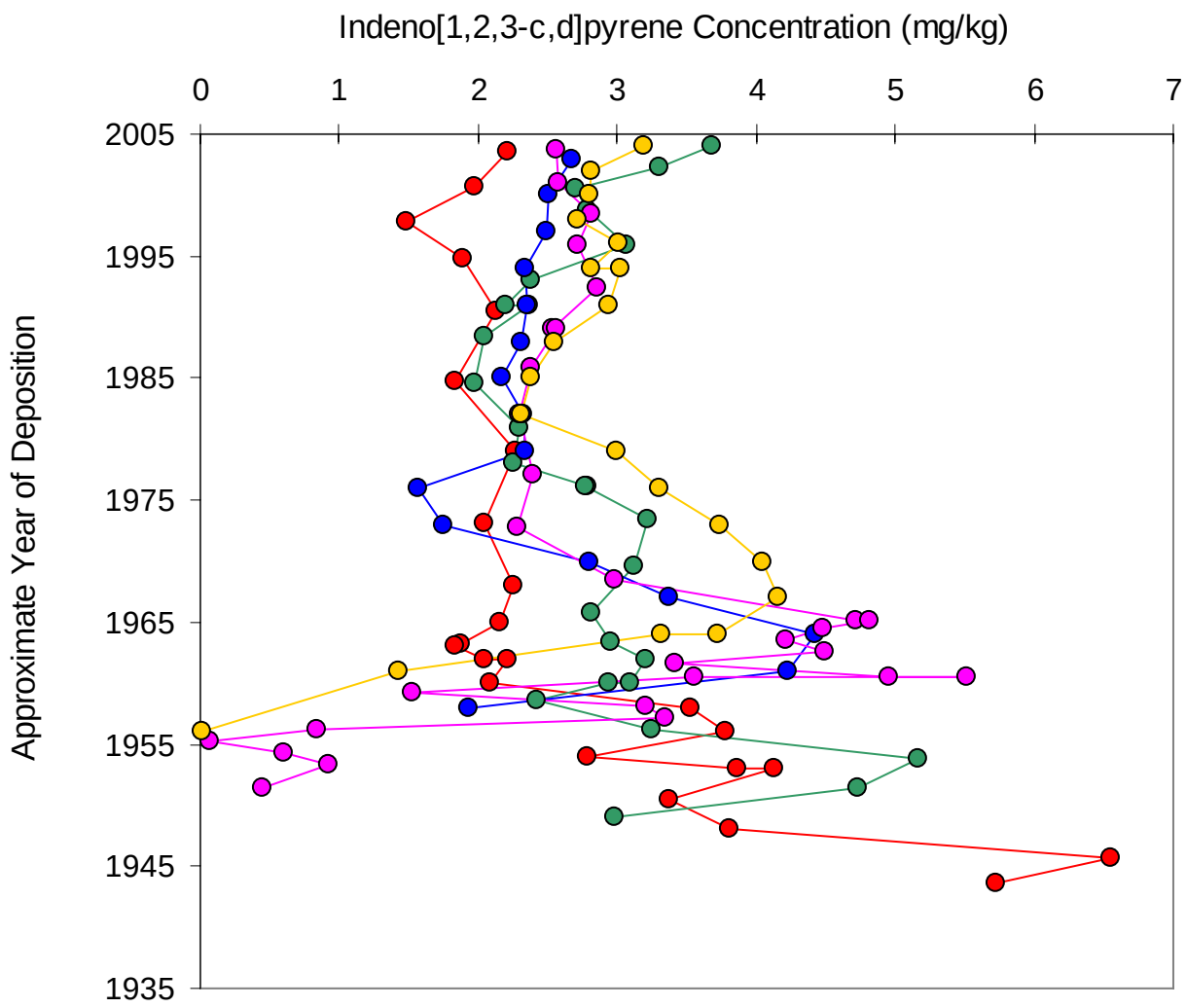
Data source: USEPA 2005 High Resolution Sediment Coring Program collected by Malcolm Pirnie, Inc.

Dated Sediment Core Profile for Fluoranthene Concentration of Lower Passaic River High Resolution Sediment Cores

Lower Passaic River Restoration Project

Figure 4-3u

June 2007



Legend

- RM1.4
- RM2.2
- RM7.8
- RM11
- RM12.6

Notes

Nondetect concentrations plotted as zero.

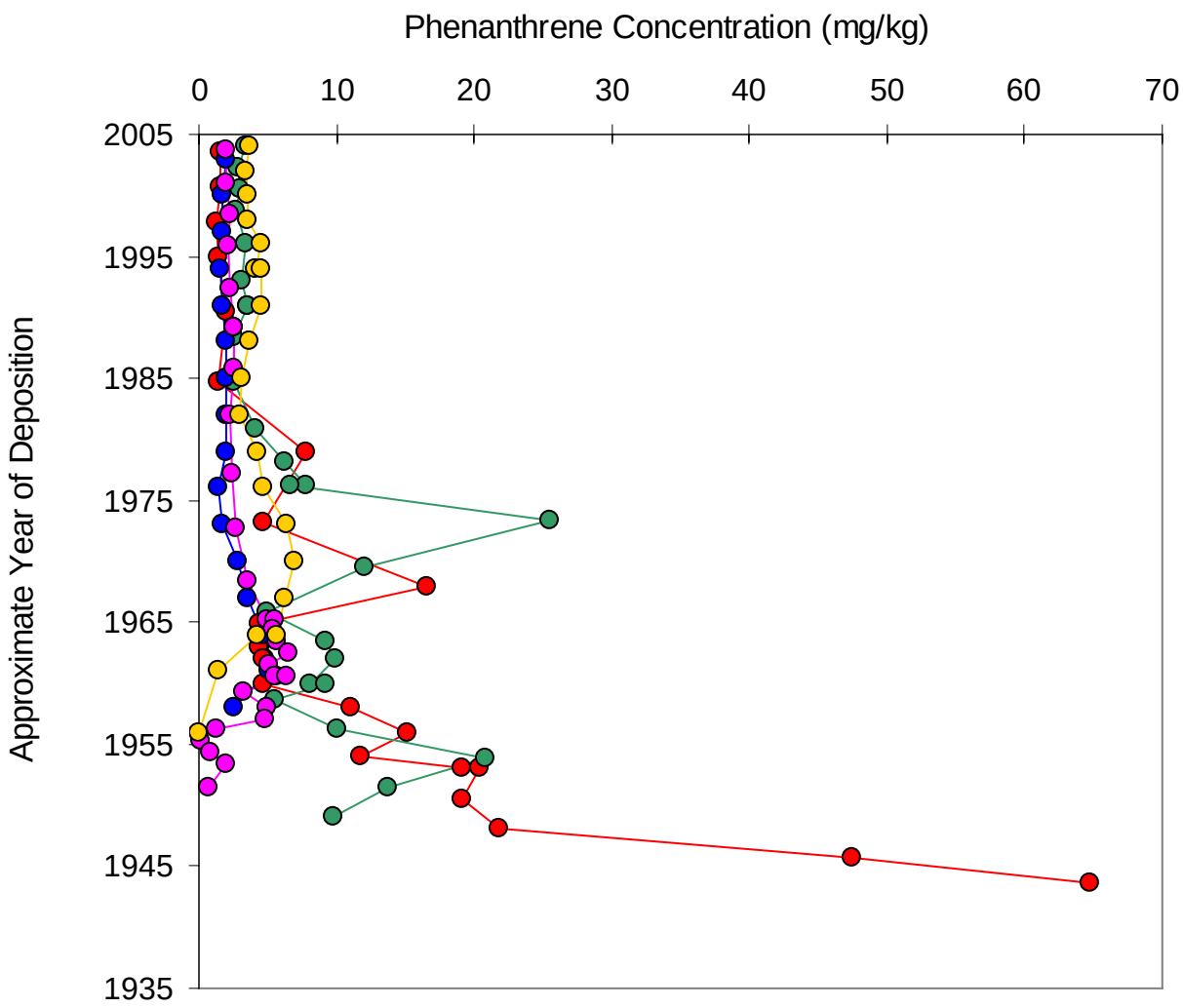
Data source: USEPA 2005 High Resolution Sediment Coring Program collected by Malcolm Pirnie, Inc.

Dated Sediment Core Profile for Indeno[1,2,3-c,d]pyrene Concentration of Lower Passaic River High Resolution Sediment Cores

Lower Passaic River Restoration Project

Figure 4-3v

June 2007



Legend

- RM1.4
- RM2.2
- RM7.8
- RM11
- RM12.6

Notes

Nondetect concentrations plotted as zero.

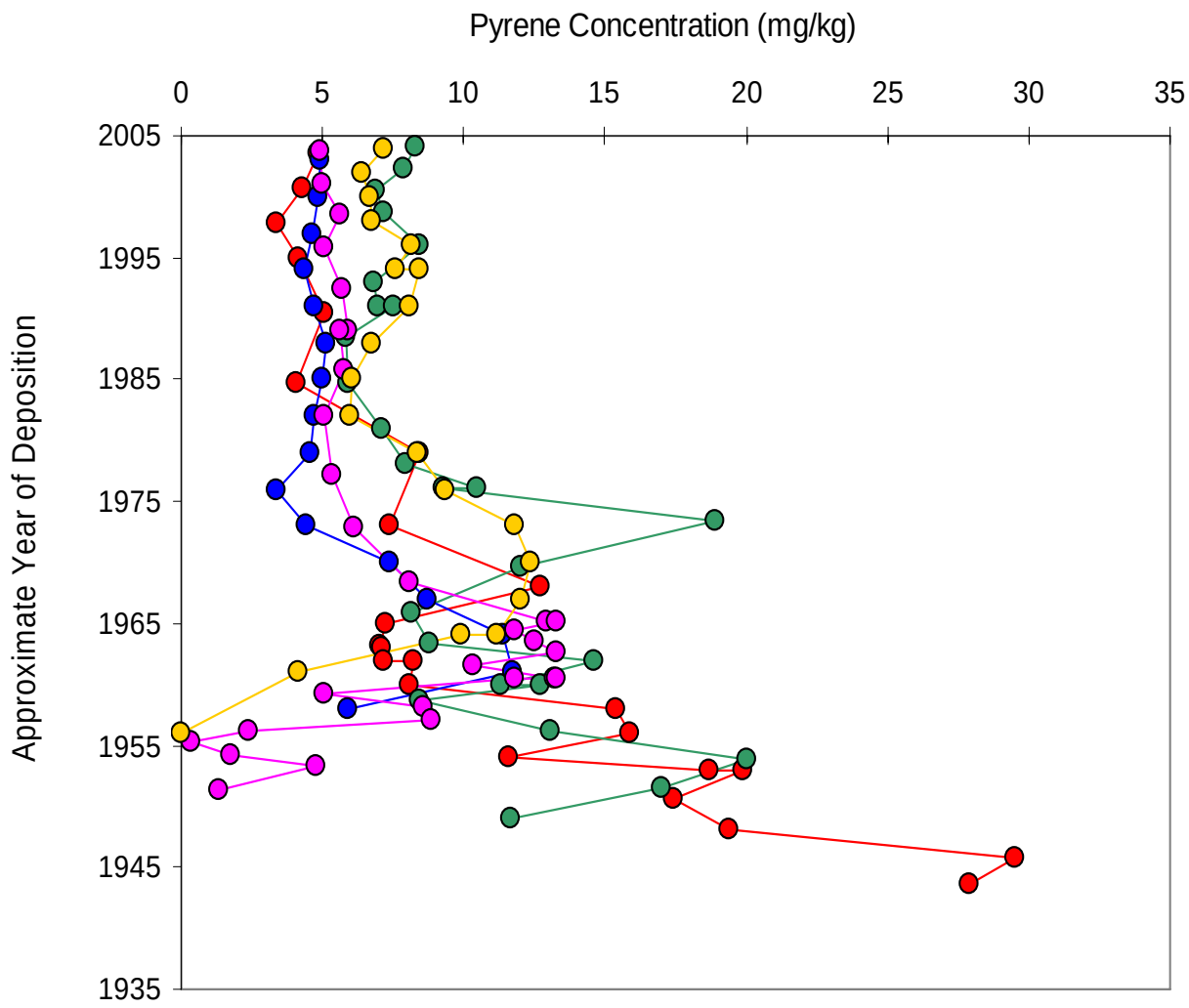
Data source: USEPA 2005 High Resolution Sediment Coring Program collected by Malcolm Pirnie, Inc.

Dated Sediment Core Profile for Phenanthrene Concentration of Lower Passaic River High Resolution Sediment Cores

Lower Passaic River Restoration Project

Figure 4-3w

June 2007



Legend

- RM1.4
- RM2.2
- RM7.8
- RM11
- RM12.6

Notes

Nondetect concentrations plotted as zero.

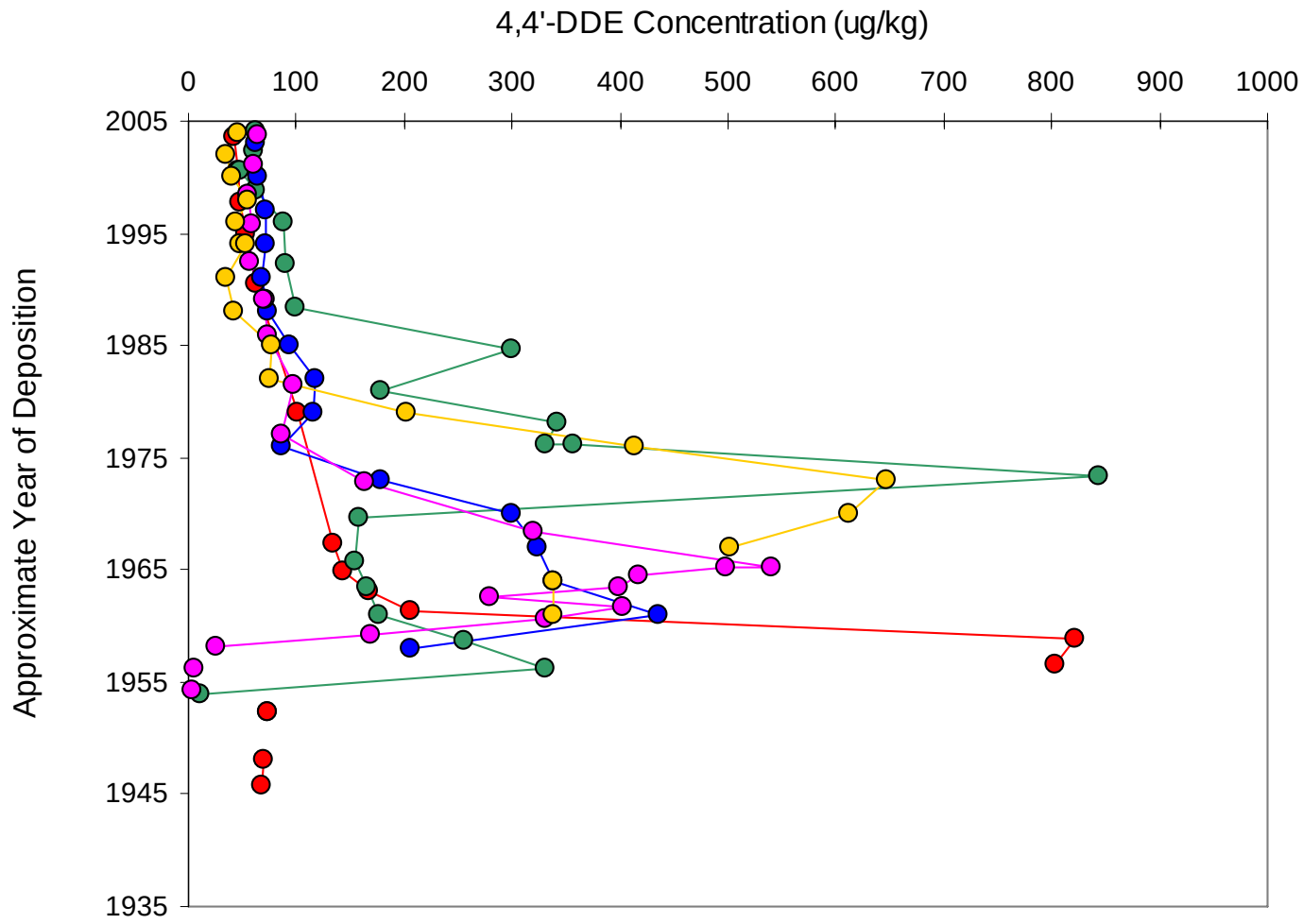
Data source: USEPA 2005 High Resolution Sediment Coring Program collected by Malcolm Pirnie, Inc.

Dated Sediment Core Profile for Pyrene Concentration of Lower Passaic River High Resolution Sediment Cores

Lower Passaic River Restoration Project

Figure 4-3x

June 2007



Legend

- RM1.4
- RM2.2
- RM7.8
- RM11
- RM12.6

Notes

DDE represents only the 4,4'-isomer.

Nondetect concentrations plotted as zero.

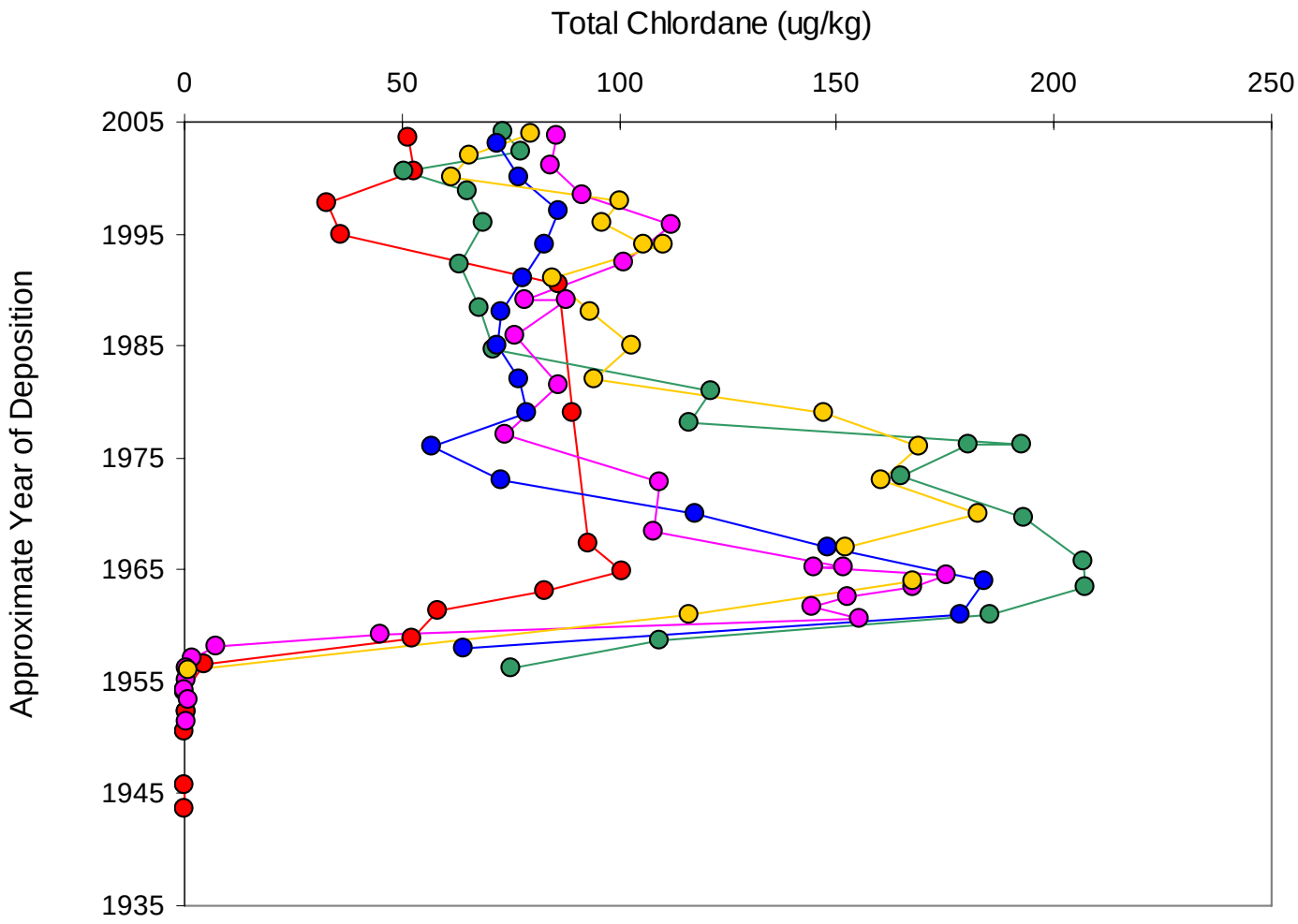
Data source: USEPA 2005 High Resolution Sediment Coring Program collected by Malcolm Pirnie, Inc.

Dated Sediment Core Profile for 4,4'-DDE Concentration of Lower Passaic River High Resolution Sediment Cores

Lower Passaic River Restoration Project

Figure 4-3y

June 2007



Legend

- RM1.4
- RM2.2
- RM7.8
- RM11
- RM12.6

Notes

Total Chlordane represents the sum of trans-chlordane and cis-chlordane with nondetects equal to zero.

Nondetect concentrations plotted as zero.

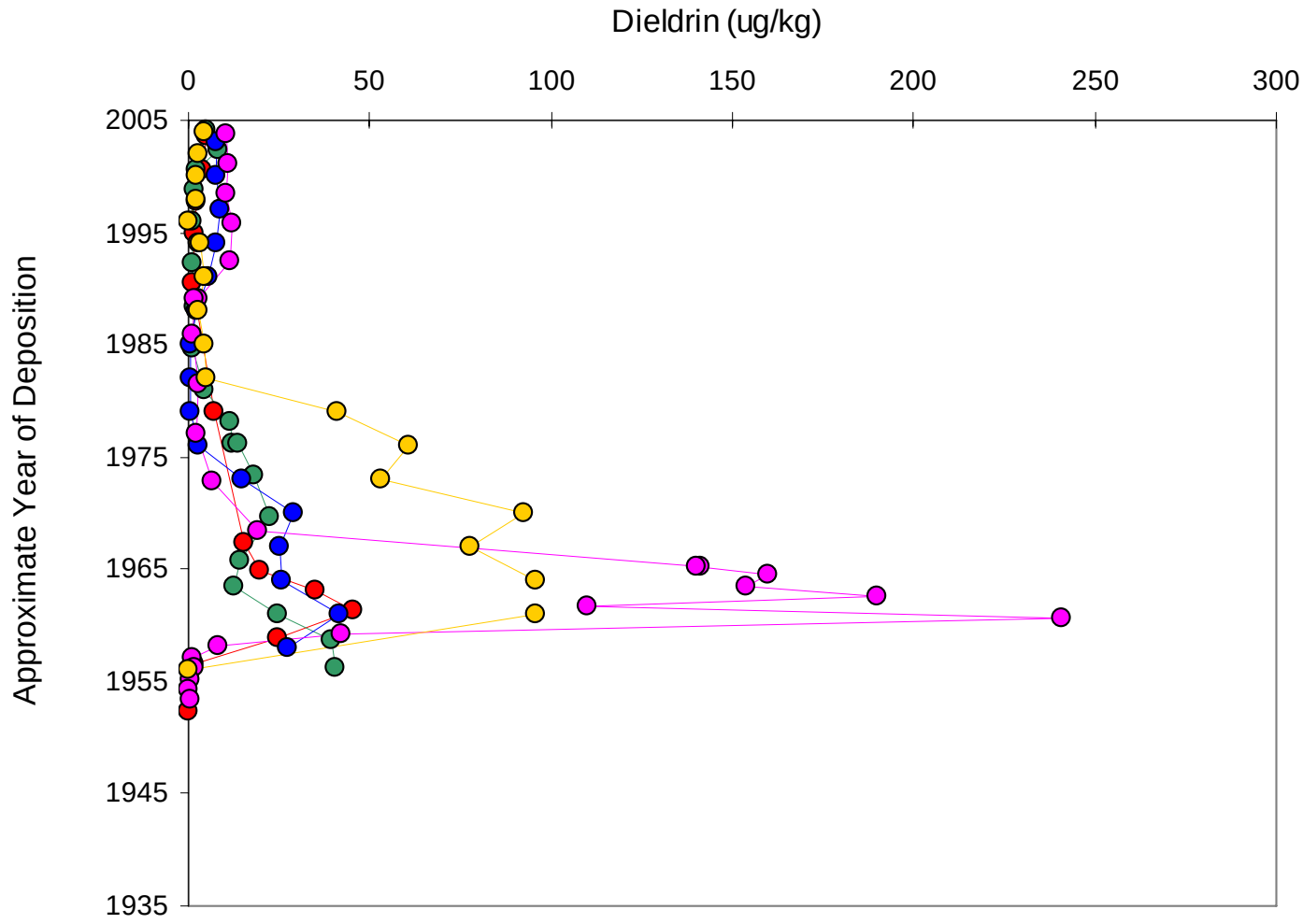
Data source: USEPA 2005 High Resolution Sediment Coring Program collected by Malcolm Pirnie, Inc.

Dated Sediment Core Profile for Total Chlordane Concentration of Lower Passaic River High Resolution Sediment Cores

Lower Passaic River Restoration Project

Figure 4-3z

June 2007



Legend

- RM1.4
- RM2.2
- RM7.8
- RM11
- RM12.6

Notes

Nondetect concentrations plotted as zero.

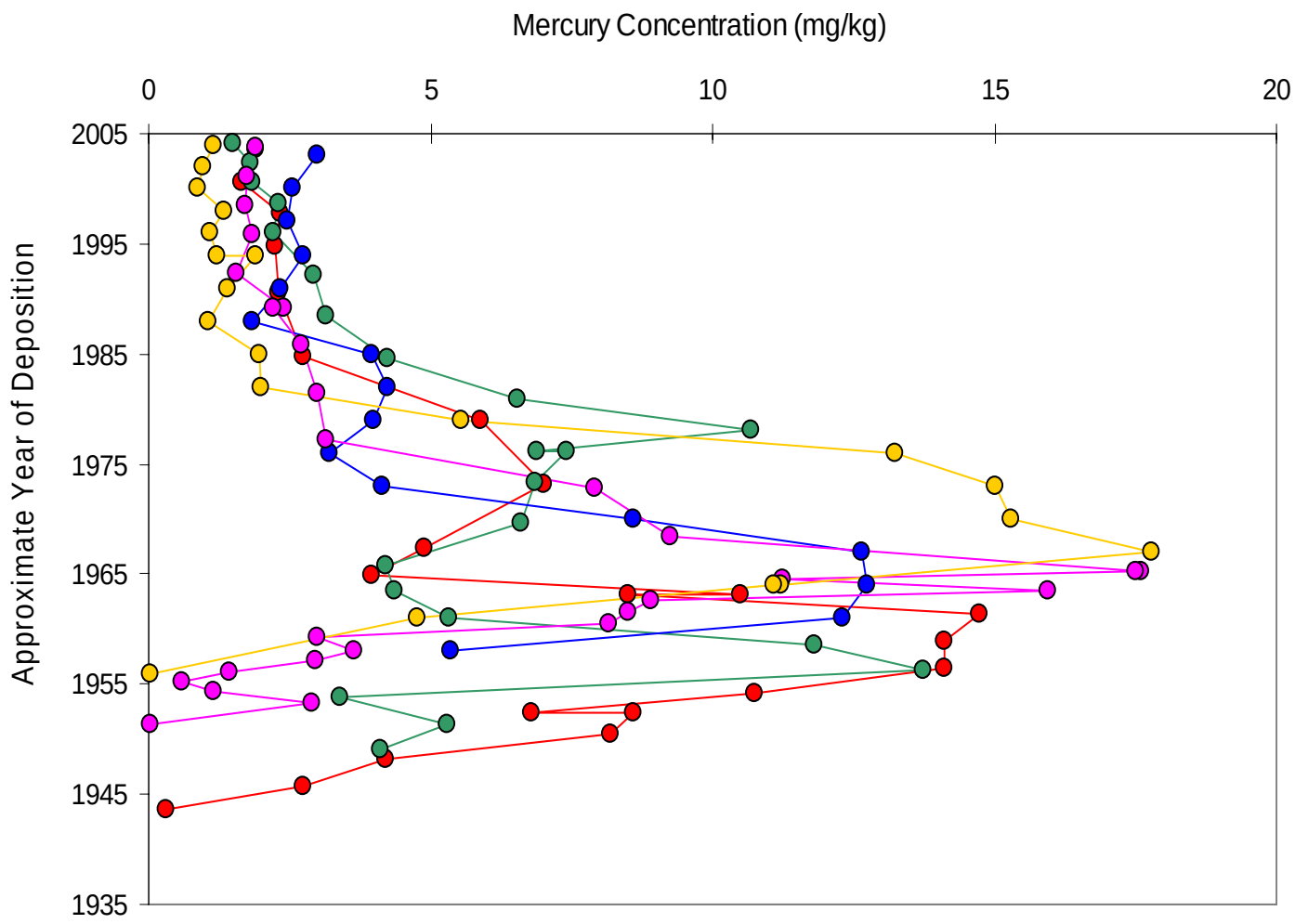
Data source: USEPA 2005 High Resolution Sediment Coring Program collected by Malcolm Pirnie, Inc.

Dated Sediment Core Profile for Dieldrin Concentration of Lower Passaic River High Resolution Sediment Cores

Lower Passaic River Restoration Project

Figure 4-3aa

June 2007



Legend

- RM1.4
- RM2.2
- RM7.8
- RM11
- RM12.6

Notes

Nondetect concentrations plotted as zero.

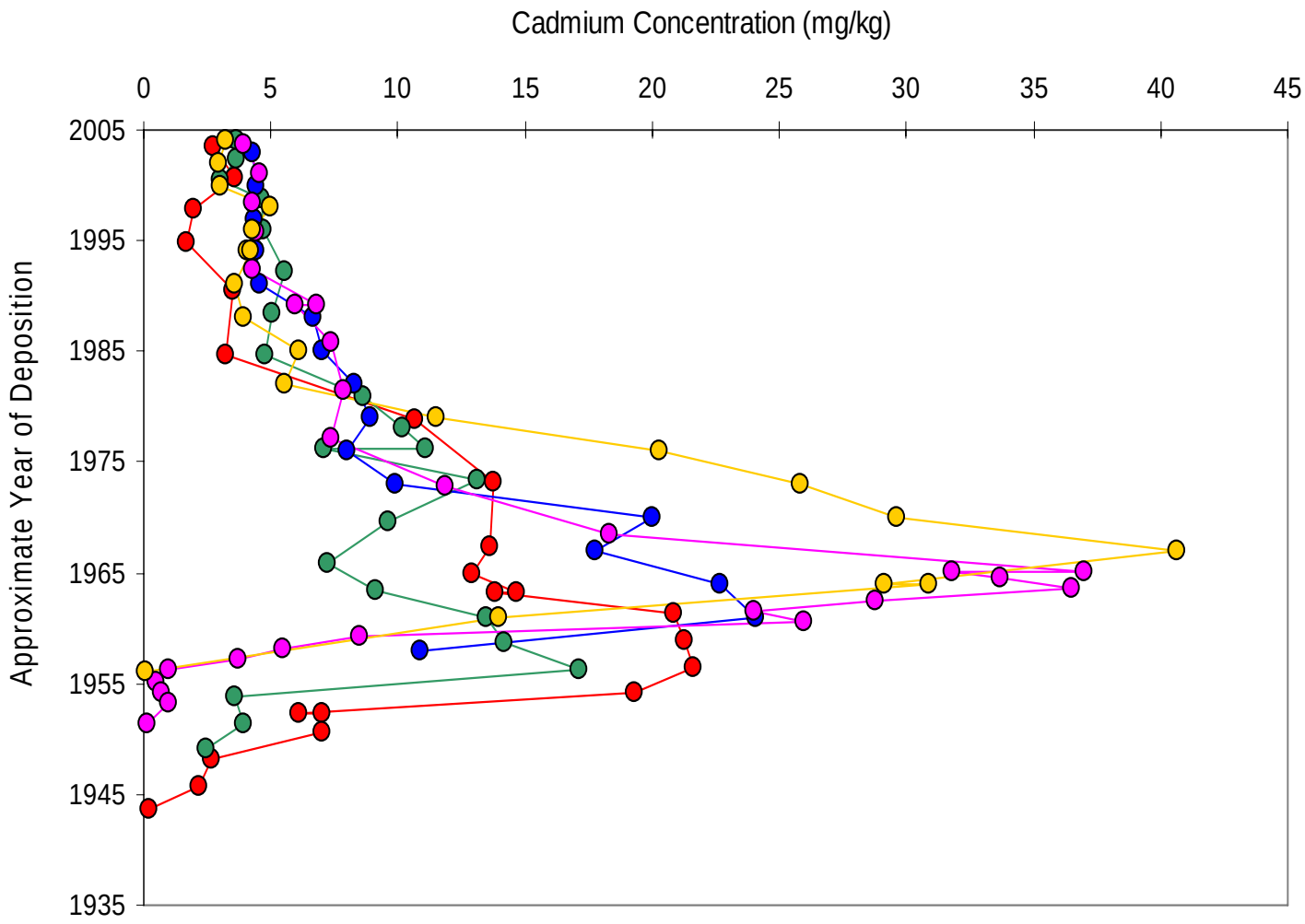
Data source: USEPA 2005 High Resolution Sediment Coring Program collected by Malcolm Pirnie, Inc.

Dated Sediment Core Profile for Mercury Concentration of Lower Passaic River High Resolution Sediment Cores

Lower Passaic River Restoration Project

Figure 4-3ab

June 2007



Legend

- RM1.4
- RM2.2
- RM7.8
- RM11
- RM12.6

Notes

Nondetect concentrations plotted as zero.

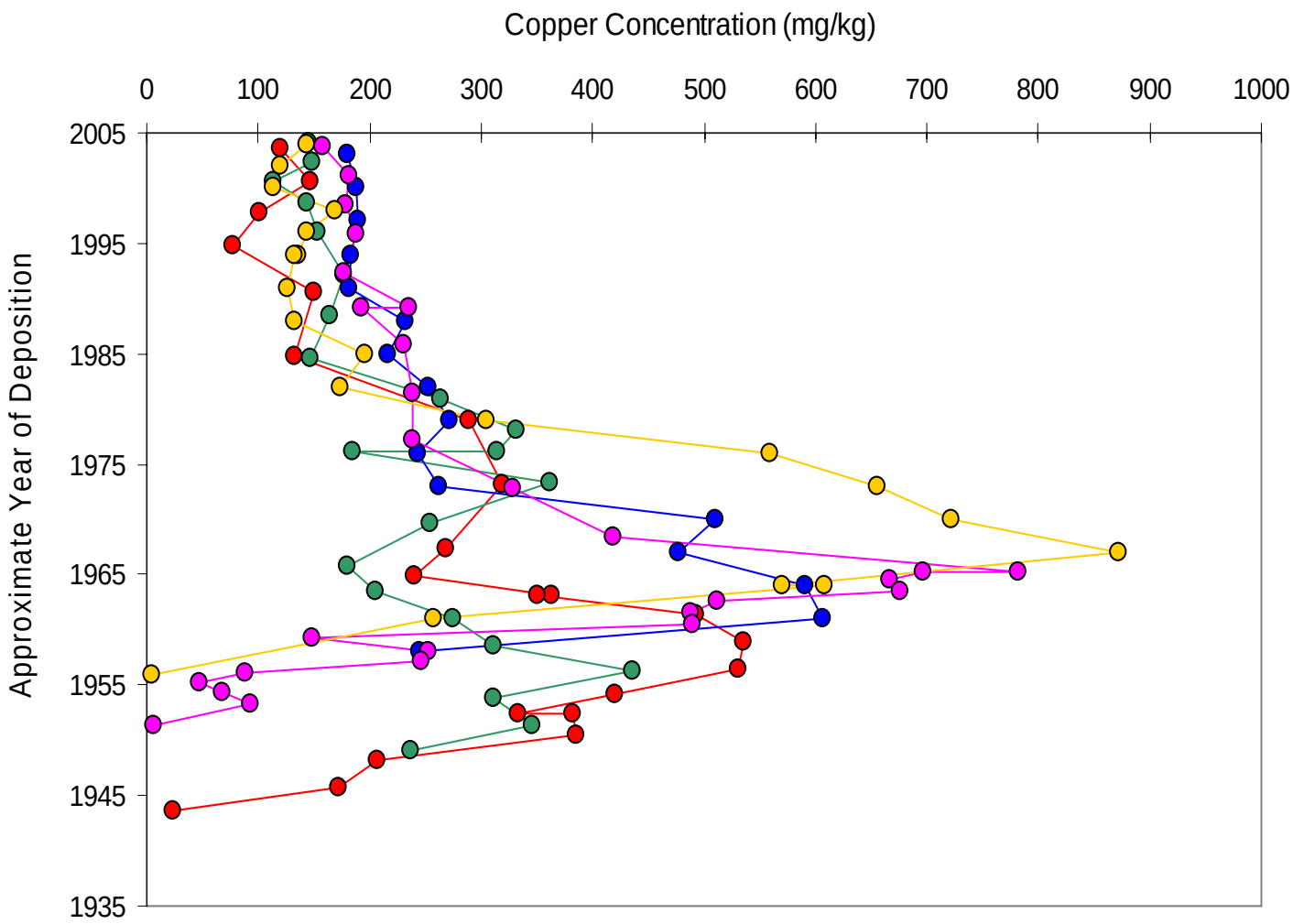
Data source: USEPA 2005 High Resolution Sediment Coring Program collected by Malcolm Pirnie, Inc.

Dated Sediment Core Profile for Cadmium Concentration of Lower Passaic River High Resolution Sediment Cores

Lower Passaic River Restoration Project

Figure 4-3ac

June 2007



Legend

- RM1.4
- RM2.2
- RM7.8
- RM11
- RM12.6

Notes

Nondetect concentrations plotted as zero.

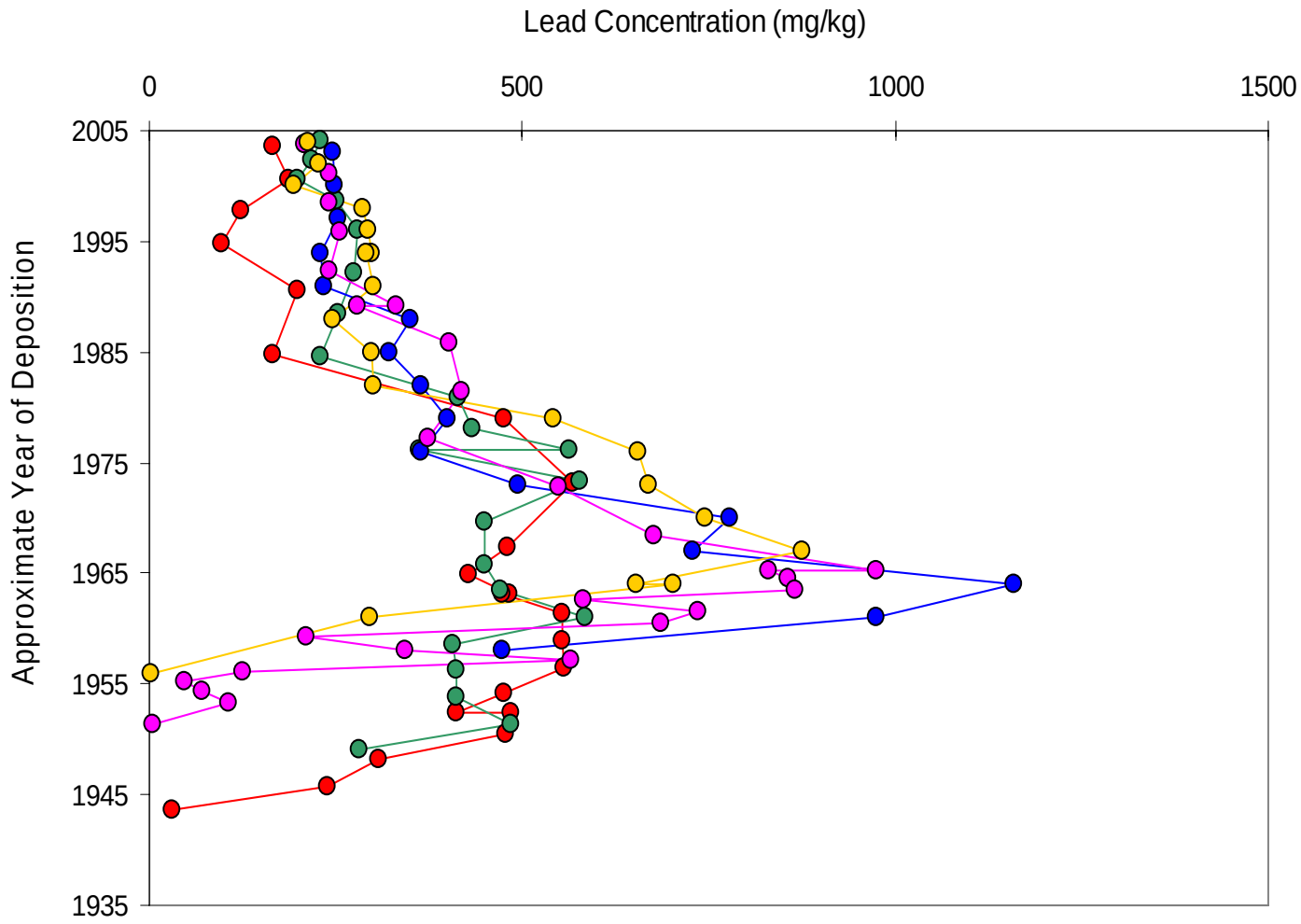
Data source: USEPA 2005 High Resolution Sediment Coring Program collected by Malcolm Pirnie, Inc.

Dated Sediment Core Profile for Copper Concentration of Lower Passaic River High Resolution Sediment Cores

Lower Passaic River Restoration Project

Figure 4-3ad

June 2007



Legend

- RM1.4
- RM2.2
- RM7.8
- RM11
- RM12.6

Notes

Nondetect concentrations plotted as zero.

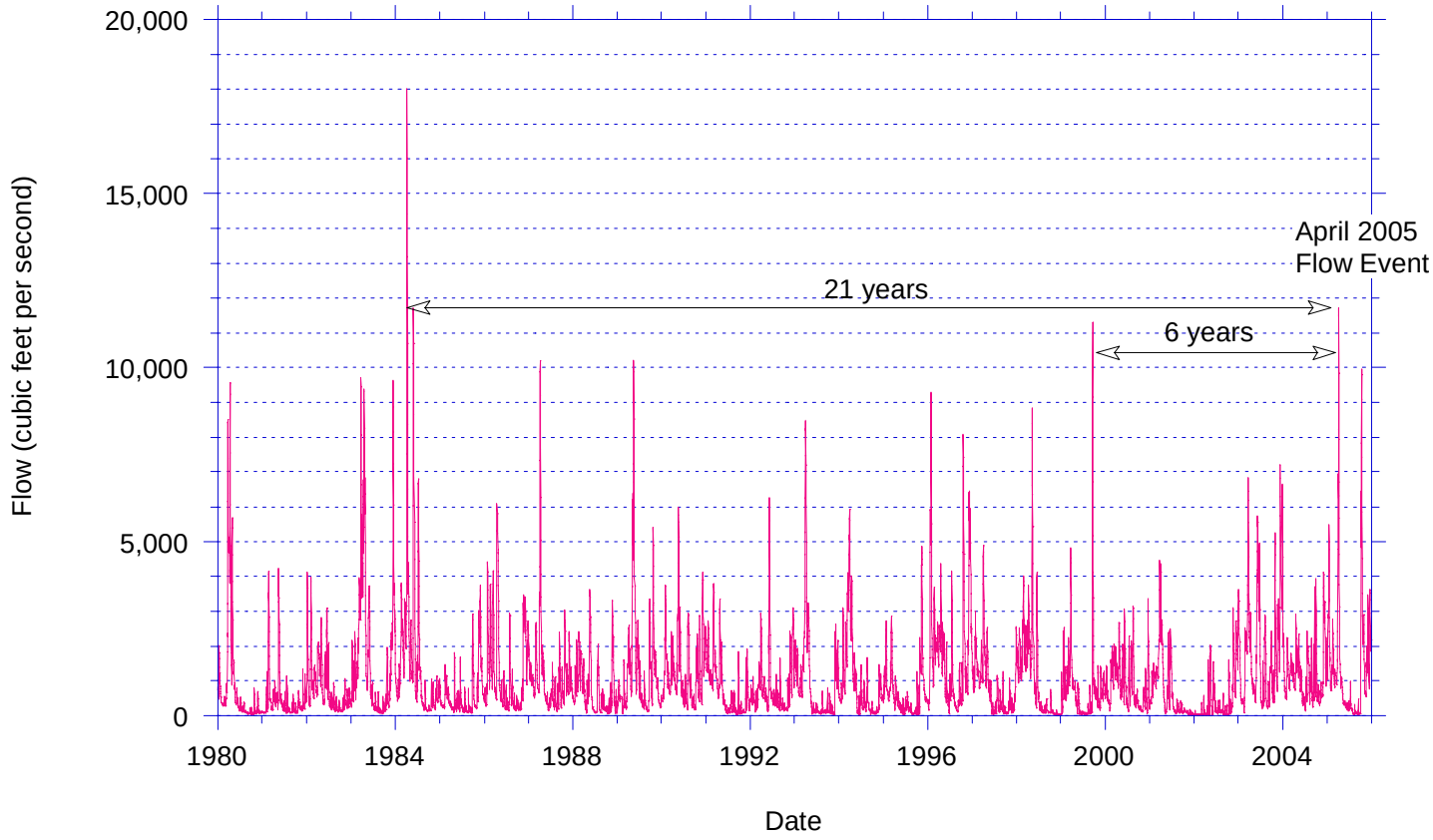
Data source: USEPA 2005 High Resolution Sediment Coring Program collected by Malcolm Pirnie, Inc.

Dated Sediment Core Profile for Lead Concentration of Lower Passaic River High Resolution Sediment Cores

Lower Passaic River Restoration Project

Figure 4-3ae

June 2007



Legend

Flow (cubic feet per second)

Notes

Data Source: USGS National Water Information System: Web Interface.

USGS Station 01389500 at Little Falls.

Lower Passaic River Flow at Little Falls, New Jersey from 1980 to 2006

Lower Passaic River Restoration Project

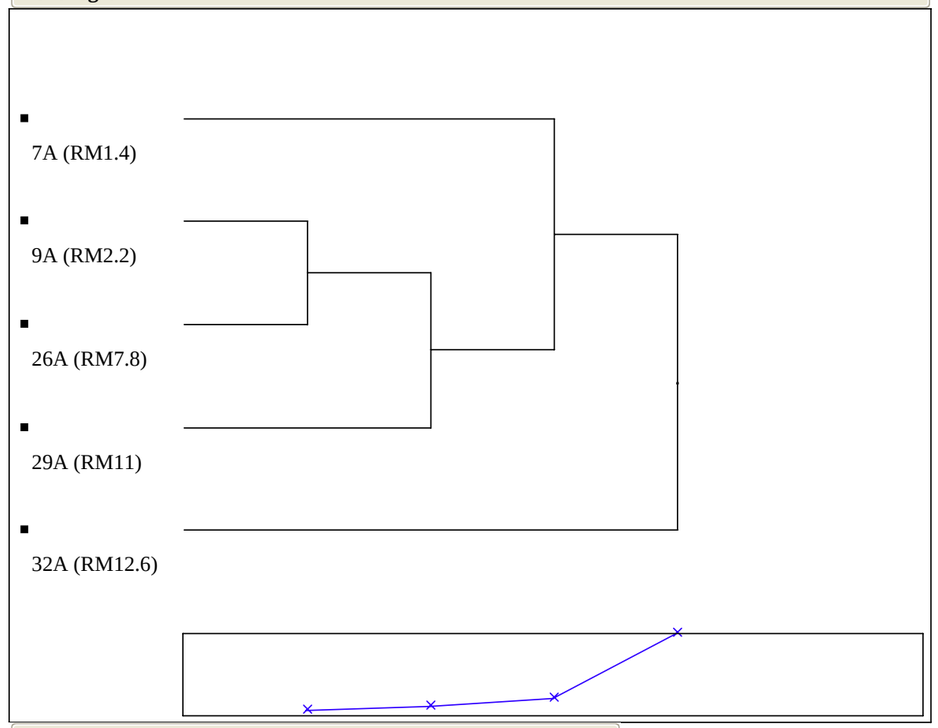
Figure 4-4

June 2007

Hierarchical Clustering 2,3,7,8-TCDD/Total TCDD Passaic River

Method = Ward

Dendrogram



Clustering History

Number of Clusters	Distance	Leader	Joiner
4	0.0122895159	9A (RM2.2)	26A (RM7.8)
3	0.0223230165	9A (RM2.2)	29A (RM11)
2	0.0411823947	7A (RM1.4)	9A (RM2.2)
1	0.1953115936	7A (RM1.4)	32A (RM12.6)

Legend

Notes

Identification numbers 7A, 9A, 26A, 29A, and 32A correspond to field location numbers of 2005 USEPA High Resolution Sediment Cores.

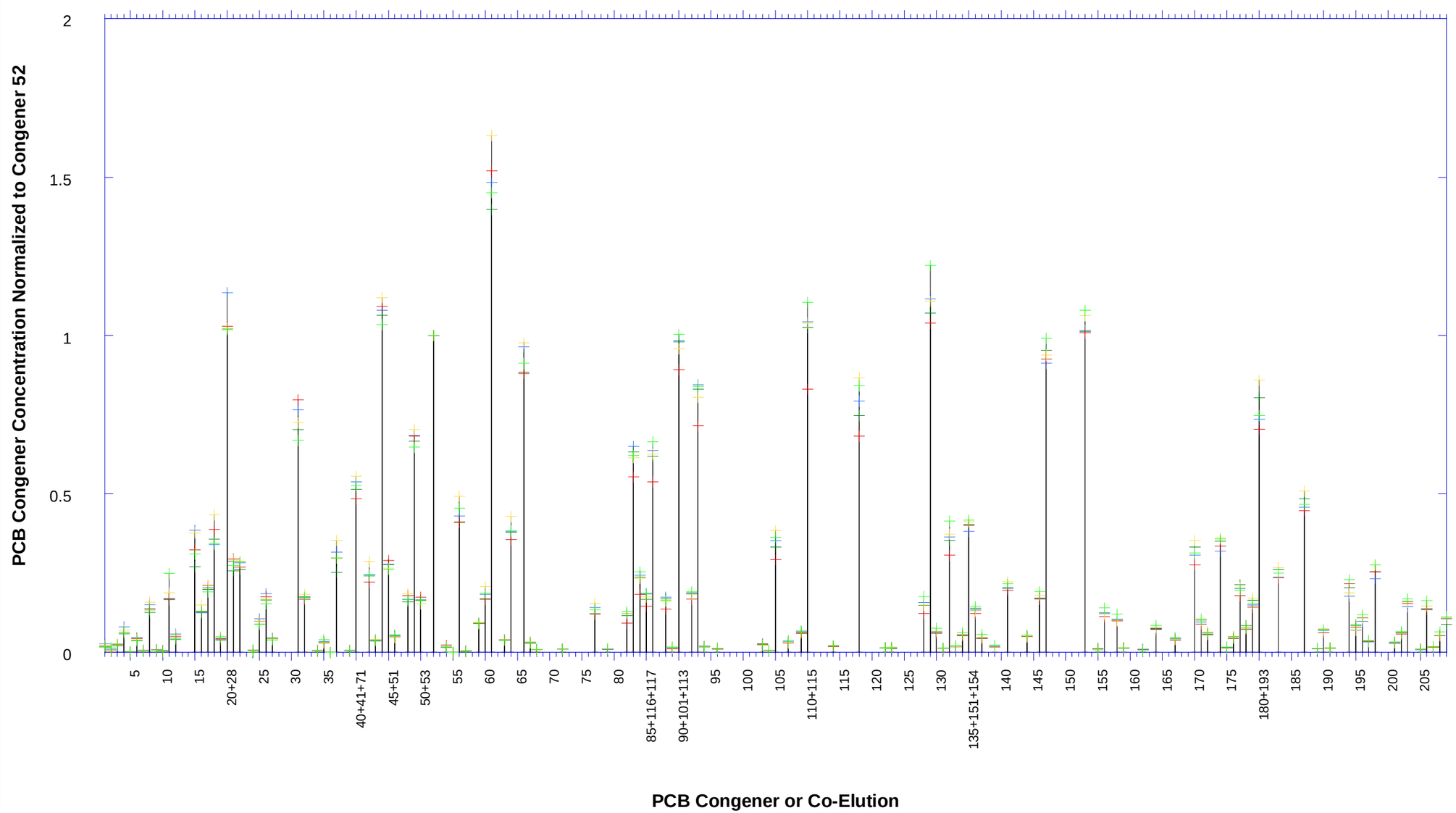
The hierarchical cluster analysis utilizes Ward's minimum variance method.

Dendrogram of Sampling Locations Cluster Analysis of 2,3,7,8-TCDD/Total TCDD Ratio in Lower Passaic River Surface Sediments

Lower Passaic River Restoration Project

Figure 4-5

June 2007



Legend

- RM1.4
- RM2.2
- RM7.8
- RM11
- RM12.6

Notes

Normalized PCB congener concentration <0.01 are not plotted.

PCB Congeners Concentration Normalized to Congener 52 for the Lower Passaic River High Resolution Cores Surface Sediments

Lower Passaic River Restoration Project

Figure 4-6

June 2007

3/22/2007 8:50AM

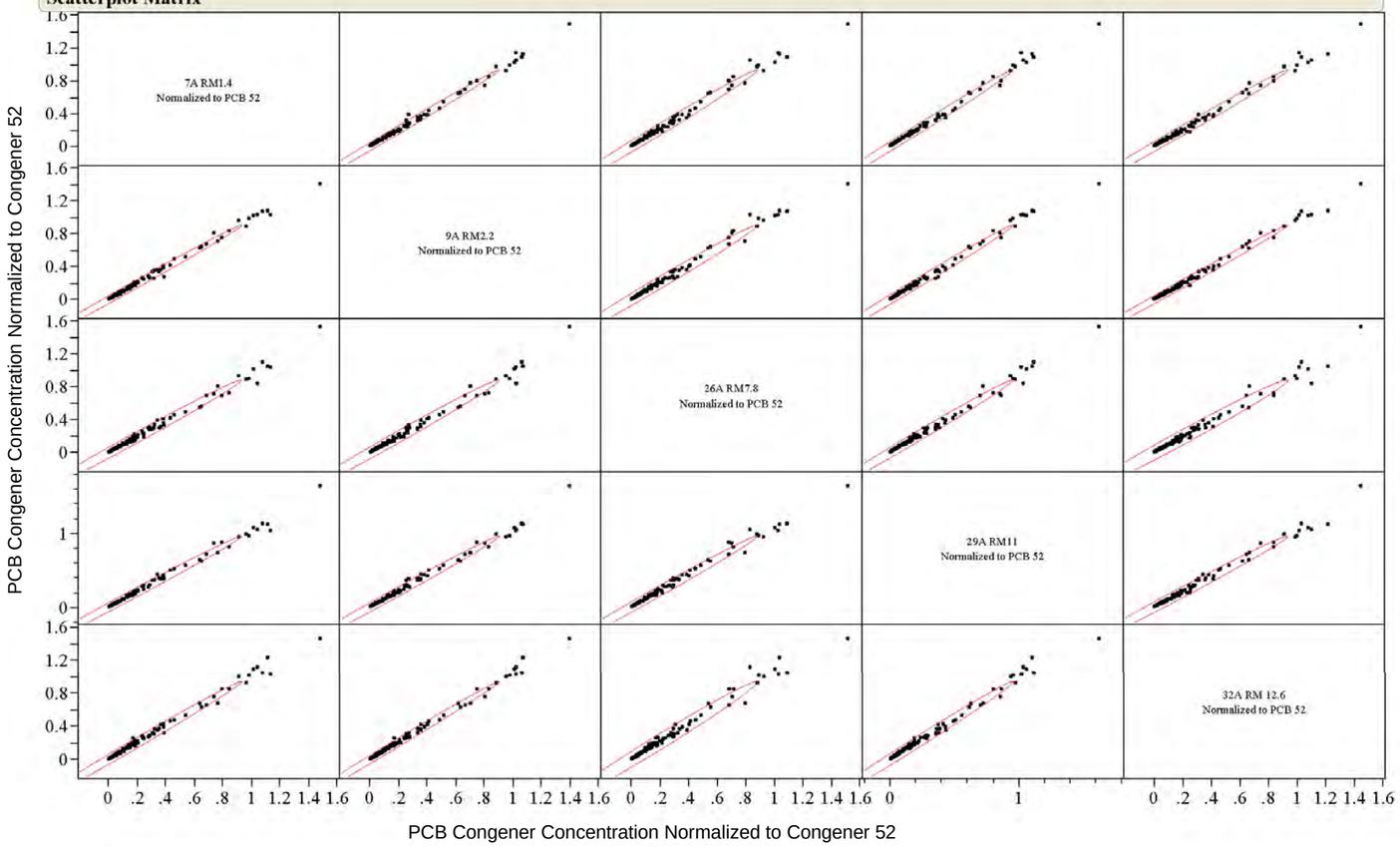
Multivariate LPR High Res Core Tops All Data

Correlations

	7A RM1.4 Normalized to PCB 52	9A RM2.2 Normalized to PCB 52	26A RM7.8 Normalized to PCB 52	29A RM11 Normalized to PCB 52	32A RM 12.6 Normalized to PCB 52
7A RM1.4 Normalized to PCB 52	1.0000	0.9975	0.9950	0.9965	0.9963
9A RM2.2 Normalized to PCB 52	0.9975	1.0000	0.9940	0.9963	0.9974
26A RM7.8 Normalized to PCB 52	0.9950	0.9940	1.0000	0.9953	0.9908
29A RM11 Normalized to PCB 52	0.9965	0.9963	0.9953	1.0000	0.9951
32A RM 12.6 Normalized to PCB 52	0.9963	0.9974	0.9908	0.9951	1.0000

24 rows not used due to missing or excluded values or frequency or weight variables missing, negative or less than one.

Scatterplot Matrix



Legend

- PCB Congeners Concentration Normalized to Congener 52

Notes

Identification numbers 7A, 9A, 26A, 29A, and 32A correspond to field location numbers of 2005 USEPA High Resolution Sediment Cores.

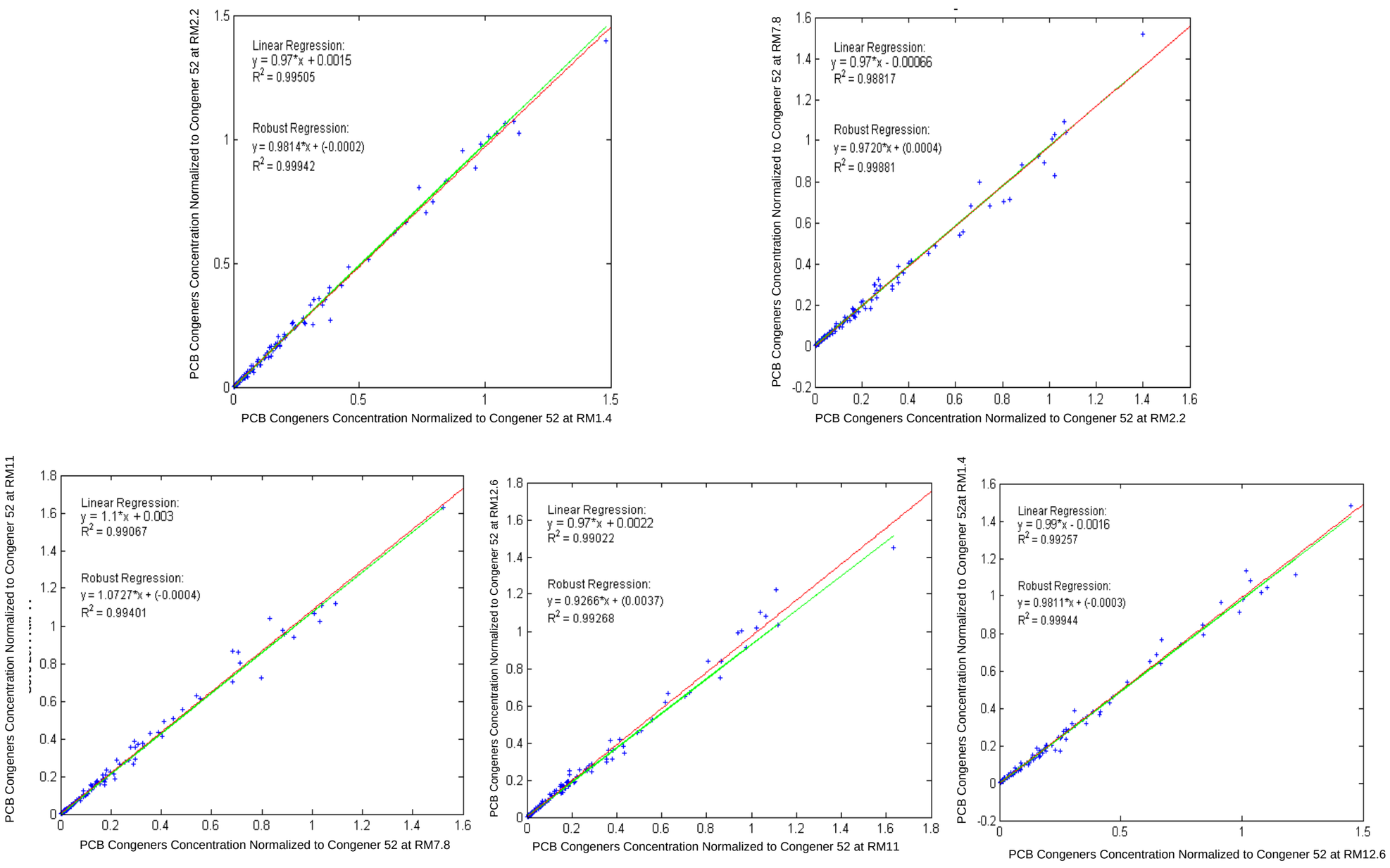
Data Source: USEPA 2005 High Resolution Sediment Coring Program collected by Malcolm Pirnie, Inc.

Correlation Among Sampling Locations for PCB Congeners of the Lower Passaic River High Resolution Cores Surface Sediments

Lower Passaic River Restoration Project

Figure 4-7

June 2007



Legend

+ PCB Congeners Concentration Normalized to Congener 52
- Linear Regression
- Robust Regression

Notes

Linear and Robust Regression for PCB Congeners Concentration Normalized to Congener 52 in the Lower Passaic River High Resolution Core Surface Sediments

Lower Passaic River Restoration Project

Figure 4-8

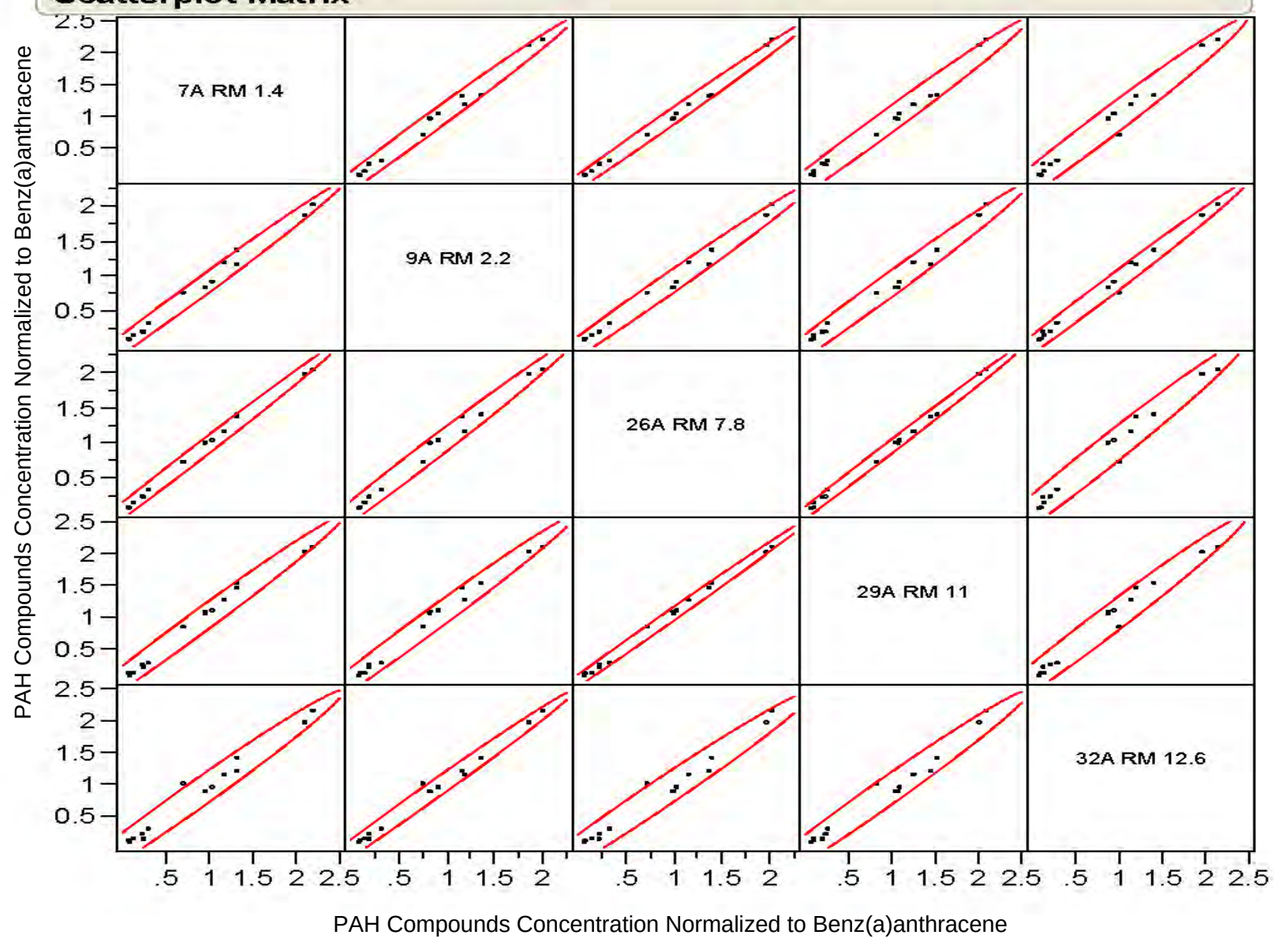
June 2007

Multivariate Passaic PAHs Normalized to BaA

Correlations

	7A RM 1.4	9A RM 2.2	26A RM 7.8	29A RM 11	32A RM 12.6
7A RM 1.4	1.0000	0.9945	0.9965	0.9917	0.9879
9A RM 2.2	0.9945	1.0000	0.9936	0.9920	0.9950
26A RM 7.8	0.9965	0.9936	1.0000	0.9979	0.9871
29A RM 11	0.9917	0.9920	0.9979	1.0000	0.9876
32A RM 12.6	0.9879	0.9950	0.9871	0.9876	1.0000

Scatterplot Matrix



Legend

- PAH Compounds Concentration Normalized to Benz(a)anthracene

Notes

Identification numbers 7A, 9A, 26A, 29A, and 32A correspond to river mile location as indicated in the figure.

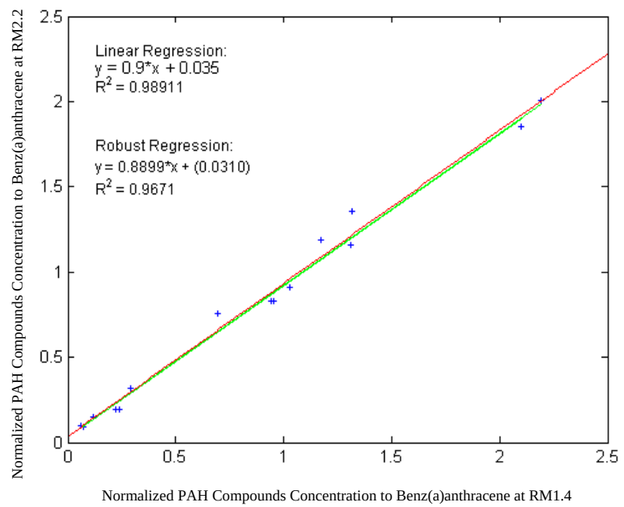
Data Source: USEPA 2005 High Resolution Sediment Coring Program collected by Malcolm Pirnie, Inc.

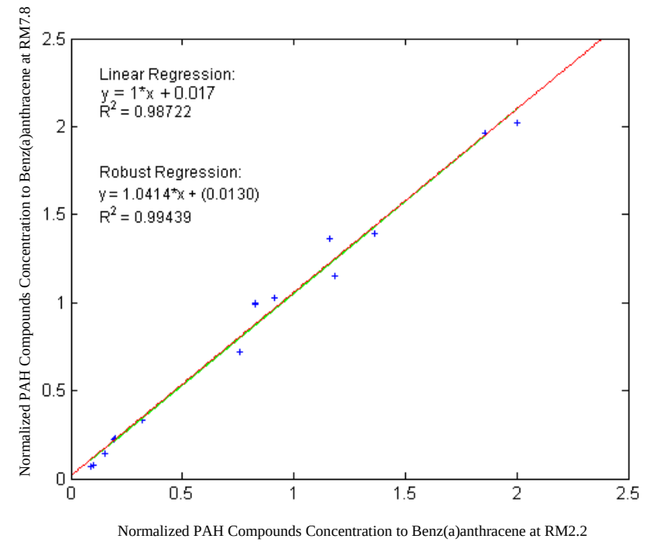
Correlation Among Sampling Locations for PAH Compounds Normalized to Benz(a)anthrazene for the Lower Passaic River High Resolution Cores Surface Sediments

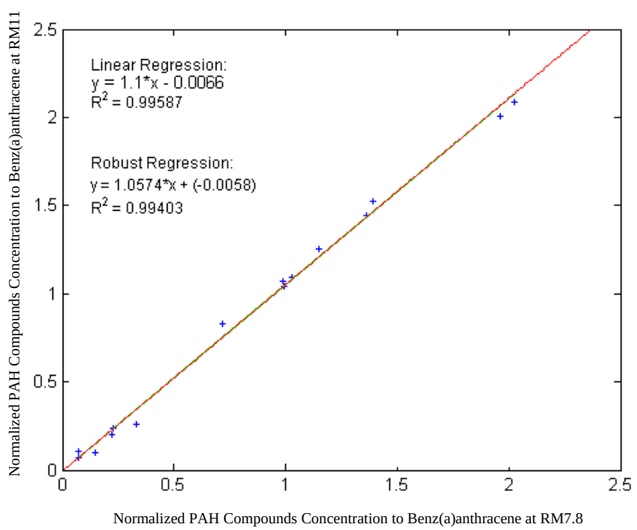
Lower Passaic River Restoration Project

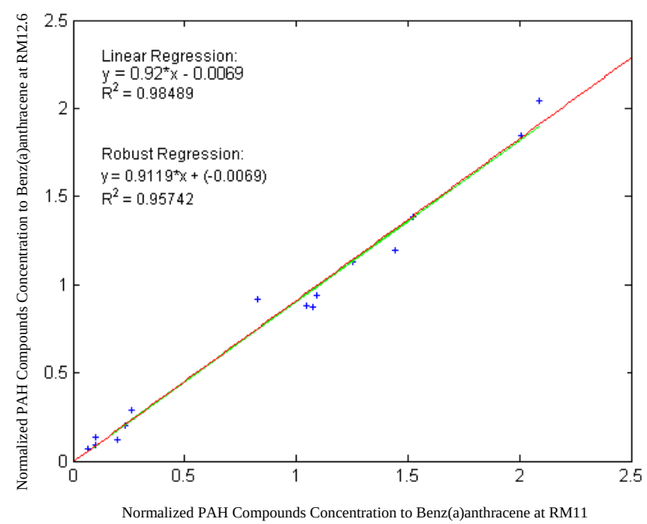
Figure 4-9

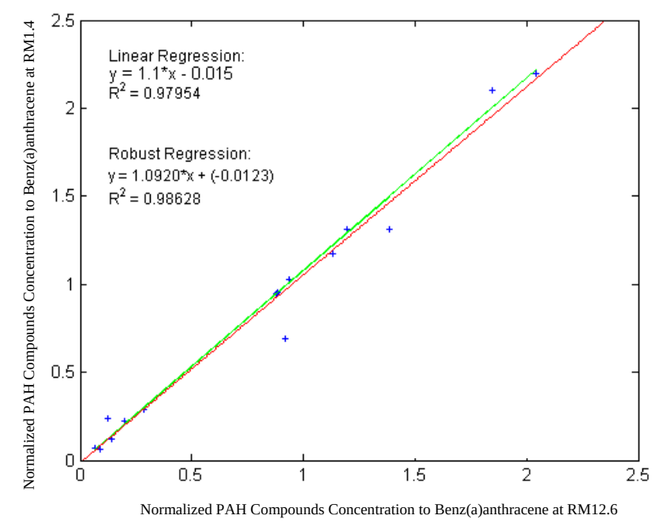
June 2007











Legend

PAH Compounds Concentration Normalized to Benz(a)anthracene

Linear Regression

Robust Regression

Notes

Linear and Robust Regression for PAH Compounds Concentration Normalized to Dieldrin in the Lower Passaic River High Resolution Core Surface Sediments

Lower Passaic River Restoration Project

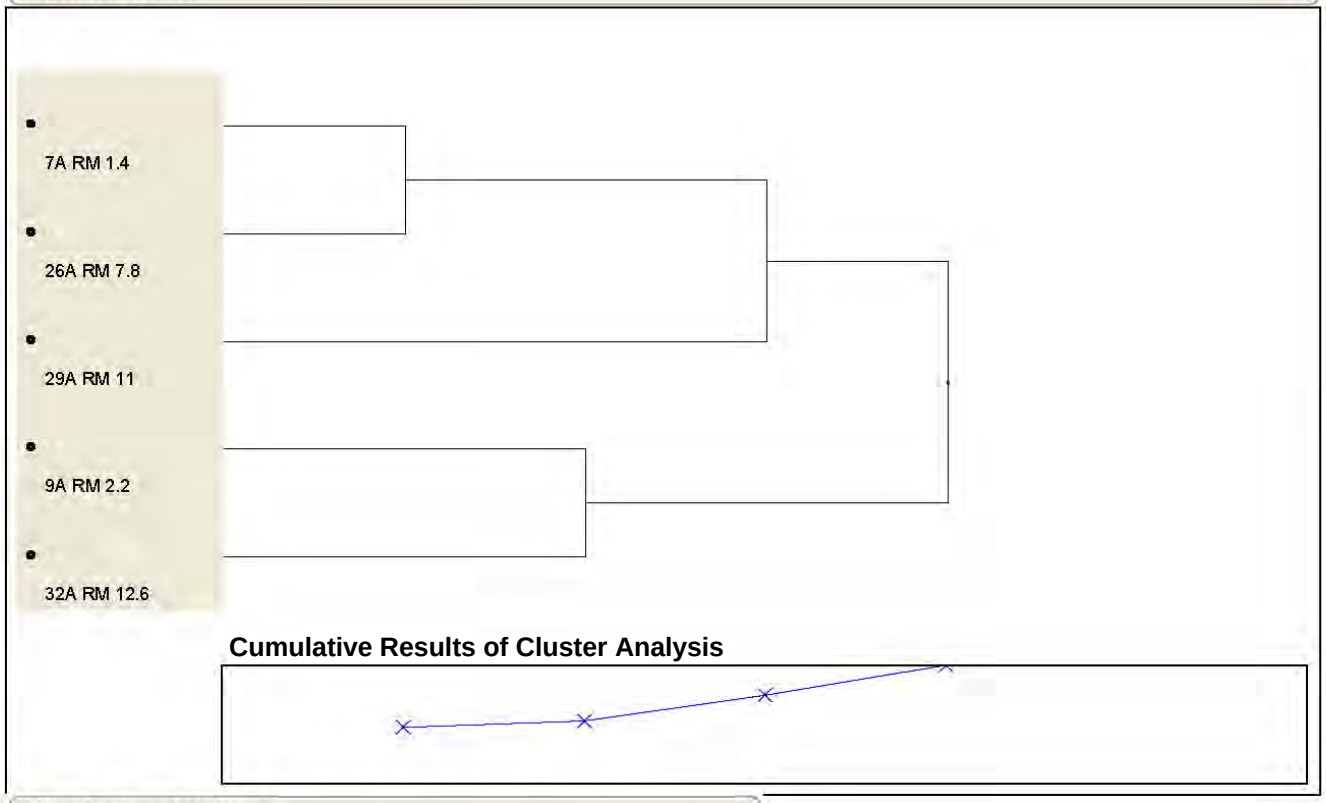
Figure 4-10

June 2007

Hierarchical Clustering

Method = Ward

Dendrogram



Clustering History

Number of Clusters	Distance	Leader	Joiner
4	2.560911359	7A RM 1.4	26A RM 7.8
3	2.852350366	9A RM 2.2	32A RM 12.6
2	4.023876300	7A RM 1.4	29A RM 11
1	5.395762219	7A RM 1.4	9A RM 2.2

Legend

Notes

Identification numbers 7A, 9A, 26A, 29A, and 32A correspond to field location numbers of 2005 USEPA High Resolution Sediment Cores.

The hierarchical cluster analysis utilizes Ward's minimum variance method.

Data Source:USEPA 2005 High Resolution Sediment Coring Program collected by Malcolm Pirnie, Inc.

Dendrogram of Sampling Locations Cluster Analysis for PAH Compounds in Lower Passaic River Surface Sediments

Lower Passaic River Restoration Project

Figure 4-11

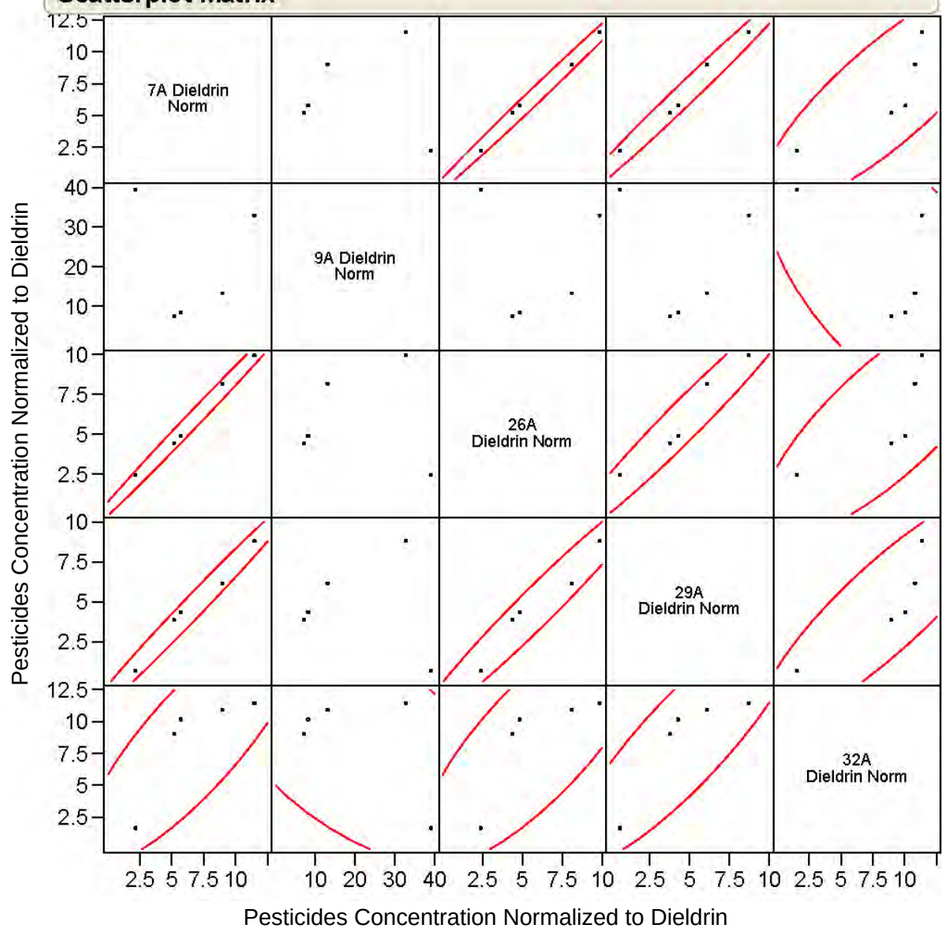
June 2007

Multivariate

Correlations

	7A Dieldrin Norm	9A Dieldrin Norm	26A Dieldrin Norm	29A Dieldrin Norm	32A Dieldrin Norm
7A Dieldrin Norm	1.0000	-0.0474	0.9959	0.9915	0.8338
9A Dieldrin Norm	-0.0474	1.0000	0.0013	-0.1104	-0.5734
26A Dieldrin Norm	0.9959	0.0013	1.0000	0.9757	0.7952
29A Dieldrin Norm	0.9915	-0.1104	0.9757	1.0000	0.8745
32A Dieldrin Norm	0.8338	-0.5734	0.7952	0.8745	1.0000

Scatterplot Matrix



Legend

- Pesticides Concentration Normalized to Dieldrin

Notes

Identification numbers 7A, 9A, 26A, 29A, and 32A correspond to field location numbers of 2005 USEPA High Resolution Sediment Cores.

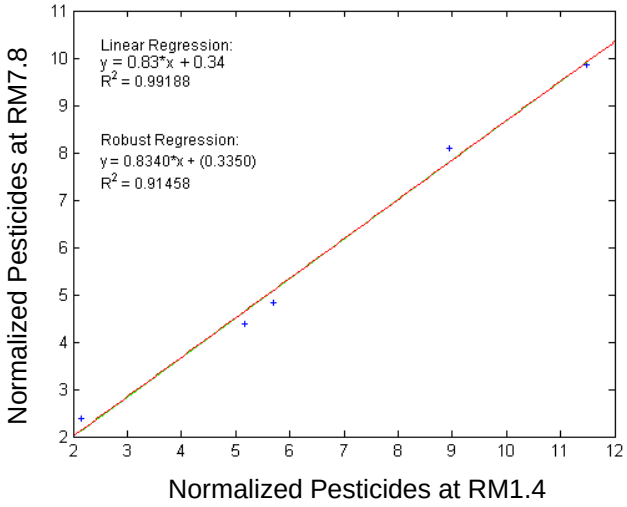
Data Source: USEPA 2005 High Resolution Sediment Coring Program collected by Malcolm Pirnie, Inc.

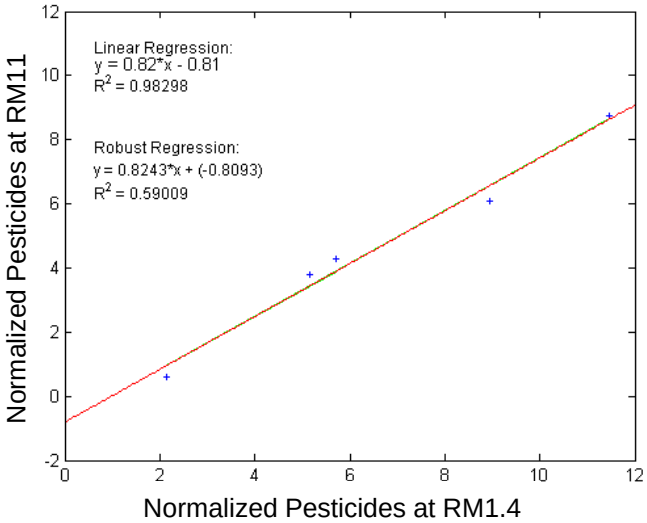
Correlation Among Sampling Locations for Pesticides Compounds Normalized to Dieldrin for the Lower Passaic River High Resolution Cores Surface Sediments

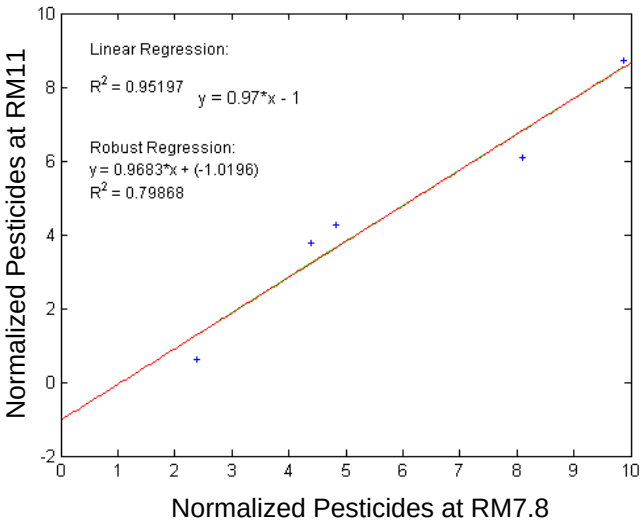
Lower Passaic River Restoration Project

Figure 4-12

June 2007







Legend

Pesticides Concentration Normalized to Dieldrin

Linear Regression

Robust Regression

Notes

Linear and Robust Regression for Pesticides in the Lower Passaic River Surface Sediments

Lower Passaic River Restoration Project

Figure 4-13

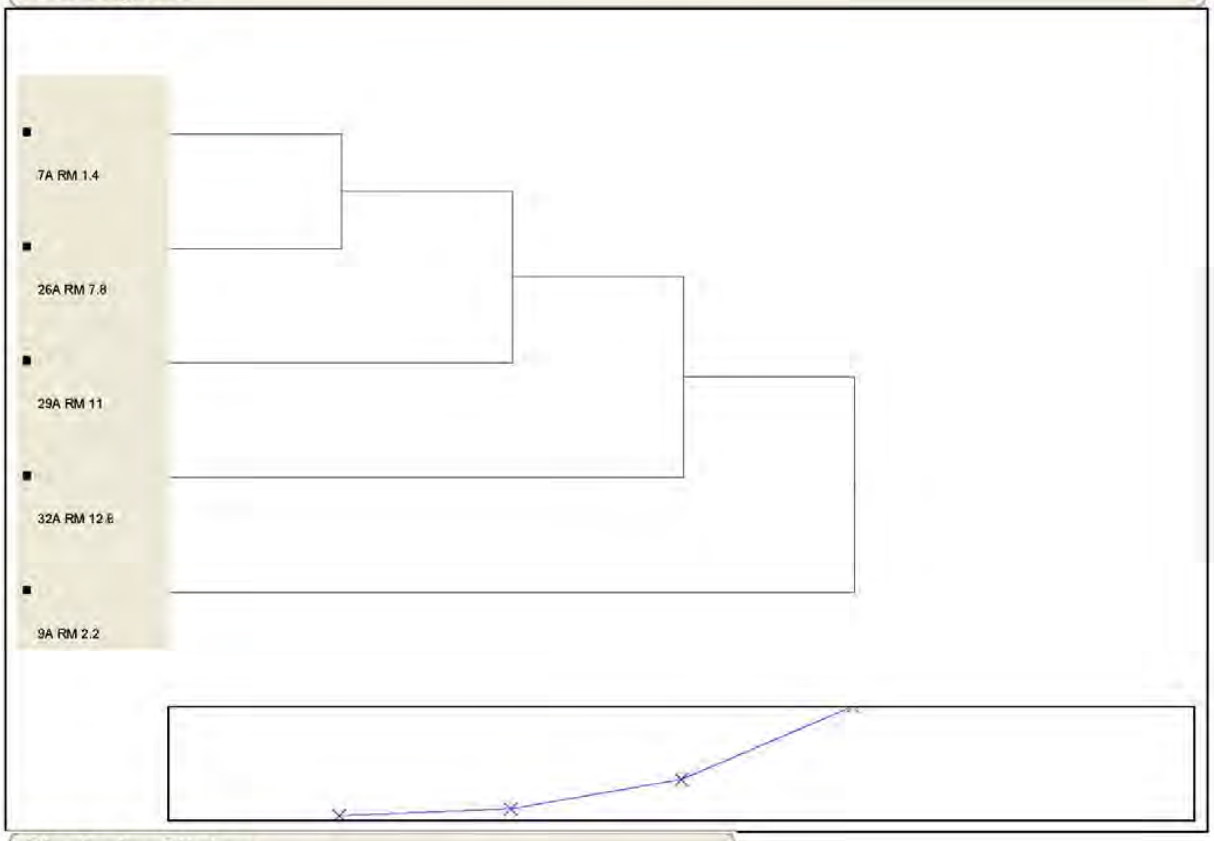
June 2007

R2-0010132

Hierarchical Clustering for Pesticides Normalized to Dieldrin

Method = Ward

Dendrogram



Clustering History

Number of Clusters	Distance	Leader	Joiner
4	0.127535775	7A RM 1.4	26A RM 7.8
3	0.286702558	7A RM 1.4	29A RM 11
2	0.984085832	7A RM 1.4	32A RM 12.6
1	2.711898948	7A RM 1.4	9A RM 2.2

Legend

Notes

Identification numbers 7A, 9A, 26A, 29A, and 32A correspond to field location numbers of 2005 USEPA High Resolution Sediment Cores.

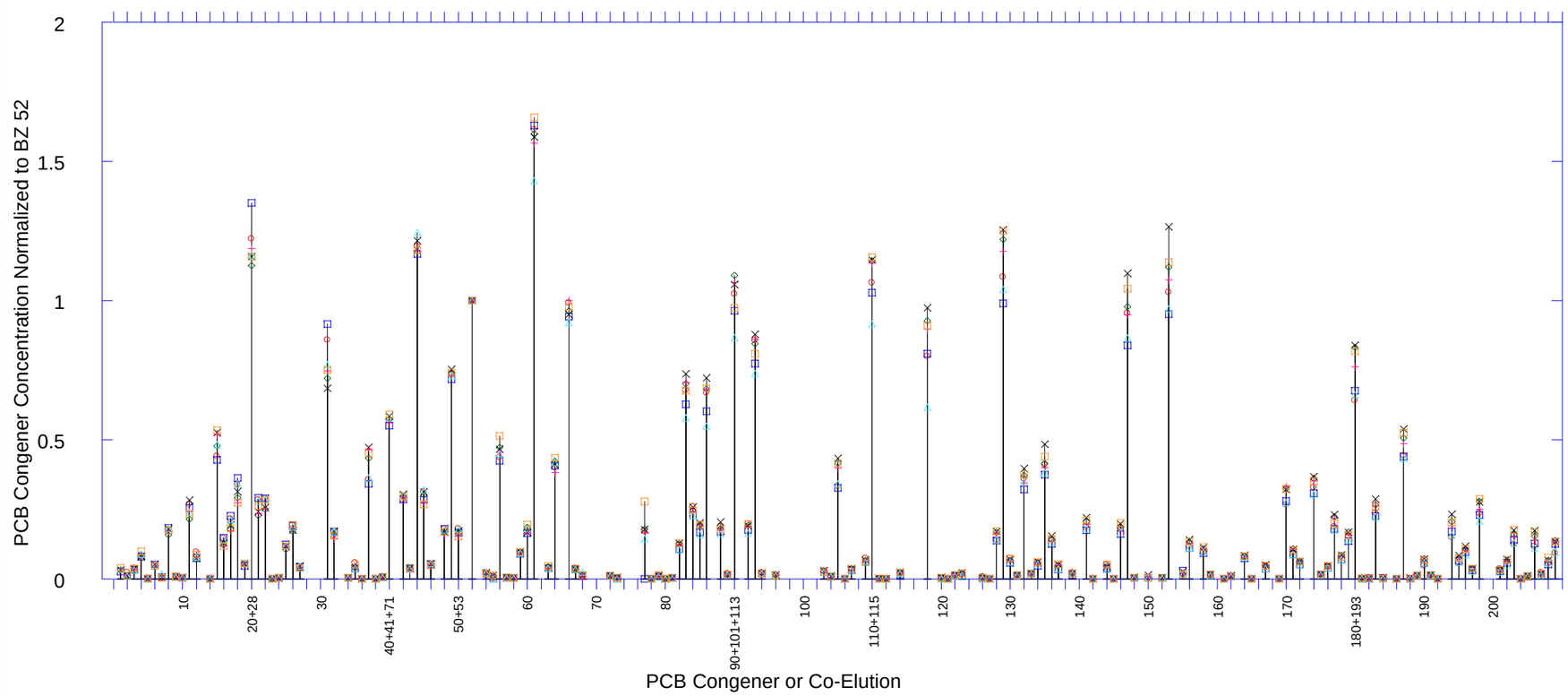
Data Source: USEPA 2005 High Resolution Sediment Coring Program collected by Malcolm Pirnie, Inc.

Dendrogram from Cluster Analysis of Sampling Locations for Pesticide Compounds Normalized to Dieldrin in Lower Passaic River High Resolution Cores Surface Sediments

Lower Passaic River Restoration Project

Figure 4-14

June 2007



Legend

- Dec5 Downriver
- Dec6 Downriver
- Dec6 Upriver
- Dec7 Upriver
- Dec8 Upriver
- Dec10 Downriver
- Dec12 Downriver

Notes

Upriver and downriver refer to the flow direction as it changes with the tide.

"Dec5 Downriver" represents the average PCB congener concentration from morning and afternoon samples collected on December 5, 2005.

"Dec6 Downriver" represents the average PCB congener concentration from morning and afternoon samples collected on December 6, 2005.

"Dec6 Upriver" represents the average PCB congener concentration from morning and afternoon samples collected on December 6, 2005.

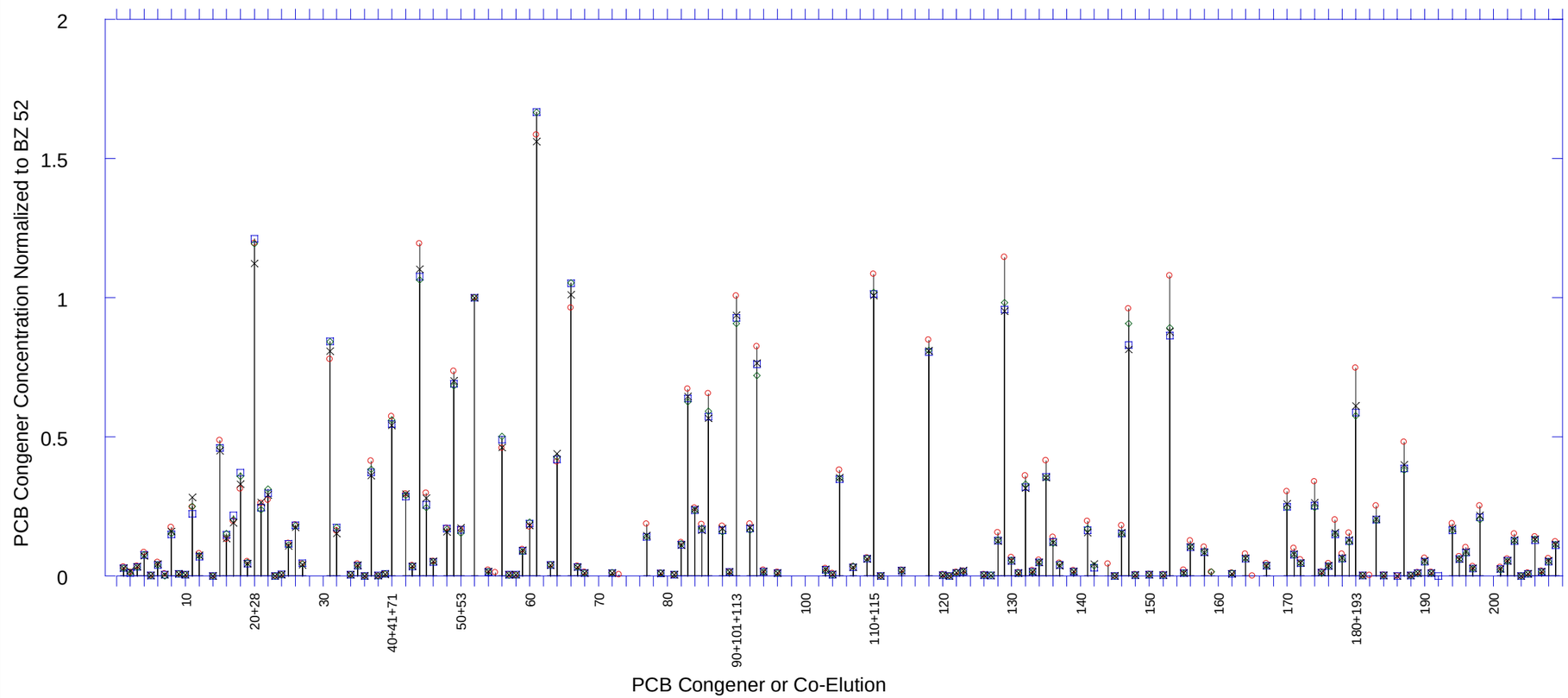
"Dec10 Downriver" represents the average PCB congener concentration from morning and afternoon samples collected on December 10, 2005.

PCB Congener Concentration Normalized to BZ 52 on Suspended Solids: USGS TOPS

Lower Passaic River Restoration Project

Figure 4-15a

June 2007



Legend

- Average USGS TOPS
- Field-Filtered TOPS
- Laboratory-Filtered TOPS
- Infiltrex

Notes

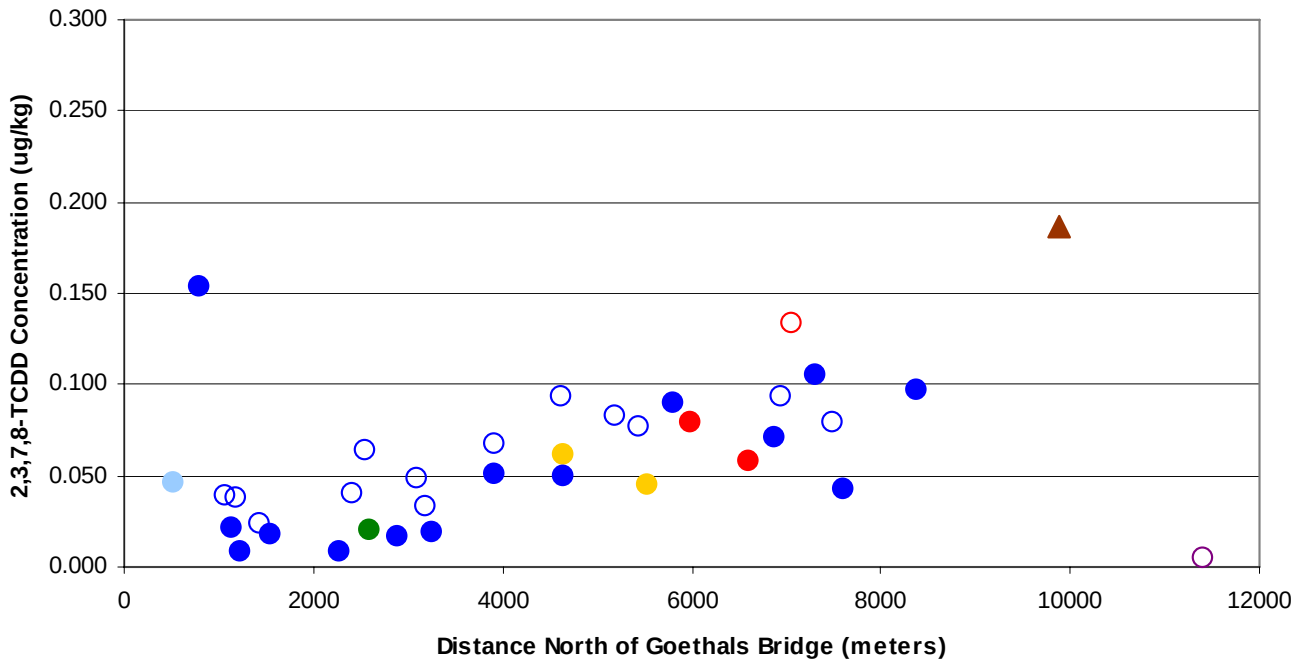
"Average USGS TOPS" represents the average PCB congener concentration from samples collected on December 5, 2005 through December 12, 2005.

PCB Congener Concentrations Normalized to BZ 52 on Suspended Solids: USGS TOPS, Field-Filtered TOPS, Laboratory-Filtered TOPS, and Infiltrex

Lower Passaic River Restoration Project

Figure 4-15b

June 2007



Legend

- Newark Bay
- Confluence of unnamed creek with Hackensack River
- Port Newark
- Port Elizabeth
- South Elizabeth Channel
- Arthur Kill
- Lower Passaic River (2005)

Symbols Legend

- Coring Locations in Navigation Channels
- Coring Locations outside Navigation Channels

Notes:

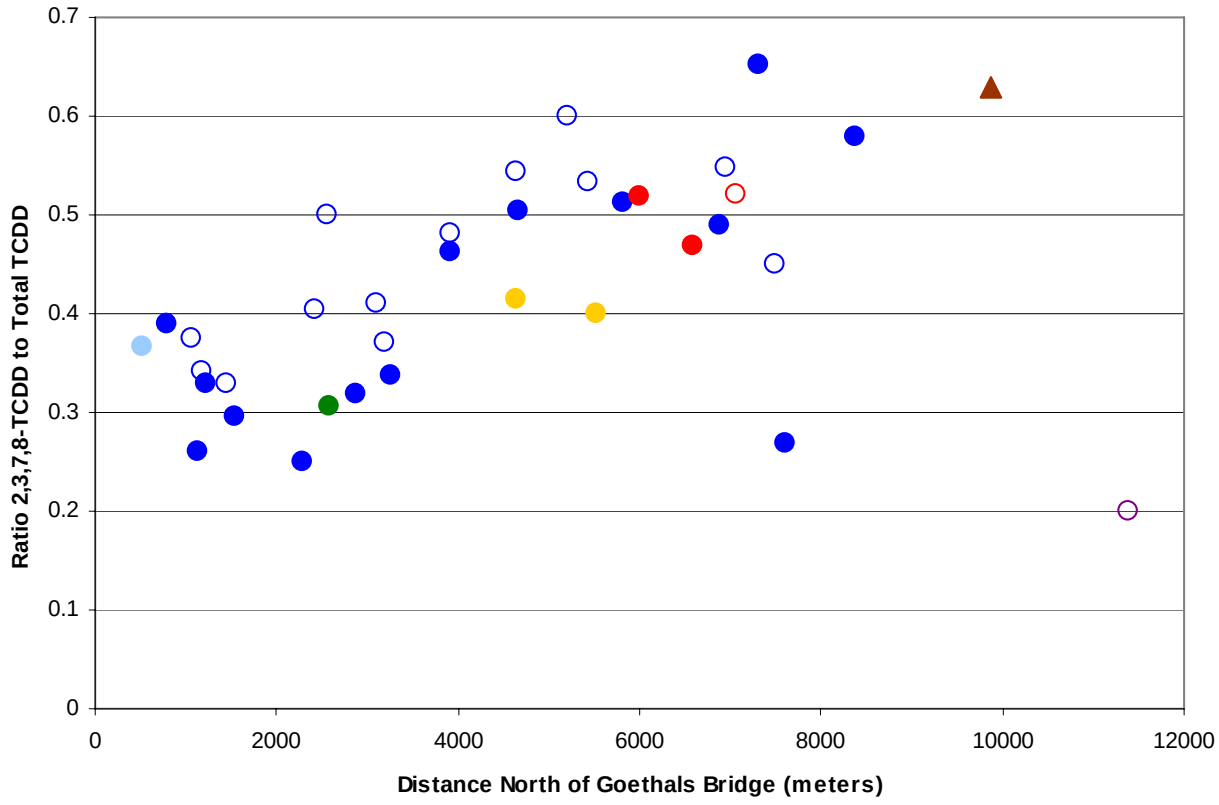
1. 2,3,7,8-TCDD surface concentrations represent the top 6 inches of the core.
2. When duplicate 2,3,7,8-TCDD values are provided by the laboratory, the average concentration is plotted.
3. No nondetected 2,3,7,8-TCDD values were reported for the surface sediment.
4. 2,3,7,8-TCDD concentrations are plotted only for depositional environments, indicated by Beryllium-7 detections more than 0.5 pCi/g in the top inch of the core.
5. Data Source: Malcolm Pirnie, Inc. High Resolution Sediment Core in the Lower Passaic River (RM 1.4). USEPA 2005 Sampling Program.
6. Data Source: Newark Bay Phase 2 RIWP (October 2006). Samples collected in October to December 2005.

2,3,7,8-TCDD Surface Sediment Concentrations in Newark Bay Complex

Lower Passaic River Restoration Project

Figure 4-16a

June 2007



Colors Legend

- Newark Bay
- Confluence of unnamed creek with Hackensack River
- Port Newark
- Port Elizabeth
- South Elizabeth Channel
- Arthur Kill
- Lower Passaic River (2005)

Symbols Legend

- Coring Locations in Navigation Channels
- Coring Locations outside Navigation Channels

Notes:

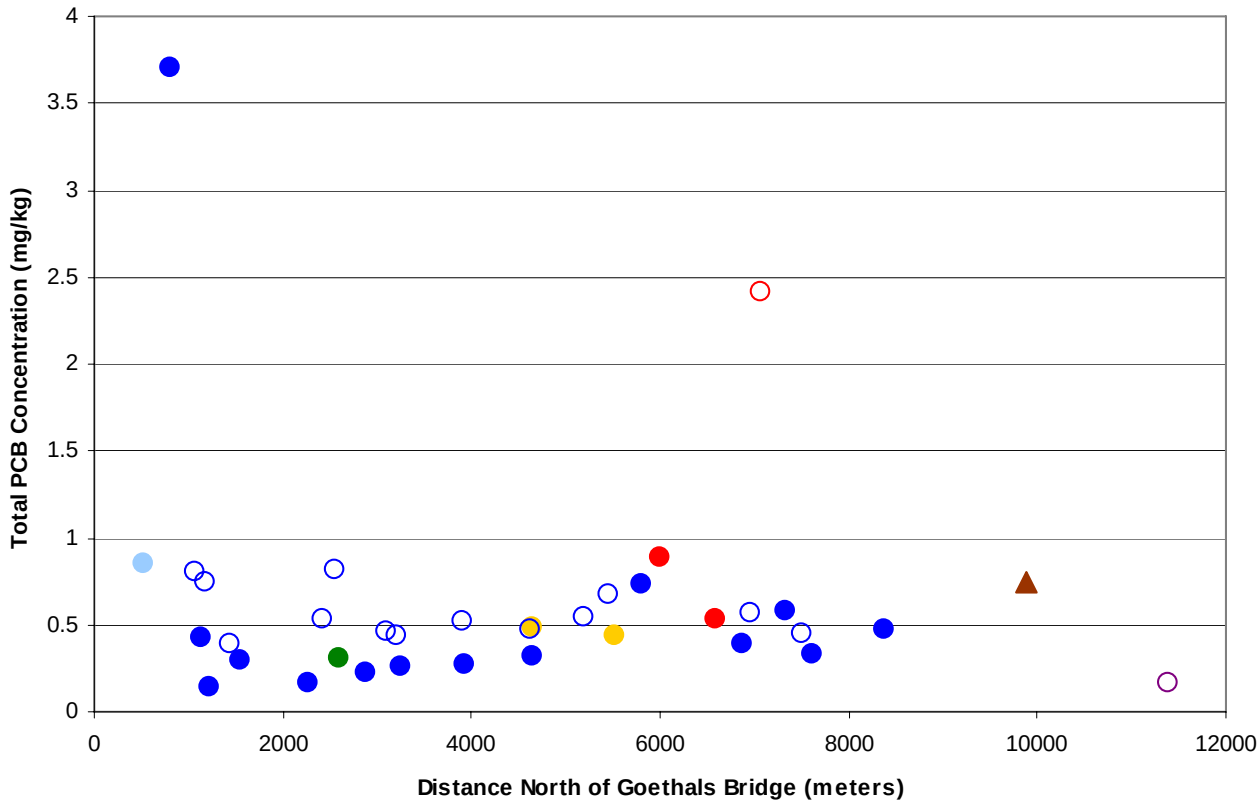
1. 2,3,7,8-TCDD and Total TCDD surface concentrations represent the top 6 inches of the core.
2. When duplicate 2,3,7,8-TCDD or Total TCDD values are provided by the laboratory, the average ratio is plotted.
3. No nondetected 2,3,7,8-TCDD or Total TCDD values were reported for the surface sediment.
4. Concentration ratios are plotted only for depositional environments, indicated by Beryllium-7 detections more than 0.5 pCi/g in the top inch of the core.
5. Data Source: Malcolm Pirnie, Inc. High Resolution Sediment Core in the Lower Passaic River (RM 1.4). USEPA 2005 Sampling Program.
6. Data Source: Newark Bay Phase 2 RIWP (October 2006). Samples collected in October to December 2005.

Ratio of 2,3,7,8-TCDD to Total TCDD Surface Sediments Concentrations in Newark Bay Complex

Lower Passaic River Restoration Project

Figure 4-16b

June 2007



Colors Legend

- Newark Bay
- Confluence of unnamed creek with Hackensack River
- Port Newark
- Port Elizabeth
- South Elizabeth Channel
- Arthur Kill
- Lower Passaic River (2005)

Symbols Legend

- Coring Locations in Navigation Channels
- Coring Locations outside Navigation Channels

Notes:

1. Total PCB surface concentrations represent the top 6 inches of the core.
2. Total PCB represents the sum of 209 congeners with nondetected values incorporated into the sum as zero.
3. When duplicate PCB congener values are provided by the laboratory, the average concentration is used in the summation.
4. Total PCB concentrations are plotted only for depositional environments, indicated by Beryllium-7 detections more than 0.5 pCi/g in the top inch of the core.
5. Data Source: Malcolm Pirnie, Inc. High Resolution Sediment Core in the Lower Passaic River (RM 1.4). USEPA 2005 Sampling Program.
6. Data Source: Newark Bay Phase 2 RIWP (October 2006). Samples collected in October to December 2005.

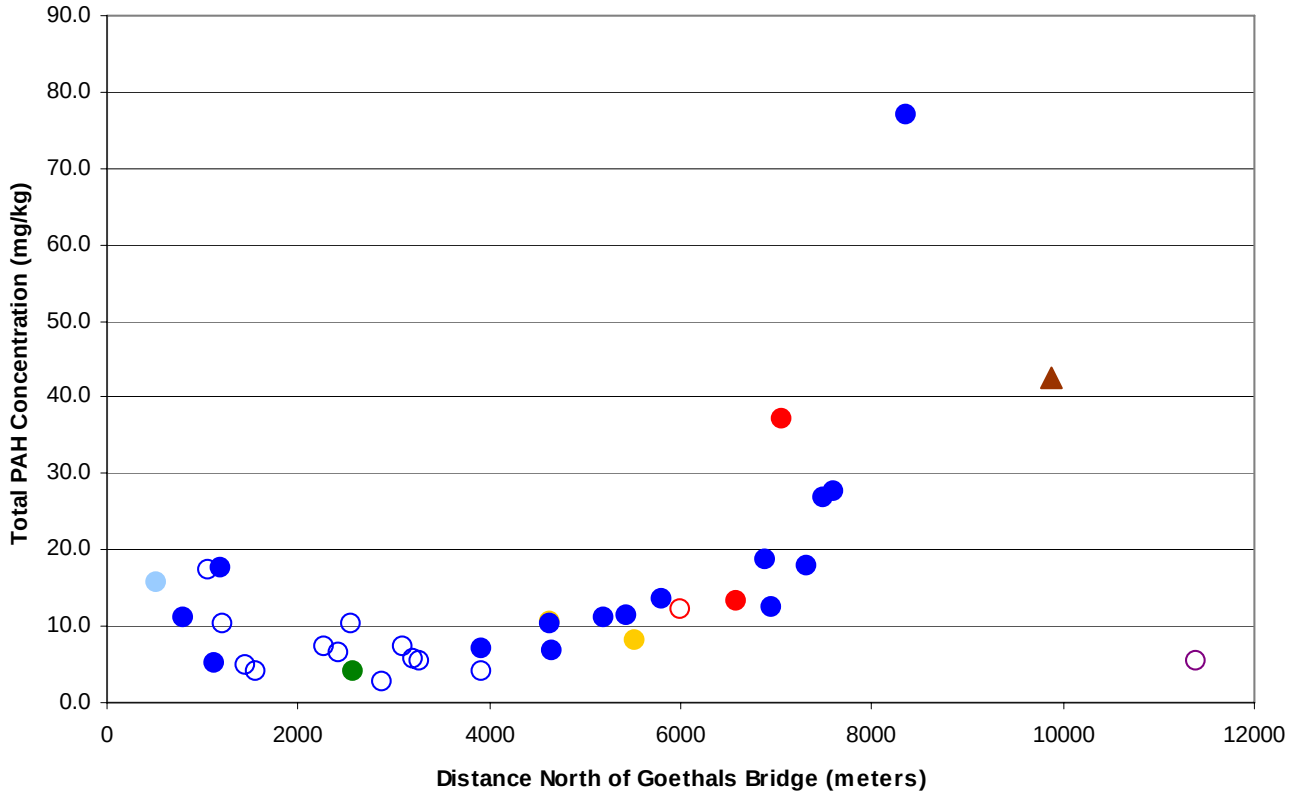
Total PCB Surface Sediments Concentrations in Newark Bay Complex

Lower Passaic River Restoration Project

Figure 4-16c

June 2007

R2-0010138



Colors Legend

- Newark Bay
- Confluence of unnamed creek with Hackensack River
- Port Newark
- Port Elizabeth
- South Elizabeth Channel
- Arthur Kill
- Lower Passaic River (2005)

Symbols Legend

- Coring Locations in Navigation Channels
- Coring Locations outside Navigation Channels

Notes:

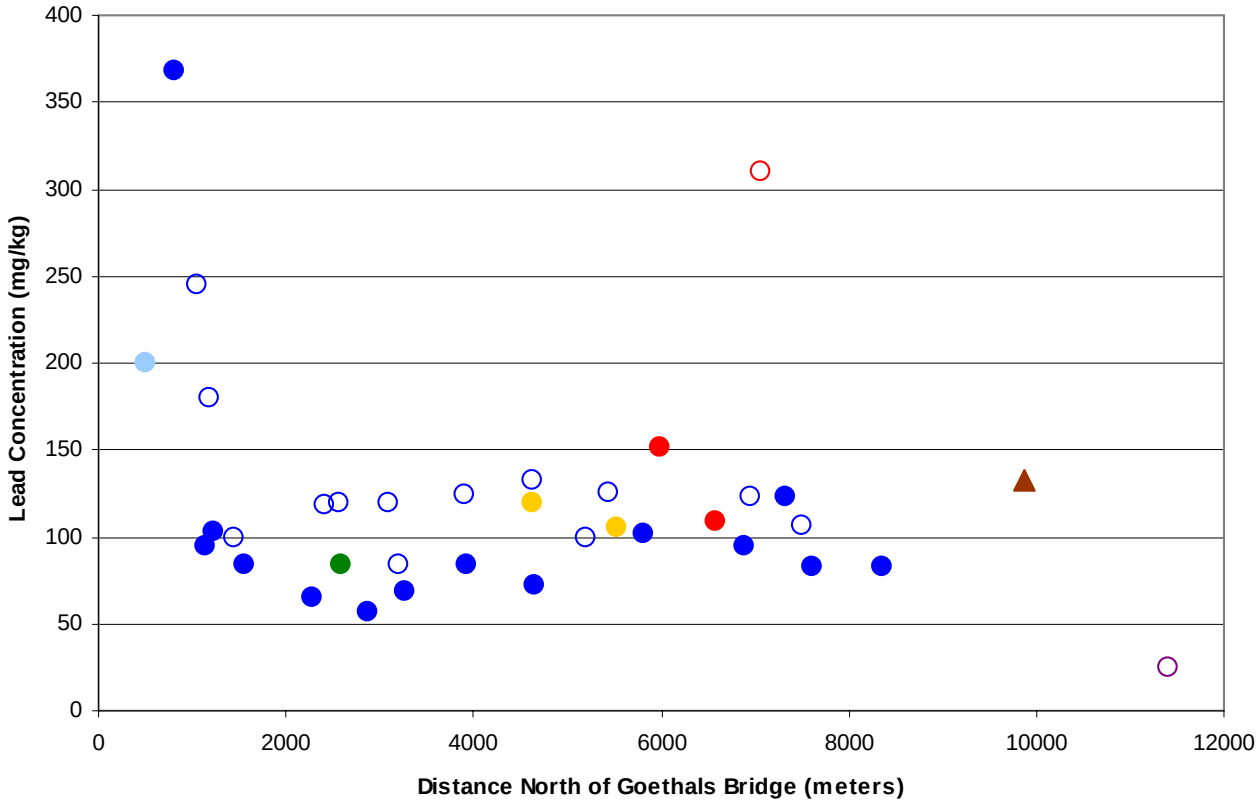
1. Total PAH surface concentrations represent the top 6 inches of the core.
2. The Total PAH value is the sum of the 16 PAHs listed in the USEPA Priority List with nondetected values incorporated into the sum as zero.
3. When duplicate PAH values are provided by the laboratory, the average concentration is used in the summation.
4. Total PAH concentrations are plotted only for depositional environments, indicated by Beryllium-7 detections more than 0.5 pCi/g in the top inch of the core.
5. Data Source: Malcolm Pirnie, Inc. High Resolution Sediment Core in the Lower Passaic River (RM 1.4). USEPA 2005 Sampling Program.
6. Data Source: Newark Bay Phase 2 RIWP (October 2006). Samples collected in October to December 2005.

Total PAH Surface Sediments Concentrations in Newark Bay Complex

Lower Passaic River Restoration Project

Figure 4-16d

June 2007



Colors Legend

- Newark Bay
- Confluence of unnamed creek with Hackensack River
- Port Newark
- Port Elizabeth
- South Elizabeth Channel
- Arthur Kill
- Lower Passaic River (2005)

Symbols Legend

- Coring Locations in Navigation Channels
- Coring Locations outside Navigation Channels

Notes:

1. Lead surface concentrations represent the top 6 inches of the core.
2. When duplicate lead values are provided by the laboratory, the average lead concentration is plotted.
3. No nondetected lead values were reported for the surface sediment.
4. Lead concentrations are plotted only for depositional environments, indicated by Beryllium-7 detections more than 0.5 pCi/g in the top inch of the core.
5. Data Source: Malcolm Pirnie, Inc. High Resolution Sediment Core in the Lower Passaic River (RM 1.4). USEPA 2005 Sampling Program.
6. Data Source: Newark Bay Phase 2 RIWP (October 2006). Samples collected in October to December 2005.

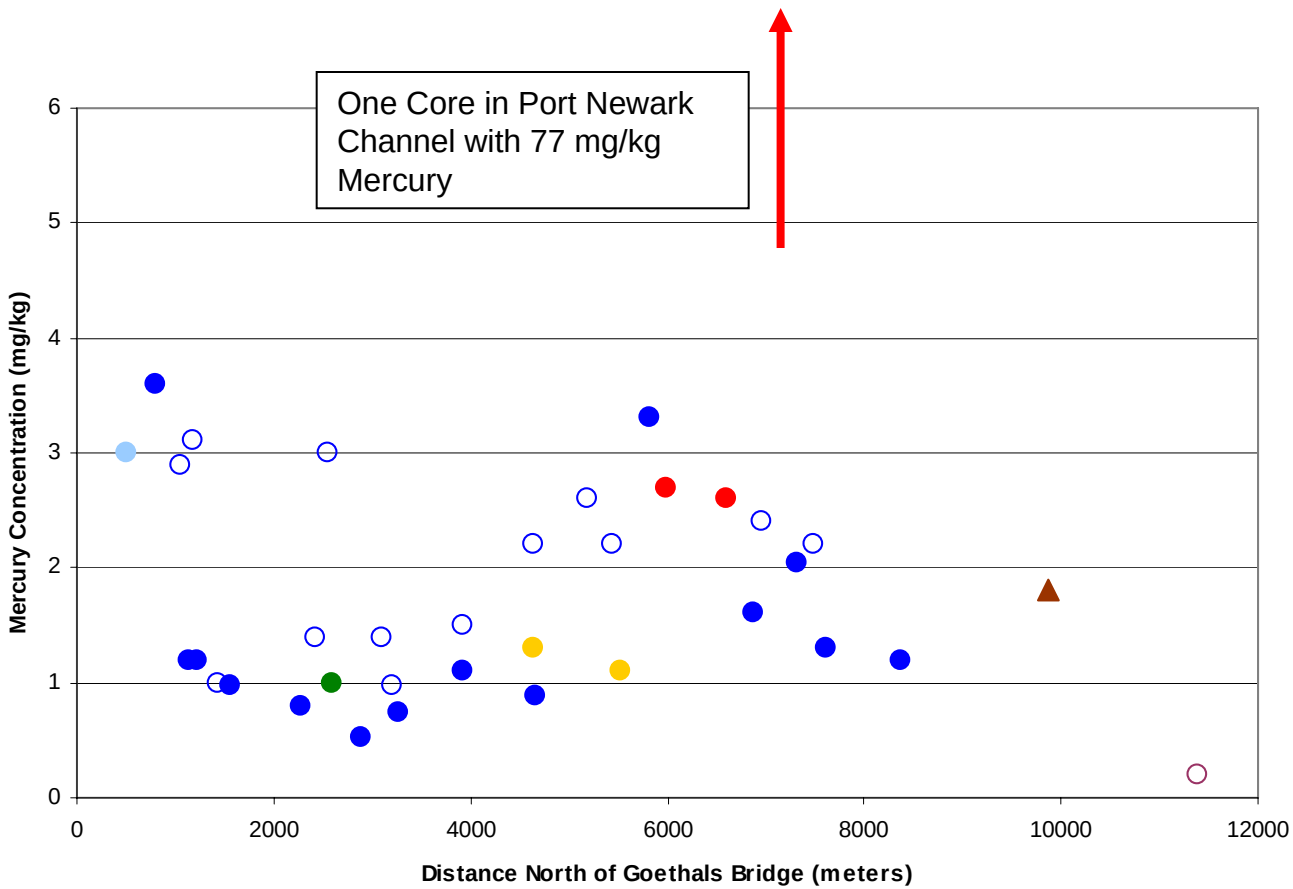
Lead Surface Sediment Concentrations in Newark Bay Complex

Lower Passaic River Restoration Project

Figure 4-16e

June 2007

R2-0010140



Colors Legend

- Newark Bay
- Confluence of unnamed creek with Hackensack River
- Port Newark
- Port Elizabeth
- South Elizabeth Channel
- Arthur Kill
- Lower Passaic River (2005)

Symbols Legend

- Coring Locations in Navigation Channels
- Coring Locations outside Navigation Channels

Notes:

1. Mercury surface concentrations represent the top 6 inches of the core.
2. When duplicate mercury values are provided by the laboratory, the average mercury concentration is plotted.
3. No nondetected mercury values were reported for the surface sediment.
4. Mercury concentrations are plotted only for depositional environments, indicated by Beryllium-7 detections more than 0.5 pCi/g in the top inch of the core.
5. Data Source: Malcolm Pirnie, Inc. High Resolution Sediment Core in the Lower Passaic River (RM 1.4). USEPA 2005 Sampling Program.
6. Data Source: Newark Bay Phase 2 RIWP (October 2006). Samples collected in October to December 2005.

Mercury Surface Sediment Concentrations in Newark Bay Complex

Lower Passaic River Restoration Project

Figure 4-16f

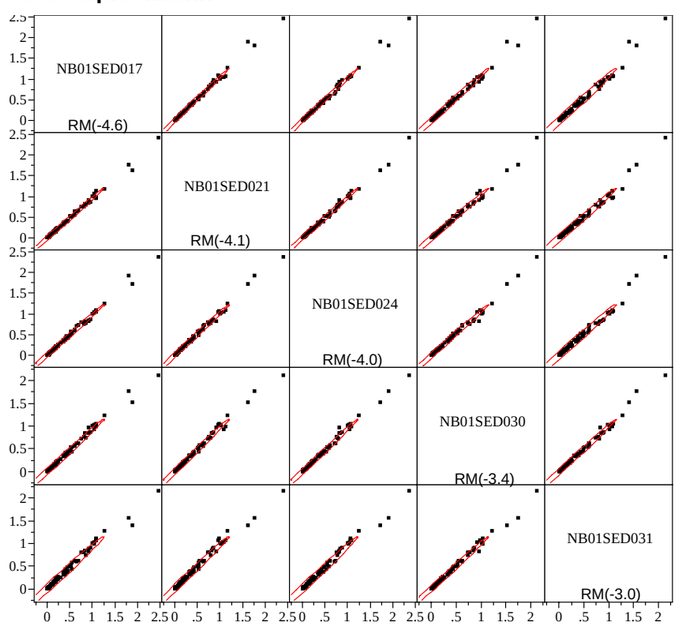
June 2007

R2-0010141

Multivariate Correlations

	NB01SED017 RM(-4.6)	NB01SED021 RM(-4.1)	NB01SED024 RM(-4.0)	NB01SED030 RM(-3.4)	NB01SED031 RM(-3.0)
NB01SED017 RM(-4.6)	1.0000	0.9978	0.9976	0.9961	0.9931
NB01SED021 RM(-4.1)	0.9978	1.0000	0.9976	0.9962	0.9941
NB01SED024 RM(-4.0)	0.9976	0.9976	1.0000	0.9969	0.9934
NB01SED030 RM(-3.4)	0.9961	0.9962	0.9969	1.0000	0.9964
NB01SED031 (-3.0)	0.9931	0.9941	0.9934	0.9964	1.0000

Scatterplot Matrix



Legend

- PCB Congeners Concentration Normalized to Congener 52

Notes

In this presentation, river miles for the Newark Bay sampling locations are assigned with respect to the distance from the mouth of the Lower Passaic River (RM0.0) and following the federal navigation channel.

Data Source: 2005 Tierra Solutions, Inc. (TSI) Remedial Investigation Phase 1 dataset

Correlation Among the Sampling Locations of PCB Congeners in Southern Newark Bay Samples

Lower Passaic River Restoration Project

Figure 4-17

June 2007

Note: In this presentation, river miles for the Newark Bay sampling locations are assigned with respect to the distance from the mouth of the Lower Passaic River (RM0.0) and following the federal navigation channel.

Site Location Map of Selected Southern Locations in Newark Bay

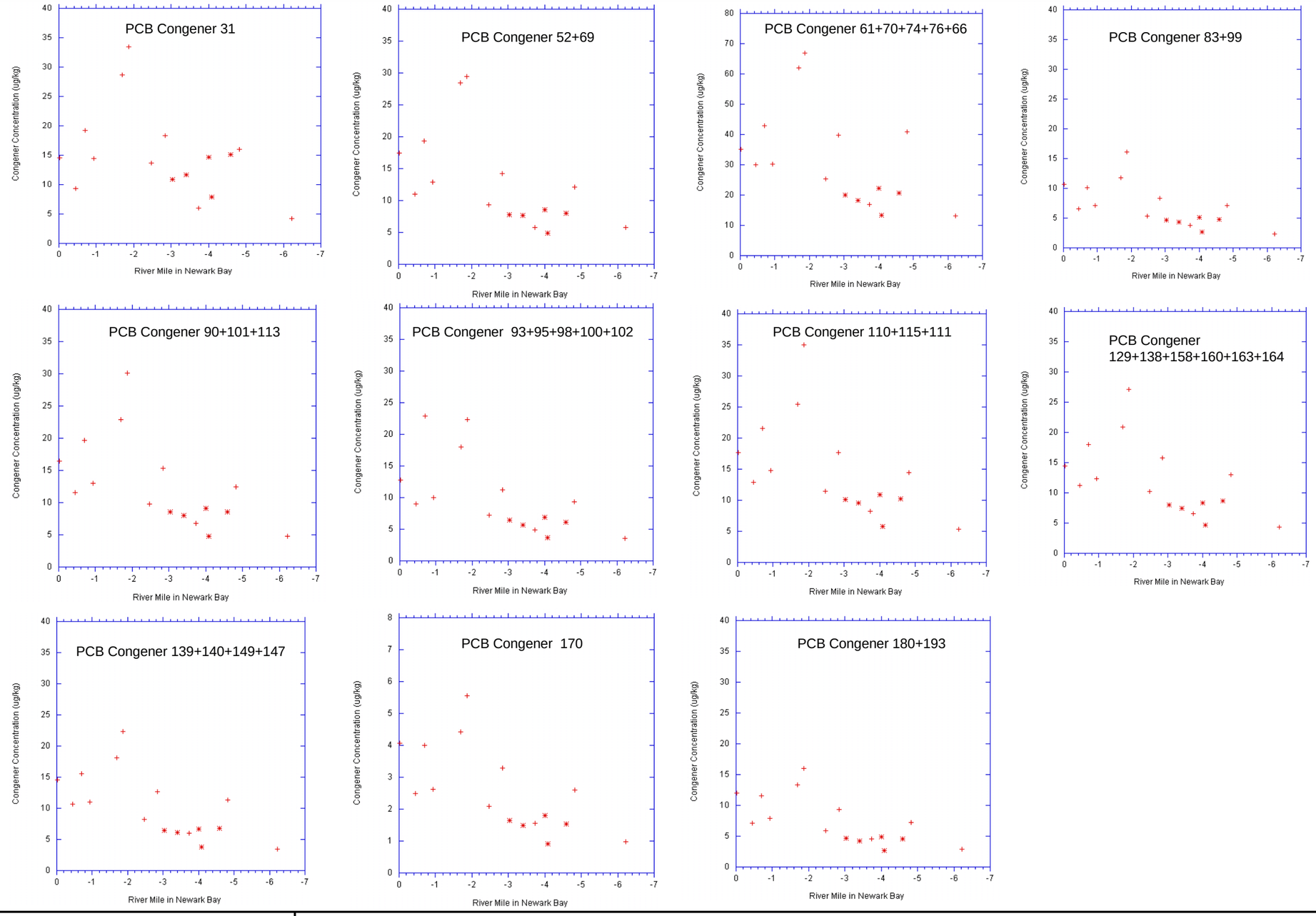
Lower Passaic River Restoration Project

Data Source: 2002 Aerial photographs from the New Jersey State data clearing house (http://njgin.state.nj.us).

Figure 4-18

June 2007

S:\Projects\PASSAIC\MapDocuments\4553001-CERCLA\Figure4-18_MassBalance.mxd - 4/27/2007 @ 6:02:16 PM



Legend

+ PCB Congener Concentration at Newark Bay Sampling Location

X Highlighted Southern Sampling Locations

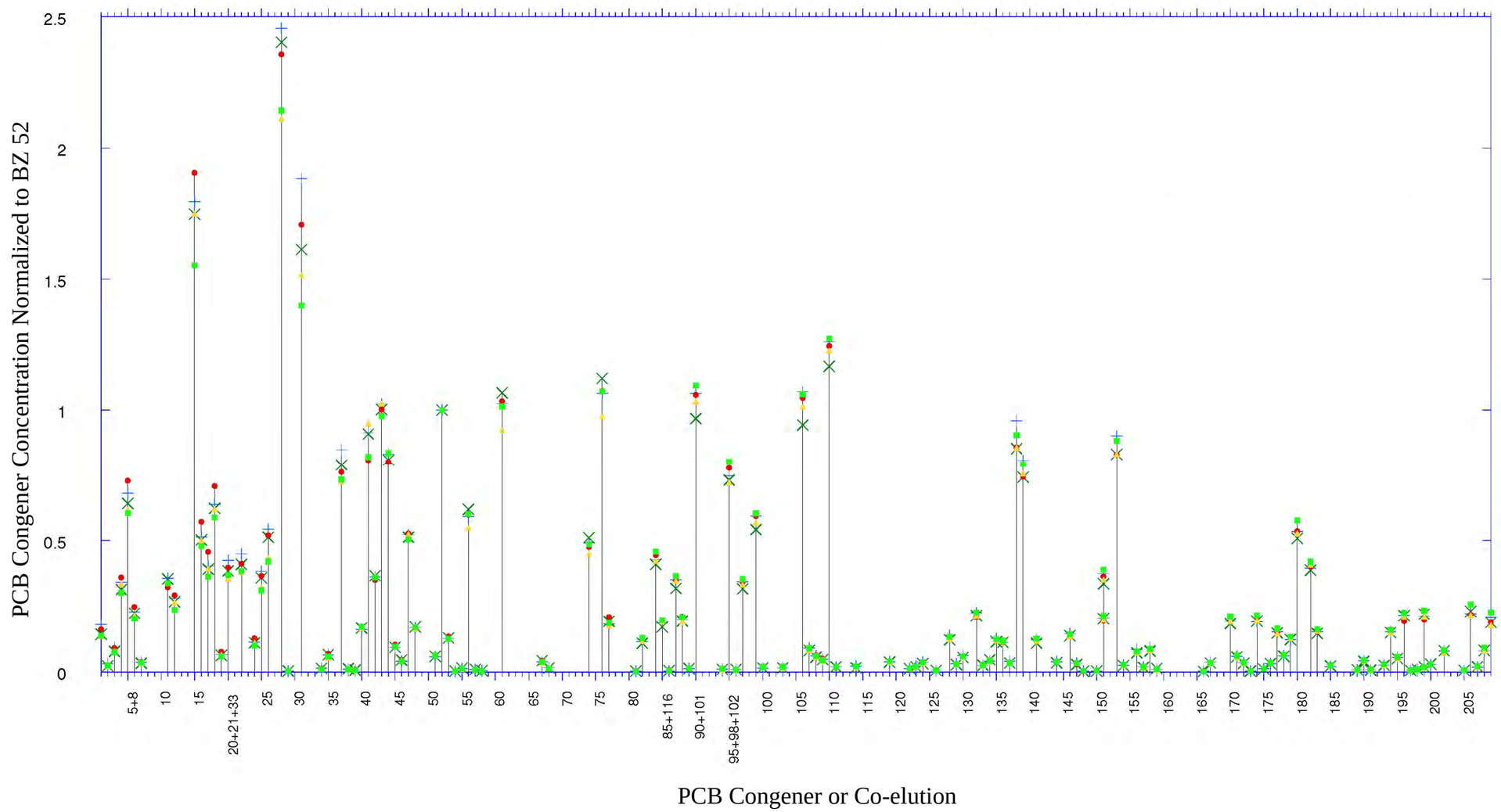
Notes

PCB Congener Surface Sediment Concentrations in Newark Bay

Lower Passaic River Restoration Project

Figure 4-19

June 2007



Legend

- RM -3.03
- RM -3.4
- RM -4.01
- RM -4.08
- RM -4.59

Notes

Normalized PCB Congener Concentration <0.01 are not plotted.

PCB Congener Concentrations Normalized to BZ 52 for Southern Locations in Newark Bay

Lower Passaic River Restoration Project

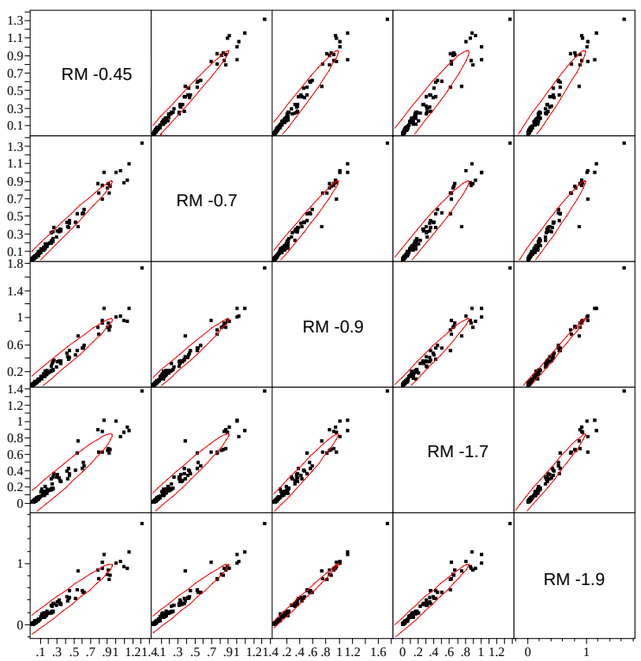
Figure 4-20

June 2007

Multivariate Correlations

	NB01SED061 (RM-0.45)	NB01SED052 (RM-0.71)	NB01SED055 (RM-0.94)	NB01SED046 (RM-1.7)	NB01SED047 (RM-1.9)
NB01SED061 (RM-0.45)	1.0000	0.9906	0.9830	0.9704	0.9778
NB01SED052 (RM-0.71)	0.9906	1.0000	0.9882	0.9796	0.9831
NB01SED055 (RM-0.94)	0.9830	0.9882	1.0000	0.9852	0.9967
NB01SED046 (RM-1.7)	0.9704	0.9796	0.9852	1.0000	0.9880
NB01SED047 (RM-1.9)	0.9778	0.9831	0.9967	0.9880	1.0000

Scatterplot Matrix



Legend

- PCB Congeners Concentration Normalized to BZ 52

Notes

In this presentation, river miles for the Newark Bay sampling locations are assigned with respect to the distance from the mouth of the Lower Passaic River (RM0.0) and following the federal navigation channel.

Data Source: 2005 Tierra Solutions, Inc. (TSI) Remedial Investigation Phase 1 dataset.

Correlation Among Sampling Locations of PCB Congeners Concentration Normalized to BZ 52 in Northern Newark Bay Samples

Lower Passaic River Restoration Project

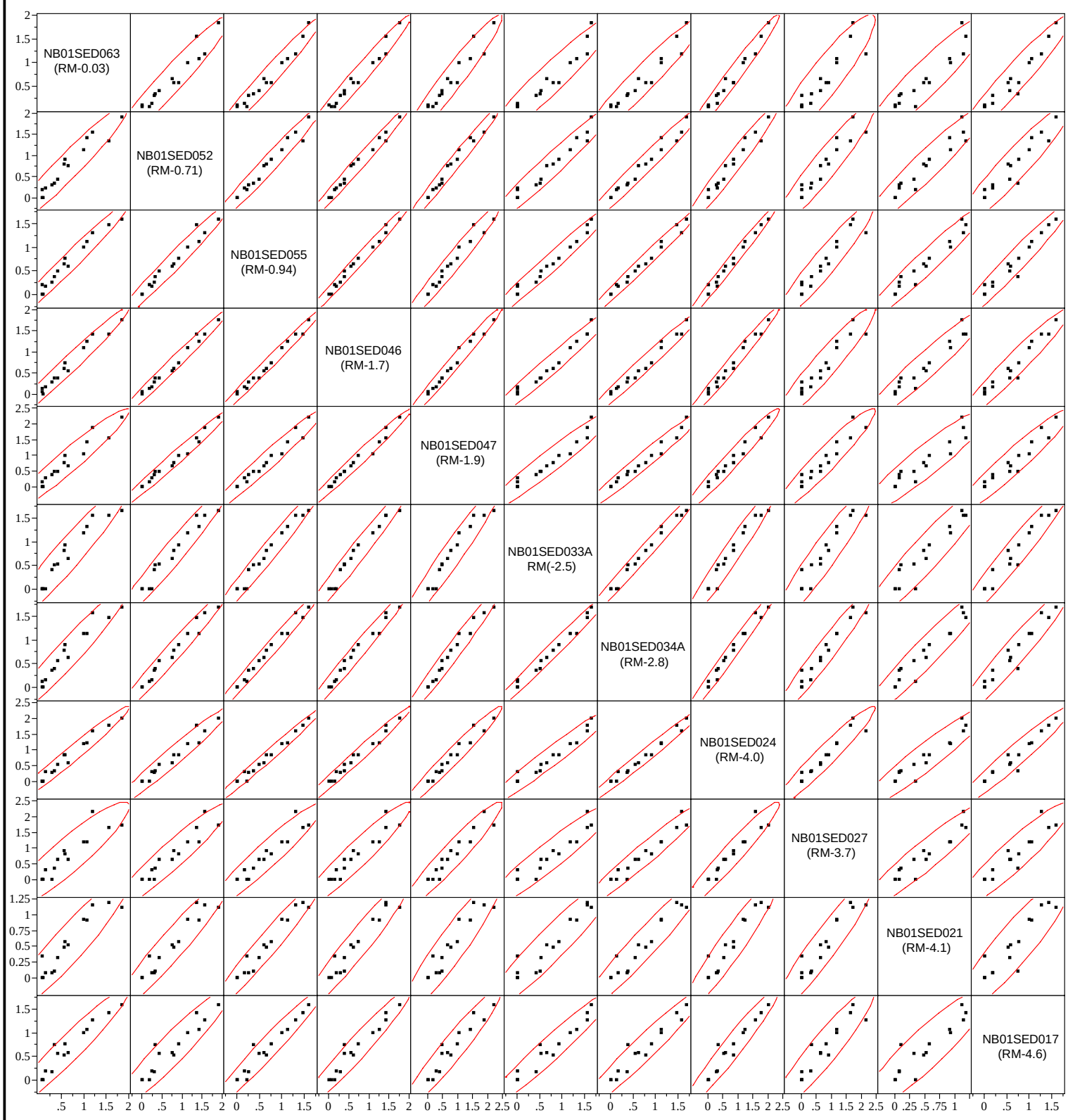
Figure 4-21

June 2007

Multivariate Correlations

	NB01SED063 (RM-0.03)	NB01SED052 (RM-0.71)	NB01SED055 (RM-0.94)	NB01SED046 (RM-1.7)	NB01SED047 (RM-1.9)	NB01SED033A RM(-2.5)	NB01SED034A (RM-2.8)	NB01SED024 (RM-4.0)	NB01SED027 (RM-3.7)	NB01SED021 (RM-4.1)	NB01SED017 (RM-4.6)
NB01SED063 (RM-0.03)	1.0000	0.9625	0.9811	0.9820	0.9627	0.9565	0.9634	0.9823	0.9171	0.9360	0.9594
NB01SED052 (RM-0.71)	0.9625	1.0000	0.9823	0.9899	0.9877	0.9740	0.9831	0.9752	0.9485	0.9570	0.9474
NB01SED055 (RM-0.94)	0.9811	0.9823	1.0000	0.9923	0.9780	0.9831	0.9904	0.9903	0.9536	0.9716	0.9725
NB01SED046 (RM-1.7)	0.9820	0.9899	0.9923	1.0000	0.9875	0.9812	0.9866	0.9872	0.9508	0.9615	0.9678
NB01SED047 (RM-1.9)	0.9627	0.9877	0.9780	0.9875	1.0000	0.9673	0.9821	0.9771	0.9534	0.9349	0.9562
NB01SED033A RM(-2.5)	0.9565	0.9740	0.9831	0.9812	0.9673	1.0000	0.9904	0.9747	0.9505	0.9479	0.9685
NB01SED034A (RM-2.8)	0.9634	0.9831	0.9904	0.9866	0.9821	0.9904	1.0000	0.9880	0.9708	0.9612	0.9651
NB01SED024 (RM-4.0)	0.9823	0.9752	0.9903	0.9872	0.9771	0.9747	0.9880	1.0000	0.9625	0.9490	0.9663
NB01SED027 (RM-3.7)	0.9171	0.9485	0.9536	0.9508	0.9534	0.9505	0.9708	0.9625	1.0000	0.9450	0.9345
NB01SED021 (RM-4.1)	0.9360	0.9570	0.9716	0.9615	0.9349	0.9479	0.9612	0.9490	0.9450	1.0000	0.9128
NB01SED017 (RM-4.6)	0.9594	0.9474	0.9725	0.9678	0.9562	0.9685	0.9651	0.9663	0.9345	0.9128	1.0000

Scatterplot Matrix



Legend

- PAH Compounds Normalized to Dieldrin

Notes

PAH Compounds normalized to dieldrin.

In this presentation, river miles for the Newark Bay sampling locations are assigned with respect to the distance from the mouth of the Lower Passaic River (RM0.0) and following the federal navigation channel.

Data Source:2005 Tierra Solutions, Inc. (TSI) Remedial Investigation Phase 1 dataset.

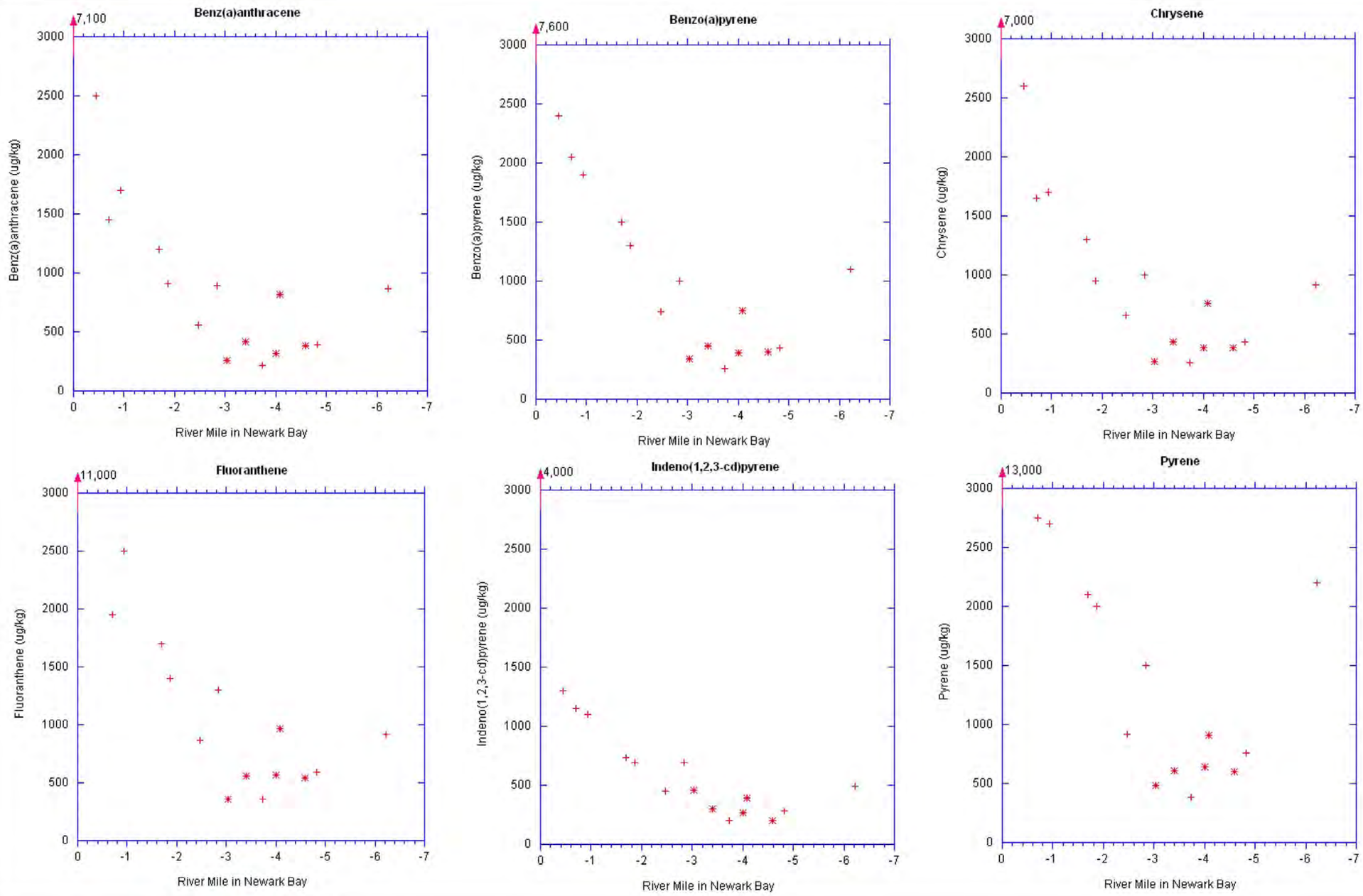
US Army Corps of Engineers

Correlation Among Sampling Locations of PAH Compounds in Newark Bay Samples

Lower Passaic River Restoration Project

Figure 4-22

June 2007



Legend

+ PAH Compounds Concentration at Newark Bay Sampling Location

X Highlighted Southern Sampling Locations

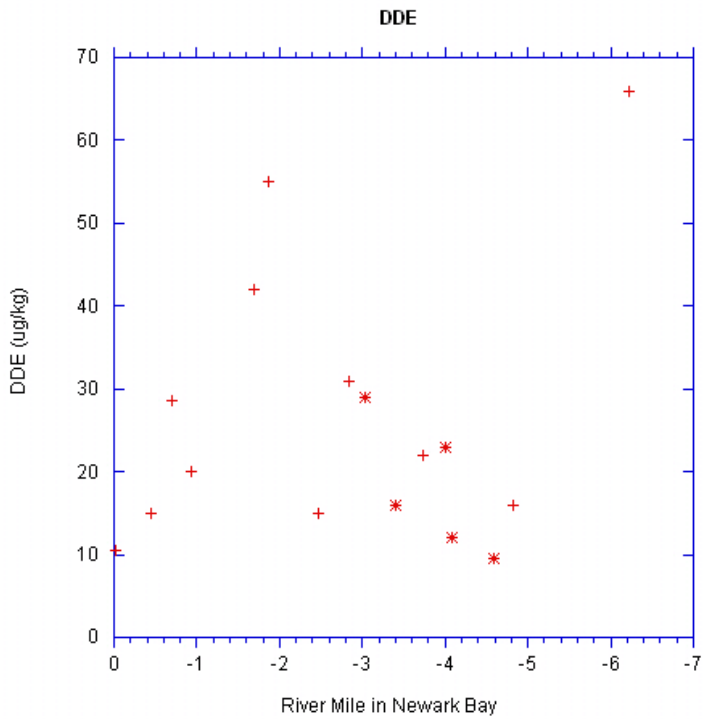
Notes

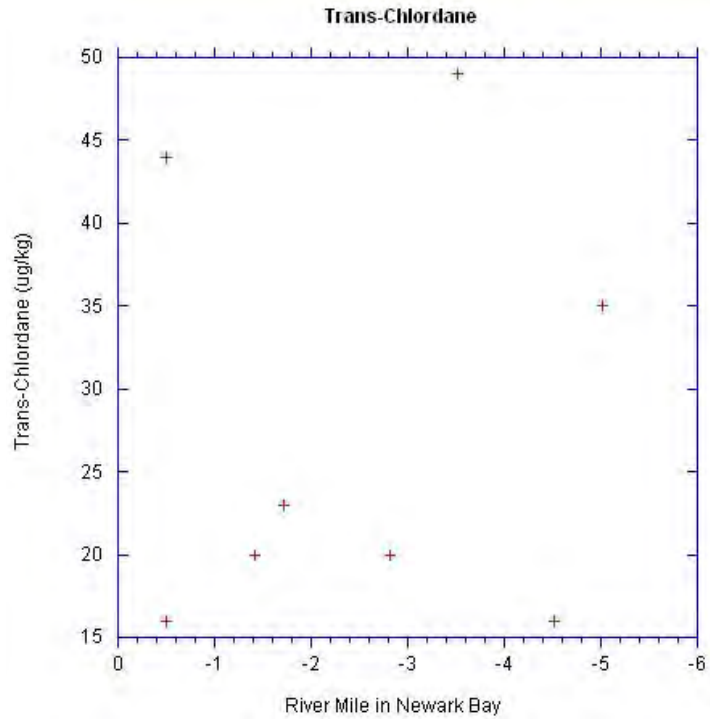
PAH Compounds Surface Sediment Concentrations in Newark Bay

Lower Passaic River Restoration Project

Figure 4-23

June 2007





Legend

+ Pesticides Concentration at Newark Bay Sampling Location

x Highlighted Southern Sampling Locations

Notes

Negative River Mile represents the distance from the mouth of the Lower Passaic River into Newark Bay following the federal navigation channel.

DDE represents only 4,4'-isomer.

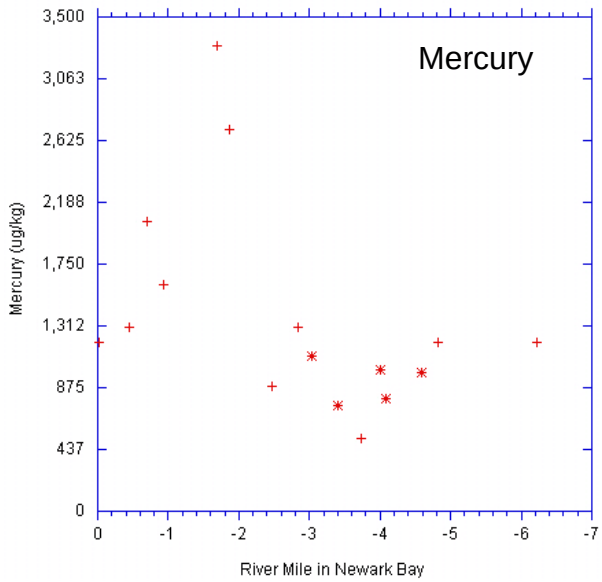
Plot only shows the selected 16 depositional locations that are located in the federal navigation channel.

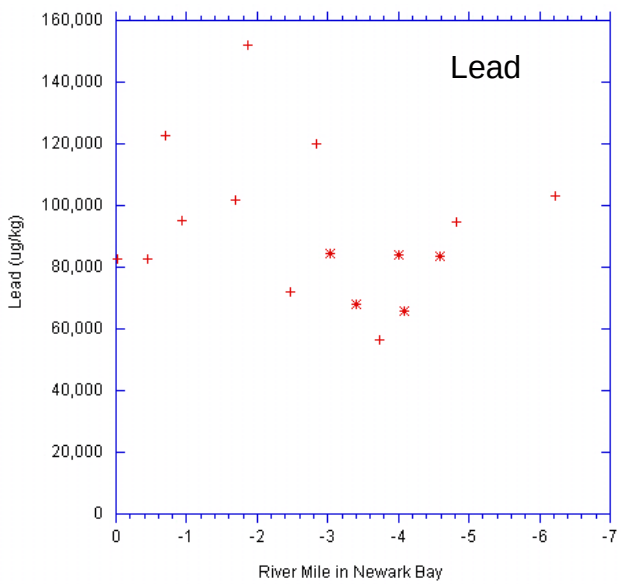
Pesticides Surface Sediment Concentrations in Newark Bay

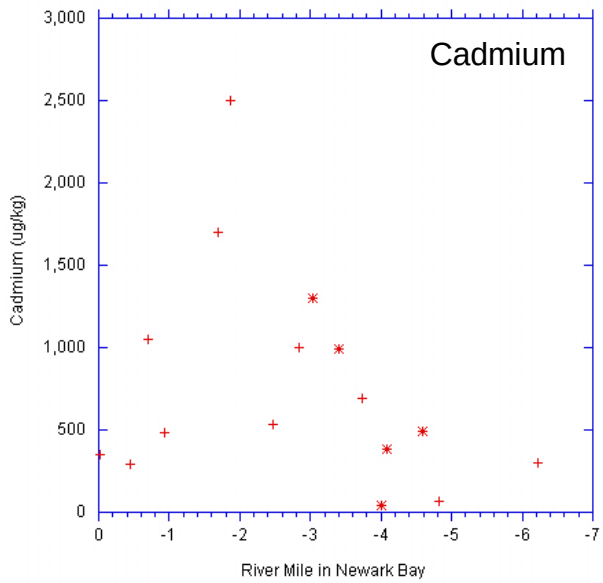
Lower Passaic River Restoration Project

Figure 4-24

June 2007







Legend

+ Metal Concentration at Newark Bay Sampling Location

x Highlighted Southern Sampling Locations

Notes

Negative River Mile represents the distance from the mouth of the Lower Passaic River into Newark Bay following the federal navigation channel.

Plot only shows the selected 16 depositional locations that are located in the federal navigation channel.

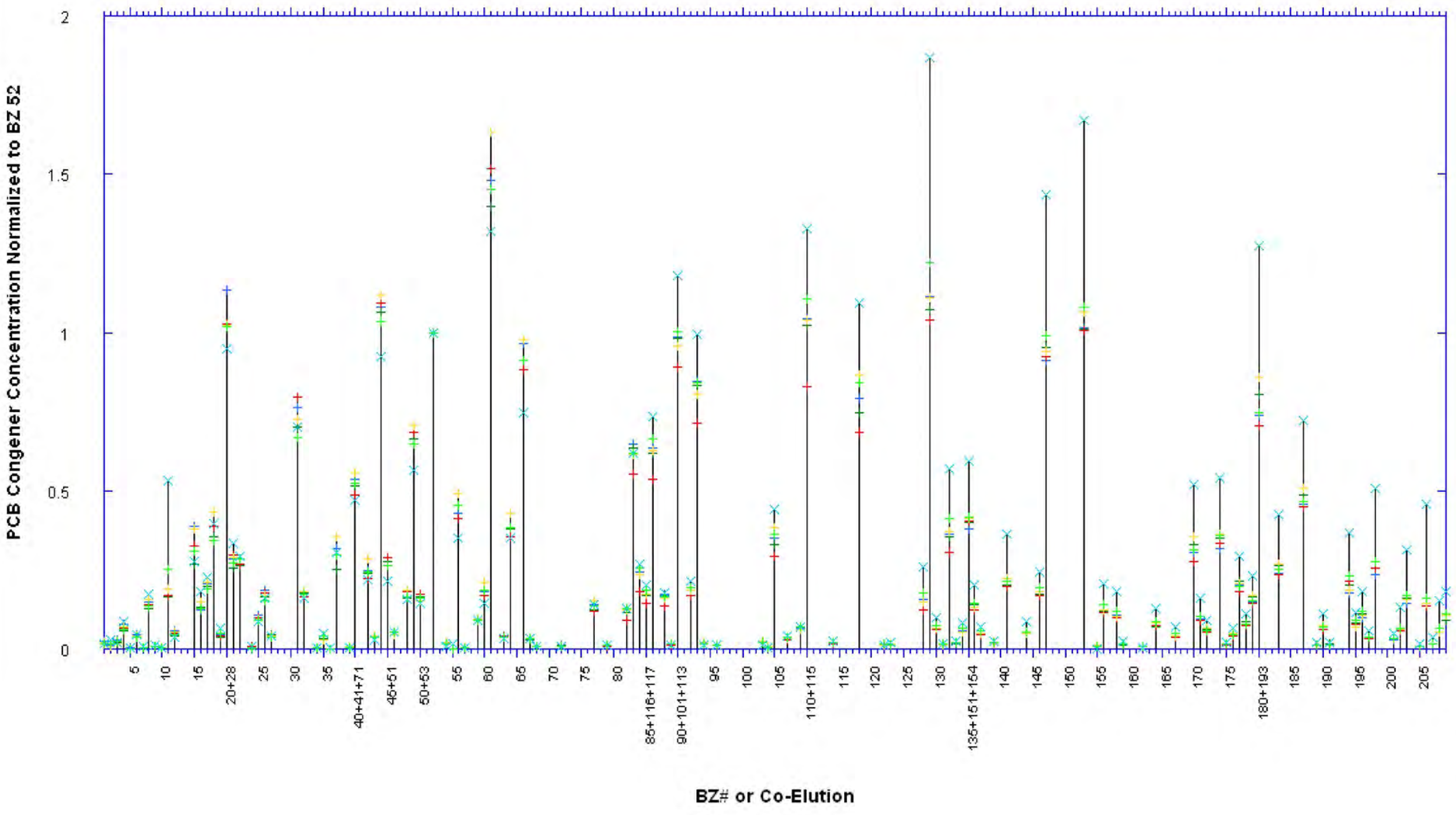
Metal Surface Sediment Concentrations in Newark Bay

Lower Passaic River Restoration Project

Figure 4-25

June 2007

R2-0010150



Legend

- RM 1.4
- RM 2.2
- RM 7.8
- RM 11
- RM 12.6
- Dundee Lake Core RM18.3

Notes

Normalized PCB Congener Concentration <0.01 are not plotted.

PCB Congener Concentration Normalized to BZ 52 for Dundee Dam and Lower Passaic River Surface Sediment

Lower Passaic River Restoration Project

Figure 4-26

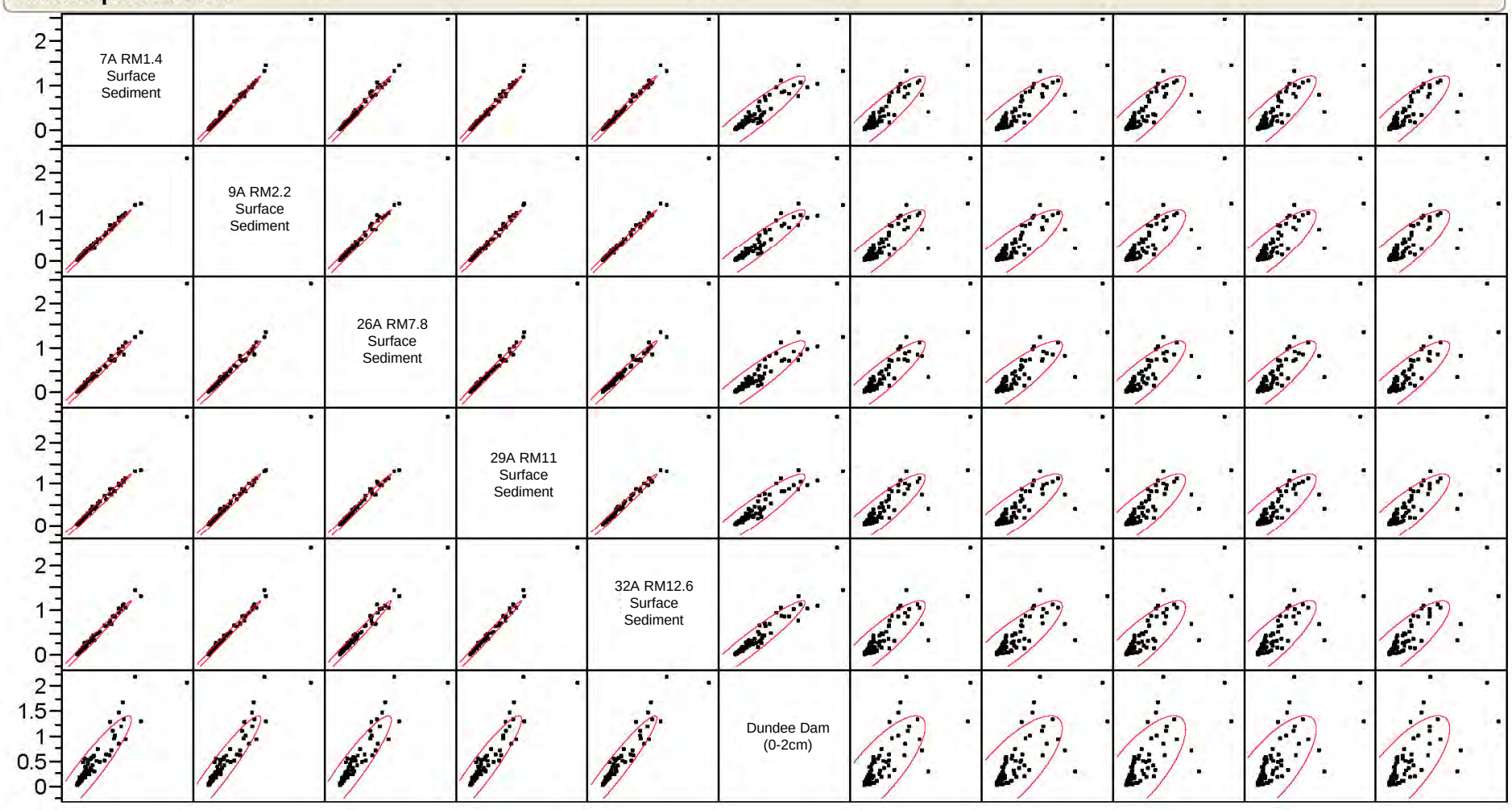
June 2007

R2-0010151

Multivariate Correlations

	7A RM1.4 Surface Sediment	9A RM2.2 Surface Sediment	26A RM7.8 Surface Sediment	29A RM11 Surface Sediment	32A RM12.6 Surface Sediment	Dundee Dam (0-2cm)	NB01SED031 (RM-3.0)	NB01SED030 (RM-3.4)	NB01SED024 (RM-4.0)	NB01SED021 (RM-4.1)	NB01SED017 (RM-4.6)
7A RM1.4 Surface Sediment	1.0000	0.9979	0.9964	0.9973	0.9967	0.9348	0.9167	0.8917	0.8755	0.8862	0.8802
9A RM2.2 Surface Sediment	0.9979	1.0000	0.9951	0.9968	0.9977	0.9467	0.8973	0.8710	0.8524	0.8629	0.8575
26A RM7.8 Surface Sediment	0.9964	0.9951	1.0000	0.9962	0.9922	0.9291	0.9119	0.8873	0.8718	0.8845	0.8774
29A RM11 Surface Sediment	0.9973	0.9968	0.9962	1.0000	0.9954	0.9346	0.9046	0.8787	0.8614	0.8731	0.8650
32A RM12.6 Surface Sediment	0.9967	0.9977	0.9922	0.9954	1.0000	0.9555	0.8931	0.8658	0.8467	0.8573	0.8525
Dundee Dam (0-2cm)	0.9348	0.9467	0.9291	0.9346	0.9555	1.0000	0.8000	0.7711	0.7475	0.7531	0.7582
NB01SED031 (RM-3.0)	0.9167	0.8973	0.9119	0.9046	0.8931	0.8000	1.0000	0.9965	0.9943	0.9952	0.9938
NB01SED030 (RM-3.4)	0.8917	0.8710	0.8873	0.8787	0.8658	0.7711	0.9965	1.0000	0.9972	0.9961	0.9965
NB01SED024 (RM-4.0)	0.8755	0.8524	0.8718	0.8614	0.8467	0.7475	0.9943	0.9972	1.0000	0.9978	0.9980
NB01SED021 (RM-4.1)	0.8862	0.8629	0.8845	0.8731	0.8573	0.7531	0.9952	0.9961	0.9978	1.0000	0.9976
NB01SED017 (RM-4.6)	0.8802	0.8575	0.8774	0.8650	0.8525	0.7582	0.9938	0.9965	0.9980	0.9976	1.0000

Scatterplot Matrix



Legend

- PCB Congeners Concentration Normalized to Congener 52

Notes

In this presentation, river miles for the Newark Bay sampling locations are assigned with respect to the distance from the mouth of the Lower Passaic River (RM0.0) and following the federal navigation channel.

US Army Corps of Engineers

Correlation Among Sampling Locations for PCB Congeners in Dundee Dam, Lower Passaic River, and Newark Bay Surface Sediment

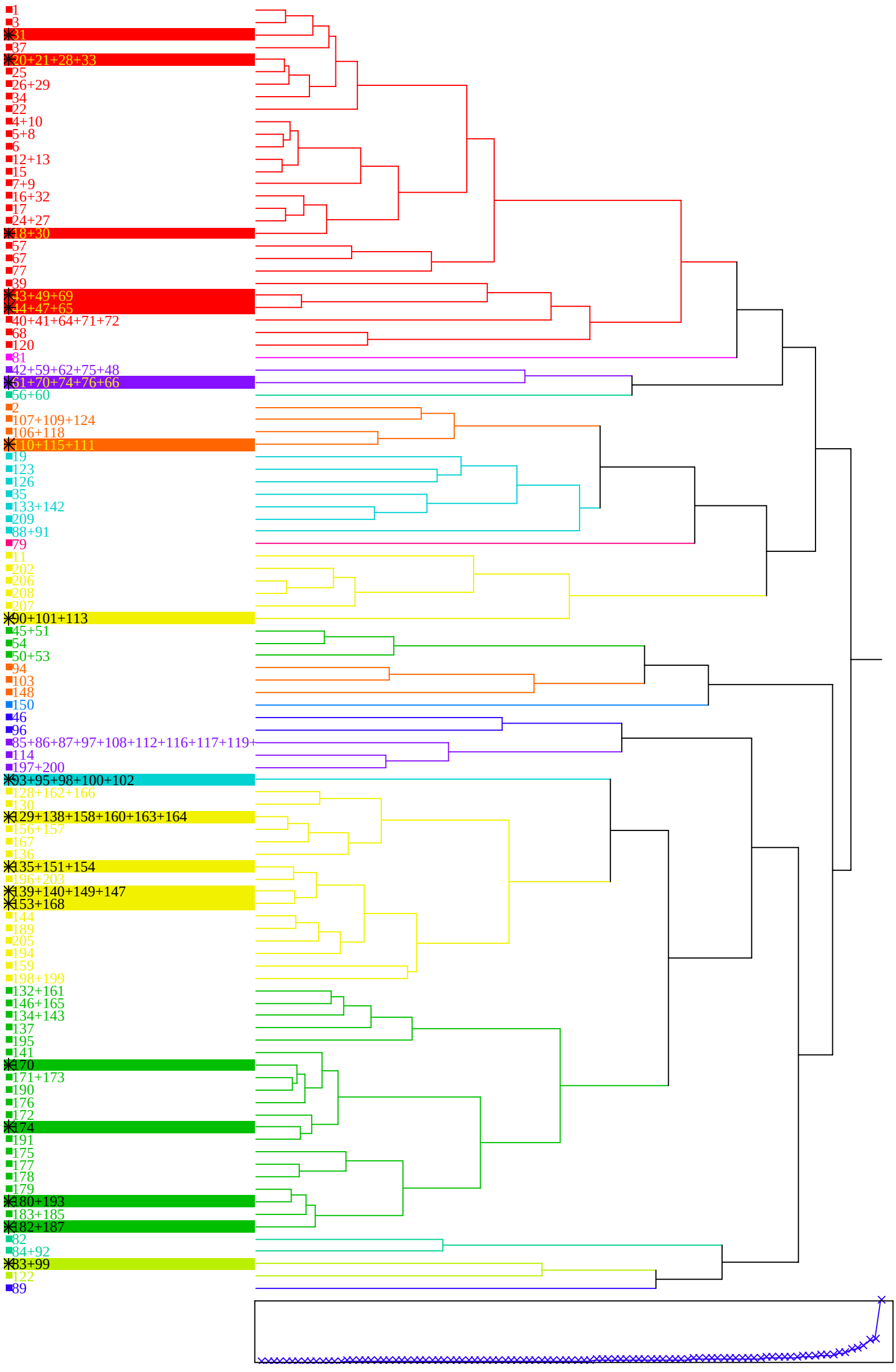
Lower Passaic River Restoration Project

Figure 4-27

June 2007

Hierarchical Clustering
Method =
Ward
Dendrogram

Highlighted congeners represent the more massive congeners that were considered for subsequent inclusion as contaminants in the EMBM.

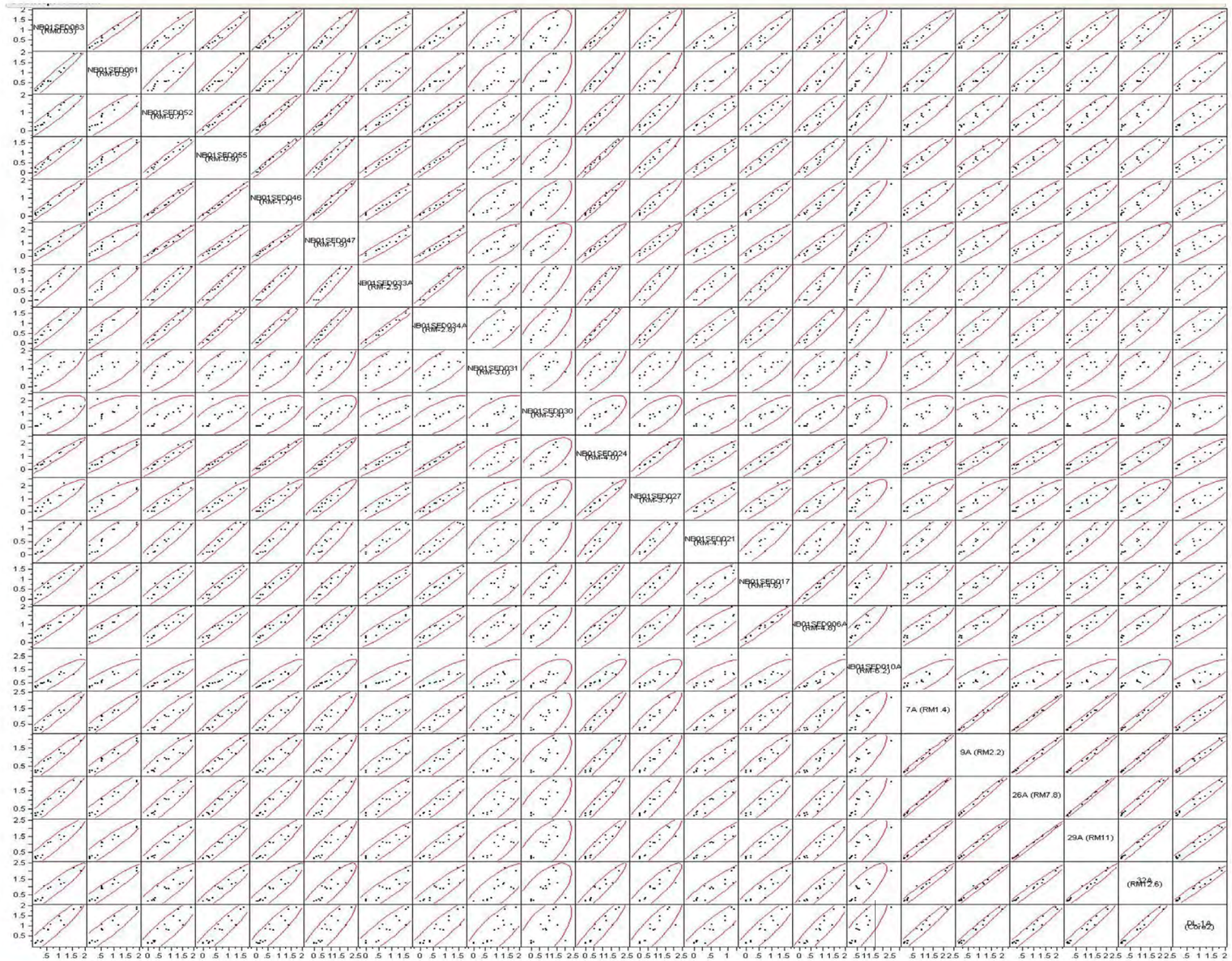


Dendrogram from Cluster Analysis of PCB Congener Concentrations Normalized to BZ 52 for Dundee Dam, Lower Passaic River, and Newark Bay Surface Sediment

Lower Passaic River Restoration Project

Figure 4-28

June 2007



Correlation Among Sampling Locations of PAH Compounds Normalized to Benz(a)anthracene in Dundee Dam, Lower Passaic River and Newark Bay Surface Sediment

Lower Passaic River Restoration Project

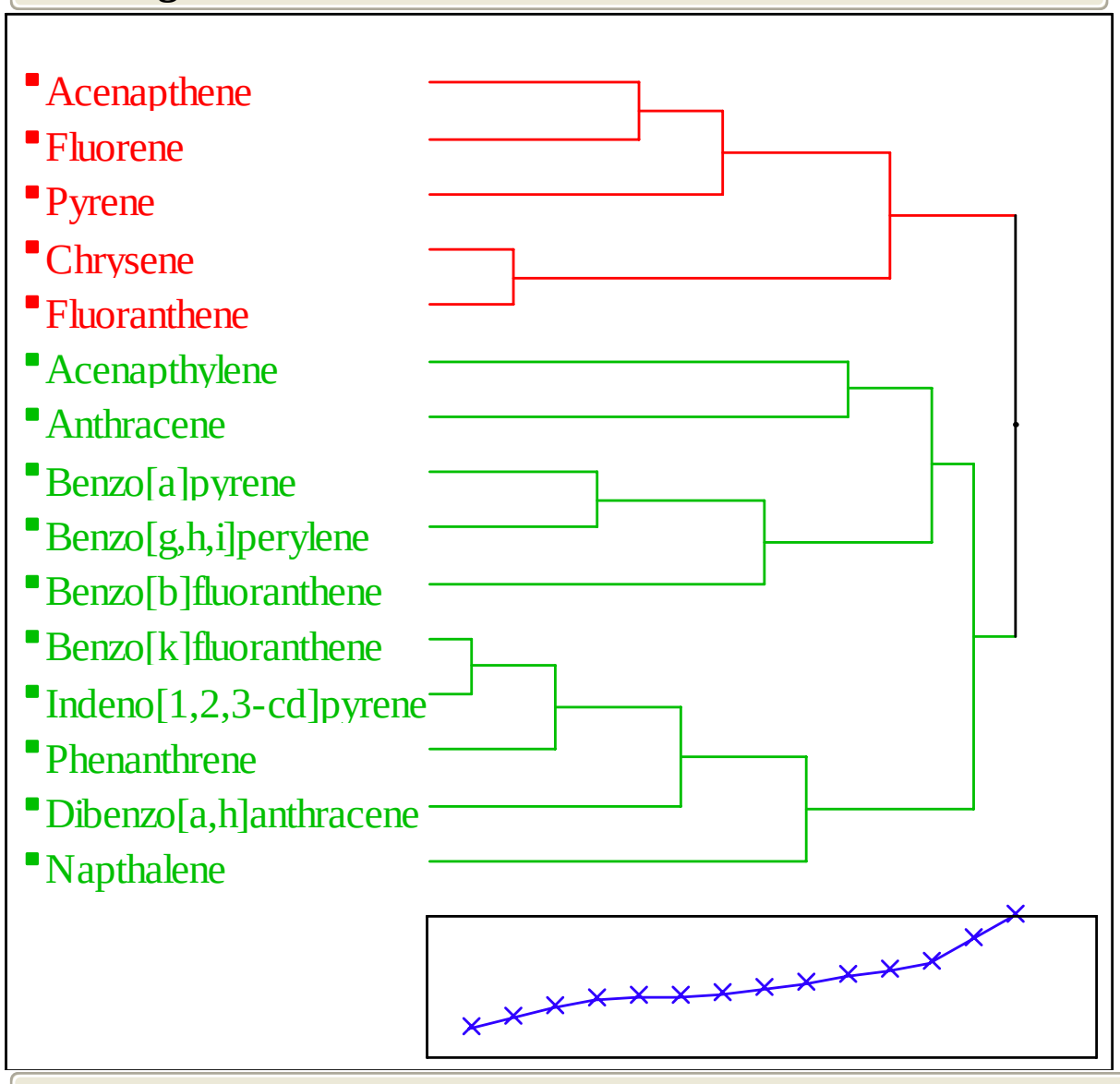
Figure 4-29

June 2007

Hierarchical Clustering

Method = Ward

Dendrogram



Clustering History

Number of Clusters	Distance	Leader	Joiner
14	1.563869517	Benzo[k]fluoranthene	Indeno[1,2,3-cd]pyrene
13	2.057125849	Chrysene	Fluoranthene
12	2.579293922	Benzo[k]fluoranthene	Phenanthrene
11	3.055352730	Benzo[a]pyrene	Benzo[g,h,i]perylene
10	3.169368134	Acenapthene	Fluorene
9	3.175997255	Benzo[k]fluoranthene	Dibenzo[a,h]anthracene
8	3.313435277	Acenapthene	Pyrene
7	3.565676064	Benzo[a]pyrene	Benzo[b]fluoranthene
6	3.882002071	Benzo[k]fluoranthene	Napthalene
5	4.192230928	Acenapthylene	Anthracene
4	4.544777391	Acenapthene	Chrysene
3	4.952518366	Acenapthylene	Benzo[a]pyrene
2	6.238358189	Acenapthylene	Benzo[k]fluoranthene
1	7.404860307	Acenapthene	Acenapthylene

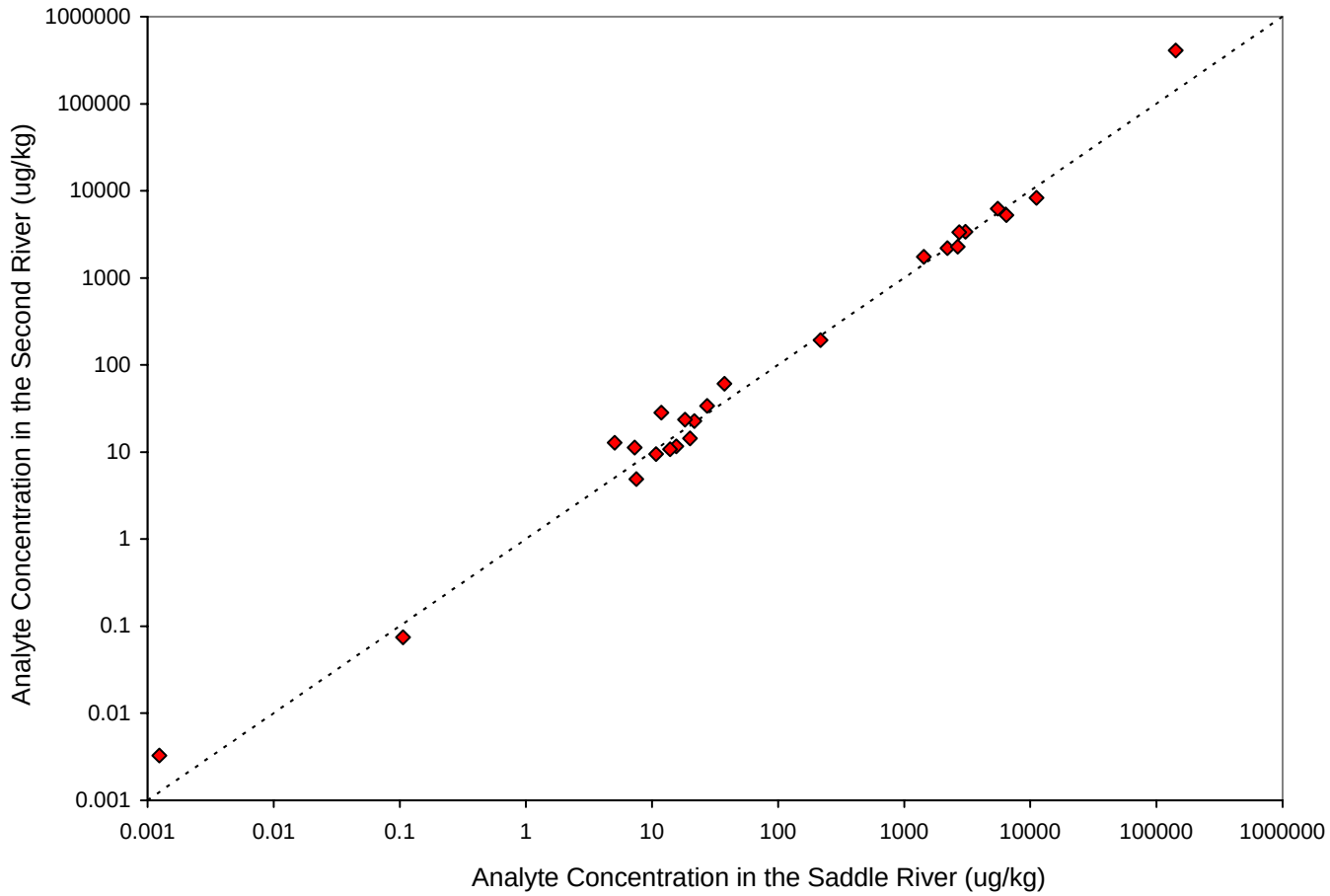
US Army Corps of Engineers

Dendrogram from Cluster Analysis of PAH Compounds Normalized to Benz(a)anthracene for Dundee Dam, Lower Passaic River, and Newark Bay Surface Sediment

Lower Passaic River Restoration Project

Figure 4-30

June 2007



Legend

Potential Modeling Parameter (Contaminant) Concentration

---- 1:1 Line

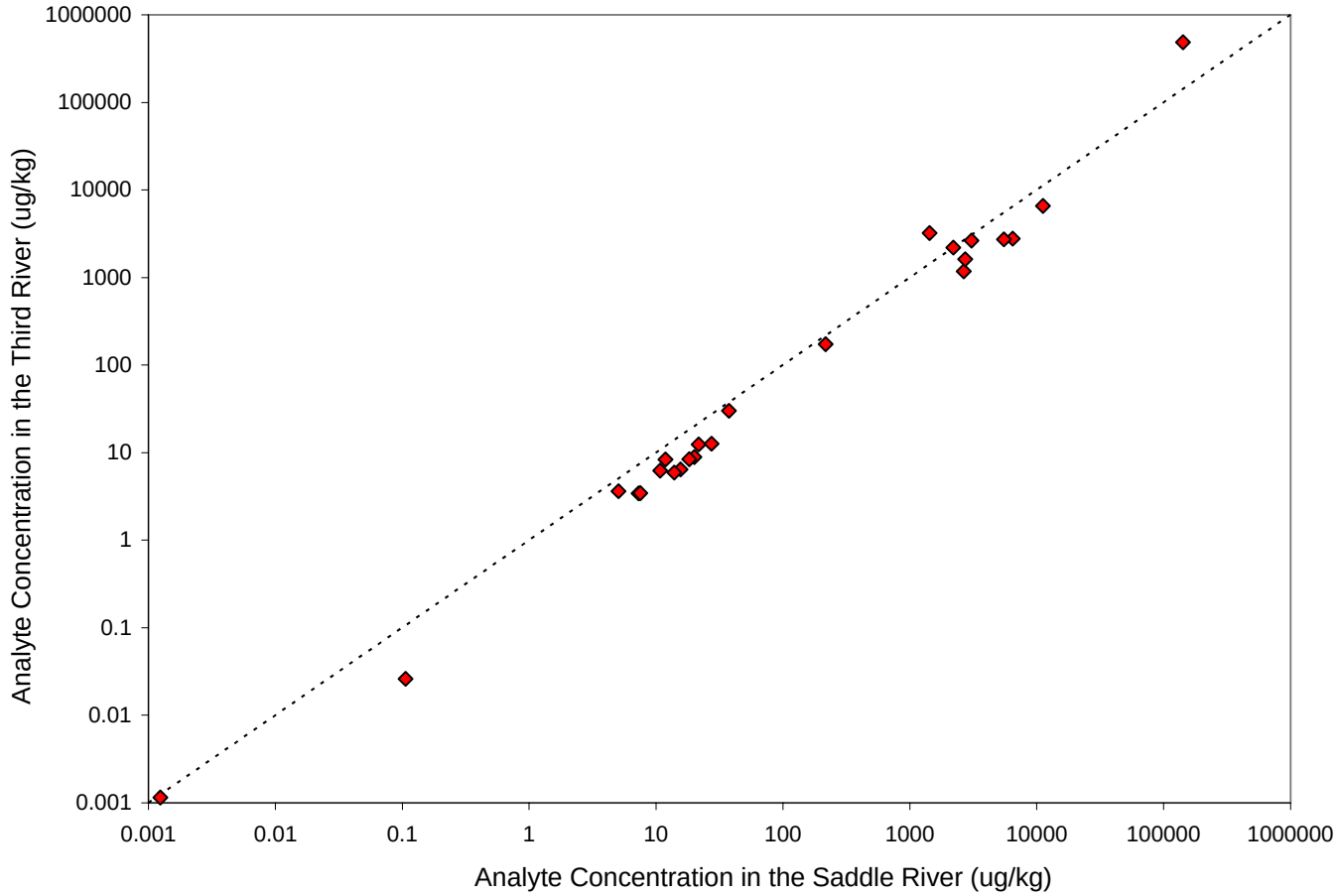
Notes

Scatter Plot of Suspended Solids Concentrations of the Potential Contaminants in the Mass Balance Model for Saddle River and Second River

Lower Passaic River Restoration Project

Figure 4-31a

June 2007



Legend

Potential Modeling Parameter (Contaminant) Concentration

---- 1:1 Line

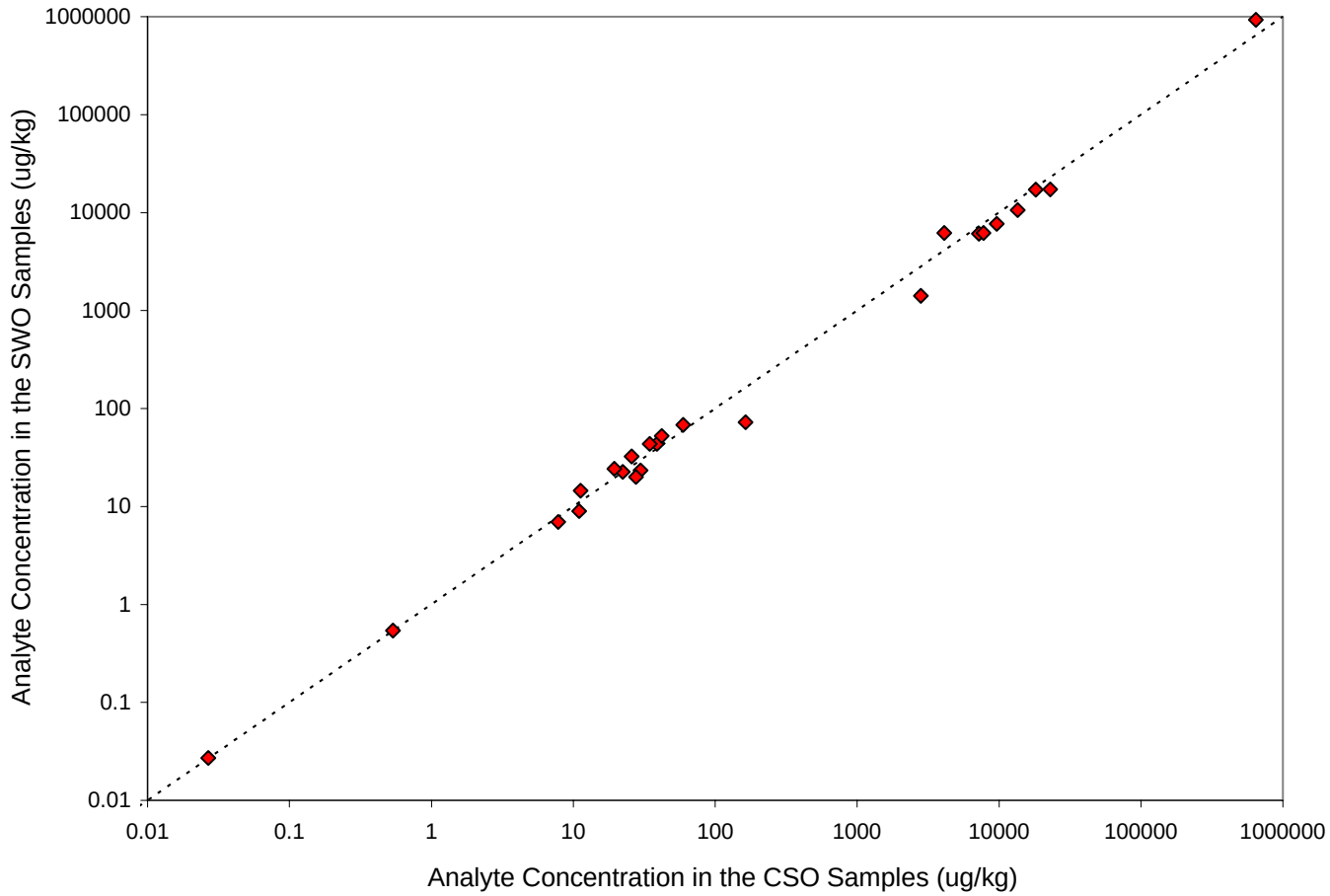
Notes

Scatter Plot of Suspended Solids Concentrations of the Potential Contaminants in the Mass Balance Model for Saddle River and Third River

Lower Passaic River Restoration Project

Figure 4-31b

June 2007



Legend

Potential Modeling Parameter (Contaminant) Concentration

1:1 Line

Notes

Scatter Plot of Suspended Solids Concentrations of the Potential Contaminants in the Mass Balance Model for CSOs and SWOs

Lower Passaic River Restoration Project

Figure 4-32

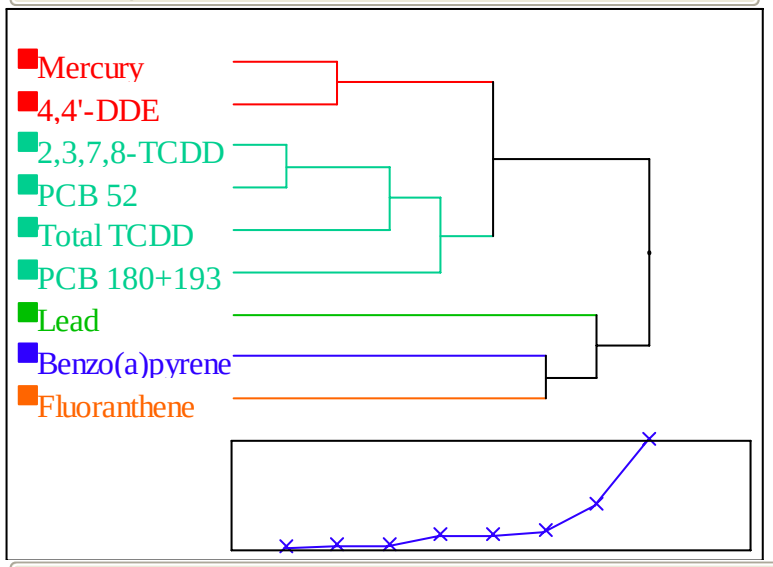
June 2007

R2-0010158

Hierarchical Clustering

Method = Ward

Dendrogram



Clustering History

Number of Clusters	Distance	Leader	Joiner
8	0.074398748	2,3,7,8-TCDD	PCB 52
7	0.149779022	Mercury	4,4'-DDE
6	0.157230836	2,3,7,8-TCDD	Total TCDD
5	0.458054519	2,3,7,8-TCDD	PCB 180+193
4	0.478892457	Mercury	2,3,7,8-TCDD
3	0.640487583	Benzo(a)pyrene	Fluoranthene
2	1.532184566	Lead	Benzo(a)pyrene
1	3.733647089	Mercury	Lead

Legend

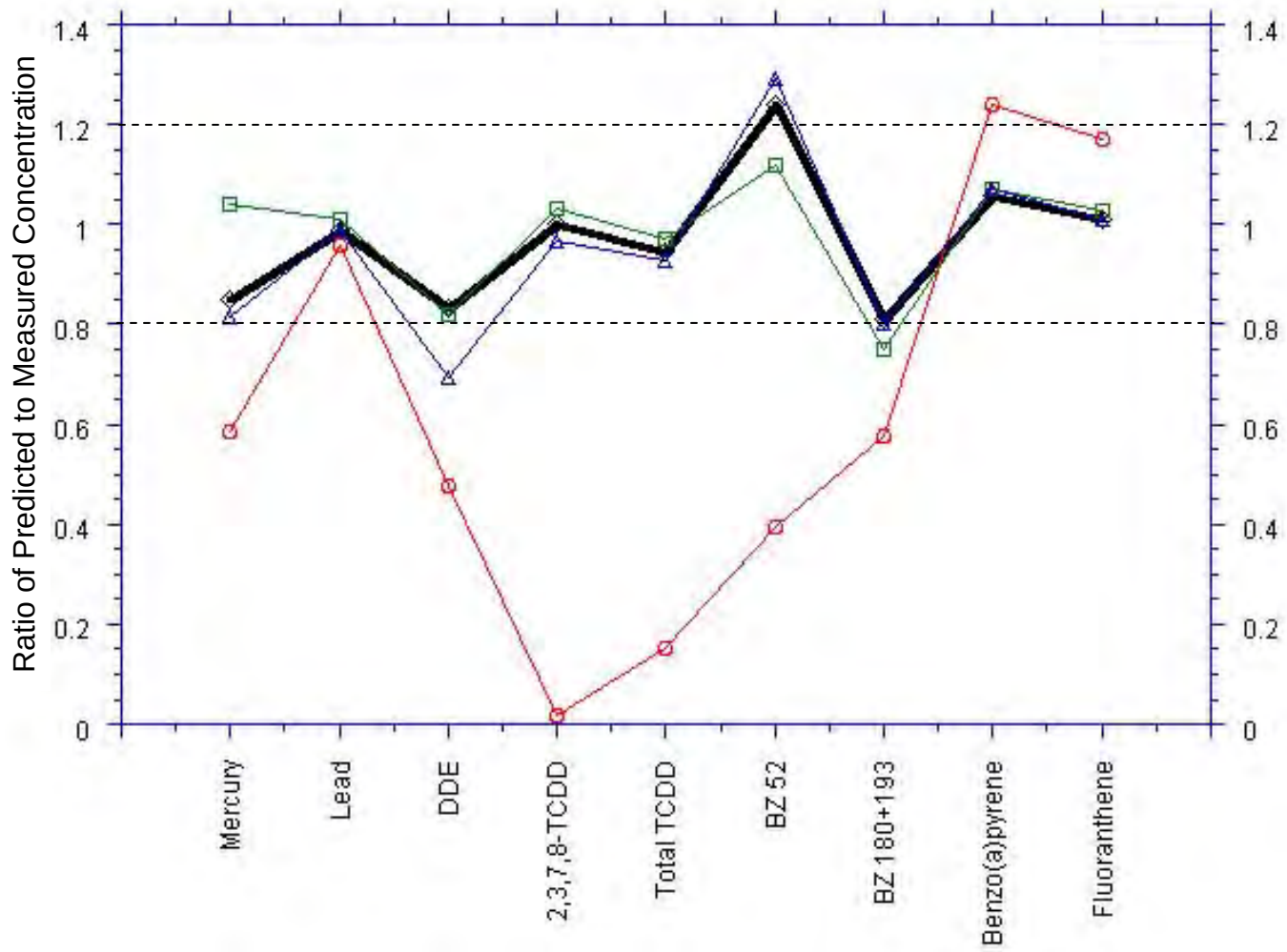
Notes

Dendrogram from Cluster Analysis of the Contaminant Selection for Mass Balance Model

Lower Passaic River Restoration Project

Figure 4-33

June 2007



Legend

- Lower Passaic River Integrated Sediment Length-Weighted Average
- Lower Passaic River 1940s
- Lower Passaic River 1950s
- Lower Passaic River 1960s
- Performance Model Target Range

Notes

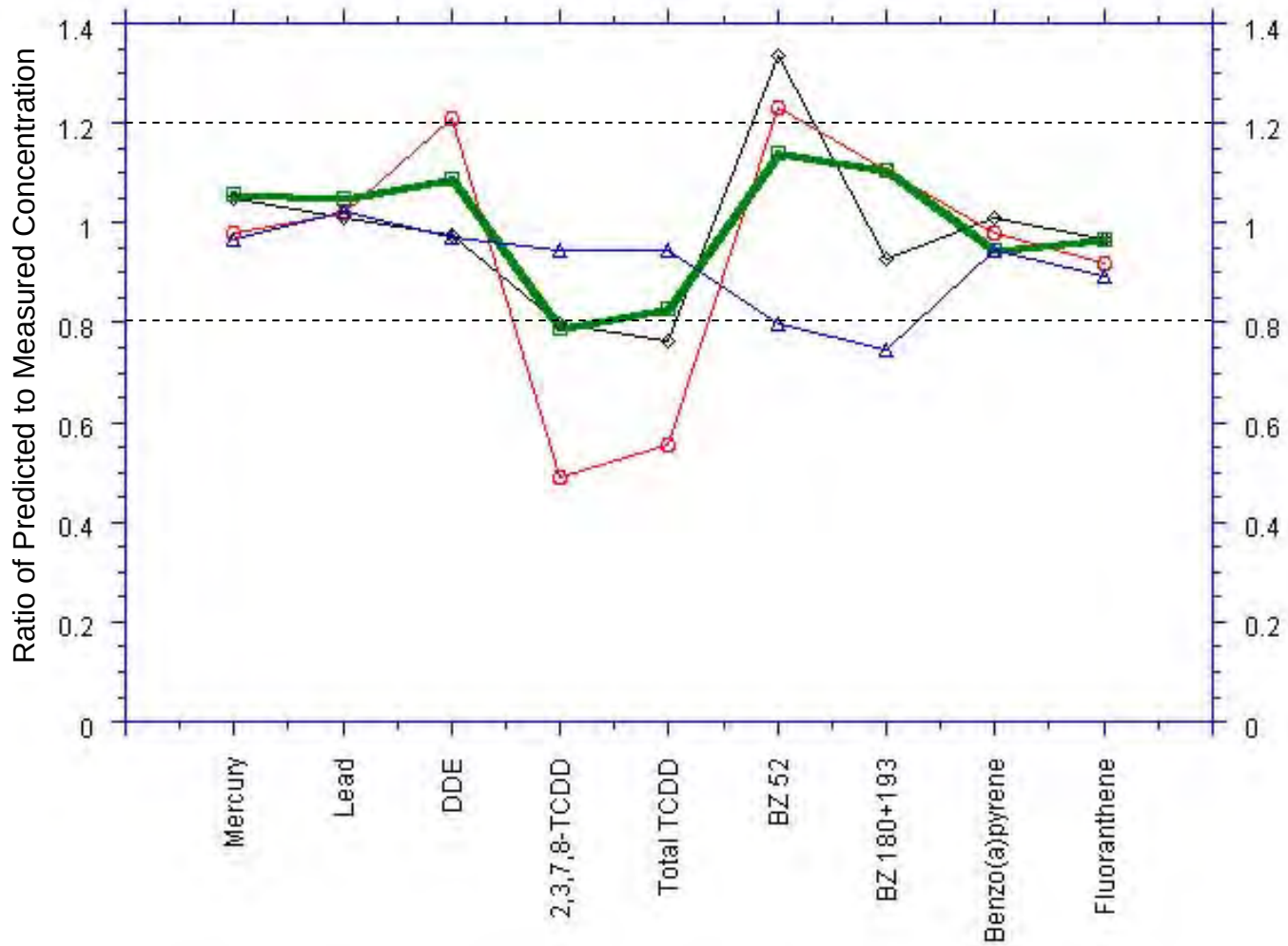
"Lower Passaic River Integrated Sediment Length-Weighted Average" is the length-weighted average concentration of high resolution cores.

Ratio of Predicted to Measured Concentration for the Various Modeling Scenarios

Lower Passaic River Restoration Project

Figure 5-1a

June 2007



Legend

- Lower Passaic River 1970s
- Lower Passaic River 1980s
- Lower Passaic River 1990s
- Lower Passaic River 2000s
- Performance Model Target Range

Notes

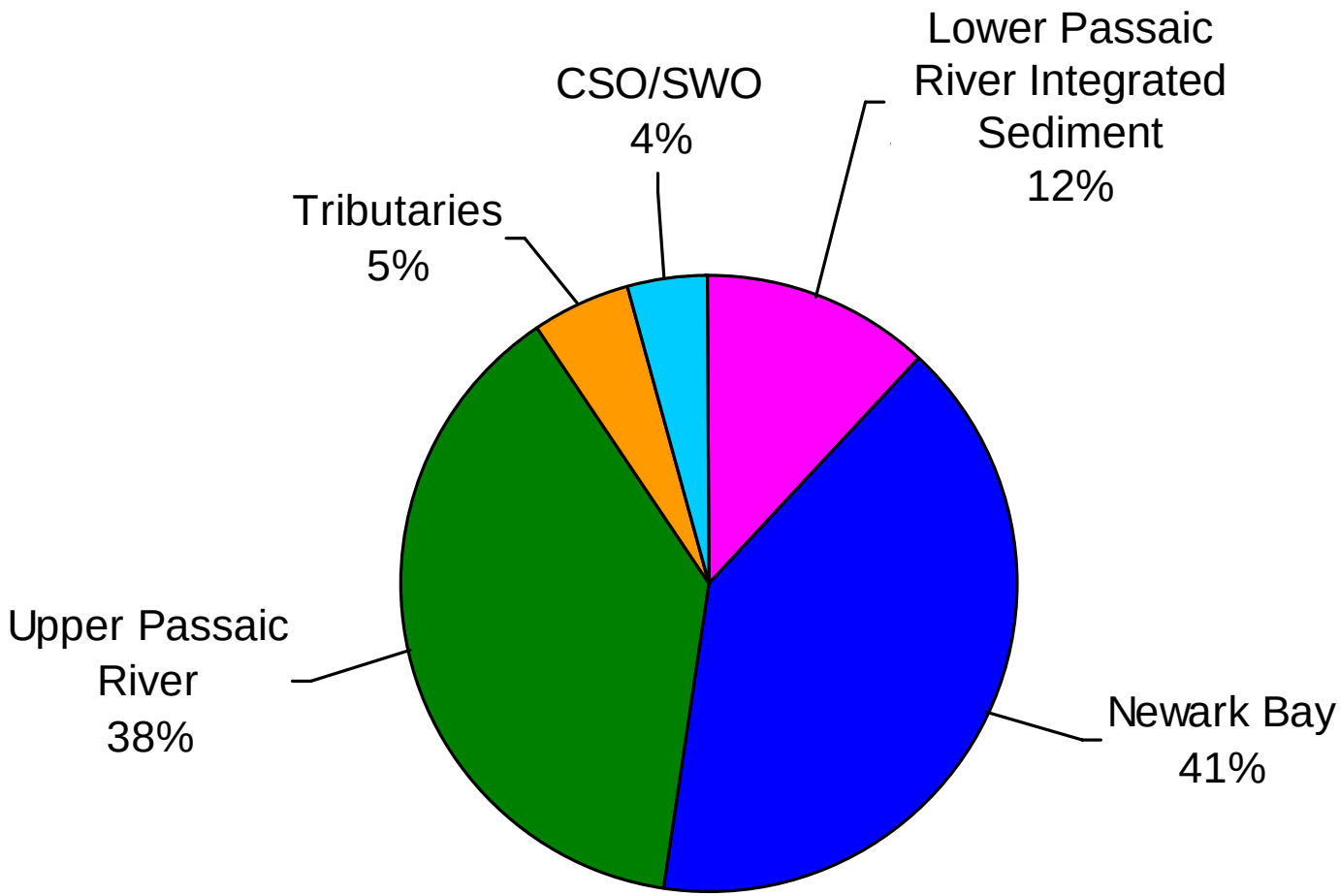
Ratio of Predicted to Measured Concentration for the Various Modeling Scenarios

Lower Passaic River Restoration Project

Figure 5-1b

June 2007

R2-0010161



Legend

- Lower Passaic River Integrated Sediment
- Newark Bay
- Upper Passaic River
- Tributaries
- CSO/SWO

Notes

"Upper Passaic River" is the core top from Dundee Lake at RM18.3.

"Tributaries" is a watershed-weighted average of Saddle River, Second River, and Third River.

"Newark Bay" represents the average of the five southern samples only.

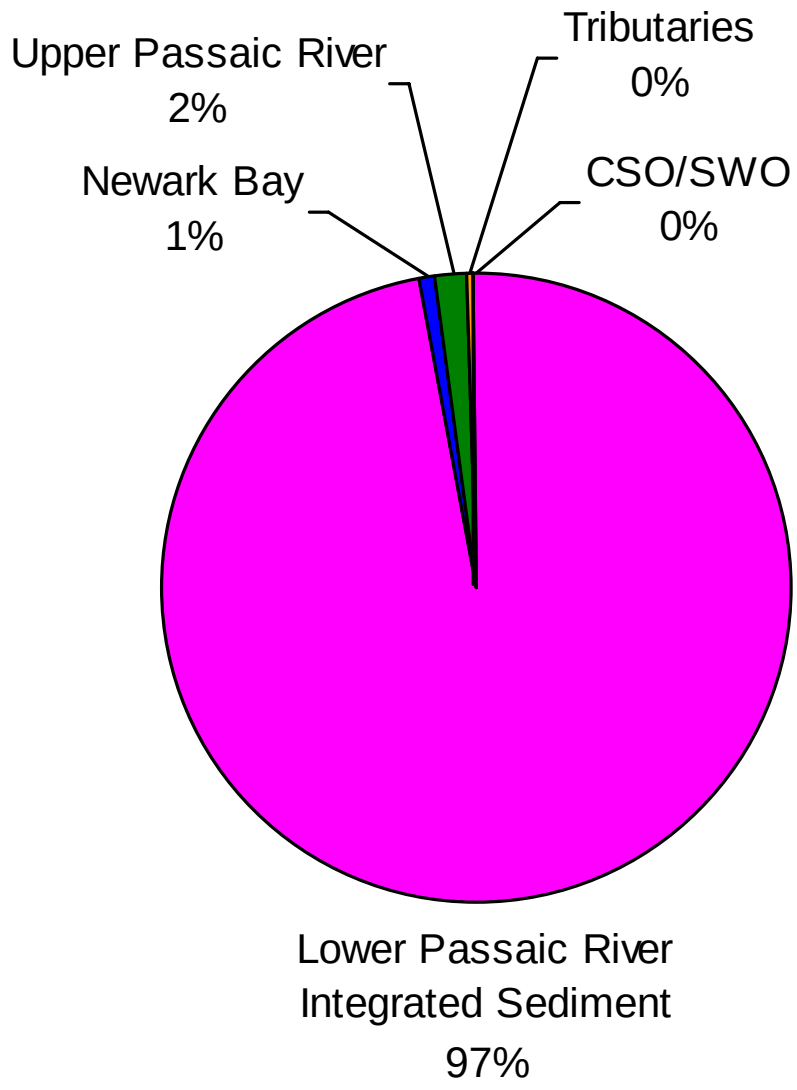
"Lower Passaic River Integrated Sediment" is the length-weighted average concentration of high resolution cores.

Solids Contribution to the Lower Passaic River for the Length-Weighted Average Scenario

Lower Passaic River Restoration Project

Figure 5-2a

June 2007



Legend

- Lower Passaic River Integrated Sediment
- Newark Bay
- Upper Passaic River
- Tributaries
- CSO/SWO

Notes

"Upper Passaic River" is the core top from Dundee Lake at RM18.3.

"Tributaries" is a watershed-weighted average of Saddle River, Second River, and Third River.

"Newark Bay" represents the average of the five southern samples only.

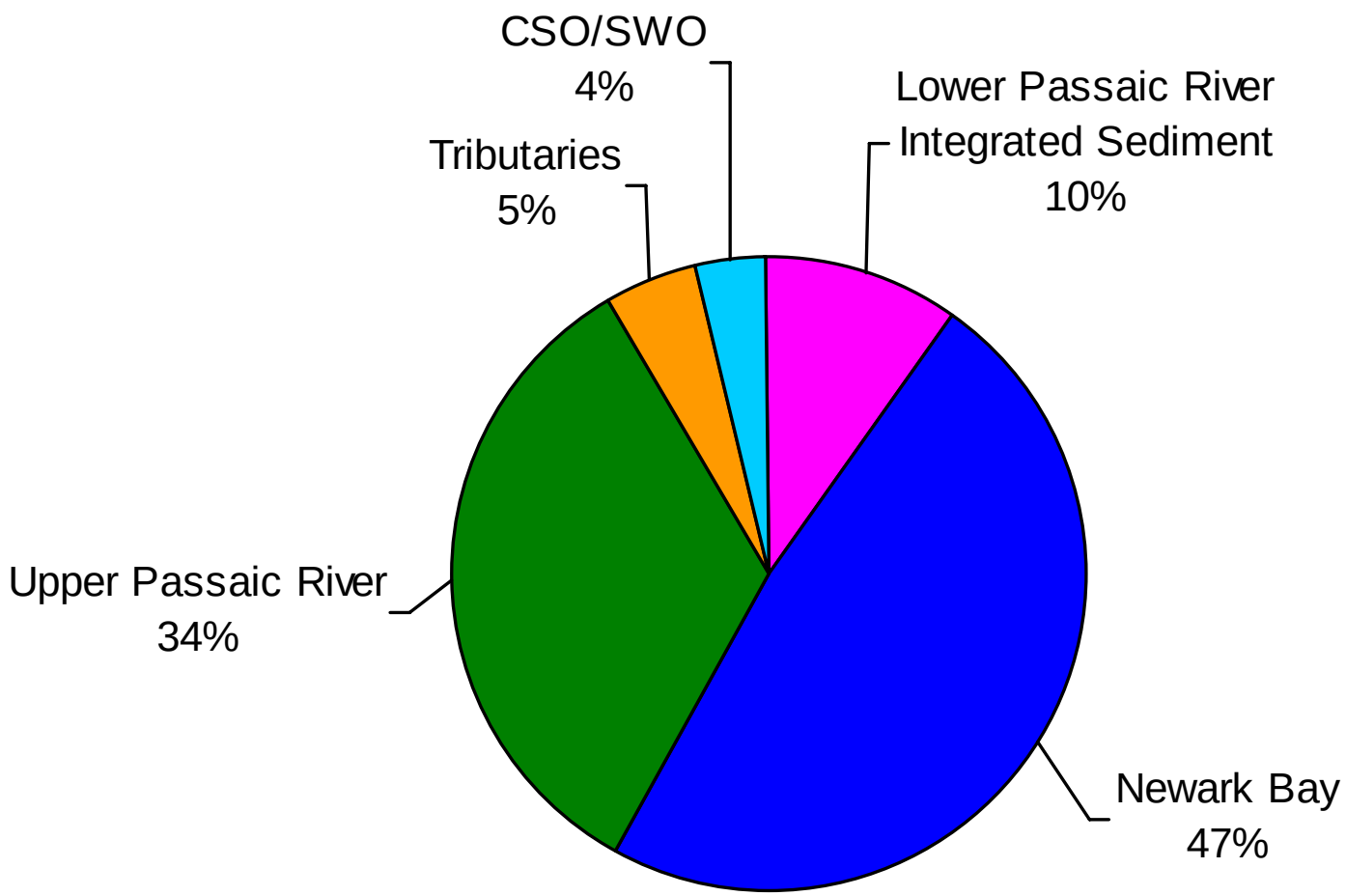
"Lower Passaic River Integrated Sediment" is the length-weighted average concentration of high resolution cores.

Solids Contribution to the Lower Passaic River for the 1990s Scenario

Lower Passaic River Restoration Project

Figure 5-2b

June 2007



Legend

- Lower Passaic River Integrated Sediment
- Newark Bay
- Upper Passaic River
- Tributaries
- CSO/SWO

Notes

"Upper Passaic River" is the core top from Dundee Lake at RM18.3.

"Tributaries" is a watershed-weighted average of Saddle River, Second River, and Third River.

"Newark Bay" represents the average of the five southern samples only.

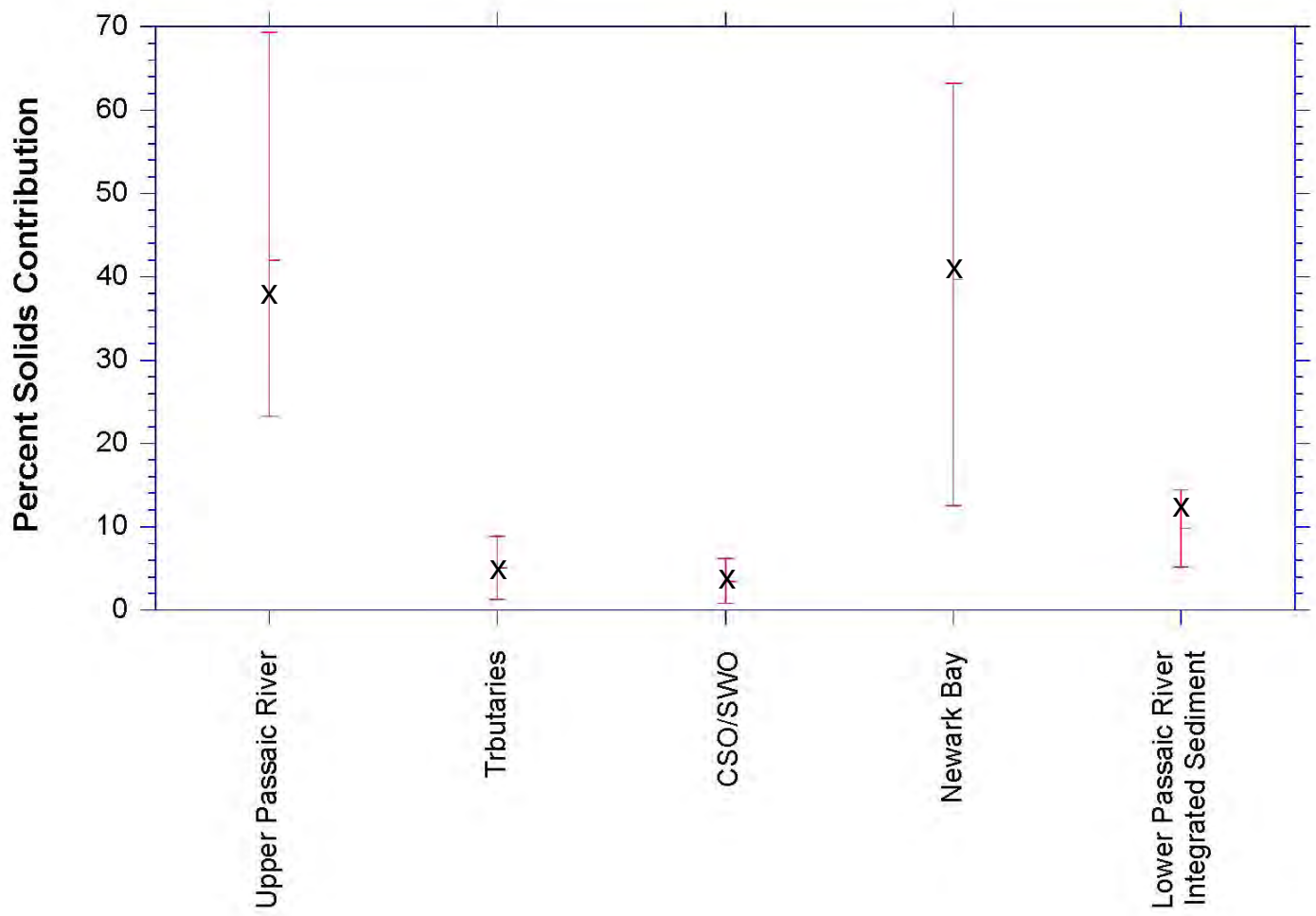
"Lower Passaic River Integrated Sediment" is the length-weighted average concentration of high resolution cores.

Sensitivity Test using Northern Newark Bay Samples

Lower Passaic River Restoration Project

Figure 5-3

June 2007



Legend

Maximum

Mean

Minimum

x Result from Deterministic Approach

Notes

"Upper Passaic River" is the core top from Dundee Lake at RM18.3.

"Tributaries" is a watershed-weighted average of Saddle River, Second River, and Third River.

"Newark Bay" represents the average of the five southern samples only.

"Lower Passaic River Integrated Sediment" is the length-weighted average concentration of high resolution cores.

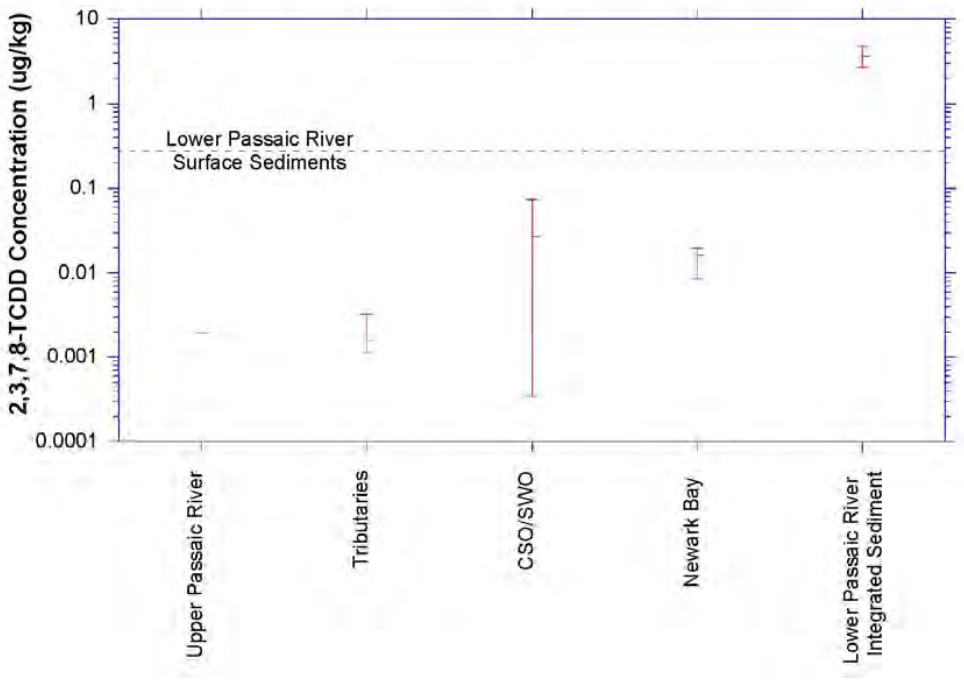
Solids Contribution to the Lower Passaic River Based on Monte Carlo Simulations

Lower Passaic River Restoration Project

Figure 5-4

June 2007

Source Concentration of 2,3,7,8-TCDD



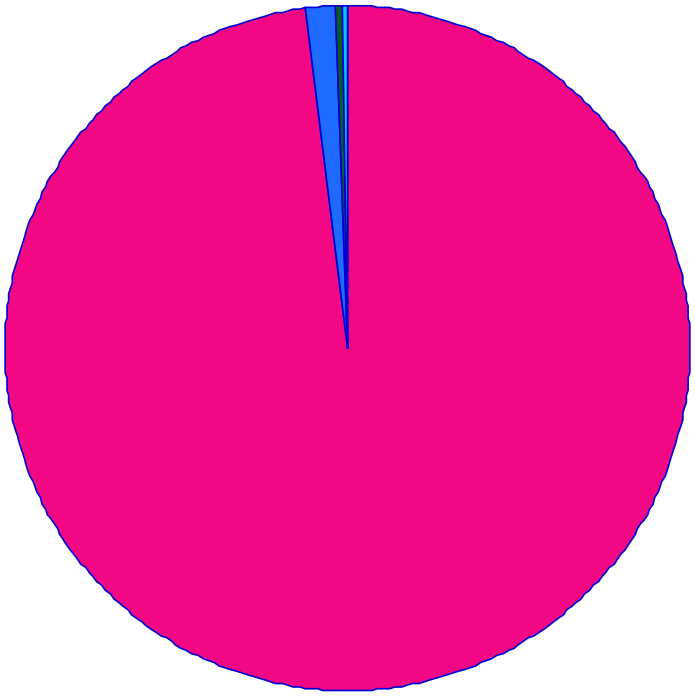
Legend

- Maximum
- Mean
- Minimum

Notes

See below.

2,3,7,8-TCDD Mass Balance



Legend

- Lower Passaic River Integrated Sediment
- Newark Bay
- Upper Passaic River
- Tributaries
- CSO/SWO

Notes

"Upper Passaic River" is the core top from Dundee Lake at RM18.3.

"Tributaries" is a watershed-weighted average of Saddle River, Second River, and Third River.

"Newark Bay" represents the average of the five southern samples only.

"Lower Passaic River Integrated Sediment" is the length-weighted average concentration of high resolution cores.

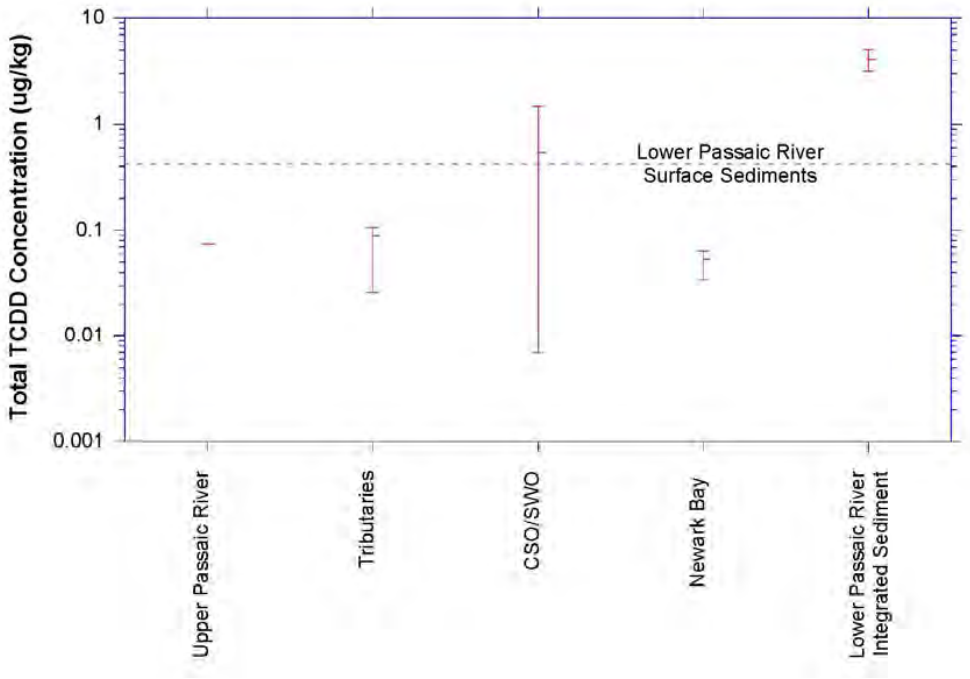
Source Concentration and Mass Balance for 2,3,7,8-TCDD

Lower Passaic River Restoration Project

Figure 6-1

June 2007

Source Concentration for Total TCDD



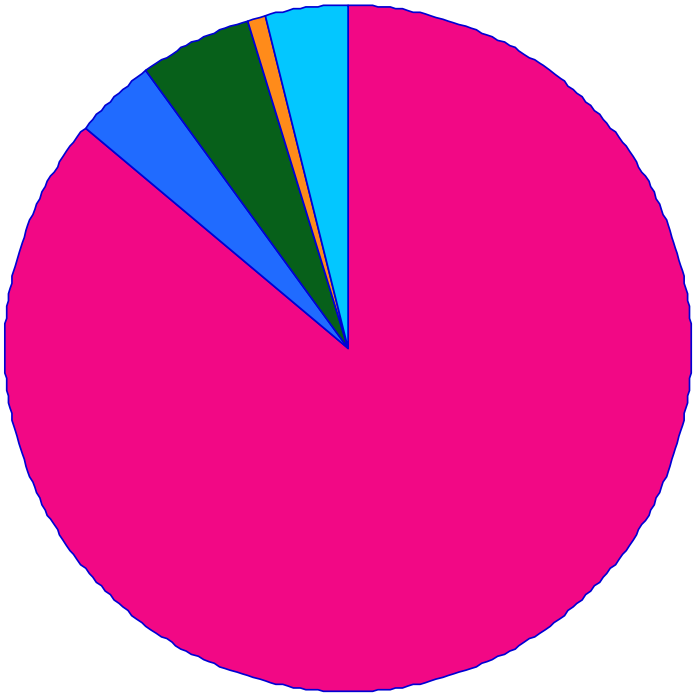
Legend

- Maximum
- Mean
- Minimum

Notes

See below.

Total TCDD Mass Balance



Legend

- Lower Passaic River Integrated Sediment
- Newark Bay
- Upper Passaic River
- Tributaries
- CSO/SWO

Notes

"Upper Passaic River" is the core top from Dundee Lake at RM18.3.

"Tributaries" is a watershed-weighted average of Saddle River, Second River, and Third River.

"Newark Bay" represents the average of the five southern samples only.

"Lower Passaic River Integrated Sediment" is the length-weighted average concentration of high resolution cores.

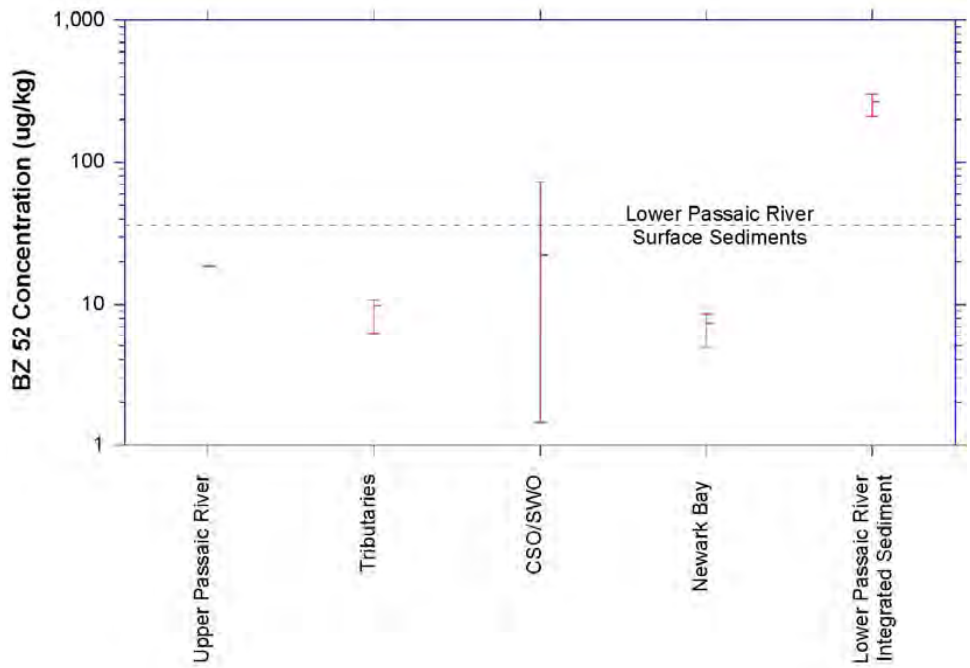
Source Concentration and Mass Balance for Total TCDD

Lower Passaic River Restoration Project

Figure 6-2

June 2007

Source Concentration for PCB Congener 52



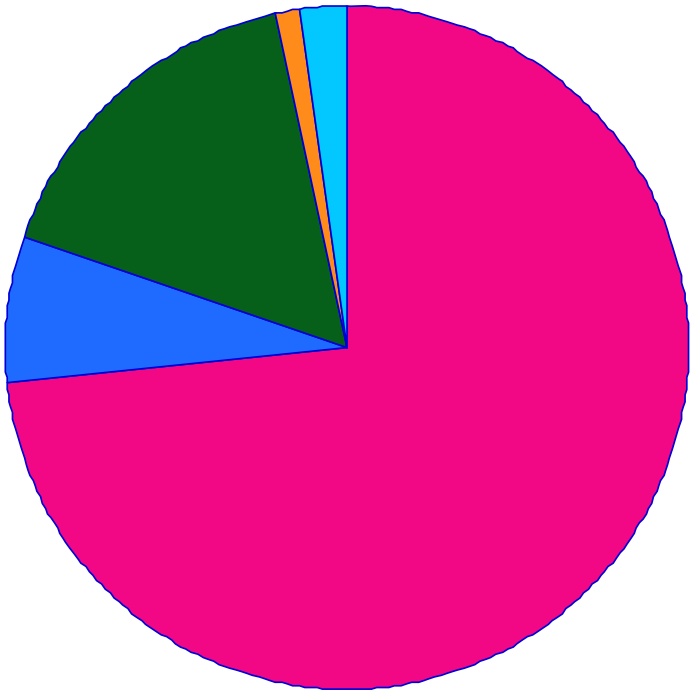
Legend

- Maximum
- Mean
- Minimum

Notes

See below.

BZ 52 Mass Balance



Legend

- Lower Passaic River Integrated Sediment
- Newark Bay
- Upper Passaic River
- Tributaries
- CSO/SWO

Notes

"Upper Passaic River" is the core top from Dundee Lake at RM18.3.

"Tributaries" is a watershed-weighted average of Saddle River, Second River, and Third River.

"Newark Bay" represents the average of the five southern samples only.

"Lower Passaic River Integrated Sediment" is the length-weighted average concentration of high resolution cores.

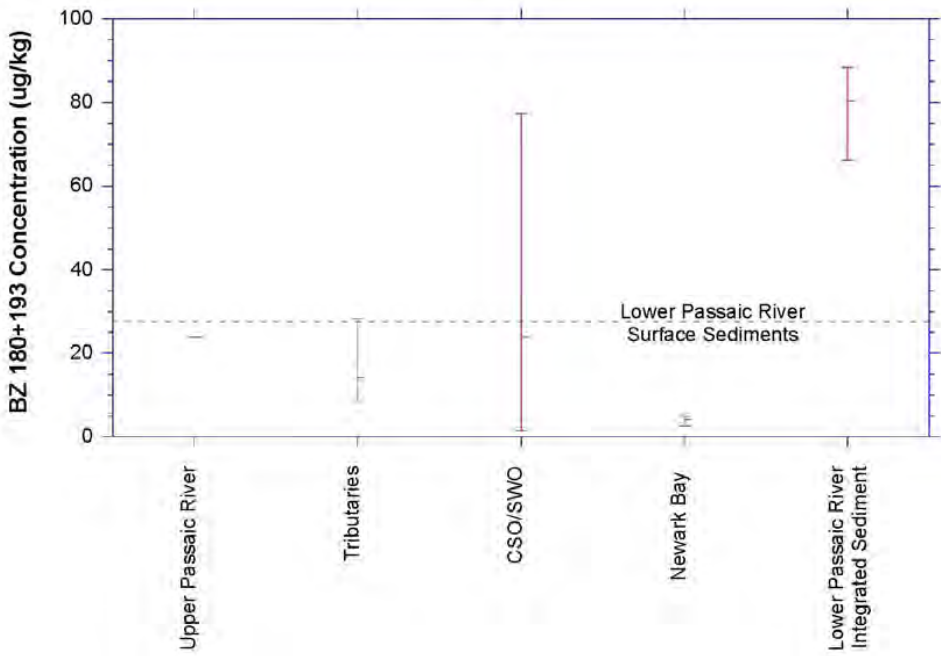
Source Concentration and Mass Balance for PCB Congener 52

Lower Passaic River Restoration Project

Figure 6-3

June 2007

Source Concentration for PCB Congener 180+193



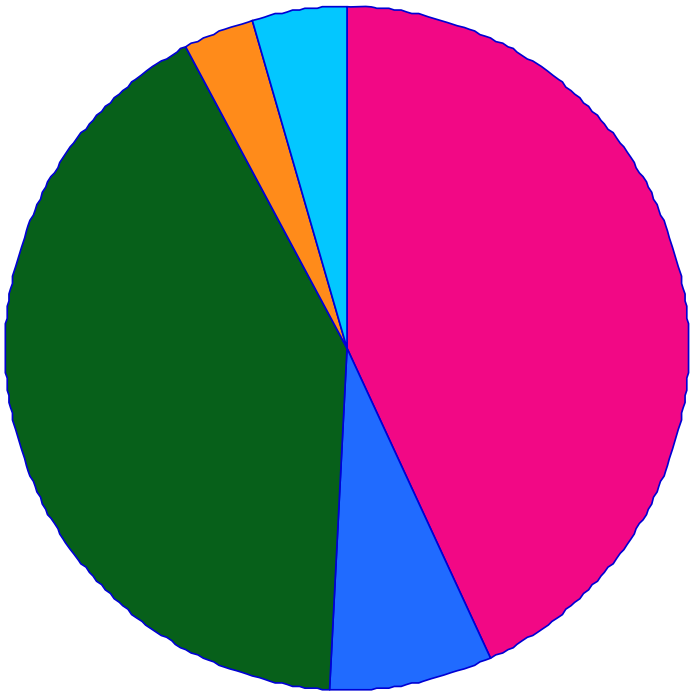
Legend

- Maximum
- Mean
- Minimum

Notes

See below.

BZ 180+193 Mass Balance



Legend

- Lower Passaic River Integrated Sediment
- Newark Bay
- Upper Passaic River
- Tributaries
- CSO/SWO

Notes

"Upper Passaic River" is the core top from Dundee Lake at RM18.3.

"Tributaries" is a watershed-weighted average of Saddle River, Second River, and Third River.

"Newark Bay" represents the average of the five southern samples only.

"Lower Passaic River Integrated Sediment" is the length-weighted average concentration of high resolution cores.

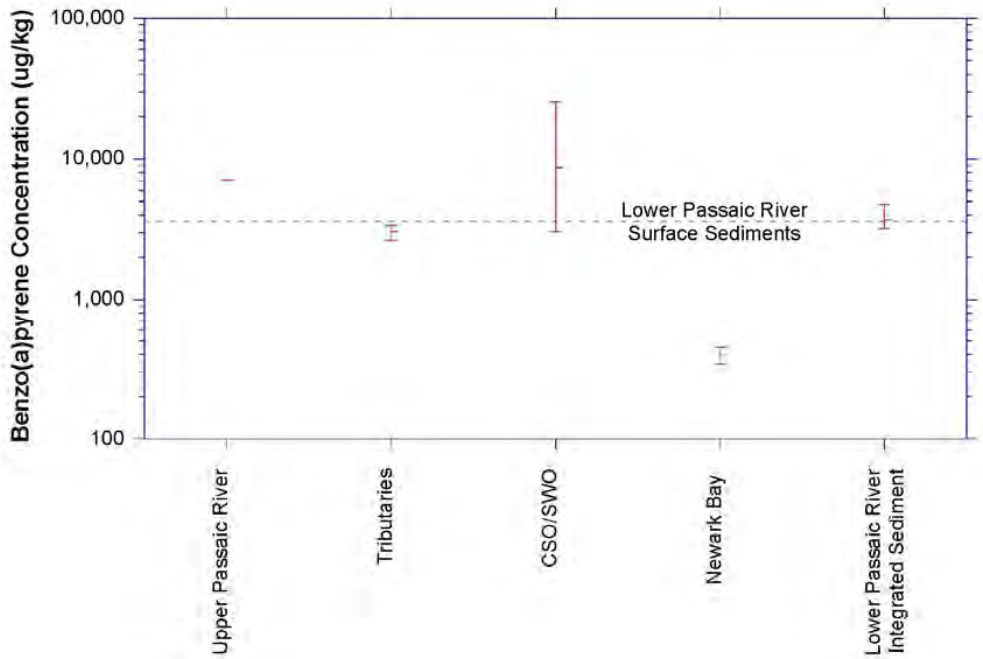
Source Concentration and Mass Balance for PCB Congener 180+193

Lower Passaic River Restoration Project

Figure 6-4

June 2007

Source Concentration for Benzo(a)pyrene



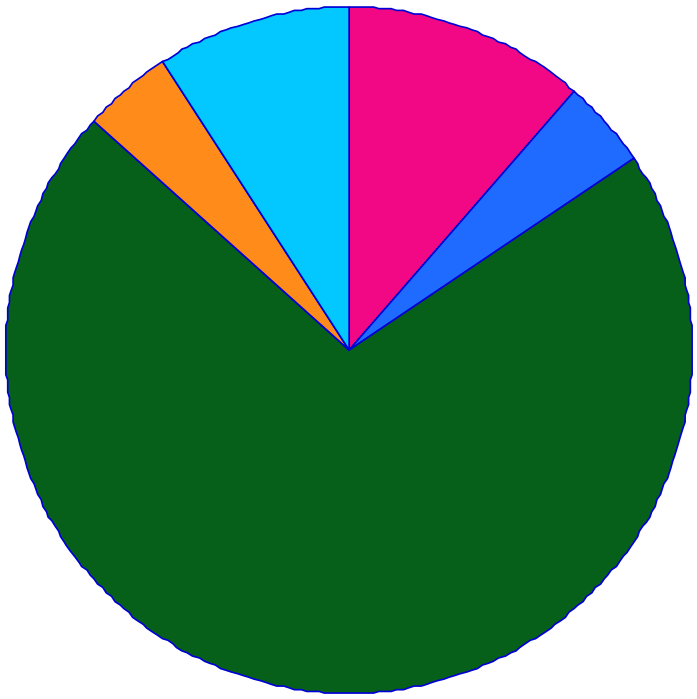
Legend

- Maximum
- Mean
- Minimum

Notes

See below.

Benzo(a)pyrene Mass Balance



Legend

- Lower Passaic River Integrated Sediment
- Newark Bay
- Upper Passaic River
- Tributaries
- CSO/SWO

Notes

"Upper Passaic River" is the core top from Dundee Lake at RM18.3.

"Tributaries" is a watershed-weighted average of Saddle River, Second River, and Third River.

"Newark Bay" represents the average of the five southern samples only.

"Lower Passaic River Integrated Sediment" is the length-weighted average concentration of high resolution cores.

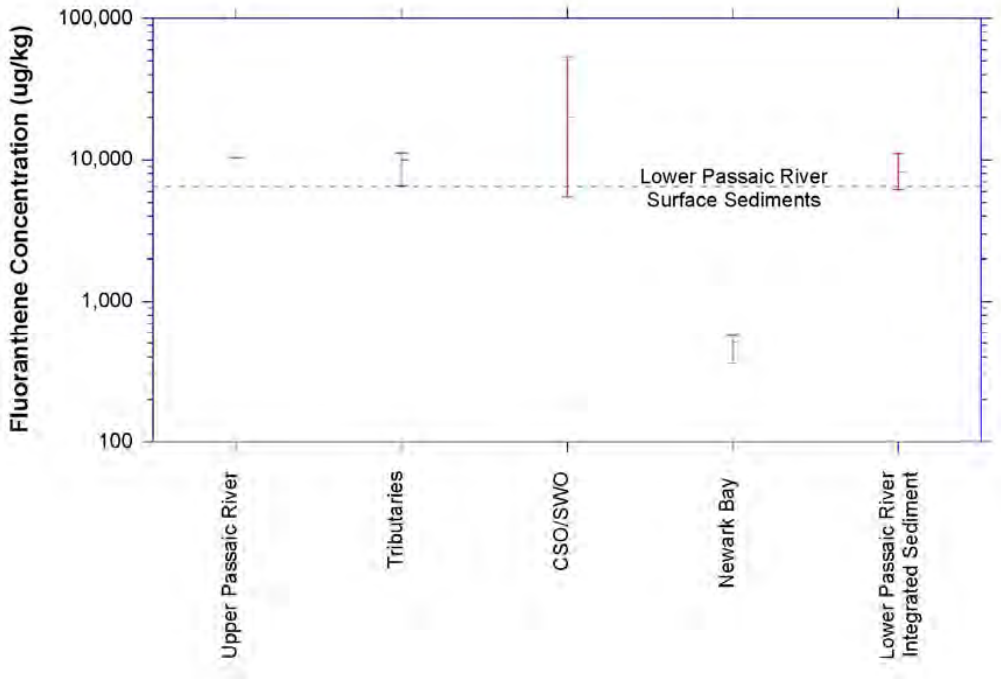
Source Concentration and Mass Balance for Benzo[a]pyrene

Lower Passaic River Restoration Project

Figure 6-5

June 2007

Source Concentration for Fluoranthene



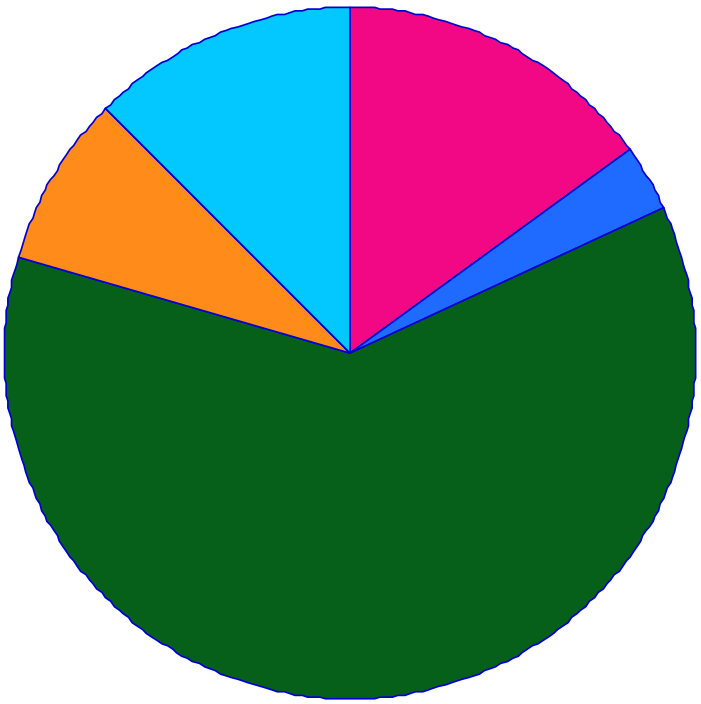
Legend

- Maximum
- Mean
- Minimum

Notes

See below.

Fluoranthene Mass Balance



Legend

- Lower Passaic River Integrated Sediment
- Newark Bay
- Upper Passaic River
- Tributaries
- CSO/SWO

Notes

"Upper Passaic River" is the core top from Dundee Lake at RM18.3.

"Tributaries" is a watershed-weighted average of Saddle River, Second River, and Third River.

"Newark Bay" represents the average of the five southern samples only.

"Lower Passaic River Integrated Sediment" is the length-weighted average of high resolution cores.

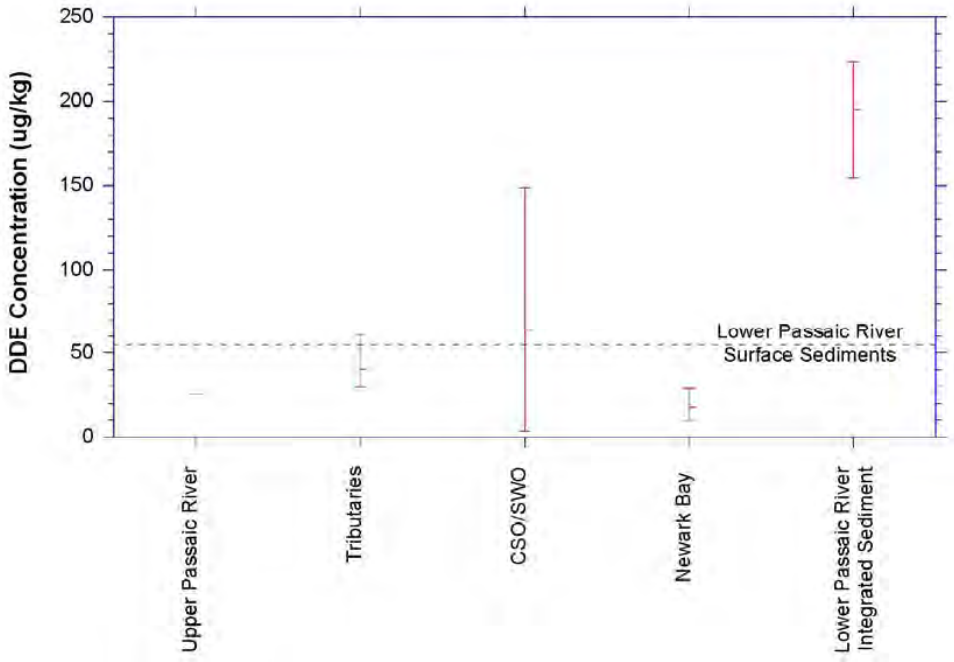
Source Concentration and Mass Balance for Fluoranthene

Lower Passaic River Restoration Project

Figure 6-6

June 2007

Source Concentration for 4,4'-DDE



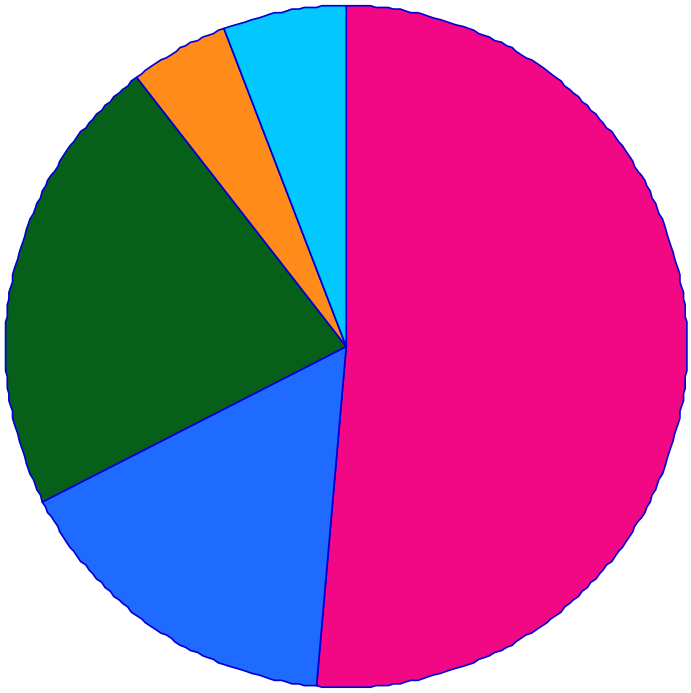
Legend

- Maximum
- Mean
- Minimum

Notes

See below.

DDE Mass Balance



Legend

- Lower Passaic River Integrated Sediment
- Newark Bay
- Upper Passaic River
- Tributaries
- CSO/SWO

Notes

DDE represents only the 4,4'-isomer.

"Upper Passaic River" is the core top from Dundee Lake at RM18.3.

"Tributaries" is a watershed-weighted average of Saddle River, Second River, and Third River.

"Newark Bay" represents the average of the five southern samples only.

"Lower Passaic River Integrated Sediment" is the length-weighted average concentration of high resolution cores.

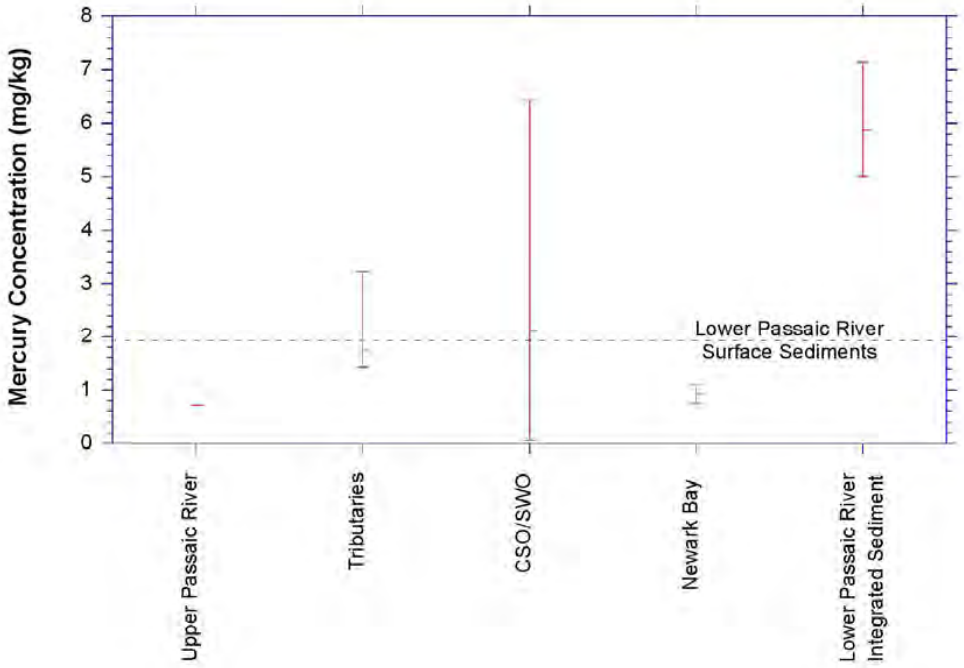
Source Concentration and Mass Balance for 4,4'-DDE

Lower Passaic River Restoration Project

Figure 6-7

June 2007

Source Concentration for Mercury



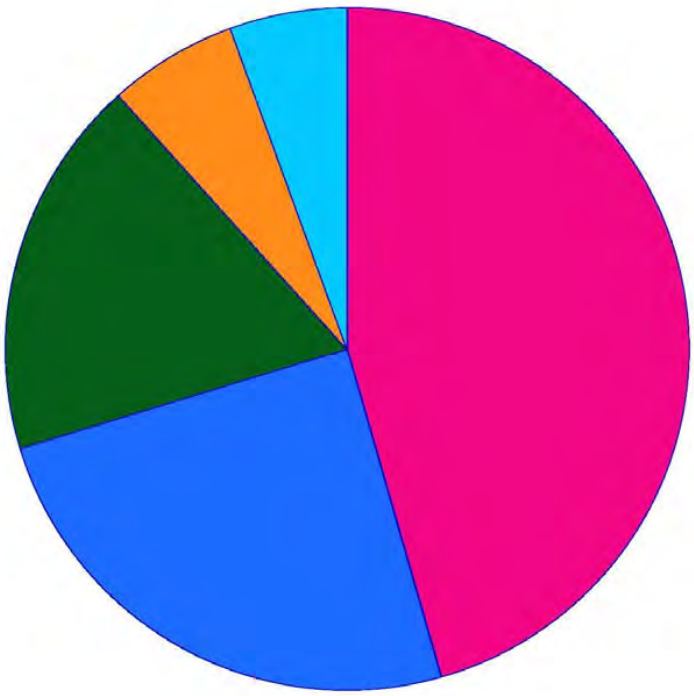
Legend

- Maximum
- Mean
- Minimum

Notes

See below.

Mercury Mass Balance



Legend

- Lower Passaic River Integrated Sediment
- Newark Bay
- Upper Passaic River
- Tributaries
- CSO/SWO

Notes

"Upper Passaic River" is the core top from Dundee Lake at RM18.3.

"Tributaries" is a watershed-weighted average of Saddle River, Second River, and Third River.

"Newark Bay" represents the average of the five southern samples only.

"Lower Passaic River Integrated Sediment" is the length-weighted average concentration of high resolution cores.

Source Concentration and Mass Balance for Mercury

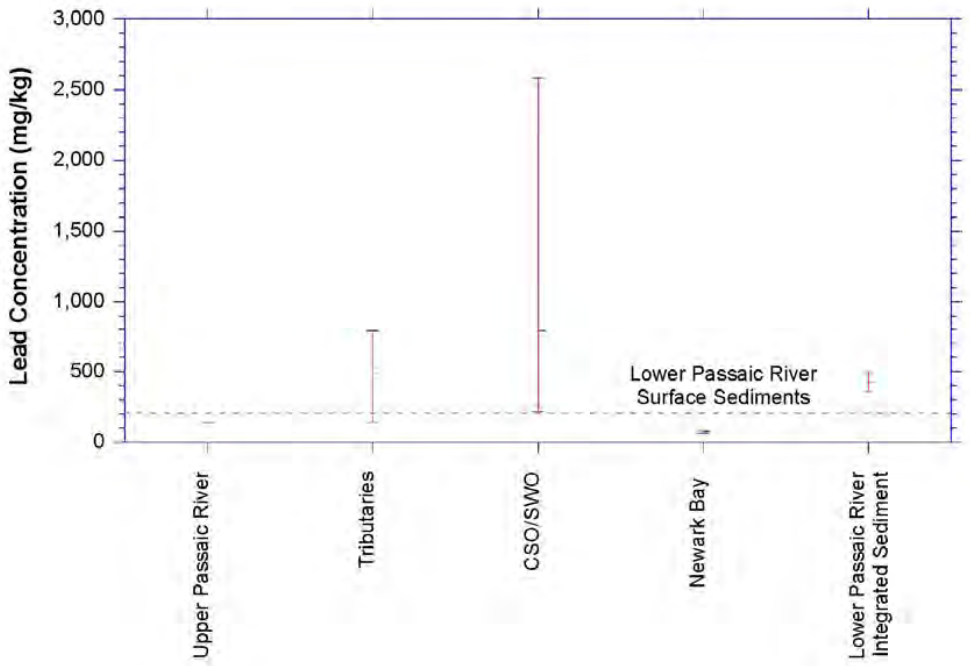
Lower Passaic River Restoration Project

Figure 6-8

June 2007

R2-0010173

Source Concentration for Lead



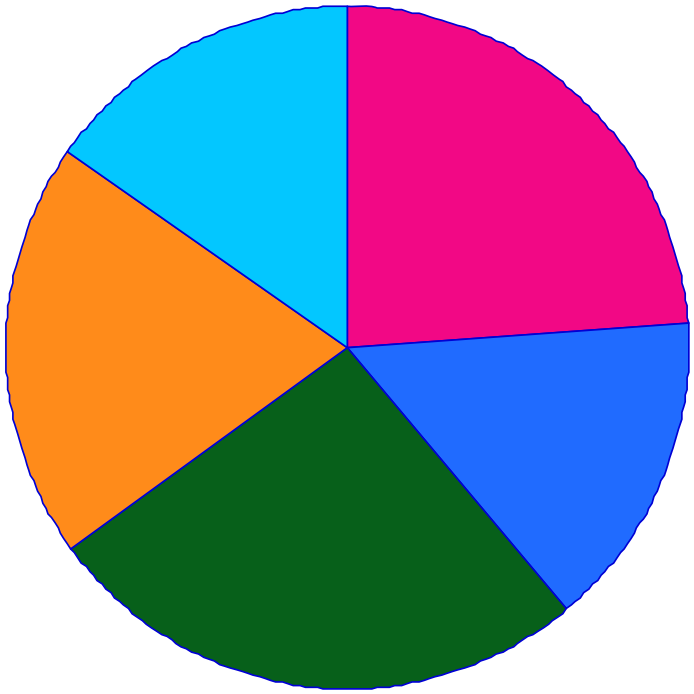
Legend

- Maximum
- Mean
- Minimum

Notes

See below.

Lead Mass Balance



Legend

- Lower Passaic River Integrated Sediment
- Newark Bay
- Upper Passaic River
- Tributaries
- CSO/SWO

Notes

"Upper Passaic River" is the core top from Dundee Lake at RM18.3.

"Tributaries" is a watershed-weighted average of Saddle River, Second River, and Third River.

"Newark Bay" represents the average of the five southern samples only.

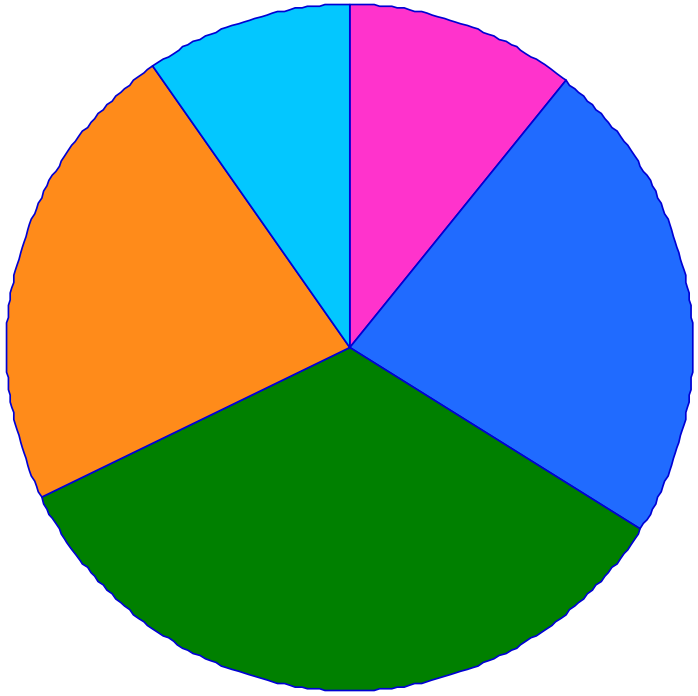
"Lower Passaic River Integrated Sediment" is the length-weighted average concentration of high resolution cores.

Source Concentration and Mass Balance for Lead

Lower Passaic River Restoration Project

Figure 6-9

June 2007



Legend

- Lower Passaic River Integrated Sediment
- Newark Bay
- Upper Passaic River
- Tributaries
- CSO/SWO

Notes

"Upper Passaic River" is the core top from Dundee Lake at RM18.3.

"Tributaries" is a watershed-weighted average of Saddle River, Second River, and Third River.

"Newark Bay" represents the average of the five southern samples only.

"Lower Passaic River Integrated Sediment" is the length-weighted average concentration of high resolution cores.

Inferred Mass Balance for Trans-Chlordane

Lower Passaic River Restoration Project

Figure 6-10

June 2007

Legend

- Lower Passaic River Integrated Sediment
- Newark Bay
- Upper Passaic River
- Tributaries
- CSO/SWO

Notes

"Upper Passaic River" is the core top from Dundee Lake at RM18.3.

"Tributaries" is a watershed-weighted average of Saddle River, Second River, and Third River.

"Newark Bay" represents the average of the five southern samples only.

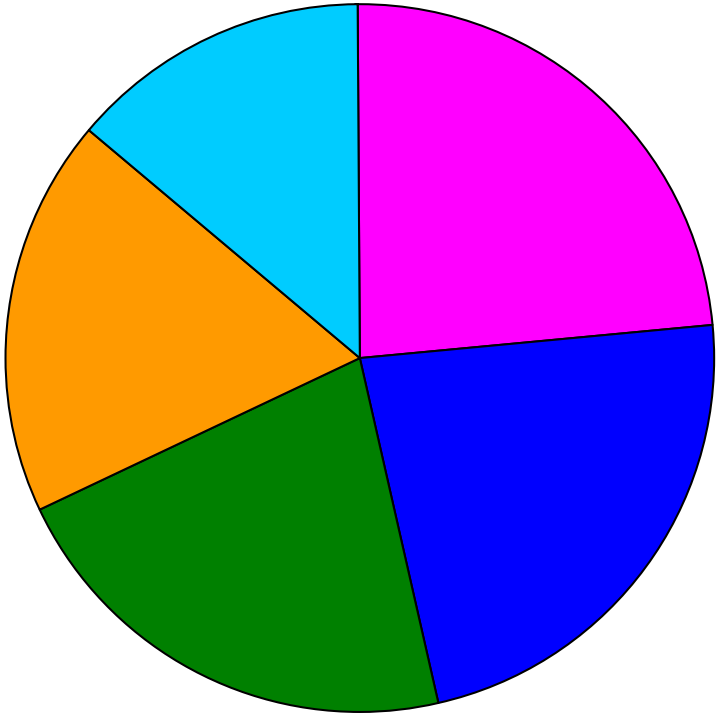
"Lower Passaic River Integrated Sediment" is the length-weighted average concentration of high resolution cores.

Inferred Mass Balance for Dieldrin

Lower Passaic River Restoration Project

Figure 6-11

June 2007



Legend

- Lower Passaic River Integrated Sediment
- Newark Bay
- Upper Passaic River
- Tributaries
- CSO/SWO

Notes

"Upper Passaic River" is the core top from Dundee Lake at RM18.3.

"Tributaries" is a watershed-weighted average of Saddle River, Second River, and Third River.

"Newark Bay" represents the average of the five southern samples only.

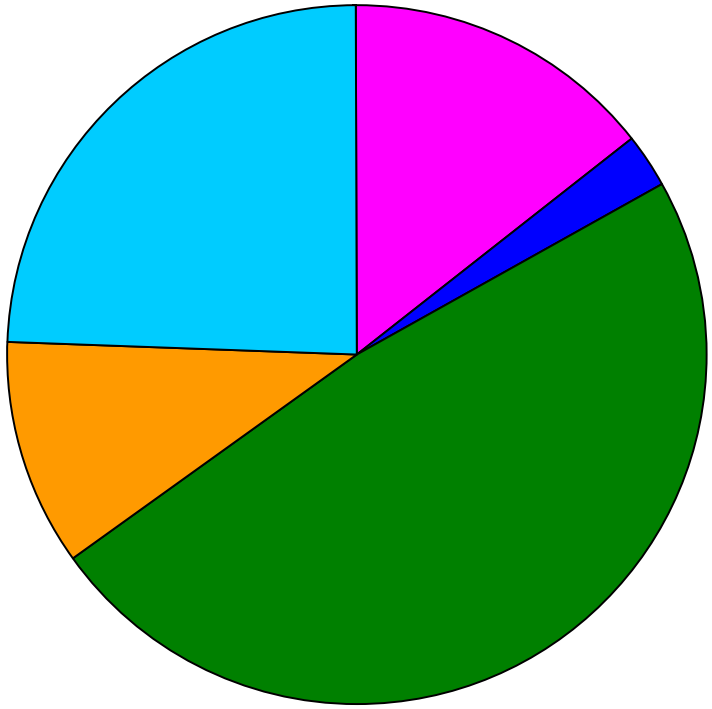
"Lower Passaic River Integrated Sediment" is the length-weighted average concentration of high resolution cores.

Inferred Mass Balance for Copper

Lower Passaic River Restoration Project

Figure 6-12

June 2007



Legend

- Lower Passaic River Integrated Sediment
- Newark Bay
- Upper Passaic River
- Tributaries
- CSO/SWO

Notes

"Upper Passaic River" is the core top from Dundee Lake at RM18.3.

"Tributaries" is a watershed-weighted average of Saddle River, Second River, and Third River.

"Newark Bay" represents the average of the five southern samples only.

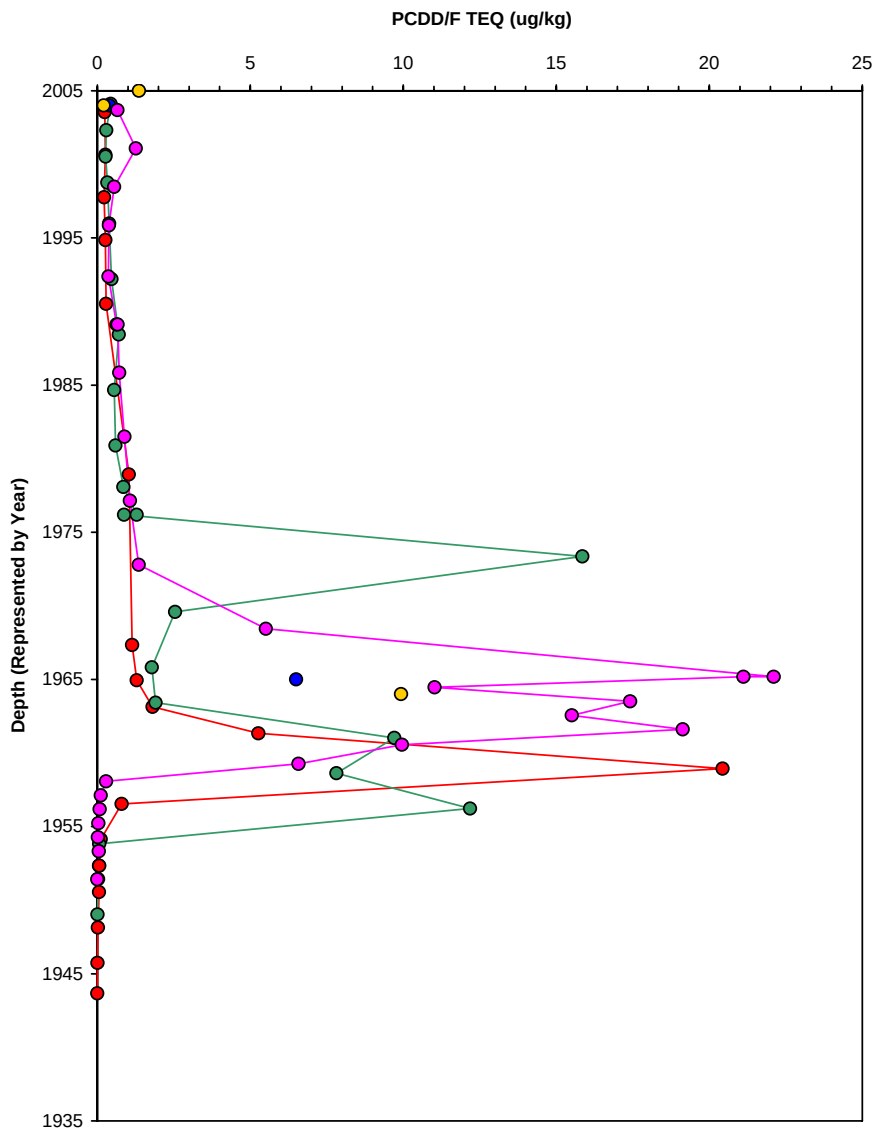
"Lower Passaic River Integrated Sediment" is the length-weighted average concentration of high resolution cores.

Inferred Mass Balance for Phenanthrene

Lower Passaic River Restoration Project

Figure 6-13

June 2007



Legend

- RM1.4
- RM2.2
- RM7.8
- RM11
- RM12.6

Notes

Toxic Equivalency (TEQ) equals the measured concentration times the Toxic Equivalent Factor (TEF).

TEF values differ for the various receptor (1998 mammal, 2005 mammal, fish, and bird).

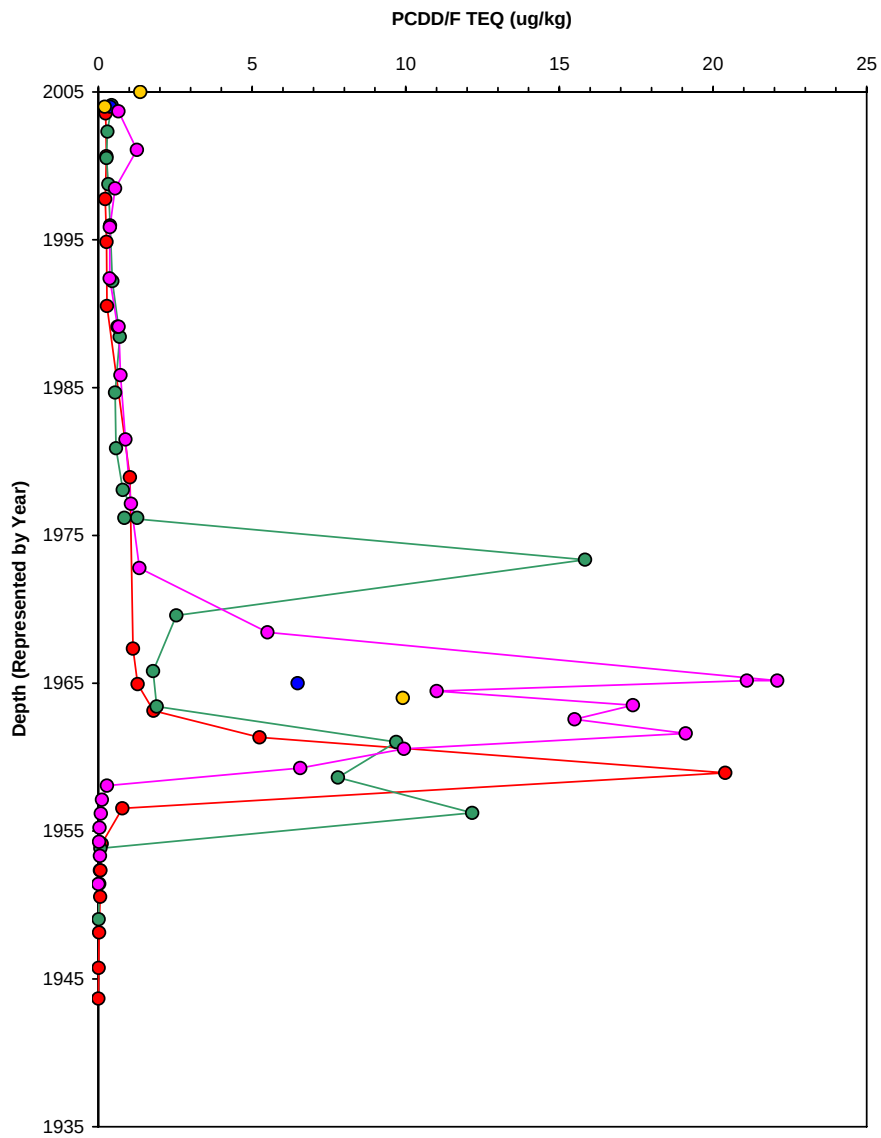
Data Source: 2005 High Resolution Cores Sampling Program collected by Malcolm Pirnie, Inc.

PCDD/F TEQ Dated Sediment Core Profile for the Lower Passaic River: 1998 Mammal Scenario

Lower Passaic River Restoration Project

Figure 7-1a

June 2007



Legend

- RM1.4
- RM2.2
- RM7.8
- RM11
- RM12.6

Notes

Toxic Equivalency (TEQ) equals the measured concentration times the Toxic Equivalent Factor (TEF).

TEF values differ for the various receptor (1998 mammal, 2005 mammal, fish, and bird).

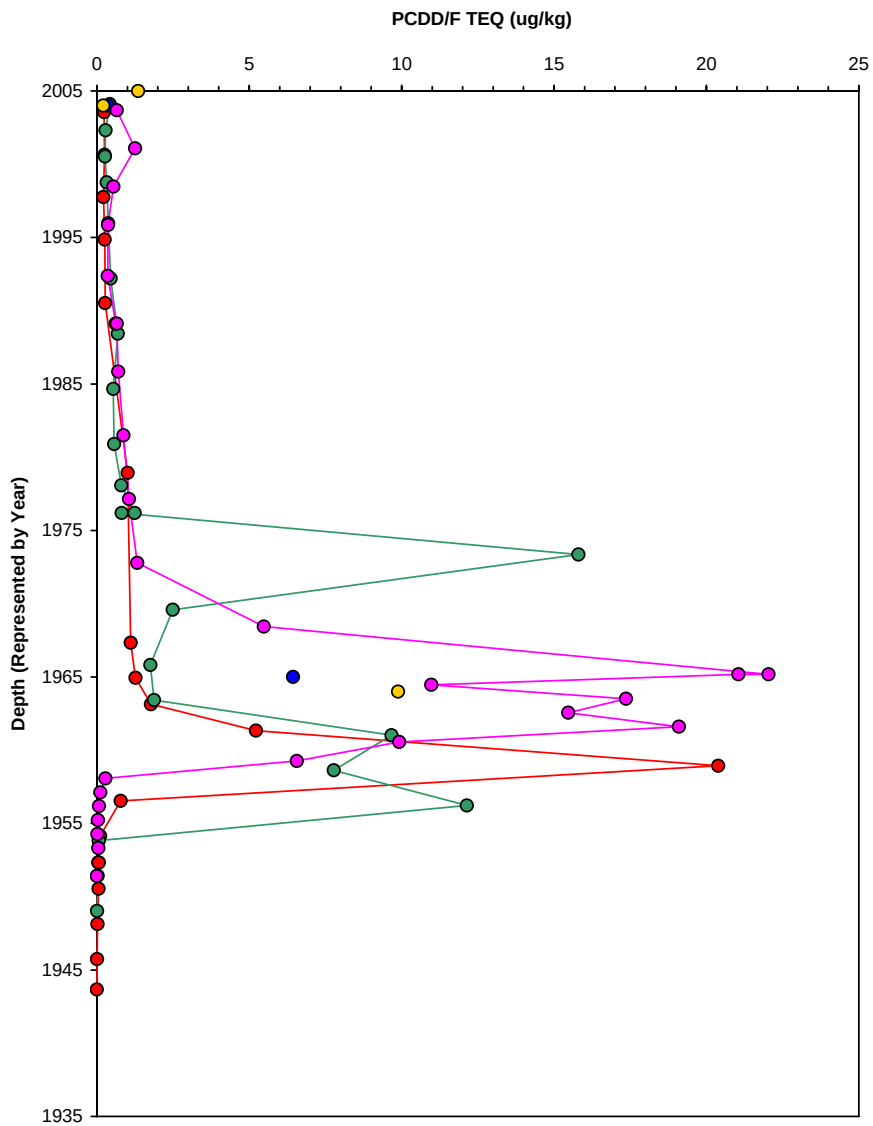
Data Source: 2005 High Resolution Cores Sampling Program collected by Malcolm Pirnie, Inc.

PCDD/F TEQ Dated Sediment Core Profiles for the Lower Passaic River: 2005 Mammal Scenario

Lower Passaic River Restoration Project

Figure 7-1b

June 2007



Legend

- RM1.4
- RM2.2
- RM7.8
- RM11
- RM12.6

Notes

Toxic Equivalency (TEQ) equals the measured concentration times the Toxic Equivalent Factor (TEF).

TEF values differ for the various receptor (1998 mammal, 2005 mammal, fish, and bird).

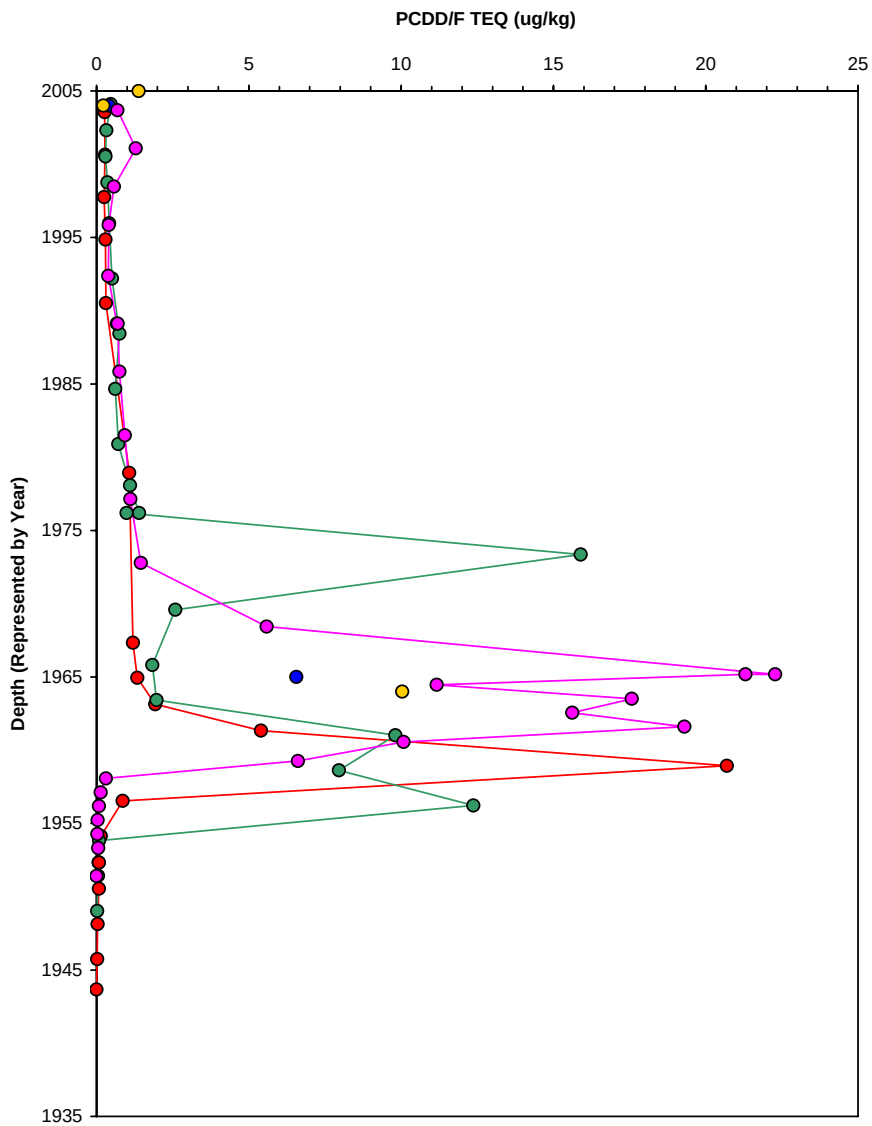
Data Source: 2005 High Resolution Cores Sampling Program collected by Malcolm Pirnie, Inc.

PCDD/F TEQ Dated Sediment Core Profile for the Lower Passaic River: Fish Scenario

Lower Passaic River Restoration Project

Figure 7-1c

June 2007



Legend

- RM1.4
- RM2.2
- RM7.8
- RM11
- RM12.6

Notes

Toxic Equivalency (TEQ) equals the measured concentration times the Toxic Equivalent Factor (TEF).

TEF values differ for the various receptor (1998 mammal, 2005 mammal, fish, and bird).

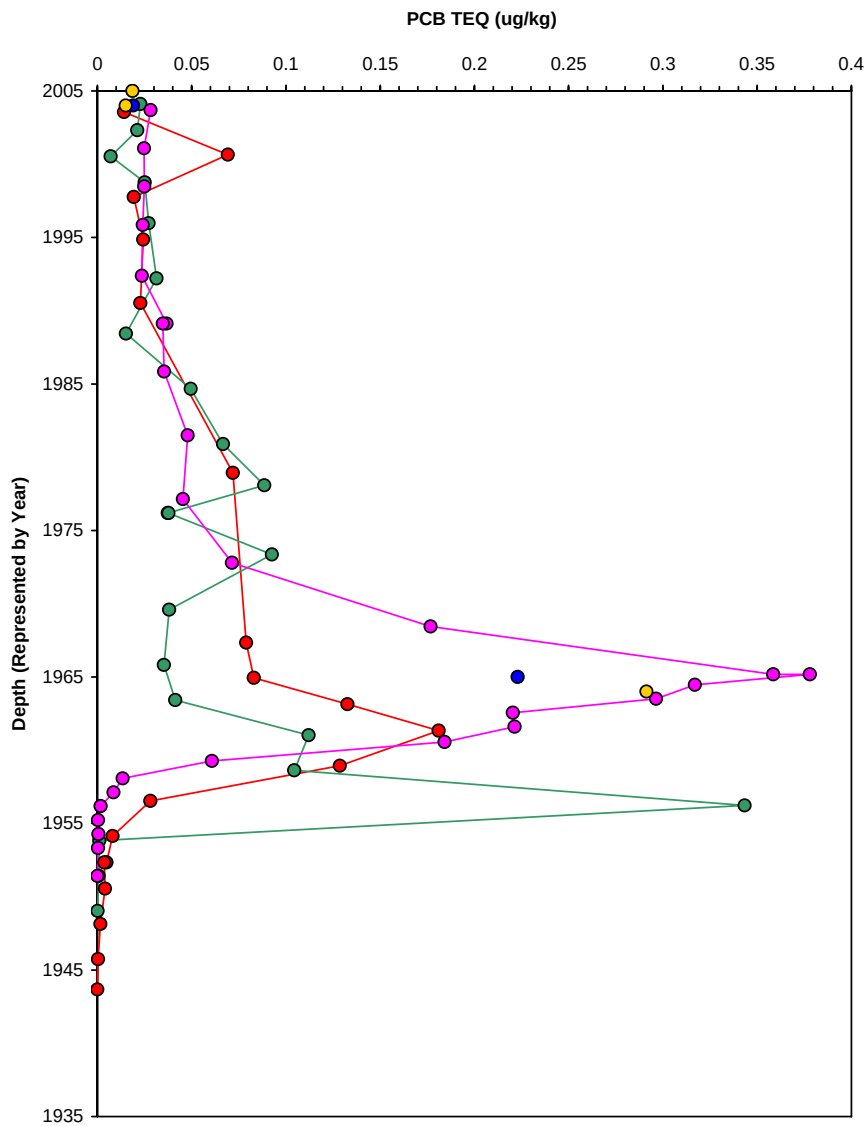
Data Source: 2005 High Resolution Cores Sampling Program collected by Malcolm Pirnie, Inc.

PCDD/F TEQ Dated Sediment Core Profile for the Lower Passaic River: Bird Scenario

Lower Passaic River Restoration Project

Figure 7-1d

June 2007



Legend

- RM1.4
- RM2.2
- RM7.8
- RM11
- RM12.6

Notes

Toxic Equivalency (TEQ) equals the measured concentration times the Toxic Equivalent Factor (TEF).

TEF values differ for the various receptor (1998 mammal, 2005 mammal, fish, and bird).

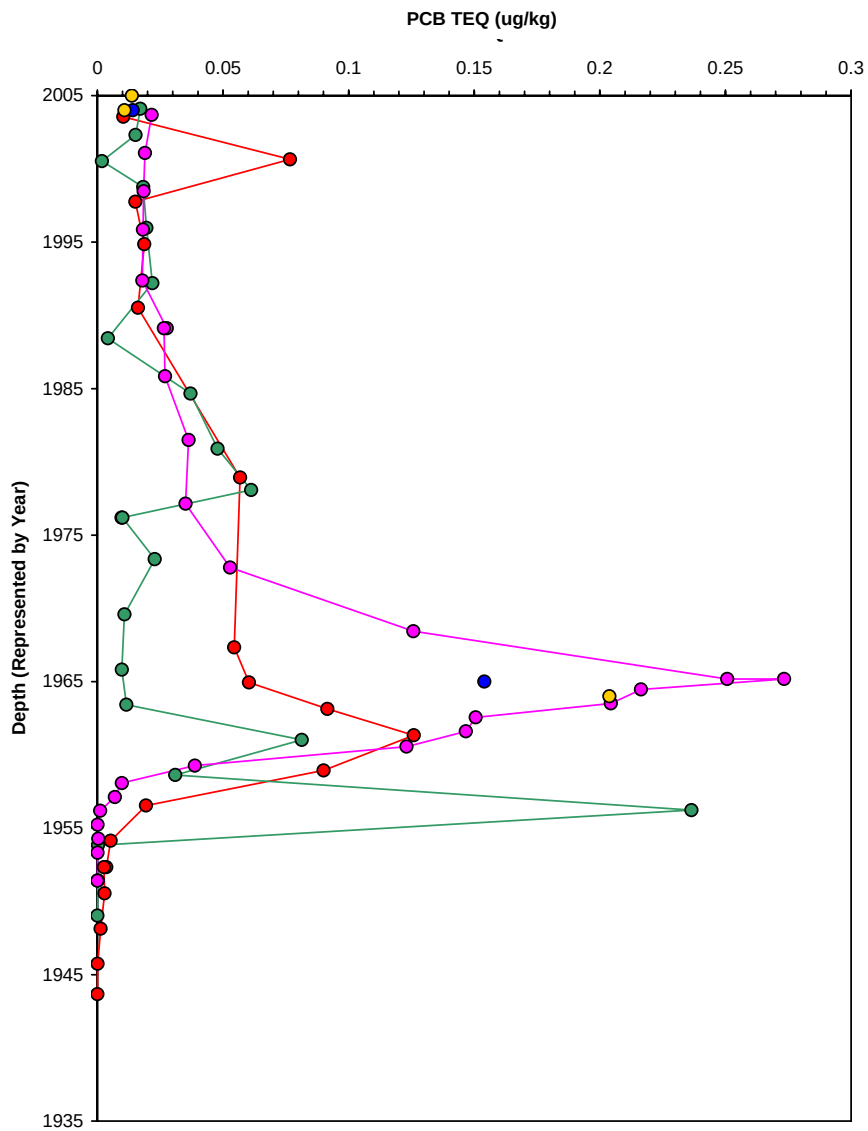
Data Source: 2005 High Resolution Cores Sampling Program collected by Malcolm Pirnie, Inc.

PCB TEQ Dated Sediment Core Profile for the Lower Passaic River: 1998 Mammal Scenario

Lower Passaic River Restoration Project

Figure 7-2a

June 2007



Legend

- RM1.4
- RM2.2
- RM7.8
- RM11
- RM12.6

Notes

Toxic Equivalency (TEQ) equals the measured concentration times the Toxic Equivalent Factor (TEF).

TEF values differ for the various receptor (1998 mammal, 2005 mammal, fish, and bird).

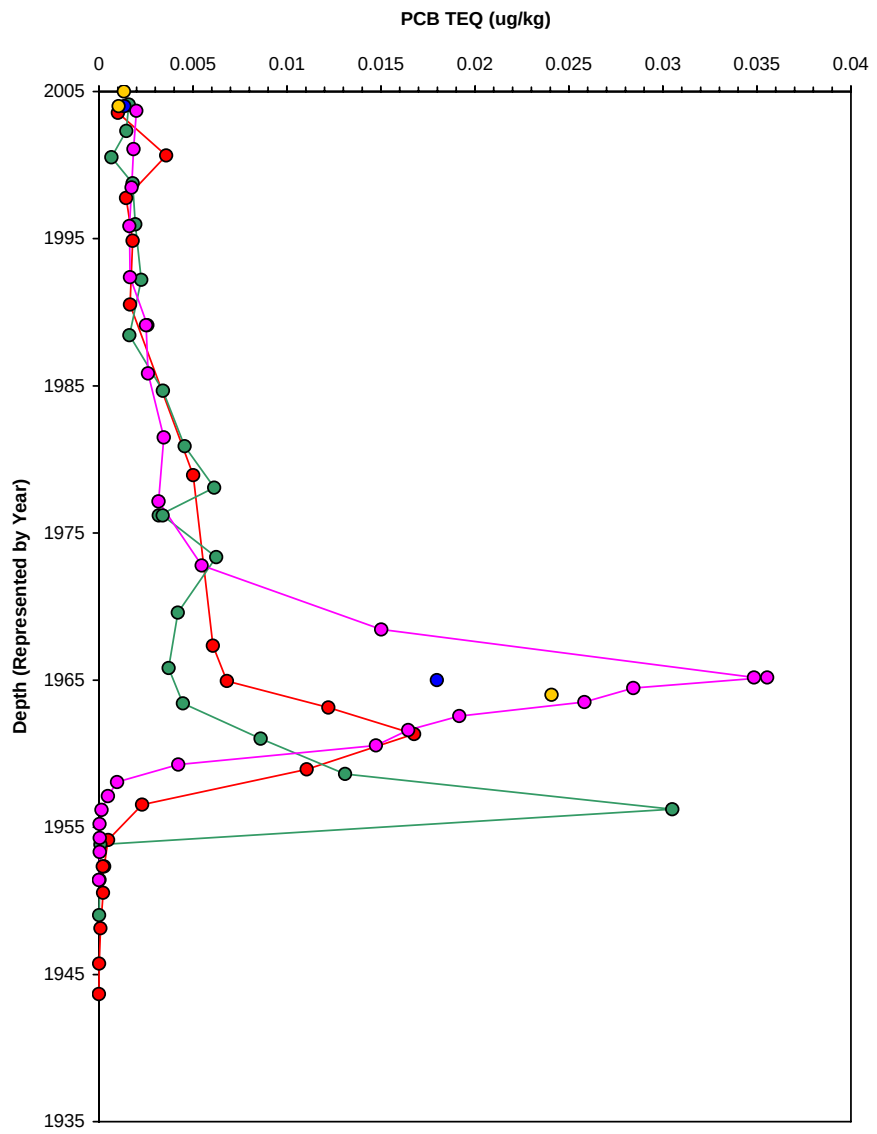
Data Source: 2005 High Resolution Cores Sampling Program collected by Malcolm Pirnie, Inc.

PCB TEQ Dated Sediment Core Profile for the Lower Passaic River: 2005 Mammal Scenario

Lower Passaic River Restoration Project

Figure 7-2b

June 2007



Legend

- RM1.4
- RM2.2
- RM7.8
- RM11
- RM12.6

Notes

Toxic Equivalency (TEQ) equals the measured concentration times the Toxic Equivalent Factor (TEF).

TEF values differ for the various receptor (1998 mammal, 2005 mammal, fish, and bird).

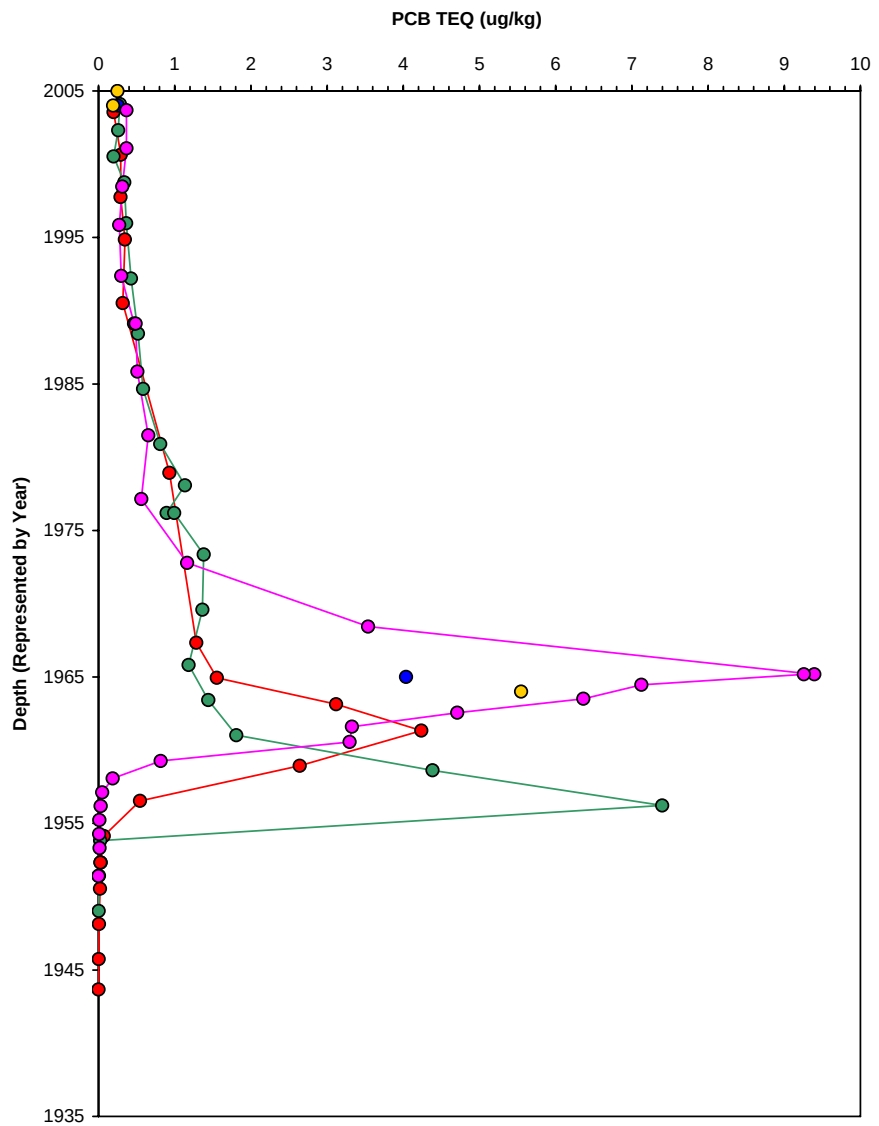
Data Source: 2005 High Resolution Cores Sampling Program collected by Malcolm Pirnie, Inc.

PCB TEQ Dated Sediment Core Profile for the Lower Passaic River: Fish Scenario

Lower Passaic River Restoration Project

Figure 7-2c

June 2007



Legend

- RM1.4
- RM2.2
- RM7.8
- RM11
- RM12.6

Notes

Toxic Equivalency (TEQ) equals the measured concentration times the Toxic Equivalent Factor (TEF).

TEF values differ for the various receptor (1998 mammal, 2005 mammal, fish, and bird).

Data Source: 2005 High Resolution Cores Sampling Program collected by Malcolm Pirnie, Inc.

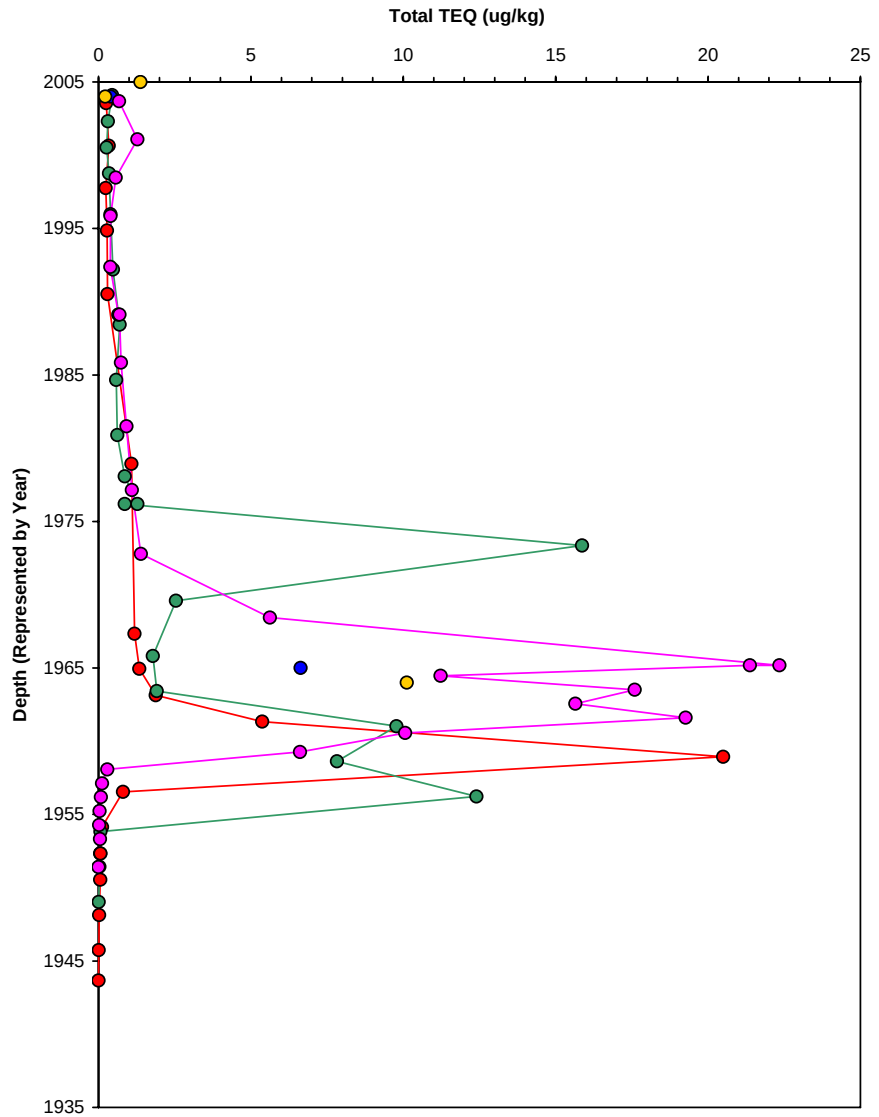
PCB TEQ Dated Sediment Core Profile for the Lower Passaic River: Bird Scenario

Lower Passaic River Restoration Project

Figure 7-2d

June 2007

R2-0010186



Legend

- RM1.4
- RM2.2
- RM7.8
- RM11
- RM12.6

Notes

Total Toxic Equivalency (TEQ) equals PCDD/F TEQ plus the PCB TEQ for the various receptor (1998 mammal, 2005 mammal, fish, and bird).

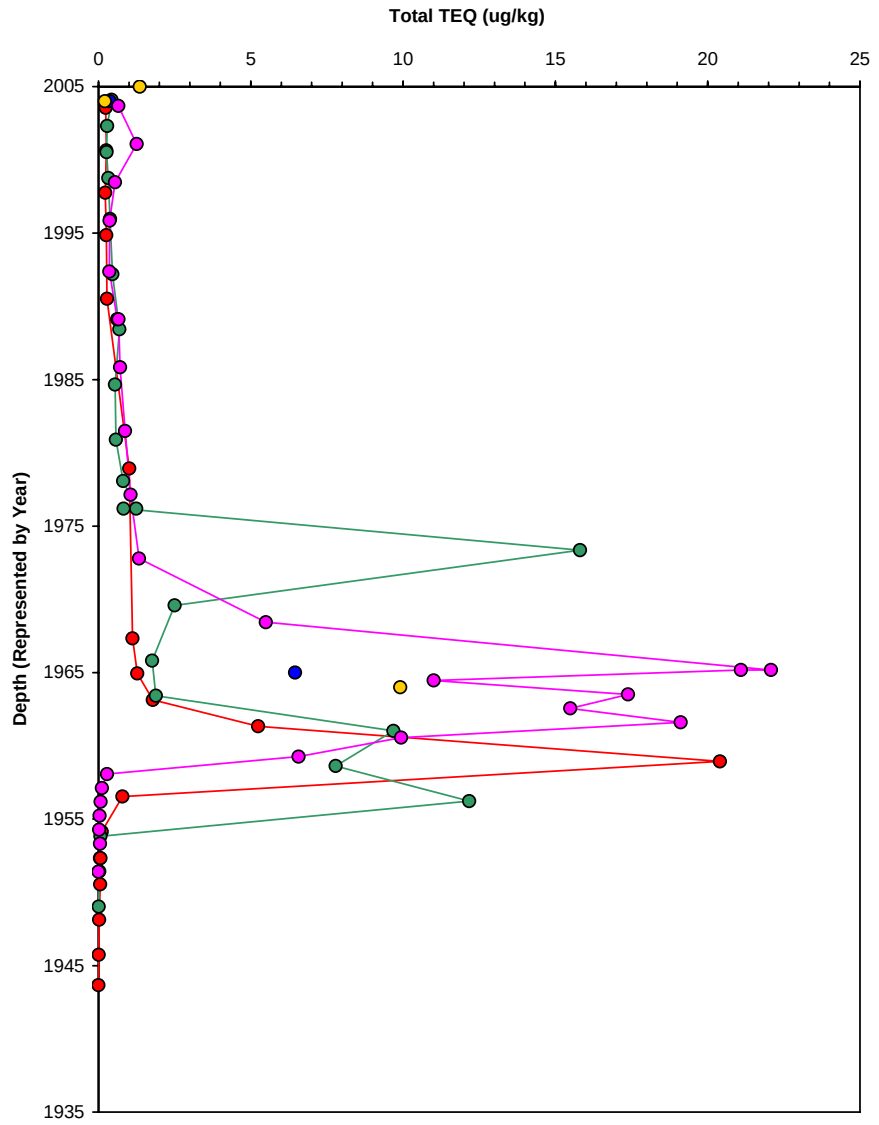
Data Source: 2005 High Resolution Cores Sampling Program collected by Malcolm Pirnie, Inc.

Total TEQ Dated Sediment Core Profile for the Lower Passaic River: 2005 Mammal Scenario

Lower Passaic River Restoration Project

Figure 7-3a

June 2007



Legend

- RM1.4
- RM2.2
- RM7.8
- RM11
- RM12.6

Notes

Total Toxic Equivalency (TEQ) equals PCDD/F TEQ plus the PCB TEQ for the various receptor (1998 mammal, 2005 mammal, fish, and bird).

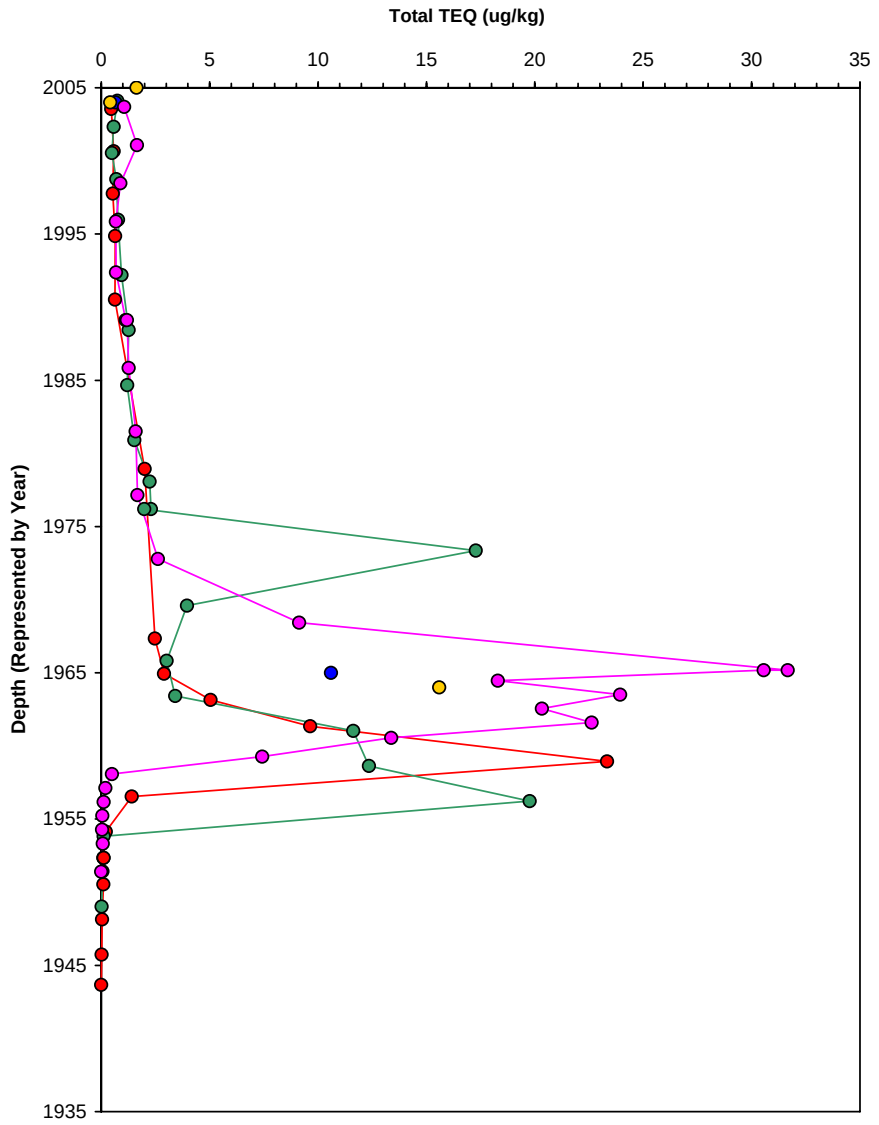
Data Source: 2005 High Resolution Cores Sampling Program collected by Malcolm Pirnie, Inc.

Total TEQ Dated Sediment Core Profile for the Lower Passaic River: Fish Scenario

Lower Passaic River Restoration Project

Figure 7-3b

June 2007



Legend

- RM1.4
- RM2.2
- RM7.8
- RM11
- RM12.6

Notes

Total Toxic Equivalency (TEQ) equals PCDD/F TEQ plus the PCB TEQ for the various receptor (1998 mammal, 2005 mammal, fish, and bird).

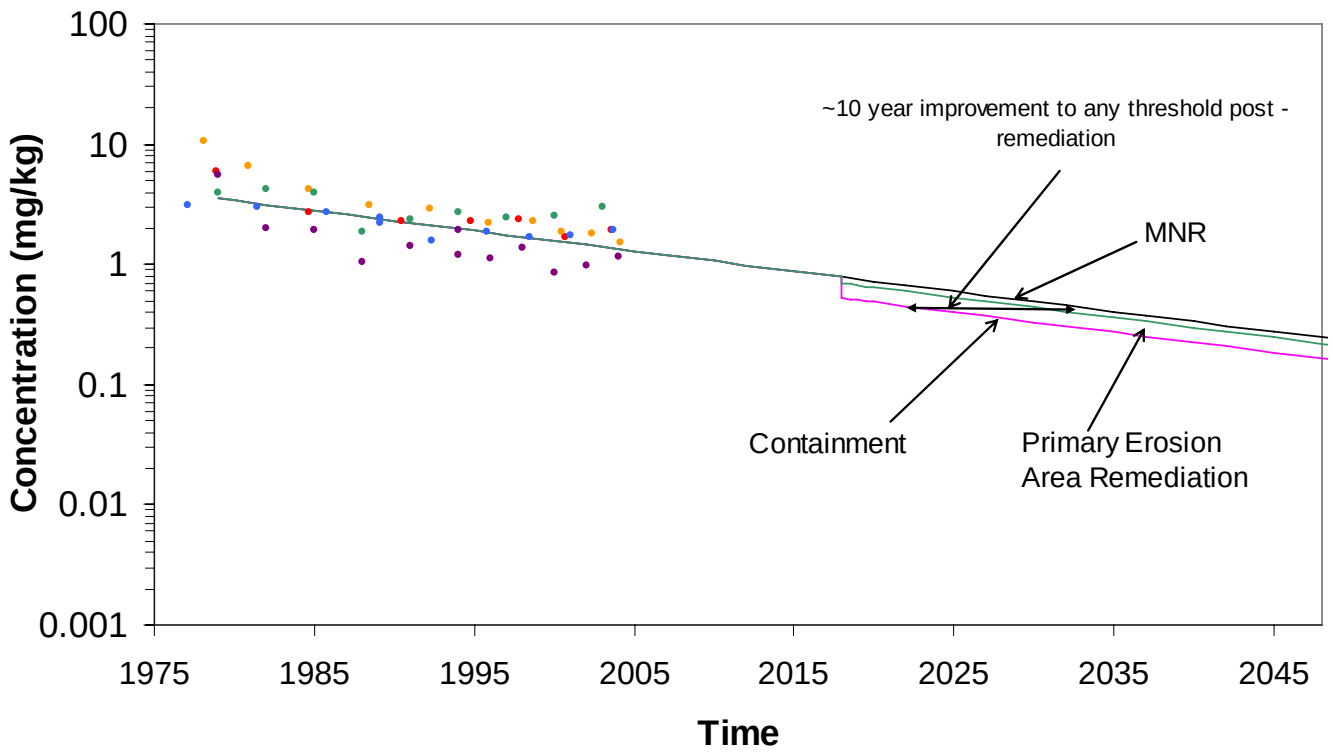
Data Source: 2005 High Resolution Cores Sampling Program collected by Malcolm Pirnie, Inc.

Total TEQ Dated Sediment Core Profile for the Lower Passaic River: Bird Scenario

Lower Passaic River Restoration Project

Figure 7-3c

June 2007



Legend

- RM1.4
- RM2.2
- RM7.8
- RM11
- RM12.6
- MNR Scenario
- Containment Scenario
- Remediation of Primary Erosional Zone Scenario

Notes

MNR trajectory follows a first-order exponential decay.

The placement of sand material between RM0 and RM8 will cover 650 acres of the 734 acres of fine-grained material.

Remediating Primary Erosional Zone will control 15 acres of the 45 acres of erosional areas between RM0 and RM15.

Assume remediation of the Primary Erosional Zone and Primary Inventory Zone together will produce the same trajectory.

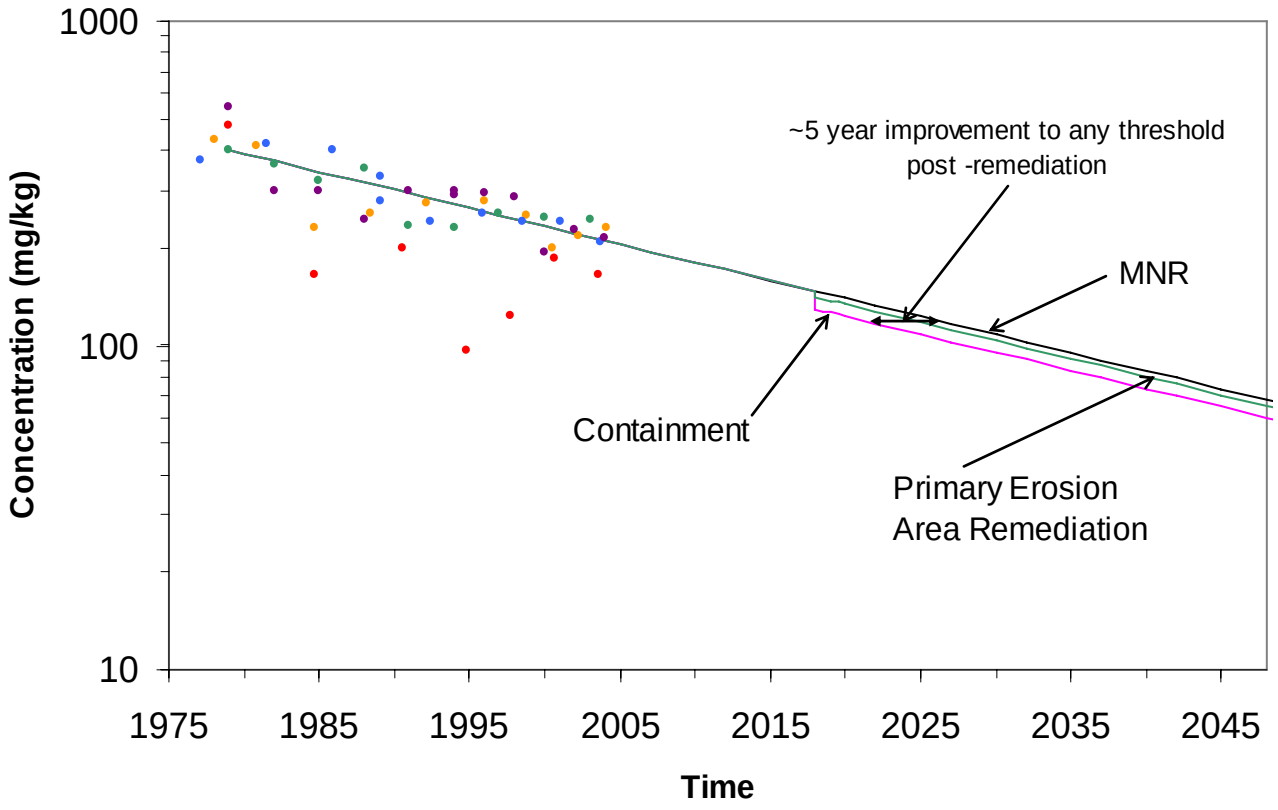
Assume remediation will be implemented in 2018.

Forecasted Surface Sediment Concentrations for Mercury

Lower Passaic River Restoration Project

Figure 7-4a

June 2007



Legend

- RM1.4
- RM2.2
- RM7.8
- RM11
- RM12.6
- MNR Scenario
- Containment Scenario
- Remediation of Primary Erosional Zone Scenario

Notes

MNR trajectory follows a first-order exponential decay.

The placement of sand material between RM0 and RM8 will cover 650 acres of the 734 acres of fine-grained material.

Remediating Primary Erosional Zone will control 15 acres of the 45 acres of erosional areas between RM0 and RM15.

Assume remediation of the Primary Erosional Zone and Primary Inventory Zone together will produce the same trajectory.

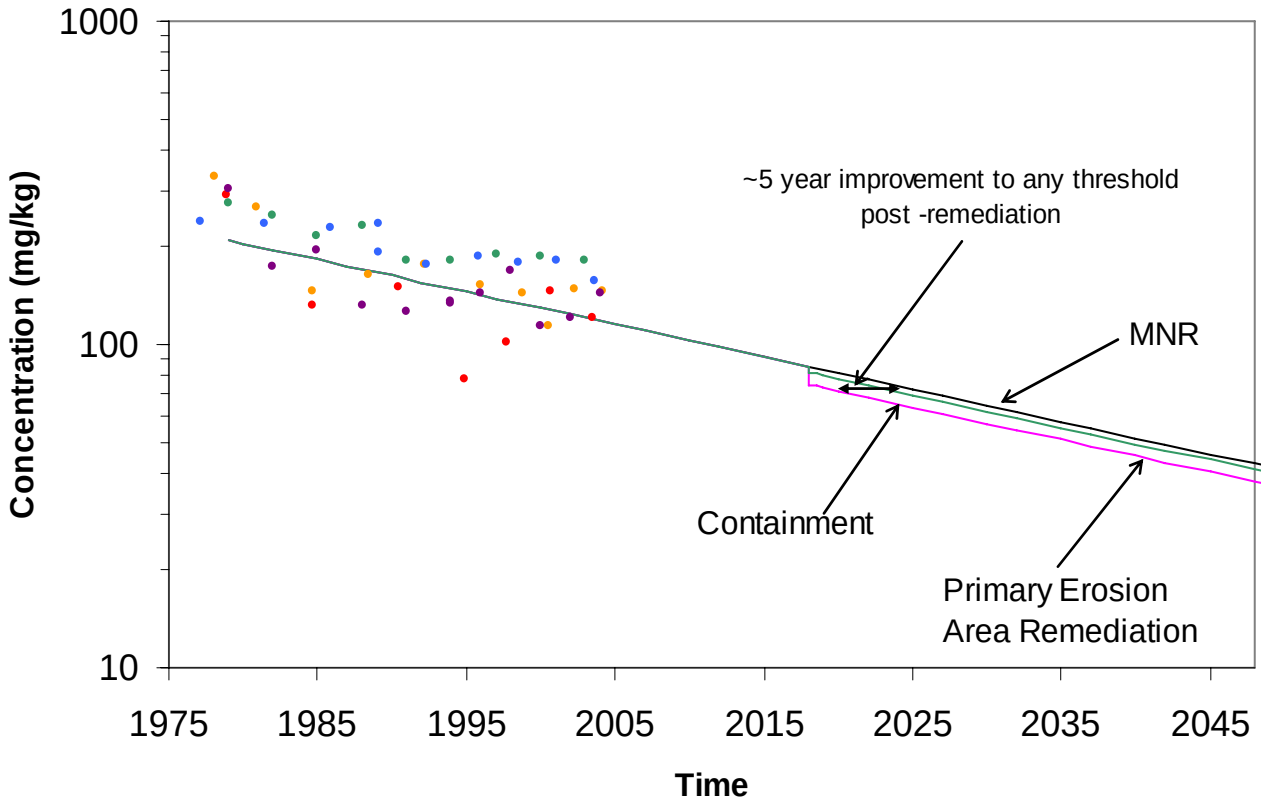
Assume remediation will be implemented in 2018.

Forecasted Surface Sediment Concentrations for Lead

Lower Passaic River Restoration Project

Figure 7-4b

June 2007



Legend

- RM1.4
- RM2.2
- RM7.8
- RM11
- RM12.6
- MNR Scenario
- Containment Scenario
- Remediation of Primary Erosional Zone Scenario

Notes

MNR trajectory follows a first-order exponential decay.

The placement of sand material between RM0 and RM8 will cover 650 acres of the 734 acres of fine-grained material.

Remediating Primary Erosional Zone will control 15 acres of the 45 acres of erosional areas between RM0 and RM15.

Assume remediation of the Primary Erosional Zone and Primary Inventory Zone together will produce the same trajectory.

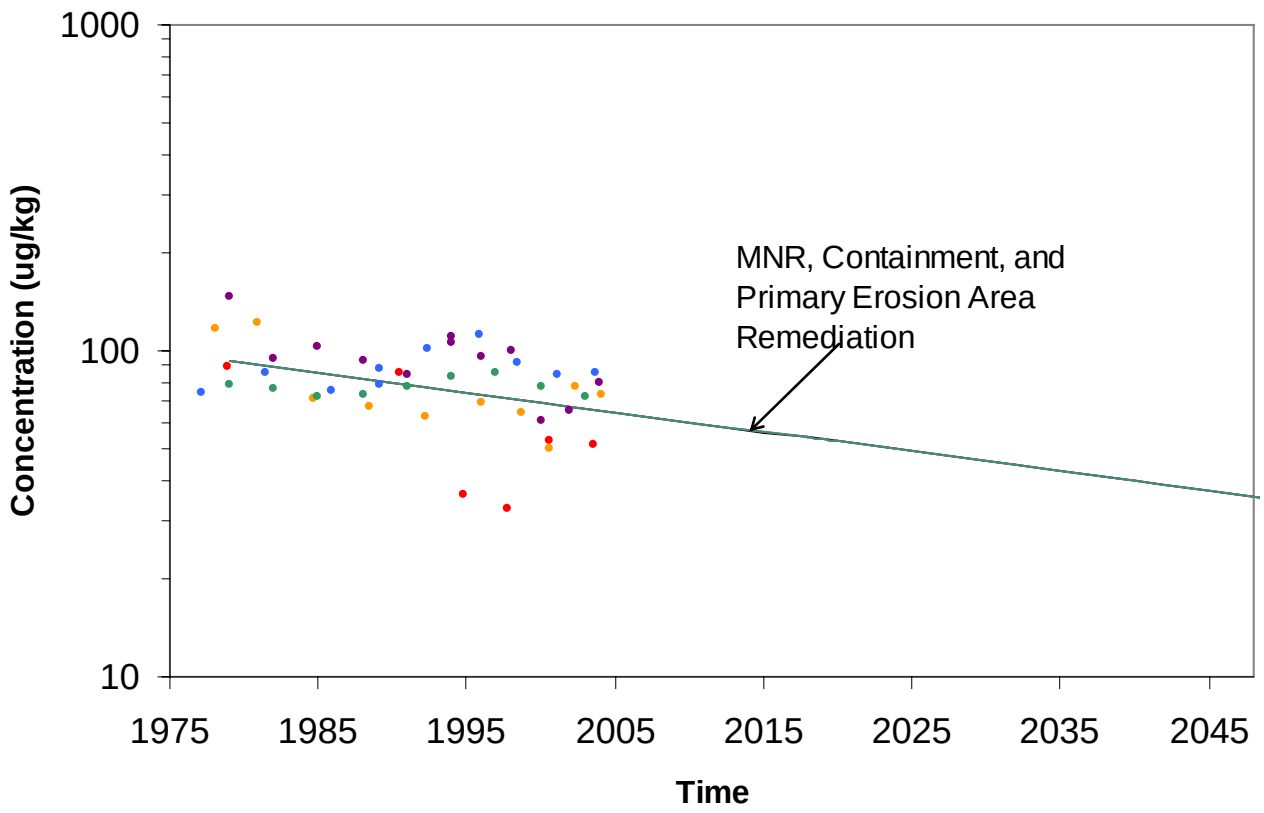
Assume remediation will be implemented in 2018.

Forecasted Surface Sediment Concentrations for Copper

Lower Passaic River Restoration Project

Figure 7-4c

June 2007



Legend

- RM1.4
- RM2.2
- RM7.8
- RM11
- RM12.6
- MNR Scenario
- Containment Scenario
- Remediation of Primary Erosional Zone Scenario

Notes

MNR trajectory follows a first-order exponential decay.

The placement of sand material between RM0 and RM8 will cover 650 acres of the 734 acres of fine-grained material.

Remediating Primary Erosional Zone will control 15 acres of the 45 acres of erosional areas between RM0 and RM15.

Assume remediation of the Primary Erosional Zone and Primary Inventory Zone together will produce the same trajectory.

Assume remediation will be implemented in 2018.

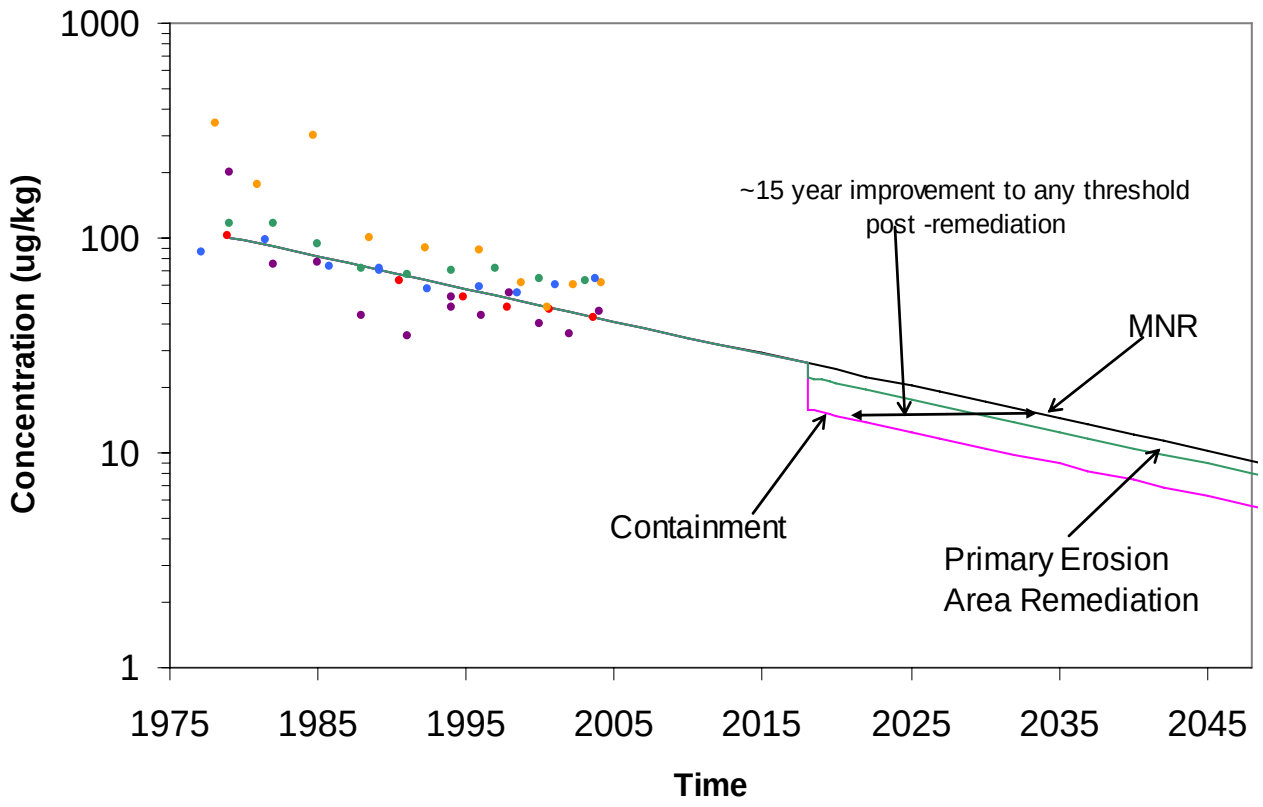
The actual calculation yielded a 0.4 percent increase in the chlordane concentration following remediation; however, considering the uncertainty of the mass balance, the trajectory reflects no change in concentration due to remediation.

Forecasted Surface Sediment Concentrations for Total Chlordane

Lower Passaic River Restoration Project

Figure 7-4d

June 2007



Legend

- RM1.4
- RM2.2
- RM7.8
- RM11
- RM12.6
- MNR Scenario
- Containment Scenario
- Remediation of Primary Erosional Zone Scenario

Notes

MNR trajectory follows a first-order exponential decay.

The placement of sand material between RM0 and RM8 will cover 650 acres of the 734 acres of fine-grained material.

Remediating Primary Erosional Zone will control 15 acres of the 45 acres of erosional areas between RM0 and RM15.

Assume remediation of the Primary Erosional Zone and Primary Inventory Zone together will produce the same trajectory.

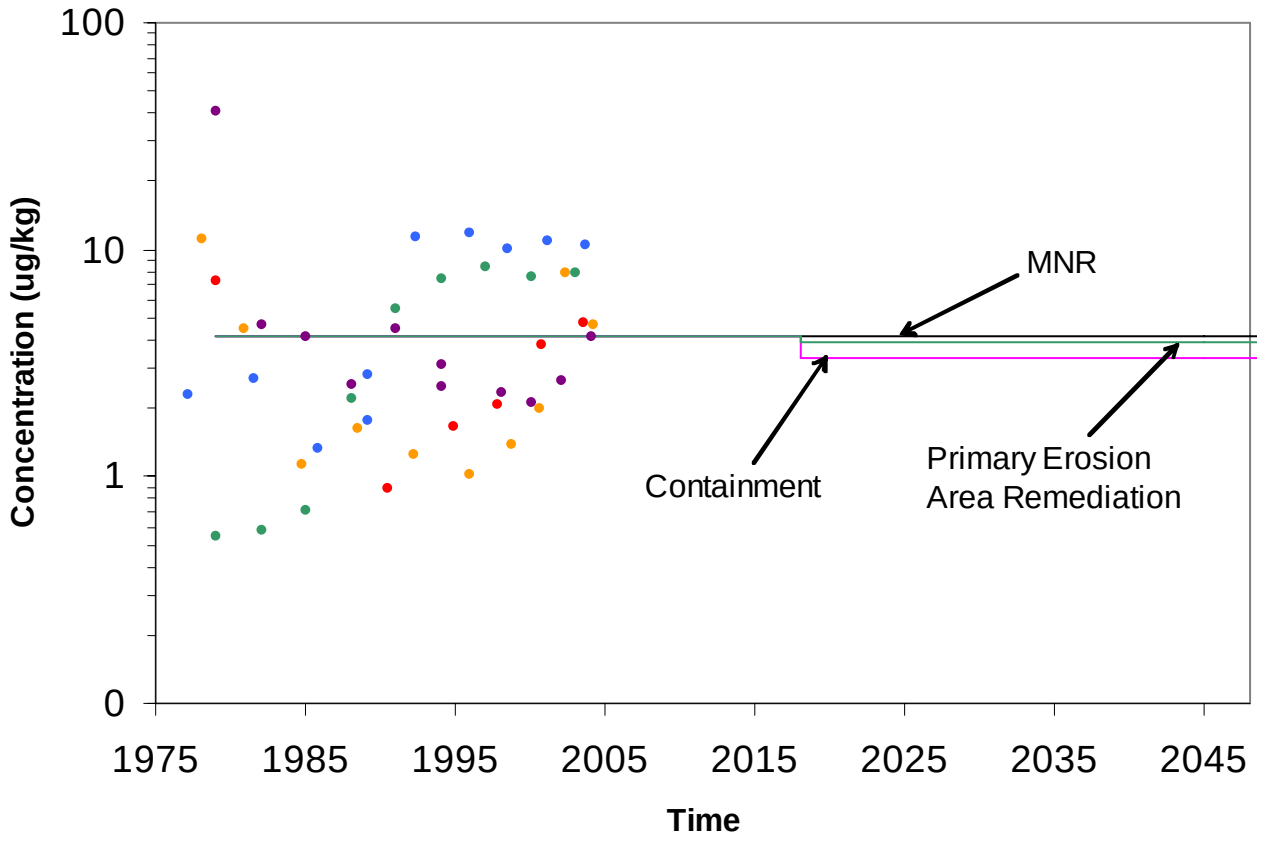
Assume remediation will be implemented in 2018.

Forecasted Surface Sediment Concentrations for 4,4'-DDE

Lower Passaic River Restoration Project

Figure 7-4e

June 2007



Legend

- RM1.4
- RM2.2
- RM7.8
- RM11
- RM12.6
- MNR Scenario
- Containment Scenario
- Remediation of Primary Erosional Zone Scenario

Notes

MNR trajectory follows a first-order exponential decay.

The placement of sand material between RM0 and RM8 will cover 650 acres of the 734 acres of fine-grained material.

Remediating Primary Erosional Zone will control 15 acres of the 45 acres of erosional areas between RM0 and RM15.

Assume remediation of the Primary Erosional Zone and Primary Inventory Zone together will produce the same trajectory.

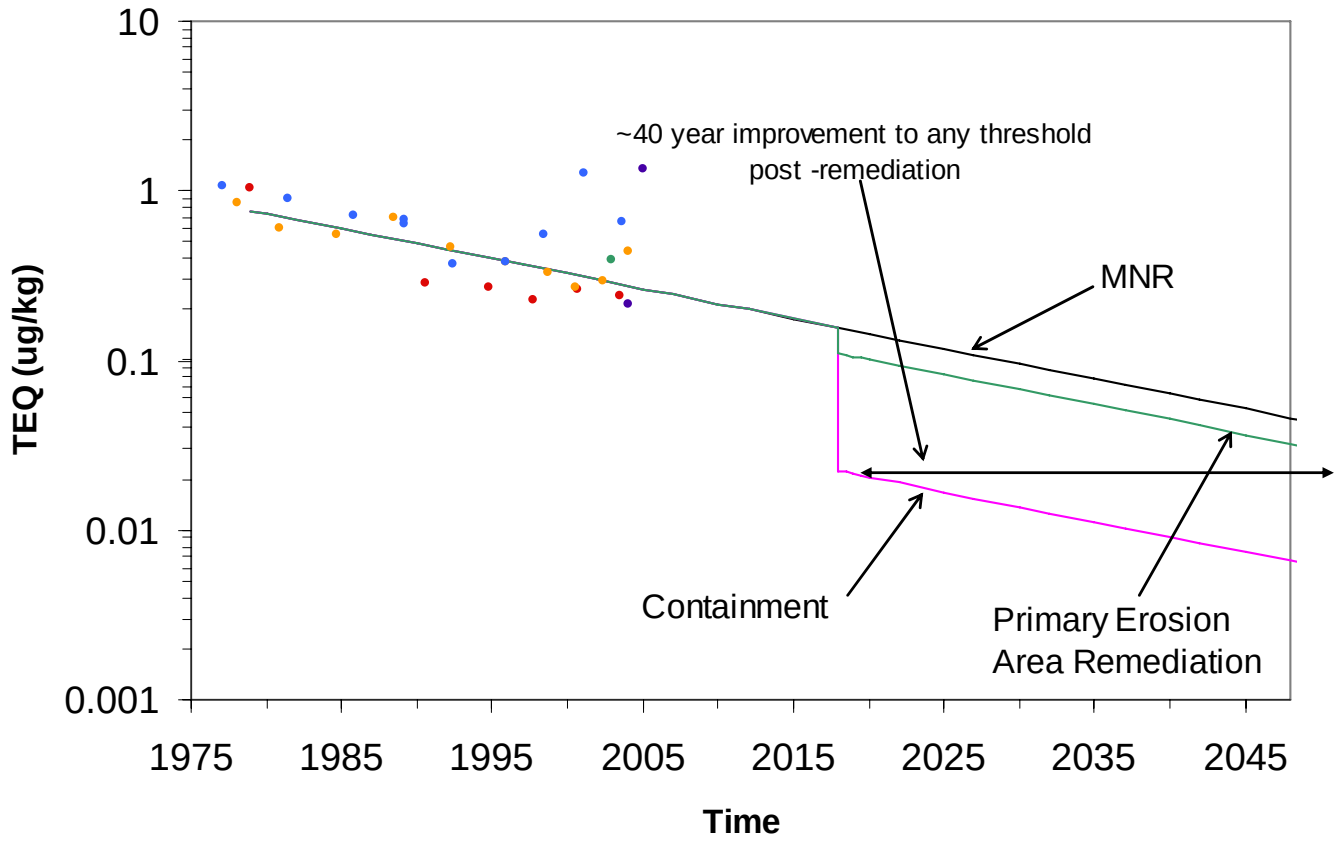
Assume remediation will be implemented in 2018.

Forecasted Surface Sediment Concentrations for Dieldrin

Lower Passaic River Restoration Project

Figure 7-4f

June 2007



Legend

- RM1.4
- RM2.2
- RM7.8
- RM11
- RM12.6
- MNR Scenario
- Containment Scenario
- Remediation of Primary Erosional Zone Scenario

Notes

MNR trajectory follows a first-order exponential decay.

The placement of sand material between RM0 and RM8 will cover 650 acres of the 734 acres of fine-grained material.

Remediating Primary Erosional Zone will control 15 acres of the 45 acres of erosional areas between RM0 and RM15.

Assume remediation of the Primary Erosional Zone and Primary Inventory Zone together will produce the same trajectory.

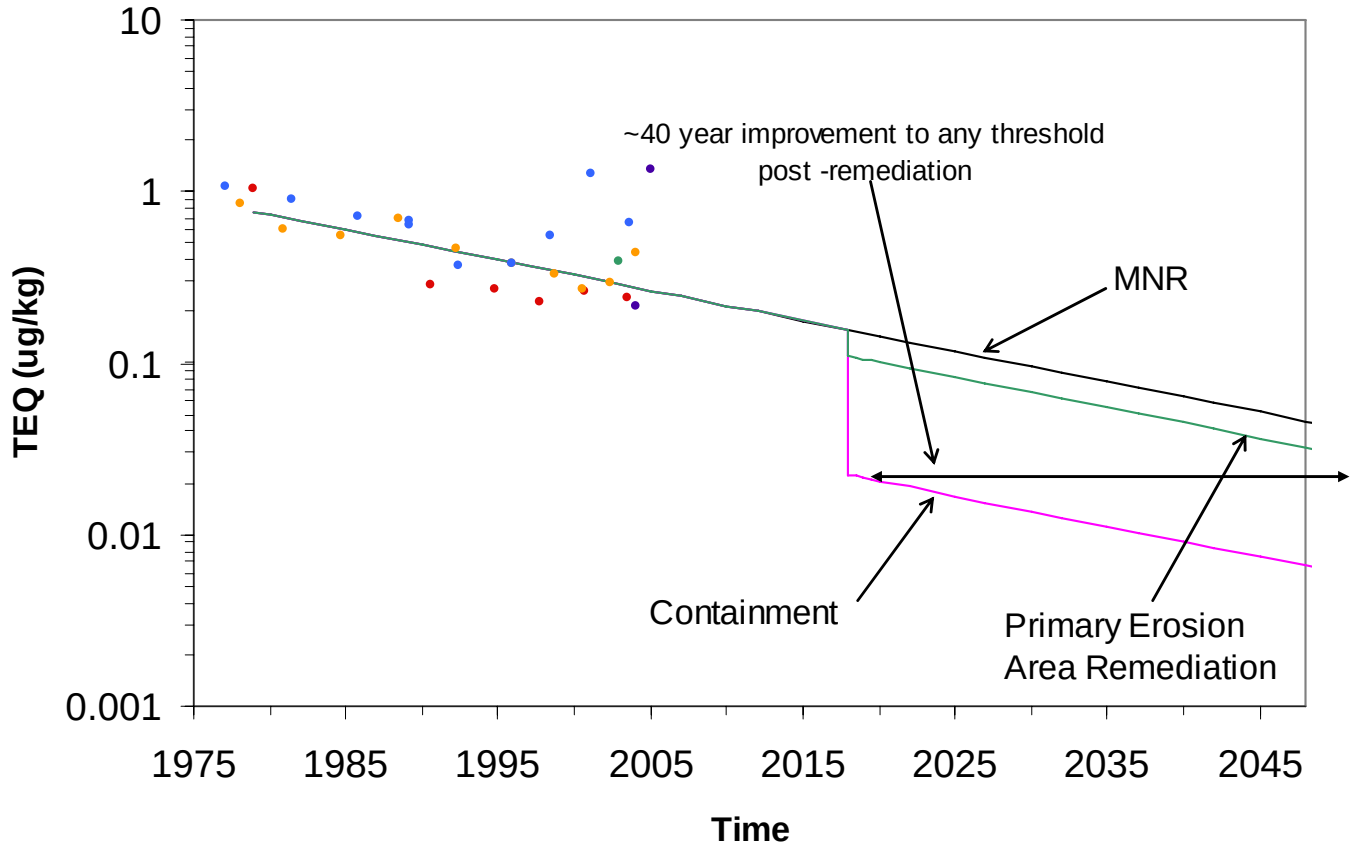
Assume remediation will be implemented in 2018.

Forecasted Surface Sediment Concentrations for 2,3,7,8-TCDD

Lower Passaic River Restoration Project

Figure 7-4g

June 2007



Legend

- RM1.4
- RM2.2
- RM7.8
- RM11
- RM12.6
- MNR Scenario
- Containment Scenario
- Remediation of Primary Erosional Zone Scenario

Notes

PCDD/F TEQ is the same for all receptors (mammal, bird, and fish).

MNR trajectory follows a first-order exponential decay.

The placement of sand material between RM0 and RM8 will cover 650 acres of the 734 acres of fine-grained material.

Remediating Primary Erosional Zone will control 15 acres of the 45 acres of erosional areas between RM0 and RM15.

Assume remediation of the Primary Erosional Zone and Primary Inventory Zone together will produce the same trajectory.

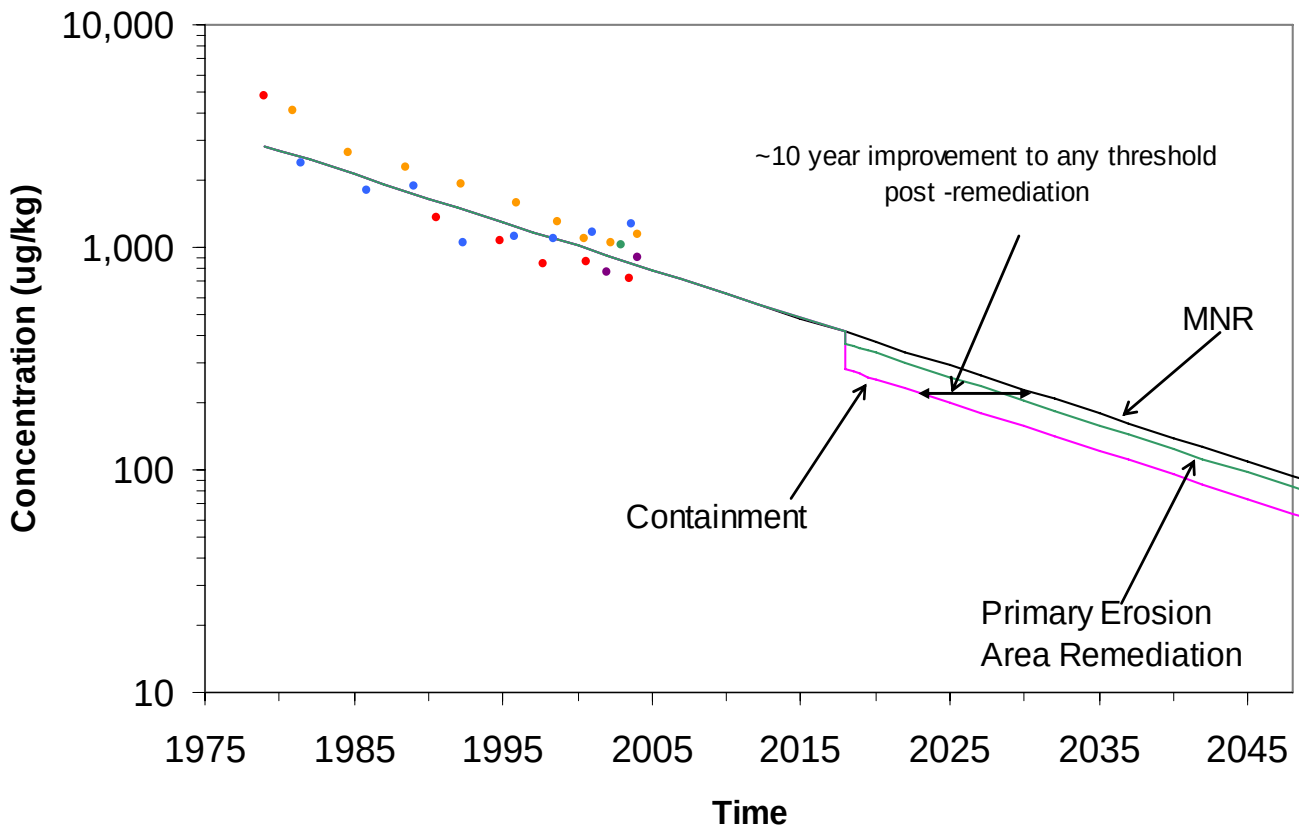
Assume remediation will be implemented in 2018.

Forecasted Surface Sediment Concentrations for PCDD/F TEQ

Lower Passaic River Restoration Project

Figure 7-4h

June 2007



Legend

- RM1.4
- RM2.2
- RM7.8
- RM11
- RM12.6
- MNR Scenario
- Containment Scenario
- Remediation of Primary Erosional Zone Scenario

Notes

MNR trajectory follows a first-order exponential decay.

The placement of sand material between RM0 and RM8 will cover 650 acres of the 734 acres of fine-grained material.

Remediating Primary Erosional Zone will control 15 acres of the 45 acres of erosional areas between RM0 and RM15.

Assume remediation of the Primary Erosional Zone and Primary Inventory Zone together will produce the same trajectory.

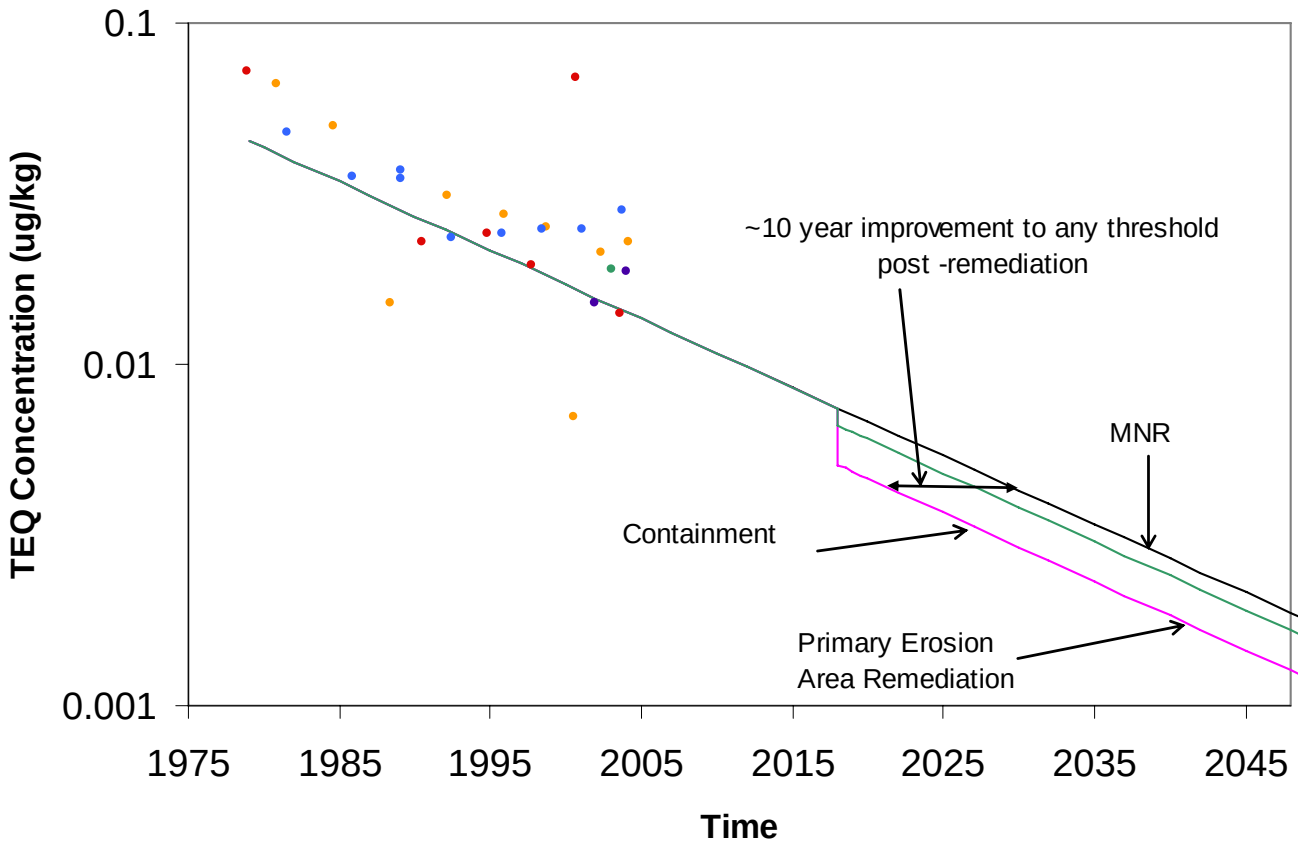
Assume remediation will be implemented in 2018.

Forecasted Surface Sediment Concentrations for Total PCB

Lower Passaic River Restoration Project

Figure 7-4i

June 2007



Legend

- RM1.4
- RM2.2
- RM7.8
- RM11
- RM12.6
- MNR Scenario
- Containment Scenario
- Remediation of Primary Erosional Zone Scenario

Notes

MNR trajectory follows a first-order exponential decay.

The placement of sand material between RM0 and RM8 will cover 650 acres of the 734 acres of fine-grained material.

Remediating Primary Erosional Zone will control 15 acres of the 45 acres of erosional areas between RM0 and RM15.

Assume remediation of the Primary Erosional Zone and Primary Inventory Zone together will produce the same trajectory.

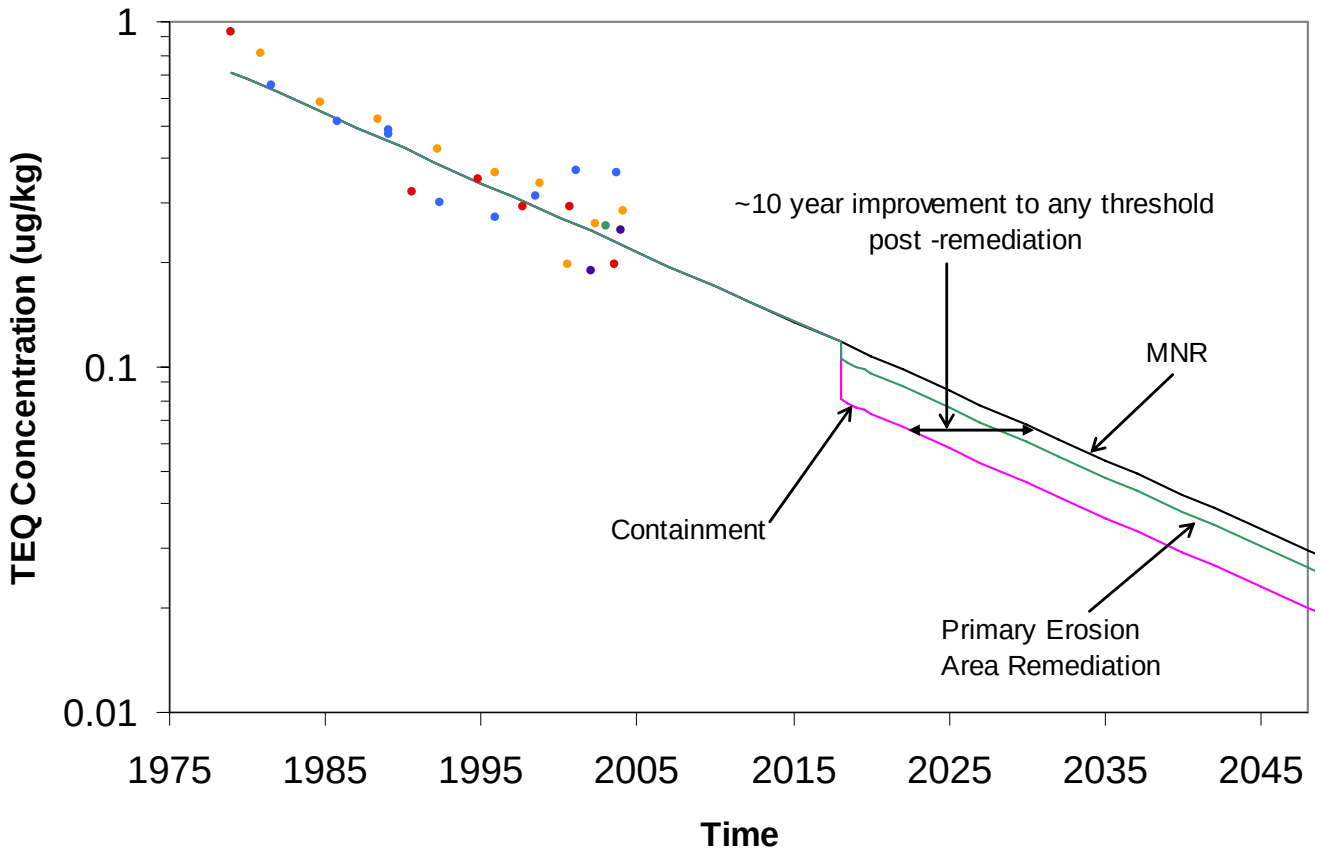
Assume remediation will be implemented in 2018.

Forecasted Surface Sediment Concentrations for PCB TEQ Mammal

Lower Passaic River Restoration Project

Figure 7-4j

June 2007



Legend

- RM1.4
- RM2.2
- RM7.8
- RM11
- RM12.6
- MNR Scenario
- Containment Scenario
- Remediation of Primary Erosional Zone Scenario

Notes

MNR trajectory follows a first-order exponential decay.

The placement of sand material between RM0 and RM8 will cover 650 acres of the 734 acres of fine-grained material.

Remediating Primary Erosional Zone will control 15 acres of the 45 acres of erosional areas between RM0 and RM15.

Assume remediation of the Primary Erosional Zone and Primary Inventory Zone together will produce the same trajectory.

Assume remediation will be implemented in 2018.

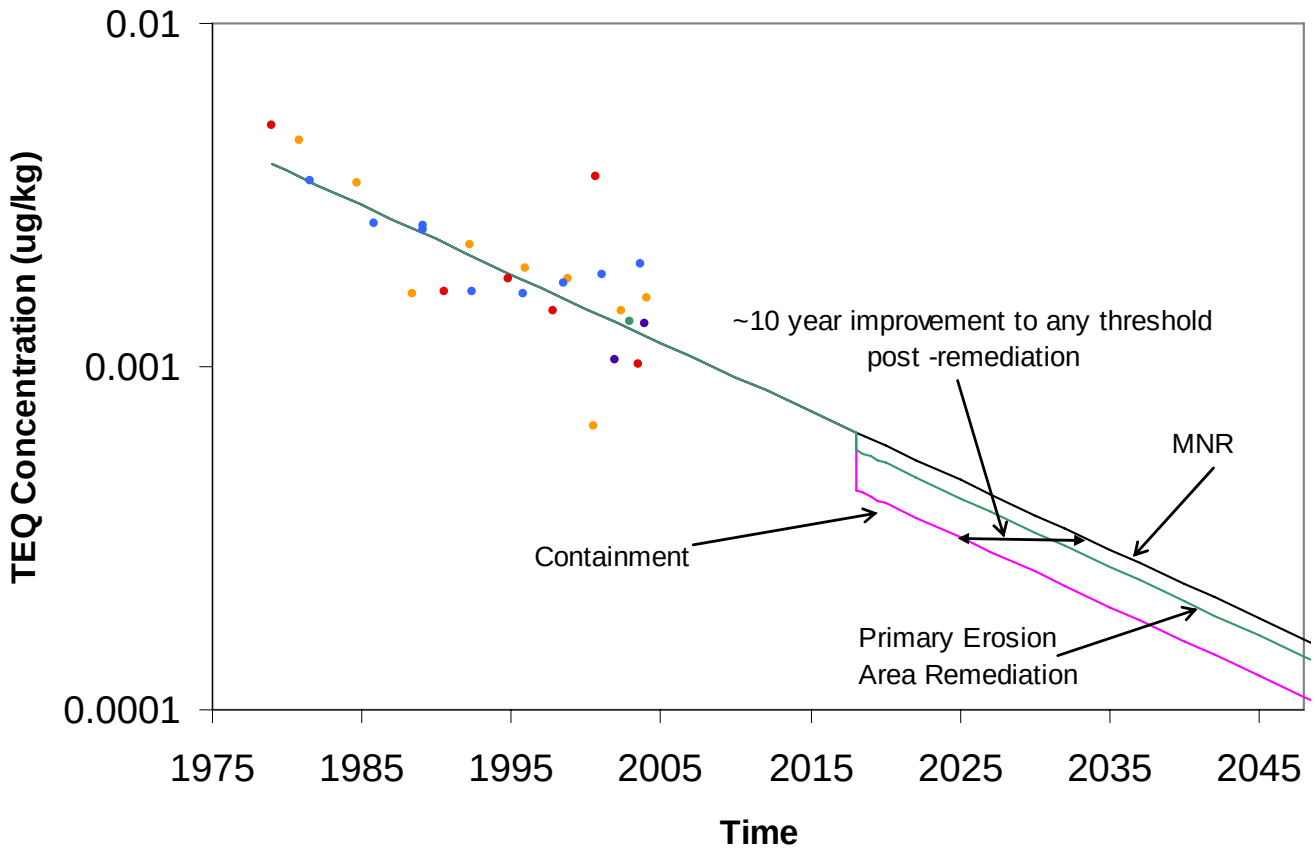
Forecasted Surface Sediment Concentrations for PCB TEQ Bird

Lower Passaic River Restoration Project

Figure 7-4k

June 2007

R2-0010200



Legend

- RM1.4
- RM2.2
- RM7.8
- RM11
- RM12.6
- MNR Scenario
- Containment Scenario
- Remediation of Primary Erosional Zone Scenario

Notes

MNR trajectory follows a first-order exponential decay.

The placement of sand material between RM0 and RM8 will cover 650 acres of the 734 acres of fine-grained material.

Remediating Primary Erosional Zone will control 15 acres of the 45 acres of erosional areas between RM0 and RM15.

Assume remediation of the Primary Erosional Zone and Primary Inventory Zone together will produce the same trajectory.

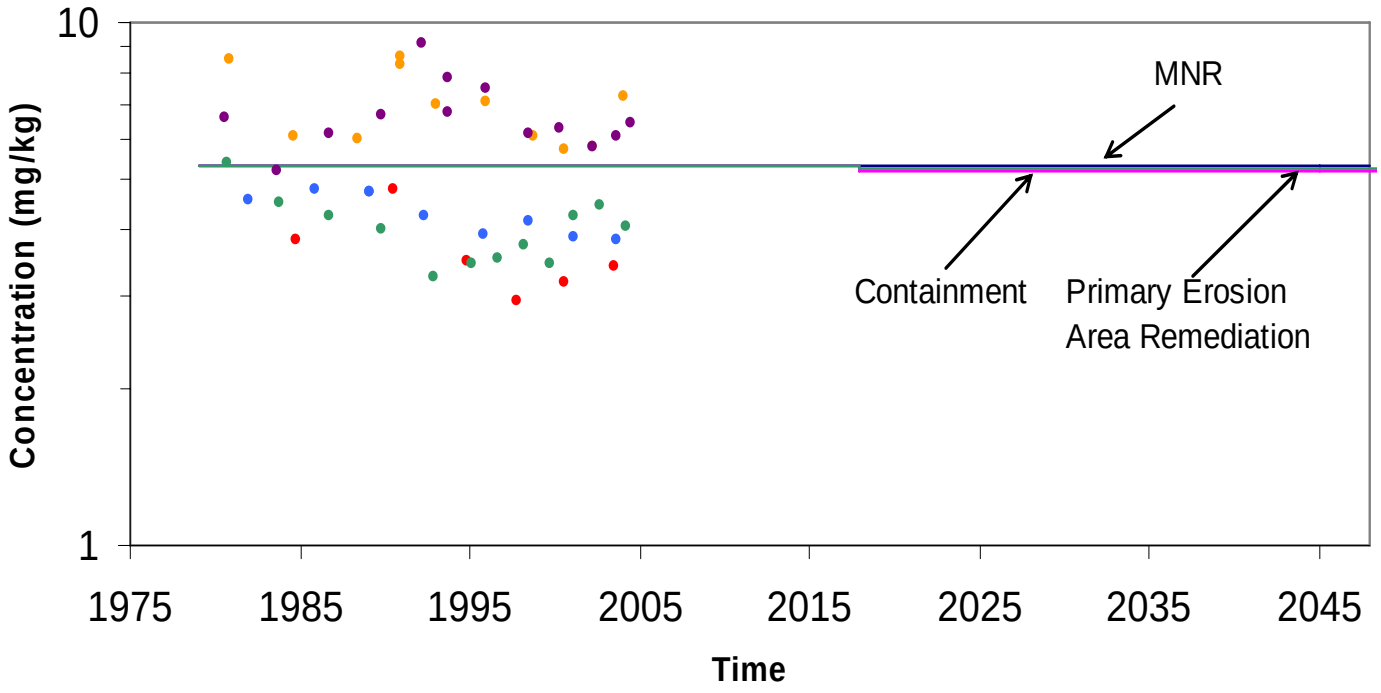
Assume remediation will be implemented in 2018.

Forecasted Surface Sediment Concentrations for PCB TEQ Fish

Lower Passaic River Restoration Project

Figure 7-4l

June 2007



Legend

- RM1.4
- RM2.2
- RM7.8
- RM11
- RM12.6
- MNR Scenario
- Containment Scenario
- Remediation of Primary Erosional Zone Scenario

Notes

LMW = Low Molecular Weight

MNR trajectory follows a first-order exponential decay.

The placement of sand material between RM0 and RM8 will cover 650 acres of the 734 acres of fine-grained material.

Remediating Primary Erosional Zone will control 15 acres of the 45 acres of erosional areas between RM0 and RM15.

Assume remediation of the Primary Erosional Zone and Primary Inventory Zone together will produce the same trajectory.

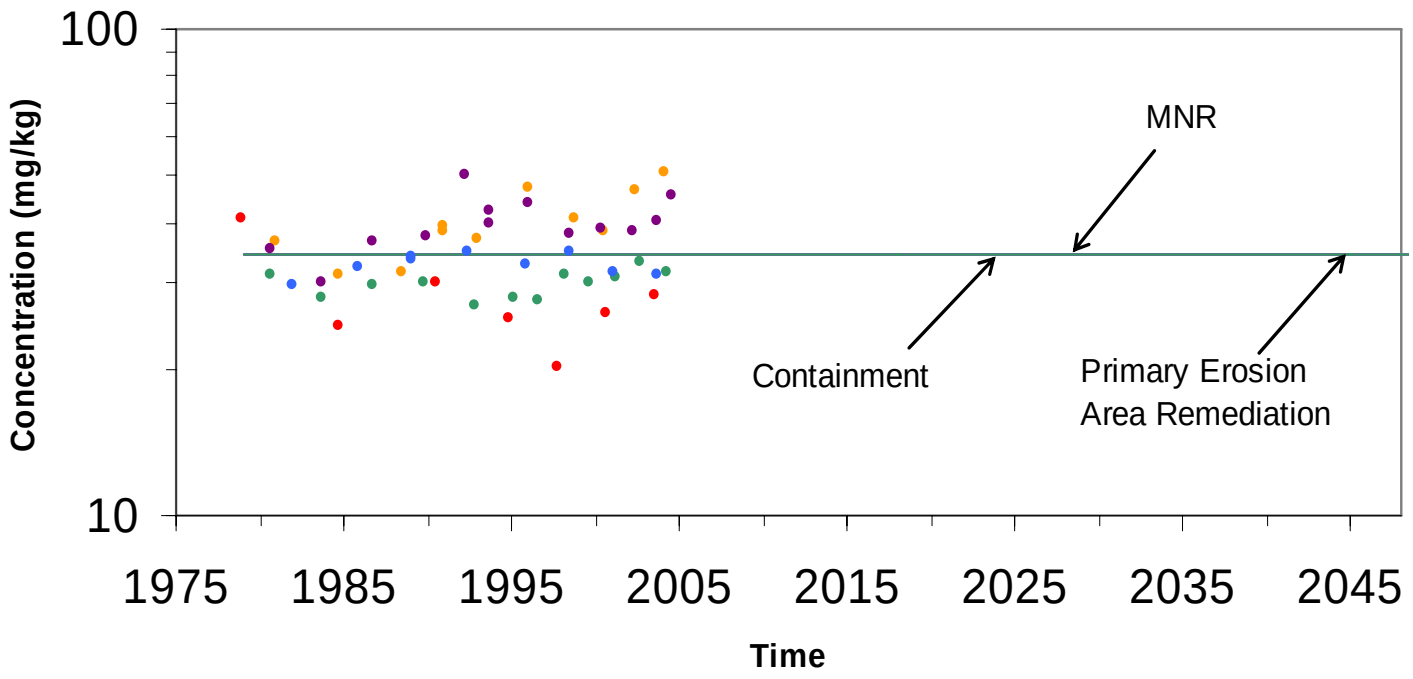
Assume remediation will be implemented in 2018.

Forecasted Surface Sediment Concentrations for LMW PAH

Lower Passaic River Restoration Project

Figure 7-4m

June 2007



Legend

- RM1.4
- RM2.2
- RM7.8
- RM11
- RM12.6
- MNR Scenario
- Containment Scenario
- Remediation of Primary Erosional Zone Scenario

Notes

HMW = High Molecular Weight

MNR trajectory follows a first-order exponential decay.

The placement of sand material between RM0 and RM8 will cover 650 acres of the 734 acres of fine-grained material.

Remediating Primary Erosional Zone will control 15 acres of the 45 acres of erosional areas between RM0 and RM15.

Assume remediation of the Primary Erosional Zone and Primary Inventory Zone together will produce the same trajectory.

Assume remediation will be implemented in 2018.

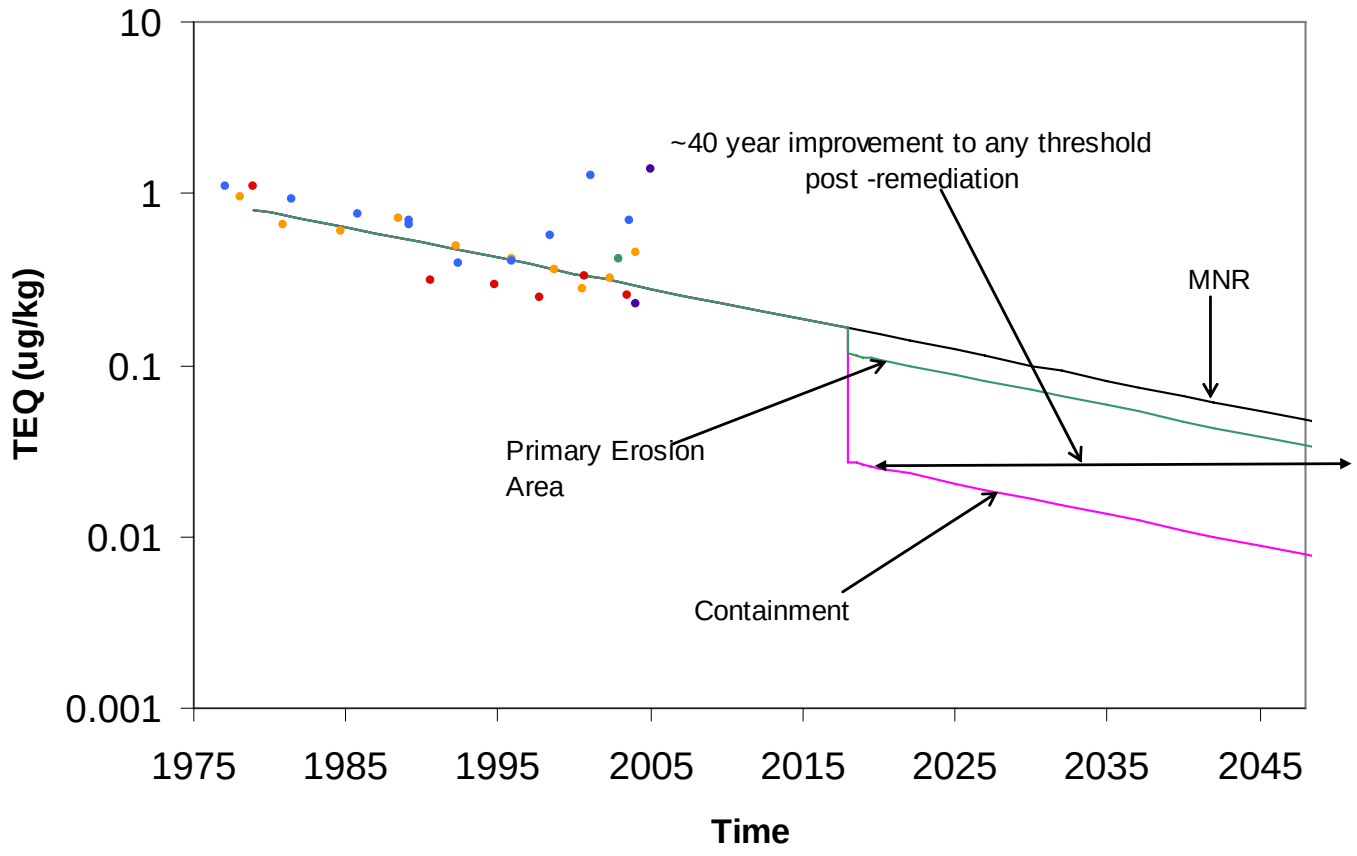
Forecasted Surface Sediment Concentrations for HMW PAH

Lower Passaic River Restoration Project

Figure 7-4n

June 2007

R2-0010203



Legend

- RM1.4
- RM2.2
- RM7.8
- RM11
- RM12.6
- MNR Scenario
- Containment Scenario
- Remediation of Primary Erosional Zone Scenario

Notes

MNR trajectory follows a first-order exponential decay.

The placement of sand material between RM0 and RM8 will cover 650 acres of the 734 acres of fine-grained material.

Remediating Primary Erosional Zone will control 15 acres of the 45 acres of erosional areas between RM0 and RM15.

Assume remediation of the Primary Erosional Zone and Primary Inventory Zone together will produce the same trajectory.

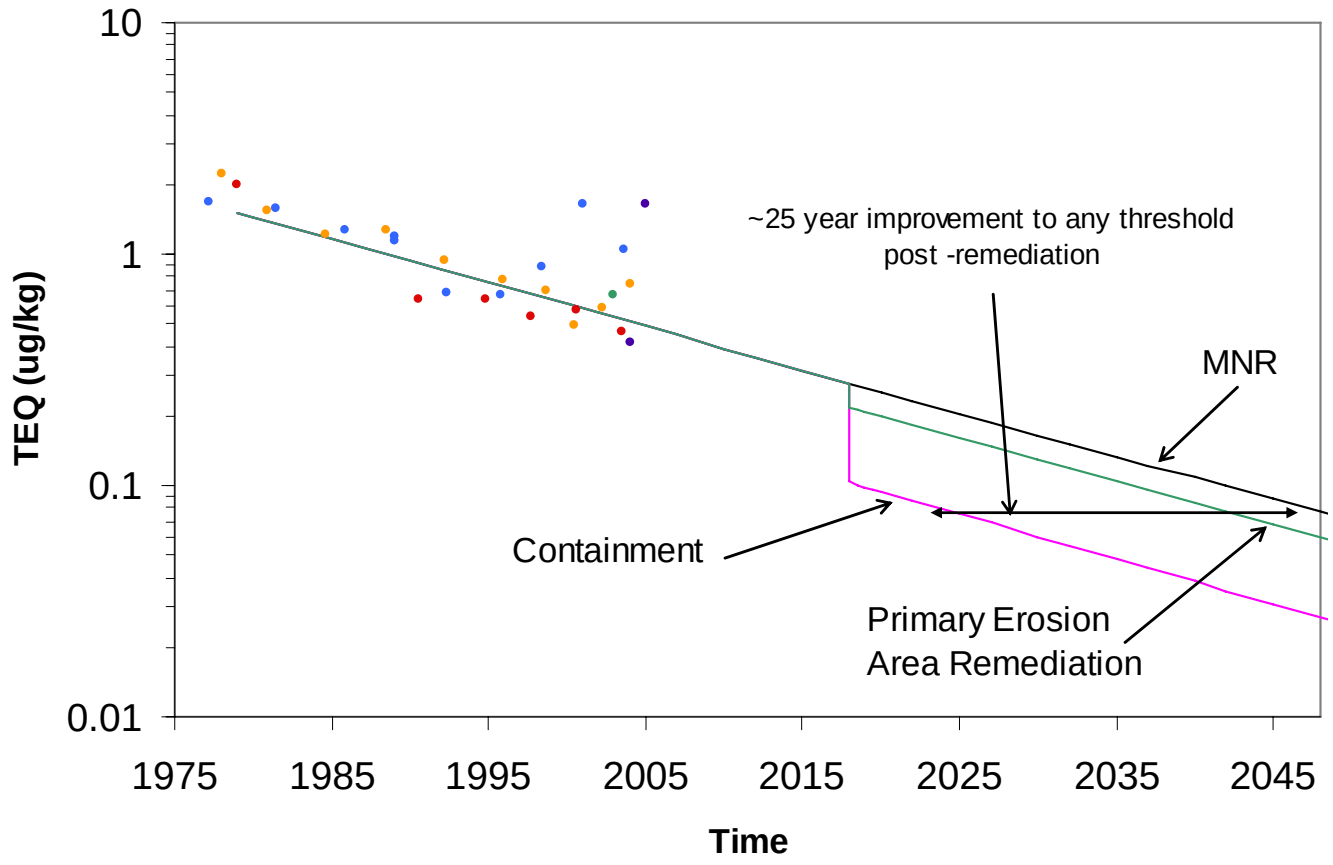
Assume remediation will be implemented in 2018.

Forecasted Surface Sediment Concentrations for Total TEQ Mammal

Lower Passaic River Restoration Project

Figure 7-4o

June 2007



Legend

- RM1.4
- RM2.2
- RM7.8
- RM11
- RM12.6
- MNR Scenario
- Containment Scenario
- Remediation of Primary Erosional Zone Scenario

Notes

MNR trajectory follows a first-order exponential decay.

The placement of sand material between RM0 and RM8 will cover 650 acres of the 734 acres of fine-grained material.

Remediating Primary Erosional Zone will control 15 acres of the 45 acres of erosional areas between RM0 and RM15.

Assume remediation of the Primary Erosional Zone and Primary Inventory Zone together will produce the same trajectory.

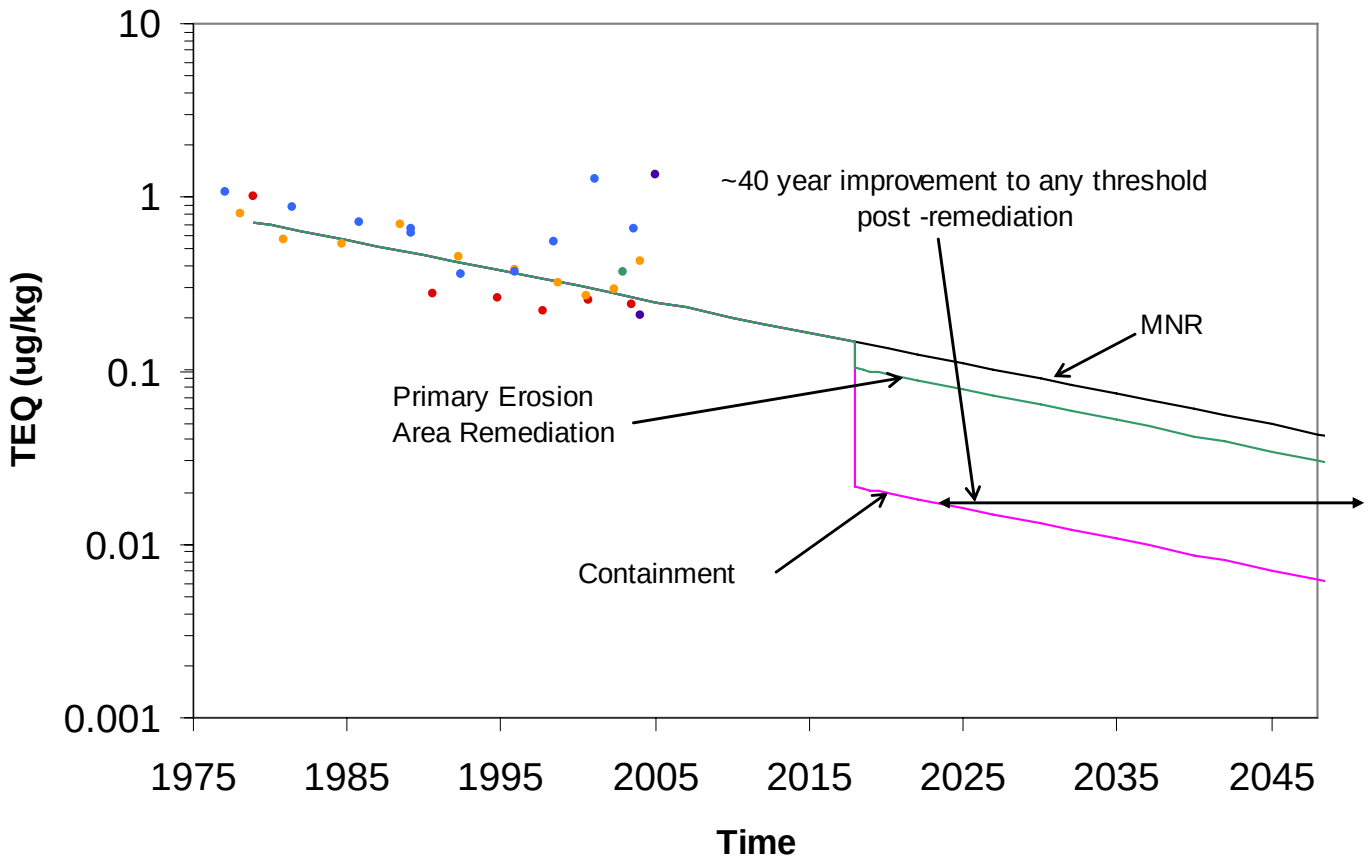
Assume remediation will be implemented in 2018.

Forecasted Surface Sediment Concentrations for Total TEQ Bird

Lower Passaic River Restoration Project

Figure 7-4p

June 2007



Legend

- RM1.4
- RM2.2
- RM7.8
- RM11
- RM12.6
- MNR Scenario
- Containment Scenario
- Remediation of Primary Erosional Zone Scenario

Notes

MNR trajectory follows a first-order exponential decay.

The placement of sand material between RM0 and RM8 will cover 650 acres of the 734 acres of fine-grained material.

Remediating Primary Erosional Zone will control 15 acres of the 45 acres of erosional areas between RM0 and RM15.

Assume remediation of the Primary Erosional Zone and Primary Inventory Zone together will produce the same trajectory.

Assume remediation will be implemented in 2018.

Forecasted Surface Sediment Concentrations for Total TEQ Fish

Lower Passaic River Restoration Project

Figure 7-4q

June 2007

Attachment A

Average Decadal Concentrations

R2-0010207

Attachment A-1
Lower Passaic River Integrated Sediment 1940s (Source: 2005 USEPA High Resolution Sediment Coring Program)

Chemical Class	Potential Modeling Parameter	Statistics (ug/kg)								
		Count	Average	Standard Deviation	Standard Error	Median	Geomean	Minimum	Maximum	Coefficient of Variation
Metals	Mercury	3	2669	2279.759	1316.22	3867		40	4100	0.854
	Lead	3	184395.8	154501.2	89201.29	264387.5		6300	282500	0.838
	Cadmium	3	1875.417	1531.233	884.058	2450		140	3036.25	0.816
Pesticides	Trans-Chlordane	2	0	0	0	0		0	0	
	DDE	2	22.95	32.4562	22.95	22.95		0	45.9	1.41
PCDD/F	2,3,7,8-TCDD	2	0.001728	0.000313	0.000222	0.001728		0.001507	0.00195	18.1
	Total TCDD	2	0.01085	0.001485	0.00105	0.01085		0.0098	0.0119	13.7
PCB Congeners	PCB Congener 31	2	0.451	0.281428	0.199	0.451		0.252	0.65	62.4
	PCB Congener 52	2	1.174317	0.149459	0.105683	1.174317		1.068633	1.28	12.7
	PCB Congener Co-Elution 61+70+74+76+66	2	1.42745	0.236951	0.16755	1.42745		1.2599	1.595	16.6
	PCB Congener Co-Elution 83+99	2	0.552967	0.038137	0.026967	0.552967		0.526	0.579933	6.90
	PCB Congener Co-Elution 90+101+113	2	0.913467	0.166123	0.117467	0.913467		0.796	1.030933	18.2
	PCB Congener Co-Elution 93+95+98+100+102	2	0.65985	0.18505	0.13085	0.65985		0.529	0.7907	28.0
	PCB Congener Co-Elution 110+115+111	2	0.890933	0.250222	0.176933	0.890933		0.714	1.067867	28.1
	PCB Congener Co-Elution 129+138+158+160+163+164	2	1.25403	0.555263	0.39263	1.25403		0.8614	1.64666	44.3
	PCB Congener Co-Elution 139+140+147+149	2	1.48782	0.061829	0.043719	1.48782		1.4441	1.531539	4.16
	PCB Congener 170	2	0.467017	0.059421	0.042017	0.467017		0.425	0.509033	12.7
	PCB Congener Co-Elution 180+193	2	6.876333	3.229592	2.283667	6.876333		4.592667	9.16	47.0
PAHs	Benz(a)anthracene	2	8923.5	3413.204	2413.5	8923.5		6510	11337	38.2
	Benzo(a)pyrene	2	6959.5	2573.162	1819.5	6959.5		5140	8779	37.0
	Chrysene	2	10760	3309.26	2340	10760		8420	13100	30.8
	Fluoranthene	2	18430	9659.079	6830	18430		11600	25260	52.4
	Indeno(1,2,3-cd)pyrene	2	3836	1210.567	856	3836		2980	4692	31.6
	Pyrene	2	17200	7778.175	5500	17200		11700	22700	45.2

Attachment A-2
Lower Passaic River Integrated Sediment 1950s (Source: 2005 USEPA High Resolution Sediment Coring Program)

Chemical Class	Potential Modeling Parameter	Statistics (ug/kg)								
		Count	Average	Standard Deviation	Standard Error	Median	Geomean	Minimum	Maximum	Coefficient of Variation
Metals	Mercury	5	6433.829	4923.904	2202.037	7966.667		25	12766.67	0.765
	Lead	5	369138.8	239641.9	107171.1	448555.6		2350	602933.3	0.649
	Cadmium	5	10322.81	7433.685	3324.445	10261.11		190	19138.89	0.720
Pesticides	Trans-Chlordane	5	16.57213	17.76898	7.946529	7.766		0.773	42.05	1.07
	DDE	5	143.8995	138.5349	61.9547	149.4		0	339.51	0.96
PCDD/F	2,3,7,8-TCDD	3	3.273667	2.112617	1.21972	4.096706		0.873403	4.850893	64.5
	Total TCDD	3	3.743824	2.454454	1.417079	4.88492		0.926553	5.42	65.6
PCB Congeners	PCB Congener 31	3	202.6468	264.9783	152.9853	73.135		27.33288	507.4725	131
	PCB Congener 52	3	205.0926	252.0279	145.5084	92.755		28.76775	493.755	123
	PCB Congener Co-Elution 61+70+74+76+66	3	526.1108	678.6704	391.8305	211.468		61.86688	1304.998	129
	PCB Congener Co-Elution 83+99	3	74.12486	79.25582	45.75837	43.726		14.56858	164.08	107
	PCB Congener Co-Elution 90+101+113	3	131.4353	145.6135	84.06999	73.373		23.8105	297.1225	111
	PCB Congener Co-Elution 93+95+98+100+102	3	110.7665	126.2586	72.89546	57.356		19.99091	254.9525	114
	PCB Congener Co-Elution 110+115+111	3	142.2659	160.7812	92.82708	72.06576		28.52185	326.21	113
	PCB Congener Co-Elution 129+138+158+160+163+164	3	122.4136	123.4738	71.28761	78.7777		26.68282	261.7803	101
	PCB Congener Co-Elution 139+140+147+149	3	84.68793	81.15333	46.8539	58.5936		19.79168	175.6785	95.8
	PCB Congener 170	3	21.87559	19.19453	11.08197	18.121		4.835763	42.67	87.7
	PCB Congener Co-Elution 180+193	3	57.07959	43.05993	24.86066	49.72		18.17376	103.345	75.4
PAHs	Benz(a)anthracene	5	3673.722	3014.275	1348.025	2576.5		11	7527	82.0
	Benzo(a)pyrene	5	3201.014	2475.946	1107.277	2436		9.96	6439	77.3
	Chrysene	5	4881.798	4037.001	1805.402	3465		15.1	10336	82.7
	Fluoranthene	5	7833.818	6287.627	2811.912	6010		22.2	14678	80.3
	Indeno(1,2,3-cd)pyrene	5	2024.707	1396.632	624.593	1925.5		8.7	3715	69.0
	Pyrene	5	7346.92	5621.017	2513.795	5875		28.6	14112	76.5

Attachment A-3
Lower Passaic River Integrated Sediment 1960s (Source: 2005 USEPA High Resolution Sediment Coring Program)

Chemical Class	Potential Modeling Parameter	Statistics (ug/kg)								
		Count	Average	Standard Deviation	Standard Error	Median	Geomean	Minimum	Maximum	Coefficient of Variation
Metals	Mercury	5	9229.389	3711.157	1659.68	11850		4900	12029.17	0.402
	Lead	5	657253.3	206722.1	92448.92	634500		459100	943833.3	0.315
	Cadmium	5	20411.33	9350.212	4181.542	20800		8800	30383.33	0.458
Pesticides	Trans-Chlordane	5	87.22529	22.35373	9.996894	92.96429		49.05	103.6167	0.256
	DDE	5	293.5881	118.6299	53.0529	366.3333		162.75	392.6667	0.404
PCDD/F	2,3,7,8-TCDD	3	6.795278	6.31301	3.644818	4.213333		2.1825	13.99	92.9
	Total TCDD	3	7.772976	6.33399	3.656931	6.08		2.4575	14.78143	81.5
PCB Congeners	PCB Congener 31	3	553.0119	339.1374	195.8011	439.75		285	934.2857	61.3
	PCB Congener 52	3	548.127	296.4691	171.1665	467		300.6667	876.7143	54.1
	PCB Congener Co-Elution 61+70+74+76+66	3	1340.397	783.1692	452.1629	1128		685.3333	2207.857	58.4
	PCB Congener Co-Elution 83+99	3	209.4722	105.0746	60.66484	167.75		131.6667	329	50.2
	PCB Congener Co-Elution 90+101+113	3	351.7183	179.1502	103.4324	280.25		219.3333	555.5714	50.9
	PCB Congener Co-Elution 93+95+98+100+102	3	294.7183	158.898	91.73981	233.75		175.3333	475.0714	53.9
	PCB Congener Co-Elution 110+115+111	3	370.2012	190.8355	110.1789	293.7813		229.419	587.4033	51.5
	PCB Congener Co-Elution 129+138+158+160+163+164	3	328.9972	162.892	94.04575	243.275		226.8667	516.85	49.5
	PCB Congener Co-Elution 139+140+147+149	3	239.2312	92.55829	53.43855	190.4925		181.2267	345.9743	38.7
	PCB Congener 170	3	58.8	23.1	13.33679	48.9		42.3	85.2	39.3
	PCB Congener Co-Elution 180+193	3	140.4516	59.98846	34.63435	114.3333		97.95	209.0714	42.7
PAHs	Benz(a)anthracene	5	4466.976	600.6034	268.598	4593.333		3530	5180.714	13.4
	Benzo(a)pyrene	5	4582.357	871.7037	389.8377	4873.333		3185	5529.286	19.0
	Chrysene	5	6422.905	1171.459	523.8926	6530		4546.667	7717.857	18.2
	Fluoranthene	5	10543.38	584.9695	261.6063	10470		10038.33	11468.57	5.55
	Indeno(1,2,3-cd)pyrene	5	3401.155	867.6562	388.0276	3721.25		2086.667	4227.857	25.5
	Pyrene	5	10495.31	1005.077	449.4842	10533.33		8991.667	11765.71	9.58

Attachment A-4
Lower Passaic River Integrated Sediment 1970s (Source: 2005 USEPA High Resolution Sediment Coring Program)

Chemical Class	Potential Modeling Parameter	Statistics (ug/kg)								
		Count	Average	Standard Deviation	Standard Error	Median	Geomean	Minimum	Maximum	Coefficient of Variation
Metals	Mercury	5	7392.667	3226.767	1443.054	6866.667		4533.333	12733.33	0.436
	Lead	5	541163.3	71601.64	32021.23	497900		492833.3	659083.3	0.132
	Cadmium	5	13581.67	4864.947	2175.671	11120		10580	22108.33	0.358
Pesticides	Trans-Chlordane	5	62.655	27.56258	12.32636	45.825		40.25	103.95	0.440
	DDE	5	257.38	173.9894	77.81041	170.075		102	468.75	0.676
PCDD/F	2,3,7,8-TCDD	3	2.261125	2.219613	1.281494	1.0735		0.888	4.821875	98.2
	Total TCDD	3	2.542542	2.278214	1.315328	1.275		1.18	5.172625	89.6
PCB Congeners	PCB Congener 31	3	255.5083	203.7517	117.6361	184		97.15	485.375	79.7
	PCB Congener 52	3	240.1333	155.9237	90.0226	199		108.9	412.5	64.9
	PCB Congener Co-Elution 61+70+74+76+66	3	475.7	227.2364	131.195	428		276.1	723	47.8
	PCB Congener Co-Elution 83+99	3	91.44167	44.48108	25.68116	75.6		57.05	141.675	48.6
	PCB Congener Co-Elution 90+101+113	3	143.85	63.54009	36.68489	129		89.05	213.5	44.2
	PCB Congener Co-Elution 93+95+98+100+102	3	130.8	61.80227	35.68155	118		76.4	198	47.2
	PCB Congener Co-Elution 110+115+111	3	153.7726	69.43728	40.08963	133.0824		97.0321	231.2032	45.2
	PCB Congener Co-Elution 129+138+158+160+163+164	3	175.7783	64.02822	36.96671	160.7		120.635	246	36.4
	PCB Congener Co-Elution 139+140+147+149	3	129.8288	46.39448	26.78587	125.65		85.665	178.1713	35.7
	PCB Congener 170	3	38.77083	10.45628	6.036936	38.8		28.3	49.2125	27.0
	PCB Congener Co-Elution 180+193	3	91.075	22.1772	12.80401	95.7		66.95	110.575	24.4
PAHs	Benz(a)anthracene	5	3581.25	1311.069	586.3278	3300		2140	5200	36.6
	Benzo(a)pyrene	5	3543	1038.772	464.5531	3190		2360	4832.5	29.3
	Chrysene	5	5038.917	1855.324	829.7259	4360		3083.333	7126.25	36.8
	Fluoranthene	5	8487.25	3671.523	1641.955	8580		4310	13206.25	43.3
	Indeno(1,2,3-cd)pyrene	5	2563.45	675.2602	301.9856	2335		1886	3596.25	26.3
	Pyrene	5	8208.833	3268.46	1461.7	7895		4436.667	12185	39.8

Attachment A-5
Lower Passaic River Integrated Sediment 1980s (Source: 2005 USEPA High Resolution Sediment Coring Program)

Chemical Class	Potential Modeling Parameter	Statistics (ug/kg)								
		Count	Average	Standard Deviation	Standard Error	Median	Geomean	Minimum	Maximum	Coefficient of Variation
Metals	Mercury	5	3231.61	967.0068	432.4586	3350		2057.143	4650	0.299
	Lead	5	316373.8	52272.19	23376.83	317142.9		241750	383000	0.165
	Cadmium	5	6310	975.4231	436.2225	6150		5025	7285.714	0.155
Pesticides	Trans-Chlordane	4	37.89167	2.27472	1.13736	37.88333		35.33333	40.46667	0.0600
	DDE	4	108.1833	57.43716	28.71858	87.43333		65.36667	192.5	0.531
PCDD/F	2,3,7,8-TCDD	2	0.562	0.129165	0.091333	0.562		0.470667	0.653333	23.0
	Total TCDD	2	0.74775	0.095813	0.06775	0.74775		0.68	0.8155	12.8
PCB Congeners	PCB Congener 31	2	80.13333	41.29504	29.2	80.13333		50.93333	109.3333	51.5
	PCB Congener 52	2	94.55833	35.74425	25.275	94.55833		69.28333	119.8333	37.8
	PCB Congener Co-Elution 61+70+74+76+66	2	210.75	52.39661	37.05	210.75		173.7	247.8	24.9
	PCB Congener Co-Elution 83+99	2	50.94167	14.55461	10.29167	50.94167		40.65	61.23333	28.6
	PCB Congener Co-Elution 90+101+113	2	79.09167	19.85792	14.04167	79.09167		65.05	93.13333	25.1
	PCB Congener Co-Elution 93+95+98+100+102	2	67.925	18.63226	13.175	67.925		54.75	81.1	27.4
	PCB Congener Co-Elution 110+115+111	2	80.42911	17.87079	12.63656	80.42911		67.79255	93.06567	22.2
	PCB Congener Co-Elution 129+138+158+160+163+164	2	99.0725	10.7822	7.624167	99.0725		91.44833	106.6967	10.9
	PCB Congener Co-Elution 139+140+147+149	2	75.68333	10.97901	7.763333	75.68333		67.92	83.44667	14.5
	PCB Congener 170	2	24.29167	1.425999	1.008333	24.29167		23.28333	25.3	5.87
	PCB Congener Co-Elution 180+193	2	57.375	2.250957	1.591667	57.375		55.78333	58.96667	3.92
PAHs	Benz(a)anthracene	5	2653.333	303.8092	135.8676	2640		2210	2983.333	11.5
	Benzo(a)pyrene	5	2944.333	229.5031	102.6369	3048.333		2620	3150	7.79
	Chrysene	5	3637	508.3093	227.3228	3851.667		2810	4030	14.0
	Fluoranthene	5	5512.333	945.1202	422.6706	5558.333		4120	6386.667	17.1
	Indeno(1,2,3-cd)pyrene	5	2201.667	239.8147	107.2484	2283.333		1830	2405	10.9
	Pyrene	5	5407	954.4227	426.8308	5521.667		4060	6293.333	17.7

Attachment A-6
Lower Passaic River Integrated Sediment 1990s (Source: 2005 USEPA High Resolution Sediment Coring Program)

Chemical Class	Potential Modeling Parameter	Statistics (ug/kg)								
		Count	Average	Standard Deviation	Standard Error	Median	Geomean	Minimum	Maximum	Coefficient of Variation
Metals	Mercury	5	1925.457	547.0703	244.6573	2022.222		1119.231	2620	0.284
	Lead	5	224216.7	44287.07	19805.78	241583.3		145288.9	250500	0.198
	Cadmium	5	3822.278	778.7752	348.2788	4195.833		2533.333	4410	0.204
Pesticides	Trans-Chlordane	5	35.42133	8.758738	3.917027	38.72		22.22	45	0.247
	DDE	5	57.80257	10.77091	4.816895	59.52		43.44286	68.35	0.186
PCDD/F	2,3,7,8-TCDD	3	0.350211	0.201991	0.11662	0.278833		0.1936	0.5782	57.7
	Total TCDD	3	0.499433	0.222523	0.128474	0.4345		0.3166	0.7472	44.6
PCB Congeners	PCB Congener 31	3	29.52222	5.414094	3.125829	26.66		26.14	35.76667	18.3
	PCB Congener 52	3	40.57111	7.841316	4.527186	38.84		33.74	49.13333	19.3
	PCB Congener Co-Elution 61+70+74+76+66	3	95.48556	10.24378	5.914247	95.1		85.44	105.9167	10.7
	PCB Congener Co-Elution 83+99	3	24.69333	5.004092	2.889114	24.02		20.06	30	20.3
	PCB Congener Co-Elution 90+101+113	3	38.17556	6.857263	3.959043	38.68		31.08	44.76667	18.0
	PCB Congener Co-Elution 93+95+98+100+102	3	33.97444	7.624213	4.401842	32.34		27.3	42.28333	22.4
	PCB Congener Co-Elution 110+115+111	3	40.06005	5.363565	3.096656	41.84968		34.03048	44.3	13.4
	PCB Congener Co-Elution 129+138+158+160+163+164	3	50.68833	6.906667	3.987566	53.254		42.866	55.945	13.6
	PCB Congener Co-Elution 139+140+147+149	3	37.38288	6.997038	4.039742	38.0476		30.0772	44.02383	18.7
	PCB Congener 170	3	12.48556	2.650439	1.530232	12.88		9.66	14.91667	21.2
	PCB Congener Co-Elution 180+193	3	30.37667	6.424923	3.709431	31.68		23.4	36.05	21.2
PAHs	Benz(a)anthracene	5	2919.197	761.904	340.7338	2518		2206	3851.429	26.1
	Benzo(a)pyrene	5	3380.508	715.2866	319.8859	3190		2630	4266.429	21.2
	Chrysene	5	4044.686	896.4251	400.8935	3896		2956	5031.429	22.2
	Fluoranthene	5	6193.083	1630.978	729.3953	5576		4626	8062.857	26.3
	Indeno(1,2,3-cd)pyrene	5	2592.327	405.1817	181.2028	2708		1938	2935.556	15.6
	Pyrene	5	5842.737	1488.893	665.853	5256		4338	7513.571	25.5

Attachment B

Length-Weighed Average Concentrations

R2-0010214

Attachment B-1

Lower Passaic River Integrated Sediment Length-Weighted Average (Source: 2005 USEPA High Resolution Sediment Coring Program)

Chemical Class	Potential Modeling Parameter	Statistics (ug/kg)								
		Count	Average	Standard Deviation	Standard Error	Median	Geomean	Minimum	Maximum	Coefficient of Variation
Metals	Mercury	5	5737.709	814.3216	364.1757	5521.685	5695.393	5009.128	7138	0.137
	Lead	5	417969.2	54832.15	24521.68	397812	415172	360407	495600	0.131
	Cadmium	5	11098.08	1906.238	852.4955	10948.72	10957.22	8199.679	13290	0.172
Pesticides	Trans-Chlordane	3	44.14515	13.35719	7.711776	45.00045	42.7269	30.38087	57.05414	0.303
	DDE	5	191.0991	30.38951	13.5906	206.9259	189.0972	154.652	223.5978	0.159
PCDD/F	2,3,7,8-TCDD	3	3.591875	1.068003	0.616612	3.349724	3.489926	2.66574	4.760163	0.297
	Total TCDD	3	4.076546	0.967152	0.558386	3.994939	4.000159	3.152783	5.081916	0.237
PCB Congeners	PCB Congener 31	3	268.2942	67.55249	39.00145	300.9561	261.9467	190.618	313.3084	0.252
	PCB Congener 52	3	268.3589	50.19558	28.98043	292.0292	264.9721	210.7048	302.3429	0.187
	PCB Congener Co-Elution 61+70+74+76+66	3	637.2664	123.3199	71.19879	680.7299	628.7225	498.0995	732.9697	0.194
	PCB Congener Co-Elution 83+99	3	105.4916	17.84367	10.30205	114.5657	104.4104	84.93455	116.9747	0.169
	PCB Congener Co-Elution 90+101+113	3	175.1206	30.60801	17.67154	189.4759	173.2024	139.9734	195.9124	0.175
	PCB Congener Co-Elution 93+95+98+100+102	3	150.0934	27.18695	15.69639	164.6868	148.3174	118.7259	166.8676	0.181
	PCB Congener Co-Elution 110+115+111	3	185.2572	35.29555	20.3779	201.8178	182.8277	144.7265	209.2273	0.191
	PCB Congener Co-Elution 129+138+158+160+163+164	3	174.4662	31.98409	18.46602	192.7493	172.3482	137.5348	193.1147	0.183
	PCB Congener Co-Elution 139+140+147+149	3	126.728	18.40913	10.62852	132.0124	125.7956	106.2545	141.917	0.145
	PCB Congener 170	3	33.24662	5.736894	3.312198	34.22878	32.90365	27.08205	38.42902	0.173
	PCB Congener Co-Elution 180+193	3	80.37013	12.28171	7.090849	86.4281	79.70332	66.23636	88.44593	0.153
PAHs	Benz(a)anthracene	5	3717.904	932.6935	417.1132	3185.136	3631.794	2930	5132.687	0.251
	Benzo(a)pyrene	5	3709.68	624.3199	279.2043	3439.05	3671.512	3213.789	4761.526	0.168
	Chrysene	5	5108.962	1129.22	505.0025	4605.837	5018.916	4153.579	6956.83	0.221
	Fluoranthene	5	8221.827	2175.035	972.7053	7009.127	8002.107	6181.158	11042.52	0.265
	Indeno(1,2,3-cd)pyrene	5	2639.88	233.9459	104.6238	2613.801	2631.889	2402.692	3014.642	0.0886
	Pyrene	5	7886.28	1767.017	790.2342	7008.756	7737.093	6171.263	10493.81	0.224

Attachment C

Lower Passaic River Surface Sediment Concentrations and Statistics

R2-0010216

Attachment C-1
Lower Passaic River (Source: 2005 USEPA High Resolution Sediment Coring Program)

Chemical Class	Potential Modeling Parameter	Statistics (ug/kg)								
		Count	Average	Standard Deviation	Standard Error	Median	Geomean	Minimum	Maximum	Coefficient of Variation
Metals	Mercury	5	1,790	510	226	1,900	1,730	1,150	2,500	0.285
	Lead	5	212,000	28,600	12,800	214,000	210,000	166,000	241,000	0.135
	Cadmium	5	3,560	575	257	3,650	3,520	2,750	4,200	0.162
Pesticides	Trans-Chlordane	5	33.2	6.23	2.78	34.1	32.7	24.5	40.1	0.188
	DDE	5	53.8	9.80	4.38	54.7	53.1	42.5	64.6	0.182
PCDD/F	2,3,7,8-TCDD	3	0.276	0.0790	0.0456	0.303	0.268	0.187	0.338	0.286
	Total TCDD	3	0.420	0.108	0.0621	0.461	0.410	0.298	0.501	0.256
PCB Congeners	PCB Congener 31	5	25.6	5.90	2.64	28.4	25.0	19.2	30.9	0.230
	PCB Congener 52	5	34.9	7.63	3.41	37.9	34.2	25.1	42.6	0.218
	PCB Congener Co-Elution 61+70+74+76+66	5	84.7	20.1	9.00	91.0	82.8	61.4	111	0.238
	PCB Congener Co-Elution 83+99	5	21.4	4.47	2.00	21.0	21.0	16.3	26.2	0.209
	PCB Congener Co-Elution 90+101+113	5	33.5	6.89	3.08	33.8	33.0	24.7	40.8	0.206
	PCB Congener Co-Elution 93+95+98+100+102	5	28.1	5.77	2.58	27.1	27.6	21.2	34.3	0.206
	PCB Congener Co-Elution 110+115+111	5	35.0	7.55	3.38	31.7	34.4	26.2	44.3	0.216
	PCB Congener Co-Elution 129+138+158+160+163+164	5	45.0	8.67	3.88	46.0	44.3	32.6	55.0	0.193
	PCB Congener Co-Elution 139+140+147+149	5	33.7	7.28	3.26	35.8	33.0	23.4	40.8	0.216
	PCB Congener 170	5	11.1	3.06	1.37	10.5	10.8	7.70	15.1	0.275
	PCB Congener Co-Elution 180+193	5	27.2	7.51	3.36	26.7	26.3	18.5	36.6	0.277
PAHs	Benz(a)anthracene	5	3,100	924	413	2,600	3,000	2,320	4,450	0.298
	Benzo(a)pyrene	5	3,640	1,060	476	3,070	3,530	2,720	5,270	0.291
	Chrysene	5	4,320	1,240	553	3,730	4,180	3,050	6,050	0.287
	Fluoranthene	5	6,450	1,810	808	5,260	6,260	5,090	8,920	0.281
	Indeno(1,2,3-cd)pyrene	5	2,850	585	262	2,590	2,800	2,210	3,680	0.205
	Pyrene	5	6,060	1,560	696	5,100	5,910	4,870	8,260	0.257

Attachment D

Newark Bay Surface Sediment Concentrations and Statistics

R2-0010218

Attachment D-1
Newark Bay Northern Samples (Source: 2005 Tierra Solutions, Inc. (TSI) Remedial Investigation Phase I dataset)

Chemical Class	Potential Modeling Parameter	Statistics (ug/kg)								
		Count	Average	Standard Deviation	Standard Error	Median	Geomean	Minimum	Maximum	Coefficient of Variation
Metals	Mercury	5	2190	814.2481	364.1428	2050	2069.851	1300	3300	0.372
	Lead	5	110820	27187.53	12158.63	102000	108307	82600	152000	0.245
	Cadmium	5	1204	909.5219	406.7505	1050	909.1666	290	2500	0.755
Pesticides	Trans-Chlordane									
	DDE	5	32.1	16.3875	7.328711	28.5	28.78165	15	55	0.511
PCDD/F	2,3,7,8-TCDD	5	0.07747	0.023425	0.010476	0.0793	0.074192	0.0426	0.10555	0.302
	Total TCDD	5	0.1646	0.019269	0.008617	0.159	0.163724	0.144	0.193	0.117
PCB Congeners	PCB Congener 31	5	21.046	9.916858	4.434954	19.25	19.05136	9.38	33.4	0.471
	PCB Congener 52	5	20.23	8.546608	3.822159	19.35	18.72281	11	29.4	0.422
	PCB Congener Co-Elution 61+70+74+76+66	5	46.373	17.33764	7.753627	42.825	43.78396	30.1	66.8	0.374
	PCB Congener Co-Elution 83+99	5	10.34769	3.881859	1.73602	10.16685	9.791003	6.54	16.1	0.375
	PCB Congener Co-Elution 90+101+113	5	19.46	7.55996	3.380917	19.7	18.29169	11.6	30.1	0.388
	PCB Congener Co-Elution 93+95+98+100+102	5	16.4535	6.639232	2.969155	18.036	15.2663	9.001	22.9305	0.404
	PCB Congener Co-Elution 110+115+111	5	21.9492	8.901147	3.980714	21.591	20.55412	12.909	35.03	0.406
	PCB Congener Co-Elution 129+138+158+160+163+164	5	17.8968	6.497875	2.905938	17.975	16.96695	11.211	27.102	0.363
	PCB Congener Co-Elution 139+140+147+149	5	15.52992	4.900346	2.191501	15.561	14.91872	10.6769	22.29	0.316
	PCB Congener 170	5	3.82	1.285768	0.575013	4.01	3.644599	2.48	5.55	0.337
	PCB Congener Co-Elution 180+193	5	11.1933	3.750073	1.677084	11.6055	10.6775	7.072	16.057	0.335
PAHs	Benz(a)anthracene	4	1315	338.477	169.2385	1325	1280.884	910	1700	0.257
	Benzo(a)pyrene	4	1687.5	347.3111	173.6555	1700	1660.105	1300	2050	0.206
	Chrysene	4	1400	348.8075	174.4037	1475	1364.269	950	1700	0.249
	Fluoranthene	4	1887.5	466.1455	233.0728	1825	1845.601	1400	2500	0.247
	Indeno(1,2,3-cd)pyrene	4	917.5	241.0221	120.5111	915	893.4405	690	1150	0.263
	Pyrene	4	2387.5	392.3752	196.1876	2400	2363.124	2000	2750	0.164

Attachment D-2
Newark Bay Southern Samples (Source: 2005 Tierra Solutions, Inc. (TSI) Remedial Investigation Phase I dataset)

Chemical Class	Potential Modeling Parameter	Statistics (ug/kg)								
		Count	Average	Standard Deviation	Standard Error	Median	Geomean	Minimum	Maximum	Coefficient of Variation
Metals	Mercury	5	926	146	65.4	980	917	750	1100	0.158
	Lead	5	77200	9440	4220	83600	76700	65600	84600	0.122
	Cadmium	5	641	500	224	490	405	45.5	1300	0.781
Pesticides	Trans-Chlordane	7	25.6	14.0	5.30	19.0	22.8	14.0	52	0.547
	DDE	5	17.9	8.03	3.59	16.0	16.5	9.50	29	0.449
PCDD/F	2,3,7,8-TCDD	4	0.0163	0.00524	0.00262	0.0185	0.0155	0.00854	0.0196	0.322
	Total TCDD	4	0.0538	0.0134	0.00668	0.0584	0.0523	0.0342	0.0642	0.248
PCB Congeners	PCB Congener 31	5	12.1	2.95	1.32	11.7	11.8	7.92	15.1	0.245
	PCB Congener 52	5	7.41	1.44	0.644	7.79	7.28	4.91	8.61	0.194
	PCB Congener Co-Elution 61+70+74+76+66	5	18.9	3.47	1.55	20.0	18.6	13.2	22.2	0.184
	PCB Congener Co-Elution 83+99	5	4.32	0.965	0.431	4.7	4.22	2.66	5.11	0.223
	PCB Congener Co-Elution 90+101+113	5	7.77	1.74	0.777	8.52	7.58	4.75	9.10	0.223
	PCB Congener Co-Elution 93+95+98+100+102	5	5.75	1.24	0.554	6.12	5.63	3.67	6.86	0.215
	PCB Congener Co-Elution 110+115+111	5	9.32	2.01	0.898	10.1	9.11	5.82	10.8	0.215
	PCB Congener Co-Elution 129+138+158+160+163+164	5	7.43	1.58	0.708	7.97	7.27	4.72	8.70	0.213
	PCB Congener Co-Elution 139+140+147+149	5	5.99	1.26	0.564	6.48	5.86	3.78	6.82	0.210
	PCB Congener 170	5	1.47	0.342	0.153	1.54	1.44	0.904	1.80	0.232
	PCB Congener Co-Elution 180+193	5	4.19	0.903	0.404	4.51	4.10	2.63	4.84	0.215
PAHs	Benz(a)anthracene	4	345	70	35	350	339	260	420	0.203
	Benzo(a)pyrene	4	395	45.1	22.5	395	393	340	450	0.114
	Chrysene	4	365	67.6	33.8	380	360	270	430	0.185
	Fluoranthene	4	508	99.1	49.6	550	499	360	570	0.195
	Indeno(1,2,3-cd)pyrene	4	308	110	55.0	285	294	200	460	0.358
	Pyrene	4	583	70.4	35.2	605	579	480	640	0.121

Attachment E

Co-Elution of PCB Congeners

R2-0010221

Table E-1: Combined Congeners/Co-eluting Congeners

IUPAC	Newark Bay BZ Number or Co-elutions	Lower Passaic River and Upper Passaic River BZ Number or Co-elutions	Combined Co-elutions Lower Passaic River, Upper Passaic River, and Newark Bay
1	1	1	1
2	2	2	2
3	3	3	3
4	4+10	4	4+10
5	5+8	5	5+8
6	6	6	6
7	7+9	7	7+9
8		8	
9		9	
10		10	
11	11	11	11
12	12+13	12+13	12+13
13			
14	14	14	14
15	15	15	15
16	16+32	16	16+32
17	17	17	17
18	18	18+30	18+30
19	19	19	19
20	20+21+33	20+28	20+21+28+33
21		21+33	
22	22	22	22
23	23	23	23
24	24+27	24	24+27
25	25	25	25
26	26	26+29	26+29
27		27	
28	28		
29	29		
30	30		
31	31	31	31
32		32	
33			
34	34	34	34
35	35	35	35
36	36	36	36

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IUPAC	Newark Bay BZ Number or Co-elutions	Lower Passaic River and Upper Passaic River BZ Number or Co-elutions	Combined Co-elutions Lower Passaic River, Upper Passaic River, and Newark Bay
37	37	37	37
38	38	38	38
39	39	39	39
40	40	40+41+71	40+41+64+71+72
41	41+64+71+72		
42	42+59	42	42+59+62+75+48
43	43+49	43	43+49+69
44	44	44+47+65	44+47+65
45	45	45+51	45+51
46	46	46	46
47	47		
48	48+75	48	
49		49+69	
50	50	50+53	50+53
51	51		51
52	52+69	52	52+69
53	53		
54	54	54	54
55	55	55	55
56	56+60	56	56+60
57	57	57	57
58	58	58	58
59		59+62+75	
60		60	
61	61+70	61+70+74+76	61+70+74+76+66
62	62		
63		63	63
64		64	
65	65		65
66		66	
67	67	67	67
68	68	68	68
69			
70			
71			
72		72	
73	73	73	73

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IUPAC	Newark Bay BZ Number or Co-elutions	Lower Passaic River and Upper Passaic River BZ Number or Co-elutions	Combined Co-elutions Lower Passaic River, Upper Passaic River, and Newark Bay
74	74		
75			
76	76+66		
77	77	77	77
78	78	78	78
79	79	79	79
80	80	80	80
81	81	81	81
82	82	82	82
83	83	83+99	83+99
84	84+92	84	84+92
85	85+116	85+116+117	85+86+87+97+108+112+116+117+119+200
86	86	86+87+97+108+119+125	
87	87+117+125		
88	88+91	88+91	88+91
89	89	89	89
90	90+101	90+101+113	90+101+113
91			
92		92	92
93	93	93+95+98+100+102	93+95+98+100+102
94	94	94	94
95	95+98+102		
96	96	96	96
97	97		
98			
99	99		
100	100		
101			
102			
103	103	103	103
104	104	104	104
105		105	105
106	106+118	106	106+118
107	107+109	107+124	107+109+124
108	108+112		
109	109	109	109
110	110	110+115	110+115+111

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IUPAC	Newark Bay BZ Number or Co-elutions	Lower Passaic River and Upper Passaic River BZ Number or Co-elutions	Combined Co-elutions Lower Passaic River, Upper Passaic River, and Newark Bay
111	111+115	111	
112		112	
113			
114	114	114	114
115			
116			
117			
118		118	118
119	119		119
120	120	120	120
121	121	121	121
122	122	122	122
123	123	123	123
124	124		
125			
126	126	126	126
127	127	127	127
128	128+162	128+166	128+162+166
129	129	129+138+160+163	129+138+158+160+163+164
130	130	130	130
131	131	131	131
132	132+161	132	132+161
133	133+142	133	133+142
134	134+143	134+143	134+143
135	135	135+151+154	135+151+154
136	136	136	136
137	137	137	137
138	138+163+164		
139	139+149	139+140	139+140+149+147
140	140		
141	141	141	141
142		142	
143			
144	144	144	144
145	145	145	145
146	146+165	146	146+165
147	147	147+149	

IUPAC	Newark Bay BZ Number or Co-elutions	Lower Passaic River and Upper Passaic River BZ Number or Co-elutions	Combined Co-elutions Lower Passaic River, Upper Passaic River, and Newark Bay
148	148	148	148
149			
150	150	150	150
151	151		
152	152	152	152
153	153	153+168	153+168
154	154		
155	155	155	155
156	156	156+157	156+157
157	157		
158	158+160	158	
159	159	159	159
160			
161		161	
162		162	
163			
164		164	
165		165	
166	166		
167	167	167	167
168	168		
169	169	169	169
170	170	170	170
171	171	171+173	171+173
172	172	172	172
173	173		
174	174	174	174
175	175	175	175
176	176	176	176
177	177	177	177
178	178	178	178
179	179	179	179
180	180	180+193	180+193
181	181	181	181
182	182+187	182	182+187
183	183	183+185	183+185
184	184	184	184
185	185		

IUPAC	Newark Bay BZ Number or Co-elutions	Lower Passaic River and Upper Passaic River BZ Number or Co-elutions	Combined Co-elutions Lower Passaic River, Upper Passaic River, and Newark Bay
186	186	186	186
187		187	
188	188	188	188
189	189	189	189
190	190	190	190
191	191	191	191
192	192	192	192
193	193		
194	194	194	194
195	195	195	195
196	196+203	196	196+203
197	197	197+200	197+200
198	198	198+199	198+199
199	199		
200	200		
201		201	201
202	202	202	202
203		203	
204	204	204	204
205	205	205	205
206	206	206	206
207	207	207	207
208	208	208	208
209	209	209	209

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Attachment F

Tributary Concentrations and Statistics

R2-0010228

Attachment F-1

Tributaries: Area-Weighted Average (Sources: 2005 USEPA SPMD Deployments and 2005 USEPA Small Volume Water Column Program)

Chemical Class	Potential Modeling Parameter	Statistics (ug/kg)								
		Count	Average	Standard Deviation	Standard Error	Median	Geomean	Minimum	Maximum	Coefficient of Variation
Metals	Mercury		1741	623				1430	3230	0.358
	Lead		235694	142314				142000	486000	0.604
	Cadmium		5159					2200	2200	
Pesticides	Trans-Chlordane		207	16.2				174	217	0.0781
	DDE		40.4	9.60				30.0	60.9	0.238
PCDD/F	2,3,7,8-TCDD		0.00157	0.000770				0.00115	0.00328	0.492
	Total TCDD		0.0892	0.0284				0.0260	0.106	0.319
PCB Congeners	PCB Congener 31		7.38	2.19				3.43	11.2	0.296
	PCB Congener 52		9.92	1.60				6.22	10.8	0.161
	PCB Congener Co-Elution 61+70+74+76+66		20.5	3.37				12.4	22.7	0.164
	PCB Congener Co-Elution 83+99		6.49	1.57				3.44	7.50	0.242
	PCB Congener Co-Elution 90+101+113		13.6	3.28				6.44	15.6	0.241
	PCB Congener Co-Elution 93+95+98+100+102		12.2	2.84				5.91	13.9	0.232
	PCB Congener Co-Elution 110+115+111		17.5	4.08				8.91	20.0	0.234
	PCB Congener Co-Elution 129+138+158+160+163+164		26.3	6.12				12.6	33.8	0.232
	PCB Congener Co-Elution 139+140+147+149		17.7	4.30				8.39	23.6	0.243
	PCB Congener 170		6.13	3.03				3.64	12.8	0.493
	PCB Congener Co-Elution 180+193		14.1	6.50				8.38	28.3	0.460
PAHs	Benz(a)anthracene		2380	516				1180	2660	0.216
	Benzo(a)pyrene		3050	205				2650	3380	0.0672
	Chrysene		5730	1290				2780	6450	0.225
	Fluoranthene		10000	1770				6580	11200	0.176
	Indeno(1,2,3-cd)pyrene		2670	488				1620	3340	0.183
	Pyrene		5240	1070				2730	6250	0.203

Attachment F-2
Saddle River (Sources: 2005 USEPA SPMD Deployments and 2005 USEPA Small Volume Water Column Program)

Chemical Class	Potential Modeling Parameter	Statistics (ug/kg)								
		Count	Average	Standard Deviation	Standard Error	Median	Geomean	Minimum	Maximum	Coefficient of Variation
Metals	Mercury	1	1430							0
	Lead	1	142000							0
	Cadmium	1	2200							0
Pesticides	Trans-Chlordane		217							0
	DDE		37.5							0
PCDD/F	2,3,7,8-TCDD		0.00124							0
	Total TCDD		0.106							0
PCB Congeners	PCB Congener 31		7.27							0
	PCB Congener 52		10.8							0
	PCB Congener Co-Elution 61+70+74+76+66		21.6							0
	PCB Congener Co-Elution 83+99		7.50							0
	PCB Congener Co-Elution 90+101+113		15.6							0
	PCB Congener Co-Elution 93+95+98+100+102		13.9							0
	PCB Congener Co-Elution 110+115+111		20.0							0
	PCB Congener Co-Elution 129+138+158+160+163+164		27.4							0
	PCB Congener Co-Elution 139+140+147+149		18.2							0
	PCB Congener 170		5.05							0
	PCB Congener Co-Elution 180+193		11.9							0
PAHs	Benz(a)anthracene		2660							0
	Benzo(a)pyrene		3050							0
	Chrysene		6450							0
	Fluoranthene		11200							0
	Indeno(1,2,3-cd)pyrene		2730							0
	Pyrene		5520							0

Attachment F-3
Second River (Sources: 2005 USEPA SPMD Deployments and 2005 USEPA Small Volume Water Column Program)

Chemical Class	Potential Modeling Parameter	Statistics (ug/kg)								
		Count	Average	Standard Deviation	Standard Error	Median	Geomean	Minimum	Maximum	Coefficient of Variation
Metals	Mercury	1	1750							0
	Lead	1	409000							0
	Cadmium	1	2200							0
Pesticides	Trans-Chlordane		194							0
	DDE		60.9							0
PCDD/F	2,3,7,8-TCDD		0.00328							0
	Total TCDD		0.0744							0
PCB Congeners	PCB Congener 31		11.2							0
	PCB Congener 52		9.46							0
	PCB Congener Co-Elution 61+70+74+76+66		22.7							0
	PCB Congener Co-Elution 83+99		4.91							0
	PCB Congener Co-Elution 90+101+113		11.6							0
	PCB Congener Co-Elution 93+95+98+100+102		10.7							0
	PCB Congener Co-Elution 110+115+111		14.4							0
	PCB Congener Co-Elution 129+138+158+160+163+164		33.8							0
	PCB Congener Co-Elution 139+140+147+149		23.6							0
	PCB Congener 170		12.8							0
	PCB Congener Co-Elution 180+193		28.3							0
PAHs	Benz(a)anthracene		2280							0
	Benzo(a)pyrene		3380							0
	Chrysene		5250							0
	Fluoranthene		8320							0
	Indeno(1,2,3-cd)pyrene		3340							0
	Pyrene		6250							0

Attachment F-4
Third River (Sources: 2005 USEPA SPMD Deployments and 2005 USEPA Small Volume Water Column Program)

Chemical Class	Potential Modeling Parameter	Statistics (ug/kg)								
		Count	Average	Standard Deviation	Standard Error	Median	Geomean	Minimum	Maximum	Coefficient of Variation
Metals	Mercury	1	3230							0
	Lead	1	486000							0
	Cadmium	1	2200							0
Pesticides	Trans-Chlordane		174							0
	DDE		30.0							0
PCDD/F	2,3,7,8-TCDD		0.00115							0
	Total TCDD		0.0260							0
PCB Congeners	PCB Congener 31		3.43							0
	PCB Congener 52		6.22							0
	PCB Congener Co-Elution 61+70+74+76+66		12.4							0
	PCB Congener Co-Elution 83+99		3.44							0
	PCB Congener Co-Elution 90+101+113		6.44							0
	PCB Congener Co-Elution 93+95+98+100+102		5.91							0
	PCB Congener Co-Elution 110+115+111		8.91							0
	PCB Congener Co-Elution 129+138+158+160+163+164		12.6							0
	PCB Congener Co-Elution 139+140+147+149		8.39							0
	PCB Congener 170		3.64							0
	PCB Congener Co-Elution 180+193		8.38							0
PAHs	Benz(a)anthracene		1180							0
	Benzo(a)pyrene		2650							0
	Chrysene		2780							0
	Fluoranthene		6580							0
	Indeno(1,2,3-cd)pyrene		1620							0
	Pyrene		2730							0

Attachment G

CSO/SWO Concentrations and Statistics

R2-0010233

Attachment G-1
CSO&SWO (Source: 2001-2004 CARP dataset)

Chemical Class	Potential Modeling Parameter	Statistics (ug/kg)								
		Count	Average	Standard Deviation	Standard Error	Median	Geomean	Minimum	Maximum	Coefficient of Variation
Metals	Mercury	18	2115.753	1404.011				62.72794	6433.877	0.664
	Lead		788269	502520.1				217210.1	2581955	0.637
	Cadmium		5159.103	3021.929				2471.17	15137.1	0.586
Pesticides	Trans-Chlordane		118.1313	81.86259				15.06613	371.8322	0.693
	DDE		63.77542	45.48051				3.572204	148.6614	0.713
PCDD/F	2,3,7,8-TCDD		0.026939	0.024708				0.000344	0.073886	0.917
	Total TCDD		0.538778	0.494164				0.006875	1.47772	0.917
PCB Congeners	PCB Congener 31		7.383109	7.691155				0.459541	28.05714	1.04
	PCB Congener 52		22.42454	20.91556				1.444347	72.76982	0.933
	PCB Congener Co-Elution 61+70+74+76+66		41.12172	39.77481				1.884475	137.3727	0.967
	PCB Congener Co-Elution 83+99		12.86596	9.499196				1.164136	32.74871	0.738
	PCB Congener Co-Elution 90+101+113		29.09137	21.55842				2.612133	73.51884	0.741
	PCB Congener Co-Elution 93+95+98+100+102		21.87565	15.10652				2.427562	53.71378	0.691
	PCB Congener Co-Elution 110+115+111		39.0811	29.66345				3.746777	97.20987	0.759
	PCB Congener Co-Elution 129+138+158+160+163+164		47.16583	41.08907				4.101269	131.413	0.871
	PCB Congener Co-Elution 139+140+147+149		26.57099	22.46836				2.591447	75.65716	0.846
	PCB Congener 170		9.980587	8.138812				0.71065	24.71992	0.815
	PCB Congener Co-Elution 180+193		23.85474	21.49133				1.524032	77.3716	0.901
PAHs	Benz(a)anthracene		6652.219	5645.053				2234.328	20060.05	0.849
	Benzo(a)pyrene		8661.538	7057.36				3047.38	25412.95	0.815
	Chrysene		12057.27	9386.215				3739.407	35098.66	0.778
	Fluoranthene		20126.95	14783.26				5509.952	53550.18	0.735
	Indeno(1,2,3-cd)pyrene		6982.374	5768.638				2117.883	19843.61	0.826
	Pyrene		17649.87	13310.94				6393.265	45962.91	0.754

Attachment G-2
CSO Suspended Solids (Source: 2001-2004 CARP dataset)

Chemical Class	Potential Modeling Parameter	Statistics (ug/kg)								
		Count	Average	Standard Deviation	Standard Error	Median	Geomean	Minimum	Maximum	Coefficient of Variation
Metals	Mercury	9	2810	1690	564	2280	2440	1150	6430	0.602
	Lead	9	646000	227000	75600	707000	596000	217000	947000	0.351
	Cadmium	9	4110	1470	488	3840	3890	2470	6840	0.357
Pesticides	Trans-Chlordane	9	164	97.8	32.6	176	139	47.7	372	0.597
	DDE	9	59.5	36.8	12.3	62.6	46.2	10.4	128	0.619
PCDD/F	2,3,7,8-TCDD	9	0.0268	0.0221	0.00666	0.0223	0.0181	0.00423	0.0692	0.825
	Total TCDD	9	0.54	0.442	0.133	0.446	0.361	0.0846	1.38	0.825
PCB Congeners	PCB Congener 31	9	7.83	8.76	2.85	5.30		1.31	28.1	1.12
	PCB Congener 52	9	22.3	20.2	6.23	15.9		2.69	71.6	0.905
	PCB Congener Co-Elution 61+70+74+76+66	9	38.8	40.1	12.4	31.0		4.93	137	1.03
	PCB Congener Co-Elution 83+99	9	11.2	6.75	1.97	10.7		1.52	24.5	0.601
	PCB Congener Co-Elution 90+101+113	9	25.7	15.5	4.27	24.5		3.84	53.9	0.602
	PCB Congener Co-Elution 93+95+98+100+102	9	19.4	10.7	2.94	18.1		5.30	41.6	0.549
	PCB Congener Co-Elution 110+115+111	9	34.6	21.1	5.63	30.8		6.51	75.8	0.610
	PCB Congener Co-Elution 129+138+158+160+163+164	9	42.0	29.6	6.00	33.1		11.6	108	0.706
	PCB Congener Co-Elution 139+140+147+149	9	29.8	21.5	4.10	20.1		11.4	75.7	0.720
	PCB Congener 170	9	11.0	8.04	1.47	6.70		4.69	24.7	0.731
	PCB Congener Co-Elution 180+193	9	27.6	23.9	4.09	15.5		9.48	77.4	0.866
PAHs	Benz(a)anthracene	9	7210	6070	2020	5930	5460	2230	20100	0.841
	Benzo(a)pyrene	9	9630	7340	2450	8520	7610	3050	25400	0.762
	Chrysene	9	13500	9350	3120	13000	11100	4850	35100	0.691
	Fluoranthene	9	23000	14200	4750	22000	19400	8720	53600	0.620
	Indeno(1,2,3-cd)pyrene	9	7770	5590	1860	7200	6220	2610	19800	0.719
	Pyrene	9	18100	11800	3930	17000	15500	7450	46000	0.650

Attachment G-3
SWO Suspended Solids (Source: 2001-2004 CARP dataset)

Chemical Class	Potential Modeling Parameter	Statistics (ug/kg)								
		Count	Average	Standard Deviation	Standard Error	Median	Geomean	Minimum	Maximum	Coefficient of Variation
Metals	Mercury	9	1420	1040		1150		63	3600	0.732
	Lead	9	931000	673000		698000		342000	2580000	0.723
	Cadmium	9	6210	4010		4430		2690	15100	0.646
Pesticides	Trans-Chlordane	8	72.5	61.9	21.9	51.1	51.7	15.1	186	0.854
	DDE	9	68.0	52.7	17.6	42.3	45.1	3.57	149	0.775
PCDD/F	2,3,7,8-TCDD	8	0.0271	0.0271	0.00902	0.0205	0.0121	0.000344	0.0739	0.999
	Total TCDD	8	0.54	0.54	0.180	0.410	0.243	0.00687	1.48	0.999
PCB Congeners	PCB Congener 31	9	6.93	6.45	2.15	5.67		0.460	20.5	0.931
	PCB Congener 52	9	22.5	21.6	7.21	18.0		1.44	73	0.960
	PCB Congener Co-Elution 61+70+74+76+66	9	43.4	39.4	13.1	35.4		1.88	117	0.907
	PCB Congener Co-Elution 83+99	9	14.5	11.6	3.87	10.8		1.16	32.7	0.801
	PCB Congener Co-Elution 90+101+113	9	32.5	26.3	8.75	25.5		2.61	73.5	0.809
	PCB Congener Co-Elution 93+95+98+100+102	9	24.3	18.5	6.17	22.8		2.43	53.7	0.761
	PCB Congener Co-Elution 110+115+111	9	43.6	36.3	12.1	31.9		3.75	97.2	0.832
	PCB Congener Co-Elution 129+138+158+160+163+164	9	52.3	50.0	16.7	35.2		4.10	131	0.955
	PCB Congener Co-Elution 139+140+147+149	9	23.3	23.4	7.81	20.0		2.59	75.0	1.00
	PCB Congener 170	9	8.96	8.23	2.74	6.33		0.71	22.8	0.919
	PCB Congener Co-Elution 180+193	9	20.1	18.7	6.25	12.8		1.52	51.0	0.934
PAHs	Benz(a)anthracene	9	6090	5180	1730	3650	4690	2410	15300	0.851
	Benzo(a)pyrene	9	7690	6760	2250	4440	5900	3080	19800	0.879
	Chrysene	9	10600	9420	3140	6080	7940	3740	28000	0.890
	Fluoranthene	9	17300	15300	5100	8770	12800	5510	49100	0.885
	Indeno(1,2,3-cd)pyrene	9	6190	5940	1980	3280	4530	2120	16800	0.960
	Pyrene	9	17200	14700	4890	9990	13200	6390	45700	0.854

Attachment H

Derivation of Equation 7-4

R2-0010237

ATTACHMENT H
DERIVATION OF EQUATION 7-4

The sediment EMBM used to construct the mass balance for the Lower Passaic River was formulated as given in Equation 2-1 as:

$$C_{Surface} = \frac{M_{RSP} + M_{UP} + M_{NB} + M_{Trib} + M_{CSO/SWO}}{S_T} \qquad \text{Equation H-1}$$

Where

$C_{Surface}$:	surface sediment concentration in the Lower Passaic River
M_{UP}:	contaminant mass delivered by the Upper Passaic River
M_{Trib}:	contaminant mass delivered by the tributaries (Saddle, Second and Third Rivers)
$M_{CSO/SWO}$:	contaminant mass delivered by CSO/SWO sites
M_{NB}:	contaminant mass delivered by Newark Bay
M_{RSP}:	contaminant mass resulting from sediment resuspension
S_T:	total solids load deposited in the Lower Passaic River

In terms of chemical concentration and solids load from each source, this can be re-written as:

$$C_{Surface} = C_{RSP}\frac{S_{RSP}}{S_T} + C_{UP}\frac{S_{UP}}{S_T} + C_{NB}\frac{S_{NB}}{S_T} + C_{Trib}\frac{S_{Trib}}{S_T} + C_{CSO/SWO}\frac{S_{CSO/SWO}}{S_T} \qquad \text{Equation H-2}$$

Where:

C_{RSP} and S_{RSP}:	chemical concentration and solids load from sediment resuspension
C_{UP} and S_{UP}:	chemical concentration and solids load from Upper Passaic River
C_{NB} and S_{NB}:	chemical concentration and solids load from Newark Bay
C_{Trib} and S_{Trib}:	chemical concentration and solids load from Tributary
$C_{CSO/SWO}$ and $S_{CSO/SWO}$:	chemical concentration and solids load from CSOs and SWOs

The CMB mass balance model in general does not predict the solids load, but rather the relative solids fraction (f) from each sources based on the following formulation:

$$C_{Surface} = C_{RSP} f_{RSP} + C_{UP} f_{UP} + C_{NB} f_{NB} + C_{Trib} f_{Trib} + C_{CSO/SWO} f_{CSO/SWO} \qquad \text{Equation H-3}$$

Where

f:	solids fraction from the various sources. Note that $\sum f = 1$.

This model infers the contribution of solids and contaminants to the surface of the Lower Passaic River and forms a basis for evaluating Monitored Natural Recovery (MNR). Thus, $C_{Surface}$ can be replaced by C_{MNR} in the above equations. However, when a particular area in the Lower Passaic River is capped, the resuspension of contaminant from that area ceases, and some adjustment

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needs to be made to account for this effect. The following derivation provides the basis for evaluating a capping scenario using the sediment EMBM formulation. This formulation estimates the surface concentration from the contaminants delivered on top of the remediated surface of the Lower Passaic River and it assumes no mixing with the cap. This is a conservative assumption because the mixing of sediments with the cleaner cap material will serve to lower the surface concentration.

Assume that *b* is the fraction of the area capped in the Lower Passaic River and let the fraction of the uncapped area be *a* = 1-*b*. Immediately after capping:

$$C_{REM} = \frac{C_{RSP} S'_{RSP}}{S'_T} + \frac{C_{UP} S_{UP}}{S'_T} + \frac{C_{NB} S_{NB}}{S'_T} + \frac{C_{Trib} S_{Trib}}{S'_T} + \frac{C_{CSO/SWO} S_{CSO/SWO}}{S'_T} \qquad \text{Equation H-4}$$

Where:

C_{REM}:	chemical concentration in surface sediment immediately after capping in the Lower Passaic River
S'_{RSP}:	solids load due to resuspension after capping
S'_T:	total solids load delivered to the Lower Passaic River after capping

Now the variables S'_{RSP} and S'_T are related to the area capped as follows:

$$S'_{RSP} = aS_{RSP} = (1-b)S_{RSP} \qquad \text{Equation H-5}$$

$$S'_T = S_T - bS_{RSP} = S_T - bS_{RSP} \cdot \frac{S_T}{S_T} = S_T(1 - bf_{RSP}) \qquad \text{Equation H-6}$$

Substituting S'_{RSP} and S'_T from equations H-5 and H-6 into H-4 and simplifying further:

$$C_{REM} = \frac{C_{RSP}(1-b)S_{RSP}}{S_T(1-bf_{RSP})} + \frac{C_{UP} S_{UP}}{S_T(1-bf_{RSP})} + \frac{C_{NB} S_{NB}}{S_T(1-bf_{RSP})} + \frac{C_{Trib} S_{Trib}}{S_T(1-bf_{RSP})} + \frac{C_{CSO/SWO} S_{CSO/SWO}}{S_T(1-bf_{RSP})}$$

$$C_{REM} = \frac{C_{RSP} f_{RSP}(1-b)}{(1-bf_{RSP})} + \frac{C_{UP} f_{UP}}{(1-bf_{RSP})} + \frac{C_{NB} f_{NB}}{(1-bf_{RSP})} + \frac{C_{Trib} f_{Trib}}{(1-bf_{RSP})} + \frac{C_{CSO/SWO} f_{CSO/SWO}}{(1-bf_{RSP})}$$

$$C_{REM} = \frac{1}{1-bf_R}\left(C_{RSP} f_{RSP} + C_{UP} f_{UP} + C_{NB} f_{NB} + C_{Trib} f_{Trib} + C_{CSO/SWO} f_{CSO/SWO}\right) - \frac{bC_{RSP} f_{RSP}}{1-bf_{RSP}}$$

$$C_{REM} = \frac{C_{MNR}}{1-bf_{RSP}} - \frac{bC_{RSP} f_{RSP}}{1-bf_{RSP}} \qquad \text{Equation H-7}$$

Equation H-7 expresses the Lower Passaic River surface concentration following capping in terms of the chemical concentrations of the Lower Passaic River surface sediments and resuspension sediment source under MNR, the fraction of solids resuspended under NMR and

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the area capped. The concentration of resuspended sediments C_{RSP} can be expressed in term of C_{MNR} though the contaminant mass fraction as follows:

$$F_{RSP} = \frac{M_{RSP}}{M_{MNR}} = \frac{C_{RSP} S_{RSP}}{C_{MNR} S_T} = \frac{C_{RSP} f_{RSP}}{C_{MNR}} \quad \Rightarrow \quad C_{RSP} f_{RSP} = C_{MNR} F_{RSP} \qquad \text{Equation H-8}$$

Where

F_{RSP}: fraction of chemical mass due to resuspension under MNR

Note the difference between F_{RSP}, which is the fraction of chemical mass due to resuspension, and f_{RSP}, which is the fraction of solid due to resuspension. Substituting equation H-8 into H-7 yields:

$$C_{REM} = \frac{C_{MNR}}{1 - bf_{RSP}} - \frac{bC_{MNR} F_{RSP}}{1 - bf_{RSP}} \qquad \text{Equation H-9}$$

Equation H-9 can be finally simplified to:

$$C_{REM} = C_{MNR} \frac{(1 - bF_{RSP})}{(1 - bf_{RSP})} \qquad \text{Equation H-10}$$

Equation H-10 is the formulation used to determine the surface concentration in the year 2018 under a capping remedy, as described in Section 7.4.2.

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Appendix E

Engineering Memoranda

Assessment of Dredge Area Containment on Pages E-2 to E-47
Slope Stability and Consolidation on Pages E-48 to E-84
Armor and Filter Design on Pages E-85 to E-104
Silt Trap Evaluation on Pages E-105 to E-111
Summary of In Situ Stabilization Case Studies on Pages E-112 to E-115

MALCOLM PIRNIE

Interoffice Correspondence

Date: April 18, 2007

To: L. Bossi (WHI)

Copy: S. Thompson (WHI), L. Warner (WHI), B. Fidler (NNJ)

From: E. Garvey (NNJ)

Re: Assessment of Dredge Area Containment

Several generally perceived benefits exist related to the containment of areas being dredged. The most prominent generally-perceived-benefit is that sediment, which is disturbed and resuspended due to the movement of the dredge head, is isolated from the free flowing portion of the river by the containment structure, thereby reducing the potential for dispersion of contaminants. This reduction in dispersion potential could also facilitate the management of dredging residuals, which would be confined within the contained dredging area rather than spread over a larger area of the river bed. In addition, if a more contaminated surface were to be exposed by removal of overlying, cleaner material, the utilization of a containment structure might reduce the interaction between the contaminated surface and the organisms present in the free flowing portion of the river. This reduction in interaction could result in lower risk and environmental impact associated with implementation of dredging operations.

Methods and equipment for containing dredge areas are relatively common. They range in cost from relatively low (*e.g.* silt curtains) to relatively high (*e.g.* sheetpile containment structures). As the total cost depends not only the equipment selected but also on the magnitude of the area to be contained, several analyses were conducted to attempt to define discrete areas where a contained dredge operation might be able to achieve the generally perceived benefits discussed above. These analyses, which use historical data from the project database, include:

- Examination of the vertical distribution of 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD) concentrations using histograms and box-and-whisker plots, including estimation of the mean and median concentration at a given depth (Figure 1 through Figure 3).
- Calculation of the length-weighted average (LWA) concentration for each coring location for Total polychlorinated biphenyls (PCB) and 2,3,7,8-TCDD.
- Examination of the spatial correlation of LWA and depth of contamination (DOC) for Total PCB and 2,3,7,8-TCDD using Thiessen Polygons (Figures 4 through Figures 7).
- Examination of the relationships for Total PCB and 2,3,7,8-TCDD among the parameters mass per unit area (MPA), LWA, and DOC (Figures 8 and 9).
- Examination of the relationships among the variables LWA, MPA, and DOC for 2,3,7,8-TCDD concentration profiles at select locations (Figure 10).

These analyses were conducted to determine if areas or layers of sediment could be identified that could be treated separately from the surrounding areas/layer. For example, were the top two feet of sediment consistently low as compared to deeper sediments, so that they could be handled differently? Alternatively, could locations be identified that had consistently higher average values (*i.e.*, LWA) such that areas of the river bottom could be identified for possible containment? The results of these analyses are presented below.

RESULTS

<u>2,3,7,8-TCDD Vertical Distribution (Figure 1 through Figure 3)</u>

- Logarithmically transformed concentrations of 2,3,7,8-TCDD show non-normal distributions. Nevertheless, sufficient numbers of samples exist to statistically support estimates of the river-wide median/mean of concentrations for each depth interval. Note that Figure 1 includes all core segments; segment depth intervals that did not exactly match the intervals plotted were included in the interval containing their mid point (*e.g.*, a core segment of 0.9-1.6 feet was included in 0.5-1.5 feet interval). Figure 3 includes only exact sediment intervals (*i.e.*, segments matching the most commonly occurring interval such as 0-0.5 feet, 0.5-1.5 feet, 1.5-2.5 feet, *etc*.).

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- Figure 2 presents the box-and-whiskers diagrams for 2,3,7,8-TCDD concentrations at various depth intervals. Concentrations vary by several orders of magnitude at each depth interval. There are no major distinctions in median concentrations for segments with midpoints between 1 foot and 5.5 feet. Median concentrations increased for the segment intervals between 6 feet and 8.5 feet relative to the shallower intervals. Note that the data suggest that most contamination lies shallower than 12 feet; however, this observation may be an artifact of the lack of core segments greater than 8 feet. The mean 2,3,7,8-TCDD concentration increased from the surface to a depth to 5.5 feet by over two orders of magnitude. However, much variability exists in concentrations at each depth interval, evident from several perspectives. For example, the central 50 percent of the distribution, or "box" in each diagram, spans more than two orders of magnitude for each interval. The mean and median deviate by greater amounts as depth increases to about 6 feet. The mean for any interval frequently falls beyond the 95th percentile of the data, due to the occurrence of a few very high values at every depth. The maximum concentration in a given core can fall at any interval. Perhaps the most disconcerting observation is the occurrence of bimodal distributions at several depths, such as 2.6 to 3.5 feet or 4.6 to 5.5 feet, where the peaks of the two centers differ by three orders of magnitude.
- On average, the top 2 to 3 feet of sediment have the lowest concentrations, but even this interval contains many segments above 1,000 picogram per gram (pg/g). [More than 25 percent of the segments with midpoints between 1 foot and 1.5 feet have values greater than 1,000 pg/g (refer to the fourth box-and-whisker diagram from the right in Figure 2).]

<u>LWA and DOC Maps (Figures 4 through 7)</u>

The previously calculated MPA values, determined as part of the *Draft Geochemical Evaluation (Step 2)* (Malcolm Pirnie, Inc., 2006), were used to simplify the calculation of LWA. LWA and DOC were examined for Total PCB and for 2,3,7,8-TCDD based on the high fraction of complete cores for Total PCB and the overall importance of 2,3,7,8-TCDD as a risk driver compared to other contaminants, respectively. Despite the

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differences in the number of complete cores, both contaminants suggest similar conclusions.

- There is a high degree of heterogeneity in LWA and DOC patterns, although perhaps less than that observed for MPA. High LWA and consistent DOC levels of Total PCB and 2,3,7,8-TCDD occur in several general areas and for several miles in some cases including: near river mile (RM)1 to RM2, RM3 to RM4, and RM6 to RM7. These areas correspond to the hot regions identified in the *Draft Geochemical Evaluation (Step 2)* (Malcolm Pirnie Inc., 2006).
- As also observed in the *Draft Geochemical Evaluation (Step 2)* (Malcolm Pirnie Inc., 2006), the DOC for Total PCB is consistently shallower than that for 2,3,7,8-TCDD and appears to be more spatially variable for Total PCB relative to 2,3,7,8-CTDD (compare Figures 5 and 7, particularly 5c and 7c). The lower degree of variation apparent in the 2,3,7,8-TCDD DOC is likely to be an artifact of the much higher frequency of incomplete cores for 2,3,7,8-TCDD. This scenario is because of the large number of cores between 5.5 and 7.5 feet in length and the effect of the extrapolation process that would tend to similarly increase the incomplete cores.

<u>MPA versus DOC (Figure 8a and Figure 9a)</u>

- The data suggest a consistent semi-logarithmic relationship between 0 foot and 6 feet (*i.e.*, log MPA = a*DOC + b) as shown by the straight-line portion of Figure 8a and Figure 9a.
- Beyond 6 feet, this relationship ends and the curve suggests little additional increase of MPA with DOC.
- The initial (0-6 feet) relationship spans two orders of magnitude for Total PCB and nearly four orders of magnitude for 2,3,7,8-TCDD. However, even over this range, the degree of MPA variability is high, at least a factor of three variation at any given DOC value.

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LWA versus DOC (Figure 8b and Figure 9b)

- Like MPA, the data suggest a consistent semi logarithmic relationship between 0 foot and 6 feet (*i.e.*, log LWA = a*DOC + b), as shown by the straight-line portion of Figure 8b and Figure 9b.
- Again like MPA, beyond 6 feet, this relationship ends and the curve suggests little additional increase of LWA with DOC. The change in LWA beyond 6 feet appears to be less than that for MPA.
- The initial (0-6 feet) relationship again spans two orders of magnitude for Total PCB and nearly four orders of magnitude for 2,3,7,8-TCDD. However, even over this range, the degree of LWA variability is high, at least a factor of three variation at any given DOC value.

LWA versus MPA (Figure 8c and Figure 9c)

These figures yielded an unexpected result, suggesting a fairly close relationship between MPA and LWA. This observation was unexpected since MPA is related to the product of LWA and depth and not simply LWA. While this observation is consistent with the observations shown in Figures 8a, 9a, 8b, and 9b, there is still much variability in the relationship (*e.g.*, the scatter in MPA at any given LWA is still a factor of three or more).

- Nearly linear relationship between logarithmically transformed data [linear regression coefficient (r^2) greater than 0.7].
- No real change in the scatter between the complete and incomplete cores.
- These results suggest the following scenario. In each core, the MPA is primarily driven by one or two highly contaminated segments, which are an order of magnitude "hotter" than the rest of the core. Thus, unless the core is very shallow, additional core segments do not affect the MPA and no relationship with depth is observed. The consistent core length combined with this condition also serves to yield LWA values that are tied to the "hottest" segments, yielding a strong relationship between LWA and MPA. This hypothesis should be further examined to see if it can explain all of the observed relationships.

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LWA versus MPA (Figure 10)

This figure examines some individual profiles to better understand the relationships observed in Figures 8 and 9. Notably:

- For complete cores, the maximum concentration can occur at any depth.
- Higher LWA and/or MPA correlate with the thickness of the interval(s) with the highest concentrations.
- Individual cores span several orders of magnitude. Note Tierra Solutions, Inc. (TSI) core identification number 234 and TSI core 284 in Figure 10a. TSI core 234 has the maximum MPA while TSI core 284 has the maximum LWA. While the differences in MPA and LWA between the cores are large, they still fall within the factor of three variability noted in Figure 9c, thus upholding the relationship previously noted.

DISCUSSION

Given the variability in the concentrations of Total PCB and 2,3,7,8-TCDD along the river and with depth, it is difficult to distinguish discrete areas where containment might yield a significant positive impact. Similarly, the LWA/MPA maps suggest only large areas where LWA is similar but generally quite high. The adjacent less contaminated small areas are typically only supported by a few cores and thus should not be singled out for different treatment based on the available data. The scatter observed in any depth interval suggests that the maximum concentration in any core can occur at any interval and thus no simple “rule of thumb” can be developed to remove sediment by layers while changing the type or degree of containment. Because there is such a wide range in concentrations vertically, a single high concentration segment can significantly skew MPA/LWA values.

The analyses above are not able to identify discrete areas where containment of dredging operations would be able to realize the generally perceived benefits. In addition, the use of dredge area containment over the entire Area of Focus is not considered feasible for the reasons described below.

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The strong currents and bidirectional flow present in the Lower Passaic River would potentially require that dredge area containment be achieved by sheetpile containment structures. The construction of these structures would cause a significant amount of resuspension, as equipment used to drive sheetpile in marine settings typically uses impact or vibratory hammers, and the availability of specific equipment capable of driving sheetpile while minimizing resuspension is unknown. In addition, the movement and positioning of the equipment will cause resuspension, especially if tugs are used in shallow areas.

The depth to which sheetpile would have to be driven would be controlled by dredging depth. In some areas, dredge depths may exceed 15 feet, and would require an associated sheetpile depth of at least 45 feet. This extensive depth requirement, as well as the high potential for both surface and subsurface debris, would likely pose a substantial challenge to the implementability of driving the sheetpile in contiguous sections. In addition, the stability of the sheetpile structure following removal of the targeted sediment contained within may require that backfill be placed up to the level of the surrounding grade prior to removal of the sheetpile.

Perhaps more importantly, the obstruction of the river flow by the containment structures would cause increased current velocities in the remaining portion of the river cross section. These increased velocities would serve to resuspend sediments at a greater rate in these areas. Similarly, the reduction of cross-sectional area available for flow due to the sheetpile walls may cause flooding impacts. Given these considerations, the magnitude of resuspension resulting from the construction and use of containment structures would almost certainly be higher than the current load of suspended solids, and could potentially be higher than the magnitude of resuspension due to dredging using best management practices.

Finally, the flow conditions present in the Lower Passaic River create daily potential for dispersion both upriver and downriver, and the implementation of dredging operations in

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this environment will cause resuspension and dispersion of highly contaminated sediment at a level greater than the existing load of suspended sediments. Longer project durations will result in a longer timeframe available for deposition of this highly contaminated sediment to occur on top of any cap or backfill material placed in areas where removal operations are complete. Therefore, completion of remedial operations in a shorter timeframe will result in a shorter period for the deposition of highly contaminated sediment on top of the cap or backfill material. The shorter period would also allow for the application of multiple cap or backfill layers to isolate any of the redeposited sediments. It is likely that construction of containment structures using sheetpile would control the critical path of implementation and substantially increase the total project duration, potentially resulting in a greater volume of highly contaminated sediment being deposited on top of cap or backfill material due simply to increased period of general dredging activities. Following completion of remedial operations, deposition on top of the cap or backfill material would be controlled by ongoing sources of suspended sediment load, which are substantially less contaminated.

CONCLUSION

Several generally perceived benefits exist related to the containment of areas being dredged. Analyses conducted to attempt to identify areas in the Lower Passaic River where these benefits could be realized during dredging operations were not able to distinguish discrete areas from their surroundings. However, the use of dredge area containment over the entire Area of Focus would likely result in negative impacts associated with the construction of dredge area containment structures.

Nevertheless, best management practices could be used to reduce resuspension and dispersion of contaminated sediments during dredging operations. Additionally, sequencing of dredging operations could be conducted to minimize the contaminant concentrations in redeposited material that will not be subsequently addressed. Specifically, dredging of areas of higher inventory (*i.e.*, deeper deposits and other areas with an associated potential for higher loss of contaminant mass) could be conducted (a) early in the project when resuspended sediments would have a greater likelihood of

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depositing in areas that will later be remediated, or (b) during seasonal lower flow conditions, when the potential for resuspension is reduced and silt curtains could potentially be used.

REFERENCE

Malcolm Pirnie, Inc., 2006. "Draft Geochemical Evaluation (Step 2)." Lower Passaic River Restoration Project. March 2006

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Figures

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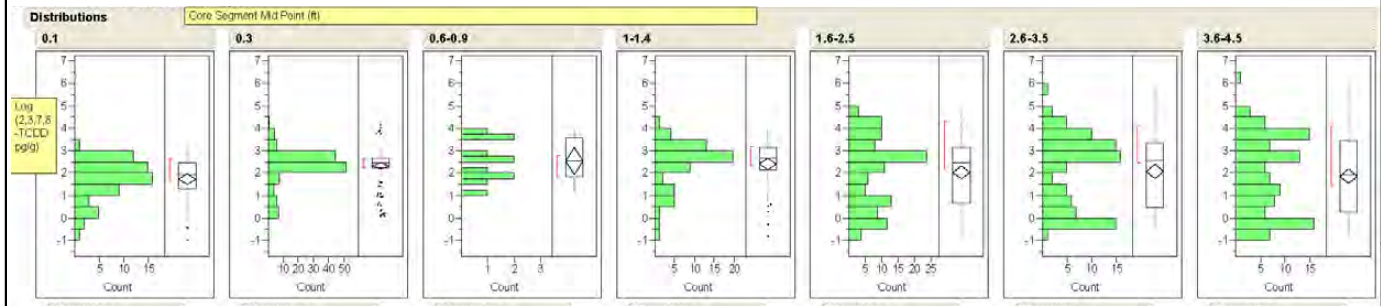

Quantiles

		0.1	0.3	0.6-0.9	1-1.4	1.6-2.5	2.6-3.5	3.6-4.5
100.0%	maximum	3.281	4.1303	3.9528	4.000	4.892	5.969	6.041
99.5%		3.281	4.1303	3.9528	4.000	4.892	5.969	6.041
97.5%		3.079	3.8416	3.9528	3.989	4.536	4.757	4.798
90.0%		2.749	2.9890	3.9019	3.485	4.086	3.865	4.016
75.0%	quartile	2.431	2.6459	3.5729	3.141	3.134	3.340	3.436
50.0%	median	1.922	2.4533	2.5315	2.651	2.435	2.579	1.943
25.0%	quartile	1.200	2.2279	1.8513	2.136	0.630	0.456	0.288
10.0%		0.341	1.0144	1.2755	0.627	-0.107	-0.256	-0.401
2.5%		-0.664	0.1260	1.2041	-0.532	-0.738	-0.478	-0.604
0.5%		-1.000	0.0414	1.2041	-0.839	-0.939	-0.569	-0.921
0.0%	minimum	-1.000	0.0414	1.2041	-0.839	-0.939	-0.569	-0.921

Moments

	0.1	0.3	0.6-0.9	1-1.4	1.6-2.5	2.6-3.5	3.6-4.5
Mean	1.7410952	2.3072882	2.5309635	2.4017102	2.0290072	2.0796321	1.8672294
Std Dev	0.8982568	0.7784742	0.9059499	1.064422	1.5415984	1.6066142	1.7173432
Std Err Mean	0.1122821	0.0672499	0.2731542	0.1351817	0.1437548	0.169352	0.1683994
upper 95% Mean	1.965473	2.440306	3.139589	2.6720228	2.3137843	2.4163309	2.2012098
lower 95% Mean	1.5167173	2.1742704	1.9223381	2.1313976	1.7442301	1.7433332	1.5332489
N	64	134	11	62	115	90	104
Sum Wgt	64	134	11	62	115	90	104
Sum	111.43009	309.17662	27.840599	148.90603	233.33583	187.18489	194.19185
Variance	0.8068652	0.6060221	0.8207453	1.1329943	2.3765255	2.581209	2.9492677
Skewness	-0.90225	-1.102253	0.2902397	-1.090321	-0.159132	-0.165182	0.0323389
Kurtosis	0.5753229	1.9549567	-1.038218	0.7607865	-1.100384	-1.071388	-1.128998
CV	51.59148	33.739792	35.794666	44.319338	75.977965	77.247302	91.972905
N Missing	732	662	785	734	681	706	692

Legend

2,3,7,8-TCDD Distribution

Notes

Data Source: JMP Version 6.0.0 “Statistical Discovery” from SAS Institute Inc.

Units are in pg/g for the concentration.

Units are in feet for the core segment mid point.

Distribution of 2,3,7,8-TCDD in All Core Segments: log basis

Lower Passaic River Restoration Project

Figure 1a

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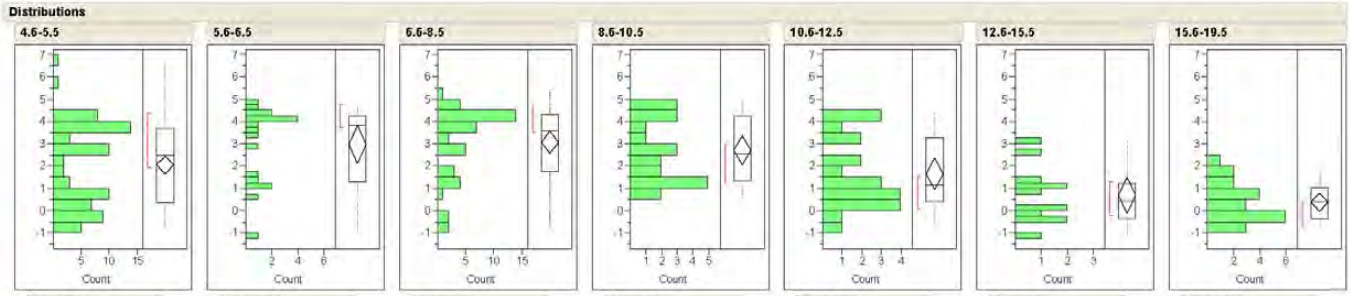


4.6-5.5

Quantiles		
100.0%	maximum	6.724
99.5%		6.724
97.5%		6.061
90.0%		4.214
75.0%	quartile	3.691
50.0%	median	2.496
25.0%	quartile	0.358
10.0%		-0.342
2.5%		-0.729
0.5%		-0.796
0.0%	minimum	-0.796

Moments	
Mean	2.0430442
Std Dev	1.8583311
Std Err Mean	0.2145816
upper 95% Mean	2.4706074
lower 95% Mean	1.6154811
N	75
Sum Wgt	75
Sum	153.22832
Variance	3.4533944
Skewness	0.1251235
Kurtosis	-1.054682
CV	90.958926
N Missing	721

5.6-6.5

Quantiles		
100.0%	maximum	4.760
99.5%		4.760
97.5%		4.760
90.0%		4.649
75.0%	quartile	4.239
50.0%	median	3.809
25.0%	quartile	1.308
10.0%		0.496
2.5%		-1.022
0.5%		-1.022
0.0%	minimum	-1.022

Moments	
Mean	2.9659854
Std Dev	1.7046792
Std Err Mean	0.4017967
upper 95% Mean	3.8137024
lower 95% Mean	2.1182684
N	18
Sum Wgt	18
Sum	53.387738
Variance	2.905931
Skewness	-0.954843
Kurtosis	0.148419
CV	57.474293
N Missing	778

6.6-8.5

Quantiles		
100.0%	maximum	5.380
99.5%		5.380
97.5%		5.309
90.0%		4.611
75.0%	quartile	4.291
50.0%	median	3.577
25.0%	quartile	1.756
10.0%		0.212
2.5%		-0.770
0.5%		-0.783
0.0%	minimum	-0.783

Moments	
Mean	3.0654932
Std Dev	1.6513885
Std Err Mean	0.2461745
upper 95% Mean	3.5616252
lower 95% Mean	2.5693612
N	45
Sum Wgt	45
Sum	137.94719
Variance	2.727084
Skewness	-0.989998
Kurtosis	-0.038216
CV	53.870239
N Missing	751

8.6-10.5

Quantiles		
100.0%	maximum	4.9894
99.5%		4.9894
97.5%		4.9894
90.0%		4.6595
75.0%	quartile	4.2545
50.0%	median	2.5173
25.0%	quartile	1.3321
10.0%		1.0136
2.5%		0.5366
0.5%		0.5366
0.0%	minimum	0.5366

Moments	
Mean	2.7043816
Std Dev	1.4154453
Std Err Mean	0.301774
upper 95% Mean	3.3319549
lower 95% Mean	2.0768083
N	22
Sum Wgt	22
Sum	59.496395
Variance	2.0034655
Skewness	0.201618
Kurtosis	-1.391716
CV	52.338966
N Missing	774

10.6-12.5

Quantiles		
100.0%	maximum	4.456
99.5%		4.456
97.5%		4.456
90.0%		4.213
75.0%	quartile	3.273
50.0%	median	1.155
25.0%	quartile	0.371
10.0%		-0.300
2.5%		-0.688
0.5%		-0.688
0.0%	minimum	-0.688

Moments	
Mean	1.6515127
Std Dev	1.5950025
Std Err Mean	0.3400557
upper 95% Mean	2.3586972
lower 95% Mean	0.9443282
N	22
Sum Wgt	22
Sum	36.33328
Variance	2.544033
Skewness	0.4867085
Kurtosis	-0.990764
CV	96.578274
N Missing	774

12.6-15.5

Quantiles		
100.0%	maximum	3.228
99.5%		3.228
97.5%		3.228
90.0%		3.073
75.0%	quartile	1.267
50.0%	median	0.442
25.0%	quartile	-0.340
10.0%		-0.933
2.5%		-1.143
0.5%		-1.143
0.0%	minimum	-1.143

Moments	
Mean	0.6924925
Std Dev	1.3078752
Std Err Mean	0.377551
upper 95% Mean	1.5234767
lower 95% Mean	-0.138492
N	12
Sum Wgt	12
Sum	8.3099097
Variance	1.7105375
Skewness	0.7237063
Kurtosis	-0.070347
CV	188.8649
N Missing	784

15.6-19.5

Quantiles		
100.0%	maximum	2.179
99.5%		2.179
97.5%		2.179
90.0%		1.672
75.0%	quartile	1.034
50.0%	median	0.390
25.0%	quartile	-0.379
10.0%		-0.715
2.5%		-0.824
0.5%		-0.824
0.0%	minimum	-0.824

Moments	
Mean	0.3746351
Std Dev	0.8772166
Std Err Mean	0.1914244
upper 95% Mean	0.7739393
lower 95% Mean	-0.024669
N	21
Sum Wgt	21
Sum	7.8673363
Variance	0.769509
Skewness	0.4081113
Kurtosis	-0.848419
CV	234.1523
N Missing	775

Legend

2,3,7,8-TCDD Distribution

Notes

Data Source: JMP Version 6.0.0 "Statistical Discovery" from SAS Institute Inc.

Units are in pg/g for the concentration.

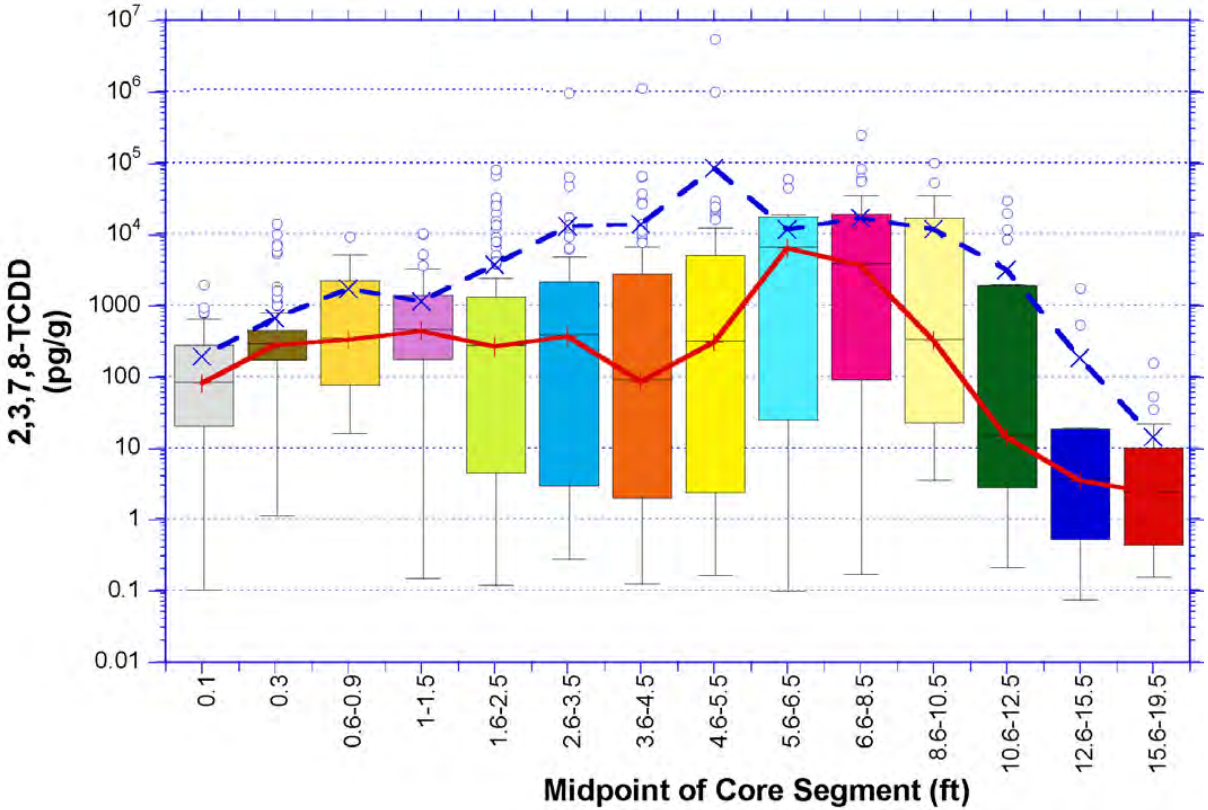
Units are in feet for the core segment mid point.

Distribution of 2,3,7,8-TCDD in All Core Segments: log basis

Lower Passaic River Restoration Project

Figure 1b

June 2007



Legend

Median

Mean

Notes

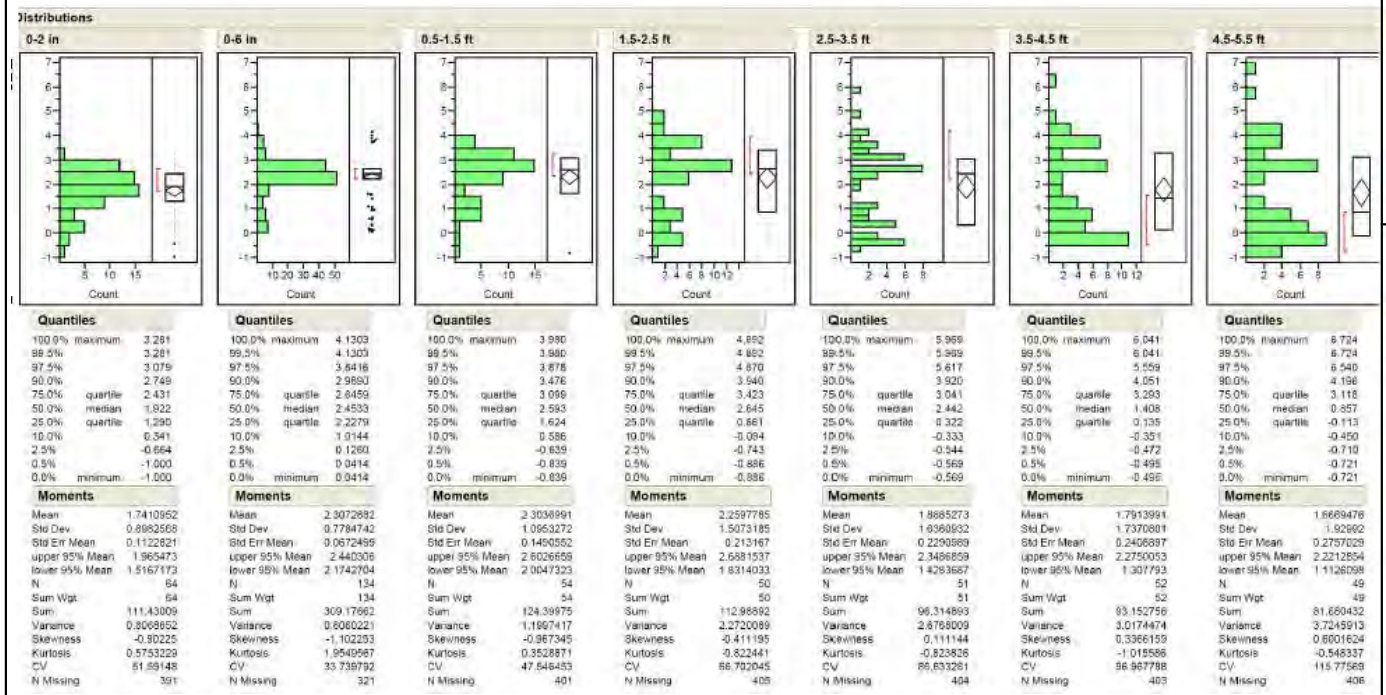
2,3,7,8-TCDD Concentration Grouped by Core Segment Midpoint
All Data

Lower Passaic River Restoration Project

Figure 2

June 2007

R2-0010254



Legend

2,3,7,8-TCDD Distribution

Notes

Data Source: JMP Version 6.0.0 "Statistical Discovery" from SAS Institute Inc.

Units are in pg/g for the concentration.

Units are in feet for the core segment mid point.

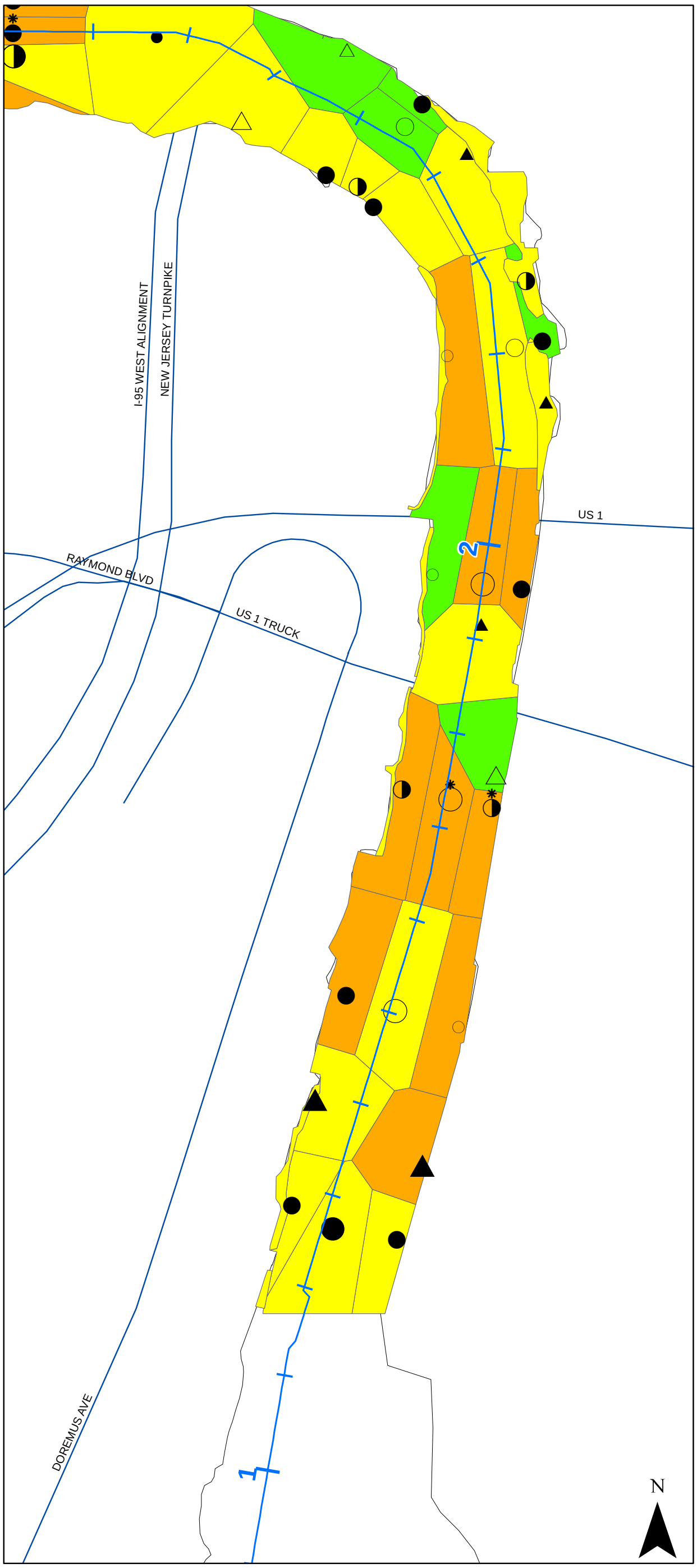
Distribution of 2,3,7,8-TCDD in Exact Core Intervals, Typically in Continuous Cores, log scale

Lower Passaic River Restoration Project

Figure 3

June 2007

R2-0010255



Legend

Length Weighted Average ng/g

- < 100
- 101 - 316
- 317 - 1000
- 1001 - 3162
- 3163 - 10000
- > 10000

Core Type

Continuous

- ○ < 125 ng/g at core bottom
- ◑ ≥ 125 ng/g at core bottom, Bottom Conc < 50% Max Conc
- ● ≥ 125 ng/g at core bottom, Bottom Conc ≥ 50% Max Conc

Interpolated[a]

- △ < 125 ng/g at core bottom
- ◭ ≥ 125 ng/g at core bottom, Bottom Conc < 50% Max Conc
- ▲ ≥ 125 ng/g at core bottom, Bottom Conc ≥ 50% Max Conc

Depth (feet)

- 0 - 5
- 5 - 10
- 10 - 15
- 15 - 20

Rejected Measurement(s) Present in Core[b]

- ✱ Federally Authorized (USACE) Navigational Channel Centerline

Notes:

[a] Unlike a continuous core, an interpolated core was not sampled continuously throughout its length. Contaminant concentrations between measured intervals were linearly interpolated.

[b] Rejected measurement present in one or more segments for one or more analytes. Rejected values were replaced with an interpolated value based on adjoining segments in the core.

500 250 0 500 Feet

US Army Corp of Engineers

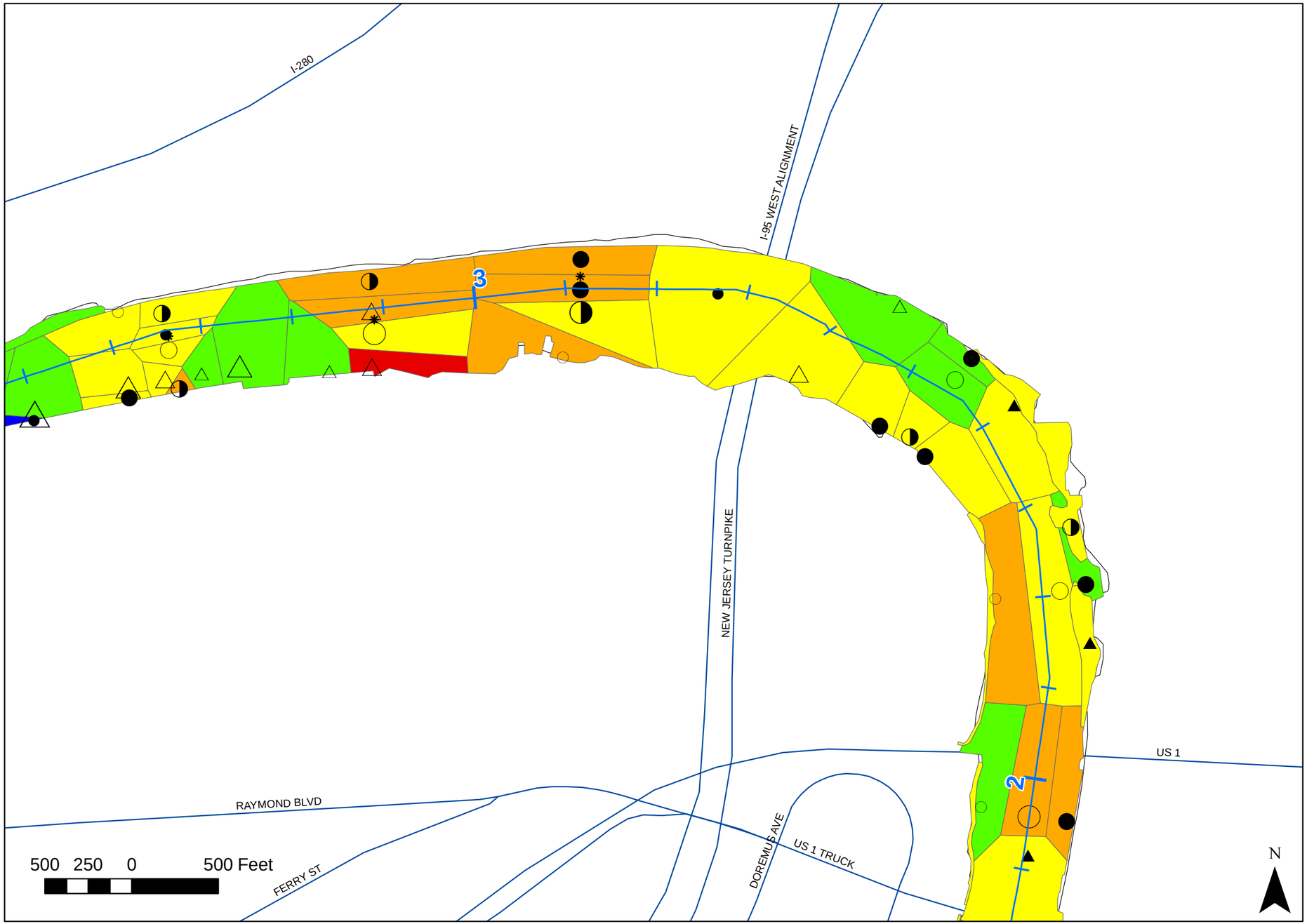
Sum of Aroclors 1248, 1254 and 1260
Length Weighted Average
River Mile 1 to 2
Lower Passaic River Restoration Project

Figure 4a

June 2007

S:\Projects\PASSAIC\Map Documents\4553025-IRM\IRM\LWA\from_extrapolated\MPA\LWA_PCBSum_Thiessen_Portrait.mxd

R2-0010256



Legend

Length Weighted Average
ng/g

- < 100
- 101 - 316
- 317 - 1000
- 1001 - 3162
- 3163 - 10000
- > 10000

Core Type

Continuous

- < 125 ng/g at core bottom
- ≥ 125 ng/g at core bottom, Bottom Conc < 50% Max Conc
- ≥ 125 ng/g at core bottom, Bottom Conc ≥ 50% Max Conc

Interpolated[a]

- < 125 ng/g at core bottom
- ≥ 125 ng/g at core bottom, Bottom Conc < 50% Max Conc
- ≥ 125 ng/g at core bottom, Bottom Conc ≥ 50% Max Conc

Depth (ft)

- 0 - 5
- 5 - 10
- 10 - 15
- 15 - 20

Rejected Measurement(s) Present in Core[b]

✱

Federally Authorized (USACE) Navigational Channel Centerline

Notes:
[a] Unlike a continuous core, an interpolated core was not sampled continuously throughout its length. Contaminant concentrations between measured intervals were linearly interpolated.
[b] Rejected measurement present in one or more segments for one or more analytes. Rejected values were replaced with an interpolated value based on adjoining segments in the core.

US Army Corps of Engineers®

Sum of Aroclors 1248, 1254 and 1260 Length Weighted Average

River Mile 2 to 3

Lower Passaic River Restoration Project

Figure 4b

June 2007

S:\Projects\PASSAIC\MapDocuments\4553025-IRM\IRM\LWA\from_extrapolated\PAL\WA_PCB Sum_Thiessen_Landscape.mxd

Legend

Length Weighted Average
ng/g

- < 100
- 101 - 316
- 317 - 1000
- 1001 - 3162
- 3163 - 10000
- > 10000

Core Type

Continuous

- < 125 ng/g at core bottom
- ≥ 125 ng/g at core bottom, Bottom Conc < 50% Max Conc
- ≥ 125 ng/g at core bottom, Bottom Conc ≥ 50% Max Conc

Interpolated[a]

- < 125 ng/g at core bottom
- ≥ 125 ng/g at core bottom, Bottom Conc < 50% Max Conc
- ≥ 125 ng/g at core bottom, Bottom Conc ≥ 50% Max Conc

Depth (ft)

- 0 - 5
- 5 - 10
- 10 - 15
- 15 - 20

Rejected Measurement(s) Present in Core[b]

*

Federally Authorized (USACE) Navigational Channel Centerline

Notes:
[a] Unlike a continuous core, an interpolated core was not sampled continuously throughout its length. Contaminant concentrations between measured intervals were linearly interpolated.
[b] Rejected measurement present in one or more segments for one or more analytes. Rejected values were replaced with an interpolated value based on adjoining segments in the core.

US Army Corps of Engineers®

Sum of Aroclors 1248, 1254 and 1260 Length Weighted Average

River Mile 3 to 4

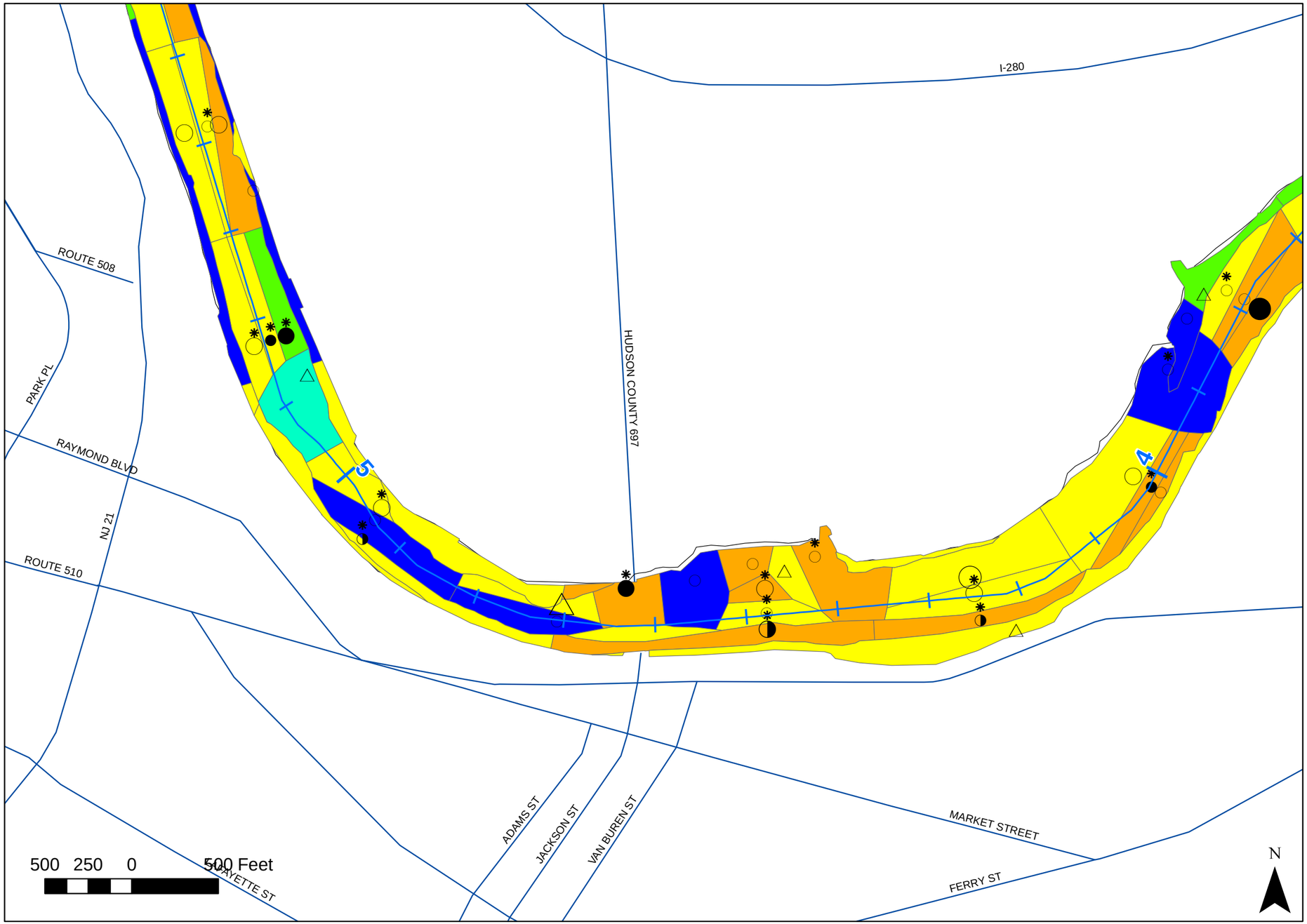
Lower Passaic River Restoration Project

Figure 4c

June 2007

S:\Projects\PASSAIC\MapDocuments\455025-IRM\IRM\LWA\from_extrapolated\PAL\WA_PCB Sum_Thiessen_Landscape.mxd

R2-0010258



Legend

Length Weighted Average
ng/g

- < 100
- 101 - 316
- 317 - 1000
- 1001 - 3162
- 3163 - 10000
- > 10000

Core Type

Continuous

- ○ < 125 ng/g at core bottom
- ◑ ≥ 125 ng/g at core bottom, Bottom Conc < 50% Max Conc
- ● ≥ 125 ng/g at core bottom, Bottom Conc ≥ 50% Max Conc

Interpolated[a]

- △ < 125 ng/g at core bottom
- ≥ 125 ng/g at core bottom, Bottom Conc < 50% Max Conc
- ▲ ≥ 125 ng/g at core bottom, Bottom Conc ≥ 50% Max Conc

Depth (ft)

- 0 - 5
- 5 - 10
- 10 - 15
- 15 - 20

Rejected Measurement(s) Present in Core[b]

✱

Federally Authorized (USACE) Navigational Channel Centerline

Notes:
[a] Unlike a continuous core, an interpolated core was not sampled continuously throughout its length. Contaminant concentrations between measured intervals were linearly interpolated.
[b] Rejected measurement present in one or more segments for one or more analytes. Rejected values were replaced with an interpolated value based on adjoining segments in the core.

US Army Corps of Engineers®

Sum of Aroclors 1248, 1254 and 1260 Length Weighted Average

River Mile 4 to 5

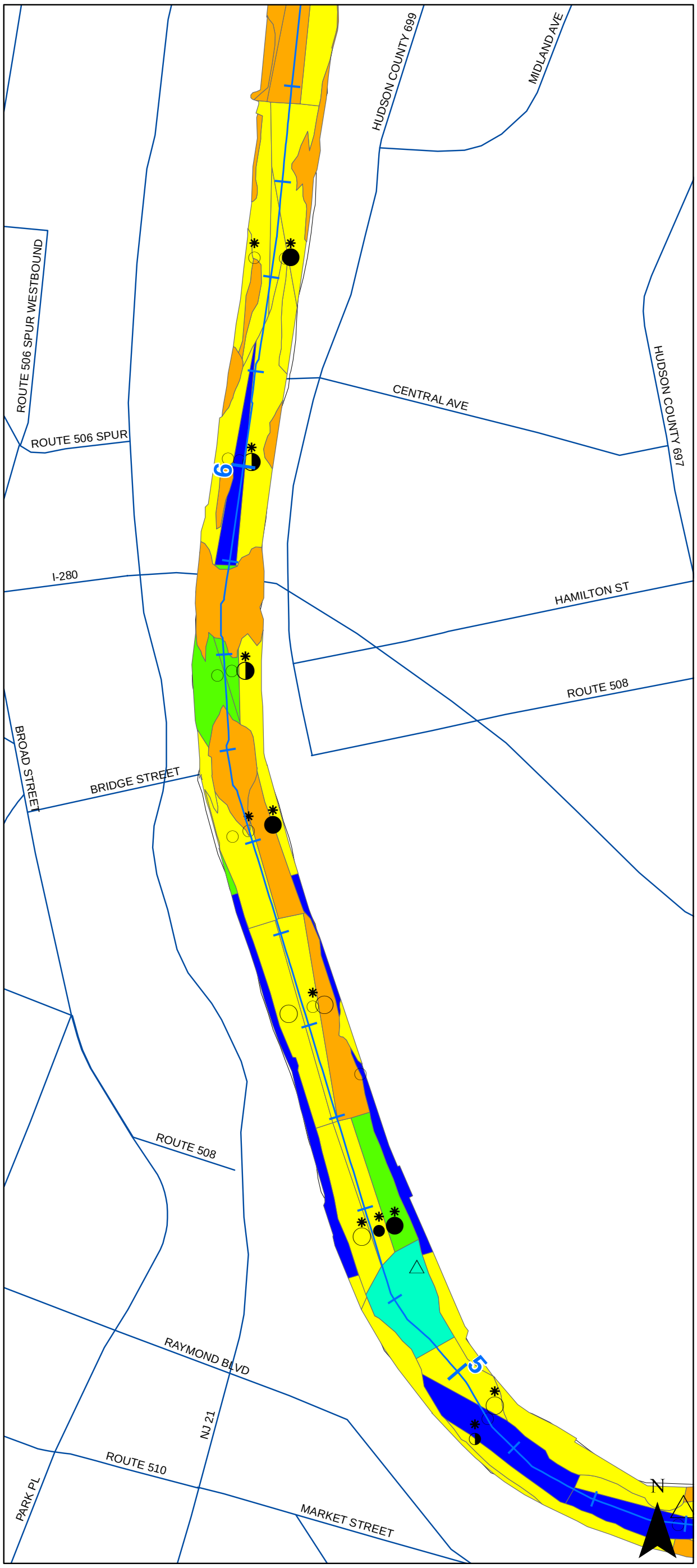
Lower Passaic River Restoration Project

Figure 4d

June 2007

S:\Projects\PASSAIC\MapDocuments\455\025-IRM\IRM\LWA\from_extrapolated\PALWA_PCBSum_Thiessen_Landscape.mxd

R2-0010259



Legend

Length Weighted Average ng/g

- < 100
- 101 - 316
- 317 - 1000
- 1001 - 3162
- 3163 - 10000
- > 10000

Core Type

Continuous

- < 125 ng/g at core bottom
- ≥ 125 ng/g at core bottom, Bottom Conc < 50% Max Conc
- ≥ 125 ng/g at core bottom, Bottom Conc ≥ 50% Max Conc

Interpolated[a]

- < 125 ng/g at core bottom
- ≥ 125 ng/g at core bottom, Bottom Conc < 50% Max Conc
- ≥ 125 ng/g at core bottom, Bottom Conc ≥ 50% Max Conc

Depth (feet)

- 0 - 5
- 5 - 10
- 10 - 15
- 15 - 20

Rejected Measurement(s) Present in Core[b]

- ✱
- Federally Authorized (USACE) Navigational Channel Centerline

Notes:

[a] Unlike a continuous core, an interpolated core was not sampled continuously throughout its length. Contaminant concentrations between measured intervals were linearly interpolated.

[b] Rejected measurement present in one or more segments for one or more analytes. Rejected values were replaced with an interpolated value based on adjoining segments in the core.

500 250 0 500 Feet

US Army Corp of Engineers

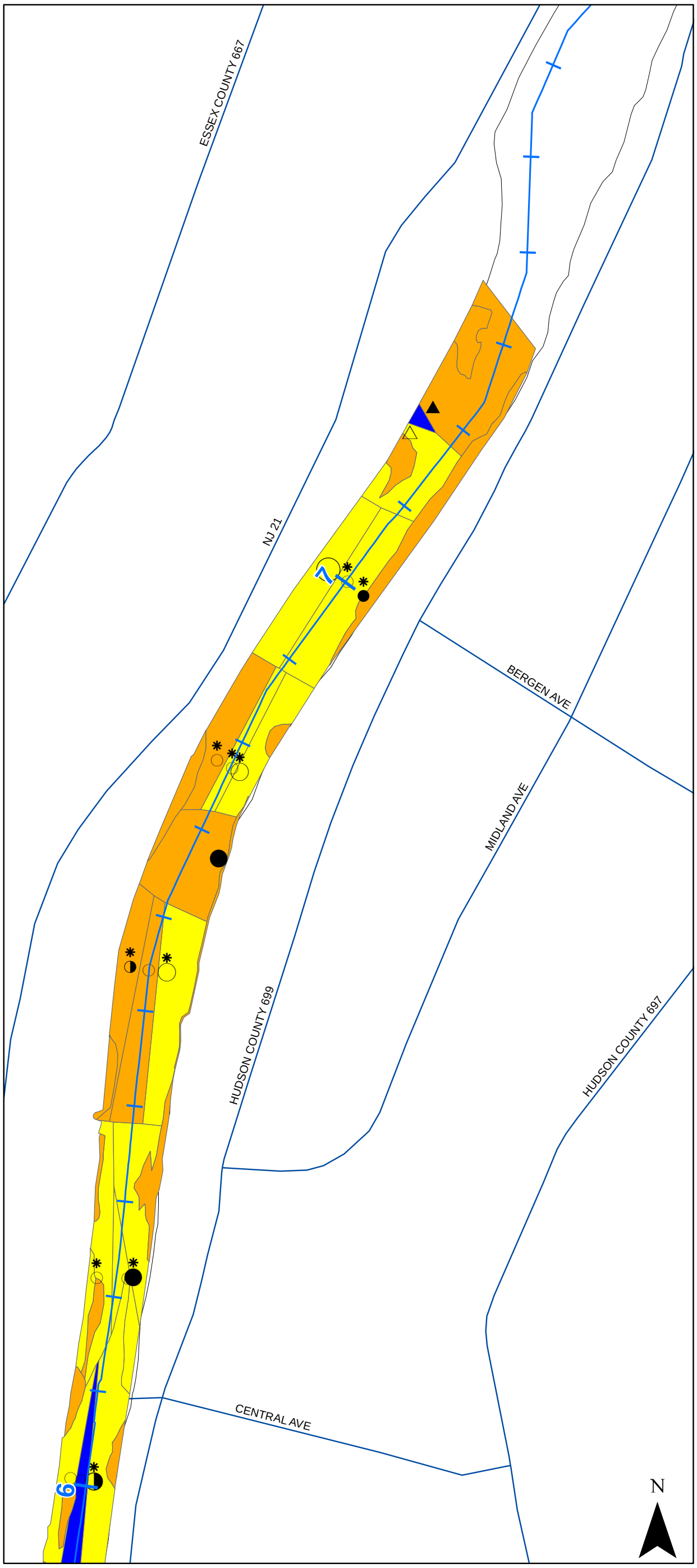
Sum of Aroclors 1248, 1254 and 1260
Length Weighted Average
River Mile 5 to 6
Lower Passaic River Restoration Project

Figure 4e

June 2007

S:\Projects\PASSAIC\MapDocuments\4553025\RM\RM\LWA\from_extrapolated\PALWA_PCBSum_Thiessen_Portrait.mxd

R2-0010260



Legend

Length Weighted Average ng/g

- < 100
- 101 - 316
- 317 - 1000
- 1001 - 3162
- 3163 - 10000
- > 10000

Core Type

Continuous

- < 125 ng/g at core bottom
- ≥ 125 ng/g at core bottom, Bottom Conc < 50% Max Conc
- ≥ 125 ng/g at core bottom, Bottom Conc ≥ 50% Max Conc

Interpolated[a]

- < 125 ng/g at core bottom
- ≥ 125 ng/g at core bottom, Bottom Conc < 50% Max Conc
- ≥ 125 ng/g at core bottom, Bottom Conc ≥ 50% Max Conc

Depth (feet)

- 0 - 5
- 5 - 10
- 10 - 15
- 15 - 20

Rejected Measurement(s) Present in Core[b]

- ✱ Federally Authorized (USACE) Navigational Channel Centerline

Notes:

[a] Unlike a continuous core, an interpolated core was not sampled continuously throughout its length. Contaminant concentrations between measured intervals were linearly interpolated.

[b] Rejected measurement present in one or more segments for one or more analytes. Rejected values were replaced with an interpolated value based on adjoining segments in the core.

500 250 0 500 Feet

US Army Corp of Engineers

Sum of Aroclors 1248, 1254 and 1260
Length Weighted Average
River Mile 6 to 7
Lower Passaic River Restoration Project

Figure 4f

June 2007

S:\Projects\PASSAIC\Map Documents\4553025-IRM\IRM\LWA\from_extrapolated\MPA\LWA_PCBSum_Thiessen_Portrait.mxd

Legend

Depth of Contamination

Feet (extrapolated)

- 0.0 - 2.5
- 2.6 - 5.0
- 5.1 - 7.5
- 7.6 - 10.0
- 10.1 - 12.5
- 12.6 - 25.7
- "Special" Cores

Core Type

Continuous

- ○ < 125 ng/g at core bottom
- ◑ ≥ 125 ng/g at core bottom, Bottom Conc < 50% Max Conc
- ● ≥ 125 ng/g at core bottom, Bottom Conc ≥ 50% Max Conc

Interpolated[a]

- △ < 125 ng/g at core bottom
- ≥ 125 ng/g at core bottom, Bottom Conc < 50% Max Conc
- ▲ ≥ 125 ng/g at core bottom, Bottom Conc ≥ 50% Max Conc

Rejected Measurement(s) Present in Core[b]

- ✱ Federally Authorized (USACE) Navigational Channel Centerline

Notes:

[a] Unlike a continuous core, an interpolated core was not sampled continuously throughout its length. Contaminant concentrations between measured intervals were linearly interpolated.

[b] Rejected measurement present in one or more segments for one or more analytes. Rejected values were replaced with an interpolated value based on adjoining segments in the core.

500 250 0 500 Feet

US Army Corp of Engineers

Sum of Aroclors 1248, 1254 and 1260
Depth of Contamination (Extrapolated)
River Mile 1 to 2

Lower Passaic River Restoration Project

Figure 5a

June 2007

S:\Projects\PASSAIC\Map Documents\4553025-IRM\IRM\DOC\from_extrapolated\PA\DOCex_PCBSum_Thiessen_Portrait.mxd

Legend

Depth of Contamination

Feet (extrapolated)

- 0.0 - 2.5
- 2.6 - 5.0
- 5.1 - 7.5
- 7.6 - 10.0
- 10.1 - 12.5
- > 12.5
- "Special" Cores

Core Type

Continuous

- < 125 ng/g at core bottom
- ≥ 125 ng/g at core bottom, Bottom Conc < 50% Max Conc
- ≥ 125 ng/g at core bottom, Bottom Conc ≥ 50% Max Conc

Interpolated[a]

- < 125 ng/g at core bottom
- ≥ 125 ng/g at core bottom, Bottom Conc < 50% Max Conc
- ≥ 125 ng/g at core bottom, Bottom Conc ≥ 50% Max Conc

Rejected Measurement(s) Present in Core[b]

✱

Federally Authorized (USACE) Navigational Channel Centerline

Notes:

[a] Unlike a continuous core, an interpolated core was not sampled continuously throughout its length. Contaminant concentrations between measured intervals were linearly interpolated.

[b] Rejected measurement present in one or more segments for one or more analytes. Rejected values were replaced with an interpolated value based on adjoining segments in the core.

US Army Corps of Engineers®

Sum of Aroclors 1248, 1254 and 1260 Depth of Contamination (Extrapolated)

River Mile 2 to 3

Lower Passaic River Restoration Project

Figure 5b

June 2007

S:\Projects\PASSAIC\MapDocuments\4563025-IRM\IRM\DOC\Item_extrapolate\MPAUDOCex_PCBSum_Thiessen_Landscape.mxd

R2-0010263

Legend

Depth of Contamination

Feet (extrapolated)

- 0.0 - 2.5
- 2.6 - 5.0
- 5.1 - 7.5
- 7.6 - 10.0
- 10.1 - 12.5
- > 12.5
- "Special" Cores

Core Type

Continuous

- ◯ < 125 ng/g at core bottom
- ◑ ≥ 125 ng/g at core bottom, Bottom Conc < 50% Max Conc
- ● ≥ 125 ng/g at core bottom, Bottom Conc ≥ 50% Max Conc

Interpolated[a]

- △ < 125 ng/g at core bottom
- ◬ ≥ 125 ng/g at core bottom, Bottom Conc < 50% Max Conc
- ▲ ≥ 125 ng/g at core bottom, Bottom Conc ≥ 50% Max Conc

Rejected Measurement(s) Present in Core[b]

✱

Federally Authorized (USACE) Navigational Channel Centerline

Notes:

[a] Unlike a continuous core, an interpolated core was not sampled continuously throughout its length. Contaminant concentrations between measured intervals were linearly interpolated.

[b] Rejected measurement present in one or more segments for one or more analytes. Rejected values were replaced with an interpolated value based on adjoining segments in the core.

US Army Corps of Engineers®

Sum of Aroclors 1248, 1254 and 1260 Depth of Contamination (Extrapolated)

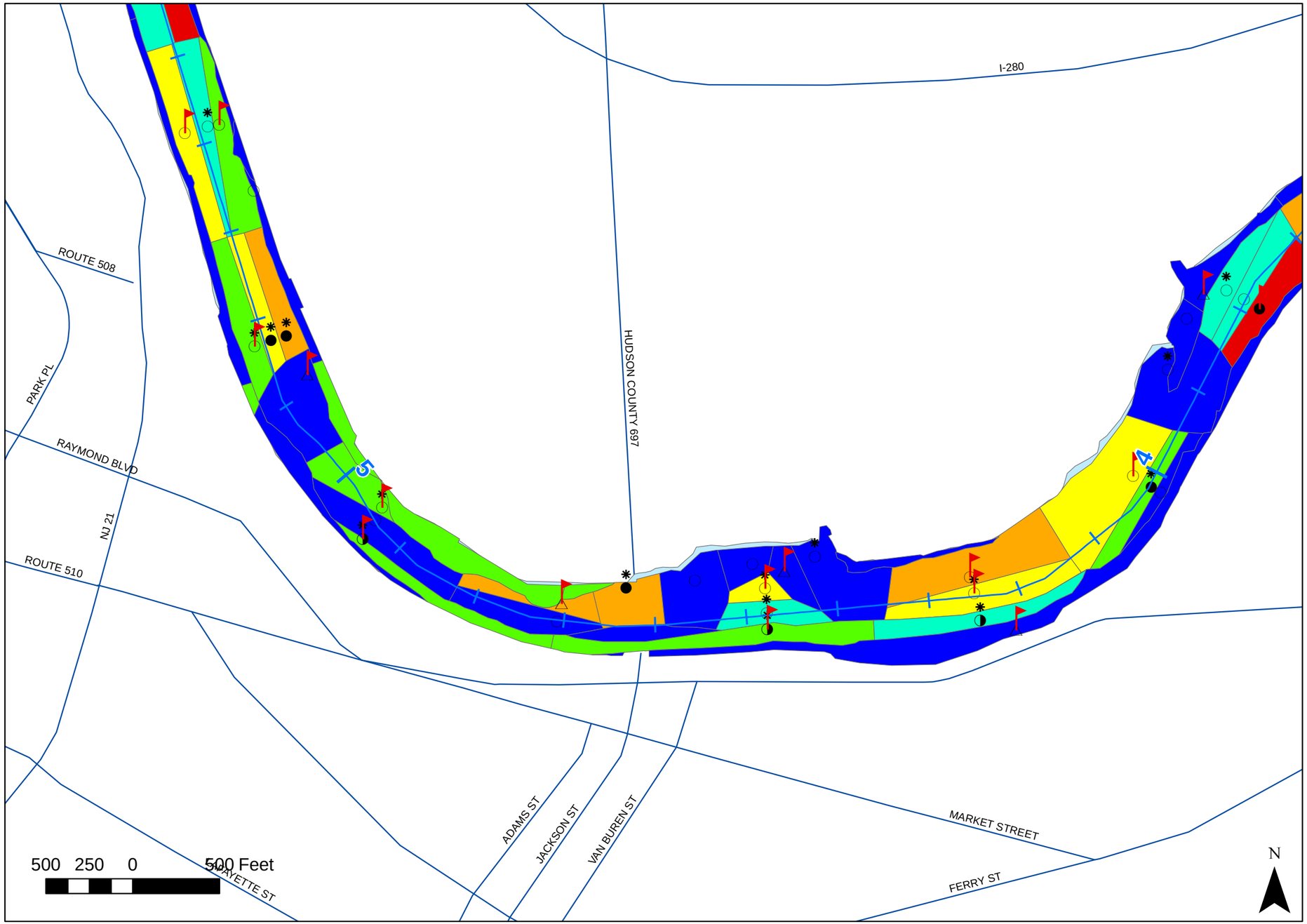
River Mile 3 to 4

Lower Passaic River Restoration Project

Figure 5c

June 2007

S:\Projects\PASSAIC\MapDocuments\455305-IRM\IPM\DOC\from_extrapolate\MPAIDOCex_PCBSum_Thiessen_Landscape.mxd



Legend

Depth of Contamination

Feet (extrapolated)

- 0.0 - 2.5
- 2.6 - 5.0
- 5.1 - 7.5
- 7.6 - 10.0
- 10.1 - 12.5
- > 12.5
- "Special" Cores

Core Type

Continuous

- ◯ < 125 ng/g at core bottom
- ◑ ≥ 125 ng/g at core bottom, Bottom Conc < 50% Max Conc
- ● ≥ 125 ng/g at core bottom, Bottom Conc ≥ 50% Max Conc

Interpolated[a]

- △ < 125 ng/g at core bottom
- ◬ ≥ 125 ng/g at core bottom, Bottom Conc < 50% Max Conc
- ▲ ≥ 125 ng/g at core bottom, Bottom Conc ≥ 50% Max Conc

Rejected Measurement(s) Present in Core[b]

✱

Federally Authorized (USACE) Navigational Channel Centerline

Notes:

[a] Unlike a continuous core, an interpolated core was not sampled continuously throughout its length. Contaminant concentrations between measured intervals were linearly interpolated.

[b] Rejected measurement present in one or more segments for one or more analytes. Rejected values were replaced with an interpolated value based on adjoining segments in the core.

Sum of Aroclors 1248, 1254 and 1260 Depth of Contamination (Extrapolated)

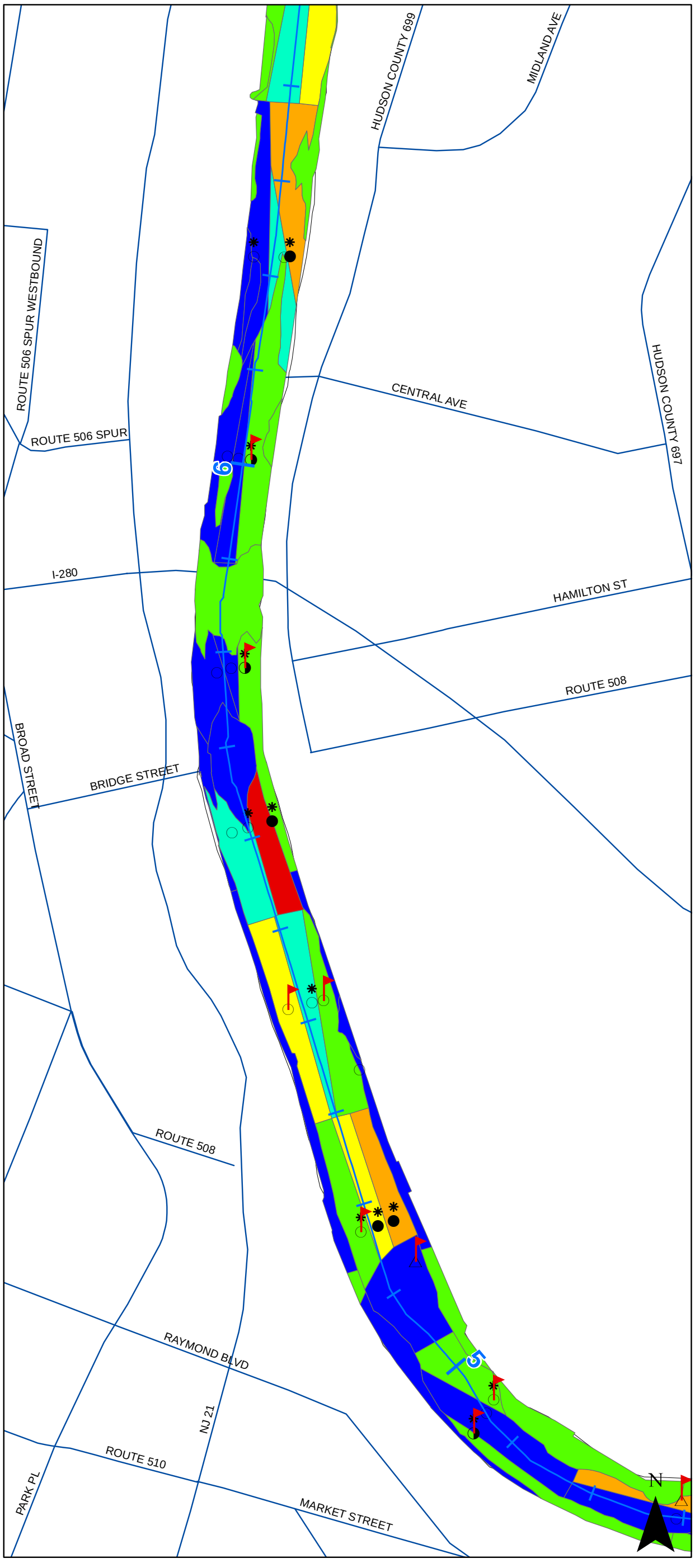
River Mile 4 to 5

Lower Passaic River Restoration Project

Figure 5d

June 2007

S:\Projects\PASSAIC\MapDocuments\4553025-IRM\IRM\DOC\from_extrapolated\PAIDOCex_PCBSum_Thiessen_Landscape.mxd



Legend

Depth of Contamination

Feet (extrapolated)

- 0.0 - 2.5
- 2.6 - 5.0
- 5.1 - 7.5
- 7.6 - 10.0
- 10.1 - 12.5
- 12.6 - 25.7
- "Special" Cores

Core Type

Continuous

- ○ < 125 ng/g at core bottom
- ◑ ≥ 125 ng/g at core bottom, Bottom Conc < 50% Max Conc
- ● ≥ 125 ng/g at core bottom, Bottom Conc ≥ 50% Max Conc

Interpolated[a]

- △ < 125 ng/g at core bottom
- ≥ 125 ng/g at core bottom, Bottom Conc < 50% Max Conc
- ▲ ≥ 125 ng/g at core bottom, Bottom Conc ≥ 50% Max Conc

Rejected Measurement(s) Present in Core[b]

- ✱ Federally Authorized (USACE) Navigational Channel Centerline

Notes:

[a] Unlike a continuous core, an interpolated core was not sampled continuously throughout its length. Contaminant concentrations between measured intervals were linearly interpolated.

[b] Rejected measurement present in one or more segments for one or more analytes. Rejected values were replaced with an interpolated value based on adjoining segments in the core.

500 250 0 500 Feet

US Army Corp of Engineers

Sum of Aroclors 1248, 1254 and 1260
Depth of Contamination (Extrapolated)
River Mile 5 to 6

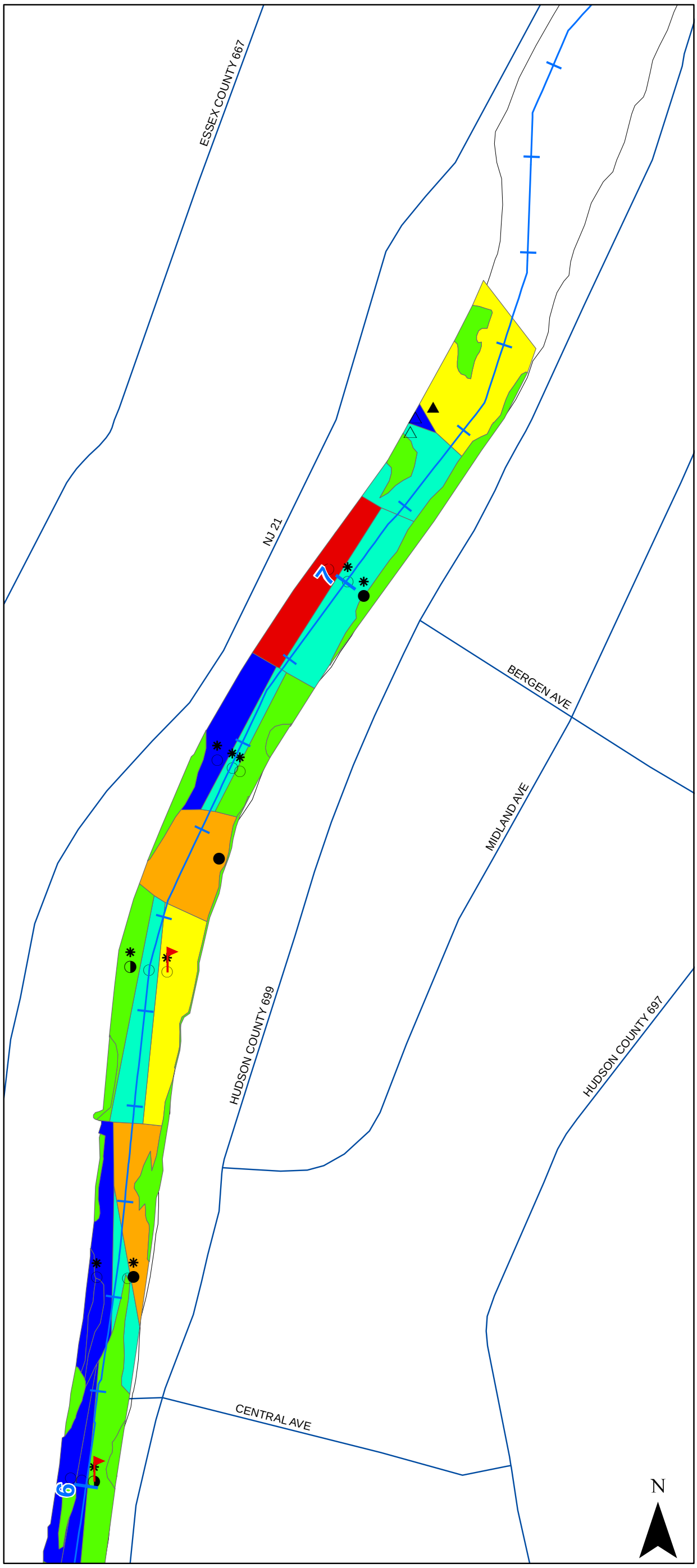
Lower Passaic River Restoration Project

Figure 5e

June 2007

S:\Projects\PASSAIC\MapDocuments\4553025-IRM\IRM\DOC\from_extrapolated\MPA\DOCex_PCBSum_Thiessen_Portrait.mxd

R2-0010266



Legend

Depth of Contamination

Feet (extrapolated)

- 0.0 - 2.5
- 2.6 - 5.0
- 5.1 - 7.5
- 7.6 - 10.0
- 10.1 - 12.5
- 12.6 - 25.7
- "Special" Cores

Core Type

Continuous

- ○ < 125 ng/g at core bottom
- ◑ ≥ 125 ng/g at core bottom, Bottom Conc < 50% Max Conc
- ● ≥ 125 ng/g at core bottom, Bottom Conc ≥ 50% Max Conc

Interpolated[a]

- △ < 125 ng/g at core bottom
- ◭ ≥ 125 ng/g at core bottom, Bottom Conc < 50% Max Conc
- ▲ ≥ 125 ng/g at core bottom, Bottom Conc ≥ 50% Max Conc

Rejected Measurement(s) Present in Core[b]

- ✱
- Federally Authorized (USACE) Navigational Channel Centerline

Notes:

[a] Unlike a continuous core, an interpolated core was not sampled continuously throughout its length. Contaminant concentrations between measured intervals were linearly interpolated.

[b] Rejected measurement present in one or more segments for one or more analytes. Rejected values were replaced with an interpolated value based on adjoining segments in the core.

500 250 0 500 Feet

US Army Corp of Engineers

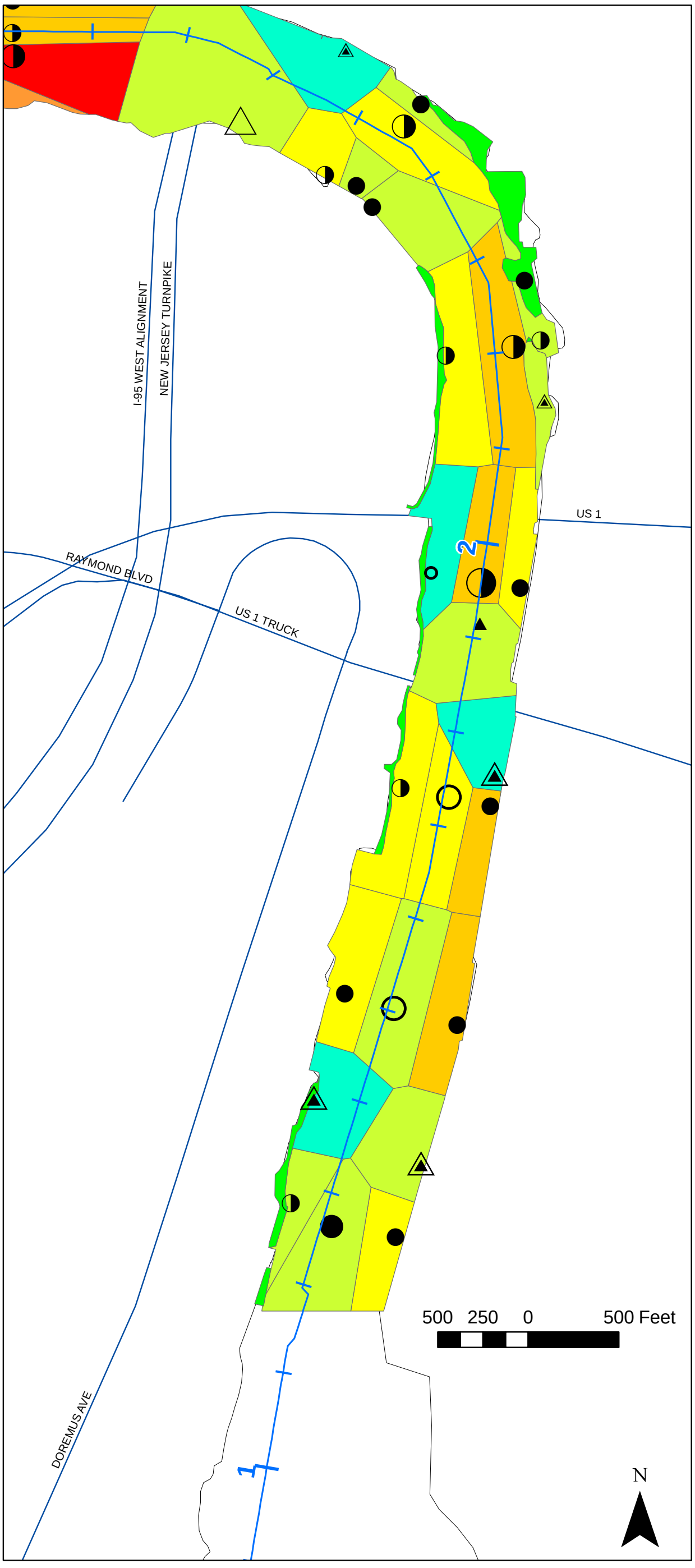
Sum of Aroclors 1248, 1254 and 1260
Depth of Contamination (Extrapolated)
River Mile 6 to 7

Lower Passaic River Restoration Project

Figure 5f

June 2007

S:\Projects\PASSAIC\MapDocuments\4553025-IRM\IRM\DOC\from_extrapolated\MPA\DOCex_PCBSum_Thiessen_Portrait.mxd



Legend

Length Weighted Average (pg/g)

- 0 - 10
- 10 - 32
- 32 - 100
- 100 - 320
- 320 - 1000
- 1000 - 3200
- 3200 - 10000
- 10000 - 32000
- > 32000

Core Type

Continuous

- ○ < 2 pg/g at core bottom
- ◑ ≥ 2 pg/g at core bottom, Bottom Conc < 50% Max Conc
- ● ≥ 2 pg/g at core bottom, Bottom Conc ≥ 50% Max Conc

Interpolated[b]

- △ < 2 pg/g at core bottom
- ▲ ≥ 2 pg/g at core bottom, Bottom Conc < 50% Max Conc
- ▲ ≥ 2 pg/g at core bottom, Bottom Conc ≥ 50% Max Conc

Depth (feet)

- 0 - 5
- 5 - 10
- 10 - 15
- 15 - 20

Federally Authorized (USACE) Navigational Channel Centerline

Notes:

There is no rejected measurement present for 2,3,7,8-TCDD.

[a] MPA scale was combined since only 9 data present in this range.

[b] Unlike a continuous core, an interpolated core was not sampled continuously throughout its length. Contaminant concentrations between measured intervals were linearly interpolated.

US Army Corp of Engineers

2,3,7,8-TCDD Length Weighted Average

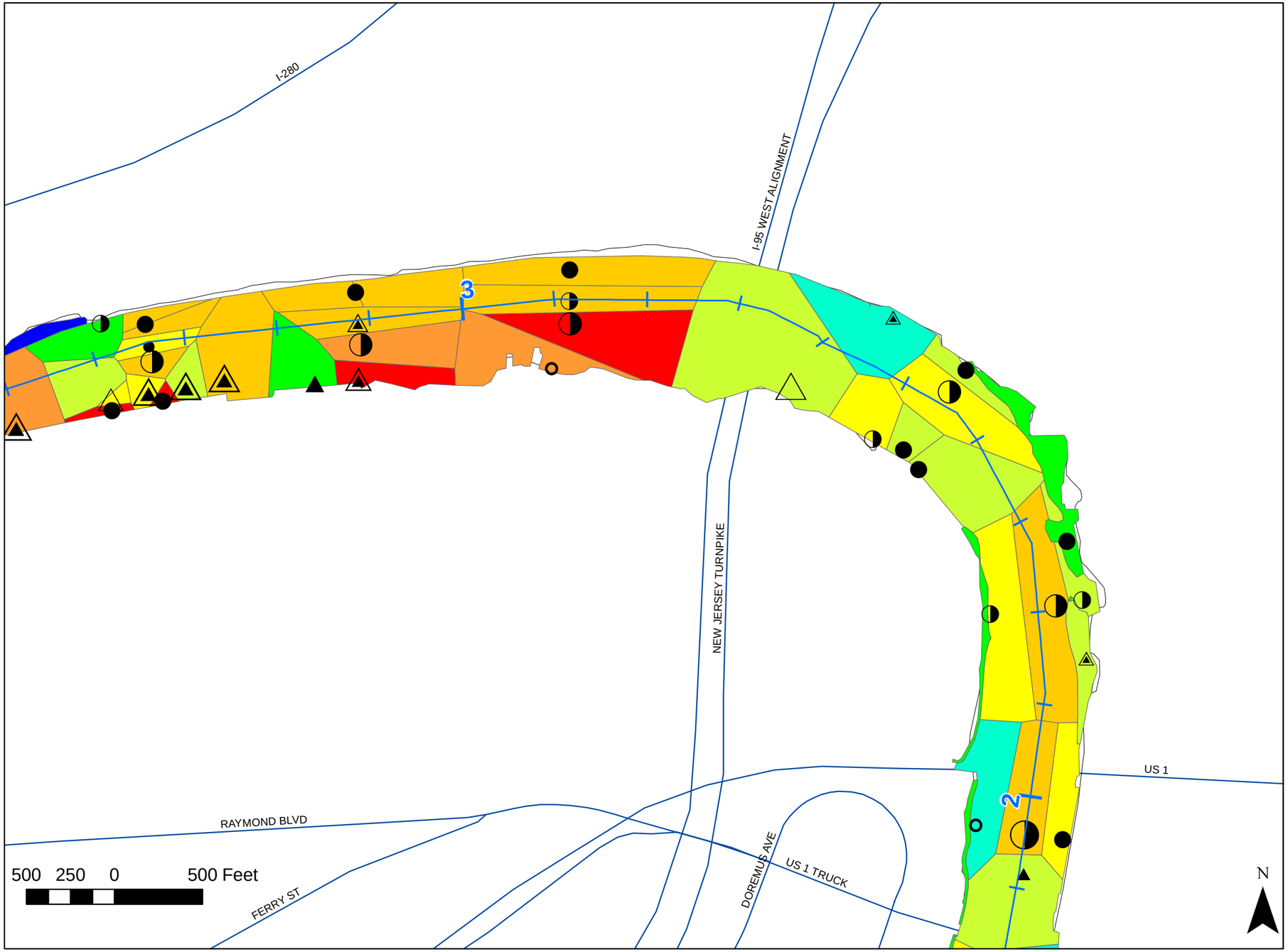
River Mile 1 to 2

Lower Passaic River Restoration Project

Figure 6a

June 2007

S:\Projects\PASSAIC\MapDocuments\455 3025-IRM\IRM\LWA\from_extrapolated\MPA\LWA_TCDD_Thiessen_Portrait.mxd



Legend

Length Weighted Average (pg/g)

- 0 - 10
- 10 - 32
- 32 - 100
- 100 - 320
- 320 - 1000
- 1000 - 3200
- 3200 - 10000
- 10000 - 32000
- > 32000

Core Type

Continuous

- < 2 pg/g at core bottom
- ≥ 2 pg/g at core bottom, Bottom Conc < 50% Max Conc
- ≥ 2 pg/g at core bottom, Bottom Conc ≥ 50% Max Conc

Interpolated[b]

- < 2 pg/g at core bottom
- ≥ 2 pg/g at core bottom, Bottom Conc < 50% Max Conc
- ≥ 2 pg/g at core bottom, Bottom Conc ≥ 50% Max Conc

Depth (feet)

- 0 - 5
- 5 - 10
- 10 - 15
- 15 - 20

Federally Authorized (USACE) Navigational Channel Centerline

Notes:
There is no rejected measurement present for 2,3,7,8-TCDD.
[a] MPA scale was combined since only 9 data present in this range.
[b] Unlike a continuous core, an interpolated core was not sampled continuously throughout its length. Contaminant concentrations between measured intervals were linearly interpolated.

US Army Corps of Engineers

2,3,7,8-TCDD Length Weighted Average

River Mile 2 to 3

Lower Passaic River Restoration Project

Figure 6b

June 2007

S:\Projects\PASSAIC\MapDocuments\485302\5-IRM\IRM\LWA\from_extrapolated\MPA\LWA_TCDD_Thiessen_Landscape.mxd

R2-0010269

Legend

Length Weighted Average (pg/g)

- 0 - 10
- 10 - 32
- 32 - 100
- 100 - 320
- 320 - 1000
- 1000 - 3200
- 3200 - 10000
- 10000 - 32000
- > 32000

Core Type

Continuous

- ○ < 2 pg/g at core bottom
- ◑ ≥ 2 pg/g at core bottom, Bottom Conc < 50% Max Conc
- ● ≥ 2 pg/g at core bottom, Bottom Conc ≥ 50% Max Conc

Interpolated[b]

- △ < 2 pg/g at core bottom
- ◬ ≥ 2 pg/g at core bottom, Bottom Conc < 50% Max Conc
- ▲ ≥ 2 pg/g at core bottom, Bottom Conc ≥ 50% Max Conc

Depth (feet)

- 0 - 5
- 5 - 10
- 10 - 15
- 15 - 20

Federally Authorized (USACE) Navigational Channel Centerline

Notes:
There is no rejected measurement present for 2,3,7,8-TCDD.
[a] MPA scale was combined since only 9 data present in this range.
[b] Unlike a continuous core, an interpolated core was not sampled continuously throughout its length. Contaminant concentrations between measured intervals were linearly interpolated.

US Army Corps of Engineers®

2,3,7,8-TCDD Length Weighted Average

River Mile 3 to 4

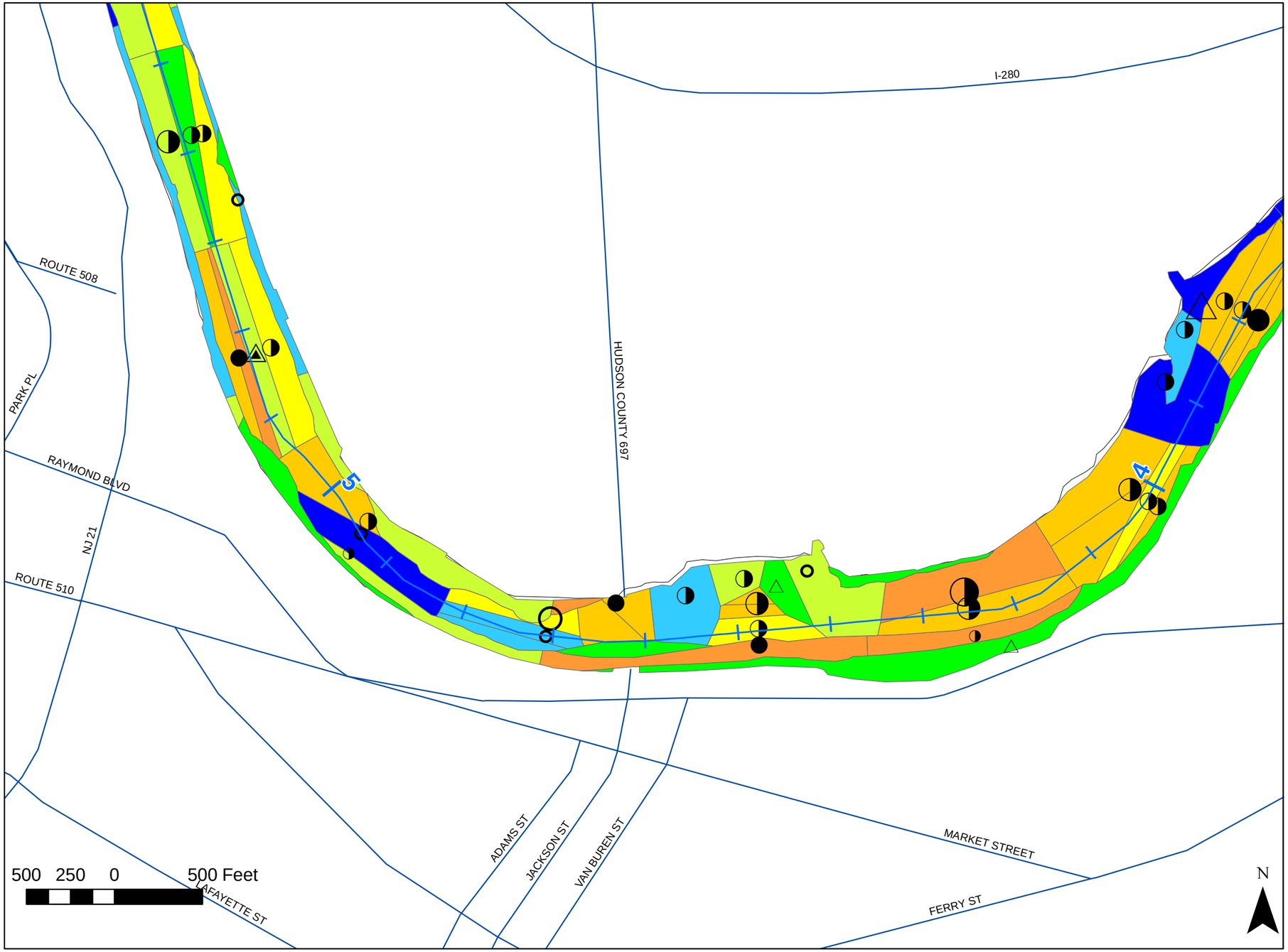
Lower Passaic River Restoration Project

Figure 6c

June 2007

S:\Projects\PASSAIC\MapDocuments\455.3025-IRM\IRM\LWA\from_extrapolated\PA\LWA_TCDD_Thiessen_Landscape.mxd

R2-0010270



Legend

Length Weighted Average (pg/g)

- 0 - 10
- 10 - 32
- 32 - 100
- 100 - 320
- 320 - 1000
- 1000 - 3200
- 3200 - 10000
- 10000 - 32000
- > 32000

Core Type

Continuous

- < 2 pg/g at core bottom
- ≥ 2 pg/g at core bottom, Bottom Conc < 50% Max Conc
- ≥ 2 pg/g at core bottom, Bottom Conc ≥ 50% Max Conc

Interpolated[b]

- < 2 pg/g at core bottom
- ≥ 2 pg/g at core bottom, Bottom Conc < 50% Max Conc
- ≥ 2 pg/g at core bottom, Bottom Conc ≥ 50% Max Conc

Depth (feet)

- 0 - 5
- 5 - 10
- 10 - 15
- 15 - 20

Federally Authorized (USACE) Navigational Channel Centerline

Notes:
There is no rejected measurement present for 2,3,7,8-TCDD.
[a] MPA scale was combined since only 9 data present in this range.
[b] Unlike a continuous core, an interpolated core was not sampled continuously throughout its length. Contaminant concentrations between measured intervals were linearly interpolated.

US Army Corps of Engineers

2,3,7,8-TCDD Length Weighted Average

River Mile 4 to 5

Lower Passaic River Restoration Project

Figure 6d

June 2007

S:\Projects\PASSAIC\Map\Documents\455\025_IRM\IRM\LWA\from_extrapolated\MPA\LWA_TCDD_Thiessen_Landscape.mxd

R2-0010271

Legend

Length Weighted Average (pg/g)

- 0 - 10
- 10 - 32
- 32 - 100
- 100 - 320
- 320 - 1000
- 1000 - 3200
- 3200 - 10000
- 10000 - 32000
- > 32000

Core Type

Continuous

- ○ < 2 pg/g at core bottom
- ◑ ≥ 2 pg/g at core bottom, Bottom Conc < 50% Max Conc
- ● ≥ 2 pg/g at core bottom, Bottom Conc ≥ 50% Max Conc

Interpolated[b]

- △ < 2 pg/g at core bottom
- ◭ ≥ 2 pg/g at core bottom, Bottom Conc < 50% Max Conc
- ▲ ≥ 2 pg/g at core bottom, Bottom Conc ≥ 50% Max Conc

Depth (feet)

- 0 - 5
- 5 - 10
- 10 - 15
- 15 - 20

Federally Authorized (USACE) Navigational Channel Centerline

Notes:

There is no rejected measurement present for 2,3,7,8-TCDD.

[a] MPA scale was combined since only 9 data present in this range.

[b] Unlike a continuous core, an interpolated core was not sampled continuously throughout its length. Contaminant concentrations between measured intervals were linearly interpolated.

US Army Corp of Engineers

2,3,7,8-TCDD Length Weighted Average

River Mile 5 to 6

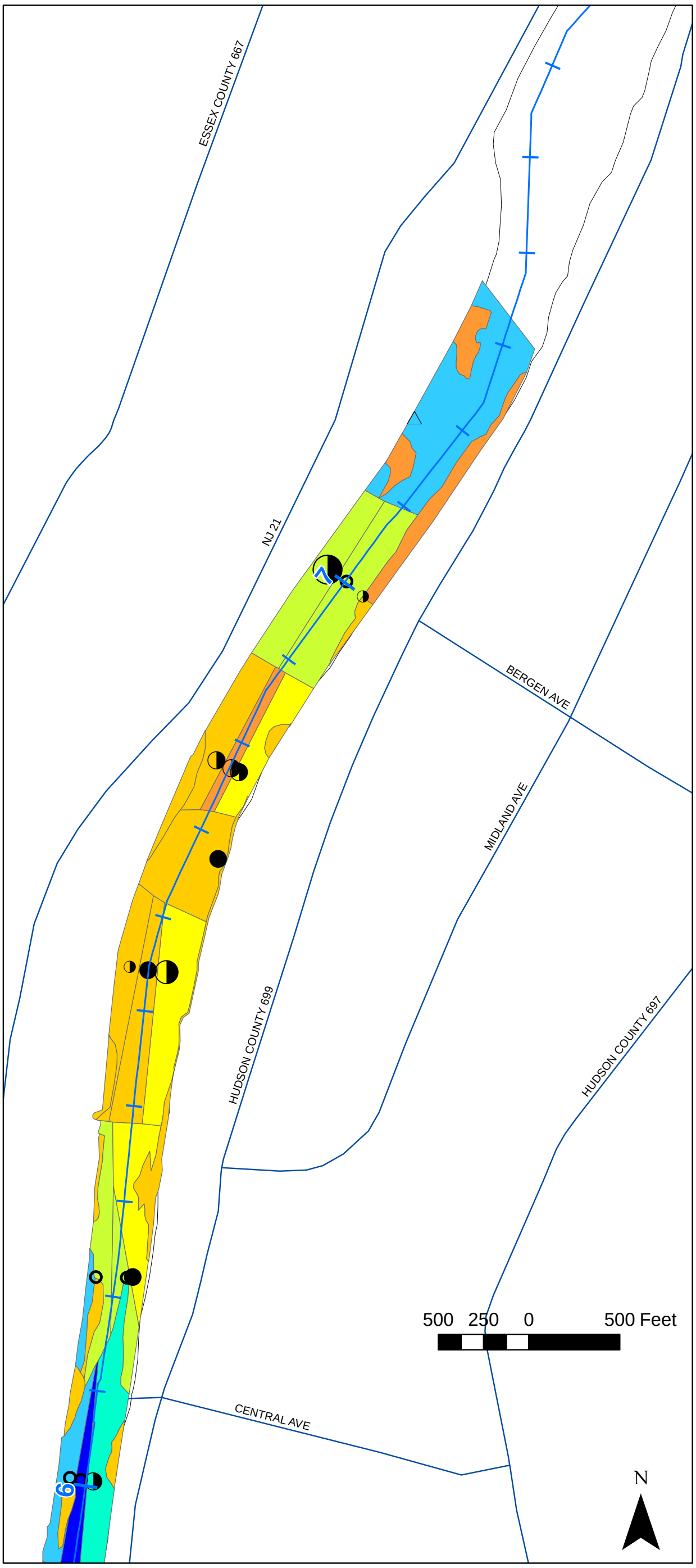
Lower Passaic River Restoration Project

Figure 6e

June 2007

S:\Projects\PASSAIC\MapDocuments\453025-IRM\IRM\LWA\from_extrapolated\MPA\LWA_TCDD_Thiessen_Portrait.mxd

R2-0010272



Legend

Length Weighted Average (pg/g)

- 0 - 10
- 10 - 32
- 32 - 100
- 100 - 320
- 320 - 1000
- 1000 - 3200
- 3200 - 10000
- 10000 - 32000
- > 32000

Core Type

Continuous

- < 2 pg/g at core bottom
- ≥ 2 pg/g at core bottom, Bottom Conc < 50% Max Conc
- ≥ 2 pg/g at core bottom, Bottom Conc ≥ 50% Max Conc

Interpolated[b]

- < 2 pg/g at core bottom
- ≥ 2 pg/g at core bottom, Bottom Conc < 50% Max Conc
- ≥ 2 pg/g at core bottom, Bottom Conc ≥ 50% Max Conc

Depth (feet)

- 0 - 5
- 5 - 10
- 10 - 15
- 15 - 20

Federally Authorized (USACE) Navigational Channel Centerline

Notes:

There is no rejected measurement present for 2,3,7,8-TCDD.

[a] MPA scale was combined since only 9 data present in this range.

[b] Unlike a continuous core, an interpolated core was not sampled continuously throughout its length. Contaminant concentrations between measured intervals were linearly interpolated.

US Army Corp of Engineers

2,3,7,8-TCDD Length Weighted Average

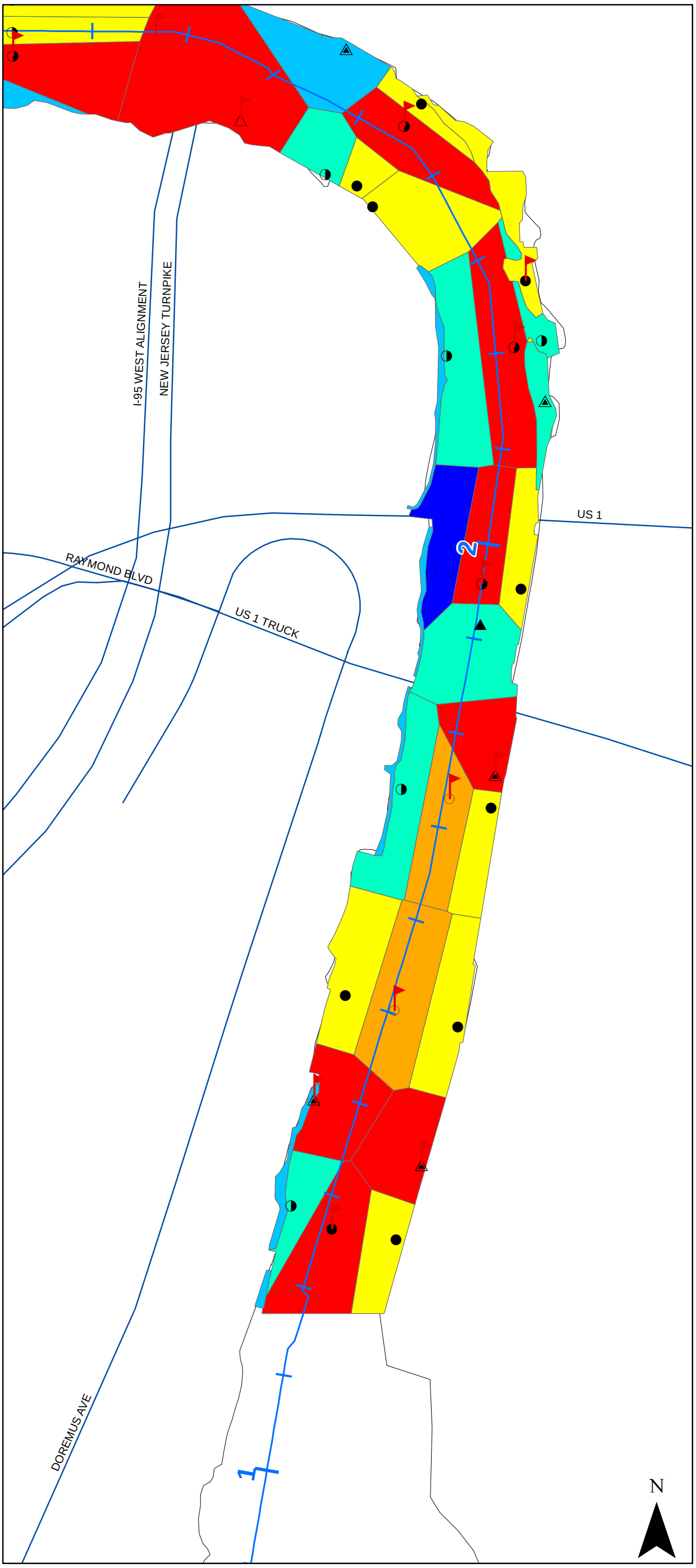
River Mile 6 to 7

Lower Passaic River Restoration Project

Figure 6f

June 2007

S:\Projects\PASSAIC\MapDocuments\4553025-IRM\IRM\LWA\from_extrapolatedMPA\LWA_TCDD_Thiessen_Portrait.mxd



Legend

Depth of Contamination

Feet (extrapolated)

- < 2.5
- 2.6 - 5.0
- 5.1 - 7.5
- 7.6 - 10.0
- 10.1 - 12.5
- 12.6 - 15.0
- > 15
- "Special" Cores

Core Type

Continuous

- ○ < 2 pg/g at core bottom
- ◑ ≥ 2 pg/g at core bottom, Bottom Conc < 50% Max Conc
- ● ≥ 2 pg/g at core bottom, Bottom Conc ≥ 50% Max Conc

Interpolated[b]

- △ < 2 pg/g at core bottom
- ◬ ≥ 2 pg/g at core bottom, Bottom Conc < 50% Max Conc
- ▲ ≥ 2 pg/g at core bottom, Bottom Conc ≥ 50% Max Conc

Federally Authorized (USACE) Navigational Channel Centerline

Notes:
There is no rejected measurement present for 2,3,7,8-TCDD.
[a] Unlike a continuous core, an interpolated core was not sampled continuously throughout its length. Contaminant concentrations between measured intervals were linearly interpolated.

500 250 0 500 Feet

US Army Corp of Engineers

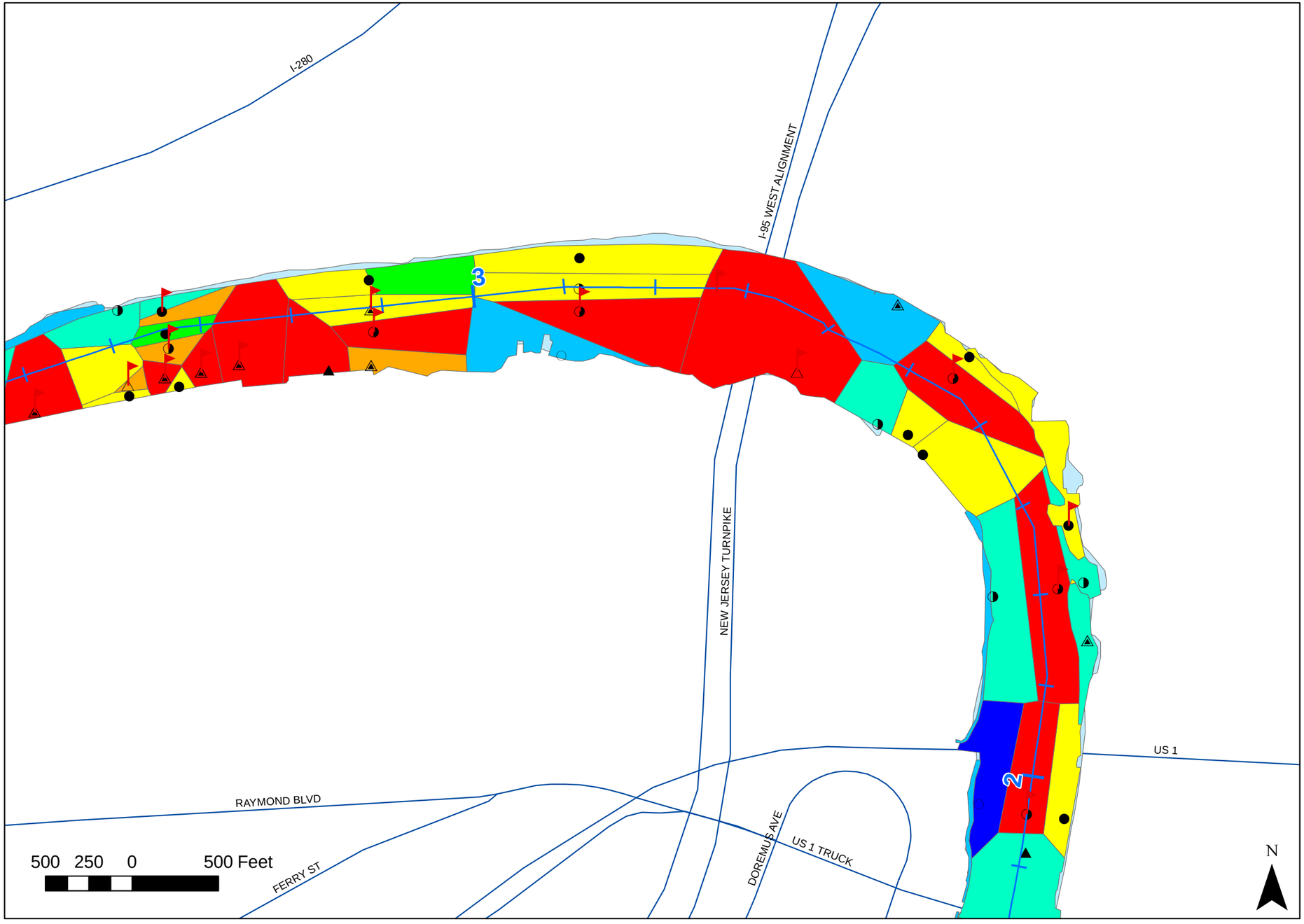
2,3,7,8-TCDD
Depth of Contamination (Extrapolated)
River Mile 1 to 2
Lower Passaic River Restoration Project

Figure 7a

June 2007

S:\Projects\PASSAIC\MapDocuments\4553025-IRM\IRM\DOC\from_extrapolatedMPA\DOCex_TCDDSum_Thiessen_Portrait.mxd

R2-0010274



Legend

Depth of Contamination

Feet (extrapolated)

- < 2.5
- 2.6 - 5.0
- 5.1 - 7.5
- 7.6 - 10.0
- 10.1 - 12.5
- 12.6 - 15.0
- > 15
- "Special" Cores

Core Type

Continuous

- < 2 pg/g at core bottom
- ≥ 2 pg/g at core bottom, Bottom Conc < 50% Max Conc
- ≥ 2 pg/g at core bottom, Bottom Conc ≥ 50% Max Conc

Interpolated[b]

- < 2 pg/g at core bottom
- ≥ 2 pg/g at core bottom, Bottom Conc < 50% Max Conc
- ≥ 2 pg/g at core bottom, Bottom Conc ≥ 50% Max Conc

Federally Authorized (USACE) Navigational Channel Centerline

Notes:
There is no rejected measurement present for 2,3,7,8-TCDD.
[a] Unlike a continuous core, an interpolated core was not sampled continuously throughout its length. Contaminant concentrations between measured intervals were linearly interpolated.

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2,3,7,8-TCDD Depth of Contamination (Extrapolated)

River Mile 2 to 3

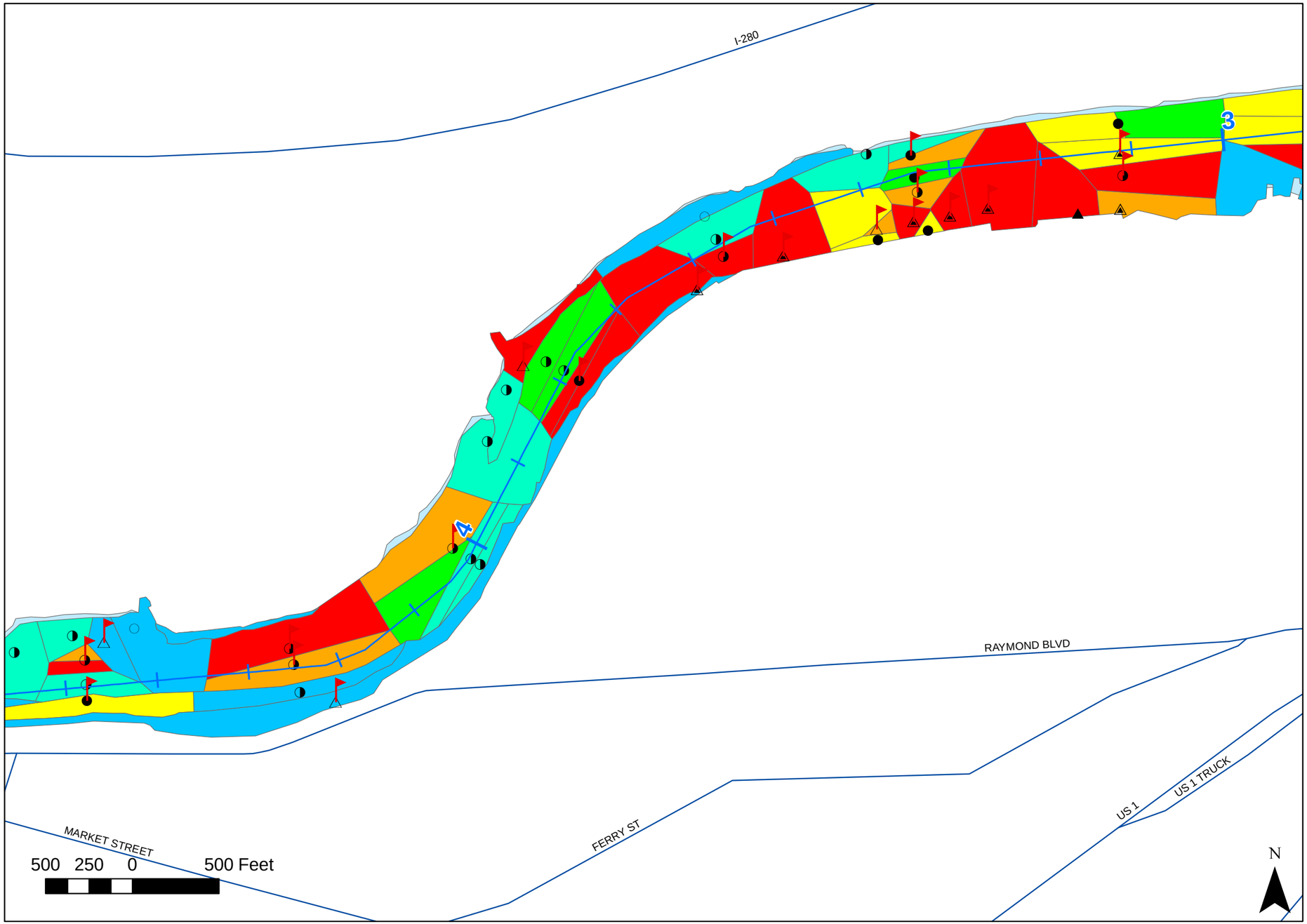
Lower Passaic River Restoration Project

Figure 7b

June 2007

S:\Projects\PASSAIC\Map\Documents\41553025-IRM\IRM\DOC\from_extrapolated\PA\DOC\ex_TCDDSum_Thiessen_Landscape.mxd

R2-0010275



Legend

Depth of Contamination

Feet (extrapolated)

- < 2.5
- 2.6 - 5.0
- 5.1 - 7.5
- 7.6 - 10.0
- 10.1 - 12.5
- 12.6 - 15.0
- > 15
- "Special" Cores

Core Type

Continuous

- < 2 pg/g at core bottom
- ≥ 2 pg/g at core bottom, Bottom Conc < 50% Max Conc
- ≥ 2 pg/g at core bottom, Bottom Conc ≥ 50% Max Conc

Interpolated[b]

- < 2 pg/g at core bottom
- ≥ 2 pg/g at core bottom, Bottom Conc < 50% Max Conc
- ≥ 2 pg/g at core bottom, Bottom Conc ≥ 50% Max Conc

Federally Authorized (USACE) Navigational Channel Centerline

Notes:
There is no rejected measurement present for 2,3,7,8-TCDD.
[a] Unlike a continuous core, an interpolated core was not sampled continuously throughout its length. Contaminant concentrations between measured intervals were linearly interpolated.

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2,3,7,8-TCDD Depth of Contamination (Extrapolated)

River Mile 3 to 4

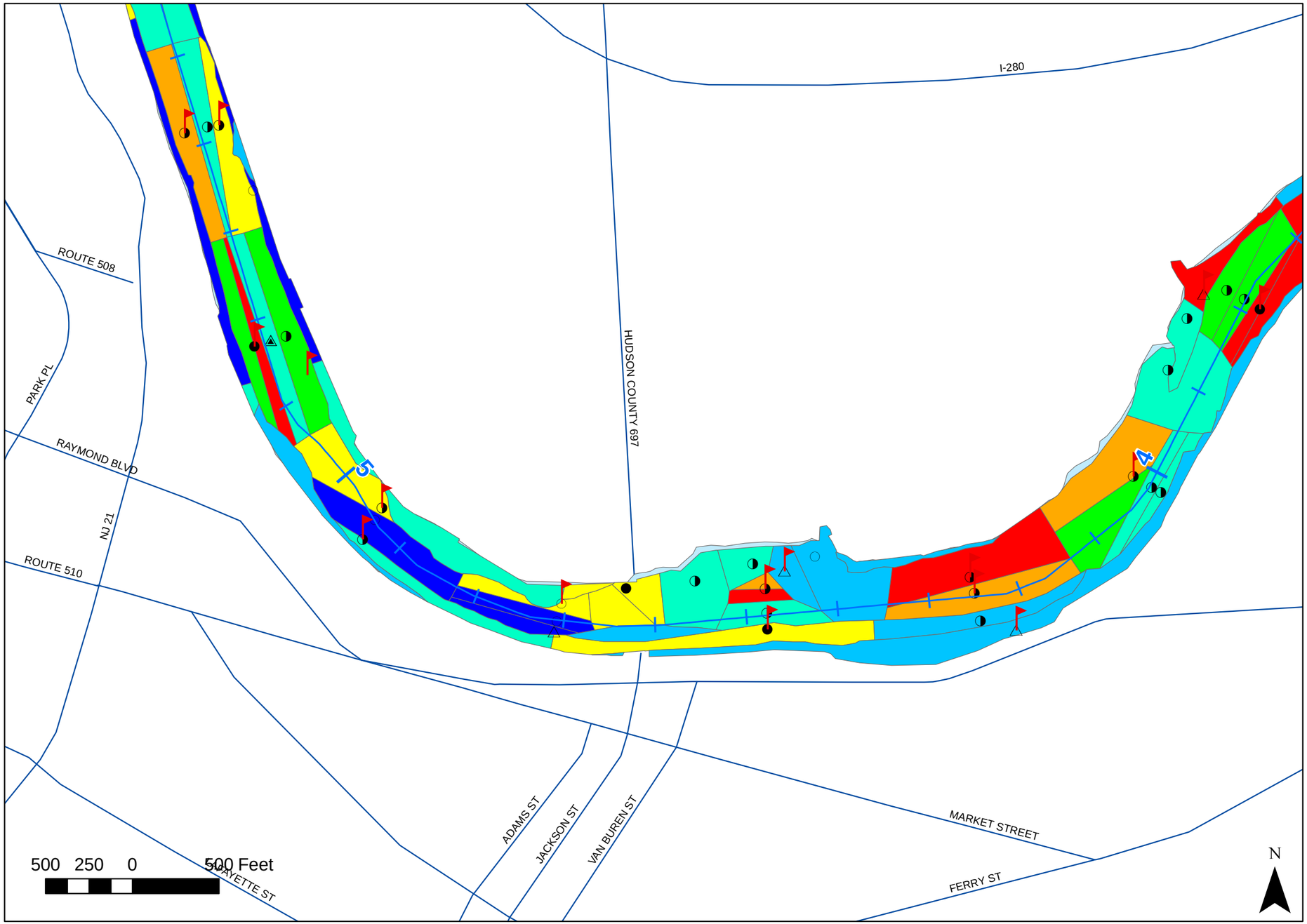
Lower Passaic River Restoration Project

Figure 7c

June 2007

S:\Projects\PASSAIC\MapDocuments\4553025-IRM\IRM\DOC\from_extrapolated\PAIDOCex_TCDDSum_Thiessen_Landscape.mxd

R2-0010276



Legend

Depth of Contamination

Feet (extrapolated)

- < 2.5
- 2.6 - 5.0
- 5.1 - 7.5
- 7.6 - 10.0
- 10.1 - 12.5
- 12.6 - 15.0
- > 15
- "Special" Cores

Core Type

Continuous

- < 2 pg/g at core bottom
- ≥ 2 pg/g at core bottom, Bottom Conc < 50% Max Conc
- ≥ 2 pg/g at core bottom, Bottom Conc ≥ 50% Max Conc

Interpolated[b]

- < 2 pg/g at core bottom
- ≥ 2 pg/g at core bottom, Bottom Conc < 50% Max Conc
- ≥ 2 pg/g at core bottom, Bottom Conc ≥ 50% Max Conc

Federally Authorized (USACE) Navigational Channel Centerline

Notes:
There is no rejected measurement present for 2,3,7,8-TCDD.
[a] Unlike a continuous core, an interpolated core was not sampled continuously throughout its length. Contaminant concentrations between measured intervals were linearly interpolated.

US Army Corps of Engineers®

2,3,7,8-TCDD Depth of Contamination (Extrapolated)

River Mile 4 to 5

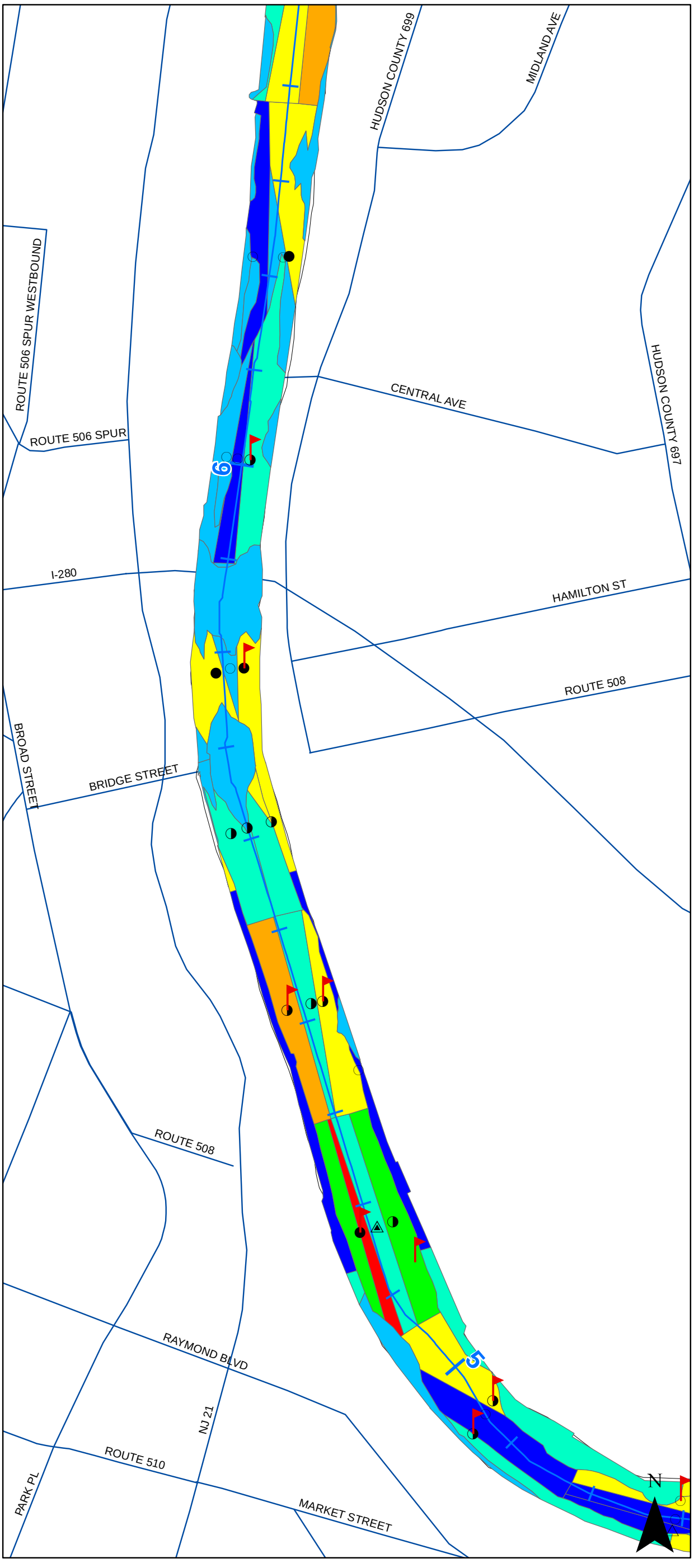
Lower Passaic River Restoration Project

Figure 7d

June 2007

S:\Projects\PASSAIC\MapDocuments\4553025-IRM\IRM\DOC\from_extrapolated\PAIDOCex_TCDDSum_Thiessen_Landscape.mxd

R2-0010277



Legend

Depth of Contamination

Feet (extrapolated)

- < 2.5
- 2.6 - 5.0
- 5.1 - 7.5
- 7.6 - 10.0
- 10.1 - 12.5
- 12.6 - 15.0
- > 15
- "Special" Cores

Core Type

Continuous

- < 2 pg/g at core bottom
- ≥ 2 pg/g at core bottom, Bottom Conc < 50% Max Conc
- ≥ 2 pg/g at core bottom, Bottom Conc ≥ 50% Max Conc

Interpolated[b]

- < 2 pg/g at core bottom
- ≥ 2 pg/g at core bottom, Bottom Conc < 50% Max Conc
- ≥ 2 pg/g at core bottom, Bottom Conc ≥ 50% Max Conc

Federally Authorized (USACE) Navigational Channel Centerline

Notes:
There is no rejected measurement present for 2,3,7,8-TCDD.
[a] Unlike a continuous core, an interpolated core was not sampled continuously throughout its length. Contaminant concentrations between measured intervals were linearly interpolated.

500 250 0 500 Feet

US Army Corp of Engineers

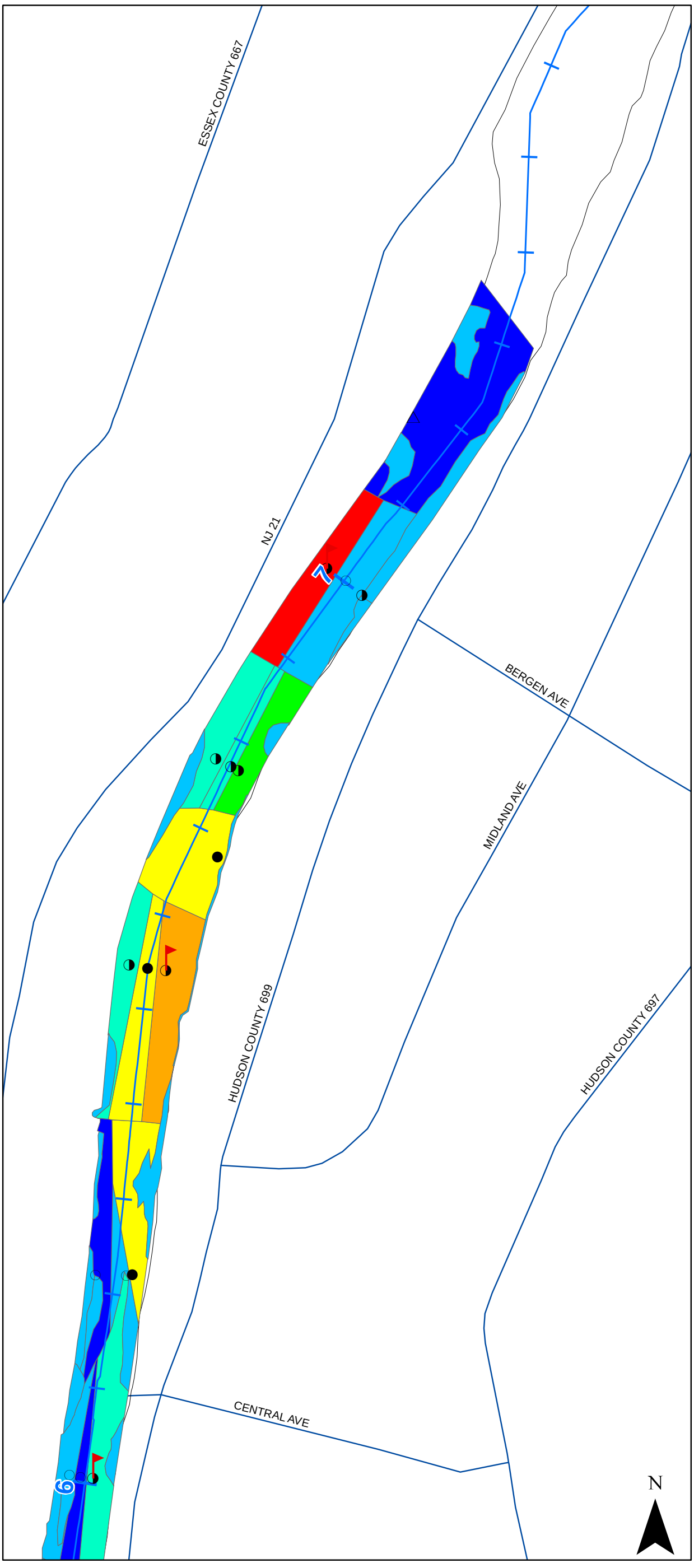
2,3,7,8-TCDD
Depth of Contamination (Extrapolated)
River Mile 5 to 6
Lower Passaic River Restoration Project

Figure 7e

June 2007

S:\Projects\PASSAIC\MapDocuments\4553025-IRM\IRM\DOC\from_extrapolated\MPA\DOCex_TCDDSum_Thiessen_Portrait.mxd

R2-0010278



Legend

Depth of Contamination

Feet (extrapolated)

- < 2.5
- 2.6 - 5.0
- 5.1 - 7.5
- 7.6 - 10.0
- 10.1 - 12.5
- 12.6 - 15.0
- > 15
- "Special" Cores

Core Type

Continuous

- < 2 pg/g at core bottom
- ≥ 2 pg/g at core bottom, Bottom Conc < 50% Max Conc
- ≥ 2 pg/g at core bottom, Bottom Conc ≥ 50% Max Conc

Interpolated[b]

- < 2 pg/g at core bottom
- ≥ 2 pg/g at core bottom, Bottom Conc < 50% Max Conc
- ≥ 2 pg/g at core bottom, Bottom Conc ≥ 50% Max Conc

Federally Authorized (USACE) Navigational Channel Centerline

Notes:
There is no rejected measurement present for 2,3,7,8-TCDD.
[a] Unlike a continuous core, an interpolated core was not sampled continuously throughout its length. Contaminant concentrations between measured intervals were linearly interpolated.

500 250 0 500 Feet

US Army Corp of Engineers

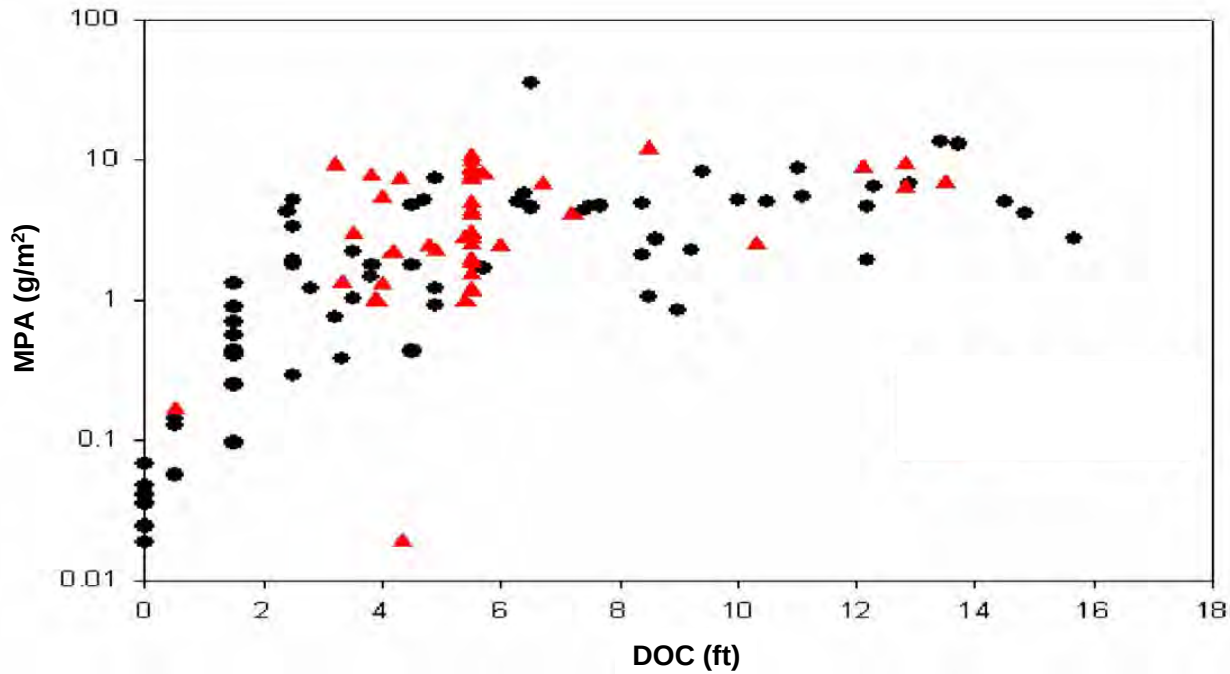
2,3,7,8-TCDD
Depth of Contamination (Extrapolated)
River Mile 6 to 7
Lower Passaic River Restoration Project

Figure 7f

June 2007

S:\Projects\PASSAIC\MapDocuments\4553025-IRM\IRM\DOC\from_extrapolatedMPA\DOCex_TCDDSum_Thiessen_Portrait.mxd

R2-0010279



Legend

- ● Complete Core
- ▲ Incomplete Core

Notes

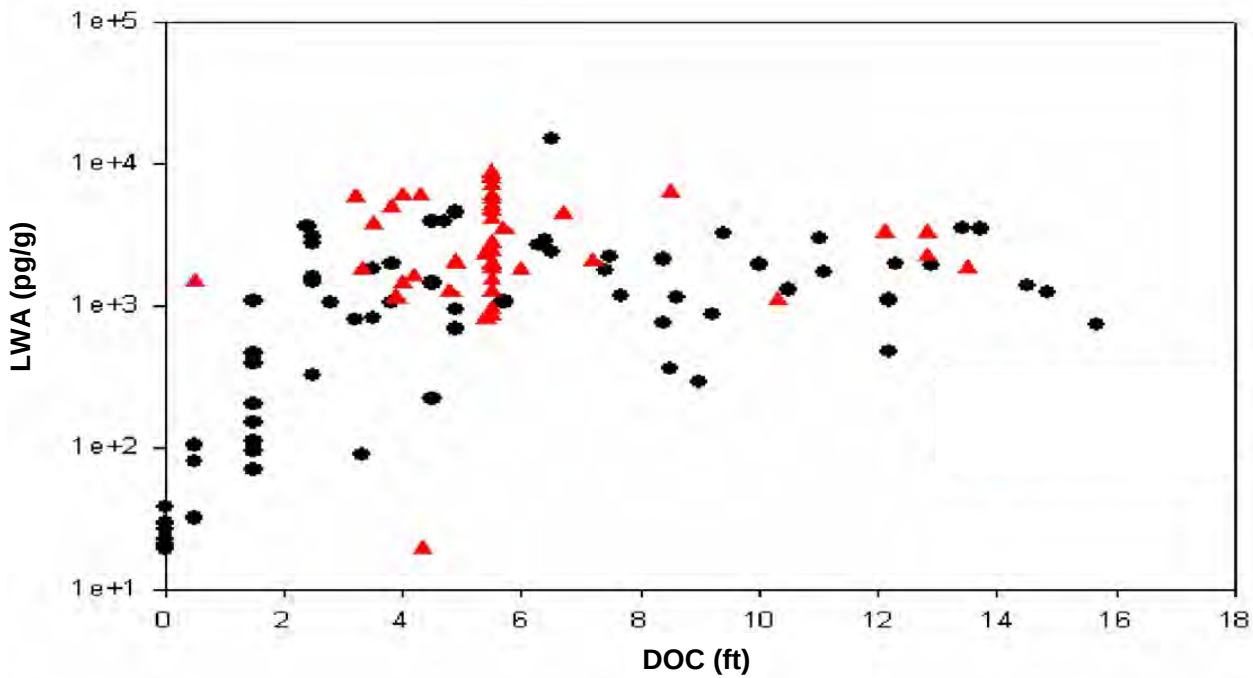
Total PCB MPA versus DOC

Lower Passaic River Restoration Project

Figure 8a

June 2007

R2-0010280



Legend

- ● Complete Core
- ▲ Incomplete Core

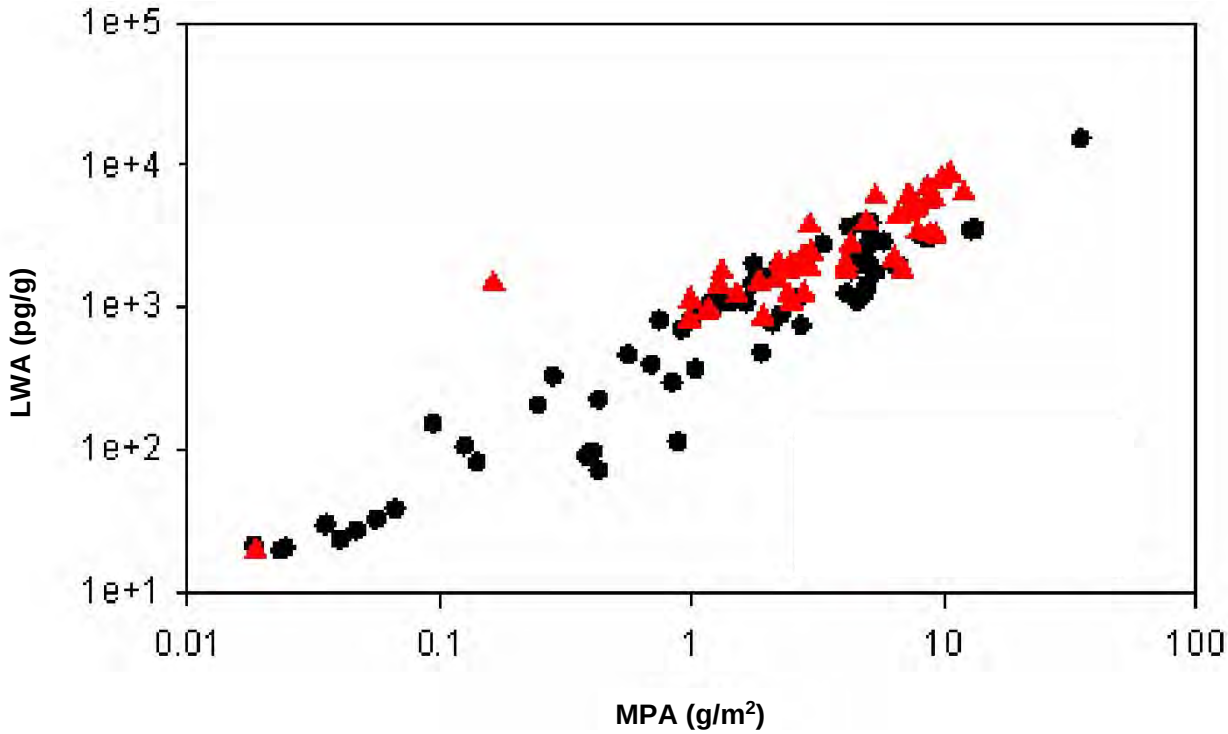
Notes

Total PCB LWA versus DOC

Lower Passaic River Restoration Project

Figure 8b

June 2007



Legend

- ● Complete Core
- ▲ Incomplete Core

Notes

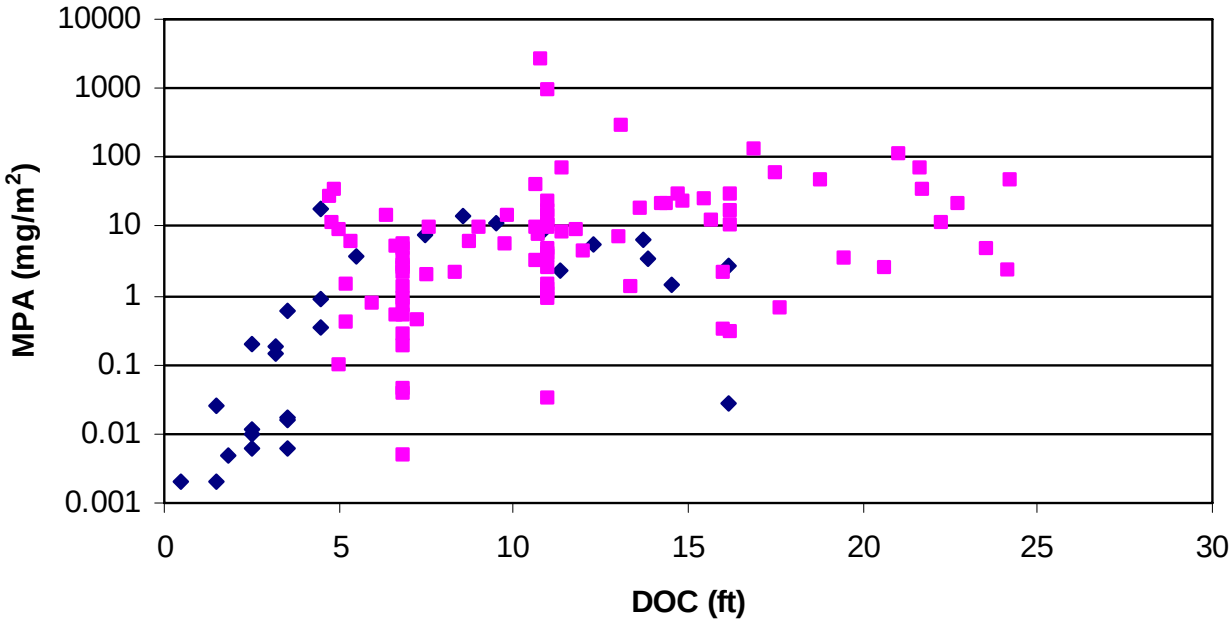
Total PCB LWA versus MPA

Lower Passaic River Restoration Project

Figure 8c

June 2007

R2-0010282



Legend

- Complete Core
- Incomplete Core

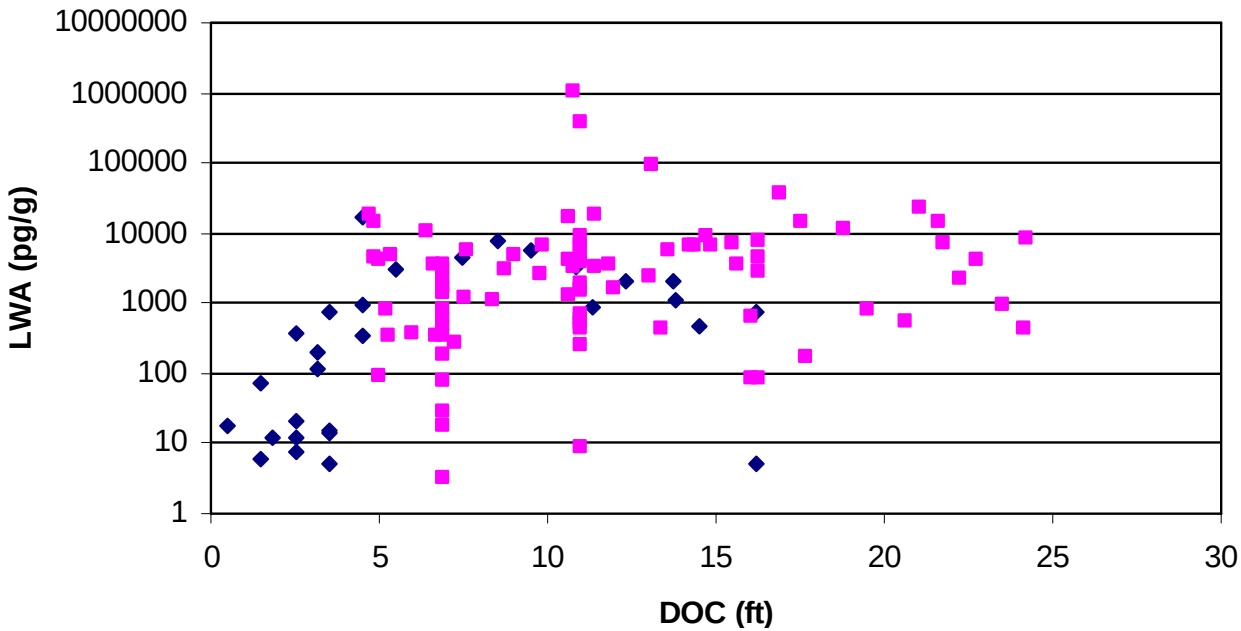
Notes

2,3,7,8-TCDD MPA versus DOC

Lower Passaic River Restoration Project

Figure 9a

June 2007



Legend

- Complete Core
- Incomplete Core

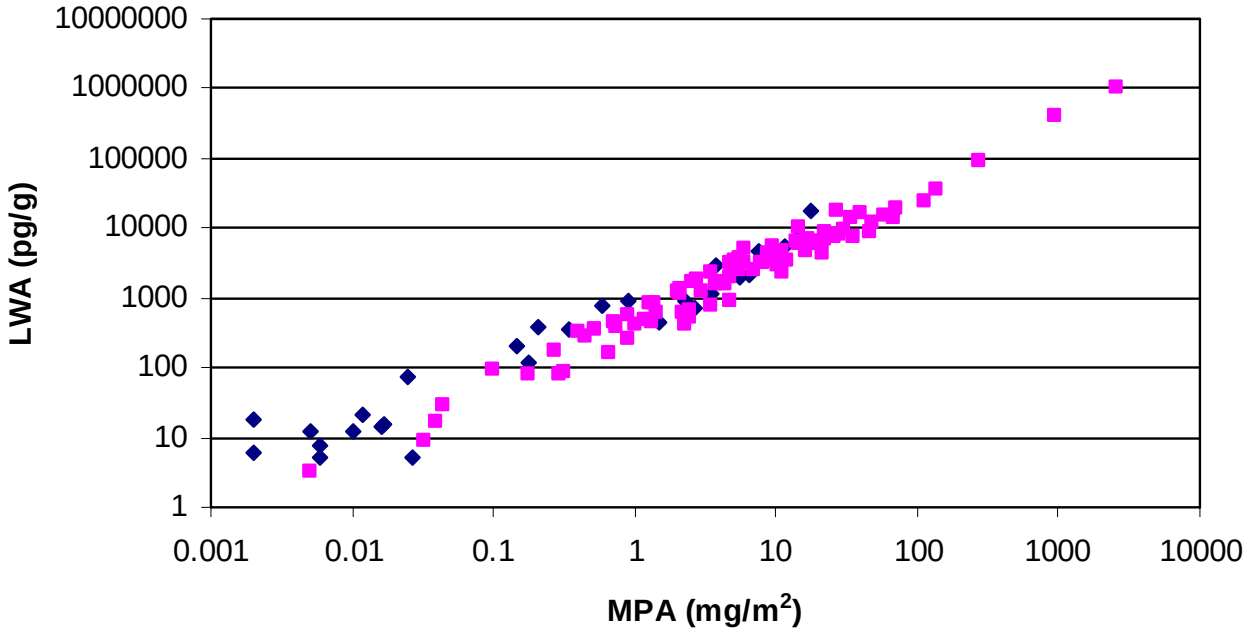
Notes

2,3,7,8-TCDD LWA versus DOC

Lower Passaic River Restoration Project

Figure 9b

June 2007



Legend

- Complete Core
- Incomplete Core

Notes

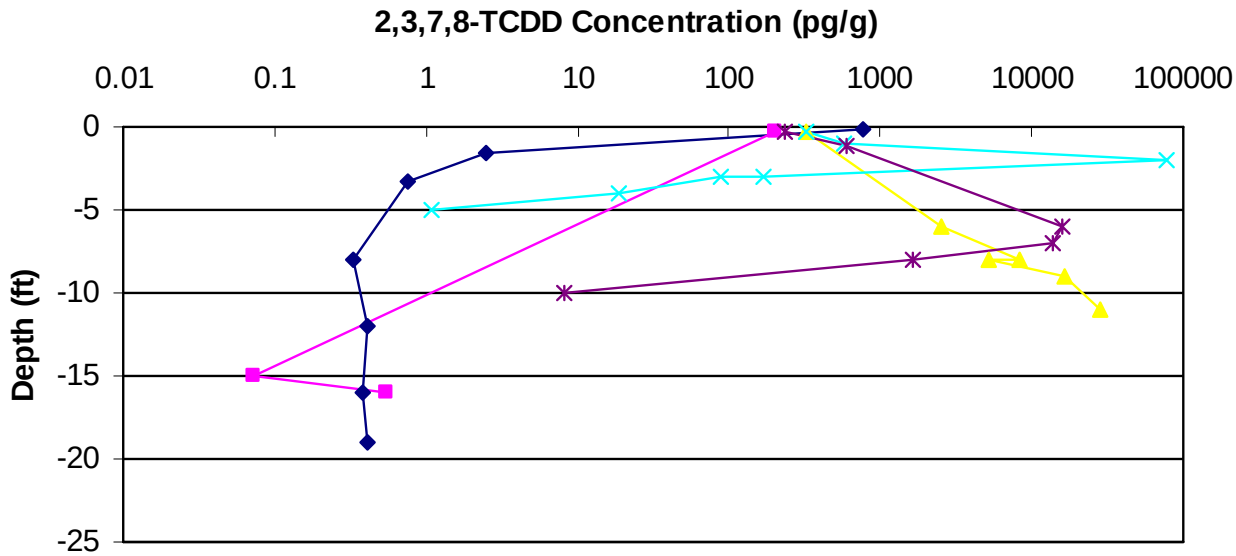
2,3,7,8-TCDD LWA versus MPA

Lower Passaic River Restoration Project

Figure 9c

June 2007

R2-0010285



Legend	DOC	MPA	LWA
USEPA Core 14A	3.2	0.1	204
TSI Core 208	13.7	6.4	2093
TSI Core 234	24.2	46.6	8647
TSI Core 284	4.5	17.5	17503
TSI Core 228	13.6	17.7	5825

Legend

- USEPA Core 14A
- TSI Core 208
- TSI Core 234
- TSI Core 284
- TSI Core 228

Notes

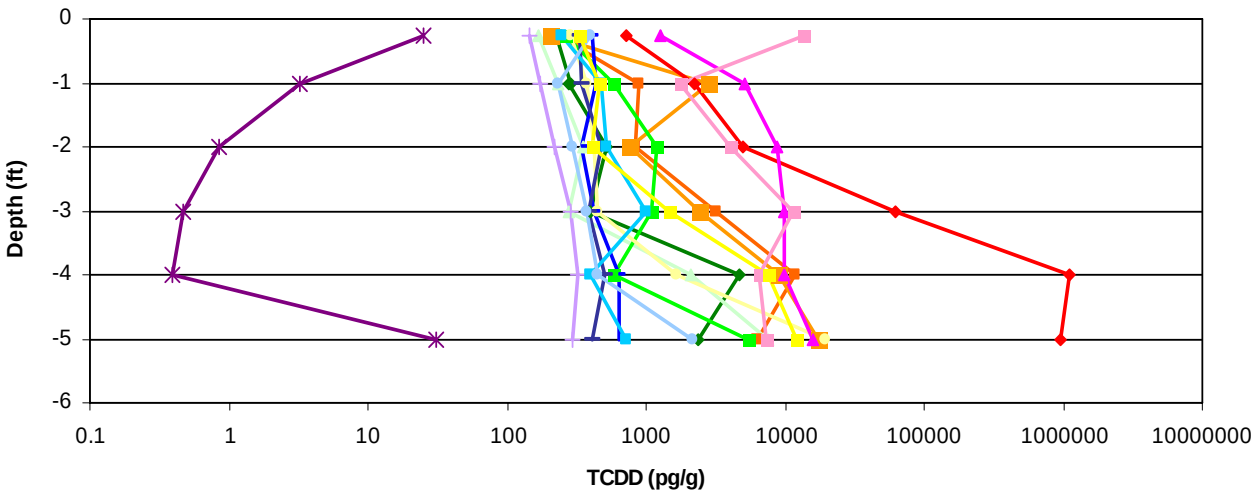
Data source: United State Environmental Protection Agency (USEPA) 1991 Sediment Coring Program and Tierra Solutions, Inc. (TSI) 1995 dataset.

2,3,7,8-TCDD Profiles for Selected Cores

Lower Passaic River Restoration Project

Figure 10a

June 2007



Legend

- TSI Core 203
- TSI Core 206
- TSI Core 204
- TSI Core 209
- TSI Core 212
- TSI Core 292
- TSI Core 295
- TSI Core 282
- TSI Core 216
- TSI Core 286
- TSI Core 218
- TSI Core 227
- TSI Core 224
- TSI Core 261
- TSI Core 263
- TSI Core 296

Notes

Data source: United State Environmental Protection Agency (USEPA) 1991 Sediment Coring Program and Tierra Solutions, Inc. (TSI) 1995 dataset.

2,3,7,8-TCDD Profile for Selected Incomplete Cores

Lower Passaic River Restoration Project

Figure 10b

June 2007

R2-0010287

MALCOLM PIRNIE

Interoffice Correspondence

Date: April 23, 2007

To: L. Bossi (WHI)

Copy: S. Thompson (WHI), G. Druback (WHI)

From: K. Pathirage (WHI)

RE: Stability (Static) Evaluation of Proposed Cap System and Evaluation of Settlement of Proposed Cap: Lower Passaic River

INTRODUCTION

A sand cap of 2.5 feet in thickness is being evaluated in the Focused Feasibility Study (FFS). However, several locations of the proposed sand cap were identified by HydroQual, Inc. as susceptible to erosion. To mitigate this concern, an erosion protection layer (armor stone layer) on top of the sand cap was proposed to protect the integrity of the proposed sand cap in locations where potential erosion is identified. Furthermore, a portion of the river bed would require pre-dredging prior to placing the proposed sand cap or both the cap and the armor stone layer. This memorandum documents preliminary analyses conducted to evaluate:

- The stability of the slopes of the navigation channel and intertidal riverbanks along with the proposed sand cap (*i.e.*, 2.5-foot of sand layer) and the armor stone layer (*i.e.*, an 18-inch stone layer) under both high and low water levels in the river.
- The stability of the slopes of the navigation channel and intertidal riverbanks with the proposed sand cap only under both high and low water levels in the river.
- The purpose of the slope stability analyses was to determine the required slope for the navigation channel side banks and the intertidal riverbanks that would remain stable slopes from slip failures under static conditions for the proposed sand cap and the armor stone layer.

SLOPE/W (GEO-SLOPE, International, Ltd. Version 4.23) was used to perform the slope stability analysis. All slope stability analyses were performed and subsequent factors of safety were calculated against a circular failure mode. In addition, a preliminary consolidation analysis was conducted to estimate a potential loss of elevation of the proposed cap (*i.e.*, a reduction of sediment thickness) due to a probable consolidation of the subgrade material in the river bed caused by the vertical stress induced from the proposed cap material weight.

Limited geotechnical data exist for the Lower Passaic River. Consequently, the strength parameters used in the stability analyses and settlement calculations were derived from technical literature. (Refer to the reference section of this memorandum for literature utilized in these analyses.) A final design-level cap stability evaluation will require a geotechnical testing program to obtain samples for laboratory analyses to confirm the assumed values and the strata elevations assumed in this preliminary analysis.

STABILITY EVALUATION CRITERIA

Lateral channel slopes along with the intertidal areas were assumed to vary by the channel depth, the presence or lack of stone armor, the tide conditions, and presence or lack of silty sediment materials.

Analyses considered two navigation channel water depth scenarios (*i.e.*, 20 feet deep and 30 feet deep channel) along with a 1 vertical to 2 horizontal slope (1V:2H) and a 1 vertical to 3 horizontal (1V:3H) for the side slopes of the navigation channel in addition to a slope of 1 vertical to 4 horizontal (1V:4H) for the intertidal riverbank slopes. Furthermore, analyses considered both high and low tide water levels in the river to conduct stability analyses. No pore water pressure dissipation in the intertidal riverbanks was considered for modeling with the low water level condition (*i.e.*, low water conditions occur twice a day due to the tidal effect) in the river. The purpose of this approach was to evaluate a slope configuration for the navigation channel and intertidal riverbanks when supporting the proposed cap under low water conditions. In addition, dredging of berth areas may have occurred in the Lower Passaic River, but locations of

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these historical berth areas have not been identified. Areas of historical berth dredging, if they exist, likely contain thick sequences of silty material, which extend from the current bathymetry to the depth of historical dredging. To account for this potential condition in the river, the side slopes of the navigation channel were modeled not only with the stronger native soil material but also with the weaker silty material (*i.e.*, presence or lack of silty sediment material). Note that the stability analyses discussed in this memorandum consider only static conditions and no seismic conditions were considered in the stability analyses.

CROSS SECTIONS CONSIDERED FOR STABILITY ANALYSES

The stability analyses considered one cross-section collected at river mile (RM) 1 (boring 1A-C; Aqua Survey, Inc., 2006). A copy of the boring log is presented in Attachment 1.

SOIL PARAMETERS

Several Vibracore boring logs were reviewed, and the information obtained from one Vibracore collected at RM1.7 (*i.e.*, boring 2A in Attachment 1; Aqua Survey, Inc., 2006) was used to infer subsurface strata layers for stability analyses since this boring was the deepest boring drilled in the area [*i.e.*, boring refusal was recorded approximately 30 feet below ground surface (bgs)]. Based on information obtained from this review, a general profile of soils in the area was developed for the stability model. A layer of sandy lean clay was encountered at depths approximately 23 feet bgs. This layer is overlain by a fine-medium sand layer approximately 11 feet thick. On top of this layer is an approximately 3-foot layer of clayey silt. This layer is overlain by a peat layer approximately 2 feet thick and the uppermost layer consists of silt approximately 7 feet thick. No blow counts (*i.e.*, N-values) from Standard Penetration Test or laboratory test results were available.[1] Values published in the literature were used in the stability models. (See the reference section of this memorandum for list of literature.)

[1] ASTM D 1586 "Standard Test Method for Penetration Test and Split Barrel Sampling of Soils."

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Stability analyses were conducted using the computer program SLOPE/W and the Morgenstern-Price analysis method was used to determine the factor of safety (FOS) of the proposed cap (Table 1).

Table 1: Assumed Strength Parameters of the Subgrade Material used in Stability Analyses

Description	Cohesion, Pounds per square foot	Angle of Internal Friction, φ	Unit weight, Pounds per cubic foot
Silty Sand	0	30	120
Armor Stone layer	0	35	135
Sand Cap	0	30	110
Silt	0	26	100
Peat	100	0	90
Clayey Silt	300	10	100
Fine-Medium Sand	0	32	115
Sandy Lean Clay	600	0	115

The resulting factors of safety are tabulated in Table 2 and Table 3. The slope stability analyses results are presented in Attachment 2.

Table 2: FOS for Slopes of Navigation Channel and Riverbanks of Native Materials With the Armor Stone Layer and the Sand Cap

Analysis Details	Channel Depth/Water Condition	Calculated FOS
Navigation Channel Slope 2H:1V and Intertidal Riverbank Slope 4H:1 (sand cap and armor stone layer, side slopes with native material)	Shallow Section/ High Water	1.32
Navigation Channel Slope 2H:1V and Intertidal Riverbank Slope 4H:1 (sand cap and armor stone layer, side slopes with native material)	Shallow Section/ Low Water	1.17
Navigation Channel Slope 2H:1V and Intertidal Riverbank Slope 4H:1 (sand cap and armor stone layer, side slopes with native material)	Deep Section/ High Water	1.22
Navigation Channel Slope 2H:1V and Intertidal Riverbank Slope 4H:1 (sand cap and armor stone layer, side slopes with native material)	Deep Section/ Low Water	1.04

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Table 3: FOS for Slopes of Navigation Channel and Riverbanks of Native Materials With the Sand Cap Only

Analysis Details	Channel Depth/Water Condition	Calculated FOS
Navigation Channel Slope 2H:1V and Intertidal Riverbank Slope 4H:1 (sand cap, side slopes with native material)	Shallow Section/ High Water	1.30
Navigation Channel Slope 2H:1V and Intertidal Riverbank Slope 4H:1 (sand cap, side slopes with native material)	Shallow Section/ Low Water	1.12
Navigation Channel Slope 2H:1V and Intertidal Riverbank Slope 4H:1 (sand cap, side slopes with native material)	Deep Section/ High Water	1.14
Navigation Channel Slope 2H:1V and Intertidal Riverbank Slope 4H:1 (sand cap, side slopes with native material)	Deep Section/ Low Water	1.01

Stability analyses assuming native material navigation channel slopes and riverbanks indicate (Table 4 and Table 5):

- Locations where the proposed sand cap along with the armor stone layer are placed over the native material (*i.e.*, sandy soils with at least a frictional value of 30 degrees) yielded a FOS above 1 with the slopes of 1V:2H and 1V:4H for the navigation channel and the intertidal river banks, respectively.
- Locations where only the proposed sand cap is placed over the native material (*i.e.*, sandy soils at least a frictional value of 30 degrees) also yielded a FOS above 1 with the slopes of 1V:2H and 1V:4H for the navigation channel and the intertidal river banks, respectively.

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Table 4: FOS for Slopes of Navigation Channel and Riverbanks of Silty Sediment With the Armor Stone Layer and the Sand Cap

Analysis Details	Channel Depth/Water Condition	Calculated FOS
Navigation Channel Slope 2H:1V and Intertidal Riverbank Slope 4H:1 (sand cap and armor stone layer, side slopes with silty material)	Shallow Section/ High Water	1.26
Navigation Channel Slope 2H:1V and Intertidal Riverbank Slope 4H:1 (sand cap and armor stone layer, side slopes with silty material)	Shallow Section/ Low Water	1.05
Navigation Channel Slope 2H:1V and Intertidal Riverbank Slope 4H:1 (sand cap and armor stone layer, side slopes with silty material)	Deep Section/ High Water	1.12
Navigation Channel Slope 2H:1V and Intertidal Riverbank Slope 4H:1 (sand cap and armor stone layer, side slopes with silty material)	Deep Section/ Low Water	0.98

Table 5: FOS for Slopes of Navigation Channel and Riverbanks of Silty Sediment With the Sand Cap Only

Analysis Details	Channel Depth/Water Condition	Calculated FOS
Navigation Channel Slope 2H:1V and Intertidal Riverbank Slope 4H:1 (sand cap, side slopes with silty material)	Shallow Section/ High Water	1.17
Navigation Channel Slope 2H:1V and Intertidal Riverbank Slope 4H:1 (sand cap, side slopes with silty material)	Shallow Section/ Low Water	1.09
Navigation Channel Slope 2H:1V and Intertidal Riverbank Slope 4H:1 (sand cap, side slopes with silty material)	Deep Section/ High Water	1.08
Navigation Channel Slope 2H:1V and Intertidal Riverbank Slope 4H:1 (sand cap, side slopes with silty material)	Deep Section/ Low Water	0.98

Stability analyses assuming silty sediment navigation channel slopes and riverbanks, accounting for historical berth dredging, indicate (Table 6):

- Locations where the proposed sand cap along with the armor stone layer is placed over the silty material (*i.e.*, silty soils with a frictional value of 26 degrees) yielded a FOS above 1 with the slopes of 1V:2H and 1V:4H for the navigation channel and the intertidal river banks, respectively.
- Locations where only the proposed sand cap is placed over the silty material (*i.e.*, silty soils with a frictional value of 26 degrees) also yielded a FOS above 1 with the

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slopes of 1V:2H and 1V:4H for the navigation channel and the intertidal river banks, respectively under high water levels in the river. However, during the low tides in the river, the resulting FOS is marginal (slightly less than 1). Therefore, it is prudent to consider shallower slopes (*i.e.*, a slope of 1V:3H, Table 6) for the proposed sand cap construction at locations that contain thick sequences of silty material which extend from the current bathymetry to the depth of historical dredging. Alternatively, geosynthetics could be used to improve the stability of the cap in areas where the navigation channel slopes are adjacent to thick silt sequences (*i.e.*, historical berth areas).

Table 6: FOS for Slopes of Navigation Channel and Riverbanks of Silty Sediment With the Sand Cap Only

Analysis Details	Channel Depth/Water Condition	Calculated FOS
Navigation Channel Slope 3H:1V and Intertidal Riverbank Slope 4H:1 (sand cap, side slopes with silty material)	Deep Section/ Low Water	1.15

COMPRESSION OF SUBGRADE ("CONSOLIDATION")

Consolidation of the subgrade in the riverbed, induced by the placement of the proposed sand cap and armor layer was estimated by computing elastic deformations, since the subgrade consists mainly of non-plastic silty material. These settlement calculations were performed to estimate the loss of the cap grade resulting from the consolidation of the subgrade. Based on results of the consolidation analyses, it can be anticipated that the proposed sand cap may settle 6 to 10 inches (approximately 1-2 inches per foot of silt) due to consolidation in the silty subgrade. The result of consolidation calculations is included in Attachment 3.

DISCUSSION

Slope stability analyses and consolidation analyses were conducted using derived strength parameters from the technical literature. It is necessary to conduct a geotechnical program (*i.e.*, borings plus laboratory tests) to obtain representative samples for laboratory analyses to confirm the assumed strength values and the strata elevations that were used in these preliminary analyses prior to finalizing a design.

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REFERENCES

Aqua Survey, Inc., 2006. "Technical Report: Geophysical Survey Lower Passaic RiverRestoration Project." Lower Passaic River Restoration Project. July 2006.

Carter, M and Bently SP. 1990. "Correlations of Soil Properties." American Society of Civil Engineers, 1990.

Das, BJ. 2002. Principles of Geotechnical Engineering. 5th Edition. Brooks/Cole.

Teng, W. 1962. Foundation Design. Prentice Hall.

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ATTACHMENT 1

BORING LOGS FROM TECHNICAL REPORT, GEOPHYSICAL SURVEY (Aqua Survey, Inc., 2006)

R2-0010296

MALCOLM PIRNIE, INC.

17-17 ROUTE 208 NORTH, FAIRLAWN, NEW JERSEY 07410

BORING: **1A-C**
Time: 1306

PROJECT NAME:	**Lower Passaic River Geotechnical**	**DATE:**	**6/9/2005**
JOB NUMBER:	**3473007**	**LOCATION:**	**Mile 1**
DRILLING FIRM:	**Aqua-Survey, Inc.**	**WEATHER:**	**Clear and Hot**
DRILLING METHOD:	**Vibracore**	**ELEVATION:**	**N/A**
DRILLER:	**Mark Padover**	**DATUM:**	**NAD83**
HELPER:		**HYDROGEOLOGIST:**	**D. Auld**

SAMPLE INFORMATION										
No.	**Depth**	**Rec**	**Blows per 6"**				**Depth**	**SOIL DESCRIPTION**	**USCS Lithology**	**REMARKS**
1	0 - 45"						0 - 45"	Silt w/Fine Sand (<15% Fine Sand)	ML	Medium Bluish Gray (5YR 5/1)
2	45 - 111"						45 - 111"	Elastic Silt w/Fine-Medium Sand (~ 10% Sand)	MH	Medium Bluish Gray (5YR 5/1)
										Sample # 30 (60 - 77")
3	111 - 127"						111 - 127"	Poorly Graded Silt w/Sand (>15% Fine Sand)	SW	Dark Gray (7.5YR 4/2)
								Refusal @ 127"		
										East: 597382.6 North: 687155.0
										Core Barrel Advanced: 144" Recovery: 127"

Sample ID	Lab Sample ID	SDG	Analysis_Date	Analysis Method	Analysis Method Description	Cas No/Param_Code	Description	Results	Units
DC-01A-C	20050763		7/1/2005	ASTMD422	Particle Size Analysis	%_GRAVEL	%_GRAVEL	1.12%	%
DC-01A-C	20050763		7/1/2005	ASTMD422	Particle Size Analysis	%_SAND	%_SAND	93.76%	%
DC-01A-C	20050763		7/1/2005	ASTMD422	Particle Size Analysis	%_SILT	%_SILT	1.04%	%
DC-01A-C	20050763		7/1/2005	ASTMD422	Particle Size Analysis	%_CLAY	%_CLAY	4.08%	%
DC-01A-C	20050763		6/24/2005	ASTMD2974	Moisture Content	%_MOISTURE	%_MOISTURE	14.7	%
DC-01A-C	20050763		7/1/2005	ASTMC136	Sieve Analysis	SA_1in	% passing 1"	100.00%	%
DC-01A-C	20050763		7/1/2005	ASTMC136	Sieve Analysis	SA_3/4in	% passing 3/4"	100.00%	%
DC-01A-C	20050763		7/1/2005	ASTMC136	Sieve Analysis	SA_3/8in	% passing 3/8"	100.00%	%
DC-01A-C	20050763		7/1/2005	ASTMC136	Sieve Analysis	SA_4	% passing #4	99.88%	%
DC-01A-C	20050763		7/1/2005	ASTMC136	Sieve Analysis	SA_10	% passing #10	98.88%	%
DC-01A-C	20050763		7/1/2005	ASTMC136	Sieve Analysis	SA_20	% passing #20	93.90%	%
DC-01A-C	20050763		7/1/2005	ASTMC136	Sieve Analysis	SA_40	% passing #40	72.24%	%
DC-01A-C	20050763		7/1/2005	ASTMC136	Sieve Analysis	SA_60	% passing #60	41.07%	%
DC-01A-C	20050763		7/1/2005	ASTMC136	Sieve Analysis	SA_100	% passing #100	35.48%	%
DC-01A-C	20050763		7/1/2005	ASTMC136	Sieve Analysis	SA_200	% passing #200	33.61%	%
DC-01A-C	20050763		6/22/2005	ASTMD422	Hydrometer Analysis	HA_LDIS2min	Largest diameter of particle in suspension at 2 minutes	0.037197	mm
DC-01A-C	20050763		6/22/2005	ASTMD422	Hydrometer Analysis	HA_LDIS5min	Largest diameter of particle in suspension at 5 minutes	0.023526	mm
DC-01A-C	20050763		6/22/2005	ASTMD422	Hydrometer Analysis	HA_LDIS15min	Largest diameter of particle in suspension at 15 minutes	0.013583	mm
DC-01A-C	20050763		6/22/2005	ASTMD422	Hydrometer Analysis	HA_LDIS30min	Largest diameter of particle in suspension at 30 minutes	0.009630	mm
DC-01A-C	20050763		6/22/2005	ASTMD422	Hydrometer Analysis	HA_LDIS60min	Largest diameter of particle in suspension at 60 minutes	0.006810	mm
DC-01A-C	20050763		6/22/2005	ASTMD422	Hydrometer Analysis	HA_LDIS250miin	Largest diameter of particle in suspension at 250 minutes	0.003336	mm
DC-01A-C	20050763		6/22/2005	ASTMD422	Hydrometer Analysis	HA_LDIS1440min	Largest diameter of particle in suspension at 1440 minutes	0.001390	mm
DC-01A-C	20050763		6/22/2005	ASTMD422	Hydrometer Analysis	HA_%FTDat2min	% finer than diameter calculated at 2 minutes	5.00%	%
DC-01A-C	20050763		6/22/2005	ASTMD422	Hydrometer Analysis	HA_%FTDat5min	% finer than diameter calculated at 5 minutes	5.00%	%
DC-01A-C	20050763		6/22/2005	ASTMD422	Hydrometer Analysis	HA_%FTDat15min	% finer than diameter calculated at 15 minutes	5.00%	%
DC-01A-C	20050763		6/22/2005	ASTMD422	Hydrometer Analysis	HA_%FTDat30min	% finer than diameter calculated at 30 minutes	4.00%	%
DC-01A-C	20050763		6/22/2005	ASTMD422	Hydrometer Analysis	HA_%FTDat60min	% finer than diameter calculated at 60 minutes	4.00%	%
DC-01A-C	20050763		6/22/2005	ASTMD422	Hydrometer Analysis	HA_%FTDat250min	% finer than diameter calculated at 250 minutes	4.00%	%
DC-01A-C	20050763		6/22/2005	ASTMD422	Hydrometer Analysis	HA_%FTDat1440min	% finer than diameter calculated at 1440 minutes	4.00%	%
DC-01A-C	20050763		7/20/2005	ASTMD4318	Atterberg Limits	AL_LL%M	Liquid Limit	<1>	%
DC-01A-C	20050763		7/20/2005	ASTMD4318	Atterberg Limits	AL_PL%M	Plastic Limit	<1>	%
DC-01A-C	20050763		7/20/2005	ASTMD4318	Atterberg Limits	PI	Plasticity Index	<1>	%
DC-01A-C	20050763		7/20/2005	ASTMD4318	Atterberg Limits	AL_LLMC	Liquid Limit Moisture Content	<1>	%
DC-01A-C	20050763		7/20/2005	ASTMD4318	Atterberg Limits	AL_PLMC	Plastic Limit Moisture Content	<1>	%
DC-01A-C	20050763		7/20/2005	ASTMD4531	Bulk Density	BULK_DEN	Bulk Density in grams/milliliter, dry recovery	1.549	
DC-01A-C	20050763		6/17/2005	EPA 9060	TOC	TOC	Total Organic Carbon	1,136	ppm
DC-01A-C	20050763		6/17/2005	EPA 9060	% TOC	TOC_%DW	% Total Organic Carbon of dry weight	0.11	%

<1> Sample did not exhibit plastic qualities due to insufficient sample passing through #40 sieve.

* Location DC-01A-C was sampled on 9 June and 13 June 2005. The analysis was done on the sample from 13 June 2005.

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MALCOLM PIRNIE, INC.

17-17 ROUTE 208 NORTH, FAIRLAWN, NEW JERSEY 07410

BORING: **2A**
Time: 0840

PROJECT NAME:	**Lower Passaic River Geotechnical**	**DATE:**	**6/14/2005**
JOB NUMBER:	**3473007**	**LOCATION:**	**Mile 2**
DRILLING FIRM:	**Aqua-Survey, Inc.**	**WEATHER:**	**Hazy and Hot**
DRILLING METHOD:	**Vibracore**	**ELEVATION:**	**N/A**
DRILLER:	**Mark Padover**	**DATUM:**	**NAD83**
HELPER:		**HYDROGEOLOGIST:**	**D. Auld**

SAMPLE INFORMATION										
No.	**Depth**	**Rec**	**Blows per 6"**				**Depth**	**SOIL DESCRIPTION**	**USCS Lithology**	**REMARKS**
1	0 - 80"						0 - 80"	Silt	ML	Black (5YR 2.5/1)
2	80 -96"						80 - 96"	Peat	OL	Brownish Gray (5YR 4/1)
3	96 - 111"						96 - 111"	Clayey Silt	ML	Reddish Gray (5YR 5/2)
4	111 - 121"						111 - 121"	Poorly Graded Fine - Medium Sand w/Silt (~20% Fines)	SP	Medium Bluish Gray (5B 5/1)
5	121 - 152"						121 - 152"	Very Loose Fine-Medium Sand w/Silt (>15% Fines)	SP	Medium Bluish Gray (5B 5/1)
										Sample # 35 (121 - 140")
6	152 - 203"						152 - 203"	Medium-Coarse Sand w/Gravel (<20% Fine Gravel)	SW/SP	Moderate Yellowish Brown (10YR 5/4)
7	203 - 226"						203 - 226"	Clay w/Medium Plasticity and Silt Lenses	CH	Dark Reddish Brown (10R 3/4)
8	226 - 231"						226 - 231"	Fine - Medium Well Graded Sand/Silt (<15% Fines)	SW	Dark Reddish Brown (10R 3/4)
								Refusal @ 360" (30-ft.)		East: 597693.0 North: 691338.9 Core Barrel Advanced: 360" Recovery: 231"

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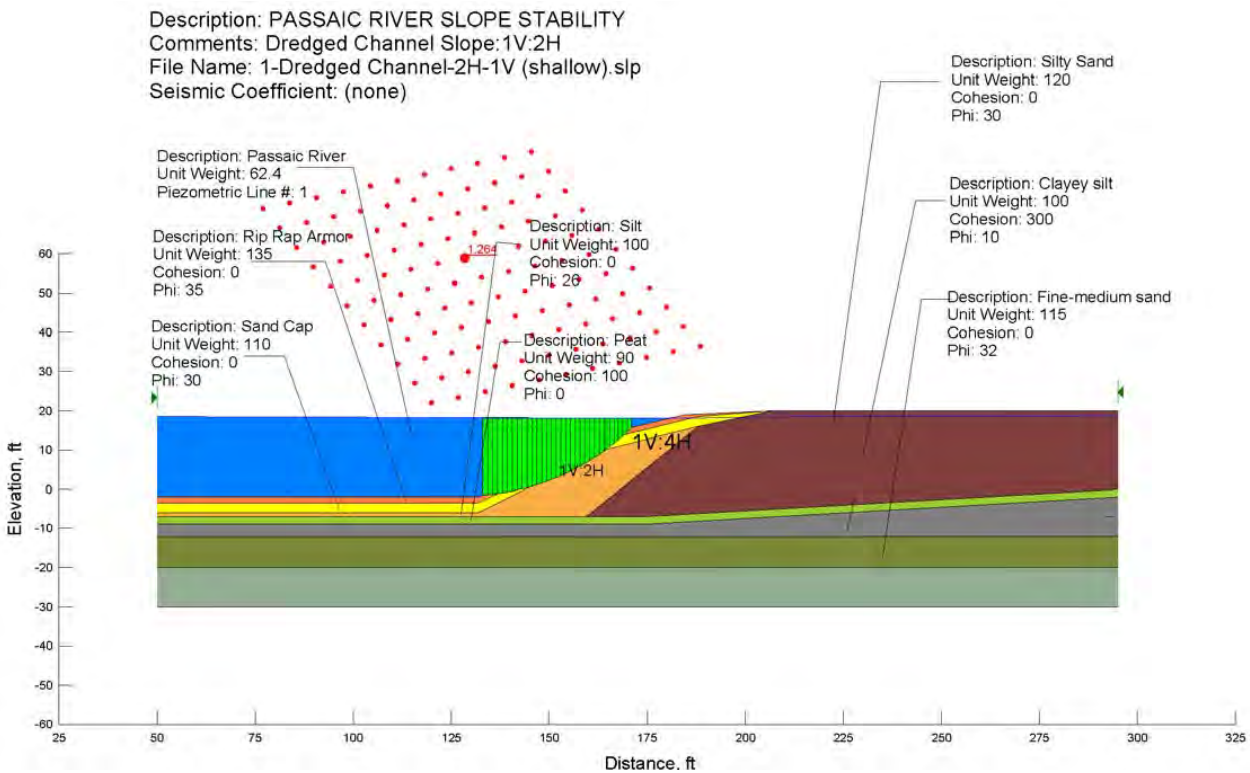
Sample ID	Lab Sample ID	SDG	Analysis_Date	Analysis Method	Analysis Method Description	Cas No/Param_Code	Description	Results	Units
DC-02A	20050767		7/1/2005	ASTMD422	Particle Size Analysis	%_GRAVEL	%_GRAVEL	0.00%	%
DC-02A	20050767		7/1/2005	ASTMD422	Particle Size Analysis	%_SAND	%_SAND	82.59%	%
DC-02A	20050767		7/1/2005	ASTMD422	Particle Size Analysis	%_SILT	%_SILT	9.56%	%
DC-02A	20050767		7/1/2005	ASTMD422	Particle Size Analysis	%_CLAY	%_CLAY	7.86%	%
DC-02A	20050767		6/24/2005	ASTMD2974	Moisture Content	%_MOISTURE	%_MOISTURE	18.0	%
DC-02A	20050767		7/1/2005	ASTMC136	Sieve Analysis	SA_1in	% passing 1"	100.00%	%
DC-02A	20050767		7/1/2005	ASTMC136	Sieve Analysis	SA_3/4in	% passing 3/4"	100.00%	%
DC-02A	20050767		7/1/2005	ASTMC136	Sieve Analysis	SA_3/8in	% passing 3/8"	100.00%	%
DC-02A	20050767		7/1/2005	ASTMC136	Sieve Analysis	SA_4	% passing #4	100.00%	%
DC-02A	20050767		7/1/2005	ASTMC136	Sieve Analysis	SA_10	% passing #10	100.00%	%
DC-02A	20050767		7/1/2005	ASTMC136	Sieve Analysis	SA_20	% passing #20	99.64%	%
DC-02A	20050767		7/1/2005	ASTMC136	Sieve Analysis	SA_40	% passing #40	97.40%	%
DC-02A	20050767		7/1/2005	ASTMC136	Sieve Analysis	SA_60	% passing #60	88.48%	%
DC-02A	20050767		7/1/2005	ASTMC136	Sieve Analysis	SA_100	% passing #100	64.38%	%
DC-02A	20050767		7/1/2005	ASTMC136	Sieve Analysis	SA_200	% passing #200	46.03%	%
DC-02A	20050767		6/22/2005	ASTMD422	Hydrometer Analysis	HA_LDIS2min	Largest diameter of particle in suspension at 2 minutes	0.035559	mm
DC-02A	20050767		6/22/2005	ASTMD422	Hydrometer Analysis	HA_LDIS5min	Largest diameter of particle in suspension at 5 minutes	0.023013	mm
DC-02A	20050767		6/22/2005	ASTMD422	Hydrometer Analysis	HA_LDIS15min	Largest diameter of particle in suspension at 15 minutes	0.013324	mm
DC-02A	20050767		6/22/2005	ASTMD422	Hydrometer Analysis	HA_LDIS30min	Largest diameter of particle in suspension at 30 minutes	0.009474	mm
DC-02A	20050767		6/22/2005	ASTMD422	Hydrometer Analysis	HA_LDIS60min	Largest diameter of particle in suspension at 60 minutes	0.006736	mm
DC-02A	20050767		6/22/2005	ASTMD422	Hydrometer Analysis	HA_LDIS250miin	Largest diameter of particle in suspension at 250 minutes	0.003300	mm
DC-02A	20050767		6/22/2005	ASTMD422	Hydrometer Analysis	HA_LDIS1440min	Largest diameter of particle in suspension at 1440 minutes	0.001375	mm
DC-02A	20050767		6/22/2005	ASTMD422	Hydrometer Analysis	HA_%FTDat2min	% finer than diameter calculated at 2 minutes	20.20%	%
DC-02A	20050767		6/22/2005	ASTMD422	Hydrometer Analysis	HA_%FTDat5min	% finer than diameter calculated at 5 minutes	12.12%	%
DC-02A	20050767		6/22/2005	ASTMD422	Hydrometer Analysis	HA_%FTDat15min	% finer than diameter calculated at 15 minutes	11.11%	%
DC-02A	20050767		6/22/2005	ASTMD422	Hydrometer Analysis	HA_%FTDat30min	% finer than diameter calculated at 30 minutes	9.09%	%
DC-02A	20050767		6/22/2005	ASTMD422	Hydrometer Analysis	HA_%FTDat60min	% finer than diameter calculated at 60 minutes	7.07%	%
DC-02A	20050767		6/22/2005	ASTMD422	Hydrometer Analysis	HA_%FTDat250min	% finer than diameter calculated at 250 minutes	7.07%	%
DC-02A	20050767		6/22/2005	ASTMD422	Hydrometer Analysis	HA_%FTDat1440min	% finer than diameter calculated at 1440 minutes	7.07%	%
DC-02A	20050767		7/21/2005	ASTMD4318	Atterberg Limits	AL_LL%M	Liquid Limit	<1>	%
DC-02A	20050767		7/21/2005	ASTMD4318	Atterberg Limits	AL_PL%M	Plastic Limit	<1>	%
DC-02A	20050767		7/21/2005	ASTMD4318	Atterberg Limits	PI	Plasticity Index	<1>	%
DC-02A	20050767		7/21/2005	ASTMD4318	Atterberg Limits	AL_LLMC	Liquid Limit Moisture Content	<1>	%
DC-02A	20050767		7/21/2005	ASTMD4318	Atterberg Limits	AL_PLMC	Plastic Limit Moisture Content	<1>	%
DC-02A	20050767		7/21/2005	ASTMD4531	Bulk Density	BULK_DEN	Bulk Density in grams/milliliter, dry recovery	1.466	
DC-02A	20050767		6/17/2005	EPA 9060	TOC	TOC	Total Organic Carbon	1,471	ppm
DC-02A	20050767		6/17/2005	EPA 9060	% TOC	TOC_%DW	% Total Organic Carbon of dry weight	0.15	%

<1> Sample did not exhibit plastic qualities due to the amount of fine sand content.

ATTACHMENT 2

SLOPE STABILITY ANALYSIS RESULTS

R2-0010301



Legend

- Passaic River
- Rip Rap Armor
- Sand Cap
- Silt
- Silty Sand
- Peat
- Clayey Silt
- Fine-medium Sand
- Sandy Lean Clay
- Failure Circle
- Grid Pattern

Notes

1V:2H = 1 Vertical:2 Horizontal

Data Source: SLOPE/W GEO-SLOPE, International, Ltd. Version 4.23.

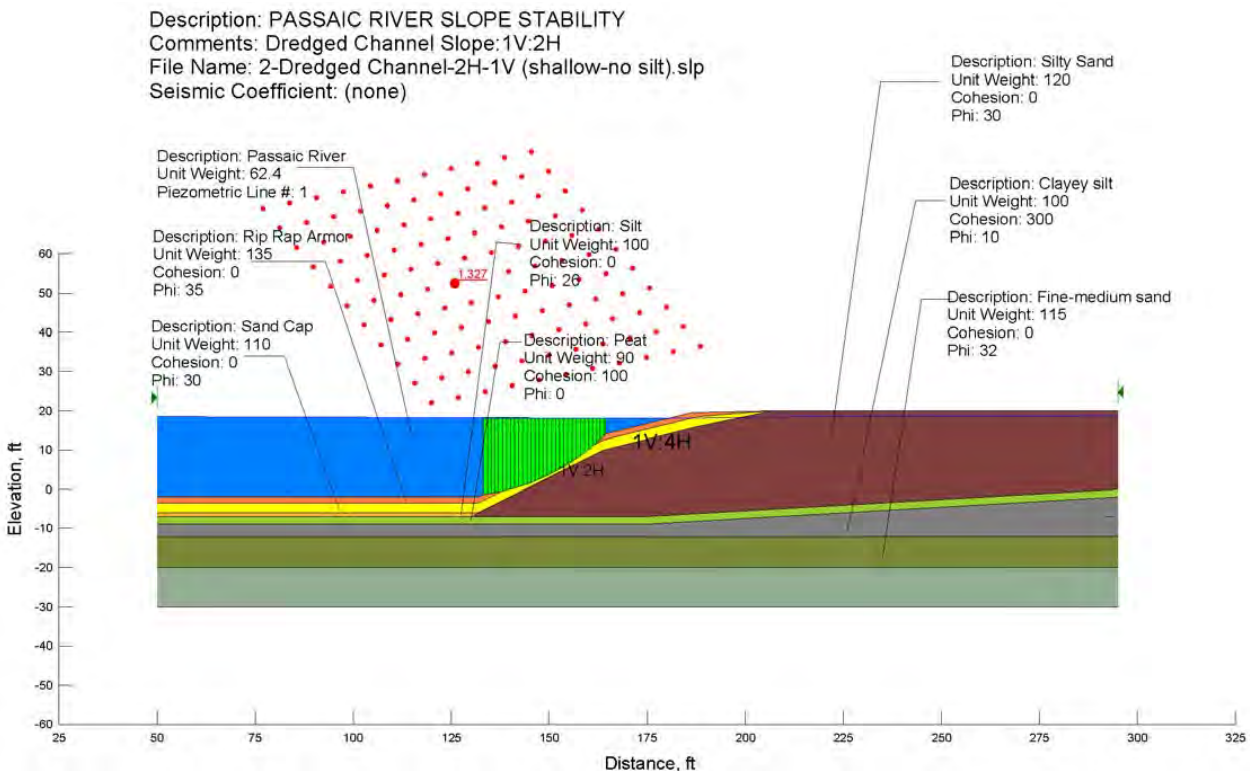
Passaic River Slope Stability

Lower Passaic River Restoration Project

Figure 1

June 2007

R2-0010302



Legend

- Passaic River
- Rip Rap Armor
- Sand Cap
- Silt
- Silty Sand
- Peat
- Clayey Silt
- Fine-medium Sand
- Sandy Lean Clay
- Failure Circle
- Grid Pattern

Notes

1V:2H = 1 Vertical:2 Horizontal

Data Source: SLOPE/W GEO-SLOPE, International, Ltd. Version 4.23.

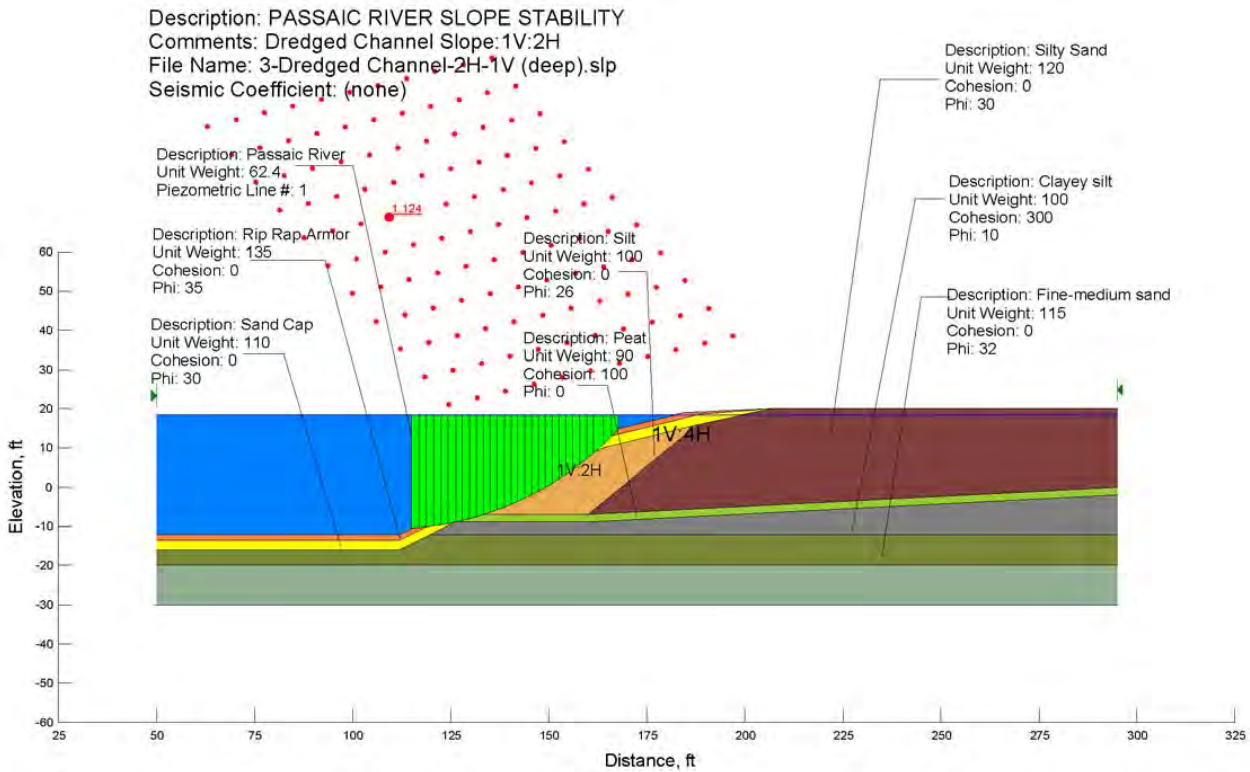
Passaic River Slope Stability

Lower Passaic River Restoration Project

Figure 2

June 2007

R2-0010303



Legend

- Passaic River
- Rip Rap Armor
- Sand Cap
- Silt
- Silty Sand
- Peat
- Clayey Silt
- Fine-medium Sand
- Sandy Lean Clay
- Failure Circle
- Grid Pattern

Notes

1V:2H = 1 Vertical:2 Horizontal

Data Source: SLOPE/W GEO-SLOPE, International, Ltd. Version 4.23.

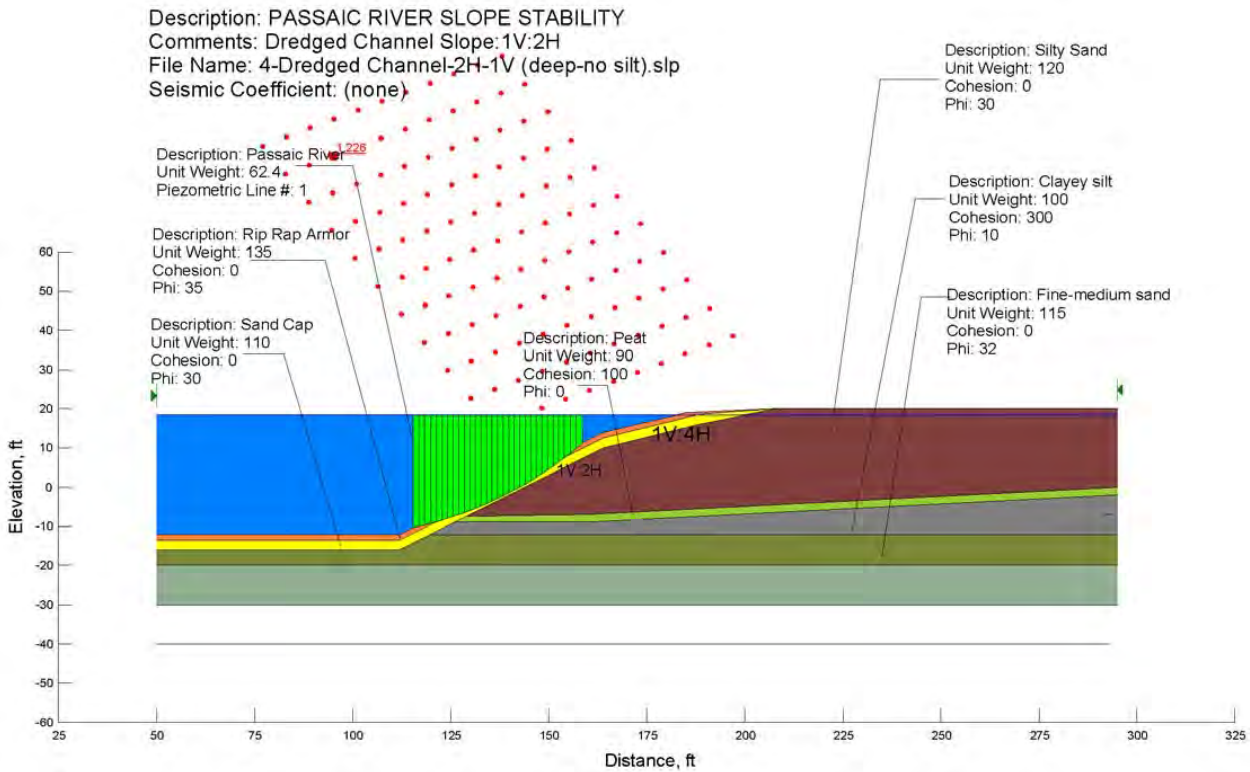
Passaic River Slope Stability

Lower Passaic River Restoration Project

Figure 3

June 2007

R2-0010304



Legend

- Passaic River
- Rip Rap Armor
- Sand Cap
- Silty Sand
- Peat
- Clayey Silt
- Fine-medium Sand
- Sandy Lean Clay
- Failure Circle
- Grid Pattern

Notes

1V:2H = 1 Vertical:2 Horizontal

Data Source: SLOPE/W GEO-SLOPE, International, Ltd. Version 4.23.

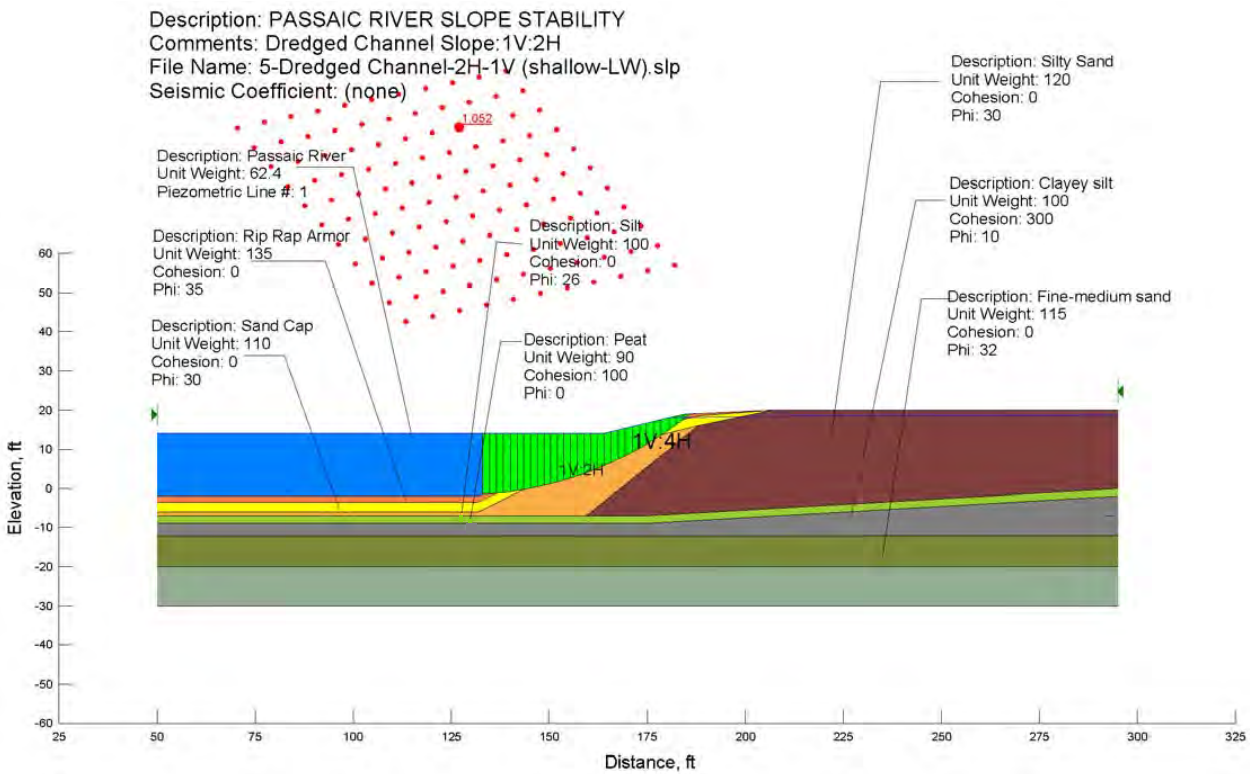
Passaic River Slope Stability

Lower Passaic River Restoration Project

Figure 4

June 2007

R2-0010305



Legend

- Passaic River
- Rip Rap Armor
- Sand Cap
- Silt
- Silty Sand
- Peat
- Clayey Silt
- Fine-medium Sand
- Sandy Lean Clay
- Failure Circle
- Grid Pattern

Notes

1V:2H = 1 Vertical:2 Horizontal

Data Source: SLOPE/W GEO-SLOPE, International, Ltd. Version 4.23.

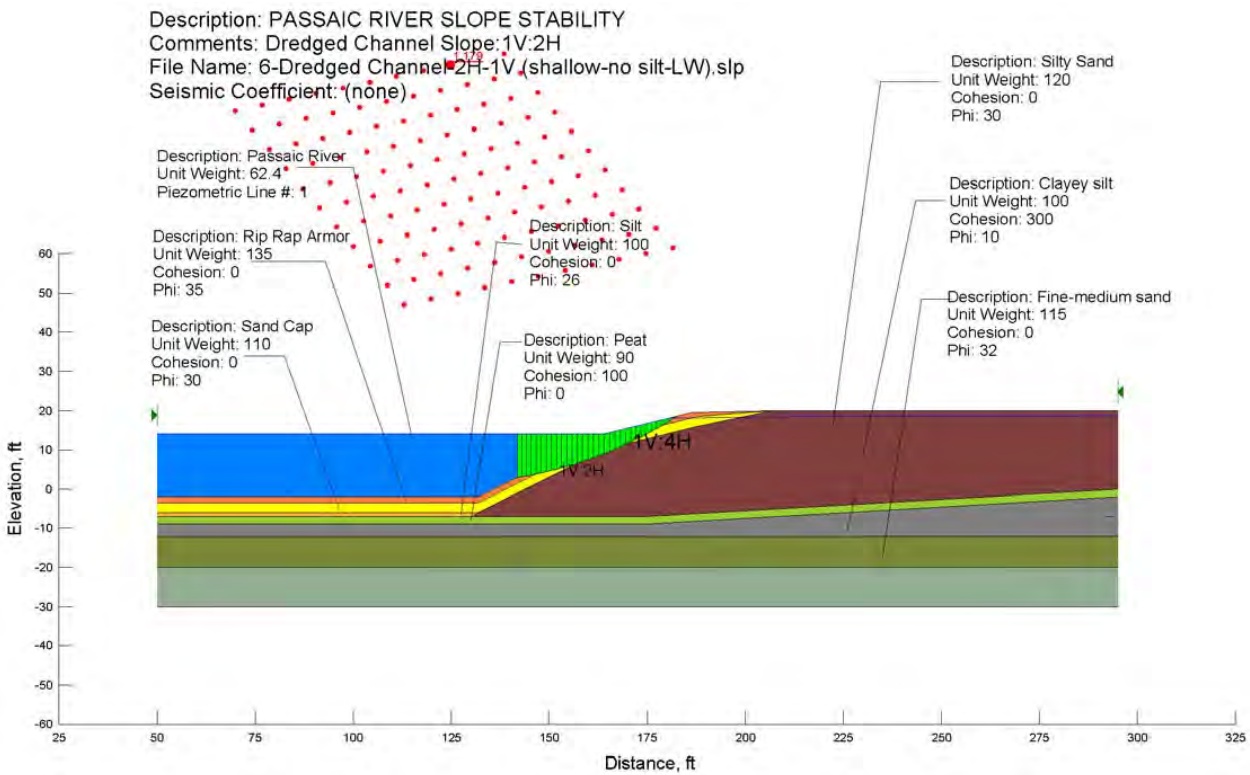
Passaic River Slope Stability

Lower Passaic River Restoration Project

Figure 5

June 2007

R2-0010306



Legend

- Passaic River
- Rip Rap Armor
- Sand Cap
- Silt
- Silty Sand
- Peat
- Clayey Silt
- Fine-medium Sand
- Sandy Lean Clay
- Failure Circle
- Grid Pattern

Notes

1V:2H = 1 Vertical:2 Horizontal

Data Source: SLOPE/W GEO-SLOPE, International, Ltd. Version 4.23.

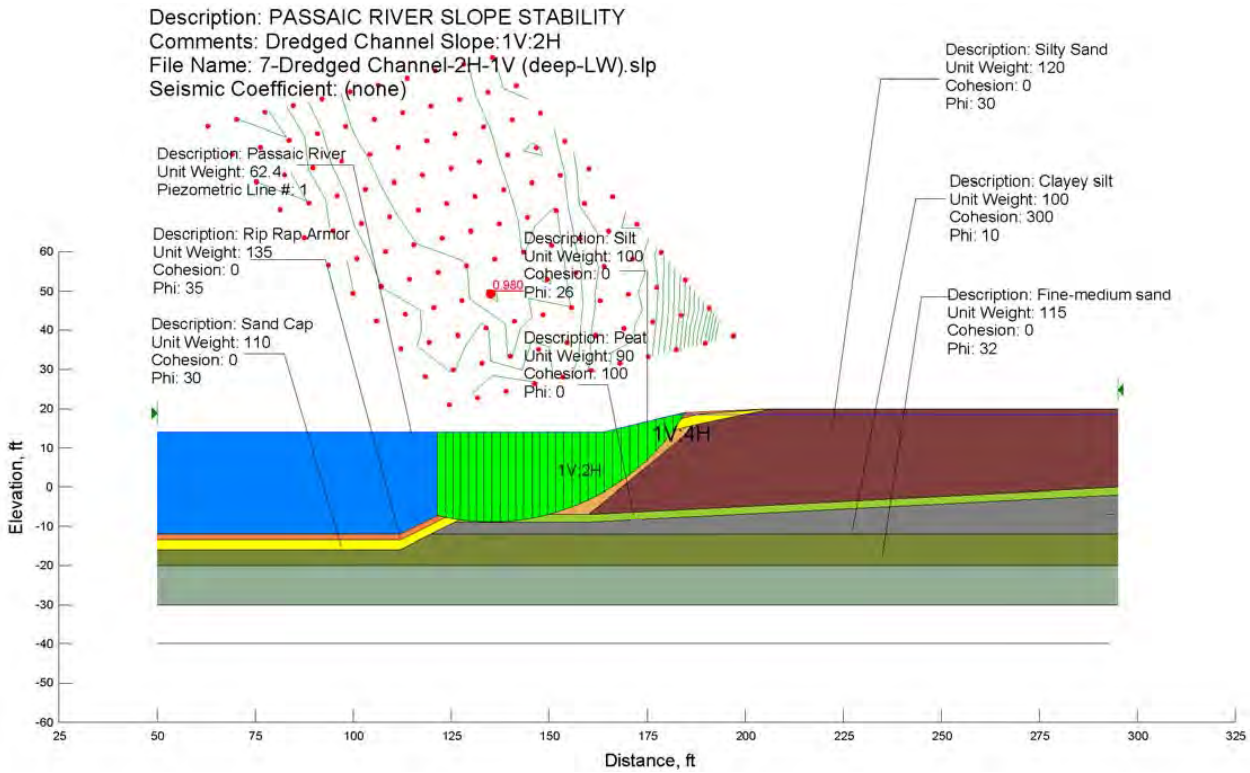
Passaic River Slope Stability

Lower Passaic River Restoration Project

Figure 6

June 2007

R2-0010307



Legend

- Passaic River
- Rip Rap Armor
- Sand Cap
- Silt
- Silty Sand
- Peat
- Clayey Silt
- Fine-medium Sand
- Sandy Lean Clay
- Failure Circle
- Grid Pattern
- Contours of Factors of Safety

Notes

1V:2H = 1 Vertical:2 Horizontal

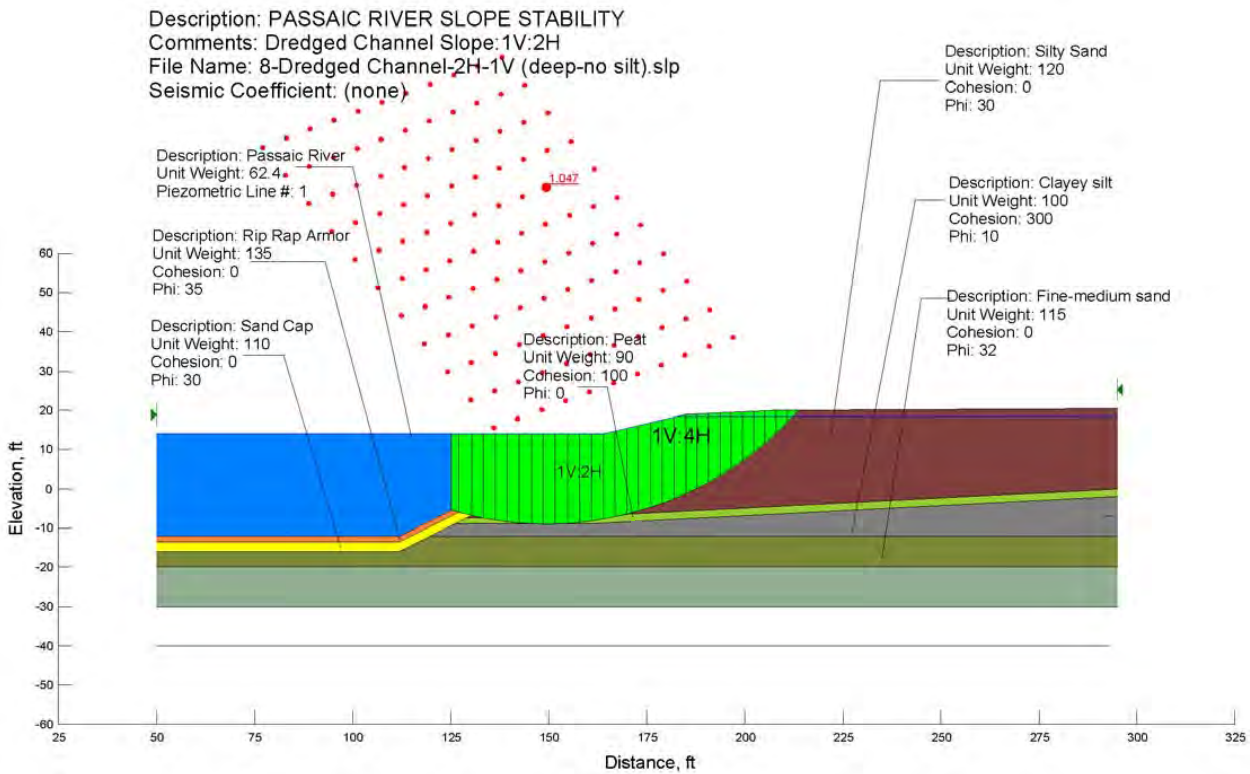
Data Source: SLOPE/W GEO-SLOPE, International, Ltd. Version 4.23.

Passaic River Slope Stability

Lower Passaic River Restoration Project

Figure 7

June 2007



Legend

- Passaic River
- Rip Rap Armor
- Sand Cap
- Silty Sand
- Peat
- Clayey Silt
- Fine-medium Sand
- Sandy Lean Clay
- Failure Circle
- Grid Pattern

Notes

1V:2H = 1 Vertical:2 Horizontal

Data Source: SLOPE/W GEO-SLOPE, International, Ltd. Version 4.23.

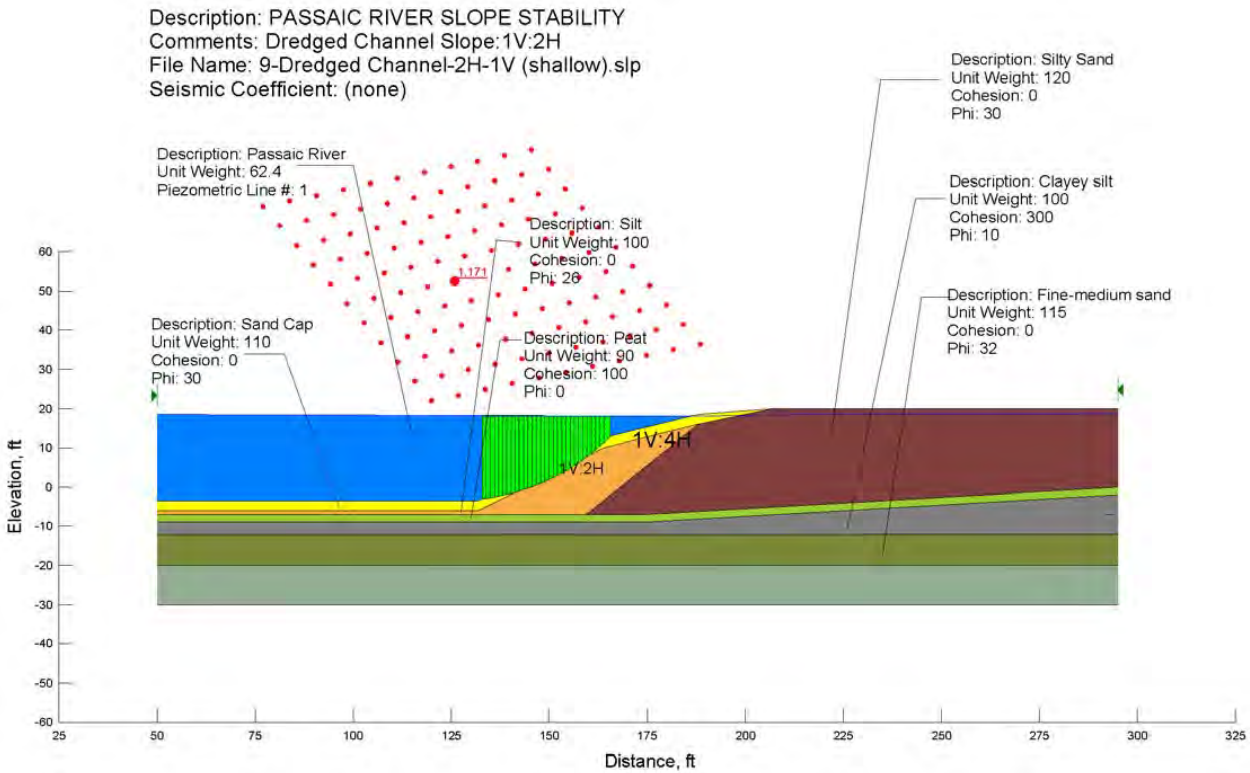
Passaic River Slope Stability

Lower Passaic River Restoration Project

Figure 8

June 2007

R2-0010309



Legend

- Passaic River
- Sand Cap
- Silt
- Silty Sand
- Peat
- Clayey Silt
- Fine-medium Sand
- Sandy Lean Clay
- Failure Circle
- Grid Pattern

Notes

1V:2H = 1 Vertical:2 Horizontal

Data Source: SLOPE/W GEO-SLOPE, International, Ltd. Version 4.23.

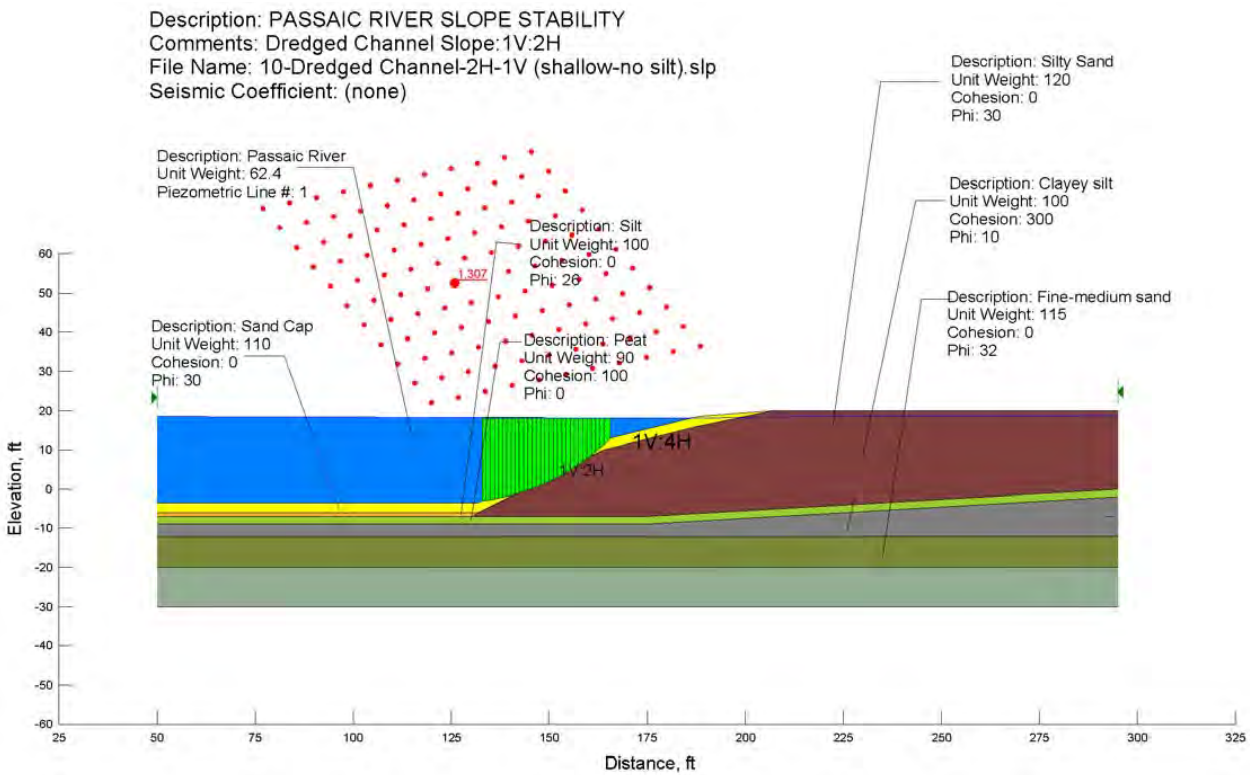
Passaic River Slope Stability

Lower Passaic River Restoration Project

Figure 9

June 2007

R2-0010310



Legend

- Passaic River
- Sand Cap
- Silt
- Silty Sand
- Peat
- Clayey Silt
- Fine-medium Sand
- Sandy Lean Clay
- Failure Circle
- Grid Pattern

Notes

1V:2H = 1 Vertical:2 Horizontal

Data Source: SLOPE/W GEO-SLOPE, International, Ltd. Version 4.23.

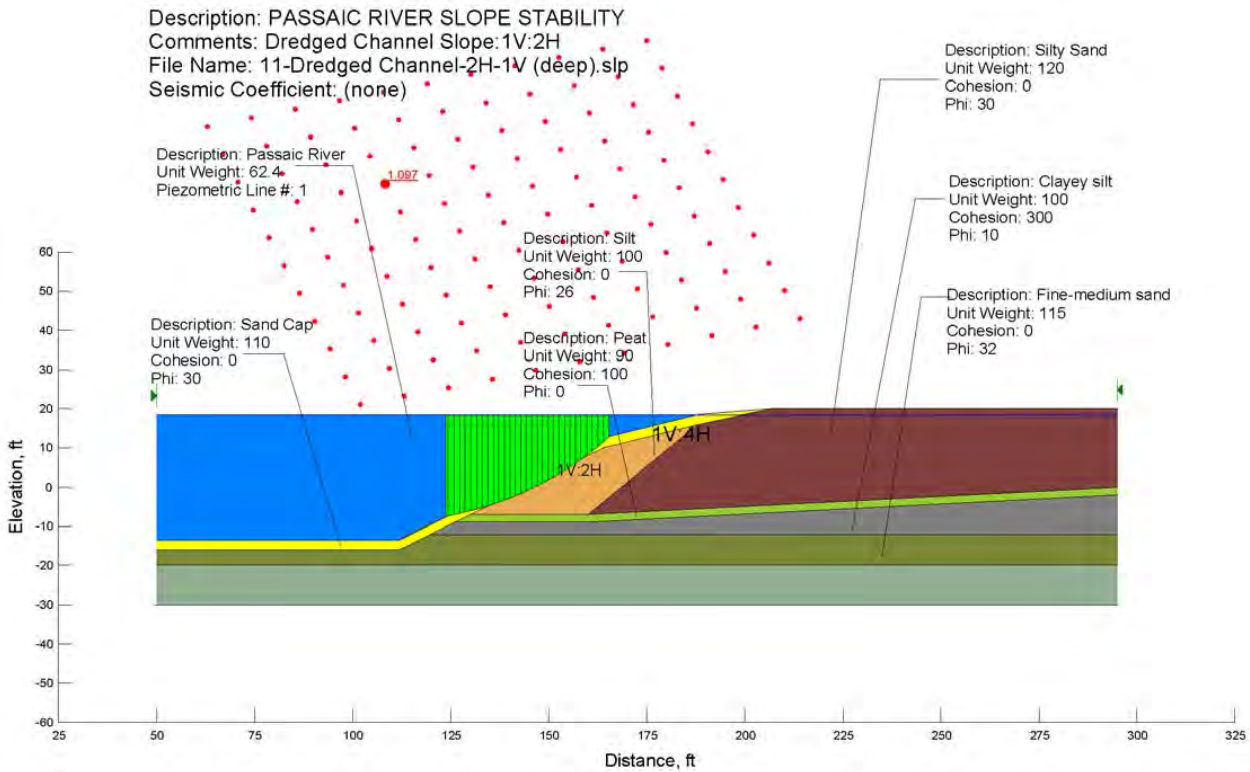
Passaic River Slope Stability

Lower Passaic River Restoration Project

Figure 10

June 2007

R2-0010311



Legend

- Passaic River
- Sand Cap
- Silt
- Silty Sand
- Peat
- Clayey Silt
- Fine-medium Sand
- Sandy Lean Clay
- Failure Circle
- Grid Pattern

Notes

1V:2H = 1 Vertical:2 Horizontal

Data Source: SLOPE/W GEO-SLOPE, International, Ltd. Version 4.23.

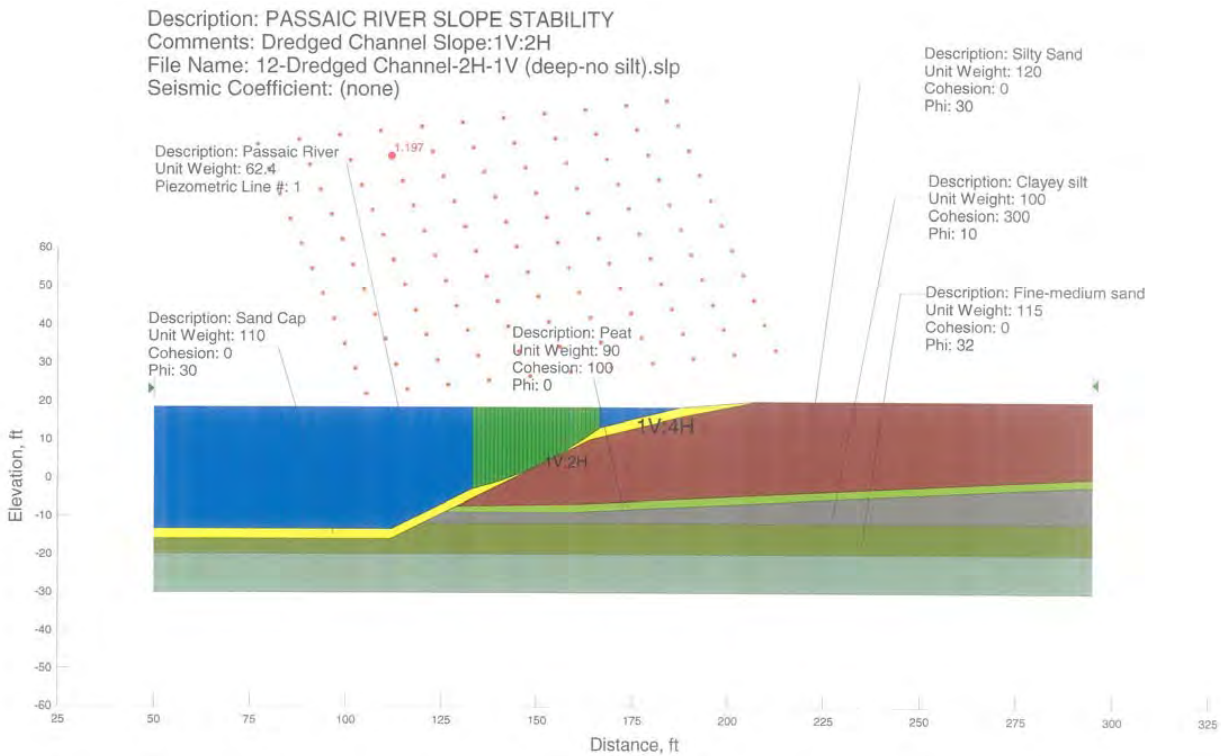
Passaic River Slope Stability

Lower Passaic River Restoration Project

Figure 11

June 2007

R2-0010312



Legend

- Passaic River
- Sand Cap
- Silty Sand
- Peat
- Clayey Silt
- Fine-medium Sand
- Sandy Lean Clay
- Grid Pattern

Notes

1V:2H = 1 Vertical:2 Horizontal

Data Source: SLOPE/W GEO-SLOPE, International, Ltd. Version 4.23.

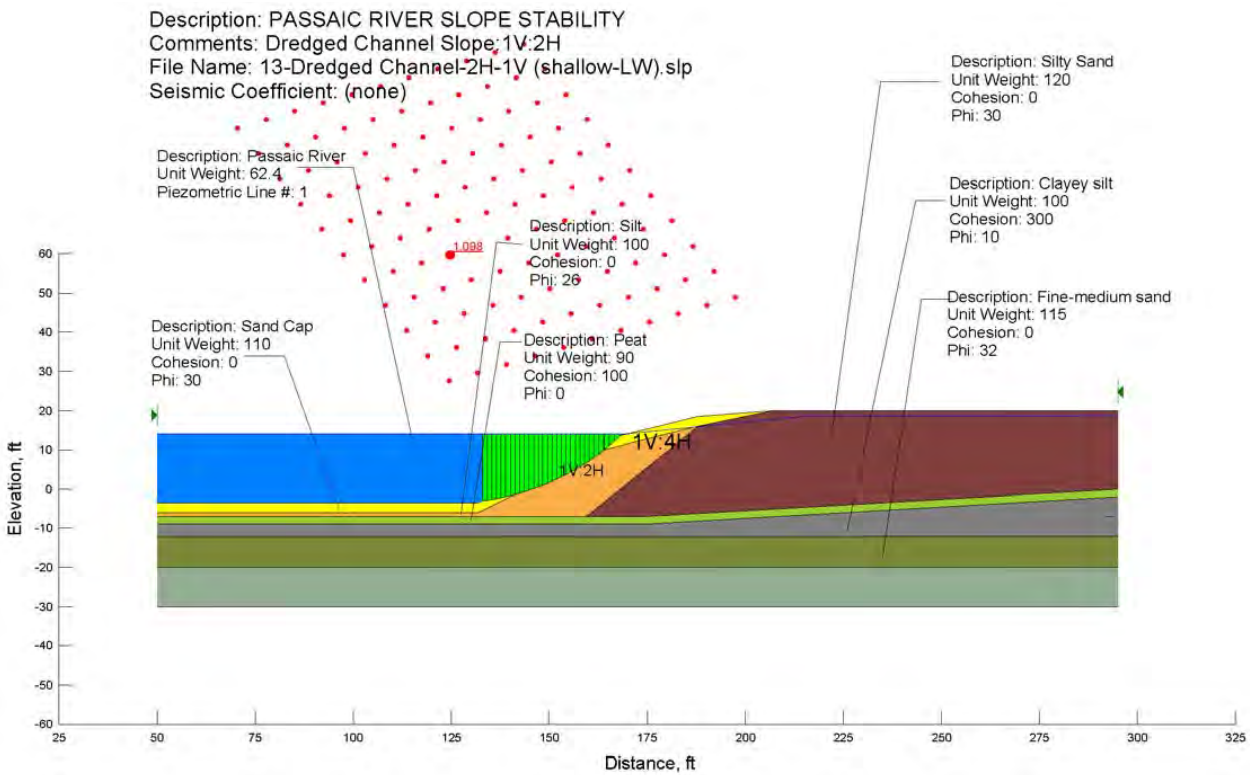
Passaic River Slope Stability

Lower Passaic River Restoration Project

Figure 12

June 2007

R2-0010313



Legend

- Passaic River
- Sand Cap
- Silt
- Silty Sand
- Peat
- Clayey Silt
- Fine-medium Sand
- Sandy Lean Clay
- Failure Circle
- Grid Pattern

Notes

1V:2H = 1 Vertical:2 Horizontal

Data Source: SLOPE/W GEO-SLOPE, International, Ltd. Version 4.23.

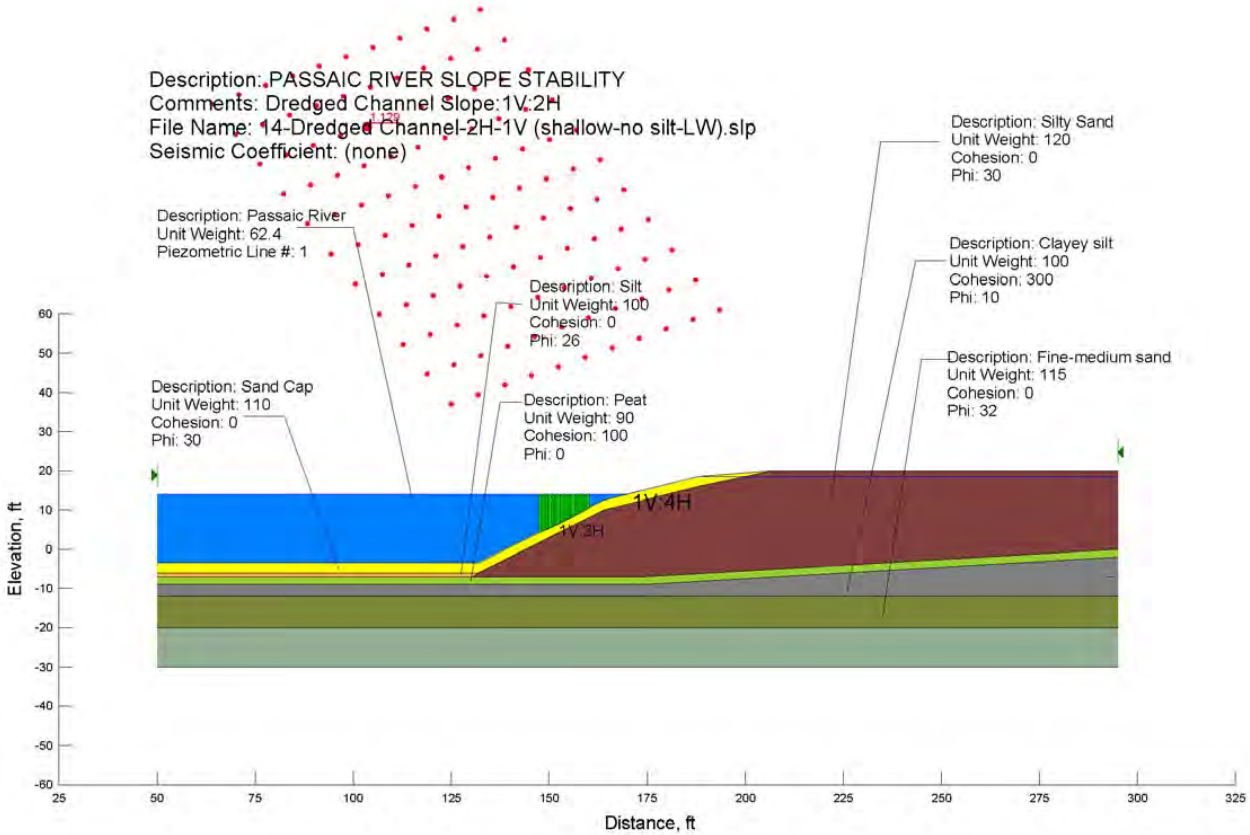
Passaic River Slope Stability

Lower Passaic River Restoration Project

Figure 13

June 2007

R2-0010314



Legend

- Passaic River
- Sand Cap
- Silt
- Silty Sand
- Peat
- Clayey Silt
- Fine-medium Sand
- Sandy Lean Clay
- Failure Circle
- Grid Pattern

Notes

1V:2H = 1 Vertical:2 Horizontal

Data Source: SLOPE/W GEO-SLOPE, International, Ltd. Version 4.23.

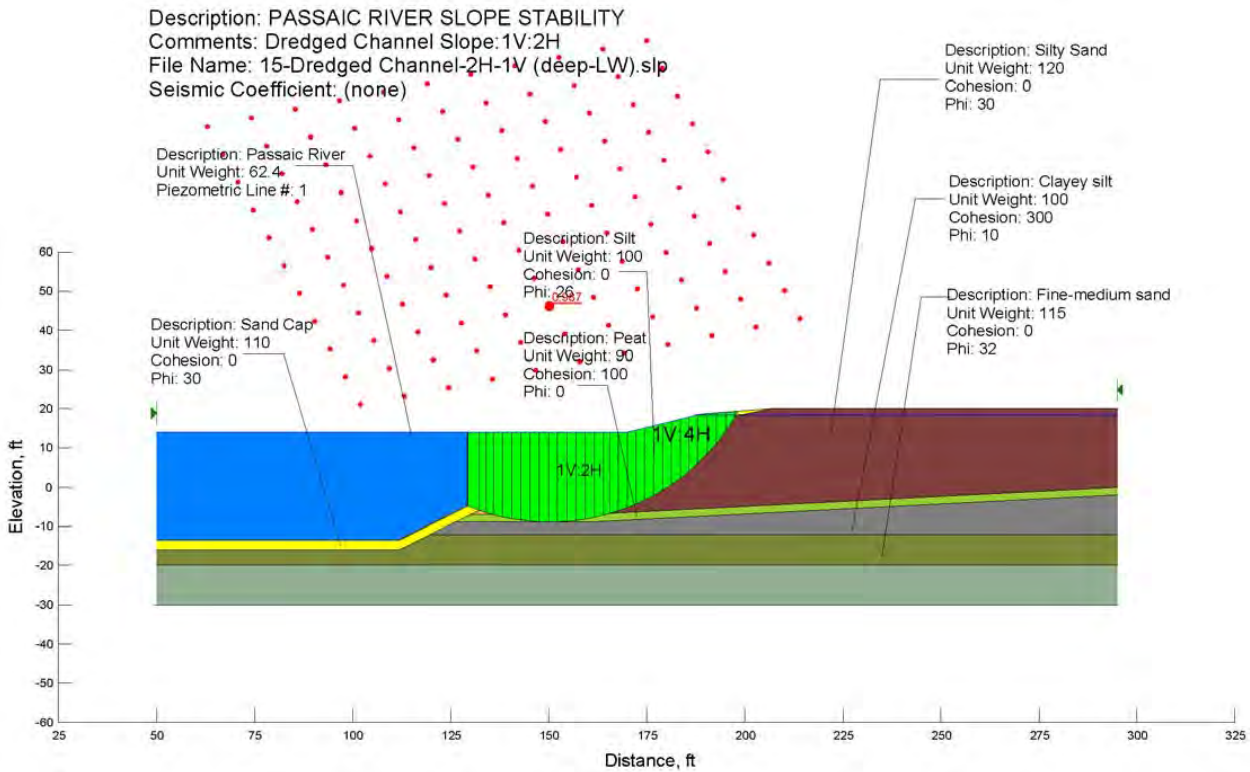
Passaic River Slope Stability

Lower Passaic River Restoration Project

Figure 14

June 2007

R2-0010315



Legend

- Passaic River
- Sand Cap
- Silt
- Silty Sand
- Peat
- Clayey Silt
- Fine-medium Sand
- Sandy Lean Clay
- Failure Circle
- Grid Pattern

Notes

1V:2H = 1 Vertical:2 Horizontal

Data Source: SLOPE/W GEO-SLOPE, International, Ltd. Version 4.23.

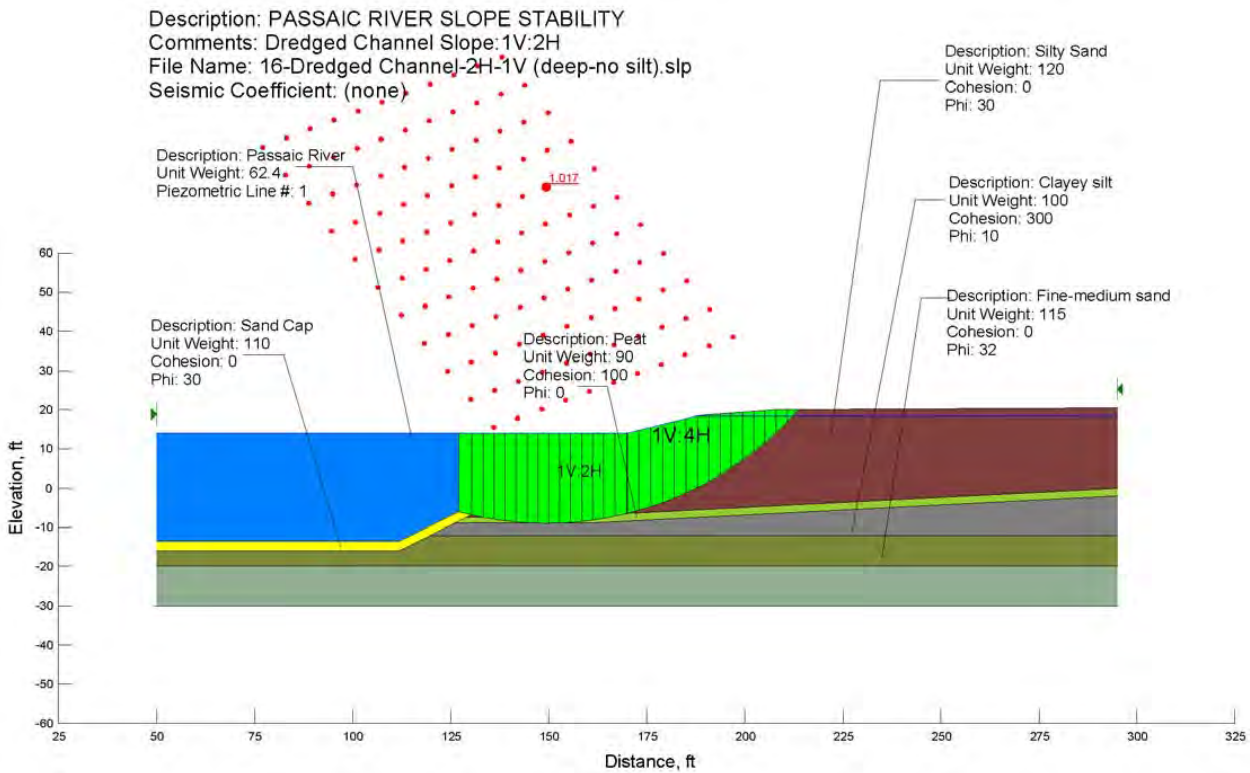
Passaic River Slope Stability

Lower Passaic River Restoration Project

Figure 15

June 2007

R2-0010316



Legend

- Passaic River
- Sand Cap
- Silty Sand
- Peat
- Clayey Silt
- Fine-medium Sand
- Sandy Lean Clay
- Failure Circle
- Grid Pattern

Notes

1V:2H = 1 Vertical:2 Horizontal

Data Source: SLOPE/W GEO-SLOPE, International, Ltd. Version 4.23.

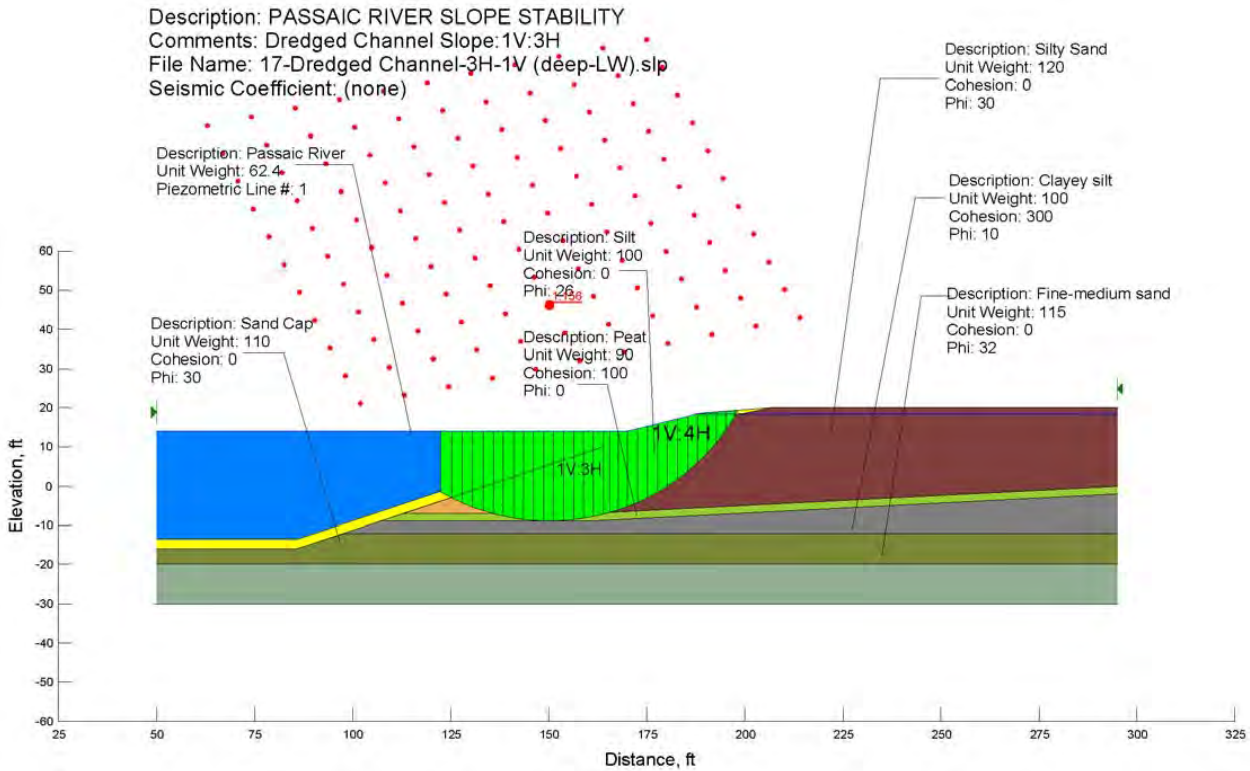
Passaic River Slope Stability

Lower Passaic River Restoration Project

Figure 16

June 2007

R2-0010317



Legend

- Passaic River
- Sand Cap
- Silt
- Silty Sand
- Peat
- Clayey Silt
- Fine-medium Sand
- Sandy Lean Clay
- Failure Circle
- Grid Pattern

Notes

1V:2H = 1 Vertical:2 Horizontal

Data Source: SLOPE/W GEO-SLOPE, International, Ltd. Version 4.23.

Passaic River Slope Stability

Lower Passaic River Restoration Project

Figure 17

June 2007

R2-0010318

ATTACHMENT 3

CONSOLIDATION CALCULATIONS

R2-0010319

MALCOLM PIRNIE

MALCOLM PIRNIE, INC.
INDEPENDENT ENVIRONMENTAL ENGINEERS, SCIENTISTS, & CONSULTANTS
GEOTECHNICAL & DAM ENGINEERING SERVICES PROGRAM

CLIENT:	Lower Passaic River Restoration Project	PROJECT:	Focused Feasibility Study
BY:	KSP	DATE: 12-Mar-06	ob No.: 4553031
CHKD BY:		DATE:	SHEET No.:

SUBJECT: Attachment 3: Consolidation of Erosion Protection Layer for the Proposed Cap, Conceptual Design

MathCAD 7 Professional, MathSoft, Inc. c.1986-1997

Unit Description:

$psf \equiv 1 \cdot \frac{lb}{ft^2}$ $\quad pcf \equiv 1 \cdot \frac{lb}{ft^3}$ $\quad ksf := \frac{kip}{ft^2}$ $\quad ton \equiv 2000 \cdot lb$ $\quad kip \equiv 1000 \cdot lb$

$ksi := \frac{kip}{in^2}$ $\quad tsf := \frac{ton}{ft^2}$ $\quad psi \equiv 1 \frac{lb}{in^2}$ $\quad kpf := \frac{kip}{ft}$

PROBLEM STATEMENT:

ANALYSIS METHOD:

Estimate the settlement in subgrade caused by the applied load using the elastic theory.

REFERENCES :

1. BRAJA M. DAS(1998) Principal of Foundation Engineering.

Input Parameters:

$d_{rock} := 18in$ $d_{sand} := 2ft$ $\gamma_{rock} := 135pcf$ $\gamma_{sand} := 120pcf$ $\phi_{sand} := 30deg$

$C := 0psf$ $\gamma_w := 62.4pcf$ $B_{sand} := 500ft$ $L_{sand} := 1000ft$ $Df := 0ft$

$\gamma_{silt} := 78pcf$

$Load := \left[d_{rock}\cdot\left(\gamma_{rock} - \gamma_w\right) + d_{sand}\cdot\left(\gamma_{sand} - \gamma_w\right)\right]\cdot B_{sand}$ $Load = 112.05\frac{kip}{ft}$

Method I: ELASTIC THEORY BASIS:

$$S := \frac{qs\cdot B\cdot\left(1 - \mu^2\right)\cdot\alpha_{av}}{E}$$

Where,

S = Settlement

qs = Applied Uniform Surcharge Stress

B = Least Lateral Footing Dimension

μ = POISSON'S Ratio

E = Elastic Modulus

α_{av} = Influence Factor

E and υ from Table 4.5 (Ref. 1, Page 250)

E = 600-3000 lb/in2 μ = 0.25-0.4

Say, E1 = --:

$E := 1000psi$ $\mu := 0.3$

α_{av} from Table 4.18 (Ref. 1, Page 242)

$\alpha_{av} := 1.2$

R2-0010321

Determine the Applied Uniform Stress, qs

$$qs := \frac{Load}{B_{sand}} \qquad qs = 224.1\,psf$$

$$q1 := Df \cdot \left(\gamma_{silt} - \gamma_w\right) \qquad q1 = 0$$

$$\Delta q := qs - q1$$

Note: Weight of the excavated soils was not considered

Determine the Settlements

$$S := \frac{qs \cdot B_{sand} \cdot \left(1 - \mu^2\right) \cdot \alpha_{av}}{E} \qquad S = 10.197\,in$$

Unit Description:

$psf \equiv 1 \cdot \frac{lb}{ft^2}$ $kip \equiv 1000 \cdot lb$ $ksf := \frac{kip}{ft^2}$ $ksi := \frac{kip}{in^2}$ $kpf := \frac{kip}{ft}$ $psi \equiv 1 \frac{lb}{in^2}$ $ton \equiv 2000 \cdot lb$

PROBLEM STATEMENT:

Estimate the potential settlement in the subgrade due to the construction of the proposed cap.

ANALYSIS METHOD:

Estimate the settlement in subgrade caused by the applied load using the elastic theory.

REFERENCES :

1. BRAJA M. DAS(1998) Principal of Foundation Engineering.

Ref 1, page 316
" if a foundation of width "say B" is subjected to a load per unit area of q, it will undergo a settlement, Δ." The settlement Δ can be defined as

$\Delta := \frac{q}{k}$ where k is the coefficient of subgrade modulus.

Ref 1, page 318; $k := 29 \frac{lb}{in^3}$

Input Parameters:

$d_{rock} := 18in$ $d_{sand} := 2ft$ $\gamma_{rock} := 135pcf$ $\gamma_{sand} := 120pcf$ $\phi_{sand} := 28deg$

$C := 0psf$ $\gamma_w := 62.4pcf$

$\gamma_{silt} := 100pcf$

$k := 29\frac{lb}{in^3}$ coefficient of subgrade modulus.

$q := \left[d_{rock}\cdot\left(\gamma_{rock} - \gamma_w\right) + d_{sand}\cdot\left(\gamma_{sand} - \gamma_w\right)\right]$ $q = 224.1\,psf$

$\Delta := \frac{q}{k}$ $\Delta = 0.054\,in$

As reported, the thickness of the nepheloid layer ranges from 6 in to 10 inches and it is assumed that the thickness of this layer would reduce to zero once the proposed cap is placed on top it. Therefore, the anticipated settlement may vary from 6 inches to 10 inches.

R2-0010324

MALCOLM PIRNIE

Interoffice Correspondence

Date: April 19, 2007

To: L. Bossi (WHI)

Copy: S. Thompson and G. Druback (WHI)

From: K. Pathirage (WHI)

RE: Conceptual Design of Erosion Protection Layer (Armor) for Proposed Cap - Lower Passaic River, NJ

INTRODUCTION

This memorandum addresses the conceptual design aspects of the proposed erosion protection layer and presents a preliminary cost for its construction. This conceptual design is developed in accordance with the United States Army Corps of Engineers (USACE, 1991) recommendations and guidelines in order to estimate the materials and quantities that may be needed to install the erosion protection system. The conceptual design developed here is intended only for cost estimation purposes, and a detailed design analysis will be required if capping is implemented as part of the proposed remedial action.

The conceptual design was based on modeled river flow velocities and water depths provided by HydroQual, Inc. The data were based on modeled erosion susceptibility of the proposed cap due to a 100-year storm event.

DESIGN CONSIDERATIONS

The design presented herein considers the river being subjected to a 100-year flood event, which increases both flow and velocity of water in comparison to normal conditions. The proposed erosion protection layer would be constructed of stone material, and the material will be selected (sized) with a factor of safety of 1.3. This factor of safety was independently applied to river flow velocity, water depth, the unit weight of stone, and the angle of repose of stones. A total of 7 cross sections were selected for analyses

within the river stretches susceptible to erosion as identified by HydroQual, Inc., shown on Figure 1. Design parameters were conservatively defined by selecting the highest water velocities and shallowest depths at each river cross section. The flow depths and velocities at respective river cross sections under future capped conditions are tabulated along with the assumed unit weight of stone in Table 1.

Table 1: River Sections

Location	Depth of Water[a], meters	Velocity of Water Flow[a], meters/second	Unit Weight of Stone, pounds per cubic foot
Section 0	3.91	1.67	155
Section 1	3.65	1.76	155
Section 2	2.49	2.04	155
Section 3	4.36	1.58	155
Section 4	2.46	2.07	155
Section 5	2.78	1.98	155
Section 6	3.75	1.71	155

a: River velocities and depths provided by HydroQual, Inc.

SUMMARY OF RESULTS

The calculation of the size of stone erosion protection material follows the USACE Engineering and Design Manual EM 110-2-1601. See Attachment 1 for calculations of stone size for the river sections considered in analysis. Table 2 shows the median stone size (D_{50}) based upon preliminary hydraulics analysis.

Table 2: Median Stone Size (D_{50})

Location	Median Stone Size (D_{50}), inch
Section 0	2.61
Section 1	3.02
Section 2	4.67
Section 3	2.20
Section 4	4.96
Section 5	4.30
Section 6	2.75

The required median size (D_{50}) of stones varies along this river stretch from approximately 2.2 inches to 5 inches at Sections 0 through 6. It is recommended that a

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single median size (D_{50}) of 5 inches be selected for the armoring requirement at Sections 2, 4, and 5. The areas that fall under sections 0, 1, 3, and 6 shall also be protected with a single median size (D_{50}) of 3 inches.

The proposed erosion protection layer shall be composed of a well-graded mixture, such that 50% of the mixture by weight shall be larger than the D_{50} size (i.e., 3-inch and 5-inch at respective locations). Stone will be placed to a minimum thickness of 3 times the D_{50} size, which is approximately 9 inches and 15 inches in thickness, respectively. The diameter of the largest stone size in such a mixture shall be 1.5 times the D_{50} size. Additionally, the D_{75} of the mixture shall be 1.25 times the D_{50} and the D_{15} of the mixture shall be 0.5 times the D_{50}.

In addition, it is recommended that a transition layer (i.e., filter layer) be placed between the proposed sand cap and the erosion protection layer to mitigate any potential internal erosion conditions of the proposed sand cap. The filter layer was designed using typical filter design guidelines provided by the United States Department of Interior Bureau of Reclamation (1987).

The filter layer shall have a minimum thickness of 12 inches and be composed of a well-graded material such that the D_{15} shall be between 3 and 42 millimeters and the D_{85} between 30 and 50 millimeters.

PRELIMINARY CONSTRUCTION COSTS FOR CAP

For preliminary cost estimates, a unit price of $58 per ton can be used for purchasing, transporting and placing the stone material on the proposed cap area; a unit price of $30 per ton can be used for purchase, transport and placement of the filter layer material. These preliminary unit costs are tabulated in the Table 3 below.

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Table 3: Summary of Preliminary Costs

Layer	Unit Price, $ per ton
Stone Armor Sections 0 - 6	58[a]
Filter Layer Sections 0 - 6	30[b]

a: USACE, New Orleans District: $50 per ton (offshore project completed in 2002); unit price includes purchase, delivery, and placement; adjusted to reflect 3% annual inflation.
b: Local contractor material and delivery unit rate; unit price adjusted to include RS Means cost of barge, tug with operator, loader with operator, crane with operator, clamshell bucket.

REFERENCES

United States Army Corps of Engineers, 1991. *Engineering and Design Manual: Hydraulic Design of Flood Control Channels*. USACE EM 110-2-1601.

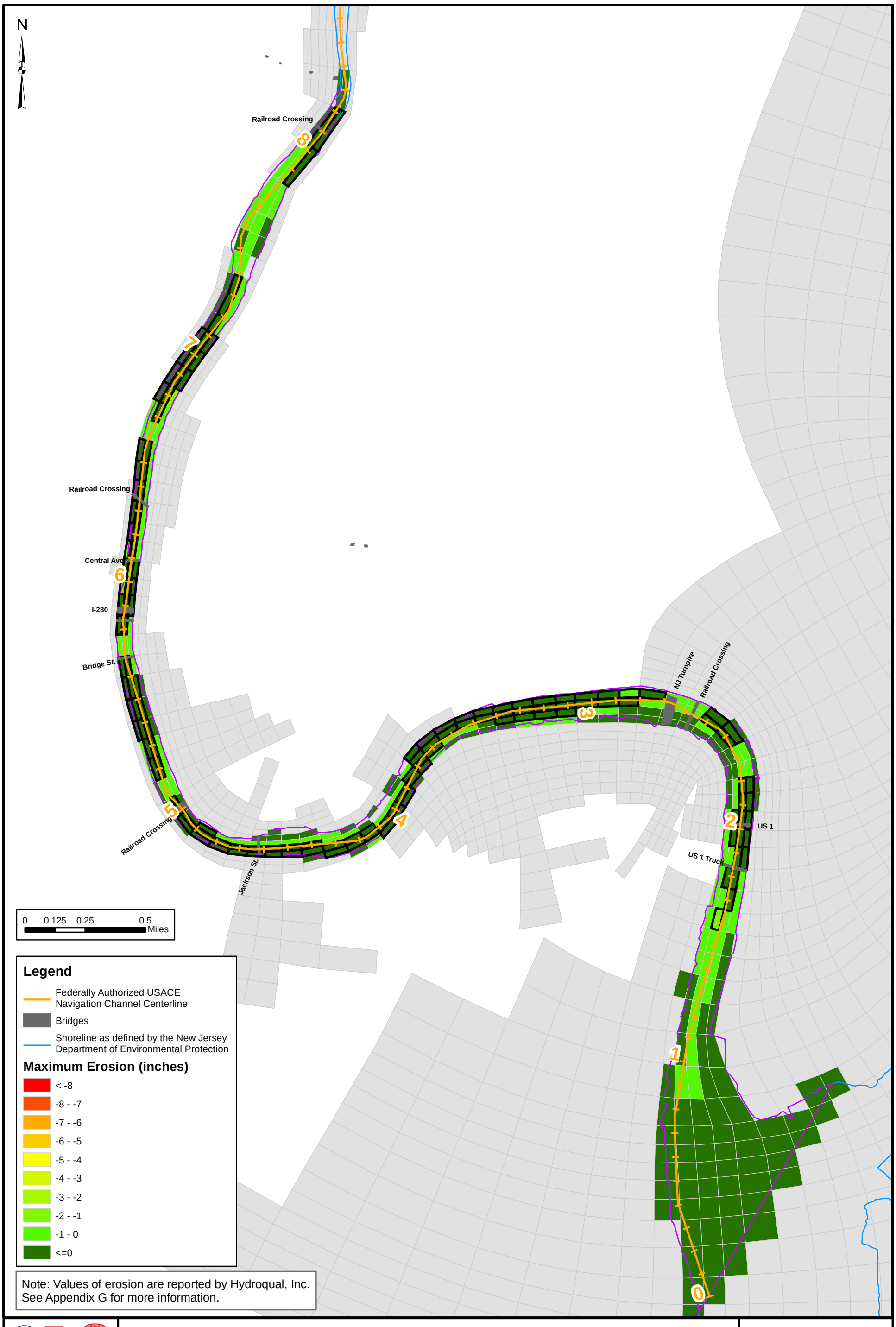
United States Department of the Interior, Bureau of Reclamation, 1987. *Design of Small Dams*. 3rd Ed. United States Government Printing Office.

R2-0010328

Figures

R2-0010329

Map Document: (S:\Projects\PASSAIC\MapDocuments\4553001-CERCLA\Bed_Elevation_change\armor_1in.mxd)
2/20/2007 -- 3:21:11 PM



Armor Areas: Maximum Erosion

Lower Passaic River Restoration Project

Figure 1

June 2007
Draft

R2-0010330

ATTACHMENT 1

CALCULATIONS

R2-0010331

MALCOLM PIRNIE	MALCOLM PIRNIE, INC. INDEPENDENT ENVIRONMENTAL ENGINEERS, SCIENTISTS, & CONSULTANTS GEOTECHNICAL & DAM ENGINEERING SERVICES PROGRAM		
CLIENT:	Lower Passaic River Restoration Project	PROJECT:	Focused Feasibility Study
BY: KSP	DATE: 12-Mar-06	Job No.:	4553031
CHKD BY:	DATE:	SHEET No.:	
SUBJECT:	Attachment 1: Erosion Protection Layer for the Proposed Cap, Conceptual Design		

MathCAD 7 Professional, MathSoft, Inc. c.1986-1997

STATEMENT : Size the stone requirement for the proposed erosion protection layer in order to protect the proposed cap.

Additional Unit Definitions:

$pcf \equiv 1 \cdot \frac{lb}{ft^3}$ $\quad psf \equiv 1 \cdot \frac{lb}{ft^2}$ $\quad kip \equiv 1000 \cdot lb$ $\quad ft \equiv 12 \cdot in$ $\quad m \equiv 3.28 \cdot ft$

$\$ \equiv 1$ $\quad ton \equiv 2000 \cdot lb$ $\quad cy \equiv 27 \cdot ft^3$

References:

1. **Hydraulic Design of Flood Control Channels (Engineer Manual 1110-2-1601), Department of the Army, US Army Corps of Engineers.**
2. **Velocities and Water Depths estimates from HydroQual, Inc. in locations of potential erosion due to a 100-year storm event.**
3. **Standards for Soil Erosion and Sediment Control in New Jersey**

Input Parameters:

$S_f := 1.3$ Safety factor (Engineer Manual 1110-2-1601)

$C_s := 0.3$ Stability coefficient (angular rock, Engineer Manual 1110-2-1601))

$C_v := 1.0$ Vertical velocity distribution for straight channel (Engineer Manual 1110-2-1601)

$C_t := 1.0$ Thickness coefficient (Engineer Manual 1110-2-1601)

$a := \frac{D_{85}}{D_{15}}$

$a := 3.5$ Varies from 1.7 to 5.2 (Engineer Manual 1110-2-1601 and ASTM D 6092)

$n := 0 .. 6$

$$d := \begin{pmatrix} 12.85 \\ 11.99 \\ 8.19 \\ 14.33 \\ 8.09 \\ 9.12 \\ 12.31 \end{pmatrix} ft$$

Local depth (varies), from HydroQual, Inc. estimates

$i := 0 .. 6$

$\gamma_w := 62.4pcf$ Unit weight of Water

$\gamma_s := 155pcf$ Unit weight of stone

$\gamma_f := 120pcf$ Unit weight of filter material

$$V := \begin{pmatrix} 5.5 \\ 5.8 \\ 6.7 \\ 5.2 \\ 6.8 \\ 6.5 \\ 5.6 \end{pmatrix} \frac{ft}{sec}$$

Velocity (varies) from HydroQual, Inc. estimates

$\theta := 20deg$ Angle of side slope with horizontal (most steep angle)

$\phi := 40deg$ Angle of repose of riprap material

$$K_1 := \sqrt{1 - \frac{\sin(\theta)^2}{\sin(\phi)^2}}$$

$K_1 = 0.847$

$g = 9.807\ m \cdot s^{-2}$ Gravity constant

$$D30_{i,n} := S_f \cdot C_s \cdot C_v \cdot C_t \cdot d_n \cdot \left[\left(\frac{\gamma_w}{\gamma_s - \gamma_w} \right)^{0.5} \cdot \frac{V_i}{\sqrt{K_1 \cdot g \cdot d_n}} \right]^{2.5}$$

$D30_{0,0} = 0.044\ m$

$D30_{1,1} = 0.051\ m$

$D30_{2,2} = 0.08\ m$

$D30_{3,3} = 0.037\ m$

$D30_{4,4} = 0.083\ m$

$D30_{5,5} = 0.072\ m$

$D30_{6,6} = 0.046\ m$

$V_i =$

1.676
1.768
2.042
1.585
2.073
1.981
1.707

$m \cdot s^{-1}$

$d_n =$

3.917
3.655
2.496
4.368
2.466
2.78
3.752

m

$$D50_{i,n} := D30_{i,n} \cdot \left(\frac{D_{85}}{D_{15}} \right)^{0.33}$$

The approximate relationship between D_{50} and D_{30}

$$D50_{i,n} := D30_{i,n} \cdot a^{0.33}$$

$$D_{50} = \begin{pmatrix} 2.601 & 2.646 & 2.911 & 2.531 & 2.92 & 2.834 & 2.629 \\ 2.97 & 3.022 & 3.324 & 2.891 & 3.335 & 3.236 & 3.002 \\ 4.26 & 4.335 & 4.768 & 4.146 & 4.783 & 4.641 & 4.306 \\ 2.261 & 2.3 & 2.53 & 2.2 & 2.538 & 2.463 & 2.285 \\ 4.421 & 4.498 & 4.948 & 4.302 & 4.963 & 4.817 & 4.469 \\ 3.949 & 4.018 & 4.42 & 3.843 & 4.434 & 4.303 & 3.992 \\ 2.721 & 2.768 & 3.045 & 2.648 & 3.055 & 2.964 & 2.75 \end{pmatrix} in$$

$D50_{0,0} = 2.601\ in$

$D50_{1,1} = 3.022\ in$

$D50_{2,2} = 4.768\ in$

$D50_{3,3} = 2.2\ in$

$D50_{4,4} = 4.963\ in$

$D50_{5,5} = 4.303\ in$

$D50_{6,6} = 2.75\ in$

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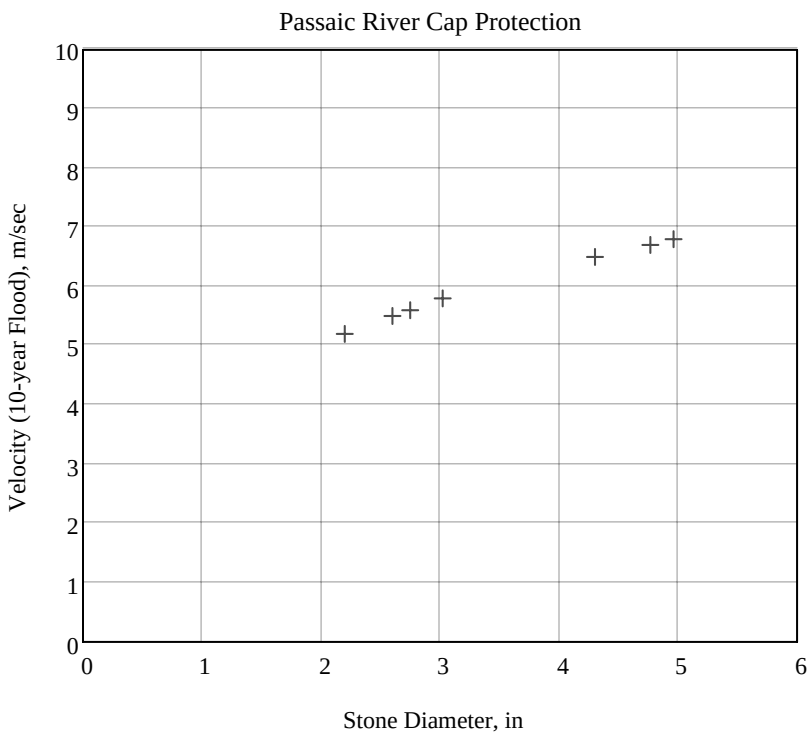
$$Stone_D_{50} := \begin{pmatrix} D50_{0,0} \\ D50_{1,1} \\ D50_{2,2} \\ D50_{3,3} \\ D50_{4,4} \\ D50_{5,5} \\ D50_{6,6} \end{pmatrix} \qquad Stone_D_{50} = \begin{pmatrix} 66.067 \\ 76.766 \\ 121.107 \\ 55.879 \\ 126.063 \\ 109.292 \\ 69.857 \end{pmatrix} mm \qquad Stone_D_{50} = \begin{pmatrix} 2.601 \\ 3.022 \\ 4.768 \\ 2.2 \\ 4.963 \\ 4.303 \\ 2.75 \end{pmatrix} in \qquad V = \begin{pmatrix} 5.5 \\ 5.8 \\ 6.7 \\ 5.2 \\ 6.8 \\ 6.5 \\ 5.6 \end{pmatrix} \frac{ft}{sec}$$

$$l := 0 .. length(Stone_D_{50}) - 1$$



Analyses indicate that the required median size (D_{50}) of stones varies from approximately 2.2" to 5" at locations considered in analyses discussed above (i.e., sections 0 through 6). In addition, analyses indicate that a single median size, i.e., D_{50} of 5" is suitable for sections 2, 4, and 5 and D_{50} of 3" is suitable for Sections 0, 1, 3, and 6.

The proposed erosion protection layer shall be composed of a well-graded mixture such that 50% of the mixture by weight shall be larger than the D_{50} size (i.e., 3" and 5") at respective locations. Stone shall be placed to a thickness of 3 times D_{50} size, which is approximately 9 inches and 15 inches, respectively.

STATEMENT: Design a filter layer that is to be placed in between the proposed sand cap and the erosion protection layer.

REFERENCES:

1. United States Department of the Interior, Bureau of Reclamation, Design of Small Dams, Third Edition, 1987, Pages 218 through 220.
2. DOT Specifications, New Jersey.

Filter compatibility between the embankment and foundation is based on the following criteria:

$$\frac{D_{15}\,\text{Filter}}{D_{15}\,\text{Base}} \geq 5$$ ***Reference 1, Equation 1, Page 218***

$$\frac{D_{15}\,\text{Filter}}{D_{85}\,\text{Base}} \leq 5$$ ***Reference 1, Equation 2, Page 218***

This design is suitable for sections 1-2, 2-2, 3-3, 4-4, 5-5, and 6-6. The d_{50} and d_{30} of the proposed erosion protection layer at these stations are summarized below:

$D30_{0,0} = 43.696\,\text{mm}$ $D30_{5,5} = 72.284\,\text{mm}$ $D50_{0,0} = 66.067\,\text{mm}$ $D50_{5,5} = 109.292\,\text{mm}$

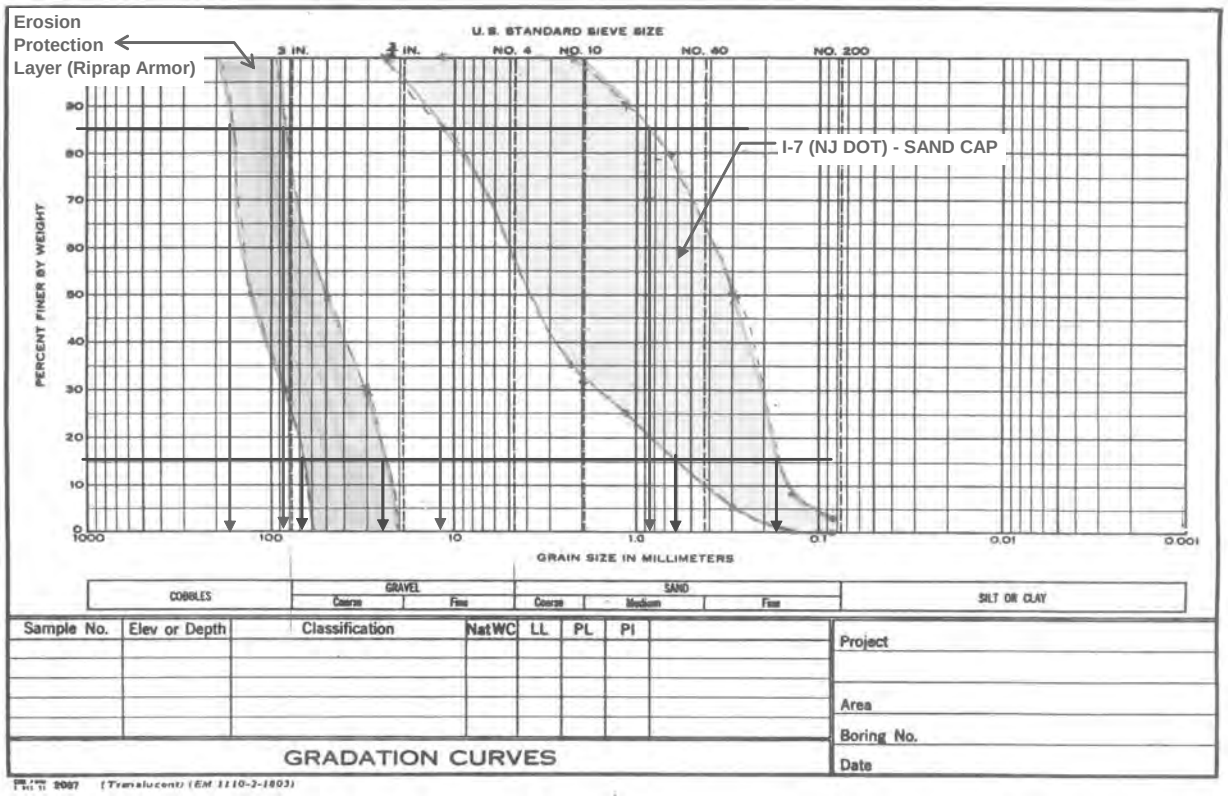
$D30_{1,1} = 50.772\,\text{mm}$ $D30_{6,6} = 46.202\,\text{mm}$ $D50_{1,1} = 76.766\,\text{mm}$ $D50_{6,6} = 69.857\,\text{mm}$

$D30_{2,2} = 80.099\,\text{mm}$ $D50_{2,2} = 121.107\,\text{mm}$

$D30_{3,3} = 36.958\,\text{mm}$ $D50_{3,3} = 55.879\,\text{mm}$

$D30_{4,4} = 83.377\,\text{mm}$ $D50_{4,4} = 126.063\,\text{mm}$

D_{30} **and** D_{50} ***of the erosion protection layer range from 36mm to 83mm and 55mm to 126mm, respectively (see the gradation envelope presented below). Based on the standard soil aggregate gradation, New Jersey, Sand "I-7" has been assumed for the proposed sand cap, and the gradation curve for this sand type is presented below:***



Design Parameters

Based on the gradation curve for the type "I-7", presented above, upper and lower limit values were obtained for the proposed Sand Cap (SC). Gradation for the filter was determined through the following analyses.

Gradation Limits for the proposed Sand Cap (SC)

Lower Limits

$D15SCLower := 0.18mm$

$D85SCLower := 0.85mm$

Upper Limits

$D15SCUpper := 0.6mm$

$D85SCUpper := 12mm$

Gradation Limits for the Filter

Lower Limits

$D15FilterLower := 3mm$

$D85FilterLower := 30mm$

Upper Limits

$D15FilterUpper := 4.2mm$

$D85FilterUpper := 50mm$

Determination of Filter Compatibility:

The filter criteria (i.e. equations 1 and 2) are analyzed separately below.

Equation 1:

Recall: $\frac{D_{15}\,\text{Filter}}{D_{15}\,\text{Base}} \geq 5$ ***Reference 1, Equation 1, Page 218***

Lower Bound

Based on the specific condition addressed, if a satisfactory result is obtained, the following will be true:

s := "Lower Bound of D15 of the Filter is SATISFIED"

Based on the specific condition addressed, if an unsatisfactory result is obtained, the following will be true:

n := "Lower Bound of D15 of the Filter is NOT SATISFIED"

From equation 1, the filter capacity of a lower limit embankment material being filtered by a lower limit foundation material can be determined.

$$D15FilterL := \text{if}\left(\frac{D15FilterLower}{D15SCLower} \geq 5, s, n\right) \qquad \frac{D15FilterLower}{D15SCLower} = 16.667$$

D15FilterL = "Lower Bound of D15 of the Filter is SATISFIED"

From equation 1, the filter capacity of a lower limit embankment material being filtered by an upper limit foundation material can be determined.

$$D15FilterU := \text{if}\left(\frac{D15FilterUpper}{D15SCLower} \geq 5, s, n\right) \qquad \frac{D15FilterUpper}{D15SCLower} = 23.333$$

D15FilterU = "Lower Bound of D15 of the Filter is SATISFIED"

Upper Bound

Based on the specific condition addressed, if a satisfactory result is obtained, the following will be true:

s1 := "Upper Bound of D15 of the Filter is SATISFIED"

Based on the specific condition addressed, if an unsatisfactory result is obtained, the following will be true:

n1 := "Upper BoundD15 of the Filter is NOT SATISFIED"

From equation 1, the filter capacity of an upper limit embankment material being filtered by a lower limit foundation material can be determined.

$$D15Filter1L := \text{if}\left(\frac{D15FilterLower}{D15SCUpper} \geq 5, s1, n1\right) \qquad \frac{D15FilterLower}{D15SCUpper} = 5$$

D15Filter1L = "Upper Bound of D15 of the Filter is SATISFIED"

From equation 1, the filter capacity of an upper limit embankment material being filtered by an upper limit foundation material can be determined.

$$D15Filter1U := \text{if}\left(\frac{D15FilterUpper}{D15SCUpper} \geq 5, s1, n1\right) \qquad \frac{D15FilterUpper}{D15SCUpper} = 7$$

D15Filter1U = "Upper Bound of D15 of the Filter is SATISFIED"

Equation 2:

Recall: $\frac{D_{15}\,\text{Filter}}{D_{85}\,\text{Base}} \le 5$ ***Reference 1, Equation 2, Page 218***

Lower Bound

Based on the specific condition addressed, if a satisfactory result is obtained, the following will be true:

p := "Lower Bound of D85 of the Filter is SATISFIED"

Based on the specific condition addressed, if an unsatisfactory result is obtained, the following will be true:

q := "Lower Bound of D85 of the Filter is NOT SATISFIED"

From equation 2, the filter capacity of a lower limit embankment material being filtered by a lower limit foundation material can be determined.

$$D15Filter2L := \text{if}\left(\frac{D15FilterLower}{D85SCLower} \le 5, p, q\right) \qquad \frac{D15FilterLower}{D85SCLower} = 3.529$$

D15Filter2L = "Lower Bound of D85 of the Filter is SATISFIED"

From equation 2, the filter capacity of a lower limit embankment material being filtered by an upper limit foundation material can be determined.

$$D15Filter4U := \text{if}\left(\frac{D15FilterUpper}{D85SCLower} \le 5, p, q\right) \qquad \frac{D15FilterUpper}{D85SCLower} = 4.941$$

D15Filter4U = "Lower Bound of D85 of the Filter is SATISFIED"

Upper Bound

Based on the specific condition addressed, if a satisfactory result is obtained, the following will be true:

p1 := "Upper Bound of D85 of the Filter is SATISFIED"

Based on the specific condition addressed, if an unsatisfactory result is obtained, the following will be true:

q1 := "Upper BoundD85 of the Filter is NOT SATISFIED"

From equation 2, the filter capacity of an upper limit embankment material being filtered by a lower limit foundation material can be determined.

$$D15Filter3L := \text{if}\left(\frac{D15FilterLower}{D85SCUpper} \le 5, p1, q1\right) \qquad \frac{D15FilterLower}{D85SCUpper} = 0.25$$

D15Filter3L = "Upper Bound of D85 of the Filter is SATISFIED"

From equation 2, the filter capacity of an upper limit embankment material being filtered by an upper limit foundation material can be determined.

$$D15Filter5U := \text{if}\left(\frac{D15FilterUpper}{D85SCUpper} \le 5, p1, q1\right) \qquad \frac{D15FilterUpper}{D85SCUpper} = 0.35$$

D15Filter5U = "Upper Bound of D85 of the Filter is SATISFIED"

Results

D15FilterL = "Lower Bound of D15 of the Filter is SATISFIED"

D15FilterU = "Lower Bound of D15 of the Filter is SATISFIED"

D15Filter2L = "Lower Bound of D85 of the Filter is SATISFIED"

D15Filter4U = "Lower Bound of D85 of the Filter is SATISFIED"

D15Filter1L = "Upper Bound of D15 of the Filter is SATISFIED"

D15Filter1U = "Upper Bound of D15 of the Filter is SATISFIED"

D15Filter3L = "Upper Bound of D85 of the Filter is SATISFIED"

D15Filter5U = "Upper Bound of D85 of the Filter is SATISFIED"

Gradation for the filter material that is to be placed in between the proposed sand cap and the erosion protection layer shall have the following gradation details:

Lower Limits

D15FilterLower = 3 mm

D85FilterLower = 30 mm

Upper Limits

D15FilterUpper = 4.2 mm

D85FilterUpper = 50 mm

STEP 2

Check the compatibility of the filter material with the proposed erosion protection layer. During this step of analyses, the filter discussed above becomes the base material and the erosion protection layer material becomes the filter material.

Gradation Limits for the base material

Lower Limits

D15BaseLower := D15FilterLower

D85BaseLower := D85FilterLower

Upper Limits

D15BaseUpper := D15FilterUpper

D85BaseUpper := D85FilterUpper

Gradation Limits for the erosion protection layer (EPL) (i.e., Filter)

Lower Limits

D15FilterLower_EPL := 26mm

D85FilterLower_EPL := 90mm

Upper Limits

D15FilterUpper_EPL := 70mm

D85FilterUpper_EPL := 180mm

Determination of Filter Compatibility:

The filter criteria (i.e. equations 1 and 2) are analyzed separately below.

Equation 1:

Recall: $\frac{D_{15}\,\text{Filter}}{D_{15}\,\text{Base}} \geq 5$ ***Reference 1, Equation 1, Page 218***

Lower Bound

Based on the specific condition addressed, if a satisfactory result is obtained, the following will be true:

s := "Lower Bound of D15 of the Filter is SATISFIED"

Based on the specific condition addressed, if an unsatisfactory result is obtained, the following will be true:

n := "Lower Bound of D15 of the Filter is NOT SATISFIED"

From equation 1, the filter capacity of a lower limit embankment material being filtered by a lower limit foundation material can be determined.

$$D15FilterL := \text{if}\left(\frac{D15FilterLower_EPL}{D15BaseLower} \geq 5, s, n\right) \quad \frac{D15FilterLower_EPL}{D15BaseLower} = 8.667$$

D15FilterL = "Lower Bound of D15 of the Filter is SATISFIED"

From equation 1, the filter capacity of a lower limit embankment material being filtered by an upper limit foundation material can be determined.

$$D15FilterU := \text{if}\left(\frac{D15FilterUpper_EPL}{D15BaseLower} \geq 5, s, n\right) \quad \frac{D15FilterUpper_EPL}{D15BaseLower} = 23.333$$

D15FilterU = "Lower Bound of D15 of the Filter is SATISFIED"

Upper Bound

Based on the specific condition addressed, if a satisfactory result is obtained, the following will be true:

s1 := "Upper Bound of D15 of the Filter is SATISFIED"

Based on the specific condition addressed, if an unsatisfactory result is obtained, the following will be true:

n1 := "Upper BoundD15 of the Filter is NOT SATISFIED"

From equation 1, the filter capacity of an upper limit embankment material being filtered by a lower limit foundation material can be determined.

$$D15Filter1L := \text{if}\left(\frac{D15FilterLower_EPL}{D15BaseUpper} \geq 5, s1, \text{г}\right. \quad \frac{D15FilterLower_EPL}{D15BaseUpper} = 6.19$$

D15Filter1L = "Upper Bound of D15 of the Filter is SATISFIED"

From equation 1, the filter capacity of an upper limit embankment material being filtered by an upper limit foundation material can be determined.

$$D15Filter1U := \text{if}\left(\frac{D15FilterUpper_EPL}{D15BaseUpper} \geq 5, s1, \text{г}\right. \quad \frac{D15FilterUpper_EPL}{D15BaseUpper} = 16.667$$

D15Filter1U = "Upper Bound of D15 of the Filter is SATISFIED"

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Equation 2:

Recall: $\frac{D_{15}\,\text{Filter}}{D_{85}\,\text{Base}} \le 5$ ***Reference 1, Equation 2, Page 218***

Lower Bound

Based on the specific condition addressed, if a satisfactory result is obtained, the following will be true:

p := "Lower Bound of D85 of the Filter is SATISFIED"

Based on the specific condition addressed, if an unsatisfactory result is obtained, the following will be true:

q := "Lower Bound of D85 of the Filter is NOT SATISFIED"

From equation 2, the filter capacity of a lower limit embankment material being filtered by a lower limit foundation material can be determined.

$$D15Filter2L := \text{if}\left(\frac{D15FilterLower_EPL}{D85BaseLower} \le 5, p, q\right) \quad \frac{D15FilterLower_EPL}{D85BaseLower} = 0.867$$

D15Filter2L = "Lower Bound of D85 of the Filter is SATISFIED"

From equation 2, the filter capacity of a lower limit embankment material being filtered by an upper limit foundation material can be determined.

$$D15Filter4U := \text{if}\left(\frac{D15FilterUpper_EPL}{D85BaseLower} \le 5, p, q\right) \quad \frac{D15FilterUpper_EPL}{D85BaseLower} = 2.333$$

D15Filter4U = "Lower Bound of D85 of the Filter is SATISFIED"

Upper Bound

Based on the specific condition addressed, if a satisfactory result is obtained, the following will be true:

p1 := "Upper Bound of D85 of the Filter is SATISFIED"

Based on the specific condition addressed, if an unsatisfactory result is obtained, the following will be true:

q1 := "Upper BoundD85 of the Filter is NOT SATISFIED"

From equation 2, the filter capacity of an upper limit embankment material being filtered by a lower limit foundation material can be determined.

$$D15Filter3L := \text{if}\left(\frac{D15FilterLower_EPL}{D85BaseUpper} \le 5, p1, q\right) \quad \frac{D15FilterLower_EPL}{D85BaseUpper} = 0.52$$

D15Filter3L = "Upper Bound of D85 of the Filter is SATISFIED"

From equation 2, the filter capacity of an upper limit embankment material being filtered by an upper limit foundation material can be determined.

$$D15Filter5U := \text{if}\left(\frac{D15FilterUpper_EPL}{D85BaseUpper} \le 5, p1, q\right) \quad \frac{D15FilterUpper_EPL}{D85BaseUpper} = 1.4$$

D15Filter5U = "Upper Bound of D85 of the Filter is SATISFIED"

Results

D15FilterL = "Lower Bound of D15 of the Filter is SATISFIED"

D15FilterU = "Lower Bound of D15 of the Filter is SATISFIED"

D15Filter2L = "Lower Bound of D85 of the Filter is SATISFIED"

D15Filter4U = "Lower Bound of D85 of the Filter is SATISFIED"

D15Filter1L = "Upper Bound of D15 of the Filter is SATISFIED"

D15Filter1U = "Upper Bound of D15 of the Filter is SATISFIED"

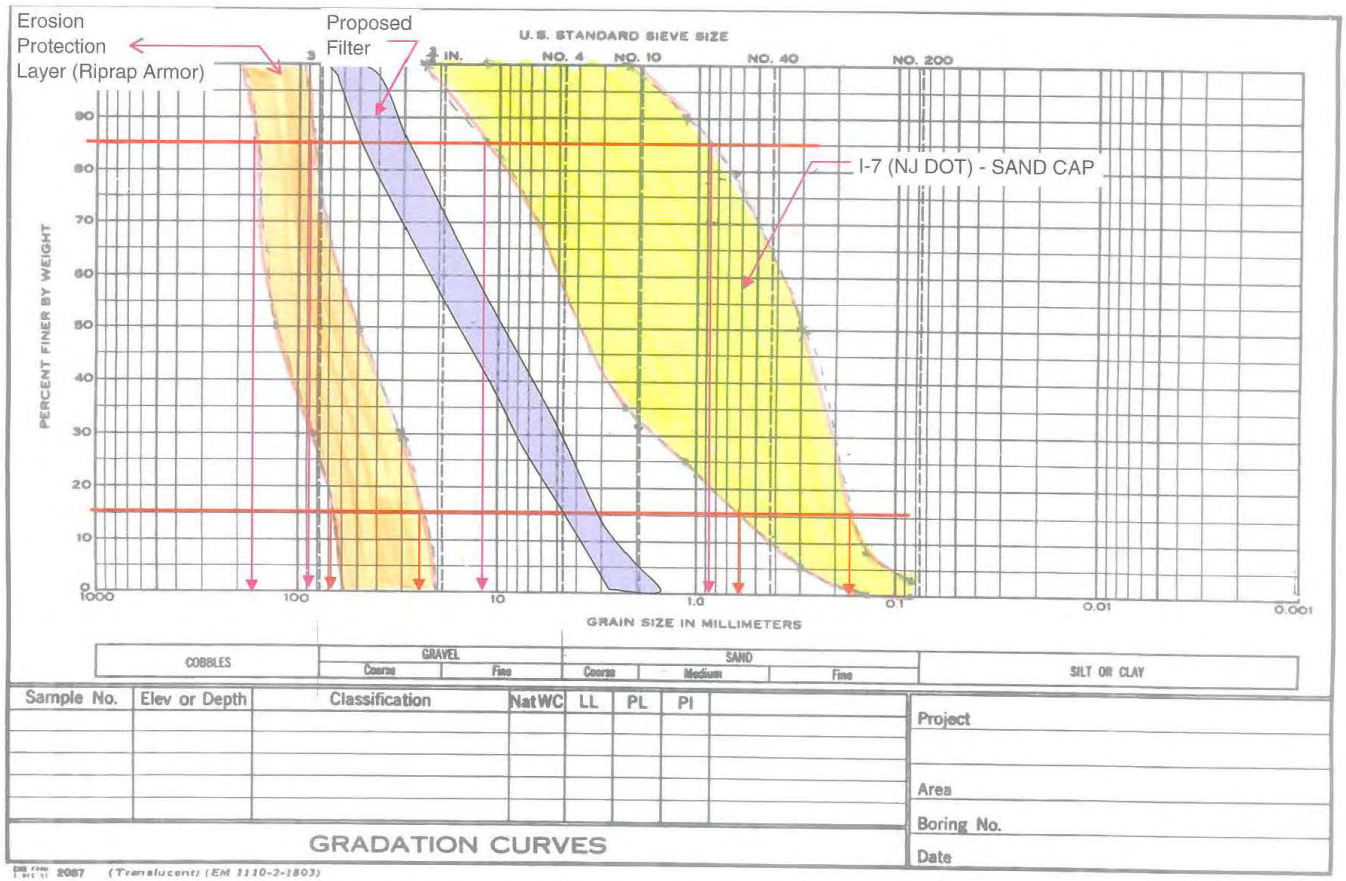
D15Filter3L = "Upper Bound of D85 of the Filter is SATISFIED"

D15Filter5U = "Upper Bound of D85 of the Filter is SATISFIED"

Gradation for the filter material that is to be placed in between the proposed sand cap and the erosion protection layer shall have the following gradation details:

Lower Limits	Upper Limits
D15FilterLower = 3 mm	D15FilterUpper = 4.2 mm
D85FilterLower = 30 mm	D85FilterUpper = 50 mm

R2-0010343


Erosion Protection Layer (Riprap Armor)
Proposed Filter
U.S. STANDARD SIEVE SIZE
3
3/4 IN.
NO. 4
NO. 10
NO. 40
NO. 200
I-7 (NJ DOT) - SAND CAP
PERCENT FINER BY WEIGHT
90
80
70
60
50
40
30
20
10
0
1000
100
10
1.0
0.1
0.01
0.001
GRAIN SIZE IN MILLIMETERS
COBBLES
GRAVEL
Coarse
Fine
SAND
Coarse
Medium
Fine
SILT OR CLAY
Sample No.
Elev or Depth
Classification
Nat WC
LL
PL
PI
Project
Area
Boring No.
Date
GRADATION CURVES
ENG FORM 1 DEC 61 2087 (Translucent) (EM 1110-2-1803)

R2-0010344

MALCOLM PIRNIE

Interoffice Correspondence

Date: September 21, 2006

To: S. Thompson (WHI)

Copy: L. Bossi (WHI)

From: S. Gbondo-Tugbawa (NNJ) E. Garvey (NNJ)

Re: Lower Passaic River Focused Feasibility Study: Silt Trap Evaluation

INTRODUCTION

This memorandum describes an assessment of the effectiveness of a silt trap in the Lower Passaic River and Newark Bay system using a simplified theoretical model and review of the literature on particle dynamics in estuaries. A silt trap is intended to create low velocity regions in which a large part of the suspended sediments will have a chance to settle out. The silt trap was considered to be placed near river mile (RM) 1 within the Lower Passaic River. This location was chosen since the historical bathymetric survey data show that it is already a highly depositional environment with an average sedimentation rate of more than 5 inches/year.

Although hypothetical calculations would indicate the potential usefulness of a silt trap for sequestering particles of the size distributions found in Lower Passaic River sediments, the actual manifestation of water-borne particles in the Lower Passaic River in the form of flocs indicates that the hypothetical calculations are not applicable, and that such a silt trap would not be effective.

METHODS AND ANALYSIS

The proper size and shape of the silt trap depends on the stream size, hydrology, and sediment load. This assessment of silt trap efficiency and design was based on the ideal settling theory for a rectangular settling tank. Ideal settling theory is also applied to estimate trap removal efficiency for sediment other than the target size. The theory of ideal settling is based on the following assumptions:

- There is no scouring or resuspension of deposited material.
- The through-flow velocity is steady and uniform.
- Sediment particles settle at a constant velocity throughout the tank.

The amount of sediment that will settle in the tank depends on the flow velocity, silt trap dimensions, and water depth: a shallower trap means less settling. Alternatively, it is expected that a deeper trap will decrease the flow velocity and increase the amount of sediment deposited in the trap. The fraction of sediment that settles to the bottom of the trap can be calculated as:

$$\beta = \frac{\alpha L_e \omega_s}{UH} \tag{1}$$

Where:

β = fraction of sediment captured in the trap (dimensionless)

L_e = settling zone of the trap [units of feet (ft)]

w_s = particle settling velocity [units of meters per second (m/s)]

U = flow velocity (units of m/s)

H = depth of water before trap excavation (units of ft)

α = adjusting coefficient for non-uniform particle concentration in the water column (dimensionless)

The various parameters in Equation 1 above and assumptions in parameters values are defined below.

Settling Velocity

The settling velocity is calculated on the basis of Chang (1997) as follows:

$$\omega_s = \frac{\upsilon}{d}\left[\left(25 + 1.2d_*^2\right)^{1/2} - 5\right]^{3/2} \tag{2}$$

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Where

$$d_* = d\left[\left(\frac{\rho_p - \rho_w}{\rho_w}\right)\frac{g}{\upsilon^2}\right]$$

Where

ω_s	=	settling velocity (units of m/s)
d	=	diameter of the particle [units of meters (m)]
g	=	gravitational constant [units of meters per second square (m/s^2)]
ν	=	kinematic viscosity of water [units of meters squared per second (m^2/s)]
ρ_p	=	particle density [units of kilogram per cubic meter (kg/m^3)]
ρ_w	=	water density (units of kg/m^3)

Equation 2 is an empirical approach for predicting the settling velocity of natural sediment particles in freshwater suspensions. It is applicable to a wide range of Reynolds numbers from the Stokes flow to the turbulent regime.

Flow Velocity

The flow velocity (U) is the average unidirectional horizontal current in the water column under normal conditions. When a scenario involving excavation below the current river depth is assumed, the river flow is unchanged; however, the increased depth in the sediment trap results in a decrease in flow velocity. When the particles are collected at the bottom of the sediment trap, it is expected that the decreased depth should affect the velocity. However, it is assumed that all sediments deposited in the trap are removed frequently to keep the depth close to the value assumed for each scenario.

Settling Zone

Settling Zone is defined as the portion of the trap length over which settling effectively occurs and in this analysis it is assumed that the 10 percent of the trap length at each end is ineffective (*i.e.*, L_e = 80 percent of the trap length). This assumption was made to

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account for circulation effects close to the boundaries of the trap, as well as the fact that the flow is bi-directional.

Adjusting Coefficient

The adjusting coefficient accounts for non-uniform distribution of concentration of particles in the vertical direction, which depends on the stratification, flocculation processes, and shear velocity. If the suspended sediment is uniformly distributed, then α is 1. In most cases, α is between 1 and 2, because the concentration of sediment in the river bottom is greater than that at the surface. In this assessment, α is set to a value of 1.5.

Depth

The depth is the water depth before any excavation of the trap occurs; it is not the total trap depth. It is assumed that once a particle settles beyond the original sediment water interface it will be deposited in the trap, regardless of the depth of the trap itself. Thus, no resuspension of particles that settle below the original water-sediment interface is considered.

APPLICATION TO LOWER PASSAIC RIVER

An illustration of the capture efficiency of a silt trap near RM1 is as follows:

- Assume width of 400 ft close to the width of the river.
- Assume total length of 1,000 ft for the trap. The effective length or settling zone is 80 percent of this length, or 800 ft.
- Assume $\alpha = 1.5$.
- Original water depth assumed 20 ft before excavation of the trap. For trap excavation scenarios, removal of 50 ft of sediment from the bottom was assumed. Note that H equals 20 ft for both cases.
- Assume velocity of 0.25 m/s based on review of project hydrodynamic measurements and the Hydrodynamic Model Calibration Report (HydroQual, 2006).

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Table 1 presents the estimated capture efficiency under current water depth and under a 50-foot trap excavation scenario. Notably, the deeper silt trap captures all of the coarse silt, about a third of the medium silt and just under a one-tenth of the fine silt. No significant removal of suspended clay particles are expected in the absence of flocculation.

Table 1: Estimated Capture Efficiency Under Current Water Depth and 50-foot Trap Excavation

Scenario	AGU Class	Particle Size (micron)	ωs (m/s)	α	Q (m3/s)	U (m/s)	Width (ft)	L_e (ft)	Total Depth (ft)	β
No Trap	Coarse silt	31 - 62	1.41E-01	1.5	223.0	0.25	400	800	20	34%
No Trap	Medium silt	16 - 31	3.68E-02	1.5	223.0	0.25	400	800	20	9%
No Trap	Fine silt	8 - 16	9.63E-03	1.5	223.0	0.25	400	800	20	2%
No Trap	Very fine silt	4 - 8	2.41E-03	1.5	223.0	0.25	400	800	20	0.6%
No Trap	Coarse clay	2 - 4	6.03E-04	1.5	223.0	0.25	400	800	20	0.14%
No Trap	Medium clay	1 - 2	1.51E-04	1.5	223.0	0.25	400	800	20	0.04%
No Trap	Fine clay	0.5 - 1	3.77E-05	1.5	223.0	0.25	400	800	20	0.01%
No Trap	Very fine clay	0.24 - 0.5	9.17E-06	1.5	223.0	0.25	400	800	20	0.00%
50ft Trap	Coarse silt	31 - 62	1.41E-01	1.5	223.0	0.071	400	800	70	100 %
50ft Trap	Medium silt	16 - 31	3.68E-02	1.5	223.0	0.071	400	800	70	31%
50ft Trap	Fine silt	8 - 16	9.63E-03	1.5	223.0	0.071	400	800	70	8%
50ft Trap	Very fine silt	4 - 8	2.41E-03	1.5	223.0	0.071	400	800	70	2%
50ft Trap	Coarse clay	2 - 4	6.03E-04	1.5	223.0	0.071	400	800	70	0.5%
50ft Trap	Medium clay	1 - 2	1.51E-04	1.5	223.0	0.071	400	800	70	0.13%
50ft Trap	Fine clay	0.5 - 1	3.77E-05	1.5	223.0	0.071	400	800	70	0.03%
50ft Trap	Very fine clay	0.24 - 0.5	9.17E-06	1.5	223.0	0.071	400	800	70	0.01%

AGU = American Geological Union

Q = Discharge Flow

The hypothetical calculations above would suggest that, depending on the length and depth of the trap excavated and the size of the water-borne particles, the silt trap has a potential to be effective in removing coarse silt sediments and sediments of higher grain sizes. However, the conditions in the Lower Passaic River are far from the ideal setting assumed above, and the silt trap will be much less efficient in capturing the flocculated water column particles that actually exist in the system. The following research results and data support this premise:

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- Recent investigations on the particle size distribution in the water column of the Lower Passaic River by the Chesapeake Biogeochemical Associates (Owens *et al*., 2006) during sediment coring for erosion experiments and by Rutgers University during dredge pilot monitoring using a Laser In Situ Scattering Transmissometry (LISST) device, suggest that the majority of the in-situ particles exceed 63 micrometers (µm) in diameter. Published data using a digital floc camera (Mikkelsen *et al.*, 2005) in Newark Bay reported median particle size of about 500 µm. Such high values were observed under stratified conditions. However, under unstratified conditions, median particle sizes decrease to about 100 µm as a result of the greater turbulence. For both of these floc particle sizes, neither Cheng's formula above nor Stokes' Law can be used to estimate settling speeds because their densities are much less than the densities of the individual mineral particles (Lick *et al.*, 2006).
- Water-borne particles in the Lower Passaic River are not coarse mineral particles (*e.g*., sands, or coarser materials) as median particle size measurements might suggest because such particles need significant energy to be resuspended and transported. Rather, the water-borne particles in the Lower Passaic River are aggregates of fine-grained sediments, as discussed above.
- Settling velocities as a function of floc diameter have been measured for both fresh water and sea water as a function of fluid shear and sediment concentration as documented in Lick *et al*. (2006). The speeds were generally on the order of 0.01 centimeters per second (cm/sec) or less. This corresponds to values estimated for medium silts and smaller grain sizes that as presented in Table 1. Notably, particles with settling velocities on the order of 0.01 cm/sec would not be captured efficiently by the trap, suggesting that the silt trap will likely not work for the floc-like, less-dense particles that exist in this system.

In summary, although hypothetical calculations would indicate the potential usefulness of a silt trap for sequestering particles of the size distributions found in Lower Passaic River sediments, the actual manifestation of water-borne particles in the Lower Passaic River in the form of flocs indicates that the hypothetical calculations are not applicable, and that such a silt trap would not be effective.

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MALCOLM PIRNIE

Interoffice Correspondence

Date: April 2007

To: S. Thompson (WHI)

From: D. Navon (TAM)

RE: Summary of In Situ Stabilization Case Studies

MINAMATA BAY CASE STUDY OF IN SITU SOLIDIFICATION/ STABILIZATION

Between 1930 and 1971, releases of mercury from the production processes of acetaldehyde and vinyl chloride at the Minamata plant of Chisso Co. Ltd. resulted in approximately 150 – 225 tons of mercury being discharged to Minamata Bay. The local government initiated mercury monitoring of sediments in 1959. In 1973, it was determined that sediments covering the entire area of Minamata Bay [2 square kilometers (km^2)] contained mercury concentrations of at least 15 milligrams per kilogram (mg/kg), with maximum concentrations of approximately 600 mg/kg. Beginning in 1977, site preparation measures were initiated to minimize migration of fish and reduce transport of suspended sediment between Minamata Bay and the neighboring Yatsushiro Sea. A cofferdam was installed between Koijishima Island and Cape Myojinsaki to close one of the bay openings and reduce the intra-bay current. Boundary nets were also installed surrounding the bay, and acoustic devices were utilized to discourage fish migration through the only opening of the net.

Following implementation of these exclusionary measures, remedial activities commenced in 1980. The area to be remediated, which was approximately 2,000,000 square meters (m^2), was divided into two areas. The nearshore area, which was the most heavily contaminated area of Minamata Bay, encompassed 582,000 m^2 and was estimated to contain 48% of the targeted contaminant mass. The remaining offshore area, where measured mercury concentrations were lower, encompassed 1,510,000 m^2. The nearshore area was divided into two zones, and each zone was enclosed by watertight

cofferdam revetments. The revetments were constructed of prefabricated cylinders, each composed of 232 piles. Installation of the revetments was performed using vibratory hammers. In order to minimize resuspension of silty sediment during revetment installation, sand was used to cap the area of installation, and the revetments were hammered through the sand into the underlying silt. Upon installation of the cylindrical revetments, sand was used to fill the revetments. Following completion of the nearshore enclosures, sediment in the offshore area was dredged using cutterless hydraulic suction dredges to an average depth of approximately 0.5 meters. The dredged material was then transported via pipeline to the enclosed nearshore area. The most heavily contaminated sediment, which remained in place and was enclosed by the revetments, was thus capped by less contaminated material dredged from the bay.

Once all targeted sediment was dredged from the offshore area of the bay and placed over the heavily contaminated nearshore area enclosed by the revetments, the enclosed areas were capped. Due to the silty nature of the dredged material, direct capping with native "good quality mountain soil" was not possible without initial stabilization of the dredged material. Approximately 80 centimeters of volcanic ash were placed on top of the dredged material "with assistance of membrane nets" to increase the trafficability and bearing capacity. After this surficial treatment by the ash earth, "good quality mountain soil was overlaid and leveled" (Hosokawa, 1993).

The Minamata Bay remediation project was one of the first major contaminated sediment remediation projects conducted in the world. The use of innovative measures to reduce sediment migration (isolation of the bay from neighboring waterbodies to reduce current flow, use of cutterless suction dredge to minimize resuspension, and placement of dredged material in nearby constructed confined disposal facility) displayed the commitment to reduction of environmental risk embodied in this project. However, several factors limit the extrapolation of the remedial strategy employed in Minamata Bay to the Lower Passaic River:

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- Water velocities inside the bay were relatively low, and were reduced further by closing one of the bay entrances.
- Dredging of silty material was conducted to an average depth of 0.5 meters and a maximum depth of 1 meter, at which depths the material was likely unconsolidated.
- The dredged material only required transport to the nearby confined disposal facility and was able to be used as capping material.
- Stabilization of the dredged material was performed within the revetment enclosure, excluding it from erosive forces altogether.

NEW YORK/NEW JERSEY HARBOR CEMENT MIXING DEMONSTRATION

The New Jersey Department of Transportation Office of Maritime Resources (NJDOT/OMR) sponsored a demonstration project to investigate the feasibility of using Cement Deep Soil Mixing (CDSM) to solidify/stabilize sediments in the New York/New Jersey Harbor. The study was performed in the fall of 2004 by Rutgers University (Maher, Najm, and Boile, 2005). The stated objectives of the study were to evaluate: 1) the efficacy of the CDSM technology to stabilize sediments and associated contaminants; 2) the optimum percentage of pozzolanic additive; 3) the potential for dispersion of sediments during treatment; and 4) the impact that highly organic enrichment might have on the pozzolanic treatment. Three cells with dimensions of 18.5 feet by 14 feet by 10 feet deep were amended with a Portland cement slurry at three different mixing ratios equivalent to 7%, 10.5%, and 14% cement added to the sediments on a wet-weight basis. The mixing equipment included a barge-mounted crane and triple auger system. Subsurface investigations, in situ testing, and laboratory testing were conducted on the cells before and after CDSM to evaluate the changes in the engineering properties of the sediments. In addition, total suspended solids (TSS) were measured prior to, during, and after the CDSM was performed. Upon completion of the study, the solidified sediments were dredged using conventional dredging buckets and disposed of at a permitted upland facility.

The study demonstrated a significant increase in the shear strength of the mixed sediments, with standard penetration test (SPT) N-value increasing from ‘weight of rod’

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to 46. An average reduction of 40% in moisture content was measured within the solidified sediments. Sheer strength tests performed approximately two months after mixing, and then again approximately one year after mixing, indicated that although the strength gain was significant, it was not so high that sediment dredging would become problematic. The TSS study indicated that TSS was at background values for sampling points located beyond 125 feet from the mixing location.

The study did not examine the effects of solidification/stabilization on the leachate characteristics of the amended material. Therefore, a critical component of the solidification/stabilization technology – that is, whether contaminants are sequestered within the amended matrix – cannot be determined based on this study. In addition, the authors recommended additional study of the effects of volatilization of contaminants during the solidification/stabilization process.

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Appendix F

Navigation Studies

Draft Contractor Document: Subject to Continuing Agency Review

United States Army Corps of Engineers

Lower Passaic River Navigation Analysis

CENAN-PL-F 20 March 2007

MEMORANDUM TO: Thomas J. Hodson, J.D. Ph.D; Chief, Plan Formulation Branch

From: Naomi Rosamond Fraenkel; Plan Formulation Branch

CC: Paul Sabalis, Plan Formulation Branch
Peter Weppler, Environmental Assessment Branch

Date: 20 March 2007

Subject: **Lower Passaic River Navigation Analysis**

The Lower Passaic River has been a Project under a number of differing Corps authorities. Beyond its initial navigation purpose, the Corps has two ongoing flood damage reduction studies.[1] This memorandum has been prepared to assist the New York District and other partner agencies in assessing the status of and potential for commercial navigation on the Lower Passaic River. The report uses information on the past and current uses of the waterway and its abutting landside facilities to determine whether, and to what extent, commercial navigation and commerce on the waterway may be limited/impacted if possible early remedial alternatives are implemented on the River. These potential remedial alternatives may include dredging, capping and combinations therein. The approach to answering that question involves:

- Description of the area to be studied;
- Description of past and current waterborne commerce in the area; and
- Discussion of the present and most likely future operations of the shippers using the River both with and without implementation of dredge and/or cap alternatives considered within EPA's Focused Feasibility Study (FFS).

Information for this memorandum was gathered from multiple sources, including physical surveys, *Waterborne Commerce Statistics*, census information, U.S. Army Corps of Engineers (USACE) policy guidance, bridge opening logs, and telephone interviews with people currently engaged in the conduct of maritime operations on this waterway or who might possibly be engaged in such operations in the future.

A. The Lower Passaic River

The Lower Passaic River is the tidally influenced, lower 17-miles of the Passaic River waterway. The river runs through Essex, Bergen, Hudson, and Passaic counties. The part of the Passaic River that could be navigable by cargo carrying commercial vessels is that part that lies between the mouth of the river at the head of Newark Bay and the Dundee Dam in Garfield, New Jersey, as shown in Figure 1, below.

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[1] These are the Peckman River Basin and Harrison Floodwall Studies.

Figure 1: Lower Passaic River

Most, but not all of that part of the river has been deepened as a result of various navigation projects. The navigation projects can be divided into four segments, extending from Mile 0.0 upstream to Mile 15.4 in Wallington, New Jersey.

There are four segments[2] at different depths in the commercially navigable portion of the Passaic River. These are:

- River Mile 0.0 upstream to River Mile 2.5 (Junction Light in the Newark Bay Turning Basin to 600 feet seaward of the General Pulaski Skyway Bridge), the authorized and constructed depth is 30 feet mean low water (MLW). The mean tide range in this segment of the river is 5.5 feet.
- From River Mile 2.5 upstream to River Mile 4.6(600 feet seaward of the General Pulaski Skyway Bridge to Jackson Street in Harrison), the authorized and constructed depth is 20 feet MLW.
- From River Mile 4.6 to River Mile 7.1 (Jackson Street in Harrison to the Naim Linoleum Works facility in Kearny), the authorized depth is 20 feet MLW; however, the project was only constructed to 16 feet MLW.
- From River Mile 7.1 to River Mile 8.1 (the Naim Linoleum Works facility in Kearny to

[2] There is an approximate .2 to .3 mile discrepancy between the Corps Operation and Maintenance Surveys and the Lower Passaic River Restoration Project base maps. To look at these maps on the same scale, add .3 miles to the Lower Passaic River Restoration Project's base maps. This may account for the perception of a "missing mile" between the Passaic River and Newark Bay Federal Channels.

the Montclair and Greenwood Lake/Erie Railroad Bridge in Arlington), the authorized and constructed depth is 16 feet MLW.

- From River Mile 8.1 to 15.4 in Passaic, New Jersey, the authorized and constructed depth is 10 feet MLW.

The 30 feet and 20 feet MLW segments can best be characterized as fully industrially developed on the right bank of the river in Newark, NJ. The left bank of the river in Harrison, NJ is occupied by the railroad tracks of the Port Authority Trans Hudson (PATH) system and by an intermodal container-handling facility. Upstream of the Jackson Street Bridge is a transitional area on both sides of the river. The right bank is dominated by McCarter Highway (NJ Rt. 21), and Joseph G. Minish Waterfront Park, a current collaborative effort of the Corps, New Jersey Department of Environmental Protection, and the City of Newark. The left bank is being re-developed as a combination of residential and recreational uses. Redevelopment transition can be seen at Clay Street in Newark on the right bank, where a complex of storage tanks appears to be in the process of being dismantled. McCarter Highway continues north along the right bank of the River to Dundee Dam (the 16-foot to 10-foot MLW segments). The left bank of the River along the aforementioned segments is characterized recreational parkland, containing at least one small public marina and a few private docking facilities for recreational craft. A recent examination of the river from adjacent roads revealed no storage tanks, manifolds, or facilities for commercial cargo vessels upstream of the tanks at Clay Street described in the previous paragraph.

Physical Constraints[3]

USACE survey information has shown that the Lower Passaic Federal Channel has width constraints. The abutments of a formerly utilized railroad freight bridge lie as approximately River Mile 1.2. These abutments limit channel width to 145 feet (see USACE Operations Division November 2006 Survey). Because safe navigation requires channel width to be five times the beam of the vessel for two-way traffic, and three times the beam of the vessel for one-way traffic; the largest vessel that could safely pass Kearny Point, just beyond River Mile 1.0, would be, at a maximum, 48 feet in beam.[4] At River Mile 2.5 lies the Point-No-Point Swing Bridge which limits vertical clearance to 16 feet at high water, requires four hours notice to open, and limits channel width to 103 feet.

[3] Corps Guidance is found in EM 1110-2-1613, Hydraulic Design of Deep Draft Navigation Channels
[4] Beam is defined as the width of a vessel in a transverse horizontal direction at its widest points, usually midship.

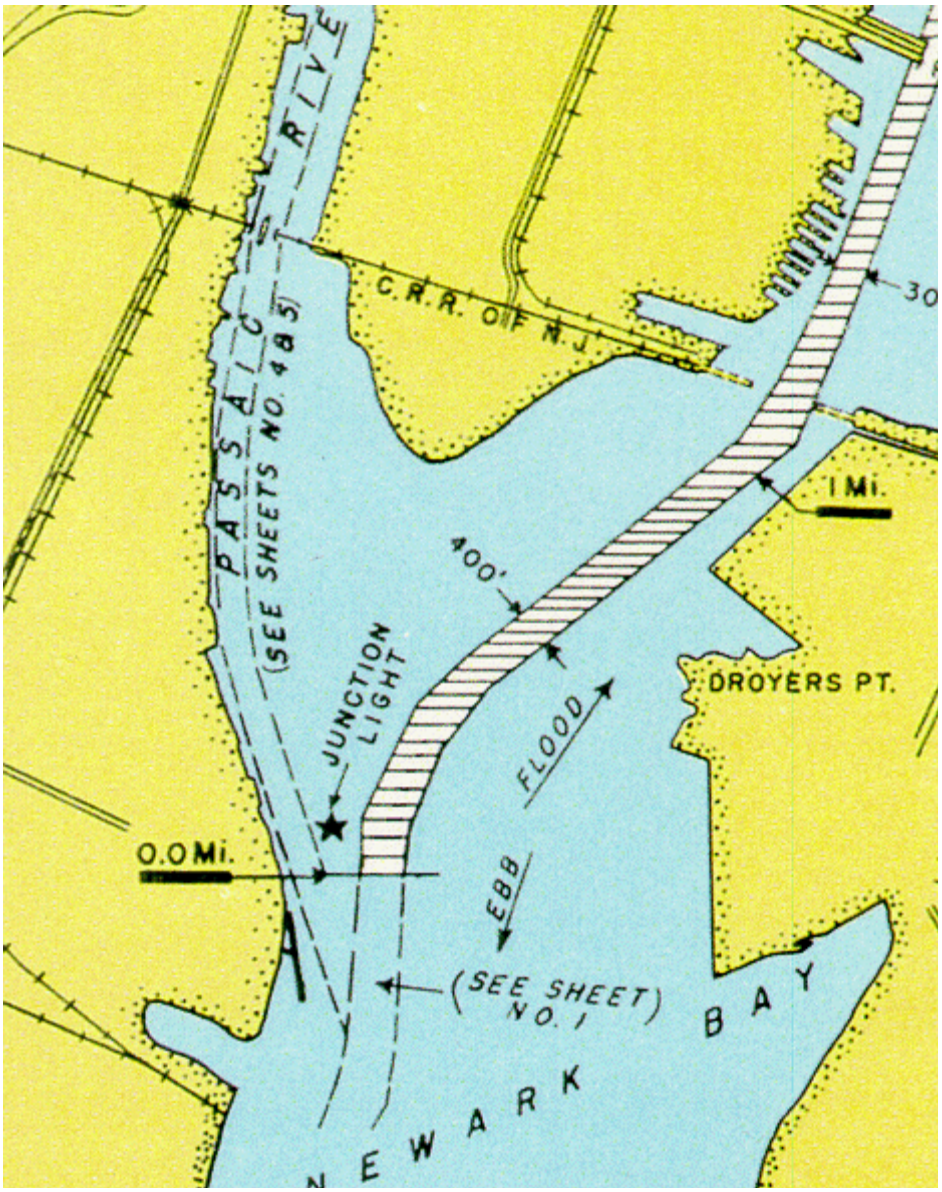


Figure 2: Area of Detail from Figure 1

If we assume the greatest depth vessel to reach or pass mile 2.5 must draw 27 feet or less (assuming 3 feet of underkeel clearance) and have a beam of 45 feet or less, (34 feet or less beyond Point-No-Point) there are a number of inferences that can be drawn:

1. Of the three principal types of ocean-going cargo carrying vessels – containerships, car carriers, and bulk carriers – only bulk carriers could potentially be used efficiently on this waterway. This is because there just aren't any such vessels in the container fleet or the car carrying fleet. Such vessels would not be built because these specifications do not allow for car carriers or containerships that could operate in an economically efficient manner.

2. The number of bulk carriers/tankers that could be used is rapidly diminishing because

they cannot be operated in an economically efficient manner with such low payload. Recent interviews with barge operators in the area suggested that a tank barge with a 70-foot beam is considered small for efficient transport of fuel-based products. Unless intended for a specific physically-constrained waterway, a barge operator would not use or order a 70-foot beam vessel (which is at least two times the beam width of any vessel that could currently utilize the Passaic in a safe manner, even under one-way traffic conditions). Current fuel terminal operations use 60K barrel barges, which are light loaded, and therefore not being used optimally.

Another important physical condition that limits traffic would be the requirement that turning basins have a diameter of at least 1.2 times the length of the design ship and preferably 1.5 times the length of the ship. This specification further limits the number of ships that could use the Passaic River.

B. Operational Information

Types & Volumes of Commodity Flow

Waterborne Commerce of the United States reveals several interesting characteristics of the waterborne commerce conducted on the Passaic River over the 1980 – 2004 period. These statistics are displayed in Figures 3 and 4, below. For purposes of the present inquiry, the most salient of these statistical facts are:

1. From 1980 to 1999, the trend in the volume of commerce (measured in short tons) was generally down, peaking at roughly 9.5 million tons in 1982 and reaching a trough of about 1.5 million tons in 1999. Since 1999, the volume of commerce has been rising, reaching just over 4 million tons in 2004.

2. Throughout this period, the overwhelming bulk of this commerce consisted of petroleum and petroleum products. This has been especially so in recent years, in which petroleum and petroleum products have accounted for more than 90 percent of the total tonnage. The remainder is mostly gypsum and gypsum related items (*e.g.*, gravel and sand).

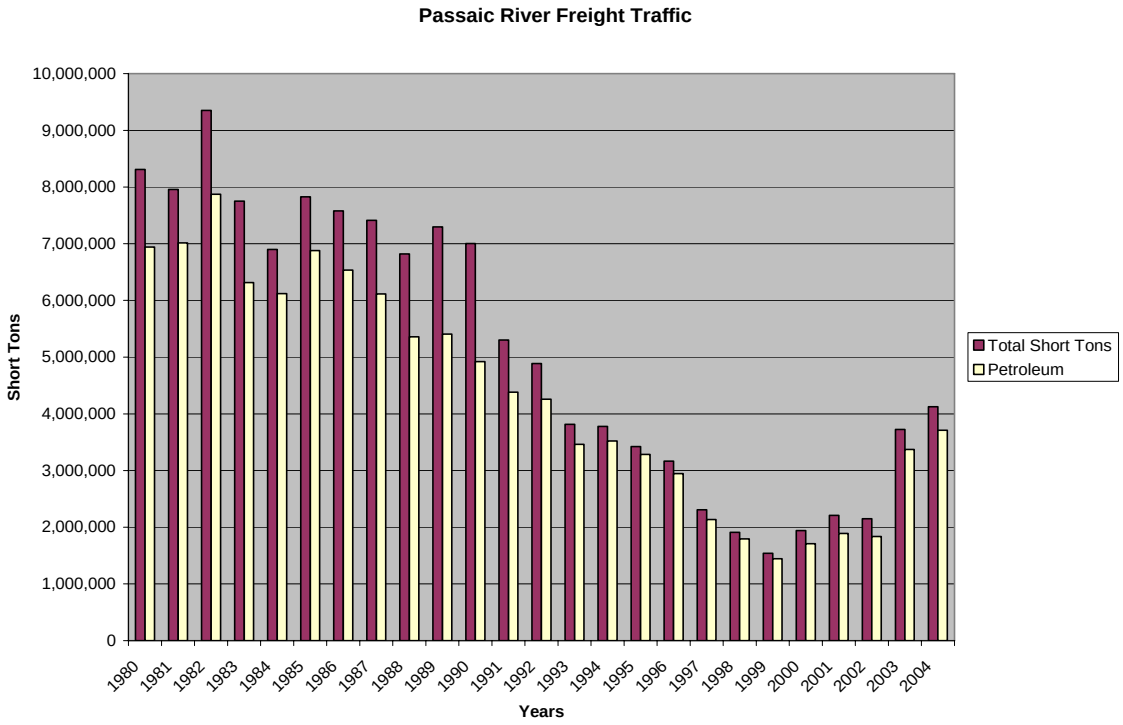


Figure 3: Passaic River Freight Traffic

3. The carriage of this commerce is dominated by vessels whose loaded draft is 13 feet or less; however, there is some record of barges needing 26 feet, specifically 13 in 2004. This is accounted for by fuel deliveries by barge to facilities at River Mile 0.0, which lies just to the west of the Newark Bay turning basin.

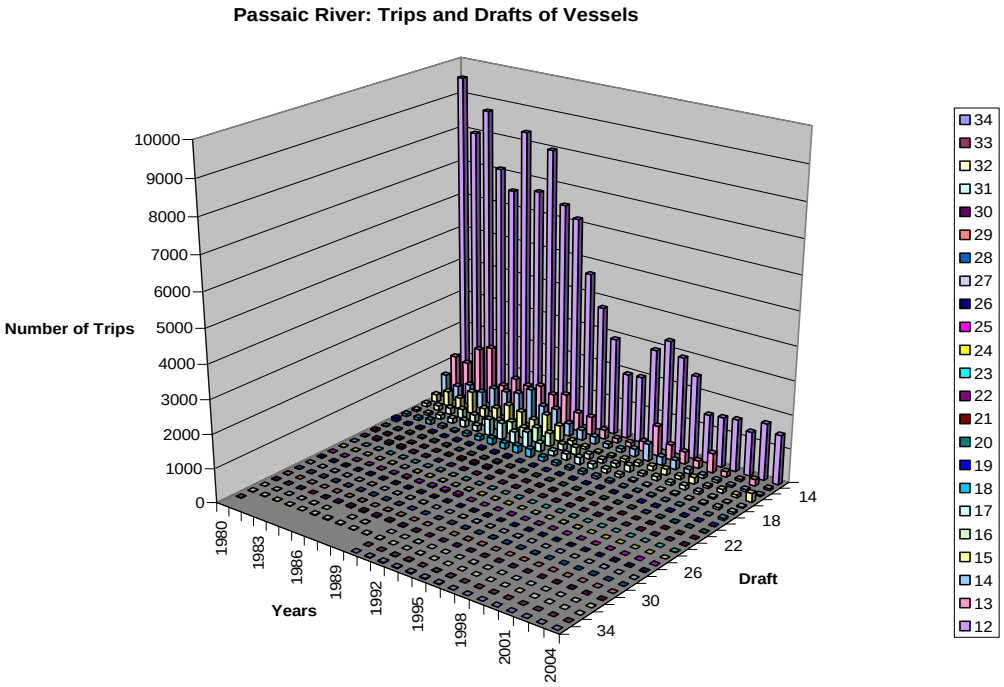


Figure 4: Passaic River Trips and Drafts of Vessels, by Year

Interviews

The volume of commerce is, essentially, fully accounted for by two categories, petroleum products and stone and aggregates, and for that reason only a small number of interviews (fewer than ten) are necessary in order to gain a complete view of current and future operations of the shippers using the River. To locate appropriate interview subjects, an examination of commercially available listings of firms by Standard Industrial Classification (SIC) code (*e.g.*, 5171 Petroleum Bulk Stations and Terminals, 5172 Petroleum and Petroleum Products Wholesalers, Except Bulk Stations and Terminals, 3272 Concrete Products, Except Block and Brick) generated candidate firms. A letter requesting an interview was sent to each of these firms. Attachment 1 provides basic information about these firms. Figure 5, below, depicts their locations.

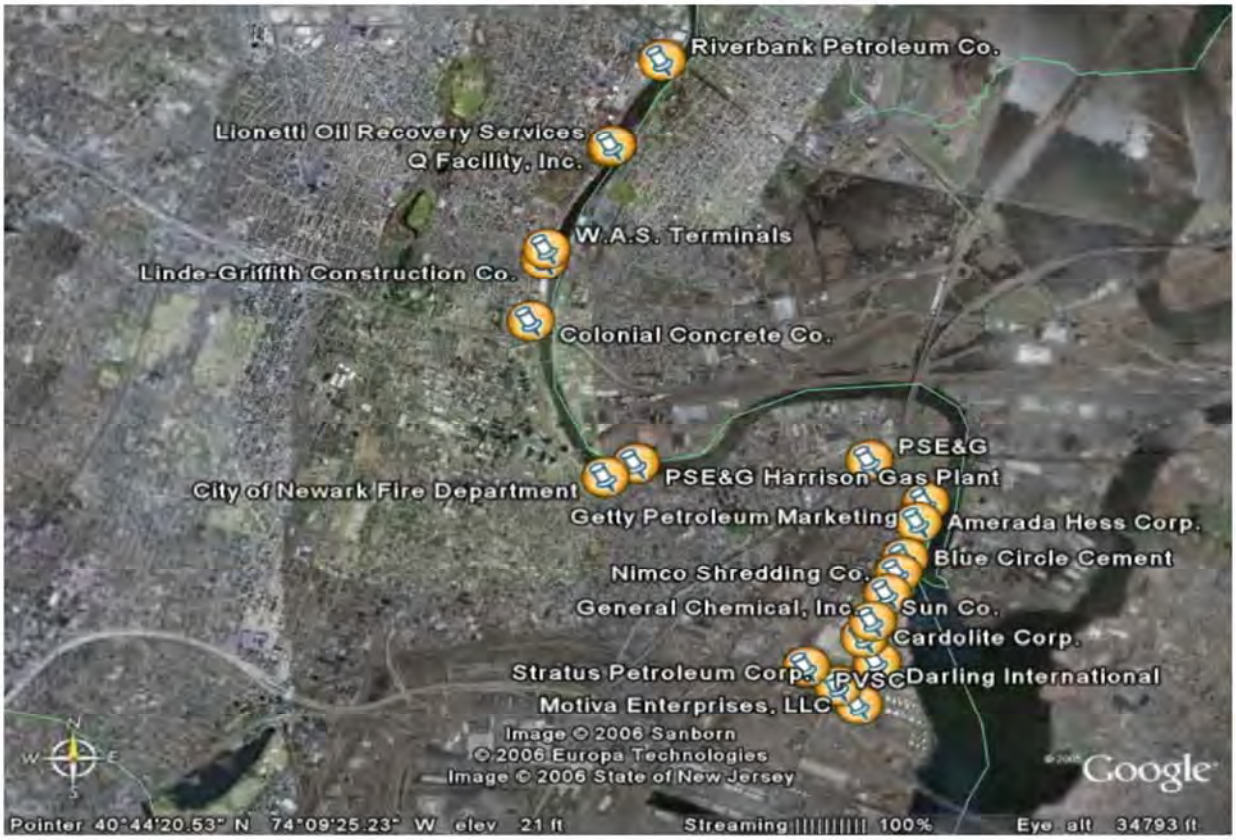


Figure 5 Candidate Commercial Entities Based on Review of SIC Codes

A. Stone and Aggregate

The interview conducted in September 2006 with two officials of Colonial Concrete was particularly revealing. Although Colonial has used barges to bring stone and aggregate to their Newark facility in the past, they indicated that they have not done so in more than ten years and are, "99.9 percent sure" that their firm will not use that method of transportation in the future. At present, they produce all their transportation using trucks. They acknowledged that waterborne transportation is substantially less expensive than truck transportation on a per ton-mile basis, but pointed out that there are other costs associated with getting stone and aggregate from their supplier to their production processing equipment.

One such cost is that of operating and maintaining the crane that is necessary to move stone and aggregate from a docked barge to their premises. They indicated that a crane is not necessary when transportation is produced by trucks and that the cost of operating and maintaining a crane more than overcomes the saving in transportation cost that would be generated by using barges instead of trucks. This point was amplified and confirmed by the fact that Colonial is in the process of dismantling the crane at their Newark facility and does not plan to replace it.

They went on to point out that even if the crane operation costs could be substantially reduced, they would still not be likely to return to using waterborne transportation methods. The reason for this stems from the fact that, inevitably, moving stone and aggregate by crane from a barge results in some the material being spilled into the water in the berthing area. Eventually, this will render the berthing area unusable without maintenance dredging which, they pointed out, has become so expensive as to render waterborne transportation uneconomic relative to truck transportation at current prices, or any likely future prices.

B. Petroleum and Petroleum Products

In light of the initial paucity of responses from firms in the petroleum line of business to the direct request for information, a different strategy was pursued. The production of refined petroleum products in this area is dominated by a single refinery, so there is a high probability that each of the firms using waterborne commerce on the Passaic is a customer of this particular refinery. Therefore, an official of the refinery was asked to supply more specific contact information regarding these firms, and he agreed to do so. This official reports that there are currently no petroleum operations occurring north of the Stickle Bridge, at mile 6.0.

Interviews with officials at oil facilities at Delancey Street provided further illumination about the petroleum related operations in the area.

Public Service Electric & Gas (PSE&G) operates the Essex Generating Station that can be seen from the PATH Train at approximately mile 2.5. The local redevelopment agency has told the Corps that coal used to be barged into this facility along the Passaic River, but this practice stopped about 30 years ago and now the facility uses natural gas turbines. Natural gas arrives at the site via pipeline. Many of the oil tanks at the site are unused.

Bridge Openings

Data collected by Essex County and Hudson County data indicate that in 2004, a total of 384 bridge openings were reported at the Jackson Street, Clay Street, Bridge Street and Avondale locations. In 2005, there were 230 bridge openings at the above locations. Bridge openings were limited due to necessary repair work. At any rate, these bridges lie upstream of the Point-No-Point Conrail Bridge – which, by virtue of its width constraints, limits vessel access – bridge openings are of little relevance to the commercial navigation of the Passaic studied here.

C. Changes to Channel Operations

In general, Corps' cost-sharing in navigation improvements is conditioned upon a showing of net National Economic Development (NED) benefit, or net monetary benefits to the nation. These benefits are generally derived through the reduction of transportation costs. Because the Lower Passaic River is depth - and more importantly – width constrained, additional benefits could not be derived through the employment of larger vessels.

Similarly, channel maintenance must be economically justified. The Executive Branch, acting through the Office of Management and Budget, requires that net benefits to the nation of navigation channels be calculated and arrayed against each other in order to determine funding priorities. As there is very little commerce on this portion of the Passaic River, it is unlikely that dredging the Lower Passaic would be a funding priority.

Changes to the authorized dimensions can be accomplished through §216 of USACE ER 1105-2-100, which reads:

Review of Completed Projects. *Section 216 of the River and Harbor and Flood Control Act of 1970 authorizes investigations for modification of completed projects or their operation when found advisable due to significantly changed physical or economic conditions and for improving the quality of the environment in the overall public interest. Initial appraisal reports are prepared under Section 216 using operations and maintenance (O&M) funds. The cost of preparing the initial appraisal report is limited to $20,000. Results from this report can be used to support initiation of a reconnaissance study through normal budgetary process. Following the initial appraisal, the 216 study process is of the same as a normal General Investigations study. A feasibility study under Section 216 authority would be appropriate for large scale ecosystem restoration projects linked to existing Civil Works projects, but whose costs would be too large for Section 1135, Section 206, or Section 204 authorities. Additional guidance can be found in ER 1165-2-119.*

This would be due to changed conditions and does not constitute a design deficiency. It would require Congressional authorization, as a feasibility-level decision document.

Conclusions

The overwhelming bulk of the tonnage moving on the Passaic River is accounted for by

petroleum and petroleum products (see Figure 1), and nearly 100 percent of that cargo (indeed, all cargos) is carried in vessels loaded to less than 13 feet (see Figure 2). Moreover, almost all of the firms receiving these shipments of petroleum or petroleum products are located in that part of the river for which the authorized and constructed depth is 30 feet MLW and are between Mile 0.0 and Mile 1.2 (see Figure 2).

Following the findings of the *New York and New Jersey Harbor Feasibility Study* of 1999, an operational requirement of three feet of underkeel clearance will be assumed. For example, a vessel loaded to a depth of 13 feet would require 16 feet of water depth to ensure safe passage. Given the 5.5 foot tidal range in the lower 2.5 miles of the river and assuming that the channel is maintained to its authorized depth, a remedial alternative that reduced the authorized channel depth at MLW by more than 14 feet would affect this commerce by adding an operational requirement that it be conducted so as to coincide with high tide. Dredge and cap alternatives that reduced the channel depth at MLW by less than 14 feet may impose operational limitations as to the timing of the passage of this commerce as some degree tide delay could be incurred.

Summary

- Commercial navigation on the Lower Passaic River may or may not be depth limited; however, beyond the abandoned freight bridge that crosses the River at Mile 1.2, channel width becomes the limiting factor for vessel transit.
- Although there are facilities on the Passaic River that may have at one time had oil deliveries by barge, many of these facilities are no longer in use or have changed their operations to use of other types of energy and/or move oil by truck when necessary.
- Federal navigation channels may be modified through §216 of USACE ER 1105-2-100.

New Jersey Department of Transportation

New Jersey's Position on the Future Navigational Use on the Lower Passaic River, River Miles 0 – 8

State of New Jersey

New Jersey's Position on the Future Navigational Use on the Lower Passaic River River Miles 0 – 8

March 29, 2007

ACKNOWLEDGEMENTS

This position paper was prepared with input from the following Divisions within NJDOT and NJDEP:

New Jersey Department of Transportation
Division of Environmental Resources and Context Sensitive Solutions
Office of Statewide Planning
Freight Planning and Intermodal Coordination
Office of Maritime Resources
Project Planning and Development
Office of the Commissioner

New Jersey Department of Environmental Protection
Office of the Commissioner

Prepared by the Division of Environmental Resources and Context Sensitive Solutions

R2-0010372

1.0 BACKGROUND

The Lower Passaic River is a 17-mile tidal stretch from Dundee Dam to the confluence with Newark Bay. The river has a long history of industrialization, which has resulted in degraded water quality, sediment contamination, loss of wetlands and abandoned or underutilized properties along the shore.

The U.S. Environmental Protection Agency (USEPA), U.S. Army Corps of Engineers (USACE) and New Jersey Department of Transportation (NJDOT) have formed a partnership with the New Jersey Department of Environmental Protection (NJDEP), National Oceanic and Atmospheric Administration (NOAA) and U.S. Fish and Wildlife Service (USFWS) to carry out the Lower Passaic River Restoration Project. The agencies are bringing together the authorities of the Superfund Program, the Water Resources Development Act, the Clean Water Act and other laws to improve the health of the river. The primary goals of the Lower Passaic River Restoration Project are to remediate contaminated sediments, improve water quality, restore degraded shorelines, restore and create new habitats and enhance human use.

Since December 2005, USEPA in consultation with the Partner agencies, have been evaluating potential early action alternatives through the development of a Focused Feasibility Study (FFS). NJDOT and NJDEP have worked collectively to determine the State's position on future navigational use of the Lower Passaic River to aid in the development of the FFS. The FFS has evaluated dredging and capping scenarios for the lower 8 miles of the River. A critical component of the remedy may include capping the Target Areas with a 2-3 ft sand cap, with armor (rock) in erosional zones. Therefore, a determination of the resulting depth at the top of the cap is critical to the future use of the river and maintenance of cap integrity.

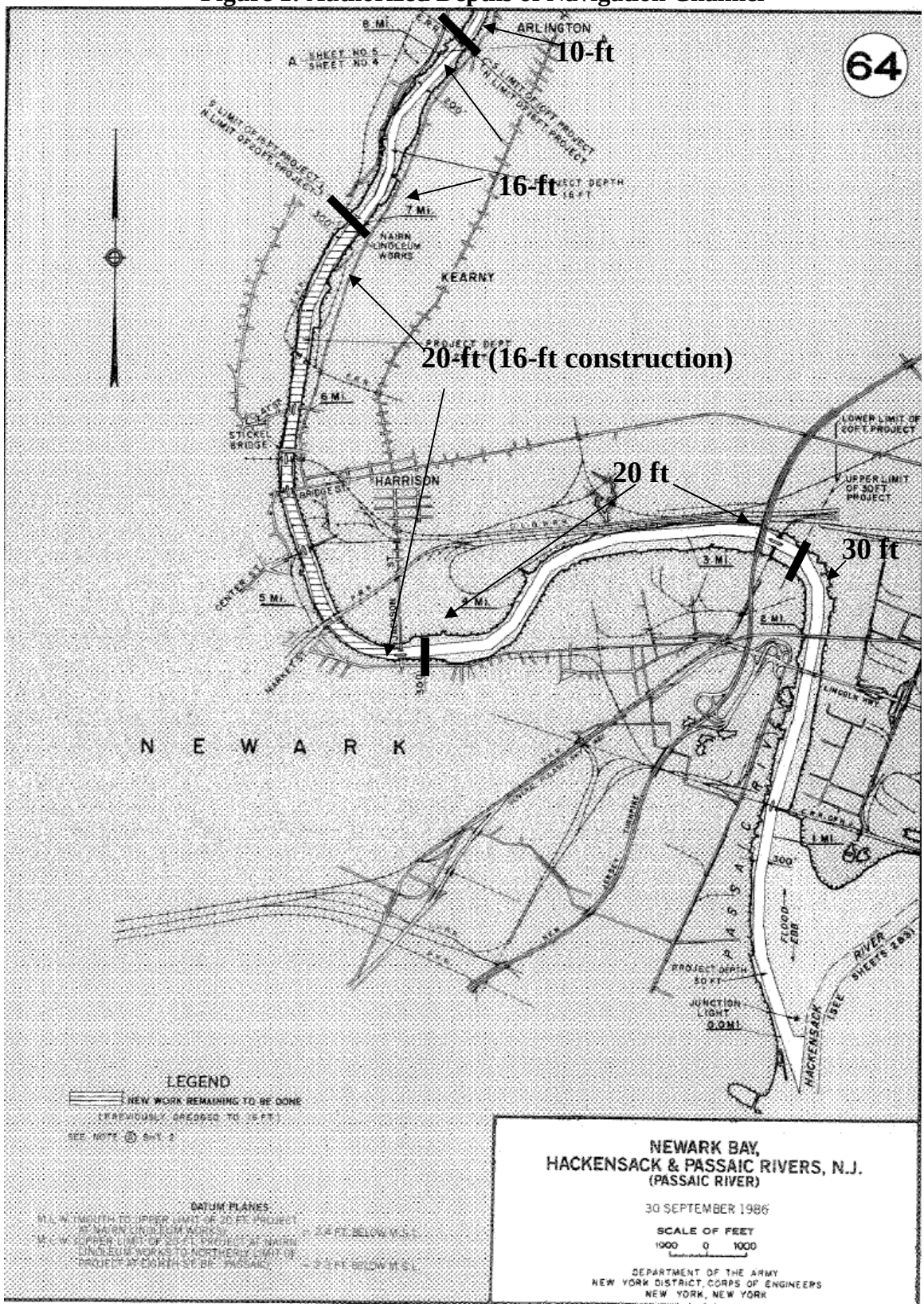
This memorandum reflects the State of New Jersey's position on reasonably anticipated future use of the Lower Passaic River related to the municipalities planning efforts and the State's pursuit of economic revitalization in the region. This report is limited to the analysis of navigational use and does not address other issues (e.g., flooding, contamination, etc.) associated with the evaluation of remedial alternatives.

The current authorized depths of the channel are as follows (Figure 1):
River Mile (RM) 0.0 - 2.5 (Point No Point Bridge): 30 feet
RM 2.5 to 4.6 (Jackson St. Bridge): 20 ft
RM 4.6 to 7.1: 20 ft, however only constructed to 16 ft
RM 7.1 to 8.1: 16 ft
RM 8.1 to 15.4: 10 ft

The potential selected early remedial action could result in a modification of the current authorized depth of the above river reaches. The State's position is based on the following three key pieces of information in order to recommend a minimum depth requirement in each of the river reaches necessary for future navigation. This minimum depth would require maintenance in the future to preserve the uses stated within.

R2-0010373

Figure 1: Authorized Depths of Navigation Channel



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1) **Municipality Surveys for Future Use and Master Plans**: Over 70 surveys were mailed to representatives (Mayors, Assemblymen, Senators, Congressmen) involved in planning for approximately 17 municipalities within the 17-mile study area. A total of 13 surveys were returned covering areas within Clifton, Rutherford, Nutley, East Rutherford, Belleville, Bloomfield, Kearny, East Newark, Harrison, Bayonne and Elizabeth. In addition to the surveys, master plans from Newark, Harrison, Kearny and Belleville have also been obtained to identify potential redevelopment initiatives in the future. All surveys will be utilized for the overall FS and restoration planning for the entire 17-mile study area.

2) **USACE-NY District Lower Passaic River Navigation Analysis**: The USACE conducted an analysis of past, current and potential use of commercial entities located on the Passaic River. This study did not attempt to predict future use by the commercial facilities.

3) **Additional NJDOT/NJDEP Considerations:** The navigational recommendations must be supportive of the goals and objectives for many Statewide programs including: Brownfield Development, Portfields Initiatives, Smart Growth Initiatives, Comprehensive Statewide Freight Planning, the Long Range Transportation Plan, Transportation Choices 2030, State Development and Redevelopment Plan and the Liberty Corridor Initiative. These programs are important considerations for the future economic revitalization and development of the region which may be constrained by the future authorized depth of the channel.

2.0 RESULTS

2.1 Municipality Surveys on Future Use and Master Plans

Surveys and master plans outline current and proposed land use patterns which are related to the overall depth required for such designated uses. This memorandum attempts to translate proposed plans for future use with minimum draft requirements necessary within each river segment. It should be noted, that all individual property owners must apply for appropriate development permits and are required to comply with NJDEP Coastal Zone Management Regulations NJAC 7:7et.seq.

A summary of the results of the future use surveys for the majority of municipalities are presented in Table A (Attachment 1). The surveys indicated that the communities in the Upper 9 miles of the Study Area reflect their objectives to enhance public access, preserve open space and improve the recreational uses (e.g., boating, fishing, ecotourism, parks/fields) along the river. In addition, the Passaic River Boat Club (among other non-profit organizations) are working to improve waterfront access (e.g., locations, adequate depths, overcoming bridge limitations for boating), provide facilities (e.g., marinas, docks, anchorages, restaurants to attract and support boating), and spearhead recreational regional events (e.g., Spring Fishing Tournament, Fall Boat and Maritime Festival, Eco-tours) (Personal Communication with Edward Marchese, 3/1/07). The Lower Passaic and Saddle River Alliance has also proposed a Water Kayak and Canoe Trail from Pompton River (RM

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32) to the confluence with Newark Bay and up the Hackensack River (Personal Communication with Alliance, 4/13/07). Receipt of master plans and visioning with these municipalities is necessary to ensure that all planning initiatives are considered. This information will also be considered for the overall FS and the Comprehensive Restoration Plan (CRP).

The information provided for the lower 8 miles was obtained from surveys and/or master plans provided by Kearny, East Newark, Harrison, and Newark. A compilation of both sources provides insight on future navigational use within the Target Areas for the FFS. Future proposed land use and planning efforts are summarized in Figure A and Table A (Attachment 1).

Eastern Bank
Kearny (RM 0-3.2 and 6.1-8.5), Harrison (RM 3.2-5.6) and the Borough of East Newark (5.6-6.1) have plans for redevelopment that include residential, commercial (office/retail), warehousing and waterfront access.

Kearny
Kearny's master plan (Heyer, Gruel & Associates, 2002) and survey indicated a focus on 2 areas designated as Kearny Urban Enterprise Zones (KUEZ) which has introduced new economic, residential and recreational opportunities to former industrial areas. The Passaic Avenue Redevelopment Plan (above mile 6.1) calls for the transformation of the industrial and commercial properties along the Passaic River into a regional, mixed use, urban entertainment destination featuring new housing, shopping (i.e., commercial retail) and recreational activities with public connections to a riverfront walkway. Plans for RM 7 to 8 include green acres, town parks and a hockey rink. In addition, a boat ramp at RM 7 (Bergen and Passaic Aves) and dock at RM 8 (Kearny Board of Education Crew Program) are focal points for public access.

Although not included in Kearny's current master plan or survey, the use of water taxis, water tours and smaller ferries could be effective in optimizing waterfront usage within areas of the river above RM 4.8 (see Newark's plan). Enhancing already planned waterfront access points (e.g., marinas, boat docks) in upstream river segments would provide benefits to waterfront revitalization opportunities in the region. These commercial services could provide an opportunity for local residents to have access to areas downstream (NJPAC in Newark, Stadium in Harrison, etc) and provide surrounding residents with access to the proposed urban entertainment destination.

The Kearny Redevelopment Area under the jurisdiction of the New Jersey Meadowlands Commission within the Harrison Reach (RM 2.5 to 3.6) is slated for open space and passive recreation. Much of this riverfront is occupied by the railroad tracks of the Port Authority Trans Hudson (PATH) system. Therefore, the future plans of the town of Kearny above mile 2.5 would require navigational depths suitable for recreational uses and commercial services (e.g., water taxis/ferries).

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South Kearny (RM 0-2.5) peninsula has plans for light industrial, manufacturing activities, warehousing and intermodal activities due to its location and access to Newark Bay. A 27 acre area (SKM-1) has been identified as a Portfields site in order to support operations within the Port of NY and NJ. The plans for Kearny Point also include public access and a waterfront walkway. In addition, a resolution has been passed by Mayor Santos that supports the implementation of Bulking and Tiering Wetland Systems along the banks of Kearny on a trial basis for the purposes of restoration (Resolution, 2006-(R)-543; Attachment 1).

Harrison

Harrison's Waterfront Redevelopment Plan includes an area approximately 250 acres along the Passaic River on the southern portion of the Town. The proposed plans indicate land use planning that will accommodate residential, office commercial (e.g., offices, retail, hotels, retail, restaurants, etc), a new stadium, the USACE's floodwall and levee system, and a waterfront walkway and park from Interstate 280 to Jackson St. Bridge. The Park/Walkway District will provide a public promenade for the Town with open space parallel to the water's edge for active and passive recreation. A bridge is also planned from Harrison (Cape May Street/Parkway) to Newark (Brill Street) in order to provide an auto/pedestrian connection to the proposed Stadium (Heyer, Gruel & Associates. 2003).

East Newark Borough

The Borough of East Newark has future plans for commercial and residential development along Passaic Avenue. A recent resolution for the East Newark Planning/Zoning Board (12/06) stated "The Passaic River waterfront needs to be planned for commercial re-use. While the concrete plant may want to stay because of the benefits of its location, the success of the hotel down river in Harrison argues well for this type of use along the East Newark Riverfront. Newark is planning great things on its shoreline; so should the Borough of East Newark.". This resolution provides the directive to re-examine the East Newark's master plan dated 1992.

<u>Western Bank</u>

Newark

Recent planning meetings held by the City of Newark indicate advancement in the preparation of a waterfront master plan within the next two years. This master plan would likely have components similar to those outlined in the available planning documents (personal communications with Carol Johnston, 2/1/07 and Joel Sonkin, 2/21/07). The Passaic Riverfront Revitalization Plan (12/15/99; RM 3.6-5), Passaic Riverfront Redevelopment Plan (1/22/04), Ironbound Open Space and Recreation Plan (May 2002; RM 2.4-5) and Land Use Element of the Master Plan for the City of Newark (12/06) provide a comprehensive picture of what has been considered for the waterfront downstream of RM 6.1.

All four plans primarily focus on the redevelopment upstream of the "Industrial Zone" located below RM 3.6. These plans outline mixed use commercial development that provide recreational and entertainment uses including marinas, pleasure and dinner boating, crew racing, river festivals, and water taxis (to New York City or Jersey City). In addition, open space, parks and recreational ball fields (buffer between industrial zone and upstream) are of high priority for the waterfront. A key component of the plans, include a waterfront walkway

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corridor that begins at the boundary of the industrial zone and links the region to Patterson. Public access would be provided throughout as a result of the connectivity of the walkway to city streets.

Water taxis have been identified as an activity that would be the primary influencing factor for the recommendations for minimum depths in the areas downstream of the Amtrak's Dock Bridge (RM 5). In addition, ferry service may also be considered as a potential future opportunity. NY Water Taxis' vessels with a capacity of up to 149 passengers (length: 72.2 ft) have a vessel draft of 4.3 ft. (http://www.nywatertaxi.com). Recent additions to the NY Water Taxi fleet include larger Durst-class vessels with a draft of 5.6 ft. Ferries generally draft 5 to 7 feet depending on their size and vessel type. Typically, a 350 to 400 passenger ferry draws approximately 6-ft of water with beams of approximately 35-ft. Vessels that would likely be utilized on the river would be smaller passenger propeller or waterjet vessels that could easily operate within 7-ft depth (Personal Communication, John Koenig, consultant for Derecktor's Shipyard and former President of NY Fast Ferry Service, 2/16/07). Seastreak vessels, the largest used in the Harbor, have capacities of 400 passengers, are 140-ft in length and draft 6.4-ft of water (www.seastreak.com). A 90-ft long Catamaran ferry, a member of NY Waterways fleet, has a draft of 5-ft (Bruno et. al., 2002). Based on vessel draft information for water taxis and ferries currently in operation in the NY/NJ Harbor, an authorized depth of 10-ft would satisfactorily accommodate this commercial service within the Lower Passaic.

An additional concern with this commercial use of the river may possibly result in enhanced prop wash that may impact cap integrity. This issue is likely addressed through the preliminary dredging requirements for cap construction where there is additional depth added below the authorized depth. At least 5-ft depth would be included above the cap to include advanced maintenance dredging and buffer for cap protection. Thus, a total of 15-ft to the top of cap could exist due to preliminary dredging requirements. Therefore, the future plans of Newark above RM 3.6 could be accommodated with navigational depths suitable for recreational/commercial service uses (minimum of 10-ft).

Plans for the current "Industrial Zone", downstream of Sherwin Williams (60 Lister Avenue) call for continued industrial use, and the area would provide additional non-residential uses following remediation of upland sites. The industrial zone includes an active Brownfield Development Area (BDA) [Lister Avenue BDA], with three of its five sites located on the waterfront in the Harrison Reach, downstream of RM 3.6. Also in the vicinity and on the waterfront is a priority Portfield Site (Blanchard Street/Fairmont Chemical Development Area). Warehousing, brownfield redevelopment and continued industrial uses will provide significant jobs and ratables for the revitalization of the region. Currently, plans for operations of these facilities between RM 3.6 and 2.5 would be access via truck transportation. However, given State and private resources directed at Brownfield redevelopment and economic revitalization, along with the anticipated increase in port activity over time, this industrial zone may provide additional access to waterborne transportation as is experienced currently in stable industrial areas in Newark downstream of RM 2.5. It should be noted that Newark's Passaic River Revitalization Plan (1999) indicates

a desire for a public walkway (minimum 30-ft width) adjacent to industrial property with a natural edge.

2.2 USACE-NY District Lower Passaic River Navigation Analysis

The results established by the USACE (USACE, 2007) are based on statistics of usage between 1980 and 2004 from Waterborne Commerce of the US (Figure 2). More than 90% of the commodities coming to the Passaic are petroleum products with the remainder being gypsum products (e.g., sand and gravel).

Figure 2: Passaic River Freight Traffic from 1980 – 2004 (USACE, 2007)

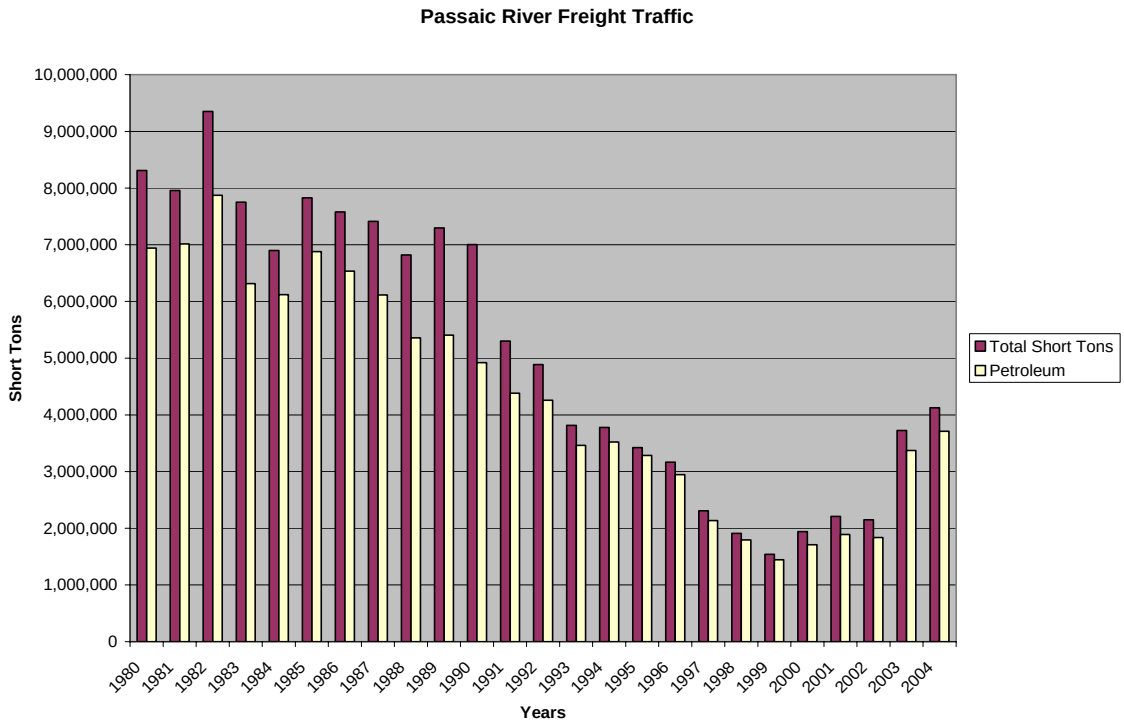

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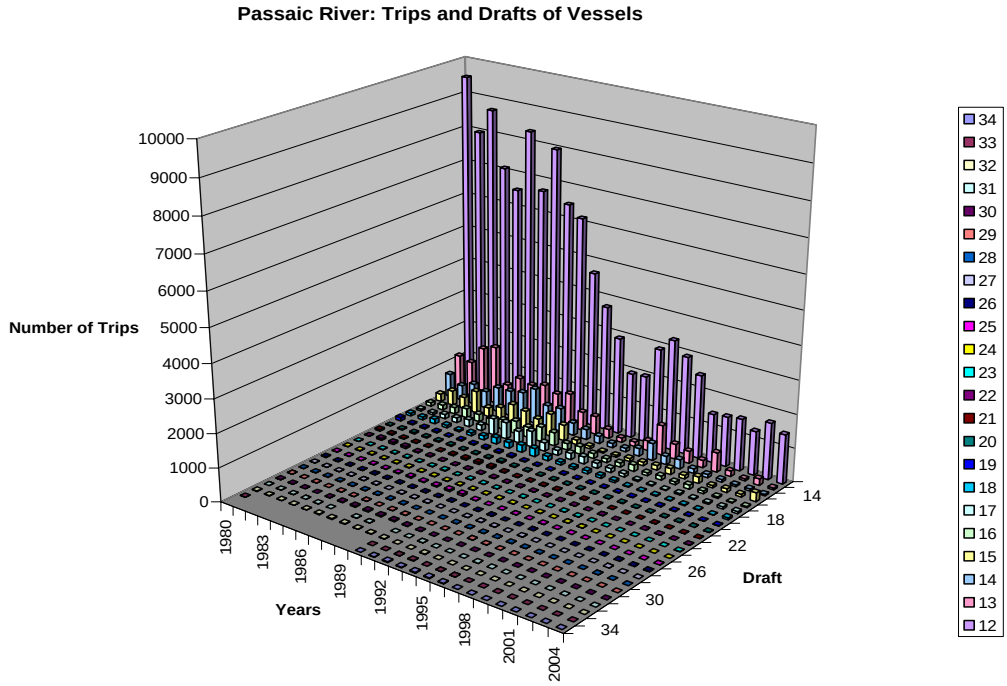
Figure 3: Trips and Drafts of Vessels on the Passaic River from 1980-2004 (USACE, 2007)



The Passaic river trips and drafts of these vessels by year (Figure 3), illustrate commerce is dominated by vessels whose loaded draft is 13-ft or less. However, there are records of barges needing 26-ft in 2004. These barges arrived at facilities near RM 0.0, just west of the Newark Bay turning basin. USACE identified facilities currently located on the waterfront using Standard Industrial Classification (SIC) codes. The majority of these active facilities are located below RM 1.2 (Figure 4).

The USACE analysis also highlights that use by facilities above RM 2.5 would be limited due to the width/beam restrictions of the Point No Point Bridge (103-ft wide) and the abutment of a formerly utilized railroad freight bridge (145-ft wide) at approximately RM 1.2. The horizontal clearance through these abutments may be navigational constraints according to the USACE's guidance for safe navigation (USACE, 2006: Engineering Manual- EM 1110-2-1613). However, the Coast Guard does not limit the passage of vessels through these bridges as long as the vessel operator has clearance assuming all liability.

The USACE has determined that current navigational use of the river could be accommodated by a depth of 16-ft (vessels drafting 13-ft vessels), within RM 0 to 2.5. However, the use of 26-ft draft vessels in the Passaic and existing dredging permits at berths (e.g., Motiva, 35-ft; Darling International, 31-ft; Hess, 25-ft; Stratus Petroleum, 23-ft) indicate that existing and future use of the river require depths similar to that authorized (30-ft) below RM 1.2.

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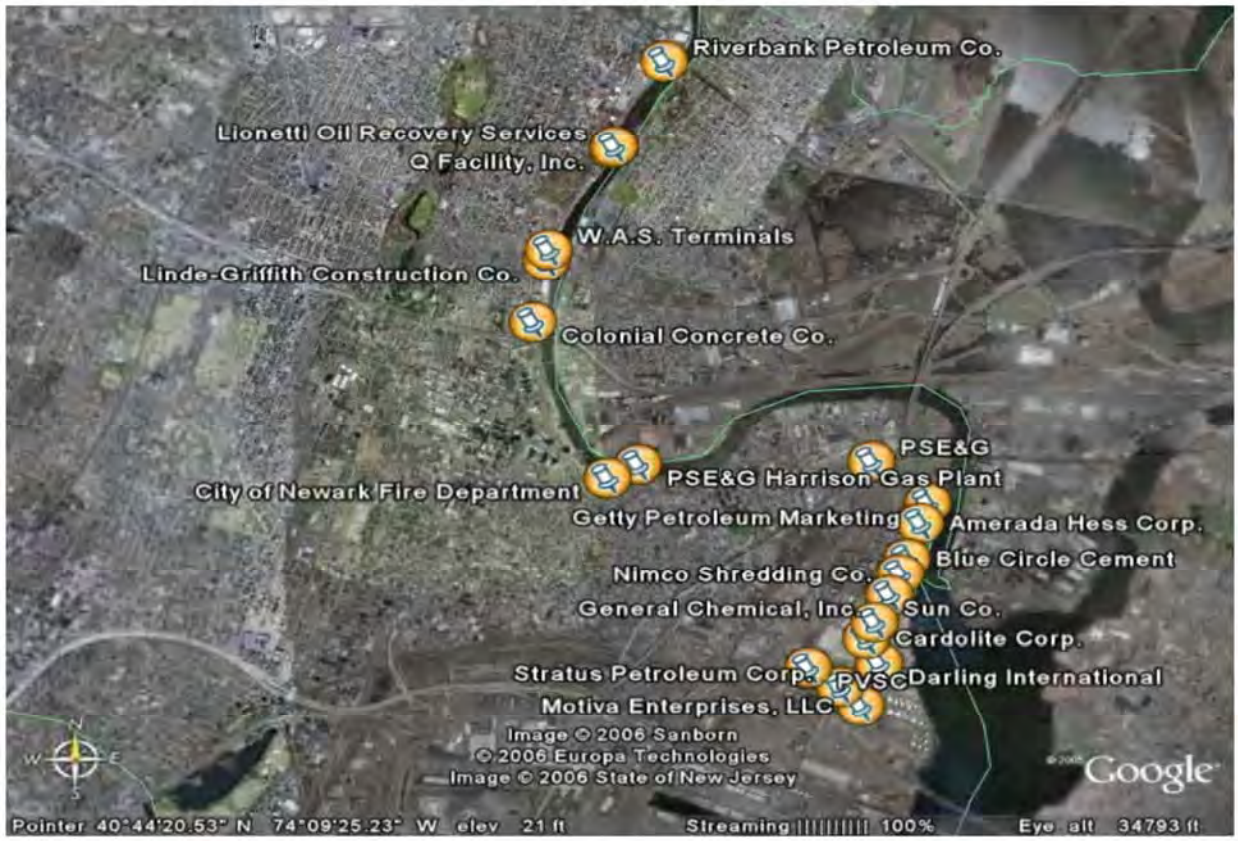
Figure 4: Commercial/Industrial Entities Present on the River (based on SIC Codes, USACE, 2007)



2.3 Additional NJDOT/NJDEP Considerations

The area within Newark's Industrial Zone adjacent and downstream of RM 3.6 is a prime location for the State of New Jersey to support mixed-use economic growth and revitalization. This area has been identified as such due to existing densities, infrastructure capacities, disturbed areas and current impervious surfaces. Newark's unparalleled transportation network and large amount of industrially-developed land which is far removed from residential areas, will allow it to continue to retain or even attract new industrial users (particularly the heavy industrial users), to these areas of the City (City of Newark Department of Economic & Housing Development, et. al., 2004).

The area within this zone has been designated as the Lister Avenue BDA slated for remediation and reuse (Figure A). Specifically in the area between RM 3.6 and 2.5, Blanchard Street/Fairmont Chemical Redevelopment Area has been identified as a potential site in the Portfields Program. This property would be used to support Port operations through the placement of much needed warehouse distribution operations (Personal Communications with Joel Sonkin [Newark Office of Economic and Housing Development], Mike Collins [New Jersey Economic Development Authority] and Peter Zantall [Port Commerce, Port Authority of NY/NJ] 2/20/07 and 2/21/07).

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Other areas within the BDA (e.g., Sherwin Williams, the Diamond Alkali Superfund Site, Hilton Davis) are in earlier stages of planning with uncertainties associated with their specific redevelopment. The former Diamond Alkali property has undergone an Interim Remedial Measure (IRM) and long term plans remain unknown. Therefore, based on these uncertainties, the significant private investment in Brownfield redevelopment, and the State's alignment of programs encouraging Brownfield redevelopment, the future growth potential for this area should be preserved on all fronts to the extent possible. Similarly, Brownfield, Portfield and industrial use opportunities continue downstream to Newark Bay in Newark and Kearny serving as important locations for continued and future development of commercial and industrial use within the river corridor and the region as a whole.

Many State entities and efforts are aligned to provide remedial support and investment in future land uses that spur economic revitalization in the region. The minimum depth requirements should not limit the potential for the future uses identified above. Several divisions within NJDOT (Statewide Planning, Freight Planning and Intermodal Coordination, Office of Maritime Resources and Project Planning and Development) have determined that the recommendations contained herein support the goals and objectives of the draft Long Range Transportation Plan, Liberty Corridor Initiative, Transportation Choices 2030, and the Urban Supplement for Newark. In addition, the recommendations support the goals, polices and strategies of the State Development and Redevelopment Plan and compliment Smart Growth Initiatives.

3.0 CONCLUSIONS

The information above provides a basis for the following recommendation of minimum depth requirements in the lower 8-miles of the Passaic River. A summary of these conclusions are presented in Table 1. A single minimum depth requirement within each segment of the river is proposed below to represent the State's interest.

River Miles 0-2.5 (Newark and Kearny): The USACE has determined that current navigational use of the river could be accommodated by an authorized depth of 16-ft (vessels drafting 13-ft), within RM 0 to 2.5. United State's Waterborne Commerce data and current dredging permits have indicated use by vessels requiring 26-ft. Based on the recent polling of existing users and examination of current permitted berth dredging, it appears that there is need for commercial drafts of at least 26 feet today, specifically near the confluence of Newark Bay. Since current users of the river are located in the lower 1.2 miles of the river reach, the depth requirements for this reach could be divided into two segments.

1) RM 0-1.2: Facilities that are currently using the river justify maintaining the current authorized depth of 30-ft. The State does not recommend modification of the existing authorized depth of 30-ft in this segment.

2) RM 1.2-2.5: The depth should not be less than 16-ft based on future industrial users, brownfields and portfields sites. Additional discussions need to take place among the State and the City of Newark and Kearny for this upper reach.

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River Miles 2.5 -3.6 (Newark and Kearny): Although Newark's Industrial Zone above RM 2.5 does not currently utilize the river for waterborne transportation purposes, the future plans for this segment may result in complete redevelopment of the area. The minimum depth requirement will be determined by future land use patterns following upland remediation. The State's recommendations for depth of the Passaic should not preclude the possibility of navigational use of the river for the Lister Avenue BDA, consistent with the Liberty Corridor Initiative, or for a use not yet identified. Therefore, a minimum of 16-ft depth would be required in this segment in order to preserve the potential for future navigational use and economic revitalization of the region.

River Miles 3.6 – 4.6 (Newark and Harrison): Depths upstream of Newark's Industrial Zone and downstream of the Jackson Street Bridge should be a minimum of 10-ft. This depth should be more than adequate to accommodate recreational and commercial services (e.g., water taxis/ferries proposed at RM 4.8) in the river. This recommendation would accommodate activities and plans outlined in master plans and municipality surveys.

River Miles 4.6 – 8 (Newark, Kearny and East Newark): A primary goal of the Lower Passaic Restoration Project is to improve public access and enhance recreational use of the river (e.g., boating, fishing, etc). River depths between Jackson Street and Amtrak Bridges should accommodate proposed water taxis/ferries within the river stretch. In addition, river reaches upstream of the Amtrak Bridge must accommodate future recreational uses and the possibility of commercial services (e.g., water taxis/ferries). Most recreational vessels (e.g., powerboats, sailboats, fishing) less than 30-ft in length have drafts of less than 3-ft (http://www.nauticexpo.com/index.html and http://www.gradywhite.com). A minimum of 5-ft would be necessary to accommodate nearly all recreational vessels on the Passaic River. A minimum of 7-ft should accommodate all reasonably anticipated recreational uses. In addition, if commercial services considered a route upstream of the Amtrak Bridge, a depth of 10-ft would accommodate this potential need. It should be noted that limited bridge openings are a constraint for optimizing recreational use in the upstream reaches of the river.

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Table 1: Summary of Current and Recommended Navigational Depths

Reach (RM)	Authorized Depth (ft)	Constructed Depth (ft)	Existing Depth (ft) Average and Range	Min. Depth for Anticipated Future Use (ft)	Comments
0-1.2	30	30	Avg: 17.2 9.5-20.9	30	Maintain existing and future Industrial Use
1.2-2.5	30	30	Avg: 19.7 14.8-24.7	16	Preserve future potential Industrial Uses/Brownfields/ Portfields
2.5-3.6	20	20	Avg: 15.2 13.0-18.4	16	Preserve future potential Industrial Uses/Brownfields/ Portfields
3.6-4.6	20	20	Avg: 16.4 11.9-22.1	10	Future Recreational/ commercial services (e.g., water taxis/ferries)
4.6-8	20 (4.6-7) 16 (7-8)	16	Avg: 15.7 5.1-21.9	10	Future Recreational/ commercial services (e.g., water taxis/ferries)

4.0 REFERENCES

Bruno M., Fullerton B., and R. Datla (Stevens Institute of Technology). 2002. Ferry Wake Wash in NY/NJ Harbor. Technical Report SIT-DL-02-9-2812. Prepared for NJDOT.

Clarke Caton Hintz / Ehrenkrantz Eckstut & Kuhn. 1999. Passaic Riverfront Revitalization, Newark, NJ. City of Newark (12/15/1999).

Clarke Caton Hintz / Ehrenkrantz Eckstut & Kuhn Architects. 2004. Passaic Riverfront Redevelopment Plan, Newark, NJ. City of Newark (Presentation 1/22/04).

City of Newark Dept. of Economic & Housing Development and Phillips Preiss Shapiro Associates, Inc., Schoor DePalma. 2004. Land Use Element of the Master Plan for the City of Newark. Prepared for the Central Planning Board City of Newark (12/6/04)

East Newark Planning/Zoning Board, County of Hudson, State of New Jersey. 12/2006. Resolution Adopting the Borough of East Newark's Re-Examination of the Master Plan and Development Regulations as Prepared by Robert D. Cotter, PP, AICP, Planning Consultant.

Heyer, Gruel & Associates, 2002. Town of Kearny Master Plan Reexamination Report.

Heyer, Gruel & Associates. 2003. Harrison Waterfront Redevelopment Plan.

Personal Communication between Carol Johnston, Ironbound Community Corporation and Lisa Baron, NJDOT. 2/1/07.

Personal Communication between John Keineg, NY Waterway and Lisa Baron, NJDOT. 2/15/07

Personal Communication between Joel Sonkin, Newark Office of Economic and Housing Development and Lisa Baron, NJDOT. 2/21/07.

Personal Communication between Mike Collins, New Jersey Economic Development Authority and Lisa Baron, NJDOT. 2/20/07.

Personal Communication between Peter Zantall, Port Commerce, Port Authority of NY/NJ and Lisa Baron, NJDOT. 2/20/07.

Personal Communication between Ed Marchese, Passaic River Boat Club (President) and Lisa Baron, NJDOT. 3/1/07.

Personal Communication between Lower Passaic and Saddle River Alliance, Watershed Management Area 4 and Lisa Baron, NJDOT. 4/13/07.

USACE, 2007. Lower Passaic River Navigation Analysis. CENAN-PL-F Memorandum to Thomas J. Hodson, Chief, Plan Formulation Branch

USACE, 2006. Engineering and Design - Hydraulic Design of Deep Draft Navigation Projects (Chapter 8). Publication Number: EM 1110-2-1613, CECW-CE.

Wallace, Roberts & Todd. 2002. Expanding Recreation Opportunities: The Ironbound Community Recreation and Open Space Plan, Phase I Report: Analysis and Recommendations. Prepared for the Ironbound Community Corporation, Community Planning Steering Committee and Ironbound Community.

Municipality Surveys:

Bayonne/Hudson County (RM 0): James Monkowski, City of Bayonne, Municipal building, 630 Ave C., Bayonne, NJ 07002.

Belleville Township/Essex County (RM 8-10): Thomas Herits, 429 Stephens St. Belleville, NJ 07109. (11/10/06)

Borough of East Newark/Hudson County (RM 5.6-6.1): Robert B. Knapp, Acting Burough Clerk, 34 Sherman Avenue, East Newark, NJ 07029

City of Clifton, Passaic County: (RM 11-13 and RM 17): Ms. Macil Homza, Secretary, Clifton Environmental Protective Commission, City Hall, 900 Clifton Avenue, Clifton, NJ 07013. (10/13/06)

Elizabeth (south of RM0): Oscar Ocasio, Department of Planning & Community Development, 50 Winfield Scott Plaza, Elizabeth. (10/11/06)
East Rutherford/Bergen (RM 13): James Cassella, Mayor, 1 Everett Place, East Rutherford, NJ 07073 (10/20/06).

Essex (Third River): Lawrence Ferchak, Essex County Division of Mosquito Control, 99 W. Bradford Avenue, Cedar Grove, NJ 07009.

Passaic County (Clifton/Nutley line to Dundee Dam): Anthony DeNova, County of Passaic, 401 Grand Street, Paterson, NJ 07505. (10/26/06)

Rutherford Borough/Bergen County (RM12&13): Timothy Stafford, Borough Administrator, 176 Park Avenue, Rutherford, NJ 07070. (10/25/06)

Town of Harrison/Hudson County (RM 3.5 to 5.6): Peter Higgins, Harrison Redevelopment Agency, 600 Essex Street, Harrison, NJ 07029. (2/13/07)

Town of Kearny (RM 0.0-8.0): Michael J. Martello, Construction Code, 402 Kearny Avenue, Kearny NJ 07032. (1/26/07)

Township of Nutley Essex (RM 8-11): Dominic Ferry, 1 Kennedy Dr. Nutley, NJ 07110.

Township of Bloomfield, Essex County (Third River): Paul D. Lasek, P.E., Township Engineer, 1 Municipal Plaza, Bloomfield, NJ 07003 (10/25/06)

R2-0010386

ATTACHMENT 1

SUMMARY OF MUNICIPALITY FUTURE USE QUESTIONNAIRES AND MASTER PLANS

TABLE A

MUNICIPALITY FUTURE USE QUESTIONNAIRE SUMMARY

Future Use Questionnaire Summary
Table A

Municipality	Affiliation	River Miles	Current Use (mile)	River Impact Use?	Master Plan	* Future Use (mile)	Additional Restoration Actions
City of Clifton, Passaic County	Clifton Environmental Protection Commission	11.3-12.7 16.7-17.4 3rd River	Commercial Industrial Open Space/Preserved: (Dundee Island Preserve 17) Wetlands (11, 17) Residential (3rd River, 11)	Need better access for recreational uses	Yes	Open Space/Preserved/ River Access/Wetland Creation (Dundee Island Preserve Expansion 17; 3rd river)	1-Expand Dundee Island Preserve (walkway, nature study area, boat ramp, fishing pier (17)) 2- Wetland enhancement at Anderson Tract Route 3/3rd river 3- Lower 3rd river greenway from Anderson Tract to confluence
Rutherford Borough/Bergen County	Borough Administrator	11.6- 13.4	Residential Open space/preserved, river access: Nereid (12) Recreational/parks (13)	View is Rt 21and industries	No	* Same as current	Continued renovations on Nereid Boat Club
County of Passaic	County Administrator	11.3-17.4 Clifton/Nutley line to Dundee Dam	Commercial (City Motors) Open Space/Preserved (Dundee Island) River Access (Passaic City) Residential	Limited Access due to river walls and private ownership	No	* Same as current River Walk	None
East Rutherford/Bergen	Mayor	13.4-13.9	Commercial Recreational Open space/preserved Residential Parks/Walkways	No	No	* Bike Path, Recreational/fields parks, Open space	1-Better recognition of historical points 2-Navigation is a problem due to low bridges and do not open. 3-Reduce the time it takes to get through permitting process for parks and open space.
Township of Nutley, Essex	Mayors' office	10-11.3	Recreation/Fields/Parks: Third River Public Access (11)	No	No	* Recreation/Fields/Parks/ River Access Points (11) Recreation/Fields/Parks/ Open Space/Preserved (3rd River)	None

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Future Use Questionnaire Summary
Table A

Municipality	Affiliation	River Miles	Current Use (mile)	River Impact Use?	Master Plan	* Future Use (mile)	Additional Restoration Actions
Belleville Township, Essex	Township Engineer (Senator Rice)	8-10	Commercial (9) Industrial (8,10) Residential (8-10) NJ State Hwy 21 (prevents access)	Yes- Need public access for recreation	Yes	* Commercial	Clean and navigable PR
Township of Bloomfield, Essex	Township Engineer	Third River Only (miles from confluence)	Commercial (5.7-5.9) Industrial (4.9-5) Recreational/Fields/Parks (4.1-4.4; 5-5.4; 5.5-5.7; 6.2-6.7) Open Space (6.7-7.1) Residential (5.4-5.5; 5.9-6.2)	No	Yes	* Recreational/Sports Fields/Parks (4.9-5; 5.9-6.2) Open Space/Preserved (4.9-5; 5.9-6.2) Residential (4.9-5; 5.9-6) These sites are currently abandoned/underutilized industrial areas for township re-development	
Essex	Essex County Division of Mosquito Control	Third River Only	"3rd River for Obstructions"	No	No	Ensure free flow condition and minimize any mosquito habitats developing.	
Kearny	Construction Code and Zoning Office	0-4 6.3-8.8	Commercial retail (6-7) Industrial warehousing/ storage (1-3) Recreational/Parks (7-8) Open Space (7 and 8) River Access (7 and 8)	Yes- cleanup, improve smell and routine debris removal	Yes	-Commercial retail (6-7) Passaic Ave Redevelopment Plan: -River walkway (6-7) -Residential (6-7) Arlington Reach would be used more by recreational boating if water was marked and maintained.	Kearny Point plans for warehousing and distribution (restoration and public access is inconsistent). Although, waterfront walkways are proposed.
Borough of East Newark/Hudson	Acting Borough Clerk	5.8-6.3	Industrial	Yes- could impact anticipated redevelopment	Yes (in process- Passaic Ave)	Commercial Residential Remediation would enhance redevelopment plans.	

R2-0010390

Future Use Questionnaire Summary
Table A

Municipality	Affiliation	River Miles	Current Use (mile)	River Impact Use?	Master Plan	* Future Use (mile)	Additional Restoration Actions
Town of Harrison/ Hudson County	Harrison Redevelopment Agency	3.4 - 5.8	Commercial Industrial	No	Yes	-Recreational/Fields/Parks /Open Space/Preserved Residential Authorized depths would enable river access points to be incorporated in future open space planning.	None in addition to Master Plan
Bayonne/Hudson County	City of Bayonne	0	Recreational/Fields/Parks, Open Space/Preserved, River Access, Wetlands, Residential	-	No	* Recreational/Fields/ Parks/Open Space/Preserved Residential	Recently constructed 13-acre Park w/wetlands etc. should be example
Elizabeth	Dept. of Planning & Community Development	South of 0	All uses are within the shores of the Arthur Kill	Yes- Passaic brings sediment into AK need for dredging	Yes- Arthur Kill	* Recreational Fields/Parks Residential	NA
Master Plans							
Newark	Passaic Riverfront Revitalization (12/15/99)	~3.6-6.1 (west bank from Clay and Brill Street), Second River				- Mixed use commercial development -Recreational and entertainment uses: pleasure and dinner boating, marinas, floating restaurants, crew racing/ kayak centers, river festivals and water taxi services (downtown Newark to Manhattan and Jersey City) - Recreational facilities along riverfront and pedestrian access from Ironbound neighborhoods. - Linear park system along banks from Newark to Paterson (20 miles). - Extend city's streets to connect with river walk. - Extend Ironbound neighborhood to river's edge and maintain low rise scale. - Joseph G Minish Park and linkage to commercial and residential development. Expand Minish with minimum width 60 ft. - Connection of NJPAC to waterfront, Riverfront	

R2-0010391

Future Use Questionnaire Summary
Table A

Municipality	Affiliation	River Miles	Current Use (mile)	River Impact Use?	Master Plan	* Future Use (mile)	Additional Restoration Actions
Newark	Passaic Riverfront Revitalization [cont.] (12/15/99)	~3.6-6.1 (west bank from Clay and Brill Street), Second River				Stadium and waterfront development having sports theme. - Renovate Riverbank Park - All future development requires construction to have public access way along river creating "continuous river corridor open space system". - sprint rowing course between Penn Station and Bridge Street (w/ boat houses) - Navigation channel: "the regulated width of the channel should be reduced to reflect needs of recreational boating." -I280-Belleville: industrial sites expected to relocate, and land becomes open space and residential uses. - Second River Corridor as passive open space connection to waterfront (from Broadway to confluence). -Eastern shoulder (Diamond) will remain an industrial zone providing jobs (future non-residential use after cleanup). - Installation of open space buffer between Terrell Homes and Industrial zone. - Public Walkway (minimum 30 ft width) adjacent to industrial property with natural edge. - New Essex County Park (stacked containers) - Extend Minish Park to RM 2.5 (NJ Turnpike)	
Newark	Passaic Riverfront Redevelopment Plan (1/22/04)	Jackson St. to Bridge St (4.6-5.7)				- Proposed Park (Ironbound Community Corps) including environmental education center, stage barge, docking for the "Odyssey" educational ferryboat - Consensus Plan: Access to NJPAC, creation of Minish Park, pedestrian upland connections to waterfront, 60ft minimum view corridors, access for large marine vessels, water taxi, tour boats, Odyssey Educational Boat (~RM 4.6), boathouses and rowing clubs (~RM 5.1), Pedestrian bridge (~RM 5), Wetlands Parks (~RM 4.9)	

R2-0010392

Future Use Questionnaire Summary
Table A

Municipality	Affiliation	River Miles	Current Use (mile)	River Impact Use?	Master Plan	* Future Use (mile)	Additional Restoration Actions
Newark	Land Use Element of Master Plan for the City of Newark (12/04)	0-8.3				- Mixed-use environment with strong residential, open space and recreational component. - Continued Industrial development in Industrial Zone (up to RM 3.6). - Minish Restoration and Historic Area Park project - Park space between Mott Street and Brill Street w/ active recreation (baseball, soccer fields, tennis and in-line hockey rink) - Coordination with Passaic Riverfront Revitalization Study - Office buildings/Hotel	
Newark	Ironbound Community Recreation and Open Space Plan (May 2002)	2.4-8.3				- Entire riverfront as a park (Raymond Blvd to river and Penn Station to Chapel St) - Pedestrian corridors linking parks, playgrounds, etc - Minish Park - Riverbank Park - Recreational fields from Sherwin Williams west (containers removed)	
Harrison	Harrison Waterfront Redevelopment Plan (Oct 2003)	3.4-5.8				- Waterfront Walkway (from I 280 to Jackson St Bridge) and Park - Bridge to Newark (with pedestrian walk/link to proposed Stadium) - USACE Harrison Flood Control Project (floodwall and levee system) - Public access points - Residential, Stadium, Office Commercial	
Kearny	Town of Kearny Master Plan Reexamination (July 2002)	0-3.5 6.3-8.8				Kearny Urban Enterprise Zones (south RM 0-2.5 and RM 6.1- 8) - South RM 0-2.5 (South Kearny Industrial South (SKI-S): Portfields site (SKM-1) for warehousing and manufacturing center - Passaic Avenue Plan: mixed-use, urban entertainment destination new housing, shopping and recreational activities with riverfront walk. Park and open space system. - Upgrade of boat launch at Passaic Ave and Bergen	

R2-0010393

Future Use Questionnaire Summary
Table A

Municipality	Affiliation	River Miles	Current Use (mile)	River Impact Use?	Master Plan	* Future Use (mile)	Additional Restoration Actions
Kearny	Town of Kearny Master Plan Reexamination [cont.] (July 2002)					Ave. - Meadowlands District and Redevelopment Area (RM 2.5 to 3.5): - New commercial, light industrial mixed use and recreational uses. - Kearny Marsh remediation/restoration	
Belleville	Reexamination Report, Belleville Master Plan (April 2007)	8.3-10.2				- Redevelopment within the Valley from Industrial reduced and replaced by commercial, retail and residential. - Bike path along 2nd River - State Historic Register consideration: Passaic River Valley Historic District near the Passaic River's west bank and the Second River's north bank.	

* Respondents to Questionnaire indicated that the municipality would not use the river differently if authorized depths were maintained.

R2-0010394

Future Use Questionnaire Summary
Table A

References

Municipality Surveys

Bayonne/Hudson County (RM 0): James Monkowski, City of Bayonne, Municipal building, 630 Ave C., Bayonne, NJ 07002.

Belleville Township/Essex County (RM 8-10): Thomas Herits, 429 Stephens St. Belleville, NJ 07109. (11/10/06)

Borough of East Newark/Hudson County (RM 5.6-6.1): Robert B. Knapp, Acting Burough Clerk, 34 Sherman Avenue, East Newark, NJ 07029

City of Clifton, Passaic County: (RM 11-13 and RM 17): Ms. Macil Homza, Secretary, Clifton Environmental Protective Commission, City Hall, 900 Clifton Avenue, Clifton, NJ 07013. (10/13/06)

Elizabeth (south of RM0): Oscar Ocasio, Department of Planning & Community Development, 50 Winfield Scott Plaza, Elizabeth. (10/11/06)

East Rutherford/Bergen (RM 13): James Cassella, Mayor, 1 Everett Place, East Rutherford, NJ 07073 (10/20/06).

Essex (Third River): Lawrence Ferchak, Essex County Division of Mosquito Control, 99 W. Bradford Avenue, Cedar Grove, NJ 07009.

Passaic County (Clifton/Nutley line to Dundee Dam): Anthony DeNova, County of Passaic, 401 Grand Street, Paterson, NJ 07505. (10/26/06)

Rutherford Borough/Bergen County (RM12&13): Timothy Stafford, Borough Administrator, 176 Park Avenue, Rutherford, NJ 07070. (10/25/06)

Town of Harrison/Hudson County (RM 3.5 to 5.6): Peter Higgins, Harrison Redevelopment Agency, 600 Essex Street, Harrison, NJ 07029. (2/13/07)

Town of Kearny (RM 0.0-8.0): Michael J. Martello, Construction Code, 402 Kearny Avenue, Kearny NJ 07032. (1/26/07)

Township of Nutley Essex (RM 8-11): Dominic Ferry, 1 Kennedy Dr. Nutley, NJ 07110.

R2-0010395

Township of Bloomfield, Essex County (Third River): Paul D. Lasek, P.E., Township Engineer, 1 Municipal Plaza, Bloomfield, NJ 07003 (10/25/06)

Master Plans

Clarke Caton Hintz / Ehrenkrantz Eckstut & Kuhn. 1999. Passaic Riverfront Revitalization, Newark, NJ. City of Newark (12/15/1999).

Clarke Caton Hintz / Ehrenkrantz Eckstut & Kuhn Architects. 2004. Passaic Riverfront Redevelopment Plan, Newark, NJ. City of Newark (Presentation 1/22/04).

City of Newark Dept. of Economic & Housing Development and Phillips Preiss Shapiro Associates, Inc., Schoor DePalma. 2004. Land Use Element of the Master Plan for the City of Newark. Prepared for the Central Planning Board City of Newark (12/6/04)

East Newark Planning/Zoning Board, County of Hudson, State of New Jersey. 12/2006. Resolution Adopting the Borough of East Newark's Re-Examination of the Master Plan and Development Regulations as Prepared by Robert D. Cotter, PP, AICP, Planning Consultant.

Heyer, Gruel & Associates, 2002. Town of Kearny Master Plan Reexamination Report.

Heyer, Gruel & Associates. 2003. Harrison Waterfront Redevelopment Plan.

Master Plan Reexamination Subcommittee and Maser Consulting. 2007. Reexamination Report Belleville Master Plan, Township of Belleville, NJ (April 2007).

Wallace, Roberts & Todd. 2002. Expanding Recreation Opportunities: The Ironbound Community Recreation and Open Space Plan, Phase I Report: Analysis and Recommendations. Prepared for the Ironbound Community Corporation, Community Planning Steering Committee and Ironbound Community.

FIGURE A

SUMMARY OF MUNICIPALITY FUTURE PROPOSED LAND USE AND PLANNING EFFORTS

RIVER MILES 0-8

new jersey
department of transportation

Lower Passaic River Restoration Project

Municipality Plans for Future Use of River
Miles 0 to 8

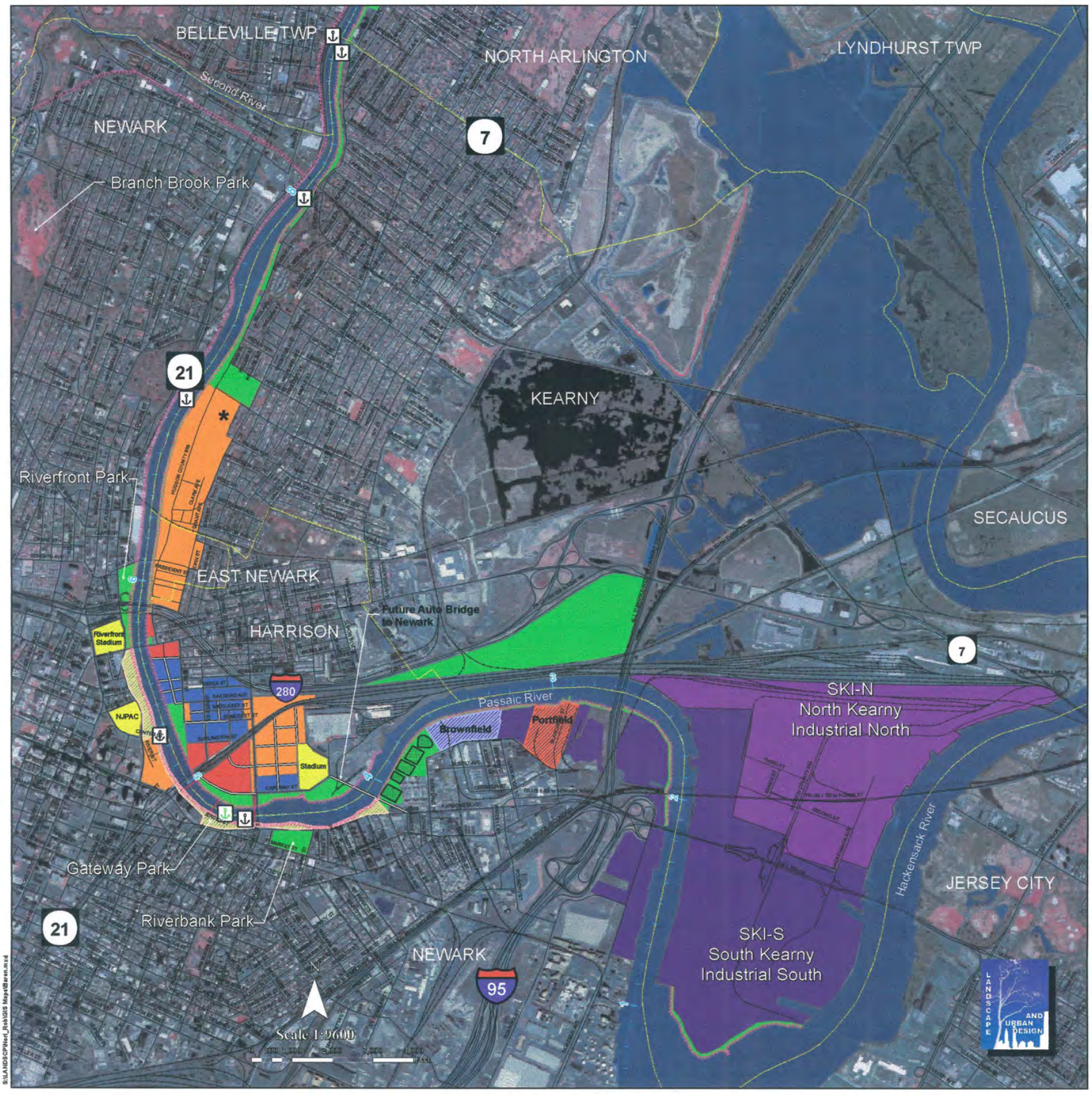
Legend

- Lister Avenue Brownfield Development Area
- Blanchard Street/Fairmont Chemical Development Area
- Boating: Recreation/Commercial (marina, dock, ramp)
- Bikepath/Walkway
- Proposed Street
- Pedestrian Bridge
- Athletic Fields
- Entertainment
- Minish Park Boundary
- Open Space/Recreation
- Industrial
- Mixed Use (Residential/Commercial [Retail/Office])
- Residential
- Commercial

Notes:
1. Aerial photograph is 2002 Orthophotography. These files are projected as 1983 New Jersey State Plane Coordinates in feet.

Boating area to include water taxi, tour & educational boats

* Also includes recreation activities & entertainment destination



S:\LANDSCP\Nwrl_Rob\GIS Maps\Bzero.mxd

ATTACHMENT 2

MUNICIPALITY FUTURE USE QUESTIONNAIRES

Lower Passaic River Restoration Project
Future Use Questionnaire

Municipality/County: _____

Name _____

Affiliation/Agency Representing: _____

Address _____

Phone/Fax numbers: _____

Municipality Location- Specific River Miles (see enclosed map): _____

The State of New Jersey (NJDOT and NJDEP) needs your help to understand what the communities and region envision for the future of the Lower Passaic River watershed. The information you provide in this questionnaire will be used with the other Partner agencies (US Environmental Protection Agency, US Army Corps of Engineers, National Oceanic and Atmospheric Administration and US Fish and Wildlife Service) for the Lower Passaic River Restoration Project to plan for the clean up and comprehensive restoration of the Lower Passaic River and its major tributaries (specifically Saddle River and Second and Third Rivers). Local municipalities and regional efforts are critical in the planning process for the future use of the river. Please submit your completed questionnaire by October 13, 2006 to:

Lisa Baron
New Jersey Department of Transportation
PO Box 837
1035 Parkway Avenue
Trenton, NJ 08625-0837
609-530-4779

Section 1: Current Uses

1) Please indicate your municipality's current uses of the Passaic River, tributaries and waterfront areas (Please indicate river mile – see enclosed map):

( ) Commercial _____
( ) Industrial _____
( ) Recreational/Sports Fields and Parks _____
( ) Open Space/Preserved _____
( ) River Access points (e.g., marinas, boat ramps) _____
( ) Commuter/Recreational Transportation (e.g., water taxis, cruises) _____
( ) Wetlands or scenic landscape _____
( ) Residential _____

R2-0010400

( ) Other _____

2) Does the current condition of the Passaic River negatively impact your municipality's use of the Passaic River and waterfront areas? Yes/No _____ If yes, please describe. _____

_____

_____

_____

3) Please indicate any public access (including their condition) to the river and primary tributaries in your municipality (Please indicate river mile – see enclosed map):

( ) Marinas_____
( ) Boat ramps_____
( ) Walkways_____
( ) Parks_____
( ) Other_____

Section 2 : Future Planning

1) Does your municipality have a master plan or plan for future development of the Passaic River waterfront, tributaries or adjacent areas? Yes/No _____

If possible, please send to Lisa Baron at the above address at your earliest convenience.

2) Please identify the primary components currently included in the plan or any other plans for development currently under consideration in your municipality for the Passaic River, tributaries and waterfront areas (note river mile- see map):

( ) Commercial _____
( ) Industrial _____
( ) Recreational/Sports Fields and Parks_____
( ) Open Space/Preserved _____
( ) River Access points (e.g., marinas, boat ramp creation or rehabilitation)
( ) Commuter/Recreational Transportation (e.g., water taxis, cruises) _____
( ) Wetland Creation _____
( ) Residential _____
( ) Other _____

3) The federal navigation channel in the Passaic River has not been maintained since 1983 (lower 2 miles), 1937 (miles 2.6 to 4.6), or before the 1950s in specific upper reach locations. Would the Passaic River be used more or would your municipality's development plans change if the federal navigation channel in the

river were remediated and restored to its current authorized depth? Authorized depths are currently:

- Point No Point Reach (river mile 0 to 2.2) at 30 feet;
- Harrison Reach (river mile 2.2 to 7) at 20 feet;
- Arlington Reach (river mile 7 to 8) at 16 ft;
- Upstream (river mile 8 to 15) at 10 ft. (see enclosed map)

Yes/No _____If yes, please specify.

_____

_____

_____

4) In the absence of a master plan, please indicate what additional development your municipality considers appropriate for the Passaic River, tributaries and waterfront areas (note river mile- see map):

( ) Commercial _____
( ) Industrial _____
( ) Recreational/Sports Fields and Parks_____
( ) Open Space/Preserved _____
( ) River Access points (e.g., marinas, boat ramp creation or rehabilitation)
( ) Commuter/Recreational Transportation (e.g., water taxis, cruises) _____
( ) Wetland Creation _____
( ) Residential _____
( ) Other _____

5) Before answering the final question, please review the attachments (DRAFT map of the vision for the river, goals and potential restoration actions):

If the draft map is not inclusive of any proposed actions or master plans for future development within your municipality or if there are additional restoration actions that you would like to see included on our list, please identify three (3) specific project or actions that you would like to see undertaken.

_____

_____

_____

_____

_____

Additional comments:

_____

_____

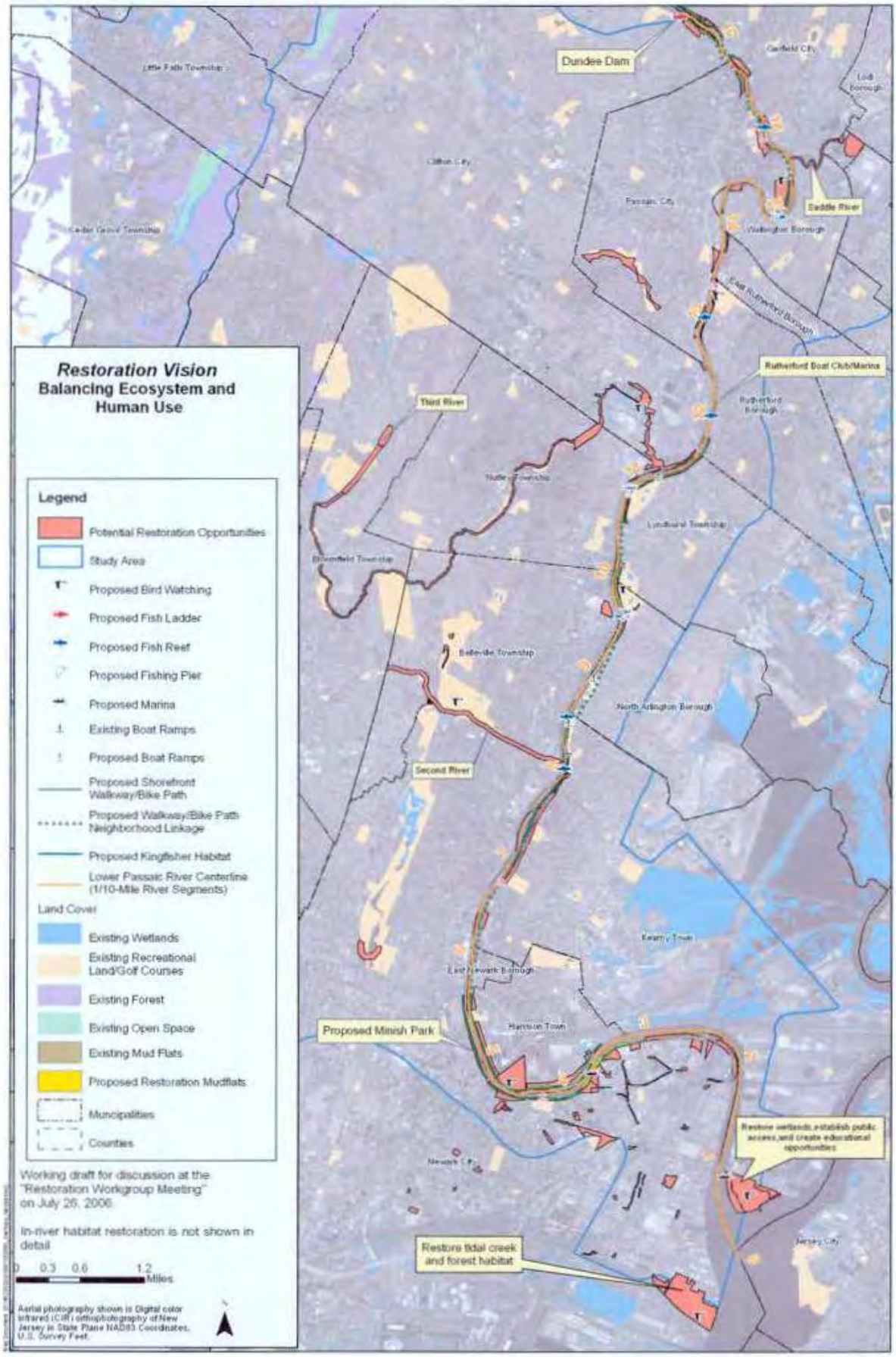
_____

_____

THANK YOU FOR YOUR TIME!

Attachment 1

DRAFT
Map- Restoration of the Lower Passaic River


Restoration Vision
Balancing Ecosystem and Human Use
Legend
Potential Restoration Opportunities
Study Area
Proposed Bird Watching
Proposed Fish Ladder
Proposed Fish Reef
Proposed Fishing Pier
Proposed Marina
Existing Boat Ramps
Proposed Boat Ramps
Proposed Shorefront Walkway/Bike Path
Proposed Walkway/Bike Path Neighborhood Linkage
Proposed Kingfisher Habitat
Lower Passaic River Centerline (1/10-Mile River Segments)
Land Cover
Existing Wetlands
Existing Recreational Land/Golf Courses
Existing Forest
Existing Open Space
Existing Mud Flats
Proposed Restoration Mudflats
Municipalities
Counties
Working draft for discussion at the "Restoration Workgroup Meeting" on July 26, 2006
In-river habitat restoration is not shown in detail
0 0.3 0.6 1.2 Miles
Aerial photography shown is Digital color infrared (CIR) orthophotography of New Jersey in State Plane NAD83 Coordinates, U.S. Survey Feet.
Dundee Dam
Saddle River
Rutherford Boat Club/Marina
Third River
Second River
Proposed Minish Park
Restore tidal creek and forest habitat
Restore wetlands, establish public access, and create educational opportunities

Attachment 2

Project Goals

- Create, enhance and restore habitat (including subtidal, intertidal, riparian and upland).
- Improve water quality
- Enhance vegetative communities
- Enhance faunal communities (e.g., increase diversity and abundance of fish, birds, mammals, herpetefauna and benthic communities)
- Improve sediment quality
- Support human use
    - Economic Revitalization
    - Improve public access
    - Improve aesthetics
    - Improve public education opportunities
    - Improve navigation
    - Improve passive recreation opportunities
    - Improve recreational fishing opportunities
    - Improve flood storage and attenuation
    - Improve brownfield and greenfield development

Project Goals abridged for purposes of this questionnaire.

Potential Restoration Actions

- Procure upland and wetland property
- Restore habitat
- Reduce sources of untreated storm water and sewer system outflows
- Add riparian forests, maritime forests, freshwater wetlands and salt marshes
- Restore contiguous areas (e.g., Oak Island Yards, Kearny Point, Tributaries)
- Green development (e.g., create green roofs, rain gardens and downspout connections)
- Build/rehabilitate fish piers
- Reduce floatables
- Remove obstacles to navigation
- Create bird watching access
- Implement Minish Park Mitigation Pilot
- Remove containers on river banks
- Establish river boat ecotourism opportunities
- Create small craft and non-motorized boat access points, information kiosks and public waterfront areas
- Create greenways/fields and parks
- Establish fish passage (ladder) /shad run
- Establish brownfield remediation and redevelopment
- Convert brownfields to greenfields
- Remove or modify constrained channels and connections between open waters

R2-0010405

City of Clifton, Passaic County
10/13/06

ENVIRONMENTAL PROTECTIVE COMMISSION

CITY HALL
900 CLIFTON AVENUE
CLIFTON, NEW JERSEY 07013

MEETING THE 1ST WEDNESDAY
OF THE MONTH AT CITY HALL

PHONE: 973-470-5754
FAX: 973-470-9456

October 10, 2006

Ms. Lisa A. Baron
Project Manager
State of New Jersey
Department of Transportation
P.O. Box 837
1035 Parkway Avenue, 3rd Floor MOB
Trenton, New Jersey 08625-0837

RE: Lower Passaic River Restoration Project
Future Use Questionnaire

Dear Ms. Baron:

Per you request, attached is a copy of the Lower Passaic River Restoration Project Future Use Questionnaire which has been filled out by the Clifton Environmental Protective Commission on behalf of the City of Clifton.

Should you need any additional information, do not hesitate to contact this office.

Very truly yours,

Joseph A. Labriola mh
JOSEPH A. LABRIOLA
COMMISSIONER

JAL:mh

Attachment

RECEIVED
OCT 13 2006
MARITIME RESOURCES

Lower Passaic River Restoration Project
Future Use Questionnaire

Municipality/County: City of Clifton, Passaic County

Name: Ms. Macil Homza, Secretary
Clifton Environmental Protective Commission

Affiliation/Agency Representing: Clifton Environmental Protective Commission

Address: City Hall
900 Clifton Avenue, Clifton, N.J. 07013

Phone/Fax numbers: (973) 470-5754

Municipality Location- Specific River Miles (see enclosed map): RM 11-10-13 and RM 17

The State of New Jersey (NJDOT and NJDEP) needs your help to understand what the communities and region envision for the future of the Lower Passaic River watershed. The information you provide in this questionnaire will be used with the other Partner agencies (US Environmental Protection Agency, US Army Corps of Engineers, National Oceanic and Atmospheric Administration and US Fish and Wildlife Service) for the Lower Passaic River Restoration Project to plan for the clean up and comprehensive restoration of the Lower Passaic River and its major tributaries (specifically Saddle River and Second and Third Rivers). Local municipalities and regional efforts are critical in the planning process for the future use of the river. Please submit your completed questionnaire by October 13, 2006 to:

Lisa Baron
New Jersey Department of Transportation
PO Box 837
1035 Parkway Avenue
Trenton, NJ 08625-0837
609-530-4779

Section 1: Current Uses

1) Please indicate your municipality's current uses of the Passaic River, tributaries and waterfront areas (Please indicate river mile – see enclosed map):

(✓) Commercial R.M 11-13, RM 17, Third River
(✓) Industrial R.M. 11-13, RM 17
( ) Recreational/Sports Fields and Parks
(✓) Open Space/Preserved Dundee Island Preserve (NJDOT) RM 17
( ) River Access points (e.g., marinas, boat ramps)
( ) Commuter/Recreational Transportation (e.g., water taxis, cruises)
(✓) Wetlands or scenic landscape RM 17, RM 11
(✓) Residential Third River, below River Road vicinity R.M 11

R2-0010408

Other _____

2) Does the current condition of the Passaic River negatively impact your municipality's use of the Passaic River and waterfront areas? (Yes)/No _____ If yes, please describe. Need better access for recreational uses

3) Please indicate any public access (including their condition) to the river and primary tributaries in your municipality (Please indicate river mile – see enclosed map):

( ) Marinas _____
( ) Boat ramps _____
(✓) Walkways NJDOT, Dundee Island Preserve, RM 17, Riverwalk at Third River vic RM 11
(✓) Parks _____
( ) Other _____

Section 2 : Future Planning

1) Does your municipality have a master plan or plan for future development of the Passaic River waterfront, tributaries or adjacent areas? (Yes)/No _____
As part of City of Clifton Master Plan

If possible, please send to Lisa Baron at the above address at your earliest convenience.

2) Please identify the primary components currently included in the plan or any other plans for development currently under consideration in your municipality for the Passaic River, tributaries and waterfront areas (note river mile- see map):

( ) Commercial _____
( ) Industrial _____
( ) Recreational/Sports Fields and Parks RM 17
(✓) Open Space/Preserved Dundee Island Preserve Expansion, Ponders on Track along Third River
(✓) River Access points (e.g., marinas, boat ramp creation or rehabilitation) Dundee Island Preserve, RM 17
( ) Commuter/Recreational Transportation (e.g., water taxis, cruises) _____
(✓) Wetland Creation Dundee Island Preserve Expansion RM 17
( ) Residential _____
( ) Other _____

3) The federal navigation channel in the Passaic River has not been maintained since 1983 (lower 2 miles), 1937 (miles 2.6 to 4.6), or before the 1950s in specific upper reach locations. Would the Passaic River be used more or would your municipality's development plans change if the federal navigation channel in the

river were remediated and restored to its current authorized depth? Authorized depths are currently:

- Point No Point Reach (river mile 0 to 2.2) at 30 feet;
- Harrison Reach (river mile 2.2 to 7) at 20 feet;
- Arlington Reach (river mile 7 to 8) at 16 ft;
- Upstream (river mile 8 to 15) at 10 ft. (see enclosed map)

(Yes) No _____ If yes, please specify.

Upstream to allow future boat ramps and fishing piers

4) In the absence of a master plan, please indicate what additional development your municipality considers appropriate for the Passaic River, tributaries and waterfront areas (note river mile- see map):

( ) Commercial _____
( ) Industrial _____
( ) Recreational/Sports Fields and Parks _____
(✓) Open Space/Preserved Dundee Island Preserve, RM 17, Third River
(✓) River Access points (e.g., marinas, boat ramp creation or rehabilitation) "
( ) Commuter/Recreational Transportation (e.g., water taxis, cruises) _____
(✓) Wetland Creation Dundee Island Preserve RM 17, Third River vic. RM 11
(✓) Residential RM 12
( ) Other _____

5) Before answering the final question, please review the attachments (DRAFT map of the vision for the river, goals and potential restoration actions):

If the draft map is not inclusive of any proposed actions or master plans for future development within your municipality or if there are additional restoration actions that you would like to see included on our list, please identify three (3) specific project or actions that you would like to see undertaken.

Generally shown on Draft Map, but specifically:

- Expanded Dundee Island Preserve at RM 17 with walkway, nature study areas, boat ramp, fishing pier
- Wetland Enhancement at Anderson Tract Route 3/Third River
- Lower Third River Greenway from Anderson Tract to confluence with Passaic River at RM 11

Additional comments:

THANK YOU FOR YOUR TIME!

Rutherford Borough/Bergen County
10/25/06

SCHOOR DEPALMA
Engineers and Consultants

October 25, 2006

Lisa Baron
NJ Department of Transportation
PO Box 837
1035 Parkway Avenue
Trenton, NJ 08625-0837

RE: Lower Passaic River Questionnaire
Our Project Number 060106401

Dear Ms. Baron

On behalf of the Borough of Rutherford I am forwarding the enclosed, completed Lower Passaic river questionnaire. If you have any questions please do not hesitate to contact me.

Very truly yours,

SCHOOR DEPALMA INC.

David K. Maski PP, AICP
Borough Planner

c: Timothy Stafford, Borough Administrator

M:\project\2006\0601064\01\passaic river\questionnaire.transmittal.DOT.doc

RECEIVED
OCT 27 2006
MARITIME RESOURCES

Lower Passaic River Restoration Project
Future Use Questionnaire

Municipality/County: Rutherford Borough / Bergen County

Name: Timothy Stafford

Affiliation/Agency Representing: Borough Administrator

Address: 176 Park Avenue, Rutherford, New Jersey 07070

Phone/Fax numbers: (201) 460-3004 / (201) 460-6121

Municipality Location- Specific River Miles (see enclosed map): 12 & 13

The State of New Jersey (NJDOT and NJDEP) needs your help to understand what the communities and region envision for the future of the Lower Passaic River watershed. The information you provide in this questionnaire will be used with the other Partner agencies (US Environmental Protection Agency, US Army Corps of Engineers, National Oceanic and Atmospheric Administration and US Fish and Wildlife Service) for the Lower Passaic River Restoration Project to plan for the clean up and comprehensive restoration of the Lower Passaic River and its major tributaries (specifically Saddle River and Second and Third Rivers). Local municipalities and regional efforts are critical in the planning process for the future use of the river. Please submit your completed questionnaire by October 27, 2006 to:

Lisa Baron
New Jersey Department of Transportation
PO Box 837
1035 Parkway Avenue
Trenton, NJ 08625-0837
609-530-4779

Section 1: Current Uses

1) Please indicate your municipality's current uses of the Passaic River, tributaries and waterfront areas (Please indicate river mile – see enclosed map):

( ) Commercial
( ) Industrial
(X) Recreational/Sports Fields and Parks 13
(X) Open Space/Preserved 12
(X) River Access points (e.g., marinas, boat ramps) 12
( ) Commuter/Recreational Transportation (e.g., water taxis, cruises)
( ) Wetlands or scenic landscape
(X) Residential 12 & 13

R2-0010413

( ) Other _____

2) Does the current condition of the Passaic River negatively impact your municipality's use of the Passaic River and waterfront areas? Yes/No Yes If yes, please describe. View across river into Passaic County is of Highway (route 21) and Industrial uses.

3) Please indicate any public access (including their condition) to the river and primary tributaries in your municipality (Please indicate river mile – see enclosed map):

( ) Marinas
(x) Boat ramps 12 (Rowing Club)
( ) Walkways
(x) Parks 12 & 13
( ) Other

Section 2 : Future Planning

1) Does your municipality have a master plan or plan for future development of the Passaic River waterfront, tributaries or adjacent areas? Yes/No NO

If possible, please send to Lisa Baron at the above address at your earliest convenience.

2) Please identify the primary components currently included in the plan or any other plans for development currently under consideration in your municipality for the Passaic River, tributaries and waterfront areas (note river mile- see map): N/A

( ) Commercial
( ) Industrial
( ) Recreational/Sports Fields and Parks
( ) Open Space/Preserved
( ) River Access points (e.g., marinas, boat ramp creation or rehabilitation)
( ) Commuter/Recreational Transportation (e.g., water taxis, cruises)
( ) Wetland Creation
( ) Residential
( ) Other

3) The federal navigation channel in the Passaic River has not been maintained since 1983 (lower 2 miles), 1937 (miles 2.6 to 4.6), or before the 1950s in specific upper reach locations. Would the Passaic River be used more or would your municipality's development plans change if the federal navigation channel in the

river were remediated and restored to its current authorized depth? Authorized depths are currently:

- Point No Point Reach (river mile 0 to 2.2) at 30 feet;
- Harrison Reach (river mile 2.2 to 7) at 20 feet;
- Arlington Reach (river mile 7 to 8) at 16 ft;
- Upstream (river mile 8 to 15) at 10 ft. (see enclosed map)

Yes/No NO If yes, please specify.

4) In the absence of a master plan, please indicate what additional development your municipality considers appropriate for the Passaic River, tributaries and waterfront areas (note river mile- see map):

( ) Commercial
( ) Industrial
(X) Recreational/Sports Fields and Parks 12 & 13
(X) Open Space/Preserved 12 & 13
(X) River Access points (e.g., marinas, boat ramp creation or rehabilitation) 12 & 13
( ) Commuter/Recreational Transportation (e.g., water taxis, cruises)
( ) Wetland Creation
( ) Residential
( ) Other

5) Before answering the final question, please review the attachments (DRAFT map of the vision for the river, goals and potential restoration actions):

If the draft map is not inclusive of any proposed actions or master plans for future development within your municipality or if there are additional restoration actions that you would like to see included on our list, please identify three (3) specific project or actions that you would like to see undertaken.

"The Nereid Boat Club at mile 12 plans to continue renovations of their existing facility."

Additional comments:

THANK YOU FOR YOUR TIME!

County of Passaic
10/26/06

County of Passaic

Administration Building
401 Grand Street, Room 205
Paterson, New Jersey 07505-2023

Anthony J. DeNova
County Administrator

TEL: (973) 881-4405
FAX: (973) 881-2853
Email: adenova@passaiccountynj.org

Board of Chosen Freeholders

Elease Evans
Director

Sonia Rosado
Deputy Director

Lois A. Cuccinello

Terry Duffy

James Gallagher

Bruce James

Pat Lepore

October 26, 2006

Ms. Lisa A. Baron, Project Manager
State of New Jersey
Department of Transportation
1035 Parkway Avenue, 3rd Floor MOB
Trenton, NJ 08625

Dear Ms. Baron:

Enclosed please find the completed Future Use Questionnaire for the Lower Passaic River Restoration Project.

If I can be of any further assistance, please do not hesitate to contact my office.

Sincerely,

Anthony J. DeNova
County Administrator

AJD/psr
Enclosure

RECEIVED
OCT 27 2006
MARITIME RESOURCES

Lower Passaic River Restoration Project
Future Use Questionnaire

Municipality/County: Passaic County

Name: Anthony J. DeNova

Affiliation/Agency Representing: County of Passaic

Address: 401 Grand Street, Paterson, NJ 07505

Phone/Fax numbers: 973-881-4405

Municipality Location- Specific River Miles (see enclosed map): Clifton/Nutley line to Dundee Dam

The State of New Jersey (NJDOT and NJDEP) needs your help to understand what the communities and region envision for the future of the Lower Passaic River watershed. The information you provide in this questionnaire will be used with the other Partner agencies (US Environmental Protection Agency, US Army Corps of Engineers, National Oceanic and Atmospheric Administration and US Fish and Wildlife Service) for the Lower Passaic River Restoration Project to plan for the clean up and comprehensive restoration of the Lower Passaic River and its major tributaries (specifically Saddle River and Second and Third Rivers). Local municipalities and regional efforts are critical in the planning process for the future use of the river. Please submit your completed questionnaire by October 27, 2006 to:

Lisa Baron
New Jersey Department of Transportation
PO Box 837
1035 Parkway Avenue
Trenton, NJ 08625-0837
609-530-4779

Section 1: Current Uses

1) Please indicate your municipality's current uses of the Passaic River, tributaries and waterfront areas (Please indicate river mile – see enclosed map):

(X) Commercial Some, but minimal (City Motors)
(X) Industrial
(X) Recreational/Sports Fields and Parks
(X) Open Space/Preserved Dundee Island
(X) River Access points (e.g., marinas, boat ramps) Passaic Count
( ) Commuter/Recreational Transportation (e.g., water taxis, cruises)
( ) Wetlands or scenic landscape
(X) Residential Apartment complex (Monroe St.), minimal single family

R2-0010418

) Other _____

2) Does the current condition of the Passaic River negatively impact your municipality's use of the Passaic River and waterfront areas? Yes/No Yes If yes, please describe. Limited access due to river walls. Private property prevents access.

3) Please indicate any public access (including their condition) to the river and primary tributaries in your municipality (Please indicate river mile – see enclosed map):

( ) Marinas _____
(x) Boat ramps Passaic City
( ) Walkways _____
( ) Parks _____
( ) Other _____

Section 2 : Future Planning

1) Does your municipality have a master plan or plan for future development of the Passaic River waterfront, tributaries or adjacent areas? Yes/No No

If possible, please send to Lisa Baron at the above address at your earliest convenience.

2) Please identify the primary components currently included in the plan or any other plans for development currently under consideration in your municipality for the Passaic River, tributaries and waterfront areas (note river mile- see map):

( ) Commercial _____
( ) Industrial _____
( ) Recreational/Sports Fields and Parks _____
( ) Open Space/Preserved _____
( ) River Access points (e.g., marinas, boat ramp creation or rehabilitation)
( ) Commuter/Recreational Transportation (e.g., water taxis, cruises) _____
( ) Wetland Creation _____
( ) Residential _____
( ) Other _____

3) The federal navigation channel in the Passaic River has not been maintained since 1983 (lower 2 miles), 1937 (miles 2.6 to 4.6), or before the 1950s in specific upper reach locations. Would the Passaic River be used more or would your municipality's development plans change if the federal navigation channel in the

river were remediated and restored to its current authorized depth? Authorized depths are currently:

- Point No Point Reach (river mile 0 to 2.2) at 30 feet;
- Harrison Reach (river mile 2.2 to 7) at 20 feet;
- Arlington Reach (river mile 7 to 8) at 16 ft;
- Upstream (river mile 8 to 15) at 10 ft. (see enclosed map)

Yes/No ____No__If yes, please specify.

4) In the absence of a master plan, please indicate what additional development your municipality considers appropriate for the Passaic River, tributaries and waterfront areas (note river mile- see map):

(X) Commercial
( ) Industrial
(X) Recreational/Sports Fields and Parks
(X) Open Space/Preserved
(X) River Access points (e.g., marinas, boat ramp creation or rehabilitation)
( ) Commuter/Recreational Transportation (e.g., water taxis, cruises)
( ) Wetland Creation
( ) Residential
(X) Other River walk

5) Before answering the final question, please review the attachments (DRAFT map of the vision for the river, goals and potential restoration actions):

If the draft map is not inclusive of any proposed actions or master plans for future development within your municipality or if there are additional restoration actions that you would like to see included on our list, please identify three (3) specific project or actions that you would like to see undertaken.

Additional comments:

THANK YOU FOR YOUR TIME!

East Rutherford/Bergen County
10/20/06

State of New Jersey

DEPARTMENT OF TRANSPORTATION
P.O. Box 600
Trenton, New Jersey 08625-0600

JON S. CORZINE
Governor

KRIS KOLLURI, esq.
Commissioner

October 4, 2006

Honorable James Cassella
Mayor, Borough of East Rutherford
Municipal Building
1 Everett Place
East Rutherford, NJ 07073

Dear Mayor Cassella

NJ Department of Transportation (NJDOT) and NJ Department of Environmental Protection (NJDEP) need your help and input as we prepare for the future of the Lower Passaic River. As you are aware, the Partner agencies (NJDOT, NJDEP, US Army Corps of Engineers (USACE), US Environmental Protection Agency (USEPA), National Oceanic and Atmospheric Administration (NOAA), and US Fish and Wildlife Service (USFWS)) are working together to determine a comprehensive solution for the clean up and restoration of the Lower Passaic River and watershed. The Project Study area includes the 17-mile stretch of Lower Passaic River and its tributaries (including Saddle, Second and Third Rivers) from the Dundee Dam to the confluence with Newark Bay. Please go to www.ourpassaic.org for additional information about the Restoration Project.

As the overall Feasibility Study is in progress, the agencies are actively evaluating if early remedial actions can take place. In order to determine the appropriate remedial strategy and conduct comprehensive restoration planning, the future vision and planning efforts of the municipalities must be understood and considered. This will assist in planning for remediation, since the resultant depth of the river may influence how your community can use this vital resource and also impact the role navigation can have in economic revitalization of the region.

Please take the time to fill out the attached questionnaire on behalf of your county, town, district or community and mail back to me by October 27, 2006 (1035 Parkway Avenue, 3rd Floor MOB, Trenton, NJ, 08625). We would then like to set up a follow-up meeting to discuss your vision for the future. Thank you in advance for your cooperation and we look forward to working with you on the restoration of this valuable resource. If you have any questions, please feel free to contact me at 609-530-4779 or Janine MacGregor at NJDEP at 609-633-0784.

Sincerely,

Lisa A. Baron

Lisa A. Baron
Project Manager

c Janine MacGregor, NJDEP
Alice Yeh, USEPA
Megan Grubb, USACE
Reyhan Mehran, NOAA
Tim Kubiak, USFWS

RECEIVED
OCT 20 2006
MARITIME RESOURCES

R2-0010422

Lower Passaic River Restoration Project
Future Use Questionnaire

Municipality/County: East Rutherford / Bergen

Name: James L. Cassella

Affiliation/Agency Representing: Mayor

Address: 1 Everett Place East Rth NJ 07073

Phone/Fax numbers (201) 933 3444 / (201) 933 6111

Municipality Location- Specific River Miles (see enclosed map):

The State of New Jersey (NJDOT and NJDEP) needs your help to understand what the communities and region envision for the future of the Lower Passaic River watershed. The information you provide in this questionnaire will be used with the other Partner agencies (US Environmental Protection Agency, US Army Corps of Engineers, National Oceanic and Atmospheric Administration and US Fish and Wildlife Service) for the Lower Passaic River Restoration Project to plan for the clean up and comprehensive restoration of the Lower Passaic River and its major tributaries (specifically Saddle River and Second and Third Rivers). Local municipalities and regional efforts are critical in the planning process for the future use of the river. Please submit your completed questionnaire by October 27, 2006 to:

Lisa Baron
New Jersey Department of Transportation
PO Box 837
1035 Parkway Avenue
Trenton, NJ 08625-0837
609-530-4779

Section 1: Current Uses

1) Please indicate your municipality's current uses of the Passaic River, tributaries and waterfront areas (Please indicate river mile – see enclosed map):

- (X) Commercial
- ( ) Industrial
- (X) Recreational/Sports Fields and Parks
- (X) Open Space/Preserved
- ( ) River Access points (e.g., marinas, boat ramps)
- ( ) Commuter/Recreational Transportation (e.g., water taxis, cruises)
- ( ) Wetlands or scenic landscape
- (X) Residential

(Other _____

2) Does the current condition of the Passaic River negatively impact your municipality's use of the Passaic River and waterfront areas? Yes/No NO If yes, please describe. _____

3) Please indicate any public access (including their condition) to the river and primary tributaries in your municipality (Please indicate river mile – see enclosed map):

(_____
13
13

Section 2 : Future Planning

1) Does your municipality have a master plan or plan for future development of the Passaic River waterfront, tributaries or adjacent areas? Yes/No NO

If possible, please send to Lisa Baron at the above address at your earliest convenience.

2) Please identify the primary components currently included in the plan or any other plans for development currently under consideration in your municipality for the Passaic River, tributaries and waterfront areas (note river mile- see map):

( ) Commercial _____
( ) Industrial _____
(X) Recreational/Sports Fields and Parks 13
(X) Open Space/Preserved 13
( ) River Access points (e.g., marinas, boat ramp creation or rehabilitation) _____
( ) Commuter/Recreational Transportation (e.g., water taxis, cruises) _____
( ) Wetland Creation _____
( ) Residential _____
(X) Other Bike/walk Path 13

3) The federal navigation channel in the Passaic River has not been maintained since 1983 (lower 2 miles), 1937 (miles 2.6 to 4.6), or before the 1950s in specific upper reach locations. Would the Passaic River be used more or would your municipality's development plans change if the federal navigation channel in the

river were remediated and restored to its current authorized depth? Authorized depths are currently:

- Point No Point Reach (river mile 0 to 2.2) at 30 feet;
- Harrison Reach (river mile 2.2 to 7) at 20 feet;
- Arlington Reach (river mile 7 to 8) at 16 ft;
- Upstream (river mile 8 to 15) at 10 ft. (see enclosed map)

Yes/No NO If yes, please specify.

4) In the absence of a master plan, please indicate what additional development your municipality considers appropriate for the Passaic River, tributaries and waterfront areas (note river mile- see map):

( ) Commercial
( ) Industrial
(x) Recreational/Sports Fields and Parks 13
(X) Open Space/Preserved 13
( ) River Access points (e.g., marinas, boat ramp creation or rehabilitation)
( ) Commuter/Recreational Transportation (e.g., water taxis, cruises)
( ) Wetland Creation
( ) Residential
( ) Other

5) Before answering the final question, please review the attachments (DRAFT map of the vision for the river, goals and potential restoration actions):

If the draft map is not inclusive of any proposed actions or master plans for future development within your municipality or if there are additional restoration actions that you would like to see included on our list, please identify three (3) specific project or actions that you would like to see undertaken.

(1) Better recognition of historical points along the river
(2) Navigation is a problem because bridges are to low and don't open.
(3) Reduce the time it takes to get through the permitting process when the use are either going to be a park or open space or both.

Additional comments:
as a community which has eliminated Junk yards, a used car lot and a trucking terminal along the Passaic River and have created or is in the process of creating passive park and open space areas we certainly support your goals for the Passaic River

THANK YOU FOR YOUR TIME!

Township of Nutley/Essex County
10/06

State of New Jersey

DEPARTMENT OF TRANSPORTATION
P.O. Box 600
Trenton, New Jersey 08625-0600

JON S. CORZINE
Governor

KRIS KOLLURI, esq.
Commissioner

October 4, 2006

Honorable Peter Scarpelli
Mayor, Township of Nutley
Municipal Building
1 Kennedy Drive
Nutley, NJ 07110

Dear Mayor Scarpelli:

NJ Department of Transportation (NJDOT) and NJ Department of Environmental Protection (NJDEP) need your help and input as we prepare for the future of the Lower Passaic River. As you are aware, the Partner agencies (NJDOT, NJDEP, US Army Corps of Engineers (USACE), US Environmental Protection Agency (USEPA), National Oceanic and Atmospheric Administration (NOAA), and US Fish and Wildlife Service (USFWS)) are working together to determine a comprehensive solution for the clean up and restoration of the Lower Passaic River and watershed. The Project Study area includes the 17-mile stretch of Lower Passaic River and its tributaries (including Saddle, Second and Third Rivers) from the Dundee Dam to the confluence with Newark Bay. Please go to www.ourpassaic.org for additional information about the Restoration Project.

As the overall Feasibility Study is in progress, the agencies are actively evaluating if early remedial actions can take place. In order to determine the appropriate remedial strategy and conduct comprehensive restoration planning, the future vision and planning efforts of the municipalities must be understood and considered. This will assist in planning for remediation, since the resultant depth of the river may influence how your community can use this vital resource and also impact the role navigation can have in economic revitalization of the region.

Please take the time to fill out the attached questionnaire on behalf of your county, town, district or community and mail back to me by October 27, 2006 (1035 Parkway Avenue, 3rd Floor MOB, Trenton, NJ, 08625). We would then like to set up a follow-up meeting to discuss your vision for the future. Thank you in advance for your cooperation and we look forward to working with you on the restoration of this valuable resource. If you have any questions, please feel free to contact me at 609-530-4779 or Janine MacGregor at NJDEP at 609-633-0784.

Sincerely,

Lisa A. Baron

Lisa A. Baron
Project Manager

c: Janine MacGregor, NJDEP
Alice Yeh, USEPA
Megan Grubb, USACE
Reyhan Mehran, NOAA
Tim Kubiak, USFWS

R2-0010427

Lower Passaic River Restoration Project
Future Use Questionnaire

Municipality/County: Township of Nutley Essex

Name: Dominic Ferry

Affiliation/Agency Representing:

Address: 1 Kennedy DR. Nutley NJ. 07110

Phone/Fax numbers: 973-284-4984 973-284-4995

Municipality Location- Specific River Miles (see enclosed map): 8 - 11

The State of New Jersey (NJDOT and NJDEP) needs your help to understand what the communities and region envision for the future of the Lower Passaic River watershed. The information you provide in this questionnaire will be used with the other Partner agencies (US Environmental Protection Agency, US Army Corps of Engineers, National Oceanic and Atmospheric Administration and US Fish and Wildlife Service) for the Lower Passaic River Restoration Project to plan for the clean up and comprehensive restoration of the Lower Passaic River and its major tributaries (specifically Saddle River and Second and Third Rivers). Local municipalities and regional efforts are critical in the planning process for the future use of the river. Please submit your completed questionnaire by October 27, 2006 to:

Lisa Baron
New Jersey Department of Transportation
PO Box 837
1035 Parkway Avenue
Trenton, NJ 08625-0837
609-530-4779

Section 1: Current Uses

1) Please indicate your municipality's current uses of the Passaic River, tributaries and waterfront areas (Please indicate river mile – see enclosed map):

( ) Commercial
( ) Industrial
(✓) Recreational/Sports Fields and Parks Third River
( ) Open Space/Preserved
(✓) River Access points (e.g., marinas, boat ramps) MILE 11
( ) Commuter/Recreational Transportation (e.g., water taxis, cruises)
( ) Wetlands or scenic landscape
( ) Residential

) Other _____

2) Does the current condition of the Passaic River negatively impact your municipality's use of the Passaic River and waterfront areas? Yes/No NO If yes, please describe. _____

3) Please indicate any public access (including their condition) to the river and primary tributaries in your municipality (Please indicate river mile – see enclosed map):

( ) Marinas _____
(✓) Boat ramps mile 11
( ) Walkways _____
( ) Parks _____
( ) Other _____

Section 2 : Future Planning

1) Does your municipality have a master plan or plan for future development of the Passaic River waterfront, tributaries or adjacent areas? Yes/No NO

If possible, please send to Lisa Baron at the above address at your earliest convenience.

2) Please identify the primary components currently included in the plan or any other plans for development currently under consideration in your municipality for the Passaic River, tributaries and waterfront areas (note river mile- see map):

( ) Commercial _____
( ) Industrial _____
(✓) Recreational/Sports Fields and Parks mile 11
( ) Open Space/Preserved _____
( ) River Access points (e.g., marinas, boat ramp creation or rehabilitation)
( ) Commuter/Recreational Transportation (e.g., water taxis, cruises) _____
( ) Wetland Creation _____
( ) Residential _____
( ) Other _____

3) The federal navigation channel in the Passaic River has not been maintained since 1983 (lower 2 miles), 1937 (miles 2.6 to 4.6), or before the 1950s in specific upper reach locations. Would the Passaic River be used more or would your municipality's development plans change if the federal navigation channel in the

river were remediated and restored to its current authorized depth? Authorized depths are currently:

- Point No Point Reach (river mile 0 to 2.2) at 30 feet;
- Harrison Reach (river mile 2.2 to 7) at 20 feet;
- Arlington Reach (river mile 7 to 8) at 16 ft;
- Upstream (river mile 8 to 15) at 10 ft. (see enclosed map)

Yes/No NO If yes, please specify.

4) In the absence of a master plan, please indicate what additional development your municipality considers appropriate for the Passaic River, tributaries and waterfront areas (note river mile- see map):

( ) Commercial
( ) Industrial
(✓) Recreational/Sports Fields and Parks Along third River
(✓) Open Space/Preserved Along Third River
(✓) River Access points (e.g., marinas, boat ramp creation or rehabilitation) 11
( ) Commuter/Recreational Transportation (e.g., water taxis, cruises)
( ) Wetland Creation
( ) Residential
( ) Other

5) Before answering the final question, please review the attachments (DRAFT map of the vision for the river, goals and potential restoration actions):

If the draft map is not inclusive of any proposed actions or master plans for future development within your municipality or if there are additional restoration actions that you would like to see included on our list, please identify three (3) specific project or actions that you would like to see undertaken.

Additional comments

THANK YOU FOR YOUR TIME!

Belleville Township/Essex County
11/10/06

NEW JERSEY SENATE

RONALD L. RICE
SENATOR, 28TH DISTRICT
1044 SOUTH ORANGE AVENUE
NEWARK, NEW JERSEY 07106
(973) 371-5665
FAX: (973) 371-6738

COMMITTEES
CHAIRMAN
COMMUNITY & URBAN AFFAIRS
CHAIRMAN
JOINT COMMITTEE ON
THE PUBLIC SCHOOLS
MEMBER
HEALTH, HUMAN SERVICES AND
SENIOR CITIZENS

November 30, 2006

Ms. Lisa A. Baron, Project Manager
New Jersey Department of Transportation
P.O. Box 600
Trenton, New Jersey 08625

Dear Ms. Baron:

Enclosed please find the completed surveys for the clean up and restoration of the Lower Passaic River and Watershed for Belleville and Bloomfield, NJ.

I would like the surveys to be considered, I apologize for the delay and inconvenience, I was out of town and did not realize the due date was October 27, 2006.

If you have any questions please feel free to contact my office

Sincerely,

Senator Ronald L. Rice
28th Legislative District

Printed on Recycled Paper

429 Stephens Street
Belleville, NJ 07109
973-450-3412 Office
973-759-3162 Fax

Belleville Township Engineering Department

Fax

To:	Senator Rice 28th District	**From:**	Tom Herits PE PP PLS Township Engineer
Fax:	973-371-6738	**Pages:**	4
Phone:	973-371-5665	**Date:**	11/10/2006
Re:	Lower Passaic River Questionnaire Project No. BLT-001		

☐ **Urgent** X **For Review** ☐ **Please Comment** ☐ **Please Reply** ☐ **Please Recycle**

Attached is a completed copy of the above referenced questionnaire.

Should you have any questions, or require any additional information, do not hesitate to contact me.

Lower Passaic River Restoration Project
Future Use Questionnaire

Municipality/County: Belleville Township/Essex County

Name: Thomas J. Herits, P.E., P.P., P.L.S.

Affiliation/Agency Representing: Township Engineer

Address: 429 Stephens Street, Belleville, NJ 07109

Phone/Fax numbers: 973-450-3412 / 973-450-5009

Municipality Location- Specific River Miles (see enclosed map): 8, 9, 10

The State of New Jersey (NJDOT and NJDEP) needs your help to understand what the communities and region envision for the future of the Lower Passaic River watershed. The information you provide in this questionnaire will be used with the other Partner agencies (US Environmental Protection Agency, US Army Corps of Engineers, National Oceanic and Atmospheric Administration and US Fish and Wildlife Service) for the Lower Passaic River Restoration Project to plan for the clean up and comprehensive restoration of the Lower Passaic River and its major tributaries (specifically Saddle River and Second and Third Rivers). Local municipalities and regional efforts are critical in the planning process for the future use of the river. Please submit your completed questionnaire by October 27, 2006 to:

Lisa Baron
New Jersey Department of Transportation
PO Box 837
1035 Parkway Avenue
Trenton, NJ 08625-0837
609-530-4779

Section 1: Current Uses

1) Please indicate your municipality's current uses of the Passaic River, tributaries and waterfront areas (Please indicate river mile – see enclosed map):

(X) Commercial 9
(X) Industrial 8, 10
( ) Recreational/Sports Fields and Parks
( ) Open Space/Preserved
( ) River Access points (e.g., marinas, boat ramps)
( ) Commuter/Recreational Transportation (e.g., water taxis, cruises)
( ) Wetlands or scenic landscape
(X) Residential 8, 9, 10

(X) Other 8, 9, 10 NJ State Hwy. 21

2) Does the current condition of the Passaic River negatively impact your municipality's use of the Passaic River and waterfront areas? Yes/No Yes If yes, please describe. Although Belleville has no direct access to the river, water related recreation in area is limited.

3) Please indicate any public access (including their condition) to the river and primary tributaries in your municipality (Please indicate river mile – see enclosed map):

( ) Marinas
( ) Boat ramps
( ) Walkways
( ) Parks
(X) Other 8, 9, 10 No direct access to the river due to the location of Route 21.

Section 2 : Future Planning

1) Does your municipality have a master plan or plan for future development of the Passaic River waterfront, tributaries or adjacent areas? Yes/No Yes

If possible, please send to Lisa Baron at the above address at your earliest convenience.

2) Please identify the primary components currently included in the plan or any other plans for development currently under consideration in your municipality for the Passaic River, tributaries and waterfront areas (note river mile- see map):

(X) Commercial
( ) Industrial
( ) Recreational/Sports Fields and Parks
( ) Open Space/Preserved
( ) River Access points (e.g., marinas, boat ramp creation or rehabilitation)
( ) Commuter/Recreational Transportation (e.g., water taxis, cruises)
( ) Wetland Creation
( ) Residential
( ) Other

3) The federal navigation channel in the Passaic River has not been maintained since 1983 (lower 2 miles), 1937 (miles 2.6 to 4.6), or before the 1950s in specific upper reach locations. Would the Passaic River be used more or would your municipality's development plans change if the federal navigation channel in the

river were remediated and restored to its current authorized depth? Authorized depths are currently:

- Point No Point Reach (river mile 0 to 2.2) at 30 feet;
- Harrison Reach (river mile 2.2 to 7) at 20 feet;
- Arlington Reach (river mile 7 to 8) at 16 ft;
- Upstream (river mile 8 to 15) at 10 ft. (see enclosed map)

Yes/No No If yes, please specify.

4) In the absence of a master plan, please indicate what additional development your municipality considers appropriate for the Passaic River, tributaries and waterfront areas (note river mile- see map): N/A

( ) Commercial
( ) Industrial
( ) Recreational/Sports Fields and Parks
( ) Open Space/Preserved
( ) River Access points (e.g., marinas, boat ramp creation or rehabilitation)
( ) Commuter/Recreational Transportation (e.g., water taxis, cruises)
( ) Wetland Creation
( ) Residential
( ) Other

5) Before answering the final question, please review the attachments (DRAFT map of the vision for the river, goals and potential restoration actions):

If the draft map is not inclusive of any proposed actions or master plans for future development within your municipality or if there are additional restoration actions that you would like to see included on our list, please identify three (3) specific project or actions that you would like to see undertaken.

N/A

Additional comments:
Belleville would benefit from a clean, navigatable Passaic River. Belleville enjoys close access to the Passaic River in Kearny and North Arlington via Rt. 7 bridge.

THANK YOU FOR YOUR TIME!

Township of Bloomfield/Essex County
Third River
11/19/06

ENGINEERING DEPARTMENT
ONE MUNICIPAL PLAZA
Room 203

Paul D. Lasek, P.E.
Township Engineer

TOWNSHIP OF BLOOMFIELD
Bloomfield, New Jersey 07003-3487

TELEPHONE
973 • 680 • 4009

FAX
973 • 748 • 3520

October 25, 2006

Senator Ronald L. Rice
28th District
1044 South Orange Avenue
Newark, New Jersey 07106

RE: Lower Passaic River Restoration Project
Future Use Questionnaire

Dear Senator Rice:

Attached please find a completed Future Use Questionnaire as requested through your correspondence with Mayor Raymond J. McCarthy.

If you have any questions or require additional information, please feel free to contact me.

Very truly yours,

Paul D. Lasek, P.E.
Township Engineer

PL:el
attach.
cc: Louise M. Palagano, Township Administrator
Hon. Raymond J. McCarthy, Mayor

Lower Passaic River Restoration Project
Future Use Questionnaire

Municipality/County: Township Of Bloomfield, Essex County

Name: Paul D. Lasek, P.E.

Affiliation/Agency Representing: Township Engineer

Address: 1 Municipal Plaza, Bloomfield, N.J. 07003

Phone/Fax numbers: phone: 973-680-4490 fax 973-748-3520

Municipality Location- Specific River Miles (see enclosed map): Third River - Only

The State of New Jersey (NJDOT and NJDEP) needs your help to understand what the communities and region envision for the future of the Lower Passaic River watershed. The information you provide in this questionnaire will be used with the other Partner agencies (US Environmental Protection Agency, US Army Corps of Engineers, National Oceanic and Atmospheric Administration and US Fish and Wildlife Service) for the Lower Passaic River Restoration Project to plan for the clean up and comprehensive restoration of the Lower Passaic River and its major tributaries (specifically Saddle River and Second and Third Rivers). Local municipalities and regional efforts are critical in the planning process for the future use of the river. Please submit your completed questionnaire by October 27, 2006 to:

Lisa Baron
New Jersey Department of Transportation
PO Box 837
1035 Parkway Avenue
Trenton, NJ 08625-0837
609-530-4779

Section 1: Current Uses

1) Please indicate your municipality's current uses of the Passaic River, tributaries and waterfront areas (Please indicate river mile – see enclosed map): *

(✓) Commercial 5.7 to 5.9
(✓) Industrial 4.9 to 5.0
(✓) Recreational/Sports Fields and Parks 4.1 to 4.4; 5.0 to 5.4; 5.5 to 5.7; 6.2 to 6.7
(✓) Open Space/Preserved 6.7 to 7.1
( ) River Access points (e.g., marinas, boat ramps) _____
( ) Commuter/Recreational Transportation (e.g., water taxis, cruises) _____
( ) Wetlands or scenic landscape _____
(✓) Residential 5.4 to 5.5; 5.9 to 6.2

* All locations are along the Third River. The mile references shown are based upon the distance upstream from the Third River discharge into the Passaic River.

R2-0010439

( ) Other _____

2) Does the current condition of the Passaic River negatively impact your municipality's use of the Passaic River and waterfront areas? Yes/No No If yes, please describe. _____

3) Please indicate any public access (including their condition) to the river and primary tributaries in your municipality (Please indicate river mile – see enclosed map):

( ) Marinas _____
( ) Boat ramps _____
( ) Walkways _____
(✓) Parks Memorial Park/Foley Field (5.0 to 5.4); Brookside Park (5.5 to 5.7); Middle School & Clarks Pond (6.2 to 7.1)
( ) Other _____

Section 2 : Future Planning

1) Does your municipality have a master plan or plan for future development of the Passaic River waterfront, tributaries or adjacent areas? Yes/No Yes

If possible, please send to Lisa Baron at the above address at your earliest convenience.

2) Please identify the primary components currently included in the plan or any other plans for development currently under consideration in your municipality for the Passaic River, tributaries and waterfront areas (note river mile- see map):

( ) Commercial _____
( ) Industrial _____
* (✓) Recreational/Sports Fields and Parks 4.9 to 5.0; 5.9 to 6.2
* (✓) Open Space/Preserved 4.9 to 5.0; 5.9 to 6.2
( ) River Access points (e.g., marinas, boat ramp creation or rehabilitation) _____
( ) Commuter/Recreational Transportation (e.g., water taxis, cruises) _____
( ) Wetland Creation _____
* (✓) Residential 4.9 to 5.0; 5.9 to 6.2
( ) Other _____

3) The federal navigation channel in the Passaic River has not been maintained since 1983 (lower 2 miles), 1937 (miles 2.6 to 4.6), or before the 1950s in specific upper reach locations. Would the Passaic River be used more or would your municipality's development plans change if the federal navigation channel in the

* These areas are currently abandoned/underused industrial areas that the Township would like to re-develop as parks, open space, residential or a combination.

river were remediated and restored to its current authorized depth? Authorized depths are currently:

- Point No Point Reach (river mile 0 to 2.2) at 30 feet;
- Harrison Reach (river mile 2.2 to 7) at 20 feet;
- Arlington Reach (river mile 7 to 8) at 16 ft;
- Upstream (river mile 8 to 15) at 10 ft. (see enclosed map)

Yes/No. No. If yes, please specify.

4) In the absence of a master plan, please indicate what additional development your municipality considers appropriate for the Passaic River, tributaries and waterfront areas (note river mile- see map):

( ) Commercial
( ) Industrial
(✓) Recreational/Sports Fields and Parks
(✓) Open Space/Preserved
( ) River Access points (e.g., marinas, boat ramp creation or rehabilitation)
( ) Commuter/Recreational Transportation (e.g., water taxis, cruises)
( ) Wetland Creation
( ) Residential
( ) Other

5) Before answering the final question, please review the attachments (DRAFT map of the vision for the river, goals and potential restoration actions):

If the draft map is not inclusive of any proposed actions or master plans for future development within your municipality or if there are additional restoration actions that you would like to see included on our list, please identify three (3) specific project or actions that you would like to see undertaken.

The Township would like to redevelop their abandoned industrial properties along the Third River. The following actions are recommended: Provide funding for (1) cleanup (2) Design & (3) Construction of Sites for recreation.

Additional comments:

THANK YOU FOR YOUR TIME!

Essex County
Third River

Lower Passaic River Restoration Project
Future Use Questionnaire

Municipality/County: ESSEX

Name: LAWRENCE J. FERCHAK

Affiliation/Agency Representing: ESSEX COUNTY DIVISION of MOSQUITO CONTROL

Address: 99 W. BRADFORD AVE, CEDAR GROVE NJ 07009

Phone/Fax numbers: 973-239-0342 (f) 973-239-8637

Municipality Location- Specific River Miles (see enclosed map):

The State of New Jersey (NJDOT and NJDEP) needs your help to understand what the communities and region envision for the future of the Lower Passaic River watershed. The information you provide in this questionnaire will be used with the other Partner agencies (US Environmental Protection Agency, US Army Corps of Engineers, National Oceanic and Atmospheric Administration and US Fish and Wildlife Service) for the Lower Passaic River Restoration Project to plan for the clean up and comprehensive restoration of the Lower Passaic River and its major tributaries (specifically Saddle River and Second and Third Rivers). Local municipalities and regional efforts are critical in the planning process for the future use of the river. Please submit your completed questionnaire by October 27, 2006 to:

Lisa Baron
New Jersey Department of Transportation
PO Box 837
1035 Parkway Avenue
Trenton, NJ 08625-0837
609-530-4779

Section 1: Current Uses

1) Please indicate your municipality's current uses of the Passaic River, tributaries and waterfront areas (Please indicate river mile – see enclosed map):

( ) Commercial _____
( ) Industrial _____
( ) Recreational/Sports Fields and Parks _____
( ) Open Space/Preserved _____
( ) River Access points (e.g., marinas, boat ramps) _____
( ) Commuter/Recreational Transportation (e.g., water taxis, cruises) _____
( ) Wetlands or scenic landscape _____
( ) Residential _____

R2-0010443

(✓) Other THIRD RIVER for OBSTRUCTIONS

2) Does the current condition of the Passaic River negatively impact your municipality's use of the Passaic River and waterfront areas? Yes/No _____ If yes, please describe. _____

3) Please indicate any public access (including their condition) to the river and primary tributaries in your municipality (Please indicate river mile – see enclosed map):

( ) Marinas___
( ) Boat ramps___
( ) Walkways___
( ) Parks___
(✓) Other 8 - THIRD RIVER | 11 THIRD RIVER

Section 2 : Future Planning

1) Does your municipality have a master plan or plan for future development of the Passaic River waterfront, tributaries or adjacent areas? Yes/No _____

If possible, please send to Lisa Baron at the above address at your earliest convenience.

2) Please identify the primary components currently included in the plan or any other plans for development currently under consideration in your municipality for the Passaic River, tributaries and waterfront areas (note river mile- see map):

( ) Commercial ___
( ) Industrial ___
( ) Recreational/Sports Fields and Parks___
( ) Open Space/Preserved ___
( ) River Access points (e.g., marinas, boat ramp creation or rehabilitation)
( ) Commuter/Recreational Transportation (e.g., water taxis, cruises) ___
( ) Wetland Creation ___
( ) Residential ___
( ) Other ___

3) The federal navigation channel in the Passaic River has not been maintained since 1983 (lower 2 miles), 1937 (miles 2.6 to 4.6), or before the 1950s in specific upper reach locations. Would the Passaic River be used more or would your municipality's development plans change if the federal navigation channel in the

river were remediated and restored to its current authorized depth? Authorized depths are currently:

- Point No Point Reach (river mile 0 to 2.2) at 30 feet;
- Harrison Reach (river mile 2.2 to 7) at 20 feet;
- Arlington Reach (river mile 7 to 8) at 16 ft;
- Upstream (river mile 8 to 15) at 10 ft. (see enclosed map)

Yes/No ____/____ If yes, please specify.

N/A

4) In the absence of a master plan, please indicate what additional development your municipality considers appropriate for the Passaic River, tributaries and waterfront areas (note river mile- see map):

( ) Commercial
( ) Industrial
( ) Recreational/Sports Fields and Parks
( ) Open Space/Preserved
( ) River Access points (e.g., marinas, boat ramp creation or rehabilitation)
( ) Commuter/Recreational Transportation (e.g., water taxis, cruises)
( ) Wetland Creation
( ) Residential
( ) Other

5) Before answering the final question, please review the attachments (DRAFT map of the vision for the river, goals and potential restoration actions):

If the draft map is not inclusive of any proposed actions or master plans for future development within your municipality or if there are additional restoration actions that you would like to see included on our list, please identify three (3) specific project or actions that you would like to see undertaken.

Additional comments:
MY MAJOR CONCERNS AS WITH ALL RIVERS AND TRIBUTARIES IS THAT THEY ARE IN A FREE FLOW CONDITION AND MINIMIZE ANY MOSQUITO HABITATS DEVELOPING

THANK YOU FOR YOUR TIME!

Town of Kearny
1/26/07

Survey and Resolution 2006-(R)-543

1/26/07

Lower Passaic River Restoration Project
Future Use Questionnaire

Municipality/County: Town of Kearny

Name: Michael J Martello

Affiliation/Agency Representing: Construction Code

Address: 402 Kearny Ave., Kearny NJ 07032

Phone/Fax numbers: 201-955-7880 fax 201-998-5171

Municipality Location- Specific River Miles (see enclosed map):

The State of New Jersey (NJDOT and NJDEP) needs your help to understand what the communities and region envision for the future of the Lower Passaic River watershed. The information you provide in this questionnaire will be used with the other Partner agencies (US Environmental Protection Agency, US Army Corps of Engineers, National Oceanic Atmospheric Administration and US Fish and Wildlife Service) for the Lower Passaic River Restoration Project to plan for the clean up and comprehensive restoration of the Lower Passaic River and its major tributaries (specifically Saddle River and Second and Third Rivers). Local municipalities and regional efforts are critical in the planning process for the future use of the river. Please submit your completed questionnaire by October 13, 2006 to:

Lisa Baron
New Jersey Department of Transportation
PO Box 837
1035 Parkway Avenue
Trenton, NJ 08625-0837
609-530-4779

Section 1: Current Uses

1) Please indicate your municipality's current uses of the Passaic River, tributaries and waterfront areas (Please indicate river mile – see enclosed map):

(x) Commercial: *Retail development is being planned between river mile 6 & 7*

(x) Industrial *warehousing/storage buildings related trucking businesses ,River mile: 1, 2 & 3*

(x) Recreational/Sports Fields and Parks *Town parks, hockey rink at river mile 7 & 8*

(x) Open Space/Preserved *Green Acres area, River mile 7 & 8*

(x) River Access points (e.g., marinas, boat ramps) *Boat ramp at river mile 7 & Kearny Board of Ed Crew program river mile 8*

3) The federal navigation channel in the Passaic River has not been maintained since 1983 (lower 2 miles), 1937 (miles 2.6 to 4.6), or before the 1950s in specific upper reach locations. Would the Passaic River be used more or would your municipality's development plans change if the federal navigation channel in the river were remediated and restored to its current authorized depth? Authorized depths are currently:
   - Point No Point Reach (river mile 0 to 2.2) at 30 feet;
   - Harrison Reach (river mile 2.2 to 7) at 20 feet;
   - Arlington Reach (river mile 7 to 8) at 16 ft;
   - Upstream (river mile 8 to 15) at 10 ft. (see enclosed map)

Yes/No ___yes_____If yes, please specify.
The Arlington reach area would be used more by recreational boating traffic if the depth of the water way was clearly marked and maintained.

4) In the absence of a master plan, please indicate what additional development your municipality considers appropriate for the Passaic River, tributaries and waterfront areas (note river mile- see map):

( ) Commercial _____
( ) Industrial _____
( ) Recreational/Sports Fields and Parks _____
( ) Open Space/Preserved _____
( ) River Access points (e.g., marinas, boat ramp creation or rehabilitation)
( ) Commuter/Recreational Transportation (e.g., water taxis, cruises) _____
( ) Wetland Creation _____
( ) Residential _____
( ) Other _____

5) Before answering the final question, please review the attachments (DRAFT map of the vision for the river, goals and potential restoration actions):

If the draft map is not inclusive of any proposed actions or master plans for future development within your municipality or if there are additional restoration actions that you would like to see included on our list, please identify three (3) specific project or actions that you would like to see undertaken.
The area indicated at Kearny point is presently under consideration for water front development with respect to warehousing and distribution. This area is a clean end development with truck usage for the distribution of goods and services. The proposed wetlands restoration and public access is not consistent with our master plan. However, water front walkways are being proposed as part of this planned development. This is located at river mile 1

Additional comments:
You can review our Zoning at GIS: http://idv.civilsolutions.biz/default.aspx

( ) Commuter/Recreational Transportation (e.g., water taxis, cruises) _____
( ) Wetlands or scenic landscape _____
( ) Residential _____
( ) Other _____

2) Does the current condition of the Passaic River negatively impact your municipality's use of the Passaic River and waterfront areas? Yes/No _Yes____ If yes, please describe. *The river requires extensive clean up to reach it's maximum potential. The smell of river and low water front areas need to be cleaned. Additionally, debris needs to be removed from the river on a regular basis.*

3) Please indicate any public access (including their condition) to the river and primary tributaries in your municipality (Please indicate river mile – see enclosed map):

( ) Marinas _____
(x) Boat ramps located at river mile 7 & 8
( ) Walkways _____
(x) Parks: *Town parks are located along the river front from river mile 7 & 8*
( ) Other _____

Section 2 : Future Planning

1) Does your municipality have a master plan or plan for future development of the Passaic River waterfront, tributaries or adjacent areas? Yes/No *YES*

If possible, please send to Lisa Baron at the above address at your earliest convenience.

2) Please identify the primary components currently included in the plan or any other plans for development currently under consideration in your municipality for the Passaic River, tributaries and waterfront areas (note river mile- see map):

(x) Commercial: *Retail development is planned between river mile 6 & 7*
( ) Industrial _____
( ) Recreational/Sports Fields and Parks _____
( ) Open Space/Preserved _____
(x) River Access points (e.g., marinas, boat ramp creation or rehabilitation): *A river walkway is being planned as part of our Passaic Ave Redevelopment plan between river mile 6 & 7*
( ) Commuter/Recreational Transportation (e.g., water taxis, cruises) _____
( ) Wetland Creation _____
(x) Residential: *Passaic Ave Redevelopment area between area 6 & 7 is being considered for major river front development.*
( ) Other _____

2006-(R) -543

BY· MAYOR SANTOS:

WHEREAS, the banks of the Kearny Riverbank Park and other portions of the lower Passaic are so severely polluted, that American Rivers, A Washington, D.C. based conservation group, has named the Passaic River on the nation's 20 most endangered rivers in 1998 because it contains more dioxiume than any river in the nation; and

WHEREAS, an existing conditions and accumulating toxic sediments on the River's banks have deterred Citizens from fully obtaining access to the River and the recreational and educational benefit that other waterfront communities with suitable conditions enjoy;

WHEREAS, a patented waterfront design trade marked "Bulking and Tiering Wetland Systems" would be particularly appropriate for safely capping sediments that are considerably contaminated or which may otherwise remain exposed and a source of contaminants to fish and other waterways in the area; and

WHEREAS, the Systems can help recreate the unique ecosystem and beautify our troubled waterway for stabilizing the banks of the River with sustainable construction material, creating safe wetland habitat, promoting public access, and providing a field for education; and

WHEREAS, besides nurturing hundreds of flora and fauna species, many endangered, wetlands purity the water by processing nutrients, blunt the ravages of tidal flooding, and provide sanctuary and serenity for humans

NOW THEREFORE BE IT RESOLVED by the Town Council of the Town of Kearny that it does hereby support the implementation of the Bulking and Tiering Wetland Systems on a trial basis along a portion of the Passaic River in the town of Kearny for the purpose of restoring the Passaic River, and

BE IT FURHTER RESOLVED that certified copies of this resolution be forwarded to the United States Environmental Protection Agency, Region II, The United States Army Corps of Engineers, New York District, and the Department of Environmental Protection, State of New Jersey.

ADOPTED: October 24, 2006

I certify that the above Resolution was adopted by the Council on October 24, 2006.

JILL E. WALLER
ACTING TOWN CLERK

COUNCIL	INTRODUCED	SECONDED	AYE	NAY	ABSTAIN	ABSENT
SHERRY	X		X			
DOYLE			X			
PETTIGREW			X			
LANDY			X			
ARCE						X
MC CURRIE			X			
ECKEL			X			
KRUSZNIS			X			
SANTOS		X	X			
ON CONSENT AGENDA			X YES		NO	

R2-0010450

Borough of East Newark
1/31/07

Survey and Planning/Zoning Board Resolution

530-3767

BOROUGH OF EAST NEWARK
34 SHERMAN AVENUE
EAST NEWARK, NEW JERSEY 07029

Telephone # (973) 481-2902 Facsimile (973) 481-0627

FACSIMILE TRANSMISSION COVER SHEET

Date: January 24, 2007

To: Jason Varado

Organization: OFFICE OF LOCAL GOVT ACCOUNTABILITY

City/State: 401 EAST STATE ST. TRENTON

FAX NUMBER: 609-633-2102

Total Number of Pages: 16 **(Including Cover Sheet)**

FROM: ROBERT B KNAPP, ACTING BOROUGH CLERK

Telephone: 973-481-2902 X221

MESSAGE:

(1) ✓ **The attached is for your information**

(2) ✓ **Please refer to the attached**

(3) ___ **Please review attached and respond**

(4) ✓ **The attached is the information which you requested**

(5) ___ **Other**

SENT VIA FAX AND U.S. MAIL

Print Message

Close this window

From Jason Varano <Jason.Varano@dep.state.nj.us>
Date 2007/01/18 Thu AM 10:40:27 EST
To boroughofeastnewark@verizon.net
Subject Passaic River Revitalization Project

Dear Mayor,

Through previous correspondence with the Department of Environmental Protection (DEP) and/or the Department of Transportation (DOT), I am sure that you are aware of the joint effort to revitalize the Lower Passaic River watershed. The DEP and the DOT are looking for significant input from the municipalities on the issues that are most important.

In the early fall, the DOT sent a survey to the six municipalities that border the target region and asked for copies of the municipal Master Plan, or at least that portion of the plan that concerns the Passaic River Waterfront.

Attached please find a copy of the letter and the survey that was previously sent to your municipality. Please take a few minutes to complete the survey and return it to me via e-mail, or fax it to me at (609) 633-2102.

In addition, please send a copy of your Master Plan (or that portion of it that concerns the Passaic River) to me:

Jason Varano
Office of Local Government Assistance
401 East State Street
PO Box 402
Trenton, NJ 08625-0402
(609) 633-7700

If you have any questions concerning the survey, please contact - Janine MacGregor at (609) 633-0784 or myself at the above number.

Thank you.

Download Attachment Future Use Questionnaire 9-19.doc

Download Attachment Future Use Cover Letter.doc

RM 5.6-6.1

Lower Passaic River Restoration Project
Future Use Questionnaire

Municipality/County: Borough of East Newark / Hudson

Name: Robert B. Knapp

Affiliation/Agency Representing: Acting Borough Clerk

Address: 34 Sherman Avenue, East Newark NJ 07029

Phone/Fax numbers: 973-481-2900 x221 (OH) / 973-481-0627 Fax

Municipality Location- Specific River Miles (see enclosed map):

The State of New Jersey (NJDOT and NJDEP) needs your help to understand what the communities and region envision for the future of the Lower Passaic River watershed. The information you provide in this questionnaire will be used with the other Partner agencies (US Environmental Protection Agency, US Army Corps of Engineers, National Oceanic Atmospheric Administration and US Fish and Wildlife Service) for the Lower Passaic River Restoration Project to plan for the clean up and comprehensive restoration of the Lower Passaic River and its major tributaries (specifically Saddle River and Second and Third Rivers). Local municipalities and regional efforts are critical in the planning process for the future use of the river. Please submit your completed questionnaire by October 13, 2006 to:

* Did not receive this in January 2006. Received this communication on 1/18/2007.

Lisa Baron
New Jersey Department of Transportation
PO Box 837
1035 Parkway Avenue
Trenton, NJ 08625-0837
609-530-4779

Section 1: Current Uses

1) Please indicate your municipality's current uses of the Passaic River, tributaries and waterfront areas (Please indicate river mile – see enclosed map):

( ) Commercial
( ) Industrial X
( ) Recreational/Sports Fields and Parks
( ) Open Space/Preserved
( ) River Access points (e.g., marinas, boat ramps)
( ) Commuter/Recreational Transportation (e.g., water taxis, cruises)
( ) Wetlands or scenic landscape
( ) Residential

( ) Other _____

2) Does the current condition of the Passaic River negatively impact your municipality's use of the Passaic River and waterfront areas? Yes/No Yes If yes, please describe. Condition of River could impact of anticipated redevelopment within Borough.

3) Please indicate any public access (including their condition) to the river and primary tributaries in your municipality (Please indicate river mile – see enclosed map):

( ) Marinas _____
( ) Boat ramps _____
( ) Walkways _____
( ) Parks _____
( ) Other _____

Section 2 : Future Planning

1) Does your municipality have a master plan or plan for future development of the Passaic River waterfront, tributaries or adjacent areas? Yes/No Yes in process for redevelopment of Passaic Avenue adjacent or across from River

If possible, please send to Lisa Baron at the above address at your earliest convenience.

2) Please identify the primary components currently included in the plan or any other plans for development currently under consideration in your municipality for the Passaic River, tributaries and waterfront areas (note river mile- see map):

(X) Commercial X
( ) Industrial _____
( ) Recreational/Sports Fields and Parks _____
( ) Open Space/Preserved _____
( ) River Access points (e.g., marinas, boat ramp creation or rehabilitation)
( ) Commuter/Recreational Transportation (e.g., water taxis, cruises) _____
( ) Wetland Creation _____
(X) Residential X
( ) Other _____

3) The federal navigation channel in the Passaic River has not been maintained since 1983 (lower 2 miles), 1937 (miles 2.6 to 4.6), or before the 1950s in specific upper reach locations. Would the Passaic River be used more or would your municipality's development plans change if the federal navigation channel in the

river were remediated and restored to its current authorized depth? Authorized depths are currently:

- Point No Point Reach (river mile 0 to 2.2) at 30 feet;
- Harrison Reach (river mile 2.2 to 7) at 20 feet;
- Arlington Reach (river mile 7 to 8) at 16 ft;
- Upstream (river mile 8 to 15) at 10 ft. (see enclosed map)

Yes/No X If yes, please specify.
REMEDIATION OF THE RIVER WOULD ENHANCE THE REDEVELOPMENT PLANS OF THE BOROUGH.

4) In the absence of a master plan, please indicate what additional development your municipality considers appropriate for the Passaic River, tributaries and waterfront areas (note river mile- see map):

(✓) Commercial X
( ) Industrial
( ) Recreational/Sports Fields and Parks
( ) Open Space/Preserved
( ) River Access points (e.g., marinas, boat ramp creation or rehabilitation)
( ) Commuter/Recreational Transportation (e.g., water taxis, cruises)
( ) Wetland Creation
(✓) Residential X
( ) Other

5) Before answering the final question, please review the attachments (DRAFT map of the vision for the river, goals and potential restoration actions):

If the draft map is not inclusive of any proposed actions or master plans for future development within your municipality or if there are additional restoration actions that you would like to see included on our list, please identify three (3) specific project or actions that you would like to see undertaken.

NO MAP WAS ATTACHED TO THIS COMMUNICATION
Please find Resolution of July 19, 2006 approving a re-examination of the Master Plan which is in process.

Additional comments:
PLS SEND MAP FOR REVIEW — ROBERT B KNAPP, ACTING BOROUGH CLERK, BOROUGH OF EAST NEWARK 34 SHERMAN AVENUE, EAST NEWARK NJ. 07029 # 973-481-2902 X 221

THANK YOU FOR YOUR TIME!

Robert B Knapp 1/24/07

borough of east newark@verizon net

JAN 31 2007 13:26 FR NJ DEP 6031 71914 TO 953803767 P.15 ** TOTAL PAGE.15 **

East Newark designates 2 areas as redevelopment zones

By ROSE DUGER
JOURNAL CORRESPONDENT

EAST NEWARK — The borough's governing body and Planning Board voted to designate two areas in town as redevelopment zones in back-to-back sessions last week.

In an attempt to fast-track the redevelopment process, which can often drag on for months or even years, Mayor Joseph R. Smith and members of the borough council approved the designation just 15 minutes after a similar vote by Planning Board members.

The two approvals pave the way for the borough to dictate any future development of the two sites, the First Republic industrial complex and the East Newark Elementary School.

"Both facilities have great potential, but are not living up to that potential in their current uses," said Robert D. Cotter, a licensed professional planner retained by the local Planning Board to study the two sites.

In a report presented to the board last month, Cotter determined that both tracts are outdated for their current uses.

The First Republic center, built in the late 1800s to house the Clark Thread Mill, is a "strong" building but doesn't meet current building codes for industrial uses, according to Cotter's report. The facility is only between 10 and 15 percent occupied, Cotter said.

"It's sort of feeding on itself," he said last week. "Its decline is evident in that we have lost buildings to keep it functional. But it's strong. It may have new life in the 21st Century."

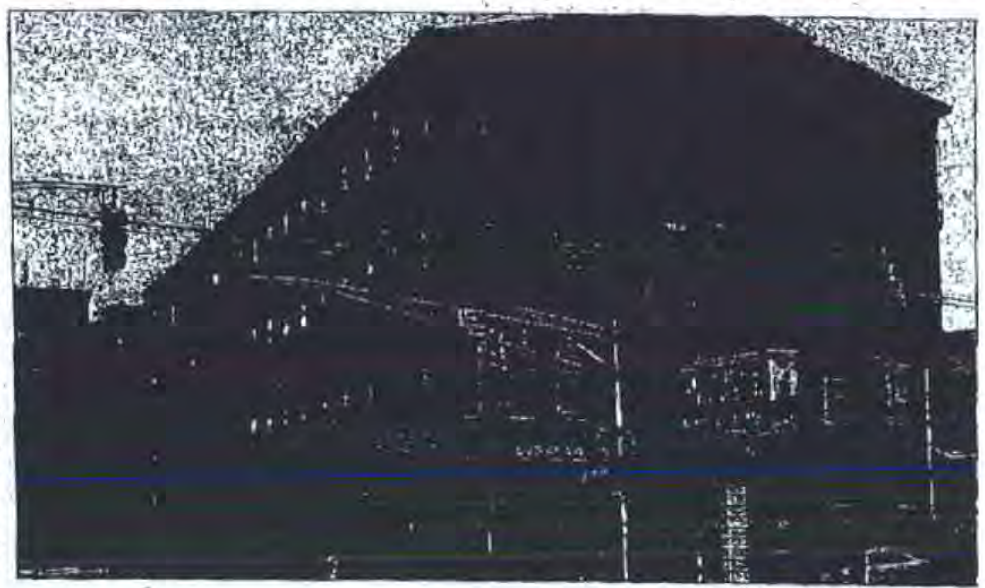
The elementary school, which still houses children in grades pre-kindergarten through 8, may also be refurbished by a private developer as condominiums in the future. The borough is seeking state aid to construct a new elementary school.

While no developer has stepped forward to redevelop the school site, Smith said borough officials have discussed selling the tract to a developer for condos.

At First Republic several developers have expressed an interest in the site, including one that has proposed some 800 condominiums, along with street-level retail.

The next step in the process calls for Cotter to draft a redevelopment plan laying out specific uses for both sites.

Smith said the plan should be completed by late January, but would probably not be approved by the governing body until April after public hearings are held.



REENA ROSE SUBRAMONIAN/JOURNAL PHOTO

THE FIRST REPUBLIC BUSINESS CENTER on Passaic and Central Avenues in East Newark.

BOROUGH OF EAST NEWARK
Planning/Zoning Board

34 SHERMAN AVENUE
EAST NEWARK, NEW JERSEY 0702
Phone: (973) 481-2902 ext. 221
Fax: (973) 481-0627
www.boroughofeastnewark.com

Joseph R. Smith
Mayor

John M. Johnson, Esq.
Attorney

Brigite I. Goncalves
Secretary

July 24, 2006

Borough of East Newark
Att: Robert B. Knapp, Acting Borough Clerk
34 Sherman Avenue
East Newark, New Jersey 07029

Dear Mr. Knapp:

Attached please find a certified copy of the resolution Adopting the Borough of East Newark's Re-Examination of The Master Plan and Development Regulations as Prepared by Robert D. Cotter, PP, AICP, Planning Consultant approved by a unanimous vote by the East Newark Planning Board on July 19, 2006.

Please retain for your records.

Should you have any questions, please feel free to contact me at your convenience.

Very Truly Yours,

Brigite I. Goncalves
Secretary
East Newark Planning/Zoning Board

12-06

EAST NEWARK PLANNING/ZONING BOARD
COUNTY OF HUDSON
STATE OF NEW JERSEY

RESOLUTION
ADOPTING THE BOROUGH OF EAST NEWARK'S RE-EXAMINATIN OF THE MASTER PLAN AND DEVELOPMENT REGULATIONS AS PREPARED BY ROBERT D. COTTER, PP, AICP, PLANNING CONSULTANT

Introduced by: Serafin

Seconded by: Sheehan

WHEREAS, the New Jersey Municipal Land Use Law, N.J.S.A. 40:55D-89 stipulates the Planning Board shall prepare and adopt by resolution a report on the findings of the Reexamination of its Municipal Master Plan and Development Regulations, and

WHEREAS, in accordance with the statutory guidelines and the directives of the East Newark Planning Board, the Borough Planner, Robert D. Cotter, P.P.,A.I.C.P., has prepared and submitted a Reexamination of the Master Plan dated July 19, 2006, and

WHEREAS, the aforementioned Reexamination prepared by Robert D. Cotter, P.P.,A.I.C.P., provide comments and recommendations relevant to existing and proposed development regulations and satisfies the criteria set-forth for a Reexamination of the Mater Plan and Development Regulations as prescribed by N.J.S.A. 40:55D-89 of the Municipal Land Use Law;

NOW, THEREFORE, BE IT RESOLVED by the East Newark Planning Board that it adopts the Reexamination of the Master Plan as prepared by Robert D. Cotter, P.P.,A.I.C.P., dated July 19, 2006, a copy of said report being attached hereto and made part hereof as Exhibit A.

BE IT FURTHER RESOLVED that a copy of this Resolution be filed with the Hudson County Planning Board, and the Municipal Clerks of each adjoining Municipality of the Borough of East Newark.

BE IT FURTHER RESOLVED that the Secretary to the East Newark Planning Board is hereby authorized and instructed to send a certified copy of this Resolution to John M. Johnson, Esq., The Hudson County Planning Board, the Clerks of each adjoining Municipality of the Borough of East Newark and the Clerk of East Newark.

ROLL CALL	AYES	NAYS	ABSENT	ABSTAIN
MAYOR JOSEPH R. SMITH	X			
COUNCILMEMBER EDWARD SERAFIN	X			

Reexamination Report
East Newark Master Plan and Regulations
July 5, 2006

Prepared by Robert D. Cotter, PP, AICP
Planning Consultant

The Borough of East Newark adopted its first Master Plan in 1984. There was an update done in 1992. There has been no re-examination report nor update since 1992.

The Municipal Land Use Law (40:55D-1 *et seq.*) (MLUL) requires a re-examination report to be conducted at least every six years, so it is clear that the Borough is long overdue in this re-examination process. The MLUL spells out the steps needed to be undertaken to complete this process.

The reexamination report shall state:

a. The major problems and objectives relating to land development in East Newark at the time of the adoption of the last reexamination report.

b The extent to which such problems and objectives have been reduced or have increased subsequent to such date

c. The extent to which there have been significant changes in the assumptions, policies and objectives forming the basis for the master plan or development regulations as last revised, with particular regard to the density and distribution of population and land uses, housing conditions, circulation, conservation of natural resources, energy conservation, collection, disposition and recycling of designated recyclable materials, and changes in State, county and municipal policies and objectives.

d. The specific changes recommended for the master plan or development regulations, if any, including underlying objectives, policies and standards, or whether a new plan or regulations should be prepared.

e The recommendations of the planning board concerning the incorporation of redevelopment plans adopted pursuant to the "Local Redevelopment and Housing Law," P.L. 1992, c. 79 (C.40A:12A-1 et al.) into the land use plan element of the municipal master plan, and recommended changes, if any, in the local development regulations necessary to effectuate the redevelopment plans of the municipality.

These requirements are addressed as follows.

The major problems and objectives relating to land development in East Newark at the time of the adoption of the last reexamination report.

The 1984 Master Plan was the first such plan ever produced for the Borough. This is likely because the MLUL was adopted in 1976 and it conveyed legal status to the municipal master plan. Essentially, the power to zone was related to the master plan and its "land use element." The new state law required every municipality that wanted to have a zoning ordinance and regulate land uses within its borders to first have a master plan with at least a land use element. There are other elements, such as circulation and community facilities, but they are optional. Since 1986, there is another mandatory element called the "housing element" or "fair share plan." This element deals with the municipality's obligations to provide its fair share of the housing needs for families of low and moderate income.

The 1984 Master Plan stated that the objectives of the master plan were.

> The creation of a seven member planning board
> The preparation of a land use element to form the basis of a zoning ordinance
> Maintain the present character of the borough and land use pattern and upgrade obsolete uses, buildings and sites wherever practical and possible
> Provide for expansion of existing community facilities to better serve the residents of the borough
> Endorse the recommendations of previous studies to eliminate traffic and water pressure problems and provide new improvements

The 1992 "Land Use Plan Update" detailed the changes in the Borough's land use patterns. It noted that the largest land use group was "residential" an d of that group the largest group was two-family homes. After that, it was three family homes and then single family homes.

One of the aspects of the borough's residential land use category was the instances of two or more principal uses on the same lot. This is not considered sound planning as it can lead to overcrowding and difficulty in zoning enforcement

The 1992 Update next spoke of Business Uses, which were found to be scattered around the Borough. The Update speaks of the concentration of mercantile uses found there. The other locations for business uses are along Central Avenue between Grant Avenue and Third Street.

The Update talks about the industrial uses along Passaic Avenue and some on the narrow block between Searing and Mullock Place.

In 1992. there were only 5 vacant parcels of land in the Borough, meaninf new development would have to occur on redeveloped properties.

The extent to which such problems and objectives have been reduced or have increased subsequent to such date.

The first objective was realized with the creation of the new nine member planning board in 1984. Since then. changes in the MLUL have allowed small towns, such as East Newark, to eliminate the separate zoning board of adjustment by creating a single, combined board that can function as either a planning board or a zoning board, as the case before it may require.

The second objective was realized in the 1984 Master Plan which contained the first such land use plan in the borough's history. The plan noted that East Newark has a very limited supply of vacant land. This is a function of the borough's age, size and location. This remained the case in the 1992 Update.

One of the key statements is the plan's desire to "promote a proper balance between residential and non-residential uses in the borough."

Three categories of residential land use were proposed: R-1 for the eastern two-thirds of the First Republic site; R-2 for the predominant type of residential uses existing in the borough; and R-3 for apartments.

Two categories of business/commercial use were recommended: Neighborhood Business (NB) and General Business and Commercial (GBC). The NB district would serve local residents with convenience shopping and services and the second district, GBC, would be less restrictive and serve a wider community.

Industrial uses would be restricted to the area west of Passaic Avenue from the "new" Engelhard Industries building south to the borough line.

The third objective was to maintain the present character of the borough and land use pattern and upgrade obsolete uses, buildings and sites wherever practical and possible. Fully developed at the beginning of the 20th Century. the borough has a rich history of industry and commerce as well as residential development within its borders. Its location on the Passaic River and along a branch of the Erie Lackawanna Railroad made it an early location for industrial land uses. The proximity to the City of Newark, the economic engine of this region in the late 19th and early 20th Century, just across the river, also gave the borough an economic boost and no doubt contributed to its development patterns.

Little change occurred up until the time of the 1984 master plan, other than the inevitable decline of the industrial uses and the aging of the residential and commercial developments. The decline in industrial and commercial development is due to market and global forces and cannot be effectively addressed at the local level. The residential market in Hudson County remains strong, and the pressure to redevelop former industrial and commercial sites for residential uses is strong.

The fourth objective of the 1984 Plan was to provide for expansion of existing community facilities to better serve the residents of the borough. This objective has been accomplished with the creation of the green acres park next door to Borough Hall on Sherman Avenue, the remodeling of the Recreation Center on Central Avenue, the creation of the Senior Center on President Street and the development of a municipal parking lot on Searing Avenue. Bids are currently being taken to build a parking lot on two lots on Central Avenue.

Finally, the Plan called for the endorsement of past the recommendations of previous studies to eliminate traffic and water pressure problems and provide new improvements. This objective has been partially met by the public works projects that have paved all the streets in the Borough and created a streetscape program on Central Avenue, but the water pressure issue remains. The cost of cleaning and relining the all of the Borough's water mains remains prohibitive.

The extent to which there have been significant changes in the assumptions, policies, and objectives forming the basis for the master plan or development regulations as last revised, with particular regard to the density and distribution of population and land uses, housing conditions, circulation, conservation of natural resources, energy conservation, collection, disposition and recycling of designated recyclable materials, and changes in State, county and municipal policies and objectives.

There have been significant changes in the assumptions, policies and objectives of the Borough of East Newark since the adoption of the 1984 Master Plan. Among these is the change in attitude toward the development of housing types as it relates to density and distribution of populations and demographics. There have been significant problems with the conversion of two-family homes into illegal three-family homes over the years intervening. These conversions are a problem on many fronts, including: over-crowding within the residence, fire code violations, non payment of taxes, over loading of the Borough's ability to park residents' cars and additional school-aged children. Conversions of new two-family homes into three-family homes is a particular concern as there is a great deal of pressure coming from this sector of the market. The pattern of building a two and converting them to threes within months of closing exists throughout the county and region.

The demographic dilemma comes at the school-age children end of the spectrum. Young families are attracted to East Newark as it is family-friendly and has a good elementary school. The growth of this segment of the population places the over-crowded school system into crisis mode. While a new school is contemplated, until it is a reality, this problem remains at the top of the list.

This population concern is also a housing concern. The market pressure is there to encourage the "tear down" development patterns going on in nearby towns. Old one and two-family homes are torn down to be replaced with new, two-family homes, which tend to be converted into illegal three-families shortly thereafter. The condition of the existing housing stock will play into this scenario to the extent it becomes deteriorated or improved.

The distribution of land uses was to be "balanced." This objective has changed as industrial land uses have further declined as more of these type jobs move out of the region, if not the nation. Taking their place are service sector jobs such as retail sales of goods and services. The ability of large industrial facilities such as First Republic to remain viable in that land use will test that objective.

There have been no significant changes in circulation, as there have been no new roads or other facilities built in this area since 1984.

There have been no other significant changes in terms of conservation of natural resources, energy conservation, and recycling. One item that may be of concern here is the recent spikes in the price of gasoline. As gas prices rise, the attractiveness of living close to Manhattan and the Hudson River waterfront and Newark office jobs grows. This may impact future land use patterns.

The specific changes recommended for the master plan or development regulations, if any, including underlying objectives, policies and standards, or whether a new plan or regulations should be prepared.

It is recommended that the master plan and development regulations be amended to include the following.

1. The one and two-family development regulations need to be revisited. There are many good reasons to eliminate the two-family housing type, including the overwhelming trend to convert up to three units. This third unit can lead to absentee landlords and the problems associated with over-crowding. A one-family limit on the majority of the Borough would reduce to pressure to tear down the old homes and build the "monster" homes we see going up throughout the region. The reduction of density would ease over-crowding in the schools, parks and on the street.
2. The Land Use Plan for the First Republic site for eventual demolition and replacement with two and three-family homes needs to be eliminated. This facility should be planned for adaptive re-use as a residential and commercial complex similar to many other industrial properties that have been converted to luxury housing throughout Hudson County.
3. The Passaic River waterfront needs to be planned for commercial re-use. While the concrete plant may want to stay because of the benefits of its location, the

success of the hotel down river in Harrison argues well for this type of use along the East Newark Riverfront. Newark is planning great things on its shoreline; so should the Borough of East Newark.

4 The creation of a new elementary school on the Sherman Avenue green acres park site should be explored. The ability to vacate the northern dead-end of John Street to enlarge the site is appealing Green Acres rules require a replacement site, which is available across the street.

5 The eventual development of a new school begs the question of what to do with the old one. It should be planned for condominium conversion with adequate off street parking.

The recommendations of the planning board concerning the incorporation of redevelopment plans adopted pursuant to the "Local Redevelopment and Housing Law," P.L. 1992, c. 79 (C.40A:12A-1 et al.) into the land use plan element of the municipal master plan, and recommended changes, if any, in the local development regulations necessary to effectuate the redevelopment plans of the municipality.

The First Republic industrial facility has a long history in East Newark and is indeed, probably responsible for the very existence of the Borough. It should be retained and re-used for loft-style housing, with ancillary commercial and retail uses. A redevelopment plan should be implemented, if the area meets the statutory criteria to be declared in need of redevelopment. Such a plan would cover all of the areas needed to assure success of the project as this is an area equal to a quarter of the Borough, and will have an extreme impact on the fiscal soundness of the Borough in the coming decades. Appropriately zoning regulations in such a redevelopment plan will help assure that success.

PLANNING BOARD MEMBERS

CHARLES BUBENAS	X	
SHIRLEY BECKER	X	
URBANO GONCALVES		X
SUSANA MOREIRA		X
ANTONIO MONTEIRO	X	
KENNETH SHEEHAN	X	
LOUIS ZARRILLO	X	
JOSE HERNANDEZ	X	
MARCO ORTEGA		

ATTEST

BRIGITE L. GONCALVES
SECRETARY

PLANNING BOARD OF
THE BOROUGH OF EAST NEWARK

SHIRLEY BECKER, CHAIRPERSON

DATED 2/19/06

ADOPTED: 2/19/06

Town of Harrison – Hudson County
2/21/07

TO: JASON VARANO 609 633 2102

FROM: PETE HIGGINS

ATTACHED IS THE SURVEY YOU REQUESTED FROM MAYOR McDONOUGH.

PLEASE CONTACT ME DIRECTLY WITH ANY QUESTIONS OR CONCERTS 973-715-8527

Pete

Lower Passaic River Restoration Project
Future Use Questionnaire

Municipality/County: TOWN OF HARRISON - HUDSON COUNTY

Name: PETER B. HIGGINS

Affiliation/Agency Representing: HARRISON REDEVELOPMENT AGENCY

Address: 600 ESSEX STREET, HARRISON NJ 07029

Phone/Fax numbers: 973-715-8527

Municipality Location- Specific River Miles (see enclosed map): THERE IS NO ENCLOSED MAP

The State of New Jersey (NJDOT and NJDEP) needs your help to understand what the communities and region envision for the future of the Lower Passaic River watershed. The information you provide in this questionnaire will be used with the other Partner agencies (US Environmental Protection Agency, US Army Corps of Engineers, National Oceanic Atmospheric Administration and US Fish and Wildlife Service) for the Lower Passaic River Restoration Project to plan for the clean up and comprehensive restoration of the Lower Passaic River and its major tributaries (specifically Saddle River and Second and Third Rivers). Local municipalities and regional efforts are critical in the planning process for the future use of the river. Please submit your completed questionnaire by October 13, 2006 to:

Lisa Baron
New Jersey Department of Transportation
PO Box 837
1035 Parkway Avenue
Trenton, NJ 08625-0837
609-530-4779

Section 1: Current Uses

1) Please indicate your municipality's current uses of the Passaic River, tributaries and waterfront areas (Please indicate river mile – see enclosed map):

- (✓) Commercial
- (✓) Industrial
- ( ) Recreational/Sports Fields and Parks
- ( ) Open Space/Preserved
- ( ) River Access points (e.g., marinas, boat ramps)
- ( ) Commuter/Recreational Transportation (e.g., water taxis, cruises)
- ( ) Wetlands or scenic landscape
- ( ) Residential

( ) Other _____

2) Does the current condition of the Passaic River negatively impact your municipality's use of the Passaic River and waterfront areas? Yes/No No If yes, please describe _____

3) Please indicate any public access (including their condition) to the river and primary tributaries in your municipality (Please indicate river mile – see enclosed map):

( ) Marinas NONE
( ) Boat ramps _____
( ) Walkways _____
( ) Parks _____
( ) Other _____

Section 2 : Future Planning

1) Does your municipality have a master plan or plan for future development of the Passaic River waterfront, tributaries or adjacent areas? Yes/No YES

If possible, please send to Lisa Baron at the above address at your earliest convenience

2) Please identify the primary components currently included in the plan or any other plans for development currently under consideration in your municipality for the Passaic River, tributaries and waterfront areas (note river mile- see map):

( ) Commercial _____
( ) Industrial _____
(✓) Recreational/Sports Fields and Parks _____
(✓) Open Space/Preserved _____
( ) River Access points (e.g., marinas, boat ramp creation or rehabilitation)
( ) Commuter/Recreational Transportation (e.g., water taxis, cruises) _____
( ) Wetland Creation _____
(✓) Residential _____
( ) Other _____

3) The federal navigation channel in the Passaic River has not been maintained since 1983 (lower 2 miles), 1937 (miles 2.6 to 4.6), or before the 1950s in specific upper reach locations. Would the Passaic River be used more or would your municipality's development plans change if the federal navigation channel in the

river were remediated and restored to its current authorized depth? Authorized depths are currently:

- Point No Point Reach (river mile 0 to 2.2) at 30 feet;
- Harrison Reach (river mile 2.2 to 7) at 20 feet;
- Arlington Reach (river mile 7 to 8) at 16 ft;
- Upstream (river mile 8 to 15) at 10 ft. (see enclosed map)

Yes/No YES If yes, please specify.
POSSIBLY SOME RIVER ACCESS POINTS COULD BE INCORPORATED IN FUTURE OPEN SPACE PLANNING

4) In the absence of a master plan, please indicate what additional development your municipality considers appropriate for the Passaic River, tributaries and waterfront areas **(note river mile- see map):**

N/A

( ) **Commercial**
( ) **Industrial**
( ) **Recreational/Sports Fields and Parks**
( ) **Open Space/Preserved**
( ) **River Access points (e.g., marinas, boat ramp creation or rehabilitation)**
( ) **Commuter/Recreational Transportation (e.g., water taxis, cruises)**
( ) **Wetland Creation**
( ) **Residential**
( ) **Other**

5) **Before answering the final question, please review the attachments (DRAFT map of the vision for the river, goals and potential restoration actions):**

If the draft map is not inclusive of any proposed actions or master plans for future development within your municipality or if there are additional restoration actions that you would like to see included on our list, please identify three (3) specific project or actions that you would like to see undertaken.

NO MAP WAS INCLUDED IN SURVEY

HARRISON WATERFRONT PROJECT RUNS FROM APPROXIMATELY 1/4 MILEL EAST OF THE JACKSON ST. BRIDGE TO THE RT 280 BRIDGE

Additional comments

THANK YOU FOR YOUR TIME!

Bayonne/Hudson County
10/06

Lower Passaic River Restoration Project
Future Use Questionnaire

Municipality/County: BAYONNE / HUDSON

Name: JAMES MONKOWSKI

Affiliation/Agency Representing: CITY OF BAYONNE

Address: MUNICIPAL BLDG. 630 AVE C, BAYONNE, N.J. 07002

Phone/Fax numbers: 201-858-6107 / 201 858-6111

Municipality Location- Specific River Miles (see enclosed map): O

The State of New Jersey (NJDOT and NJDEP) needs your help to understand what the communities and region envision for the future of the Lower Passaic River watershed. The information you provide in this questionnaire will be used with the other Partner agencies (US Environmental Protection Agency, US Army Corps of Engineers, National Oceanic and Atmospheric Administration and US Fish and Wildlife Service) for the Lower Passaic River Restoration Project to plan for the clean up and comprehensive restoration of the Lower Passaic River and its major tributaries (specifically Saddle River and Second and Third Rivers). Local municipalities and regional efforts are critical in the planning process for the future use of the river. Please submit your completed questionnaire by October 27, 2006 to:

Lisa Baron
New Jersey Department of Transportation
PO Box 837
1035 Parkway Avenue
Trenton, NJ 08625-0837
609-530-4779

Section 1: Current Uses

1) Please indicate your municipality's current uses of the Passaic River, tributaries and waterfront areas (Please indicate river mile – see enclosed map):

( ) Commercial
( ) Industrial
(X) Recreational/Sports Fields and Parks
(X) Open Space/Preserved
(X) River Access points (e.g., marinas, boat ramps)
( ) Commuter/Recreational Transportation (e.g., water taxis, cruises)
(X) Wetlands or scenic landscape
(X) Residential

R2-0010473

( ) Other _____

2) Does the current condition of the Passaic River negatively impact your municipality's use of the Passaic River and waterfront areas? Yes/No _____ If yes, please describe. _____

3) Please indicate any public access (including their condition) to the river and primary tributaries in your municipality (Please indicate river mile – see enclosed map):

(X) Marinas PRIVATE / WITH PUBLIC ACCESS - 0
(X) Boat ramps MUNICIPAL OWNED · GOOD CONDITION - 0
(X) Walkways - 0
(X) Parks - 0
( ) Other _____

Section 2 : Future Planning

1) Does your municipality have a master plan or plan for future development of the Passaic River waterfront, tributaries or adjacent areas? Yes/No N/A.

If possible, please send to Lisa Baron at the above address at your earliest convenience.

2) Please identify the primary components currently included in the plan or any other plans for development currently under consideration in your municipality for the Passaic River, tributaries and waterfront areas (note river mile- see map):

( ) Commercial _____
( ) Industrial _____
(X) Recreational/Sports Fields and Parks _____
(X) Open Space/Preserved _____
( ) River Access points (e.g., marinas, boat ramp creation or rehabilitation)
( ) Commuter/Recreational Transportation (e.g., water taxis, cruises) _____
( ) Wetland Creation _____
(X) Residential _____
( ) Other _____

3) The federal navigation channel in the Passaic River has not been maintained since 1983 (lower 2 miles), 1937 (miles 2.6 to 4.6), or before the 1950s in specific upper reach locations. Would the Passaic River be used more or would your municipality's development plans change if the federal navigation channel in the

river were remediated and restored to its current authorized depth? Authorized depths are currently:

- Point No Point Reach (river mile 0 to 2.2) at 30 feet;
- Harrison Reach (river mile 2.2 to 7) at 20 feet;
- Arlington Reach (river mile 7 to 8) at 16 ft;
- Upstream (river mile 8 to 15) at 10 ft. (see enclosed map)

Yes/No _____If yes, please specify.
NO CHANGE

4) In the absence of a master plan, please indicate what additional development your municipality considers appropriate for the Passaic River, tributaries and waterfront areas (note river mile- see map):

( ) Commercial _____
( ) Industrial _____
(X) Recreational/Sports Fields and Parks _____
(X) Open Space/Preserved _____
( ) River Access points (e.g., marinas, boat ramp creation or rehabilitation)
( ) Commuter/Recreational Transportation (e.g., water taxis, cruises) _____
( ) Wetland Creation _____
(X) Residential _____
( ) Other _____

5) Before answering the final question, please review the attachments (DRAFT map of the vision for the river, goals and potential restoration actions):

If the draft map is not inclusive of any proposed actions or master plans for future development within your municipality or if there are additional restoration actions that you would like to see included on our list, please identify three (3) specific project or actions that you would like to see undertaken.

Additional comments:
CITY OF BAYONNE HAS JUST COMPETED A NEW PARK ON NEWARK BAY. PARK CONSISTS OF 13 ACRES - RESTORED WETLANDS, WITH WALKWAY - BIRD BLINDS, BIKE PATH AROUND WETLAND + ADDITIONAL UPLAND/TRANSITIONAL ACRES. PARK IS PASSIVE IN DESIGN. LOCATION IS ADJACENT TO BAYONNE - JERSEY CITY BORDER.

THANK YOU FOR YOUR TIME!

Elizabeth
10/11/06

Lower Passaic River Restoration Project
Future Use Questionnaire

Municipality/County: Elizabeth

Name: Oscar Ocasio

Affiliation/Agency Representing: Dept. of Planning & Community Development

Address: 50 Winfield Scott Plaza

Phone/Fax numbers: (908) 820-4160 Fax (908) 820-3776

Municipality Location- Specific River Miles (see enclosed map): South of "0"

The State of New Jersey (NJDOT and NJDEP) needs your help to understand what the communities and region envision for the future of the Lower Passaic River watershed. The information you provide in this questionnaire will be used with the other Partner agencies (US Environmental Protection Agency, US Army Corps of Engineers, National Oceanic and Atmospheric Administration and US Fish and Wildlife Service) for the Lower Passaic River Restoration Project to plan for the clean up and comprehensive restoration of the Lower Passaic River and its major tributaries (specifically Saddle River and Second and Third Rivers). Local municipalities and regional efforts are critical in the planning process for the future use of the river. Please submit your completed questionnaire by October 27, 2006 to:

Lisa Baron
New Jersey Department of Transportation
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1035 Parkway Avenue
Trenton, NJ 08625-0837
609-530-4779

Section 1: Current Uses

1) Please indicate your municipality's current uses of the Passaic River, tributaries and waterfront areas (Please indicate river mile – see enclosed map):

(X) Commercial
(X) Industrial
(X) Recreational/Sports Fields and Parks
(X) Open Space/Preserved
(X) River Access points (e.g., marinas, boat ramps)
(X) Commuter/Recreational Transportation (e.g., water taxis, cruises)
(X) Wetlands or scenic landscape
(X) Residential

(X) Other All of the above uses are within the shores of the Arthur Kill

2) Does the current condition of the Passaic River negatively impact your municipality's use of the Passaic River and waterfront areas? Yes/No YES If yes, please describe. The river brings sediment into the Arthur Kill which creates the need for dredging.

3) Please indicate any public access (including their condition) to the river and primary tributaries in your municipality (Please indicate river mile – see enclosed map):

(X) Marinas
(X) Boat ramps
(X) Walkways
(X) Parks
(X) Other All within the shores of the Arthur Kill

Section 2 : Future Planning

1) Does your municipality have a master plan or plan for future development of the Passaic River waterfront, tributaries or adjacent areas? Yes/No Yes-along the Arthur Kill

If possible, please send to Lisa Baron at the above address at your earliest convenience.

2) Please identify the primary components currently included in the plan or any other plans for development currently under consideration in your municipality for the Passaic River, tributaries and waterfront areas (note river mile- see map):

( ) Commercial
( ) Industrial
(X) Recreational/Sports Fields and Parks
( ) Open Space/Preserved
( ) River Access points (e.g., marinas, boat ramp creation or rehabilitation)
( ) Commuter/Recreational Transportation (e.g., water taxis, cruises)
( ) Wetland Creation
(X) Residential
( ) Other

3) The federal navigation channel in the Passaic River has not been maintained since 1983 (lower 2 miles), 1937 (miles 2.6 to 4.6), or before the 1950s in specific upper reach locations. Would the Passaic River be used more or would your municipality's development plans change if the federal navigation channel in the

river were remediated and restored to its current authorized depth? Authorized depths are currently:

- Point No Point Reach (river mile 0 to 2.2) at 30 feet;
- Harrison Reach (river mile 2.2 to 7) at 20 feet;
- Arlington Reach (river mile 7 to 8) at 16 ft;
- Upstream (river mile 8 to 15) at 10 ft. (see enclosed map)

Yes/No _____ If yes, please specify.

One way or the other, there would be no change to the city's development plans.

4) In the absence of a master plan, please indicate what additional development your municipality considers appropriate for the Passaic River, tributaries and waterfront areas (note river mile- see map):

( ) Commercial _____
( ) Industrial _____
( ) Recreational/Sports Fields and Parks _____
( ) Open Space/Preserved _____
( ) River Access points (e.g., marinas, boat ramp creation or rehabilitation)
( ) Commuter/Recreational Transportation (e.g., water taxis, cruises) _____
( ) Wetland Creation _____
( ) Residential _____
(X) Other Not Applicable

5) Before answering the final question, please review the attachments (DRAFT map of the vision for the river, goals and potential restoration actions):

If the draft map is not inclusive of any proposed actions or master plans for future development within your municipality or if there are additional restoration actions that you would like to see included on our list, please identify three (3) specific project or actions that you would like to see undertaken.

Not Applicable

Additional comments:

THANK YOU FOR YOUR TIME!

Appendix G

Cap Erosion and Flood Modeling

Draft Contractor Document: Subject to Continuing Agency Review

TECHNICAL MEMORANDUM

HYDRODYNAMIC AND SEDIMENT TRANSPORT EVALUATION: CAPPING/ARMORING ANALYSES OF THE LOWER PASSAIC RIVER

June 8, 2007
MPIN0021

HydroQual
Environmental Engineers & Scientists

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SECTION 1

INTRODUCTION

As part of the Lower Passaic River (LPR) Restoration Project, a study of the tidal 17 miles of the river, the USEPA is evaluating early remediation of the contaminated sediment deposited in the lower eight miles of the river. The Focused Feasibility Study (FFS) calls for consideration of several alternative capping/dredging options in the first 8.3 miles of the LPR. They include capping and armoring using 2-4 ft of sand and/or rock between River Mile (RM) 0 and 8.3. This study has two main objectives:

- To provide an evaluation of the stability of the proposed sand cap and to identify those areas where erosion of the sand cap is likely, so that the sand cap can be stabilized with a layer of rock cobble armor; and
- Determine changes in water elevation along the length of the LPR that would occur under high flow and/or storm surge events that, in conjunction with the capping and armouring, may result in additional flooding of the low lying areas along the LPR.

Several extreme flow conditions were considered, including 100- and 500-year flows. Flooding due to 100-and 500-year storm surges was also considered in the study.

The hydrodynamic model used in this study is an extension of the model being developed for the lower 17 mile Passaic River and the Newark Bay remedial investigation (RI)/feasibility study (FS). The details of the model setup and calibration have been reported previously (HydroQual, 2007). The major extension of the LPR and Newark Bay hydrodynamic model used in this analysis was to expand the model grid to include the 500-year flood plain as determined by the Federal Emergency Management Administration (FEMA).

The sediment transport model used in this study is known as SEDZLJ (Jones and Lick, 2001). For the purposes of this study SEDZLJ was incorporated into HydroQual's hydrodynamic modeling code, ECOM, and the resulting modeling code is known as ECOMSEDZLJ.

As mentioned above, the hydrodynamic model being developed for the LPR and Newark Bay RI/FS was extended to include the 500-year flood plain. The first step, after extending the model grid, was to demonstrate the applicability of the model by calibrating the model against available field data. The model was also validated by application of the model to Hurricane Donna, which occurred in 1960. In addition, model estimates of the

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spatial extent of flooding, as forced by FEMA estimates of the 500-year flow and storm surge, were compared against the FEMA 500-year flood plain.

The resulting hydrodynamic model was then applied, together with the sediment transport model, SEDZLJ, to evaluate cap stability of two different classes of sand; one from the Ambrose Channel of New York/New Jersey Harbor and one available from upland sources. The results of the sediment transport model were used to identify areas with unacceptable rates of sand cap erosion. These areas would then be pre-dredged to a depth of 2-ft, capped with 2-ft of sand, and armored with 2-ft of rock cobble.

After the sand cap/rock armor analysis was completed, the hydrodynamic model was utilized again to investigate the impact that the cap/armor would have on flooding of low lying areas in the LPR under different conditions of high river flow from the LPR and storm surge from New York/New Jersey Harbor and the New York Bight Apex. It should be noted that the effects of future sea-level rise on potential flooding have not been considered in this analysis.

SECTION 2

HYDRODYNAMIC MODEL CONFIGURATION

In order to address the potential flooding issues in the LPR basin resulting from placement of a cap, the FEMA's 500-year flood area map was obtained (Figure 2-1). The source of the data set is Q3 Flood Data derived from the Flood Insurance Rate Maps published by FEMA (1996). Figure 2-1 indicates that the 100- and 500-year flood plain area in the LPR basin is confined to a fairly nar row area along both sides of the river for most of the length of the LPR; however, near the mouth of the Passaic River and in the Hackensack basin the flood-area is wide and covers much of the low lying marshes and tidal creeks in the Meadowlands.

The model grid developed for the study is shown in Figure 2-2. Also shown on the plot are land surface elevations relative to the National Geodetic Vertical Datum (NGVD) 1929. The elevations were deduced from land survey data compiled by the US Army Corps of Engineers (USACE) in 1990 as a part of the USACE's Passaic River Flood Control Project (Figure 2-3). The survey maps consist of 2 ft interval contours of the land elevations in the study area. The survey data in lower sections of the river, up to RM 5, were available in electronic data format. However, in the upstream sections of the river, only paper copies of the survey maps were available. Land elevation contours were digitized for this study in those sections within the FEMA 500-year flood areas. These detailed land survey maps helped configure the hydrodynamic model to be used in the flood analysis portion of this study. Figure 2-4 shows an example of the USACE survey map at the Riverside County Park of Lyndhurst near RM 11. The figure shows both the aerial photography of the area as well as the digitized land elevation contours. The lower panel of Figure 2-4 depicts the vertical profile on both sides of the river following the transect (A-A') shown in the upper panel of Figure 2-4.

Model depths of the river proper were estimated from surveys compiled by the USACE. The Passaic River surveys were conducted in 2004 and Hackensack River data were collected in the mid-1990s. The model also accounts for wetting and drying of appropriate grid cells based on bathymetric and tidal conditions so there are a few grid cells in the Passaic River where grid cells can become exposed during low tides. Bottom sediment texture data collected in the LPR were reviewed (Aqua Survey, 2006) during the grid design effort in order to reflect proper representation of the bottom properties. Bottom texture data show that, in upper section of the LPR, below the Dundee Dam and upstream of RM 8, there are significant portions of the river that consist of coarse gravel and rock material. Figure 2-5 shows the extent of the coarse bottom in the LPR. The unshaded areas in the

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figure indicate fine grained material such as silt and fine sands. Bottom drag coefficients of the upstream sections containing rock and gravel were scaled up to 0.1 (unitless) and the rest of the silt and fine grained sand bottom areas were specified with a baseline coefficient of 0.0025.

The computational model consists of 68×170 grid cells in the horizontal plane and 11 equally spaced σ-levels in the vertical plane (*i.e.*, 10 vertical segments). The model open boundaries are located at entrance to the Kill van Kull from New York Harbor and the entrance to Arthur Kill from Raritan Bay at South Amboy.

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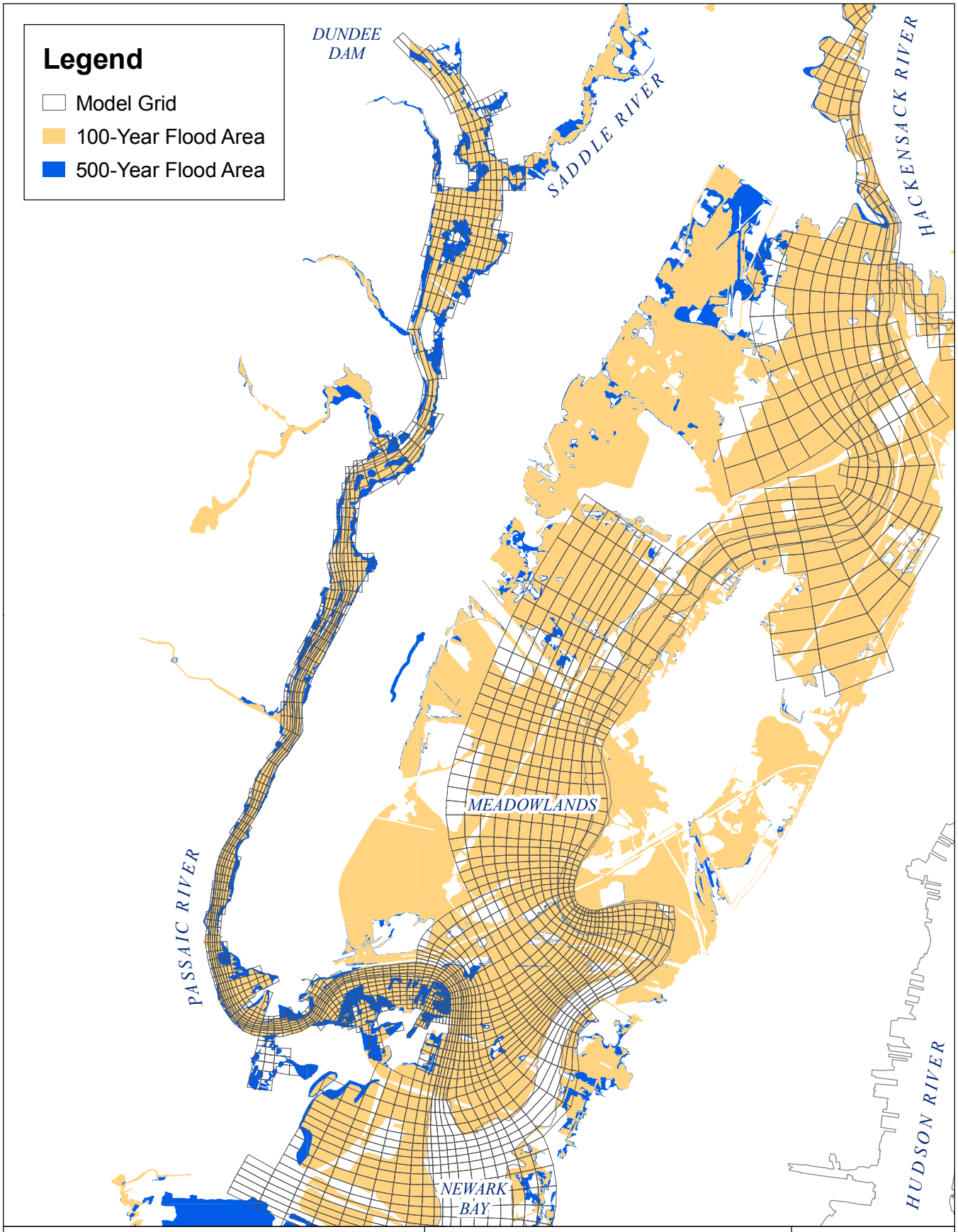

Figure 2-1. FEMA 100- and 500-year flood area with hydrodynamic model grid.

Data: FEMA Q3

0 1 2 3
Miles

HydroQual

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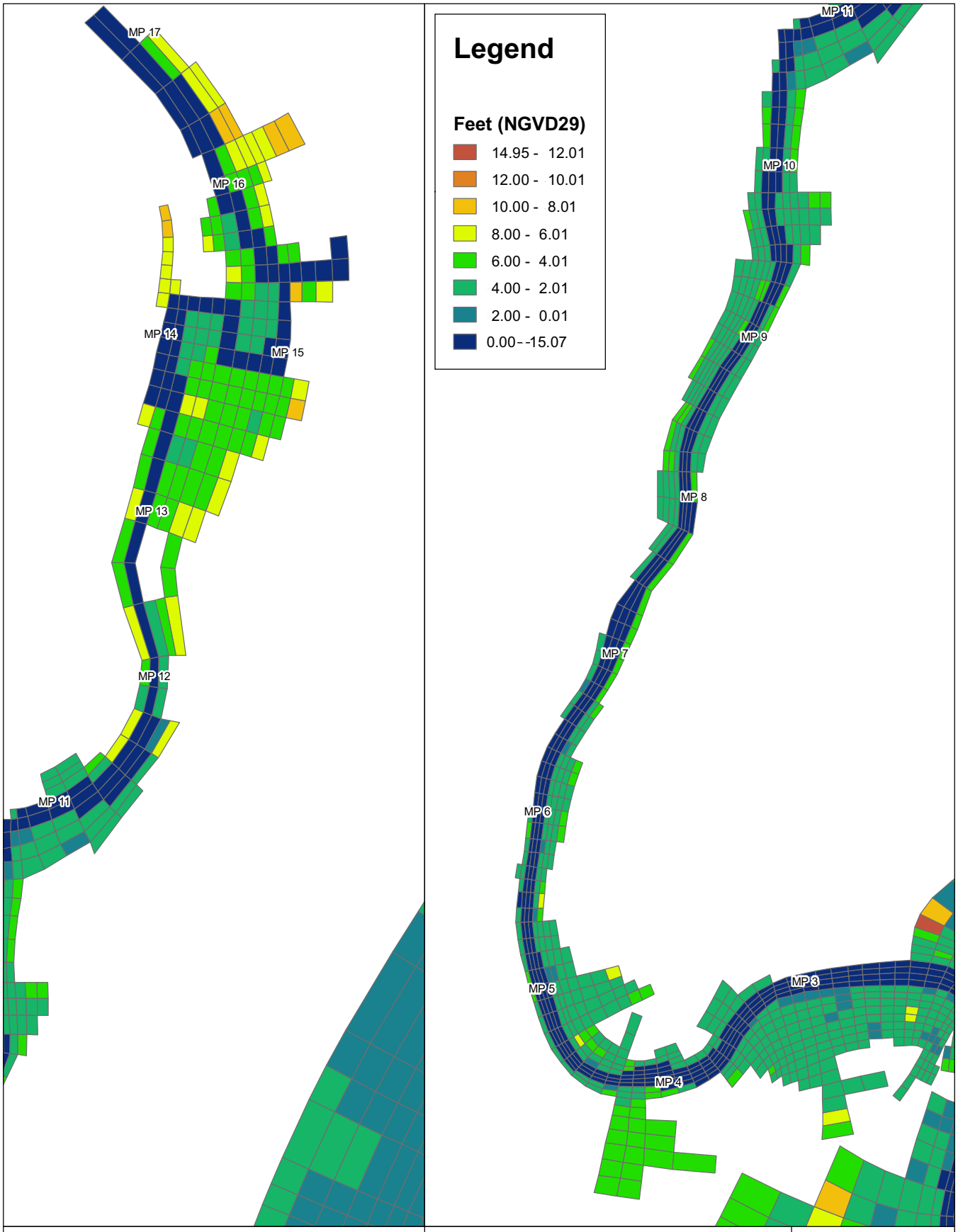

Figure 2-2. Computational grid for FFS study with depths.

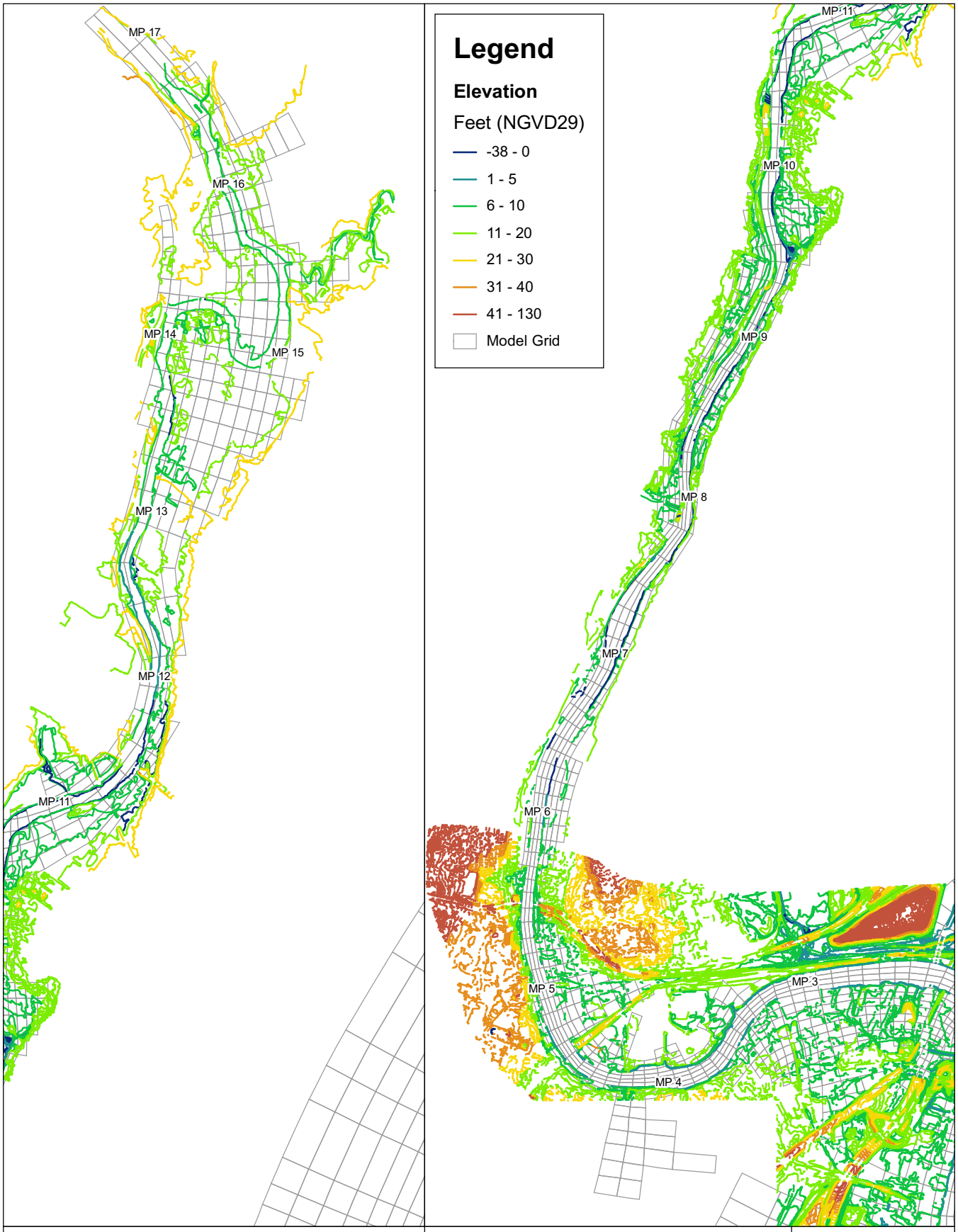

Figure 2-3. Overview of the USACE land survey data with hydrodynamic model grid.

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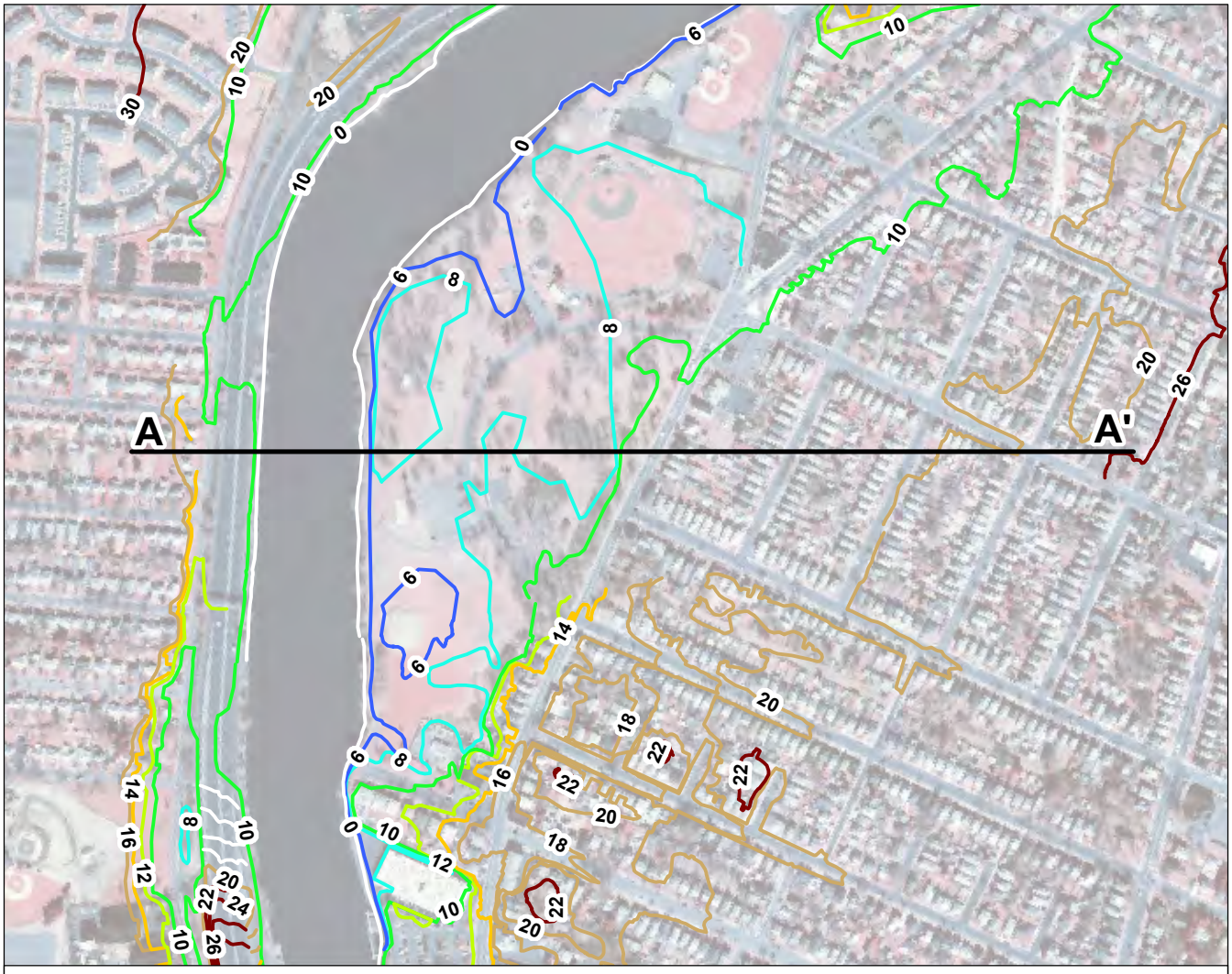

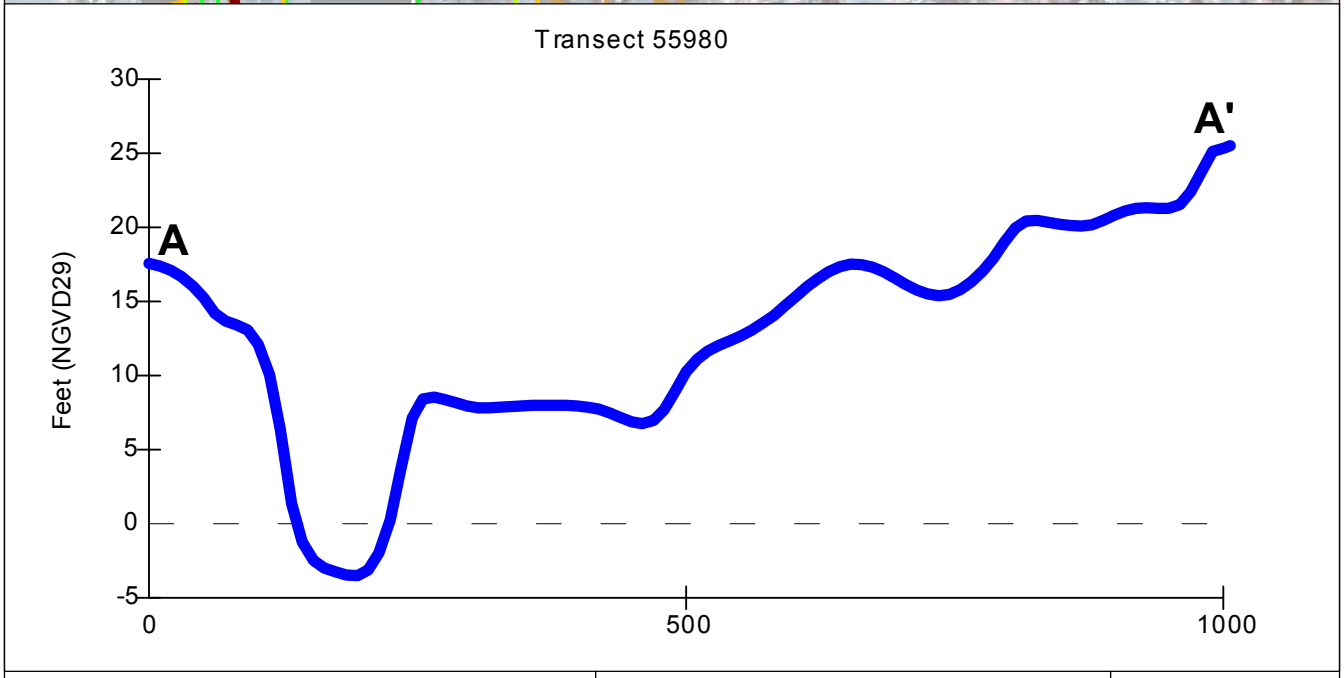

Figure 2-4. Detailed view of the USACE land survey data near RM 11 and cross -section of the land elevation.

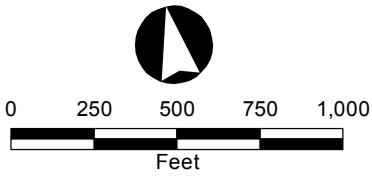

Figure 2.5. A map showing the distribution of rock , coarse gravel , gravel and sand in the Lower Passaic River.

SECTION 3

HYDRODYNAMIC MODEL CALIBRATION

The model was calibrated for a 30-day simulation using field data collected in the summer of 2004. A high quality data set, collected by the Rutgers University Institute of Marine & Coastal Sciences (IMCS), between mid-August and September 2004, was used for the calibration. This data set consisted of three bottom-mounted pressure sensors, three temperature and conductivity sensors and two bottom-mounted ADCPs (Figure 3-1).

3.1 BOUNDARY CONDITIONS AND MODEL FORCINGS

Hourly water surface elevations and temperature and salinity (Figure 3-2) along the two open-water boundaries at the Kill van Kull and South Amboy were extracted from the Water Year 2004 archives of HydroQual's LPR hydrodynamic model (HydroQual, 2007).

Freshwater inflows, both from riverine and non-point sources, were extracted from the input data used for the LPR hydrodynamic model. The bottom panel of Figure 3-2 shows the total boundary inflows from the upper Passaic River and the Hackensack River and the total flow from combined sewer outfalls (CSO) and stormwater outfalls (SWO) for the Passaic and Hackensack River basins. Lacking observed river inflow temperatures, a three-day moving average of air temperature observed at Newark International Airport was specified as inflow water temperatures (Figure 3-3).

Hourly meteorological parameters from Newark International Airport were used to compute air-sea heat exchanges as well as surface forcing functions. The parameters included wind speed and direction, air temperature, relative humidity, barometric air pressure, and cloud cover (Figure 3-3).

Detailed discussions on the boundary forcing data can be found in HydroQual's hydrodynamic report for the LPR study (HydroQual, 2007).

3.2 CALIBRATION RESULTS

3.2.1 Tidal Elevations

Water surface elevations were collected at the three pressure sensors M1, M3, and M5 in the LPR (Figure 3-1). Figure 3-4 illustrates the computed surface elevations and the measurements over a 30-day calibration period, September 1st to 30th, 2004. In the figure, blue lines are the model results while the red lines are observations. The mean range of tide in the LPR and the Newark Bay areas is between 1.5 and 1.8 m. The figure shows that the maximum water surface variation at those gauges is about 3.3 m during the calibration period. The water surface elevation during spring tides can be more than 1.0 m above mean sea level (MSL). The model-data comparisons, shown in Figure 3-4, also indicate that the amplitudes of the tide, the ranges between spring and neap tidal cycles, and

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times of high and low water are very well reproduced at those three locations in the river. A few exceptions can be noted around days 26-30 at M3 and days 28-29 at M5 when observed data at those stations show an increase in water elevations not reproduced by the model. Careful review of the observed elevations suggests that the pressure sensors deployed at M3 and M5 may have shifted their positions during the survey. The upstream freshwater flows shown in Figure 3-2 indicate that there was a second high flow event during the calibration period around day 18. While the increase in the observed water elevations at M3 and M5 around day 28 may coincide with the flow event at day 28, the other event around day 18 does not show a corresponding increase in the observed water elevations at any of the gauges. Moreover, the sudden increase in water elevations observed at M3 around day 26 occurred a few days earlier than the peak of the Passaic River flow measured at Little Falls. Although it can't be proved conclusively, these observations suggest the possibility that the M3 and M5 pressure sensors may have shifted slightly during the survey.

3.2.2 Current Velocities

Current velocity data at two locations in the LPR were available for calibration of the hydrodynamic model. The data collection instruments were two bottom moored acoustic current meters and were deployed during September 2004. The locations of the current meters are shown in Figure 3-1 (M2 and M3).

Time-series of hourly current velocities were measured at the surface, mid-depth and bottom layers, 4.1 m, 2.6 m and 0.9 m from the bottom, respectively, at Station M2. The computed results and the observed data are shown in Figure 3-5a, where positive values depict a downstream current and negative values depict an upstream current. In Figures 3-5a and 3-5b, the blue lines are the model results and the red lines are the observations. Figure 3-5a indicates that there were strong tidal currents in the LPR during the calibration period. Due to fresh water inflows around day 28 (see Figure 3-2), the maximum ebb tidal velocities at the surface were about 1.25 m/s and the maximum flood tidal velocities were about 0.85 m/s. In the vertical, it can be noted that velocities decrease with increasing depth. At the bottom layer, the maximum ebb tidal velocities were about 0.8 m/s and the maximum flood tidal velocities decreased to about 0.65 m/s. At M2, the model slightly overestimates ebb tide velocities near the surface and bottom layers around days 2, 14, and 28 during spring tidal periods. In general, the figure indicates good model performance in reproducing tidal currents, their time of occurrence, and the variations between spring and neap tidal cycles. Three sub-tidal events were recorded at days 7, 18 and around 28. At M2, the model computed slightly higher bottom velocities than those observed at 0.9 m above bottom.

Shown in Figure 3-5b are the time-series of hourly current velocities at surface, mid-depth and bottom layers, 6.0 m, 3.0 m and 1.0 m from the bottom, respectively, for Station M3. At this upstream location, surface tidal currents are not as strong as those observed at the downstream current meter, M2. The maximum ebb tidal velocities at the surface are about 1.0 m/s and the

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maximum flood tidal velocities are about 0.70 m/s. As depth increases, current velocities decrease. However, at the bottom layer, the maximum ebb and flood tidal velocities are larger than those computed at M2, 1.0 m/s and 0.75 m/s, respectively.

Only 14 days of mooring data were collected at M3 in September 2004. Figure 3-5b shows that the model reproduces the amplitudes and phases of velocity observed near the bottom quite well. At surface and mid-depth layers, the phase of current is well simulated, but the amplitude is over-estimated. Both the computed and observed current velocities show a sub-tidal event around day 28.

3.2.3 Temperature and Salinity

Continuous observations of surface and bottom water temperature and salinity were made at six locations in the LPR from August through October 2004. The locations of these stations are shown in Figure 3-1 and are denoted as M1, M2, M3, M4, Bridge St. (BS) Bridge, and M5 from downstream to upstream. The data collected at these stations in September 2004 were used to calibrate the hydrodynamic model for temperature and salinity.

The model-data comparisons of hourly temperature and salinity at these locations are shown in Figures 3-6 and 3-7, respectively. The blue lines represent the computed values and the red lines the observations at surface and bottom layers. In order to correlate changes in temperature and salinity with the model forcing terms, the upstream river inflow data are also shown with the temperature and salinity plots.

During the simulation period, temperatures were basically maintained above 20ºC in the LPR except for a decrease around day 19 due to a high flow event. The model and data indicate small differences in surface and bottom temperatures showing relatively weak thermal stratification in the river. Figure 3-6 indicates that the model computed surface and bottom temperatures follow closely the observed temperature for most of the simulation period. However, the model does not quite capture the temperature variations following the high flow event. The discrepancy in the computed and the measured temperatures around the day 19 flow event may be attributed to a lack of information concerning the proper water temperature to be assigned to freshwater inflows (see the previous section). The model-data differences are relatively small at downstream locations (M1, M2 and M3) but become more apparent at upstream locations (M4, Bridge St. Bridge and M5) closer to the source of the inflow, *i.e.*, water over the Dundee Dam.

Figure 3-7 indicates that freshwater flow and estuarine circulation have a significant influence on the salinity variations. Strong salinity stratification is shown at the downstream station during the high flow event. At M1, the surface salinity can decrease to near 0 practical salinity unit (psu) while the corresponding bottom salinity has a value of about 13.5 psu around day 18. The observed tidal variation in the surface salinity at M1 can be as much as 12 psu most of the time. This

represents the tidal excursion of high salinity water entering the river from Newark Bay during flood tide and low salinity water moving downstream from the upstream LPR during ebb tide. Moving upstream, salt intrusion and vertical stratification become weaker and freshwater flow influence becomes more dominant. At M5 and Bridge St. Bridge, the surface-to-bottom salinity differences are only about 1-2 psu during the low flow period and salinities at surface and bottom approach 0 psu during the high flow period. Corresponding to each high flow event, Figure 3-7 also shows corresponding decreases in observed and computed salinity. The surface salinity can decrease from 17 psu to close to 0 psu at the downstream stations and from 7 psu to 0 psu at the upstream stations.

In general, the model was able to reproduce both the surface and bottom salinity at all stations very well in the LPR except during a few occasions at M1 and M2 at the bottom. The computed temporal variations in surface salinity as well as vertical stratification due to tidal movement of water are in good agreement with the observations. In particular, the model reproduced the high freshwater inflow events that occurred on days 8, 18 and 28. In response to freshwater flow, both the timing and magnitude of salinity fluctuations were accurately represented by the model. At station M5 and Bridge St. Bridge, the most upstream locations of the survey where not many data were available, the computed salinities agree reasonably well with the observed data. The extent of the salt intrusion into the LPR was well represented by the model. This suggests that the physical configuration (geometry) of the LPR is adequately addressed and hydrodynamic transport and mixing characteristics are well resolved in the model.

3.3 STATISICAL ANALYSIS

Statistical analyses were performed in order to assess the model performance in terms of model/data comparisons. The model computed values of temperature, salinity, velocity and elevation were compared against the observations at several locations.

The statistical parameters considered included the root mean square error (RMSE), the relative RMSE, and the correlation coefficient. The RMSE, a measure of the error between the model and observed data, can be expressed mathematically as:

$$\mathrm{RMSE} = \sqrt{\frac{\sum (C_{OBS_i} - C_{MODEL_i})^2}{n}},$$

where C_{OBS} is the observed variable, C_{MODEL} is model calculated variable, and n is number of paired variables. The relative RMSE (%) is defined as the RMSE divided by the data range and measures the model performance in terms of reproducing the observations accounting for the variability in the observations. The correlation coefficient measures the strength of the linear association between the predicted and actual values.

3.3.1 Tidal Elevations

Table 3-1 highlights the results of the statistical analysis for tidal elevations at three tidal gauge stations (M5, M3 and M1) in terms of the above mentioned parameters. The tidal elevation data were compared with the model results for the period of one month, starting September 2004. The number of data points used in the statistical analysis, based on the data, along with the statistical parameters are presented in the table.

Table 3-1. Statistical Evaluation of Model Performance for Water Elevation

Station	No. Data Pairs	Data Range (m)	RMSE (m)	Rel. RMSE (%)	Correlation Coefficient
Upper Tidal Gauge (M5)	3887	2.66	0.22	8.2	0.92
Middle Tidal Gauge (M3)	1296	2.69	0.26	9.7	0.90
Lower Tidal Gauge (M1)	3456	2.55	0.18	7.1	0.96

For the three stations, the mean RMSE and the mean correlation coefficient are 0.22 m and 0.93, respectively. It is to be noted that the model performance in terms of reproducing the tidal elevations is better at M5 and M1 as compared to M3. The average relative RMSE is 8.3%.

The results of the statistical correlation analysis in the form of scatter plots are presented in Figure 3-8. As can be observed, the model and data values seem to be closely correlated. Most of the point comparisons lie within close proximity to the one-to-one line in the plot, emphasizing the fact that the model predicted values are in close agreement with the data measurements.

Table 3-2 compares results of harmonic analyses of computed and observed water surface elevations at the tidal gauge stations. The amplitudes and phases of four major tidal constituents, the principle lunar (M_2) and solar (S_2) semi-diurnal components and luni-solar (K_1) and principle lunar(O_1) diurnal components, are presented in the table. The dominant tidal constituent is M_2, with observed amplitude varying from 0.80 m at the M5 tide gauge to 0.72 m at the M1 gauge. For the M_2 tide, the maximum error in amplitude is about 0.06 m, and the maximum phase error is about 2° (4 minutes). Among all four tidal constituents, amplitude errors never exceed 0.06 m, while phase errors are always less than 1 hour.

For the semi-diurnal components M_2 and S_2, the comparison between observed and calculated phase shows the maximum phase error not exceeding 7° (or 15 minutes). At several instances, the calculated phase error is less than a couple of degrees, signifying the robustness of the model in capturing the dominant tidal components. In general, the harmonic analysis shows that the

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model reproduces the observed water surface elevations at the M5 and M1 tide gauges better than it does at the M3 tide gauge, which is consistent with the results from the previous statistical analysis.

The results of harmonic analysis obtained in this study compare well with the results of the earlier NY Harbor Study (Blumberg et. al., 1999), where the M2 amplitude differences are less than 10 cm and phase differences are less than 15° (or 30 minutes).

Table 3-2. Comparison of Harmonic Constants for Water Elevation

M_2 Component

Station	Observed		Calculated	
	Amp (m)	Phase (deg)	Amp (m)	Phase (deg)
Upper Tide Gauge (M5)	0.80	243	0.76	242
Middle Tide Gauge (M3)	0.80	241	0.74	239
Lower Tide Gauge (M1)	0.72	236	0.66	234

S_2 Component

Station	Observed		Calculated	
	Amp (m)	Phase (deg)	Amp (m)	Phase (deg)
Upper Tide Gauge (M5)	0.20	264	0.18	271
Middle Tide Gauge (M3)	0.20	261	0.18	268
Lower Tide Gauge (M1)	0.17	257	0.16	257

K_1 Component

Station	Observed		Calculated	
	Amp (m)	Phase (deg)	Amp (m)	Phase (deg)
Upper Tide Gauge (M5)	0.09	120	0.05	101
Middle Tide Gauge (M3)	0.08	116	0.05	99
Lower Tide Gauge (M1)	0.09	113	0.05	98

O_1 Component

Station	Observed		Calculated	
	Amp (m)	Phase (deg)	Amp (m)	Phase (deg)
Upper Tide Gauge (M5)	0.05	105	0.05	97
Middle Tide Gauge (M3)	0.06	97	0.05	96
Lower Tide Gauge (M1)	0.05	94	0.04	88

3.3.2 Current Velocities

The current velocity measurements were compared with the model predicted values to evaluate the model performance in terms of reproducing the current velocity in the system. The velocity measurements were made at two different locations at several depths.

The outcomes of the statistical analysis for current velocities are illustrated in Table 3-3. The model output was extracted at three depth levels and a comparison between the model and data values was performed.

The resulting RMSEs, relative RMSEs, and correlation coefficients are presented in Table 3-3. As can be seen in the table, the RMSEs vary from 0.15 m/s to 0.23 m/s, with a mean of 0.19 m/s and relative RMSEs vary from 8.5 % to 13.1 %, with a mean of 11.3 %. The correlation coefficient ranges from 0.74 to 0.87. The table indicates that the downstream station (M2) has relatively smaller RMSEs and relative RMSEs, and higher correlation coefficients as compared to the upstream station (M3). The RMSE values also demonstrate that the model performs better in simulating the current velocities at the bottom as compared to mid-depth or surface; however, the model and data values seem to be better correlated at the surface than at the bottom or mid-depth. The statistical analysis of currents obtained in this study compare well with the results of the earlier New York Harbor(NYH) study (Blumberg et. al., 1999), where the RMSE on the current meters deployed in the East River varied between 0.15 m/s and 0.43 m/s. The correlation coefficients of current velocities in the NYH study were above 0.95.

Table 3-3. Statistical Evaluation of Model Performance for Current Velocity

Station	No	Data Range	RMSE (m/s)	Rel. RMSE	Correlation Coefficient
M3					
Surface(5.5m)	648	1.68	0.22	13.1	0.86
Mid-depth(2.5m)	648	1.69	0.22	13.0	0.81
Bottom(0.5m)	648	1.63	0.18	11.0	0.74
M2					
Surface(3.62m)	1436	2.06	0.23	11.2	0.87
Mid-depth(2.12m)	2141	1.99	0.17	8.5	0.86
Bottom(0.37m)	2112	1.39	0.15	10.8	0.81

The results of the statistical correlation analysis at different depth levels for both the stations have been presented in the form of scatter plots in Figure 3-9. As can be observed, the model and data values seem to be closely correlated. Most of the points are well distributed around the one-to-one line in the plot, emphasizing the fact that the model predicted values are in good correspondence with the data measurements.

3.3.3 Temperature and Salinity

The model was calibrated by comparing model results to temperature measured by sensors collected at six locations in the region during the month of September 2004. Table 3-4 presents the

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statistical evaluation of model performance in terms of RMSE, relative RSME and correlation coefficient between computed and observed water temperature at surface and bottom. The RMSE in water temperature predictions varies from 1.6 ºC to 5.0 ºC, with relative RMSE varying from 9.3 % to 31.3%. In general, the model does a better job simulating the surface temperatures and the model predictions at the downstream stations are better than the upstream stations. Figure 3-10 shows the statistical correlation between the model and data values. The model and data values seem to be relatively well correlated to each other at the downstream stations (M1, M2, and M3) but at some times significantly deviate from the 1-to-1 correlation line at the upstream stations (Bridge St. Bridge and M4). This is likely due to uncertainties in the freshwater temperature specified in the model, which has been discussed in the previous section.

Table 3-4. Statistical Evaluation of Model Performance for Temperature

Station	No. of Data	Data Range (Deg C)	RMSE (Deg C)	Rel. RMSE	Correlation Coefficient
BS					
Surface	335	5.1	1.6	31.3	0.50
Bottom	338	7.8	1.6	20.7	0.39
M5					
Surface	No data				
Bottom	35	3	0.5	15.0	0.85
M4					
Surface	623	8.1	1.2	14.5	0.73
Bottom	338	7.8	1.4	18.1	0.53
M3					
Surface	359	3.6	0.7	18.5	0.62
Bottom	359	3.8	0.7	19.1	0.64
M2					
Surface	695	7.8	1.0	12.3	0.81
Bottom	695	7.8	1.0	13.1	0.81
M1					
Surface	695	7.9	0.7	9.3	0.87
Bottom	198	5.3	0.7	12.7	0.87

Comparisons between the model predicted and measured salinity values were made at six locations in the study area for the month of September, 2004. Table 3-5 presents the statistical evaluation of model performance in terms of RMSE, relative RSME and correlation coefficient between computed and observed salinity at surface and bottom. The RMSE in salinity predictions varies from 1.1 psu to 4.6 psu, while the relative RMSE varies from 13.07 % to 38.40%. Similar to the behavior of model predicted temperature, it can be noticed that the model does a better job simulating the surface salinity as compared to the bottom salinity. Figure 3-11 shows the statistical correlation between the model and data values. The figure indicates that model-data correlation is

better at surface than at bottom where the observed salinity is generally higher than computed (see Figure 3-7).

Table 3-5. Statistical Evaluation of Model Performance for Salinity

No	Station	No. of Data	Data Range (psu)	RMSE (psu)	Rel. RMSE	Correlation Coefficient
1	BS					
	Surface	318	6.4	1.1	17.1	0.68
	Bottom	36	9.7	3.0	30.7	0.55
2	M5					
	Surface	No data				
	Bottom	35	4.5	1.6	34.8	0.53
3	M4					
	Surface	605	12.1	1.6	13.5	0.85
	Bottom	36	9.7	3.7	38.4	0.63
4	M3					
	Surface	366	12.5	2.2	17.3	0.83
	Bottom	360	16.0	5.3	33.1	0.71
5	M2					
	Surface	677	16.5	2.5	15.2	0.88
	Bottom	695	16.2	4.6	28.5	0.69
6	M1					
	Surface	677	17.1	2.2	13.1	0.88
	Bottom	198	18.7	3.1	16.7	0.67

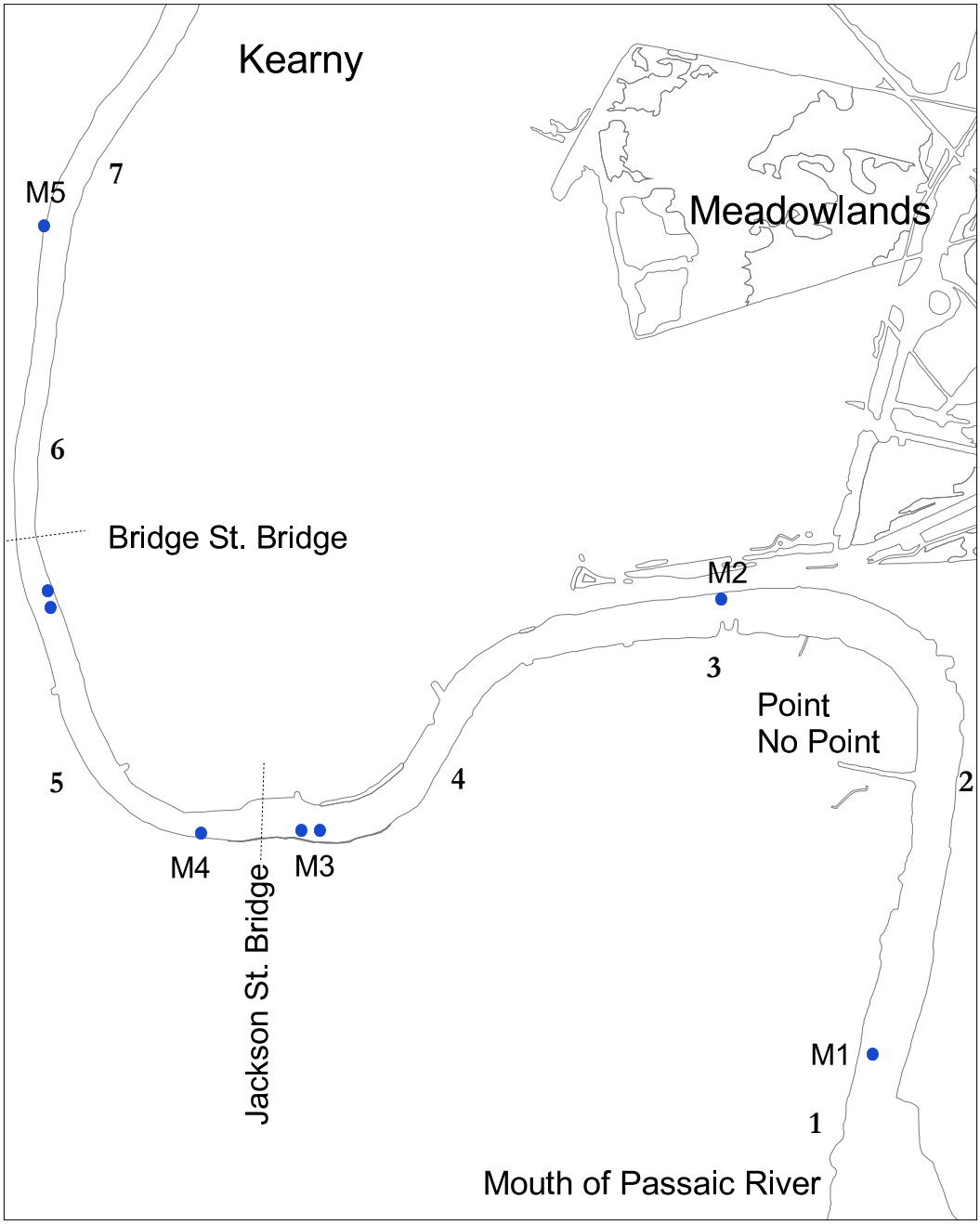

Figure 3-1. Locations of the 2004 IMCS field sampling stations in the Lower Passaic River.

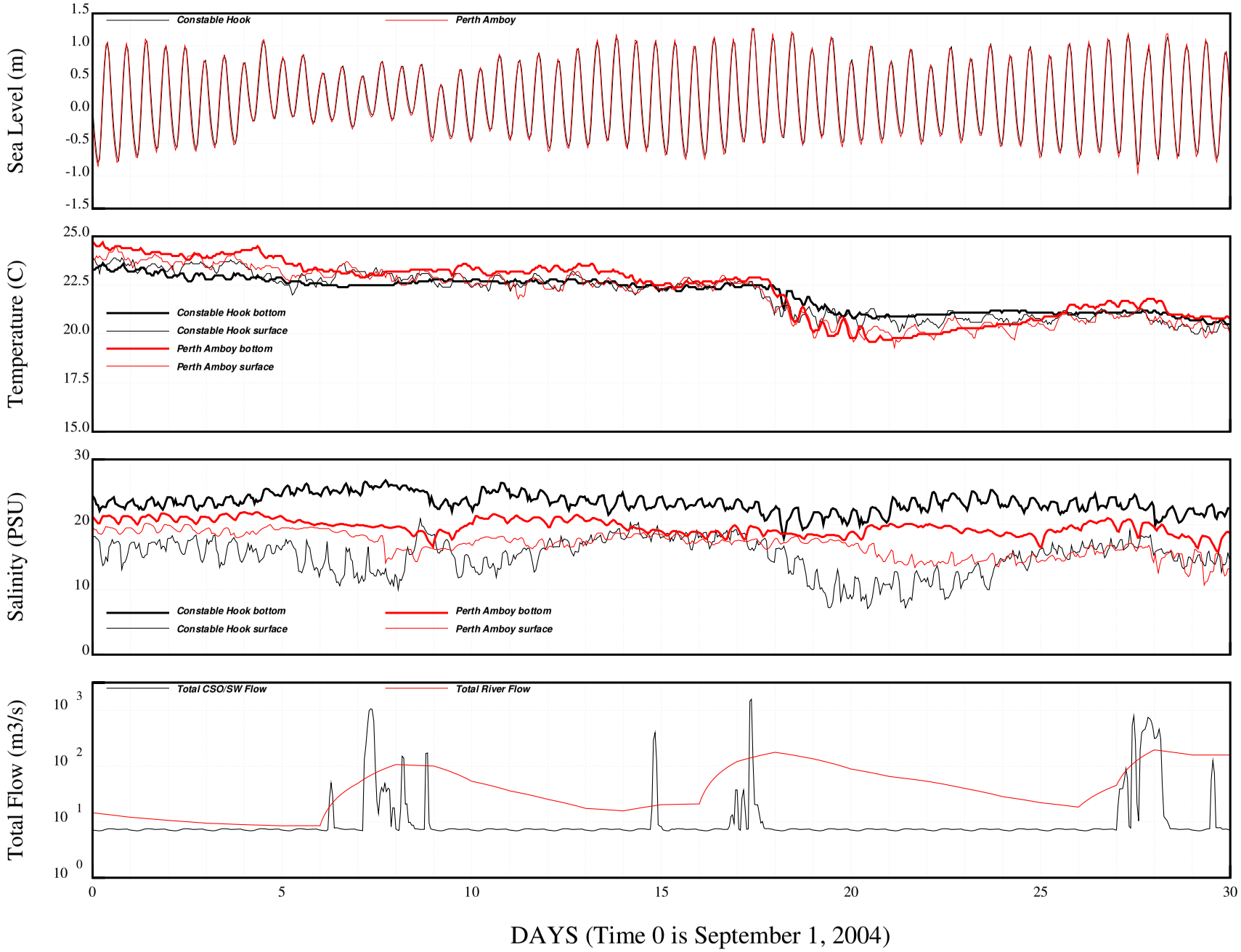

Figure 3-2. Boundary forcing data used for the model calibration.

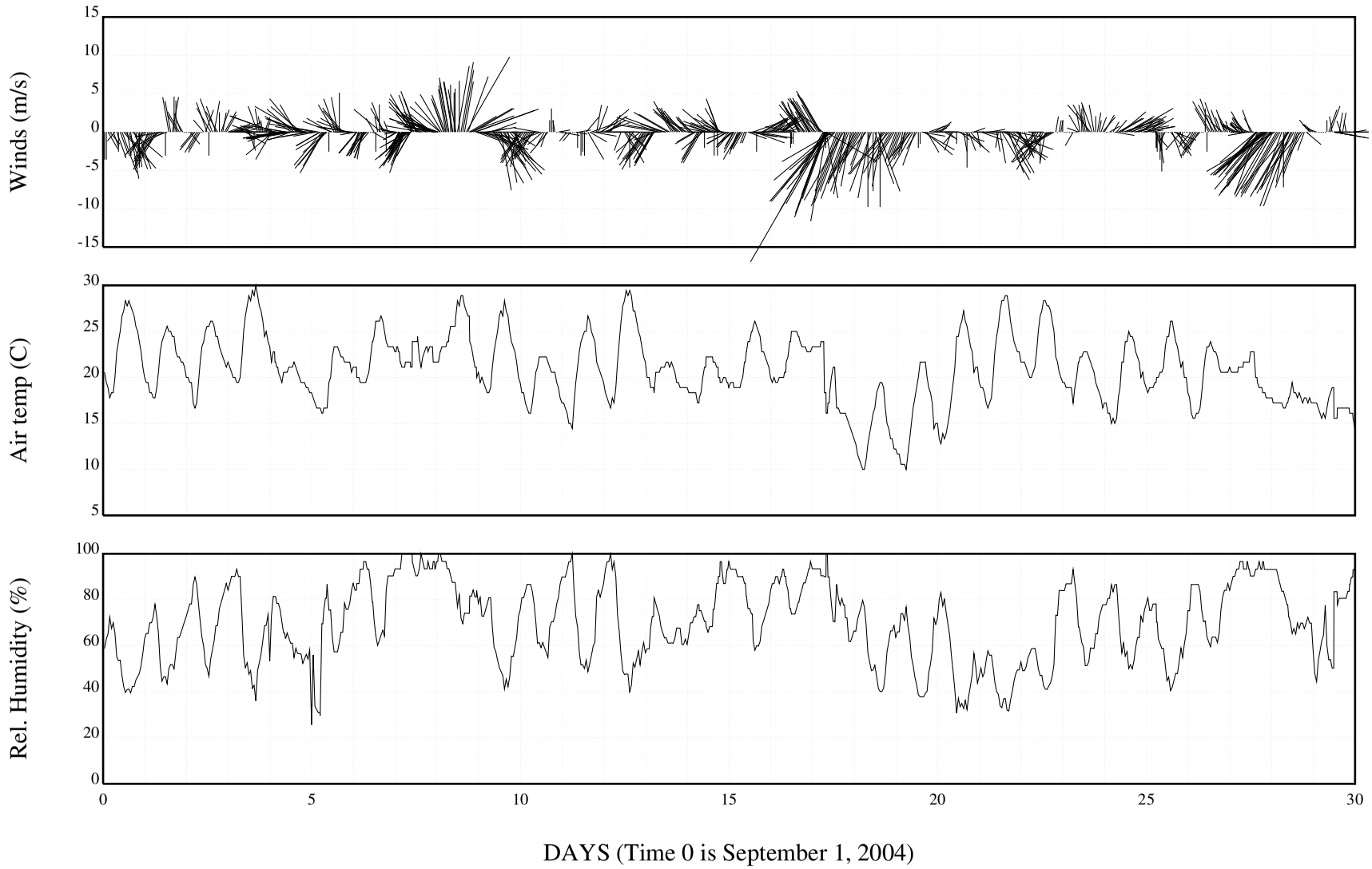

Figure 3-3. Meteorological data used for the model calibration.

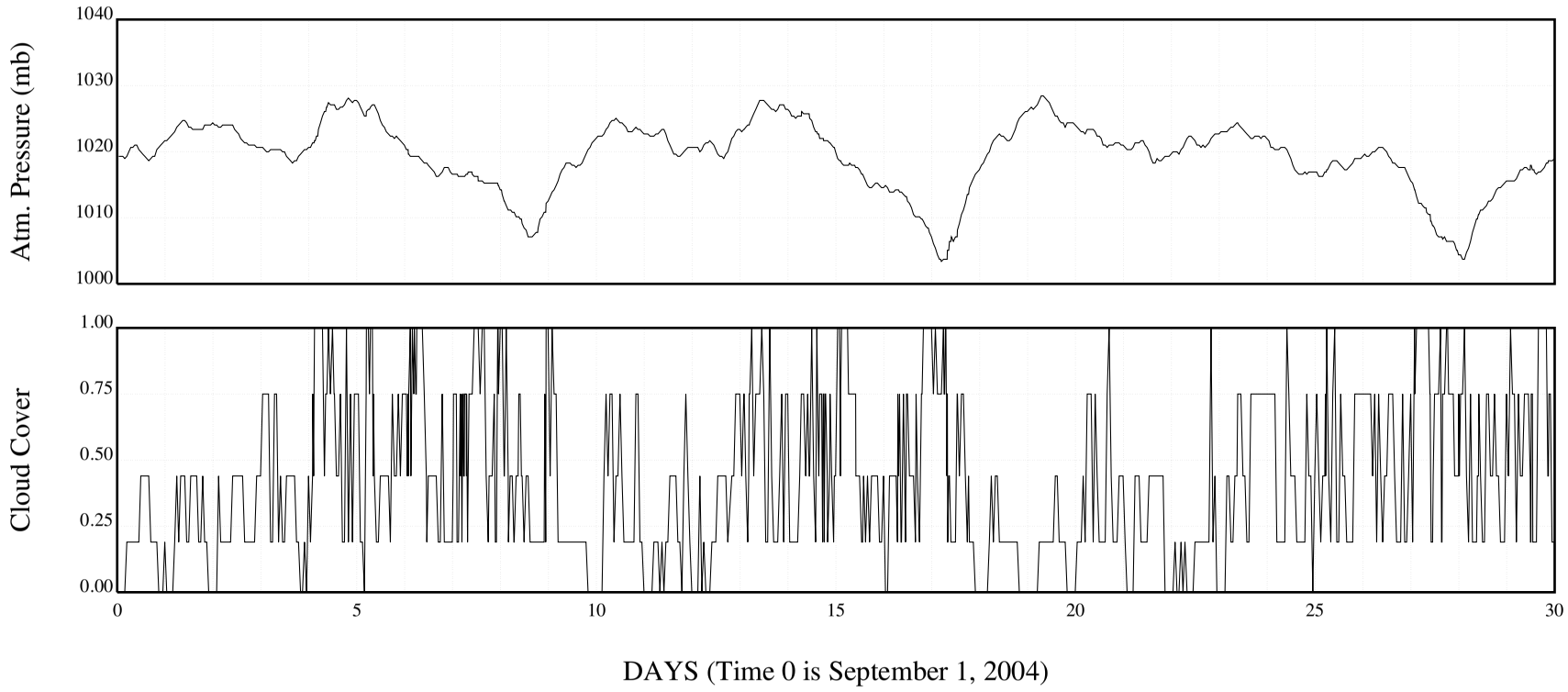

Figure 3-3 (continued). Meteorological data used for the model calibration.

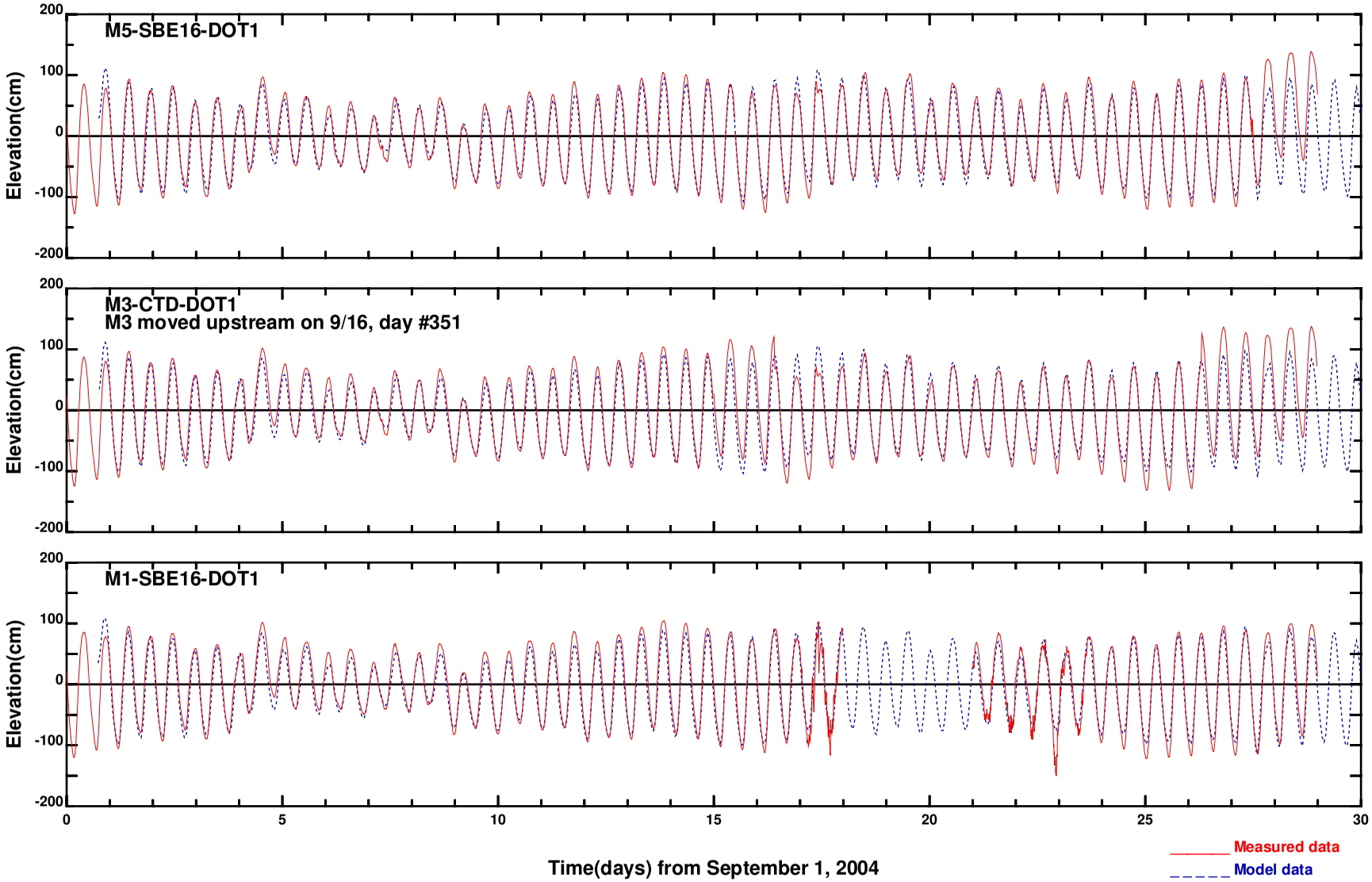

Figure 3-4. Comparison of computed water elevations with observed data.

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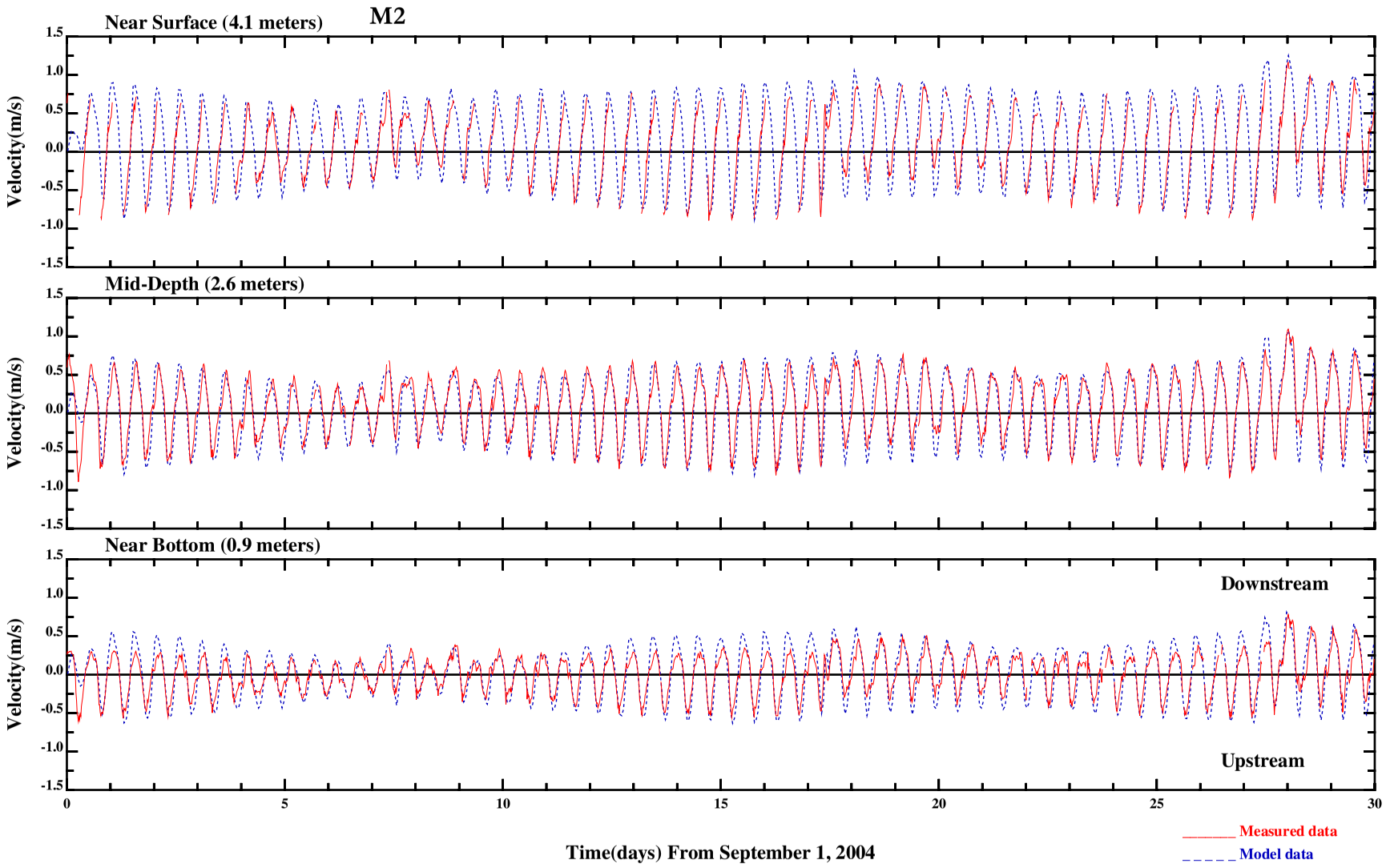

Figure 3-5a. Comparison of computed current velocities at three depths with observed data at M2.

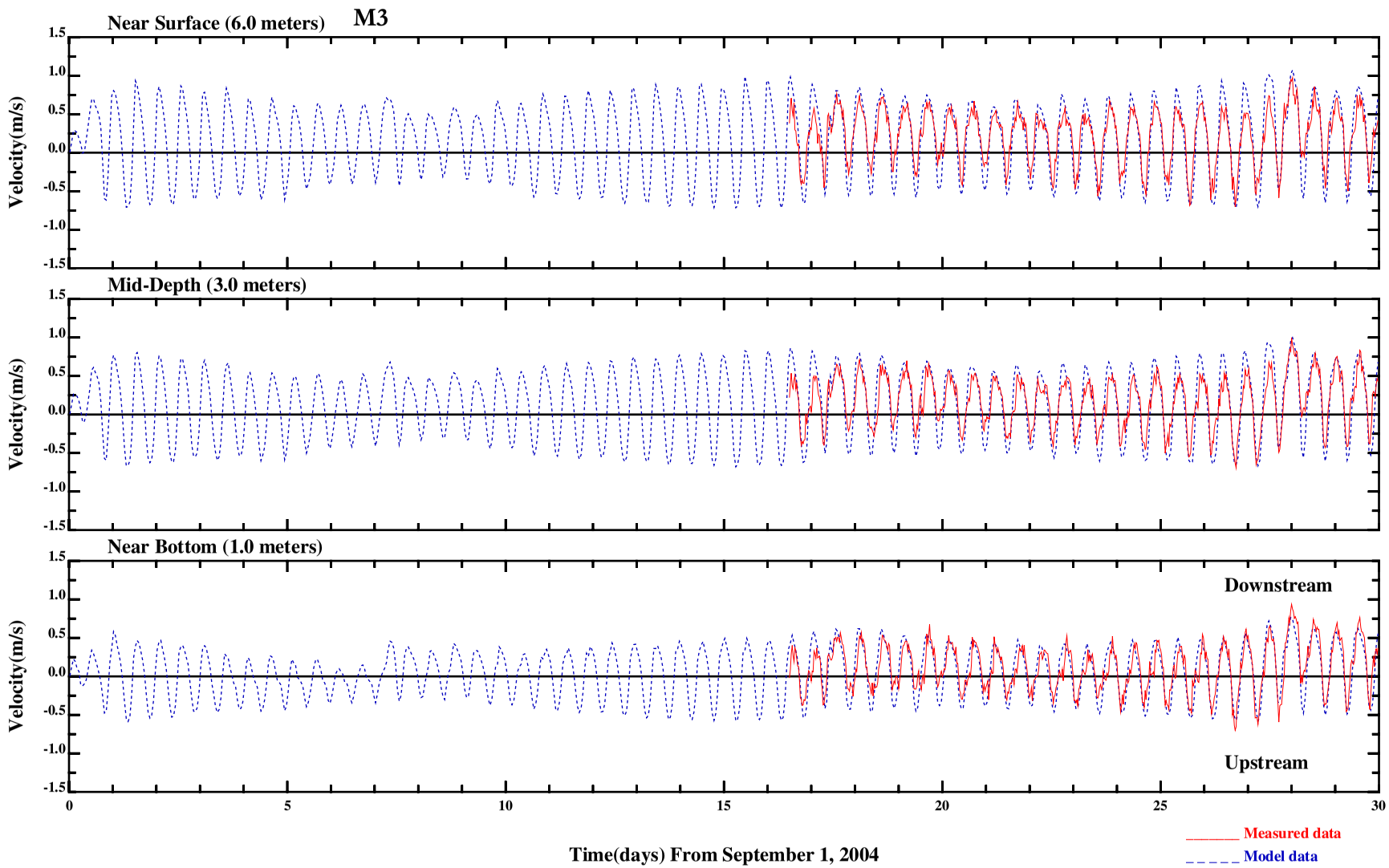

Figure 3-5b. Comparison of computed current velocities at three depths with observed data at M3.

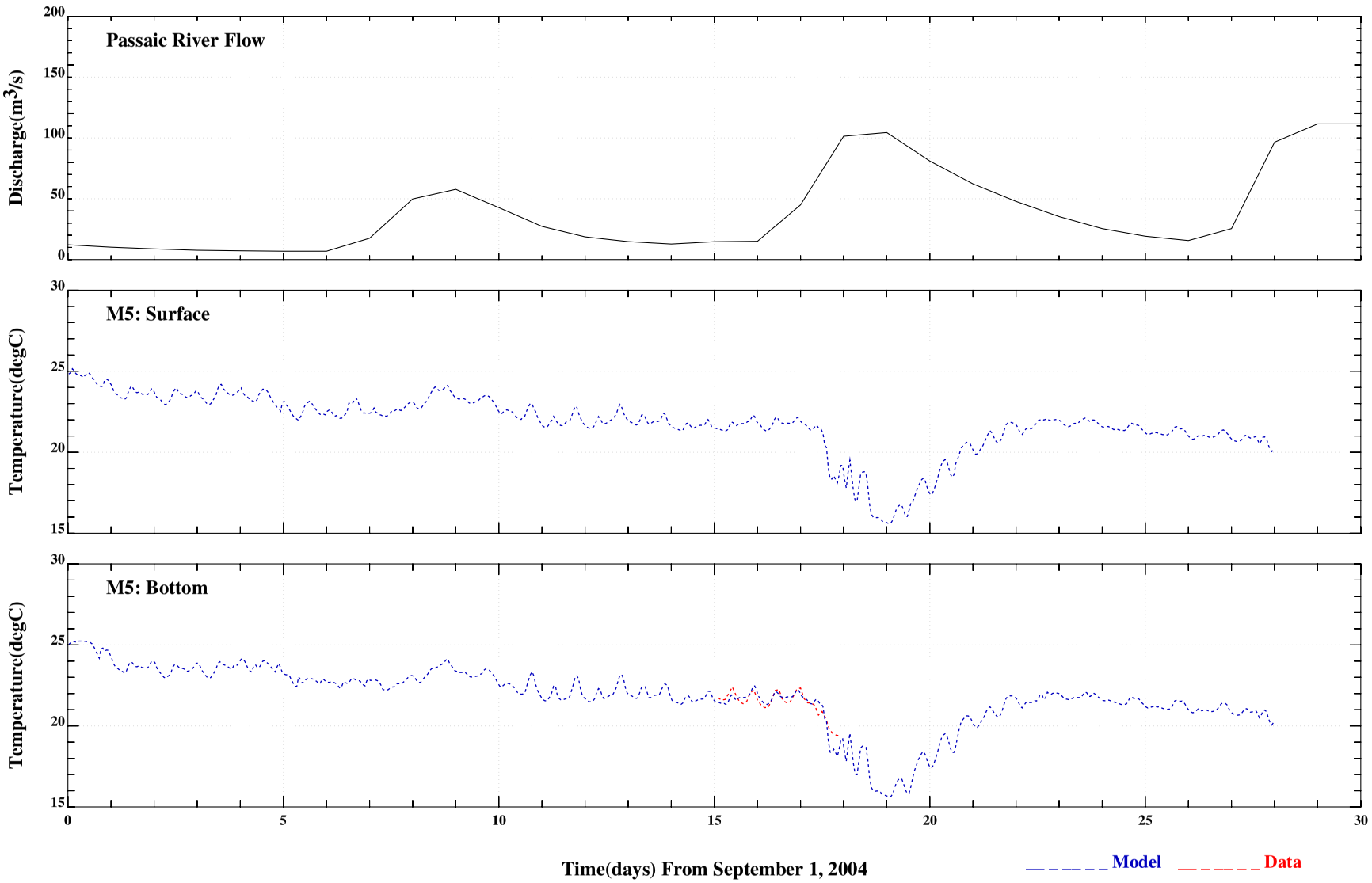

Figure 3-6. Comparison of computed water temperature with observed data.

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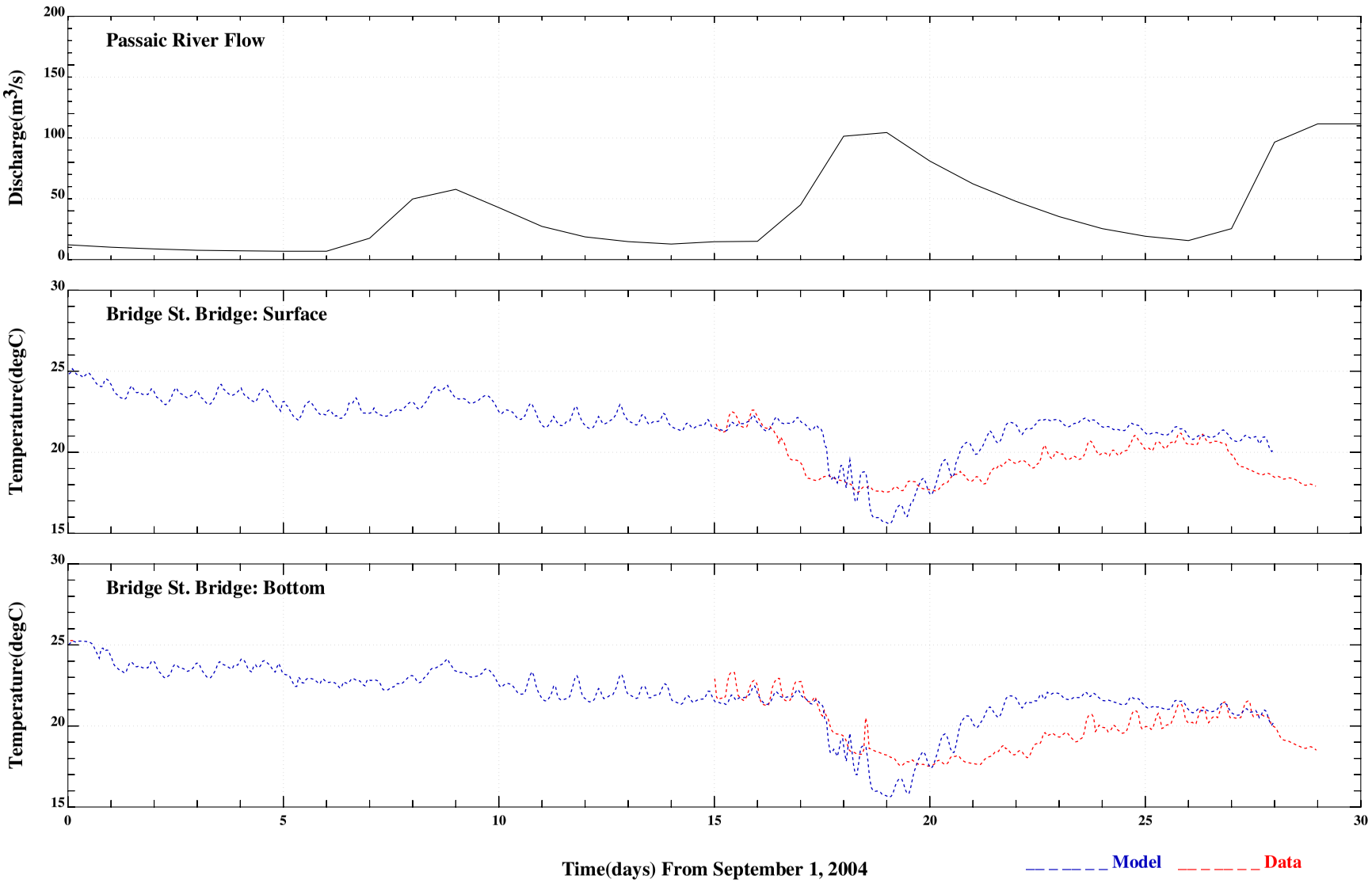

Figure 3-6. Comparison of computed water temperature with observed data (continued).

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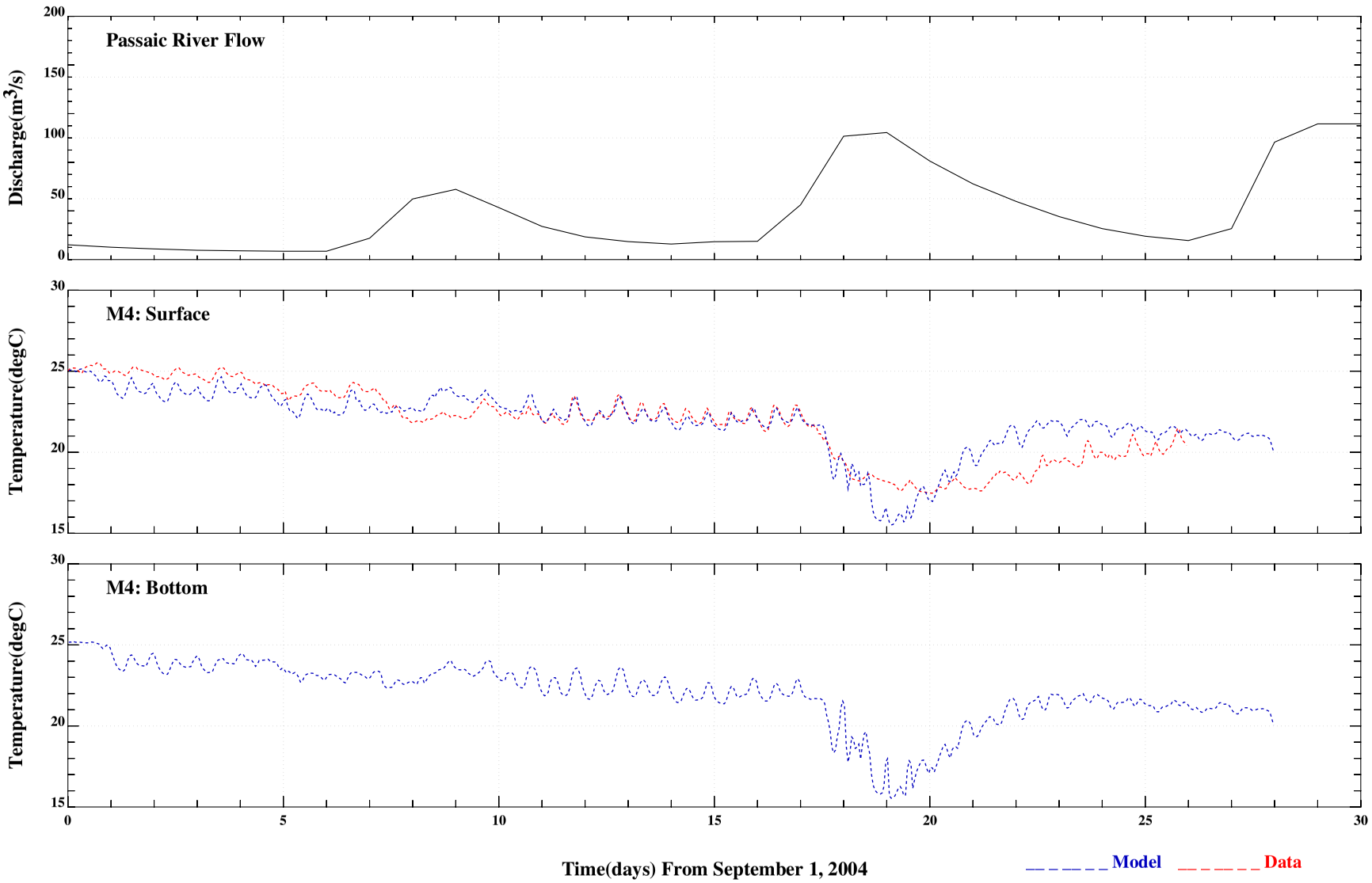

Figure 3-6. Comparison of computed water temperature with observed data (continued).

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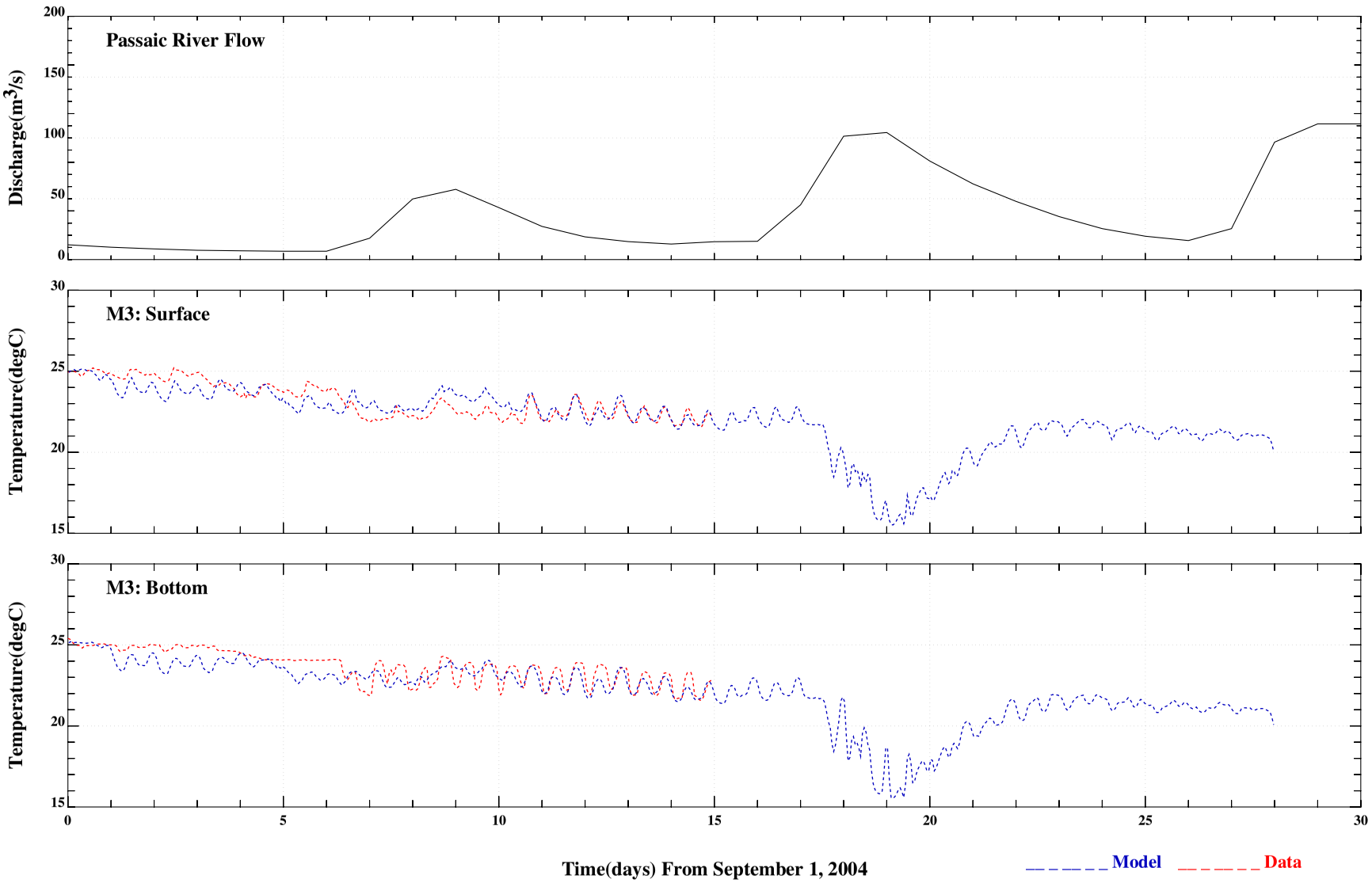

Figure 3-6. Comparison of computed water temperature with observed data (continued).

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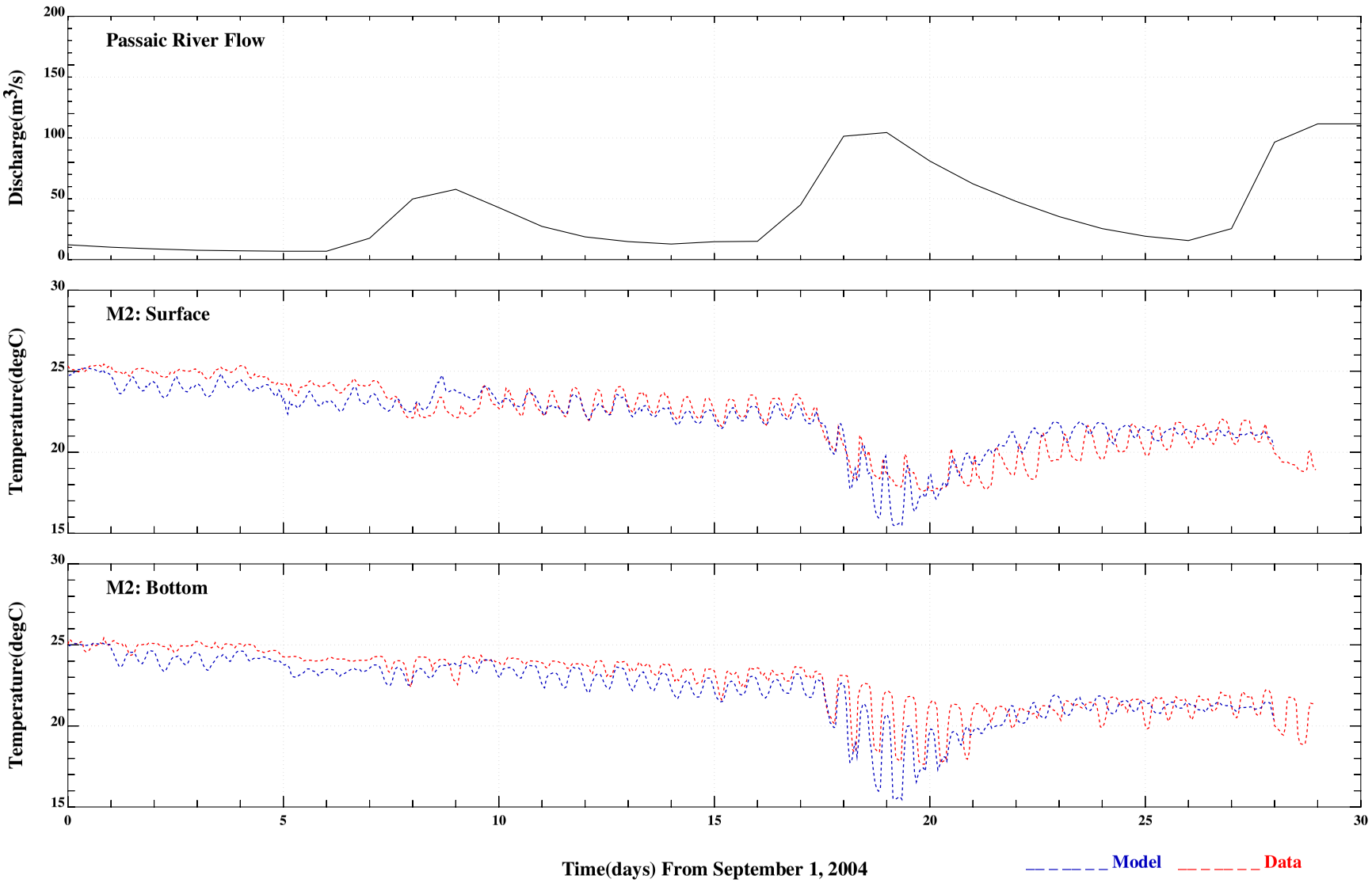

Figure 3-6. Comparison of computed water temperature with observed data (continued).

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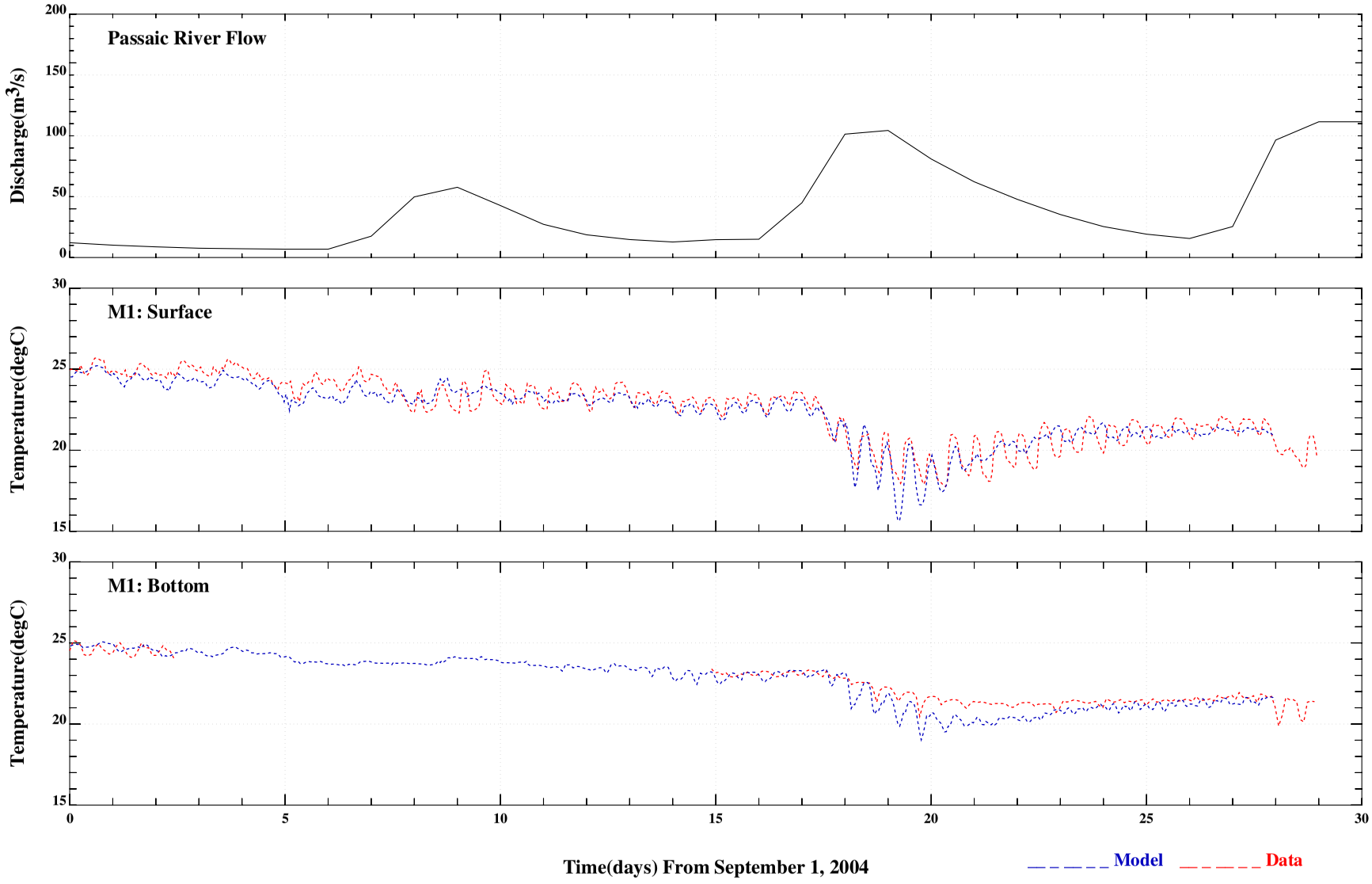

Figure 3-6. Comparison of computed water temperature with observed data (continued).

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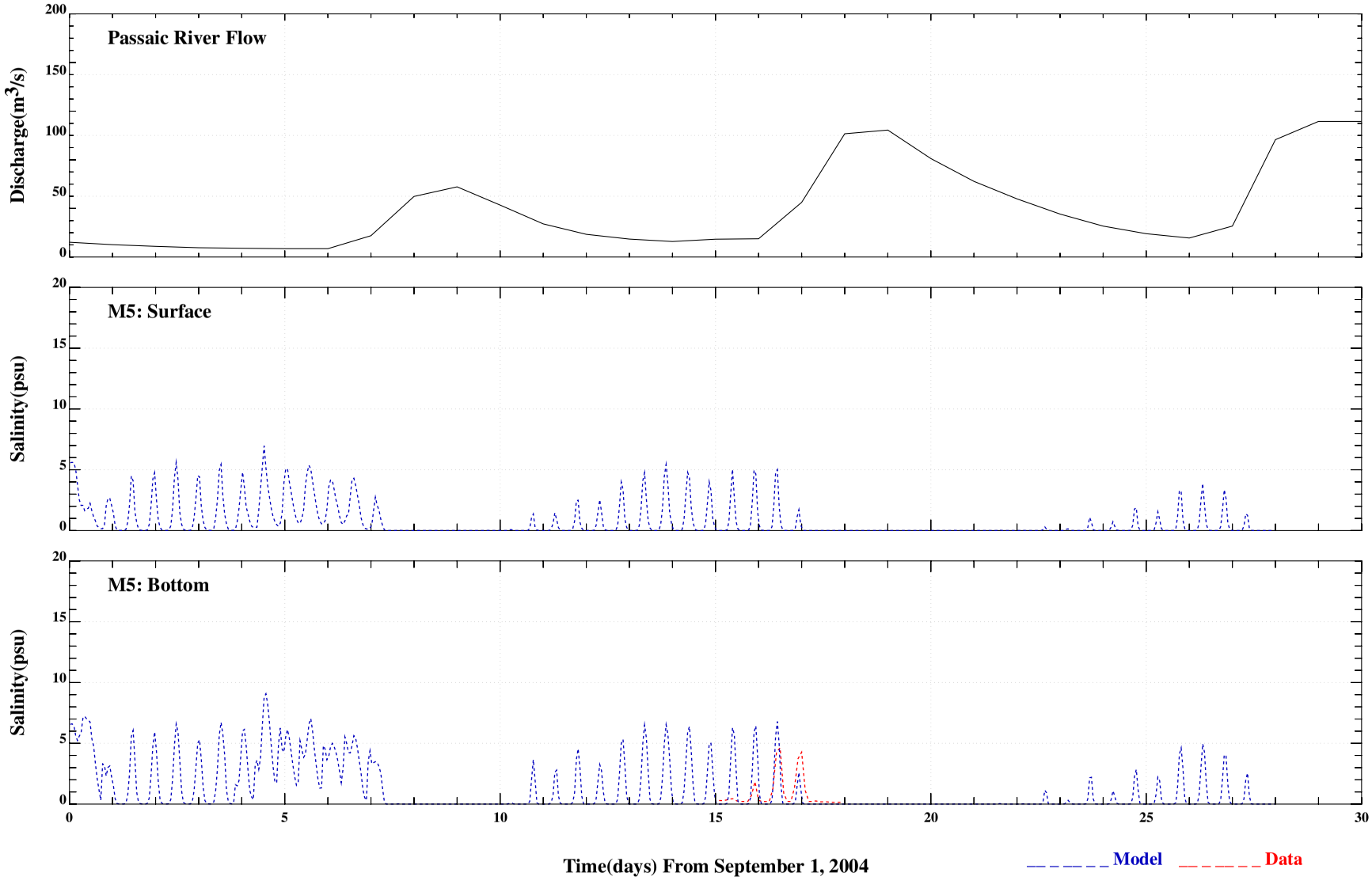

Figure 3-7. Comparison of computed salinity with observed data.

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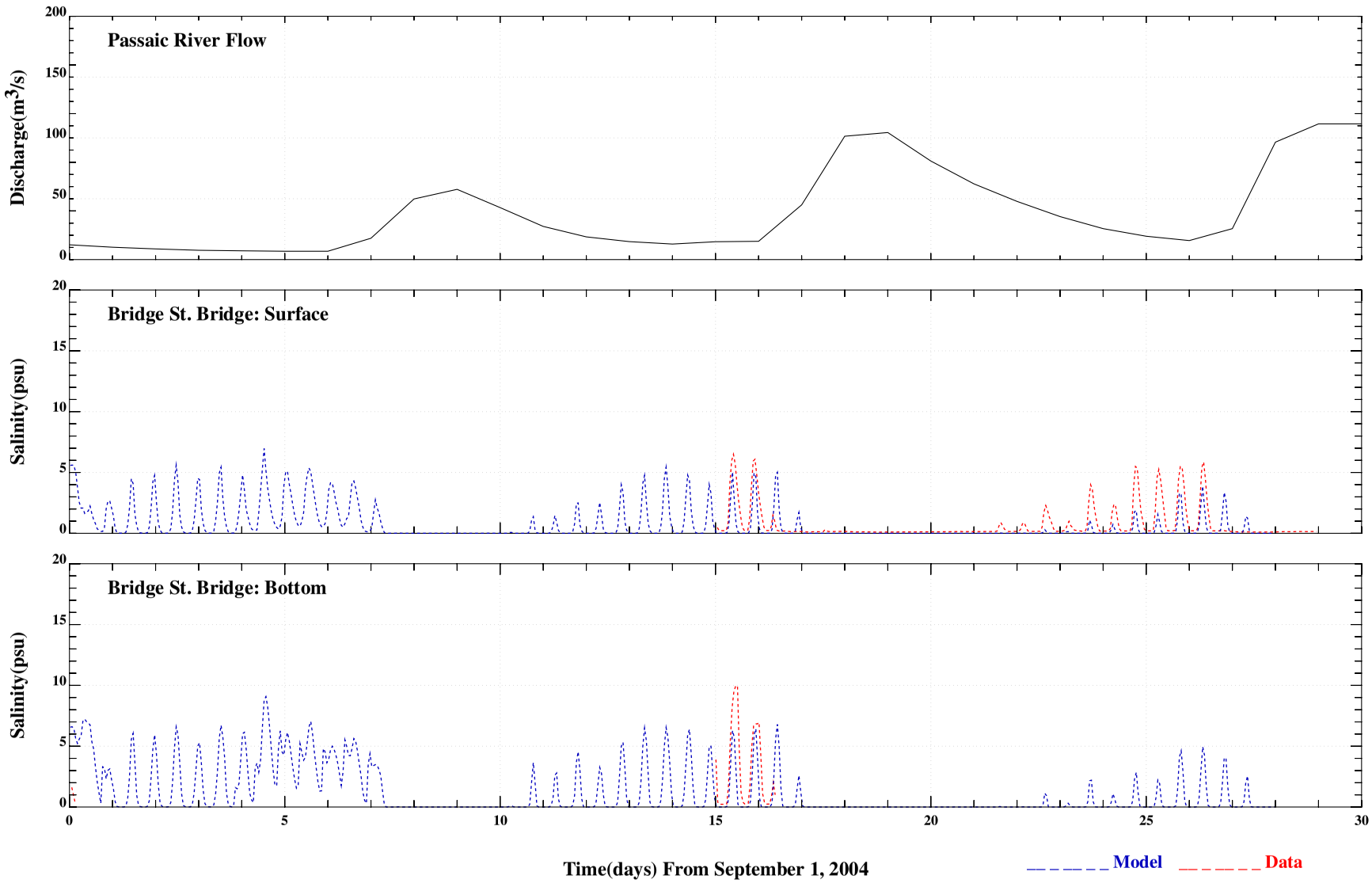

Figure 3-7. Comparison of computed salinity with observed data (continued).

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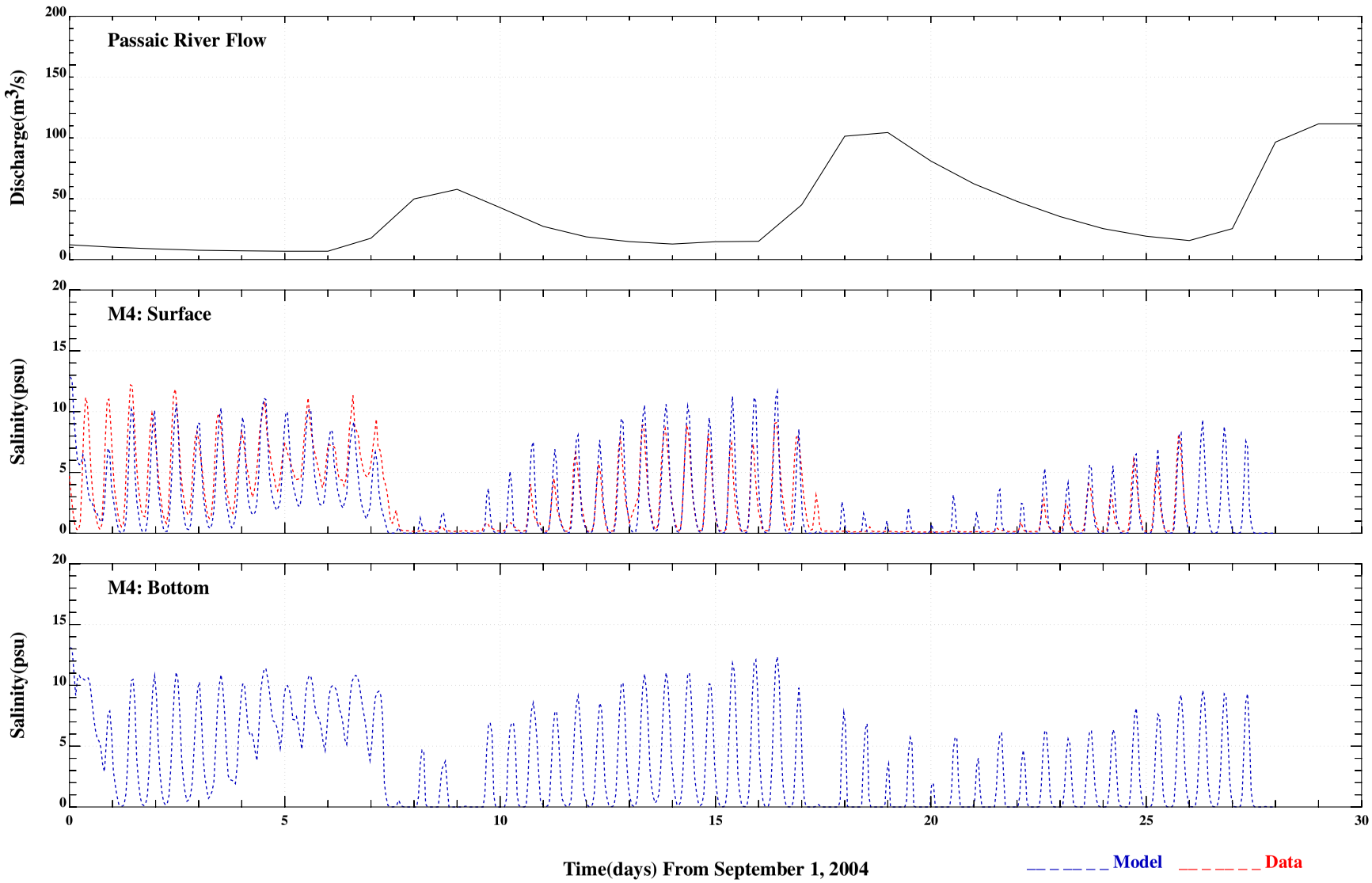

Figure 3-7. Comparison of computed salinity with observed data (continued).

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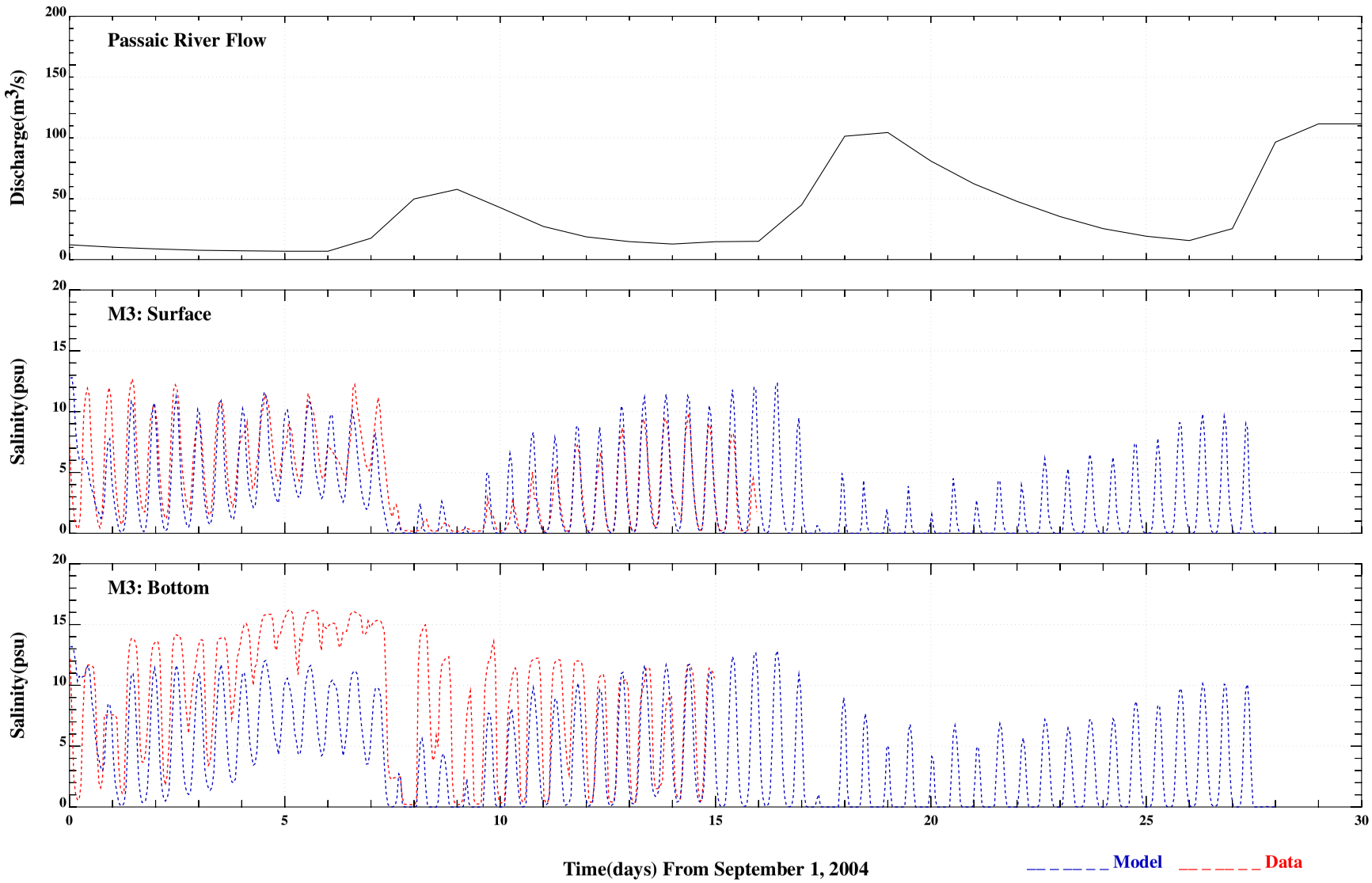

Figure 3-7. Comparison of computed salinity with observed data (continued).

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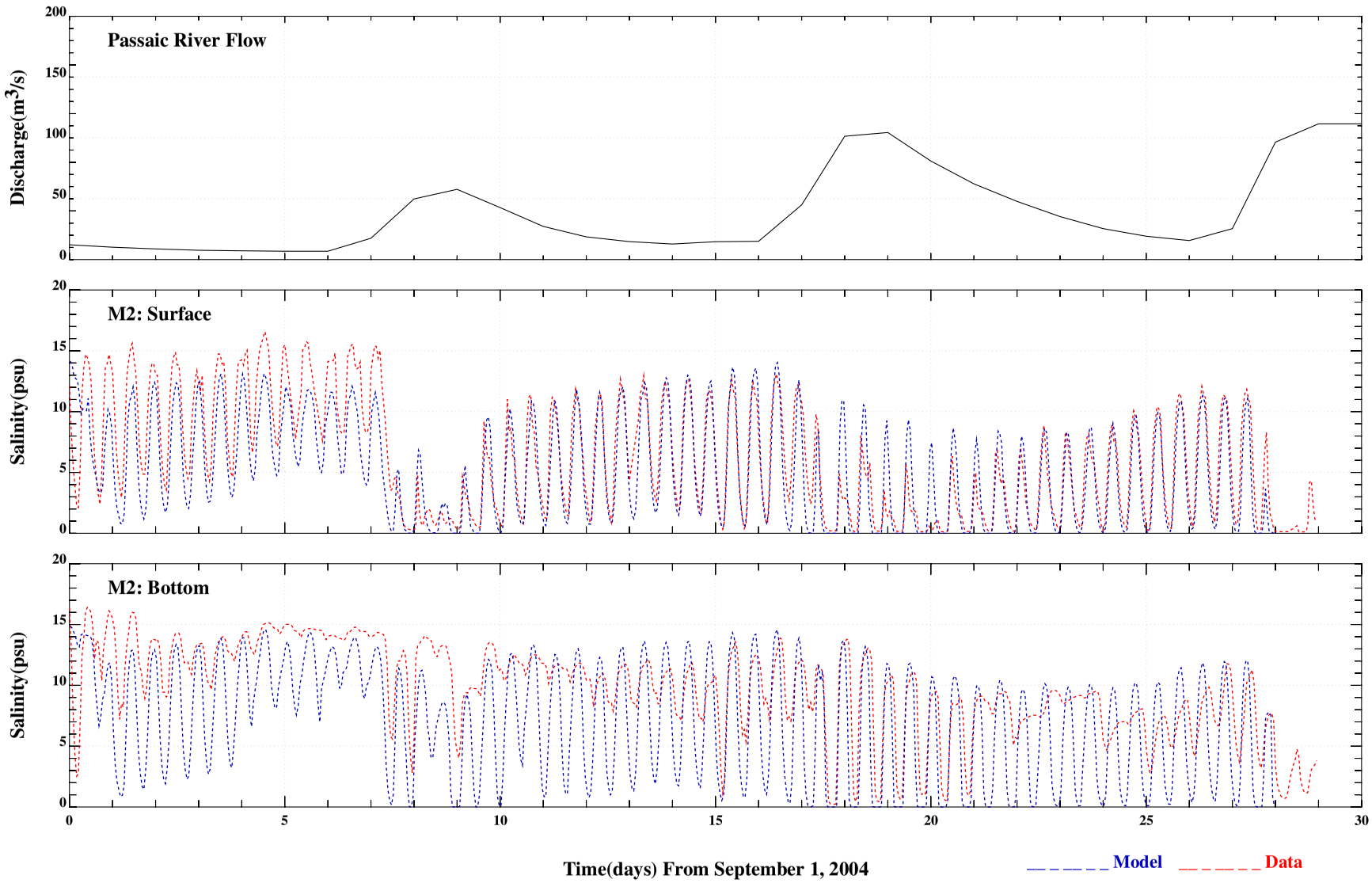

Figure 3-7. Comparison of computed salinity with observed data (continued).

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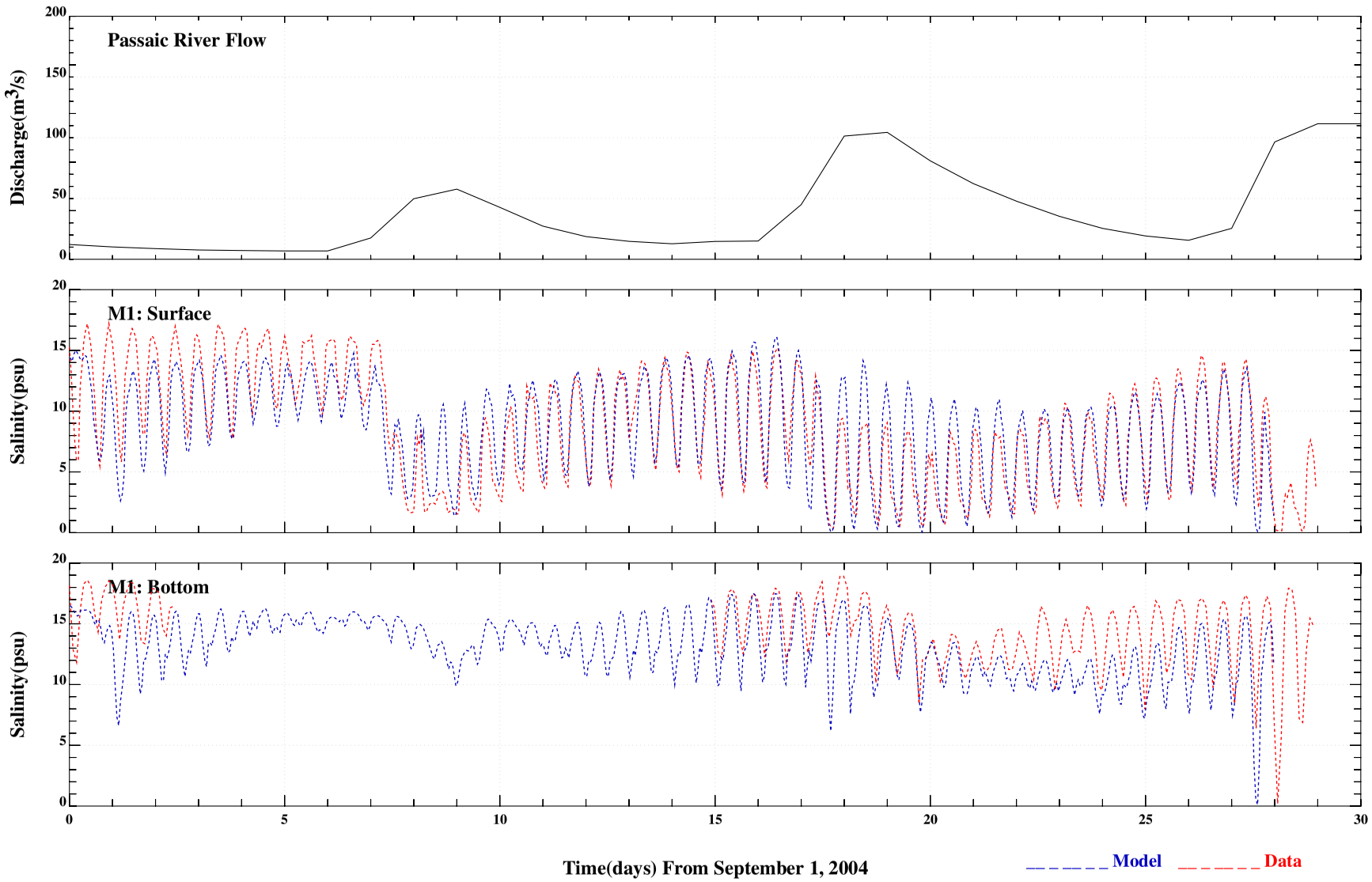

Figure 3-7. Comparison of computed salinity with observed data (continued).

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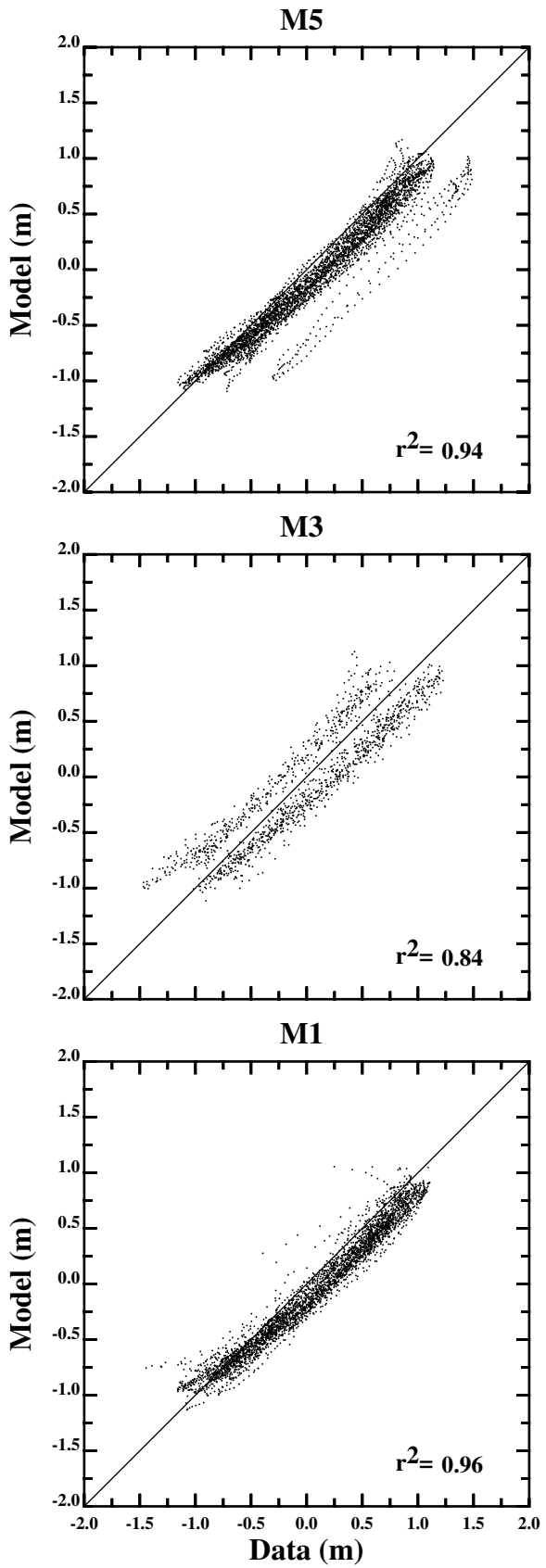

Figure 3-8. Scatter plot of computed water elevation with observed data.

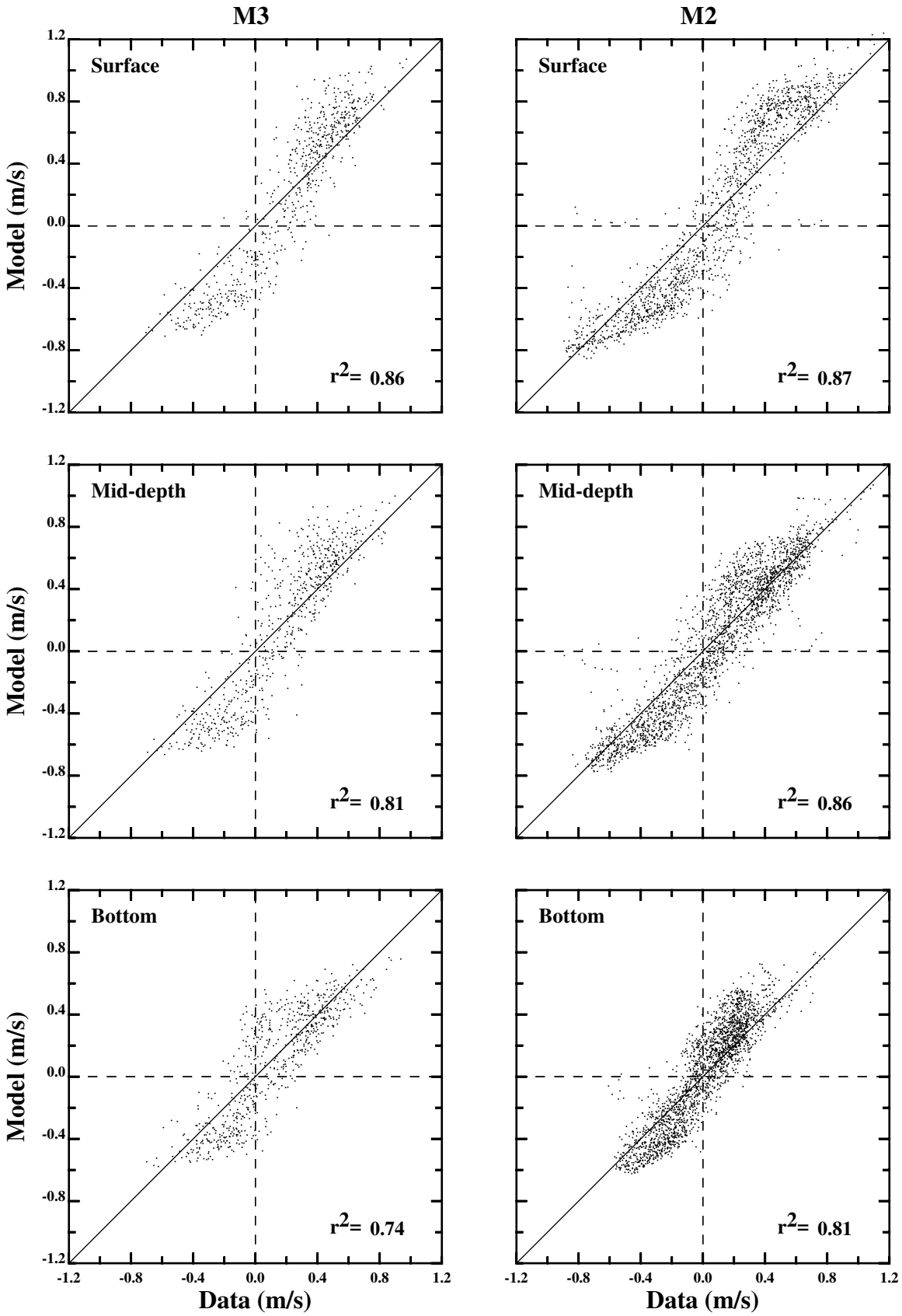

Figure 3-9. Scatter plot of computed current velocities with observed data.

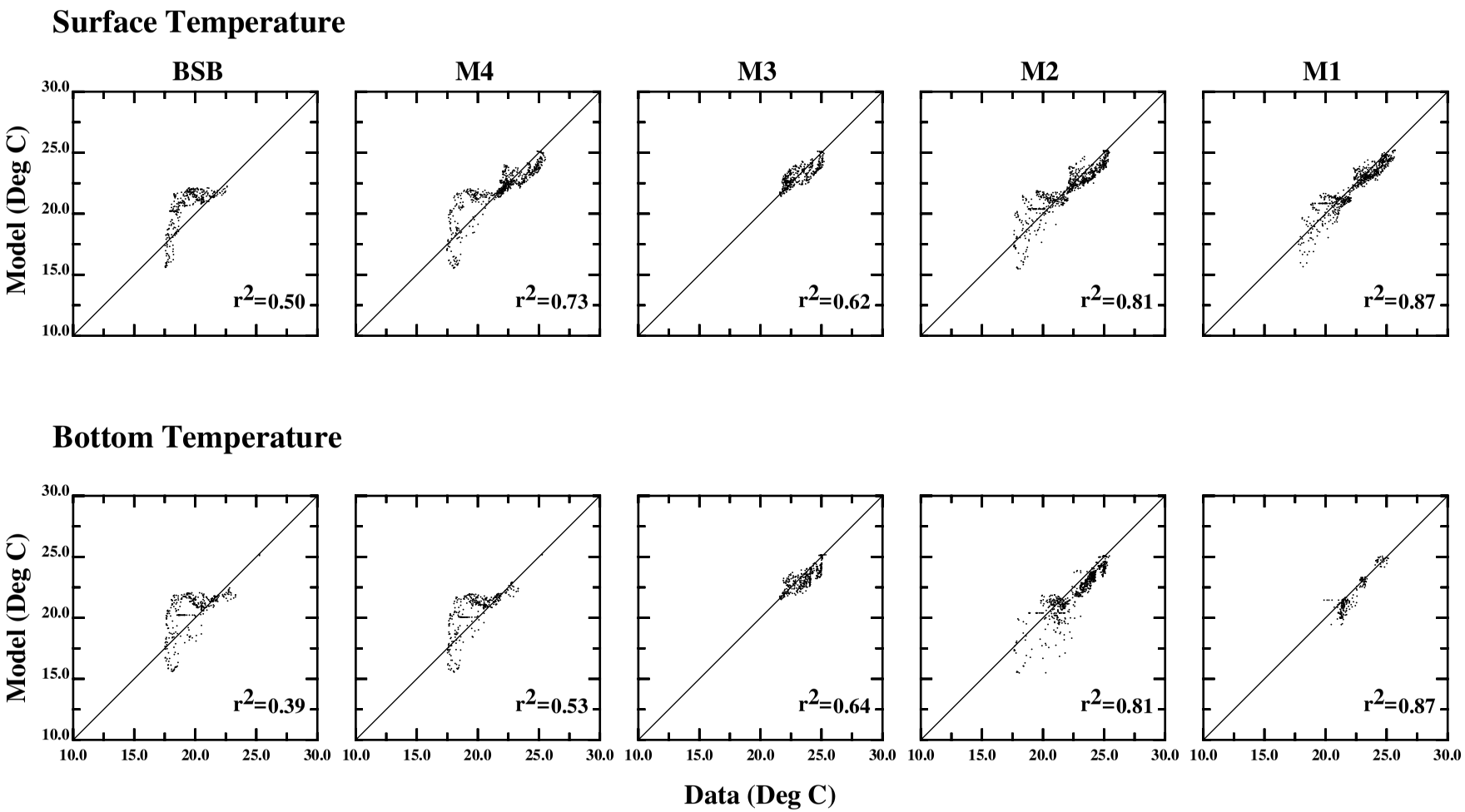

Figure 3-10 Scatter plot of computed temperature with observed data.

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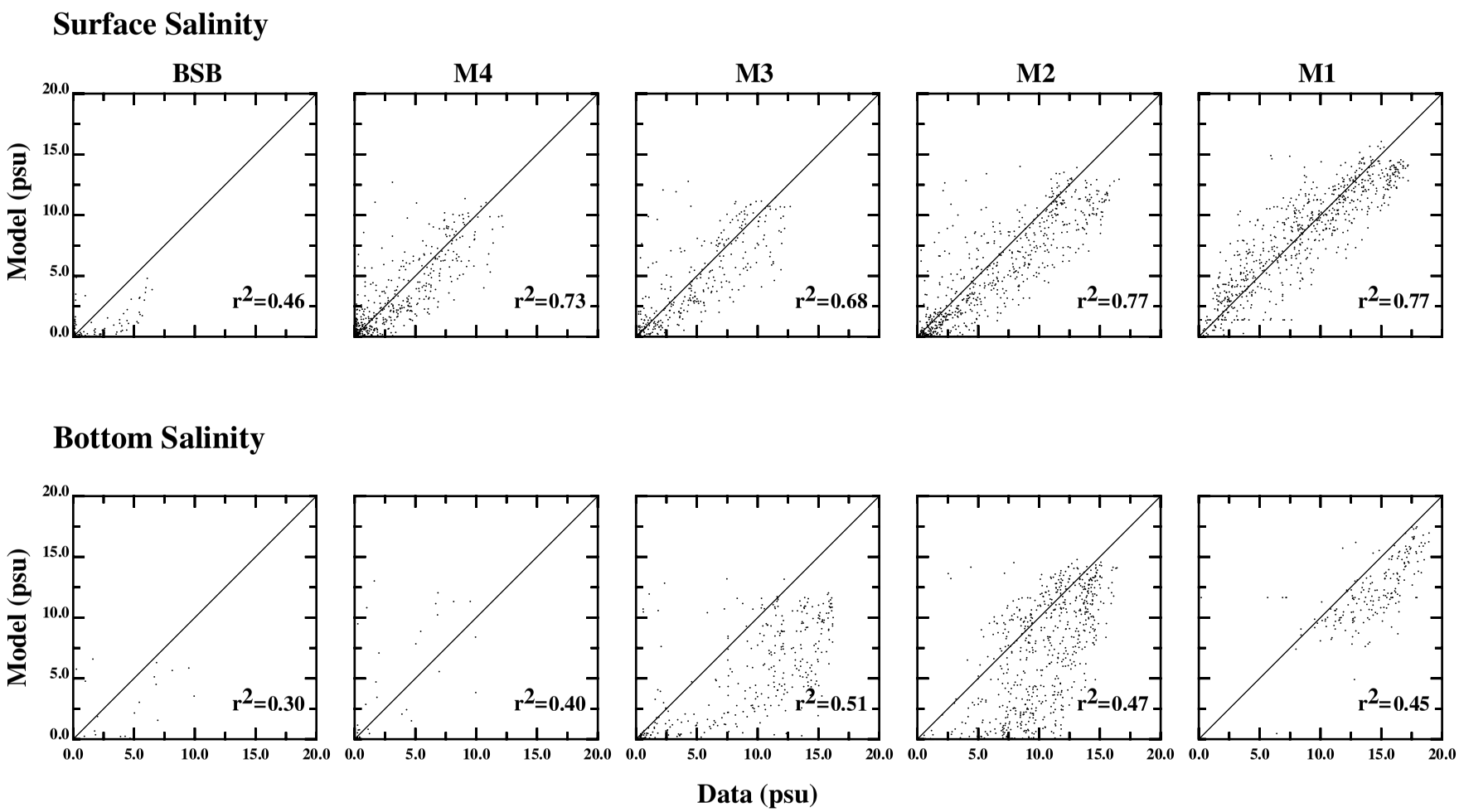

Figure 3-11 Scatter plot of computed salinity with observed data.

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SECTION 4

HYDRODYNAMIC MODEL VALIDATION: HURRICANE DONNA

Hurricane Donna, which passed over the NY-area on September 12, 1960, is one of the largest storms ever to hit the region. The hurricane produced extensive coastal flooding in Florida, North Carolina, and many states along the eastern Atlantic seaboard before the eye of the hurricane passed over the eastern end of Long Island. In many parts of New York Harbor, the arrival of the peak surge coincided with the normal high tide for the day (Harris, 1963). NOAA tidal stations in the NY region report the historical maximum water elevation as being attributable to Hurricane Donna. Both the NOAA Battery and Sandy Hook stations recorded a storm surge of 2.56 m (NGVD29) during the hurricane.

Harris (1963) described the characteristics of the hurricane storm surges from 1928 through 1961 and included discussion on storm surge elevations in the NY region that were recorded during Hurricane Donna. To validate the hydrodynamic model using the passage of Hurricane Donna, a model simulation was performed using the water surface elevations observed at the NOAA Battery station and the USGS stream gauge data measured at the Little Falls (Figure 4-1). Physical conditions of the Passaic River and land elevations were assumed the same as the calibration runs. While the surge elevation was one of the highest in the records, the river inflow volumes during the Hurricane were about 5,000 cfs, which is approximately the 1.25 year return flow volume for the station. This suggests that no significant upland rainfall events in the upstream LPR drainage basin were associated with the passage of the Hurricane.

The model results show that the maximum surge elevations during Hurricane Donna are in good agreement with the observed data within the LPR (Figure 4-2). The maximum water elevation rises to 2.6 m up to RM 7 and then increases further upstream. The computed water elevation, 2.93 m, at RM 12 matches very well with the observed elevation. As shown in Figure 4-3, the model computed flooded areas in the LPR basin during Hurricane Donna are estimated to be approximately about 945 acres. However, there are no data available to compare to the modeled flooding areas.

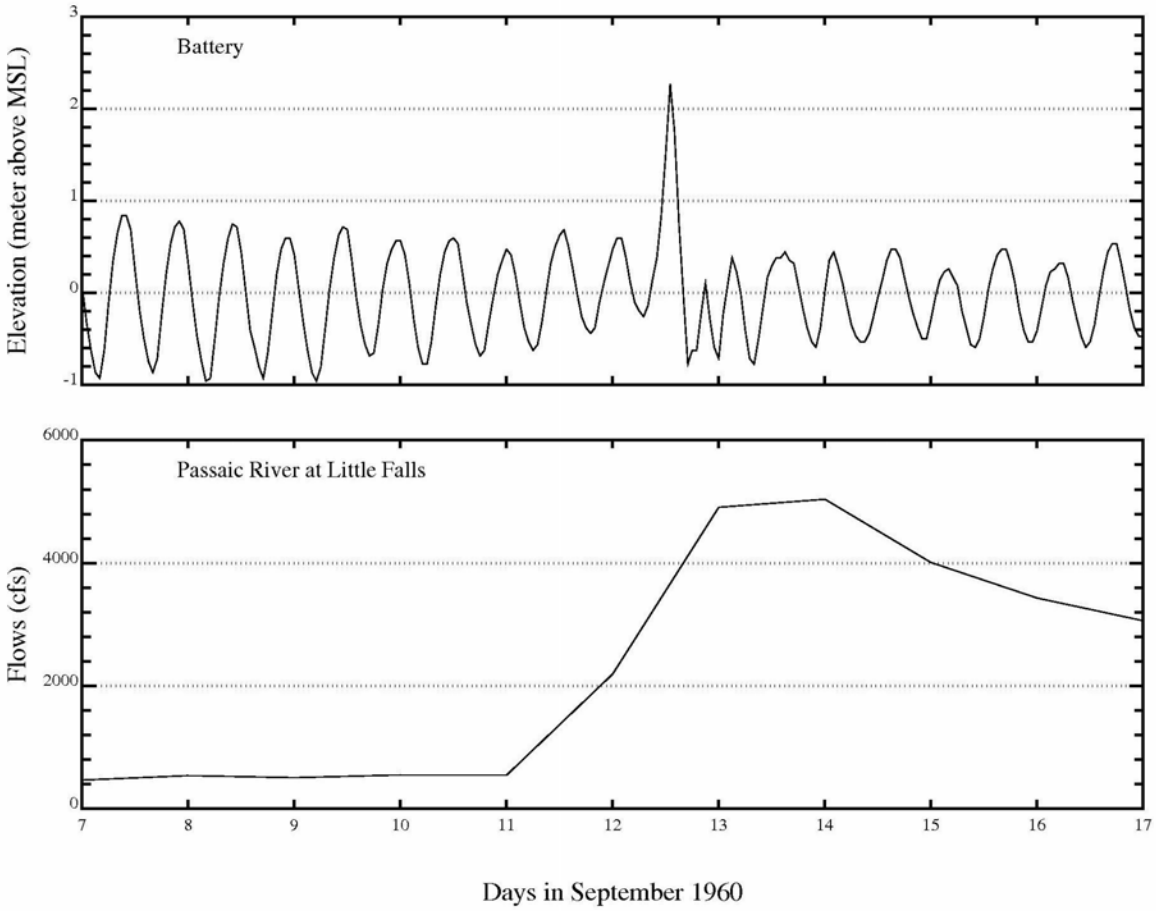

Figure 4-1. Observed water elevation at the Battery (upper frame) and the Passaic River flow at Little Falls (lower frame) during Hurricane Donna.

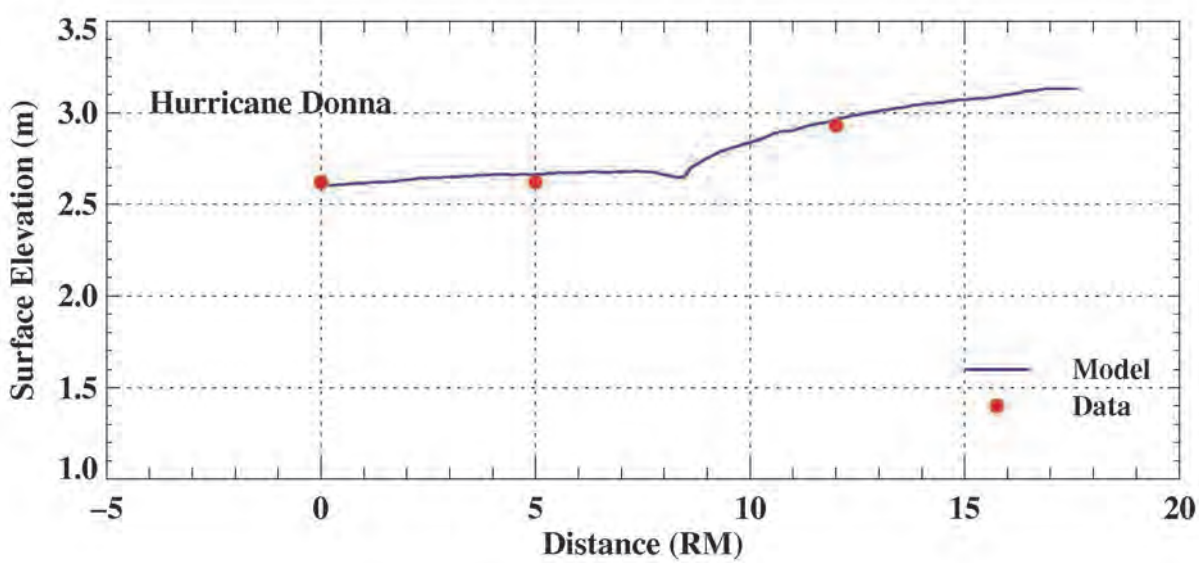

Figure 4-2. Maximum water elevations along the Lower Passaic River during Hurricane Donna.

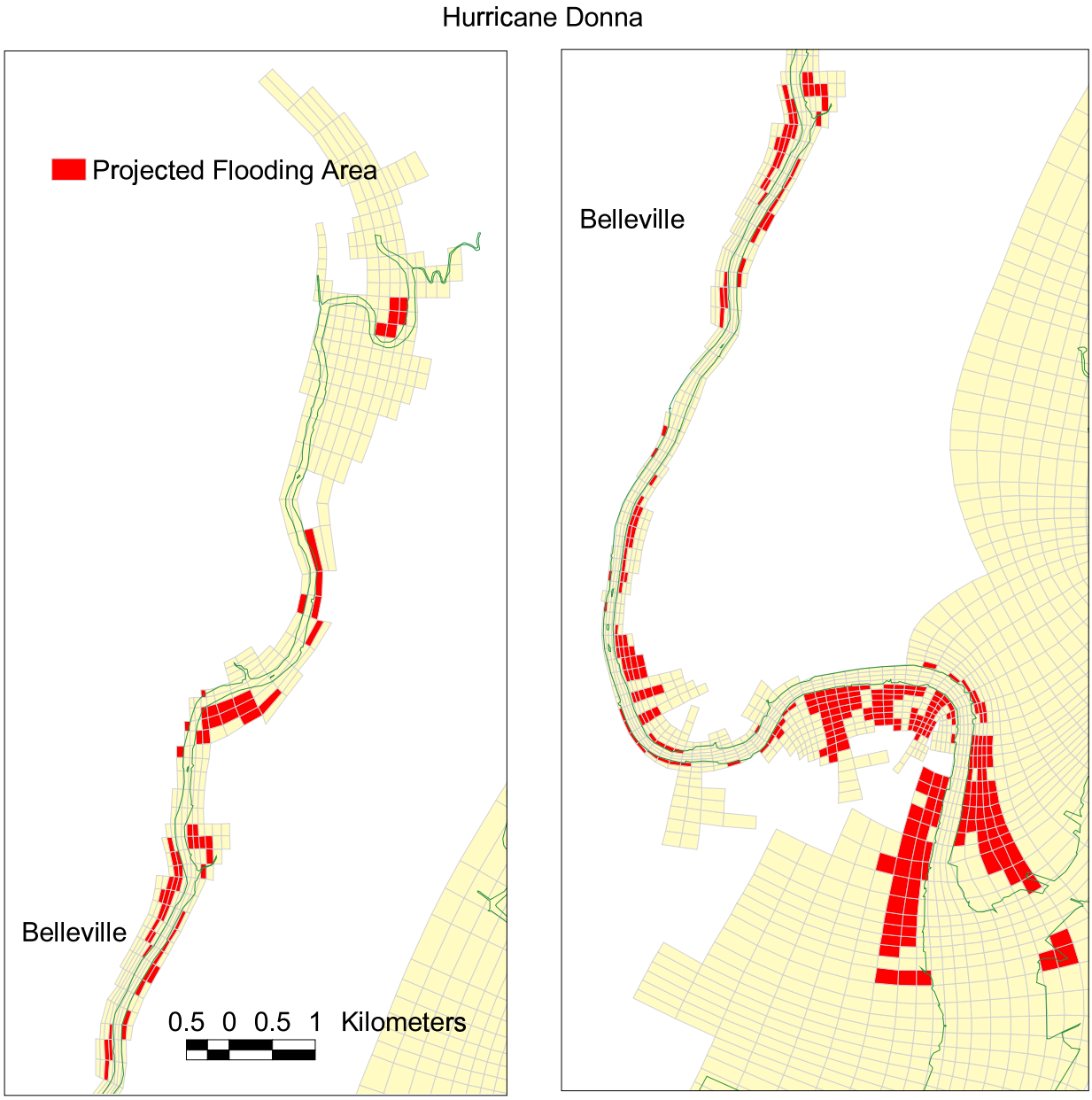

Figure 4-3. Projected flood area during Hurricane Donna.

SECTION 5

SEDIMENT TRANSPORT ANALYSIS OF CAP STABILITY AND EROSION FOR THE LOWER PASSAIC RIVER

5.1 INTRODUCTION

As part of the FFS for the LPR, USEPA is evaluating (among other options) the placement of a sand cap as a remedial alternative to address concerns associated with contaminated sediment in the river. The stability and erosion of the proposed sand capping alternatives were examined using a hydrodynamic and sediment transport model and sediment grain size analyses. Descriptions of the physical setting of the river, elements of cap design, and other aspects of the overall study are presented in the FFS.

5.2 SEDIMENT MODEL FRAMEWORK

Descriptions of the model framework, the grid, and model set-up and parameterization for cap stability and erosion analyses follow.

5.2.1 Model Description and Governing Equations

For the LPR cap stability and erosion analysis, an existing, peer-reviewed sediment transport model (SEDZLJ) (Jones and Lick, 2001) was incorporated into HydroQual's hydrodynamic model framework, ECOMSED (HydroQual, 2004). SEDZLJ uses measured erosion rates for sands obtained from the literature (Roberts et al., 1998) as the basis to compute sediment transport. The incorporation of SEDZLJ into ECOMSED was performed by Dr. Craig Jones (developer of the SEDZLJ computer code) of Sea Engineering, Inc. (SEI). The resulting computer code is termed ECOMSEDZLJ and was peer-reviewed by Dr. Earl Hayter of the USEPA.

The integration of SEDZLJ sediment transport routines into ECOMSED and other related code modifications provided four primary benefits needed to fulfill project goals:

1. Computation of erosion fluxes as a function of measured erosion rates,
2. Division of total erosion fluxes into bedload and suspended load components,
3. Simulation of bedload transport, and
4. Simulation of a user-defined number of particle size classes.

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These code modifications substantially improve the ability of ECOMSEDZLJ to simulate the expected differential transport of sediments and cap materials comprised of particles with a continuum of grain sizes and subject to significant bedload transport.

The governing equations for hydrodynamics, following a system of orthogonal cartesian coordinates (X, Y, Z) and using the hydrostatic pressure assumption (*i.e.* the weight of the fluid identically balances the pressure) and the Boussinesq approximation (*i.e.* density differences are negligible unless the differences are multiplied by gravity), are:

Conservation of Mass (Continuity Equation)

$$\nabla \cdot \vec{V} + \frac{\partial W}{\partial Z} = 0 \tag{5-1}$$

Conservation of Momentum (Reynolds Momentum Equations)

$$\frac{\partial U}{\partial t} + \vec{V} \cdot \nabla U + W \frac{\partial U}{\partial Z} - fV = -\frac{1}{\rho_0}\frac{\partial P}{\partial X} + \frac{\partial}{\partial Z}\left(K_M \frac{\partial U}{\partial Z} \right) + F_X \tag{5-2}$$

$$\frac{\partial V}{\partial t} + \vec{U} \cdot \nabla V + W \frac{\partial V}{\partial Z} + fU = -\frac{1}{\rho_0}\frac{\partial P}{\partial Y} + \frac{\partial}{\partial Z}\left(K_M \frac{\partial V}{\partial Z} \right) + F_Y \tag{5-3}$$

$$\rho g = -\frac{\partial P}{\partial Z} \tag{5-4}$$

where: $\vec{V}$ = horizontal vector operator with velocity components U and V; ∇ = horizontal gradient operator; U, V, W = velocities in the X-, Y-, and Z-direction, respectively; f = Coriolis parameter; ρ, ρ_0 = potential and reference density of the fluid; P = pressure; K_M = vertical eddy diffusivity of turbulent momentum mixing; and F_X, F_Y = horizontal diffusion in the X- and Y-direction, respectively.

The horizontal diffusion terms represent small (sub-grid) scale processes not directly resolved by the model grid and are expressed in a form analogous to molecular diffusion:

$$F_X = \frac{\partial}{\partial X}\left(2A_M \frac{\partial U}{\partial X} \right) + \frac{\partial}{\partial Y}\left[A_M \left(\frac{\partial U}{\partial Y} + \frac{\partial V}{\partial X} \right) \right] \tag{5-5}$$

$$F_Y = \frac{\partial}{\partial Y}\left(2A_M \frac{\partial V}{\partial Y} \right) + \frac{\partial}{\partial X}\left[A_M \left(\frac{\partial U}{\partial Y} + \frac{\partial V}{\partial X} \right) \right] \tag{5-6}$$

where: A_M = horizontal diffusivity.

These equations are transformed for use in a curvilinear, orthogonal, sigma (σ)-level coordinate system as described by HydroQual (2004).

The governing equations for erosion in SEDZLJ (Jones and Lick, 2001) are:

Erosion Rate

$$E(\tau^b) = \left(\frac{\tau_{m+1} - \tau^b}{\tau_{m+1} - \tau_m}\right) E_m + \left(\frac{\tau^b - \tau_m}{\tau_{m+1} - \tau_m}\right) E_{m+1} \tag{5-7}$$

$$\ln E(T) = \left(\frac{T_0 - T}{T_0}\right) \ln E^{L+1} + \left(\frac{T}{T_0}\right) \ln E^{L} \tag{5-8}$$

where: $E(\tau^b)$ = erosion rate as a function of shear stress (τ); τ^b = bottom shear stress; τ_m = shear stress less than τ^b; τ_{m+1} = shear stress greater than τ^b; $E(T)$ = erosion rate as a function of depth in the sediment bed; T = sediment layer thickness; T_0 = initial sediment layer thickness; and the superscript L and $L+1$ denote depths in the sediment profile at the upper and low limits of the eroding sediment layer. Equations 5-7 and 5-8 can be combined to express the erosion rate as a function of both shear stress and depth. The onset of erosion is identified as the critical shear stress for erosion, τ_{ce}, and is defined as the shear stress at which erosion is initiated at a rate of 10^{-4} cm/s.

For non-cohesive particles, the critical shear stress for erosion can be estimated from the particle diameter as:

$$\tau_{ce} = \begin{cases} d & \text{for } d \le 400\,\mu m \\ 4.14d & \text{for } d > 400\,\mu m \end{cases} \tag{5-9}$$

When the shear stress acting on grains comprising the bed exceeds the critical shear stress for a given grain size, particles may be transported as bedload (in a thin layer in contact with the bed) or as suspended load (fully entrained in the water column away from the bed). The governing equations used to fractionate eroded sediments into bedload and suspended load are:

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Non-Cohesive Bedload vs. Suspended Load Fractionation

$$\tau_{cs} = \begin{cases} \dfrac{1}{\rho_w}\left(\dfrac{4w_s}{d_*}\right)^2 & for\ d \le 400\,\mu m \\ \dfrac{1}{\rho_w}(4w_s)^2 & for\ d > 400\,\mu m \end{cases} \tag{5-10}$$

$$f_{SL} = \begin{cases} 0 & for\ \tau^b \le \tau_{ce} \\ \dfrac{\ln(u_*/w_s) - \ln\left(\sqrt{\tau_{cs}/\rho_w}/w_s\right)}{\ln(4) - \ln\left(\sqrt{\tau_{cs}/\rho_w}/w_s\right)} & for\ \tau^b > \tau_{cs} \\ 1 & for\ \dfrac{u_*}{w_s} \le \tau_{cs} \end{cases} \tag{5-11}$$

where: τ_{cs} = critical shear stress for transport as suspended load; w_s = particle fall velocity; d_* = particle dimensionless diameter = $d\left[(\rho_s - 1)g/\nu^2\right]$; d = particle diameter; ρ_s = particle density; f_{SL} = fraction of the total amount eroded that is transported as suspended load; and u_* = shear velocity. The fraction transported as bedload = (1-f_{SL}). Equations 5-10 and 5-11 can be used in conjunction with the particle grain size distribution and critical shear stress for erosion to express the erosion flux of sediment by grain size that is transported by bedload and suspended load as a function of the bottom shear stress.

The bottom shear stress acting on the bed (*i.e.* the total bed shear stress) is a function of the total hydrodynamic roughness and can be expressed in terms of two separate components: (1) form roughness; and (2) grain roughness (*i.e.* skin friction). Individual grains on the surface of the sediment bed are subjected only to the skin friction component of the total bed shear stress. The total bed shear stress is computed from the near-bed hydrodynamic velocities according to the "log law" velocity profile:

$$u(z_b) = \frac{u_{*T}}{\kappa}\ln\left(\frac{z_b}{z_0}\right) \tag{5-12}$$

$$\tau_T = \rho u_{*T}{}^2 = \rho C_d\, u(z_b)^2 \tag{5-13}$$

$$C_d = \left(\frac{\kappa}{\ln \frac{z_b}{z_0}} \right)^2 \tag{5-14}$$

where: $u(z_0)$ = near-bed flow velocity, u_{*T} = near-bed shear (friction) velocity; κ = von Karman constant = 0.4, z_b = height of the near-bed layer above the bed surface; and z_0 = bed roughness height; τ_T = total bed shear stress; ρ = density of the fluid; and C_d = coefficient of drag. In the sigma layer coordinate system of the hydrodynamic model, z_b is height above the bed at the mid-point of the bottom sigma layer.

The shear stress component associated with skin friction can be computed as a function of the total bed shear stress as follows (Grant and Madsen, 1982; Glenn and Grant, 1987):

$$u_{*S} = u_{*T} \left(\frac{\ln \frac{z_b}{z_0}}{\ln \frac{z_b}{z_{0S}}} \right) \tag{5-15}$$

$$\tau_S = \rho u_{*S}{}^2 \tag{5-16}$$

where: u_{*S} = the near-bed shear velocity attributable to skin friction; and z_{OS}= the roughness height of particles comprising the bed surface; τ_S = the skin friction shear stress.

As part of the model development process, SEI and HydroQual verified that the SEDZLJ code was properly implemented in ECOMSED by simulating and successfully reproducing the laboratory results of Little and Mayer (1972). The results of these numerical tests are presented in Attachment A. As an additional quality assurance measure, simulations were also conducted using a truncated curvilinear grid for the LPR from RM 0 to RM 12 to ensure that the enhanced transport computations within ECOMSEDZLJ code properly conserved mass. These tests both indicated that the model code functions properly.

5.2.2 Model Set-up and Parameterization

The full model grid for the cap erosion study is shown in Figure 5-1. For reference, land surface elevations relative to the National Geodetic Vertical Datum (NGVD) 1929 are also shown in Figures 2-1 and 2-2. This grid is identical to the grid described in Section 2 of this memorandum. Although the focus of the cap erosion study is the LPR, the full grid includes the Hackensack River and Newark Bay as needed to account for tides and other flow conditions that impact the river. Model depths for the river were based on surveys compiled by the USACE as described in Section 2. The model accounts for the wetting and drying of grid cells as needed to account for changing water surface elevations that occur as a result of fluctuating tidal conditions. This is a necessary aspect of model formulation because there are several shallow locations in the Passaic River where grid cells representing portions of the river bed can become exposed (*i.e.*, dry) during low points in the tidal cycle.

The computational domain consists of 68×170 grid cells in the horizontal plane and 11 equally spaced σ-levels in the vertical plane (*i.e.*, 10 vertical segments). The model open boundaries are located at the entrance to Kill van Kull from New York Harbor and the entrance to Arthur Kill from Raritan Bay at South Amboy. Throughout the remainder of this section, the visual display and descriptions of model results focus on the LPR from RM 0 to RM 8.3.

It is important to note that boat wake and wind-induced waves were not considered in this analysis. With respect to boat wakes, Dr. Craig Jones (pers. comm.) suggested that boat wake or propeller wash effects would largely act to "mix" the capping material locally, since it would be unlikely that a boat (or boats) would follow the exact same path within the river time after time. With respect to wind-induced waves, due to the narrowness of the river and due to the meandering nature of the river it is unlikely that significant wind-waves could develop.

5.2.3 Description of Modeling Scenarios

Simulations were conducted to explore the stability and erosion of a sand cap in response to flow events of different magnitude. For these analyses, Passaic River flow records from the USGS Little Falls gauging station for the period 1891 through 2005 were analyzed to determine return flows, including flood conditions, of different recurrence intervals. The drainage area at the Little Falls gage (780 square miles) accounts for 77% of the total Passaic River basin (1,013 square miles). To compute total flows for the entire basin, the flows at Little Falls were multiplied by a factor of 1.3 to account for the portion of the drainage basin below Little Falls and to represent the flow at the river mouth. For this study, total basin flows were specified as inputs at Dundee Dam (RM 17) to simplify model set-up. This is a reasonable approach since nearly all of the remaining tributary inputs to the river

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(Saddle River, Third River, etc.) occur near or above the upstream limit of the cap area and direct drainage is expected to be small. This also represents a worst case for the stability analysis because the entire flow through the system occurs along the entire length of the capped area. The return flows used for this study, based on a statistical analysis (log – normal recurrence internal) of daily flow data, are summarized in Table 5-1. Further details of the return flow analysis are provided in Section 6.1.1 of this memorandum. The one-month, six-month and one-year return flows were estimated separately. This was accomplished by analyzing probability of occurrence using the recent 20 years of monthly peak flows at Little Falls. The one-month return flow was estimated as the 50th percentile, the six-month return flow as the 83.3th percentile and the one-year return flow as the 91.7th percentile, which yielded 5,060 and 5,840, and 8,050 cfs, respectively, when corrected for the below Little Falls drainage area.

Table 5-1. Lower Passaic River Return Flows for Cap Stability and Erosion Analysis

Return Period	***Flow (cfs)***	
	Little Falls	*River Mouth*
1-month	3,900	5,060
6-month	4,500	5,840
1-year	6,200	8,050
2-year	6,751	8,767
5-year	9,968	12,945
10-year	12,219	15,869
25-year	15,280	19,844
50-year	17,465	22,681
100-year	19,808	25,725

The erosion and stability of two basic capping scenarios were evaluated in the study:

1. Placement of a two foot thick sand cap across entire bed of the LPR from RM 0 to RM 8.3 (Figure 5-2), and
2. Placement of armor stone on selected model cells to protect the cap and reduce the potential for erosion. The armored areas were pre-dredged to a depth of 2 feet before 2 feet of sand and 2 feet of armor (rock cobble) are put in place. (Figure 5-2).

For scenarios that include cap placement only (no armor), the placement of the cap on the bed reduces river depths (increases bed elevations) by two feet throughout the capped area. For armor placement scenarios, it was assumed that pre-dredging would be conducted

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such that bed elevations in armored areas would be reduced by the specified thickness of the armor layer prior to armor placement such that bed elevations after armoring would be no greater than for the sand cap alone.

For each of these scenarios, two types of sands were evaluated as cap materials: (1) Ambrose Sand (AS) (d_{50} = 386 μm); and (2) Upland Borrow Sand (UBS) (d_{50} = 1,441 μm). Grain size distributions for these materials and corresponding particle size classes used in ECOMSEDZLJ are presented in Tables 5-2. To best represent the spectrum of particles comprising the capping sands in the model, AS was simulated as four size classes and UBS was simulated as five size classes. The armor stone was considered to be non-erodible under the flow conditions simulated (*i,e.* 6-inch angular rock). All design aspects of cap placement, thickness, the types of sand evaluated, and sizing of armor stone were specified in the FFS.

Table 5-2. Characteristics of Capping Materials

Property	*Size Class*				
	1	2	3	4	5
Ambrose Sand					
d_p (μm)	125	222	1,020	3,360	N/A
Composition By Weight (%)	10	80	6	4	N/A
τ_{ce} (dynes/cm^2)	1.2	1.7	5.4	25	N/A
w_s (cm/s)	0.9	2.3	11.3	25	N/A
τ_{cs} (dynes/cm^2)	1.2	2.4	16.8	81	N/A
Upland Barrow Sand					
d_p (μm)	150	300	1180	2360	4750
Composition By Weight (%)	5	25	35	30	5
τ_{ce} (dynes/cm^2)	1.6	1.9	6.5	16	39.4
w_s (cm/s)	1.2	3.4	12.6	20	30
τ_{cs} (dynes/cm^2)	1.6	2.8	21	53.4	121

For each size class simulated, the particle diameter given is the mean particle diameter of the grains in that class. As a rule of thumb, the largest size class is chosen as the largest size for which more than 2-3% of the mass is retained on a sieve. Similarly, the smallest size class can be chosen as the smallest size for which 2-3% of the mass is retained on the smallest sand-sized sieve. For AS, the grain size distribution is comparatively narrow with 80% of the distribution having a diameter of 222 μm and the entire distribution could be represented with four size classes. For the UBS, the size distribution was less well sorted, with up to 5% of the distribution in the range of 4,750 μm. Consequently, the UBS was

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represented as five size classes. Additionally, since a wider size range occurs in the upland sand, an additional size class is needed to more accurately simulate the expected coarsening of the bed that would occur over time.

Four river depth conditions were also explored as part of the analysis: (1) 8-mile Cap – Armor Area Pre-dredging Scenario: the bottom of the LPR capped from RM 0 to RM 8.3, with two feet of pre-dredging in armored areas, resulting in post-remediation depths two feet above pre-remediation bathymetry; (2) 8-mile Cap – Full Pre-dredging Scenario: the bottom of the LPR pre-dredged two to four feet from RM 0 to RM 8.3 prior to cap placement, resulting in post-remediation depths at the same elevation as pre-remediation bathymetry; (3) Current Navigation Usage – Full Pre-dredging Scenario: the bottom of the LPR pre-dredged from RM 0 to RM 8.3 prior to cap placement with a 21-31 ft navigation channel between RM 0 and RM 2.5; and (4) Future Navigation Usage – Full Pre-dredging Scenario: the bottom of the LPR pre-dredged from RM 0 to RM 8.3 prior to cap placement with a 15-31 ft navigation channel between RM 0 and RM 8.3. For both navigation usages, present depths were applied outside of the pre-dredged areas.

Tables which summarize the navigation channel depths and corresponding modeled depths for the Current Navigation Usage and Future Navigation Usage scenarios are included as Tables 5-3 and 5-4, respectively. The depth modeled corresponds to the approximate depth of the top of the cap or backfill. Further discussion on how the top of cap or backfill is determined can be found in the FFS.

Table 5-3. Relationship between Proposed Navigation Channel Depth and Modeled Depth – Current Navigation Usage (Unit: feet, MLW)

Location	Constructed Depth	Proposed Depth	Treatment in Navigation Channel	Modeled Depth for Future Use
RM 0-RM 1.2	30	30	Backfill	31
RM 1.2-RM 2.5	30	16	Cap	21
RM 2.5-RM 8.3	20	Existing Bathymetry	Cap	Existing Bathymetry

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Table 5-4. Relationship between Proposed Navigation Channel Depth and Modeled Depth – Future Navigation Usage (Unit: feet, MLW)

Location	Constructed Depth	Future Use Depth	Treatment in Navigation Channel	Modeled Depth for Future Use
RM 0-RM 1.2	30	30	Backfill	31
RM 1.2-RM 2.5	30	16	Cap	21
RM 2.5-RM 3.6	20	16	Backfill	21
RM 3.6-RM 4.6	20	10	Cap	15
RM 4.6-RM 8.1	16	10	Backfill	17
RM 8.1-RM 8.3	10	10	Backfill	11

Major high flow hydrographs observed between 1891 and 2005 at the USGS Little Falls gauging station were reviewed for the shape and duration of each flow event. Most of high flow events recorded at the Little Falls station were less than five days in duration. The high flow event observed in April 1984, with a peak flow of 18,400 cfs, was selected for this study. This is the highest flow event recorded at Little Falls in recent decades. The peak of each flow event was coupled with the peak spring tide at the open boundaries, based on astronomical harmonic tidal constituents obtained from NOAA. For the AS capping, 10-day simulations were conducted for the 1-year, 25-year and 100-year return flow events and for the UBS capping, 10-day simulations were conducted for each of the nine identified return flow events. For the combination of UBS capping, armoring, and river depth conditions, 10-day simulations were conducted with the 100-year return flow event. Hydrographs for each return flow were constructed by scaling the April 1984 flow curve by the ratio of peak flows. All hydrographs have the same shape and consist of the following: ramp-up from a zero initial velocity condition (days 1-2), rising limb (days 3-5), peak (day 5), and falling limb (days 5-10).

To represent sand in capped areas, the bottom roughness height used in the model is the same as determined during the prior hydrodynamic model calibration (Z_0 = 0.001 m). To represent the expected additional roughness and flow resistance caused by large, angular stone, the bottom roughness height in armored areas (on a cell by cell basis in the model) was increased by a factor of 10 (Z_0 = 0.01 m).

Erosion characteristics (τ_{ce}) for sands were determined based on the measurements of Roberts et al. (1998). Fall velocities (w_s) for each particle type simulated were determined from the formula of Cheng (1997). Similarly, the critical shear stress for transport as

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suspended load (τ_{cs}) was determined from fall velocity and particle diameter as described from Equation (5-9) following the method of van Rijn (1984). A summary of these parameters is also presented in Table 5-2.

5.3 MODEL APPLICATION AND RESULTS

Computer simulations of hydrodynamics and cap sand sediment transport for the LPR were performed. Simulations were conducted across a range of flow events for combinations of sand cap materials, armor stone, and channel depth conditions. Results of the ECOMSEDZLJ model application to the study area are described below.

5.3.1 Cap Stability and Erosion Analysis: Ambrose Channel Sand

ECOMSEDZLJ was used to examine the response of sands taken from the Ambrose Channel, located at just outside the mouth of New York/New Jersey Harbor, and placed on the river bed. The model was set to run four non-cohesive particle size classes as defined in Table 5-2. Ten-day simulations were set up and conducted for three return flow events. Results for all simulations were summarized for the river bed from RM 0 to RM 8.3 in terms of the cross-river averaged net bed elevation change at the end of the simulation, the maximum bed erosion computed during the simulation period and bottom shear stress as presented in Figure 5-3. Bottom shear stresses discussed in this section refer to the "skin friction" component of the total bottom shear stress. Results for each of the three individual events showing net bed elevation change, the maximum bed erosion and bottom shear stress for each model cell are presented in Attachment B. Figure 5-4 displays the horizontal distributions of the maximum bed erosion for the 1-year and 25-year flow events. In this sequence of figures, blue shaded areas indicate net deposition while red shaded areas indicate net erosion. It should be noted that in some locations it is possible that bed erosion could occur initially as the smaller sand particle size classes are eroded but later these areas show a net increase in bed elevation from the relocation of upstream sand particles.

The model results in Figures 5-3 and 5-4 indicate that excessive transport and net erosion of an Ambrose Sand cap can be expected. At some locations along the river, nearly the entire thickness of the cap (2-feet) could be eroded by a 25-year event. Around RM 5.5, even a 1-year event has the potential to erode approximately 1-foot (~30 cm) of the sand cap.

Bottom shear stresses vary by position along the river as well as with freshwater and tidal conditions. Note that the maximum cross-sectionally-averaged bottom shear stress is greater than 40 dynes/cm^2 for the 100-year flow condition (Figure 5-3). This is substantially larger than the critical shear stress for erosion of even the largest particles used in the AS grain size distribution (maximum τ_{ce} = 25 dynes/cm^2).

These results indicate that fine to medium sand capping materials such as AS will not be stable unless substantial areas of the cap are also protected with armor stone. In this case, the extent of erosion was judged to be so severe and so extensive that no further simulations using AS as a cap material were attempted.

5.3.2 Cap Stability and Erosion Analysis: Upland Borrow Sand

ECOMSEDZLJ was also used to examine the response of UBS placed on the river bed. Similar to the AS capping scenarios, ten-day simulations were set up and conducted for each of the nine return flow events. Results for all simulations were summarized for the river bed from RM 0 to RM 8.3 in terms of the cross-river averaged net bed elevation change at the end of the simulation, the maximum bed erosion during the simulation, and the bottom shear stress as presented in Figure 5-5. UBS was divided into five grain size classes for use in the sediment transport model. The size classes and initial distributions for each capping segment were assigned as presented in Table 5-2. Results for each of the nine individual events showing net bed elevation change, maximum bed erosion, and bottom shear stress for each model cell are presented in Attachment C. In this sequence of figures, blue shaded areas again indicate net deposition and red shaded areas indicate net erosion.

Because it contains an appreciable fraction of very coarse sand and very fine gravel, the UBS is subject to less erosion and generally is expected to be more stable than AS. To further illustrate the erosion characteristics of the borrow sand, 10 representative locations along the river, as identified in Figure 5-6, were examined in more detail. Bed elevation change (BEC) and bottom shear stress (BSS) over time are shown for each of these locations in Figure 5-7. Each location was represented by a single grid cell rather than the cross-river averages presented in Figure 5-5. The cells at RM 3.06, 3.48, 3.80, 5.30 and 6.47 are located in the deep channel and at RM 1.74, 2.52, 4.56 and 6.06 are located on the side channel of the river. Basically the cells in the mid-channel correspond to higher bottom shear stress and, therefore, higher rates of erosion. The results presented in Figure 5-7 and Attachment C also indicate that in most locations, for most flow conditions, bottom shear stresses typically do not exceed the critical shear stress for erosion of the largest grain size (4,750 μm, τ_{ce} = 39.4 dynes/cm^2). However, for larger events (25-year and larger) more than 10 cm of erosion can occur at some of the locations in the capped region.

Although the very coarse sand and very fine gravel components of the UBS provide some measure of stability for the cap, at a small number of high bottom shear stress locations more severe erosion is expected. For example, for events with a 50-year or longer return interval, almost one foot (~30 cm) of the cap is still expected to erode at several locations around RM 3, RM 5 and RM 8.

To address areas with more severe erosion (*i.e.*, more than one inch (2.54 cm) of erosion for any flow event), a further series of simulations was conducted to examine the effectiveness of placement of protective armor stone over the sand cap. Based on a review of the locations subject to one inch or more erosion, areas for armor stone placement and protection were identified as presented in Figure 5-2. For these armoring simulations, 140, 104, 101 and 42 individual cells on the model grids were armored for the 8-mile Cap – Armor Area Pre-dredging, the 8-mile Cap – Full Pre-dredging, the Current Navigation Usage - Full Pre-dredging and the Future Navigation Usage - Full Pre-dredging, respectively. The navigation channel restoration areas are presented in Figure 5-8.

Armored cells were assumed to be non-erodible. To account for the expected increase in roughness and flow resistance caused by the placement of large, angular stone, the bottom roughness height (Z_0) in armored cells was increased by a factor of 10 from 0.001 to 0.01 m. To represent a worst case scenario, simulations were conducted using the UBS for the 100-year return flow under four scenarios, with and without armoring. Cross-river averaged net bed elevation change, maximum bed erosion, and maximum bottom shear stresses are presented in Figure 5-9. Net bed elevation change, maximum erosion and bottom shear stress for each scenario (capping only and capping/pre-dredging, and two capping scenarios plus armoring for the existing depth and similarly for navigation channel restoration) are presented in Attachment D. For capping scenarios, navigation channel restorations, especially the future navigation usage, significantly reduce cap erosion between RM 0 and 8.3. For capping plus armoring scenarios, armoring greatly reduces cap erosion regardless of channel depth configuration (*i.e.* with or without navigation channel restorations). To obtain the final armored cells, iterative simulations were conducted. For each iteration, HydroQual provided the maximum erosion values for each grid cell to Malcolm Pirnie, Inc. (MPI). Then, MPI identified the grid cells to be armored and a new simulation was conducted with the adjustment of armored areas. This procedure was repeated until no sand capped cells were found eroding more than 1 inch (2.54 cm) after the 10-day simulation for the 100-year return flow under the four different scenarios.

5.4 DISCUSSION

The model results indicate that severe erosion is expected for a cap composed of AS. Even under low to moderate flows such as the 1-year return flow event, approximately 10 cm of the cap could erode in areas that experience high bottom shear stresses. Over time, a sequence of small events could lead to significant cap loss. For high flow conditions and in certain locations, the entire depth of the cap could be eroded in a single event. This high potential for erosion is a reflection of the small median particle diameter (222 μm) and narrow range of grain sizes comprising this material.

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In contrast, the UBS is expected to be far more stable under typical flow conditions in the Passaic River. Although significant erosion may still occur along some areas of the bed, the depth of maximum erosion is expected to be much lower than for the AS. This decreased erosion potential is a reflection of the larger mean particle diameter (1,440 μm) and broad range of grain sizes comprising this material, including very coarse sand and very fine gravel. However, along high shear stress areas of the bed, even UBS could be subject to significant erosion.

The placement of armor stone in high shear stress areas of the bed is expected to greatly increase the stability of the cap. Such armoring is expected to improve cap stability regardless of channel depth configuration. With armor, the maximum erosion was found to be less than 1 inch (2.54 cm) for the 100-year return flow.

It is worth noting that cap stability may be influenced by smaller, more frequent events as well as for larger storms. A series of smaller to moderate events may collectively contribute to more substantial erosion than any single event. This suggests that the placement of protective armor may be a necessary component of cap design for the LPR even if large events were not considered.

It should also be noted that the analysis conducted herein does not include consideration of any sands (non-cohesive) and cohesive solids that might enter the LPR system at the Dundee Dam or from rainfall related runoff from the drainage area below the Dundee Dam. Hence, the cap erosion results presented in this memorandum may be considered to be conservative in nature.

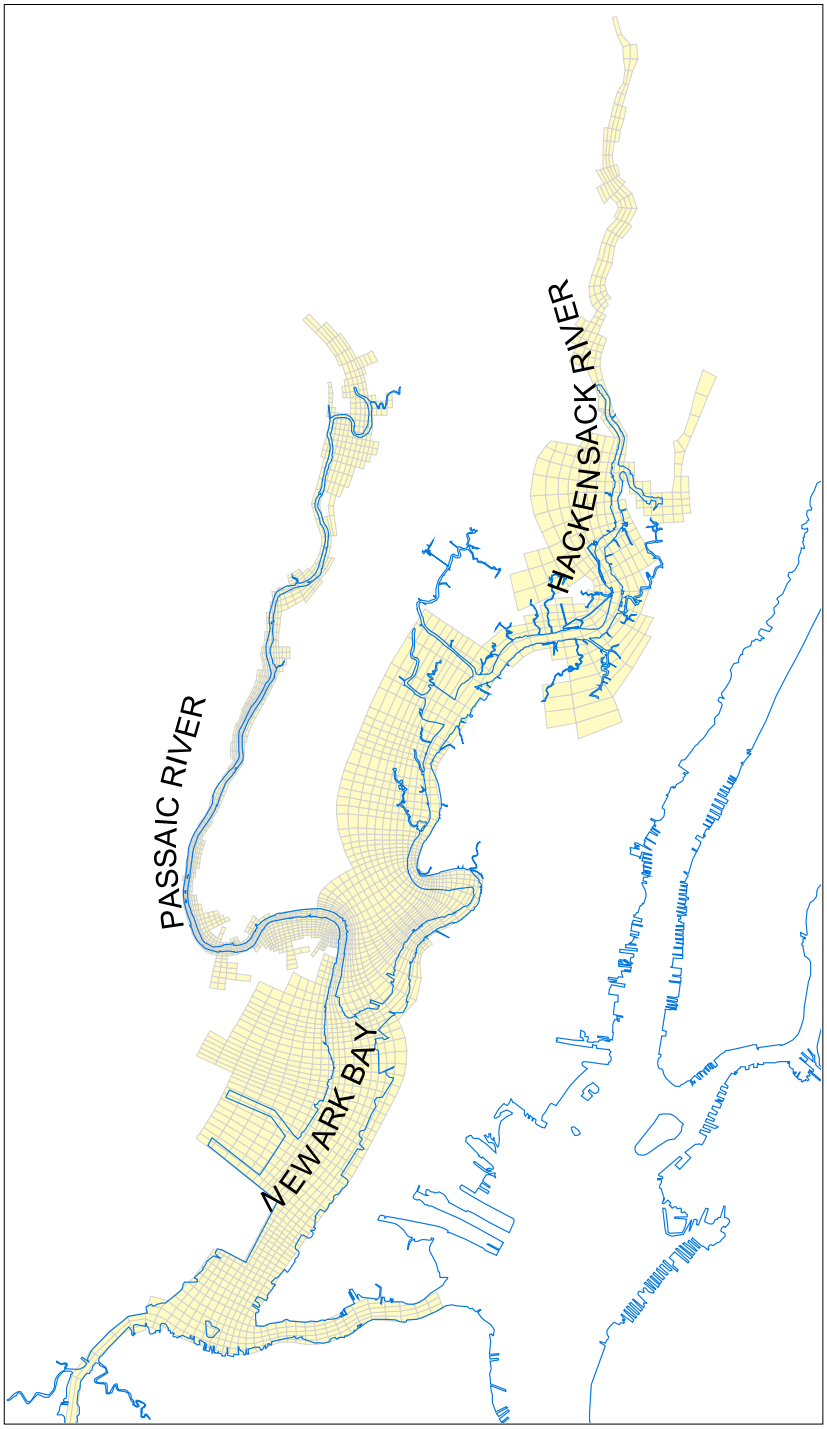

Figure 5-1. Study area of the Lower Passaic River, the Hackensack River and Newark Bay with the orthogonal curvilinear model grid.

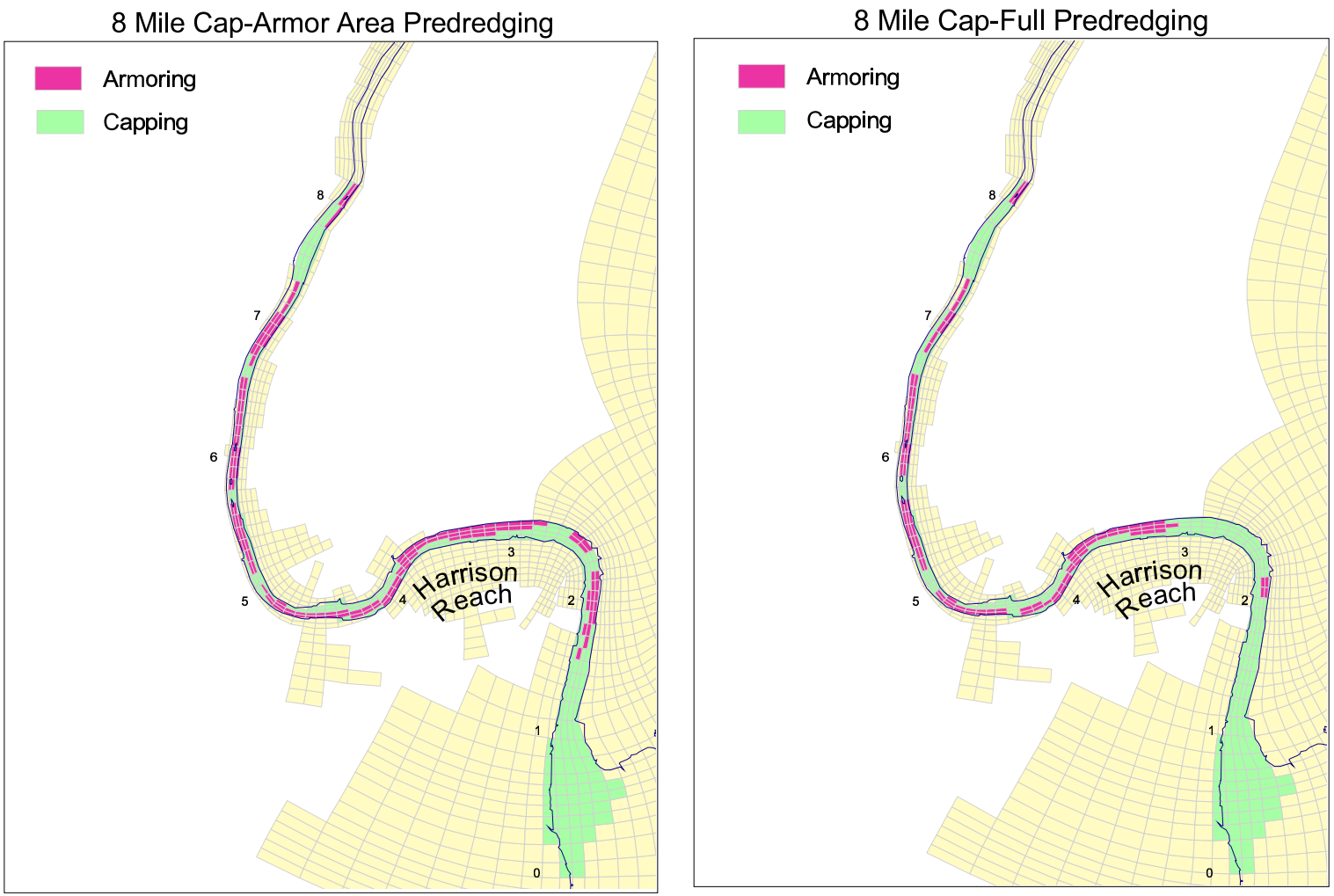

Figure 5-2. Capped and armored areas between RM 0 and RM 8.3 for different simulation scenarios.

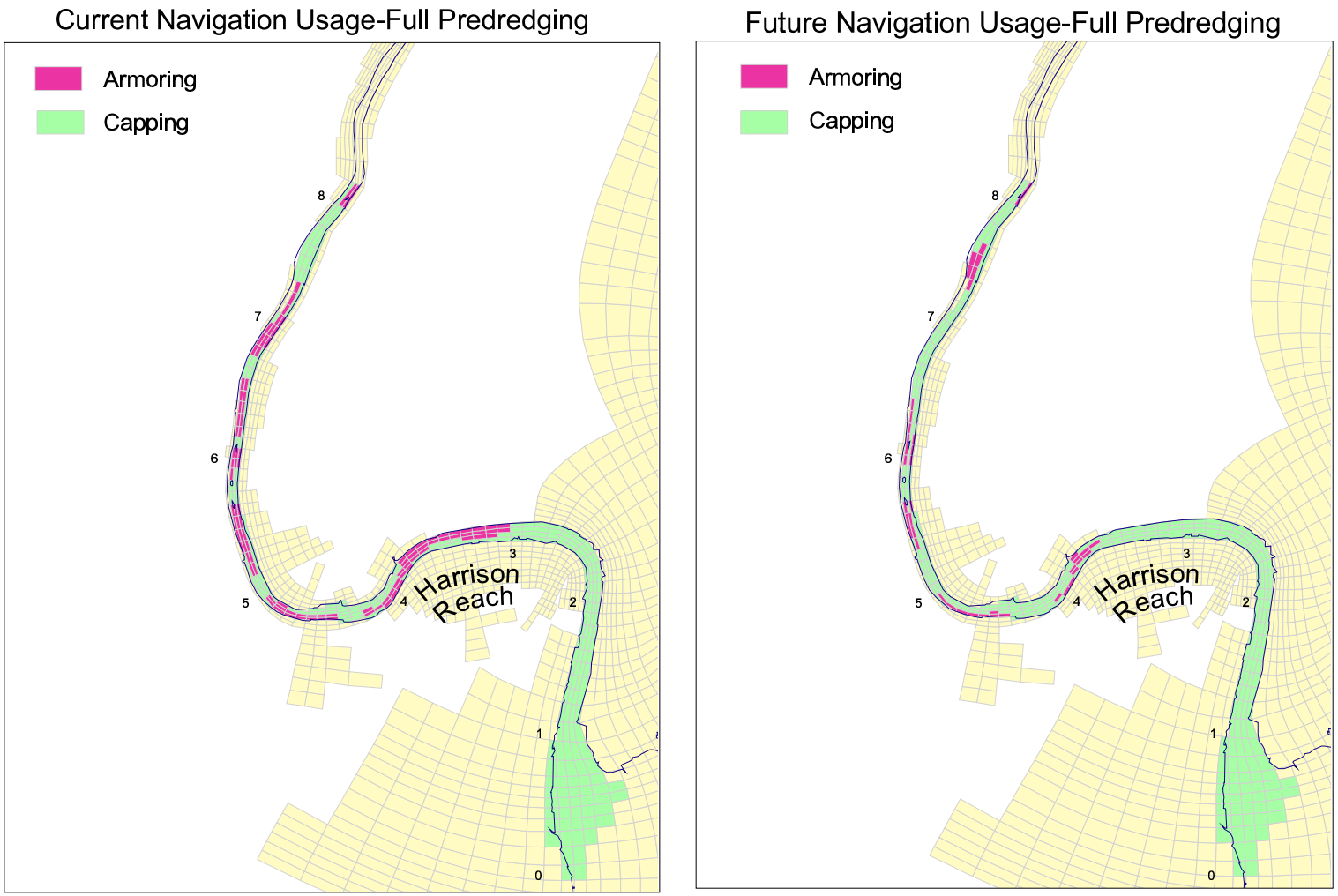

Figure 5-2. Capped and armored areas between RM 0 and RM 8.3 for different simulation scenarios (continued).

Figure 5-3. Cross-river average net bed elevation change, the maximum erosion and bottom shear stress along the river under the 1-year, 25-year and 100-year return flow conditions at the end of each simulation (Ambrose sand used as the capping material).

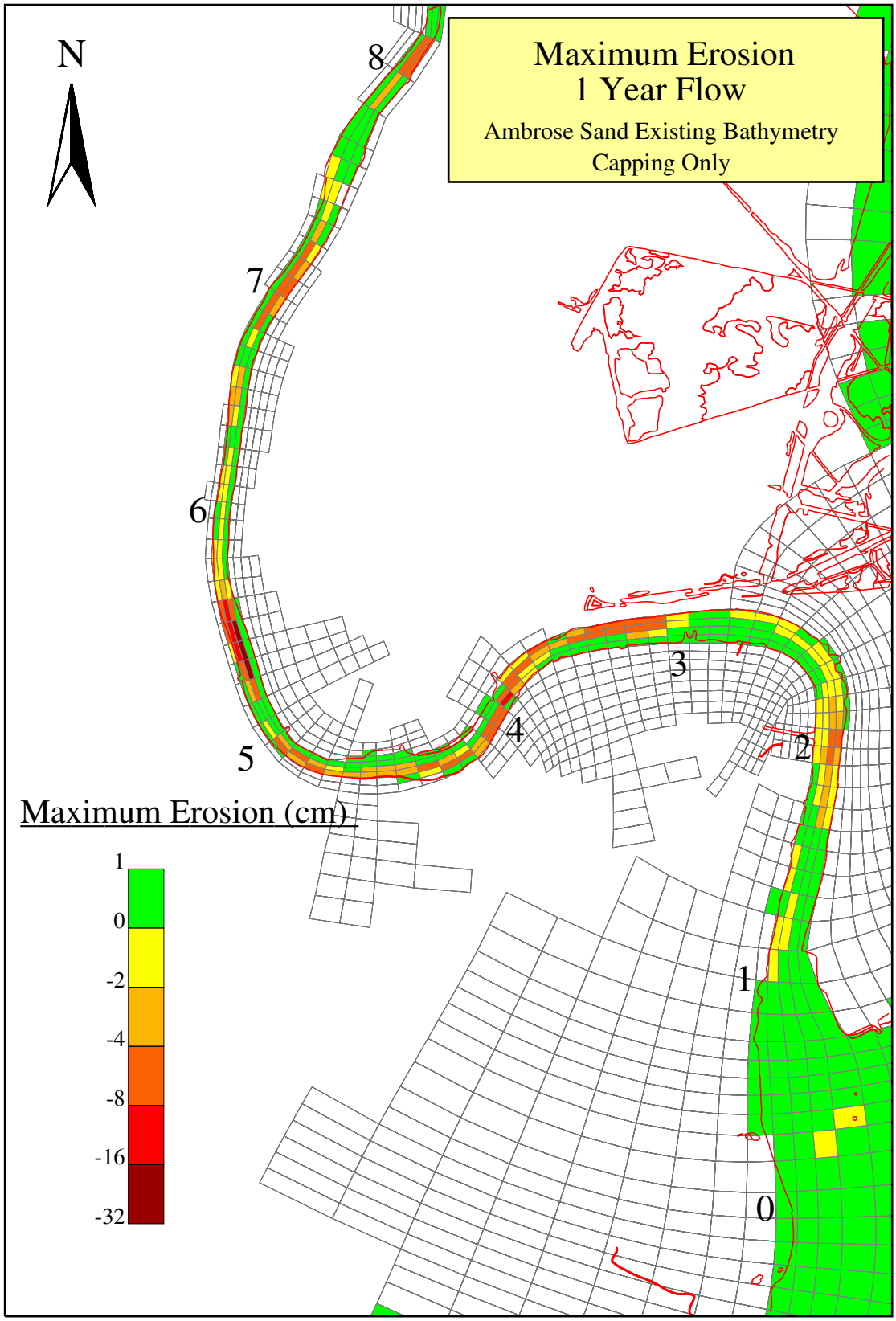

Figure 5-4a. Plan view of the maximum erosion under the 1-year return flow conditions (Ambrose sand used as the capping material).

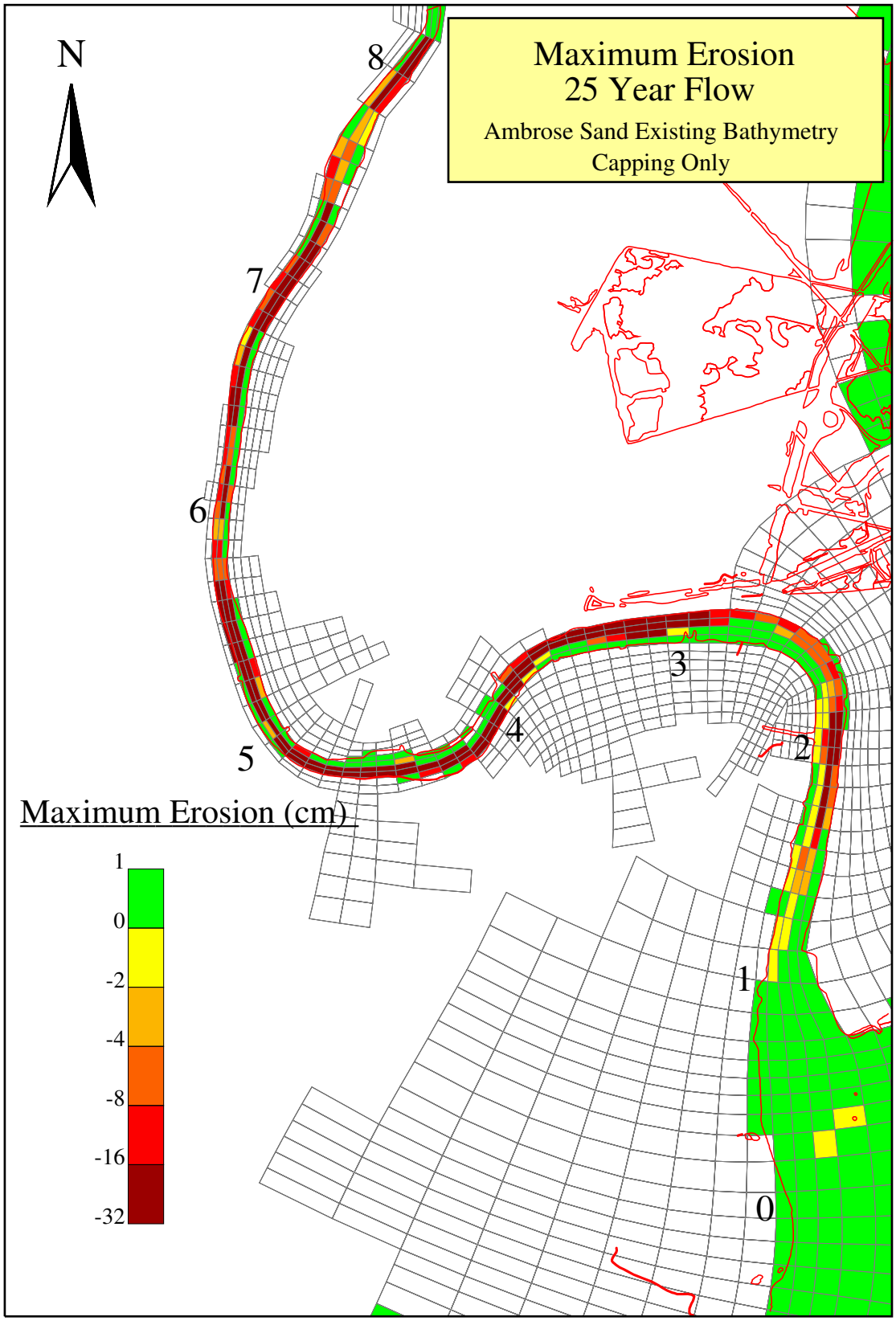

Figure 5-4b. Plan view of the maximum erosion under the 25-year return flow conditions (Ambrose sand used as the capping material).

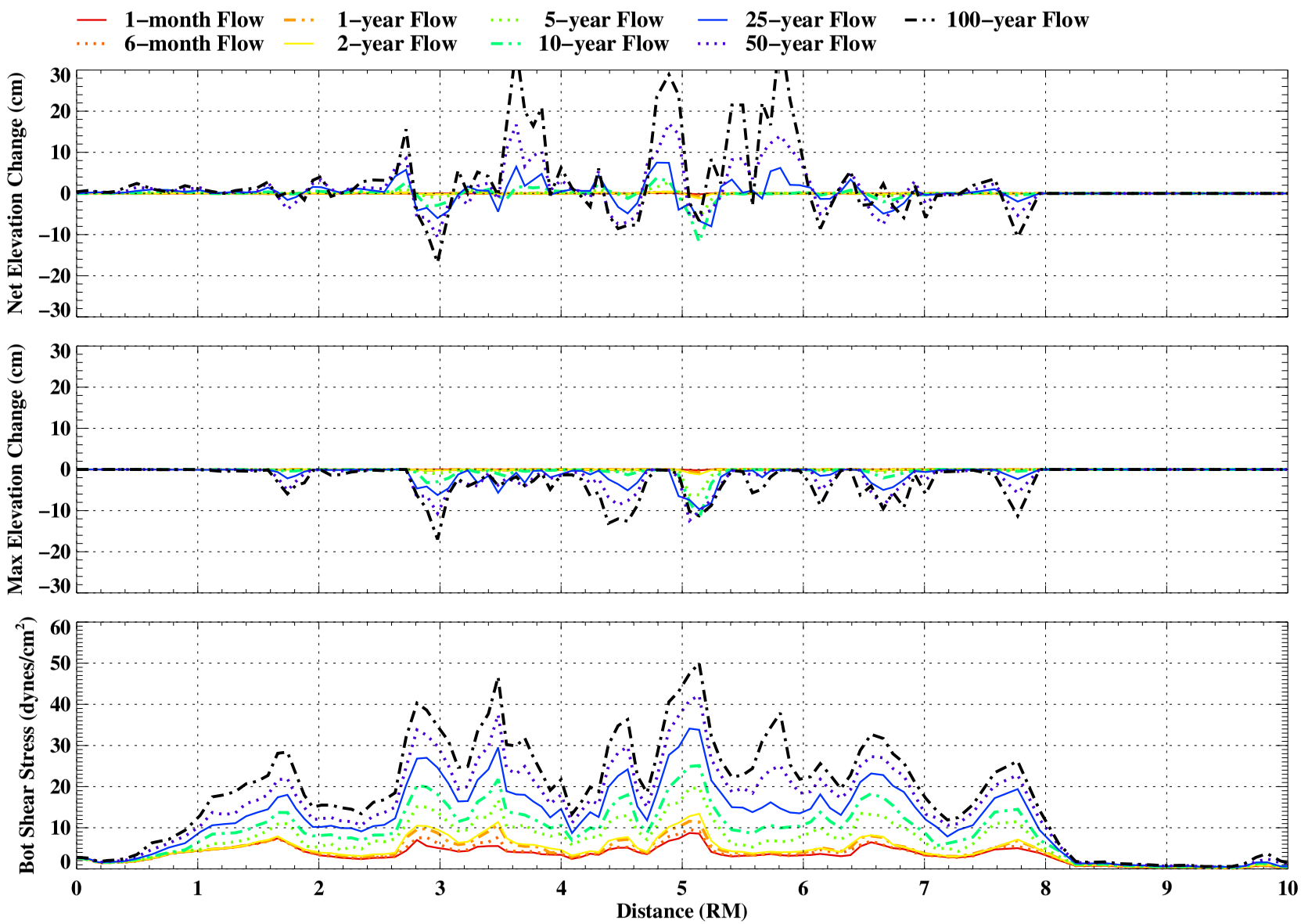

Figure 5-5. Cross-river average net bed elevation change, the maximum erosion and bottom shear stress along the river under the 1-month, 6-month, 1-year, 2-year, 5-year, 10-year, 25-year, 50-year and 100-year return flow conditions at the end of each simulation (Upland borrow sand used as the capping material).

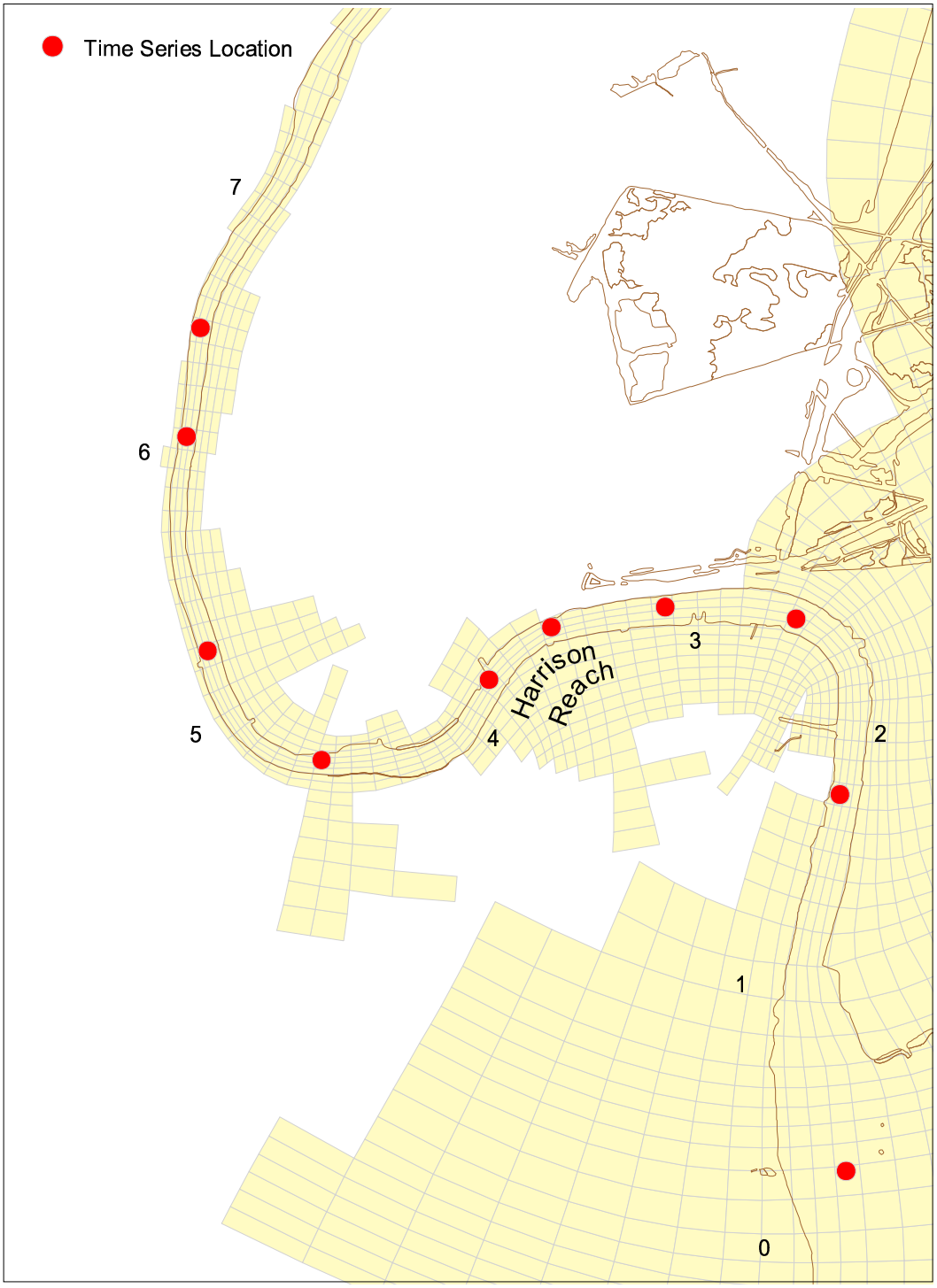

Figure 5-6. Map showing 10 selected locations along the river, where time-series are presented.

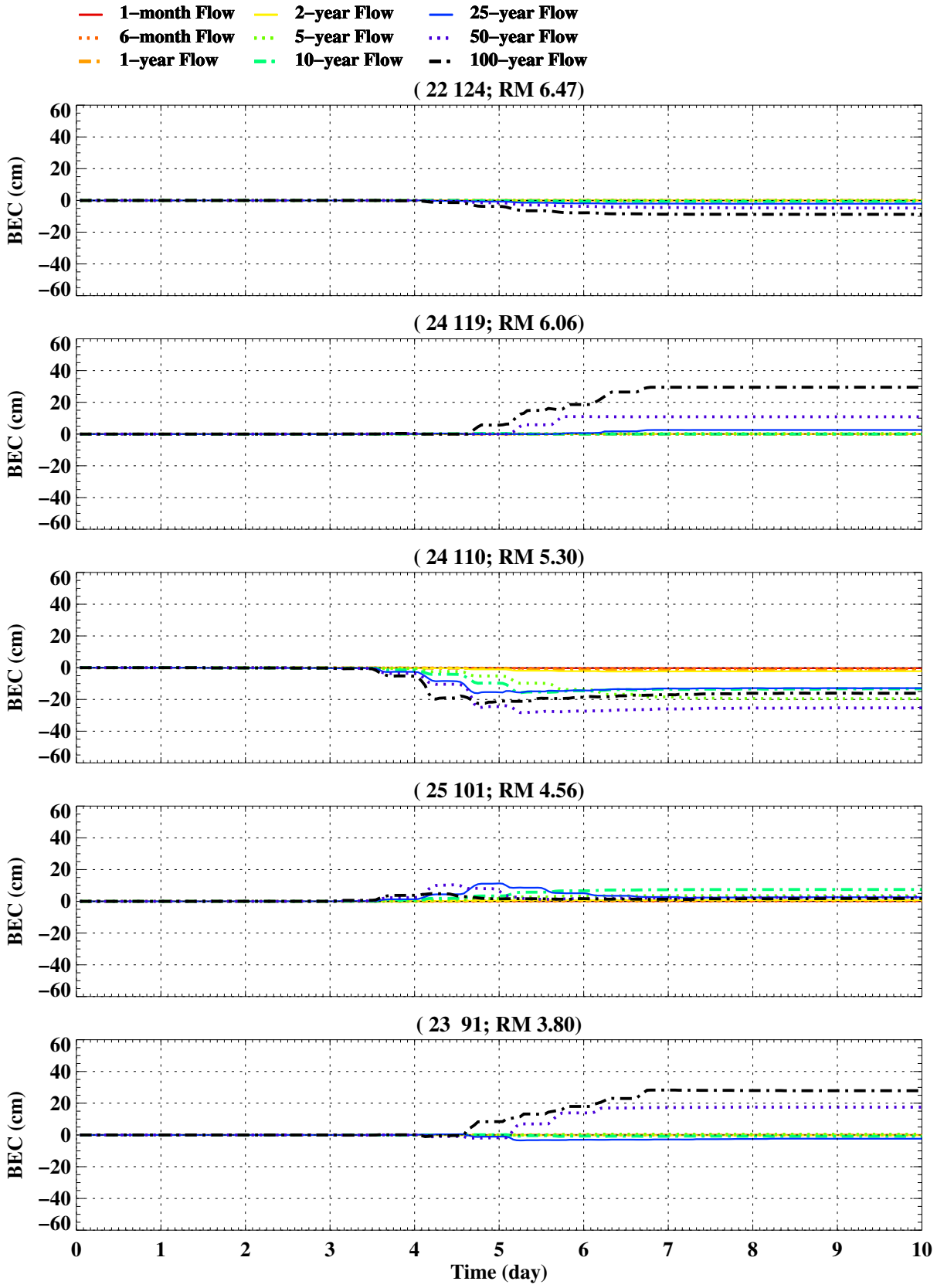

Figure 5-7. Time-series of bed elevation change (BEC) and bottom shear stress (BSS) at the 10 selected locations along the river (Upland borrow sand used as the capping material).

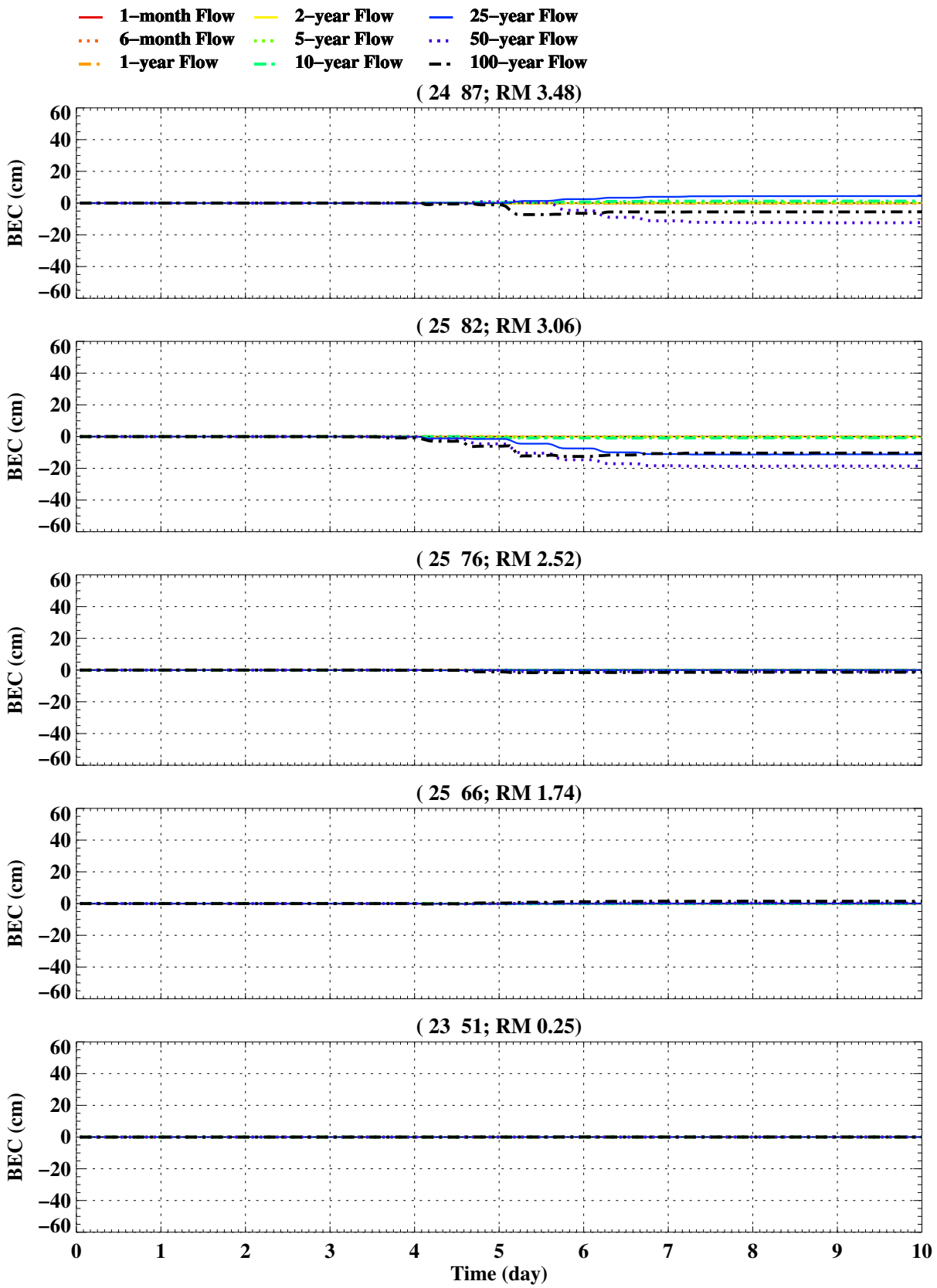

Figure 5-7. Time-series of bed elevation change (BEC) and bottom shear stress (BSS) at the 10 selected locations along the river (Upland borrow sand used as the capping material) (continued).

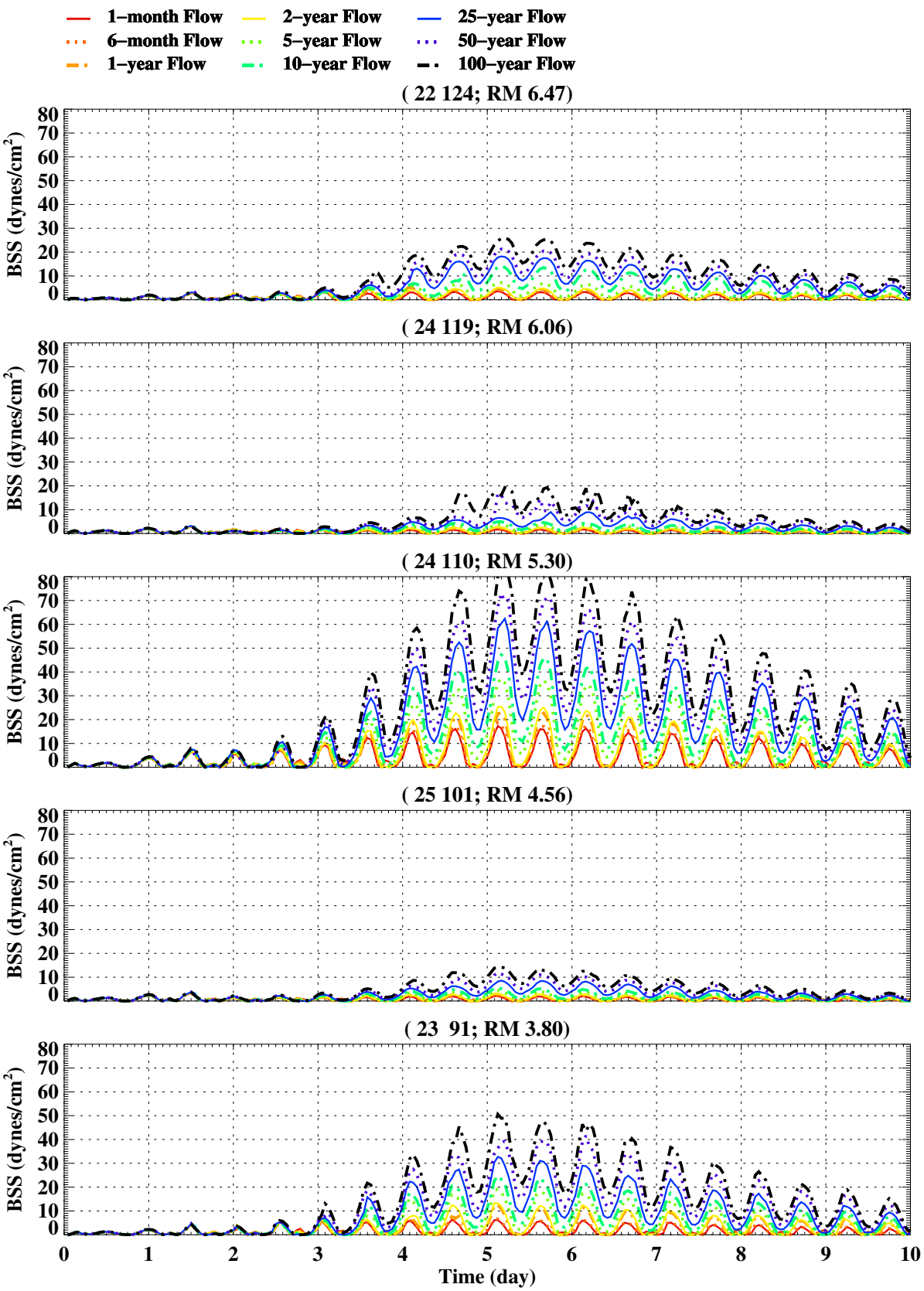

Figure 5-7. Time-series of bed elevation change (BEC) and bottom shear stress (BSS) at the 10 selected locations along the river (Upland borrow sand used as the capping material) (continued).

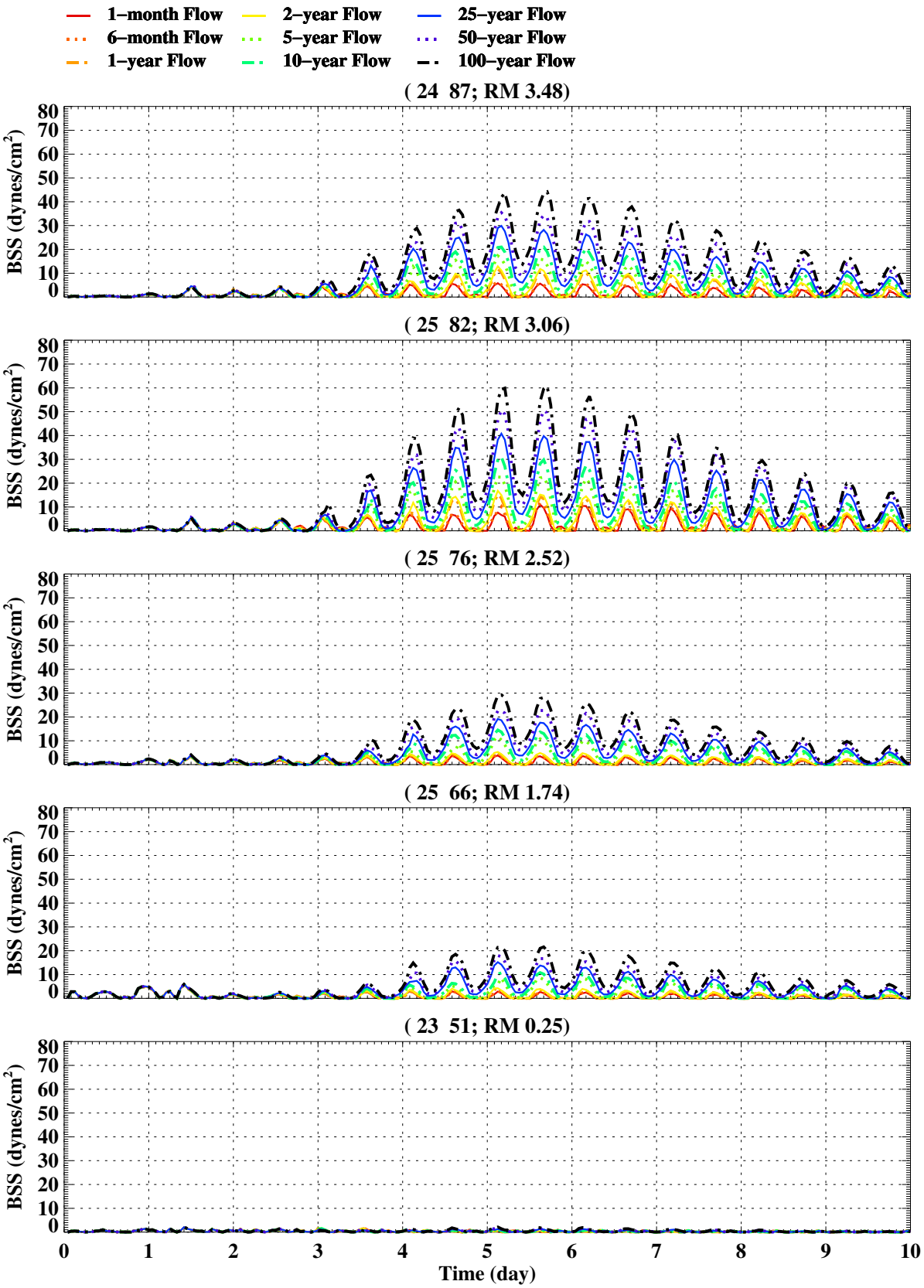

Figure 5-7. Time-series of bed elevation change (BEC) and bottom shear stress (BSS) at the 10 selected locations along the river (Upland borrow sand used as the capping material) (continued).

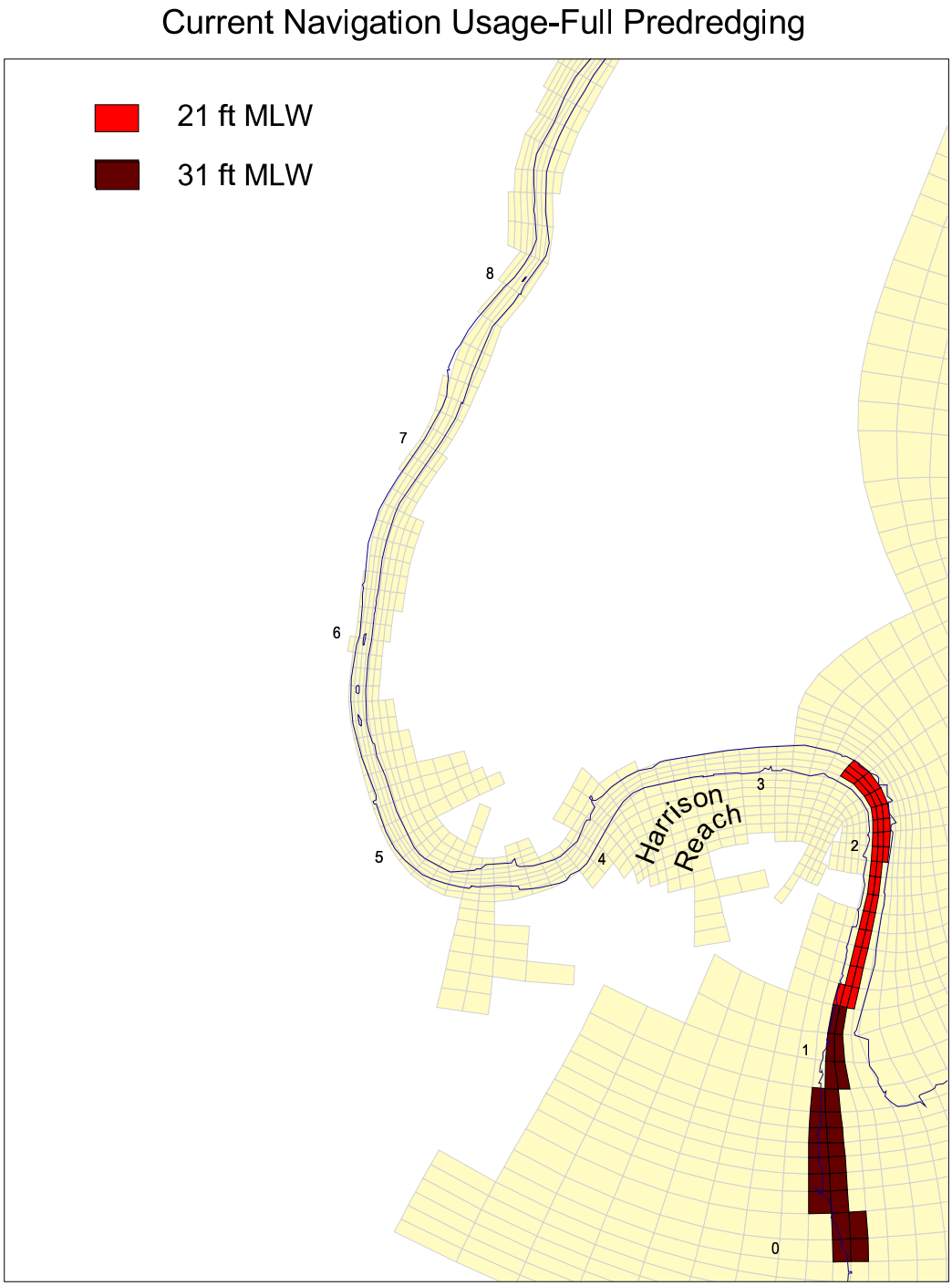

Figure 5-8a. "Current Navigation Usage" areas between RM 0 and RM 2.5.

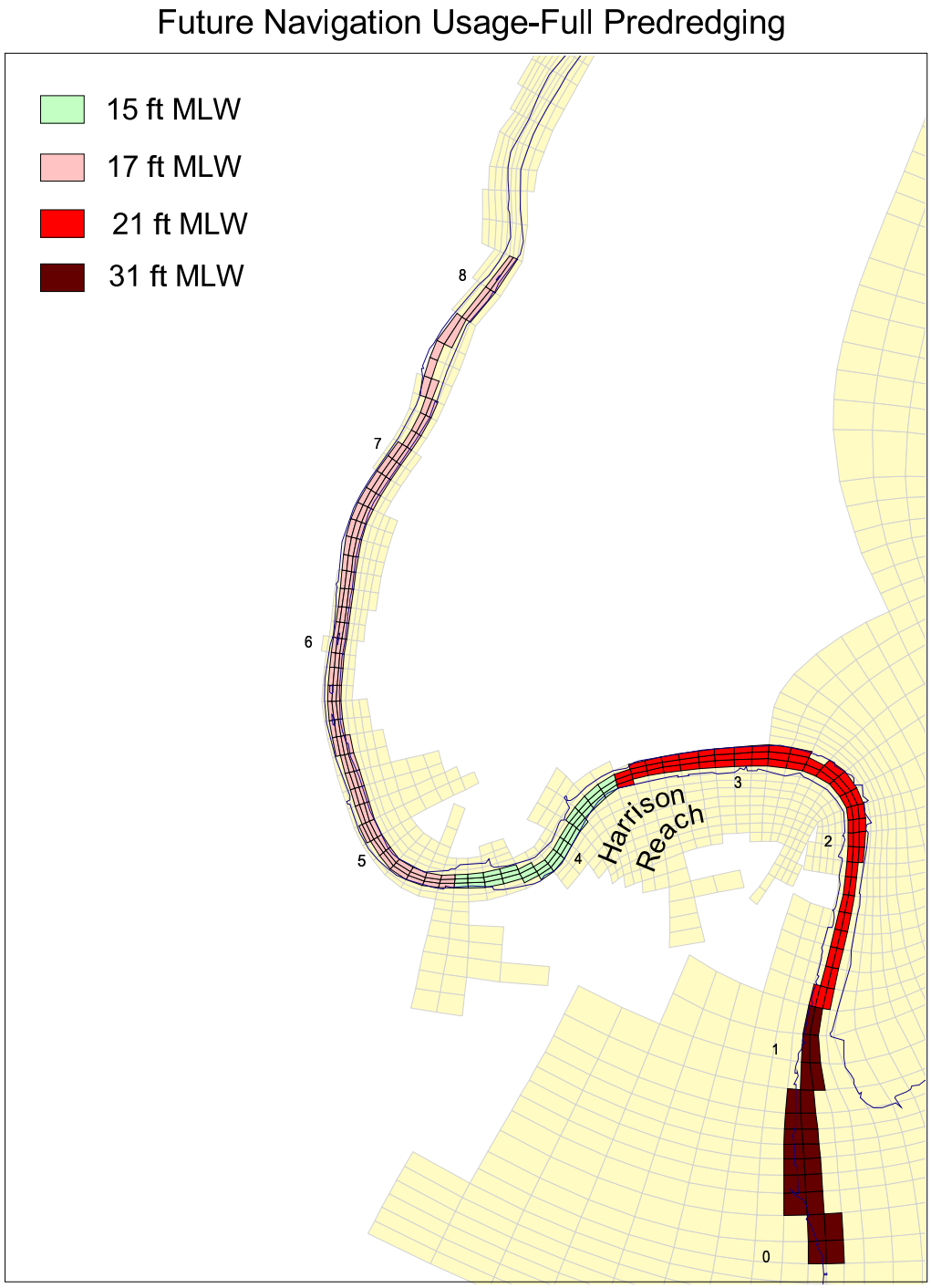

Figure 5-8b. "Future Navigation Usage" areas between RM 0 and RM 8.3.

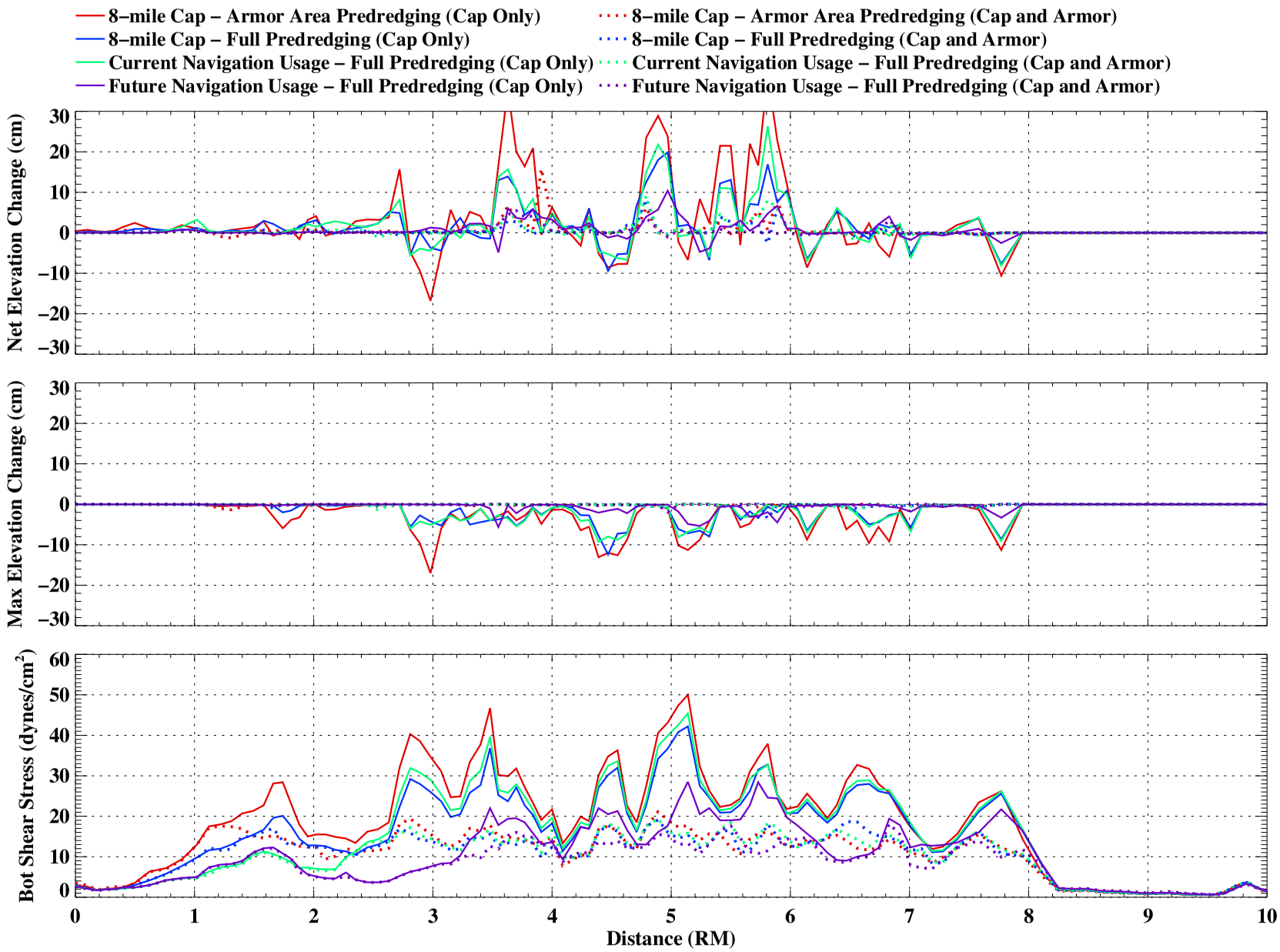

Figure 5-9. Comparisons of cross-river average net bed elevation change, the maximum erosion and bottom shear stress along the river under the different depth conditions and the different capping/armoring scenarios. The 100-year return flow was used for these simulations and upland borrow sand used as the capping material.

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SECTION 6

FLOODING ANALYSIS

6.1 FLOW AND STORM SURGE ANALYSES

Daily mean stream flow data for the Passaic River at Little Falls, NJ from USGS (Station #01389500) and historic monthly extreme values of water level from NOAA's Bergen Point (Station #8519483 NY) were downloaded from the agencies' websites. These data sets were used to perform flood and storm surge analyses.

6.1.1 Flow Analysis

Daily mean stream flow data at the Little Falls gauging station are available from 1891 through 2005. The long-term averaged (105 years) flow of the Passaic River measured at this most downstream gauging station is 1,140 cfs. During the past 105 years, the maximum peak flow measured at Little Falls was 31,700 cfs, which was observed on October 10, 1903. During the last few decades, a maximum peak flow of 18,400 cfs was measured on April 7, 1984. On a yearly averaged basis, water year 1902 yielded the largest flow of 2,400 cfs while the driest year, 1965, yielded 270 cfs. Maximum daily flow for each year was extracted from this 105 year data record (Figure 6-1). Figure 6-2 shows the probability distribution of annual maximum flows. The figure indicates that median annual maximum flow of the Passaic River is about 7,000 cfs. The 100-year return flow (plotted at the 99.0th percentile) lies between 18,000 cfs and 24,000 cfs and depends on how one extrapolates the distribution curve beyond the 95th percentile. Determining the 500-year return flow (which occurs at the 99.8th percentile) from this flow probability distribution plot is more difficult to estimate due to lack of data at this high flow range.

Estimation of the 100- and 500-year floods was performed using a parametric flood-frequency curve procedure elaborated in "Methods of Stream-flow Data Analysis" by Andre Leher of Humboldt State University (2005), which is based on the methods suggested by Chow et. el. (1988). Leher suggests two different methods for estimating flow recurrence intervals: (1) Log-Normal and (2) Type 1 Extreme (Gumbel) methods. These procedures are described below:

- Compile a list of water-year annual maximum flows,
- Take common logs (log10) of the annual flows, and
- Compute the mean $\bar{x}$ and standard deviations of the original data, then compute the mean $\bar{x}_I$, standard deviation s_I, and coefficient of skewness g_I of the log-transformed data.

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The general form of the equation defining the flows of different recurrence intervals (Q_{Tr}) is

$$Q_{Tr} = \bar{x} + K_T \ s \qquad (6\text{-}1)$$

where K_T is the frequency factor and depends on the probability distribution assumed for the flows.

Log-Normal distribution

For a log-normal fit, the defining equation is:

$$Q_{Tr} = 10^{\bar{x}_l + K_{TL} s_l} \qquad (6\text{-}2)$$

The values of K_{TL} to use in the equation are listed in the table below and the corresponding return-year flows for the Passaic River are shown in Table 6-1.

Table 6-1. Frequency factor K_{TL} used for log-normal recurrence interval computation and the recurrence flows for the Passaic River at Little Falls.

Recurrence interval T_r	Frequency factor	Flow
1.5	-0.439	5,510
2	0.000	6,751
5	0.842	9,968
10	1.282	12,219
25	1.751	15,180
50	2.054	17,465
100	2.326	19,808
200	2.576	22,237
500	2.878	25,572

The computed discharges can be plotted versus recurrence interval on a semi-log or flood frequency paper and fitted with a smooth line

Type I extreme–value (Gumbel) distribution

For an extreme value fit, the defining equation is:

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$$Q_{Tr} = \bar{x} + K_{TG}\ s \qquad (6\text{-}3)$$

where $K_{TG} = -\frac{\sqrt{6}}{\pi}\{0.577 + \ln[\ln T_r - \ln(T_r - 1)]\}$ Values for the frequency factor and the computed recurrence flows for the Passaic River are listed in the Table 6-2

Table 6-2. Frequency factor K_{TG} used for Type I Extreme (Gumbel) recurrence interval computation and the recurrence flows for the Passaic River at Little Falls.

Recurrence interval T_r (year)	Frequency factor K_{TG}	Flow Q_{Tr}
1.5	-0.523	5,509
2	-0.164	6,890
5	0.720	10,293
10	1.305	12,544
25	2.044	15,389
50	2.592	17,498
100	3.137	19,596
200	3.679	21,682
500	4.395	24,483

Figure 6-3 shows the results of both the Log-Normal and Type I Extreme methods. Both analyses yield similar results for the 100-year flow, which are 19,808 and 19,596 cfs, respectively; a difference of about one percent. However, due to relatively few records exceeding 20,000 cfs in the past 105 years, the estimations of 500-year flow yield somewhat different results by each method. The Log-Normal method yields 25, 572 cfs and the Type 1 Extreme method yields 24,483 cfs (approximately a 4% difference).

During the study, HydroQual contacted the USGS Trenton Office and sought their advice concerning these estimates. The USGS Trenton Office provided their 100- and 500-year flow estimates as 20,000 and 26,000 cfs, respectively, which were estimated by the Pearson Type III frequency distribution method (USGS, 1982). The USGS estimates were used for the specification of 100- and 500-year flows.

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6.1.2 Storm Surge Analysis

Monthly extreme water elevations observed at the NOAA Bergen Point station are available from 1982 through 2003 (Figure 6-4). These extreme water elevations represent storm surges associated with the passage of low-pressure systems through the region. Due to the orientation of the coastlines off New York Harbor, which, in general, run in southwest and northeast directions, persistent northeasterly winds with several days of duration bring coastal waters into the Harbor and can result in coastal flooding. Annual extreme elevations were extracted from the data and processed to estimate the probability distribution of extreme events. The results are shown in Figure 6-5. The plot suggests that the 100-year storm surge elevation lies between 1.84 and 1.92 m above MSL. Based on the Bergen Point data the 500-year storm surge is about 1.96 m above MSL.

Due to the relatively short records at Bergen Point, additional analysis of extreme water elevations was conducted using the data observed at the Battery. This station has more than 50 years of tidal observations and during the existence of the station it recorded one of the highest water levels observed in the New York Harbor region, which is the storm surge related to the passage of Hurricane Donna on September 12, 1960. Hurricane Donna caused extreme water elevations, as much as 2.56 m (8.4 ft) relative to NGVD29, in many parts of the coastal areas around the New York Harbor (Harris, 1963). The highest water level within the LPR was 2.93 m (9.6 ft) relative to NGVD29 near Rutherford, NJ.

In order to justify the use of the Battery data for inferring surge events in the LPR area, a correlation analysis of extreme water elevations at both gauges was conducted. Monthly extreme events observed from 1982 through 2004 were used for this analysis. The results shown in Figure 6-6 indicate that there is a high correlation ($R^2 = 0.96$) between these stations due to proximity. The linear regression also suggests that, in general, the extreme elevations at Bergen Point are about 10 cm higher than those observed at the Battery. The probability distribution of the annual extreme water elevations at the Battery is shown in Figure 6-7. The results suggest that 100- and 500-year storm surges for Bergen Point are 2.4m and 2.67 m above MSL, respectively.

6.1.3 Correlation of flow and storm surge events

Further analysis of flood waters from upstream freshwater inflows resulting from heavy rainfall events and the storm surge elevations was conducted to find out whether any correlations exist between the high river inflows and storm surge events. The monthly extreme water elevations at Bergen Point are plotted against the daily flows of the Passaic River measured at the Little Falls to deduce correlation between high flows and storm surge (Figure 6-8).

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The correlation results are shown in Figure 6-9 (upper panel) and the correlation coefficient (R^2) is less than 0.02. Further efforts were conducted to evaluate whether lagged flow data (2nd, 3rd, and 4th day) were correlated with storm surge (remaining panels in Figure 6-9). The correlation coefficients improve when comparing the flow records a few days after the storm surge events. However, the results do not produce a meaningful correlation between the high flow events and storm surge events and it was concluded that there is no direct correlation between them.

6.2 CAPPING AND SIMULATION SCENARIOS

The boundary forcing data of the model include freshwater flows from rivers, and water surface elevation, temperature and salinity at open boundaries. Several model forcing conditions were considered for the capping scenarios:

- 100-year flow,
- 500-year flow,
- 100-year storm surge, and
- 500-year storm surge

The 100- and 500-year flow events were constructed to provide freshwater inflows at Dundee Dam, as two extreme flow conditions. However, the measured freshwater inflow volumes for each flow event account only for the flow measured at Little Falls. The drainage area above Little Falls (780 square miles) accounts for 77 percent of the total Passaic River basin (1,013 square miles). The remaining 23 percent of the drainage area includes the downstream area of the Passaic River below Little Falls (178 square miles) as well as the drainage area of the Saddle River (55 square miles), which enters the Passaic River just downstream of Dundee Dam. The total flow volumes assigned at Dundee Dam were estimated by multiplying by 1.3, which is the ratio of the total drainage area of the Passaic River Basin to the gauged drainage area. The final peak flow volumes for the 100- and 500-year flows are 26,000 and 33,800 cfs, respectively. Although no correlation between flow and storm surge events was found, as discussed in the previous section, this does not mean that this never occurs in nature. It may, however, be unrealistic to assume that the 100- and 500-year flow and storm surge events occur simultaneously. Therefore, it was decided to conduct the model simulations for high flow and storm surge events separately. It should also be noted that modeled estimates of storm surge are based on historical data and do not take into account future increases in sea level elevation.

The harmonic constituents in the New York Harbor were used to generate water surface elevations along open boundaries. A storm surge analysis of water surface elevation

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data at the Battery was conducted and the 100 and 500-year surge peaks were obtained (2.40 m and 2.67 m above MSL). A storm surge curve observed at the Battery during Hurricane Donna in 1960 which lasted about two days was used for this study. These water elevations were added to the astronomical tide for projection simulations. In order to create the maximum possible water elevation during each simulation, the storm surge peaks were added to the peak spring tide within the simulation period. Constant temperature and salinity were applied to the open boundaries.

Several capping/armoring scenarios were considered in the study with various combinations of capping/armoring areas with different depth conditions:

- Base Case Scenario: using existing bathymetry conditions in the LPR and no capping/armoring.
- "8-mile Cap - Armor Area Pre-Dredging" Scenario: the first 8.3 miles of the LPR were capped with 2 feet of UBS and armored at selected locations with 2 feet of 6-inch angular cobble. Armored areas were to be pre-dredged 2 ft before being capped with sand and then armored with stone. Therefore, the top of armored areas would be level with other areas that are sand capped, and post-remediation depths would be two feet shallower than pre-remediation depths.
- "8-mile Cap – Full Pre-Dredging" Scenario: the bottom of the LPR between RM 0 and RM 8.3 was dredged by 2 feet before capping and 4 feet before capping and armoring. With this configuration, current river depths would be maintained in the capped/armored areas.
- "Current Navigation Usage – Full Pre-Dredging" Scenario: assumed that a 31-ft deep navigation channel would be constructed in the river between RM 0 and RM 1.2, and a 21-ft deep navigation channel between RM 1.2 and RM 2.5. The rest of the upstream section of the river was maintained at the existing bathymetry. The navigation channel depths (*i.e.*, 31 and 21 feet) denote the water depths below MLW to the top of capping/armor layer. The remaining bottom of the LPR between RM 0 and RM 8.3 was dredged by 2 feet before capping and 4 feet before capping and armoring.
- "Future Navigation Usage – Full Pre-Dredging" Scenario: assumed various future navigational channel conditions in the RM 0 through RM 8.3. The breakdown of navigation channel depths at various RM points are:
    - RM 0 – RM 1.2: 31' below MLW
    - RM 1.2 – RM 3.6: 21' below MLW

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- RM 3.6 – RM 4.6: 15' below MLW
- RM 4.6 – RM 8.1: 17' below MLW
- RM 8.1 – RM 8.3: existing bathymetry

Under this scenario, the bottom of the LPR between RM 0 and RM 8 was dredged by 2 feet before capping and 4 feet before capping and armoring. The navigation channel depths denote the water depths below MLW to the top of capping/armoring layer.

Figure 6-10 shows the extent of different capping and armoring scenarios. Ten-day simulations were set up for the various capping/armoring scenarios and the forcing conditions (high flow and storm surge). The Base Case Scenario runs were also performed, using the existing bathymetry with no capping or armoring for the 100- and 500-year flows and storm surge events in order to determine any change in the flooding areas under the different capping/armoring and dredging scenarios.

Modification of model bathymetry resulting from capping/armoring activities could change the total water volume in the river, and, therefore, change the distributions of computed water surface elevations and current velocities. In addition, sediment grain size distributions could modify model-computed fields of current velocities and water surface elevations since the bottom drag coefficient in the hydrodynamic model is directly correlated with sediment grain size. Equation (6-4) shows the formulation used to estimate the bottom drag coefficient (C_D) in ECOMSEDZLJ (Blumberg and Mellor, 1987).

$$C_D = \left[\frac{1}{\kappa} \ln(0.5 * Z_b / Z_0) / z_0 \right]^{-2}, \qquad (6\text{-}4)$$

where z_0 is the bottom roughness, z_b is the thickness of the grid nearest the bottom and κ is the von Karman constant. In the above equation, C_D is a function of hydrodynamic bottom roughness (z_0), which is related to sediment grain size (Kamphuis, 1974). Table 6-3 displays hydrodynamic bottom roughness lengths specified in the LPR model. Using Equation (6-4) and assuming a grid cell depth of 5 m, the corresponding bottom drag coefficients are estimated in Table 6-4.

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Table 6-3. Hydrodynamic Bottom Roughness Length (m) under Different Bottom Conditions in the Lower Passaic River

Base Case	0.001
Capping Area	0.001
Armoring Area	0.010

Table 6-4. Bottom Drag Coefficient for a Grid Cell with a 5m Depth under Different Model Bottom Conditions in the Lower Passaic River

Base Case	0.005
Capping Area	0.005
Armoring Area	0.015

6.3 RESULTS

The output variables considered in this section include water surface elevation, bottom velocity, and bottom shear stress. In ECOMSEDZLJ the bottom shear stress is determined by

$$\overline{\tau_b} = \rho_0 C_D |V_b| V_b, \qquad (6\text{-}5)$$

where ρ_0 is the water density and V_b is the bottom velocity. Time-series of water surface elevations, current velocities, and bottom shear stresses at select locations were processed. Figure 6-11 shows the station locations.

Figure 6-12 shows the 500-year flow discharge specified at the upstream boundary and computed water surface elevations for the Base Case Scenario in the Harrison Reach and near the Dundee Dam. The flow event presents a maximum freshwater inflow of 965 m^3/s (33,800 cfs). Corresponding to the extreme flow event, the increase in water surface elevation is most significant near the Dundee Dam, which rises up to 4.0 m above NGVD29 during the peak of the flow, and, at the upstream end of Harrison Reach (RM 5), where the maximum water surface elevation reaches 2.5 m above NGVD29. At the Harrison Reach (RM 3), the maximum water elevation is about 1.7 above NGVD29. Hereafter, all water and land elevations are in meters relative to NGVD29.

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6.3.1 Changes in Water Elevations

Maximum values of water surface elevation at each model grid cell were extracted from the model computations during each 10-day simulation period. A summary of along-river variation of the maximum water surface elevation through the entire length of the LPR is shown in Figure 6-13. The figure summarizes the maximum water elevations at different locations in the river under different flow and storm surge conditions in response to various capping and armoring scenarios.

For all simulations, the results indicate that the water surface elevations increase in an upstream direction. Under the Base Case Scenario, which uses the existing depth of the river, the downstream-upstream difference can be as large as 3.6 m during the 100-year flow event and 4.2 m during the 500-year flow event (blue lines in Figure 6-13). However, this increase is mainly limited to the narrow upper section of the river (upstream of RM 8). In the downstream section below RM 8, where the river becomes wider, the increase in the water level during the 100-year flow is computed to be less than 0.5 m between RM 0 and RM 8 and less than 0.8 m during the 500-year flow.

Comparing the "8-mile Cap – Armoring Area Pre-Dredging" Scenario (green lines in Figure 6-13) to the Base Case Scenarios under the existing river depths, it can be seen that the largest water elevation increase occurs immediately upstream of the armored regions, which are around RM 3 and RM 12. This increase is as large as 0.5 m and 0.8 m for the 100 and 500-year flows, respectively. High bottom drag coefficients were used for the armored areas, which were about 3 times larger than those used for the other non-armoring scenarios (Table 6-4). It appears that high bottom drag coefficients in the armored area hinder movement of water downstream and result in the increase of water elevations in upstream locations, *i.e.*, a backwater is generated. These changes in the water elevations in the upstream section of the river result in additional flooding in the low lying areas. The spatial extent of flooding areas due to various capping and armoring scenarios will be discussed below.

Full pre-dredging of 2 to 4 feet in the lower 8.3 miles of the river, where capping (2 feet) and armoring (additional 2 feet) is planned, results in a reduction of about 0.2 to 0.4 m in water elevation rise compared to the non-pre-dredged, *i.e.* existing bathymetry, "8 mile Cap – Armor Area Pre-Dredging" Scenario for both the 100 and 500-year flows. The results reflect the water level change in response to the downstream water depth change, *i.e.* the pre-dredging. The results of water level rise under the "Future Navigation Use – Full Pre-Dredging" Scenario are less than those in the Base Case Scenario, which suggest that deepening some portions of the capping/armoring area could have beneficial effects in reducing the extent of flooding during high flow events. It is noted that there are no

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significant elevation differences between the "8 mile Cap – Full Pre-Dredging" (red lines in Figure 6-13) and "Current Navigation Use – Full Pre-Dredging" Scenarios (yellow lines in Figure 6-13) for each flow event. The results indicate that channel deepening of the lower 2.5 miles would not significantly change flood stages in upstream locations.

During the 100- and 500-year storm surge events, the upstream-to-downstream difference in water surface elevation is about 0.2 m (the two bottom panels in Figure 6-13). However, water elevations in the LPR rise about 2.8 m and 3.1 m above normal elevation, respectively, for the 100 and 500-year storm surges, which would result in additional flooding in the low lying regions near the mouth and the upstream portions of the river. It was found that during storm surge events the maximum water elevation between RM 3 and RM 8 would be lower under the capping/armoring scenario compared to the Base Case Scenario. It appears that those armored areas with higher bottom roughness would impede the progression of storm surge upstream and, hence, result in lower elevation rise compared to those computed under relatively smooth bottom conditions under the Base Case Scenario. The "Future Navigation Use – Full Pre-Dredging" Scenario would raise water elevations slightly (about 1 cm or less) compared to those computed under the Base Case Scenario. This is due to deepening of the lower 8.3 miles of the LPR, which allows more water to travel upstream with less resistance.

6.3.2 Flooded Areas

The flooded areas in the LPR are determined by comparing water surface elevations in the river to nearby landside digital elevation information during the simulations. Total flooded areas for each simulation are tabulated in Table 6-5, and do not include the in-river areas inundated during normal tides, *i.e.* within river wetting and drying areas under normal tidal elevations.

6.3.2.1 Scenarios During the 100-Year Flow

Figure 6-14 shows the grid cells flooded during the 100-year flow under the Base Case Scenario. Under the Base Case Scenario, the 100-year flow event would flood an area of 499 acres along the river (Table 6-5). During the 100-year flow, the "8 mile Cap - Armor Area Pre-Dredging" Scenario would increase the water elevation by 0.5 m and increase the projected flooding area by 93 acres for a total of 592 acres (Figure 6-15). The additional flooding area under the "8 mile Cap - Full Pre-Dredging" Scenario is projected to occur between RM 5 and RM 12. The "8 mile Cap - Full Pre-Dredging" Scenario would result in a projected flooded area of 523 acres about 69 acres less than computed for the scenario where only the armored area is pre-dredged. The results indicate that pre-dredging of the capping/armoring areas would raise water level less than 0.1 m in the upstream locations (Figure 6-16) compared to those computed under the Base Case Scenario. As indicated in

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Figure 6-13, the "Current Navigation Use - Full Pre-Dredging" Scenario, which deepens water depths in the first 2.5 miles of the LPR, would not significantly change the flooding area compared to that computed under "8 mile Cap - Full Pre-Dredging" Scenario. However, the "Future Navigation Use - Full Pre-Dredging" Scenario would only flood 482 acres, and is about 17 acres less than areas projected to flood under the Base Case Scenario (see Figure 6-17 and Table 6-5).

6.3.2.2 Scenarios During the 500-Year Flow

The 500-year flow would raise the upstream water levels as much as 3.8 m under the Base Case Scenario and it would cause flooding of 794 acres, as shown in Figure 6-18. The model results indicate that additional areas downstream of the Dundee Dam, especially between RM 8 and RM 11, would be flooded during the 500-year flow, in comparison to the areas flooded during the 100-year flow under the Base Case Scenario.

During the 500-year flow event, the water elevations would increase about 0.8 m in the area upstream of the capping/armoring region under the "8 mile Cap – Armor Area Pre-Dredging" Scenario (Figure 6-13) compared to those under the Base Case Scenario. This water elevation increase would affect many grid cells near the County Park in Lyndhurst (RM 11) and downstream. Under this "8 mile Cap – Armor Area Pre-Dredging" Scenario, the flooded area is projected to be 880 acres (Figure 6-19), which adds about 86 acres to the flooded area relative to the Base Case Scenario during the 500-year flow.

It is found that pre-dredging of the capping/armoring area would lower the water elevations in the upstream locations (Figure 6-13). On average, the water elevation would increase by less than 0.1 m due to the pre-dredging, compared to those computed under the Base Case Scenario. The total flooded area under the "8 mile Cap – Full Pre-Dredging" Scenario is 822 acres as shown in Figure 6-20. The "Current Navigation Use – Full Pre-Dredging" Scenario would flood essentially the same areas as the "8 mile Cap – Full Pre-Dredging" Scenario, *i.e.*, the deepening of the lower 2.5 miles would have minimal effect as far as flooded area is concerned. However, the "Future Navigation Use – Full Pre-Dredging" Scenario would lower the water elevation along the length of the river and would reduce the flooded area to 767 acres. The flooded areas would be reduced by 27 acres, compared to those under the Base Case Scenario. Comparing the flooded areas under this "Future Navigation Use – Full Pre-Dredging" Scenario to those under the "8 mile Cap – Armor Area Pre-Dredging" Scenario with existing bathymetry, the "Future Navigation Use – Full Pre-Dredging" Scenario would reduce the flooded area by as much as 113 acres (Figure 6-21). It is clear from these results that flooding would be significantly reduced if the deeper channel depths could be maintained in the LPR.

6.3.2.3 Scenarios During Storm Surge Events

The 100- and 500-year storm surges would cause the most flooding between the river mouth and RM 3.5, where land elevations are relatively low. As indicated in Table 6-5, flooded areas during storm surge events are much greater than those under 100-and 500-year flows. The increase in water elevations of as much as 3.0 m would result in the flooding of 1,249 acres and 1,504 acres during 100- and 500-year storm surges, respectively (Figure 6-22 and 6-23). Although most of the flooded areas are in the lower 5 miles of the river, both the low lying areas in the County Park of Lyndhurst and the area just downstream of the Dundee Dam would also be flooded during the extreme storm surge events. As indicated in earlier sections, the scenarios with capped/armored condition result in less maximum water elevation rise compared to those under the Base Case Scenario. However, the differences in the water elevations are less than 0.05 m at most of the locations in the LPR and do not change the flood areas significantly as compared to the Base Case Scenario. It is worthy to note that under the "Future Navigation Use – Full Pre-Dredging" Scenario, where the lower 8.3 miles of the LPR would be deepened to maintain a navigation channel, the maximum water level increases compared to those computed under the Base Case Scenario. However, the increase is less than 0.01 m and has no significant impact on the flooding computations.

Table 6-5. Total Areas (acres) Flooded under Different Simulation Scenarios

	Base Case (Existing Depth)	8 Mile Cap: Armor Area Pre-Dredging	Full Pre-Dredging before Capping/Armoring		
			8 Mile Cap	Current Navigation Use	Future Navigation Use
100-Year Flow	499	592	523	523	482
500-Year Flow	794	880	822	822	767
100-Year Storm Surge	1,249	1,249	1,249	1,249	1,249
500-Year Storm Surge	1,504	1,504	1,504	1,504	1,504

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6.4 SENSIVITITY ANALYSES

6.4.1 Sensitivity to Land Surface Elevation

To properly estimate potential flooding areas under different conditions in the LPR basin, the best available shoreline and land elevation information were incorporated into the hydrodynamic model (see Section 2). The initial model land elevations were configured using the 2-foot contour lines from the USACE survey maps. However, even these data resulted in shoreline and land elevation uncertainties of ± 1 foot. Therefore, a sensitivity run was performed, where the land elevations used in the model were reduced by 1 foot, to see how the uncertainty in the shoreline elevation might affect the estimates of the flooding areas. The simulation scenario selected was the "8 mile Cap – Armor Area Pre-Dredging" Scenario. The 100- and 500-year flows at Dundee Dam and predicted tides at the open boundaries of the model were used as model forcing functions.

Figure 6-24 shows the maximum water surface elevation along the LPR during the simulations. In the figure, blue lines are corresponding to the model results obtained with the original shoreline elevation while the red lines are the sensitivity run results obtained with 1 foot lowered land elevation. The model results indicate that lowering the land surface elevations slightly decreases maximum water surface elevations during flood events when compared to the original land elevation configurations (Figure 6-24). On average, the difference between using the original and the modified shoreline elevations is less than few centimeters during the 100- and the 500-year flow events.

Table 6-6 displays the flooded areas and the area changes under different shoreline elevations. Clearly the decrease in land surface elevations results in a larger flooded area. When the estimated land elevations were reduced by 1 foot, the flooded areas were projected to increase by about 25% and 17% during 100- and 500-year flow events, respectively. During the 100-year flow conditions, the additional flooding areas due to 1 foot adjustment of land elevations are limited from RM 8 to RM 12, especially in the relatively flat land near the County Park in Lyndhurst near RM 11 (Figure 6-25). However, under the 500-year flow conditions, most of the additional flooding areas are located from RM 3 to the region immediately upstream of the Harrison Reach (Figure 6-26).

R2-0010574

Table 6-6. Total Areas (acres) Flooded under Different Shoreline Elevations.

Sensitivity	Original	Modified	Difference (%)
100-Year Flow	592	738	25
500-Year Flow	880	1,028	17

6.4.2 Sensitivity to Bottom Roughness Length

The AS originally selected as the capping material for this study was found to be easily subject to bedload transport under normal tidal condition during the cap erosion analysis. This was also found to be true for the smaller sand particle sizes for the UBS source. Even moderate tidal currents of about 1 ft/sec would mobilize a portion of the capped material as bedload transport. Under this mode of transport, sand grains would form ripples and dunes depending on the variation of the current speed. This process is not formulated within the current hydrodynamic model algorithms. During the modeling efforts, the bottom roughness of the capping material is assumed to be 0.001 m. Literature values indicate the bottom roughness length of medium to coarse sand would vary from 0.0003 to 0.006 m depending on the height of sand ripples and dunes (Dyer, 1986). In order to estimate the effect of this transient nature of bottom roughness length due to non-cohesive sand capping material, a sensitivity run was conducted with using a value of 0.005. A model run was performed using various bottom roughness lengths: 0.001 for non capped/armored areas, 0.005 for capped areas, and 0.01 for armored areas. Four simulations are conducted: "8 mile Cap – Armor Area Pre-Dredging" Scenario and "8 mile Cap – Full Pre-Dredging" Scenario for 100- and 500-year flow events. The maximum water level rise for these simulations are shown in Figure 6-27. The results indicate that, with higher bottom roughness length, maximum water level rise would increase by 10 to 15 cm for both existing depth and pre-dredged depth conditions.

Table 6-7 summarizes the flooded areas and the area changes under different hydrodynamic roughness lengths. The increase in water elevation rise due to higher bottom roughness results in a larger flooded area. However, the change in the flooded areas were projected to increase only by between 0.5-2.5% and 1.3-2.4% during 100- and 500-year flow events, respectively for both the existing depth and pre-dredged depth conditions, which are relatively small changes. This computation provides a bound on the range of uncertainty in the extent of flooded area associated with transient bottom roughness due to the mobile portions of the sand cap.

R2-0010575

Table 6-7. Total Areas (acres) Flooded under Different Hydrodynamic Roughness Lengths of Capped Area

	Maximum Capping/Armoring Existing Bathymetry			Maximum Capping/Armoring Full Pre-Dredging		
	Original	Higher Zo	Difference (%)	Original	Higher Zo	Difference (%)
100-Year Flow	592	595	0.5	523	536	2.5
500-Year Flow	880	891	1.3	822	833	1.4

6.5 FEMA FLOW AND STORM SURGE SIMULATIONS

Two model runs were constructed in order to compare the flood areas computed by ECOMSEDZLJ with those estimated by FEMA. FEMA used 100- and 500-year flow and storm surge conditions estimated by USACE (1972 and 1973) and applied both the flow and storm surge conditions concurrently for the estimation of the flood areas in the LPR.

Following is the summary of the flow and storm surge conditions of the FEMA flood study:

- 100-year condition
  - Flow: 30,200 cfs
  - Storm surge: 10.2 ft (3.1m) ((NGVD29)
- 500-year conditions
  - Flow: 46,200 cfs
  - Storm surge: 12.8 ft (3.9m) (NGVD29)

It is worth noting that FEMA's 500-year flow and storm surge values are about 75% and 30% higher, respectively, than those estimated by HydroQual for use in this study. The model was configured with the above forcing information and simulated for 10 days. Maximum water elevations along the LPR during the 100- and 500-year events are shown in Figure 6-28. The figure also shows the maximum water level rise along the river computed by FEMA. The results indicate that the ECOMSEDZLJ computed water level during the 100 year event rises from 3.1m at the river mouth to 6.0 m at the upstream end of the river.

During the 500 year event, the water level rises from 4.0 m to 7.5m. However, the FEMA results indicate that water level rise during the 100-year event varies from 3.2 m at RM 8 to 6.9m at the upstream end. The FEMA 500-year event shows even more significant water level rise: 3.8m at RM 8 to 8.4m at the upstream end. The two model results show comparable water level rises in the narrow sections of the LPR upstream of RM 8. However, there are still a few underlying differences in the application of two models. The most probable causes of the differences could be:

1) Physical configuration of the river such as hydraulic capacity (channel dimension), bottom resistance, land elevation, etc. As described in Section 2, ECOMSEDZLJ model was configured with most recent USACE survey data for both the river (2004) and land elevations (1995). There are about 10 bridges that are partially or fully submerged during the 500-year flow. These would likely impact the water surface elevation profile significantly. These man-made structures are not considered in ECOMSEDZLJ.

2) Modes of hydraulic computation: steady-state (FEMA) vs. dynamic computation (ECOMSEDZLJ). In steady-state computation, it is assumed that the surge and flow conditions are constant. On the contrary, ECOMSEDZLJ defined a flow curve which reaches the peak flow for only a short period of time (*i.e.* less than few hours).

Figure 6-28 indicates that 500-year FEMA estimated water elevation at RM 8 is about 3.8m, which is the storm surge elevation expected at the mouth of the river. The figure shows that FEMA estimated no elevation change from the mouth of the river to RM 8 whereas ECOMSEDZLJ computed about 0.5m water level rise in the same distance, which suggests another inconsistency between FEMA and ECOMSEDZLJ configuration.

Figures 6-29 and 6-30 show the projected flood areas computed by ECOMSEDZLJ for the 100- and 500-year events. About 2,080 acres and 2,650 acres would be flooded under the 100- and 500-year events using the FEMA-estimated values for flow and storm surge. The model results indicate that most of the downstream locations are flooded during events except some areas where the land elevations are higher than 6m. The ECOMSEDZLJ computed flood areas were compared with the FEMA-estimated 500-year flood areas in the LPR. The approximate FEMA 500-year flood areas in the LPR are about 3,500 acres counting from the mouth of the river. ECOMSEDZLJ computed 500-year flood areas that account for about 75 percent of the area estimated by FEMA. Most of the discrepancies in the flooded areas are found to occur within the first three miles of the river (see Figures 6-29 and 6-30), where the yellow shaded areas are FEMA estimated 500-year flood areas and red shaded areas are the ECOMSEDZLJ computed flood areas. In upstream locations, the ECOMSEDZLJ computed flood areas overlap most of the FEMA

R2-0010577

estimated areas except for a few locations downstream of the Dundee Dam and the "S" shaped section of the river near the City of Passaic. ECOMSEDZLJ computed flooded areas upstream of RM 3 account for about 75% (1.485 acres out of 1.816 acres) of the area estimated by FEMA.

R2-0010578

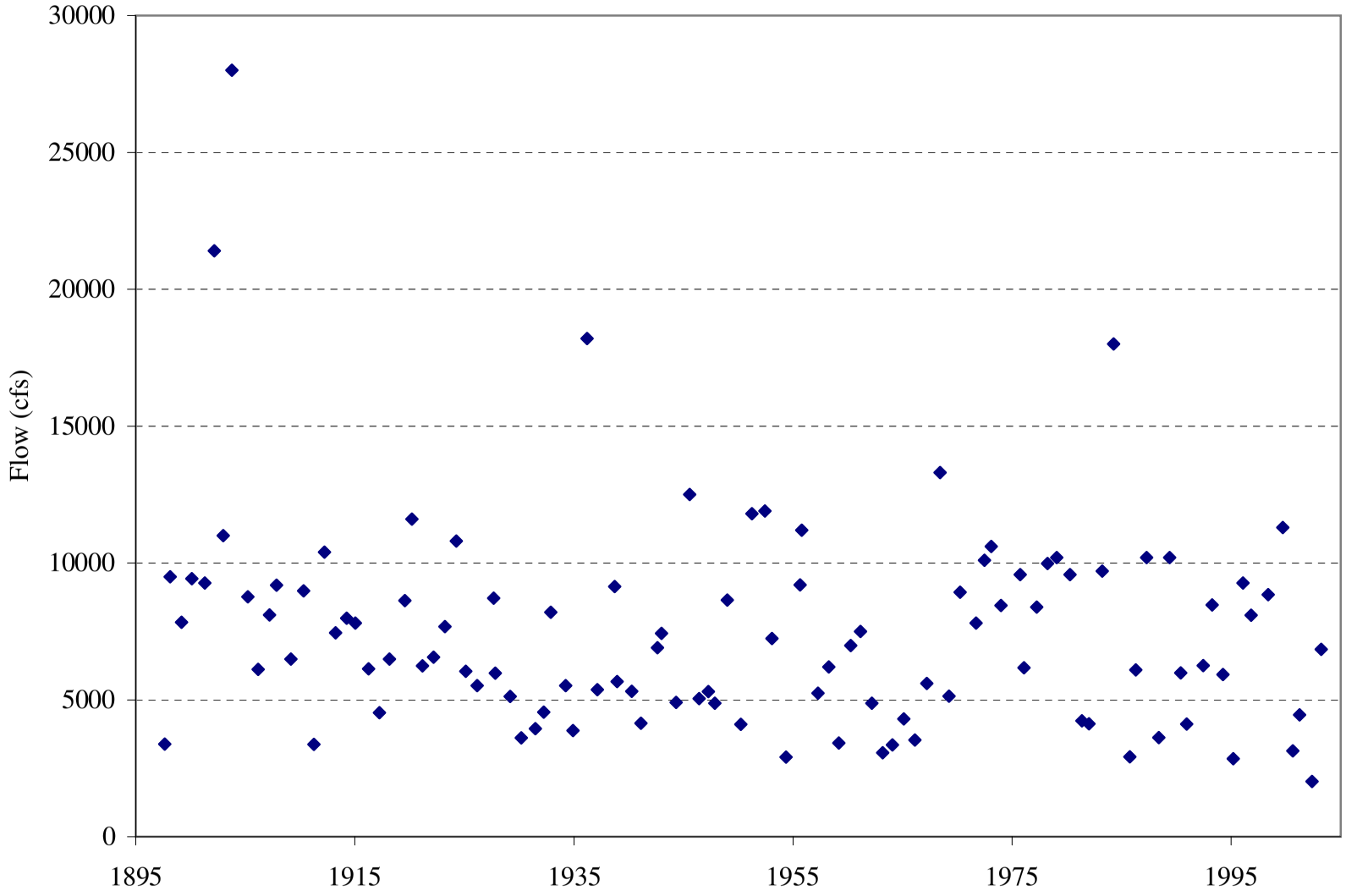


Figure 6-1. Annual maximum daily flows at Little Falls between 1981 and 2005.

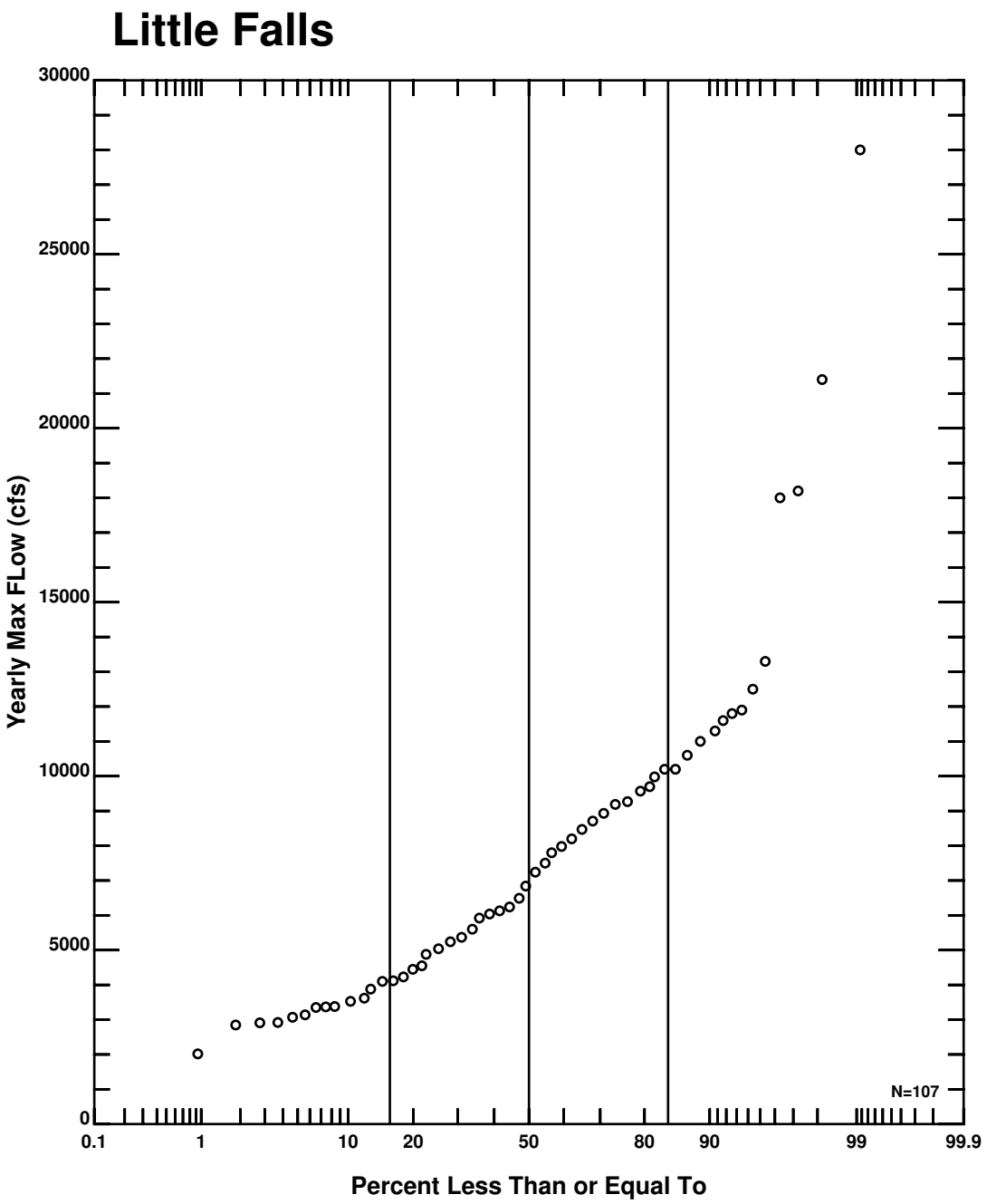


Figure 6-2. Probability distribution of annual maximum flows observed at Little Falls.

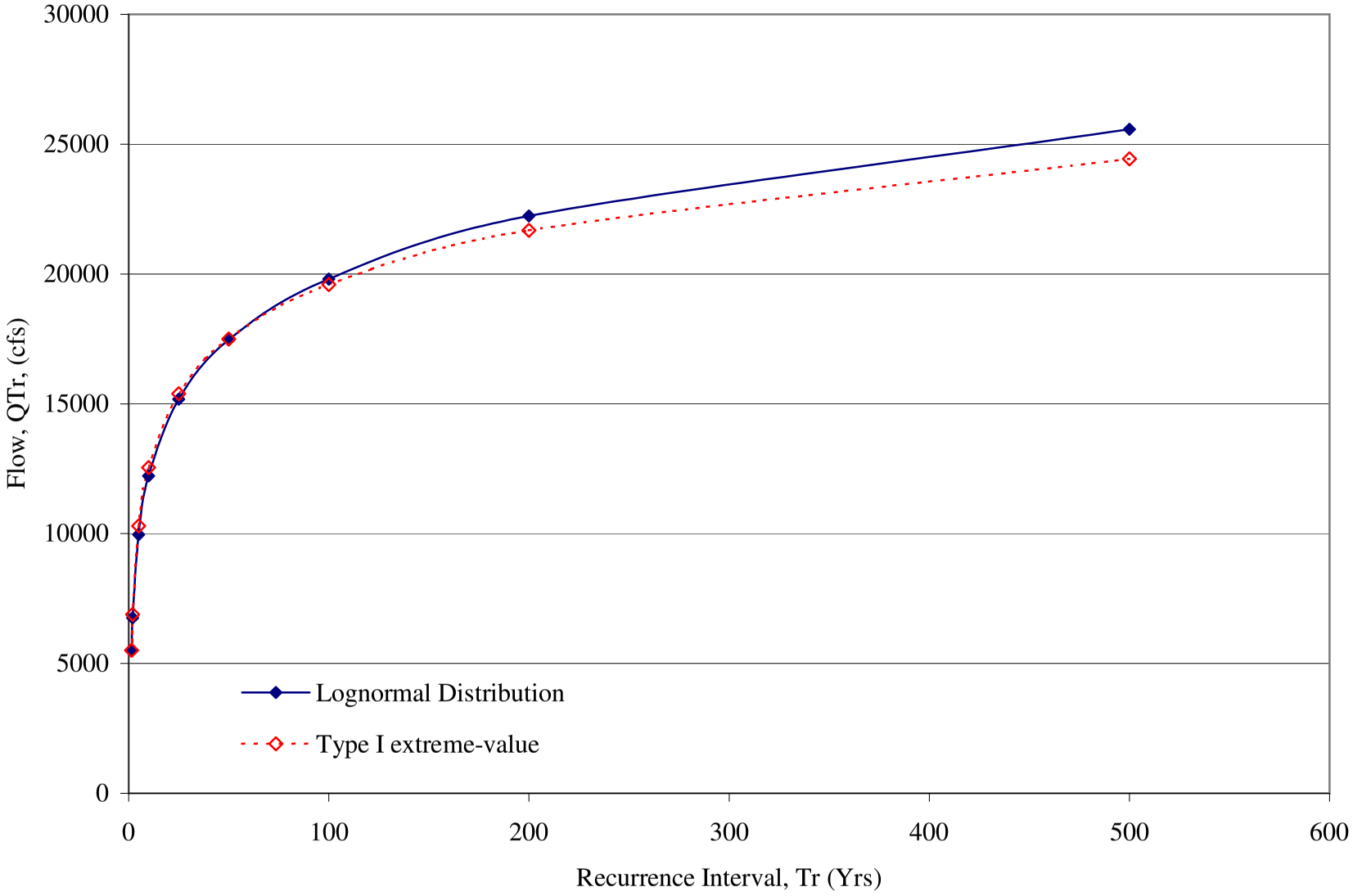


Figure 6-3. Estimated 100- and 500-year flows using Log-Normal and Type 1 Extreme (Gumbel) methods.

R2-0010581

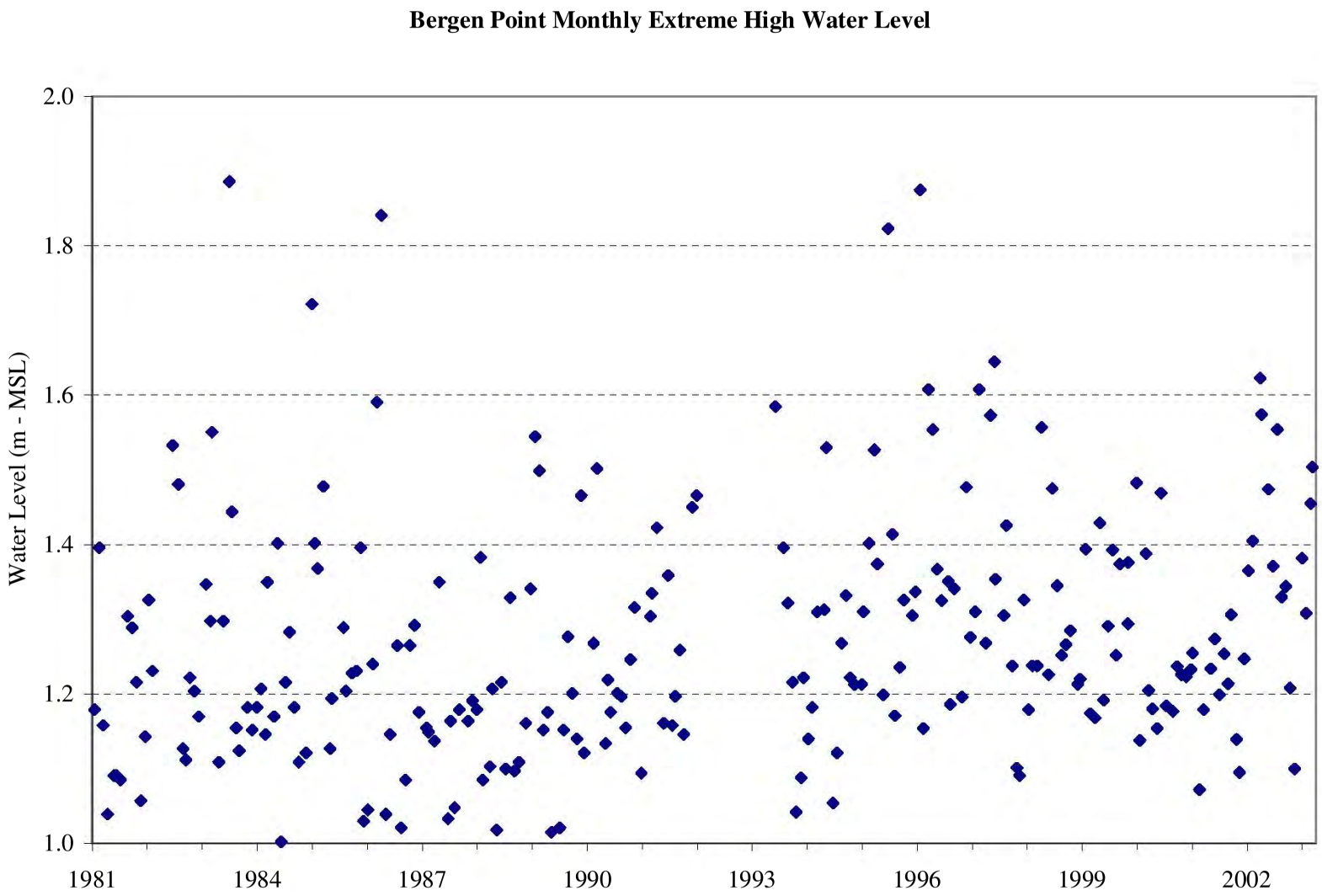


Figure 6-4. Monthly extreme high water levels at Bergen Point between 1982 and 2003.

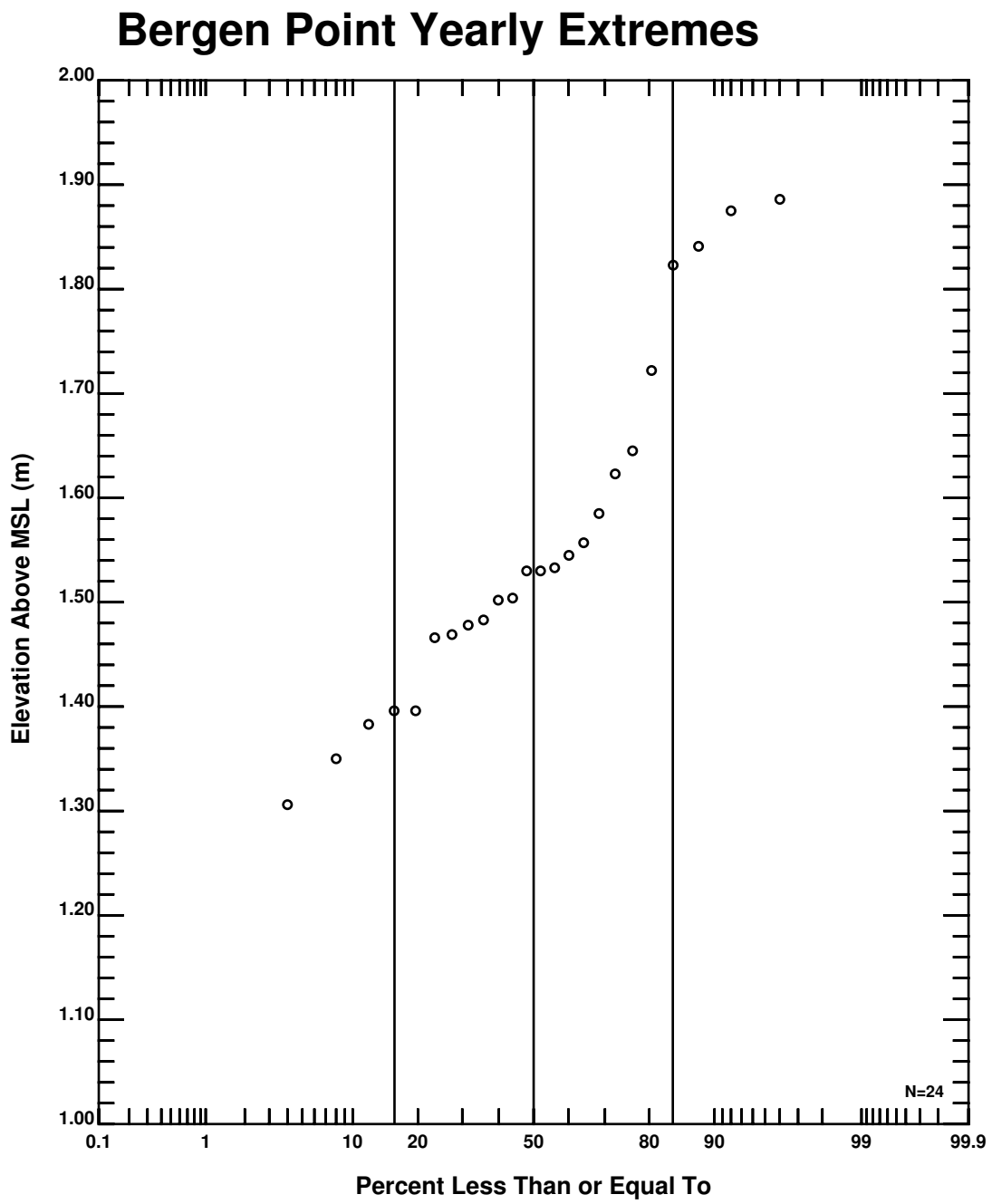


Figure 6-5. Probability distribution of annual extreme elevations observed at Bergen Point.

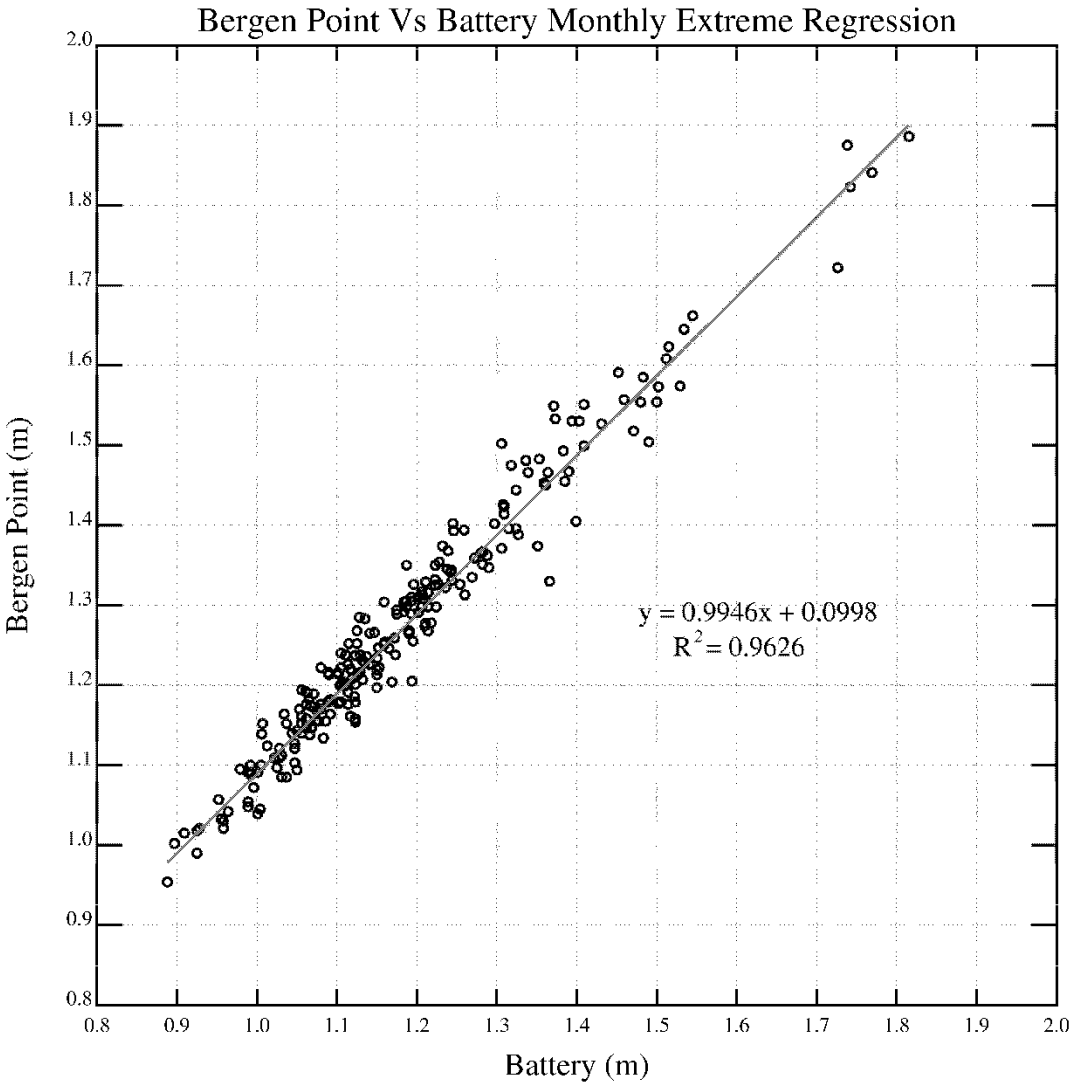


Figure 6-6. Correlation analysis of the monthly extreme water elevations between Bergen Point and the Battery NOAA stations.

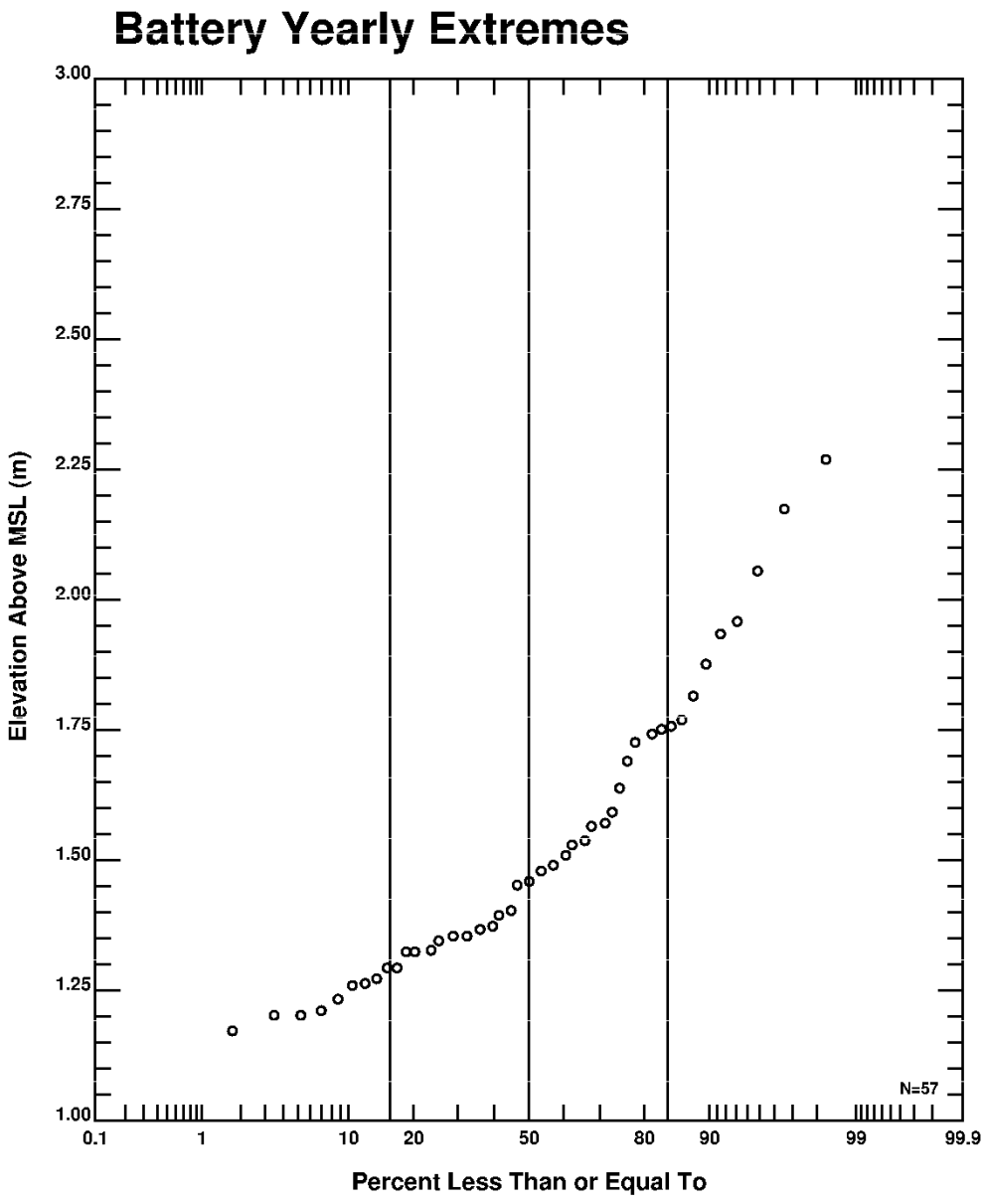


Figure 6-7. Probability distribution of annual extreme elevations observed at the Battery.

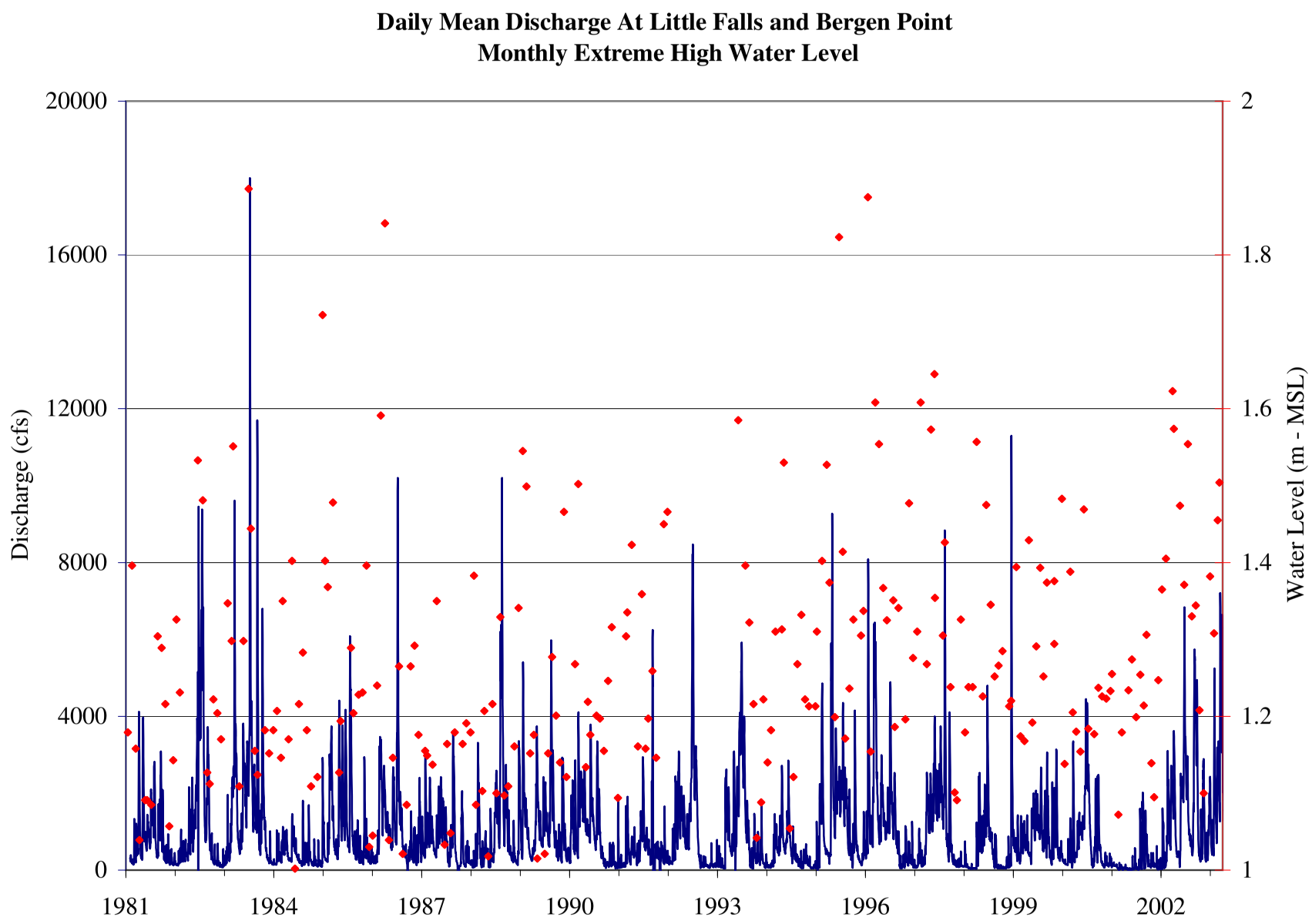


Figure 6-8. Daily flows measured at Little Falls and monthly extreme high water levels at Bergen Point between 1982 and 2003.

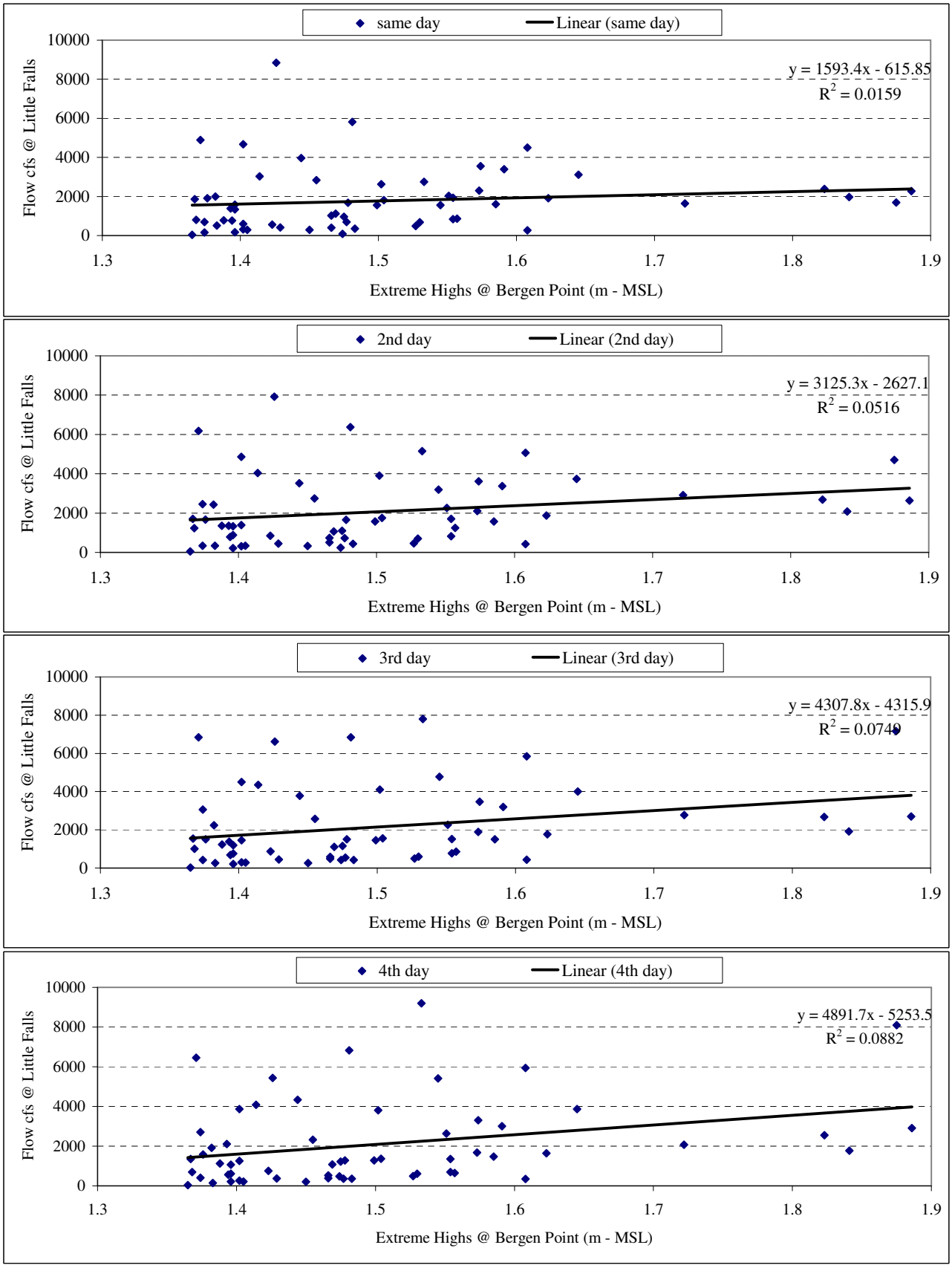


Figure 6-9. Correlation analysis of extreme water levels and daily flows: correlation of same day events (top panel); water level vs. flow of second day(2nd panel); water level vs. flow of third day (3rd panel); water level vs. flow of 4th day (bottom panel).

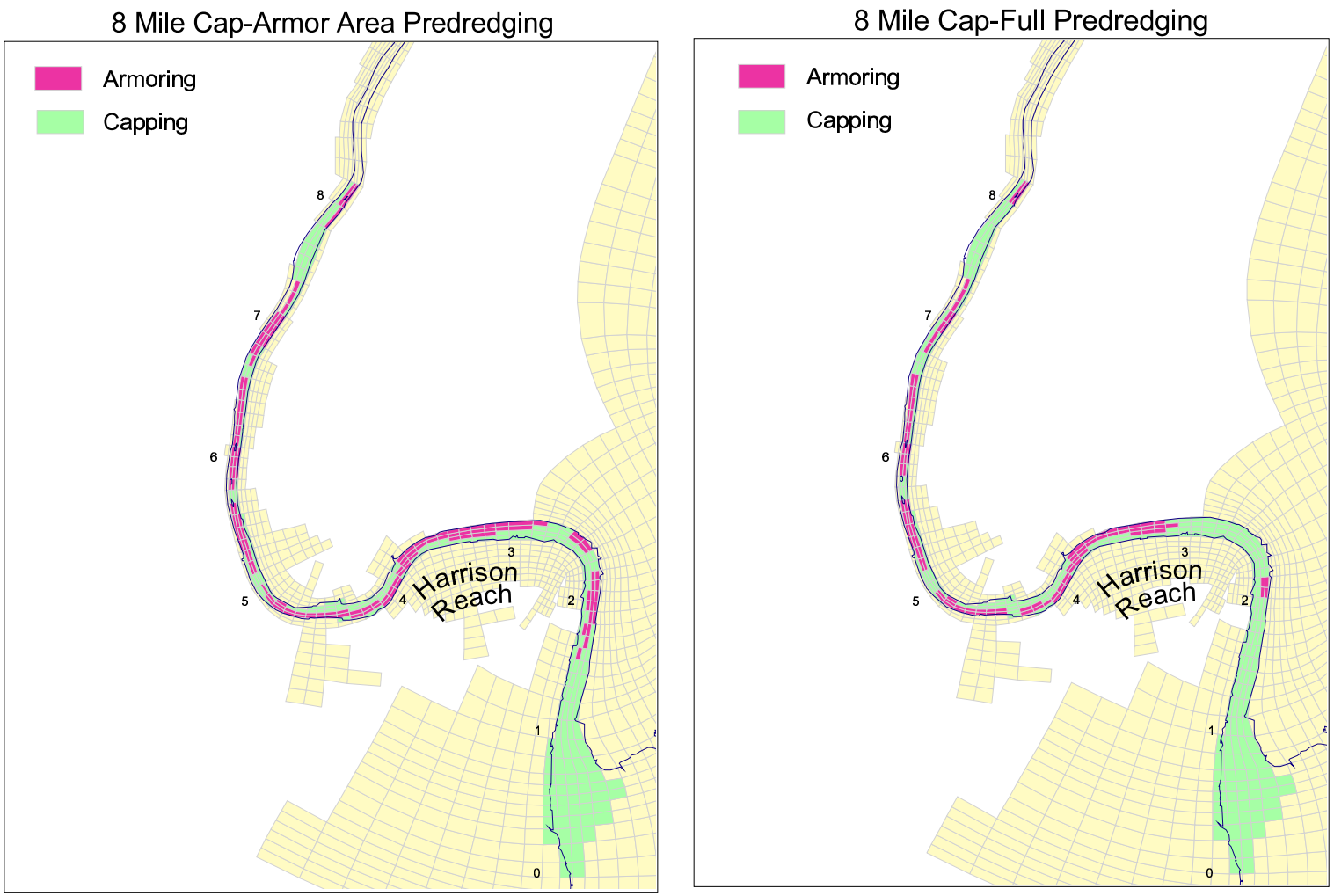


Figure 6-10. Extent of capping/armoring scenarios : capping and armoring areas for 8 mile cap-armor area predredging (left panel) and 8 mile cap-full predredging (right panel) are shown.

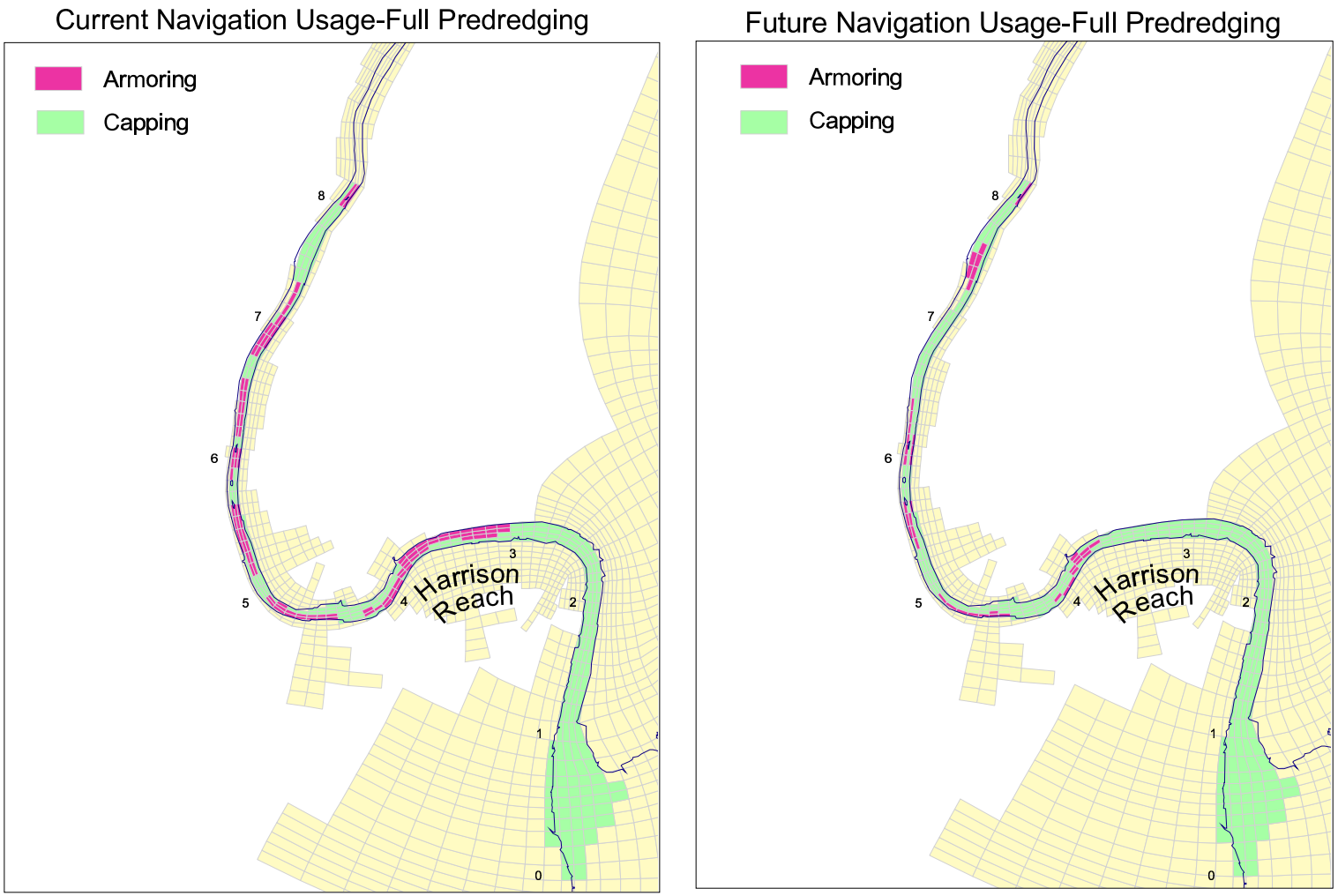


Figure 6-10. (continued) Extent of capping/armoring scenarios : "Current Navigation Usage" and "Future Navigation Usage" areas are shown.

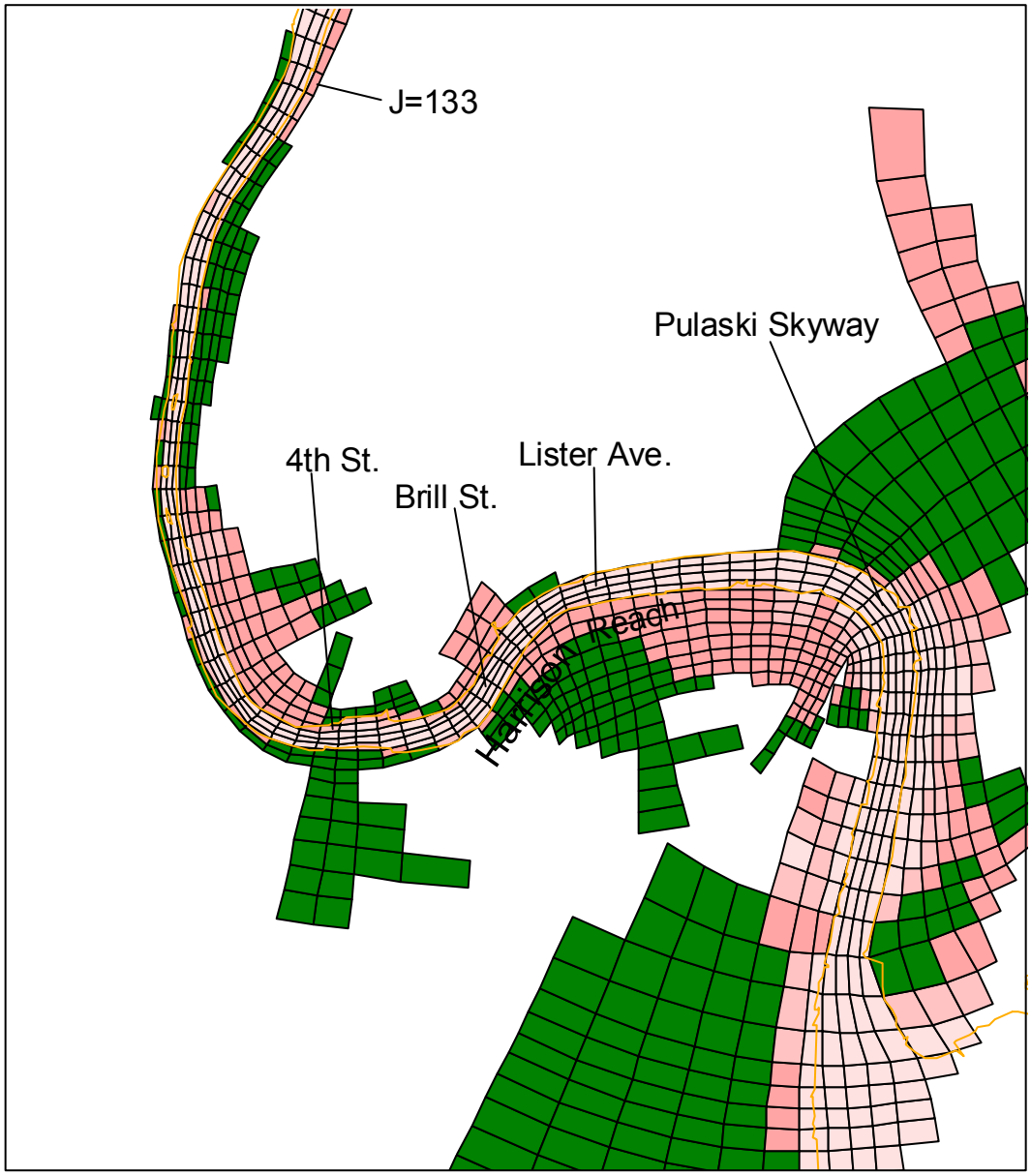
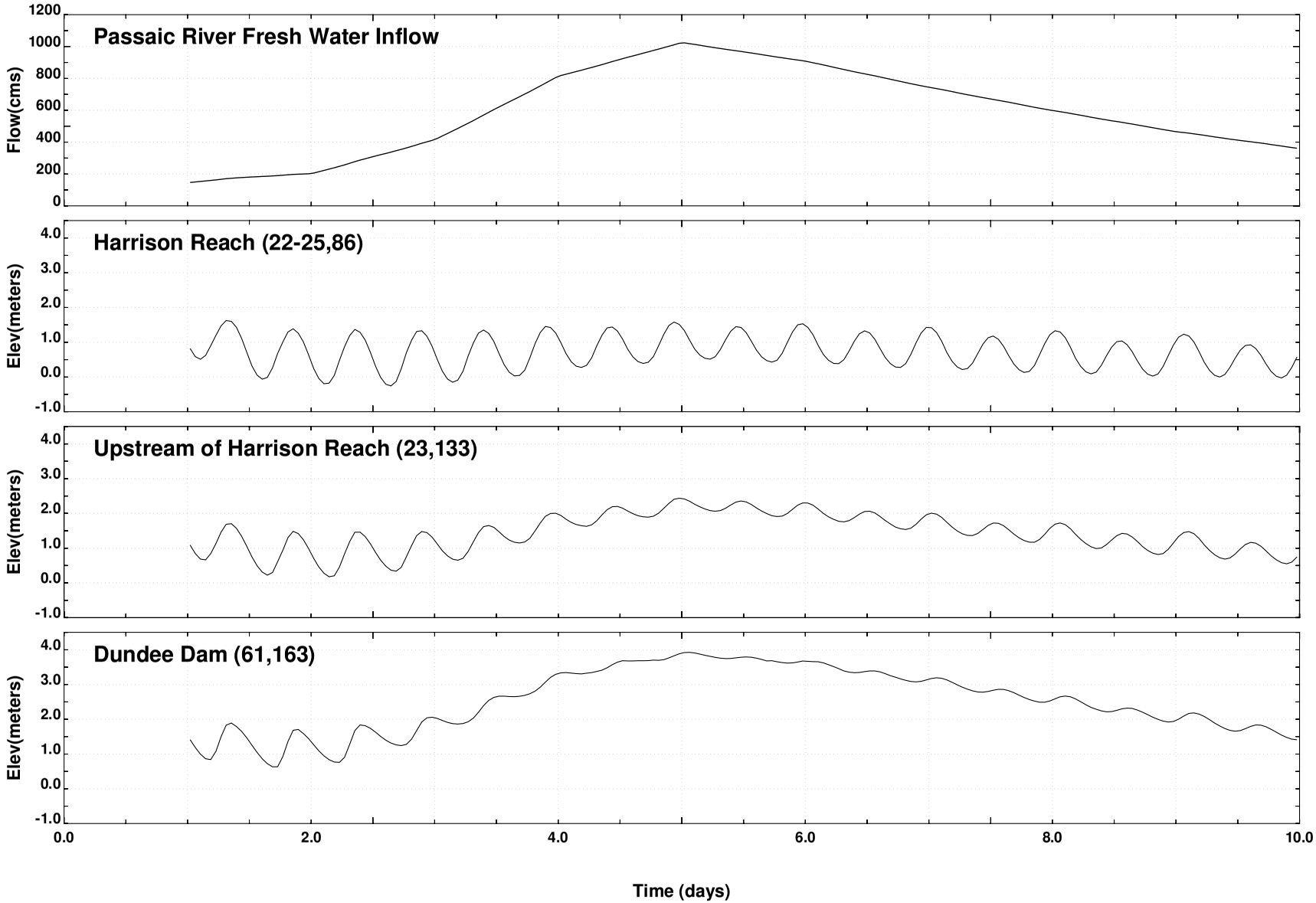


Figure 6-11. Map showing the time series output locations.



Baseline (500-Year Flood)

Figure 6-12. The 500-year flow (top panel) and water surface elevation for the Base Case Scenario in Harrison Reach and near Dundee Dam.

R2-0010591

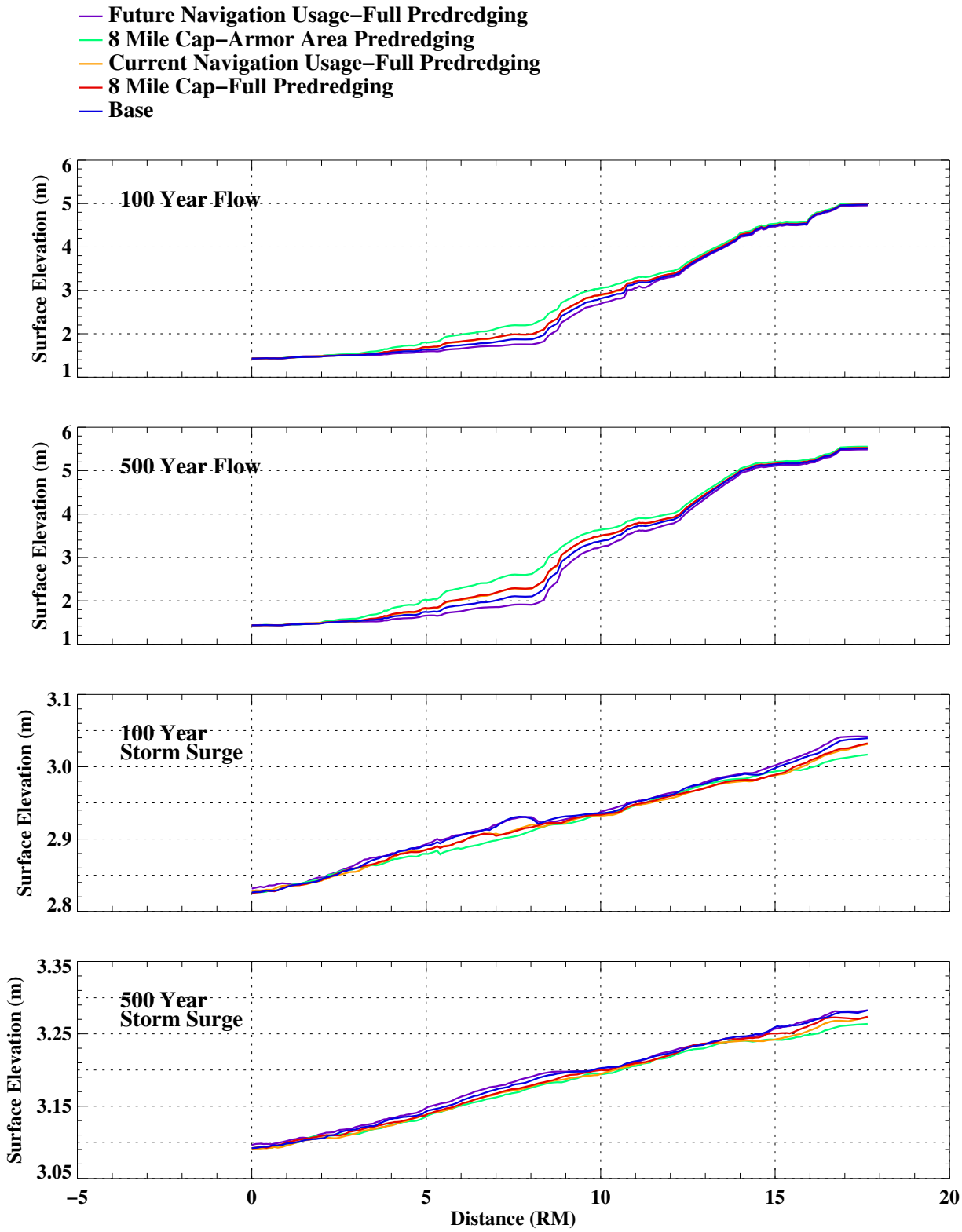


Figure 6-13. Maximum water surface elevations under different simulation scenarios along the Passaic River.

100 Year Flow for Base Case

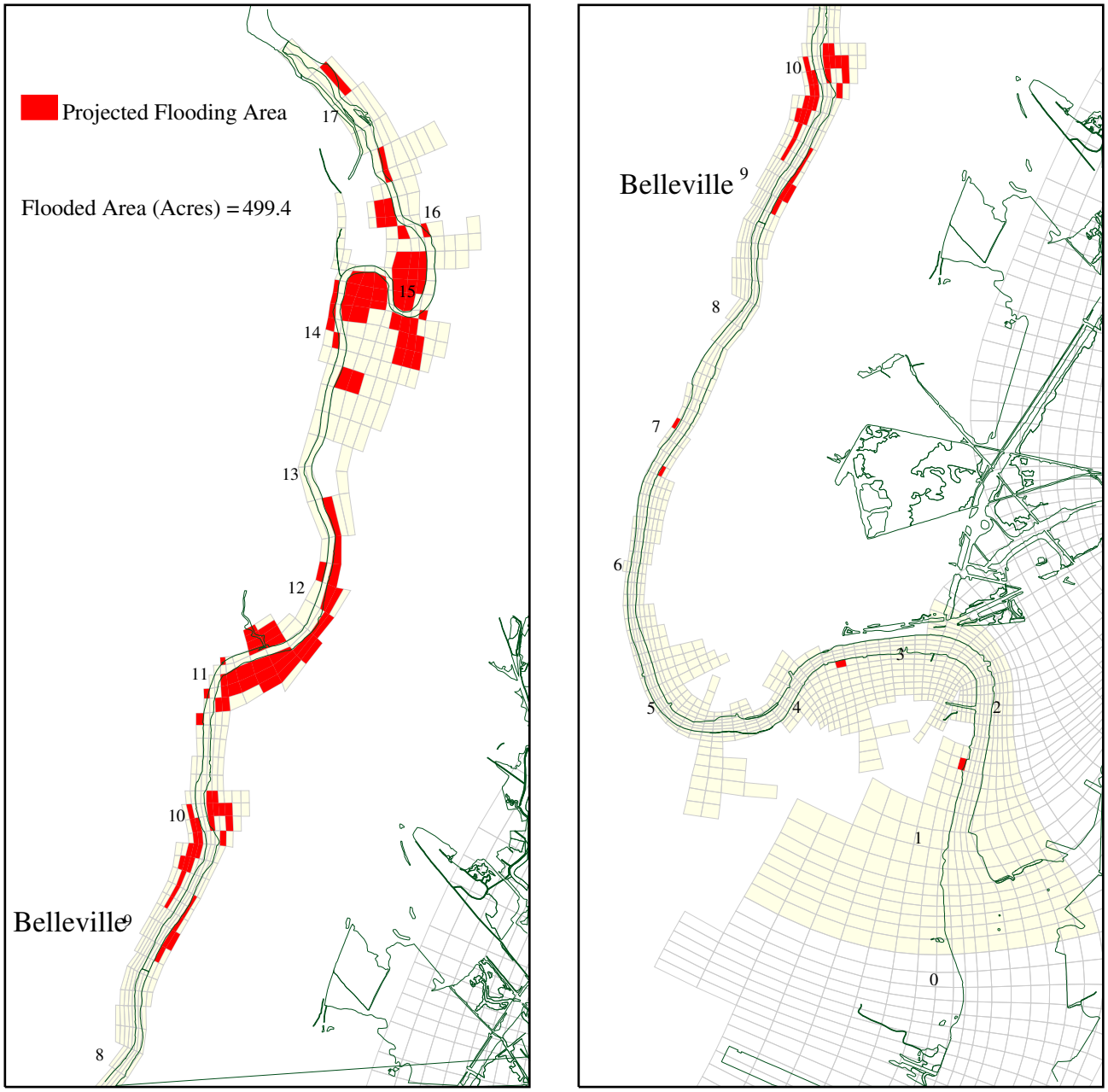


Figure 6-14. Projected flood area under the Base Case Scenario during the 100-year flow

100 Year Flow for 8 Mile Cap-Armor Area Predredging

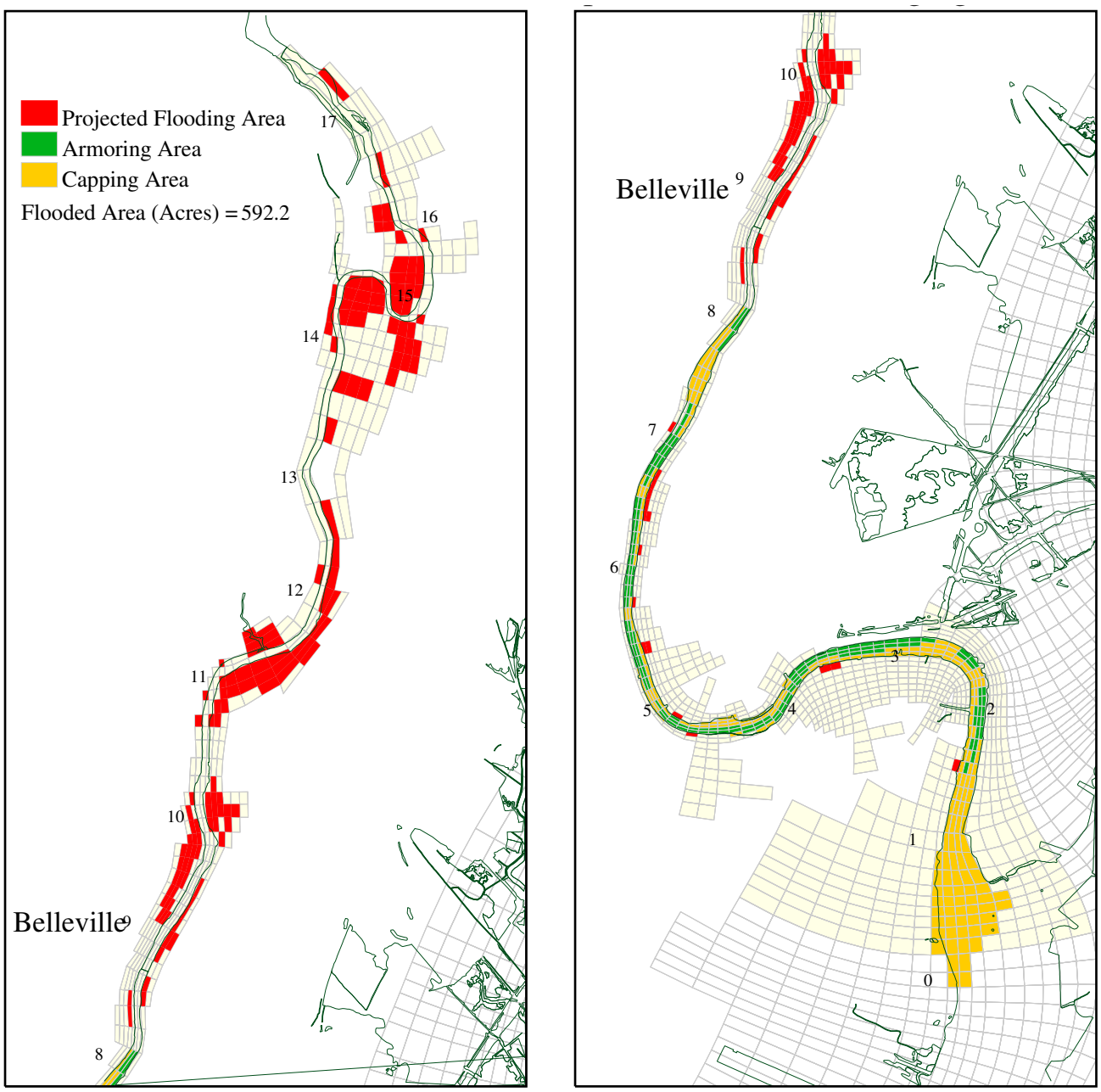


Figure 6-15. Projected flood area under the 8 Mile Cap-Armor Area Predredging Scenario during the 100-year flow.

100 Year Flow for 8 Mile Cap-Full Predredging

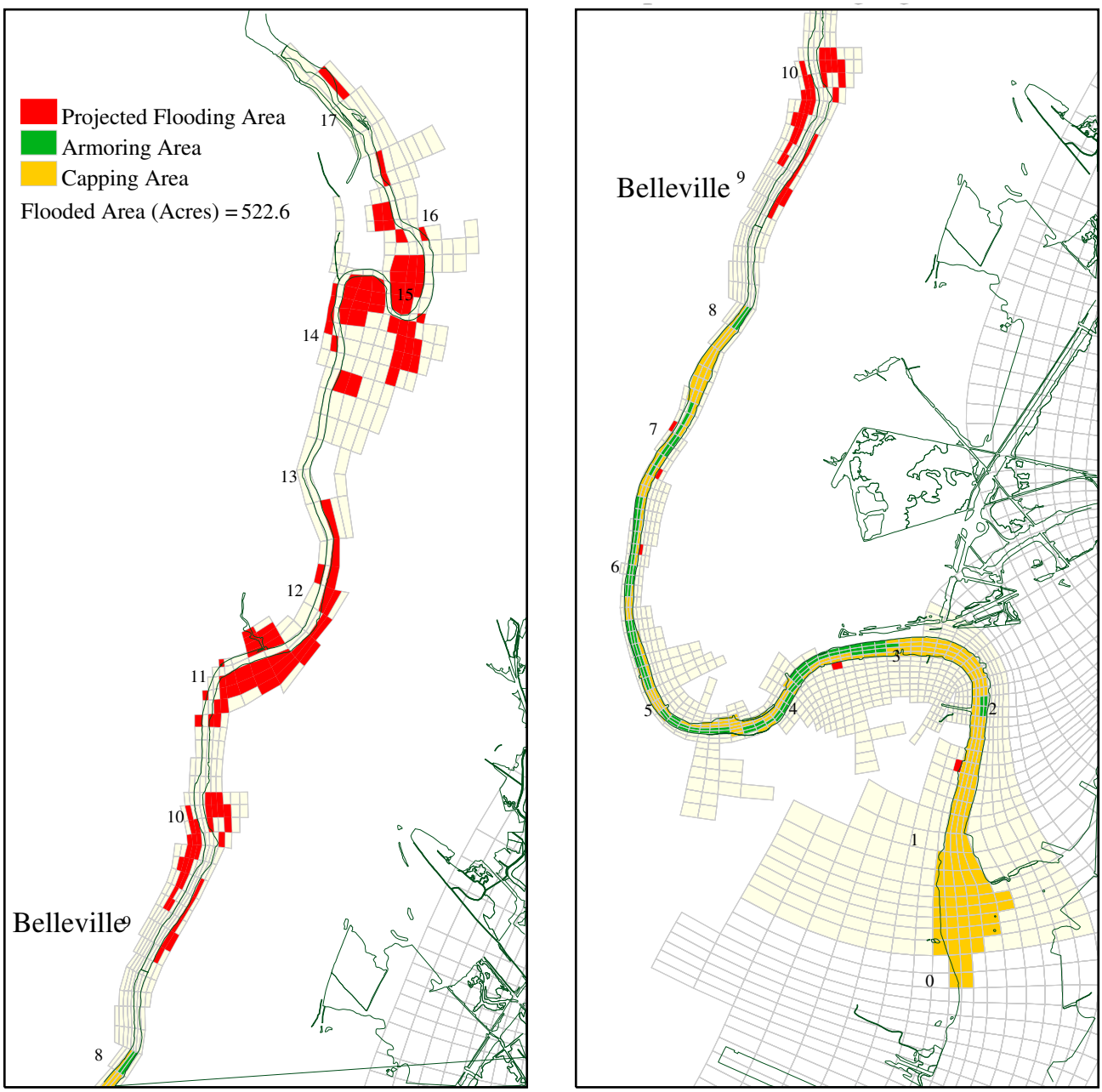


Figure 6-16. Projected flood area under the 8 Mile Cap-Full Predredging Scenario during the 100-year flow.

100 Year Flow for Future Navigation Usage-Full Predredging

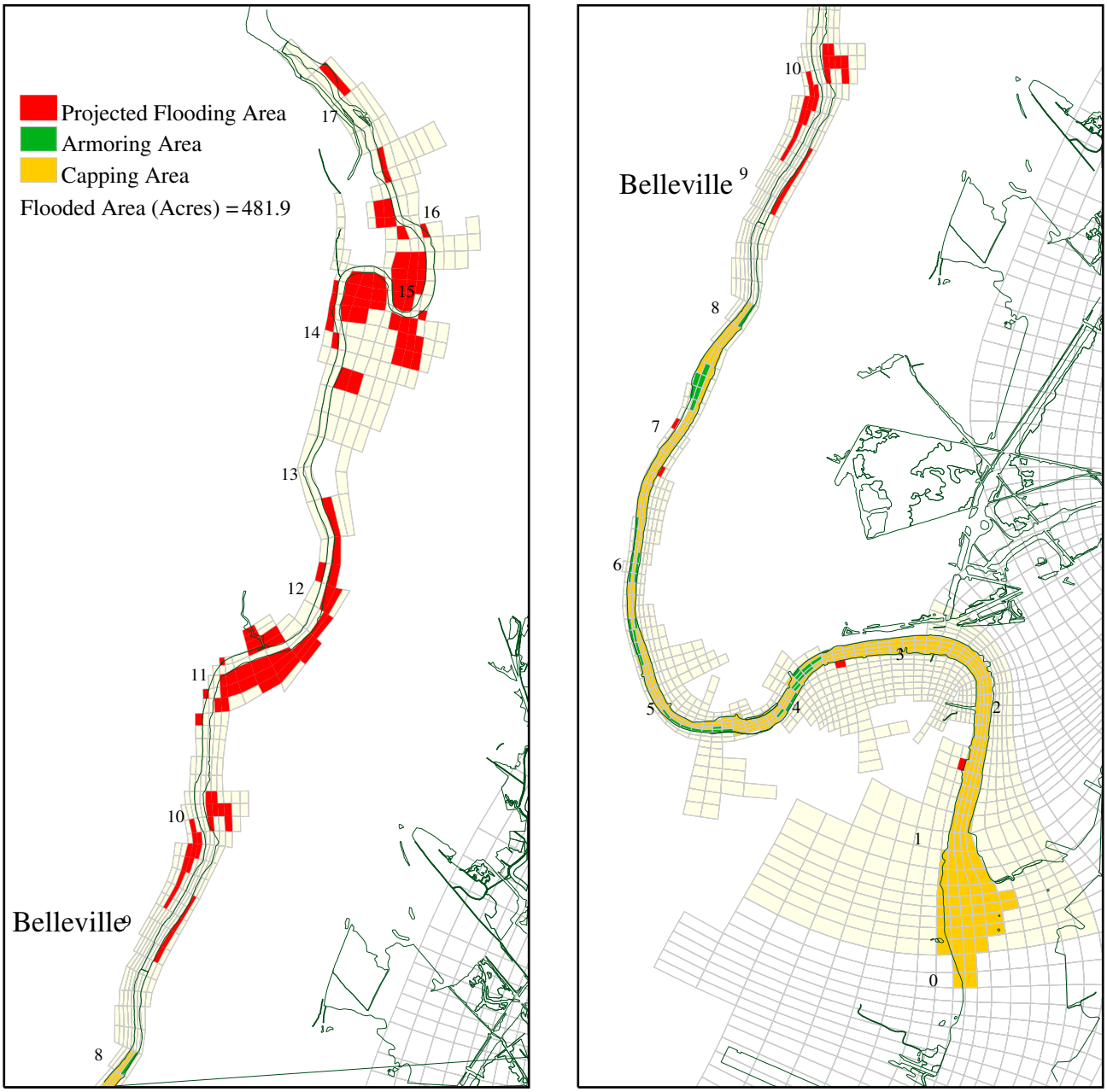


Figure 6-17. Projected flood area under the Future Navigation Usage-Full Predredging Scenario during the 100-year flow.

500 Year Flow for Base Case

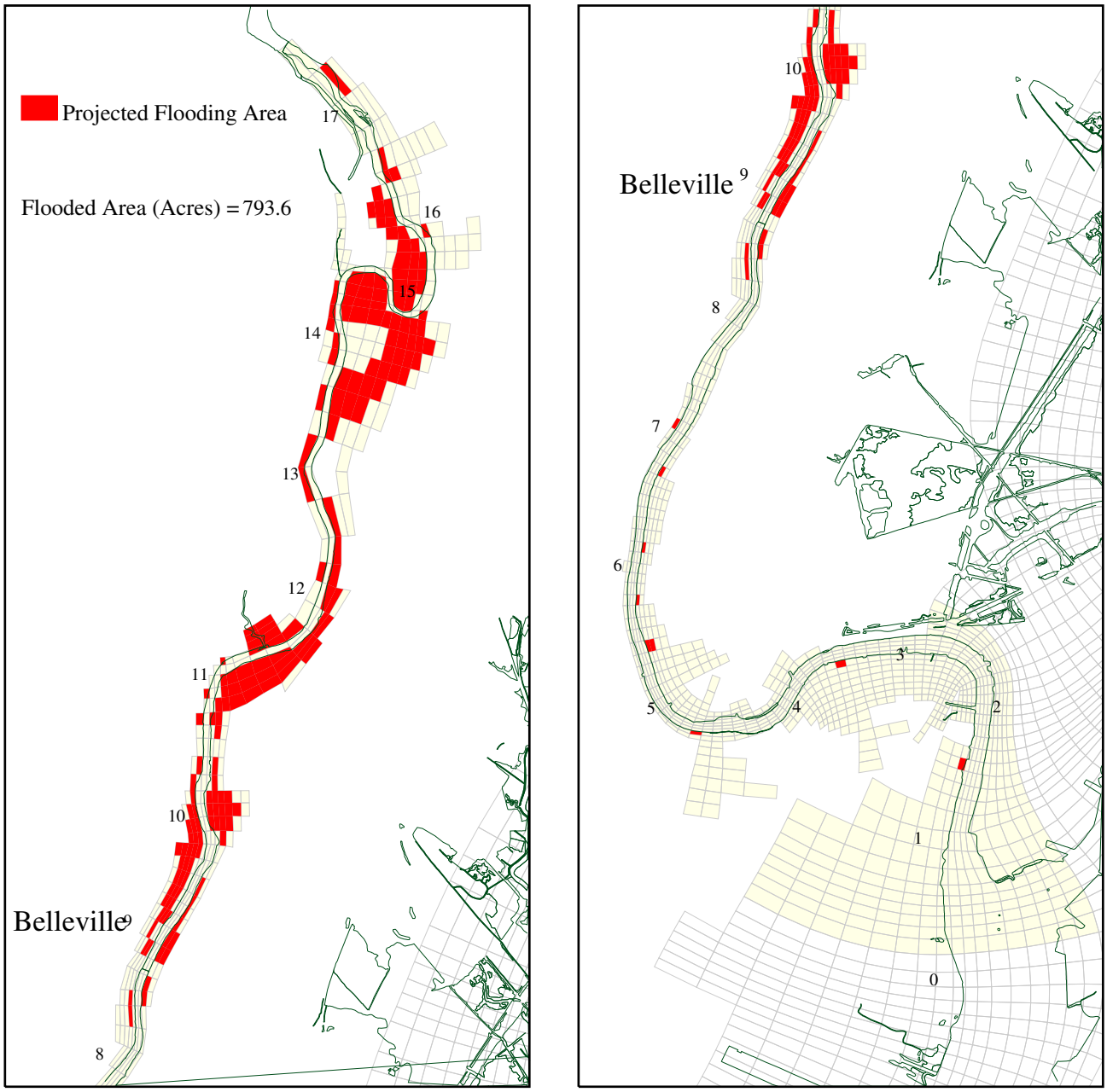


Figure 6-18. Projected flood area under the Base Case Scenario during the 500-year flow.

500 Year Flow for 8 Mile Cap-Armor Area Predredging

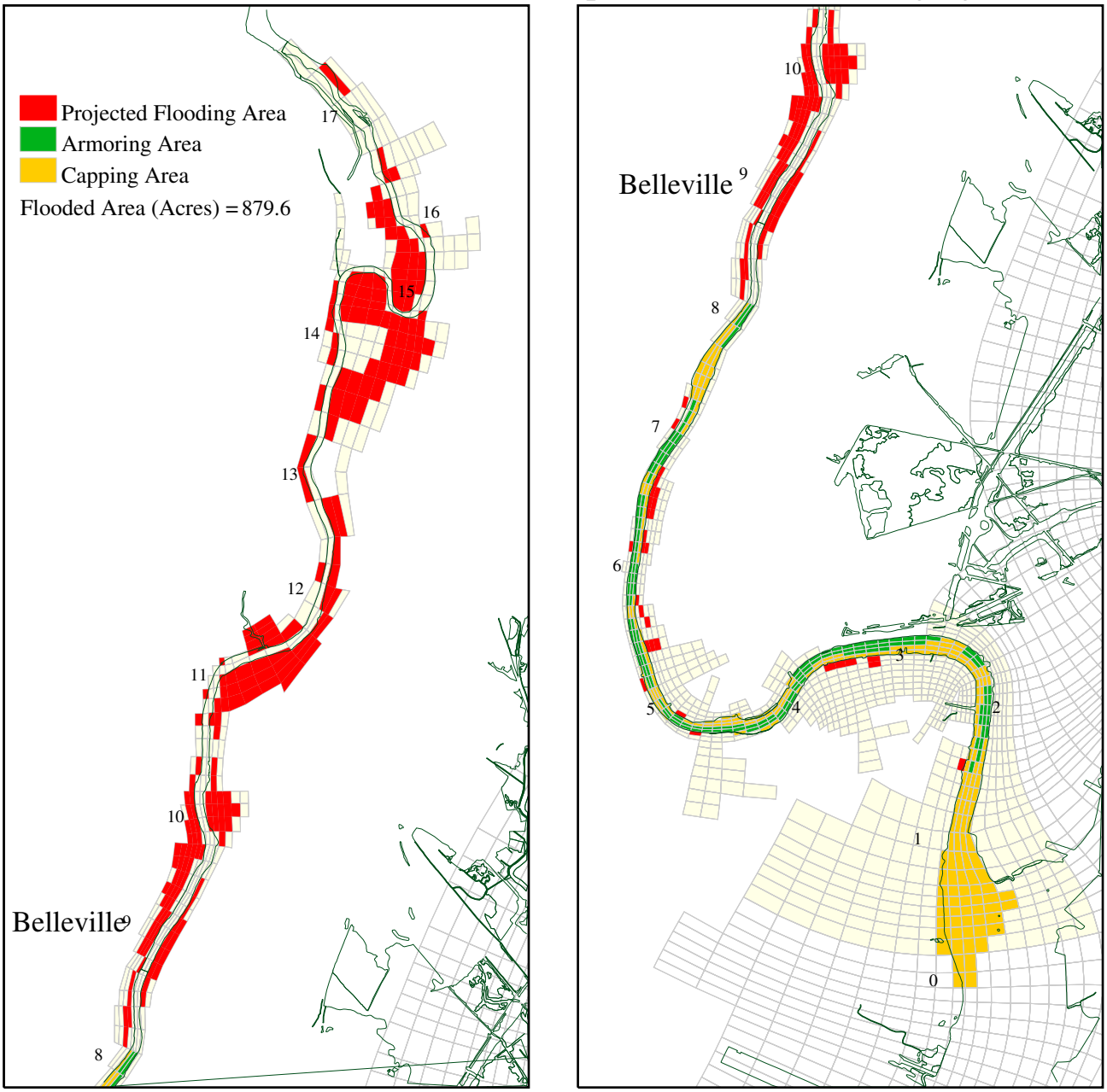


Figure 6-19. Projected flood area under the 8 Mile Cap-Armor Area Predredging Scenario during the 500-year flow.

500 Year Flow for 8 Mile Cap-Full Predredging

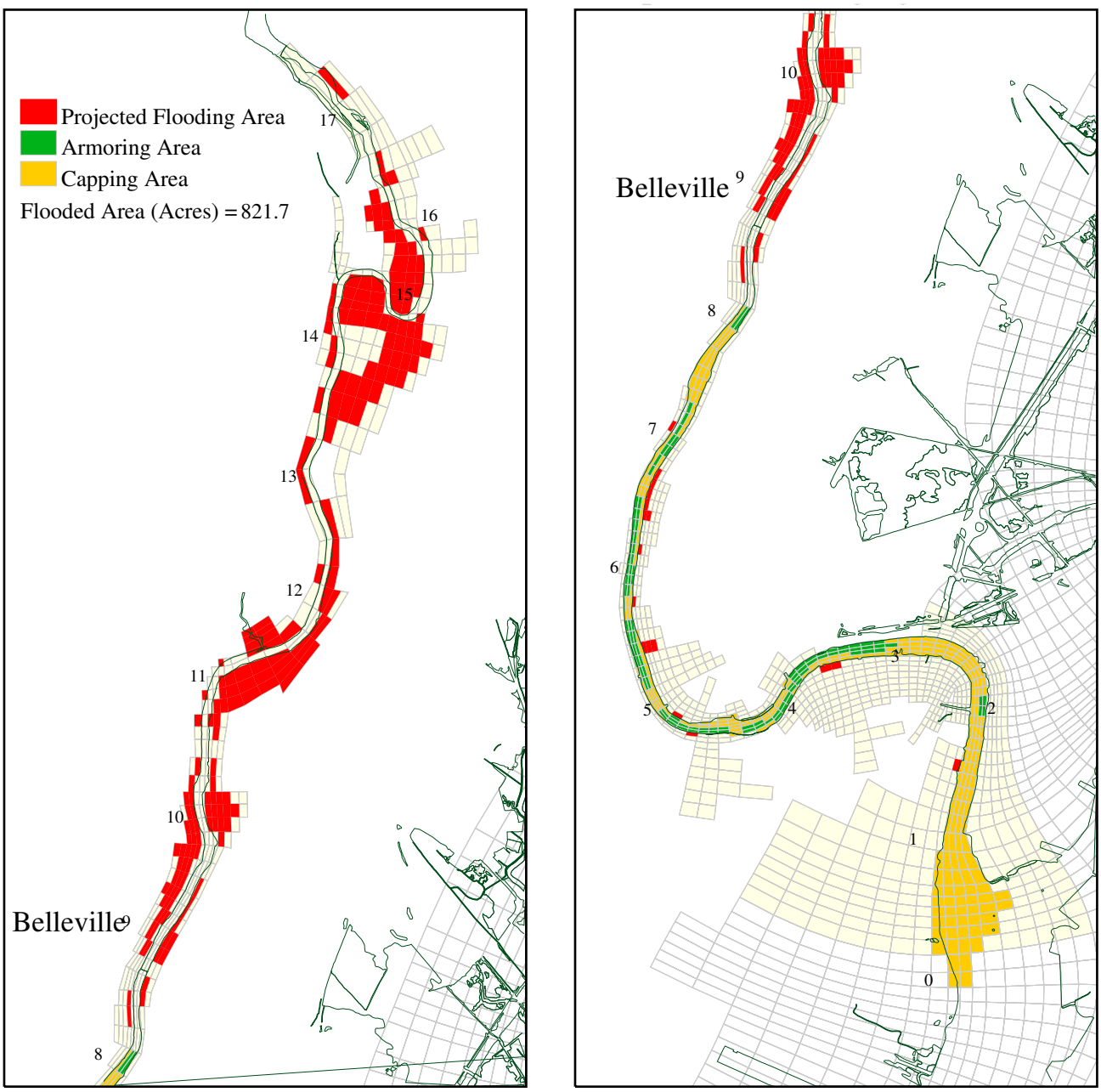


Figure 6-20. Projected flood area under the 8 Mile Cap-Full Predredging Scenario during the 500-year flow.

500 Year Flow for Future Navigation Usage-Full Predredging

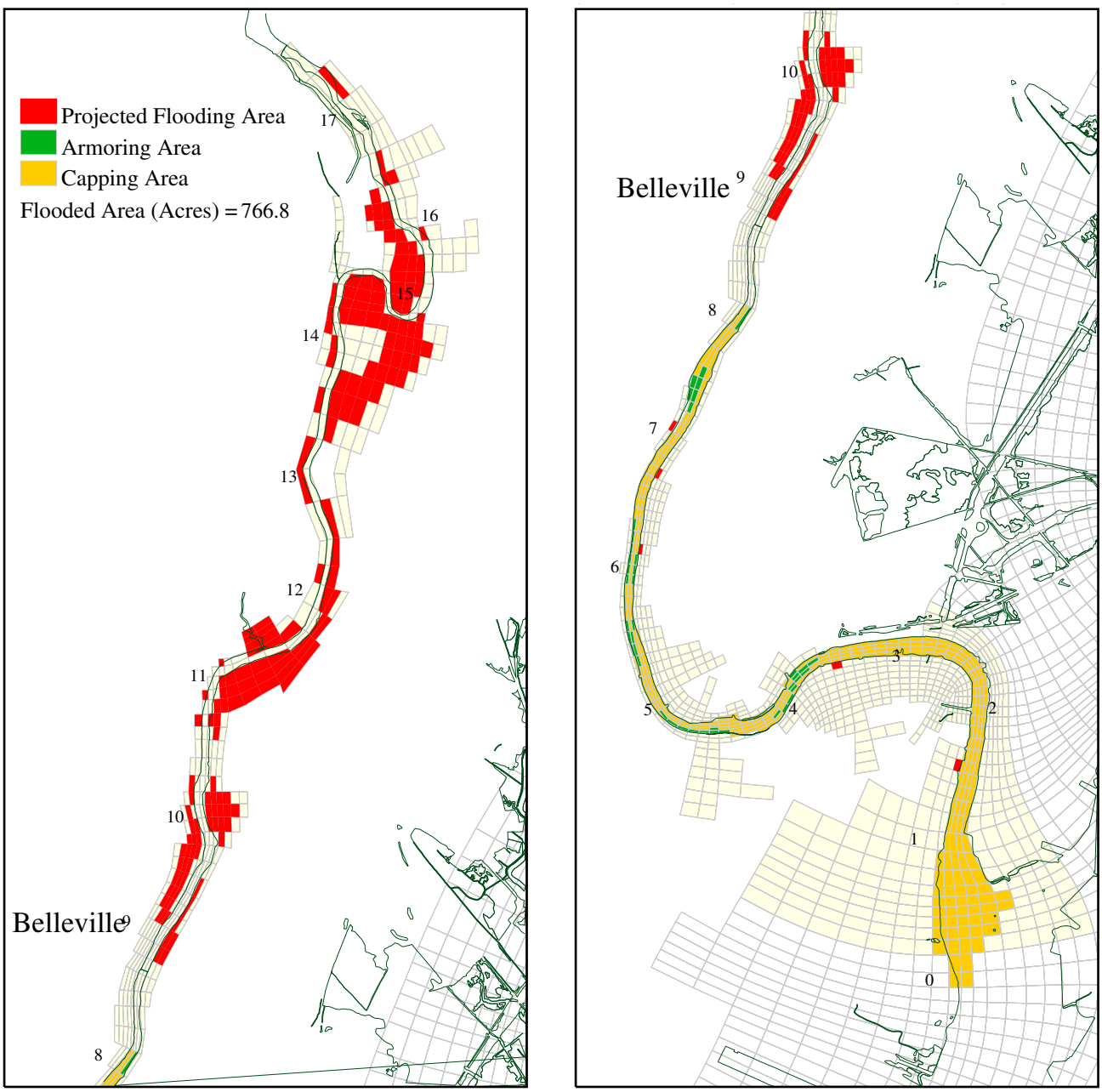


Figure 6-21. Projected flood area under the Future Navigation Usage-Full Predredging Scenario during the 500-year flow.

100 Year Storm Surge for Base Case

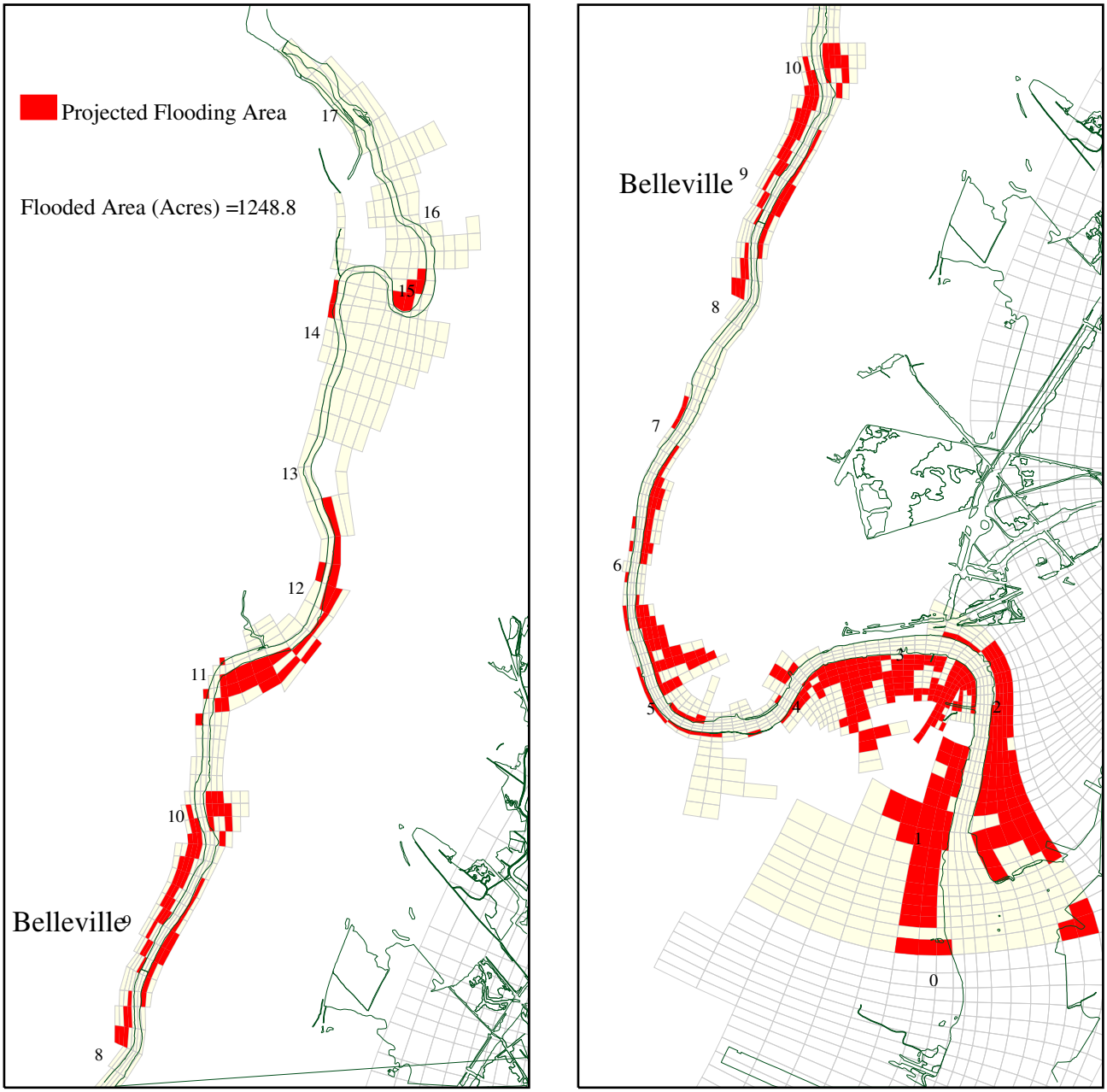


Figure 6-22. Projected flood area under the Base Case Scenario during the 100-year storm surge.

500 Year Storm Surge for Base Case

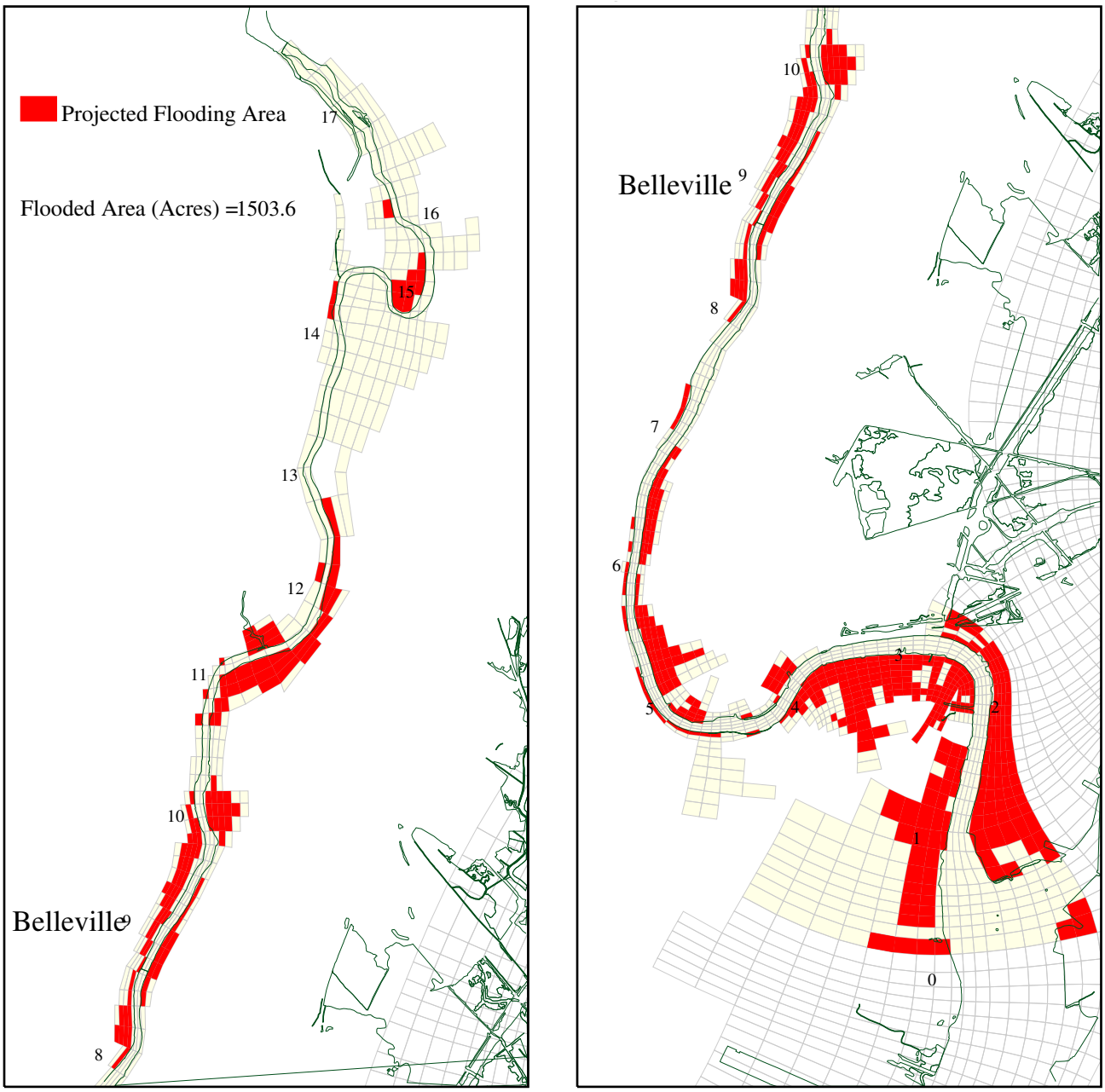


Figure 6-23. Projected flood area under the Base Case Scenario during the 500-year storm surge.

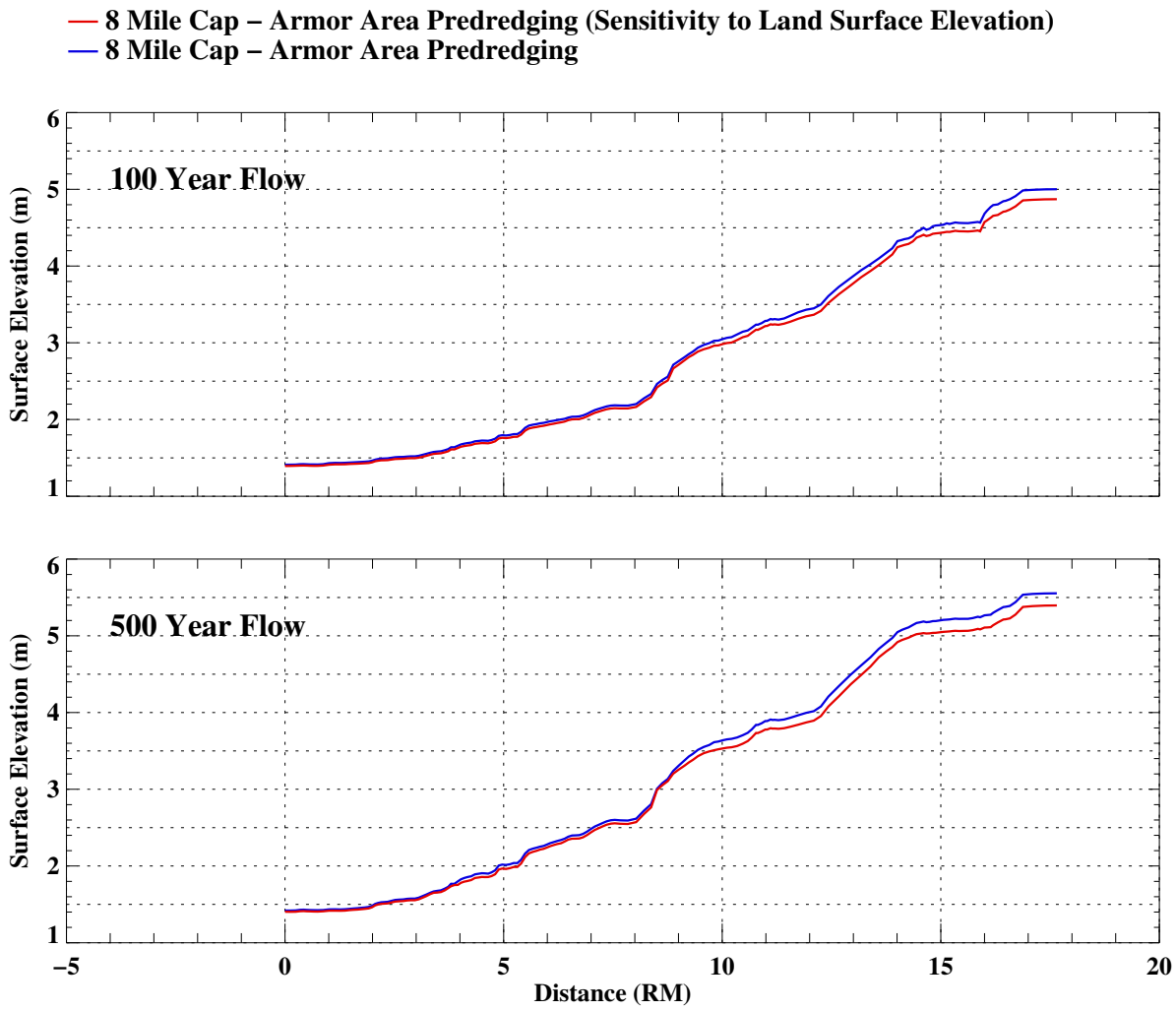


Figure 6-24. Comparison of water surface elevations for land elevation sensitivity runs for the 100-year flow (upper frame) and the 500-year flow (lower frame).

100 Year Flow for 8 Mile Cap-Armor Area Predredging
(Sensitivity to Land Surface Elevation)

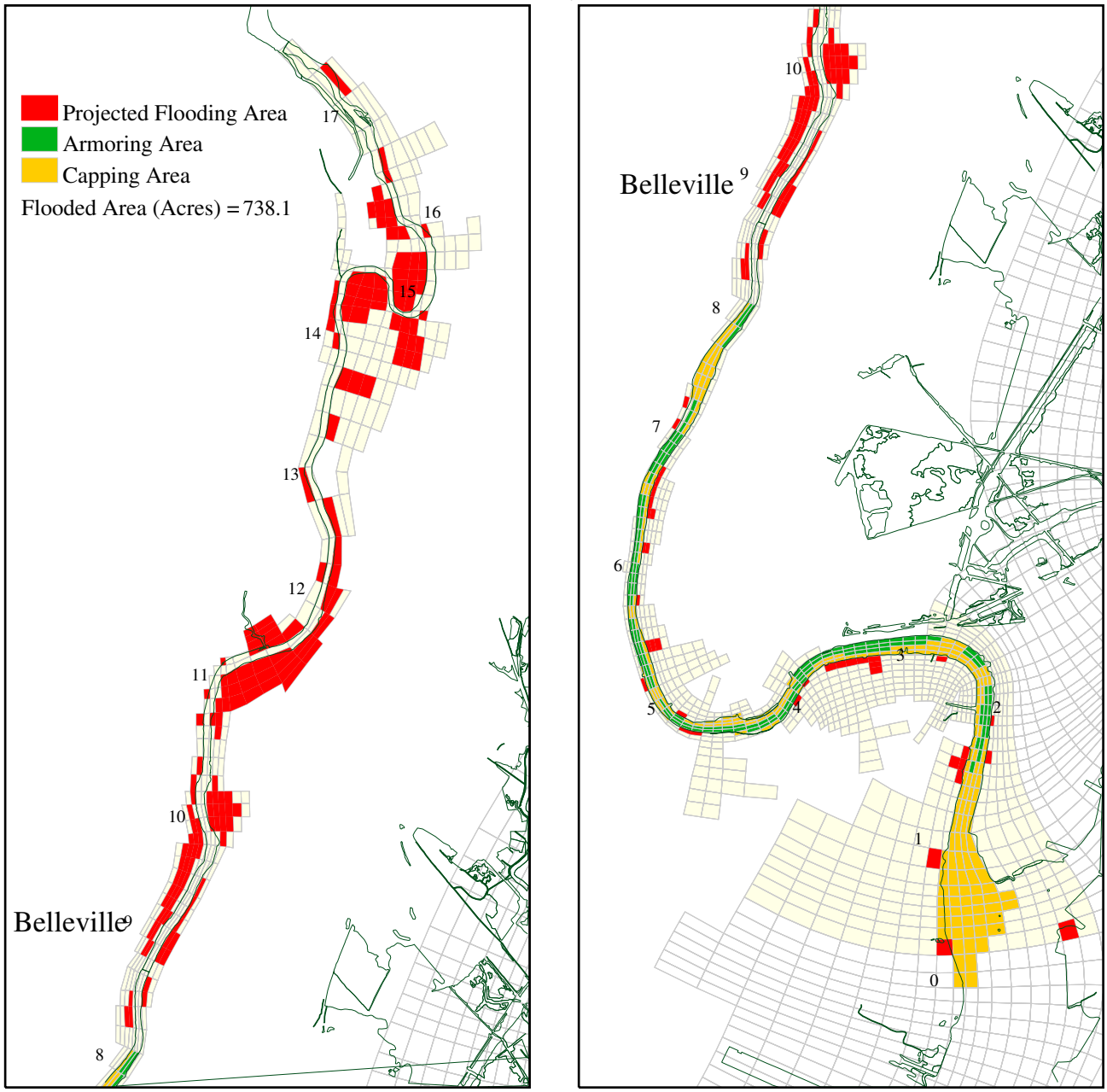


Figure 6-25. Projected flood area with 1 ft lowered land elevation under the 8 Mile Cap-Armor Area Predredging Scenario during the 100-year flow.

500 Year Flow for 8 Mile Cap-Armor Area Predredging
(Sensitivity to Land Surface Elevation)

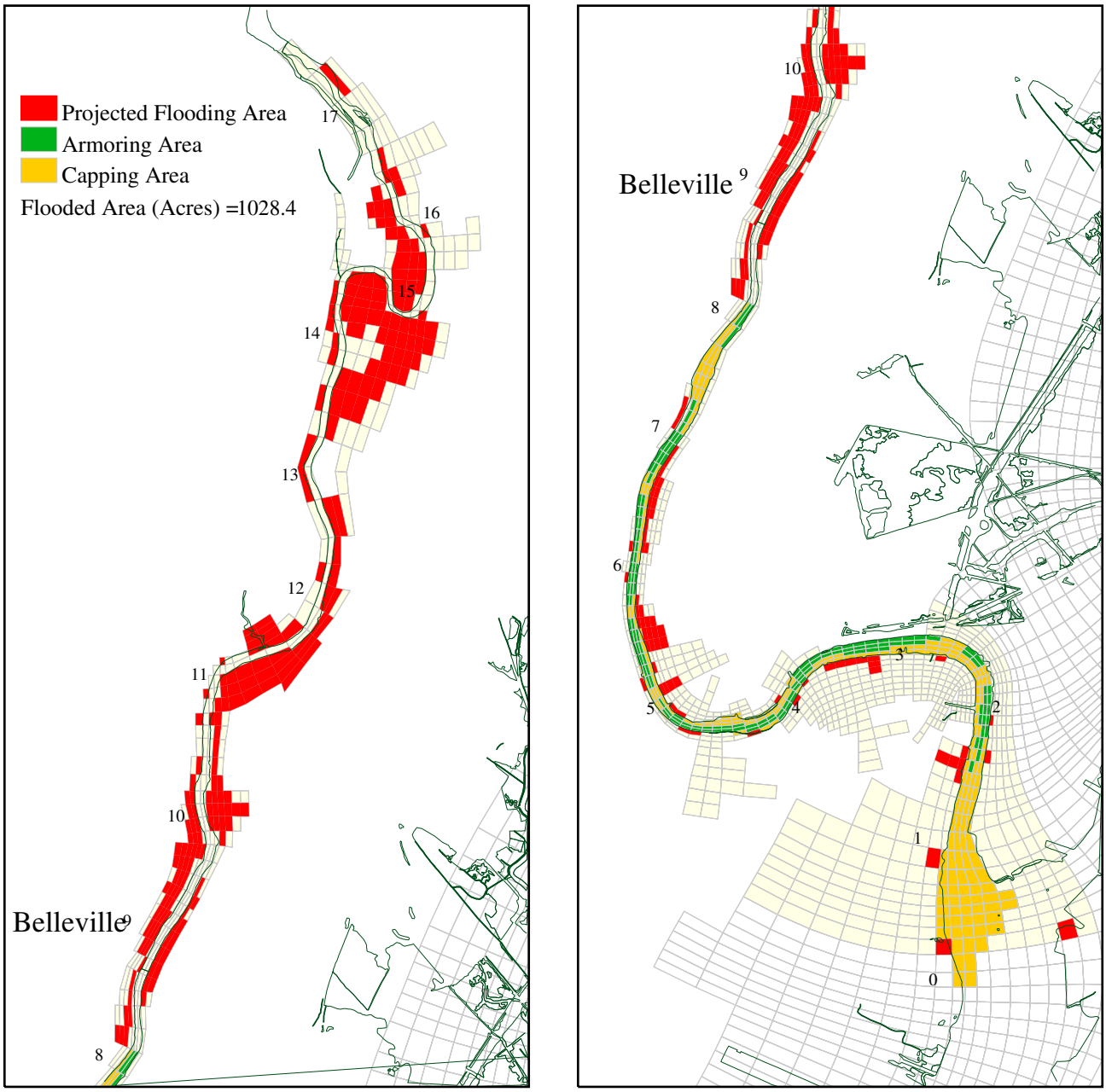


Figure 6-26. Projected flood area with 1 ft lowered land elevation under the 8 Mile Cap-Armor Area Predredging Scenario during the 500-year flow.

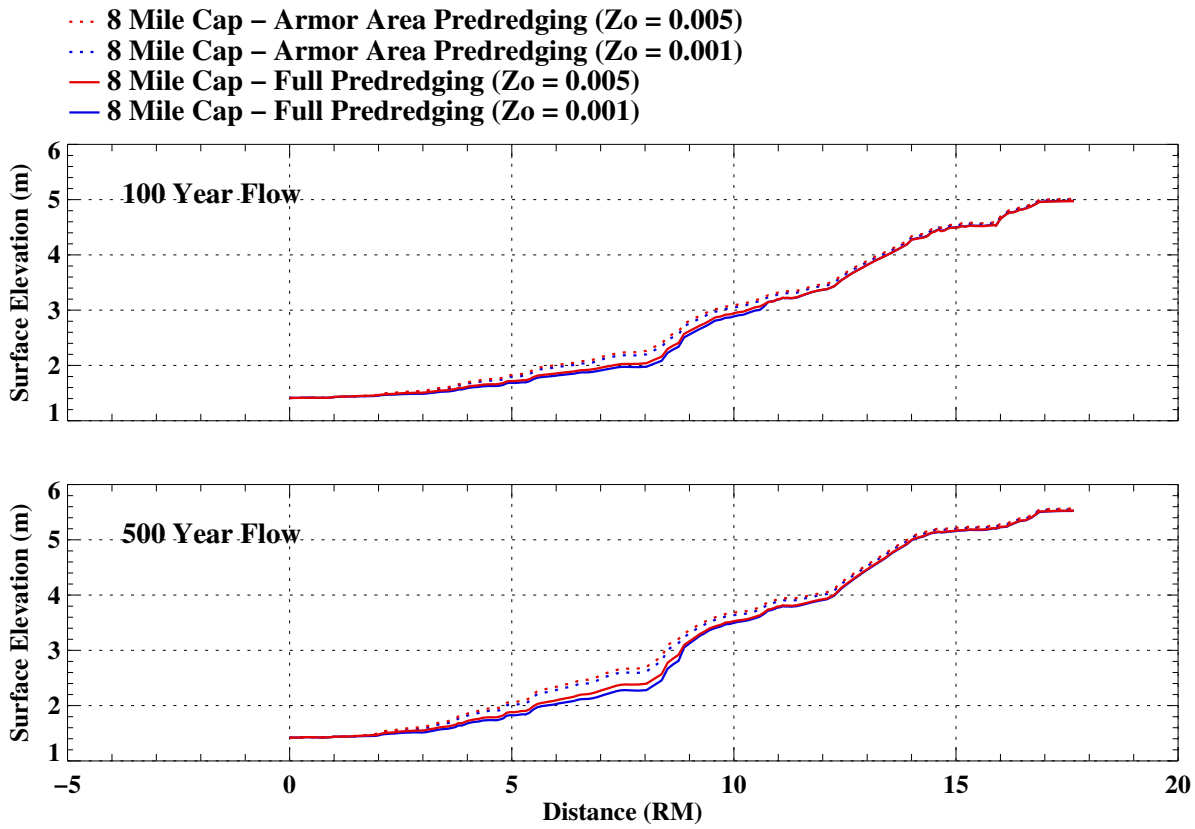


Figure 6-27. Maximum water surface elevations under different bottom roughness lengths along the Lower Passaic river.

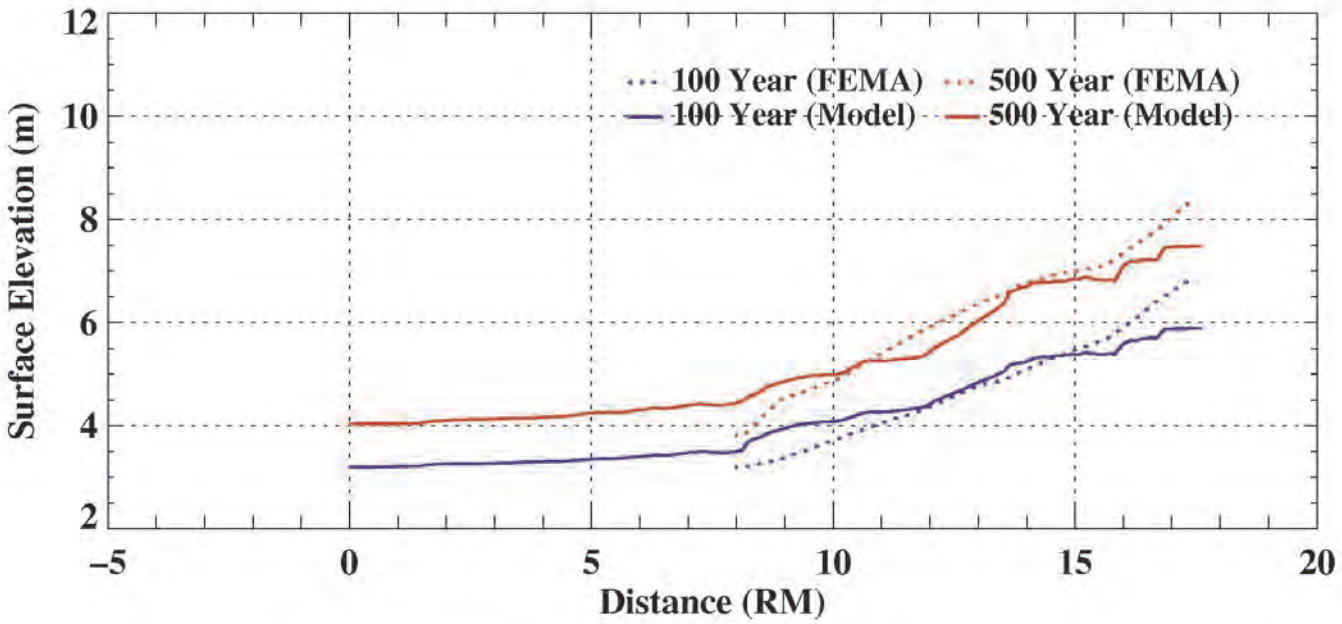


Figure 6-28. Maximum water elevations computed along the Lower Passaic River during the FEMA flood events.

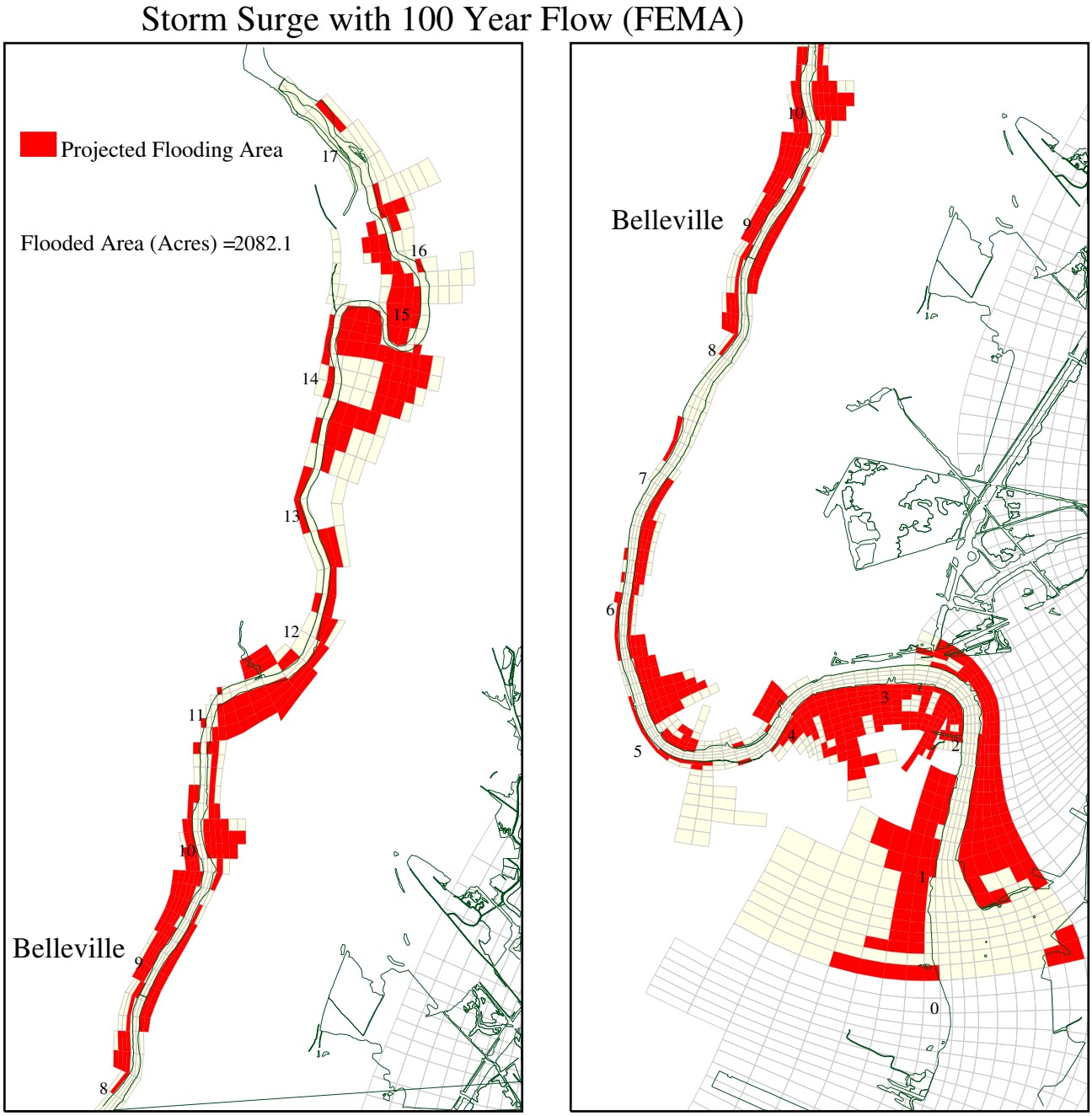


Figure 6-29. Projected flood area during the FEMA 100-year event.

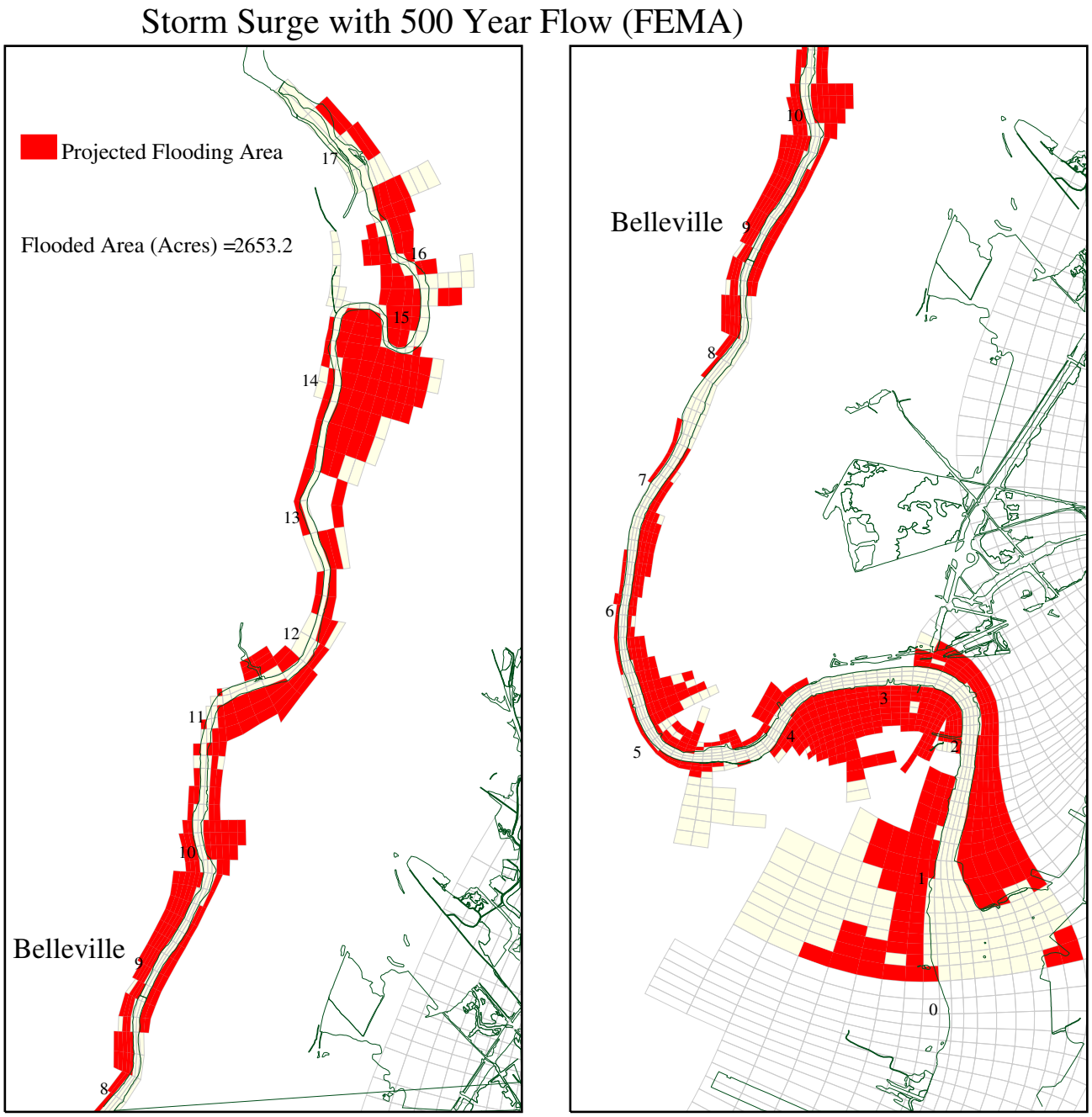


Figure 6-30. Projected flood area during the FEMA 500-year event.

SECTION 7

CONCLUSIONS

A three-dimensional hydrodynamic-sediment transport model was developed to evaluate the migration of cap material that might be placed to remediate sediment contamination in the first 8.3 miles of the LPR. The FEMA 500-year flood plain was included in the model domain and 2 ft contour USACE land survey data were used to configure the elevation of the banks of the LPR and to determine potential flooding areas.

The hydrodynamic model used in this study is an extension of the model developed by HydroQual for use in the LPR and Newark Bay RI/FS (HydroQual, 2007). A model calibration was performed using field survey data collected in the summer of 2004. Model computed water surface elevations, current velocities, and temperature and salinity were compared against observed data. Model validation was conducted using the storm surge data of Hurricane Donna and the observed surge elevations were well reproduced by the model at various locations in the study area. The FEMA 100- and 500-year events were also used for model validation. Although the hydrodynamic model did not exactly reproduce the areas of inundation within the FEMA 500-year flood plain, the model was able to reproduce comparable FEMA computed water level rises and flooding areas in the LPR.

As part of the cap stability/erosion analysis, conducted using the sediment transport model-SEDZLJ, it was found that sands from the Ambrose Channel were highly erodible and thus not suitable for use as a sand cap in the LPR. Instead, it will be necessary to utilize sands from an upland borrow source. These upland sands are comprised of sands with larger particle grain sizes, which are heavier and less subject to the forces of erosion experienced in the LPR. These are, however, areas within the river where it will be necessary to place protective armor (rock cobble) over the sand cap so as to prevent erosion of the cap. This occurs in regions of the river which experience high bottom water velocities with accompanying high bottom shear stress.

Analyses of extreme flow and surge events were also conducted. The 100- and 500-year flows are estimated as 20,000 and 26,000 cfs and the 100- and 500-year storm surges as 2.4 m and 2.67 m above MSL, respectively, in the study area. The model was configured with the 100- and 500-year flow and storm surge events. Four capping/armoring scenarios were evaluated against a Base Case Scenario: 1) 8 mile Cap – Armor Area Pre-Dredging; 2) 8 mile Cap – Full Pre-Dredging; 3) Current Navigation Usage – Full Pre-Dredging; and 4) Future Navigation Usage – Full Pre-Dredging. A summary of the modeling results is as follows:

- Under the Base Case Scenario, the 100 and 500-year flows would inundate areas of 499 and 794 acres, respectively.
- The "8 mile Cap – Armor Area Pre-Dredging" Scenario would increase the water elevation by as much as 0.5 and 0.8 m from those in the Base Case Scenario during the 100- and 500-year flows, respectively. Compared to the Base Case Scenario, the "8 mile Cap – Armor Area Pre-Dredging" Scenario would flood an additional 93 acres during the 100-year flow (total flooded area of 592 acres) and 86 acres during the 500-year flow (total flooded area of 880 acres).
- The "8 mile Cap – Full Pre-Dredging" Scenario would increase the water elevation by 0.1 and 0.2 m, as compared to the Base Case Scenario during the 100- and 500-year flows, respectively. The flooded areas would increase by 24 acres during the 100-year flow (total flooded area of 523 acres) and by 28 acres during the 500-year flow (total flooded area of 822 acres) compared to those computed under the Base Case Scenario.
- The "Current Navigation Usage – Full Pre-Dredging" Scenario would produce similar results to those under the "8 mile Cap – Full Pre-Dredging" Scenario, both for water elevation rise and flooded areas.
- The "Future Navigation Usage – Full Pre-Dredging" Scenario would reduce the maximum water level rise by 0.1 and 0.2 m, compared with the Base Case Scenario during the 100- and 500-year flows, respectively. The flooded areas would decrease by 17 acres during the 100-year flow (total flooded area of 482 acres) and by 27 acres during the 500-year flow (total flooded areas of 767 acres) compared to those computed under the Base Case Scenario.
- Model results indicate that the 100 and 500-year storm surges would cause the maximum flooding in the study area (1,249 and 1,504 acres, respectively, under the Base Case Scenario) and most of the flooding would occur in the low lying areas near the mouth of the river. Different capping/armoring scenarios would not change the flooded areas during the storm surge events, compared to those computed under the Base Case Scenario.
- A few sensitivity runs of the model were conducted to account for the uncertainty of the land elevation by reducing the land elevation by 1 foot and for the uncertainty of the bottom roughness lengths of the upland sand cap material by increasing the bottom roughness lengths by a factor of five. The results suggest that, by lowering the land elevation by 1 foot, the flooding area during the 100- and 500-year flow would increase as much as 25 percent compared to the results using the original land

elevation configuration. A higher bottom roughness length (a value of 0.005) for the sand cap material would result in about a 0.5 to 2.5 % increase in the flooding areas compared to those computed with the value (0.001) used for the flooding analyses.

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SECTION 8

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ATTACHMENT A

SEDZLJ INCORPORATION INTO ECOMSEDZLJ

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September 25, 2006

SEDZLJ incorporation into ECOM

Sediment Transport Model Implementation

As part of the Lower Passaic River Restoration Project, HydroQual and the Technical Advisory Committee (TAC) decided to implement a pre-existing, peer-reviewed (Jones and Lick, 2001) sediment transport model into HydroQual's hydrodynamic model, ECOM. SEDZLJ uses measured sediment erosion data as the basis for modeling sediment transport in a system. Rather than attempt to reconstruct a computer code equivalent to SEDZLJ using information contained in the Jones and Lick paper, it was determined to be more expedient and cost-effective for Sea Engineering, Inc. (SEI) to incorporate SEDZLJ into ECOM. This technical memo outlines the completion of the first two sub-tasks of the sediment transport modeling effort. The sub-tasks are:

> **Model Code Integration:** SEI will implement the existing version of SEDZLJ into HydroQual's current hydrodynamic/sediment transport model, ECOMSED. HydroQual will provide SEI with a copy of the current version of the ECOMSED computer code, User's Guide and a model input file that has been used in testing and conducting quality control checks for the performance of the ECOMSED model.
>
> **Model Code Verfication:** As part of the implementation process SEI will verify that the SEDZLJ code has been properly implemented within ECOMSED by simulating and reproducing the laboratory data set generated by Little and Mayer (1972).

Model Code Integration
The SEDZLJ code was integrated into the ECOM model to accomplish two goals. The first goal is to calculate the net flux of sediments ($g/cm^2/s$) at the sediment/water interface due to erosion and deposition. The second goal is to calculate bedload transport of sand sized sediments on the computational grid. Water column transport of sediments is unchanged from the current ECOM implementation with the exception of allowing more than two size classes.

The integration was accomplished through the inclusion of multiple subroutines to handle the input and calculation of the above processes. Figure 1 is a flowchart illustrating the main features of the model integration. Point "A" calls the SEDZLJ input routines, point "B" calls the water column transport routines from ECOM to transport all size classes of sediment utilized, and point "C" calls the routines to calculate the sediment flux and the bedload transport. The implementation of this structure allows for easy integration while preserving the main structure of ECOM. The model structure indicated has been verified to fit into the ECOM structure and operate with no variable conflicts or input conflicts. Full variable definitions and input file descriptions will be provided upon finalization of SEDZLJ implementation.

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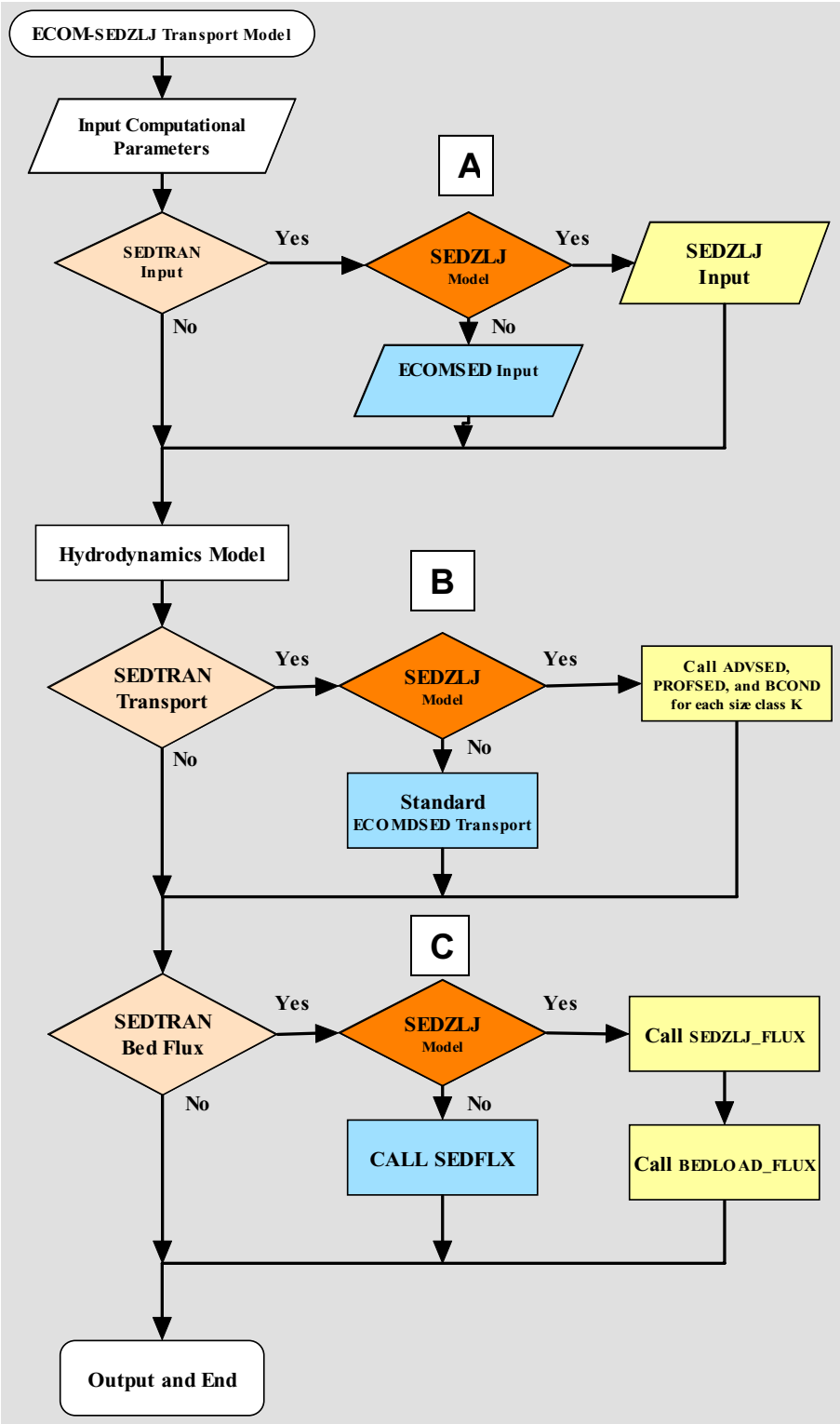

Figure 1. Flow chart illustrating main points of SEDLZJ Integration into ECOM

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Model Code Verification

The evaluation and validation of the SEDZLJ implementation (ECOM-SEDZLJ) required modeling a set of well-documented physical experiments. Little and Mayer (1972) conducted detailed measurements of non-cohesive bed-armoring and transport in a straight flume. This case was utilized as a verification here because the bed-armoring and transport processes in the experimental setup require the utilization of critical algorithms in the sediment transport model. No detailed cohesive data sets for model verification exist at this time, so the model framework is only validated with non-cohesive data.

In the experiment, a flume 12.2 m long and 0.6 m wide was filled with a distribution of sand and gravel sediments. Clear water was then run over the sediment bed at a flow rate of 0.016 m^3/s. The eroded sediment was collected at the outlet of the flume, and the sediment transport rate was determined. When the sediment transport rate had decreased to 1 percent of the beginning transport rate, the bed was assumed to be fully armored and the experiment was ended. The full armoring of the sediment bed occurred in 75.5 hours. The final armored bed particle size distribution of the sediment surface was then measured by means of a wax cast.

The experiment was simulated with ECOM-SEDZLJ. Thirteen elements with a downstream dimension of 100 cm and cross-stream dimension of 60 cm were used to discretize the domain. The initial sediment distribution in the model was set equal to the distribution in the flume experiments. The sediment bed comprised 9 size classes selected to accurately represent the sediment bed in the experiment. Table 1 shows the 9 size classes used in the model and their corresponding properties of settling speed, w_s, critical shear stress for erosion, t_{ce}, and critical shear stress for suspension, t_{cs}. Data from the Roberts et al. (1998) Sedflume studies on quartz were used to define the erosion rates and critical shear stresses for sediments in the model. The coefficient of friction was set such that the measured shear stress of 1.0 N/m^2 was reproduced in the model.

Table 1. Sediment size class properties used for Little and Mayer (1972) study.

Particle Size (m)	Initial Bed Percentage by Mass	w_s (cm/s)	ce (N/m^2)	cs (N/m^2)
125	2	0.9	0.15	0.15
222	8	2.25	0.24	0.26
432	23	5.2	0.33	0.45
1020	32	11.3	0.425	2.12
2000	11	18.01	0.93	5.36
2400	8	20.18	0.97	6.73
3000	6	23.07	1.2	8.79
4000	6	27.25	1.6	12.26
6000	4	34.13	2.48	19.2

Model Results

The model was run for 75.5 hr with a time step of 0.1 s. The model shows good agreement with the experimental data. In the first few hours, there is a rapid increase in the average particle size from 1,600 to 2,500 m; this is followed by a much slower rate of increase to a little above 2,500 m by the end of the experiment. Associated with this increase, is a four order-of-magnitude decrease in erosion rate. The reason for this decrease is that the finer particle sizes are eroded from the sediment bed while the coarser particles are left behind,

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thereby increasing the average particle size of the bed and decreasing the erosion rates. This is responsible for the drop in the net transport rate of sediments from the channel, and is consistent with bed coarsening as discussed earlier. Initially the transport is almost equally bedload and suspended load, but as the bed coarsens the transport rate becomes almost exclusively bedload. This armoring process is expected since coarse particles, incapable of suspension at this shear stress, are concentrated in the bed. The modeled and measured transport rate and average particle size are shown in Figure 2 as a function of time.

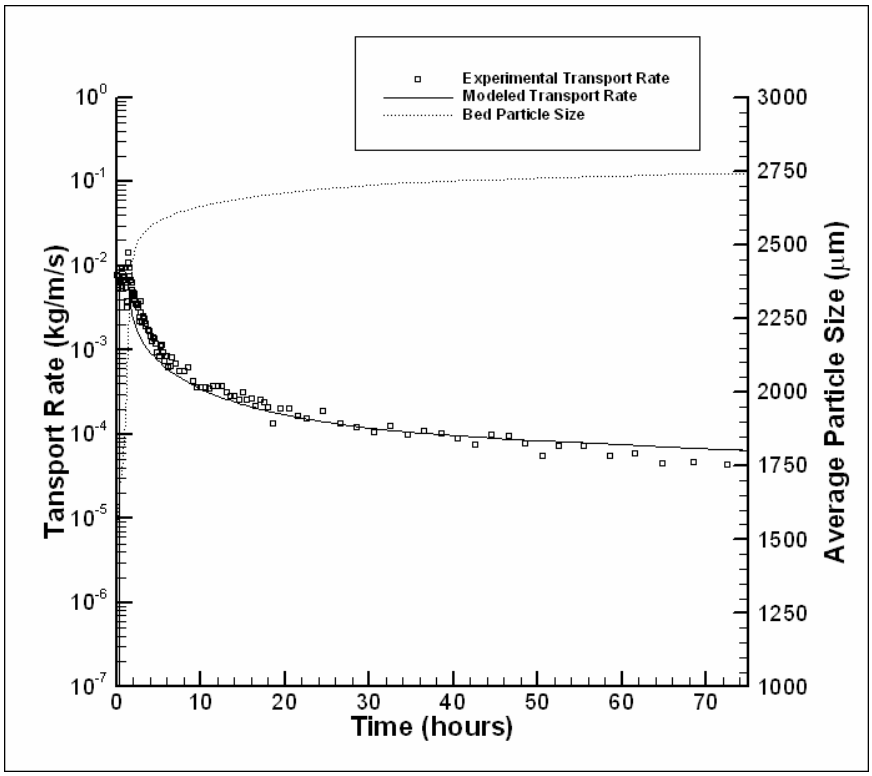

Figure 2. Modeled vs. measured transport rates and average particle size as a function of time.

A comparison is also made between the final particle size distribution in the active layer of the model and the particle size distribution of the surface of the bed in the experiment. Although the distributions are not identical, the final d_{50} was 2,750 m in the model and 3,200 m in the experiment yielding a difference of 14 percent. Discrepancies between the two distributions are most evident at smaller particle sizes.

The results from this model show good overall agreement with the data and trends observed in the experiments. Such agreement indicates that the model accurately estimates the erosion, transport, and subsequent coarsening of a sediment bed.

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ATTACHMENT B

BED ELEVATION CHANGES, MAXIMUM EROSION AND BOTTOM SHEAR STRESSES FOR AMBROSE SAND CAP

Figure B-1a. Plan view of the net elevation change under the 1-year return flow conditions (Ambrose sand used as the capping material).

Figure B-1b. Plan view of the maximum erosion under the 1-year return flow conditions (Ambrose sand used as the capping material).

Figure B-1c. Plan view of the bottom shear stress under the 1-year return flow conditions (Ambrose sand used as the capping material).

Figure B-2a. Plan view of the net elevation change under the 25-year return flow conditions (Ambrose sand used as the capping material).

Figure B-2b. Plan view of the maximum erosion under the 25-year return flow conditions (Ambrose sand used as the capping material).

Figure B-2c. Plan view of the bottom shear stress under the 25-year return flow conditions (Ambrose sand used as the capping material).

Figure B-3a. Plan view of the net elevation change under the 100-year return flow conditions (Ambrose sand used as the capping material).

Figure B-3b. Plan view of the maximum erosion under the 100-year return flow conditions (Ambrose sand used as the capping material).

Figure B-3c. Plan view of the bottom shear stress under the 100-year return flow conditions (Ambrose sand used as the capping material).

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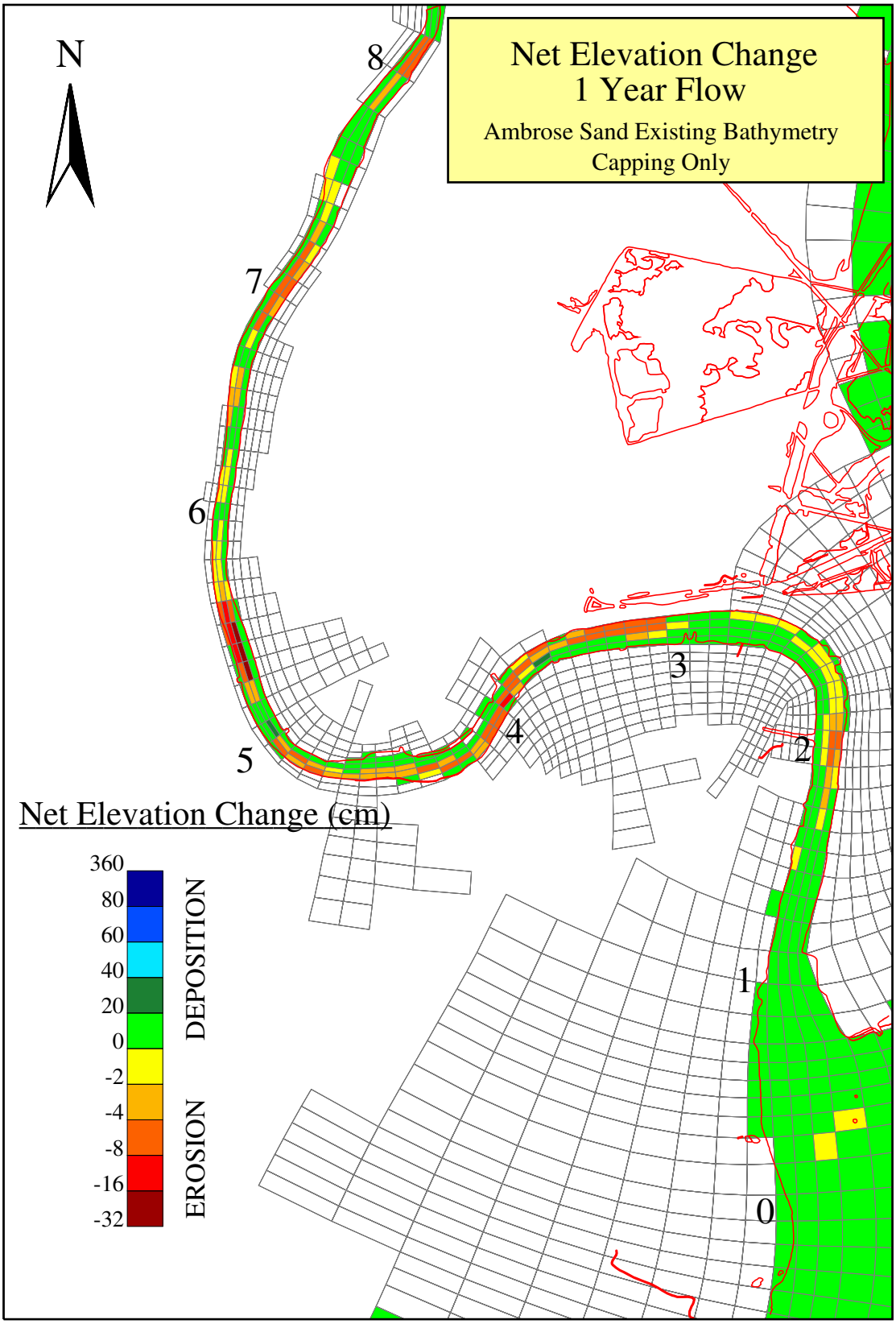

Figure B-1a. Plan view of the net elevation change under the 1-year return flow conditions (Ambrose sand used as the capping material).

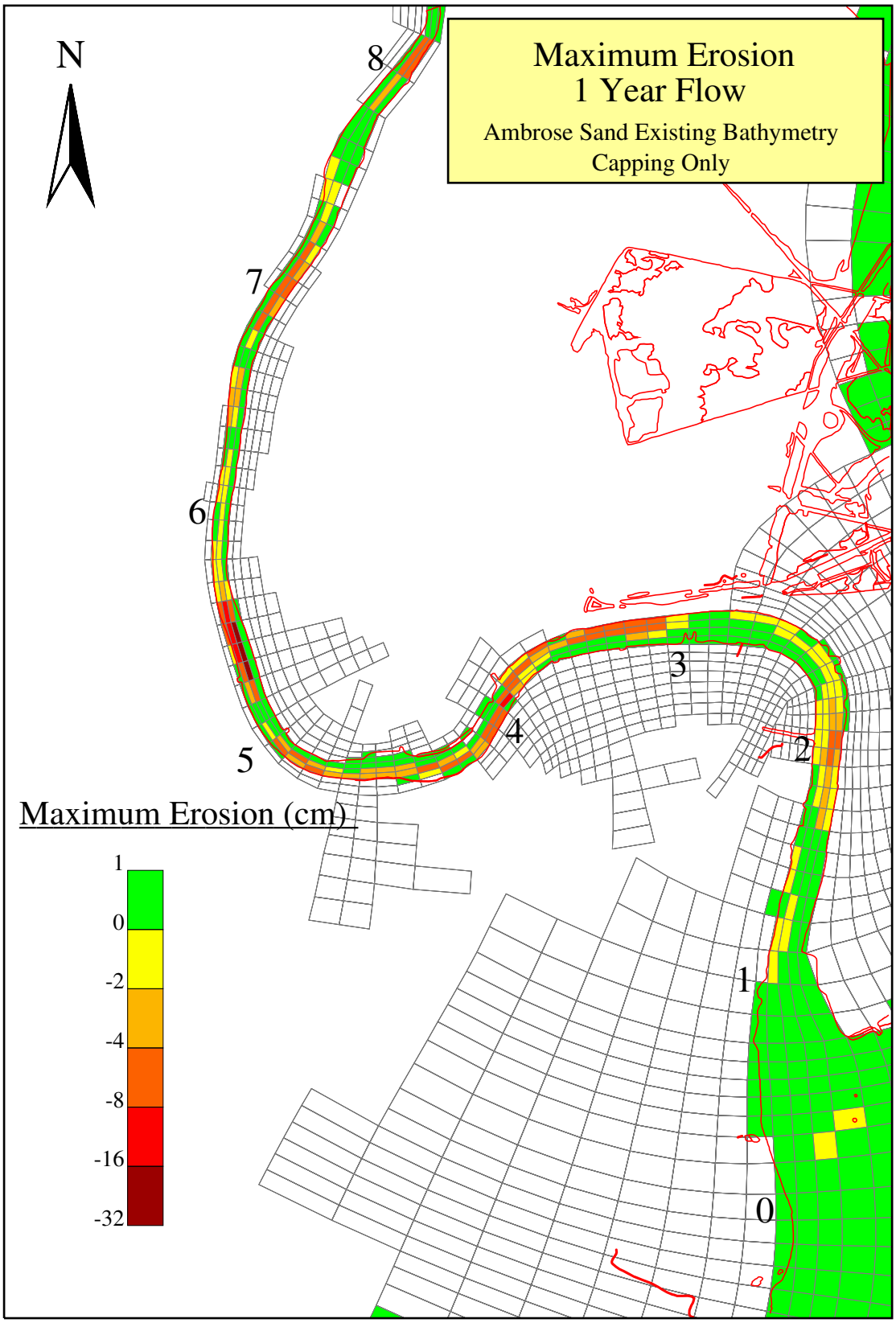

Figure B-1b. Plan view of the maximum erosion under the 1-year return flow conditions (Ambrose sand used as the capping material).

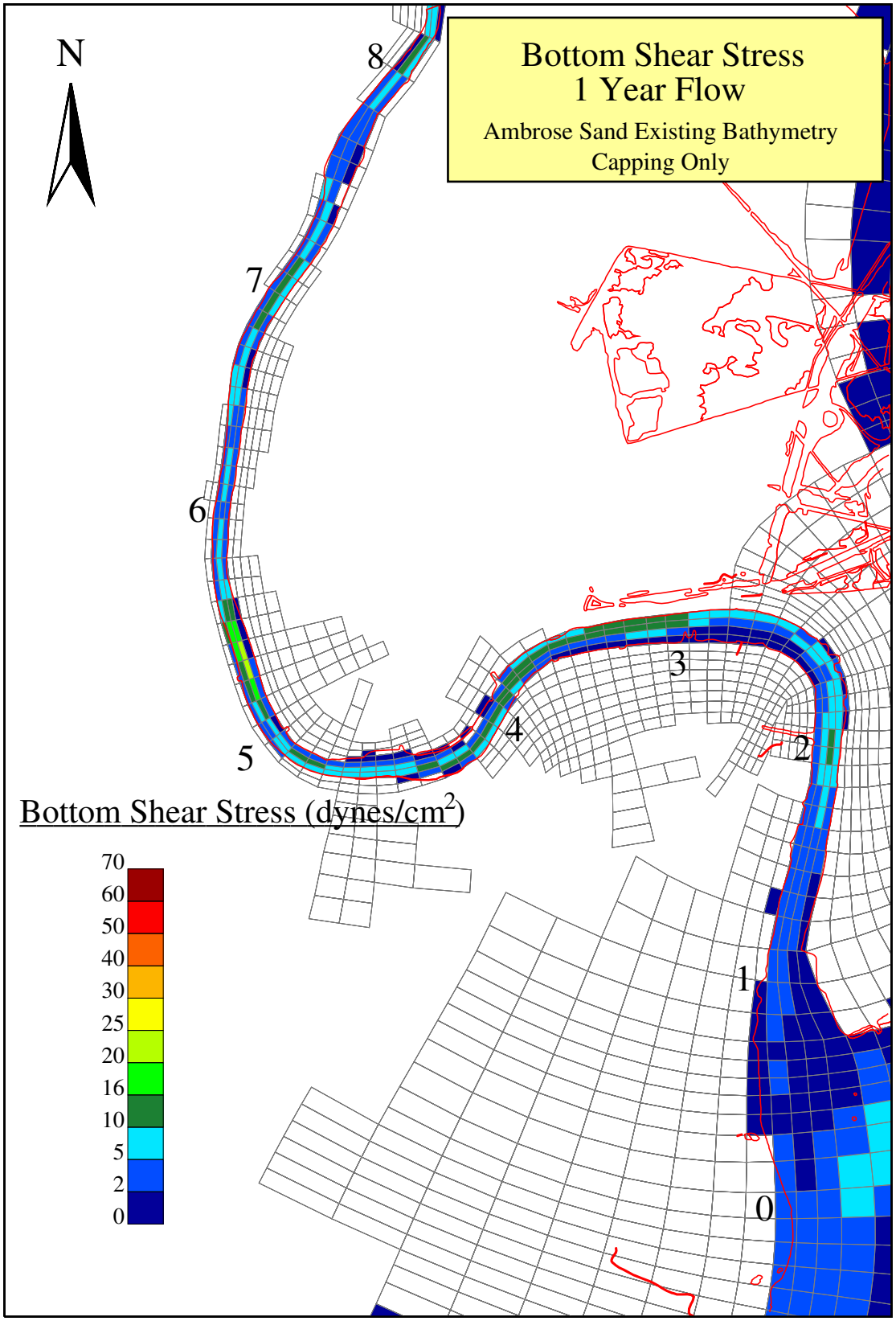

Figure B-1c. Plan view of the bottom shear stress under the 1-year return flow conditions (Ambrose sand used as the capping material).

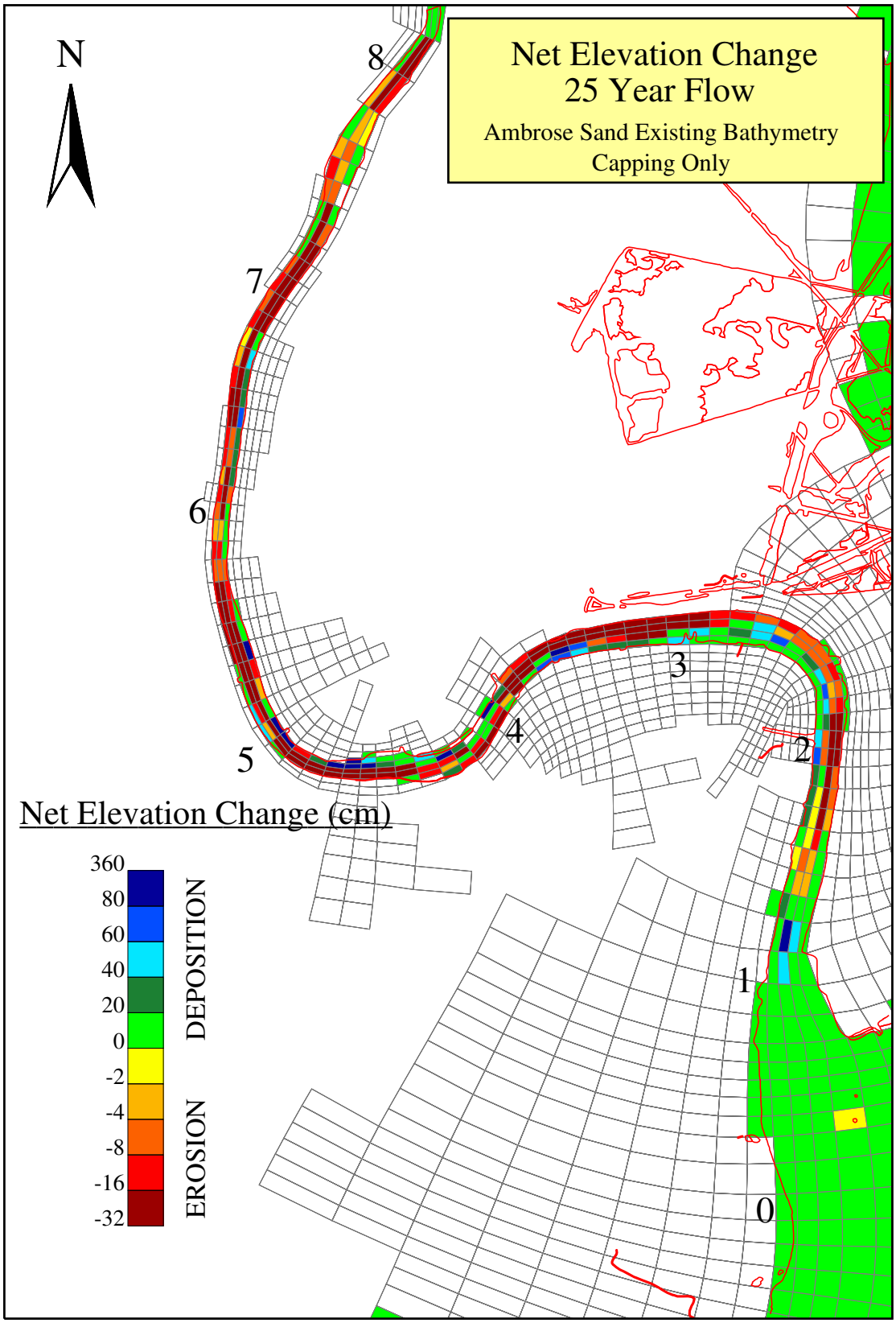

Figure B-2a. Plan view of the net elevation change under the 25-year return flow conditions (Ambrose sand used as the capping material).

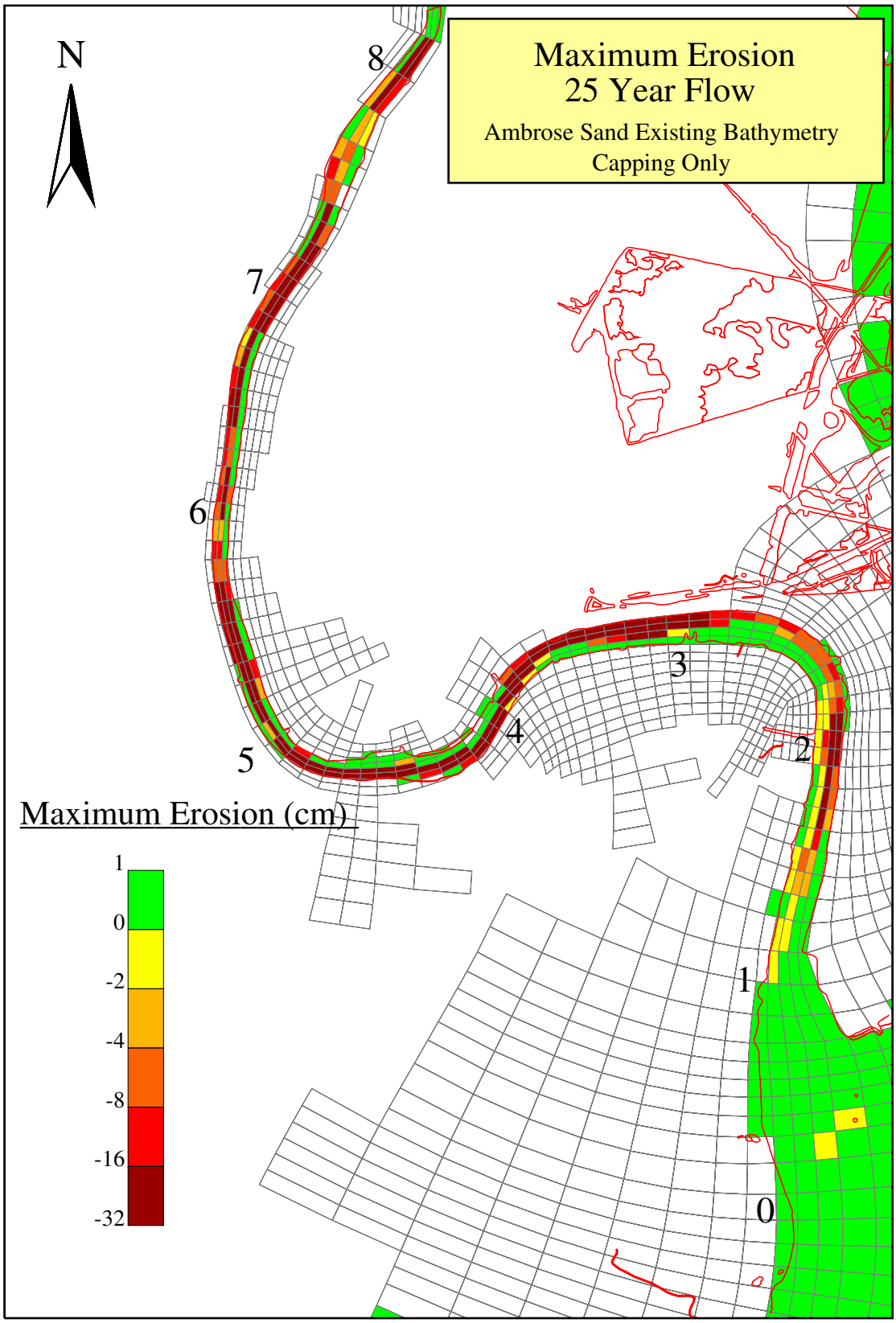

Figure B-2b. Plan view of the maximum erosion under the 25-year return flow conditions (Ambrose sand used as the capping material).

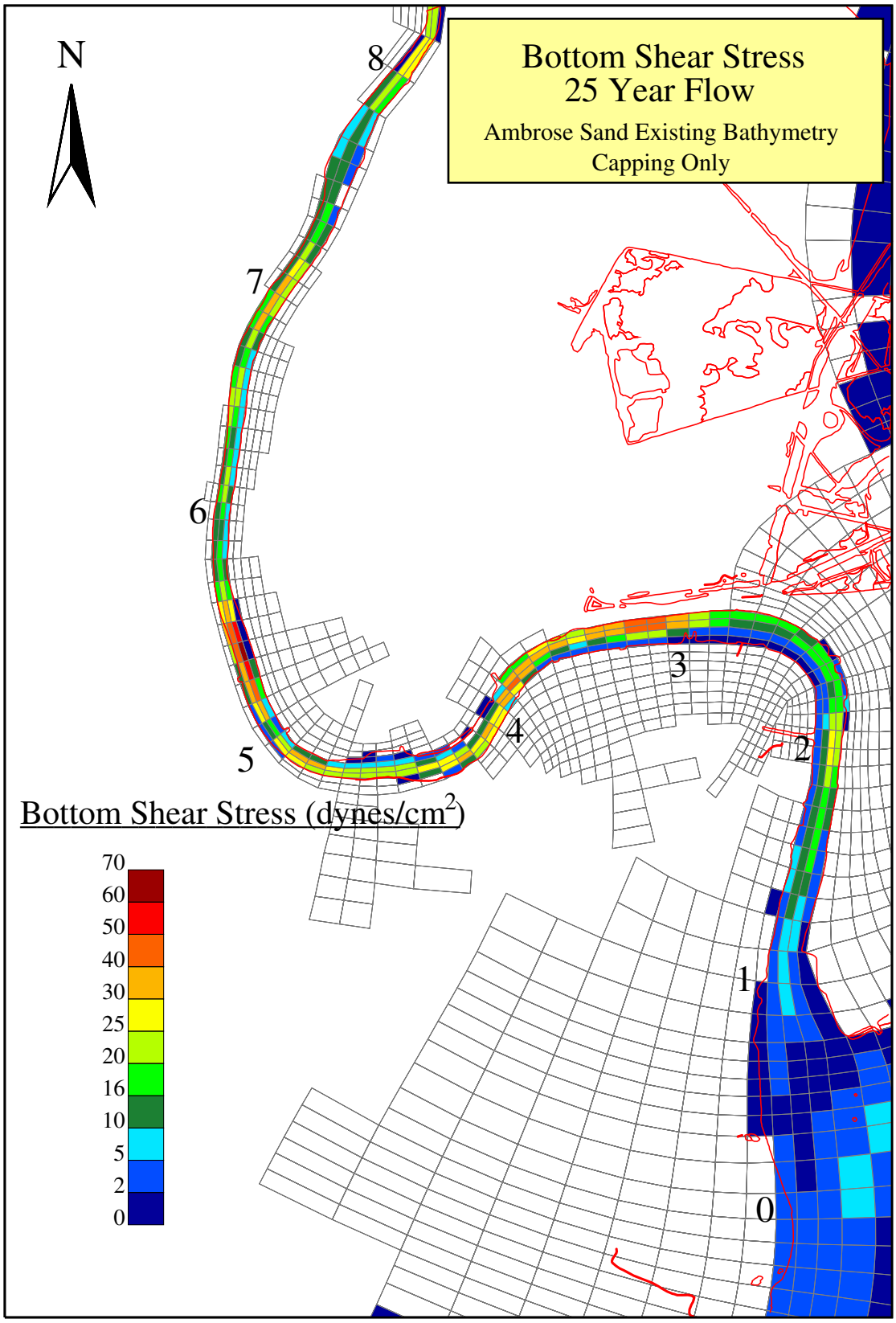

Figure B-2c. Plan view of the bottom shear stress under the 25-year return flow conditions (Ambrose sand used as the capping material).

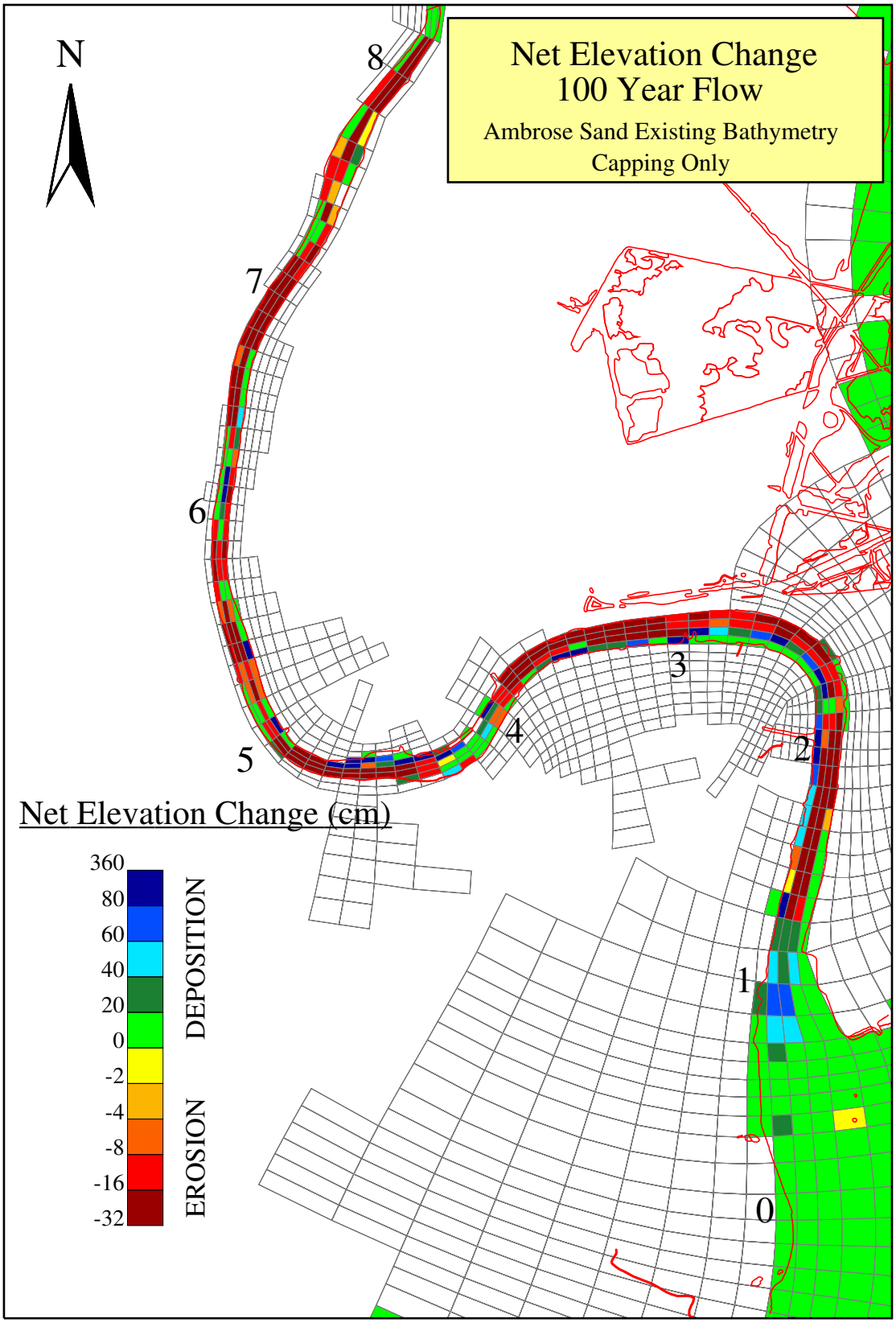

Figure B-3a. Plan view of the net elevation change under the 100-year return flow conditions (Ambrose sand used as the capping material).

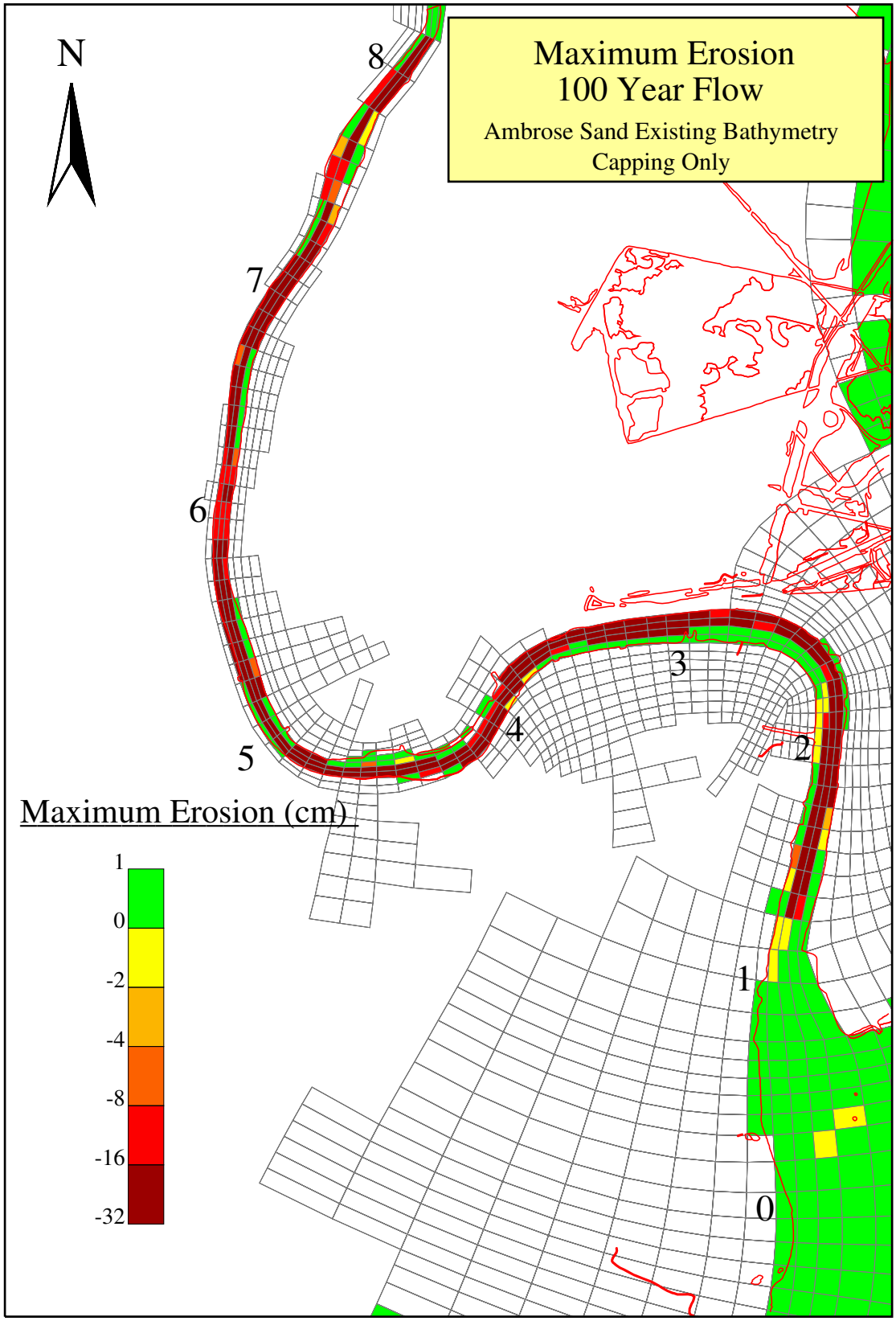

Figure B-3b. Plan view of the maximum erosion under the 100-year return flow conditions (Ambrose sand used as the capping material).

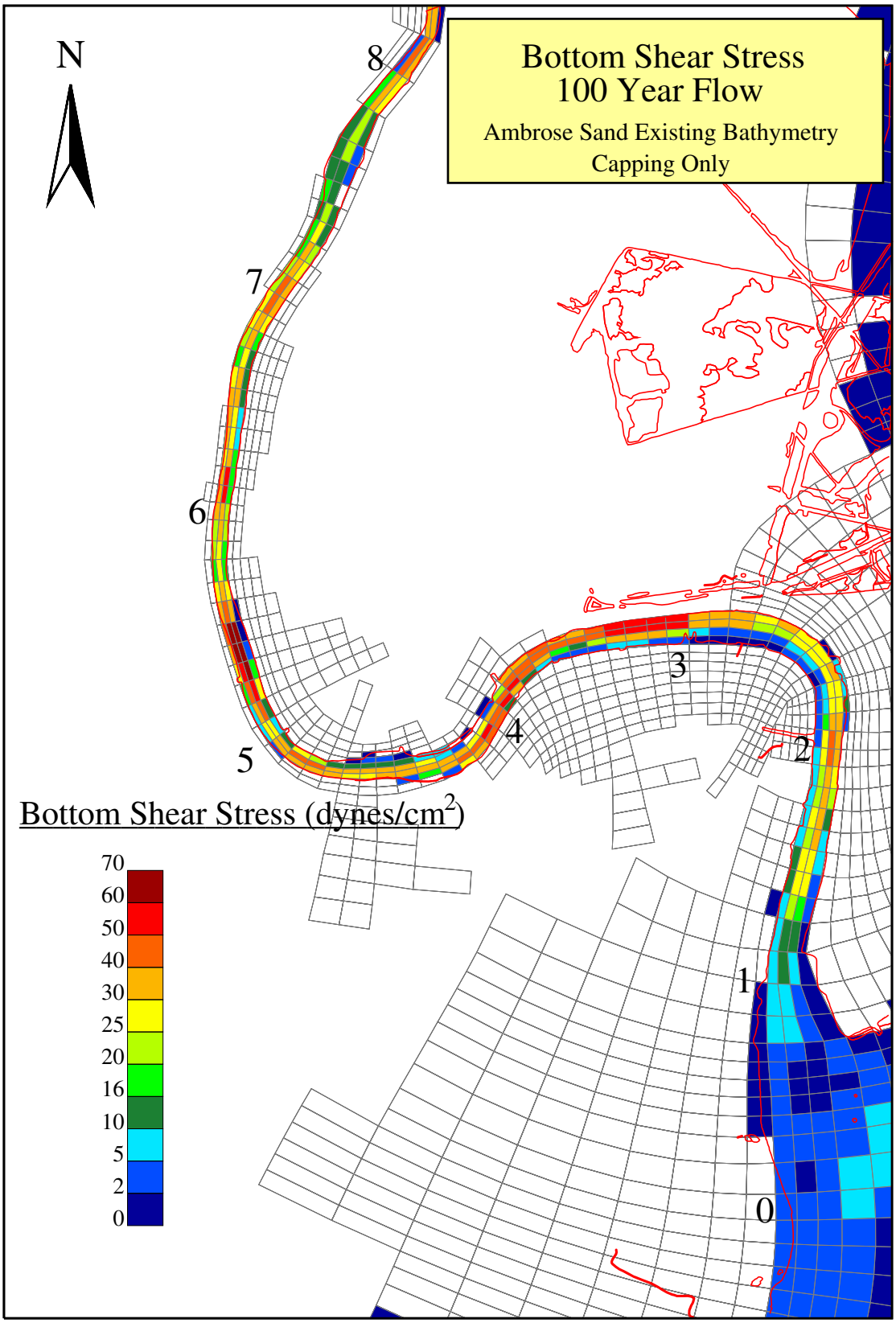

Figure B-3c. Plan view of the bottom shear stress under the 100-year return flow conditions (Ambrose sand used as the capping material).

ATTACHMENT C

BED ELEVATION CHANGES, MAXIMUM EROSION AND BOTTOM SHEAR STRESSES FOR UPLAND BORROW SAND CAP

Figure C-1a. Plan view of the net elevation change under the 1-month return flow conditions (Upland Borrow sand used as the capping material).

Figure C-1b. Plan view of the maximum erosion under the 1-month return flow conditions (Upland Borrow sand used as the capping material).

Figure C-1c. Plan view of the bottom shear stress under the 1-month return flow conditions (Upland Borrow sand used as the capping material).

Figure C-2a. Plan view of the net elevation change under the 6-month return flow conditions (Upland Borrow sand used as the capping material).

Figure C-2b. Plan view of the maximum erosion under the 6-month return flow conditions (Upland Borrow sand used as the capping material).

Figure C-2c. Plan view of the bottom shear stress under the 6-month return flow conditions (Upland Borrow sand used as the capping material).

Figure C-3a. Plan view of the net elevation change under the 1-year return flow conditions (Upland Borrow sand used as the capping material).

Figure C-3b. Plan view of the maximum erosion under the 1-year return flow conditions (Upland Borrow sand used as the capping material).

Figure C-3c. Plan view of the bottom shear stress under the 1-year return flow conditions (Upland Borrow sand used as the capping material).

Figure C-4a. Plan view of the net elevation change under the 2-year return flow conditions (Upland Borrow sand used as the capping material).

Figure C-4b. Plan view of the maximum erosion under the 2-year return flow conditions (Upland Borrow sand used as the capping material).

Figure C-4c. Plan view of the bottom shear stress under the 2-year return flow conditions (Upland Borrow sand used as the capping material).

Figure C-5a. Plan view of the net elevation change under the 5-year return flow conditions

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(Upland Borrow sand used as the capping material).
Figure C-5b. Plan view of the maximum erosion under the 5-year return flow conditions (Upland Borrow sand used as the capping material).

Figure C-5c. Plan view of the bottom shear stress under the 5-year return flow conditions (Upland Borrow sand used as the capping material).

Figure C-6a. Plan view of the net elevation change under the 10-year return flow conditions (Upland Borrow sand used as the capping material).

Figure C-6b. Plan view of the maximum erosion under the 10-year return flow conditions (Upland Borrow sand used as the capping material).

Figure C-6c. Plan view of the bottom shear stress under the 10-year return flow conditions (Upland Borrow sand used as the capping material).

Figure C-7a. Plan view of the net elevation change under the 25-year return flow conditions (Upland Borrow sand used as the capping material).

Figure C-7b. Plan view of the maximum erosion under the 25-year return flow conditions (Upland Borrow sand used as the capping material).

Figure C-7c. Plan view of the bottom shear stress under the 25-year return flow conditions (Upland Borrow sand used as the capping material).

Figure C-8a. Plan view of the net elevation change under the 50-year return flow conditions (Upland Borrow sand used as the capping material).

Figure C-8b. Plan view of the maximum erosion under the 50-year return flow conditions (Upland Borrow sand used as the capping material).

Figure C-8c. Plan view of the bottom shear stress under the 50-year return flow conditions (Upland Borrow sand used as the capping material).

Figure C-9a. Plan view of the net elevation change under the 100-year return flow conditions (Upland Borrow sand used as the capping material).

Figure C-9b. Plan view of the maximum erosion under the 100-year return flow conditions (Upland Borrow sand used as the capping material).

Figure C-9c. Plan view of the bottom shear stress under the 100-year return flow conditions (Upland Borrow sand used as the capping material).

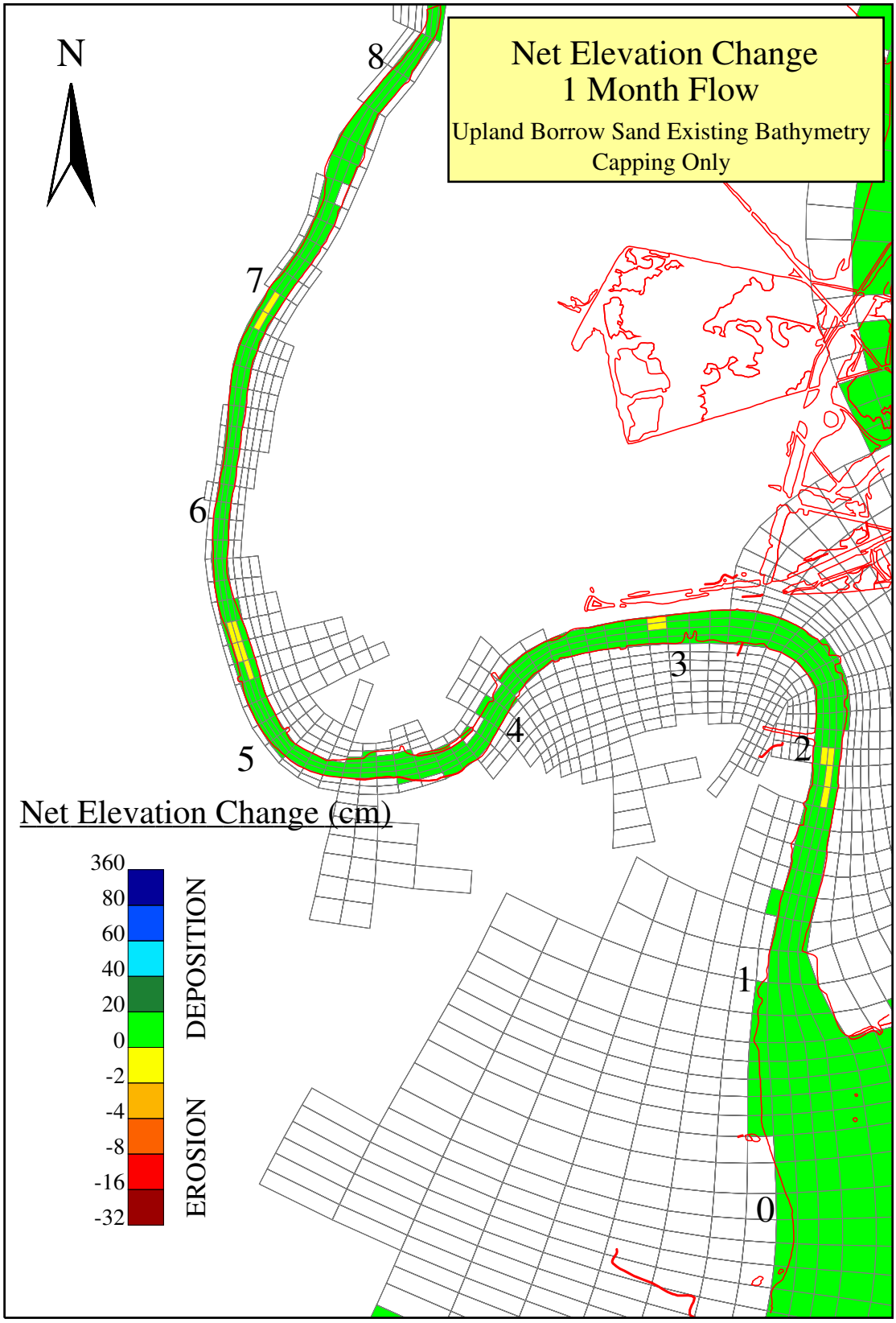

Figure C-1a. Plan view of the net elevation change under the 1-month return flow conditions (Upland Borrow sand used as the capping material).

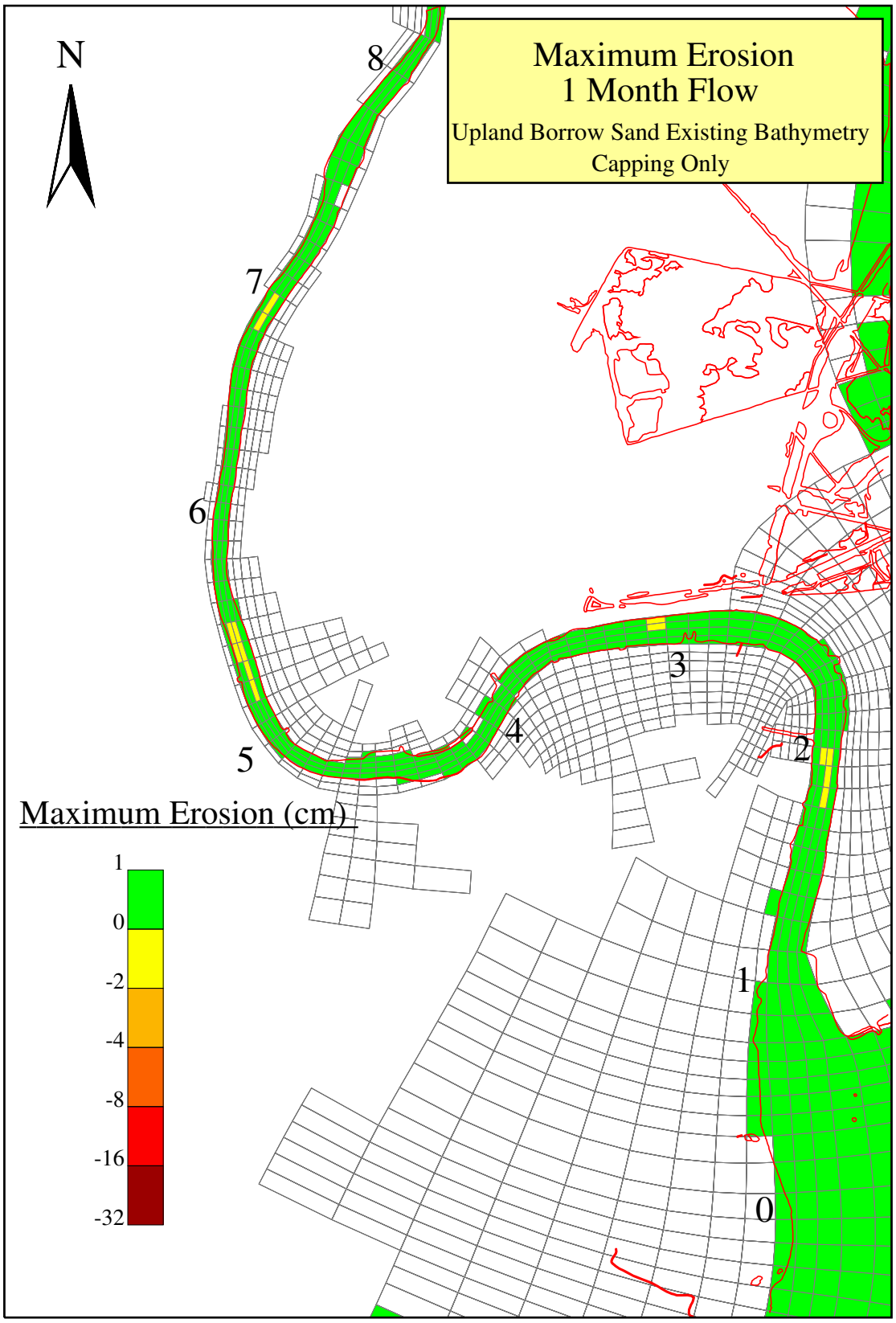

Figure C-1b. Plan view of the maximum erosion under the 1-month return flow conditions (Upland Borrow sand used as the capping material).

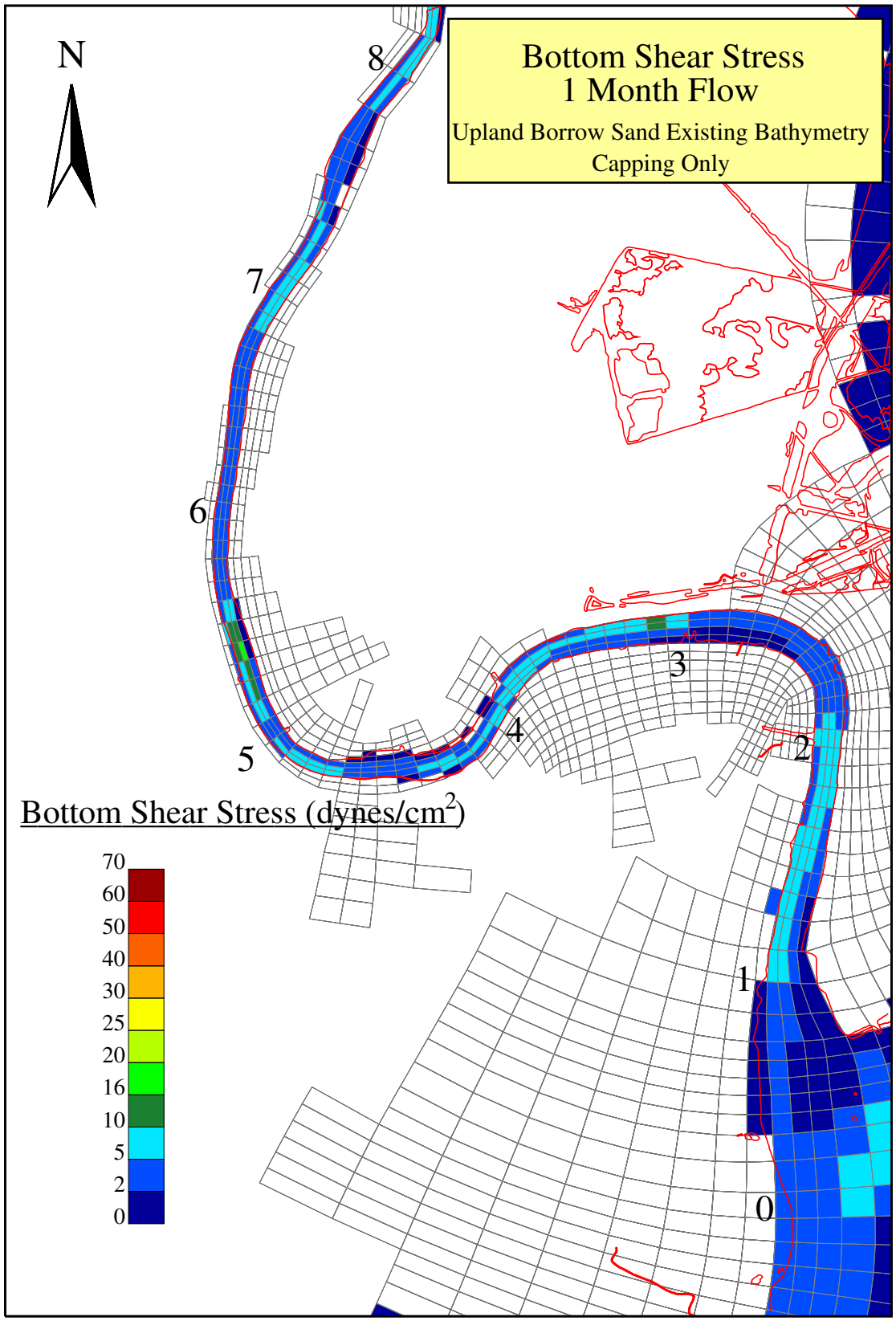

Figure C-1c. Plan view of the bottom shear stress under the 1-month return flow conditions (Upland Borrow sand used as the capping material).

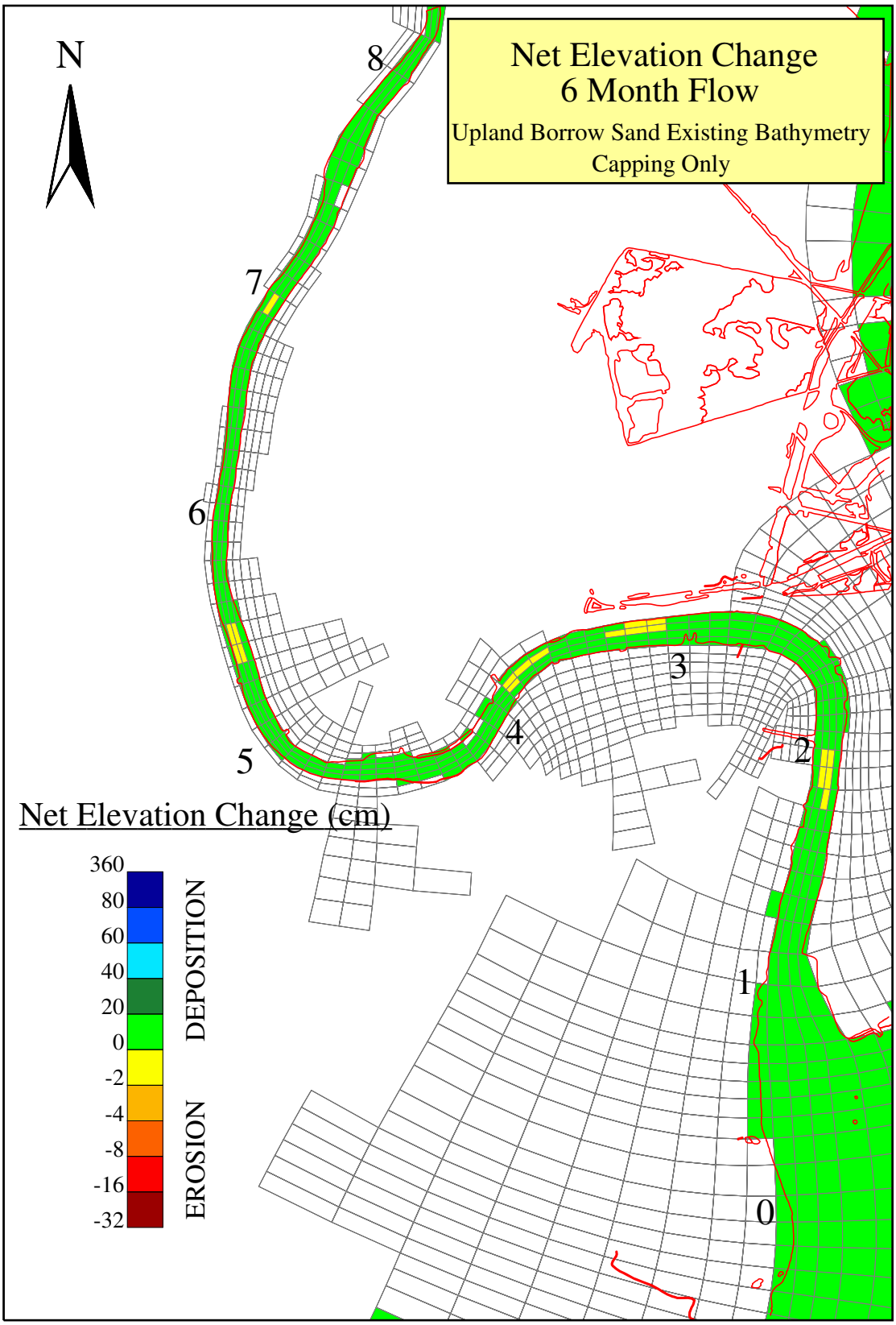

Figure C-2a. Plan view of the net elevation change under the 6-month return flow conditions (Upland Borrow sand used as the capping material).

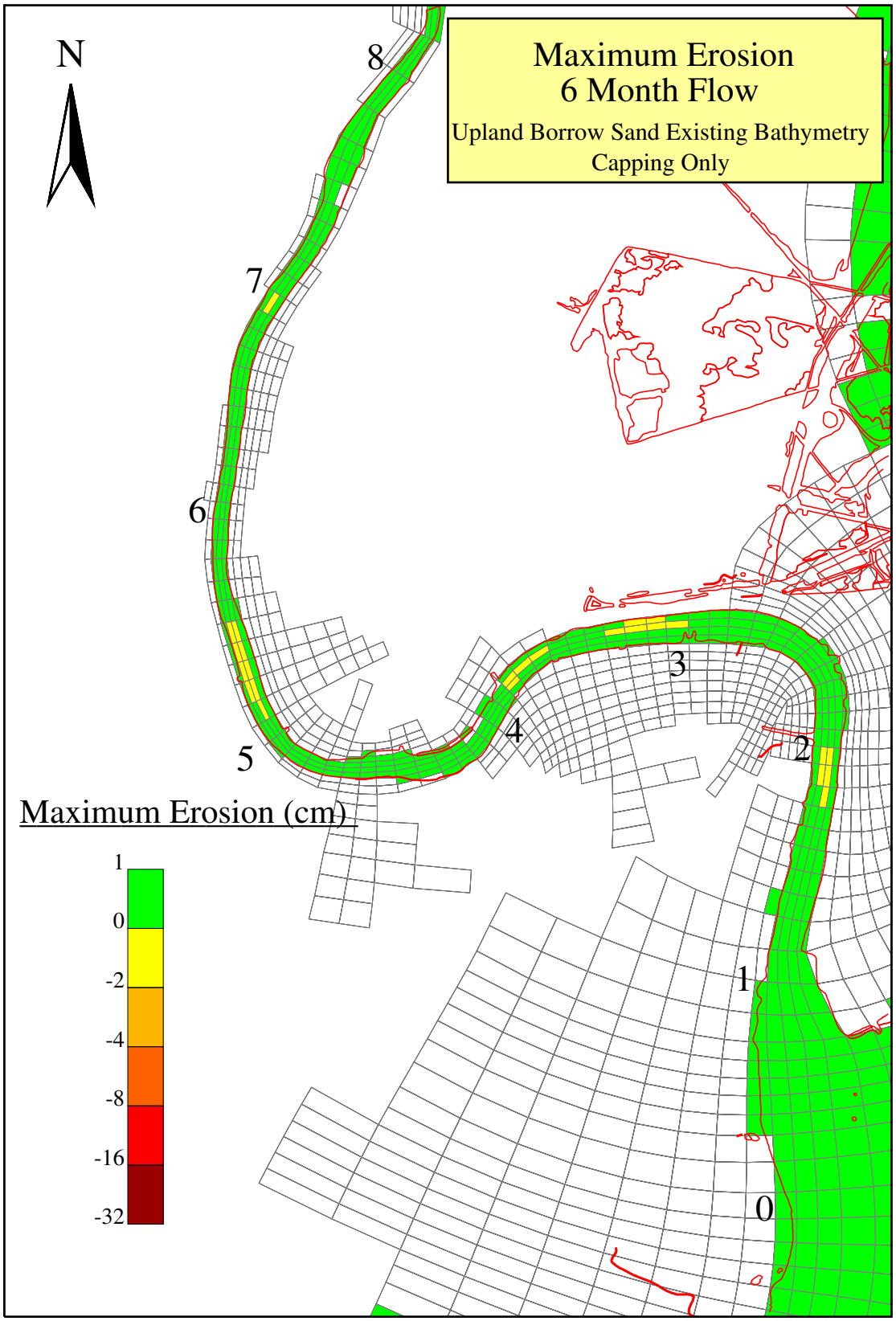

Figure C-2b. Plan view of the maximum erosion under the 6-month return flow conditions (Upland Borrow sand used as the capping material).

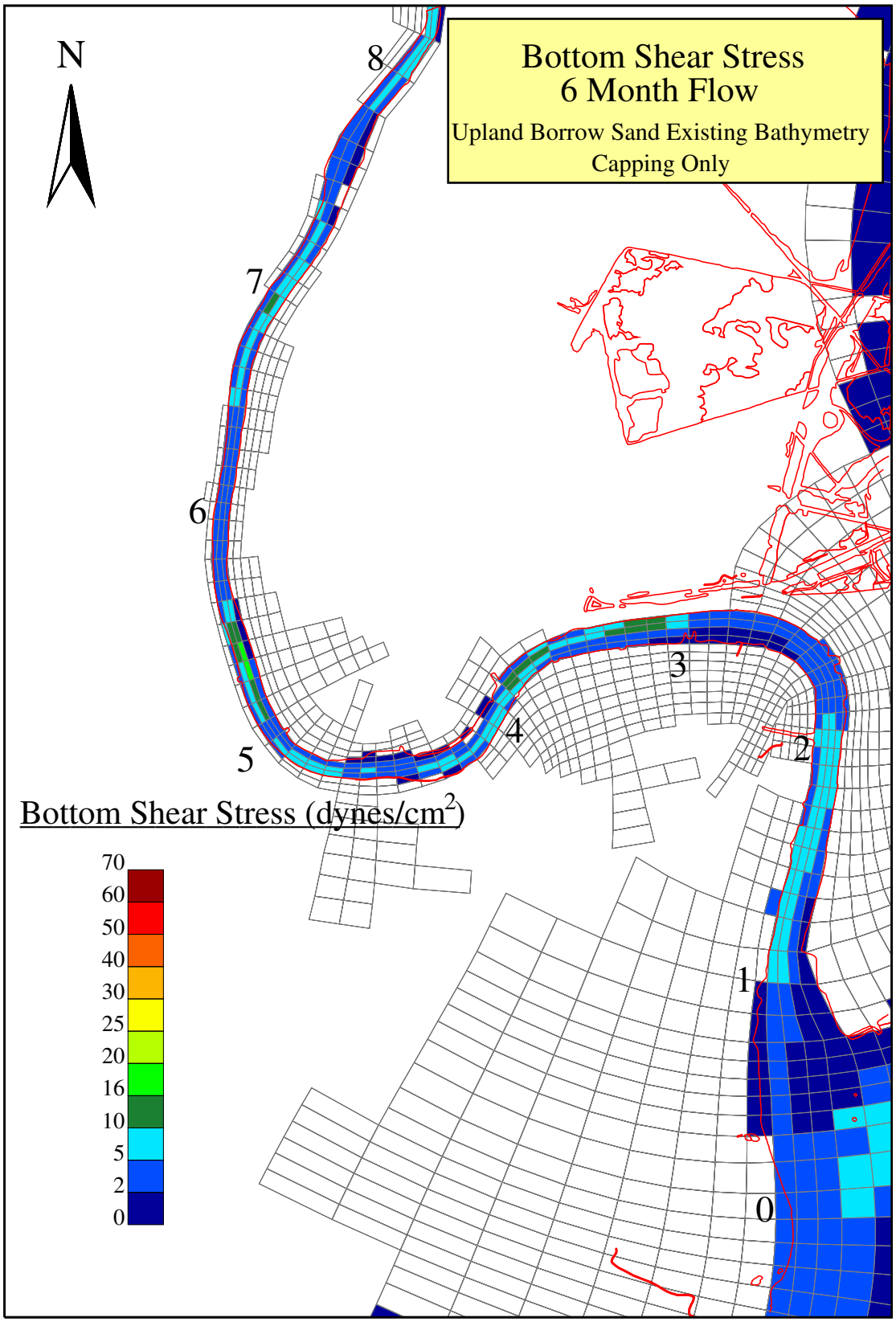

Figure C-2c. Plan view of the bottom shear stress under the 6-month return flow conditions (Upland Borrow sand used as the capping material).

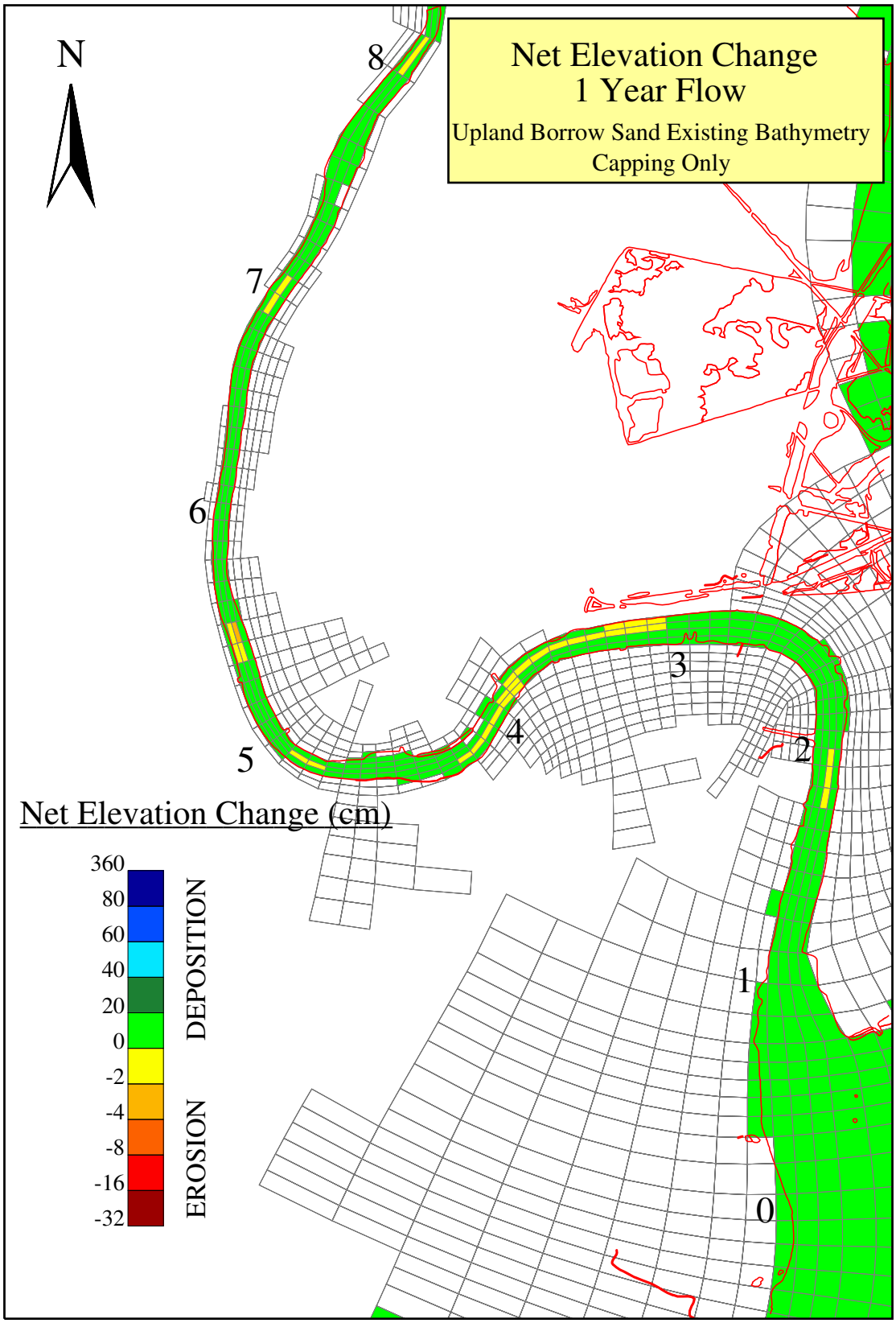

Figure C-3a. Plan view of the net elevation change under the 1-year return flow conditions (Upland Borrow sand used as the capping material).

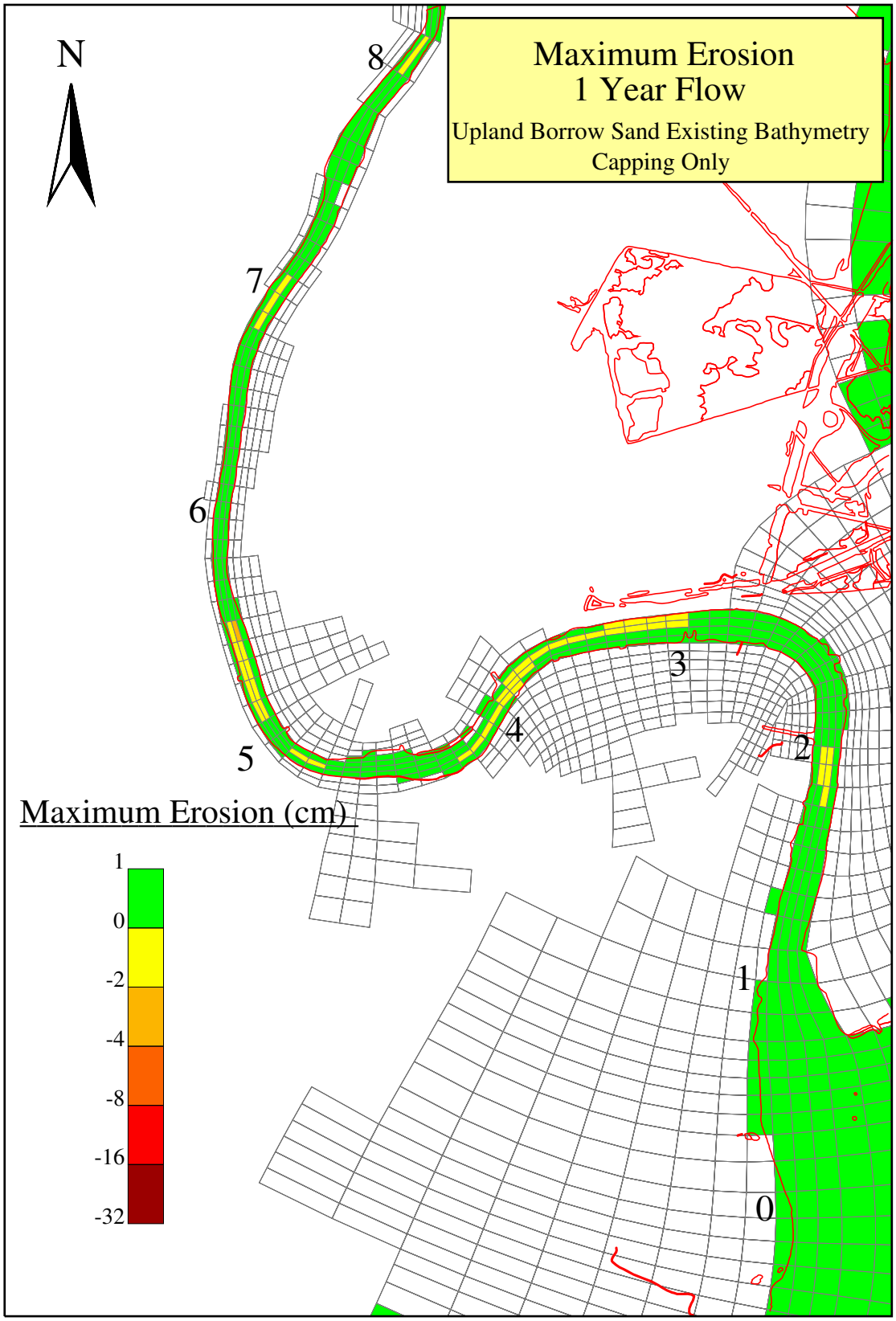

Figure C-3b. Plan view of the maximum erosion under the 1-year return flow conditions (Upland Borrow sand used as the capping material).

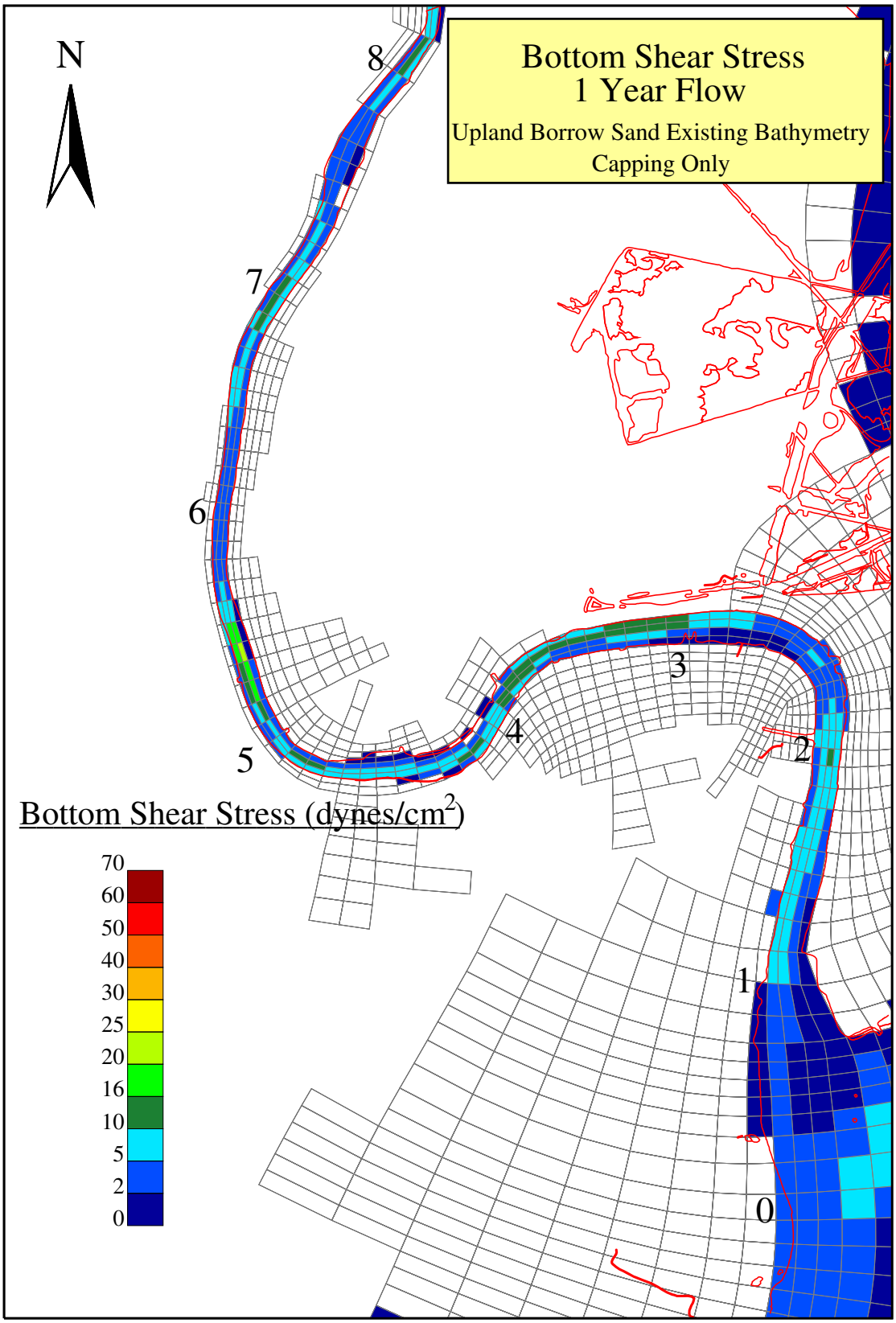

Figure C-3c. Plan view of the bottom shear stress under the 1-year return flow conditions (Upland Borrow sand used as the capping material).

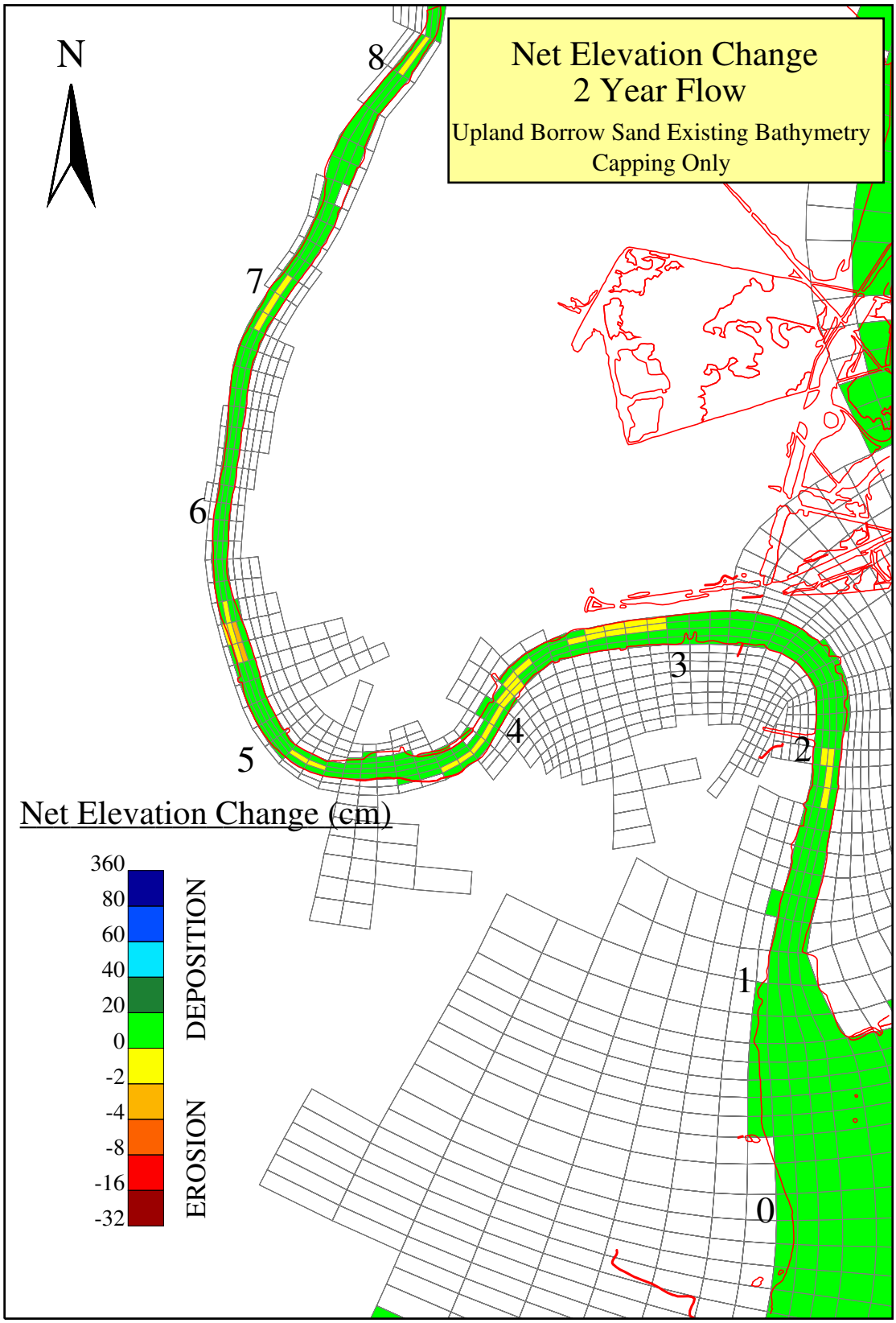

Figure C-4a. Plan view of the net elevation change under the 2-year return flow conditions (Upland Borrow sand used as the capping material).

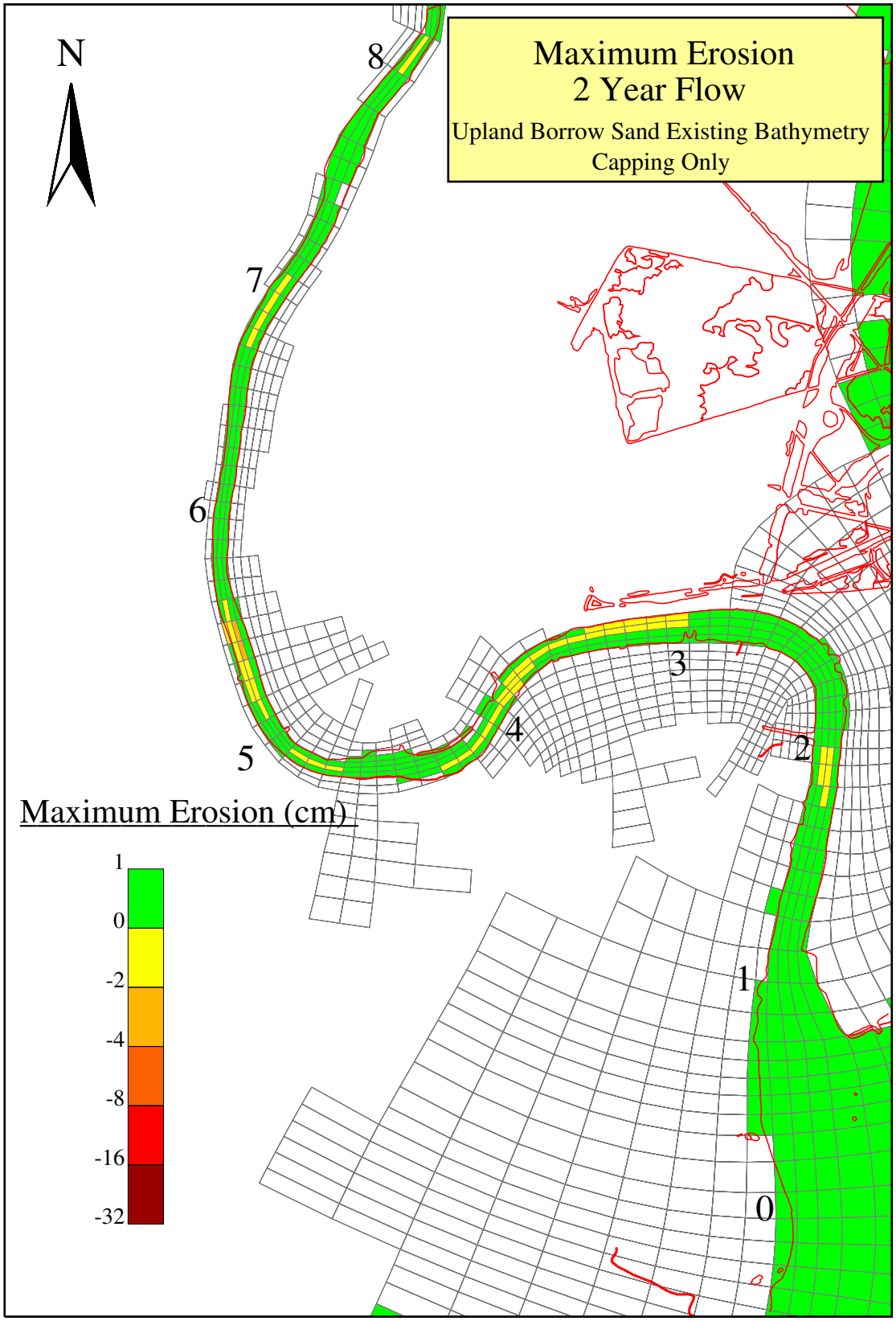

Figure C-4b. Plan view of the maximum erosion under the 2-year return flow conditions (Upland Borrow sand used as the capping material).

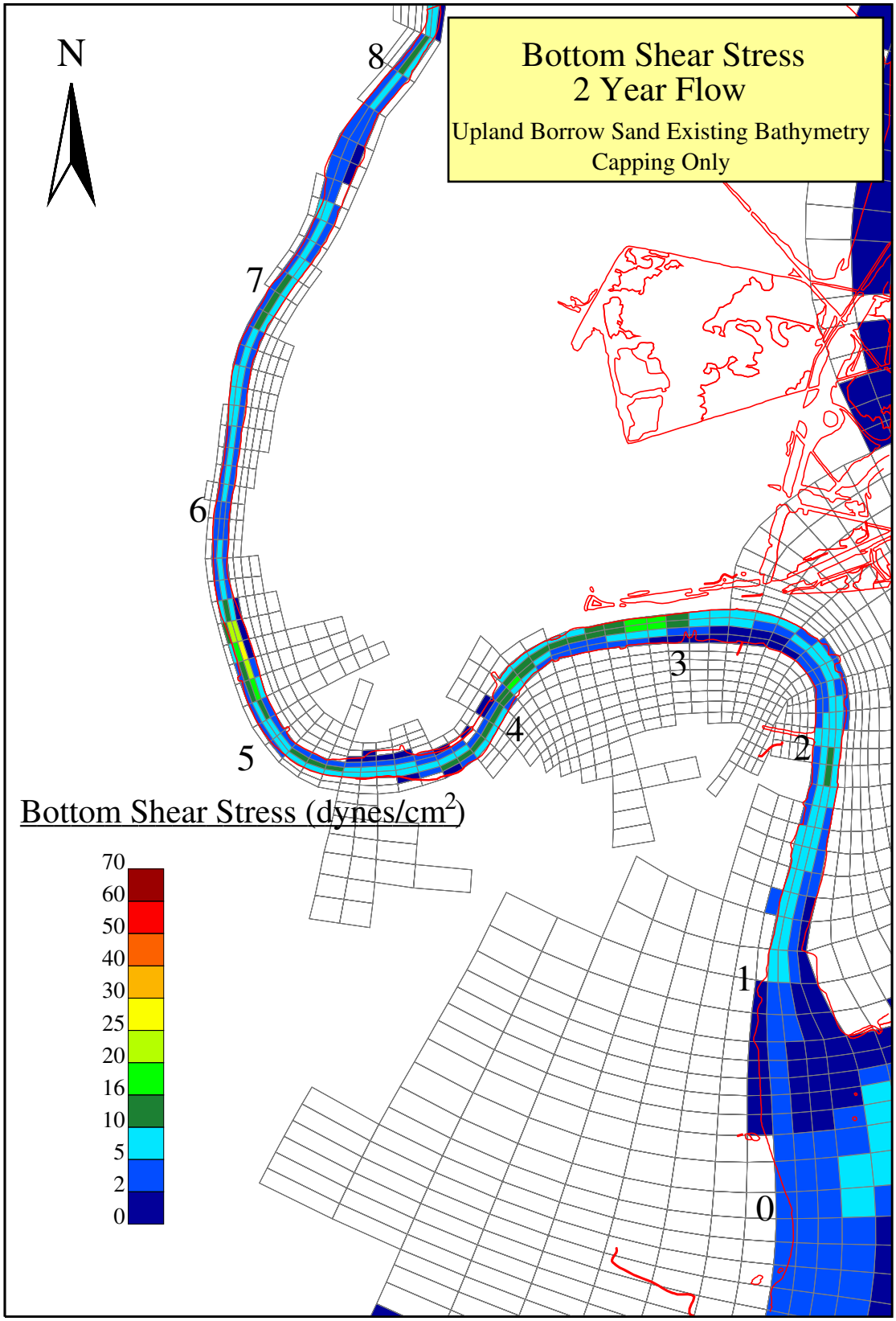

Figure C-4c. Plan view of the bottom shear stress under the 2-year return flow conditions (Upland Borrow sand used as the capping material).

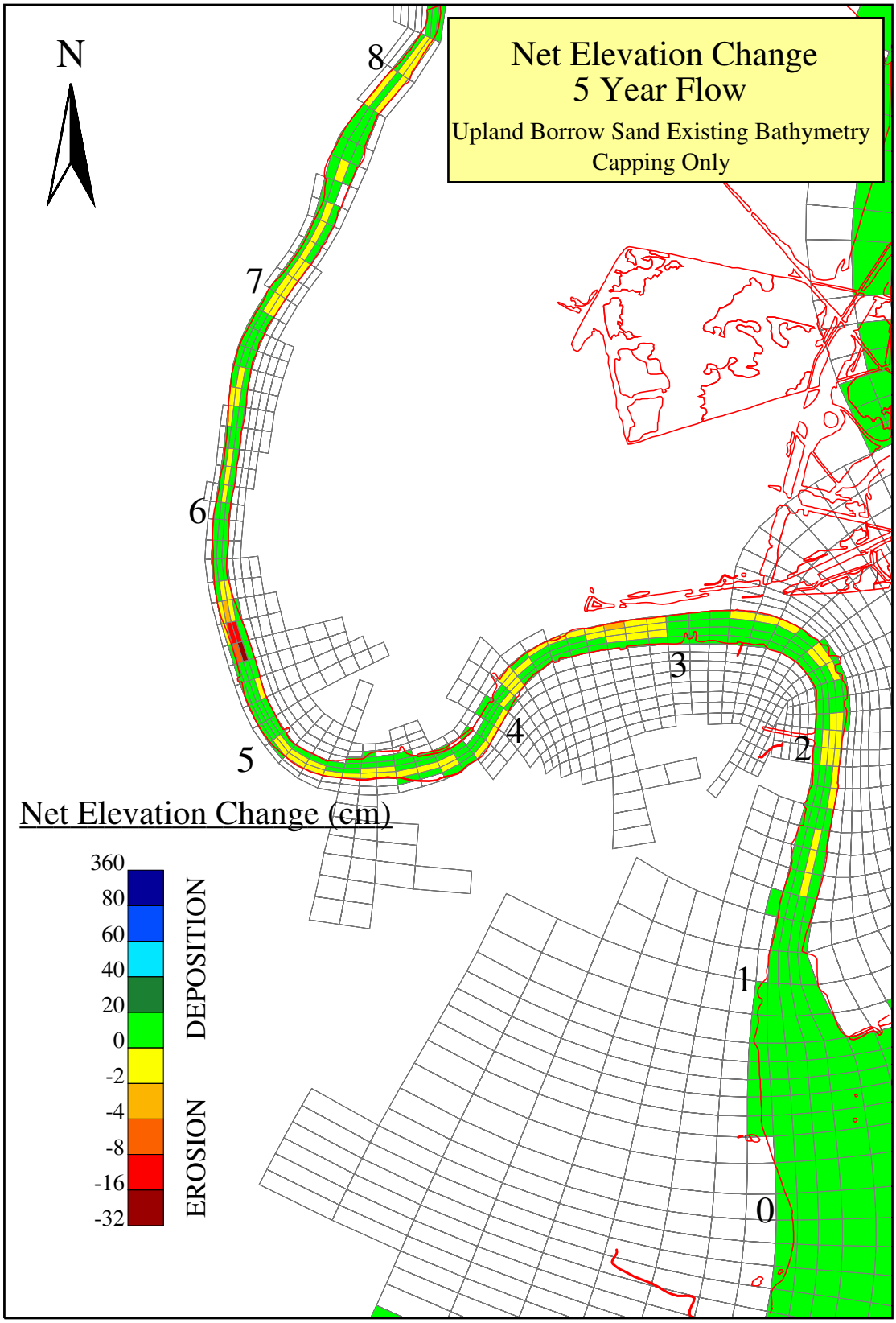

Figure C-5a. Plan view of the net elevation change under the 5-year return flow conditions (Upland Borrow sand used as the capping material).

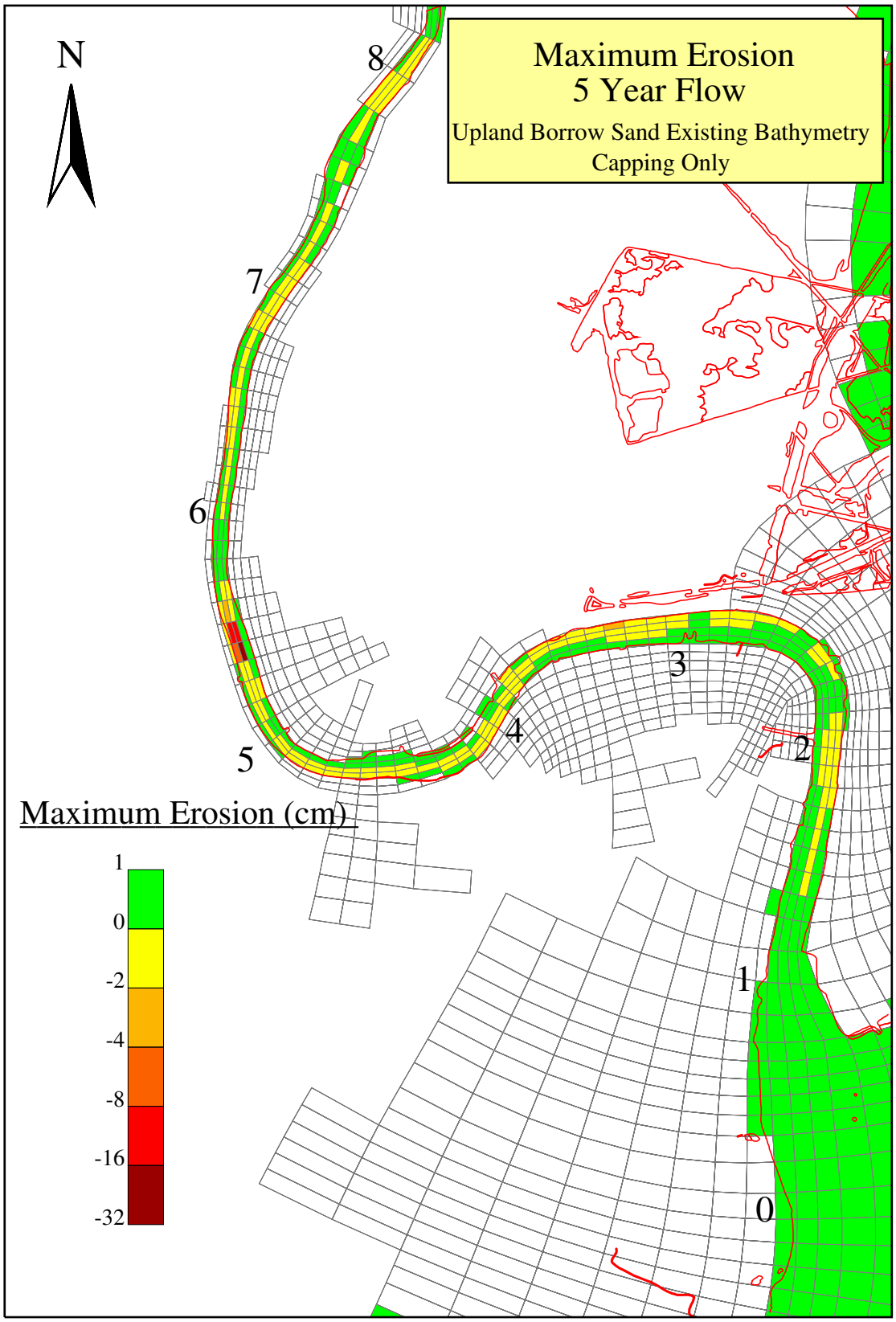

Figure C-5b. Plan view of the maximum erosion under the 5-year return flow conditions (Upland Borrow sand used as the capping material).

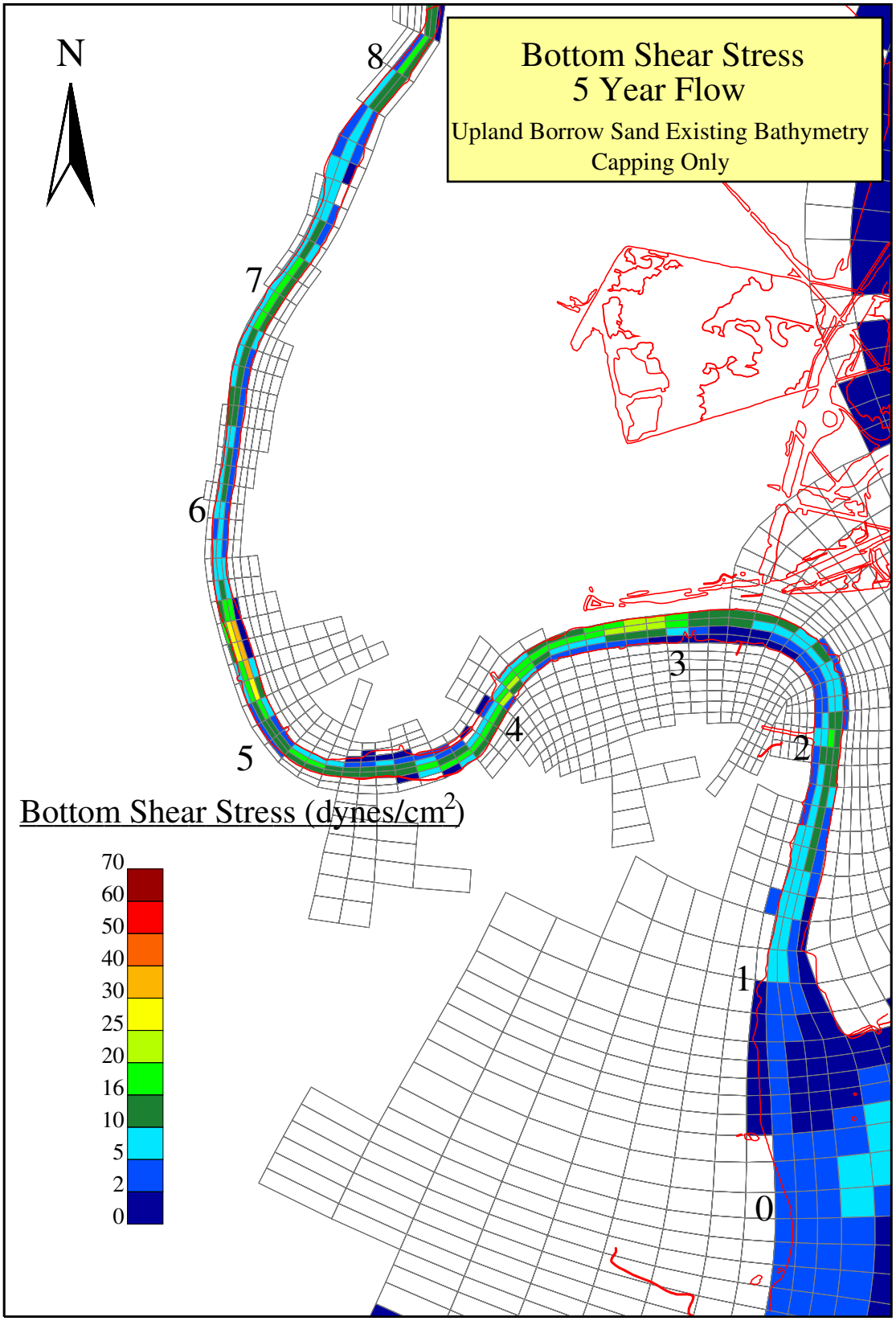

Figure C-5c. Plan view of the bottom shear stress under the 5-year return flow conditions (Upland Borrow sand used as the capping material).

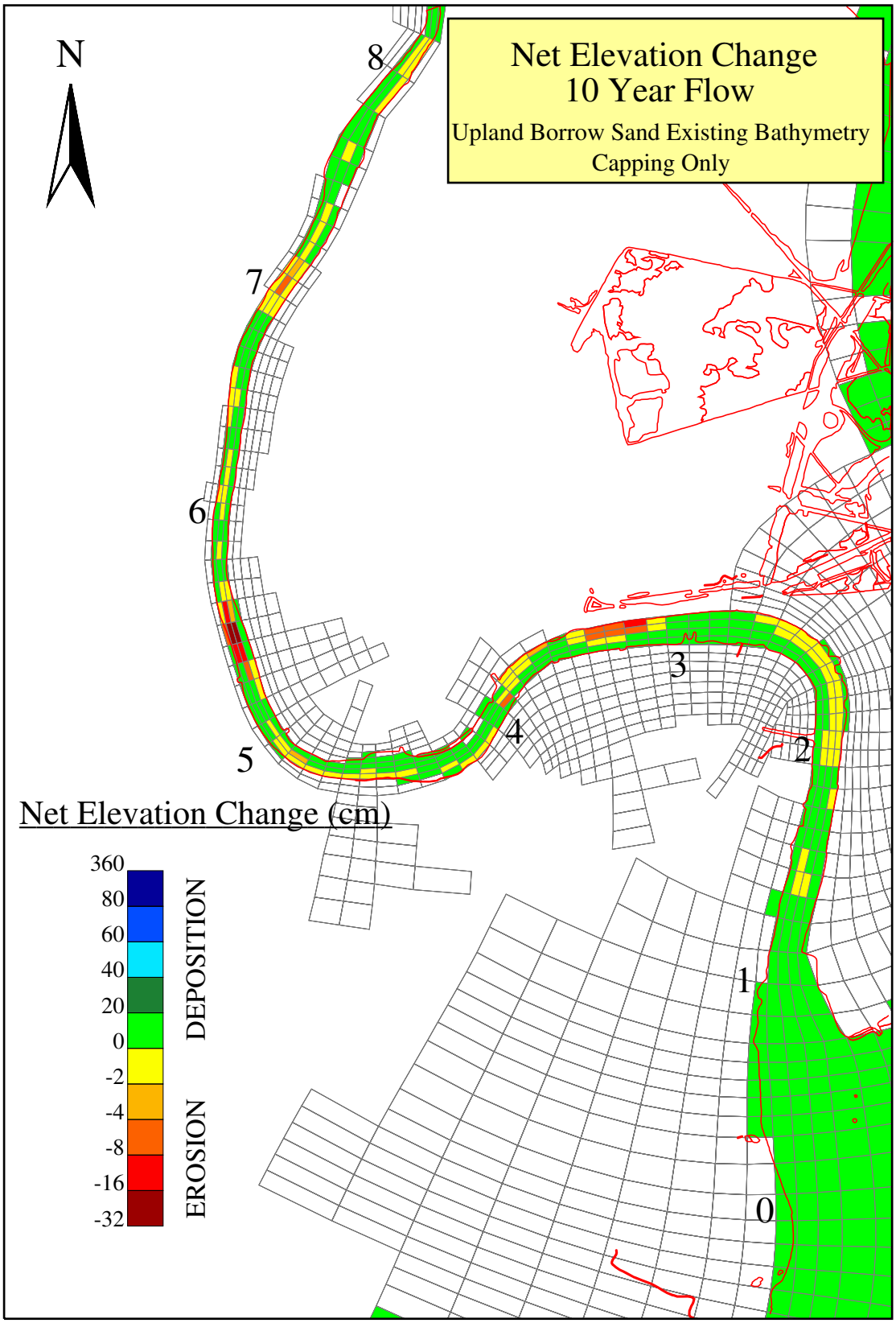

Figure C-6a. Plan view of the net elevation change under the 10-year return flow conditions (Upland Borrow sand used as the capping material).

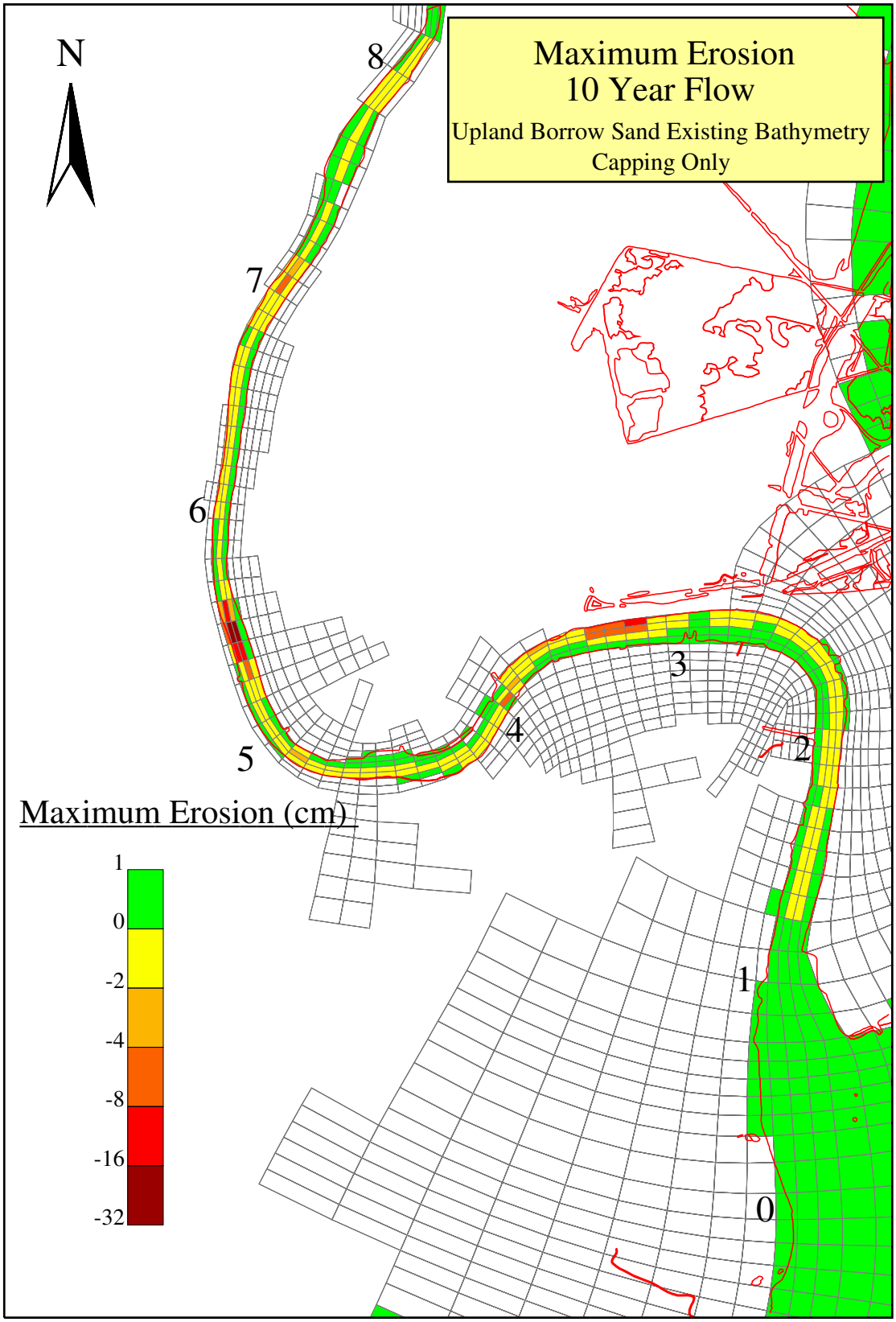

Figure C-6b. Plan view of the maximum erosion under the 10-year return flow conditions (Upland Borrow sand used as the capping material).

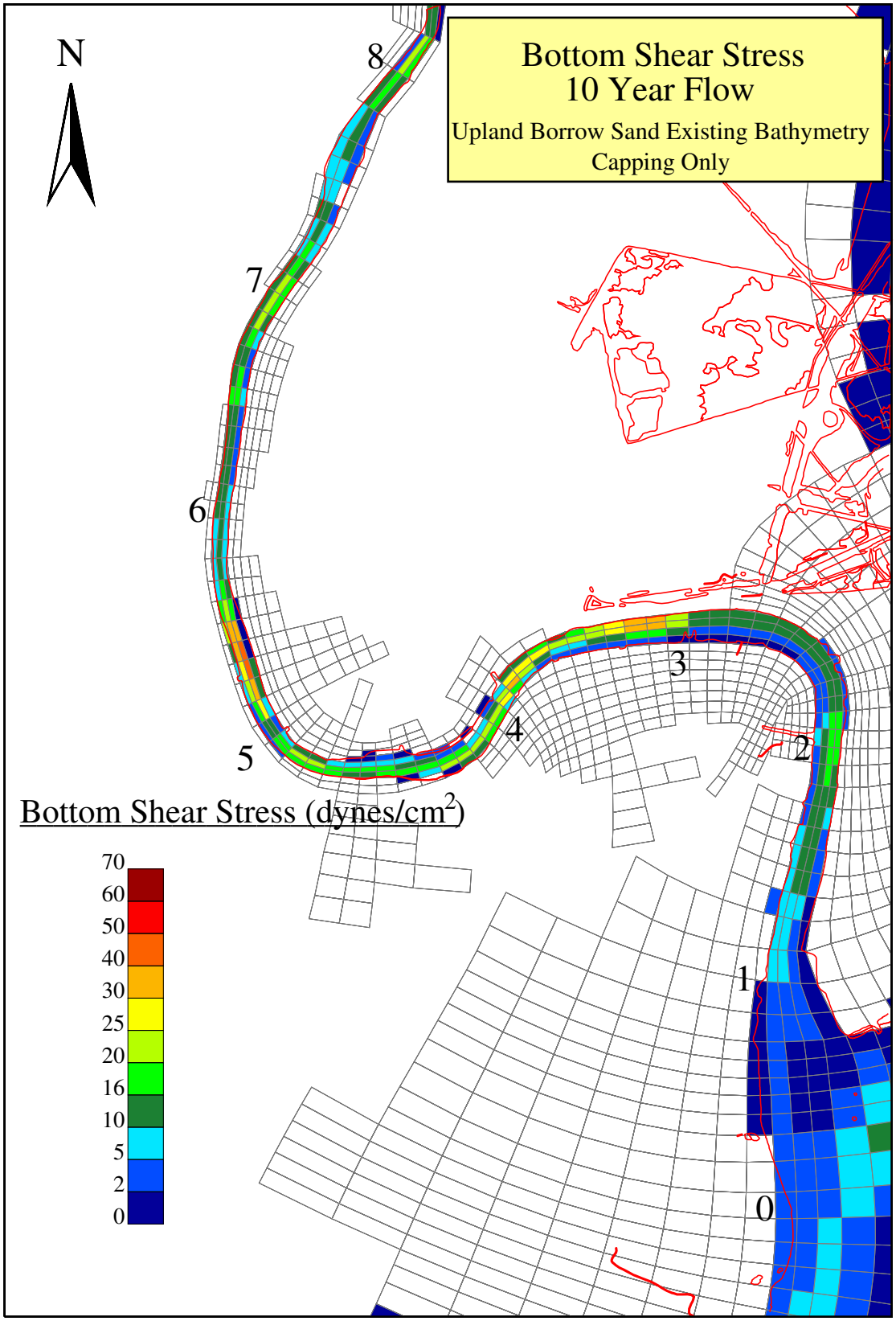

Figure C-6c. Plan view of the bottom shear stress under the 10-year return flow conditions (Upland Borrow sand used as the capping material).

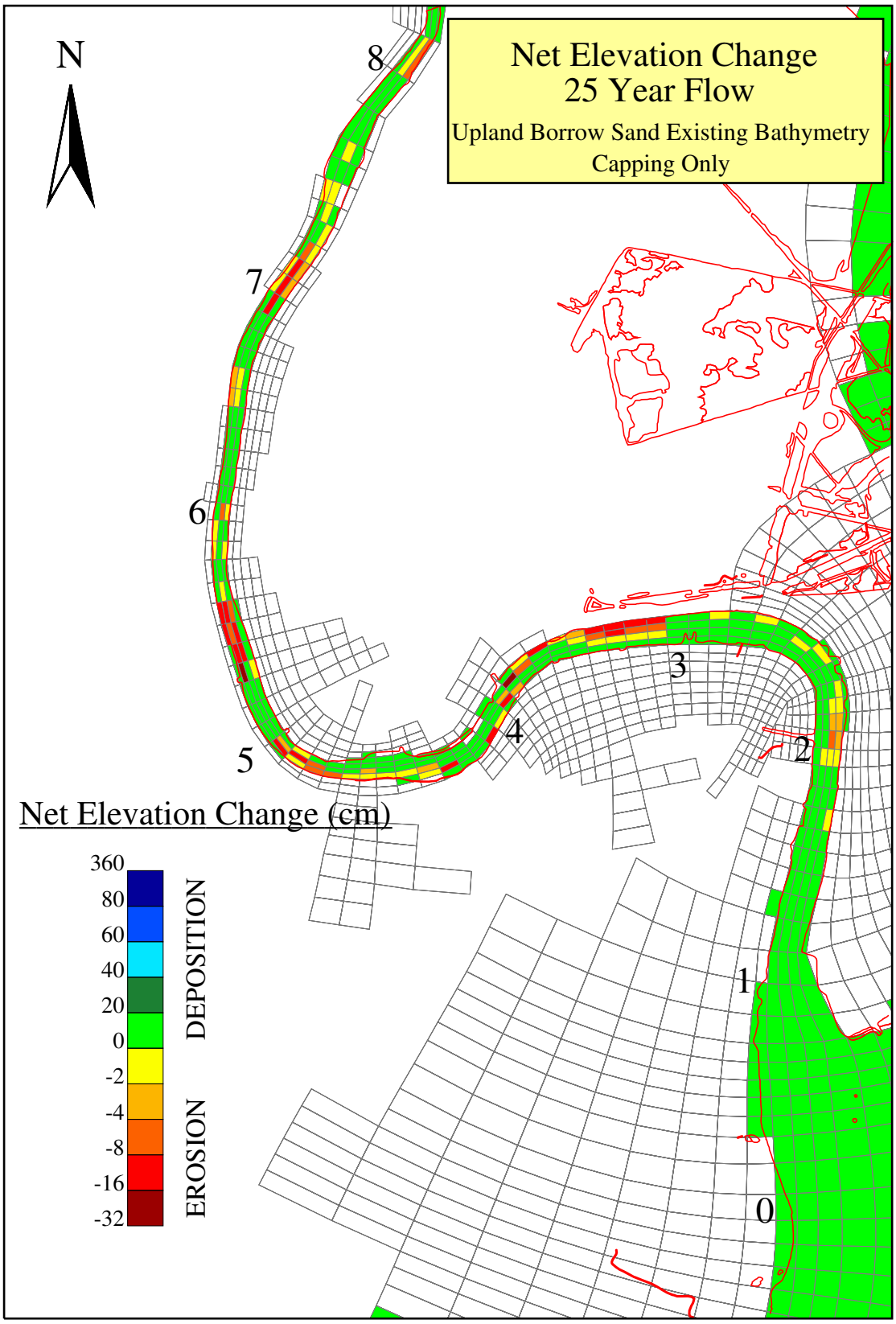

Figure C-7a. Plan view of the net elevation change under the 25-year return flow conditions (Upland Borrow sand used as the capping material).

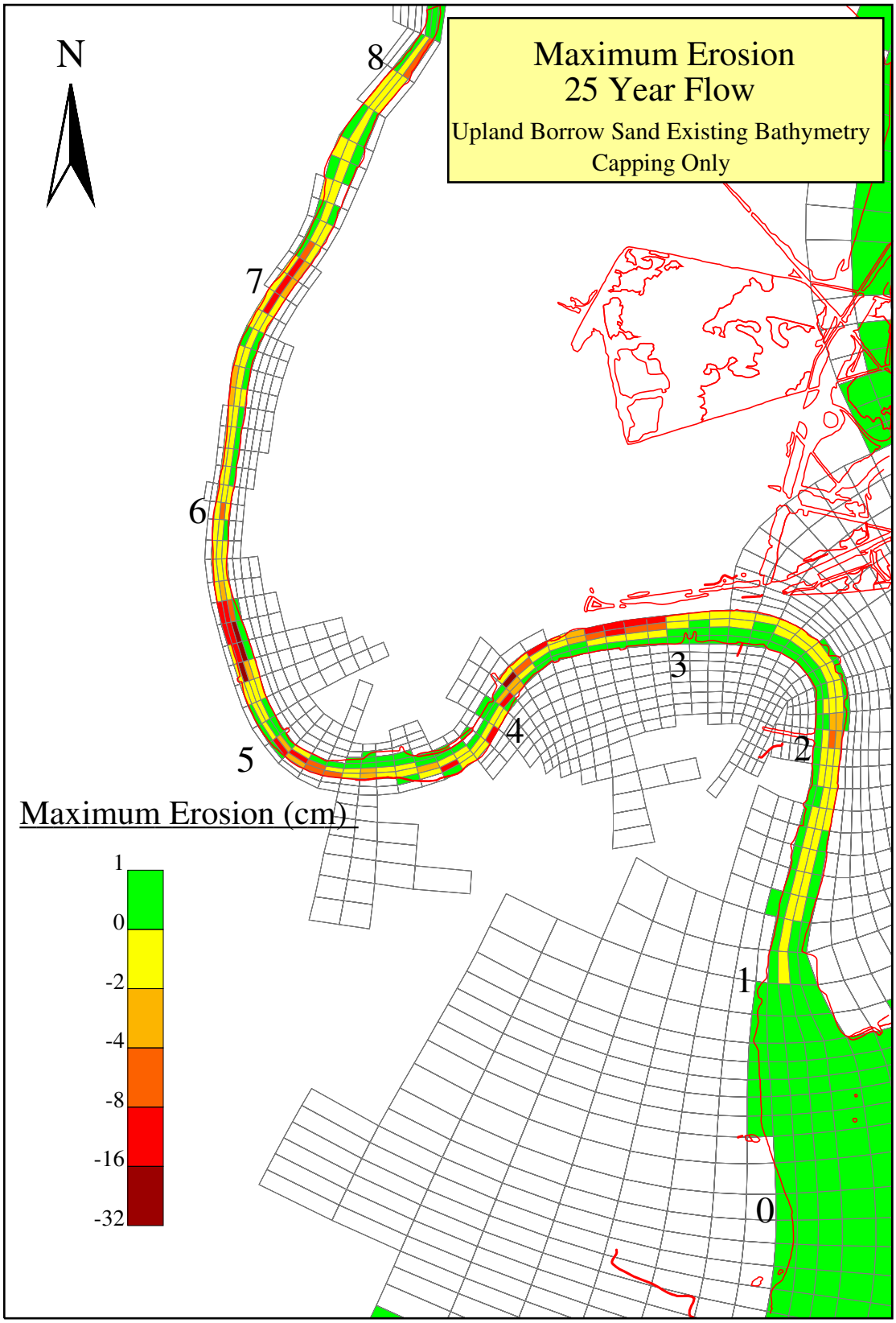

Figure C-7b. Plan view of the maximum erosion under the 25-year return flow conditions (Upland Borrow sand used as the capping material).

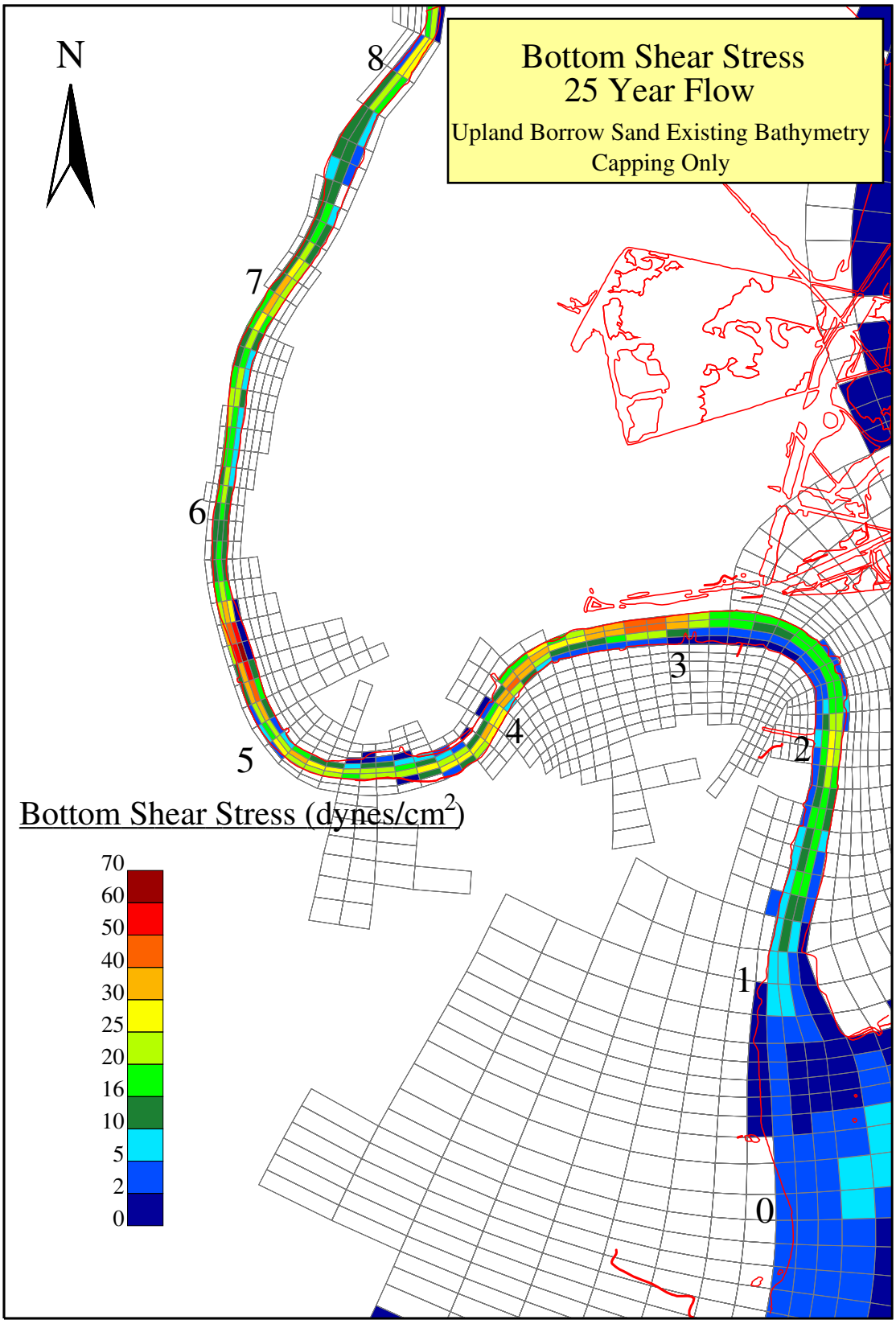

Figure C-7c. Plan view of the bottom shear stress under the 25-year return flow conditions (Upland Borrow sand used as the capping material).

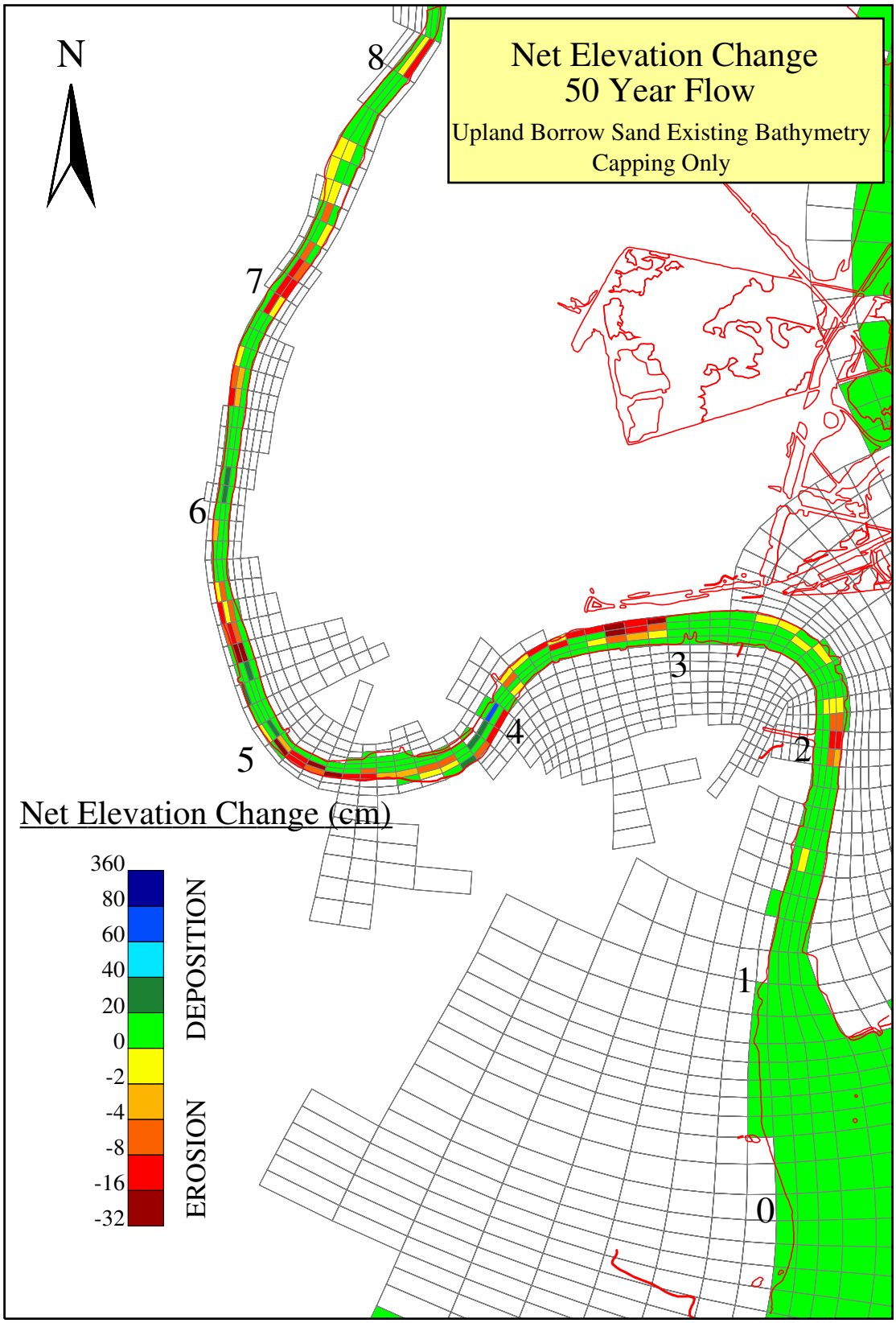

Figure C-8a. Plan view of the net elevation change under the 50-year return flow conditions (Upland Borrow sand used as the capping material).

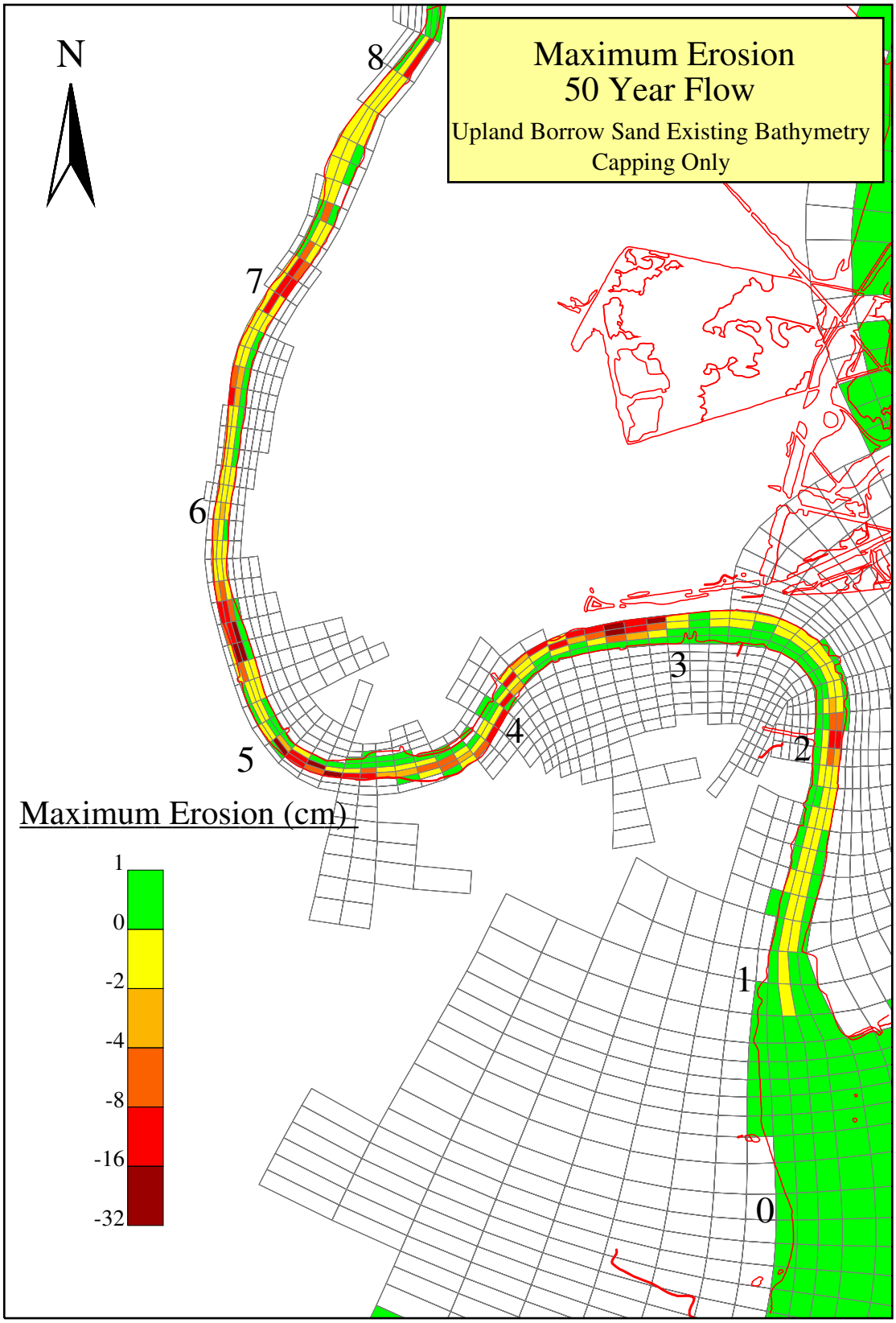

Figure C-8b. Plan view of the maximum erosion under the 50-year return flow conditions (Upland Borrow sand used as the capping material).

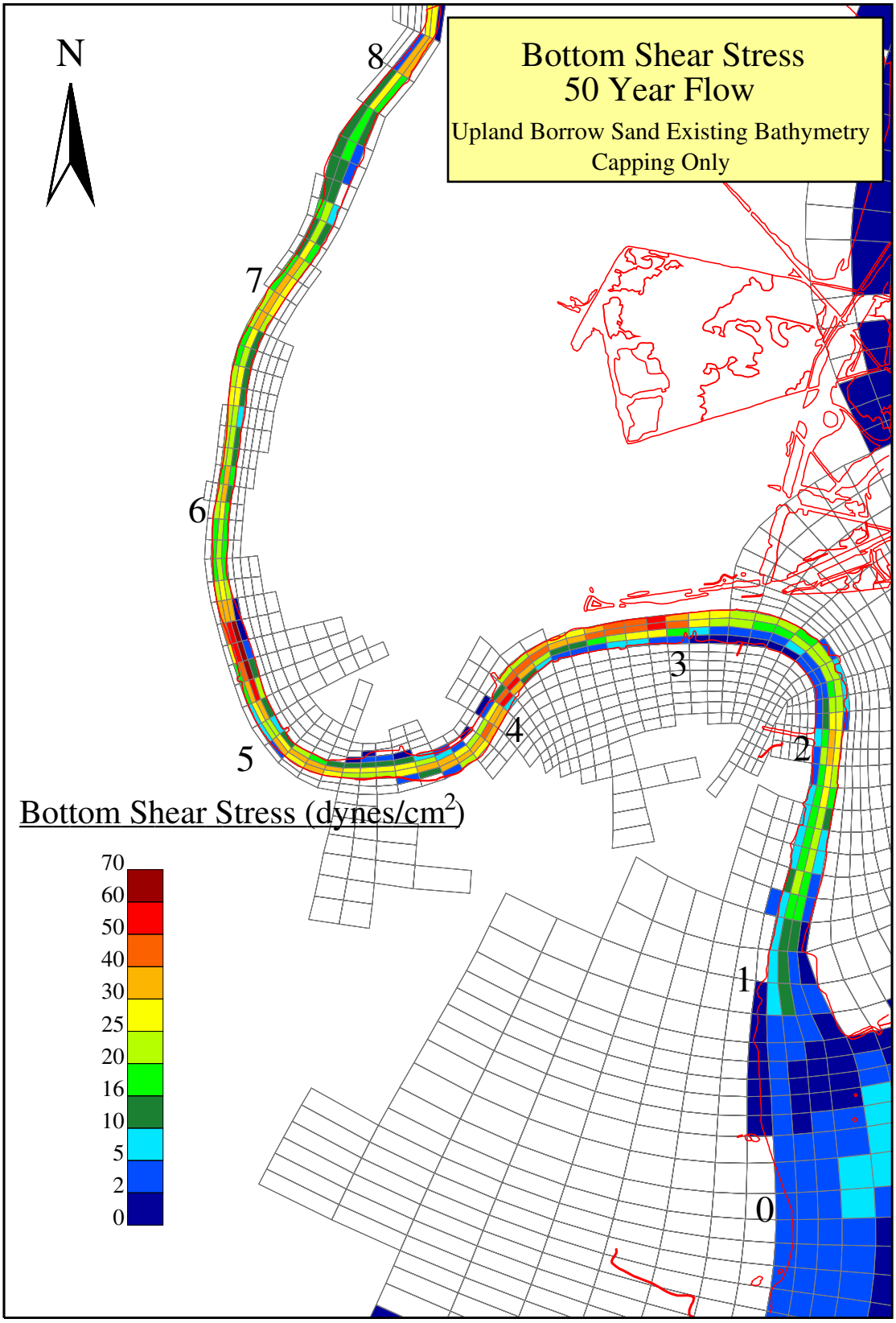

Figure C-8c. Plan view of the bottom shear stress under the 50-year return flow conditions (Upland Borrow sand used as the capping material).

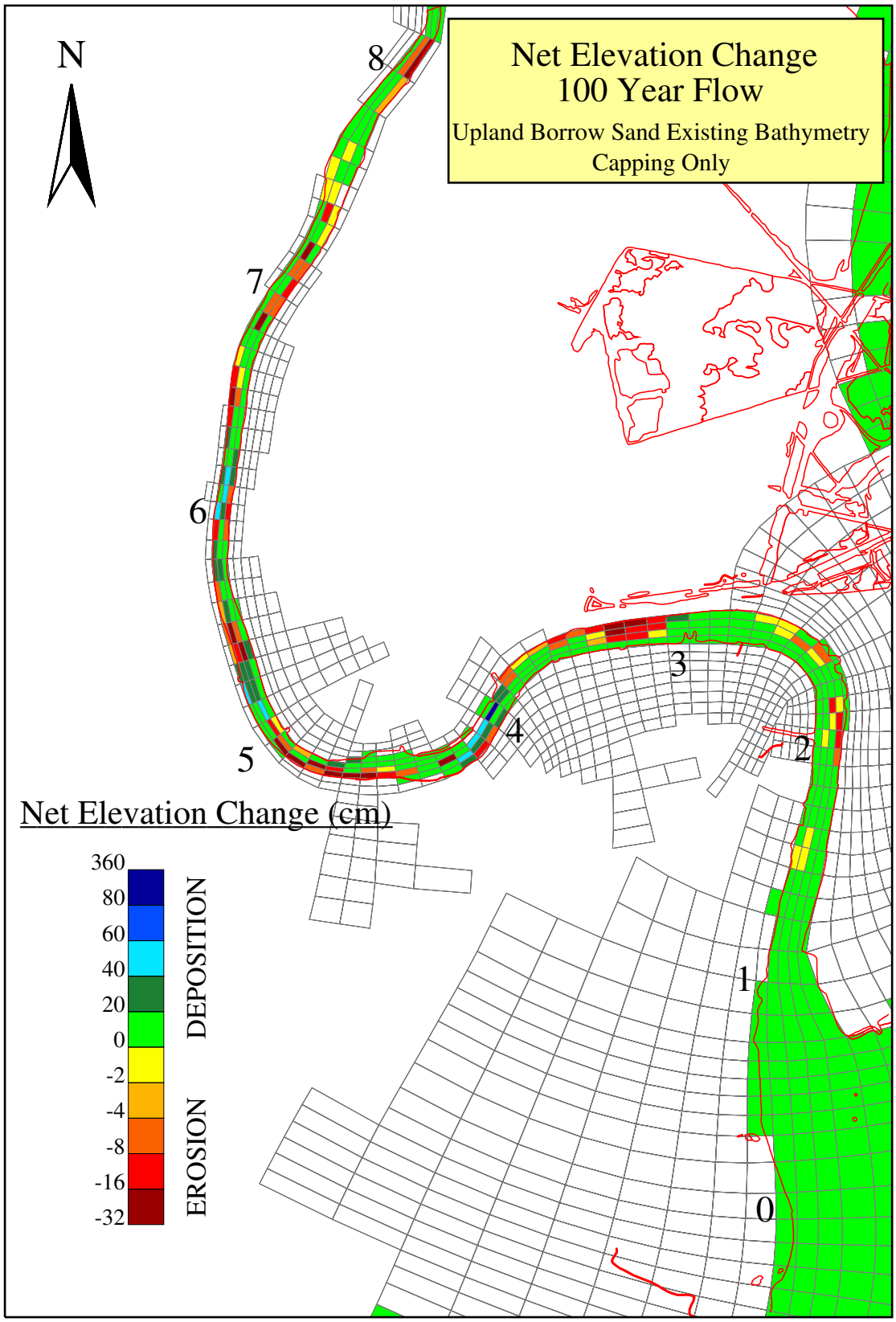

Figure C-9a. Plan view of the net elevation change under the 100-year return flow conditions (Upland Borrow sand used as the capping material).

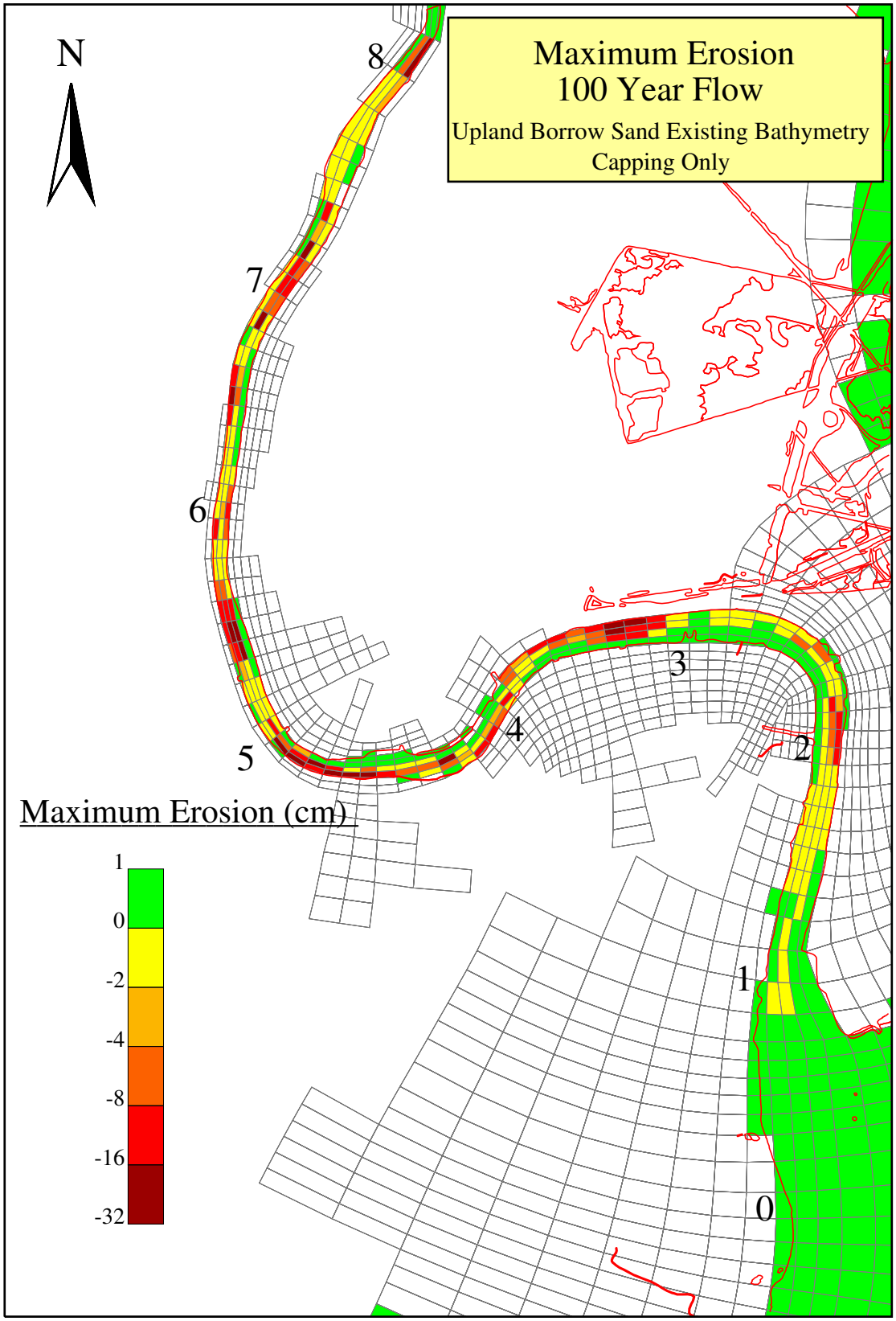

Figure C-9b. Plan view of the maximum erosion under the 100-year return flow conditions (Upland Borrow sand used as the capping material).

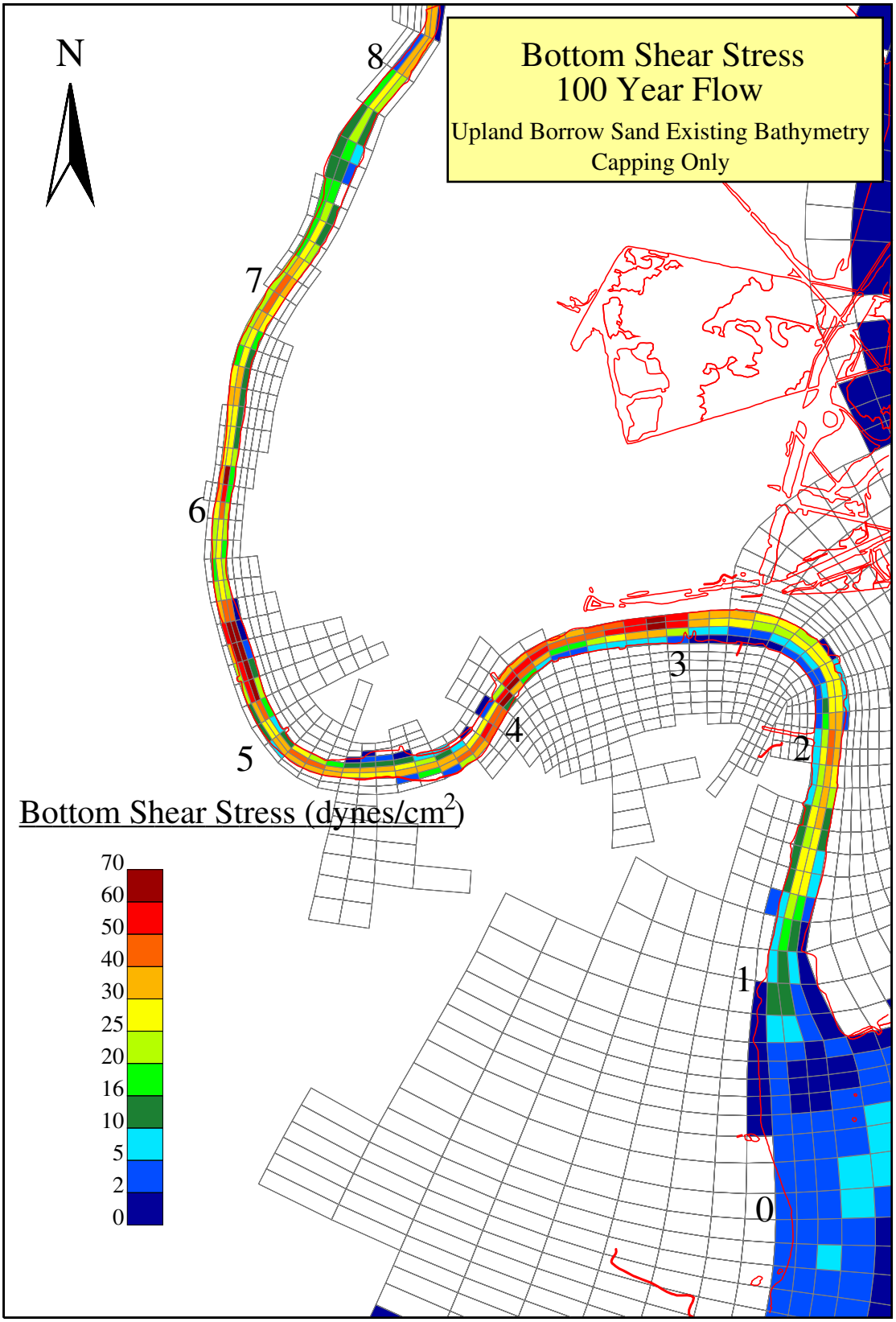

Figure C-9c. Plan view of the bottom shear stress under the 100-year return flow conditions (Upland Borrow sand used as the capping material).

ATTACHMENT D

BED ELEVATION CHANGES, MAXIMUM EROSION AND BOTTOM SHEAR STRESSES UNDER DIFFERENT DEPTH AND CAPPING/ARMORING SCENARIOS

Figure D-1a. Plan view of the net elevation change under 8-Mile Cap-Armor Area Predredging (Capping only) scenario.

Figure D-1b. Plan view of the maximum erosion under 8-Mile Cap-Armor Area Predredging (Capping only) scenario.

Figure D-1c. Plan view of the bottom shear stress under 8-Mile Cap-Armor Area Predredging (Capping only) scenario.

Figure D-2a. Plan view of the net elevation change under 8-Mile Cap-Armor Area Predredging (Capping and Armoring) scenario.

Figure D-2b. Plan view of the maximum erosion under 8-Mile Cap-Armor Area Predredging (Capping and Armoring) scenario.

Figure D-2c. Plan view of the bottom shear stress under 8-Mile Cap-Armor Area Predredging (Capping and Armoring) scenario.

Figure D-3a. Plan view of the net elevation change under 8-Mile Cap-Full Predredging (Capping only) scenario.

Figure D-3b. Plan view of the maximum erosion under 8-Mile Cap-Full Predredging (Capping only) scenario.

Figure D-3c. Plan view of the bottom shear stress under 8-Mile Cap-Full Predredging (Capping only) scenario.

Figure D-4a. Plan view of the net elevation change under 8-Mile Cap-Full Predredging (Capping and Armoring) scenario.

Figure D-4b. Plan view of the net maximum erosion under 8-Mile Cap-Full Predredging (Capping and Armoring) scenario.

Figure D-4c. Plan view of the bottom shear stress under 8-Mile Cap-Full Predredging (Capping and Armoring) scenario.

Figure D-5a. Plan view of the net elevation change under Current Navigation Usage-Full Predredging (Capping only) scenario.

Figure D-5b. Plan view of the maximum erosion under Current Navigation Usage-Full Predredging (Capping only) scenario

Figure D-5c. Plan view of the bottom shear stress under Current Navigation Usage-Full Predredging (Capping only) scenario

Figure D-6a. Plan view of the net elevation change under Current Navigation Usage-Full Predredging (Capping and Armoring) scenario.

Figure D-6b. Plan view of the maximum erosion under Current Navigation Usage-Full Predredging (Capping and Armoring) scenario.

Figure D-6c. Plan view of the bottom shear stress under Current Navigation Usage-Full Predredging (Capping and Armoring) scenario.

Figure D-7a. Plan view of the net elevation change under Future Navigation Usage-Full Predredging (Capping only) scenario.

Figure D-7b. Plan view of the maximum erosion under Future Navigation Usage-Full Predredging (Capping only) scenario.

Figure D-7c. Plan view of the bottom shear stress under Future Navigation Usage-Full Predredging (Capping only) scenario

Figure D-8a. Plan view of the net elevation change under Future Navigation Usage-Full Predredging (Capping and Armoring) scenario.

Figure D-8b. Plan view of the maximum erosion under Future Navigation Usage-Full Predredging (Capping and Armoring) scenario.

Figure D-8c. Plan view of the bottom shear stress under Future Navigation Usage-Full Predredging (Capping and Armoring) scenario.

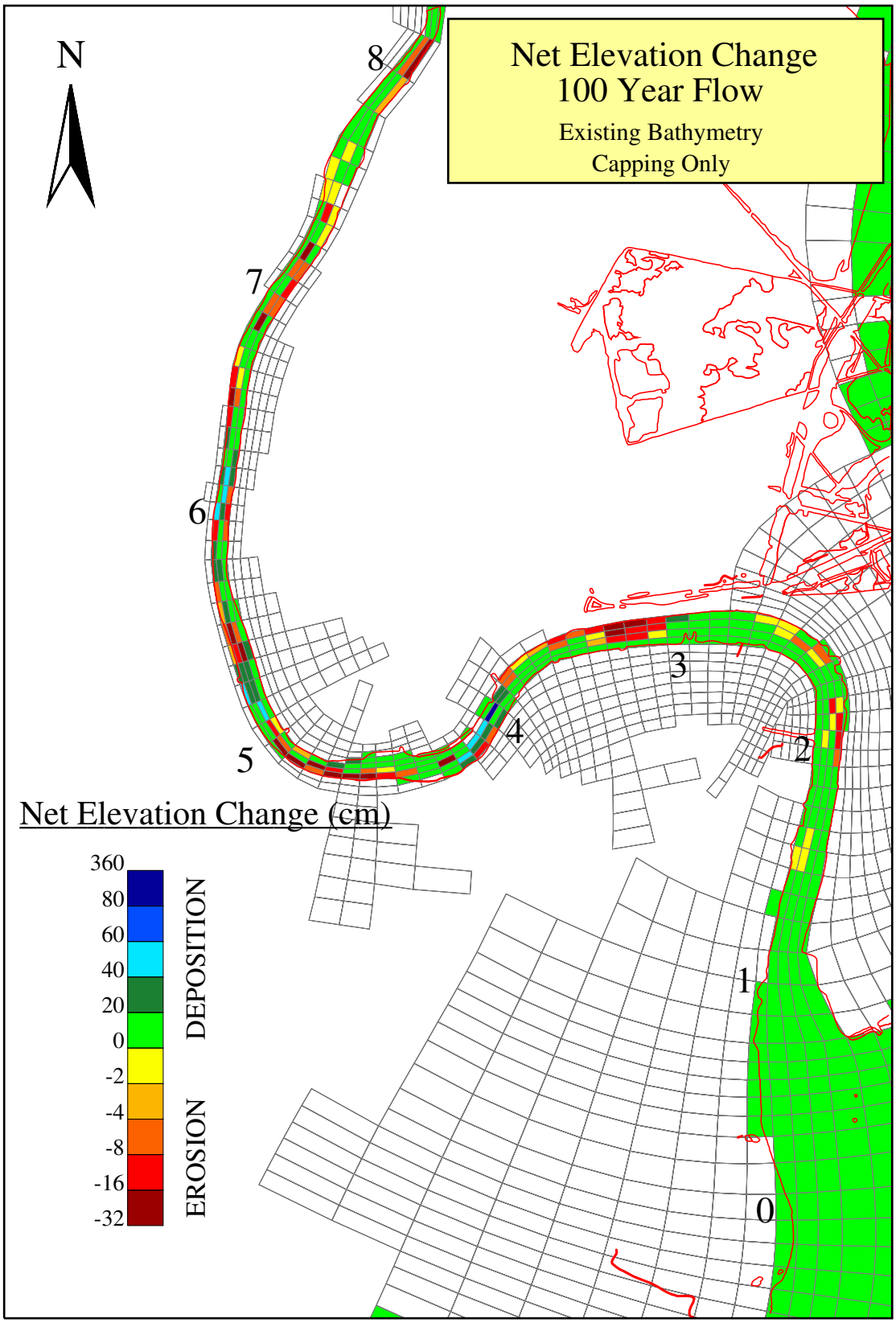

Figure D-1a. Plan view of the net elevation change under 8-Mile Cap-Armor Area Predredging (Capping only) scenario.

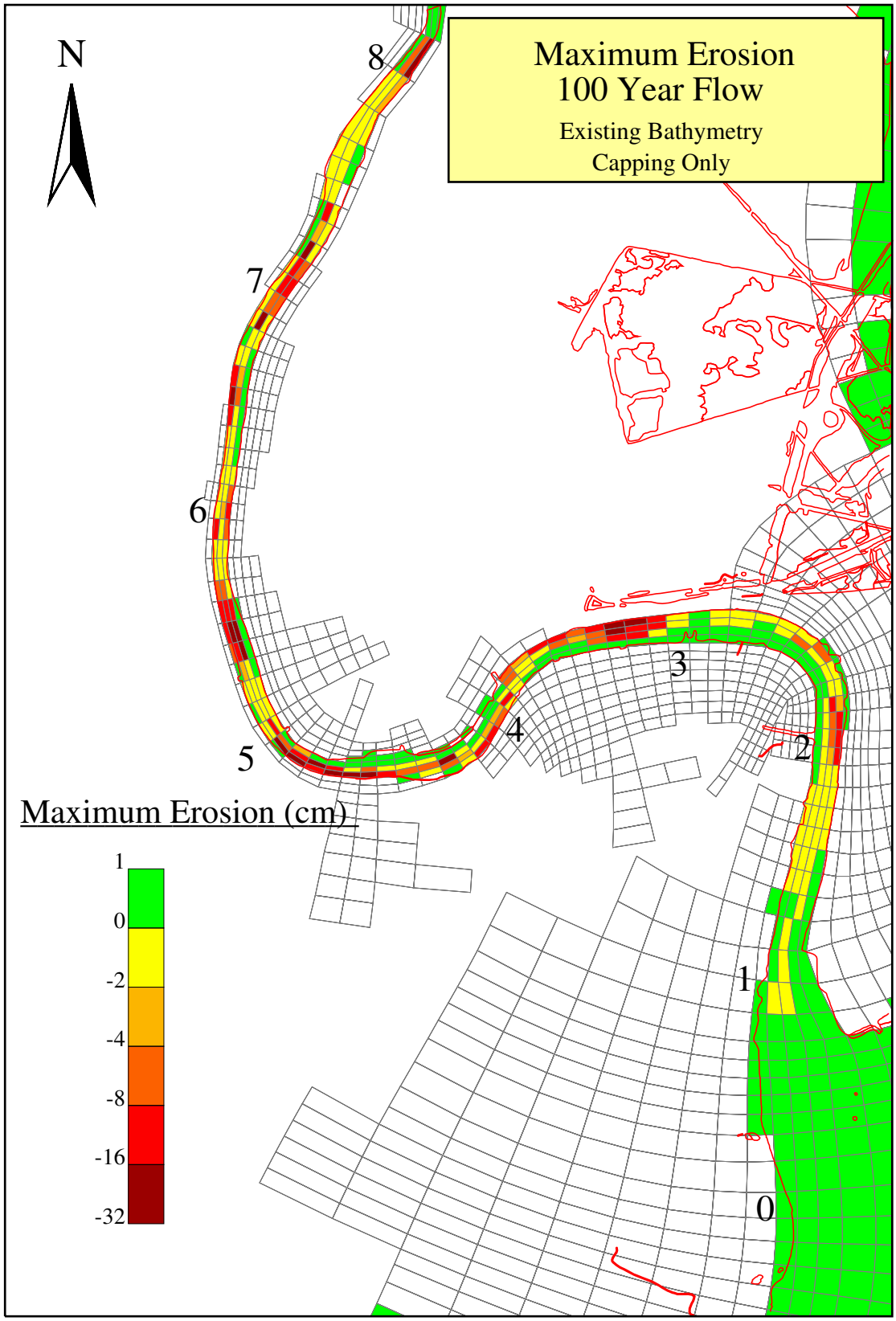

Figure D-1b. Plan view of the maximum erosion under 8-Mile Cap-Armor Area Predredging (Capping only) scenario.

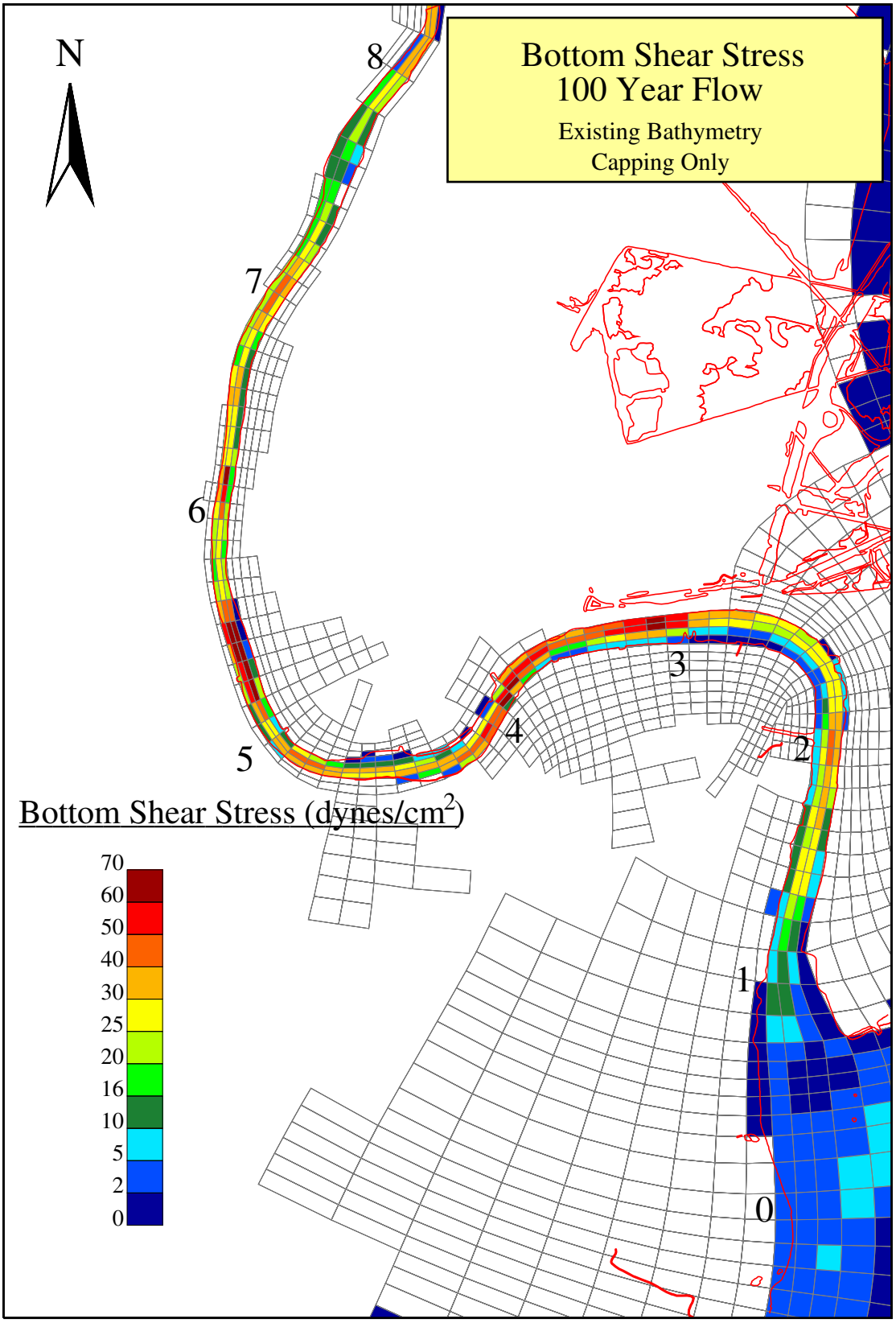

Figure D-1c. Plan view of the bottom shear stress under 8-Mile Cap-Armor Area Predredging (Capping only) scenario.

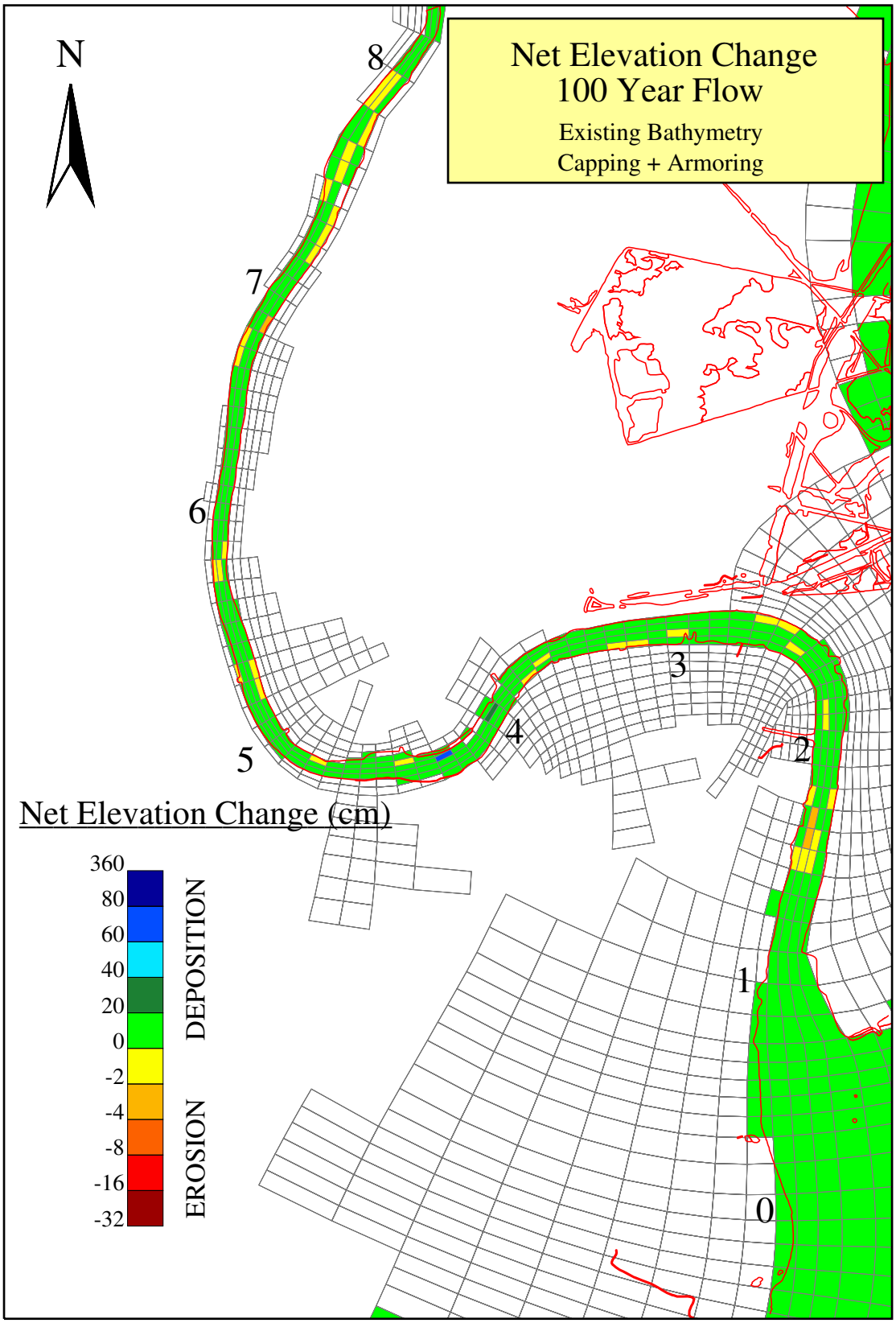

Figure D-2a. Plan view of the net elevation change under 8-Mile Cap-Armor Area Predredging (Capping and Armoring) scenario.

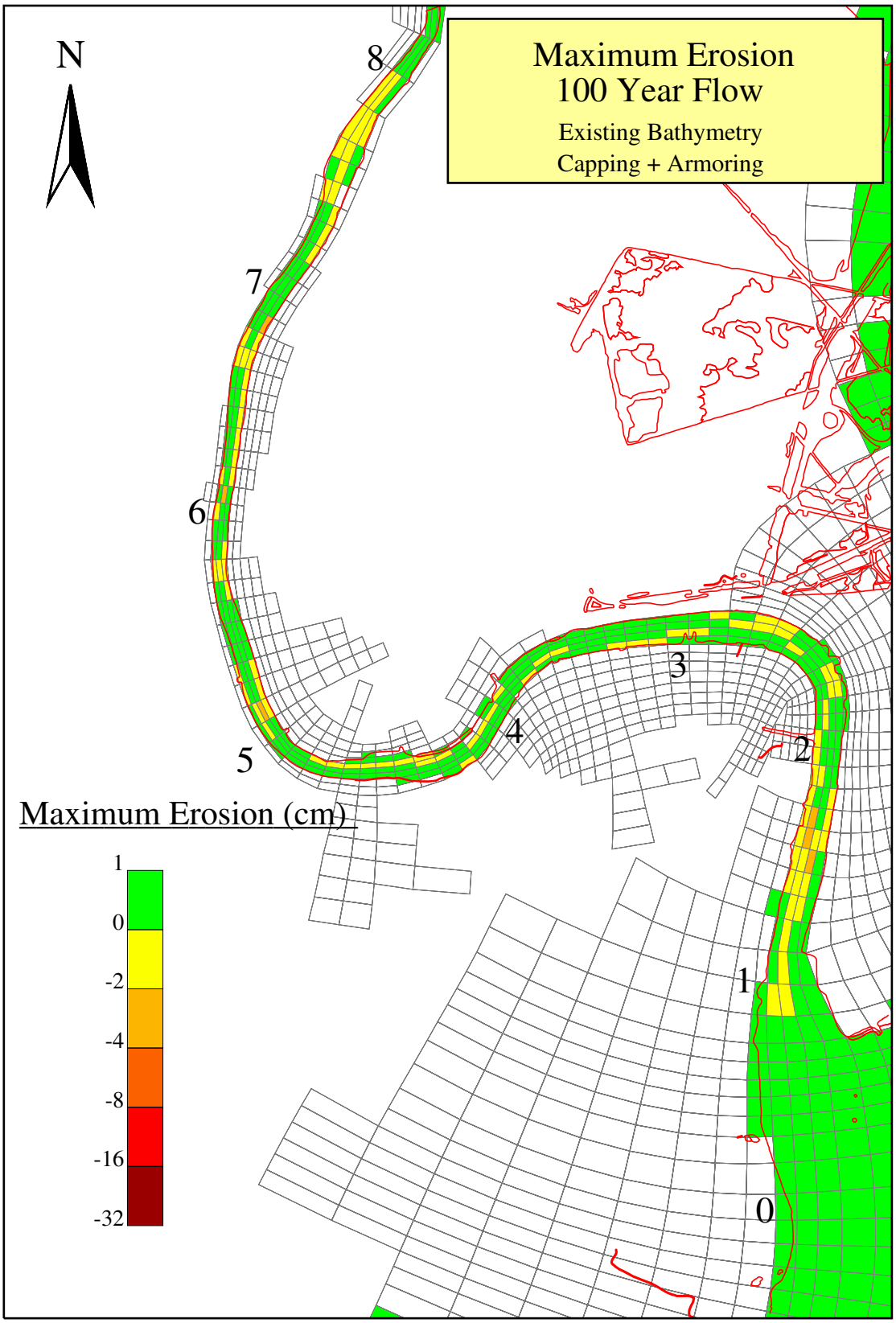

Figure D-2b. Plan view of the maximum erosion under 8-Mile Cap-Armor Area Predredging (Capping and Armoring) scenario.

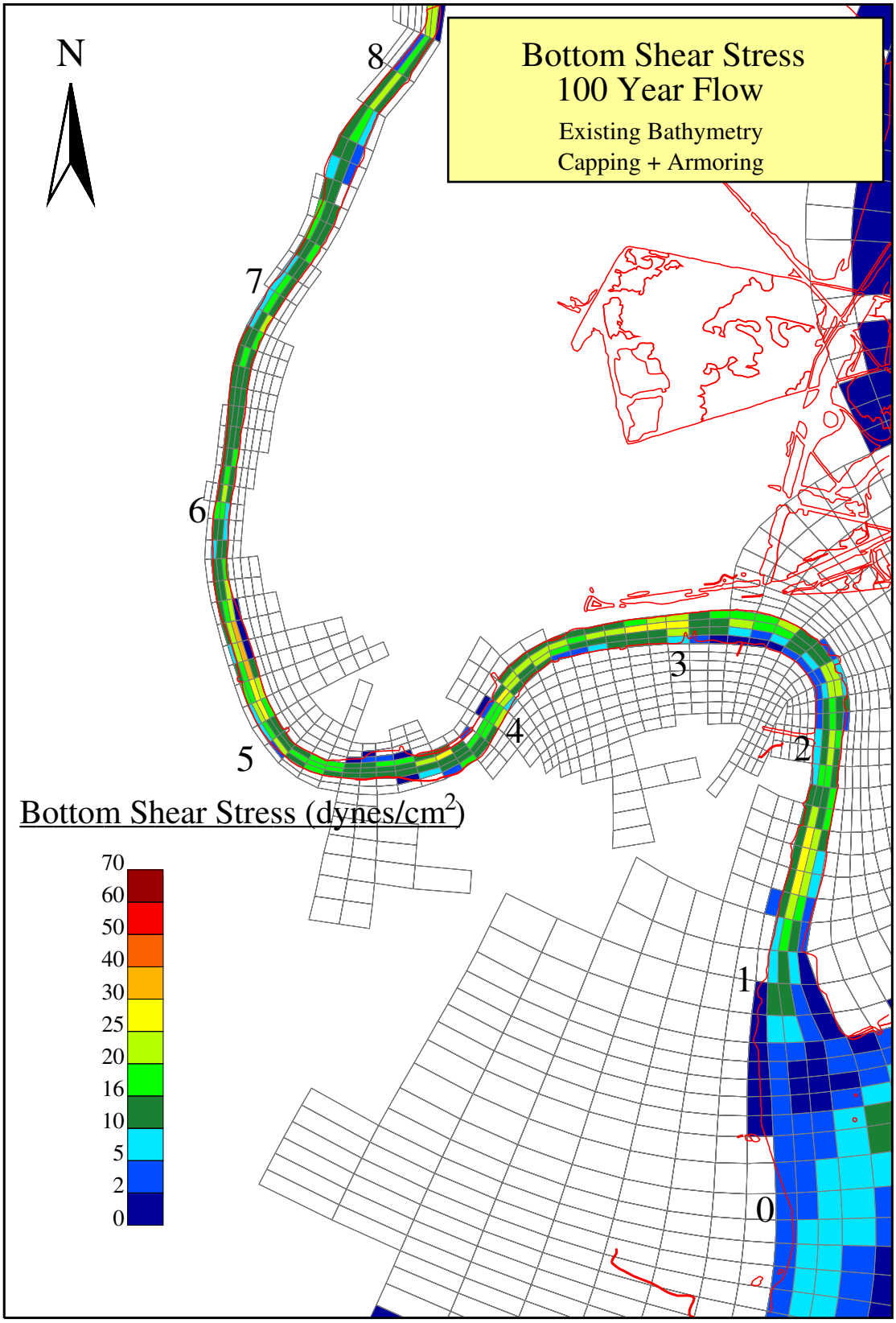

Figure D-2c. Plan view of the bottom shear stress under 8-Mile Cap-Armor Area Predredging (Capping and Armoring) scenario.

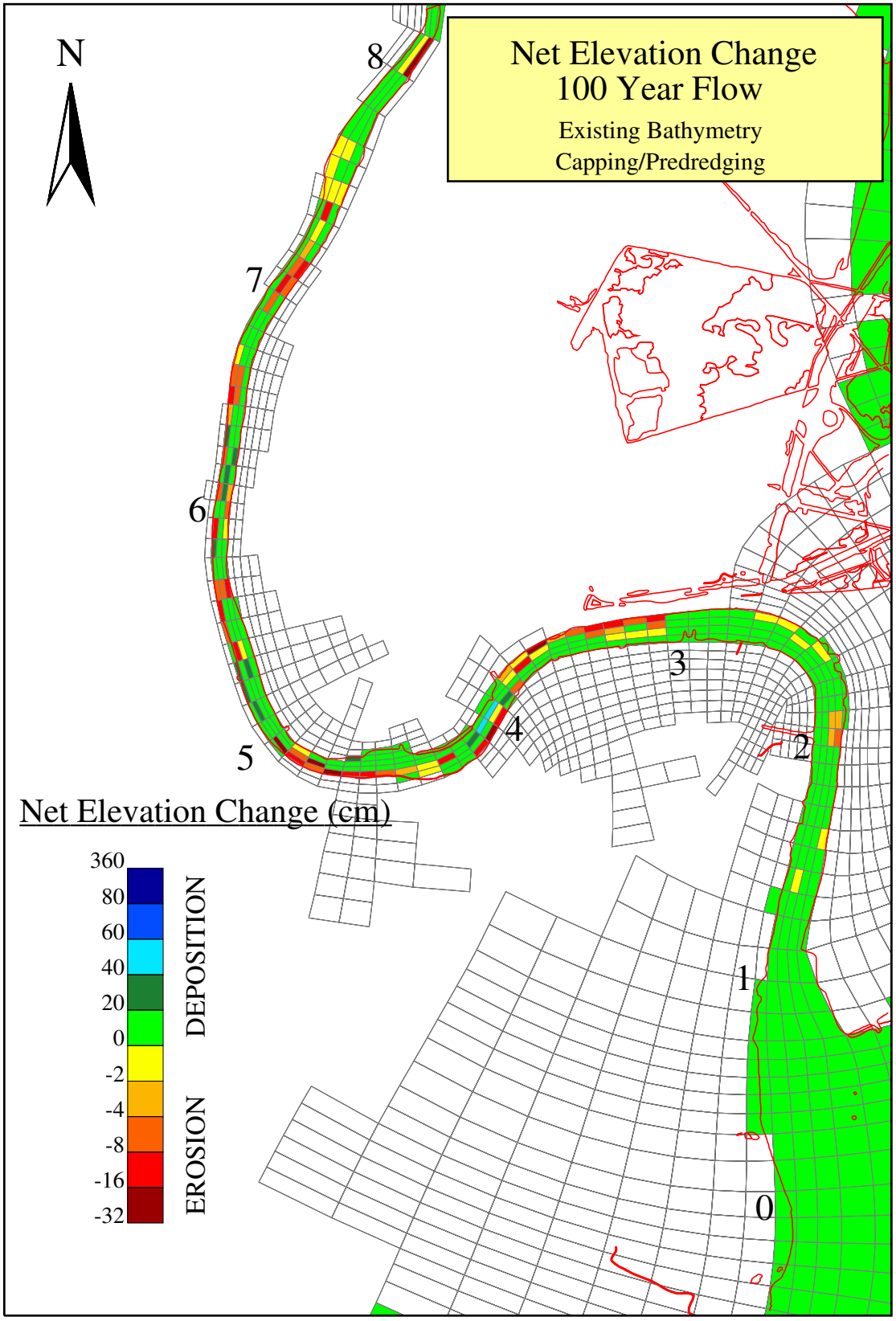

Figure D-3a. Plan view of the net elevation change under 8-Mile Cap-Full Predredging (Capping only) scenario.

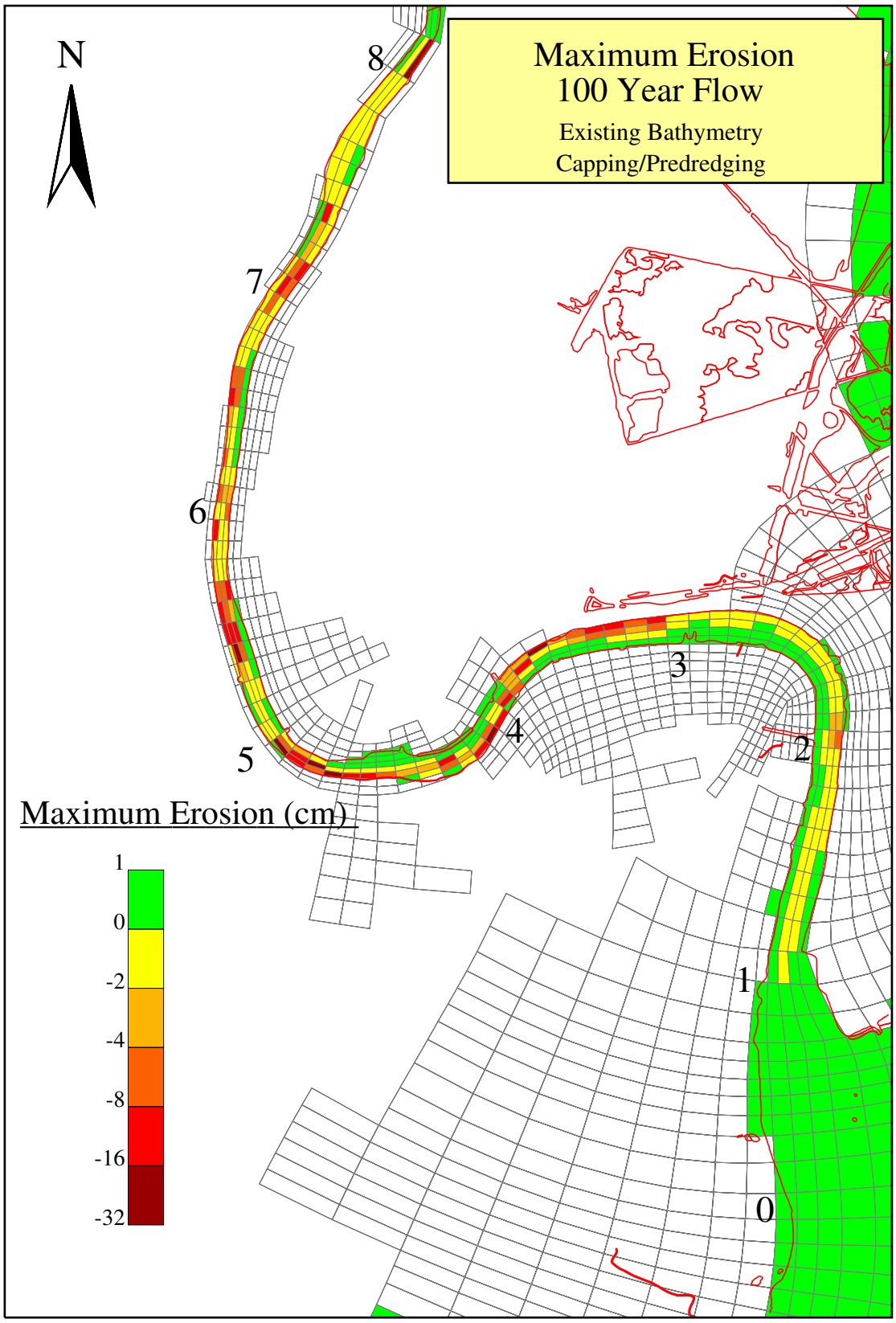

Figure D-3b. Plan view of the maximum erosion under 8-Mile Cap-Full Predredging (Capping only) scenario.

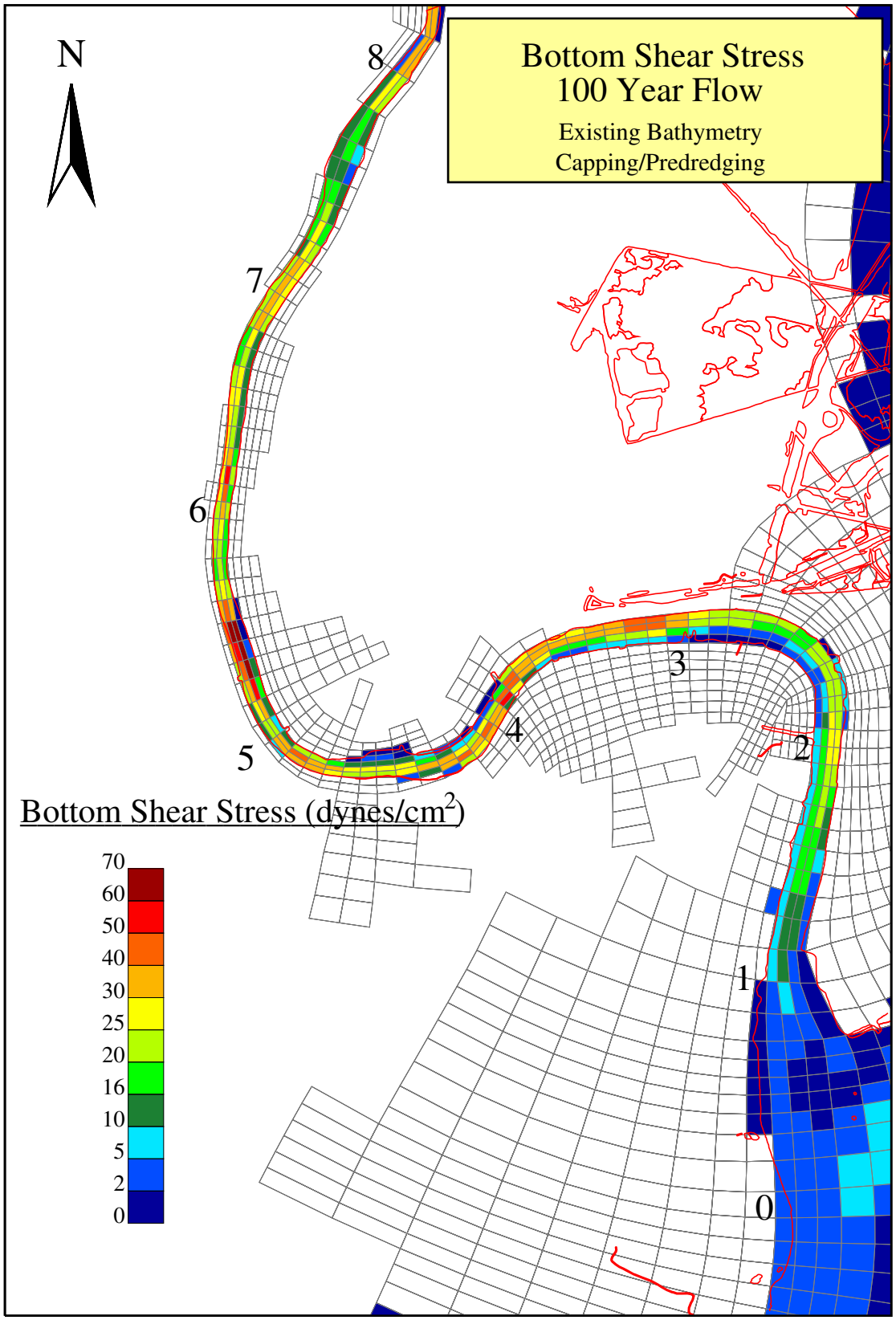

Figure D-3c. Plan view of the bottom shear stress under 8-Mile Cap-Full Predredging (Capping only) scenario.

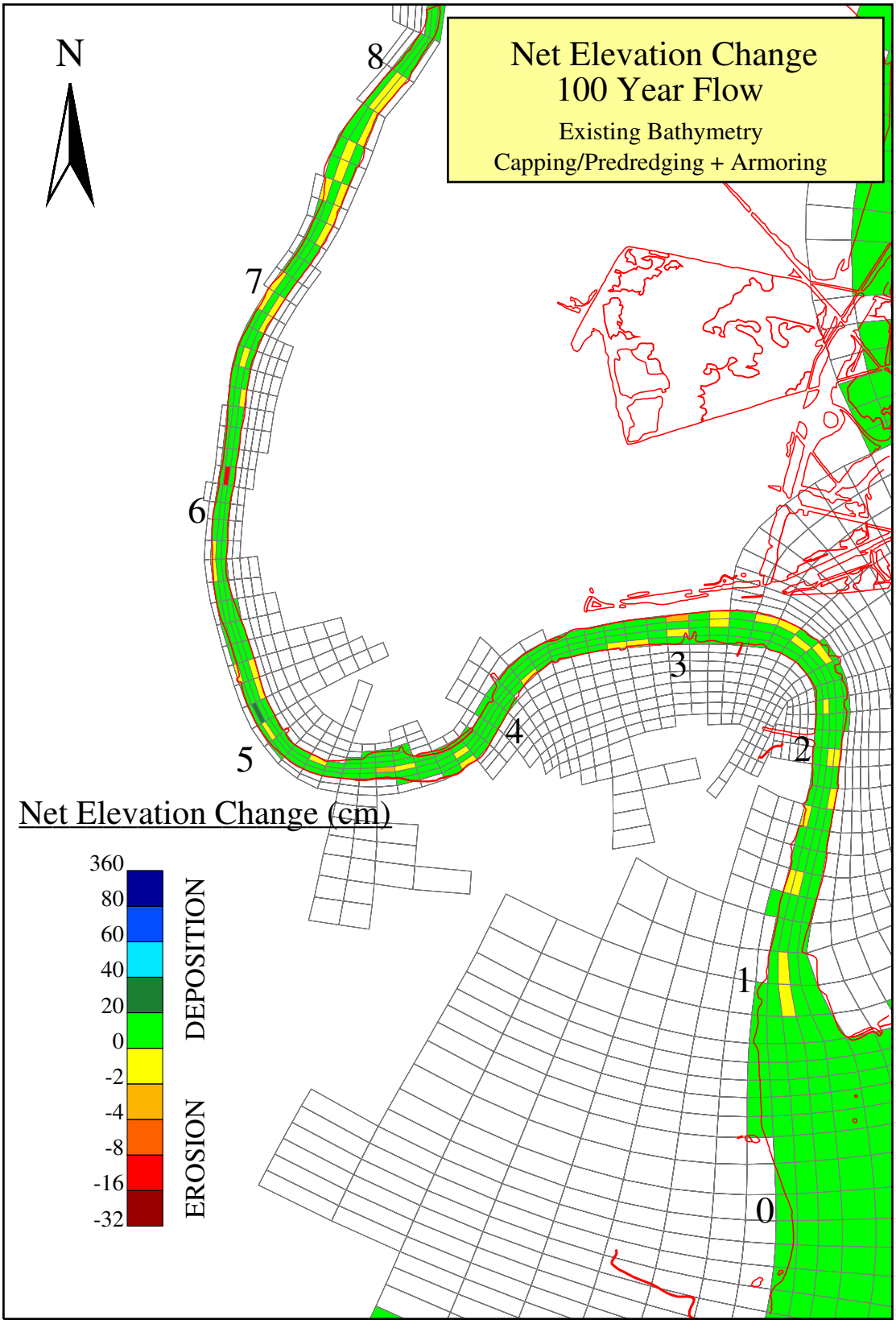

Figure D-4a. Plan view of the net elevation change under 8-Mile Cap-Full Predredging (Capping and Armoring) scenario.

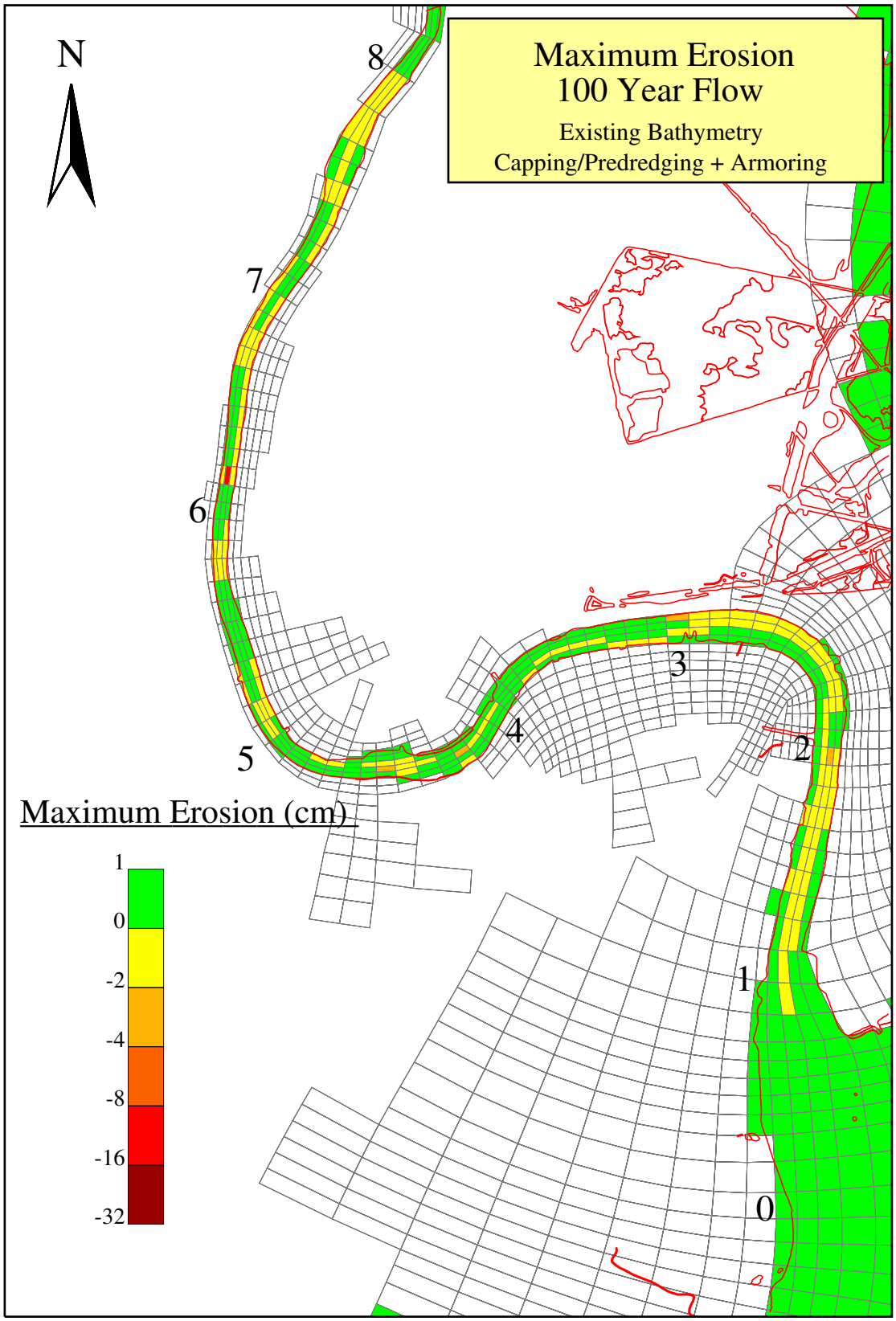

Figure D-4b. Plan view of the maximum erosion under 8-Mile Cap-Full Predredging (Capping and Armoring) scenario.

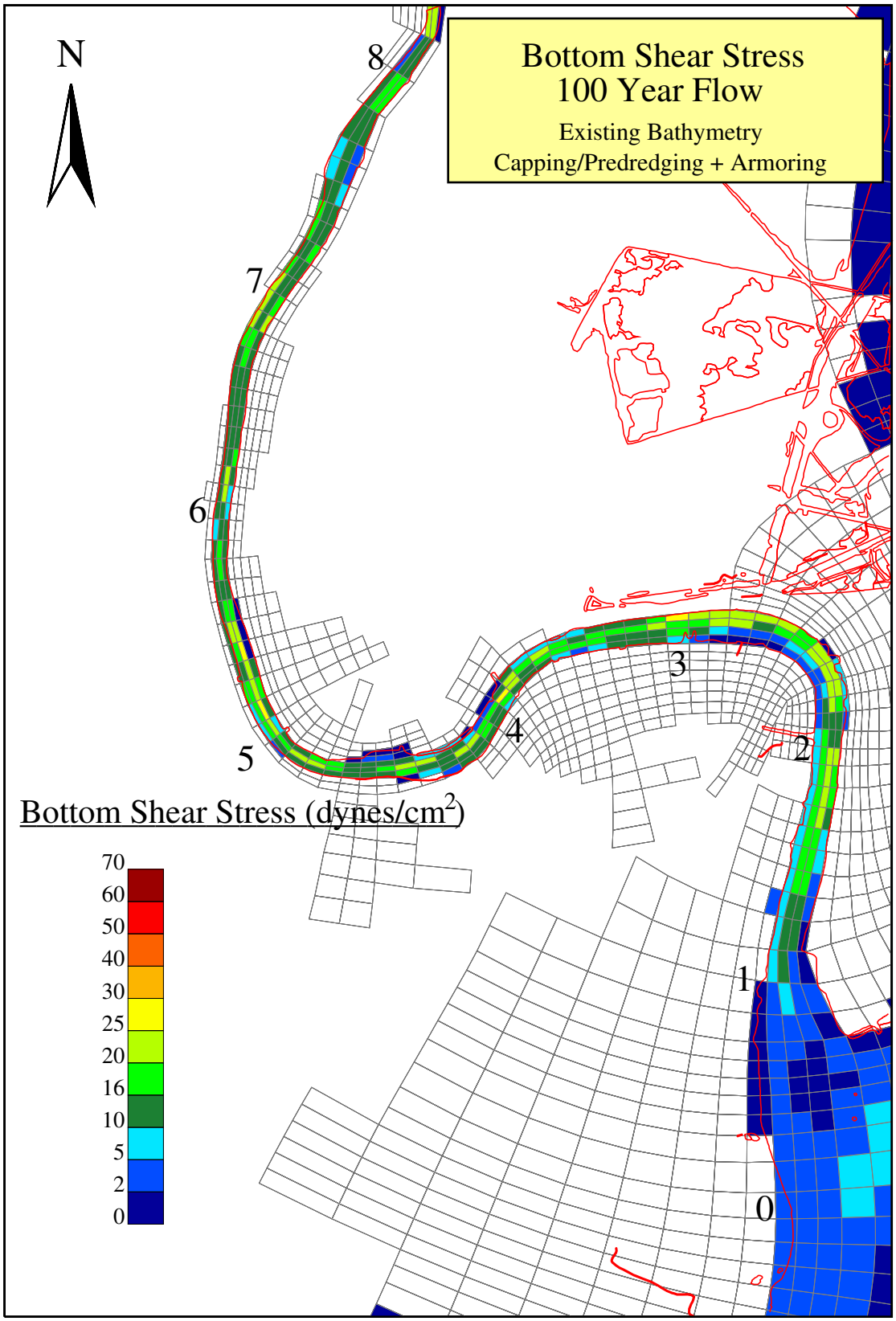

Figure D-4c. Plan view of the bottom shear stress under 8-Mile Cap-Full Predredging (Capping and Armoring) scenario.

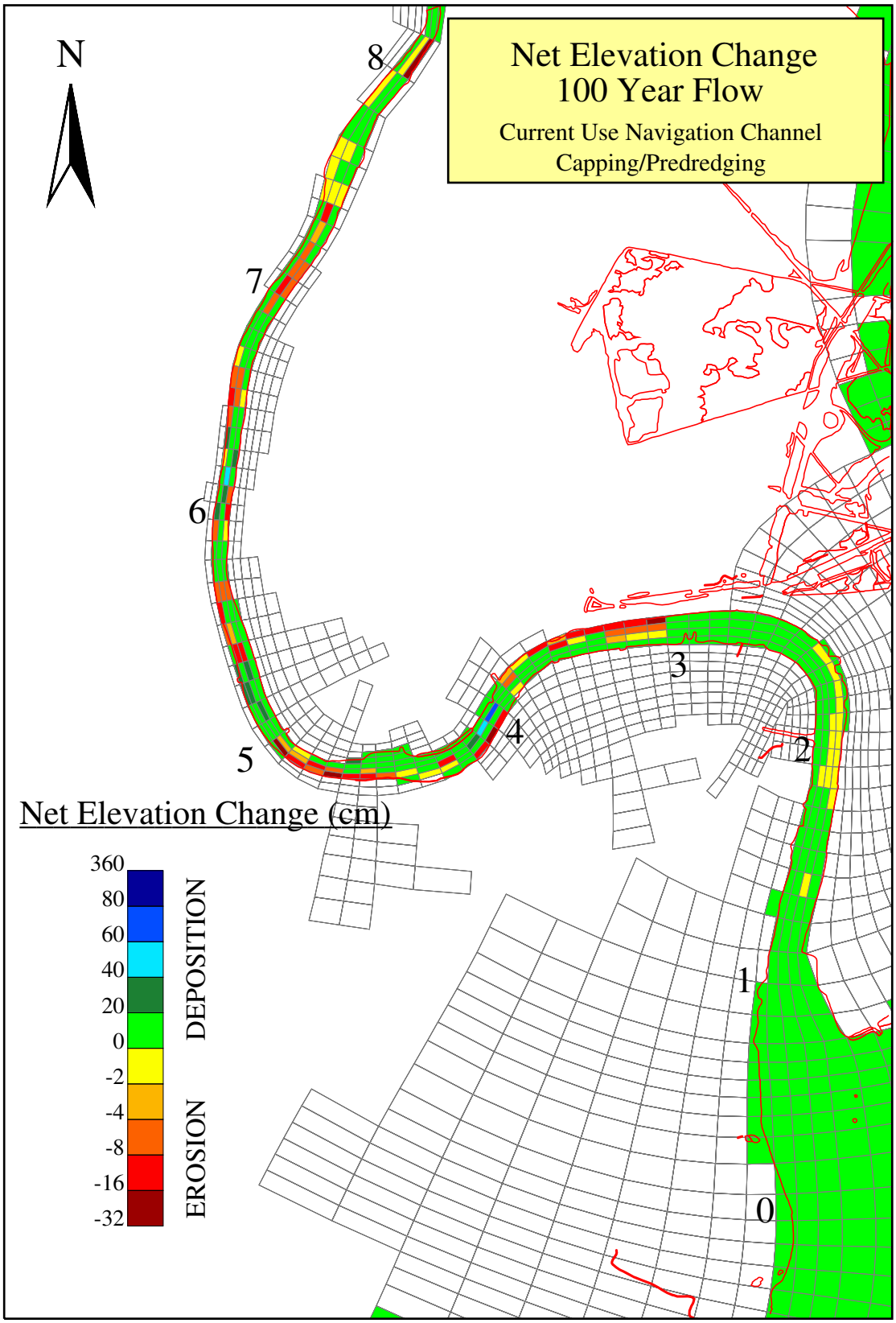

Figure D-5a. Plan view of the net elevation change under Current Navigation Usage-Full Predredging (Capping only) scenario.

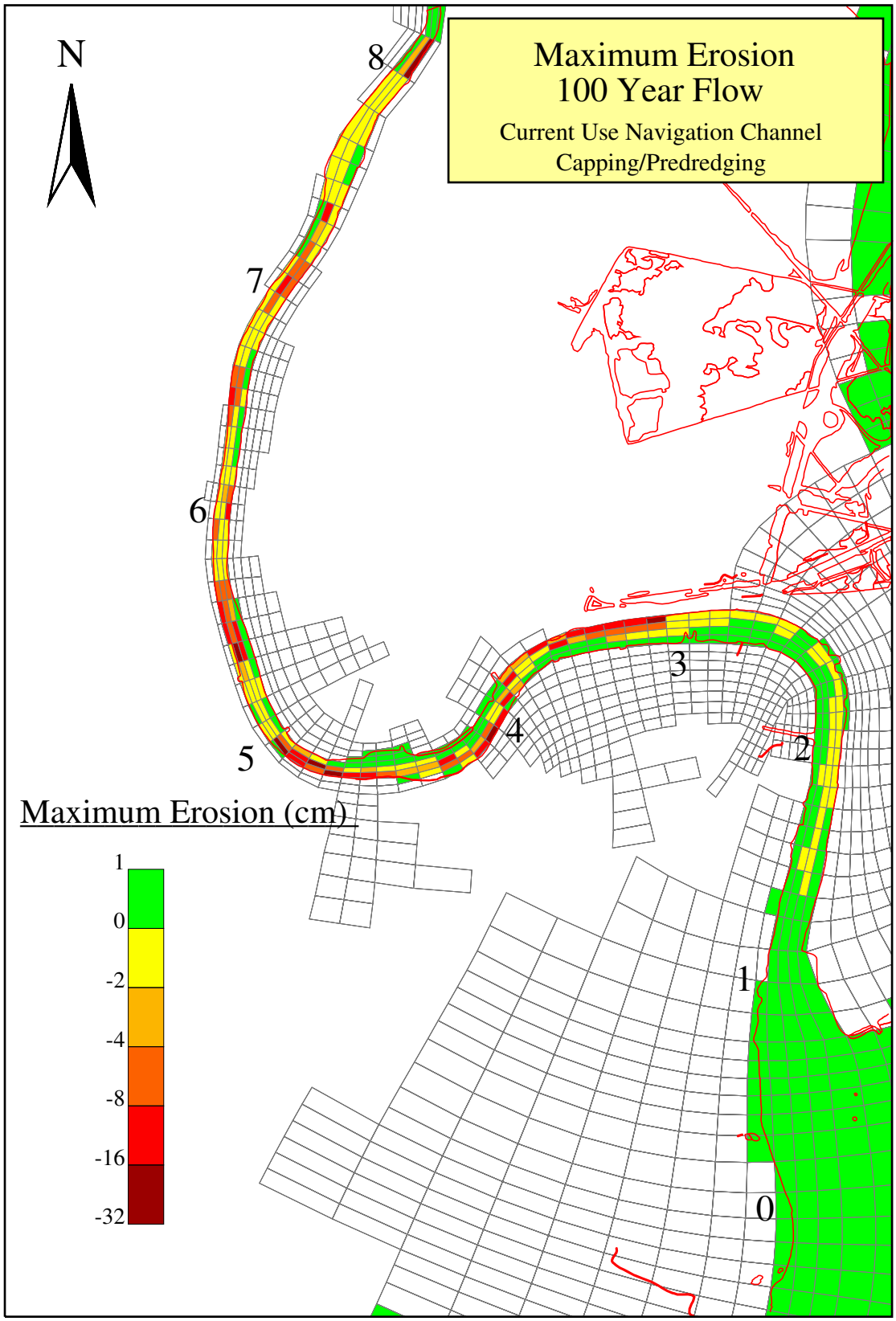

Figure D-5b. Plan view of the maximum erosion under Current Navigation Usage-Full Predredging (Capping only) scenario

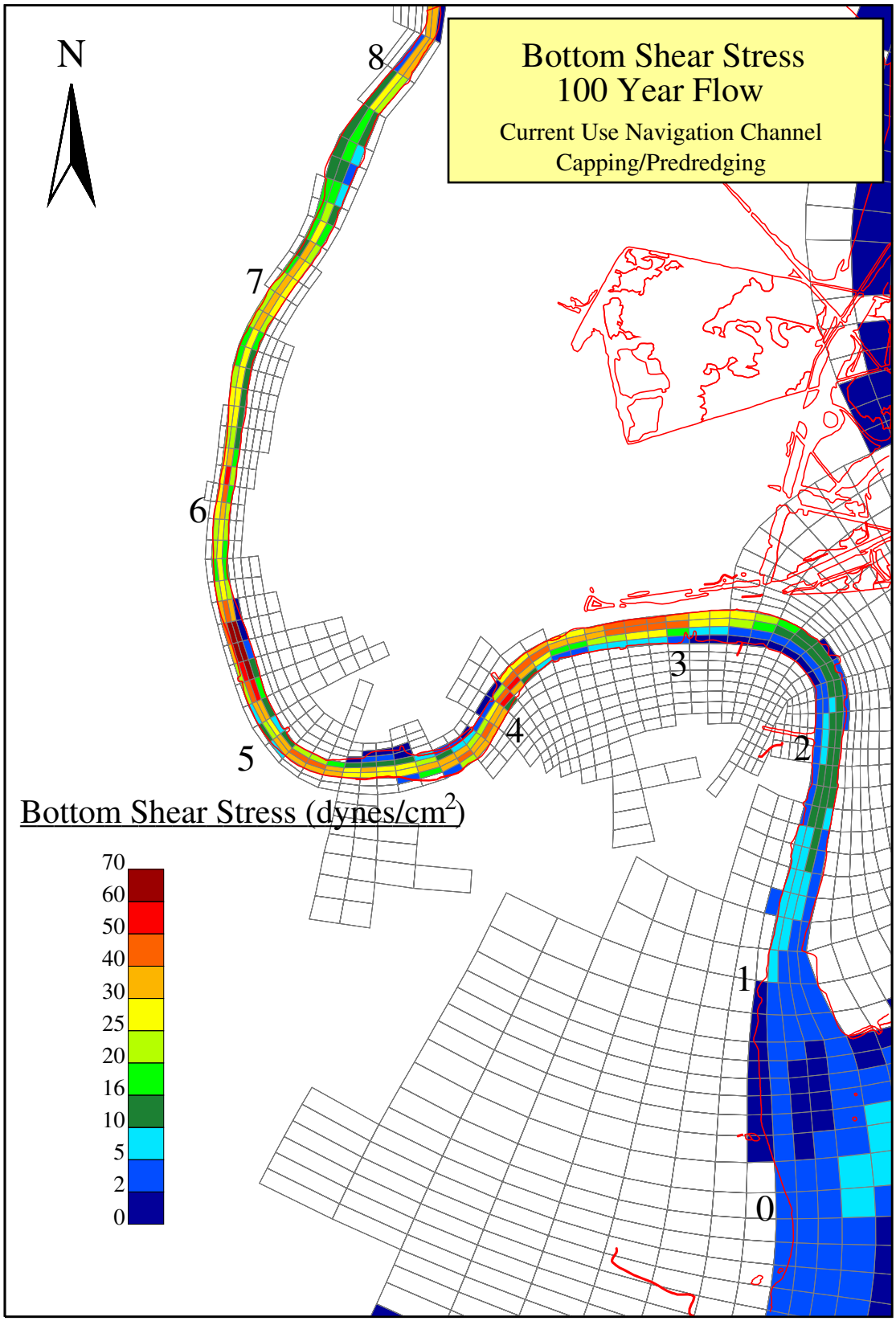

Figure D-5c. Plan view of the bottom shear stress under Current Navigation Usage-Full Predredging (Capping only) scenario

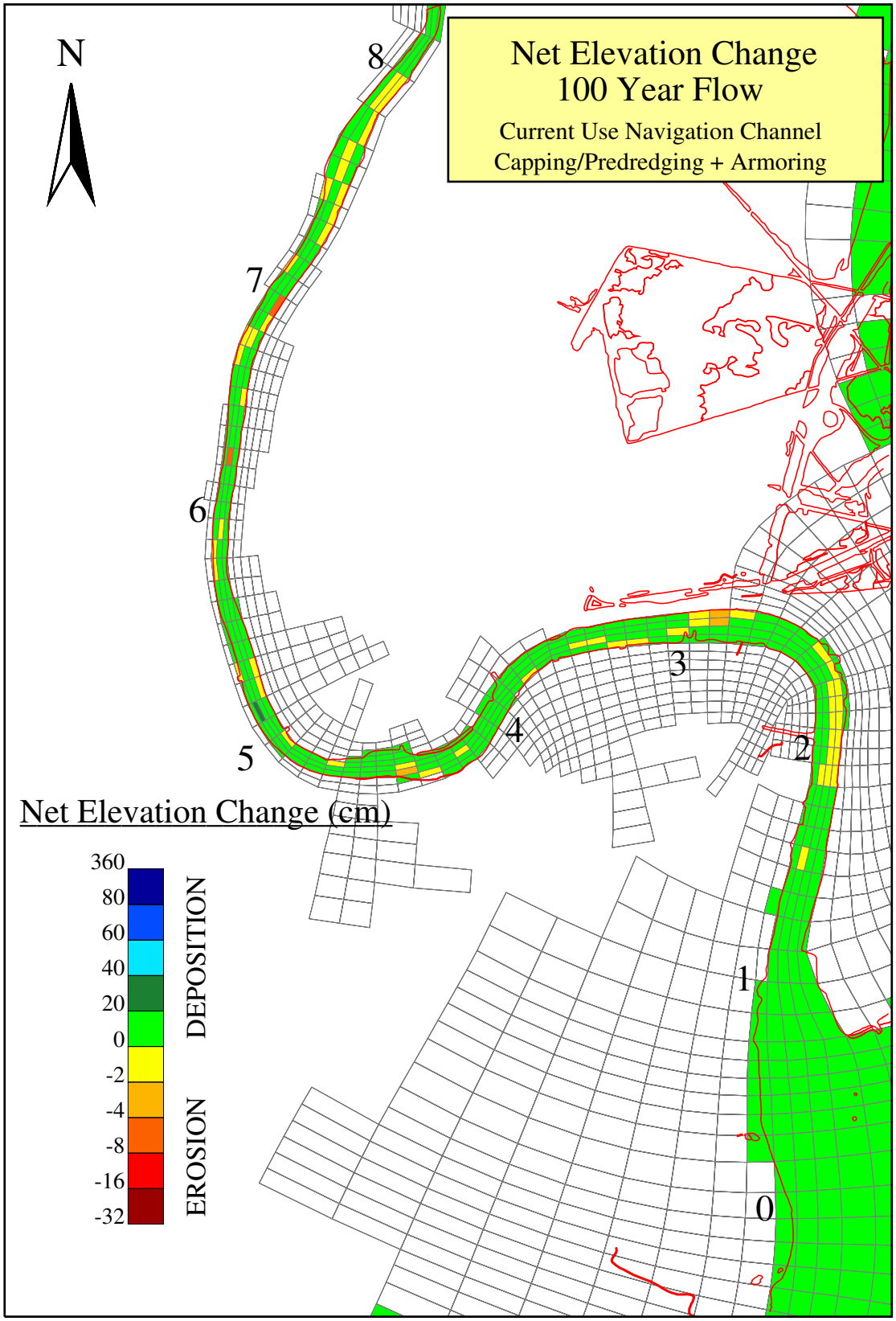

Figure D-6a. Plan view of the net elevation change under Current Navigation Usage-Full Predredging (Capping and Armoring) scenario.

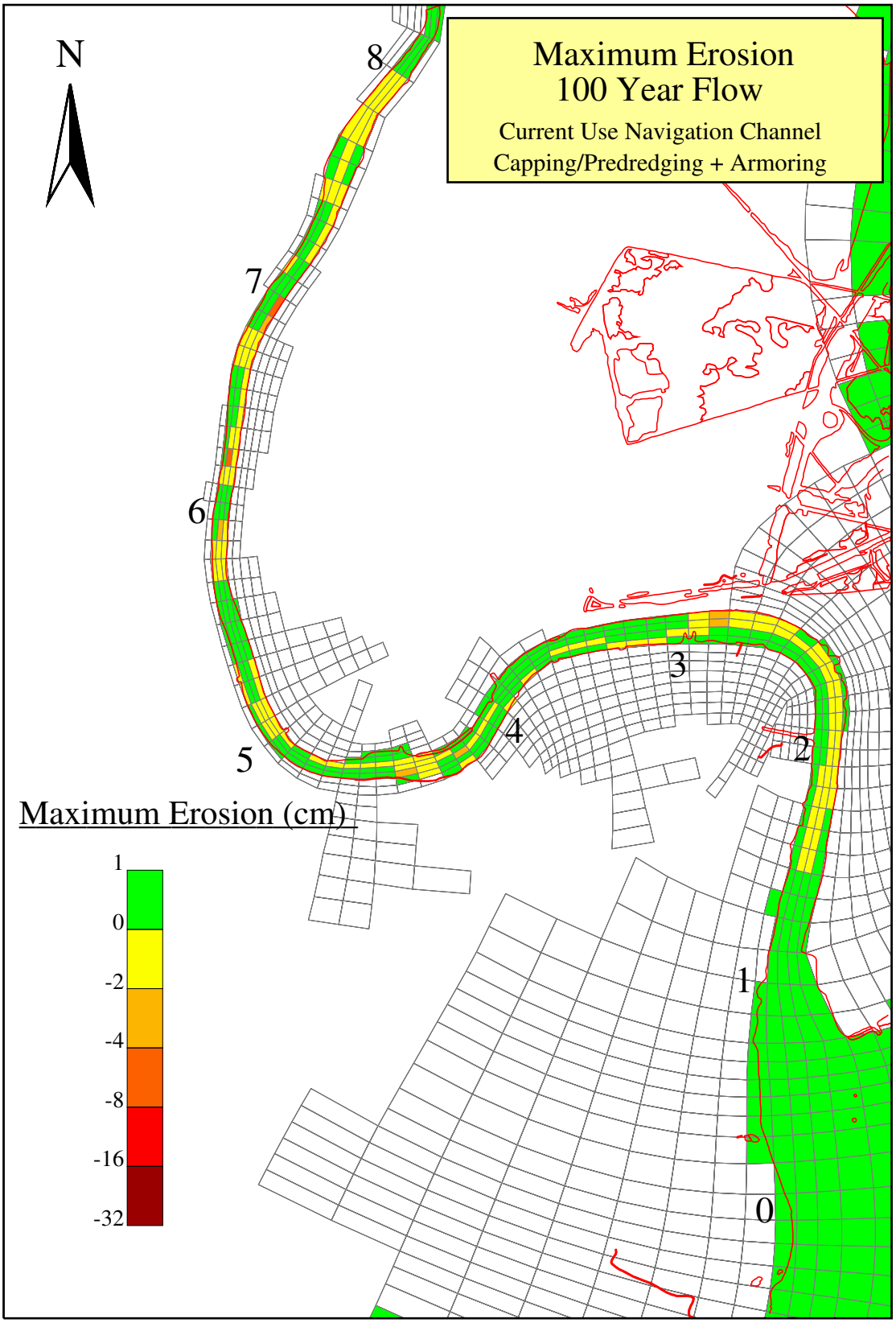

Figure D-6b. Plan view of the maximum erosion under Current Navigation Usage-Full Predredging (Capping and Armoring) scenario.

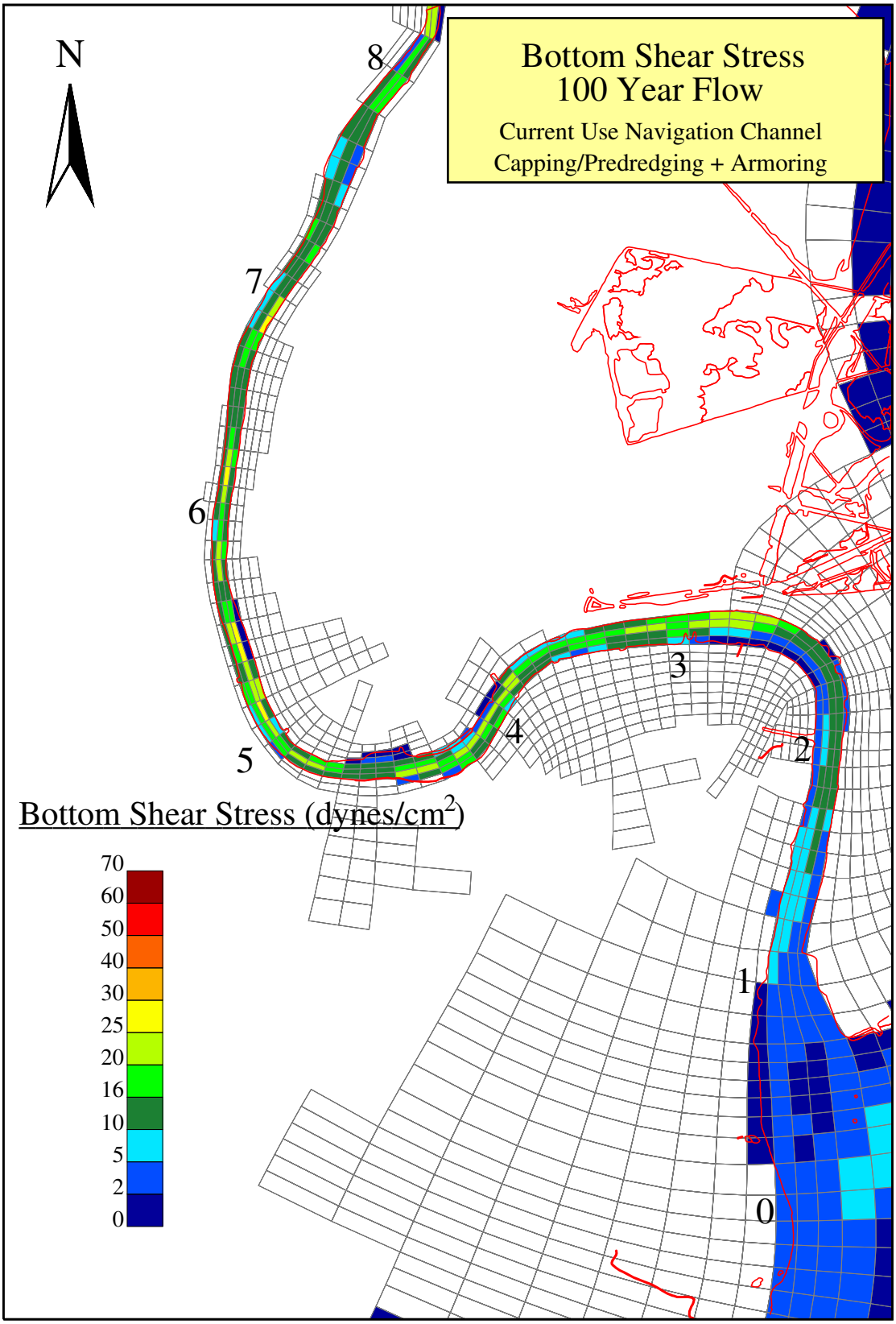

Figure D-6c. Plan view of the bottom shear stress under Current Navigation Usage-Full Predredging (Capping and Armoring) scenario.

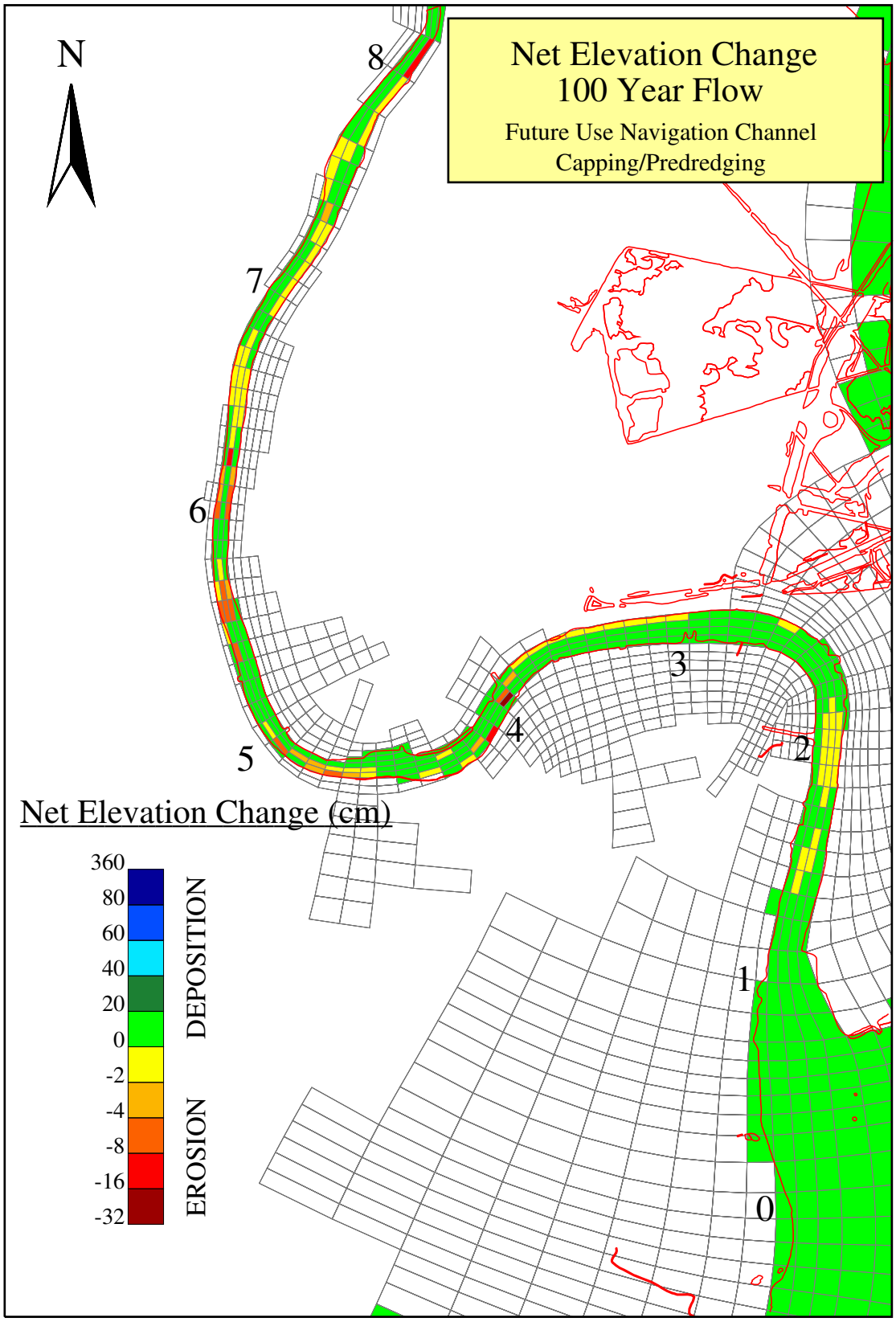

Figure D-7a. Plan view of the net elevation change under Future Navigation Usage-Full Predredging (Capping only) scenario.

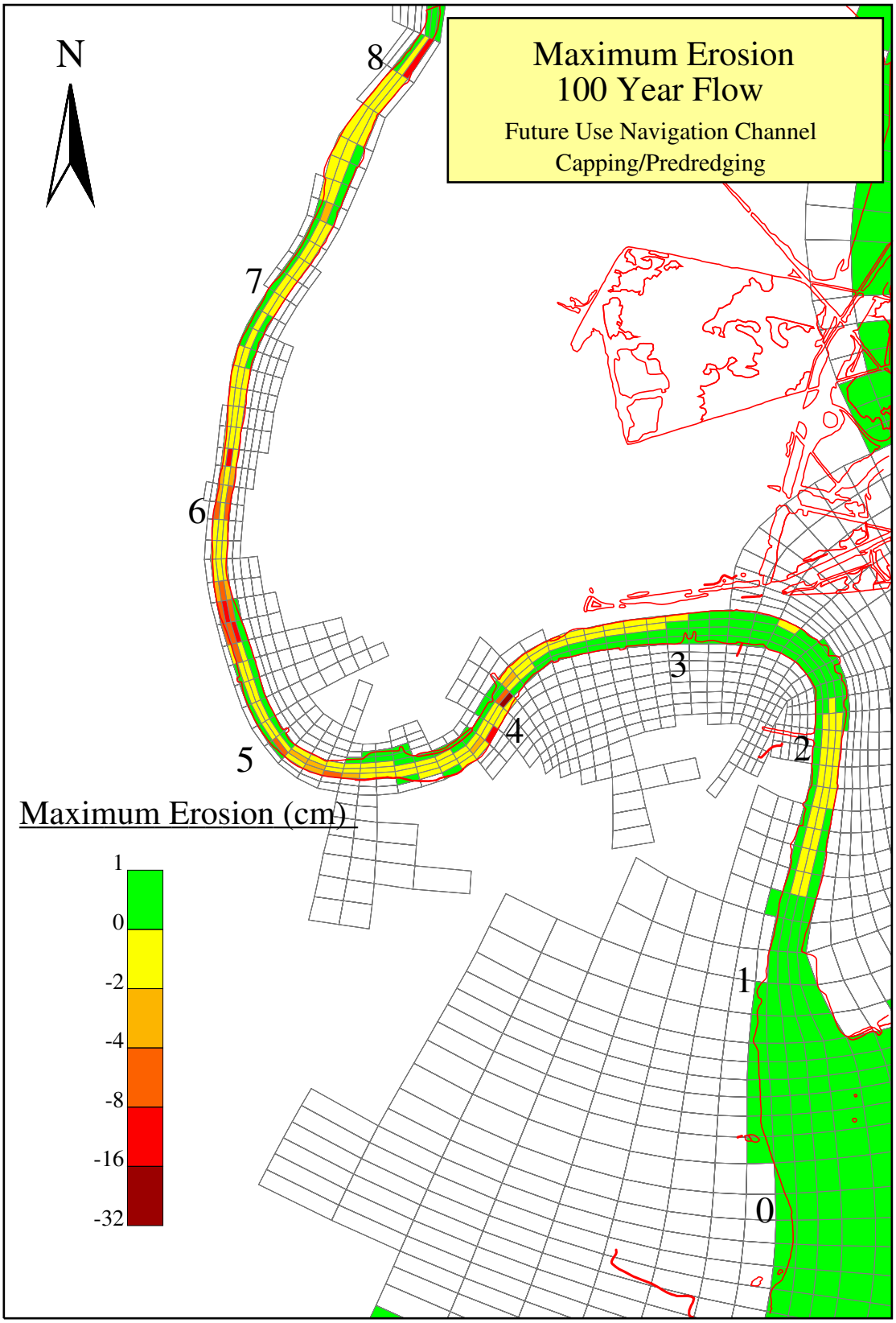

Figure D-7b. Plan view of the maximum erosion under Future Navigation Usage-Full Predredging (Capping only) scenario.

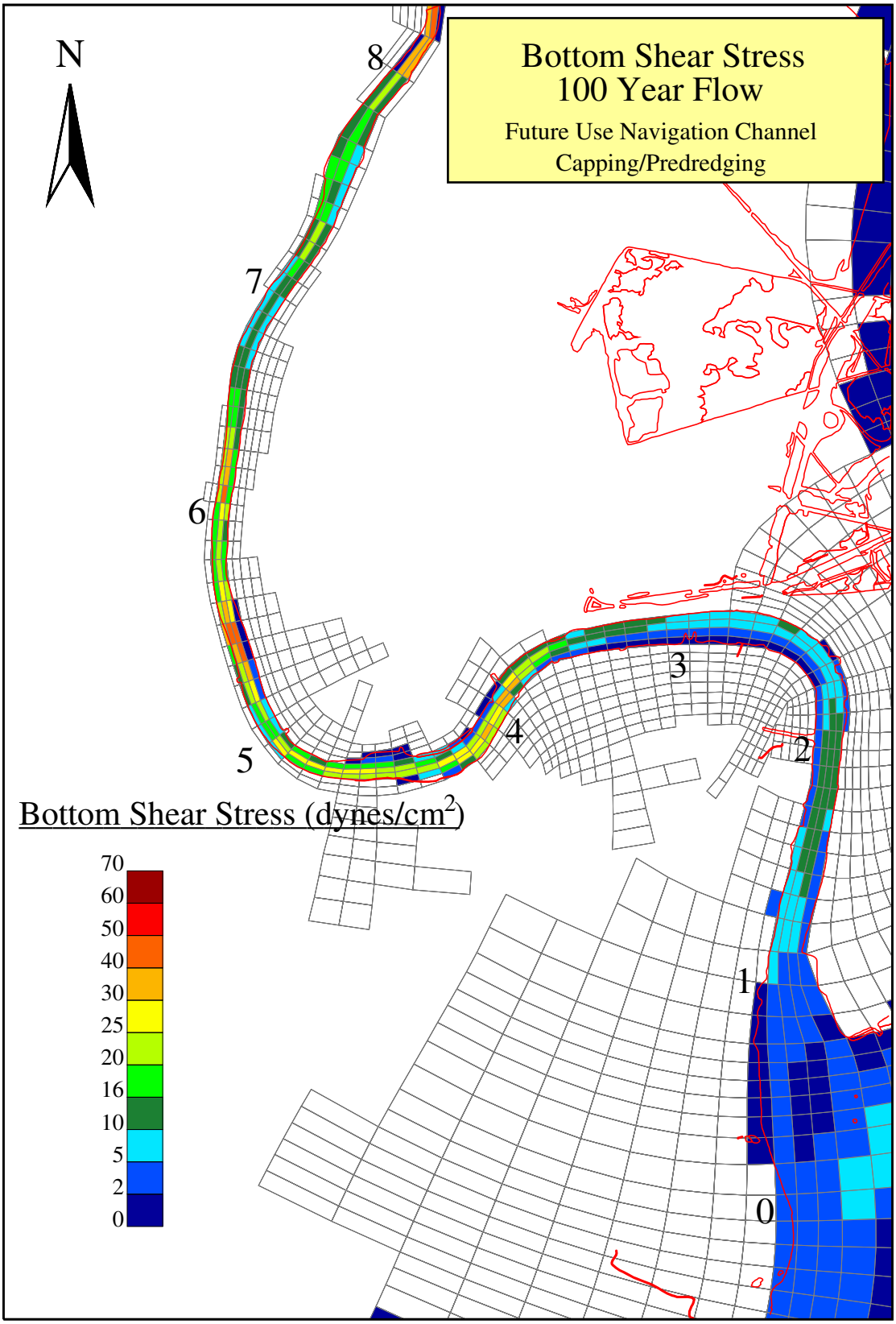

Figure D-7c. Plan view of the bottom shear stress under Future Navigation Usage-Full Predredging (Capping only) scenario

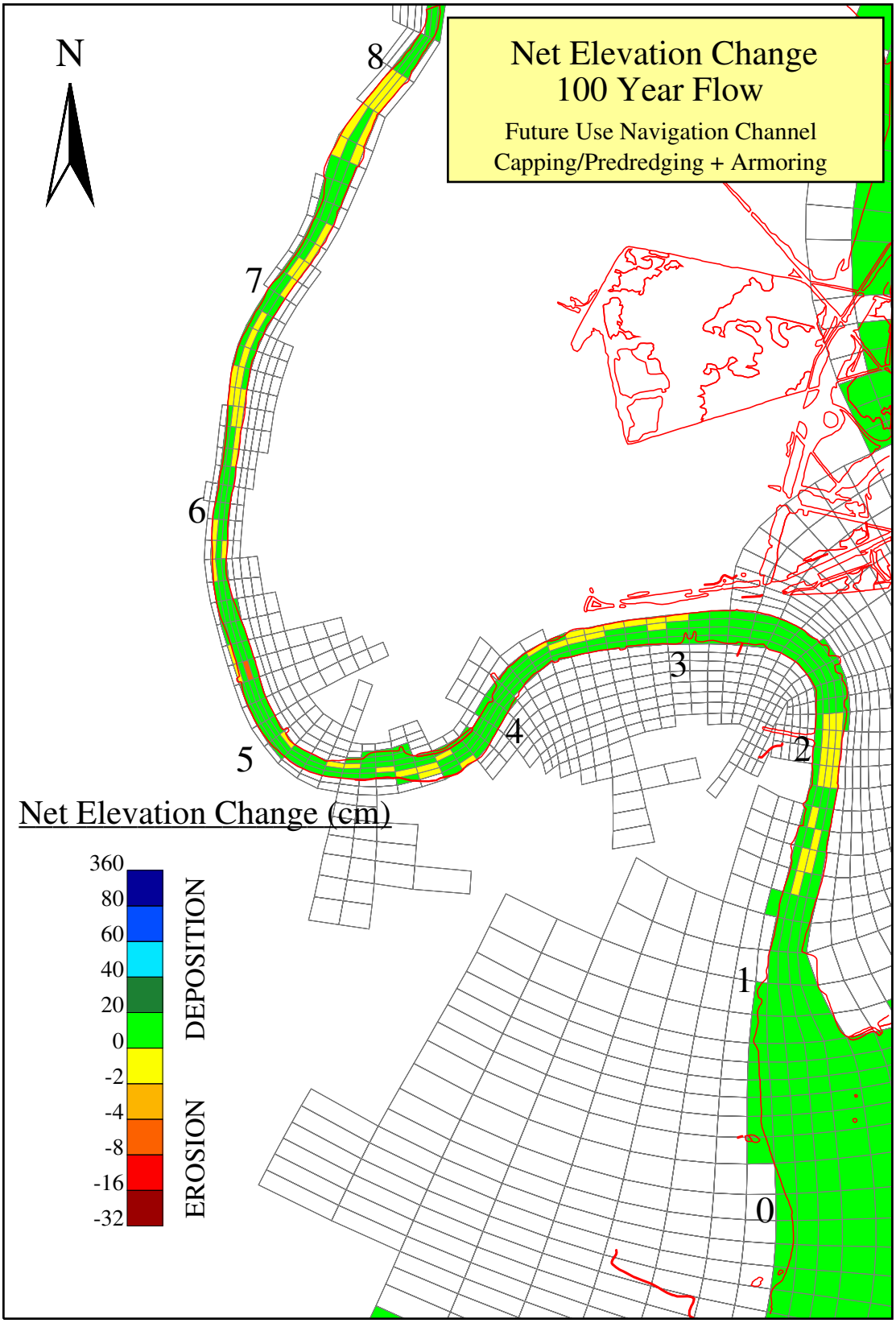

Figure D-8a. Plan view of the net elevation change under Future Navigation Usage-Full Predredging (Capping and Armoring) scenario.

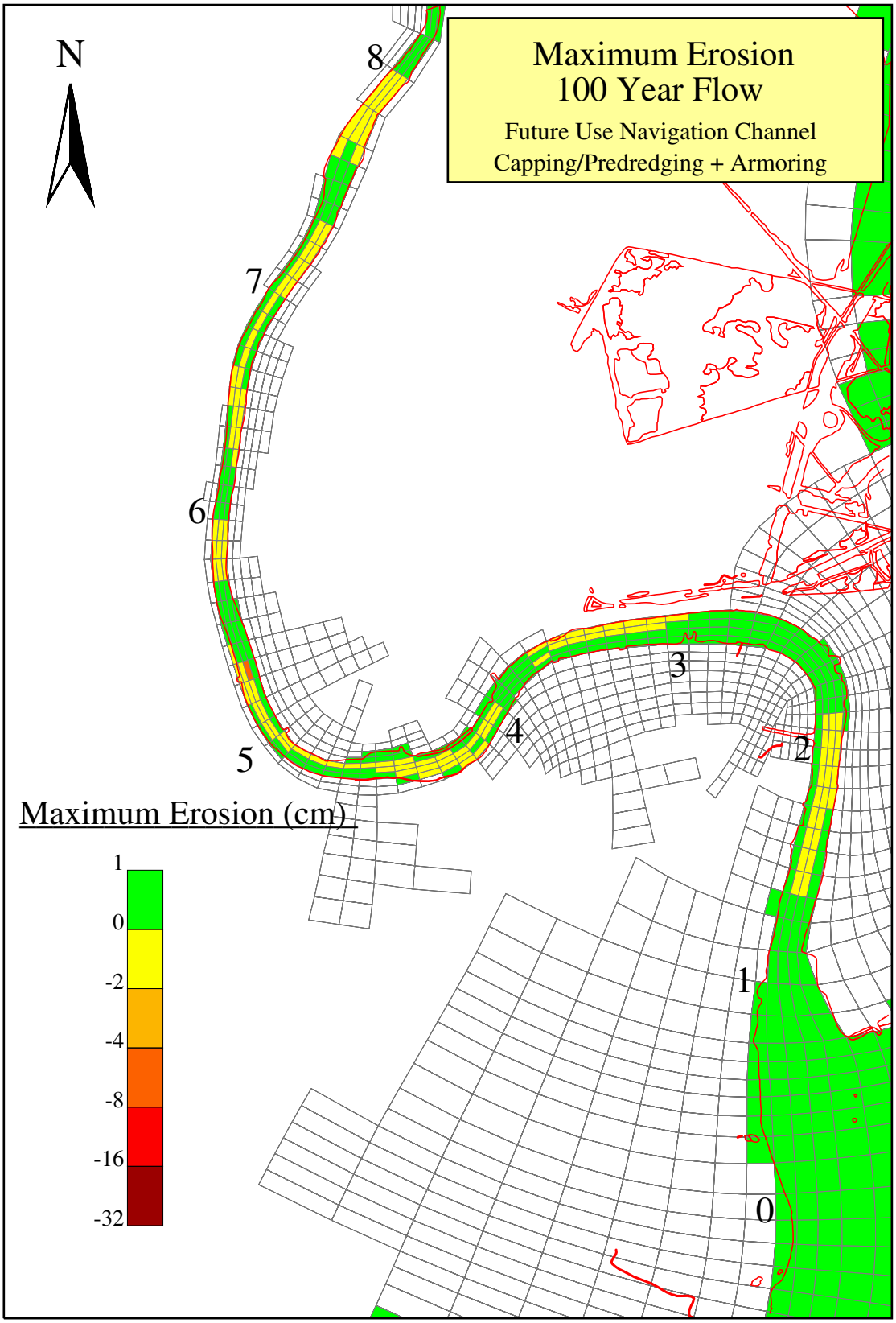

Figure D-8b. Plan view of the maximum erosion under Future Navigation Usage-Full Predredging (Capping and Armoring) scenario.

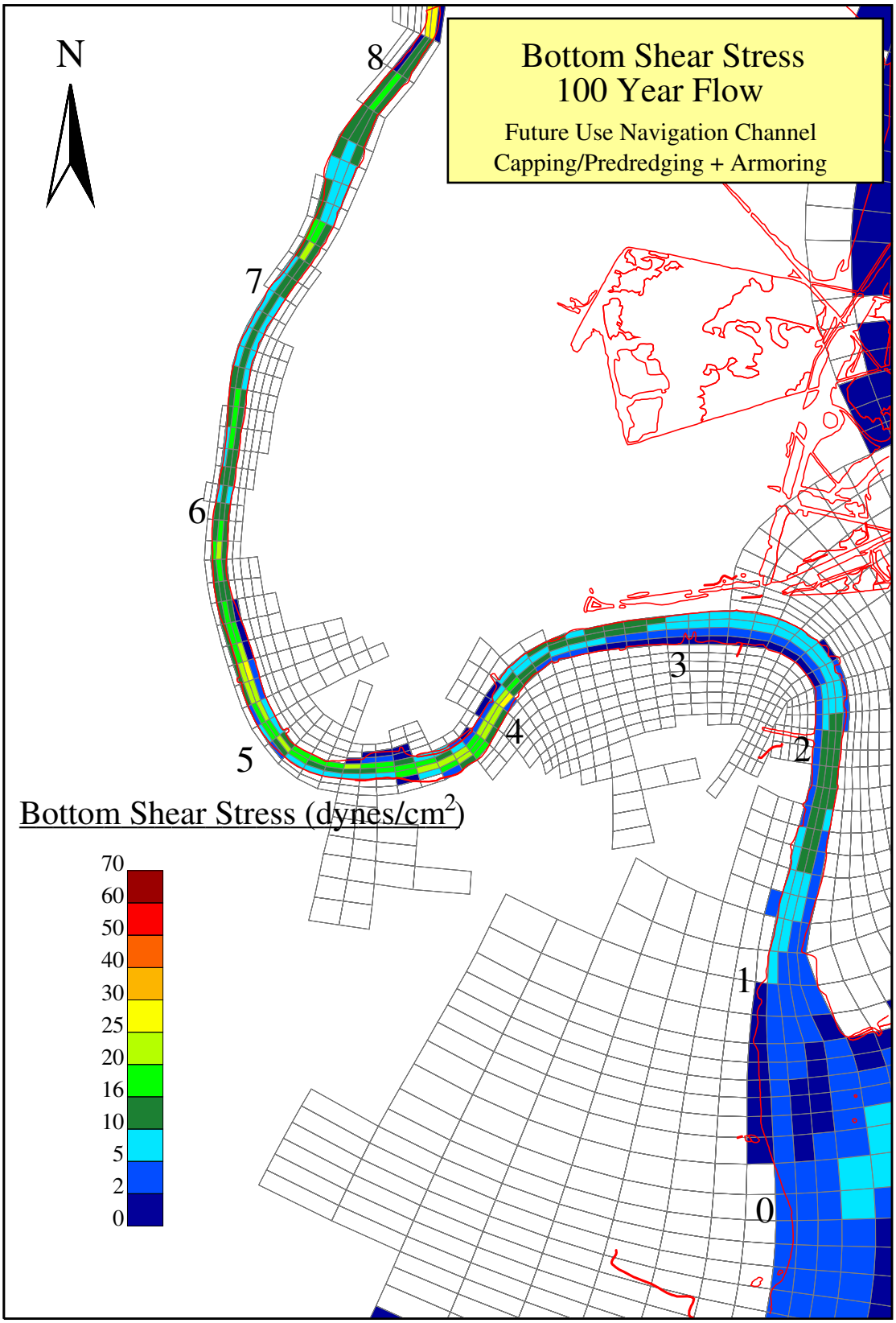

Figure D-8c. Plan view of the bottom shear stress under FutureNavigation Usage-Full Predredging (Capping and Armoring) scenario.

Appendix H

Dredged Material Management Assessments

Waste Characterization Assessment on Pages H-2 to H-5
Off-Site Disposal Facility on Pages H-6 to H-10
Upland Processing and Placement Facility Siting Study on Pages H-11 to H-13
Sediment Decontamination Full-scale Demonstration Treatability Studies on Page H-14
and Associated Decontamination Memos "BIOGENESIS Sediment Washing
Demonstration Project" on Pages H-15 to H-86 and "ENDESCO Clean
Harbors, L.L.C." on Pages H-87 to H-162

Draft Contractor Document: Subject to Continuing Agency Review

MALCOLM PIRNIE

Interoffice Correspondence

Date: April 6, 2007

To: L. Bossi (WHI)

Copy: S. Thompson (WHI), B. Fidler (NNJ)

From: A. Nolan (MOB)

Re: Waste Characterization Assessment

On-site Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) remedial actions must comply with (or waive) requirements of the Resource Conservation and Recovery Act (RCRA) that are determined to be applicable or relevant and appropriate requirements (ARARs). For RCRA Subtitle C hazardous waste requirements to be applicable, the CERCLA response action must constitute treatment, storage, transport, or disposal of a RCRA hazardous waste. The United States Environmental Protection Agency (USEPA) generally considers contaminated environmental media (such as sediments) to contain hazardous waste: when they exhibit a characteristic of hazardous waste, or when they are contaminated with concentrations of hazardous constituents from listed hazardous waste that are above health-based levels.

The USEPA has determined that the sediments from the Lower Passaic River do not contain a listed hazardous waste. Thus, the purpose of this memorandum is to present the methodology and results of an analysis to determine whether sediment from the Lower Passaic River could be classified as a characteristic waste due to toxicity as defined through the Toxicity Characteristic Leaching Procedure (TCLP).

METHODOLOGY

For purposes of RCRA regulations, a solid waste exhibits the characteristic of toxicity if the extract (Method 1311) from a representative waste sample contains any of the contaminants listed in the 40 CFR 261.24 (Table 1) at concentrations equal to or greater than the reported value. Section 1.2 of the TCLP procedure (Method 1311) allows for a

total constituent analysis in lieu of the TCLP extraction. The results of the total constituent analysis may be divided by 20 to convert the total results into the maximum leachable concentration. This factor is derived from the 20:1 liquid-to-solid ratio employed in the TCL method. If the maximum theoretical leachate concentrations are less than the applicable limits under 40 CFR 261.24, then the waste does not exhibit the toxicity characteristic (TC) and the TCLP analysis does not need to be performed. Alternatively, if the total waste analysis data yield a maximum theoretical leachate concentration that equals or exceeds the TC threshold, the data cannot be used to demonstrate conclusively that the waste does not exceed the TC.

The data used for this analysis include samples from the historical sediment cores collected in 1991, 1993, and 1995. Only the data for contaminants listed in 40 CFR 261.24 were used for this comparison. The sample data were compared to the associated threshold TCLP concentrations listed in 40 CFR 261.24 to determine if the individual samples exhibit RCRA TC. The following procedure was used to calculate the percentage of samples that exceed the TCLP concentrations (Table 1):

- The maximum concentration of each analyte was divided by 20 (herein expressed as "Max/20").
- The Max/20 result was compared to the TCLP threshold for each analyte.
- If the Max/20 did not exceed the TCLP threshold, then none of the sediment samples exceed the TCLP threshold for that analyte.
- If the Max/20 exceeded the TCLP threshold, then all concentrations for that analyte were divided by 20 (herein expressed as "Concentration/20").
- The number of times the Concentration/20 exceeded the TCLP was calculated for each analyte.
- The exceedance count was divided by the total sample count to determine the "Exceedance Percentage" for each analyte.

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Table 1: Toxicity Characterization Analysis Results

Contaminant	TCLP Threshold (mg/L)	Max/20 (mg/kg)	Sample Count	Exceedance Count	Exceedance Percentage
1,1-Dichloroethylene	0.7	0.0014	648	0	0
1,2-Dichloroethane	0.5	0	648	0	0
1,4-Dichlorobenzene	7.5	10500	748	19	2.5
2,4,5-TP (Silvex)	1	0.0308	569	0	0
2,4,5-Trichlorophenol	400	41.5	739	0	0
2,4,6-Trichlorophenol	2	17	739	1	0.14
2,4-D	10	32.3	567	1	0.18
2,4-Dinitrotoluene	0.13	0.5	737	1	0.14
4-Methylphenol (p-Cresol)	200	0.315	739	0	0
Arsenic	5	235	755	11	1.5
Barium	100	66.5	740	0	0
Benzene	0.5	0.165	648	0	0
BHC, gamma (Lindane)	0.4	0.00184	713	0	0
Cadmium	1	2.27	768	97	13
Carbon tetrachloride	0.5	0	648	0	0
Chlordane	0.03	0.03955	698	1	0.14
Chlorobenzene	100	14.5	648	0	0
Chloroform	6	0	648	0	0
Chromium	5	108	768	558	73
Endrin	0.02	0.083	713	2	0.28
Heptachlor (and its epoxide)	0.008	0.00022	715	0	0
Hexachlorobenzene	0.13	29	756	5	0.66
Hexachlorobutadiene	0.5	0.0335	747	0	0
Hexachloroethane	3	0.0345	736	0	0
Lead	5	1100	715	590	83
Mercury	0.2	1.48	760	401	53
Methoxychlor	10	0.0273	677	0	0
Methyl ethyl ketone	200	0.15	637	0	0
Nitrobenzene	2	0	736	0	0
o-Cresol	200	0	738	0	0
Selenium	1	4.13	680	1	0.15
Silver	5	1.335	722	0	0
Tetrachloroethylene	0.7	0.012	648	0	0
Toxaphene	0.5	0.055	694	0	0
Trichloroethylene	0.5	0.00255	648	0	0
Vinyl chloride	0.2	0.00245	648	0	0
Cresol	200	0	0	0	0
m-Cresol	200	0	0	0	0
Pentachlorophenol	100	0.65	736	0	0
Pyridine	5	0		0	0

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RESULTS

Samples for 13 contaminants could theoretically be determined to exceed the RCRA TC thresholds. Table 2 presents the percentage of samples containing each analyte at concentrations that could potentially exceed the RCRA TC threshold.

Table 2: Percentage of Samples that Could Exceed TC Thresholds for Various Analytes

Contaminants	Exceedance Percentage
1,4-Dichlorobenzene	2.5
2,4,6-Trichlorophenol	0.14
2,4-D	0.18
2,4-Dinitrotoluene	0.14
Arsenic	1.5
Cadmium	13
Chlordane	0.14
Chromium	73
Endrin	0.28
Hexachlorobenzene	0.66
Lead	83
Mercury	53
Selenium	0.15

CONCLUSIONS

In conclusion, there is a reasonable probability that some sediment from the Lower Passaic River could exceed TC criteria if the TCLP test were performed. In particular, the analytes most likely to exceed the TC thresholds are chromium, lead, and mercury, given their high frequency of exceedance of the Max/20 limit.

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MALCOLM PIRNIE

Interoffice Correspondence

Date: March 29, 2007

To: L. Bossi (WHI)

Copy: S. Thompson (WHI), B. Fidler (WHI)

From: J. Perry (NNJ)

Re: Off-Site Disposal Facilities

Remedial alternatives involving dredging of the Lower Passaic River may result in several waste streams requiring off-site disposal. This memorandum presents the results of a preliminary survey of existing off-site disposal facilities that could potentially accept dredged debris and sediment from the Lower Passaic River. The survey focused on local disposal facilities (*i.e.*, facilities located in New Jersey, New York, and Connecticut); however, the survey boundaries were extended for hazardous wastes when local disposal options are limited. This preliminary survey does not represent the full range of options that may be available for disposal of these waste streams (*e.g.*, beneficial uses such as construction fill, or landfill daily cover, *etc*.). The purpose here is only to list readily available off-site disposal options, such as landfills and incinerators. Table 1 below summarizes the types of dredged material waste streams that could be generated and the corresponding types of facilities that could potentially accept these wastes.

Table 1: Dredged Material Waste Streams and Potentially Applicable Disposable Facilities

Type of Waste	Disposal Facility
Hazardous waste[a] sediment with concentrations above land ban[b] regulation levels	Hazardous waste incinerator
Hazardous waste sediment with concentrations below land ban regulation levels	Subtitle C (hazardous waste)[c] landfill, hazardous waste incinerator
Contaminated non-hazardous waste sediment	Subtitle D (municipal solid waste)[d] landfill, municipal solid waste incinerator
Contaminated debris (hazardous)	Subtitle C landfill
Decontaminated or non-contaminated debris (non-hazardous)	Subtitle D landfill, recycling facility, construction and demolition landfill, municipal solid waste incinerator

a: "Hazardous waste" defined in 40 CFR 261.
b: Land ban regulations are provided in 40 CFR 268 RCRA.
c: Subtitle C landfills regulations are provided in 40 CFR 264 RCRA.
d: Subtitle D landfill regulations are provided in 40 CFR 258.

Table 2 and Table 3 (attached) list the locations of United States Subtitle C hazardous waste incinerators and landfills, respectively. These data are based upon reports generated by *Environmental Heath and Safety Online* (http://www.ehso.com). Table 4 (attached) lists locations of municipal solid waste incinerators in New Jersey and New York. Only facilities with current permits are listed. In addition to these facilities, a total of 143 solid waste landfill sites in Connecticut (24 landfills), New Jersey (46 landfills), and New York (73 landfills) were identified. These landfills varied among construction and demolition landfills, industrial landfills, municipal solid waste landfills, commercial sanitary landfills, and private sanitary landfills. In New Jersey, 102 Class B recycling facilities were also identified.[1]

Transport of any dredged material to these facilities would require generation of a detailed waste profile and additional inquiries to each facility to confirm that the waste profile meets permit and capacity requirements.

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[1] "Class B recyclable material" means a source separated recyclable material which is subject to NJDEP approval prior to receipt, storage, processing or transfer at a recycling center in accordance with N.J.S.A. 13:1E-99.34b, and which includes, but is not limited to, the following:

(a) Source separated, non-putrescible, waste concrete, asphalt, brick, block, asphalt-based roofing scrap and wood waste.
(b) Source separated, non-putrescible, waste materials other than metal, glass, paper, plastic containers, corrugated and other cardboard resulting from construction, remodeling, repair and demolition operations on houses, commercial buildings, pavements and other structures.
(c) Source separated whole trees, tree trunks, tree parts, tree stumps, brush and leaves provided that they are not composted.
(d) Source separated scrap tires.
(e) Source separated petroleum contaminated soil.

TABLE 2: HAZARDOUS WASTE INCINERATORS IN THE UNITED STATES

Facility	City and State	Toxic Substances Control Act (TSCA) Permit	Notes	Source of Notes
Aptus (now Clean Harbors)	West Aragon, UT	Information not provided.		
Chemical Waste Management (now Onyx)	Port Arthur, TX	Yes	Capacity of 400 tons/day	Veolia/Onyx website
Chemical Waste Management (now Onyx)	Sauget, IL	No		
Clean Harbors of Braintree, Inc.	Braintree, MA	Information not provided.	No longer in operation	Clean Harbors website
Clean Harbors Technology Corporation	Kimball, NE	Information not provided.		
Diversified Scientific Services, Inc. (DSSI) (now Perma-Fix)	Kingston, TN	No		
Environmental Services Company (ENSCO)	Dalton, GA	Information not provided.		
Environmental Services Company (ENSCO) (now Clean Harbors)	El Dorado, AR	Information not provided.		
ICI Explosives Environmental	Joplin, MO	No		
Laidlaw Environmental Services (now Clean Harbors)	Bridgeport, NJ	No		
Laidlaw Environmental Services (now Clean Harbors)	Clarence, NY	No		
Laidlaw Environmental Services (now Clean Harbors)	Coffeyville, KS	Yes	No longer in operation	Clean Harbors representative (March 2006)
Laidlaw Environmental Services (now Clean Harbors)	Deer Park, TX	Yes	Capacity of 250 tons/day	Clean Harbors representative (March 2006)
Laidlaw Environmental Services (now Clean Harbors)	Roebuck, SC	No	No longer in operation	
LWD, Inc.	Calvert, KY	No		
Reynolds Metal Company	Arkadelphia, AR	No		
Rhone-Poulenc Basic Chemical Company	Baton Rouge, LA	No		
Rhone-Poulenc Basic Chemical Company	Hammond, IN	No		
Rhone-Poulenc Basic Chemical Company	Houston, TX	Information not provided.		
Ross Environmental Services	Grafton, OH	Information not provided.		
Thermal Kem	Rock Hill, SC	Information not provided.	No longer in operation	http://www.scelp.org/cases.php?show=1
WRR Environmental Services Corporation.	Eau Claire, WI	No		

Source: Environmental Health and Safety Online (http://www.ehso.com/cssepa/tsdfincin.php; date of information is not noted)

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TABLE 3: HAZARDOUS WASTE LANDFILLS IN THE UNITED STATES

Facility	City and State	Toxic Substances Control Act (TSCA) Permit	Notes
Chemical Waste Management	Arlington, OR	Yes	
Chemical Waste Management	Carlyss, LA	No	No PCDD/F
Chemical Waste Management	Emelle, AL	Yes	
Chemical Waste Management	Fort Wayne, IN	Information not provided.	
Chemical Waste Management	Kettleman City, CA	Information not provided.	
Chemical Waste Management	Model City, NY	Yes	
EnviroSafe Services of Idaho	Grandview, ID	Yes	
EnviroSafe Services of Ohio	Oregon, OH	Information not provided.	
Laidlaw Environmental Services (now Clean Harbors)	Buttonwillow, CA	No	
Laidlaw Environmental Services (now Clean Harbors)	Deer Park, TX	Yes	
Laidlaw Environmental Services (now Clean Harbors)	Deer Trail, CO	Information not provided.	No PCDD/F >1 ppb
Laidlaw Environmental Services (now Clean Harbors)	Lake Point, UT	Information not provided.	
Laidlaw Environmental Services (now Clean Harbors)	Pinewood, SC	No	
Laidlaw Environmental Services (now Clean Harbors)	Waynoka, OK	Information not provided.	
Laidlaw Environmental Services (now Clean Harbors)	Westmorland, CA	Information not provided.	
MAX Environmental Technologies	Pittsburgh, PA	No	
Peoria Disposal	Peoria, IL	No	
Texas Ecologists	Robstown, TX	No	
United States Ecology	Beatty, NV	Yes	
Waste Control Specialists	Andrews, TX	Yes	Accepts PCDD/F waste
Wayne Disposal, Inc.	Belleville, MI	Yes	

Source: Environmental Health and Safety Online (http://www.ehso.com/cssepa/tsdflandfills.php; date of information is not noted)

PCDD/F = polychlorinated dibenzodioxins/furans
ppb = parts per billion

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TABLE 4: MUNICIPAL SOLID WASTE INCINERATORS IN NEW JERSEY AND NEW YORK

FACILITY/LOCATION	COUNTY	FACILITY ID	WASTE TYPE	CAPACITY	PERMIT ISSUED	PERMIT EXPIRES	SOURCE
Essex County RRF Newark, NJ	Essex	133546	10,23,27	985,500 TPY	8/16/2006	8/16/2011	http://www.nj.gov/dep/dshw/rrtp/njaincin.htm
Union County RRF Rahway, NJ	Union	1332721	10,25,27	562100 TPY	11/18/2004	2/21/2007	http://www.nj.gov/dep/dshw/rrtp/njaincin.htm
Babylon RRF, West Babylon, NY	Suffolk	N/A	Residential, Commerical	Not provided	5/31/2004	5/31/2009	http://www.dec.state.ny.us/website/dshm/sldwaste/facilities/wtelist.pdf
Islip MacArthur Waste-to-Energy Facility, Ronkonkoma, NY	Suffolk	N/A	Residential, Commerical, Treated RMW	Not provided	11/5/2004	11/4/2009	http://www.dec.state.ny.us/website/dshm/sldwaste/facilities/wtelist.pdf
Wheelabrator Hudson Falls, Hudson Falls, NY	Washington	N/A	Residential, Commerical, Waste Tires	Not provided	Not Provided	5/30/2010	http://www.dec.state.ny.us/website/dshm/sldwaste/facilities/wtelist.pdf
Onondaga County Resource Recovery Facility, Jamesville, NY	Onondaga	N/A	Residential, Commerical, Construction and Demolition Debris	Not provided	11/16/2001	11/16/2011	http://www.dec.state.ny.us/website/dshm/sldwaste/facilities/wtelist.pdf
Oswego County Energy Recovery Facility, Fulton, NY	Oswego	N/A	Residential, Commerical	Not provided	7/28/2004	7/28/2014	http://www.dec.state.ny.us/website/dshm/sldwaste/facilities/wtelist.pdf
Covanta Niagara, L.P., Niagara Falls, NY	Niagara	N/A	Residential, Commerical, Construction and Demolition Debris, Industrial	Not provided	4/1/2005	3/31/2015	http://www.dec.state.ny.us/website/dshm/sldwaste/facilities/wtelist.pdf

Notes:
NJ Waste ID 10 = Municipal waste
NJ Waste ID 23 = Vegetative waste
NJ Waste ID 25 = Animal and food processing waste
NJ Waste ID 27 = Dry industrial waste

RMW = regulated medical waste
RRF = resource recovery facility
TPY = tons per year

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MALCOLM PIRNIE

Interoffice Correspondence

Date: March 29, 2007

To: L. Bossi (WHI)

Copy: S. Thompson (WHI), B. Fidler (NNJ)

From: D. Lewitt (WHI)

Re: Upland Processing and Placement Facility Siting Study

A screening survey was conducted by New Jersey Department of Environmental Protection (NJDEP) to determine whether any sites exist that could be candidates for the development of either a processing facility or placement site to handle dredged material from the Lower Passaic River. The extent of the survey covered a 15 mile radius around the Harrison Reach [approximately river mile (RM) 2.5 to RM4.6] of the Lower Passaic River under the assumption that dredging activities would be centralized around this location. The survey area includes heavily industrialized inland and waterfront areas around Newark Bay, Lower Passaic River, Hackensack River, Arthur Kill, and Kill Van Kull.

Factors influencing identification of potential candidates included site accessibility and land use. Waterborne, rail, and road access were evaluated for each candidate site, including presence of piers/bulkheads, water depths, paved roads, proximity to major highways, and distance to rail lines or spurs. Land use considerations included the existence of vacant lots, open space, and degree of development. Other considerations included confirmation of loading/docking facilities, nearby bridge heights, and location of residential areas.

A total of 87 locations that could be potential placement or processing sites were identified within the extent of the survey. Table 1 summarizes the site characteristics by acreage of visible available land. Table 2 summarizes the site characteristics by distance in river miles from the Diamond Alkali Superfund Site (Operable Unit 1), which is

located at RM3.1. In addition, both tables summarize available modes of transportation and site access.

Table 1: Summary of Potential Placement/Processing Sites by Acreage

Sites		Access [a]		
Area (Land acres)	Total Number of Sites	Sites with Waterfront Access	Sites with Rail Access	Sites with Road Access
<10	18	13	3	16
10 – 20	17	11	6	17
20 – 30	17	9	7	16
30 – 50	16	9	5	13
50 – 100	6	4	1	6
100 – 200	11	10	7	9
>200	2	2	1	2
TOTAL	**87**	**58**	**30**	**79**

a: Sites can be grouped into more than one category.

Table 2: Summary of Potential Placement/Processing Sites with Waterfront Access by Distance

Sites		Access [a]		
Distance (river mile)[b]	Total Number of Sites	Sites with Waterfront Access	Sites with Rail Access	Sites with Road Access
<2	14	14	2	13
2 – 5	15	15	2	15
5 – 10	11	11	4	10
>10	18	18	8	17
TOTAL	**58**	**58**	**16**	**55**

a: Sites can be grouped into more than one category.
b: Approximate distance measured from the Diamond Alkali Superfund Site (Operable Unit 1)

The majority of identified sites were under 30 acres in size and less than 10 river miles from the Diamond Alkali Site. However, 19 large (greater than 50 acres) sites were also identified. Of these large sites, 8 sites are within 10 miles of the Harrison Reach. Sixty-seven percent of the total sites had waterfront access to allow for barges or scows, although bulkheading and/or dredging activities would likely be required at many locations. Rail and road access were identified at 34 and 91 percent of the sites, respectively. A total of 58 sites have waterfront access. Of these waterfront access sites, 16 have rail access and 55 have road access as well.

In conclusion, several candidate sites exists that could be considered suitable sites for processing or placement sites based on adequate size and being within an acceptable distance of the Lower Passaic River. These results are being used to confirm in general

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the feasibility of the dredging alternatives. However, since this screening survey did not extend to identification of land ownership or confirmation of future development plans, its results are not useable for actual siting of processing or placement sites. Actual siting will need to be conducted during the future design phase.

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION II

DATE: April 11, 2007

SUBJECT: Sediment Decontamination Full-scale Demonstration Treatability Studies – lower Passaic River, NJ
Technical Memoranda:
BioGenesis Enterprises / Gas Technology Institute – Endesco Clean Harbors

FROM: Eric A. Stern – DEPP/DMMT
Regional Contaminated Sediment Program Manager
NY/NJ Harbor Sediment Decontamination Program

TO: Alice Yeh - ERRD
Remedial Project Manager
Passaic River Restoration Study

Please find attached Technical Memoranda prepared by BioGenesis Enterprises, Inc and Gas Technology Institute / Endesco Clean Harbors (ECH). Both BioGenesis and GTI / ECH participated in the lower Passaic River Restoration Sediment Decontamination Treatability Study. These memoranda have been developed for consideration / inclusion as part of the Passaic River Focused Feasibility Study. These memoranda should be considered as a first preliminary interpretation of results from the 2006-2007 testing efforts. Data is still undergoing QA/QC validation. Furthermore, GTI will be conducting another demonstration test in May 2007. BioGenesis, GTI, EPA, NJDOT Office of Maritime Resources, and Brookhaven National Laboratory will be meeting shortly to start the interpretive evaluation process.

If you have any questions regarding these studies, please contact me at 212.637.3806 / stern.eric@epa.gov .

CC: Douglas Pabst - EPA
Keith Jones – BNL
Scott Douglas – NJDOT
Michael Mensinger – GTI
John Sontag - BioGenesis

D R A F T
Rev 2

TECHNICAL MEMORANDUM on the BIOGENESIS^{SM} SEDIMENT WASHING DEMONSTRATION PROJECT in support of THE LOWER PASSAIC RIVER RESTORATION PROJECT

Prepared by: BioGenesis Enterprises, Inc.
June 1, 2007

Introduction

During 2005/2006 BioGenesis Washing BGW, LLC conducted a full-scale demonstration project of the BioGenesis^{SM} Sediment Washing Technology in the New York/New Jersey Harbor. The main purposes of the demonstration project were to confirm the ability of the BioGenesis^{SM} process to treat contaminated sediments to levels acceptable for beneficial use and to develop commercial scale operational and cost data. Currently, BioGenesis is in the process of evaluating the data collected during the demonstration project and preparing the final report.

The demonstration project is being conducted under contract to the New Jersey Department of Transportation, Office of Maritime Resources (NJDOT/OMR) under the State of New Jersey's Sediment Decontamination Technology Demonstration Program in coordination with the U.S. Environmental Protection Agency (EPA) under the Water Resources Development Act (WRDA).

The USEPA and NJDOT have partnered along with the U.S. Army Corps of Engineers New York District and the New Jersey Department of Environmental Protection (NJDEP) to perform a joint study to cleanup and restore the Lower Passaic River. As part of that work, a Focused Feasibility Study is being prepared to evaluate interim remedial options for the Lower Passaic River. This Technical Memorandum discusses a small portion of the overall aspects of the demonstration project and has been prepared to provide interim information to the federal/state Lower Passaic River Restoration group for the preparation of the Focused Feasibility Study Report while the final report is being completed. This Technical Memorandum should be considered DRAFT and will be replaced by the Final Report when it is completed.

BioGenesis^{SM} Sediment Washing Technology

The BioGenesis^{SM} Sediment Decontamination Technology is a patented low temperature decontamination process for fine-grained sediment, which uses impact forces and propriety chemicals to remove organic and inorganic contamination. The resulting decontaminated sediment can be used to produce high-end topsoil or other construction grade products.

The BioGenesis^{SM} Sediment Washing Technology consists of seven main processing steps including:

- Material preparation – offloading, screening, storage, and addition of proprietary washing chemicals
- Pre-Processing – disaggregation of the sediment particles from each other and from the loosely-associated naturally occurring organic material (called biomass)
- Application of Collision Impact forces – stripping the biofilm layer and adsorbed contaminants from the solid sediment particles
- Cavitation/Oxidation – destruction of organic contaminants using enhanced oxidation
- Solid/Liquid Separation – recovery of the cleaned sediment particles
- Wastewater Treatment – pre-treatment of the resulting wastewater and discharge to the local publicly owned treatment works
- Soil Manufacturing – blending of the decontaminated sediment with other raw materials to produce a high-end topsoil

Demonstration Project

BioGenesis constructed the temporary full-scale demonstration plant at a facility in Keasbey, New Jersey, in Woodbridge Township, adjacent to the Raritan River. Waterfront facilities were constructed for offloading and material storage. During the demonstration project, dredged material was decontaminated from three sources in the New York/New Jersey Harbor:

Raritan River – approx. 3,540 cyds
Arthur Kill – approx. 8,500 cyds
Lower Passaic River – approx. 2,620 cyds

Dredged material from the Lower Passaic River was offloaded from two delivery scows, screened to remove oversized materials and pumped to a storage vessel for temporary storage. The raw sediment was then pumped from the storage vessel to the preprocessor mix tank in the treatment facility where proprietary specialty chemicals including surfactants, chelating agents, and defoamers were added to prepare the sediment for decontamination by decreasing the affinity among contaminants, sediment solids, and naturally occurring biomass. The sediment was then pumped to the BioGenesis^{SM} preprocessor unit where physical action from high-pressure water jets disaggregated the sediment particles from each other and separated the loosely associated material from the biomass-coated particles. The result was that clumped particles were disaggregated and suspended in the aqueous phase and the biomass is fractionated and transferred to the aqueous phase.

Next, collision impact forces were applied to the isolated particles in the BioGenesis^{SM} collision chamber to strip the biofilm layer and adsorbed contaminants from the solid sediment particles and transfer them into the aqueous phase.

Following the physical separation of the contaminants from the sediment particles, the organic contaminants and naturally occurring organic biomass that have been segregated from the sediment particles were destroyed using cavitation and oxidation. Hydrogen peroxide, a strong oxidizing agent, was added to the sediment slurry upstream of the BioGenesis^{SM} cavitation system. Cavitation occurs when air bubbles created in the slurry implode. The implosion causes instantaneous high pressure and temperature, which in the presence of a strong oxidizing agent, causes organic molecules to break down into carbon dioxide and water. At the conclusion of the BioGenesis^{SM} cavitation system, the slurry consists of inorganic sediment particles that have been washed of contaminants, suspended organic biomass containing residual organic and inorganic contaminants, and water that contains the majority of contaminants (mainly inorganic) that have been desorbed from the sediment particles and biomass.

Following the above decontamination steps, the slurry was immediately processed through solid/liquid separation units to segregate the decontaminated solids fraction from the liquid fraction containing the inorganic contaminants and the residual organic contaminants. The solid/liquid separation system included fine mesh scalping screens, hydrocyclones, and a centrifuge. The cleaned sediment solids separated from the aqueous phase were then sampled and stockpiled. The aqueous phase containing the inorganic and organic contaminants was processed through a wastewater treatment system and discharged to the local sewer system.

The stockpiled decontaminated sediment was processed with other raw materials (washed sand and mulch) in the initial step to produce a manufactured topsoil. The resulting material was screened using a trommel screen to ensure a consistent blend was achieved, and the material was stockpiled and sampled. Initial sample results indicated that the material was not a manufactured topsoil because it needed additional coarse material added to it to provide the required structural characteristics of topsoil. This work is planned for the summer of 2007.

Treatment Results

Throughout the demonstration project BioGenesis performed several test runs on the sediment from the Lower Passaic River in preparation for the final run, which was conducted during the 1st week of May 2006. During the initial test runs significant problems were encountered with the sediment plugging in the piping and processing equipment. This was due to an unusually high amount of trash and debris in the Passaic River sediment that was dredged and delivered for the demonstration project. The debris included household trash such as plastic bags, straws, and food wrappers as well as organic debris such as twigs and leaves. This amount of debris would cause blockages in the piping and process equipment and did not allow for consistent uninterrupted operations.

In order to remove this debris a secondary screening step was installed which removed the debris greater than 0.03 inches (#20 mesh size). This secondary screening step drastically improved the ability to operate continuously. Once the secondary screen was installed, several additional test runs were conducted at varying operating conditions to determine the most effective operating scenario. This culminated in the test run conducted on May 2, 3 and 4, 2006. Presented in Tables 1 and 2 attached are the results of samples collected during this confirmatory test run. The sample locations are described on the tables.

The concentrations of metals in the untreated sediment (PSS sample) were below the residential soil criteria for all constituents except lead. Through the washing process, the metal concentrations were reduced (TS sample) and they were further reduced during initial soil manufacturing (MSL sample). Lead concentrations were below the residential soil criteria following sediment washing.

The treatment of chlorinated organics (pesticides, polychlorinated biphenyls (PCBs), and dioxins/furans) was very successful. Pesticide concentrations in the untreated sediment (PSS sample) were low (at or below the residential soil criteria) and these concentrations were reduced following washing (TS sample) and further reduced following initial soil manufacturing (MSL sample). Starting PCB concentrations (PSS sample) were above the residential criteria and were reduced below the criteria during washing (TS sample) and further reduced during the initial soil manufacturing (MSL sample). Dioxin/furan concentrations were reduced by approximately 85% during washing (PSS compared to TS samples) and were further reduced during initial soil manufacturing (MSL sample) for an overall reduction of approximately 94%.

While the overall processing (including initial soil manufacturing) was able to reduce the average concentrations for the polyaromatic hydrocarbons (PAHs) to levels below the residential soil criteria (MSL samples), the PAHs in the Lower Passaic River sediment presented some challenges. In order to determine the distribution of the PAHs in the untreated sediment as well as in the treated sediment, samples were collected at interim steps throughout the processing. The results of the samples (included in the attached tables) indicate that the PAHs are bound (if not integral to) the organic debris (twigs, leaves) dispersed within the sediment matrix. This is evident in the elevated concentrations of PAHs in the material removed from the decks of the secondary screen (with #20 mesh size). In addition, the concentration of the PAHs in the fractions of the treated sediment (TS1, TS2, and TS3 samples) indicates that the PAHs are most prominent in the coarser material which is counterintuitive to the distribution of contaminants on sediment particles. For higher levels of PAHs the untreated sediment would be screened finer to separate more organic debris from the sediment particles prior to processing.

BioGenesis is working with the NJDEP to complete the soil manufacturing phase of the demonstration project. We have enlisted the help of the NJDOT, USEPA, BNL, and a regional university to perform the final manufacturing step to produce a manufactured topsoil which can be used as landscape soil at the university campus for the purpose of long-term monitoring of the manufactured soil. Once the material meets the physical characteristics of a topsoil, it will be sampled to ensure that the topsoil meets the requirements of NJ Residential Direct Contact Cleanup Criteria.

BioGenesis believes that re-arrangement of key system components, as well as further processing steps within the manufactured soil blending process would result in acceptable PAH concentrations to meet RDCSCC. This evaluation is critical especially as it relates to the economic viability of this process.

Projected Full-scale Costs

One of the goals of the demonstration project was to refine the projected capital and operating costs for a commercial-scale facility to be built in the New York/New Jersey Harbor region. These costs will be presented in the final report.

For the purposes of the Lower Passaic River Focused Feasibility Study, treatment costs were estimated for several scenarios depending on the quantity of sediment to be dredged and delivered to a BioGenesis^{SM} Sediment Washing Facility. Based on discussions with the Lower Passaic River Restoration team, it was assumed that a dedicated facility would be required for the Lower Passaic River Restoration project, and that a site with offloading and storage facilities would be provided.

Three costing scenarios were considered:

- 50,000 cyd project (to be dredged over the duration of the restoration project)
- 250,000 cyd/year facility to be operated for 1 to 10 years
- 500,000 cyd/year facility to be operated for 1 to 10 years

For the 50,000 cyd project, a temporary facility would be constructed consisting primarily of rental equipment. In order to eliminate rental costs for downtime during dredging, it was assumed that all the dredged material would be delivered at one time or that it would be stored (by others) until the end of the dredging activities so that it could be processed at once. Since the facility would be temporary and constructed with rental equipment, there would be no capital cost. The breakdown for a project like this is:

Estimated Time and Costs for a 50,000 cyd Project

Mobilization/Construction:	$1,450,000
Monthly Operations Cost (~12,000 cyds per month):	$1,496,000
Demobilization:	$ 546,000
50,000 cyd Project (4.2 months):	$ 8,229,300
	$ 164.59/cyd

The breakdown of the capital and operating costs for a permanent facility (250,000 or 500,000 cyds/year) are attached. The following is a summary of the unit costs for these facilities under different operating scenarios:

Total Quantity	Estimated Total Costs and Operating Time for a 250,000 cyd/yr plant		Estimated Total Costs and Operating Time for a 500,000 cyd/yr plant	
250,000 cyds	1 year	$116.13 /cyd	½ year	$151.25 /cyd
500,000 cyds	2 years	$86.59 /cyd	1 year	$101.89 /cyd
1,000,000 cyds	4 years	$71.82 /cyd	2 years	$77.22 /cyd
1,500,000 cyds	6 years	$66.89 /cyd	3 years	$68.99 /cyd
2,000,000 cyds	8 years	$64.43 /cyd	4 years	$64.88 /cyd
2,500,000 cyds	10 years	$62.95 /cyd	5 years	$62.41 /cyd

Estimated Capital and Operating Costs
Commercial-Scale BioGenesis^{SM} Sediment Washing Facility
Lower Passaic River Restoration Project

Capital Costs		***250,000 cyds/yr Facility***		***500,000 cyds/yr Facility***
Screening Facilities	$	214,000	$	214,000
PreProcessor	$	100,000	$	200,000
Water Blasters	$	576,000	$	1,146,000
Collision Chamber	$	540,000	$	1,080,000
Cav/Ox Facilities	$	298,800	$	504,800
Hydrocyclones	$	219,400	$	438,800
Centrifuge Facilities	$	1,250,000	$	2,500,000
Filter Presses	$	1,500,000	$	2,500,000
Wastewater Equalization	$	90,800	$	100,800
Floc/Clarification	$	120,000	$	225,000
Initial pH Adjustment	$	27,000	$	37,000
Filtration Facilities	$	260,000	$	510,000
Organics Removal	$	160,000	$	160,000
Final pH Adjustment	$	27,000	$	37,000
Sludge Processing	$	309,000	$	587,000
Chemical Feed Systems	$	304,960	$	586,360
Treated Sediment Storage	$	421,000	$	811,000
Plant Utility Water	$	16,000	$	16,000
Passive Vapor Phase Treatment	$	600	$	600
Plant Air Compressor	$	15,000	$	30,000
Tanks and Equipment Capital Cost	$	6,449,560	$	11,684,360
Equipment Installation (15%)	$	967,434	$	1,752,654
Mechanical (20%)	$	1,289,912	$	2,336,872
Electrical and Instrumentation (20%)	$	1,289,912	$	2,336,872
Installation Cost	$	3,547,258	$	6,426,398
Yard Piping	$	97,000	$	97,000
Processing Building	$	2,000,000	$	2,500,000
Site Preparation	$	750,000	$	750,000
Subtotal	$	12,843,818	$	21,457,758
Contingency (15%)	$	1,926,573	$	3,218,664
Total Capital Cost	***$***	***14,770,391***	***$***	***24,676,422***

Does not include site, dock, offloading, or upfront storage costs

Estimated Capital and Operating Costs
Commercial-Scale BioGenesis^{SM} Sediment Washing Facility
Lower Passaic River Restoration Project
(continued)

Annual Operations Cost	*250,000 cyds/yr Facility*	*500,000 cyds/yr Facility*
Personnel	$ 3,447,963	$ 5,337,393
Power	$ 1,670,400	$ 3,340,800
Water	$ 233,856	$ 467,712
Wastewater Disposal	$ 263,088	$ 526,176
Solids Disposal	$ 652,500	$ 1,305,000
Off-spec Solids	$ 2,610,000	$ 5,220,000
Solid Waste Disposal	$ 43,500	$ 87,000
Chemical Usage	$ 3,500,000	$ 7,000,000
Equipment Maintenance (20% Capital Cost)	$ 1,289,912.0	$ 2,336,872.0
Building Maintenance (20% Building Cost)	$ 400,000.0	$ 500,000.0
Site Maintenance (20% Site Improvement Co	$ 150,000.0	$ 150,000.0
Total Annual Operating Costs	***$ 14,261,219***	***$ 26,270,953***

BIOGENESIS SEDIMENT WASHING DEMONSTRATION PROJECT
SELECTED PHOTOGRAPHS

Photograph 1 Delivery of Sediment

Photograph 2 Offloading Operations

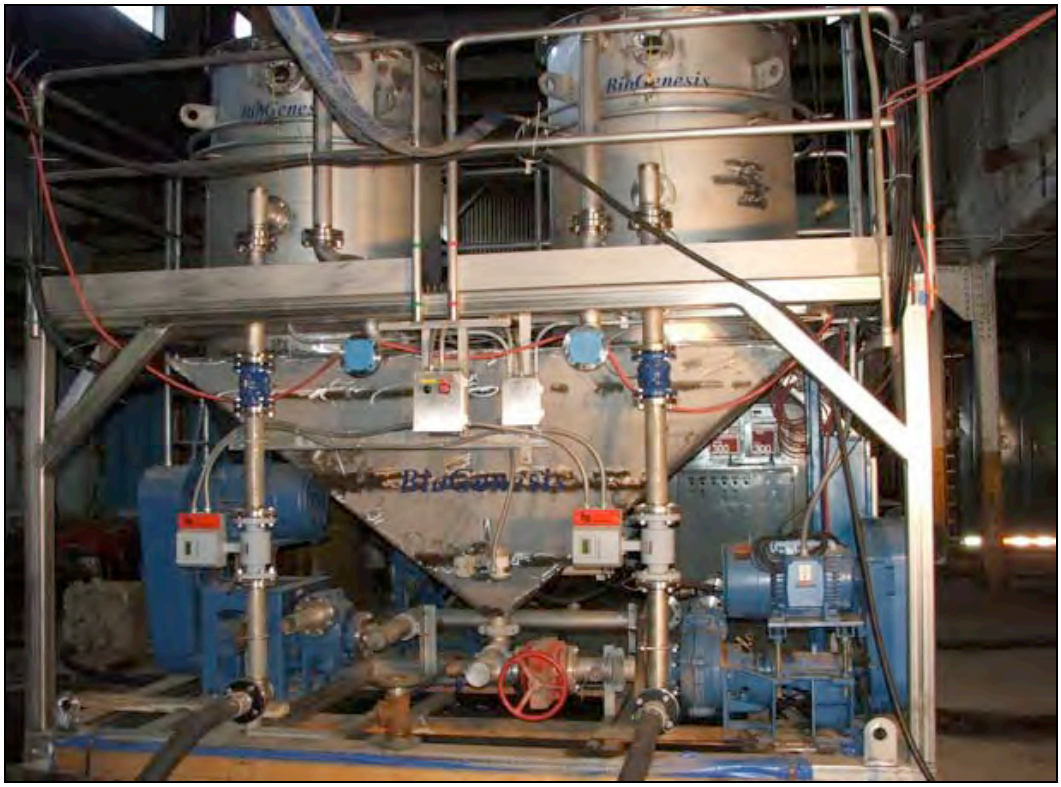
BIOGENESIS SEDIMENT WASHING DEMONSTRATION PROJECT
SELECTED PHOTOGRAPHS

Photograph 3 Sediment Screening (Primary Screen)

Photograph 4 Storage

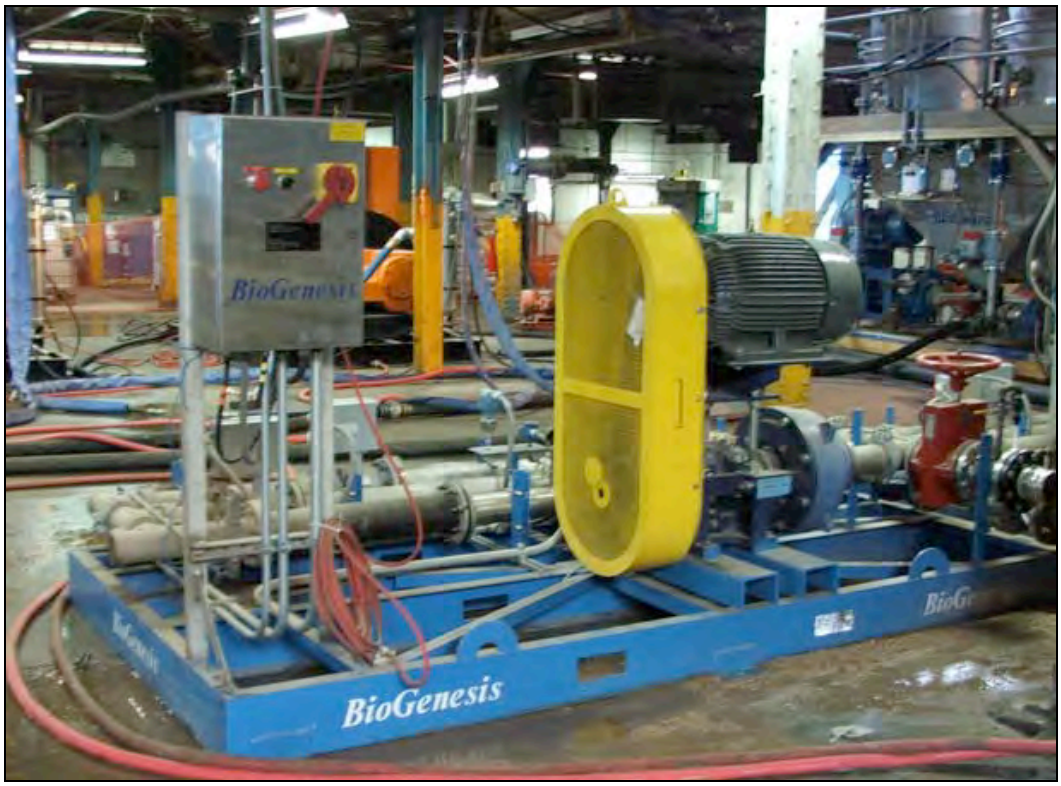
BIOGENESIS SEDIMENT WASHING DEMONSTRATION PROJECT
SELECTED PHOTOGRAPHS

Photograph 5 BioGenesis Sediment Washing – Preprocessor



Photograph 6 BioGenesis Sediment Washing – Collision Chamber

BIOGENESIS SEDIMENT WASHING DEMONSTRATION PROJECT
SELECTED PHOTOGRAPHS



Photograph 7 BioGenesis Sediment Washing – Cavitation/Oxidation

Photograph 8 BioGenesis Sediment Washing – High Pressure Waster Pump

BIOGENESIS SEDIMENT WASHING DEMONSTRATION PROJECT
SELECTED PHOTOGRAPHS

Photograph 9 BioGenesis Sediment Washing – Liquid/Solid Separation

Photograph 10 Wastewater Treatment – Clarifier

BIOGENESIS SEDIMENT WASHING DEMONSTRATION PROJECT
SELECTED PHOTOGRAPHS

Photograph 11 Wastewater Treatment – Pressure Filters

Photograph 12 Wastewater Treatment – Carbon Filters

BIOGENESIS SEDIMENT WASHING DEMONSTRATION PROJECT
SELECTED PHOTOGRAPHS

Photograph 13 Manufactured Soil

TABLE 1
LOWER PASSAIC RIVER DATA SUMMARY TABLE
BIOGENESIS SEDIMENT WASHING TECHNOLOGY DEMONSTRATION PROJECT

			Untreated Sediment Prior to Secondary Screen							
	Location Identification									
	Field Sample Identification		PSS-020506-1600	PSS-030506-1600	PSS-040506-1600	PSS-040506-1600B	*Average*	*Min*	-	*Max*
Analyte/Methods (Units)	Sample Date / Sample Time		5/2/06 1600	5/3/06 1600	5/4/06 1600	5/4/06 1600				
	New Jersey Standards									
General Soil Parameters	**RDCSCC**	**NRDCSCC**								
Percent Solids/EPA 160.3 M (%)	NE	NE	**21.5**	**26.6**	**33.5**	**44.8**	*31.6*	*21.5*	-	*44.8*
Grain Size Sand/D4464 (%)	NE	NE	**23.46**	**26.86**	**25.51**	--	*25.28*	*23.46*	-	*26.86*
Grain Size Silt/D4464 (%)	NE	NE	**57.34**	**54.43**	**55.8**	--	*55.86*	*54.43*	-	*57.34*
Grain Size Clay/D4464 (%)	NE	NE	**19.2**	**18.71**	**18.69**	--	*18.87*	*18.69*	-	*19.2*
Total Organic Carbon/Lloyd Kahn (mg/kg)	NE	NE	**57,600**	**55,400**	**48,400**	**58,700**	*55,025*	*48,400*	-	*58,700*
Total Petroleum Hydrocarbons/SW-846 9071	NE	NE	**3,940**	**3,700**	**4,310**	**8,400**	*5,088*	*3,700*	-	*8,400*
Metals/										
SW-846 6010B/7471A (mg/kg)	**RDCSCC**	**NRDCSCC**								
Arsenic	20	20	**14.9**	**10.9**	**10.6**	**11.1 B**	*11.9*	*10.6*	-	*14.9*
Barium	700	47,000	**244**	**179**	**177**	**449**	*262*	*177*	-	*449*
Cadmium	39	100	**8.2**	**7.4**	**6.7**	**7.17**	*7.4*	*6.7*	-	*8.2*
Chromium	120,000	NE	**251**	**195**	**178**	**218**	*211*	*178*	-	*251*
Lead	400	600	**505**	**412**	**354 E**	**362**	*408*	*354*	-	*505*
Nickel	250	2,400	**64.1**	**48.6**	**46.6**	**58.9**	*54.6*	*46.6*	-	*64.1*
Selenium	63	3,100	**4**	**1.7**	**0.86**	1.66 U	*2.1*	*0.86*	-	*4.0*
Silver	110	4,100	**8.4**	**7.4**	**6.3**	**7.33**	*7.4*	*6.3*	-	*8.4*
Zinc	1,500	1,500	**886 JE**	**677 E**	**620 JE**	**675**	*715*	*620*	-	*886*
Mercury	14	270	**4.5**	**4.3**	**4.6**	**4.24**	*4.4*	*4.24*	-	*4.6*

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			Untreated Sediment Prior to Secondary Screen						
	Location Identification								
	Field Sample Identification		PSS-020506-1600	PSS-030506-1600	PSS-040506-1600	PSS-040506-1600B	*Average*	*Min* -	*Max*
Analyte/Methods (Units)	**Sample Date Sample Time**		5/2/06 1600	5/3/06 1600	5/4/06 1600	5/4/06 1600			
Organochlorine Pesticides/									
SW-846 8081A (µg/kg)	**RDCSCC**	**NRDCSCC**							
4,4'-DDD	3,000	12,000	--	**350 J**	--	--	--	--	--
4,4'-DDE	2,000	9,000	--	**120 T**	--	--	--	--	--
4,4'-DDT	2,000	9,000	--	**170**	--	--	--	--	--
Aldrin	40	170	--	*20 U*	--	--	--	--	--
alpha-BHC	NE	NE	--	160 U	--	--	--	--	--
alpha-Chlordane	NE	NE	--	160 U	--	--	--	--	--
beta-BHC	NE	NE	--	160 U	--	--	--	--	--
Chlordane (technical)	NE	NE	--	1600 U	--	--	--	--	--
delta-BHC	NE	NE	--	160 U	--	--	--	--	--
Dieldrin	42	180	--	**44 T**	--	--	--	--	--
Endosulfan I	340,000[a]	6,200,000[b]	--	160 U	--	--	--	--	--
Endosulfan II	340,000[a]	6,200,000[b]	--	**110 TJ**	--	--	--	--	--
Endosulfan sulfate	340,000[a]	6,200,000[b]	--	160 U	--	--	--	--	--
Endrin	17,000	310,000	--	**130 T**	--	--	--	--	--
Endrin aldehyde	NE	NE	--	160 U	--	--	--	--	--
Endrin ketone	NE	NE	--	160 U	--	--	--	--	--
gamma-BHC (Lindane)	520	2,200	--	**20 TJ**	--	--	--	--	--
gamma-Chlordane	NE	NE	--	160 U	--	--	--	--	--
Heptachlor	150	650	--	*15 U*	--	--	--	--	--
Heptachlor epoxide	NE	NE	--	160 U	--	--	--	--	--
Methoxychlor	280,000	5,200,000	--	310 U	--	--	--	--	--
Toxaphene	100	200	--	*21 U*	--	--	--	--	--

TABLE 1
LOWER PASSAIC RIVER DATA SUMMARY TABLE
BIOGENESIS SEDIMENT WASHING TECHNOLOGY DEMONSTRATION PROJECT

		Location Identification	**Untreated Sediment Prior to Secondary Screen**							
		Field Sample Identification	PSS-020506-1600	PSS-030506-1600	PSS-040506-1600	PSS-040506-1600B	*Average*	*Min*	-	*Max*
Analyte/Methods (Units)		**Sample Date Sample Time**	5/2/06 1600	5/3/06 1600	5/4/06 1600	5/4/06 1600				
Poly Chlorinated Biphenyls (PCBs)/ SW-846 8082 (µg/kg)	**RDCSCC**	**NRDCSCC**								
(BZ 1) 2-Chlorobiphenyl	NE	NE	--	**56 TJB**	--	--	--	--		--
(BZ 101) 2,2',4,5, 5'-Pentachlorobiphenyl	NE	NE	--	**37**	--	--	--	--		--
(BZ 110) 2,3,3',4',6-Pentachlorobiphenyl	NE	NE	--	**48**	--	--	--	--		--
(BZ 141) 2,2',3,4,5,5'-Hexachlorobiphenyl	NE	NE	--	**11**	--	--	--	--		--
(BZ 151) 2,2',3,5,5',6-Hexachlorobiphenyl	NE	NE	--	6.4 U	--	--	--	--		--
(BZ 153) 2,2',4,4',5,5'-Hexachlorobiphenyl	NE	NE	--	**35**	--	--	--	--		--
(BZ 170) 2,2',3,3',4,4',5-Heptachlorobiphen	NE	NE	--	**16**	--	--	--	--		--
(BZ 18) 2,2',5-Trichlorobiphenyl	NE	NE	--	**65**	--	--	--	--		--
(BZ 180) 2,2',3,4,4',5,5'-Heptachlorobiphen	NE	NE	--	**27**	--	--	--	--		--
(BZ 187) 2,2',3,4',5,5',6-Heptachlorobiphen	NE	NE	--	**21**	--	--	--	--		--
(BZ 206) 2,2',3,3',4,4',5,5',6-Nonachlorobip	NE	NE	--	**5.2 T**	--	--	--	--		--
(BZ 31) 2,4',5-Trichlorobiphenyl	NE	NE	--	**69**	--	--	--	--		--
(BZ 5) 2,3-Dichlorobiphenyl	NE	NE	--	**1.2 TJ**	--	--	--	--		--
(BZ 52) 2,2',5,5'-Tetrachlorobiphenyl	NE	NE	--	**58**	--	--	--	--		--
(BZ 66) 2,3',4,4'-Tetrachlorobiphenyl	NE	NE	--	**58**	--	--	--	--		--
(BZ 87) 2,2',3,4,5'-Pentachlorobiphenyl	NE	NE	--	**13 J**	--	--	--	--		--
Total PCB Congeners	490	2,000	--	**520.4**	--	--	--	--		--

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LOWER PASSAIC RIVER DATA SUMMARY TABLE
BIOGENESIS SEDIMENT WASHING TECHNOLOGY DEMONSTRATION PROJECT

		Location Identification	**Untreated Sediment Prior to Secondary Screen**						
		Field Sample Identification	PSS-020506-1600	PSS-030506-1600	PSS-040506-1600	PSS-040506-1600B	*Average*	*Min* -	*Max*
Analyte/Methods (Units)		**Sample Date Sample Time**	5/2/06 1600	5/3/06 1600	5/4/06 1600	5/4/06 1600			
Semi-Volatile Organic Compounds (SVOCs)/ SW-846 8270C (µg/kg)	**RDCSCC**	**NRDCSCC**							
1,4-Dichlorobenzene	570,000	10,000,000	--	**97 T**	--	--	--	--	--
2,4,5-Trichlorophenol	5,600,000	10,000,000	--	3100 U	--	--	--	--	--
2,4,6-Trichlorophenol	62,000	270,000	--	3100 U	--	--	--	--	--
2,4-Dinitrotoluene	1,000	4,000	--	*33 U*	--	--	--	--	--
2-Methylphenol	2,800,000	10,000,000	--	3100 U	--	--	--	--	--
3-Methylphenol & 4-Methylphenol	2,800,000	10,000,000	--	3100 U	--	--	--	--	--
Acenaphthene	3,400,000	10,000,000	--	**120 T**	--	--	--	--	--
Acenaphthylene	NE	NE	--	**280 T**	--	--	--	--	--
Anthracene	10,000,000	10,000,000	--	**400 T**	--	--	--	--	--
Benzo(a)anthracene	900	4,000	--	**1000 T**	--	--	--	--	--
Benzo(a)pyrene	660	660	--	**970 T**	--	--	--	--	--
Benzo(b)fluoranthene	900	4,000	--	**1100 T**	--	--	--	--	--
Benzo(ghi)perylene	NE	NE	--	**720 T**	--	--	--	--	--
Benzo(k)fluoranthene	900	4,000	--	**450 T**	--	--	--	--	--
Chrysene	9,000	40,000	--	**1300 T**	--	--	--	--	--
Dibenz(a,h)anthracene	660	660	--	**160 T**	--	--	--	--	--
Fluoranthene	2,300,000	10,000,000	--	**1900 T**	--	--	--	--	--
Fluorene	2,300,000	10,000,000	--	**150 T**	--	--	--	--	--
Hexachlorobenzene	660	2,000	--	*63 U*	--	--	--	--	--
Hexachlorobutadiene	1,000	21,000	--	*61 U*	--	--	--	--	--
Hexachloroethane	6,000	100,000	--	3100 U	--	--	--	--	--
Indeno(1,2,3-cd)pyrene	900	4,000	--	**730 T**	--	--	--	--	--
Naphthalene	230,000	4,200,000	--	**170 T**	--	--	--	--	--
Nitrobenzene	28,000	520,000	--	3100 U	--	--	--	--	--
Pentachlorophenol	6,000	24,000	--	*4300 U*	--	--	--	--	--
Pyrene	1,700,000	10,000,000	--	**1900 T**	--	--	--	--	--

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BIOGENESIS SEDIMENT WASHING TECHNOLOGY DEMONSTRATION PROJECT

		Location Identification	**Untreated Sediment Prior to Secondary Screen**							
		Field Sample Identification	PSS-020506-1600	PSS-030506-1600	PSS-040506-1600	PSS-040506-1600B	*Average*	*Min*	-	*Max*
Analyte/Methods (Units)		**Sample Date Sample Time**	5/2/06 1600	5/3/06 1600	5/4/06 1600	5/4/06 1600				
Polynuclear Aromatic Hydrocarbons (PAHs)/ SW-846 8270 SIM (µg/kg)	**RDCSCC**	**NRDCSCC**								
Acenaphthene	3,400,000	10,000,000	**230 T**	**210**	**250**	**298**	*247*	*210*	-	*298*
Acenaphthylene	NE	NE	**510**	**460**	**490**	**414**	*469*	*414*	-	*510*
Anthracene	10,000,000	10,000,000	**840**	**870**	**1,100**	**973**	*946*	*840*	-	*1,100*
Benzo(a)anthracene	900	4,000	**2,000**	**2,100**	**2,600**	**1,780**	*2,120*	*1,780*	-	*2,600*
Benzo(a)pyrene	660	660	**2,200**	**2,000**	**2,300**	**1,800**	*2,075*	*1,800*	-	*2,300*
Benzo(b)fluoranthene	900	4,000	**2,600**	**2,500**	**2,800**	**1,770**	*2,418*	*1,770*	-	*2,800*
Benzo(ghi)perylene	NE	NE	**1,700**	**1,600**	**1,800**	**1,310**	*1,603*	*1,310*	-	*1,800*
Benzo(k)fluoranthene	900	4,000	**1,000**	**930**	**1,000**	**1,720**	*1,163*	*930*	-	*1,720*
Chrysene	9,000	40,000	**2,400**	**2,800**	**3,100**	**2,320**	*2,655*	*2,320*	-	*3,100*
Dibenzo(a,h)anthracene	660	660	**390**	**370**	**420**	**390**	*393*	*370*	-	*420*
Fluoranthene	2,300,000	10,000,000	**3,500**	**3,700**	**4,500**	**6,300**	*4,500*	*3,500*	-	*6,300*
Fluorene	2,300,000	10,000,000	**280 T**	**260**	**290**	**349**	*295*	*260*	-	*349*
Indeno (1,2,3-c,d)pyrene	900	4,000	**1,400**	**1,300**	**1,500**	**1,070**	*1,318*	*1,070*	-	*1,500*
Naphthalene	230,000	4,200,000	**250 T**	**250**	**300**	**484**	*321*	*250*	-	*484*
Phenanthrene	NE	NE	**1,700**	**1,800**	**2,800**	**2,060**	*2,090*	*1,700*	-	*2,800*
Pyrene	1,700,000	10,000,000	**3,900**	**3,300**	**3,900**	**6,470**	*4,393*	*3,300*	-	*6,470*

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BIOGENESIS SEDIMENT WASHING TECHNOLOGY DEMONSTRATION PROJECT

		Location Identification	**Untreated Sediment Prior to Secondary Screen**						
		Field Sample Identification	PSS-020506-1600	PSS-030506-1600	PSS-040506-1600	PSS-040506-1600B	*Average*	*Min* -	*Max*
Analyte/Methods (Units)		**Sample Date Sample Time**	5/2/06 1600	5/3/06 1600	5/4/06 1600	5/4/06 1600			
Dioxins and Furans/									
SW-846 8290 (pg/g)	**RDCSCC**	**NRDCSCC**							
1,2,3,4,6,7,8-HpCDD	NE	NE	--	**730**	--	--	--	--	--
1,2,3,4,6,7,8-HpCDF	NE	NE	--	**910**	--	--	--	--	--
1,2,3,4,7,8,9-HpCDF	NE	NE	--	**30**	--	--	--	--	--
1,2,3,4,7,8-HxCDD	NE	NE	--	**13 T**	--	--	--	--	--
1,2,3,4,7,8-HxCDF	NE	NE	--	**190**	--	--	--	--	--
1,2,3,6,7,8-HxCDD	NE	NE	--	**58**	--	--	--	--	--
1,2,3,6,7,8-HxCDF	NE	NE	--	**56**	--	--	--	--	--
1,2,3,7,8,9-HxCDD	NE	NE	--	**23**	--	--	--	--	--
1,2,3,7,8,9-HxCDF	NE	NE	--	**2.7 T**	--	--	--	--	--
1,2,3,7,8-PeCDD	NE	NE	--	**9.3 T**	--	--	--	--	--
1,2,3,7,8-PeCDF	NE	NE	--	**21**	--	--	--	--	--
2,3,4,6,7,8-HxCDF	NE	NE	--	**22**	--	--	--	--	--
2,3,4,7,8-PeCDF	NE	NE	--	**63**	--	--	--	--	--
2,3,7,8-TCDD	NE	NE	--	**330**	--	--	--	--	--
2,3,7,8-TCDF	NE	NE	--	**27**	--	--	--	--	--
OCDD	NE	NE	--	**8000 B**	--	--	--	--	--
OCDF	NE	NE	--	**1100**	--	--	--	--	--
Total Dioxins & Furans - summed by toxic equivalency factor (TEF) methodology	NE	NE	--	**432.17**	--	--	--	--	--

TABLE 1
LOWER PASSAIC RIVER DATA SUMMARY TABLE
BIOGENESIS SEDIMENT WASHING TECHNOLOGY DEMONSTRATION PROJECT

			Location Identification	Oversized from top deck of Secondary Screen			
			Field Sample Identification	SS1-020506-1605	SS1-030506-1605	SS1-040506-1605	SS1-040506-1605B
			Sample Date	5/2/06	5/3/06	5/4/06	5/4/06
Analyte/Methods (Units)			Sample Time	1605	1605	1605	1605
	New Jersey Standards						
General Soil Parameters	**RDCSCC**	**NRDCSCC**					
Percent Solids/EPA 160.3 M (%)	NE	NE		**25.3**	**28.7**	**32.7**	**29.3**
Grain Size Sand/D4464 (%)	NE	NE		**21.9**	**12.07**	**19.37**	**--**
Grain Size Silt/D4464 (%)	NE	NE		**61.01**	**66.57**	**61.53**	**--**
Grain Size Clay/D4464 (%)	NE	NE		**17.09**	**21.36**	**19.11**	**--**
Total Organic Carbon/Lloyd Kahn (mg/kg)	NE	NE		**282,000**	**291,000**	**187,000**	**102,000**
Total Petroleum Hydrocarbons/SW-846 9071	NE	NE		**6,250**	**5,640**	**5,970**	**15,000**
Metals/							
SW-846 6010B/7471A (mg/kg)	**RDCSCC**	**NRDCSCC**					
Arsenic	20	20		**15.7**	**14.4**	**12.8**	**12.5 B**
Barium	700	47,000		**146**	**134**	**137**	**232**
Cadmium	39	100		**5.3**	**6.8**	**6.4**	**5.61**
Chromium	120,000	NE		**157**	**155**	**149**	**157**
Lead	400	600		**297**	**314**	**324**	**284**
Nickel	250	2,400		**48.3**	**45**	**44.9**	**39.8**
Selenium	63	3,100		**3.5**	**1.8**	**1.2**	1.66 U
Silver	110	4,100		**4**	**4.4**	**4.6**	**4.01**
Zinc	1,500	1,500		**1330 J**	**749**	**635 J**	**591**
Mercury	14	270		**3**	**3**	**2.9**	**3**

TABLE 1
LOWER PASSAIC RIVER DATA SUMMARY TABLE
BIOGENESIS SEDIMENT WASHING TECHNOLOGY DEMONSTRATION PROJECT

		Location Identification	**Oversized from top deck of Secondary Screen**			
		Field Sample Identification	SS1-020506-1605	SS1-030506-1605	SS1-040506-1605	SS1-040506-1605B
Analyte/Methods (Units)		**Sample Date** **Sample Time**	5/2/06 1605	5/3/06 1605	5/4/06 1605	5/4/06 1605
Polynuclear Aromatic Hydrocarbons (PAHs)/						
SW-846 8270 SIM (µg/kg)	**RDCSCC**	**NRDCSCC**				
Acenaphthene	3,400,000	10,000,000	**260 T**	**340 T**	**280**	**920**
Acenaphthylene	NE	NE	**720**	**520**	**430**	**901**
Anthracene	10,000,000	10,000,000	**1,100**	**920**	**9,500**	**5,440**
Benzo(a)anthracene	900	4,000	**2,800**	**2,700**	**4,000**	**11,800**
Benzo(a)pyrene	660	660	**2,400**	**2,500**	**2,200**	**9,490**
Benzo(b)fluoranthene	900	4,000	**2,700**	**2,900**	**2,500**	**7,810**
Benzo(ghi)perylene	NE	NE	**1,500**	**1,700**	**1,200**	**5,750**
Benzo(k)fluoranthene	900	4,000	**860**	**1,100**	**1,200**	**9,320**
Chrysene	9,000	40,000	**3,400**	**3,100**	**5,000**	**12,800**
Dibenzo(a,h)anthracene	660	660	**390 T**	**430 T**	**310**	**2,040**
Fluoranthene	2,300,000	10,000,000	**3,300**	**4,300**	**8,500**	**36,700**
Fluorene	2,300,000	10,000,000	**330 T**	**340 T**	**460**	**763**
Indeno (1,2,3-c,d)pyrene	900	4,000	**1,200**	**1,400**	**990**	**5,240**
Naphthalene	230,000	4,200,000	**790**	**360 T**	**150 T**	**661**
Phenanthrene	NE	NE	**1,400**	**1,800**	**4,900**	**15,900**
Pyrene	1,700,000	10,000,000	**3,900**	**4,300**	**6,800**	**31,700**

TABLE 1
LOWER PASSAIC RIVER DATA SUMMARY TABLE
BIOGENESIS SEDIMENT WASHING TECHNOLOGY DEMONSTRATION PROJECT

			Location Identification	Oversized from lower deck of Secondary Screen			
			Field Sample Identification	SS2-020506-1612	SS2-030506-1610	SS2-040506-1612	SS2-040506-1612B
Analyte/Methods (Units)			**Sample Date Sample Time**	5/2/06 1610	5/3/06 1610	5/4/06 1610	5/4/06 1610
	New Jersey Standards						
General Soil Parameters	**RDCSCC**	**NRDCSCC**					
Percent Solids/EPA 160.3 M (%)	NE	NE		**22.2**	**25.5**	**33.7**	**33.7**
Grain Size Sand/D4464 (%)	NE	NE		**55.1**	**37.65**	**26.82**	**--**
Grain Size Silt/D4464 (%)	NE	NE		**34.67**	**44.39**	**53.23**	**--**
Grain Size Clay/D4464 (%)	NE	NE		**10.23**	**17.95**	**19.95**	**--**
Total Organic Carbon/Lloyd Kahn (mg/kg)	NE	NE		**337,000**	**305,000**	**71,300**	**113,000**
Total Petroleum Hydrocarbons/SW-846 9071	NE	NE		**9,530**	**5,860**	**4,450**	**7,700**
Metals/							
SW-846 6010B/7471A (mg/kg)	**RDCSCC**	**NRDCSCC**					
Arsenic	20	20		**17.5**	**15.5**	**10.9**	**13.5 B**
Barium	700	47,000		**184**	**168**	**151**	**363**
Cadmium	39	100		**6.6**	**7.7**	**6.3**	**6.17**
Chromium	120,000	NE		**269**	**212**	**165**	**221**
Lead	400	600		**461**	**447**	**343**	**459**
Nickel	250	2,400		**57**	**82.4**	**44.2**	**50.4**
Selenium	63	3,100		**4**	**2.2**	**1.1**	**1.66** U
Silver	110	4,100		**4.9**	**5.2**	**5.3**	**5.3**
Zinc	1,500	1,500		**960 J**	**883**	**621 J**	**651**
Mercury	14	270		**3.9**	**4.1**	**3.9**	**3.71**

TABLE 1
LOWER PASSAIC RIVER DATA SUMMARY TABLE
BIOGENESIS SEDIMENT WASHING TECHNOLOGY DEMONSTRATION PROJECT

		Location Identification	**Oversized from lower deck of Secondary Screen**			
		Field Sample Identification	SS2-020506-1612	SS2-030506-1610	SS2-040506-1612	SS2-040506-1612B
Analyte/Methods (Units)		**Sample Date Sample Time**	5/2/06 1610	5/3/06 1610	5/4/06 1610	5/4/06 1610
Polynuclear Aromatic Hydrocarbons (PAHs)/ SW-846 8270 SIM (µg/kg)	**RDCSCC**	**NRDCSCC**				
Acenaphthene	3,400,000	10,000,000	**740**	**510 T**	**420**	**450**
Acenaphthylene	NE	NE	**4,200**	**1,600**	**1,000**	**1,090**
Anthracene	10,000,000	10,000,000	**3,000**	**1,900**	**1,600**	**1,710**
Benzo(a)anthracene	900	4,000	**12,000**	**5,600**	**3,800**	**3,240**
Benzo(a)pyrene	660	660	**13,000**	**5,000**	**3,600**	**3,410**
Benzo(b)fluoranthene	900	4,000	**9,900**	**5,200**	**3,800**	**3,020**
Benzo(ghi)perylene	NE	NE	**7,500**	**3,300**	**2,600**	**2,290**
Benzo(k)fluoranthene	900	4,000	**4,300**	**2,200**	**1,700**	**3,230**
Chrysene	9,000	40,000	**12,000**	**6,200**	**4,600**	**4,940**
Dibenzo(a,h)anthracene	660	660	**1,700**	**890**	**730**	**743**
Fluoranthene	2,300,000	10,000,000	**12,000**	**7,700**	**5,700**	**14,500**
Fluorene	2,300,000	10,000,000	**870**	**640**	**470**	**395**
Indeno (1,2,3-c,d)pyrene	900	4,000	**5,700**	**2,700**	**2,100**	**1,960**
Naphthalene	230,000	4,200,000	**620**	**360 T**	**380**	**599**
Phenanthrene	NE	NE	**3,600**	**3,500**	**2,700**	**2,580**
Pyrene	1,700,000	10,000,000	**18,000**	**7,300**	**5,400**	**13,700**

TABLE 1
LOWER PASSAIC RIVER DATA SUMMARY TABLE
BIOGENESIS SEDIMENT WASHING TECHNOLOGY DEMONSTRATION PROJECT

			Untreated Sediment after Secondary Screen							
	Location Identification									
	Field Sample Identification		RS-020506-1616	RS-030506-1615	RS-040506-1616	RS-040506-1616B	*Average*	*Min*	-	*Max*
Analyte/Methods (Units)	**Sample Date / Sample Time**		5/2/06 1616	5/3/06 1615	5/4/06 1616	5/4/06 1616				
	New Jersey Standards									
General Soil Parameters	**RDCSCC**	**NRDCSCC**								
Percent Solids/EPA 160.3 M (%)	NE	NE	**31**	**26**	**32.6**	**43**	*33.2*	*26.0*	-	*43.0*
Grain Size Sand/D4464 (%)	NE	NE	**24.32**	**24.32**	**24.16**	--	*24.27*	*24.16*	-	*24.32*
Grain Size Silt/D4464 (%)	NE	NE	**56.71**	**56.19**	**56.7**	--	*56.53*	*56.19*	-	*56.71*
Grain Size Clay/D4464 (%)	NE	NE	**18.97**	**19.49**	**19.14**	--	*19.20*	*18.97*	-	*19.49*
Total Organic Carbon/Lloyd Kahn (mg/kg)	NE	NE	**78,600**	**56,700**	**55,000**	**53,900**	*61,050*	*53,900*	-	*78,600*
Total Petroleum Hydrocarbons/SW-846 9071	NE	NE	**1,330**	**3,670**	**3,480**	**4,700**	*3,295*	*1,330*	-	*4,700*
Metals/										
SW-846 6010B/7471A (mg/kg)	**RDCSCC**	**NRDCSCC**								
Arsenic	20	20	**9.8**	**11**	**10.6**	**10.5 B**	*10.5*	*9.8*	-	*11*
Barium	700	47,000	**164**	**177**	**183**	**439**	*241*	*164*	-	*439*
Cadmium	39	100	**5**	**6.9**	**6.8**	**7.08**	*6.4*	*5*	-	*7.08*
Chromium	120,000	NE	**171**	**180**	**179**	**221**	*188*	*171*	-	*221*
Lead	400	600	**336**	**377**	**348**	**357**	*355*	*336*	-	*377*
Nickel	250	2,400	**44.7**	**46.9**	**46.3**	**57.7**	*48.9*	*44.7*	-	*57.7*
Selenium	63	3,100	**2.5**	**1.1**	0.77 U	1.66 U	*1.5*	*0.77*	-	*2.5*
Silver	110	4,100	**5.7**	**6.3**	**6.3**	**7.26**	*6.4*	*5.7*	-	*7.26*
Zinc	1,500	1,500	**614 J**	**655**	**617 J**	**690**	*644*	*614*	-	*690*
Mercury	14	270	**3.8**	**4**	**4.2**	**4.39**	*4.1*	*3.8*	-	*4.39*

TABLE 1
LOWER PASSAIC RIVER DATA SUMMARY TABLE
BIOGENESIS SEDIMENT WASHING TECHNOLOGY DEMONSTRATION PROJECT

		Location Identification	**Untreated Sediment after Secondary Screen**						
		Field Sample Identification	RS-020506-1616	RS-030506-1615	RS-040506-1616	RS-040506-1616B	*Average*	*Min* -	*Max*
Analyte/Methods (Units)		**Sample Date Sample Time**	5/2/06 1616	5/3/06 1615	5/4/06 1616	5/4/06 1616			
Organochlorine Pesticides/ SW-846 8081A (µg/kg)	**RDCSCC**	**NRDCSCC**							
4,4'-DDD	3,000	12,000	--	**30 TJ**	--	--	--	--	--
4,4'-DDE	2,000	9,000	--	**81 T**	--	--	--	--	--
4,4'-DDT	2,000	9,000	--	**51 TJ**	--	--	--	--	--
Aldrin	40	170	--	*20 U*	--	--	--	--	--
alpha-BHC	NE	NE	--	160 U	--	--	--	--	--
alpha-Chlordane	NE	NE	--	160 U	--	--	--	--	--
beta-BHC	NE	NE	--	160 U	--	--	--	--	--
Chlordane (technical)	NE	NE	--	1600 U	--	--	--	--	--
delta-BHC	NE	NE	--	160 U	--	--	--	--	--
Dieldrin	42	180	--	*16 U*	--	--	--	--	--
Endosulfan I	340,000[a]	6,200,000[b]	--	160 U	--	--	--	--	--
Endosulfan II	340,000[a]	6,200,000[b]	--	160 U	--	--	--	--	--
Endosulfan sulfate	340,000[a]	6,200,000[b]	--	160 U	--	--	--	--	--
Endrin	17,000	310,000	--	**43 TJ**	--	--	--	--	--
Endrin aldehyde	NE	NE	--	160 U	--	--	--	--	--
Endrin ketone	NE	NE	--	160 U	--	--	--	--	--
gamma-BHC (Lindane)	520	2,200	--	160 U	--	--	--	--	--
gamma-Chlordane	NE	NE	--	160 U	--	--	--	--	--
Heptachlor	150	650	--	*16 U*	--	--	--	--	--
Heptachlor epoxide	NE	NE	--	160 U	--	--	--	--	--
Methoxychlor	280,000	5,200,000	--	320 U	--	--	--	--	--
Toxaphene	100	200	--	*220 U*	--	--	--	--	--

TABLE 1
LOWER PASSAIC RIVER DATA SUMMARY TABLE
BIOGENESIS SEDIMENT WASHING TECHNOLOGY DEMONSTRATION PROJECT

		Location Identification	**Untreated Sediment after Secondary Screen**						
		Field Sample Identification	RS-020506-1616	RS-030506-1615	RS-040506-1616	RS-040506-1616B	*Average*	*Min* -	*Max*
Analyte/Methods (Units)		**Sample Date Sample Time**	5/2/06 1616	5/3/06 1615	5/4/06 1616	5/4/06 1616			
Poly Chlorinated Biphenyls (PCBs)/									
SW-846 8082 (µg/kg)	**RDCSCC**	**NRDCSCC**							
(BZ 1) 2-Chlorobiphenyl	NE	NE	--	**49 TJB**	--	--	--	--	--
(BZ 101) 2,2',4,5, 5'-Pentachlorobiphenyl	NE	NE	--	**31**	--	--	--	--	--
(BZ 110) 2,3,3',4',6-Pentachlorobiphenyl	NE	NE	--	**41**	--	--	--	--	--
(BZ 141) 2,2',3,4,5,5'-Hexachlorobiphenyl	NE	NE	--	**9.5**	--	--	--	--	--
(BZ 151) 2,2',3,5,5',6-Hexachlorobiphenyl	NE	NE	--	6.5 U	--	--	--	--	--
(BZ 153) 2,2',4,4',5,5'-Hexachlorobiphenyl	NE	NE	--	**29**	--	--	--	--	--
(BZ 170) 2,2',3,3',4,4',5-Heptachlorobiphen	NE	NE	--	**14**	--	--	--	--	--
(BZ 18) 2,2',5-Trichlorobiphenyl	NE	NE	--	**56**	--	--	--	--	--
(BZ 180) 2,2',3,4,4',5,5'-Heptachlorobiphen	NE	NE	--	**23**	--	--	--	--	--
(BZ 187) 2,2',3,4',5,5',6-Heptachlorobiphen	NE	NE	--	**18**	--	--	--	--	--
(BZ 206) 2,2',3,3',4,4',5,5',6-Nonachlorobip	NE	NE	--	**4.5 T**	--	--	--	--	--
(BZ 31) 2,4',5-Trichlorobiphenyl	NE	NE	--	**57**	--	--	--	--	--
(BZ 5) 2,3-Dichlorobiphenyl	NE	NE	--	6.5 U	--	--	--	--	--
(BZ 52) 2,2',5,5'-Tetrachlorobiphenyl	NE	NE	--	**51**	--	--	--	--	--
(BZ 66) 2,3',4,4'-Tetrachlorobiphenyl	NE	NE	--	**47**	--	--	--	--	--
(BZ 87) 2,2',3,4,5'-Pentachlorobiphenyl	NE	NE	--	**12 J**	--	--	--	--	--
Total PCB Congeners	490	2,000	--	**442**	--	--	--	--	--

TABLE 1
LOWER PASSAIC RIVER DATA SUMMARY TABLE
BIOGENESIS SEDIMENT WASHING TECHNOLOGY DEMONSTRATION PROJECT

		Location Identification	**Untreated Sediment after Secondary Screen**						
		Field Sample Identification	RS-020506-1616	RS-030506-1615	RS-040506-1616	RS-040506-1616B	*Average*	*Min* -	*Max*
Analyte/Methods (Units)		**Sample Date Sample Time**	5/2/06 1616	5/3/06 1615	5/4/06 1616	5/4/06 1616			
Semi-Volatile Organic Compounds (SVOCs)/ SW-846 8270C (µg/kg)	**RDCSCC**	**NRDCSCC**							
1,4-Dichlorobenzene	570,000	10,000,000	--	**230 T**	--	--	--	--	--
2,4,5-Trichlorophenol	5,600,000	10,000,000	--	3200 U	--	--	--	--	--
2,4,6-Trichlorophenol	62,000	270,000	--	3200 U	--	--	--	--	--
2,4-Dinitrotoluene	1,000	4,000	--	*34 U*	--	--	--	--	--
2-Methylphenol	2,800,000	10,000,000	--	3200 U	--	--	--	--	--
3-Methylphenol & 4-Methylphenol	2,800,000	10,000,000	--	3200 U	--	--	--	--	--
Acenaphthene	3,400,000	10,000,000	--	**300 T**	--	--	--	--	--
Acenaphthylene	NE	NE	--	**700 T**	--	--	--	--	--
Anthracene	10,000,000	10,000,000	--	**960 T**	--	--	--	--	--
Benzo(a)anthracene	900	4,000	--	**2300 T**	--	--	--	--	--
Benzo(a)pyrene	660	660	--	**2300 T**	--	--	--	--	--
Benzo(b)fluoranthene	900	4,000	--	**2600 T**	--	--	--	--	--
Benzo(ghi)perylene	NE	NE	--	**1300 T**	--	--	--	--	--
Benzo(k)fluoranthene	900	4,000	--	**1000 T**	--	--	--	--	--
Chrysene	9,000	40,000	--	**3000 T**	--	--	--	--	--
Dibenz(a,h)anthracene	660	660	--	**300 T**	--	--	--	--	--
Fluoranthene	2,300,000	10,000,000	--	**5100**	--	--	--	--	--
Fluorene	2,300,000	10,000,000	--	**340 T**	--	--	--	--	--
Hexachlorobenzene	660	2,000	--	*65 U*	--	--	--	--	--
Hexachlorobutadiene	1,000	21,000	--	*63 U*	--	--	--	--	--
Hexachloroethane	6,000	100,000	--	3200 U	--	--	--	--	--
Indeno(1,2,3-cd)pyrene	900	4,000	--	**1400 T**	--	--	--	--	--
Naphthalene	230,000	4,200,000	--	**340 T**	--	--	--	--	--
Nitrobenzene	28,000	520,000	--	3200 U	--	--	--	--	--
Pentachlorophenol	6,000	24,000	--	*4400 U*	--	--	--	--	--
Pyrene	1,700,000	10,000,000	--	**4500**	--	--	--	--	--

TABLE 1
LOWER PASSAIC RIVER DATA SUMMARY TABLE
BIOGENESIS SEDIMENT WASHING TECHNOLOGY DEMONSTRATION PROJECT

		Location Identification	**Untreated Sediment after Secondary Screen**							
		Field Sample Identification	RS-020506-1616	RS-030506-1615	RS-040506-1616	RS-040506-1616B	*Average*	*Min*	-	*Max*
Analyte/Methods (Units)		**Sample Date Sample Time**	5/2/06 1616	5/3/06 1615	5/4/06 1616	5/4/06 1616				
Polynuclear Aromatic Hydrocarbons (PAHs)/ SW-846 8270 SIM (µg/kg)	**RDCSCC**	**NRDCSCC**								
Acenaphthene	3,400,000	10,000,000	**180 T**	**240 T**	**270**	**340**	*258*	*180*	-	*340*
Acenaphthylene	NE	NE	**410**	**570**	**610**	**501**	*523*	*410*	-	*610*
Anthracene	10,000,000	10,000,000	**650**	**880**	**1,100**	**1,210**	*960*	*650*	-	*1,210*
Benzo(a)anthracene	900	4,000	**1,600**	**2,200**	**2,400**	**2,000**	*2,050*	*1,600*	-	*2,400*
Benzo(a)pyrene	660	660	**1,600**	**2,100**	**2,500**	**2,170**	*2,093*	*1,600*	-	*2,500*
Benzo(b)fluoranthene	900	4,000	**1,900**	**2,700**	**2,800**	**1,960**	*2,340*	*1,900*	-	*2,800*
Benzo(ghi)perylene	NE	NE	**1,300**	**1,900**	**2,000**	**1,730**	*1,733*	*1,300*	-	*2,000*
Benzo(k)fluoranthene	900	4,000	**720**	**770**	**1,200**	**2,060**	*1,188*	*720*	-	*2,060*
Chrysene	9,000	40,000	**1,900**	**2,800**	**3,100**	**2,560**	*2,590*	*1,900*	-	*3,100*
Dibenzo(a,h)anthracene	660	660	**300**	**460**	**470**	**513**	*436*	*300*	-	*513*
Fluoranthene	2,300,000	10,000,000	**2,800**	**4,000**	**4,600**	**6,850**	*4,563*	*2,800*	-	*6,850*
Fluorene	2,300,000	10,000,000	**210**	**290**	**320**	**412**	*308*	*210*	-	*412*
Indeno (1,2,3-c,d)pyrene	900	4,000	**1,100**	**1,600**	**1,700**	**1,410**	*1,453*	*1,100*	-	*1,700*
Naphthalene	230,000	4,200,000	**170 T**	**240 T**	**280**	**571**	*315*	*170*	-	*571*
Phenanthrene	NE	NE	**1,300**	**1,700**	**2,100**	**2,330**	*1,858*	*1,300*	-	*2,330*
Pyrene	1,700,000	10,000,000	**2,700**	**3,600**	**4,000**	**6,960**	*4,315*	*2,700*	-	*6,960*

TABLE 1
LOWER PASSAIC RIVER DATA SUMMARY TABLE
BIOGENESIS SEDIMENT WASHING TECHNOLOGY DEMONSTRATION PROJECT

		Location Identification	**Untreated Sediment after Secondary Screen**						
		Field Sample Identification	RS-020506-1616	RS-030506-1615	RS-040506-1616	RS-040506-1616B	*Average*	*Min* -	*Max*
Analyte/Methods (Units)		**Sample Date Sample Time**	5/2/06 1616	5/3/06 1615	5/4/06 1616	5/4/06 1616			
Dioxins and Furans/									
SW-846 8290 (pg/g)	**RDCSCC**	**NRDCSCC**							
1,2,3,4,6,7,8-HpCDD	NE	NE	--	**760**	--	--	--	--	--
1,2,3,4,6,7,8-HpCDF	NE	NE	--	**940**	--	--	--	--	--
1,2,3,4,7,8,9-HpCDF	NE	NE	--	**33**	--	--	--	--	--
1,2,3,4,7,8-HxCDD	NE	NE	--	**9.8 T**	--	--	--	--	--
1,2,3,4,7,8-HxCDF	NE	NE	--	**200**	--	--	--	--	--
1,2,3,6,7,8-HxCDD	NE	NE	--	**52 J**	--	--	--	--	--
1,2,3,6,7,8-HxCDF	NE	NE	--	**68**	--	--	--	--	--
1,2,3,7,8,9-HxCDD	NE	NE	--	**40**	--	--	--	--	--
1,2,3,7,8,9-HxCDF	NE	NE	--	17 U	--	--	--	--	--
1,2,3,7,8-PeCDD	NE	NE	--	**12 T**	--	--	--	--	--
1,2,3,7,8-PeCDF	NE	NE	--	**54**	--	--	--	--	--
2,3,4,6,7,8-HxCDF	NE	NE	--	**25**	--	--	--	--	--
2,3,4,7,8-PeCDF	NE	NE	--	**49**	--	--	--	--	--
2,3,7,8-TCDD	NE	NE	--	**430**	--	--	--	--	--
2,3,7,8-TCDF	NE	NE	--	**23**	--	--	--	--	--
OCDD	NE	NE	--	**8400 B**	--	--	--	--	--
OCDF	NE	NE	--	**920**	--	--	--	--	--
Total Dioxins & Furans - summed by toxic equivalency factor (TEF) methodology	NE	NE	--	**531.63**	--	--	--	--	--

TABLE 1
LOWER PASSAIC RIVER DATA SUMMARY TABLE
BIOGENESIS SEDIMENT WASHING TECHNOLOGY DEMONSTRATION PROJECT

			Treated Sediment							
	Location Identification									
	Field Sample Identification		TS-020506-1635	TS-030506-1635	TS-040506-1635	TS-040506-1635B	*Average*	*Min*	-	*Max*
Analyte/Methods (Units)	**Sample Date Sample Time**		5/2/06 1635	5/3/06 1635	5/4/06 1635	5/4/06 1635				
	New Jersey Standards									
General Soil Parameters	**RDCSCC**	**NRDCSCC**								
Percent Solids/EPA 160.3 M (%)	NE	NE	**64.7**	**68.2**	**65.1**	**66.9**	*66.2*	*64.7*	-	*68.2*
Grain Size Sand/D4464 (%)	NE	NE	**13.69**	**22.03**	**14.73**	--	*16.8*	*13.69*	-	*22.03*
Grain Size Silt/D4464 (%)	NE	NE	**66.29**	**60.25**	**65.66**	--	*64.1*	*60.25*	-	*66.29*
Grain Size Clay/D4464 (%)	NE	NE	**20.02**	**17.72**	**19.61**	--	*19.1*	*17.72*	-	*20.02*
Total Organic Carbon/Lloyd Kahn (mg/kg)	NE	NE	**51,700**	**45,900**	**44,900**	**47,800**	*47,575*	*44,900*	-	*51,700*
Total Petroleum Hydrocarbons/SW-846 9071	NE	NE	**1,900**	**1,300**	**1,320**	**3,000**	*1,880*	*1,300*	-	*3,000*
Metals/										
SW-846 6010B/7471A (mg/kg)	**RDCSCC**	**NRDCSCC**								
Arsenic	20	20	**7.7**	**6.8**	**7.2**	**8.31 B**	*7.5*	*6.8*	-	*8.31*
Barium	700	47,000	**137**	**120**	**137**	**431**	*206*	*120*	-	*431*
Cadmium	39	100	**2.9**	**3.9**	**4.2**	**5.03**	*4.0*	*2.9*	-	*5.03*
Chromium	120,000	NE	**97.3**	**86.4**	**91.2**	**148**	*106*	*86.4*	-	*148*
Lead	400	600	**241**	**221**	**234**	**266**	*241*	*221*	-	*266*
Nickel	250	2,400	**38.2**	**34**	**37.3**	**54.3**	*41*	*34*	-	*54.3*
Selenium	63	3,100	**2.1**	**0.74**	0.38 U	1.66 U	*1.2*	*0.38*	-	*2.1*
Silver	110	4,100	**3.1**	**2.8**	**3**	**4.08**	*3.2*	*2.8*	-	*4.08*
Zinc	1,500	1,500	**394 J**	**344**	**366 J**	**467**	*393*	*344*	-	*467*
Mercury	14	270	**3.2**	**2.6**	**3.3**	**3.03**	*3.0*	*2.6*	-	*3.3*

TABLE 1
LOWER PASSAIC RIVER DATA SUMMARY TABLE
BIOGENESIS SEDIMENT WASHING TECHNOLOGY DEMONSTRATION PROJECT

	Location Identification		**Treated Sediment**						
	Field Sample Identification		TS-020506-1635	TS-030506-1635	TS-040506-1635	TS-040506-1635B	*Average*	*Min* -	*Max*
Analyte/Methods (Units)		**Sample Date Sample Time**	5/2/06 1635	5/3/06 1635	5/4/06 1635	5/4/06 1635			
Organochlorine Pesticides/ SW-846 8081A (µg/kg)	**RDCSCC**	**NRDCSCC**							
4,4'-DDD	3,000	12,000	--	**98 J**	--	--	--	--	--
4,4'-DDE	2,000	9,000	--	**89**	--	--	--	--	--
4,4'-DDT	2,000	9,000	--	**120**	--	--	--	--	--
Aldrin	40	170	--	*7.8 U*	--	--	--	--	--
alpha-BHC	NE	NE	--	62 U	--	--	--	--	--
alpha-Chlordane	NE	NE	--	62 U	--	--	--	--	--
beta-BHC	NE	NE	--	62 U	--	--	--	--	--
Chlordane (technical)	NE	NE	--	620 U	--	--	--	--	--
delta-BHC	NE	NE	--	62 U	--	--	--	--	--
Dieldrin	42	180	--	**34 T**	--	--	--	--	--
Endosulfan I	340,000[a]	6,200,000[b]	--	62 U	--	--	--	--	--
Endosulfan II	340,000[a]	6,200,000[b]	--	**74 J**	--	--	--	--	--
Endosulfan sulfate	340,000[a]	6,200,000[b]	--	62 U	--	--	--	--	--
Endrin	17,000	310,000	--	**89**	--	--	--	--	--
Endrin aldehyde	NE	NE	--	62 U	--	--	--	--	--
Endrin ketone	NE	NE	--	62 U	--	--	--	--	--
gamma-BHC (Lindane)	520	2,200	--	62 U	--	--	--	--	--
gamma-Chlordane	NE	NE	--	62 U	--	--	--	--	--
Heptachlor	150	650	--	62 U	--	--	--	--	--
Heptachlor epoxide	NE	NE	--	62 U	--	--	--	--	--
Methoxychlor	280,000	5,200,000	--	120 U	--	--	--	--	--
Toxaphene	100	200	--	*83 U*	--	--	--	--	--

TABLE 1
LOWER PASSAIC RIVER DATA SUMMARY TABLE
BIOGENESIS SEDIMENT WASHING TECHNOLOGY DEMONSTRATION PROJECT

		Location Identification	**Treated Sediment**						
		Field Sample Identification	TS-020506-1635	TS-030506-1635	TS-040506-1635	TS-040506-1635B	*Average*	*Min* -	*Max*
Analyte/Methods (Units)		**Sample Date Sample Time**	5/2/06 1635	5/3/06 1635	5/4/06 1635	5/4/06 1635			
Poly Chlorinated Biphenyls (PCBs)/									
SW-846 8082 (µg/kg)	**RDCSCC**	**NRDCSCC**							
(BZ 1) 2-Chlorobiphenyl	NE	NE	--	**65 B**	--	--	--	--	--
(BZ 101) 2,2',4,5, 5'-Pentachlorobiphenyl	NE	NE	--	**28**	--	--	--	--	--
(BZ 110) 2,3,3',4',6-Pentachlorobiphenyl	NE	NE	--	**38**	--	--	--	--	--
(BZ 141) 2,2',3,4,5,5'-Hexachlorobiphenyl	NE	NE	--	**8.4**	--	--	--	--	--
(BZ 151) 2,2',3,5,5',6-Hexachlorobiphenyl	NE	NE	--	2.5 U	--	--	--	--	--
(BZ 153) 2,2',4,4',5,5'-Hexachlorobiphenyl	NE	NE	--	**26**	--	--	--	--	--
(BZ 170) 2,2',3,3',4,4',5-Heptachlorobiphen	NE	NE	--	**12**	--	--	--	--	--
(BZ 18) 2,2',5-Trichlorobiphenyl	NE	NE	--	**53**	--	--	--	--	--
(BZ 180) 2,2',3,4,4',5,5'-Heptachlorobiphen	NE	NE	--	**16 J**	--	--	--	--	--
(BZ 187) 2,2',3,4',5,5',6-Heptachlorobiphen	NE	NE	--	**15**	--	--	--	--	--
(BZ 206) 2,2',3,3',4,4',5,5',6-Nonachlorobip	NE	NE	--	**4.5**	--	--	--	--	--
(BZ 31) 2,4',5-Trichlorobiphenyl	NE	NE	--	**59**	--	--	--	--	--
(BZ 5) 2,3-Dichlorobiphenyl	NE	NE	--	**1.1 TJ**	--	--	--	--	--
(BZ 52) 2,2',5,5'-Tetrachlorobiphenyl	NE	NE	--	**49**	--	--	--	--	--
(BZ 66) 2,3',4,4'-Tetrachlorobiphenyl	NE	NE	--	**45**	--	--	--	--	--
(BZ 87) 2,2',3,4,5'-Pentachlorobiphenyl	NE	NE	--	**11 J**	--	--	--	--	--
Total PCB Congeners	490	2,000	--	**431**	--	--	--	--	--

TABLE 1
LOWER PASSAIC RIVER DATA SUMMARY TABLE
BIOGENESIS SEDIMENT WASHING TECHNOLOGY DEMONSTRATION PROJECT

		Location Identification	**Treated Sediment**						
		Field Sample Identification	TS-020506-1635	TS-030506-1635	TS-040506-1635	TS-040506-1635B	*Average*	*Min* -	*Max*
Analyte/Methods (Units)		**Sample Date Sample Time**	5/2/06 1635	5/3/06 1635	5/4/06 1635	5/4/06 1635			
Semi-Volatile Organic Compounds (SVOCs)/ SW-846 8270C (µg/kg)	**RDCSCC**	**NRDCSCC**							
1,4-Dichlorobenzene	570,000	10,000,000	--	**170 T**	--	--	--	--	--
2,4,5-Trichlorophenol	5,600,000	10,000,000	--	1200 U	--	--	--	--	--
2,4,6-Trichlorophenol	62,000	270,000	--	1200 U	--	--	--	--	--
2,4-Dinitrotoluene	1,000	4,000	--	*13 U*	--	--	--	--	--
2-Methylphenol	2,800,000	10,000,000	--	1200 U	--	--	--	--	--
3-Methylphenol & 4-Methylphenol	2,800,000	10,000,000	--	230 **T**	--	--	--	--	--
Acenaphthene	3,400,000	10,000,000	--	**190 T**	--	--	--	--	--
Acenaphthylene	NE	NE	--	**380 T**	--	--	--	--	--
Anthracene	10,000,000	10,000,000	--	**630 T**	--	--	--	--	--
Benzo(a)anthracene	900	4,000	--	**1500**	--	--	--	--	--
Benzo(a)pyrene	660	660	--	**1400**	--	--	--	--	--
Benzo(b)fluoranthene	900	4,000	--	**1700**	--	--	--	--	--
Benzo(ghi)perylene	NE	NE	--	**590 T**	--	--	--	--	--
Benzo(k)fluoranthene	900	4,000	--	**720 T**	--	--	--	--	--
Chrysene	9,000	40,000	--	**1900**	--	--	--	--	--
Dibenz(a,h)anthracene	660	660	--	**150 T**	--	--	--	--	--
Fluoranthene	2,300,000	10,000,000	--	**3600**	--	--	--	--	--
Fluorene	2,300,000	10,000,000	--	**230 T**	--	--	--	--	--
Hexachlorobenzene	660	2,000	--	*25 U*	--	--	--	--	--
Hexachlorobutadiene	1,000	21,000	--	*24 U*	--	--	--	--	--
Hexachloroethane	6,000	100,000	--	1200 U	--	--	--	--	--
Indeno(1,2,3-cd)pyrene	900	4,000	--	**660 T**	--	--	--	--	--
Naphthalene	230,000	4,200,000	--	**260 T**	--	--	--	--	--
Nitrobenzene	28,000	520,000	--	1200 U	--	--	--	--	--
Pentachlorophenol	6,000	24,000	--	*5900* U	--	--	--	--	--
Pyrene	1,700,000	10,000,000	--	**2700**	--	--	--	--	--

TABLE 1
LOWER PASSAIC RIVER DATA SUMMARY TABLE
BIOGENESIS SEDIMENT WASHING TECHNOLOGY DEMONSTRATION PROJECT

		Location Identification	**Treated Sediment**							
		Field Sample Identification	TS-020506-1635	TS-030506-1635	TS-040506-1635	TS-040506-1635B	*Average*	*Min*	-	*Max*
Analyte/Methods (Units)		**Sample Date Sample Time**	5/2/06 1635	5/3/06 1635	5/4/06 1635	5/4/06 1635				
Polynuclear Aromatic Hydrocarbons (PAHs)/ SW-846 8270 SIM (µg/kg)	**RDCSCC**	**NRDCSCC**								
Acenaphthene	3,400,000	10,000,000	**300**	**160**	**200**	**366**	*257*	*160*	-	*366*
Acenaphthylene	NE	NE	**700**	**330**	**400**	**560**	*498*	*330*	-	*700*
Anthracene	10,000,000	10,000,000	**1,200**	**600**	**800**	**1,350**	*988*	*600*	-	*1,350*
Benzo(a)anthracene	900	4,000	**2,800**	**1,500**	**1,900**	**2,340**	*2,135*	*1,500*	-	*2,800*
Benzo(a)pyrene	660	660	**2,700**	**1,400**	**1,800**	**2,670**	*2,143*	*1,400*	-	*2,700*
Benzo(b)fluoranthene	900	4,000	**3,100**	**1,700**	**2,100**	**2,440**	*2,335*	*1,700*	-	*3,100*
Benzo(ghi)perylene	NE	NE	**2,300**	**1,100**	**1,500**	**2,180**	*1,770*	*1,100*	-	*2,300*
Benzo(k)fluoranthene	900	4,000	**1,400**	**630**	**880**	**2,460**	*1,343*	*630*	-	*2,460*
Chrysene	9,000	40,000	**3,500**	**1,900**	**2,400**	**3,010**	*2,703*	*1,900*	-	*3,500*
Dibenzo(a,h)anthracene	660	660	**580**	**260**	**360**	**664**	*466*	*260*	-	*664*
Fluoranthene	2,300,000	10,000,000	**4,900**	**2,700**	**3,400**	**7,580**	*4,645*	*2,700*	-	*7,580*
Fluorene	2,300,000	10,000,000	**390**	**200**	**240**	**463**	*323*	*200*	-	*463*
Indeno (1,2,3-c,d)pyrene	900	4,000	**1,800**	**910**	**1,200**	**1,790**	*1,425*	*910*	-	*1,800*
Naphthalene	230,000	4,200,000	**380**	**200**	**270**	**718**	*392*	*200*	-	*718*
Phenanthrene	NE	NE	**2,200**	**1,200**	**1,600**	**2,660**	*1,915*	*1,200*	-	*2,660*
Pyrene	1,700,000	10,000,000	**4,300**	**2,400**	**3,000**	**7,530**	*4,308*	*2,400*	-	*7,530*

TABLE 1
LOWER PASSAIC RIVER DATA SUMMARY TABLE
BIOGENESIS SEDIMENT WASHING TECHNOLOGY DEMONSTRATION PROJECT

			Treated Sediment						
Location Identification									
Field Sample Identification			TS-020506-1635	TS-030506-1635	TS-040506-1635	TS-040506-1635B	*Average*	*Min* -	*Max*
Analyte/Methods (Units)	**Sample Date / Sample Time**		5/2/06 1635	5/3/06 1635	5/4/06 1635	5/4/06 1635			
Dioxins and Furans/									
SW-846 8290 (pg/g)	**RDCSCC**	**NRDCSCC**							
1,2,3,4,6,7,8-HpCDD	NE	NE	--	**75**	--	--	--	--	--
1,2,3,4,6,7,8-HpCDF	NE	NE	--	**87**	--	--	--	--	--
1,2,3,4,7,8,9-HpCDF	NE	NE	--	**3.7 T**	--	--	--	--	--
1,2,3,4,7,8-HxCDD	NE	NE	--	**1 T**	--	--	--	--	--
1,2,3,4,7,8-HxCDF	NE	NE	--	**28**	--	--	--	--	--
1,2,3,6,7,8-HxCDD	NE	NE	--	**7.5 J**	--	--	--	--	--
1,2,3,6,7,8-HxCDF	NE	NE	--	**5.5 T**	--	--	--	--	--
1,2,3,7,8,9-HxCDD	NE	NE	--	**1.9 T**	--	--	--	--	--
1,2,3,7,8,9-HxCDF	NE	NE	--	**2.5 T**	--	--	--	--	--
1,2,3,7,8-PeCDD	NE	NE	--	**1.4 T**	--	--	--	--	--
1,2,3,7,8-PeCDF	NE	NE	--	**3 T**	--	--	--	--	--
2,3,4,6,7,8-HxCDF	NE	NE	--	**3 T**	--	--	--	--	--
2,3,4,7,8-PeCDF	NE	NE	--	**6.8 T**	--	--	--	--	--
2,3,7,8-TCDD	NE	NE	--	**58**	--	--	--	--	--
2,3,7,8-TCDF	NE	NE	--	**6.3**	--	--	--	--	--
OCDD	NE	NE	--	**630 B**	--	--	--	--	--
OCDF	NE	NE	--	**85**	--	--	--	--	--
Total Dioxins & Furans - summed by toxic equivalency factor (TEF) methodology	NE	NE	--	**70.19**	--	--	--	--	--

TABLE 1
LOWER PASSAIC RIVER DATA SUMMARY TABLE
BIOGENESIS SEDIMENT WASHING TECHNOLOGY DEMONSTRATION PROJECT

			Location Identification	Treated Sediment - portion from initial solids removal process (scalping screen)			
			Field Sample Identification	TS1-020506-1620	TS1-030506-1620	TS1-040506-1620	TS1-040506-1620B
Analyte/Methods (Units)			**Sample Date** **Sample Time**	5/2/06 1620	5/3/06 1620	5/4/06 1620	5/4/06 1620
	New Jersey Standards						
General Soil Parameters	**RDCSCC**	**NRDCSCC**					
Percent Solids/EPA 160.3 M (%)	NE	NE		**32.8**	**42.1**	**33**	**34.5**
Grain Size Sand/D4464 (%)	NE	NE		**89.72**	**87.21**	**87.62**	--
Grain Size Silt/D4464 (%)	NE	NE		**7.95**	**9.16**	**9.08**	--
Grain Size Clay/D4464 (%)	NE	NE		**2.32**	**3.62**	**3.29**	--
Total Organic Carbon/Lloyd Kahn (mg/kg)	NE	NE		**211,000**	**181,000**	**292,000**	**332,000**
Total Petroleum Hydrocarbons/SW-846 9071	NE	NE		**6,720**	**6,510**	**8,840**	**33,000**
Metals/							
SW-846 6010B/7471A (mg/kg)	**RDCSCC**	**NRDCSCC**					
Arsenic	20	20		**15**	**11.6**	**12.6**	**15.7 B**
Barium	700	47,000		**171**	**142**	**210**	**345**
Cadmium	39	100		**3.8**	**3.7**	**5.9**	**7.55**
Chromium	120,000	NE		**127**	**106**	**152**	**213**
Lead	400	600		**484**	**420**	**635**	**648**
Nickel	250	2,400		**44.4**	**40.5**	**45.2**	**58.8**
Selenium	63	3,100		**2.9**	**0.9**	**1.5**	1.66 U
Silver	110	4,100		**1.8**	**1.9**	**2.8**	**3.46**
Zinc	1,500	1,500		**732 J**	**536**	**822 J**	**932**
Mercury	14	270		**2.9**	**2.8**	**3.7**	**3.48**

TABLE 1
LOWER PASSAIC RIVER DATA SUMMARY TABLE
BIOGENESIS SEDIMENT WASHING TECHNOLOGY DEMONSTRATION PROJECT

		Location Identification	**Treated Sediment - portion from initial solids removal process (scalping screen)**			
		Field Sample Identification	TS1-020506-1620	TS1-030506-1620	TS1-040506-1620	TS1-040506-1620B
Analyte/Methods (Units)		**Sample Date** **Sample Time**	5/2/06 1620	5/3/06 1620	5/4/06 1620	5/4/06 1620
Polynuclear Aromatic Hydrocarbons (PAHs)/						
SW-846 8270 SIM (µg/kg)	**RDCSCC**	**NRDCSCC**				
Acenaphthene	3,400,000	10,000,000	**780**	**1,200**	**1,600**	**2,750**
Acenaphthylene	NE	NE	**2,300**	**3,100**	**3,700**	**4,570**
Anthracene	10,000,000	10,000,000	**2,700**	**4,700**	**6,300**	**8,420**
Benzo(a)anthracene	900	4,000	**7,400**	**9,900**	**15,000**	**16,100**
Benzo(a)pyrene	660	660	**6,500**	**9,700**	**15,000**	**17,200**
Benzo(b)fluoranthene	900	4,000	**6,200**	**9,800**	**14,000**	**12,300**
Benzo(ghi)perylene	NE	NE	**4,100**	**6,200**	**10,000**	**11,500**
Benzo(k)fluoranthene	900	4,000	**2,400**	**3,300**	**5,800**	**13,800**
Chrysene	9,000	40,000	**7,700**	**12,000**	**16,000**	**18,300**
Dibenzo(a,h)anthracene	660	660	**1,200**	**1,800**	**2,600**	**3,750**
Fluoranthene	2,300,000	10,000,000	**9,600**	**16,000**	**21,000**	**41,600**
Fluorene	2,300,000	10,000,000	**940**	**1,500**	**1,900**	**2,650**
Indeno (1,2,3-c,d)pyrene	900	4,000	**3,400**	**5,000**	**8,100**	**9,540**
Naphthalene	230,000	4,200,000	**630**	**790**	**1,300**	**3,370**
Phenanthrene	NE	NE	**5,500**	**9,200**	**13,000**	**19,100**
Pyrene	1,700,000	10,000,000	**9,800**	**13,000**	**20,000**	**42,900**

TABLE 1
LOWER PASSAIC RIVER DATA SUMMARY TABLE
BIOGENESIS SEDIMENT WASHING TECHNOLOGY DEMONSTRATION PROJECT

			Location Identification	Treated Sediment - portion from second solids removal process (hydrocyclones)			
			Field Sample Identification	TS2-020506-1625	TS2-030506-1625	TS2-040506-1625	TS2-040506-1625B
			Sample Date	5/2/06	5/3/06	5/4/06	5/4/06
Analyte/Methods (Units)			Sample Time	1625	1625	1625	1625
	New Jersey Standards						
General Soil Parameters	**RDCSCC**	**NRDCSCC**					
Percent Solids/EPA 160.3 M (%)	NE	NE		**70.3**	**70.6**	**71.1**	**76.9**
Grain Size Sand/D4464 (%)	NE	NE		**80.01**	**80.11**	**70.66**	--
Grain Size Silt/D4464 (%)	NE	NE		**19.49**	**19.38**	**26.94**	--
Grain Size Clay/D4464 (%)	NE	NE		**0.5**	**0.51**	**2.4**	--
Total Organic Carbon/Lloyd Kahn (mg/kg)	NE	NE		**30,900**	**19,200**	**11,900**	**15,000**
Total Petroleum Hydrocarbons/SW-846 9071	NE	NE		**1,940**	**1,540**	**1,100**	**3,200**
Metals/							
SW-846 6010B/7471A (mg/kg)	**RDCSCC**	**NRDCSCC**					
Arsenic	20	20		**4**	**2.5**	**2.7**	**5.21 B**
Barium	700	47,000		**88.6**	**59.3**	**65.8**	**345**
Cadmium	39	100		**1.8**	**1.4**	**1.8**	**2.04**
Chromium	120,000	NE		**59.6**	**28.4**	**33.4**	**79.5**
Lead	400	600		**274**	**150**	**180**	**167**
Nickel	250	2,400		**25.5**	**19.7**	**21.1**	**34.8**
Selenium	63	3,100		**1.2**	0.35 U	0.35 U	1.66 U
Silver	110	4,100		**1.3**	**1.6**	**1.6**	**1.93**
Zinc	1,500	1,500		**302 J**	**173**	**193 J**	**216**
Mercury	14	270		**1.1**	**0.99**	**1.2**	**0.829**

TABLE 1
LOWER PASSAIC RIVER DATA SUMMARY TABLE
BIOGENESIS SEDIMENT WASHING TECHNOLOGY DEMONSTRATION PROJECT

	Location Identification		**Treated Sediment - portion from second solids removal process (hydrocyclones)**			
	Field Sample Identification		TS2-020506-1625	TS2-030506-1625	TS2-040506-1625	TS2-040506-1625B
	Sample Date		5/2/06	5/3/06	5/4/06	5/4/06
Analyte/Methods (Units)	**Sample Time**		1625	1625	1625	1625
Polynuclear Aromatic Hydrocarbons (PAHs)/						
SW-846 8270 SIM (µg/kg)	**RDCSCC**	**NRDCSCC**				
Acenaphthene	3,400,000	10,000,000	**140**	**98**	**150**	**134**
Acenaphthylene	NE	NE	**370**	**220**	**280**	**197**
Anthracene	10,000,000	10,000,000	**560**	**380**	**570**	**487**
Benzo(a)anthracene	900	4,000	**1,600**	**1,000**	**1,700**	**1,030**
Benzo(a)pyrene	660	660	**1,500**	**1,100**	**1,600**	**1,190**
Benzo(b)fluoranthene	900	4,000	**1,600**	**1,200**	**1,900**	**1,010**
Benzo(ghi)perylene	NE	NE	**1,100**	**860**	**1,300**	**939**
Benzo(k)fluoranthene	900	4,000	**560**	**430**	**700**	**1,090**
Chrysene	9,000	40,000	**1,700**	**1,300**	**1,900**	**1,280**
Dibenzo(a,h)anthracene	660	660	**270**	**210**	**310**	**288**
Fluoranthene	2,300,000	10,000,000	**2,500**	**1,900**	**2,800**	**3,370**
Fluorene	2,300,000	10,000,000	**180**	**120**	**170**	**160**
Indeno (1,2,3-c,d)pyrene	900	4,000	**920**	**710**	**1,100**	**798**
Naphthalene	230,000	4,200,000	**120**	**87 T**	**140**	**233**
Phenanthrene	NE	NE	**1,300**	**860**	**1,300**	**1,170**
Pyrene	1,700,000	10,000,000	**2,300**	**1,700**	**2,600**	**3,210**

TABLE 1
LOWER PASSAIC RIVER DATA SUMMARY TABLE
BIOGENESIS SEDIMENT WASHING TECHNOLOGY DEMONSTRATION PROJECT

			Treated Sediment - portion from initial solids removal process (centrifuge)			
	Location Identification					
	Field Sample Identification		TS3-020506-1630	TS3-030506-1630	TS3-040506-1630	TS3-040506-1630B
Analyte/Methods (Units)	**Sample Date / Sample Time**		5/2/06 1630	5/3/06 1630	5/4/06 1630	5/4/06 1630
	New Jersey Standards					
General Soil Parameters	**RDCSCC**	**NRDCSCC**				
Percent Solids/EPA 160.3 M (%)	NE	NE	**63.6**	**66.6**	**65.3**	**66.6**
Grain Size Sand/D4464 (%)	NE	NE	**10.9**	**19.26**	**14.12**	--
Grain Size Silt/D4464 (%)	NE	NE	**67.94**	**63.14**	**64.77**	--
Grain Size Clay/D4464 (%)	NE	NE	**21.16**	**17.6**	**21.11**	--
Total Organic Carbon/Lloyd Kahn (mg/kg)	NE	NE	**49,100**	**42,000**	**46,800**	**48,600**
Total Petroleum Hydrocarbons/SW-846 9071	NE	NE	**2,060**	**1,270**	**1,210**	**3,600**
Metals/						
SW-846 6010B/7471A (mg/kg)	**RDCSCC**	**NRDCSCC**				
Arsenic	20	20	**8**	**7.3**	**7.3**	**9.15 B**
Barium	700	47,000	**141**	**129**	**135**	**453**
Cadmium	39	100	**3.2**	**4.1**	**4.2**	**5.15**
Chromium	120,000	NE	**102**	**91.2**	**92.2**	**153**
Lead	400	600	**247**	**232**	**235**	**277**
Nickel	250	2,400	**39.3**	**36.3**	**37**	**55.9**
Selenium	63	3,100	**2.1**	**0.76**	0.38 U	1.66 U
Silver	110	4,100	**3.3**	**3**	**3**	**4.12**
Zinc	1,500	1,500	**406 J**	**352**	**371 J**	**479**
Mercury	14	270	**3.2**	**2.9**	**3**	**2.95**

TABLE 1
LOWER PASSAIC RIVER DATA SUMMARY TABLE
BIOGENESIS SEDIMENT WASHING TECHNOLOGY DEMONSTRATION PROJECT

		Location Identification	**Treated Sediment - portion from initial solids removal process (centrifuge)**			
		Field Sample Identification	TS3-020506-1630	TS3-030506-1630	TS3-040506-1630	TS3-040506-1630B
Analyte/Methods (Units)		**Sample Date** **Sample Time**	5/2/06 1630	5/3/06 1630	5/4/06 1630	5/4/06 1630
Polynuclear Aromatic Hydrocarbons (PAHs)/						
SW-846 8270 SIM (µg/kg)	**RDCSCC**	**NRDCSCC**				
Acenaphthene	3,400,000	10,000,000	**290**	**170**	**200**	**355**
Acenaphthylene	NE	NE	**580**	**350**	**390**	**557**
Anthracene	10,000,000	10,000,000	**880**	**620**	**810**	**1,280**
Benzo(a)anthracene	900	4,000	**2,000**	**1,500**	**1,900**	**2,300**
Benzo(a)pyrene	660	660	**2,000**	**1,500**	**1,700**	**2,630**
Benzo(b)fluoranthene	900	4,000	**2,200**	**1,800**	**2,000**	**2,400**
Benzo(ghi)perylene	NE	NE	**1,700**	**1,200**	**1,500**	**2,190**
Benzo(k)fluoranthene	900	4,000	**1,100**	**630**	**820**	**2,450**
Chrysene	9,000	40,000	**2,500**	**2,100**	**2,300**	**2,970**
Dibenzo(a,h)anthracene	660	660	**460**	**290**	**340**	**651**
Fluoranthene	2,300,000	10,000,000	**3,500**	**2,900**	**3,300**	**7,240**
Fluorene	2,300,000	10,000,000	**340**	**210**	**250**	**478**
Indeno (1,2,3-c,d)pyrene	900	4,000	**1,400**	**990**	**1,100**	**1,780**
Naphthalene	230,000	4,200,000	**310**	**220**	**280**	**722**
Phenanthrene	NE	NE	**1,600**	**1,300**	**1,700**	**2,540**
Pyrene	1,700,000	10,000,000	**3,400**	**2,600**	**3,100**	**7,220**

TABLE 1
LOWER PASSAIC RIVER DATA SUMMARY TABLE
BIOGENESIS SEDIMENT WASHING TECHNOLOGY DEMONSTRATION PROJECT

			Wastewater sludge			
Location Identification						
Field Sample Identification			WS-020506-1640	WS-030506-1640	WS-040506-1640	WS-040506-1640B
Sample Date			5/2/06	5/3/06	5/4/06	5/4/06
Analyte/Methods (Units)		**Sample Time**	1640	1640	1640	1640
	New Jersey Standards					
General Soil Parameters	**RDCSCC**	**NRDCSCC**				
Percent Solids/EPA 160.3 M (%)	NE	NE	**27.2**	**26.2**	**24**	**31.2**
Grain Size Sand/D4464 (%)	NE	NE	**4.36**	**7.76**	**2.61**	--
Grain Size Silt/D4464 (%)	NE	NE	**72.86**	**72.82**	**79.02**	--
Grain Size Clay/D4464 (%)	NE	NE	**22.79**	**19.42**	**18.37**	--
Total Organic Carbon/Lloyd Kahn (mg/kg)	NE	NE	**123,000**	**130,000**	**122,000**	**109,000**
Total Petroleum Hydrocarbons/SW-846 9071	NE	NE	**6,770**	**1,900**	**2,770**	**4,600**
Metals/						
SW-846 6010B/7471A (mg/kg)	**RDCSCC**	**NRDCSCC**				
Arsenic	20	20	**21.2**	**20.5**	**21.4**	**30.2 B**
Barium	700	47,000	**339**	**311**	**341**	**690**
Cadmium	39	100	**12.8**	**13.3**	**15.6**	**19.6**
Chromium	120,000	NE	**465**	**436**	**455**	**639**
Lead	400	600	**604**	**591**	**687**	**888**
Nickel	250	2,400	**69.1**	**63.4**	**69.3**	**97.9**
Selenium	63	3,100	**4.9**	**2.2**	**1.5**	1.66 U
Silver	110	4,100	**16.4**	**15.7**	**16.7**	**22.1**
Zinc	1,500	1,500	**1290 J**	**1070**	**1230 J**	**1720**
Mercury	14	270	**9**	**9.3**	**9.6**	**9.29**

TABLE 1
LOWER PASSAIC RIVER DATA SUMMARY TABLE
BIOGENESIS SEDIMENT WASHING TECHNOLOGY DEMONSTRATION PROJECT

		Location Identification	**Wastewater sludge**			
		Field Sample Identification	WS-020506-1640	WS-030506-1640	WS-040506-1640	WS-040506-1640B
Analyte/Methods (Units)		**Sample Date** **Sample Time**	5/2/06 1640	5/3/06 1640	5/4/06 1640	5/4/06 1640
Organochlorine Pesticides/						
SW-846 8081A (µg/kg)	**RDCSCC**	**NRDCSCC**				
4,4'-DDD	3,000	12,000	--	**140 TJ**	--	--
4,4'-DDE	2,000	9,000	--	**97 T**	--	--
4,4'-DDT	2,000	9,000	--	**160**	--	--
Aldrin	40	170	--	*20 U*	--	--
alpha-BHC	NE	NE	--	160 U	--	--
alpha-Chlordane	NE	NE	--	160 U	--	--
beta-BHC	NE	NE	--	160 U	--	--
Chlordane (technical)	NE	NE	--	1600 U	--	--
delta-BHC	NE	NE	--	160 U	--	--
Dieldrin	42	180	--	**40 T**	--	--
Endosulfan I	340,000[a]	6,200,000[b]	--	160 U	--	--
Endosulfan II	340,000[a]	6,200,000[b]	--	**110 TJ**	--	--
Endosulfan sulfate	340,000[a]	6,200,000[b]	--	160 U	--	--
Endrin	17,000	310,000	--	**85 TJ**	--	--
Endrin aldehyde	NE	NE	--	160 U	--	--
Endrin ketone	NE	NE	--	160 U	--	--
gamma-BHC (Lindane)	520	2,200	--	160 U	--	--
gamma-Chlordane	NE	NE	--	160 U	--	--
Heptachlor	150	650	--	160 U	--	--
Heptachlor epoxide	NE	NE	--	160 U	--	--
Methoxychlor	280,000	5,200,000	--	320 U	--	--
Toxaphene	100	200	--	*220 U*	--	--

TABLE 1
LOWER PASSAIC RIVER DATA SUMMARY TABLE
BIOGENESIS SEDIMENT WASHING TECHNOLOGY DEMONSTRATION PROJECT

		Location Identification	**Wastewater sludge**			
		Field Sample Identification	WS-020506-1640	WS-030506-1640	WS-040506-1640	WS-040506-1640B
		Sample Date	5/2/06	5/3/06	5/4/06	5/4/06
Analyte/Methods (Units)		**Sample Time**	1640	1640	1640	1640
Poly Chlorinated Biphenyls (PCBs)/						
SW-846 8082 (µg/kg)	**RDCSCC**	**NRDCSCC**				
(BZ 1) 2-Chlorobiphenyl	NE	NE	--	**60 TJB**	--	--
(BZ 101) 2,2',4,5, 5'-Pentachlorobiphenyl	NE	NE	--	6.5 U	--	--
(BZ 110) 2,3,3',4',6-Pentachlorobiphenyl	NE	NE	--	**60**	--	--
(BZ 141) 2,2',3,4,5,5'-Hexachlorobiphenyl	NE	NE	--	**14**	--	--
(BZ 151) 2,2',3,5,5',6-Hexachlorobiphenyl	NE	NE	--	6.5 U	--	--
(BZ 153) 2,2',4,4',5,5'-Hexachlorobiphenyl	NE	NE	--	**43**	--	--
(BZ 170) 2,2',3,3',4,4',5-Heptachlorobiphen	NE	NE	--	**21**	--	--
(BZ 18) 2,2',5-Trichlorobiphenyl	NE	NE	--	**88**	--	--
(BZ 180) 2,2',3,4,4',5,5'-Heptachlorobiphen	NE	NE	--	**27 J**	--	--
(BZ 187) 2,2',3,4',5,5',6-Heptachlorobiphen	NE	NE	--	**26**	--	--
(BZ 206) 2,2',3,3',4,4',5,5',6-Nonachlorobip	NE	NE	--	**8.7**	--	--
(BZ 31) 2,4',5-Trichlorobiphenyl	NE	NE	--	**93**	--	--
(BZ 5) 2,3-Dichlorobiphenyl	NE	NE	--	**1.4 TJ**	--	--
(BZ 52) 2,2',5,5'-Tetrachlorobiphenyl	NE	NE	--	**79**	--	--
(BZ 66) 2,3',4,4'-Tetrachlorobiphenyl	NE	NE	--	**72**	--	--
(BZ 87) 2,2',3,4,5'-Pentachlorobiphenyl	NE	NE	--	**16 J**	--	--
Total PCB Congeners	490	2,000	--	**609.1**	--	--

TABLE 1
LOWER PASSAIC RIVER DATA SUMMARY TABLE
BIOGENESIS SEDIMENT WASHING TECHNOLOGY DEMONSTRATION PROJECT

		Location Identification	**Wastewater sludge**			
		Field Sample Identification	WS-020506-1640	WS-030506-1640	WS-040506-1640	WS-040506-1640B
		Sample Date	5/2/06	5/3/06	5/4/06	5/4/06
Analyte/Methods (Units)		**Sample Time**	1640	1640	1640	1640
Semi-Volatile Organic Compounds (SVOCs)/						
SW-846 8270C (µg/kg)	**RDCSCC**	**NRDCSCC**				
1,4-Dichlorobenzene	570,000	10,000,000	--	**98 T**	--	--
2,4,5-Trichlorophenol	5,600,000	10,000,000	--	3200 U	--	--
2,4,6-Trichlorophenol	62,000	270,000	--	3200 U	--	--
2,4-Dinitrotoluene	1,000	4,000	--	*33 U*	--	--
2-Methylphenol	2,800,000	10,000,000	--	3200 U	--	--
3-Methylphenol & 4-Methylphenol	2,800,000	10,000,000	--	3200 U	--	--
Acenaphthene	3,400,000	10,000,000	--	**190 T**	--	--
Acenaphthylene	NE	NE	--	**360 T**	--	--
Anthracene	10,000,000	10,000,000	--	**520 T**	--	--
Benzo(a)anthracene	900	4,000	--	**910 T**	--	--
Benzo(a)pyrene	660	660	--	**860 T**	--	--
Benzo(b)fluoranthene	900	4,000	--	**1300 T**	--	--
Benzo(ghi)perylene	NE	NE	--	**360 T**	--	--
Benzo(k)fluoranthene	900	4,000	--	**510 T**	--	--
Chrysene	9,000	40,000	--	**1200 T**	--	--
Dibenz(a,h)anthracene	660	660	--	**95 T**	--	--
Fluoranthene	2,300,000	10,000,000	--	**2800 T**	--	--
Fluorene	2,300,000	10,000,000	--	**180 T**	--	--
Hexachlorobenzene	660	2,000	--	*64 U*	--	--
Hexachlorobutadiene	1,000	21,000	--	*62 U*	--	--
Hexachloroethane	6,000	100,000	--	3200 U	--	--
Indeno(1,2,3-cd)pyrene	900	4,000	--	**410 T**	--	--
Naphthalene	230,000	4,200,000	--	**170 T**	--	--
Nitrobenzene	28,000	520,000	--	3200 U	--	--
Pentachlorophenol	6,000	24,000	--	*4400 U*	--	--
Pyrene	1,700,000	10,000,000	--	**2100 T**	--	--

TABLE 1
LOWER PASSAIC RIVER DATA SUMMARY TABLE
BIOGENESIS SEDIMENT WASHING TECHNOLOGY DEMONSTRATION PROJECT

		Location Identification	**Wastewater sludge**			
		Field Sample Identification	WS-020506-1640	WS-030506-1640	WS-040506-1640	WS-040506-1640B
		Sample Date	5/2/06	5/3/06	5/4/06	5/4/06
Analyte/Methods (Units)		**Sample Time**	1640	1640	1640	1640
Polynuclear Aromatic Hydrocarbons (PAHs)/						
SW-846 8270 SIM (µg/kg)	**RDCSCC**	**NRDCSCC**				
Acenaphthene	3,400,000	10,000,000	**260 T**	**150 T**	**140**	**351**
Acenaphthylene	NE	NE	**590**	**320**	**290**	**490**
Anthracene	10,000,000	10,000,000	**770**	**450**	**480**	**992**
Benzo(a)anthracene	900	4,000	**1,400**	**960**	**810**	**1,490**
Benzo(a)pyrene	660	660	**1,400**	**900**	**840**	**1,660**
Benzo(b)fluoranthene	900	4,000	**2,000**	**1,300**	**1,200**	**1,870**
Benzo(ghi)perylene	NE	NE	**1,300**	**800**	**770**	**1,520**
Benzo(k)fluoranthene	900	4,000	**690**	**520**	**520**	**1,940**
Chrysene	9,000	40,000	**2,000**	**1,300**	**1,200**	**2,130**
Dibenzo(a,h)anthracene	660	660	**290 T**	**180 T**	**170**	**425**
Fluoranthene	2,300,000	10,000,000	**3,100**	**2,100**	**1,900**	**6,040**
Fluorene	2,300,000	10,000,000	**270 T**	**170 T**	**140**	**352**
Indeno (1,2,3-c,d)pyrene	900	4,000	**1,000**	**670**	**630**	**1,320**
Naphthalene	230,000	4,200,000	**220 T**	**130 T**	**140**	**385**
Phenanthrene	NE	NE	**1,000**	**650**	**660**	**1,520**
Pyrene	1,700,000	10,000,000	**3,000**	**2,000**	**1,700**	**6,320**

TABLE 1
LOWER PASSAIC RIVER DATA SUMMARY TABLE
BIOGENESIS SEDIMENT WASHING TECHNOLOGY DEMONSTRATION PROJECT

		Location Identification	**Wastewater sludge**			
		Field Sample Identification	WS-020506-1640	WS-030506-1640	WS-040506-1640	WS-040506-1640B
		Sample Date	5/2/06	5/3/06	5/4/06	5/4/06
Analyte/Methods (Units)		**Sample Time**	1640	1640	1640	1640
Dioxins and Furans/						
SW-846 8290 (pg/g)	**RDCSCC**	**NRDCSCC**				
1,2,3,4,6,7,8-HpCDD	NE	NE	--	**120**	--	--
1,2,3,4,6,7,8-HpCDF	NE	NE	--	**170**	--	--
1,2,3,4,7,8,9-HpCDF	NE	NE	--	**4.2 T**	--	--
1,2,3,4,7,8-HxCDD	NE	NE	--	**1 T**	--	--
1,2,3,4,7,8-HxCDF	NE	NE	--	**37**	--	--
1,2,3,6,7,8-HxCDD	NE	NE	--	**7.3 T**	--	--
1,2,3,6,7,8-HxCDF	NE	NE	--	**7.9 T**	--	--
1,2,3,7,8,9-HxCDD	NE	NE	--	**3.2 T**	--	--
1,2,3,7,8,9-HxCDF	NE	NE	--	20 U	--	--
1,2,3,7,8-PeCDD	NE	NE	--	20 U	--	--
1,2,3,7,8-PeCDF	NE	NE	--	**2.3 T**	--	--
2,3,4,6,7,8-HxCDF	NE	NE	--	**4.8 T**	--	--
2,3,4,7,8-PeCDF	NE	NE	--	**7.6 T**	--	--
2,3,7,8-TCDD	NE	NE	--	**57**	--	--
2,3,7,8-TCDF	NE	NE	--	**4**	--	--
OCDD	NE	NE	--	**1700 B**	--	--
OCDF	NE	NE	--	**140**	--	--
Total Dioxins & Furans - summed by toxic equivalency factor (TEF) methodology	NE	NE	--	**72.22**	--	--

TABLE 1
LOWER PASSAIC RIVER DATA SUMMARY TABLE
BIOGENESIS SEDIMENT WASHING TECHNOLOGY DEMONSTRATION PROJECT

NOTES:

g	gram(s)
pg/g	picogram(s) per gram
µg/kg	microgram(s) per kilogram
mg/kg	milligram(s) per kilogram
AD	Air dried
Dup	Duplicate
NRDCSCC	Non-residential direct contact soil cleanup criteria
RDCSCC	Residential direct contact soil cleanup criteria
NON-RES	Non-residential
PAH	Polynuclear aromatic hydrocarbon
PCB	Polychlorinated biphenyl
RES	Residential
RR	Rerun
SVOC	Semi-volatile organic compound
TEF	Toxicity Equivalency Factor
a	The sum of endosulfan I, endosulfan II, and endosulfan sulfate may not exceed 340,000 µg/kg.
b	The sum of endosulfan I, endosulfan II, and endosulfan sulfate may not exceed 6,200,000 µg/kg.
Bold	Bolded result indicates positively identified analyte.
Italics	Italicized result indicates the sample is reported to the method detection limit (MDL)
Shading	Shading indicates a result or reporting limit greater than the RDCSCC or NRDCSCC
--	Not scheduled
B	Analyte detected in associated blank
J	Data are estimated due to associated quality control data.
NE	Not established
NR	Not regulated in pathway
Q	Estimated maximum possible concentration (EMPC)
T	Analyte was positively identified but the reported concentration is estimated; reported concentration is less than the reporting limit, but greater than the method detection limit.
U	Analyte not detected above the method detection limit.
UB	Analyte considered not detected based on associated blank data.
UJ	Potential low bias, possible false negative.

TABLE 2
LOWER PASSAIC RIVER DATA SUMMARY TABLE
BIOGENESIS SEDIMENT WASHING TECHNOLOGY DEMONSTRATION PROJECT
Stockpiled Material

			Field Sample Identification	MSL01-040107-0905	MSL02-040107-0925	MSL03-040107-0940	MSL04-040107-0950
			Sample Date	1/4/07	1/4/07	1/4/07	1/4/07
Analyte/Methods (Units)			**Sample Time**	9:05	9:25	9:40	9:50
General Soil Parameters	**New Jersey Standards**						
MCAWW 160.3M/ASTM D4464/ Lloyd Kahn/SW-846 9071B	**RDCSCC**	**NRDCSCC**	**IGSCC**				
Percent Solids (%)	NE	NE	NE	**80.4 %**	**80.2 %**	**76.9 %**	**80.3 %**
Grain Size Sand (%)	NE	NE	NE	**9.32 %**	**14.2 %**	**12.78 %**	**12.40 %**
Grain Size Silt (%)	NE	NE	NE	**65.61 %**	**61.91 %**	**62.61 %**	**63.06 %**
Grain Size Clay (%)	NE	NE	NE	**25.07 %**	**23.89 %**	**24.61 %**	**24.53 %**
Total Organic Carbon (mg/kg)	NE	NE	NE	**22,200**	**22,400**	**25,900**	**36,000**
Total Petroleum Hydrocarbons (mg/kg)	NE	NE	NE	**767**	**619**	**672**	**598**
Inorganics/Metals (mg/kg)							
SW-846 6010B/7471A/7196A/9012A	**RDCSCC**	**NRDCSCC**	**IGSCC**				
Silver	110	4,100	NE	**0.97**	**1.0**	**1.2**	**0.99**
Arsenic	20	20	NE	**7.5**	**8.4**	**8.6**	**7.9**
Barium	700	47,000	NE	**81.6**	**96.9**	**102**	**92.6**
Cadmium	39	100	NE	**0.98**	**1.0**	**1.0**	**1.0**
Chromium (total)	NE	NE	NE	**36.0 N**	**35.5 N**	**39.1 N**	**36.9 N**
Nickel	250	2,400	NE	**15.5**	**17.3**	**17.8**	**16.6**
Lead	400	600	NE	**80.9**	**85.3**	**89.9**	**84.8**
Selenium	63	3,100	NE	**0.69**	**0.63**	**0.60**	**0.72**
Zinc	1,500	1,500	NE	**143 E**	**147 E**	**150 E**	**139 E**
Mercury	14	270	NE	**1.4**	**1.7**	**1.8**	**1.6**
Cyanide, total	1100	21,000	NE	0.62 U	0.62 U	**6.3**	0.62 U

TABLE 2
LOWER PASSAIC RIVER DATA SUMMARY TABLE
BIOGENESIS SEDIMENT WASHING TECHNOLOGY DEMONSTRATION PROJECT
Stockpiled Material

			Field Sample Identification	MSL01-040107-0905	MSL02-040107-0925	MSL03-040107-0940	MSL04-040107-0950
			Sample Date	1/4/07	1/4/07	1/4/07	1/4/07
Analyte/Methods (Units)			**Sample Time**	9:05	9:25	9:40	9:50
TCLP Metals (mg/L)							
SW-846 6010B/7471A/7196A/9012A	**RDCSCC**	**NRDCSCC**	**IGSCC**				
Silver	-	-	-	0.50 U	0.50 U	0.50 U	0.50 U
Arsenic	-	-	-	**0.21 T**	**0.21 T**	**0.21 T**	**0.22 T**
Barium	-	-	-	**0.18 T**	**0.21 T**	**0.19 T**	**0.20 T**
Cadmium	-	-	-	**0.014 T**	**0.0091 T**	**0.015 T**	**0.012 T**
Chromium (total)	-	-	-	**0.0046 T**	**0.0051 T**	**0.0055 T**	**0.0042 T**
Lead	-	-	-	**0.044 T**	**0.058 T**	**0.053 T**	**0.058 T**
Selenium	-	-	-	0.25 U	0.25 U	0.25 U	0.25 U
Mercury	-	-	-	0.00020 U	**0.00009 T**	**0.00005 T**	0.00020 U

TABLE 2
LOWER PASSAIC RIVER DATA SUMMARY TABLE
BIOGENESIS SEDIMENT WASHING TECHNOLOGY DEMONSTRATION PROJECT
Stockpiled Material

			Field Sample Identification	MSL01-040107-0905	MSL02-040107-0925	MSL03-040107-0940	MSL04-040107-0950
			Sample Date	1/4/07	1/4/07	1/4/07	1/4/07
Analyte/Methods (Units)			**Sample Time**	9:05	9:25	9:40	9:50
Organochlorine Pesticides (µg/kg)							
SW-846 8081A	**RDCSCC**	**NRDCSCC**	**IGSCC**				
Chlordane (technical)	NE	NE	NE	53 U	53 U	55 U	53 U
alpha-BHC	NE	NE	NE	5.3 U	5.3 U	5.5 U	5.3 U
beta-BHC	NE	NE	NE	5.3 U	5.3 U	5.5 U	5.3 U
delta-BHC	NE	NE	NE	5.3 U	5.3 U	5.5 U	5.3 U
gamma-BHC (Lindane)	520	2,200	50,000	5.3 U	5.3 U	5.5 U	5.3 U
Heptachlor	150	650	50,000	5.3 U	5.3 U	5.5 U	5.3 U
Aldrin	40	170	50,000	5.3 U	5.3 U	5.5 U	5.3 U
Heptachlor epoxide	NE	NE	NE	**1.8 T, PG**	**1.2 T, PG**	**1.1 T, PG**	**0.78 T, PG**
Endosulfan I	340,000[a]	6,200,000[b]	50,000[c]	5.3 U	5.3 U	5.5 U	5.3 U
Dieldrin	42	180	50,000	5.3 U	5.3 U	5.5 U	5.3 U
4,4'-DDE	2,000	9,000	50,000	**36**	**35**	**36**	**28**
Endrin	17,000	310,000	50,000	**3.7 T**	**2.9 T, PG**	**0.71 T, PG**	**0.96 T, PG**
Endrin ketone	NE	NE	NE	5.3 U	5.3 U	5.5 U	5.3 U
Endrin aldehyde	NE	NE	NE	**4.0 T, PG**	**8.2 PG**	**6.6**	**3.1 T, PG**
Endosulfan II	340,000[a]	6,200,000[b]	50,000[c]	5.3 U	5.3 U	5.5 U	5.3 U
4,4'-DDD	3,000	12,000	50,000	**38 PG**	**39 PG**	**35 PG**	**65 PG**
Endosulfan sulfate	340,000[a]	6,200,000[b]	50,000[c]	5.3 U	5.3 U	5.5 U	5.3 U
4,4'-DDT	2,000	9,000	500,000	**49**	**40**	**38**	**32**
Methoxychlor	280,000	5,200,000	50,000	**83**	**64**	**88**	**48**
alpha-Chlordane	NE	NE	NE	**8.1**	**7.8**	**3.5 T, PG**	**3.6 T, PG**
gamma-Chlordane	NE	NE	NE	5.3 U	5.3 U	**3.3 T, PG**	5.3 U
Toxaphene	100	200	50,000	*7.0 U*	*7.1 U*	*7.4 U*	*7.0 U*

TABLE 2
LOWER PASSAIC RIVER DATA SUMMARY TABLE
BIOGENESIS SEDIMENT WASHING TECHNOLOGY DEMONSTRATION PROJECT
Stockpiled Material

			Field Sample Identification	MSL01-040107-0905	MSL02-040107-0925	MSL03-040107-0940	MSL04-040107-0950
			Sample Date	1/4/07	1/4/07	1/4/07	1/4/07
Analyte/Methods (Units)			**Sample Time**	9:05	9:25	9:40	9:50
Semi-Volatile Organic Compounds (µg/kg)							
SW-846 8270C	**RDCSCC**	**NRDCSCC**	**IGSCC**				
Acenaphthene	3,400,000	10,000,000	100,000	**87 T**	**76 T**	**110 T**	**63 T**
Acenaphthylene	NE	NE	NE	**240 T**	**150 T**	**210 T**	**140 T**
Anthracene	10,000,000	10,000,000	100,000	**360 T**	**200 T**	**270 T**	**180 T**
Benzo(a)anthracene	900	4,000	500,000	**860 T**	**440 T**	**580 T**	**420 T**
Benzo(b)fluoranthene	900	4,000	50,000	**790 T**	**440 T**	**560 T**	**380 T**
Benzo(k)fluoranthene	900	4,000	500,000	**380 T**	**180 T**	**240 T**	**150 T**
Benzo(ghi)perylene	NE	NE	NE	**540 T**	**360 T**	**440 T**	**330 T**
Benzo(a)pyrene	660	660	100,000	**750 T**	**450 T**	**540 T**	**370 T**
Chrysene	9,000	40,000	500,000	**1,100 T**	**620 T**	**760 T**	**560 T**
Dibenz(a,h)anthracene	660	660	100,000	**120 T**	*34 U*	35 U	34 U
1,4-Dichlorobenzene	570,000	10,000,000	100,000	**65 T**	**49 T**	**54 T**	**43 T**
2,4-Dinitrotoluene	1,000	4,000	10,000	*22 U*	*22 U*	*23 U*	*22 U*
Fluoranthene	2,300,000	10,000,000	100,000	**1,400 T**	**660 T**	**960 T**	**640 T**
Fluorene	2,300,000	10,000,000	10,000	**150 T**	**97 T**	**150 T**	**89 T**
Hexachlorobenzene	660	2,000	100,000	*42 U*	*42 U*	*44 U*	*42 U*
Hexachlorobutadiene	1,000	21,000	100,000	*41 U*	*41 U*	*42 U*	*41 U*
Hexachloroethane	6,000	100,000	100,000	2,100 U	2,100 U	2,100 U	2,100 U
Indeno(1,2,3-cd)pyrene	900	4,000	500,000	**500 T**	**280 T**	**370 T**	**250 T**
2-Methylphenol	2,800,000	10,000,000	NE	2,100 U	2,100 U	2,100 U	2,100 U
3 and 4-Methylphenol	2,800,000	10,000,000	NE	2,100 U	2,100 U	2,100 U	2,100 U
Naphthalene	230,000	4,200,000	100,000	**110 T**	**89 T**	**110 T**	**84 T**
Nitrobenzene	28,000	520,000	10,000	2,100 U	2,100 U	2,100 U	2,100 U
Pentachlorophenol	6,000	24,000	100,000	*2,800 U*	*2,800 U*	*3,000 U*	*2,800 U*
Pyrene	1,700,000	10,000,000	100,000	**1,400 T**	**730 T**	**970 T**	**670 T**
2,4,5-Trichlorophenol	5,600,000	10,000,000	50,000	2,100 U	2,100 U	2,100 U	2,100 U
2,4,6-Trichlorophenol	62,000	270,000	10,000	2,100 U	2,100 U	2,100 U	2,100 U

TABLE 2
LOWER PASSAIC RIVER DATA SUMMARY TABLE
BIOGENESIS SEDIMENT WASHING TECHNOLOGY DEMONSTRATION PROJECT
Stockpiled Material

			Field Sample Identification	MSL01-040107-0905	MSL02-040107-0925	MSL03-040107-0940	MSL04-040107-0950
			Sample Date	1/4/07	1/4/07	1/4/07	1/4/07
Analyte/Methods (Units)			**Sample Time**	9:05	9:25	9:40	9:50
Polynuclear Aromatic Hydrocarbons µg/kg)	**RDCSCC**	**NRDCSCC**	**IGSCC**				
Acenaphthene	3,400,000	10,000,000	100,000	**94**	**68**	**130**	**79**
Acenaphthylene	NE	NE	NE	**230**	**140**	**260**	**180**
Anthracene	10,000,000	10,000,000	100,000	**350**	**180**	**340**	**220**
Benzo(a)anthracene	900	4,000	500,000	**900**	**430**	**680**	**480**
Benzo(b)fluoranthene	900	4,000	50,000	**1,000**	**530**	**930**	**580**
Benzo(k)fluoranthene	900	4,000	500,000	**460**	**240**	**300**	**270**
Benzo(ghi)perylene	NE	NE	NE	**680**	**420**	**670**	**460**
Benzo(a)pyrene	660	660	100,000	**870**	**480**	**780**	**520**
Chrysene	9,000	40,000	500,000	**1,000**	**510**	**800**	**600**
Dibenzo(a,h)anthracene	660	660	100,000	**190**	**110**	**170**	**120**
Fluoranthene	2,300,000	10,000,000	100,000	**1,100**	**680**	**1,200**	**820**
Fluorene	2,300,000	10,000,000	100,000	**130**	**86**	**150**	**96**
Indeno (1,2,3-c,d)pyrene	900	4,000	500,000	**570**	**340**	**550**	**370**
Naphthalene	230,000	4,200,000	100,000	**100**	**72**	**120**	**86**
Phenanthrene	NE	NE	NE	**630**	**430**	**800**	**490**
Pyrene	1,700,000	10,000,000	100,000	**1,300**	**760**	**1,200**	**860**

TABLE 2
LOWER PASSAIC RIVER DATA SUMMARY TABLE
BIOGENESIS SEDIMENT WASHING TECHNOLOGY DEMONSTRATION PROJECT
Stockpiled Material

			Field Sample Identification	MSL01-040107-0905	MSL02-040107-0925	MSL03-040107-0940	MSL04-040107-0950
			Sample Date	1/4/07	1/4/07	1/4/07	1/4/07
Analyte/Methods (Units)			**Sample Time**	9:05	9:25	9:40	9:50
Polychlorinated Biphenyls (µg/kg)							
SW-846 8082 (Congeners)	**RDCSCC**	**NRDCSCC**	**IGSCC**				
PCB 1 (BZ)	NE	NE	NE	**6.0 T, PG**	**13**	**6.0 T, PG**	**7.5 T, PG**
PCB 5 (BZ)	NE	NE	NE	**6.5 PG**	**9.1**	**1.9 PG**	**1.8 PG**
PCB 18 (BZ)	NE	NE	NE	**11**	**9.9**	**10**	**8.1**
PCB 31 (BZ)	NE	NE	NE	**19**	**18**	**14**	**14**
PCB 52 (BZ)	NE	NE	NE	**14**	**14**	**13**	**11**
PCB 66 (BZ)	NE	NE	NE	**11**	**9.9**	**7.1 PG**	**7.6**
PCB 87 (BZ)	NE	NE	NE	**3.3 PG**	**3.7 PG**	**2.5 PG**	**2.2 PG**
PCB 101 (BZ)	NE	NE	NE	**12**	**14**	**11**	**9.3**
PCB 110 (BZ)	NE	NE	NE	**9.1 PG**	**10 PG**	**7.8 PG**	**6.6 PG**
PCB 141 (BZ)	NE	NE	NE	**2.4**	**2.4**	**2.1**	**1.6**
PCB 151 (BZ)	NE	NE	NE	1.1 U	1.1 U	1.1 U	1.1 U
PCB 153 (BZ)	NE	NE	NE	**8.8 PG**	**12**	**7.4 PG**	**6.0 PG**
PCB 170 (BZ)	NE	NE	NE	**4.6**	**4.3**	**4.0**	**3.0**
PCB 180 (BZ)	NE	NE	NE	**9.0**	**8.3**	**8.3**	**6.1**
PCB 187 (BZ)	NE	NE	NE	**5.3**	**4.7**	**3.4 PG**	**3.5**
PCB 206 (BZ)	NE	NE	NE	**1.8**	**3.0**	**2.0**	**1.4**
Total PCBs (calculated)	490	2,000	50,000	**123.8**	**136.3**	**100.5**	**89.7**

TABLE 2
LOWER PASSAIC RIVER DATA SUMMARY TABLE
BIOGENESIS SEDIMENT WASHING TECHNOLOGY DEMONSTRATION PROJECT
Stockpiled Material

			Field Sample Identification	MSL01-040107-0905		MSL02-040107-0925		MSL03-040107-0940		MSL04-040107-0950		
			Sample Date	1/4/07		1/4/07		1/4/07		1/4/07		
Analyte/Methods (Units)			**Sample Time**	9:05		9:25		9:40		9:50		
Dioxins and Furans (pg/g)												
SW-846 8280	**RDCSCC**	**NRDCSCC**	**IGSCC**									
2,3,7,8-TCDD	NE	NE	NE	**42**		**50**		**47**		**21**		
1,2,3,7,8-PeCDD	NE	NE	NE	**1.2**	**Q,T**	**1.5**	**Q,T**	**1.4**	**T**	**1.1**	**Q,T**	
1,2,3,4,7,8-HxCDF	NE	NE	NE	**20**	**Q**	**1.4**	**Q,T**	**1.4**	**T**	**2.7**	**T**	
1,2,3,6,7,8-HxCDD	NE	NE	NE	**6.0**		**8.1**		**7.5**		**16**		
1,2,3,7,8,9-HxCDD	NE	NE	NE	**0.36**	**Q,T**	**5.2**		**3.8**	**T**	**11**		
1,2,3,4,6,7,8-HpCDD	NE	NE	NE	**100**		**130**		**110**		**800**		
OCDD	NE	NE	NE	**1,400**	**B**	**1,700**	**B**	**1,500**	**B**	**7,600**	**B,E**	
2,3,7,8-TCDF	NE	NE	NE	**4.2**	**Q,T**	**38**	**Q**	**35**	**Q**	**26**	**Q**	
1,2,3,7,8-PeCDF	NE	NE	NE	**2.3**	**T**	**3.0**	**T**	**2.4**	**Q,T**	**3.1**	**Q,T**	
2,3,4,7,8-PeCDF	NE	NE	NE	**5.3**	**Q**	**6.7**		**6.7**		**5.4**		
1,2,3,4,7,8-HxCDD	NE	NE	NE	**1.1**	**Q,T**	**24**	**Q**	**22**	**Q**	**18**	**Q**	
1,2,3,6,7,8-HxCDF	NE	NE	NE	**5.8**		**6.3**		**5.8**		**7.4**		
2,3,4,6,7,8-HxCDF	NE	NE	NE	**2.7**	**T**	**3.6**	**T**	**3.2**	**Q,T**	**4.5**	**T**	
1,2,3,7,8,9-HxCDF	NE	NE	NE	**0.57**	**T**	**0.84**	**Q,T**	5.0	U	**0.37**	**Q,T**	
1,2,3,4,6,7,8-HpCDF	NE	NE	NE	**72**	**Q**	**83**		**89**		**75**		
1,2,3,4,7,8,9-HpCDF	NE	NE	NE	**3.7**	**Q,T**	**4.1**	**Q,T**	**5.0**	**Q,T**	**4.2**	**T**	
OCDF	NE	NE	NE	**100**		**110**		**110**		**86**		
TEQ (calculated using 2005 WHO Factors)				**51**		**65**		**61**		**44**		

TABLE 2
LOWER PASSAIC RIVER DATA SUMMARY TABLE
BIOGENESIS SEDIMENT WASHING TECHNOLOGY DEMONSTRATION PROJECT
Stockpiled Material

			Field Sample Identification	MSL05-040107-1000	MSL06-040107-1015	MSL07-040107-1025	MSL08-040107-1035
			Sample Date	1/4/07	1/4/07	1/4/07	1/4/07
Analyte/Methods (Units)			**Sample Time**	10:00	10:15	10:25	10:35
General Soil Parameters	**New Jersey Standards**						
MCAWW 160.3M/ASTM D4464/ Lloyd Kahn/SW-846 9071B	**RDCSCC**	**NRDCSCC**	**IGSCC**				
Percent Solids (%)	NE	NE	NE	**81.9 %**	**81.9 %**	**80.3 %**	**80.1 %**
Grain Size Sand (%)	NE	NE	NE	**21.31 %**	**16.00 %**	**15.57 %**	**18.18 %**
Grain Size Silt (%)	NE	NE	NE	**57.32 %**	**61.25 %**	**61.84 %**	**58.91 %**
Grain Size Clay (%)	NE	NE	NE	**21.37 %**	**22.75 %**	**22.58 %**	**22.91 %**
Total Organic Carbon (mg/kg)	NE	NE	NE	**22,600**	**25,800**	**20,100**	**21,800**
Total Petroleum Hydrocarbons (mg/kg)	NE	NE	NE	**599**	**380**	**407**	**275**
Inorganics/Metals (mg/kg)							
SW-846 6010B/7471A/7196A/9012A	**RDCSCC**	**NRDCSCC**	**IGSCC**				
Silver	110	4,100	NE	**0.89**	**1.1**	**0.87**	**0.94**
Arsenic	20	20	NE	**7.7**	**9.3**	**8.1**	**7.5**
Barium	700	47,000	NE	**89.1**	**103**	**82.1**	**83.9**
Cadmium	39	100	NE	**0.92**	**1.0**	**0.89**	**0.89**
Chromium (total)	NE	NE	NE	**35.0 N**	**40.2 N**	**38.2 N**	**33.4 N**
Nickel	250	2,400	NE	**16.2**	**17.7**	**14.6**	**16.0**
Lead	400	600	NE	**77.3**	**92.8**	**77.5**	**80.3**
Selenium	63	3,100	NE	**0.59**	**0.60**	**0.62**	**0.55**
Zinc	1,500	1,500	NE	**127 E**	**174 E**	**149 E**	**147 E**
Mercury	14	270	NE	**1.5**	**1.8**	**1.5**	**1.7**
Cyanide, total	1100	21,000	NE	0.61 U	0.64 U	0.62 U	0.62 U

TABLE 2
LOWER PASSAIC RIVER DATA SUMMARY TABLE
BIOGENESIS SEDIMENT WASHING TECHNOLOGY DEMONSTRATION PROJECT
Stockpiled Material

			Field Sample Identification	MSL05-040107-1000	MSL06-040107-1015	MSL07-040107-1025	MSL08-040107-1035
			Sample Date	1/4/07	1/4/07	1/4/07	1/4/07
Analyte/Methods (Units)			**Sample Time**	10:00	10:15	10:25	10:35
TCLP Metals (mg/L)							
SW-846 6010B/7471A/7196A/9012A	**RDCSCC**	**NRDCSCC**	**IGSCC**				
Silver	-	-	-	0.50 U	0.50 U	0.50 U	0.50 U
Arsenic	-	-	-	**0.22 T**	**0.20 T**	**0.22 T**	**0.22 T**
Barium	-	-	-	**0.21 T**	**0.21 T**	**0.19 T**	**0.19 T**
Cadmium	-	-	-	**0.012 T**	**0.015 T**	**0.0076 T**	**0.0099 T**
Chromium (total)	-	-	-	**0.0057 T**	**0.0054 T**	**0.0055 T**	**0.0042 T**
Lead	-	-	-	**0.057 T**	**0.052 T**	**0.058 T**	**0.061 T**
Selenium	-	-	-	0.25 U	0.25 U	0.25 U	0.25 U
Mercury	-	-	-	0.00020 U	0.00020 U	**0.00007 T**	0.00020 U

TABLE 2
LOWER PASSAIC RIVER DATA SUMMARY TABLE
BIOGENESIS SEDIMENT WASHING TECHNOLOGY DEMONSTRATION PROJECT
Stockpiled Material

			Field Sample Identification	MSL05-040107-1000	MSL06-040107-1015	MSL07-040107-1025	MSL08-040107-1035
			Sample Date	1/4/07	1/4/07	1/4/07	1/4/07
Analyte/Methods (Units)			**Sample Time**	10:00	10:15	10:25	10:35
Organochlorine Pesticides (µg/kg)							
SW-846 8081A	**RDCSCC**	**NRDCSCC**	**IGSCC**				
Chlordane (technical)	NE	NE	NE	52 U	55 U	530 U	53 U
alpha-BHC	NE	NE	NE	5.2 U	5.5 U	53 U	5.3 U
beta-BHC	NE	NE	NE	5.2 U	5.5 U	53 U	5.3 U
delta-BHC	NE	NE	NE	5.2 U	5.5 U	53 U	5.3 U
gamma-BHC (Lindane)	520	2,200	50,000	5.2 U	5.5 U	53 U	5.3 U
Heptachlor	150	650	50,000	5.2 U	5.5 U	53 U	5.3 U
Aldrin	40	170	50,000	**1.1 T, PG**	5.5 U	*6.6 U*	5.3 U
Heptachlor epoxide	NE	NE	NE	**1.1 T, PG**	**1.3 T, PG**	53 U	**0.83 T, PG**
Endosulfan I	340,000[a]	6,200,000[b]	50,000[c]	5.2 U	5.5 U	53 U	5.3 U
Dieldrin	42	180	50,000	5.2 U	5.5 U	*5.0 U*	5.3 U
4,4'-DDE	2,000	9,000	50,000	**32**	**33**	**19 T**	**27**
Endrin	17,000	310,000	50,000	**0.71 T, PG**	**3.3 T, PG**	53 U	**1.5 T, PG**
Endrin ketone	NE	NE	NE	5.2 U	5.5 U	53 U	5.3 U
Endrin aldehyde	NE	NE	NE	**6.4**	**8.3**	53 U	**8.5**
Endosulfan II	340,000[a]	6,200,000[b]	50,000[c]	5.2 U	5.5 U	53 U	5.3 U
4,4'-DDD	3,000	12,000	50,000	**34 PG**	**39 PG**	**36 T, PG**	**28 PG**
Endosulfan sulfate	340,000[a]	6,200,000[b]	50,000[c]	5.2 U	5.5 U	53 U	5.3 U
4,4'-DDT	2,000	9,000	500,000	**42**	**34**	**30 T, PG**	**69**
Methoxychlor	280,000	5,200,000	50,000	**100**	**63**	**1,100**	**42**
alpha-Chlordane	NE	NE	NE	5.2 U	**7.4**	53 U	**2.9 T, PG**
gamma-Chlordane	NE	NE	NE	**2.2 T, PG**	**5.9**	53 U	**1.9 T, PG**
Toxaphene	100	200	50,000	*6.9 U*	*7.3 U*	*70 U*	*7.1 U*

TABLE 2
LOWER PASSAIC RIVER DATA SUMMARY TABLE
BIOGENESIS SEDIMENT WASHING TECHNOLOGY DEMONSTRATION PROJECT
Stockpiled Material

			Field Sample Identification	MSL05-040107-1000	MSL06-040107-1015	MSL07-040107-1025	MSL08-040107-1035
			Sample Date	1/4/07	1/4/07	1/4/07	1/4/07
Analyte/Methods (Units)			**Sample Time**	10:00	10:15	10:25	10:35
Semi-Volatile Organic Compounds (µg/kg)							
SW-846 8270C	**RDCSCC**	**NRDCSCC**	**IGSCC**				
Acenaphthene	3,400,000	10,000,000	100,000	**67 T**	**94 T**	**73 T**	**69 T**
Acenaphthylene	NE	NE	NE	**200 T**	**230 T**	**170 T**	**160 T**
Anthracene	10,000,000	10,000,000	100,000	**190 T**	**240 T**	**180 T**	**170 T**
Benzo(a)anthracene	900	4,000	500,000	**490 T**	**550 T**	**460 T**	**420 T**
Benzo(b)fluoranthene	900	4,000	50,000	**450 T**	**470 T**	**380 T**	**350 T**
Benzo(k)fluoranthene	900	4,000	500,000	**220 T**	**200 T**	**180 T**	**160 T**
Benzo(ghi)perylene	NE	NE	NE	**400 T**	**330 T**	**230 T**	**220 T**
Benzo(a)pyrene	660	660	100,000	**460 T**	**480 T**	**390 T**	**360 T**
Chrysene	9,000	40,000	500,000	**650 T**	**690 T**	**590 T**	**530 T**
Dibenz(a,h)anthracene	660	660	100,000	33 U	35 U	34 U	34 U
1,4-Dichlorobenzene	570,000	10,000,000	100,000	**45 T**	**55 T**	2,100 U	2,100 U
2,4-Dinitrotoluene	1,000	4,000	10,000	*21 U*	*22 U*	*22 U*	*22 U*
Fluoranthene	2,300,000	10,000,000	100,000	**770 T**	**870 T**	**790 T**	**630 T**
Fluorene	2,300,000	10,000,000	10,000	**96 T**	**110 T**	**94 T**	**92 T**
Hexachlorobenzene	660	2,000	100,000	*41 U*	*43 U*	*42 U*	*42 U*
Hexachlorobutadiene	1,000	21,000	100,000	*40 U*	*42 U*	*41 U*	*41 U*
Hexachloroethane	6,000	100,000	100,000	2,000 U	2,100 U	2,100 U	2,100 U
Indeno(1,2,3-cd)pyrene	900	4,000	500,000	**310 T**	**300 T**	**250 T**	**200 T**
2-Methylphenol	2,800,000	10,000,000	NE	2,000 U	2,100 U	2,100 U	2,100 U
3 and 4-Methylphenol	2,800,000	10,000,000	NE	2,000 U	2,100 U	2,100 U	2,100 U
Naphthalene	230,000	4,200,000	100,000	**93 T**	**110 T**	**83 T**	**75 T**
Nitrobenzene	28,000	520,000	10,000	2,000 U	2,100 U	2,100 U	2,100 U
Pentachlorophenol	6,000	24,000	100,000	*2,800 U*	*2,900 U*	*2,800 U*	*2,900 U*
Pyrene	1,700,000	10,000,000	100,000	**740 T**	**850 T**	**690 T**	**630 T**
2,4,5-Trichlorophenol	5,600,000	10,000,000	50,000	2,000 U	2,100 U	2,100 U	2,100 U
2,4,6-Trichlorophenol	62,000	270,000	10,000	2,000 U	2,100 U	2,100 U	2,100 U

TABLE 2
LOWER PASSAIC RIVER DATA SUMMARY TABLE
BIOGENESIS SEDIMENT WASHING TECHNOLOGY DEMONSTRATION PROJECT
Stockpiled Material

			Field Sample Identification	MSL05-040107-1000	MSL06-040107-1015	MSL07-040107-1025	MSL08-040107-1035
			Sample Date	1/4/07	1/4/07	1/4/07	1/4/07
Analyte/Methods (Units)			**Sample Time**	10:00	10:15	10:25	10:35
Polynuclear Aromatic Hydrocarbons µg/kg)	**RDCSCC**	**NRDCSCC**	**IGSCC**				
Acenaphthene	3,400,000	10,000,000	100,000	**87**	**91**	**94**	**87**
Acenaphthylene	NE	NE	NE	**230**	**220**	**210**	**190**
Anthracene	10,000,000	10,000,000	100,000	**270**	**250**	**270**	**230**
Benzo(a)anthracene	900	4,000	500,000	**590**	**630**	**620**	**530**
Benzo(b)fluoranthene	900	4,000	50,000	**690**	**830**	**760**	**730**
Benzo(k)fluoranthene	900	4,000	500,000	**330**	**360**	**350**	**240**
Benzo(ghi)perylene	NE	NE	NE	**630**	**600**	**620**	**550**
Benzo(a)pyrene	660	660	100,000	**640**	**670**	**690**	**600**
Chrysene	9,000	40,000	500,000	**710**	**680**	**750**	**640**
Dibenzo(a,h)anthracene	660	660	100,000	**160**	**150**	**150**	**140**
Fluoranthene	2,300,000	10,000,000	100,000	**950**	**990**	**1,100**	**870**
Fluorene	2,300,000	10,000,000	100,000	**110**	**120**	**120**	**110**
Indeno (1,2,3-c,d)pyrene	900	4,000	500,000	**480**	**490**	**500**	**440**
Naphthalene	230,000	4,200,000	100,000	**110**	**110**	**97**	**90**
Phenanthrene	NE	NE	NE	**540**	**570**	**670**	**520**
Pyrene	1,700,000	10,000,000	100,000	**910**	**1,100**	**1,100**	**950**

TABLE 2
LOWER PASSAIC RIVER DATA SUMMARY TABLE
BIOGENESIS SEDIMENT WASHING TECHNOLOGY DEMONSTRATION PROJECT
Stockpiled Material

			Field Sample Identification	MSL05-040107-1000	MSL06-040107-1015	MSL07-040107-1025	MSL08-040107-1035
			Sample Date	1/4/07	1/4/07	1/4/07	1/4/07
Analyte/Methods (Units)			**Sample Time**	10:00	10:15	10:25	10:35
Polychlorinated Biphenyls (µg/kg)							
SW-846 8082 (Congeners)	**RDCSCC**	**NRDCSCC**	**IGSCC**				
PCB 1 (BZ)	NE	NE	NE	**5.3 T, PG**	**8.9 T, PG**	**5.7 T, PG**	**5.9 T, PG**
PCB 5 (BZ)	NE	NE	NE	**1.5 PG**	**1.8 PG**	**1.4 PG**	**1.5 PG**
PCB 18 (BZ)	NE	NE	NE	**8.2**	**10**	**7.6**	**8.5**
PCB 31 (BZ)	NE	NE	NE	**13**	**16**	**12**	**14**
PCB 52 (BZ)	NE	NE	NE	**11**	**13**	**9.7**	**11**
PCB 66 (BZ)	NE	NE	NE	**5.6**	**7.3 PG**	**7.2**	**8.1**
PCB 87 (BZ)	NE	NE	NE	**2.1 PG**	**2.5 PG**	**2.0**	**2.4 PG**
PCB 101 (BZ)	NE	NE	NE	**8.5**	**10**	**8.0**	**9.8**
PCB 110 (BZ)	NE	NE	NE	**6.3 PG**	**7.9 PG**	**6.1 PG**	**7.0 PG**
PCB 141 (BZ)	NE	NE	NE	**1.6**	**2.1**	**1.7**	**1.7**
PCB 151 (BZ)	NE	NE	NE	1.0 U	1.1 U	1.1 U	1.1 U
PCB 153 (BZ)	NE	NE	NE	**5.9 PG**	**7.3 PG**	**6.1 PG**	**6.6 PG**
PCB 170 (BZ)	NE	NE	NE	**2.8**	**2.7 PG**	**3.4**	**3.0**
PCB 180 (BZ)	NE	NE	NE	**5.8**	**5.5 PG**	**6.9**	**6.2**
PCB 187 (BZ)	NE	NE	NE	**3.5**	**3.2 PG**	**4.0**	**3.8**
PCB 206 (BZ)	NE	NE	NE	**1.1 PG**	**1.8**	**1.6**	**1.7**
Total PCBs (calculated)	490	2,000	50,000	**82.2**	**100.0**	**83.4**	**91.2**

TABLE 2
LOWER PASSAIC RIVER DATA SUMMARY TABLE
BIOGENESIS SEDIMENT WASHING TECHNOLOGY DEMONSTRATION PROJECT
Stockpiled Material

			Field Sample Identification	MSL05-040107-1000		MSL06-040107-1015		MSL07-040107-1025		MSL08-040107-1035	
			Sample Date	1/4/07		1/4/07		1/4/07		1/4/07	
Analyte/Methods (Units)			**Sample Time**	10:00		10:15		10:25		10:35	
Dioxins and Furans (pg/g)											
SW-846 8280	**RDCSCC**	**NRDCSCC**	**IGSCC**								
2,3,7,8-TCDD	NE	NE	NE	**17**		**59**		**47**		**23**	
1,2,3,7,8-PeCDD	NE	NE	NE	**0.62**	**Q,T**	**2.0**	**Q,T**	**1.6**	**T**	**0.83**	**Q,T**
1,2,3,4,7,8-HxCDF	NE	NE	NE	**0.59**	**T**	**2.2**	**T**	**1.6**	**Q,T**	**0.68**	**Q,T**
1,2,3,6,7,8-HxCDD	NE	NE	NE	**3.5**	**T**	**11**		**6.9**	**Q**	**4.5**	**T**
1,2,3,7,8,9-HxCDD	NE	NE	NE	**2.1**	**T**	**5.4**		**4.4**	**T**	**2.4**	**T**
1,2,3,4,6,7,8-HpCDD	NE	NE	NE	**46**		**160**		**130**		**56**	
OCDD	NE	NE	NE	**690**	**B**	**2,400**	**B**	**1,700**	**B**	**750**	**B**
2,3,7,8-TCDF	NE	NE	NE	**17**	**Q**	**7.7**		**5.6**		**3.0**	
1,2,3,7,8-PeCDF	NE	NE	NE	**1.2**	**T**	**3.4**	**Q,T**	**3.2**	**T**	**0.98**	**Q,T**
2,3,4,7,8-PeCDF	NE	NE	NE	**3.1**	**T**	**8.3**		**7.8**		**3.7**	**T**
1,2,3,4,7,8-HxCDD	NE	NE	NE	**11**	**Q**	**33**	**Q**	**31**	**Q**	**14**	**Q**
1,2,3,6,7,8-HxCDF	NE	NE	NE	**2.6**	**T**	**9.5**		**6.5**		**4.0**	**T**
2,3,4,6,7,8-HxCDF	NE	NE	NE	**1.4**	**T**	**4.9**	**Q,T**	**3.8**	**T**	**1.7**	**Q,T**
1,2,3,7,8,9-HxCDF	NE	NE	NE	**0.44**	**T**	**0.51**	**Q,T**	**0.46**	**T**	5.0	U
1,2,3,4,6,7,8-HpCDF	NE	NE	NE	**36**		**120**		**110**		**45**	
1,2,3,4,7,8,9-HpCDF	NE	NE	NE	**2.2**	**T**	**6.5**		**5.6**		**2.5**	**Q,T**
OCDF	NE	NE	NE	**220**		**160**		**150**		**54**	
TEQ (calculated using 2005 WHO Factors)				**24**		**75**		**60**		**30**	

TABLE 2
LOWER PASSAIC RIVER DATA SUMMARY TABLE
BIOGENESIS SEDIMENT WASHING TECHNOLOGY DEMONSTRATION PROJECT
Stockpiled Material

			Field Sample Identification	MSL09-040107-1045	MSL10-040107-1055	MSL11-040107-1055
			Sample Date	1/4/07	1/4/07	1/4/07
Analyte/Methods (Units)			**Sample Time**	10:45	10:55	10:55
General Soil Parameters	**New Jersey Standards**					
MCAWW 160.3M/ASTM D4464/ Lloyd Kahn/SW-846 9071B	**RDCSCC**	**NRDCSCC**	**IGSCC**			
Percent Solids (%)	NE	NE	NE	**77.4 %**	**78.1 %**	**80.4 %**
Grain Size Sand (%)	NE	NE	NE	**17.44 %**	**17.42 %**	**16.34 %**
Grain Size Silt (%)	NE	NE	NE	**60.06 %**	**59.93 %**	**60.36 %**
Grain Size Clay (%)	NE	NE	NE	**22.51 %**	**22.65 %**	**23.31 %**
Total Organic Carbon (mg/kg)	NE	NE	NE	**23,500**	**19,900**	**19,000**
Total Petroleum Hydrocarbons (mg/kg)	NE	NE	NE	**414**	**354**	**352**
Inorganics/Metals (mg/kg)						
SW-846 6010B/7471A/7196A/9012A	**RDCSCC**	**NRDCSCC**	**IGSCC**			
Silver	110	4,100	NE	**1.0**	**0.91**	**1.0**
Arsenic	20	20	NE	**7.4**	**8.1**	**7.1**
Barium	700	47,000	NE	**72.6**	**79.6**	**83.7**
Cadmium	39	100	NE	**0.92**	**0.83**	**0.99**
Chromium (total)	NE	NE	NE	**37.1 N**	**47.1 N**	**35.5 N**
Nickel	250	2,400	NE	**15.1**	**17.9**	**15.4**
Lead	400	600	NE	**85.1**	**77.1**	**79.1**
Selenium	63	3,100	NE	**0.41**	**0.46**	**0.44**
Zinc	1,500	1,500	NE	**128 E**	**130 E**	**127 E**
Mercury	14	270	NE	**1.5**	**1.5**	**1.5**
Cyanide, total	1100	21,000	NE	0.65 U	0.64 U	0.62 U

TABLE 2
LOWER PASSAIC RIVER DATA SUMMARY TABLE
BIOGENESIS SEDIMENT WASHING TECHNOLOGY DEMONSTRATION PROJECT
Stockpiled Material

			Field Sample Identification	MSL09-040107-1045	MSL10-040107-1055	MSL11-040107-1055
			Sample Date	1/4/07	1/4/07	1/4/07
Analyte/Methods (Units)			**Sample Time**	10:45	10:55	10:55
TCLP Metals (mg/L)						
SW-846 6010B/7471A/7196A/9012A	**RDCSCC**	**NRDCSCC**	**IGSCC**			
Silver	-	-	-	0.50 U	0.50 U	0.50 U
Arsenic	-	-	-	**0.21 T**	**0.23 T**	**0.24 T**
Barium	-	-	-	**0.15 T**	**0.19 T**	**0.17 T**
Cadmium	-	-	-	**0.015 T**	**0.0051 T**	**0.0030 T**
Chromium (total)	-	-	-	**0.0057 T**	**0.0052 T**	**0.0063 T**
Lead	-	-	-	**0.031 T**	**0.053 T**	**0.055 T**
Selenium	-	-	-	0.25 U	0.25 U	0.25 U
Mercury	-	-	-	0.00020 U	0.00020 U	**0.00007**

TABLE 2
LOWER PASSAIC RIVER DATA SUMMARY TABLE
BIOGENESIS SEDIMENT WASHING TECHNOLOGY DEMONSTRATION PROJECT
Stockpiled Material

			Field Sample Identification	MSL09-040107-1045	MSL10-040107-1055	MSL11-040107-1055
			Sample Date	1/4/07	1/4/07	1/4/07
Analyte/Methods (Units)			**Sample Time**	10:45	10:55	10:55
Organochlorine Pesticides (µg/kg)						
SW-846 8081A	**RDCSCC**	**NRDCSCC**	**IGSCC**			
Chlordane (technical)	NE	NE	NE	55 U	54 U	53 U
alpha-BHC	NE	NE	NE	5.5 U	5.4 U	5.3 U
beta-BHC	NE	NE	NE	5.5 U	5.4 U	5.3 U
delta-BHC	NE	NE	NE	5.5 U	5.4 U	5.3 U
gamma-BHC (Lindane)	520	2,200	50,000	5.5 U	5.4 U	5.3 U
Heptachlor	150	650	50,000	5.5 U	5.4 U	5.3 U
Aldrin	40	170	50,000	5.5 U	5.4 U	5.3 U
Heptachlor epoxide	NE	NE	NE	**1.4 T, PG**	**1.1 T, PG**	**1.0 T, PG**
Endosulfan I	340,000[a]	6,200,000[b]	50,000[c]	5.5 U	5.4 U	5.3 U
Dieldrin	42	180	50,000	**1.6 T, PG**	5.4 U	5.3 U
4,4'-DDE	2,000	9,000	50,000	**26**	**37**	**25**
Endrin	17,000	310,000	50,000	**0.87 T, PG**	**1.2 T, PG**	**1.2 T, PG**
Endrin ketone	NE	NE	NE	5.5 U	5.4 U	5.3 U
Endrin aldehyde	NE	NE	NE	**7.3**	**6.1 PG**	**8.5**
Endosulfan II	340,000[a]	6,200,000[b]	50,000[c]	5.5 U	5.4 U	5.3 U
4,4'-DDD	3,000	12,000	50,000	**24 PG**	**35 PG**	**26 PG**
Endosulfan sulfate	340,000[a]	6,200,000[b]	50,000[c]	5.5 U	5.4 U	5.3 U
4,4'-DDT	2,000	9,000	500,000	**36**	**190**	**24**
Methoxychlor	280,000	5,200,000	50,000	**18**	**71**	**27**
alpha-Chlordane	NE	NE	NE	**8.3**	**3.2 T, PG**	**2.8 T, PG**
gamma-Chlordane	NE	NE	NE	**6.7**	**2.6 T, PG**	**2.3 T, PG**
Toxaphene	100	200	50,000	*7.3 U*	*7.2 U*	*7.0 U*

TABLE 2
LOWER PASSAIC RIVER DATA SUMMARY TABLE
BIOGENESIS SEDIMENT WASHING TECHNOLOGY DEMONSTRATION PROJECT
Stockpiled Material

			Field Sample Identification	MSL09-040107-1045	MSL10-040107-1055	MSL11-040107-1055
			Sample Date	1/4/07	1/4/07	1/4/07
Analyte/Methods (Units)			**Sample Time**	10:45	10:55	10:55
Semi-Volatile Organic Compounds (µg/kg)						
SW-846 8270C	**RDCSCC**	**NRDCSCC**	**IGSCC**			
Acenaphthene	3,400,000	10,000,000	100,000	**66 T**	**61 T**	**61 T**
Acenaphthylene	NE	NE	NE	**260 T**	**150 T**	**170 T**
Anthracene	10,000,000	10,000,000	100,000	**220 T**	**130 T**	**150 T**
Benzo(a)anthracene	900	4,000	500,000	**610 T**	**360 T**	**400 T**
Benzo(b)fluoranthene	900	4,000	50,000	**550 T**	**290 T**	**360 T**
Benzo(k)fluoranthene	900	4,000	500,000	**250 T**	**140 T**	**160 T**
Benzo(ghi)perylene	NE	NE	NE	**350 T**	**150 T**	**200 T**
Benzo(a)pyrene	660	660	100,000	**600 T**	**300 T**	**370 T**
Chrysene	9,000	40,000	500,000	**810 T**	**450 T**	**520 T**
Dibenz(a,h)anthracene	660	660	100,000	35 U	35 U	34 U
1,4-Dichlorobenzene	570,000	10,000,000	100,000	**61 T**	2,100 U	2,100 U
2,4-Dinitrotoluene	1,000	4,000	10,000	*23 U*	*22 U*	*22 U*
Fluoranthene	2,300,000	10,000,000	100,000	**1,000 T**	**620 T**	**600 T**
Fluorene	2,300,000	10,000,000	10,000	**92 T**	**58 T**	**72 T**
Hexachlorobenzene	660	2,000	100,000	*43 U*	*43 U*	*42 U*
Hexachlorobutadiene	1,000	21,000	100,000	*42 U*	*42 U*	*41 U*
Hexachloroethane	6,000	100,000	100,000	2,100 U	2,100 U	2,100 U
Indeno(1,2,3-cd)pyrene	900	4,000	500,000	**300 T**	**150 T**	**180 T**
2-Methylphenol	2,800,000	10,000,000	NE	2,100 U	2,100 U	2,100 U
3 and 4-Methylphenol	2,800,000	10,000,000	NE	2,100 U	2,100 U	2,100 U
Naphthalene	230,000	4,200,000	100,000	**94 T**	**69 T**	**63 T**
Nitrobenzene	28,000	520,000	10,000	2,100 U	2,100 U	2,100 U
Pentachlorophenol	6,000	24,000	100,000	*3,000 U*	*2,900 U*	*2,800 U*
Pyrene	1,700,000	10,000,000	100,000	**860 T**	**460 T**	**570 T**
2,4,5-Trichlorophenol	5,600,000	10,000,000	50,000	2,100 U	2,100 U	2,100 U
2,4,6-Trichlorophenol	62,000	270,000	10,000	2,100 U	2,100 U	2,100 U

TABLE 2
LOWER PASSAIC RIVER DATA SUMMARY TABLE
BIOGENESIS SEDIMENT WASHING TECHNOLOGY DEMONSTRATION PROJECT
Stockpiled Material

			Field Sample Identification	MSL09-040107-1045	MSL10-040107-1055	MSL11-040107-1055
			Sample Date	1/4/07	1/4/07	1/4/07
Analyte/Methods (Units)			**Sample Time**	10:45	10:55	10:55
Polynuclear Aromatic Hydrocarbons µg/kg)	**RDCSCC**	**NRDCSCC**	**IGSCC**			
Acenaphthene	3,400,000	10,000,000	100,000	**68 T**	**80 T**	**73 T**
Acenaphthylene	NE	NE	NE	**300**	**210**	**200**
Anthracene	10,000,000	10,000,000	100,000	**270**	**220**	**210**
Benzo(a)anthracene	900	4,000	500,000	**640**	**500**	**510**
Benzo(b)fluoranthene	900	4,000	50,000	**940**	**670**	**610**
Benzo(k)fluoranthene	900	4,000	500,000	**330**	**280**	**290**
Benzo(ghi)perylene	NE	NE	NE	**720**	**510**	**510**
Benzo(a)pyrene	660	660	100,000	**790**	**550**	**570**
Chrysene	9,000	40,000	500,000	**830**	**590**	**580**
Dibenzo(a,h)anthracene	660	660	100,000	**180**	**130**	**130**
Fluoranthene	2,300,000	10,000,000	100,000	**1,100**	**860**	**840**
Fluorene	2,300,000	10,000,000	100,000	**95**	**100**	**95**
Indeno (1,2,3-c,d)pyrene	900	4,000	500,000	**570**	**400**	**400**
Naphthalene	230,000	4,200,000	100,000	**92**	**81 T**	**71 T**
Phenanthrene	NE	NE	NE	**500**	**470**	**420**
Pyrene	1,700,000	10,000,000	100,000	**1,100**	**830**	**820**

TABLE 2
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BIOGENESIS SEDIMENT WASHING TECHNOLOGY DEMONSTRATION PROJECT
Stockpiled Material

			Field Sample Identification	MSL09-040107-1045	MSL10-040107-1055	MSL11-040107-1055
			Sample Date	1/4/07	1/4/07	1/4/07
Analyte/Methods (Units)			**Sample Time**	10:45	10:55	10:55
Polychlorinated Biphenyls (µg/kg)						
SW-846 8082 (Congeners)	**RDCSCC**	**NRDCSCC**	**IGSCC**			
PCB 1 (BZ)	NE	NE	NE	**5.7 T, PG**	**10 T**	**8.5 T, PG**
PCB 5 (BZ)	NE	NE	NE	**1.1 PG**	**1.6 PG**	**1.7 PG**
PCB 18 (BZ)	NE	NE	NE	**7.8**	**8.7**	**9.2**
PCB 31 (BZ)	NE	NE	NE	**13**	**14**	**15**
PCB 52 (BZ)	NE	NE	NE	**11**	**11**	**12**
PCB 66 (BZ)	NE	NE	NE	**8.3**	**8.3**	**8.4**
PCB 87 (BZ)	NE	NE	NE	**2.9 PG**	**2.2 PG**	**2.3 PG**
PCB 101 (BZ)	NE	NE	NE	**9.7**	**8.7**	**9.5**
PCB 110 (BZ)	NE	NE	NE	**8.0 PG**	**6.4 PG**	**7.0 PG**
PCB 141 (BZ)	NE	NE	NE	**2.0**	**1.6**	**1.7**
PCB 151 (BZ)	NE	NE	NE	1.1 U	1.1 U	1.1 U
PCB 153 (BZ)	NE	NE	NE	**10 PG**	**6.1 PG**	**8.3**
PCB 170 (BZ)	NE	NE	NE	**3.7**	**3.0**	**3.1**
PCB 180 (BZ)	NE	NE	NE	**7.4**	**6.1**	**4.4 PG**
PCB 187 (BZ)	NE	NE	NE	**4.5**	**3.6**	**3.7**
PCB 206 (BZ)	NE	NE	NE	**1.7**	**1.0 T, PG**	**1.0 T, PG**
Total PCBs (calculated)	490	2,000	50,000	**96.8**	**92.3**	**95.8**

TABLE 2
LOWER PASSAIC RIVER DATA SUMMARY TABLE
BIOGENESIS SEDIMENT WASHING TECHNOLOGY DEMONSTRATION PROJECT
Stockpiled Material

			Field Sample Identification	MSL09-040107-1045		MSL10-040107-1055		MSL11-040107-1055	
			Sample Date	1/4/07		1/4/07		1/4/07	
Analyte/Methods (Units)			**Sample Time**	10:45		10:55		10:55	
Dioxins and Furans (pg/g)									
SW-846 8280	**RDCSCC**	**NRDCSCC**	**IGSCC**						
2,3,7,8-TCDD	NE	NE	NE	**36**		**55**		**20**	
1,2,3,7,8-PeCDD	NE	NE	NE	**0.99**	**T**	**1.2**	**T**	**0.57**	**Q,T**
1,2,3,4,7,8-HxCDF	NE	NE	NE	**0.94**	**Q,T**	**1.0**	**T**	**0.49**	**Q,T**
1,2,3,6,7,8-HxCDD	NE	NE	NE	**5.9**		**6.8**		**3.1**	**Q,T**
1,2,3,7,8,9-HxCDD	NE	NE	NE	**2.9**	**T**	**3.6**	**T**	**1.8**	**T**
1,2,3,4,6,7,8-HpCDD	NE	NE	NE	**81**		**120**		**45**	
OCDD	NE	NE	NE	**970**	**B**	**1,200**	**B**	**550**	**B**
2,3,7,8-TCDF	NE	NE	NE	**4.0**		**4.6**		**2.5**	
1,2,3,7,8-PeCDF	NE	NE	NE	**1.8**	**Q,T**	**2.4**	**T**	**1.3**	**T**
2,3,4,7,8-PeCDF	NE	NE	NE	**5.3**		**6.3**		**3.1**	**T**
1,2,3,4,7,8-HxCDD	NE	NE	NE	**20**		**21**		**11**	
1,2,3,6,7,8-HxCDF	NE	NE	NE	**6.1**	**Q,T**	**5.2**		**3.7**	**T**
2,3,4,6,7,8-HxCDF	NE	NE	NE	**2.2**	**T**	**3.7**	**T**	**1.2**	**Q,T**
1,2,3,7,8,9-HxCDF	NE	NE	NE	**1.1**	**T**	**0.35**	**T**	5.0	U
1,2,3,4,6,7,8-HpCDF	NE	NE	NE	**68**		**75**		**36**	
1,2,3,4,7,8,9-HpCDF	NE	NE	NE	**2.2**	**Q,T**	**3.9**	**Q,T**	**1.5**	**Q,T**
OCDF	NE	NE	NE	**79**		**87**		**59**	
TEQ (calculated using 2005 WHO Factors)				**45**		**65**		**25**	

TABLE 2
LOWER PASSAIC RIVER DATA SUMMARY TABLE
BIOGENESIS SEDIMENT WASHING TECHNOLOGY DEMONSTRATION PROJECT
Stockpiled Material

Notes

g	gram(s)
pg/g	picogram(s) per gram
µg/kg	microgram(s) per kilogram
mg/kg	milligram(s) per kilogram
NRDCSCC	Non-residential direct contact soil cleanup criteria
RDCSCC	Residential direct contact soil cleanup criteria
NON-RES	Non-residential
PAH	Polynuclear aromatic hydrocarbon
PCB	Polychlorinated biphenyl
RES	Residential
SVOC	Semi-volatile organic compound
TEF	Toxicity Equivalency Factor
a	The sum of endosulfan I, endosulfan II, and endosulfan sulfate may not exceed 340,000 µg/kg.
b	The sum of endosulfan I, endosulfan II, and endosulfan sulfate may not exceed 6,200,000 µg/kg.
Bold	Bolded result indicates positively identified analyte.
Italics	Italicized result indicates the sample is reported to the method detection limit (MDL)
Shading	Shading indicates a result or reporting limit greater than the RDCSCC or NRDCSCC
--	Not scheduled
B	Analyte detected in associated blank
J	Data are estimated due to associated quality control data.
NE	Not established
NR	Not regulated in pathway
Q	Estimated maximum possible concentration (EMPC)
T	Analyte was positively identified but the reported concentration is estimated; reported concentration is less than the reporting limit, but greater than the method detection limit.
U	Analyte not detected above the method detection limit.
UB	Analyte considered not detected based on associated blank data.
UJ	Potential low bias, possible false negative.

Gas Technology Institute
ENDESCO Clean Harbors, L.L.C.
TECHNICAL MEMORANDUM

ECH Project Numbers:	**H-40201-21, H-05850-02**
Report For:	**November 2006 - March 2007**
Report Type:	**Project Status Report**
Project Title:	**Cement-Lock® Technology for Decontaminating Dredged Estuarine Sediments: Phase II – Demonstration-Scale Project**
Project Manager:	**Michael C. Mensinger**
Project Duration:	**May 2003 to December 31, 2007**
Status:	**Active**
NJ-DOT/OMR Contract Number	**AO-9345380 (end date 12/31/06)**
BNL Contract Number	**725043 (end date 7/31/07)**
Proposal Numbers:	**ECH No. 101R1, 115, 116, 118, and 121R2, 122 GTI No. 10021.1.18 (18656-18R2), 10116.1.45R1, 10116.1.66R2**

This Technical Memorandum includes the following major sections:

1. Background
2. Project Objectives
3. Equipment Modifications
4. Confirmation Test with Stratus Petroleum Sediment
5. Extended Duration Test with Passaic River Sediment
6. Discussion of Analytical Results
7. Comparison of Air Emission Results with New Jersey Regulations
8. Implications for Commercial Operations
9. Economic Estimates for Cement-Lock Technology
10. Summary and Conclusions
11. Future Work

1. BACKGROUND

The Cement-Lock® Technology is a thermo-chemical remediation technology that converts contaminated sediment and other wastes into construction-grade cement – a marketable product for beneficial use. In the Cement-Lock process, a mixture of sediment and modifiers is charged to a rotary kiln melter (Ecomelt® Generator). The Ecomelt Generator is maintained at a temperature in the range of 2400° to 2600°F by combustion of natural gas or other fuels with air. This temperature yields a molten homogeneous mixture with a manageable viscosity and causes the minerals in the sediment and modifier mixture to react together.

All nonvolatile heavy metals originally present in the sediment are incorporated into the melt matrix via an ionic replacement mechanism. The melt flows slowly through the Ecomelt Generator like lava as the kiln rotates. The melt then falls by gravity through a plenum and into water, which immediately quenches and granulates the melt. The quenched and granulated

material – Ecomelt® – is removed from the quench granulator by a drag conveyor, which also partially dewaters it.

Flue gas from the Ecomelt Generator flows into a Secondary Combustion Chamber (SCC), which provides an additional 2 seconds of residence time at a minimum temperature of 2200°F to ensure complete destruction of any organic compounds that survive the severe thermal conditions in the Ecomelt Generator. Flue gas exiting the SCC is rapidly cooled via direct water injection to prevent the formation or recombination of dioxin or furan precursors. In a commercial application, thermal energy of the flue gas could be used to raise steam in a heat recovery steam generator.

Powdered lime (CaO) is injected into the cooled gas to capture acid gases [i.e., sulfur dioxide (SO_2) and hydrogen chloride (HCl)] and sodium and potassium chlorides from seawater. The sulfur/salt/spent lime mixture is removed from the flue gas stream by a baghouse. The spent lime from the baghouse is containerized and shipped to a landfill. In a commercial application, a portion of the spent lime may be recycled to the front of the plant for use as a modifier. Volatile heavy metals, such as mercury, are removed from the flue gas as it passes through a fixed bed of activated carbon pellets. Cleaned flue gas is vented to the atmosphere at about 350°F via an induced draft (I.D.) fan.

In the event that nitrogen oxide (NOx) emissions need to be controlled to meet local regulations, conventional NOx reduction techniques and equipment can be included in the overall process flow diagram.

The Cement-Lock Technology was developed by the Gas Technology Institute (GTI, Des Plaines, IL) and Unitel Technologies (Mount Prospect, IL). The intellectual property associated with Cement-Lock is covered by two U.S. patents and several foreign patents. The technology is licensed by Volcano Partners, L.L.C.

Cement-Lock Demonstration Plant: ENDESCO Clean Harbors, L.L.C. (ECH, a wholly owned subsidiary of GTI) installed the Cement-Lock demonstration plant on a 2-acre parcel of land at the International Matex Tank Terminal (IMTT) in Bayonne, NJ. The demo plant incorporates the major equipment components needed to demonstrate and characterize the process (Figure 1). The final steps in producing Cement-Lock construction-grade cement – grinding and blending the Ecomelt with Portland cement or another lime source – can be accomplished at an off-site facility. The demo plant has a nominal throughput capacity of 10,000 yd^3 of sediment per year. With process enhancements (sediment predrying, oxygen enrichment), its throughput can be increased to 30,000 yd^3/year.

2. PROJECT OBJECTIVES

The overall objectives of the Phase II – Demonstration-Scale Project are to modify the Cement-Lock demo plant so that it can operate in slagging mode, confirm the operation with Stratus Petroleum sediment, and process about 200 tons of sediment dredged from the Passaic River through the system. During processing, the sediment will be converted into Ecomelt®, a portion of which will be converted into construction-grade cement for a beneficial use demonstration.

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The specific objectives of the Phase II demonstration-scale project are to:

- Complete the final design and implement equipment modifications and other necessary repairs to the Cement-Lock demo plant – specifically in the sediment and modifier feeding, the slag discharging, and the air pollution control systems.
- Secure an Environmental Improvement Pilot Test permit from the New Jersey Department of Environmental Protection (NJ-DEP) for the demonstration project.
- Conduct a Confirmation Test of up to 72 hours duration with the modified Cement-Lock demo plant to confirm that the modifications are effective using up to 100 yd^3 of Stratus Petroleum sediment remaining from the previous phase.
- Upon successful completion of the Confirmation Test and after obtaining approval from the sponsors, conduct an Extended Duration Test with the modified Cement-Lock demo plant to process about 200 tons of mechanically dewatered Passaic River sediment.
- Facilitate the environmental and air (stack) sampling task to be conducted by the EPA SITE (Superfund Innovative Technology Evaluation) Program.
- Conduct a beneficial use demonstration with Ecomelt produced from Passaic River sediment.
- Update the economics of the Cement-Lock Technology as warranted by the Phase II results.
- Arrange for the dismantlement of the Cement-Lock demo plant and restoration of the IMTT site per ECH's lease agreement.

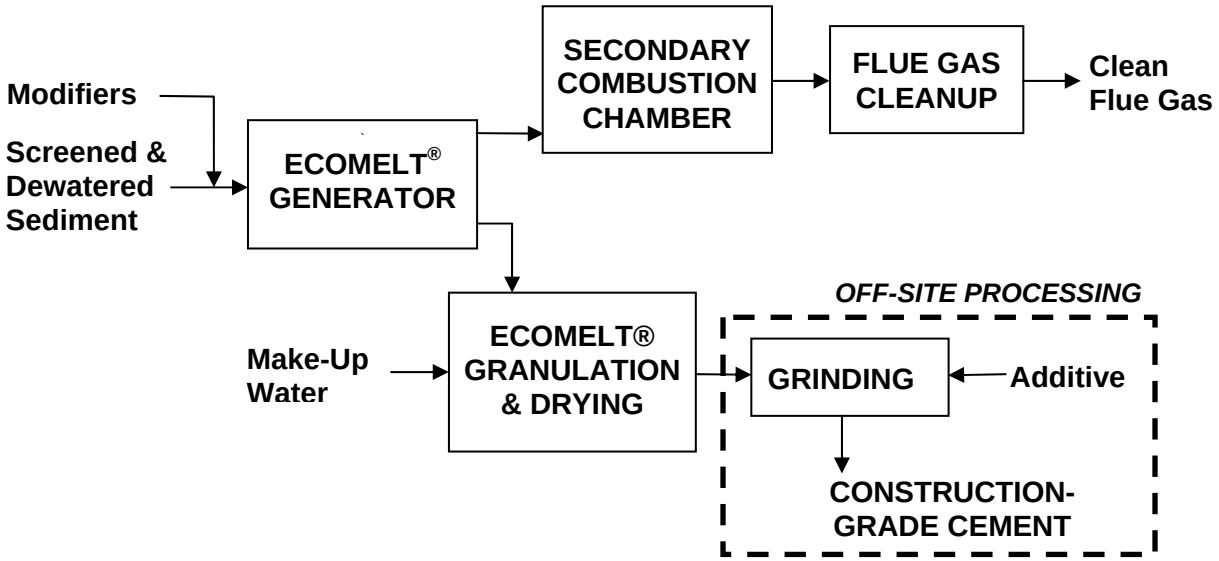

Figure 1. Process Flow Diagram for Cement-Lock Demonstration Plant

3. EQUIPMENT MODIFICATIONS

Major equipment modifications were implemented at the Cement-Lock demonstration plant to improve its performance in the critical areas of sediment/modifier feeding and mixing, and

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molten slag discharging from the drop-out box. The design work for the equipment modifications was initiated in June 2006. Procurement, construction, and installation activities were completed at the plant site from July through November 2006. Equipment modification design, procurement, and installation were sponsored by the New Jersey Department of Transportation Office of Maritime Resources (NJ-DOT/OMR) under a contract with ECH. Other work performed to ready the equipment for the Confirmation Test with Stratus Petroleum sediment and the Extended Duration Test with Passaic River sediment is described below.

Refractory Installation: Duddy Contracting (Westfield, NJ) completed installation of the new refractory in the drop-out box and the kiln nose ring in November. Duddy used a process called "guniting" to install the refractory. The refractory material – Versagun 60 – used for the kiln nose ring and drop-out box was recommended by the manufacturer (Harbison-Walker Refractories, HWR) for the fairly short-duration planned for the Confirmation Test as well as the Extended Duration Test.

Refractory Dryout: The newly installed refractory needed to be carefully dried out to prevent cracking during subsequent operation. HWR specified a dryout schedule in which the refractory would be heated to specific temperatures and "soaked" at these temperatures for specific times depending upon the refractory thickness. In all, the refractory dryout was estimated to take about 67 hours and reach a maximum temperature of 1100°F.

The dryout of the refractory was conducted by Team Industrial Services (TEAM, Aston, PA) over the course of 4 days. The TEAM equipment included a 10-million Btu/hour natural gas burner, blower, insulation, thermocouples for sensing temperature, and data acquisition equipment. The lower part of the drop-out box was closed off from the ambient using insulating blanket (Figure 2). The burner was inserted into the access hatchway on the north side of the drop-out box and insulated as shown in Figure 3.

Belt Conveyor System: The sediment belt conveyor system includes a 140-foot length of conveyor running from the sediment storage area parallel to the rotary kiln at a shallow incline. Another 40-foot section of belt conveyor runs perpendicular from the end of the 140-foot conveyor and is inclined up to the charging deck above the pug mill. The 140-foot conveyor has a 24-inch wide belt. The 40-foot conveyor has an 18-inch wide belt. Both sections of conveyor are covered.

The conveyor parts were shipped to the plant site on November 13 and 15. The mechanical contractor connected the conveyor sections and lifted them up onto the stanchions. SM Electric Company connected power to the two conveyor motors and ran conduit and wire so that the long conveyor could be started/stopped at the inlet. The belt conveyor system is shown in Figure 4.

V-Ram Solids: The V-Ram solids feeder was installed on the charging deck and the necessary electric and hydraulic connections were made. The V-Ram service technician visited the plant on November 6 to conduct shakedown testing and operator training. Also, shakedown testing of the V-Ram feeder was completed by the service technician.

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To keep the sediment-modifier mixture from flooding the V-Ram hopper, a mechanical slide gate was installation between the pug mill discharge and the V-Ram hopper. An end view of the V-Ram feeder and its hydraulic connections is shown in Figure 5.

Figure 2. New Drop-Out Box and Upper Discharge Chute in Place with Refractory Blanket Shown at Bottom

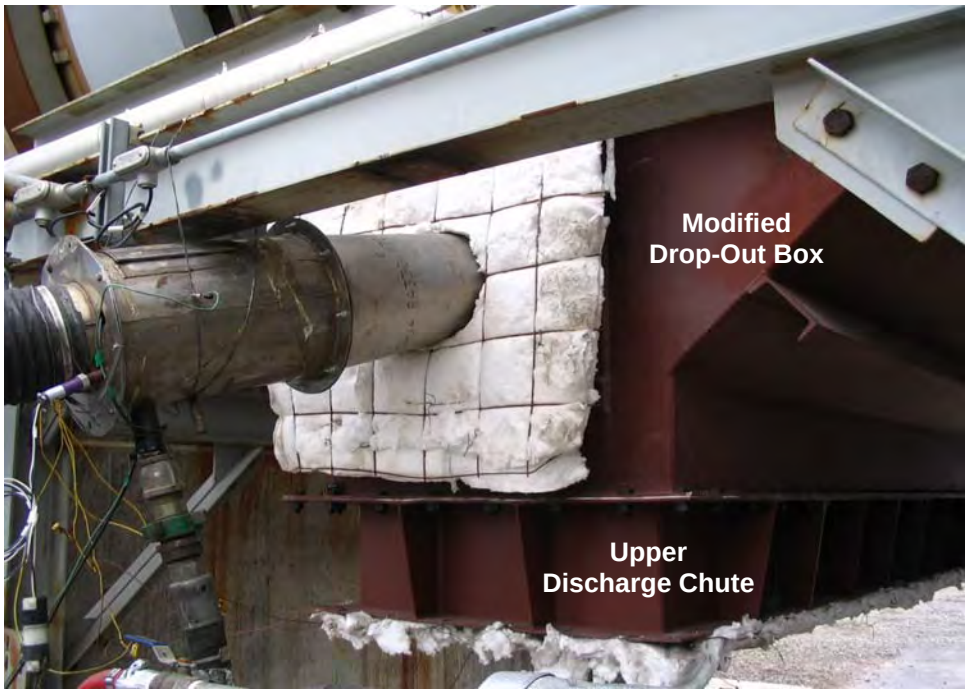

Figure 3. TEAM's 10-Million Btu/hour Burner Installed and Insulated in North Drop-Out Box Access Hatchway

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Figure 4. Covered Belt Conveyors Running from the Sediment Storage Area to the Charging Deck (left: looking west from the sediment storage area; right: looking east from the SCC platform)

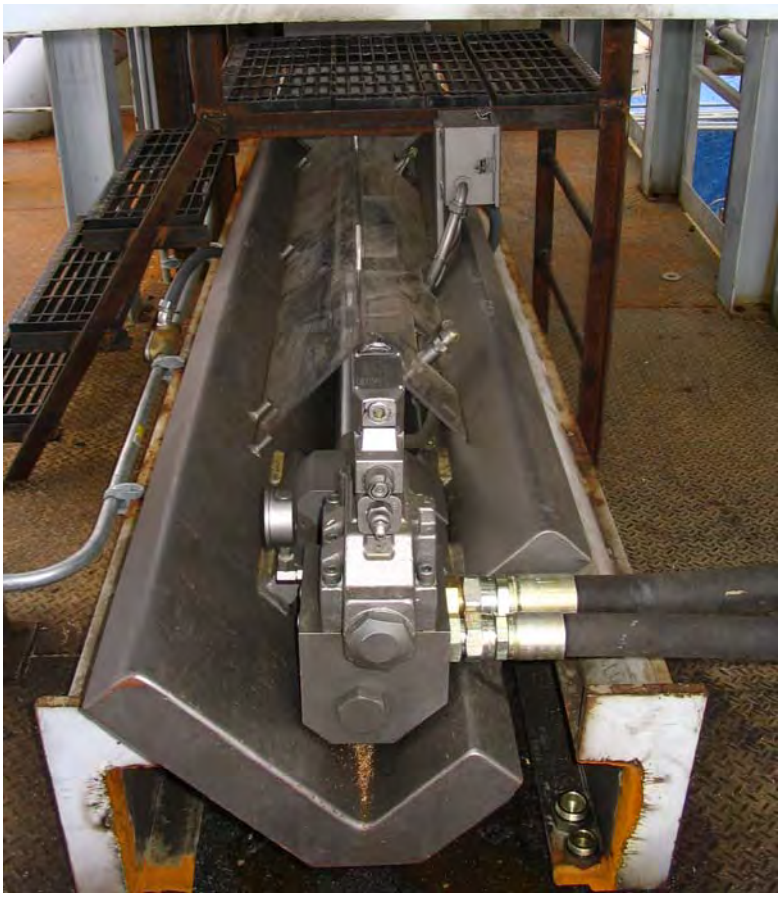

Figure 5. End-View of V-Ram and Hydraulic Connections

Scaffolding: Safety Scaffolds (Branchville, NJ) installed scaffolding at four locations: 1) the west end kiln view ports, 2) the north side drop-out box view port, 3) the activated carbon bed inlet, and 4) the main stack. Scaffolding for the west end kiln view ports and the north side drop-

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out box view port were needed for proper operation of the plant. Scaffolding for the stack and activated carbon bed were required for the EPA SITE stack and environmental sampling teams.

4. CONFIRMATION TEST WITH STRATUS PETROLEUM SEDIMENT

In preparation for the Confirmation Test operations, a 10,000-lb capacity scale was ordered and delivered from Industrial Scales (Linden, NJ). The scale is capable of weighing a skid steer with and without a bucket-full of feedstock. Using the scale, the quantity of sediment/modifier mixture being fed to the conveyor belt system and thus to the rotary kiln system could be monitored.

The emergency generator (EmGen) was delivered by Foley Power Systems on November 13 (Monday). SM Electric connected the EmGen to the emergency grid by running appropriate cables from the EmGen to the MCC. The EmGen was tested for proper function.

Also, ECH rented a NOx meter from CleanAir Rentals (Palatine, IL) for monitoring NOx in the flue gas as required by the Environmental Improvement Pilot Test (EIPT) permit.

Chronological Discussion of Confirmation Test Operations: The demo plant equipment was started up and readied for operation on November 27 (Monday). Mr. Louis Ringger, Senior Project Manager, CEntry Constructors & Engineers, was on-site during the Confirmation Test as a consultant.

Initially, some difficulty was experienced in lighting the main burner. It would spontaneously shut down after reaching a temperature of about 450°-475°F. It was suggested that some connections in the main burner control panel had become corroded and needed cleaning. After the connections had been cleaned, the burner was restarted at about 9:30 a.m. November 28 (Tuesday). The system was heated at the prescribed rate to about 1800°F and held overnight.

The next day November 29 (Wednesday), the rotary kiln reached a temperature of 2400°F at about noon. Feeding the sediment-modifier mixture to the system was initiated via the skid steer bucket. The feed rate was one bucket of sediment-modifier mixture (about 1000 lb) per hour.

Prior to sediment feeding and at a kiln temperature of about 2200°F, slag was observed dripping on the west wall opposite the kiln nose. The source of this slag was apparently fly slag from the March 2005 non-slagging campaign that had accumulated in the SCC. The fly slag was melting and flowing to the drop-out box. As time progressed, this slag accumulation grew into a "pancake" (like a toadstool on a tree) about 1 foot in diameter and about 1 foot above the water level in the granulator.

About 2,000 pounds of sediment-modifier mixture were fed to the system and some chunks of slag material came out of the granulator. Some Ecomelt granules were also produced. However, the slag pancake on the west wall continued to grow in width and height and threatened the continuation of the test. It extended from the west wall eastward almost connecting with the east wall under the kiln becoming what is known as a “devil’s tongue.” In the north-south direction, it covered about 1/3 of the drop-out box opening. At about 4:15 p.m., the slag accretion detached itself from the west wall, dropped into the granulator and jammed the drag conveyor. Efforts to clear the jam were unsuccessful and the system had to be shut down.

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At about 3:30 p.m., the cylinder packing around the V-Ram feeder piston was forced out of the cylindrical constrains and the V-Ram piston jammed. The V-Ram representative was immediately contacted to discuss options. V-Ram sent replacement packing and parts and said that it may be necessary to modify the ram to loosen up the equipment tolerances.

Overnight the kiln was cooled the kiln to 1800°F. The jam in the granulator was cleared by the night shift. In the morning (November 30, Thursday), the drag conveyor was operated in forward and reverse to get the chain moving. The broken chunks of slag were readily removed and the granulator was put back into operation at about 7:30 a.m.

Per V-Ram direction, measurements were taken of the main body of the ram and the two floating wedges. V-Ram said that the main body of the ram needed more clearance and that 0.1 inch needed to be removed from the top edge of the ram. The wedges also needed to be machined down about 1/32 inch. V-Ram also said that the grooves in the main body were not appropriate for our application and should be filled with weldment. As a result, the ram was removed from the piston and sent to a local machine shop for machining.

The temperature in the system was reduced to 1700°F and maintained overnight pending receipt of the machined parts.

The next morning, the kiln was heated to operating temperature of 2450°F. The V-Ram was reassembled with the machined ram and put back into operation. At about 2:00 pm, feeding the sediment-modifier to the system was initiated via 5-gallon pails to test the V-Ram, which operated well. The system was then from the skid steer bucket from the sediment storage area. The nominal feed rate was 2 buckets (about 2,000 lb) per hour of sediment-modifier mixture.

Sediment-modifier mixture was fed consistently all afternoon. Ecomelt was generated and two 1-yd^3 hoppers full of Ecomelt (Figure 6) and other slag material were deposited in a lined pile in the western part of the site.

In the meantime, another devil's tongue was forming on the west wall. As time progressed, the devil's tongue grew and covered much of the space between the kiln nose and the west wall. By about 6:00 p.m. feeding was halted to allow material in the kiln to exit to minimize the load on the granulator after the devil's tongue dropped off.

At 8:15 pm, the slag mass broke off the west wall and fell into the granulator. There was a sharp drop in kiln temperature and a spike in the system pressure due to the steam generated. As expected, the granulator drag chain jammed due to the slag chunk. Attempts to clear the jam were continued until about 12:00 midnight when it was decided that the system needed to be cooled to remove the slag. Cooling was initiated at that point at -100°F/hour.

By late Saturday afternoon, the kiln had cooled sufficiently so that the access hatchway on the north side of the drop-out box could be opened. The slag mass was irregularly shaped and about 2½ feet long, 1½ feet wide and 2 feet tall. It was resting on the upper drag conveyor slats. After a few impacts with a sledge, a few large chunks (½ to 1 foot in size) were fractured and removed from the mass. The slag was porous and relatively light in density.

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Figure 6. Ecomelt (Stratus Petroleum sediment) Accumulating in the Skip Hopper

Confirmation Test Summary: Overall, the December 1 (Friday) test achieved much improved and consistent feeding via the V-Ram feeder and significant production of Ecomelt. A total of 5.1 tons of Stratus Petroleum sediment-modifier mixture was fed to the system.

5. EXTENDED DURATION TEST WITH PASSAIC RIVER SEDIMENT

NJ-DOT/OMR and EPA Region 2: Per agreement between NJ-DOT/OMR and EPA Region 2, the next test was to be conducted with Passaic River sediment instead of Stratus Petroleum sediment. The initial Passaic River sediment feed rate was planned to be 2,000 pounds per hour plus modifiers.

EPA SITE Program: Stack samplers (AirNova, Pennsauken, NJ), Tetra Tech EMI (Tetra Tech, Cincinnati, OH), and a representative from the EPA SITE Program arrived at the demo plant site on December 4 and began setting up their equipment including data acquisition trailer. AirNova had conducted stack sampling for Brookhaven National Laboratory during the GTI pilot test conducted with Newtown Creek sediment at Hazen Research (Golden, CO) in 1996.

To accommodate the 8 to 12 additional staff from AirNova, Tetra Tech, and the EPA SITE program, a second trailer was rented and delivered to the site. Sanitary tanks were also ordered and installed on the two trailers (instead of one portable toilet). Electric power was connected to the AirNova data acquisition trailer, the stack, and the activated carbon bed inlet locations.

For this test, the kiln operating temperature was reduced from 2475° to 2400°F to reduce the kiln flue gas velocity and minimize slag droplet carryover to the west wall. Reducing the temperature

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will increase slag viscosity so the combined effects needed to be monitored closely. The excess air was also going to be reduced while maintaining permitted CO and O_2 levels.

Also in preparation for feeding the Passaic River sediment, both limestone and alumina feeders were recalibrated. The limestone feeder was calibrated successfully. The results of the alumina feeder calibration were inconsistent. While troubleshooting the alumina feeder, it was observed that the discharge chute from the hopper (T-104) had been installed backwards severely restricting flow. The necessary corrections were made, the feeder was reassembled, and the alumina feeder was successfully calibrated.

Chronological Discussion of the Extended Duration Test with Passaic River Sediment: On December 4 (Monday), after executing a confined space entry permit, operating personnel broke up the remaining slag mass and chipped excess slag from the kiln nose as well as the west and south walls. Very little slag was observed on the south wall.

After the system was sealed and readied for operation, some difficulty was again experienced igniting the primary burner. It was determined that one of the mechanical switches inside the Maxon switch was not making contact. This was rectified and the primary burner was ignited.

On Wednesday, Passaic River sediment and modifiers were fed at a rate of 1,400 pounds per hour beginning at about 8:20 a.m. (the sediment feed rate was 1,000 lb/hr; the modifier feed rate was 400 lb/hr). At 10:10 a.m., there was a brief power outage caused by the nose cooling blower that shut the plant down. The problem was rectified and by 11:45 a.m. the system was reheated to operating temperature (the kiln temperature had dropped during the power outage). At 1:00 p.m. the system was at the target temperature of 2400°F and feeding was resumed. During the test, the SCC temperature ranged from 2300° to 2350°F. By 3:30 p.m. enough Ecomelt had been generated to fill the skip hopper (1 yd^3). The skip hopper was transported to the western section of the plant site and the first batch of Ecomelt from Passaic River sediment was placed on a tarp.

The EPA SITE stack and environmental sampling teams took samples during the steady operating period.

During the rest of the day, a devil's tongue was observed forming on the west wall. At about 8:00 p.m. the devil's tongue fell off and jammed the granulator. By running the granulator forward and backward the jam was cleared thereby avoiding a plant shutdown. A photo of the devil's tongue discharged from the granulator is shown in Figure 7. It was about two feet long and about 1½ feet wide.

During Wednesday, a total of about 6 tons of Passaic River sediment was fed to the system. Limestone (Modifier 1) was fed to the pug mill for mixing with sediment at a rate of about 400 pounds per hour.

For the overnight shift, feeding was halted and the kiln temperature was maintained at 2400°F.

On Thursday (December 7), feeding of Passaic River sediment and modifiers was initiated at 7:40 a.m. at a rate of about 1,400 pounds per hour. The EPA SITE stack and environmental sampling teams took samples during the steady operating period.

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Figure 7. Slag Chunk Cleared from Granulator and Discharged (December 6)

At one point, the kiln temperature was increased to 2550°F in an effort to dislodge an accretion of slag. Some large chunks of slag were cleared and discharged from the granulator, but the larger fraction of the slag remained. The temperature was then reduced to 2450°F.

During Thursday, about 7 tons of Passaic River sediment were fed to the system. As before, limestone (Modifier 1) was fed to the pug mill for mixing with sediment at a rate of about 400 pounds per hour. This was the most consistent sediment feeding episode to date.

For the overnight shift, feeding was again halted and the kiln temperature was maintained at 2400°F. At about 11:00 p.m. the primary burner experienced a flameout and the kiln temperature dropped to about 1300°F. At first, it was thought that the Maxon switch had again malfunctioned; however, troubleshooting the Maxon switch did not resolve the issue. Finally, after repeated attempts, the primary burner was ignited. The kiln temperature was reheated to the target temperature of 2400°F by about 7:00 a.m. (December 8).

Overnight, the ambient temperature fell to below freezing and by morning, sediment in the pug mill and the V-Ram feeder had frozen solid. It took until past noon to clear the frozen equipment. As a result, the EPA SITE stack and environmental sampling teams were not able to take samples in a timely manner and withdrew from the site.

Feeding sediment to the system was resumed at about 2:00 p.m. at a rate of about 1,000 pound per hour plus modifiers. During this session, however, slag was observed to begin sticking to the south wall. It was posited that slag already in the kiln had cooled sufficiently during the overnight flameout episode to stick to the south wall. A shelf built up on the west wall and from the south wall as shown in the photo (Figure 8). The two slag accumulations joined up during

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the day and as more sediment was fed, the effective cross-sectional area of the drop-out box continued to diminish.

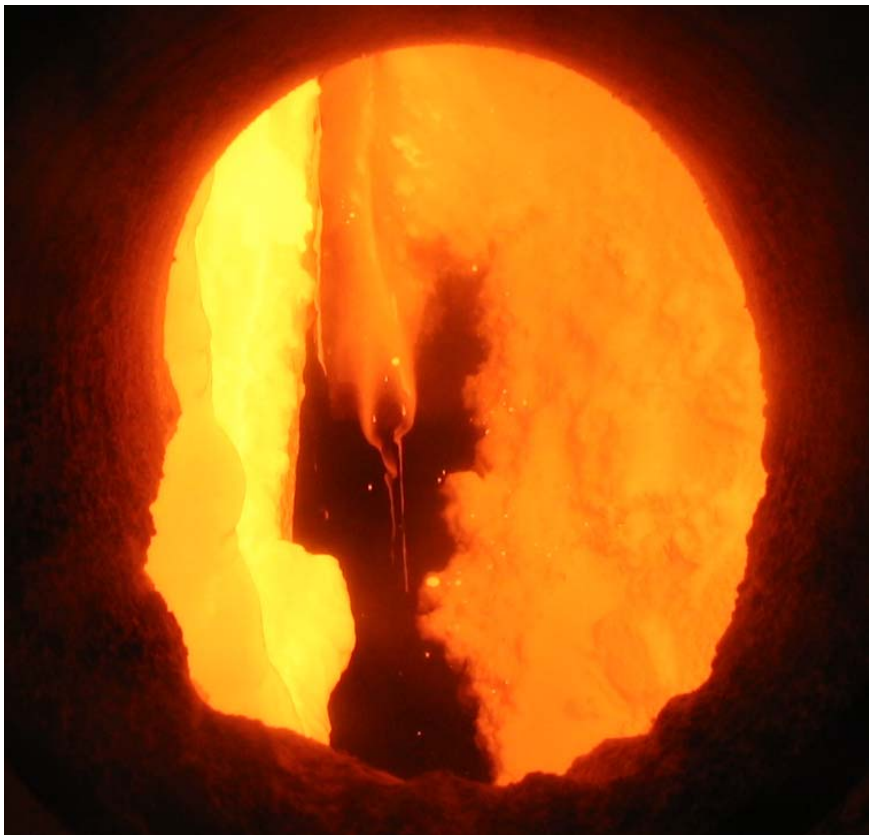

Figure 8. View from Above Drop-Out Box – Molten Slag Dripping from South Wall into the Granulator (kiln nose left, west wall right)

Fluorspar (CaF_2 – a fluxing agent) was added to the kiln in an attempt to make the slag more fluid to dislodge the blockage, but with no effect. At about 9:30 p.m. it was decided to shut the plant down. Later on Saturday (December 9) the kiln was cool enough to allow the access hatchway in the drop-out box to be opened. Looking south the photo (Figure 9) shows the well-formed devil's tongue almost in contact with the kiln nose. Note behind and below the devil's tongue is a massive black accretion of slag adhering to the south wall.

Summary: Significant milestones were achieved during the recent Cement-Lock demo plant campaigns. The equipment modifications implemented during the project extended the slagging mode operating time considerably. Sizable quantities of Ecomelt have been generated from both Stratus Petroleum as well as Passaic River sediment. The demo plant has been operated such that the EPA SITE program could conduct stack and environmental sampling – this time under slagging conditions.

Overall, the feed system performed quite well. The ALLU screening bucket performed as designed. The conveyor belts effectively conveyed the material from the sediment storage area to the pug mill on the charging deck. The mixer and V-Ram feeder also performed as designed (there was a learning curve associated with operating both of these units with sediment).

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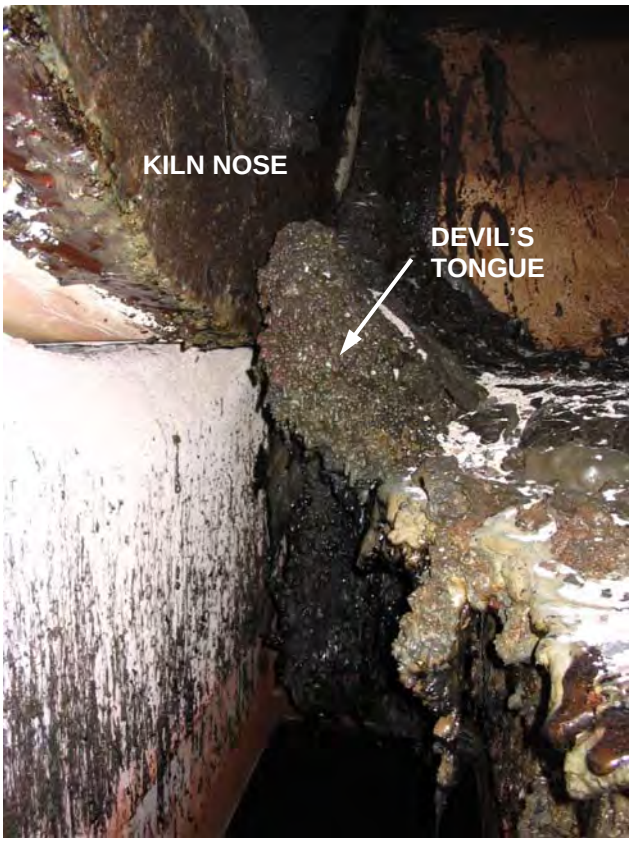

Figure 9. Devil's Tongue Extending from West Wall to Near the Kiln Nose

The modified demo plant has demonstrated the capability to process sediment at about ½ ton per hour in continuous operation. Slag accumulation in the drop-out box was significantly slowed, but not stopped. Best production achieved to date was 7 tons per day. Overall, about 5.1 tons of Stratus Petroleum sediment and about 16.5 tons of Passaic River sediment were processed.

6. DISCUSSION OF ANALYTICAL RESULTS

During the Cement-Lock demonstration campaign with Passaic River sediment, EPA SITE program and subcontractor personnel took stack and environmental samples for process characterization. Stack samples were taken by AirNova during two days of demo plant operation on December 6 and 7. Based on the results, AirNova prepared an Emission Evaluation Test Report (the draft is included in Appendix A; the final version will be forwarded upon receipt).

Samples of Passaic River sediment feed and Ecomelt product as well as other process samples were collected by Tetra Tech personnel. Analyses of these samples were conducted by Accutest Laboratories (Dayton, NJ), SGS Environmental Services (Wilmington, NC), and Element One (Wilmington, NC). The detailed chemical analyses of the feed and product samples for dioxins and furans, PCBs, metals, selected pesticides, and selected PAHs are included in Appendix B.

Leaching tests [Toxicity Characteristic Leaching Procedure (TCLP) and Synthetic Precipitation Leaching Procedure (SPLP)] were also conducted on samples of Ecomelt product and mortar

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blocks prepared from blended cement from Ecomelt. The results of the leaching tests are also presented in Appendix B.

Tetra Tech EMI performed the data validation for EPA SITE.

As specified by the project Quality Assurance Project Plant, AirNova took samples of the flue gas in the duct upstream of the Activated Carbon Bed Adsorber and downstream in the stack. The flue gas in the stack was analyzed for SO_2, NOx, CO, and VOCs. The results are these analyses are presented in Table 1.

Table 1. Cement Lock Demonstration Site -- Carbon Bed Outlet: SO_2, NO_x, CO, and VOCs Test Results Summary (AirNova Report)

Run No.	**1**	**2**	**3**	**Average**
Date	12/06/06	12/06/06	12/07/06	
Time Period	1625-1725	1812-1912	0934-1034	
Exhaust Gas Characteristics				
Oxygen (%-dry)	3.99	5.13	6.19	5.10
Carbon Dioxide (%-dry)	9.83	10.47	9.41	9.90
Temperature (°F)	287	286	304	292
Moisture (%)	51.1	54.4	53.1	52.9
Velocity (fps)	36.4	36.4	35.9	36.2
Flow Rate (ACFM)	14,983	15,002	14,795	14,927
Flow Rate (DSCFM)	5,230	4,898	4,830	4,986
Carbon Monoxide*				
Concentration (ppmVd)	> 100	17.3	4.2	> 40.5
Concentration (ppmVd	> 82.2	15.2	4.0	> 33.8
Emission Rate (lb/hr)	> 2.27	0.37	0.09	> 0.91
Volatile Organic Compounds				
Concentration (ppmVd)	4.7	4.6	0.9	3.4
Concentration (ppmVd	3.9	4.1	0.8	2.9
Emission Rate (lb/hr)	0.06	0.06	0.01	0.04
Nitrogen Oxides (as NO_2)				
Concentration (ppmVd)	94.0	134	149	126
Concentration (ppmVd	77.3	118	141	112
Emission Rate (lb/hr)	3.51	4.69	5.13	4.44
Sulfur Dioxide				
Concentration (ppmVd)	42.2	16.5	8.8	22.5
Concentration (ppmVd	34.7	14.5	8.3	19.2
Emission Rate (lb/hr)	2.19	0.80	0.42	1.14

Standard Conditions: 70°F, 29.92 inches Hg

* CO emissions during Run No. 1 were out of the calibration range of the analyzer which was operated in the 0-100 ppmV range. Therefore, CO emissions could not be quantified for this test run, and were reported as greater than the detectable quantity of 100 ppmV.

The results show that the level of CO in the flue gas during the first test exceeded the calibration limit of the analyzer. This indicates that the demo plant system was being operated at a less than

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optimum condition regarding excess air. The oxygen concentration in the first test was 3.99%, which represents about 20% excess air for stoichiometric combustion of natural gas. This level of excess air was expected to provide sufficient oxygen to keep the CO levels low as achieved during the second and third tests. It is apparent from the results that the oxygen concentration in the flue gas should be maintained at about 5% for these process conditions.

The concentration of volatile organic compounds (VOCs) in the three tests was quite low, quite consistent, and averaged 0.04 lb/hour.

The emission of NOx in the flue gas averaged 4.44 lb/hour. This is higher than the 1.53 lb/hour measured during the non-slagging test conducted in March 2005. It should be noted that the current test was operated at a much higher temperature (2400°F compared with 1835°F) than the non-slagging test and that additional NOx formation was expected.

Depending upon the scale of commercial Cement-Lock Technology operations, NOx reduction equipment may need to be incorporated into the processing scheme to maintain NOx emissions within local regulatory limits (see Section 8 – Implications for Commercial Operations). The NOx emission was within the predicted rate for the overall system, which included the NOx contribution predicted for the emergency generator.

The emission of SO_2 averaged 1.14 lb/hour during the three tests. There was considerable variation in the three samples. The concentration in the first test was 42.2 ppm compared with 16.5 and 8.8 ppm during the second and third tests, respectively. The sulfur capture efficiency of the lime added to the bags in the baghouse appears to have increased somewhat during plant operation progressed. The emission limit was within the range allowed by the EIPT permit.

The results of tests to measure hydrogen chloride and chlorine are presented in Table 2.

Table 2. Cement Lock Demonstration Site Carbon Bed Outlet (Stack), HCl and Cl_2 Test Results Summary (AirNova Report)

Run No.	**1**	**2**	**Average**
Date	12/06/06	12/07/06	
Time Period	1700-1832	0959-1110	
Exhaust Gas Characteristics			
Oxygen (%-dry)	5.1	6.3	5.7
Carbon Dioxide (%-dry)	10.5	9.2	9.9
Temperature (°F)	286	307	297
Moisture (%)	54.3	52.6	53.5
Velocity (fps)	36.4	35.8	36.1
Flow Rate (ACFM)	15,001	14,761	14,881
Flow Rate (DSCFM)	4,901	4,843	4,872
Hydrogen Chloride			
Concentration (ppmV)	59.3	51.2	55.3
Emission Rate (lb/hr)	1.64	1.40	1.52

Standard Conditions: 70°F, 29.92 inches Hg
Note: Cl_2 emissions were determined to be non-detectable for both test runs. A detailed analysis of Cl_2 quantities can be found in Appendix C of the AirNova test report.

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According to AirNova, Cl_2 was not detectable for both runs. The HCl emission rate averaged 1.52 lb/hour for the two tests. The results are within the permitted emission limits for HCl per the EIPT permit.

AirNova also took samples of flue gas upstream and downstream of the Activated Carbon Adsorber for priority metals. The complete results are included in the AirNova report. AirNova calculated the apparent collection efficiency of the Activated Carbon Bed Adsorber for these priority metal based on the inlet and outlet emission rates. The results are presented in Table 3 as the carbon bed capture efficiency. GTI added the specific results for mercury (Hg) and lead (Pb) to Table 3 to show collection efficiency of the Activated Carbon Bed Adsorber for these to metals.

Table 3. Cement Lock Demonstration Site – Carbon Bed Capture Efficiency for Toxic Metals, Mercury, and Lead – Test Results Summary (AirNova Report)

Run No.	Inlet (lb/hr)	Outlet (lb/hr)	Capture Efficiency (% wt)
1	1.6e-02	3.4e-03	78.8
2	4.5e-03	2.5e-03	44.4
[Total Toxic Metals] Average			**61.6**
Separate Results for Mercury (added by GTI)			
1 (Hg)	3.0e-3	< 2.6e-05	99.1
2 (Hg)	2.3e-3	5.9e-4	74.3
		Average (Hg)	**86.7**
Separate Results for Lead (added by GTI)			
1 (Pb)	4.5e-4	4.3e-4	4.4
2 (Pb)	2.5e-4	2.0e-4	20.0
		Average (Pb)	**12.2**

$$\text{Capture Efficiency (\%)} = \frac{[\text{(lb/hr) Toxic Metal}_{in} - \text{(lb/hr) Toxic Metal}_{out}]}{\text{(lb/hr) Toxic Metal}_{in}} \times 100\%$$

AirNova also took samples of flue gas upstream and downstream of the Activated Carbon Bed Adsorber for dioxins and furans and PCBs. As above, the complete results are included in the AirNova report. AirNova calculated the collection efficiency of the Activated Carbon Bed Adsorber for dioxins and furans and PCBs based on the inlet and outlet emission rates. The results are presented in Table 4 as carbon bed capture efficiency.

GTI calculated the DREs (destruction and removal efficiency) for dioxins and furans as well as PCBs based on the mass flow rate of each of these contaminants in the feed material compared with the mass flow rate of these contaminants in the flue gas (Please note that as additional data becomes available the presence of these in other process streams will be quantified and reported). The results of these DRE calculations are presented in Table 5. The mass flow rates of contaminants in the flue gas are taken from the AirNova results.

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Table 4. Cement Lock Demonstration Site – Carbon Bed Capture Efficiency for Dioxins and Furans and PCBs – Test Results Summary (AirNova Report)

Dioxins and Furans			
Run No.	**Inlet (lb/hr)**	**Outlet (lb/hr)**	**Capture Efficiency (% wt)**
1	7.7e-10	6.7e-11	91.3
2	6.7e-10	1.7e-13	99.9
Average (dioxins and furans)			**95.6**
PCBs			
1	1.9e-03	2.3e-04	87.9
2	1.4e-03	9.7e-05	93.1
Average (PCBs)			**90.5**

* The total emission rate (lb/hr) for the particular component from the entire demo plant including the emergency generator and the Ecomelt Generator.

$$\text{Capture Efficiency (\%)} = \left[\frac{\text{(lb/hr) D/F or PCBs}_{in} - \text{(lb/hr) D/F or PCBs}_{out}}{\text{(lb/hr) D/F or PCBs}_{in}}\right] \times 100\%$$

Table 5. DRE (GTI calculation) of Dioxins and Furans and PCBs from Cement-Lock Demo Plant Test with Passaic River Sediment

Dioxins and Furans (total of congeners*)			
Run No.	**Feed (lb/hr)**	**Outlet (lb/hr)**	**DRE (% wt)**
1	2.344e-5	6.7e-11	99.999714
2	2.344e-5	1.7e-13	99.99999927
Average (dioxins and furans)			**99.999856**
PCBs (total of congeners*)			
1	3.539e-03	2.3e-04	93.50
2	3.539e-03	9.7e-05	97.26
Average (PCBs)			**95.38**

*Non-detected congeners were included in the total assuming full detection limit

$$\text{DRE (\%)} = \left[\frac{\text{(lb/hr) D/F or PCBs}_{feed\ in} - \text{(lb/hr) D/F or PCBs}_{flue\ gas\ out}}{\text{(lb/hr) D/F or PCBs}_{feed\ in}}\right] \times 100\%$$

The treatment efficiency (TE) achieved by the Cement-Lock technology for Passaic River sediment is presented in Table 6. Treatment efficiency is the reduction in a particular contaminant, or class of contaminants, in the product (i.e., Ecomelt) compared with that particular contaminant, or class of contaminants, in the feed material.

Table 6. TE (GTI calculation) of Dioxins and Furans and PCBs from Ecomelt from Cement-Lock Demo Plant Test with Passaic River Sediment

Dioxins and Furans (total of congeners*)		
Feed (lb/hr)	**Ecomelt (lb/hr)**	**TE (% wt)**
2.344e-5*	1.0866e-8	99.953
PCBs (total of congeners*)		
3.539e-03	3.9700e-07	99.988

*Non-detected congeners were included in the total assuming full detection limit

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$$TE\ (\%) = \frac{[(\text{lb/hr})\ D/F \text{ or } PCBs_{feed\ in} - (\text{lb/hr})\ D/F \text{ or } PCBs_{product\ out}]}{(\text{lb/hr})\ D/F \text{ or } PCBs_{feed\ in}} \times 100\%$$

Additional information on the destruction of semi-volatile organic contaminants (SVOCs) is contained in the AirNova Report. These results show very low or non-detected levels of contaminants of concern in the flue gas from the Cement-Lock demo plant campaign.

The results of compressive strength tests conducted on mortar samples using Ecomelt as a partial replacement for portland cement will be included in the project final report

7. COMPARISON OF AIR EMISSIONS WITH NEW JERSEY REGULATIONS

Table 7 summarizes the air emissions from the Cement-Lock demonstration plant during the campaign with Passaic River sediment in December 2006. The results are compared with the State of New Jersey Air Quality Regulations as promulgated in N.J.A.C. Title 7, Chapter 27, Subchapter 8.

The "NJ Reporting Threshold" is the emission rate that requires notification by the emitter to the NJ-DEP in the appropriate report. The "NJ SOTA Threshold" is the emission rate that can be achieved by the state-of-the-art pollution control technologies.

The "NJ Major Facility Threshold Level" means a facility that has the potential to emit any of the air contaminants in an amount which is equal to or exceeds the applicable major facility threshold level (N.J.A.C. 7:27-8).

The table shows that if the Cement-Lock demo plant were to be operated for a full year (8,760 hours per year) then NOx and HCl emissions would need to be controlled to a higher degree than achieved with the existing air pollution control equipment. NOx was generated at a level that puts the yearly emission into the major facility threshold category. From a process standpoint, there are several commercially available NOx reduction technologies, including some developed by GTI, which can achieve 90+ percent reduction in emissions. Emissions of HCl and SO_2 can be significantly reduced by improving the efficiency of dosing lime into the duct upstream of the bag house. Emission of CO can be reduced by increasing process excess air – an operating parameter. Overall, stringent air pollution control requirements for a commercial-scale Cement-Lock plant facility can be achieved through engineered solutions and best operating practices.

8. IMPLICATIONS FOR COMMERCIAL OPERATIONS

The results of the air emission tests presented above show that the extreme temperatures employed during Cement-Lock processing are very effective in destroying organic contaminants present in the Passaic River sediment. The results also show that the elevated temperatures necessary to destroy organic contaminants also form nitrogen oxides (NOx), which are precursors to acid rain and subject to environmental restrictions. Further, priority inorganic air pollutants, such as mercury and lead, must be carefully monitored and controlled. Operation of any sediment treatment facility must also demonstrate the ability to operate for extended periods without downtime. Issues of process availability are also discussed below.

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Table 7. Comparison of Air Emissions from Cement-Lock Demo Plant Operation with Passaic River Sediment with New Jersey Regulations (N.J.A.C. 7:27-8)

	Cement-Lock Demo Plant		**NJ Reporting Threshold**	**NJ SOTA[1] Threshold**	**NJ Major Facility Threshold Level**
Air Contaminant	lb/hour	x 8760 hr	-------- Table A --------		
		ton/year	lb/hour	ton/year	Ton/year
Total VOC	0.04	0.175	0.05	5.0	25
TSP[2]	--[3]	--	0.05	5.0	100
PM-10	--	--	0.05	5.0	100
NOx	4.44	19.4	0.05	5.0	25
CO (excludes outlier)	0.23	1.01	0.05	5.0	100
SO_2 (excludes outlier)	0.61	2.67	0.05	5.0	100
Each HAP[4]	--	--	Table B	Table B	10
All HAPs Collectively	--	--	--	--	25
Any Other (ex. CO_2)	--	--	--	--	100
			-------- Table B --------		
		---------- lb/year ----------			
Cadmium (Cd)	1.4e-5	0.123	2	20	--
Cobalt (Co)	6.0e-6	0.053	20	200	--
Lead (Pb)	3.15e-4	2.76	2	20	10
Manganese (Mn)	9.2e-4	8.06	160	1,600	--
Mercury (Hg)	3.08e-4	2.70	2	20	--
Nickel (Ni)	1.3e-4	1.14	200	2,000	--
Selenium (Se)	1.9e-5	0.17	20	200	--
2,3,7,8-TCDD	ND[7]	ND	1.2e-4	1.2e-3	--
Dioxins/Furans	3.36e-11	2.9e-7	1.2e-4	1.2e-3	--
PCBs	1.64e-4	1.44	1.8	18	--
Hydrogen Chloride	1.52	13,300	2,000	10,000	--
Benzo(a)pyrene[6]	ND	ND	2	20	--
Naphthalene	4.6e-9	4.03e-5	2	20	--

1. SOTA = State-of-the-Art
2. TSP = Total Suspended Particulates
3. -- = Not analyzed
4. HAP = Hazardous Air Pollutant
5. Table B, N.J.A.C. 7:27-8, Appendix 1
6. Same threshold limits for polycyclic organic matter.
7. ND = Below analytical detection limit

The following is a discussion of the potential environmental effects of scaling-up from demo plant to commercial operation assuming that air emissions are proportional to the Passaic River sediment feed rate. The emissions of NOx, mercury, and lead as well as other contaminants of concern are regulated by the State of New Jersey Department of Environmental Protection, which has specified threshold, SOTA, and major facility levels as presented in Table 7. These limits were used in the following discussion.

NOx Emissions: If the average measured NOx emission rate from the Cement-Lock demo plant operation is scaled up to the yearly total (multiplying by 8,760 hours/year), the result – 19.4 ton/year – approaches the Major Facility Threshold Limit of 25 tons per year. As mentioned

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above, the Cement-Lock demo plant does not have any NOx reduction equipment installed. However, if it is assumed that commercially available technologies can reduce NOx emissions by 90% and 95%, respectively, then the proportional treatment capacity of a commercial Cement-Lock plant can be 68,800 yd^3/year and 137,600 yd^3/year. Achieving a NOx emission reduction of 99% would permit a treatment capacity of 688,200 yd^3/year.

Hg Emissions: Following the same logic for mercury, if the average measured Hg emission rate (< 3.1e-4 lb/hr) from the Cement-Lock demo plant operation is scaled up to the yearly total, the result – 2.7 lb/year – is above the Reporting Threshold of 2 lb/year, but below the SOTA Threshold of 20 lb/year. Based on the average Hg emission rate and the SOTA Threshold value, the proportional commercial-scale Cement-Lock plant would have a treatment capacity of 39,400 yd^3/year. On the other hand, assuming the Hg emission rate from Run #1 (< 2.6e-5 lb/hr) and the SOTA Threshold value, the proportional commercial-scale Cement-Lock plant would have a treatment capacity of 470,100 yd^3/year. Assuming the Hg emission rate from Run #2 (5.9e-4 lb/hr), the proportional commercial-scale Cement-Lock plant would have a treatment capacity of 20,700 yd^3/year.

Pb Emissions: If the average measured lead emission rate (3.2e-4 lb/hr) from the Cement-Lock demo plant operation is scaled up to the yearly total, the result – 2.76 lb/year – is above the Reporting Threshold of 2 lb/year, but below the SOTA Threshold of 20 lb/year. Based on the average Pb emission rate and the SOTA Threshold value, the proportional commercial-scale Cement-Lock plant would have a treatment capacity of 38,200 yd^3/year. Assuming the Pb emission rate from Run #1 (4.3e-4 lb/hr) and the SOTA Threshold value, the proportional commercial-scale Cement-Lock plant would have a treatment capacity of 28,400 yd^3/year. Assuming the Pb emission rate from Run #2 (2.0e-4 lb/hr), the proportional commercial-scale Cement-Lock plant would have a treatment capacity of 61,100 yd^3/year.

Clearly, the emissions of mercury and lead from large-scale commercial Cement-Lock treatment facilities must be strictly controlled. The technology must be able to operate at a treatment capacity that enables it to achieve economies of scale without countervailing the environmental benefits of sediment remediation.

Sustainable Operations: As described in Sections 3, 4, and 5 above, the Cement-Lock demo plant has undergone considerable equipment modifications and changes. The objectives of these modifications and changes were to improve plant performance and extend operating time in slagging mode. Although considerable improvement has been achieved, the plant was operated for a maximum of 12 hours continuously during the December 2006 campaign. Further, the plant demonstrated resiliency in its ability to recover from large slag accumulations that dropped into the granulator and were discharged. Prior to the equipment modifications, the drop-out box would have plugged leading to an involuntary shutdown.

During the non-slagging demonstration project conducted in March 2005, the Cement-Lock demonstration plant achieved 17 days of continuous elevated temperature operation. The Ecomelt Generator (rotary kiln) and secondary combustion chamber temperatures were maintained at 1835° and 2115°F, respectively. The nominal feed rate of sediment-modifier mixture was 1,000 lb/hour. It should be noted that overnight ambient temperatures during the

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March 2005 campaign dipped into the mid to low 20's. Considerable time was spent by operators and laborers to keep some equipment items from freezing up.

Although the equipment was operated at elevated temperature continuously during the campaign, sediment was not fed continuously, but primarily during the day and afternoon shifts. Thermally treated sediment was readily discharged from the drop-out box of the demo plant. The residence time of the sediment-modifier mixture in the rotary kiln averaged 70 to 80 minutes. The March 2005 non-slagging campaign demonstrated that the equipment could be operated in a sustained mode even under inclement weather conditions.

9. ECONOMIC ESTIMATES FOR CEMENT-LOCK TECHNOLOGY

At the request of Malcolm Pirnie Inc. (MPI), GTI prepared several project-based break-even cost estimates for different quantities of Passaic River sediment to be processed through different capacity Cement-Lock plants over different project periods. The quantities of sediment and project periods were from MPI's list of Alternative Case Numbers, specifically, Alternative Case Numbers 1, 2, 3, 8, 9, 11, 12a, and 13a (Per MPI, the Alternative Cases have been since revised).

For these estimates, GTI matched the quantity of sediment to be processed with either the demonstration-scale plant operating with oxygen enrichment (30,000 yd^3/year capacity), a 125,000 yd^3/year capacity plant (1 module), or a 250,000 yd^3/year capacity plant (2 modules).

For comparison purposes, MPI imposed the following assumptions on the cost estimates:

1. That only Passaic sediment be treated – No co-processing of other waste feedstocks
2. That the life of the plant = life of the project – No long-term amortization/capital recovery
3. Break out cost of beneficial use products
4. Provide costs with and without electric power co-generation

The cost estimates were scaled from ENDESCO Clean Harbor's N^{th} plant scenario as presented in the NJ-DOT/OMR Phase I Final Report (2006). The Nth plant scenario was for a 500,000 yd^3/year sediment treatment plant operating for an extended period of time with costs amortized over a 20-year period. The cost of natural gas was assumed to be $9.00/million Btu. Oxygen costs were escalated from a previous estimate for the Cement-Lock demo plant. Where applicable, the capital recovery costs were based on 75% debt and 25% equity. The cost of borrowing money was 6.75%. Operating costs were prorated based on the quantity of dredged sediment processed per year compared with the overall plant capacity.

In the cases in which power is generated for export, the electricity cost/price is $100/MW-hr. In the cases in which no power is generated, capital costs for power generation equipment were eliminated. The cost of beneficial use product, specifically pulverized Ecomelt, was assumed at $80/ton.

Table 8 presents the break-even tipping fees required for Cement-Lock processing of different quantities of Passaic River sediment over different project periods as specified in the MPI Alternatives. Where indicated, "P" indicates the break-even tipping fee with co-generation of

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electric power; “NP” indicates the break-even tipping fee with no co-generation of electric power.

It should be noted that co-processing of different wastes and utilizing different energy sources for propelling the Cement-Lock technology can significantly enhance the overall economics of the Cement-Lock technology as presented.

Further, as a thermal treatment process, the Cement-Lock technology can achieve destruction and removal efficiencies (DREs) of 99.99% and higher depending upon the principal hazardous organic constituent (PHOC) selected and its original concentration in the sediment.

Table 8. Summary of Break-Even Tipping Fees Required for Cement-Lock Processing of Passaic River Sediment per MPI Alternative Numbers

MPI Alternative Number	Volume of dewatered sediment, yd^3	Project Duration, years	Processing, yd^3/year	Cement-Lock ---- Plant Capacity, yd^3/year ---- 30,000 Demo/w O_2	125,000 1 module	250,000 2 modules
				- Break-Even Tipping Fee, $/$yd^3$ -		
1 P / 1 NP	383,000	5	76,600		$152 / $155	
2 P / 2 NP	707,000	4	176,750			$134 / $136
3 P / 3 NP	1,067,000	7.5	142,267			$88 / $96
8 NP	84,500	3	28,167	$223		
9 NP	52,000	3.5	14,857	$265		
11 P / 11 NP	317,500	4.5	70,556		$178 / $179	
12a P / 12a NP	731,500	5.5	133,000			$125 / $128
13a NP	104,000	7	14,857	$215		

* P = Power Generation; NP = No power generation

10. SUMMARY AND CONCLUSIONS

The Cement-Lock demonstration-scale plant was operated in December 2006 with the overall objective of thermally treating sediment dredged from the Passaic River through the system and producing a beneficial use product. Although some equipment and weather-related problems were encountered during the campaign, the operating team successfully treated some 16.5 tons of Passaic River plus appropriate modifiers through the demo plant under steady conditions. Based on the results, it is estimated that some 15.6 tons of Ecomelt was produced. The EPA SITE program was able to conduct environmental and stack sampling during two operating days.

A considerable amount of analytical work has been completed to date on the samples taken during the December campaign. Not all of the analytical results and data have been validated. However, the results show that the Cement-Lock technology – when operated under slagging

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mode – can achieve high destruction and removal efficiencies for contaminants of concern, specifically dioxins and furans and PCBs. Similarly, the Activated Carbon Bed Adsorber, the purpose of which is to capture volatile heavy metals (e.g., mercury), also successfully captured 86.7% of the mercury entering it.

The results showed that the levels of NOx produced during slagging-mode operation may require the addition of NOx reduction equipment to the overall Cement-Lock commercial plant process scheme to achieve local regulatory limits. Best management practices will be followed to enable selection of appropriate catalytic or non-catalytic NOx reduction equipment for the application.

11. FUTURE WORK

Because GTI had been operating the demo plant "at risk" to process the Passaic River sediment and the NJ-DOT/OMR contract funding had been essentially expended during the equipment modification work, GTI halted activities at the site pending receipt of contract. To minimize costs incurred, GTI had all rented equipment dismantled and returned.

During further discussions with sponsors, a roadmap was established for GTI to conduct another test campaign during which time additional Passaic River sediment would be processed through the Cement-Lock demo plant. During the planned test campaign, the plant would be operated for a period of from 5 to 7 days. The preblended sediment-modifier mixture would be fed during two shifts and flame management techniques would be employed during the third shift to address any slag accumulation issues. Also during the third shift, sediment and modifiers would be preblended in the sediment storage area. It is anticipated that the EPA SITE program will again participate in the program to provide analytical support for the environmental characterization of the process. The expected time this test campaign to be initiated is mid May 2007.

April 12, 2007

Respectfully submitted,

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This TECHNICAL MEMORANDUM was issued with the notice that the results included herein are subject to final confirmation and review.

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APPENDIX A.

DRAFT

FINAL REPORT BY AIRNOVA, INC., PENNSAUKEN, NEW JERSEY

Project No. 2982

Tetra Tech EM, Inc. @ The Phase II Cement Lock Technology Demonstration on Passaic River Sediments Fabric Filter Baghouse Outlet and Activated Carbon Bed Outlet Bayonne, New Jersey

Emission Evaluation Test Report

R2-0010798

Prepared for:

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Issued: February 2007

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Appendix E - Process Data

1.0 Introduction

AirNova, Inc. conducted an emission evaluation test program on December 6-7, 2006 at the Cement Lock Technology Demonstration Site located in Bayonne, New Jersey. Emission sampling was conducted at the Fabric Filter Baghouse Outlet (also identified as the Granular Activated Carbon Bed Inlet) and the Granular Activated Carbon Bed Outlet to evaluate air emissions associated with the Cement Lock process for the following emission parameters:

- Nitrogen Oxides (NO_X)*
- Carbon Monoxide (CO)*
- Volatile Organic Compounds (VOCs)*
- Sulfur Dioxide (SO_2)*
- Dioxins and Furans
- Toxic Metals
- Polychlorinated Biphenyls (PCBs)
- Hydrogen Chloride (HCl) and Chlorine (Cl_2)*
- Polycyclic Aromatic Hydrocarbons (PAHs) or Semivolatile Organic Compounds (SVOCs)

* These emissions were determined at the Carbon Bed Outlet only.

Emission sampling was also conducted to determine the destruction and removal efficiency (DRE) for the above emission parameters that were conducted at both the Carbon Bed Inlet and Carbon Bed Outlet.

AirNova, Inc. was responsible for the performance of the on-site sampling and sample analysis as well as preparation of this final test report presenting the test results and discussions of all sampling and analytical methods utilized.

This report contains a description of the emission sources, the test locations, and the test methodologies that were utilized in the performance of this program. Questions or comments concerning this report may be directed to:

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2.0 Source Description

The Cement Lock Technology at the Cement Lock Demonstration Site was developed by Gas Technology Institute (GTI) and is licensed by Endesco Clean Harbors (ECH). The technology is a thermo-chemical environmental remediation process that generates construction-grade cement components as a by-product. A generalized schematic of the Cement Lock process is provided in Figure 2-1 on page 5. According to GTI/ECH, feed stock for the manufacturing process can be hazardous or nonhazardous wastes such as dredged sediments, soils, sludges, municipal solid wastes, debris from Brownfields projects, chemical wastes, and incinerator ash and residues. The manufacturing process creates a calcium-alumino-silicate glass termed Ecomelt, which is expected to have characteristics suitable for incorporation into cement. The process of creating Ecomelt is claimed to destroy organic contaminants and to immobilize inorganic contaminants within the Ecomelt.

2.1 Sampling Port Locations

Emission sampling was conducted at the Granular Activated Carbon Bed Inlet in a round, vertical section of exhaust duct which has an outer diameter (O.D.) of 42 inches and an inner diameter (I.D.) of 36 inches. Two (2) sampling ports located 2.3 duct diameters downstream and 0.8 duct diameters upstream from the nearest flow disturbances were utilized for all emissions sampling. A total of twenty-four (24) traverse points were utilized for all volumetric flow rate determinations and isokinetic sampling. The traverse points were located as follows:

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Table 2-1
Cement Lock Demonstration Site
Granular Activated Carbon Bed Inlet
Emission Evaluation Test Program
Traverse Point Locations

Traverse Point	% Stack Diameter	Location (Inches)
1	2.1	0.8
2	6.7	2.4
3	11.8	4.2
4	17.7	6.4
5	25.0	9.0
6	35.6	12.8
7	64.4	23.2
8	75.0	27.0
9	82.3	29.6
10	88.2	31.8
11	93.3	33.6
12	97.9	35.2

Emission sampling was conducted at the Granular Activated Carbon Bed Outlet in a round, vertical section of exhaust duct which is 35.5 inches in diameter. Two (2) sampling ports located 6.3 duct diameters downstream and 3.5 duct diameters upstream from the nearest flow disturbances

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were utilized for all emissions sampling. A total of sixteen (16) traverse points were utilized for all volumetric flow rate determinations and isokinetic sampling. The traverse points were located as follows:

Table 2-2
Cement Lock Demonstration Site
Granular Activated Carbon Bed Outlet
Emission Evaluation Test Program
Traverse Point Locations

Traverse Point	% Stack Diameter	Location (Inches)
1	3.2	1.1
2	10.5	3.7
3	19.4	6.9
4	32.3	11.5
5	67.7	24.0
6	80.6	28.6
7	89.5	31.8
8	96.8	34.4

Figure 2-1
Cement Lock Demonstration Site
Cement Lock Technology
Generalized Process Flow Diagram

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3.0 Summary of Test Results

A complete summary of the test results conducted at the Cement Lock Demonstration Site at the Granular Activated Carbon Bed Inlet and the Granular Activated Carbon Bed Outlet is provided in tabular format. Emission sampling was conducted on December 6-7, 2006 to evaluate air emissions associated with the Cement Lock process. The list of tables which follows indicates the order in which the summary tables have been provided.

Cement Lock Demonstration Site
Emission Evaluation Test Program
Summary of Test Results Tables

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Table 3-1
Cement Lock Demonstration Site
Carbon Bed Outlet
SO_2, NO_x, CO, and VOCs
Test Results Summary

Run No.	**1**	**2**	**3**	**Average**
Date	12/06/06	12/06/06	12/07/06	
Time Period	1625-1725	1812-1912	0934-1034	
Exhaust Gas Characteristics				
Oxygen (%-dry)	3.99	5.13	6.19	5.10
Carbon Dioxide (%-dry)	9.83	10.47	9.41	9.90
Temperature (° F)	287	286	304	292
Moisture (%)	51.1	54.4	53.1	52.9
Velocity (fps)	36.4	36.4	35.9	36.2
Flow Rate (ACFM)	14,983	15,002	14,795	14,927
Flow Rate (DSCFM)	5,230	4,898	4,830	4,986
Carbon Monoxide*				
Concentration (ppmVd)	> 100	17.3	4.2	> 40.5
Concentration (ppmVd @ 7% O_2)	> 82.2	15.2	4.0	> 33.8
Emission Rate (lb/hr)	> 2.27	0.37	0.09	> 0.91
Volatile Organic Compounds				
Concentration (ppmVd)	4.7	4.6	0.9	3.4
Concentration (ppmVd @ 7% O_2)	3.9	4.1	0.8	2.9
Emission Rate (lb/hr)	0.06	0.06	0.01	0.04
Nitrogen Oxides (as NO_2)				
Concentration (ppmVd)	94.0	134	149	126
Concentration (ppmVd @ 7% O_2)	77.3	118	141	112
Emission Rate (lb/hr)	3.51	4.69	5.13	4.44
Sulfur Dioxide				
Concentration (ppmVd)	42.2	16.5	8.8	22.5
Concentration (ppmVd @ 7% O_2)	34.7	14.5	8.3	19.2
Emission Rate (lb/hr)	2.19	0.80	0.42	1.14

Standard Conditions: 70°F, 29.92 inches Hg

* CO emissions during Run No. 1 were out of the calibration range of the analyzer which was operated in the 0-100 ppmV range. Therefore, CO emissions could not be quantified for this test run, and were reported as greater than the detectable quantity of 100 ppmV.

Table 3-2
Cement Lock Demonstration Site
Carbon Bed Outlet
HCl and Cl_2
Test Results Summary

Run No.	**1**	**2**	**Average**
Date	12/06/06	12/07/06	
Time Period	1700-1832	0959-1110	
Exhaust Gas Characteristics			
Oxygen (%-dry)	5.1	6.3	5.7
Carbon Dioxide (%-dry)	10.5	9.2	9.9
Temperature (° F)	286	307	297
Moisture (%)	54.3	52.6	53.5
Velocity (fps)	36.4	35.8	36.1
Flow Rate (ACFM)	15,001	14,761	14,881
Flow Rate (DSCFM)	4,901	4,843	4,872
Hydrogen Chloride			
Concentration (ppmV)	59.3	51.2	55.3
Emission Rate (lb/hr)	1.64	1.40	1.52

Standard Conditions: 70°F, 29.92 inches Hg

Note: Cl_2 emissions were determined to be non-detectable for both test runs. A detailed analysis of Cl_2 quantities can be found in Appendix C of this test report.

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Table 3-3
Cement Lock Demonstration Site
Carbon Bed Inlet
Toxic Metals
Test Results Summary

Run No.	**1**	**2**	**Average**
Date	12/06/06	12/07/06	
Test Period	1625-1901	0930-1148	
Stack Gas Characteristics			
Oxygen (%-dry)	3.99	6.19	5.09
Carbon Dioxide (%-dry)	9.83	9.41	9.62
Temperature (° F)	337	341	339
Moisture (%)	52.8	54.6	53.7
Velocity (fps)	38.7	37.2	38.0
Flow Rate (ACFM)	16,421	15,784	16,103
Flow Rate (DSCFM)	5,101	4,672	4,887
Toxic Metals (Emission Rate - lb/hr)			
Arsenic	8.0e-05	2.0e-05	5.0e-05
Barium	5.1e-05	4.2e-05	4.7e-05
Cadmium	4.0e-05	3.1e-05	3.6e-05
Chromium	4.0e-04	3.7e-04	3.9e-04
Cobalt	1.4e-05	5.5e-06	9.8e-06
Copper	1.9e-04	1.1e-04	1.5e-04
Lead	4.5e-04	2.5e-04	3.5e-04
Manganese	9.8e-03	2.7e-04	5.0e-03
Nickel	3.4e-04	2.9e-04	3.2e-04
Selenium	1.1e-04	2.3e-05	6.7e-05
Silver	2.4e-05	1.5e-05	2.0e-05
Zinc	1.3e-03	7.9e-04	1.0e-03
Mercury	3.0e-03	2.3e-03	2.7e-03
Total Toxic Metals	**1.6e-02**	**4.5e-03**	**1.0e-02**

Standard Conditions: 70°F, 29.92 inches Hg

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Table 3-4
Cement Lock Demonstration Site
Carbon Bed Outlet
Toxic Metals
Test Results Summary

Run No.	**1**	**2**	**Average**
Date	12/06/06	12/07/06	
Test Period	1625-1915	0930-1148	
Stack Gas Characteristics			
Oxygen (%-dry)	3.99	6.19	5.09
Carbon Dioxide (%-dry)	9.83	9.41	9.62
Temperature (° F)	287	304	296
Moisture (%)	51.1	53.1	52.1
Velocity (fps)	36.4	35.9	36.2
Flow Rate (ACFM)	14,983	14,795	14,889
Flow Rate (DSCFM)	5,230	4,830	5,030
Toxic Metals (Emission Rate - lb/hr)			
Arsenic	3.5e-05	4.6e-05	4.1e-05
Barium	4.5e-05	3.5e-05	4.0e-05
Cadmium	1.6e-05	1.1e-05	1.4e-05
Chromium	6.4e-04	2.6e-04	4.5e-04
Cobalt	5.9e-06	6.1e-06	6.0e-06
Copper	1.9e-04	1.3e-04	1.6e-04
Lead	4.3e-04	2.0e-04	3.2e-04
Manganese	1.1e-03	7.4e-04	9.2e-04
Nickel	1.6e-04	9.9e-05	1.3e-04
Selenium	3.1e-05	7.5e-06	1.9e-05
Silver	5.0e-05	6.8e-06	2.8e-05
Zinc	7.1e-04	3.7e-04	5.4e-04
Mercury	< 2.6e-05	5.9e-04	< 3.1e-04
Total Toxic Metals	**3.4e-03**	**2.5e-03**	**3.0e-03**

Standard Conditions: 70°F, 29.92 inches Hg

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Table 3-5
Cement Lock Demonstration Site
Carbon Bed Inlet
Dioxins, Furans, and PCBs
Test Results Summary

Run No.	**1**	**2**	**Average**
Date	12/07/06	12/07-08/06	
Time Period	1406-1754	2026-0016	
Exhaust Gas Characteristics			
Oxygen (%-dry)	6.3	10.6	8.5
Carbon Dioxide (%-dry)	9.2	5.3	7.3
Temperature (° F)	345	342	344
Moisture (%)	49.3	48.1	48.7
Velocity (fps)	36.7	37.5	37.1
Flow Rate (ACFM)	15,551	15,890	15,721
Flow Rate (DSCFM)	5,117	5,368	5,243
Dioxins and Furans			
CDD Total Emission Rate (lb/hr)	6.8e-10	4.6e-10	5.7e-10
CDF Total Emissoin Rate (lb/hr)	9.2e-11	2.1e-10	1.5e-10
Dioxins Total Emission Rate (lb/hr)	7.7e-10	6.7e-10	7.2e-10
PCBs			
Total Emission Rate (lb/hr)	1.9e-03	1.4e-03	1.7e-03

Note: An individualized breakdown of the emission calculations for Dioxins, Furans, and PCBs can be found in Appendix B of this test report.

Standard Conditions: 70°F, 29.92 inches Hg

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Table 3-6
Cement Lock Demonstration Site
Carbon Bed Outlet
Dioxins, Furans, and PCBs
Test Results Summary

Run No.	**1**	**2**	**Average**
Date	12/07/06	12/07-08/06	
Time Period	1406-1748	2026-0016	
Exhaust Gas Characteristics			
Oxygen (%-dry)	6.3	10.6	8.5
Carbon Dioxide (%-dry)	9.2	5.3	7.3
Temperature (° F)	290	289	290
Moisture (%)	49.5	49.6	49.6
Velocity (fps)	35.6	36.2	35.9
Flow Rate (ACFM)	14,684	14,922	14,803
Flow Rate (DSCFM)	5,252	5,336	5,294
Dioxins and Furans			
CDD Total Emission Rate (lb/hr)	3.4e-13	1.7e-13	2.6e-13
CDF Total Emissoin Rate (lb/hr)	6.7e-11	ND	6.7e-11
Dioxins Total Emission Rate (lb/hr)	6.7e-11	1.7e-13	3.4e-11
PCBs			
Total Emission Rate (lb/hr)	2.3e-04	9.7e-05	1.6e-04

ND = Not Detected

Note: An individualized breakdown of the emission calculations for Dioxins, Furans, and PCBs can be found in Appendix B of this test report.

Standard Conditions: 70°F, 29.92 inches Hg

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Table 3-7
Cement Lock Demonstration Site
Carbon Bed Inlet
SVOCs
Test Results Summary

Run No.	**1**	**2**	**Average**
Date	12/07/06	12/07-08/06	
Test Period	1406-1754	2025-0016	
Stack Gas Characteristics			
Oxygen (%-dry)	6.3	10.6	8.45
Carbon Dioxide (%-dry)	9.2	5.3	7.25
Temperature (° F)	346	342	344
Moisture (%)	49.9	48.3	49.1
Velocity (fps)	37.2	37.3	37.3
Flow Rate (ACFM)	15,783	15,800	15,792
Flow Rate (DSCFM)	5,127	5,321	5,224
SVOCs (Emission Rate - lb/hr)			
Benzo(a)pyrene	5.0e-10	ND	< 5.0e-10
1-Methylnaphthalene	1.3e-08	1.9e-09	7.5e-09
2-Methylnaphthalene	1.6e-09	ND	< 1.6e-09
Naphthalene	1.3e-08	8.0e-09	1.1e-08
Phenanthrene	ND	1.0e-09	< 1.0e-09
Total SVOCs	**2.8e-08**	**1.1e-08**	**2.0e-08**

ND = Not Detected

Standard Conditions: 70°F, 29.92 inches Hg

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Table 3-8
Cement Lock Demonstration Site
Carbon Bed Outlet
SVOCs
Test Results Summary

Run No.	**1**	**2**	**Average**
Date	12/07/06	12/07-08/06	
Test Period	1406-1748	2016-0018	
Stack Gas Characteristics			
Oxygen (%-dry)	6.3	10.6	8.45
Carbon Dioxide (%-dry)	9.2	5.3	7.25
Temperature (° F)	288	285	287
Moisture (%)	50.2	50.6	50.4
Velocity (fps)	35.4	35.0	35.2
Flow Rate (ACFM)	14,611	14,416	14,514
Flow Rate (DSCFM)	5,167	5,077	5,122
SVOCs (Emission Rate - lb/hr)			
Benzo(a)pyrene	ND	ND	ND
1-Methylnaphthalene	1.2e-08	ND	< 1.2e-08
2-Methylnaphthalene	ND	ND	ND
Naphthalene	4.5e-09	4.7e-09	4.6e-09
Phenanthrene	ND	ND	ND
Total SVOCs	**1.7e-08**	**4.7e-09**	**1.1e-08**

ND = Not Detected

Standard Conditions: 70°F, 29.92 inches Hg

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Table 3-9
Cement Lock Demonstration Site
DRE of Toxic Metals
Test Results Summary

Run No.	Inlet (lb/hr)	Outlet (lb/hr)	DRE (% wt)
1	1.6e-02	3.4e-03	78.8
2	4.5e-03	2.5e-03	44.4
		Average	**61.6**

$$\text{DRE (\%)} = \frac{[\text{(lb/hr) Toxic Metal}_{in} - \text{(lb/hr) Toxic Metal}_{out}}{\text{(lb/hr) Toxic Metal}_{in}} \times 100\%$$

Table 3-10
Cement Lock Demonstration Site
DRE of Dioxins and Furans
Test Results Summary

Run No.	Inlet (lb/hr)	Outlet (lb/hr)	DRE (% wt)
1	7.7e-10	6.7e-11	91.3
2	6.7e-10	1.7e-13	99.9
		Average	**95.6**

$$\text{DRE (\%)} = \frac{[\text{(lb/hr) Dioxin}_{in} - \text{(lb/hr) Dioxin}_{out}}{\text{(lb/hr) Dioxin}_{in}} \times 100\%$$

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Table 3-11
Cement Lock Demonstration Site
DRE of PCBs
Test Results Summary

Run No.	Inlet (lb/hr)	Outlet (lb/hr)	DRE (% wt)
1	1.9e-03	2.3e-04	87.9
2	1.4e-03	9.7e-05	93.1
		Average	**90.5**

$$\text{DRE (\%)} = \frac{[\text{(lb/hr) PCBs}_{n} - \text{(lb/hr) PCBs}_{out}}{\text{(lb/hr) PCBs}_{in}} \times 100\%$$

Table 3-12
Cement Lock Demonstration Site
DRE of SVOCs
Test Results Summary

Run No.	Inlet (lb/hr)	Outlet (lb/hr)	DRE (% wt)
1	2.8e-08	1.7e-08	39.3
2	1.1e-08	4.7e-09	57.3
		Average	**48.3**

$$\text{DRE (\%)} = \frac{[\text{(lb/hr) SVOCs}_{in} - \text{(lb/hr) SVOCs}_{out}}{\text{(lb/hr) SVOCs}_{in}} \times 100\%$$

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4.0 Test Methodologies

The emission evaluation test program was conducted in determination of the following emission parameters utilizing the specified methodologies.

Table 4-1
Cement Lock Demonstration Site
Emission Evaluation Test Program
Test Methodology Summary

Emission Parameter	No. of Test Runs	Test Location	Sampling and Analytical Methodology
Traverse Point Location	*	Inlet/Outlet	EPA Reference Method 1
Volumetric Flow Rate	*	Inlet/Outlet	EPA Reference Method 2
Oxygen, Carbon Dioxide	*	Inlet/Outlet	EPA Reference Method 3 and 3A
Moisture Content	*	Inlet/Outlet	EPA Reference Method 4
Sulfur Dioxide	3	Outlet	EPA Reference Method 6C
Nitrogen Oxides	3	Outlet	EPA Reference Method 7E
Carbon Monoxide	3	Outlet	EPA Reference Method 10
Volatile Organic Compounds	3	Outlet	EPA Reference Method 25A
Specific Volatile Organic Compounds	2	Inlet/Outlet	Modified EPA Reference Method 5
Dioxins and Furans	2	Inlet/Outlet	EPA Reference Method 23
Polychlorinated Biphenyls	2	Inlet/Outlet	EPA Reference Method 23
Hydrogen Chloride and Chlorine	2	Outlet	EPA Reference Method 26A
Toxic Metals	2	Inlet/Outlet	EPA Reference Method 29

* These parameters were determined concurrently with all other emission parameters.

A description of the above referenced test methodologies is provided below.

4.1 Cyclonic Flow

The absence of cyclonic flow was demonstrated at each sampling location according to

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Section 11.4 of EPA Reference Method 1. An S-type pitot was connected to a manometer. The pitot tube was placed in such a position that the openings of the pitot tube were perpendicular to the stack gas flow. An angle finder was placed on the pitot tube which was rotated until a reading of zero (0) is obtained. The 'yaw' angle was then recorded. The cyclonic flow traverse was performed at the traverse point locations specified in Tables 2-1 and 2-2.

4.2 Stack Gas Velocity and Volumetric Flow Rate Determination

The determination of stack gas velocity and volumetric flow rate was performed in accordance with EPA Reference Method 2. Velocity traverses across the stack diameter at each test location were performed using an S-type pitot tube and type-K thermocouple. The S-type pitot tube was connected to an inclined vertical manometer via leak-free connections. The type-K thermocouple was connected to a digital temperature indicator for signal output. These readings were observed and recorded at each traverse point for each test run.

A post-test leak check of the S-type pitot tube, the manometer and the interconnecting tubing was performed in accordance with the procedure described in EPA Reference Method 2, "Determination of Stack Gas Velocity and Volumetric Flow Rate (Pitot Tube)."

4.3 Moisture Content

All moisture content determinations followed EPA Reference Method 4, Section 2.2.2 as necessary. Determinations conducted by EPA Method 4 utilized large capacity impingers and collected a minimum volume of 30 DSCF.

4.4 Gaseous Emissions Sampling System

An extractive sampling system was used to continuously determine O_2, CO_2, CO, NO_X, SO_2, and VOC concentrations. A representative sample of the flue gas was extracted through a heated (225°F) stainless steel probe and filter assembly, and transported via a heat-traced Teflon sample

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line through a heated glass fiber filter and a Teflon lined diaphragm sample pump to a condensation removal trap located in a mobile laboratory. VOC samples bypassed the condensation trap. A heated out-of-stack filter assembly was maintained at a sufficient temperature to prevent water condensation. A three-way valve was utilized to block sample gas flow and introduce calibration gases to the measurement system at the outlet of the sampling probe during system calibrations. The condensation trap was cooled to approximately 40°F. The sample was exhausted from the trap free of moisture and particulate matter. The sample was introduced into a constant-pressure manifold constructed of stainless steel and Teflon for metered distribution to the respective analyzers.

Output signals from all instrumental analyzers were stored on strip chart recorders as well as a personal computer (PC) based data acquisition system (DAS). All reference method data was reported from the DAS. The strip chart recorders were used for a backup record. All continuous analyzers utilized for the RM testing provided a linear response to the DAS over the calibrated range. This was verified by the pre-test calibration results.

4.4.1 Oxygen and Carbon Dioxide

Oxygen and carbon dioxide concentrations of the stack gases were determined by EPA Reference Method 3A. The sampling system was as described above. Oxygen concentrations were determined using a paramagnetic oxygen analyzer. The oxygen analyzer was operated in the 0-22.05% range. Carbon dioxide concentrations were determined using a non-dispersive infared analyzer which was operated in a range of 0-12.36%. Calibration gases were 0-20% (zero gas), 45-55% and 80-100% of the calibration span, which is defined as the range from zero to the actual high span gas cylinder concentration. All calibration gases were Protocol 1 grade (± 1%). A sampling system bias check was performed prior to the first test run by introducing the zero gas and the mid-

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level span gas at the sample probe/sample line interface. The sampling system bias check was repeated after each test run to determine the instrument zero and calibration drift. Oxygen and carbon dioxide concentrations were determined simultaneously with all sampling events.

In addition, oxygen and carbon dioxide concentrations were determined by EPA Reference Method 3. The sampling train consisted of a stainless steel probe with a glass fiber filter for particulate filtration. The sampling probe was attached to a water cooled condenser used to remove excess moisture from the sample stream. The condenser was attached to a leak-free diaphragm pump with an in-line needle valve to adjust the sample flow rate. The sampling train was leak-checked in accordance with the procedure described in EPA Reference Method 3, presampling run. The sample stream then passed through a surge tank (eliminating the pulsation effects of the pump) and a rotameter, which measures the sampling flow rate to within ±2% of the selected flow rate for the test, into a leak-free Tedlar bag.

Determination of percent CO_2 and O_2 was performed using a Fisher Type B No. 10-605 ORSAT gas analyzer which uses the principle of gas absorption in specific absorbing solutions. All Tedlar bags utilized for this sampling underwent the leak check procedure specified in EPA Method 10.

4.4.2 Nitrogen Oxides

Nitrogen oxides concentrations were determined by EPA Reference Method 7E. The principle of this method is to continuously extract a gaseous sample of flue gas and introduce a portion of this sample into a chemiluminescent analyzer for the determination of concentration. The principle of the analyzer is based on the following reaction:

$$NO + O_3 \rightarrow NO_2 + O_2 + \text{a photon}$$

The photons emitted by the reaction are measured by a photomultiplier tube. The

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photomultiplier signal is proportional to the number of NO molecules; therefore, the photomultiplier signal is recorded as the concentration for NO_x. The sample flowrate is carefully controlled. NO_x is comprised of NO and NO_2. NO_2 present in the sample gas is converted into NO prior to entering the reaction chamber by a NO_2 to NO converter. The NO_2 to NO converter breaks one [1] of the two [2] nitrogen-oxygen bonds by passing the sample gas through capillary tubing into an electronically controlled, heated catalytic converter. Calibration gases were 0-20% (zero gas), 45-55% and 80-100% of the calibration span. All calibration gases were NIST traceable Protocol 1. A zero and midpoint bias calibration was performed from the sample probe both before and after each test run. Output signals were stored and processed by a PC based DAS system as well as a strip chart recorder. The analyzer was operated in the 0-448.1 ppmV range. A NO_X converter calibration was performed immediately prior to the start of sampling.

4.4.3 Carbon Monoxide

Carbon monoxide concentrations were determined by gas filter correlation spectroscopy. A representative sample of stack gas is directed to the analyzer via the sample transport system described above. The sample enters the analyzer and is passed through the sample cell. Radiation from an infrared source is chopped then passed through a gas filter which alternates between CO and N_2 due to the rotation of the filter wheel. The radiation then passes through a narrow band pass interference filter and enters a multiple optical cell where absorption by the sample gas occurs. The IR radiation then exits the sample cell and is focused on the detector. The CO gas filter acts to produce a reference beam which cannot be further attenuated by CO in the sample cell. The N_2 side of the gas filter is transparent to the IR radiation. This beam is absorbed by CO present in the sample. Absorption of the IR beam by CO in the sample causes a proportional

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difference in the signals from the sample and reference cell beams. This difference is converted electronically into an output signal that is linearly proportional to the concentration of CO in the sample. Before and after each sample run, the analyzer was calibrated with NIST Protocol 1 Grade (± 1%) traceable calibration gases. Calibration gases were 0-20% (zero gas), 45-55% and 80-100% of the calibration span. The analyzer was operated in the 0-89.6 ppmV range. A zero and midpoint bias calibration was performed from the sample probe both before and after each test run. Output signals were stored and processed by a PC based DAS system as well as a strip chart recorder.

4.4.4 Volatile Organic Compounds

Volatile organic compound emissions were determined by directing a portion of the sample into a total hydrocarbon analyzer equipped with a flame ionization detector (FID). With the total hydrocarbon analyzer, sample gas is transported to the FID via a heated sample train. All hydrocarbon species present are ionized simultaneously to produce the signal output. The THC-FID was calibrated with NIST traceable Protocol 1 grade methane calibration gases. Three (3) calibration gases of 20-30%, 45-55% and 80-90% of span were utilized. A zero and midpoint bias calibration was performed for the continuous FID both before and after each test run. The THC-FID was operated in the 0-100 ppmV range. Output signals from the THC-FID were stored and processed by a PC based DAS system and strip chart recorder.

4.4.5 Sulfur Dioxide

Sulfur dioxide concentrations were determined in accordance with EPA Reference Method 6C utilizing a UV photometric analyzer.

The analyzer is comprised of a single ultraviolet source, a chopper wheel containing two interference filters, a beam splitter, one measuring cell, one reference cell and two matched

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photodetectors. During SO_2 measurement, two wavelengths are used - one which is absorbed by SO_2 is used for the measuring wavelength (285 nm) and one which is not absorbed by SO_2 or other components normally in the gas sample stream is used as a reference wavelength (585nm). The sample flows through the measuring cell while the reference cell contains only non-absorbing gases. As the chopper wheel rotates, a flash of radiation passes through the measuring filter to the beam splitter. After a brief period, a flash of radiation passes through the reference filter to reference filter to the beam splitter. These flashes of measuring and reference radiation continue at a nominal frequency of 52 times per second per filter. The beam splitter directs half the radiation through the measuring cell and half through the reference cell to the two detectors which develop electrical signals proportional to the amount of radiation that impinged on the detectors. The detector signals are demultiplexed into two measuring signals and two reference signals. The reference signals are used to automatically control the gain of each detector to independently compensate each path for optical contamination. The detector signal developed from the measuring wavelength radiation that passes through the reference cell is used to control the current to the ultraviolet source. The two detector signals developed from the reference wavelength radiation that pass through the measuring and reference cell are used to produce an analyzer output signal that is proportional to the SO_2 concentration in the measuring cell.

The SO_2 analyzer was calibrated prior to the start of sampling with NIST traceable, Protocol grade calibration gases. The analyzer was operated in the 0-500 ppmV range. A sampling system bias check was performed prior to the first test run by introducing the zero gas and the mid-level span gas at the sample probe/sample line interface. The sampling system bias check was repeated after each test run to determine the instrument

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zero and calibration drift.

4.5 Toxic Metals

Metals in the exhaust gases were determined isokinetically using EPA Reference Method 29 "Methodology for the Determination of Metal Emissions in Exhaust Gases from Hazardous Waste Incinerator Processes".

Metals sampling occurred during 2-hour sampling events. Triplicate test runs were performed with each collecting a minimum volume of 60 DSCF. The sampling train consisted of the following components:

- Quartz glass sample nozzle and probe
- Heated glass fiber filter
- A modified Greenburg Smith impinger containing 100 ml of a 5% HNO_3/10% H_2O_2
- A Greenburg-Smith impinger containing 100 ml 5% HNO_3/10% H_2O_2
- Modified Greenburg-Smith impinger initially empty
- Two (2) modified Greenburg-Smith impingers containing 100 ml 4% $KMn0_4$/10% H_2SO_4 solution
- An impinger containing approximately 225 g of silica gel desiccant
- Dry gas meter equipped with inlet and outlet thermocouples

The sample was extracted from the exhaust stream using a vane-type vacuum pump. Isokinetic sampling conditions were maintained through the use of a type "S" pitot tube to monitor the exhaust gas stream pressure differentials. A type "K" thermocouple was utilized to determine the exhaust gas temperature.

At the completion of sampling, the probe liner, nozzle, and front half of the filter housing were rinsed and brushed with 100 ml of a 0.1N nitric acid reagent and the washings were placed in a glass amber container retained for analysis. The filter was removed from the filter holder and placed in a petri dish and sealed. The contents of impingers 1 and 2 were measured for volume increase and placed in a second glass amber container. Impingers 1 and 2 and the back half of the filter housing

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were then rinsed with a total of 100 ml 0.1N nitric acid and the washings were placed in a third glass amber container. The contents of impinger 3 were measured for volume increase and placed in a fourth glass amber container along with a total of 100 ml 0.1N nitric acid washings. Impingers 4 and 5 were measured for volume increase and placed in a fifth glass amber container along with a total of 100 ml each of the fresh permanganate and distilled water rinses of all sample exposed areas for the two (2) impingers. Impingers 4 and 5 were then rinsed with a total of 25 ml of 8N HCl which was placed in a sixth glass amber container. The silica gel was recovered from the last impinger and placed in a sealed container for weight gain determination.

Prior to analysis, the collected front and back half liquid sample volumes were reduced. The filter was acid digested in accordance with the method prior to being combined with the probe rinse for analysis. Arsenic, barium, cadmium, chromium, copper, nickel, lead, selenium, silver, and zinc were determined by graphite furnace atomic absorption spectrophotometry (GFAA). Mercury was determined by cold vapor atomic absorption spectrophotometry (CVAA). Cobalt and manganese were analyzed by inductively coupled plasma-optical emission spectroscopy (ICP).

4.6 Specific Volatile Organic Compounds

SVOCs were determined utilizing a modified EPA Reference Method 5/Solid Waste Method 0010 sampling train. The sampling train consisted of the following apparatus connected in series:

- **Quartz glass probe and stainless steel nozzle**
- **Glass fiber filter contained within a heated filter holder**
- **Glass coil type condenser (water jacketed)**
- **Glass adsorbent trap containing 30 grams of XAD-2 adsorbent resin (water jacketed)**
- **A water-knockout impinger**
- **A modified Greenburg-Smith impinger containing 100 ml of distilled water**
- **A Greenburg-Smith impinger containing 100 ml of distilled water**
- **A modified Greenburg-Smith impinger-empty**
- **A modified Greenburg-Smith impinger containing 250 g of silica gel desiccant**

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All glassware utilized in the sampling was pre-cleaned as described in Section 3A of the "Manual of Analytical Methods for the Analysis of Pesticides in Human and Environmental Samples".

Sampling was conducted in duplicate 3-hour sampling events with each collecting a minimum sample volume of 105 DSCF. Prior to the start of sampling, a leak check was conducted at 15 in. Hg vacuum to ensure that all connections were leak free. The following information was recorded at each traverse point:

- **Stack temperature**
- **Dry gas meter temperature**
- **Stack gas pressure differential**
- **Differential pressure across the orifice meter**

At the completion of sampling, a post run leak check was conducted followed by sample recovery. The nozzle and probe were removed from the sampling train and both ends were capped. The filter was removed from the filter holder and placed in an identified container. The adsorbent module was capped and covered with foil. The nozzle, probe, front half of the filter holder, back half of the filter holder and the condenser were brushed and rinsed with acetone three (3) times, followed by three (3) rinses with methylene chloride. Both rinses were collected and stored in an amber glass jar with a Teflon lined lid. All rinses were combined later during analysis. The volume of the first four (4) impingers was determined and each were then rinsed three (3) times with deionized water. The contents were retained for analysis along with the deionized water rinses and the front half acetone and methylene chloride rinses. The silica gel was recovered from the fifth impinger and placed in a sealed polyethylene container.

Analysis of the samples occured by Soxhlet extraction and concentration of the

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aqueous matrices, followed by high resolution gas chromatography/mass spectrometry [GC/MS] analysis.

4.7 Dioxins, Furans, and Polychlorinated Biphenyls

Dioxins, furans, and PCBs from each test location were determined according to the procedures detailed in EPA Reference Method 23. The sampling train consisted of the following apparatus connected in series:

- Quartz glass probe and stainless steel nozzle
- Glass fiber filter contained within a heated filter holder
- Glass coil type condenser (water jacketed)
- Glass adsorbent trap containing 30 grams of XAD-2 adsorbent resin (water jacketed)
- A water-knockout impinger
- A modified Greenburg-Smith impinger containing 100 ml of distilled water
- A Greenburg-Smith impinger containing 100 ml of distilled water
- A modified Greenburg-Smith impinger-empty
- A modified Greenburg-Smith impinger containing 250 g of silica gel desiccant

All glassware utilized in the sampling was pre-cleaned as described in Section 3A of the "Manual of Analytical Methods for the Analysis of Pesticides in Human and Environmental Samples".

Sampling was conducted in duplicate 3-hour sampling events with each event collecting a minimum sample volume of 105 DSCF. Prior to the start of sampling, a leak check was conducted at 15 in. Hg vacuum to ensure that all connections were leak free. The following information was recorded at each traverse point:

- Stack temperature
- Dry gas meter temperature
- Stack gas pressure differential
- Differential pressure across the orifice meter
- Sample box temperature
- Impinger temperature
- Condenser exit temperature

At the completion of sampling, a post run leak check was conducted followed by sample recovery. The nozzle and probe was removed from the sampling train and both ends were capped.

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The filter was removed from the filter holder and placed in an identified container. The adsorbent module was capped and covered with foil. The nozzle, probe, front half of the filter holder, back half of the filter holder and the condenser were brushed and rinsed with acetone three (3) times and were collected and stored in an amber glass jar with a Teflon lined lid. The glassware was then rinsed with toluene and stored in a separate amber glass jar with a Teflon lid. All rinses were combined later during analysis. The volume of impingers 1, 2, 3, and 4 was determined for moisture gain and the contents placed in an amber glass jar with a Teflon lined lid. The pH was measured of the impinger solution, and was found to be greater than 4.5. Therefore, the impinger solution was not neutralized with 0.1N NaOH. The four impingers were rinsed three (3) times each with deionized water and were collected and stored in an amber glass jar with a Teflon lined lid. The silica gel was recovered from the fifth impinger and placed in a sealed polyethylene container.

Analysis of the samples for dioxins, furans, and PCBs involved Soxhlet extraction and concentration of the aqueous matrices, followed by high resolution gas chromatography/mass spectrometry [GC/MS] analysis.

Emissions calculations for dioxins, furans, and PCBs can be found in Appendix B of this test report.

A full list of each PCB compound can also be found in Appendix B directly before the dioxins, furans, and PCBs emission calculation spreadsheets.

4.8 Hydrogen Chloride and Chlorine

Emissions of hydrogen chloride and chlorine were determined using an EPA Reference Method 26A sampling train. The samples were collected isokinetically. The sample train consisted of the following apparatus connected in series:

- Quartz probe and nozzle
- A desiccated, tared quartz filter within a heated borosilicate glass filter holder with a Teflon frit

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- A modified Greenburg-Smith impinger containing 100 ml of 0.1 N H_2SO_4
- A Greenburg-Smith impinger containing 100 ml of 0.1 N H_2SO_4
- A Greenburg-Smith impinger containing 100 ml of 0.1 NaOH
- A modified Greenburg-Smith impinger containing 100 ml of 0.1 NaOH
- A modified Greenburg-Smith impinger containing approximately 250 g of silica gel desiccant
- Vane type pump
- Dry gas meter equipped with thermocouples

An S-type pitot tube was attached to the sample probe to monitor exhaust gas stream pressure differentials in order to maintain isokinetic sampling conditions and determine the volumetric flow rate. A type-K thermocouple was also attached to measure the exhaust gas temperature. The glass fiber filter was maintained at a temperature greater than 248 °F.

Two (2) 1-hour test runs were conducted with each event collecting a minimum of 30 DSCF. Prior to the start of sampling, a leak check was conducted at 15 in. Hg vacuum to insure that all connections were leak free. The following information was recorded at each traverse point:

- Dry gas meter volume
- Stack Temperature
- Dry gas meter temperature (inlet and outlet)
- Stack gas pressure differentials
- Differential pressure across the orifice meter
- Filter temperature in heated compartment
- Gas temperature exiting the fourth impinger (silica gel desiccant)

At the completion of sampling, the sampling train was post run leak checked at the maximum vacuum encountered during the test run and then disassembled and the sample fractions recovered. The quartz filter was removed and placed in a polyethylene container. All sample exposed areas of the front half of the sampling train (nozzle, probe and front half of the filter holder) were brushed and rinsed three (3) times with acetone and placed in a polyethylene container. The volume of impingers 1 and 2 was measured with a graduated cylinder and the contents were placed in a polyethylene container. The volume of impingers 3 and 4 was measured with a graduated cylinder and the contents were placed in a separate polyethylene container. The back half of the filter holder,

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impinger 1, and impinger 2 were washed with distilled/deionized water and placed in the same polyethylene container as the original contents of impingers 1 and 2. Impingers 3 and 4 were washed with distilled/deionized water and placed in the same polyethylene container as the original contents of impingers 3 and 4. The silica gel desiccant was removed from the last impinger and placed in its original tared polyethylene container. The samples were then transported to the AirNova, Inc. laboratory facility for subsequent analysis.

Analysis of the HCl samples was performed using a Bacharach TriDet HPLC equipped with a nonsuppressed conductivity detector. An Alltech Anion/R 10 um, 250 x 4.1 mx (or equivalent) column was used for separation of ionic species. A 4.0 g/l p-HBA (2.5% MeOH) buffer solution adjusted to a pH of 4.0 - 4.4 with LiOH was used as the eluent.

Prior to calibration and sample analysis, a stable baseline was established. The calibration curve was generated using four (4) concentrations of Cl plus a zero standard. The standards were prepared using IC high quality standards.

During the analysis of the HCl, the four (4) calibration standards were prepared for each contaminant in concentrations that were within the linear range of the field samples. The calibration standards, starting at the lowest first, were injected both before and after injection of the quality control check sample, reagent blanks, and field samples.

Chlorine was determined to be non-detectable after analysis of the samples.

4.9 Process Operating Data

The process operating conditions were documented by the plant control room personnel. The data included information such as: production rate, fuel use and any other applicable process data. All process data is included in Appendix E of this test report.

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During the testing period on December 7, 2006, the following abnormal process operations had occurred:

- For a few hours after 14:45, no sediment material was fed into the unit for processing.
- At 22:45, there was a flame out on the burner and it was never reignited. At 02:00 on December 8, 2006, the unit was shut down.

5.0 Quality Assurance/Quality Control Procedures

All of the source sampling and analytical procedures were performed in accordance with the US EPA's 'Good Laboratory Practice' guidelines. AirNova, Inc. followed the requirements of the individual test methods to ensure the precision and accuracy of the source testing procedures. In addition, AirNova, Inc. followed the procedures provided in the 'Quality Assurance Handbook for Air Pollution Measurement Systems, Volume III, Stationary Sources'. Sampling equipment that was utilized in the test program was calibrated prior to the test performance. The following procedures were utilized.

5.1 S-Type Pitot Tubes

The S-type pitot tubes were visually inspected to verify dimension requirements. Pitot tubes meeting requirements were assigned a pitot tube coefficient of 0.84. Pitot tubes which did not meet the requirements were not utilized.

5.2 Dry Gas Meters and Orifice Meters

All dry gas meters used in the field were calibrated against a transfer standard dry gas meter that is maintained in AirNova's calibration data. The transfer standard gas meter is calibrated annually and certified against an NIST traceable Bell-type Prover which operates by liquid displacement.

Field dry gas meters and orifice meters are calibrated at two month intervals at the following

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orifice meter settings:

- 0.5 in. H_2O
- 1.0 in. H_2O
- 2.0 in. H_2O
- 3.0 in. H_2O
- 4.0 in. H_2O
- 5.0 in. H_2O

The initial and final volume readings and temperature readings were recorded for the dry gas meter and the secondary standard test meter at each orifice meter setting. A dry gas meter correction factor (DGMCF) was calculated for each setting and the average DGMCF was recorded.

All calibration documentation is stored in a designated filing cabinet for future reference. All repair and maintenance documentation for each meter is stored in files that provide a history of each meter and aid in our preventative maintenance program.

AirNova, Inc. also participates in the EPA Method 5 Dry Gas Meter Audit Program.

5.3 Nozzles

Probe nozzles selected for isokinetic sampling were calibrated according to section 3.4.2 of the "Quality Assurance Handbook for Air Pollution Measurement Systems: Volume III" Upon receipt, the inner diameter of each nozzle is measured across three (3) distinct diameters with a micrometer caliper. The calibrated nozzle diameter is the average of these measurements. Each nozzle is identified uniquely and its calibrated diameter is checked prior to use.

5.4 Thermocouples

Thermocouples and thermometers utilized in the sampling program were calibrated according to section 3.4.2 of the "Quality Assurance for Air Pollution Measurement Systems: Volume III" every two months. The calibration method includes comparing each field thermometer and thermocouple at different temperatures to an ASTM certified mercury-in-glass thermometer. The temperatures

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must agree within the tolerances mentioned for the type of sampling equipment being calibrated. All the calibration data is stored in a designated filing cabinet for future reference.

1. Stack Gas and Filter Housing Thermocouples and Thermometers
   Three temperatures are measured and extrapolated over the range of temperatures encountered in field operations. The three temperatures used for calibration are:
   1. Ice bath
   2. Boiling point of water
   3. Boiling point of cooking oil (or equivalent in solid salt bath)

2. Impinger Thermometers and Thermocouples
   Two temperatures are required to calibrate:
   1. Ice bath
   2. Stabilized room temperature

3. Dry Gas Thermometers
   Two temperatures are required to calibrate:
   1. Stabilized hot water bath at approximately 104 - 122°F (40 - 50°C)
   2. Stabilized room temperature

5.5 Labels

All samples collected as part of the sampling program (silica gel desiccant samples) were affixed with labels which identify the following: 1) Project No., 2) Date, 3) Type of sample, 4) Run No., 5) Sample location, and 6) Sample fraction.

5.6 Chain-of-Custody Documentation

Chain-of-custody documentation for all samples was implemented at the completion of sampling and sample clean-up and was documented until the samples were received by the laboratory for analysis.

5.7 Calibration Gases

- NIST Traceable Protocol 1 grade (±1%) gas standards were utilized for calibration of the NO_x, O_2, CO_2, CO, **SO_2** and THC analyzers.

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APPENDIX B.

DETAILED CHEMICAL ANALYSES OF
PASSAIC RIVER SEDIMENT FEED AND ECOMELT PRODUCT

(Includes SPLP and TCLP test results on Ecomelt and
Ecomelt mortar samples)

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TABLE 1. ANALYTICAL RESULTS OF INPUT SEDIMENT SAMPLES
PHASE 2 CEMENT-LOCK DEMONSTRATION
Bayonne, New Jersey

Compound	Class	Units	P2-SS-01	P2-SS-02	P2-SS-03	P2-SS-03 (Dup)	P2-SS-04	P2-SS-05	P2-SS-06	Average**
PCBs										
1-MoCB	Congeners	pg/g	1,370 J	1,370 J	1,820 J	2,380 J	2,720	1,640	2,180 J	1,926
2-MoCB	Congeners	pg/g	1,350 J	1,220 J	1,130 J	1,550 J	1,320	1,710	1,930 J	1,459
3-MoCB	Congeners	pg/g	1,910 J	1,920 J	2,270 J	3,250 J	3,220 J	2,680	2,980 J	2,604
4-DiCB	Congeners	pg/g	10,100 J	7,810 J	9,780 J	11,500 J	9,520 J	9,730 J	8,870	9,616
5-DiCB	Congeners	pg/g	2,880	1,950	3,330 U	3,920	3,960	2,170	2,830	3,006
6-DiCB	Congeners	pg/g	7,120	5,320	8,800	11,100	11,400	6,290	6,700	8,104
7-DiCB	Congeners	pg/g	1,570	1,070	1,320	1,270	1,610	1,340	1,480	1,380
8-DiCB	Congeners	pg/g	26,500	20,000	21,000	26,900	25,700	24,800	26,600	24,500
9-DiCB	Congeners	pg/g	1,710	1,250	1,880	2,520	2,370	1,450	1,610	1,827
10-DiCB	Congeners	pg/g	223 U	387	1,310	1,480	1,310	207 U	388 U	758
11-DiCB	Congeners	pg/g	44,500	30,400	38,100	46,200	44,500	37,[illegible]	39,200	40,057
12-DiCB	Congeners	pg/g	7,460 C	6,010 C	8,430 C	10,200 C	10,100 C	[illegible] C	7,430 C	8,121 C
13-DiCB	Congeners	pg/g	C12	C12	C12	C12	C12	[illegible]	C12	
14-DiCB	Congeners	pg/g	349 U	149 U	352 U	540 U	471 U	[illegible] U	220 U	328 U
15-DiCB	Congeners	pg/g	32,200	27,600	30,500	40,100 J	36,900	31,	33,000 J	33,057
17-TrCB	Congeners	pg/g	34,200	25,000	36,100	35,200	38,200	26,300	29,100	32,014
18-TrCB	Congeners	pg/g	55,500 C	41,400 C	63,300 C	61,800 C	69,600 C	42,000 C	49,700 C	54,757 C
19-TrCB	Congeners	pg/g	9,920	7,230	11,300 J	13,900	12,500 J	8,830	10,400	10,583
20-TrCB	Congeners	pg/g	120,000 C	95,700 C	121,000 C	124,000 C	126,000 C	97,700 C	106,000 C	112,914 C
21-TrCB	Congeners	pg/g	42,900 C	33,100 C	45,200 C	45,900 C	49,000 C	34,500 C	34,300 C	40,700 C
22-TrCB	Congeners	pg/g	37,900	27,200	33,000	32,200	35,100	29,900	32,300	32,514
23-TrCB	Congeners	pg/g	69 U	89 U	91 U	135 U	110 U	76 U	74 U	92 U
24-TrCB	Congeners	pg/g	1,910	12,000	2,610	17,700	19,900	1,080	1,260	8,066
25-TrCB	Congeners	pg/g	15,000	11,600	15,200	15,500	17,200	12,500	12,500	14,214
26-TrCB	Congeners	pg/g	20,300 C	15,500 C	20,100 C	18,300 C	20,600 C	17,300 C	17,800 C	18,557 C
27-TrCB	Congeners	pg/g	6,620	5,470	7,390	149 U	6,770	5,330	6,040	5,396
28-TrCB	Congeners	pg/g	C20	C20	C20	C20	C20	[illegible]	C20	
29-TrCB	Congeners	pg/g	C26	C26	C26	C26	C26	[illegible]	C26	
30-TrCB	Congeners	pg/g	C18	C18	C18	C18	C18	[illegible]	C18	
31-TrCB	Congeners	pg/g	97,700	77,700	91 U	135 U	110 U	8[illegible]	85,300	49,291
32-TrCB	Congeners	pg/g	28,200	22,500	26,600	25,900	26,900	1[illegible]	25,500	25,043
33-TrCB	Congeners	pg/g	C21	C21	C21	C21	C21	[illegible]	C21	
34-TrCB	Congeners	pg/g	879	642	105 U	155 U	127 U	[illegible]	652	459
35-TrCB	Congeners	pg/g	3,840	3,280	222 U	5,550	3,870	[illegible]	3,970	3,500 U
36-TrCB	Congeners	pg/g	180 U	174 U	208 U	319 U	248 U	[illegible] J	175 U	205 U
37-TrCB	Congeners	pg/g	34,800	31,100	31,300	31,100	30,100	2[illegible]	33,200	31,457
38-TrCB	Congeners	pg/g	190 U	184 U	223 U	342 U	266 U	[illegible] J	184 U	218 U
39-TrCB	Congeners	pg/g	899	615	912	906	1,090	[illegible]	164 U	761
40-TeCB	Congeners	pg/g	61,900 C	56,100 C	53,400	66,000 C	62,600 C	5[illegible]	67,200 C	60,900 C
41-TeCB	Congeners	pg/g	4,080	3,570	6,040 C	5,450	6,040	[illegible]	5,630	4,980
42-TeCB	Congeners	pg/g	37,700	35,500	33,400	39,100	37,400	3[illegible]	41,000	37,129
43-TeCB	Congeners	pg/g	4,690	4,170	3,690	4,400	5,870	[illegible]	4,700	4,579
44-TeCB	Congeners	pg/g	156,000 C	135,000 C	132,000 C	158,000 C	147,000 C	14[illegible]	164,000 C	147,571 C
45-TeCB	Congeners	pg/g	42,700 C	41,200 C	44,500 C	49,000 C	43,500 C	4[illegible]	45,200 C	43,914 C
46-TeCB	Congeners	pg/g	8,570	8,190	9,260	10,900	10,200	8,870	9,070	9,294
47-TeCB	Congeners	pg/g	C44	C44	C44	C44	C44	C44	C44	
48-TeCB	Congeners	pg/g	23,100	18,300	21,300	24,900	26,400	20,200	22,200	22,343
49-TeCB	Congeners	pg/g	93,900 C	81,100 C	79,500 C	96,800 C	92,900 C	84,700 C	95,300 C	89,171 C

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Dredged Material Management Assessments
Lower Passaic River Restoration Project
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TABLE 1. ANALYTICAL RESULTS OF INPUT SEDIMENT SAMPLES
PHASE 2 CEMENT-LOCK DEMONSTRATION
Bayonne, New Jersey

Compound	Class	Units	P2-SS-01	P2-SS-02	P2-SS-03	P2-SS-03 (Dup)	P2-SS-04	P2-SS-05	P2-SS-06	Average**
50-TeCB	Congeners	pg/g	23,500 C	23,000 C	25,700 C	29,400 C	26,800 C	24,900 C	25,900 C	25,600 C
51-TeCB	Congeners	pg/g	C45	C45	C45	C45	C45	C45	C45	
52-TeCB	Congeners	pg/g	145,000	125,000	140,000	165,000	152,000	132,000	151,000	144,286
53-TeCB	Congeners	pg/g	C50	C50	C50	C50	C50	C50	C50	
54-TeCB	Congeners	pg/g	3,260	2,750	2,820	3,810	2,860	72 U	3,230 J	2,686
55-TeCB	Congeners	pg/g	254 U	202 U	2,220	4,250	279 U	1,700	2,440	1,621
56-TeCB	Congeners	pg/g	52,300	43,100	32,800	39,800	39,000	44,400	52,500	43,414
57-TeCB	Congeners	pg/g	667	678	543	663	725	234 U	610	589
58-TeCB	Congeners	pg/g	247 U	641	3,930	4,520	4,160	4,670	365 U	2,648
59-TeCB	Congeners	pg/g	12,700 C	12,600 C	13,500 C	15,900 C	14,000 C	12,400 C	14,000 C	13,586 C
60-TeCB	Congeners	pg/g	14,500	12,000	10,800	14,300	13,900	12,600	14,200	13,186
61-TeCB	Congeners	pg/g	231,000 C	187,000 C	171,000 C	210,000 C	209,000 C	200,[illegible] C	234,000 C	206,000 C
62-TeCB	Congeners	pg/g	C59	C59	C59	C59	C59	[illegible]	C59	
63-TeCB	Congeners	pg/g	4,350	4,010	4,080	4,890	298 U	4[illegible]	397 U	3,168
64-TeCB	Congeners	pg/g	54,600	48,400	51,700	63,200	58,200	50,[illegible]	58,600	54,971
65-TeCB	Congeners	pg/g	C44	C44	C44	C44	C44	[illegible]	C44	
66-TeCB	Congeners	pg/g	108,000	94,200	89,600	111,000	105,000	96,300	107,000	101,586
67-TeCB	Congeners	pg/g	4,060	3,510	3,410	4,430	4,630	3,980	4,470	4,070
68-TeCB	Congeners	pg/g	245 U	1,320	1,070	1,330	1,290	208 U	1,280	963
69-TeCB	Congeners	pg/g	C49	C49	C49	C49	C49	C49	C49	
70-TeCB	Congeners	pg/g	C61	C61	C61	C61	C61	C61	C61	
71-TeCB	Congeners	pg/g	C40	C40	C40	C40	C40	C40	C40	
72-TeCB	Congeners	pg/g	1,420	1,280	265 U	1,590	1,460	1,480	372 U	1,124
73-TeCB	Congeners	pg/g	4,970	1,120	3,190 U	5,330	4,470	1,250	1,780	3,159
74-TeCB	Congeners	pg/g	C61	C61	C61	C61	C61	C61	C61	
75-TeCB	Congeners	pg/g	C59	C59	C59	C59	C59	C59	C59	
76-TeCB	Congeners	pg/g	C61	C61	C61	C61	C61	C61	C61	
77-TeCB	Congeners	pg/g	11,000 J	10,300	10,300	24,400 J	12,500	1[illegible]	11,300 J	12,957
78-TeCB	Congeners	pg/g	279 U	222 U	271 U	332 U	302 U	[illegible] J	412 U	294 U
79-TeCB	Congeners	pg/g	1,570	185 U	1,310	1,930	1,330	[illegible]	2,050	1,401
80-TeCB	Congeners	pg/g	241 U	191 U	232 U	284 U	258 U	[illegible] J	355 U	252 U
81-TeCB	Congeners	pg/g	261 U	201 U	217 U	270 U	249 U	[illegible] J	374 U	253
82-PeCB	Congeners	pg/g	13,100	13,300	12,400	14,100	13,400	1[illegible]	14,000	13,343
83-PeCB	Congeners	pg/g	6,670	6,370	4,800	5,250	8,360	[illegible]	6,450	5,847
84-PeCB	Congeners	pg/g	33,700	32,700	28,700	35,300	30,000	3[illegible]	35,500	32,414
85-PeCB	Congeners	pg/g	18,100 C	17,900 C	15,000 C	20,400 C	19,600 C	1[illegible]	19,600 C	18,229 C
86-PeCB	Congeners	pg/g	74,400 C	70,200 C	65,800 C	79,300 C	70,700 C	6[illegible]	74,500 C	71,943 C
87-PeCB	Congeners	pg/g	C86	C86	C86	C86	C86	[illegible]	C86	
88-PeCB	Congeners	pg/g	11,100 C	22,500 C	22,700 C	27,100 C	23,200 C	2[illegible]	25,500 C	22,171 C
89-PeCB	Congeners	pg/g	1,820	1,530	1,950	2,240	1,850	[illegible]	2,000	1,854
90-PeCB	Congeners	pg/g	117,000 C	111,000 C	109,000 C	126,000 C	113,000 C	10[illegible]	121,000 C	115,000 C
91-PeCB	Congeners	pg/g	C88	C88	C88	C88	C88	[illegible]	C88	
92-PeCB	Congeners	pg/g	22,500	21,600	20,900	24,500	21,700	2[illegible]	23,700	22,271
93-PeCB	Congeners	pg/g	14,000 C	80 U	10,100 C	12,700 C	10,300 C	1[illegible]	11,000 C	9,969 C
94-PeCB	Congeners	pg/g	100 U	2,350	2,360	2,740	2,490	[illegible]	2,640	2,184
95-PeCB	Congeners	pg/g	91,200	92,300	92,600	110,000	95,900	88,900	98,500	95,629
96-PeCB	Congeners	pg/g	2,020	2,030	2,010	2,370	1,950	1,910	2,170	2,066
97-PeCB	Congeners	pg/g	C86	C86	C86	C86	C86	C86	C86	
98-PeCB	Congeners	pg/g	9,040 C	8,070 C	7,200 C	9,500 C	7,920 C	8,210 C	9,160 C	8,443 C

TABLE 1. ANALYTICAL RESULTS OF INPUT SEDIMENT SAMPLES
PHASE 2 CEMENT-LOCK DEMONSTRATION
Bayonne, New Jersey

Compound	Class	Units	P2-SS-01	P2-SS-02	P2-SS-03	P2-SS-03 (Dup)	P2-SS-04	P2-SS-05	P2-SS-06	Average**
99-PeCB	Congeners	pg/g	53,200	55,000	54,200	63,200	54,700	57,300	59,800	56,771
100-PeCB	Congeners	pg/g	C93	C93	C93	C93	C93	C93	C93	
101-PeCB	Congeners	pg/g	C90	C90	C90	C90	C90	C90	C90	
102-PeCB	Congeners	pg/g	C98	C98	C98	C98	C98	C98	C98	
103-PeCB	Congeners	pg/g	3,950	3,900	3,580	4,530	3,690	3,790	4,190	3,947
104-PeCB	Congeners	pg/g	1,270	1,020	1,470 U	1,730	1,080	1,070	1,190	1,261
105-PeCB	Congeners	pg/g	32,000	27,700	27,300	33,600	32,800	29,000	32,600	30,714
106-PeCB	Congeners	pg/g	219 U	170 U	284 U	206 U	218 U	182 U	270 U	221 U
107-PeCB	Congeners	pg/g	3,710 C	176 U	3,200 C	4,240 C	3,520 C	3,370 C	3,550 C	3,109
108-PeCB	Congeners	pg/g	C86	C86	C86	C86	C86	C86	C86	
109-PeCB	Congeners	pg/g	8,030	7,170	7,020	8,790	8,000	7,810	8,390	7,887
110-PeCB	Congeners	pg/g	123,000 C	122,000 C	105,000 C	121,000 C	112,000 C	[illegible] C	127,000 C	118,571 C
111-PeCB	Congeners	pg/g	74 U	64 U	94 U	100 U	179 U	[illegible] U	107 U	96 U
112-PeCB	Congeners	pg/g	3,740	1,160	92 U	99 U	175 U	[illegible]	1,560	1,122
113-PeCB	Congeners	pg/g	C90	C90	C90	C90	C90	[illegible]	C90	
114-PeCB	Congeners	pg/g	1,820	175 U	1,570	1,980	1,950	[illegible] U	1,700	1,341
115-PeCB	Congeners	pg/g	C110	C110	C110	C110	C110	C110	C110	
116-PeCB	Congeners	pg/g	C85	C85	C85	C85	C85	C85	C85	
117-PeCB	Congeners	pg/g	C85	C85	C85	C85	C85	C85	C85	
118-PeCB	Congeners	pg/g	80,700	71,900	73,900	90,400	84,400	71,300	79,100	78,814
119-PeCB	Congeners	pg/g	C86	C86	C86	C86	C86	C86	C86	
120-PeCB	Congeners	pg/g	73 U	432	608	748	568	603	525	508
121-PeCB	Congeners	pg/g	72 U	63 U	94 U	100 U	178 U	181	105 U	113
122-PeCB	Congeners	pg/g	1,070	1,250	1,330	218 U	1,650	207 U	1,350	1,011
123-PeCB	Congeners	pg/g	1,500	150 U	1,710 J	2,170	1,980	189 U	1,340	1,291
124-PeCB	Congeners	pg/g	C107	C107	C107	C107	C107	C107	C107	
125-PeCB	Congeners	pg/g	C86	C86	C86	C86	C86	C86	C86	
126-PeCB	Congeners	pg/g	238 U	180 U	250 U	189 U	1,000	[illegible]	965	569
127-PeCB	Congeners	pg/g	227 U	176 U	266 U	193 U	204 U	[illegible] U	280 U	219 U
128-HxCB	Congeners	pg/g	16,900 C	16,400 C	15,900 C	19,600 C	16,500 C	[illegible] C	17,600 C	17,214
129-HxCB	Congeners	pg/g	392 U	115,000 C	112,000 C	132,000 C	116,000 C	[illegible] C	131,000 C	104,913
130-HxCB	Congeners	pg/g	7,090	6,430	7,100	515 U	597 U	[illegible]	7,460	5,190
131-HxCB	Congeners	pg/g	1,710	499 U	1,220	1,630	1,290	[illegible]	1,880	1,398
132-HxCB	Congeners	pg/g	39,200	35,800	33,800	40,500	36,300	[illegible]	40,500	37,843
133-HxCB	Congeners	pg/g	2,330	447 U	2,210	3,040	559 U	[illegible] U	2,680	1,647
134-HxCB	Congeners	pg/g	5,840	6,570	6,830	8,580	6,960	[illegible]	7,190	6,850
135-HxCB	Congeners	pg/g	45,000 C	42,100 C	42,400 C	49,900 C	45,300 C	[illegible] C	48,400 C	45,657 C
136-HxCB	Congeners	pg/g	17,000	16,000	16,500	19,300	17,200	[illegible]	18,400	17,471
137-HxCB	Congeners	pg/g	4,720	4,210	4,210	419 U	4,510	[illegible]	7,920	4,741
138-HxCB	Congeners	pg/g	C129	C129	C129	C129	C129	[illegible]	C129	
139-HxCB	Congeners	pg/g	2,320 C	2,090 C	2,260 C	2,460 C	509 U	[illegible] C	2,260 C	2,021
140-HxCB	Congeners	pg/g	C139	C139	C139	C139	C139	[illegible]	C139	
141-HxCB	Congeners	pg/g	21,100	18,300	19,300	22,900	19,800	[illegible]	21,100	20,371
142-HxCB	Congeners	pg/g	433 U	464 U	497 U	513 U	594 U	[illegible] U	564 U	477 U
143-HxCB	Congeners	pg/g	419 U	449 U	448 U	462 U	535 U	[illegible] U	547 U	446 U
144-HxCB	Congeners	pg/g	5,700	5,160	5,250	6,410	5,720	5,870	6,140	5,750
145-HxCB	Congeners	pg/g	213 U	106 U	127 U	155 U	191 U	95 U	153 U	149 U
146-HxCB	Congeners	pg/g	19,900	19,000	18,700	21,200	19,300	20,700	20,600	19,914
147-HxCB	Congeners	pg/g	107,000 C	102,000 C	94,500 C	114,000 C	102,000 C	109,000 C	113,000 C	105,929 C

TABLE 1. ANALYTICAL RESULTS OF INPUT SEDIMENT SAMPLES
PHASE 2 CEMENT-LOCK DEMONSTRATION
Bayonne, New Jersey

Compound	Class	Units	P2-SS-01	P2-SS-02	P2-SS-03	P2-SS-03 (Dup)	P2-SS-04	P2-SS-05	P2-SS-06	Average**
148-HxCB	Congeners	pg/g	631	136 U	729 U	671	262 U	1,000	663	585
149-HxCB	Congeners	pg/g	C147	C147	C147	C147	C147	C147	C147	
150-HxCB	Congeners	pg/g	193 U	873	853	1,060	1,030	1,130	1,010	878
151-HxCB	Congeners	pg/g	C135	C135	C135	C135	C135	C135	C135	
152-HxCB	Congeners	pg/g	205 U	102 U	466 U	395	203 U	91 U	590	293
153-HxCB	Congeners	pg/g	337 U	108,000 C	101,000 C	115,000 C	107,000 C	122,000 C	121,000 C	96,334
154-HxCB	Congeners	pg/g	223 U	3,860	4,120	4,780	5,160	99 U	4,230	3,210
155-HxCB	Congeners	pg/g	5,640	5,610	5,500	7,370	6,290	6,440 J	6,820	6,239
156-HxCB	Congeners	pg/g	11,700 C	10,000 C	10,900 C	12,300 C	11,000 C	11,400 JC	11,500 C	11,257 C
157-HxCB	Congeners	pg/g	C156	C156	C156	C156	C156	C156	C156	
158-HxCB	Congeners	pg/g	11,100	10,300	10,500	12,200	10,900	11,200	11,300	11,071
159-HxCB	Congeners	pg/g	1,730	1,470	1,740	1,940	1,640	[illegible]	285 U	1,601
160-HxCB	Congeners	pg/g	297 U	319 U	308 U	318 U	1,760	[illegible] U	388 U	511 U
161-HxCB	Congeners	pg/g	311 U	333 U	336 U	346 U	401 U	[illegible] U	406 U	333 U
162-HxCB	Congeners	pg/g	206 U	197 U	1,281 U	1,193 U	1,315 U	[illegible] U	271 U	683 U
163-HxCB	Congeners	pg/g	C129	C129	C129	C129	C129	C[illegible]	C129	
164-HxCB	Congeners	pg/g	8,420	7,410	7,770	9,170	8,040	6,270	6,060	7,591
165-HxCB	Congeners	pg/g	333 U	358 U	350 U	361 U	418 U	210 U	435 U	352 U
166-HxCB	Congeners	pg/g	C128	C128	C128	C128	C128	C128	C128	
167-HxCB	Congeners	pg/g	4,050	3,720	4,270 J	4,470	4,390	4,080	4,050	4,147
168-HxCB	Congeners	pg/g	C153	C153	C153	C153	C153	C153	C153	
169-HxCB	Congeners	pg/g	208 UJ	174 U	1,137 U	1,121 U	1,220 U	291 U	278 U	633 U
16-TrCB	Congeners	pg/g	22,300	20,100	15,800	17,800	20,000	16,900	20,600	19,071
170-HpCB	Congeners	pg/g	32,400	30,300	31,500	37,800	33,500	37,600	32,500	33,657
171-HpCB	Congeners	pg/g	10,800 C	11,000 C	9,550 C	10,800 C	10,500 C	12,400 C	11,400 C	10,921 C
172-HpCB	Congeners	pg/g	5,820	5,870	6,170	6,860	6,400	6,830	6,140	6,299
173-HpCB	Congeners	pg/g	C171	C171	C171	C171	C171	C171	C171	
174-HpCB	Congeners	pg/g	36,400	34,700	31,600	40,500	38,900	4[illegible]	38,500	37,800
175-HpCB	Congeners	pg/g	1,600	1,610	1,390	1,680	204 U	[illegible]	1,800	1,441
176-HpCB	Congeners	pg/g	5,410	4,710	5,030	5,460	5,220	[illegible]	5,390	5,281
177-HpCB	Congeners	pg/g	21,400	21,600	20,100	24,700	23,300	2[illegible]	23,800	22,871
178-HpCB	Congeners	pg/g	8,140	7,860	8,120	9,380	8,260	[illegible]	8,240	8,501
179-HpCB	Congeners	pg/g	18,200	17,000	17,600	18,900	17,800	2[illegible]	18,700	18,343
180-HpCB	Congeners	pg/g	72,900 C	72,200 C	70,200 C	85,200 C	75,800 C	9[illegible]	76,800 C	77,700 C
181-HpCB	Congeners	pg/g	313 U	241 U	370 U	250 U	455 U	[illegible] J	196 U	292 U
182-HpCB	Congeners	pg/g	167 U	130 U	219 U	151 U	194 U	[illegible] J	192 U	177 U
183-HpCB	Congeners	pg/g	23,900 C	22,200 C	25,100 C	30,000 C	25,800 C	2[illegible]	25,900 C	25,843 C
184-HpCB	Congeners	pg/g	129 U	277	224 U	306	283	[illegible] J	271	233
185-HpCB	Congeners	pg/g	C183	C183	C183	C183	C183	[illegible]	C183	
186-HpCB	Congeners	pg/g	132 U	103 U	117 U	122 U	157 U	[illegible] J	152 U	133 U
187-HpCB	Congeners	pg/g	47,200	45,500	42,000	52,700	47,400	5[illegible]	48,800	48,943
188-HpCB	Congeners	pg/g	133 U	239	211 U	295	136 U	[illegible] J	307	209
189-HpCB	Congeners	pg/g	1,080	999	1,160	1,220	1,290	[illegible]	1,110	1,158
190-HpCB	Congeners	pg/g	7,380	6,690	6,420	7,610	6,820	[illegible] J	160 U	5,037
191-HpCB	Congeners	pg/g	1,440	196 U	1,330	1,590	1,670	[illegible]	1,540	1,339
192-HpCB	Congeners	pg/g	253 U	195 U	320 U	216 U	393 U	178 U	159 U	245 U
193-HpCB	Congeners	pg/g	C180	C180	C180	C180	C180	C180	C180	
194-OcCB	Congeners	pg/g	19,600	17,800	18,700	21,300	19,500	36,700	21,300	22,129
195-OcCB	Congeners	pg/g	7,870	6,860	7,520	8,880	8,180	12,800	7,940	8,579

TABLE 1. ANALYTICAL RESULTS OF INPUT SEDIMENT SAMPLES
PHASE 2 CEMENT-LOCK DEMONSTRATION
Bayonne, New Jersey

Compound	Class	Units	P2-SS-01	P2-SS-02	P2-SS-03	P2-SS-03 (Dup)	P2-SS-04	P2-SS-05	P2-SS-06	Average**
196-OcCB	Congeners	pg/g	10,900	9,750	9,930	12,000	11,200	20,800	11,300	12,269
197-OcCB	Congeners	pg/g	1,040 C	2,990 C	2,650 C	3,070 C	2,550 C	5,000 C	3,450 C	2,964 C
198-OcCB	Congeners	pg/g	22,100 C	21,200 C	21,600 C	25,500 C	22,500 C	33,500 C	23,700 C	24,300 C
199-OcCB	Congeners	pg/g	C198	C198	C198	C198	C198	C198	C198	
200-OcCB	Congeners	pg/g	C197	C197	C197	C197	C197	C197	C197	
201-OcCB	Congeners	pg/g	3,250	2,780	2,480	3,440	2,900	4,480	3,160	3,213
202-OcCB	Congeners	pg/g	4,630 J	4,240	4,940	5,490	5,030	7,420	5,110	5,266
203-OcCB	Congeners	pg/g	12,500	12,100	12,800	14,500	13,600	16,800	13,300	13,657
204-OcCB	Congeners	pg/g	103 U	239 U	255 U	217 U	243 U	160 U	177 U	199 U
205-OcCB	Congeners	pg/g	161 U	769	1,030 J	220 U	1,050 J	90 U	154 U	496
206-NoCB	Congeners	pg/g	9,670	9,170	10,600	11,800	11,100	17,400	11,500	11,606
207-NoCB	Congeners	pg/g	1,360	1,420	1,400	1,720	1,590	2,750	1,520	1,680
208-NoCB	Congeners	pg/g	3,480	3,500	3,650	191 U	4,450 J	4,610	4,370	3,464
209-DeCB	Congeners	pg/g	8,110	7,820	8,410 J	8,060	7,930	8,180	10,300	8,401
Total of PCB Congeners*			3,252,077	3,114,840	3,109,518	3,644,480	3,417,274	3,371,196	3,551,332	3,351,531
TEQ (PCB)	TEQ	ng/kg	32	27	36	37	126	135	117	73

R2-0010839

TABLE 1. ANALYTICAL RESULTS OF INPUT SEDIMENT SAMPLES
PHASE 2 CEMENT-LOCK DEMONSTRATION
Bayonne, New Jersey

Compound	Class	Units	P2-SS-01	P2-SS-02	P2-SS-03	P2-SS-03 (Dup)	P2-SS-04	P2-SS-05	P2-SS-06	Average**
DIOXINS/FURANS										
1,2,3,4,6,7,8-HpCDD	Dioxins-Furans	pg/g	1,170	1,100	1,010	969	1,080	1,020	1,060 J	1,058
1,2,3,4,6,7,8-HpCDF	Dioxins-Furans	pg/g	1,130	1,660	1,010	917	1,200	1,010	1,020 J	1,135
1,2,3,4,7,8,9-HpCDF	Dioxins-Furans	pg/g	36	44 J	32 J	28 J	35 J	36	35	35
1,2,3,4,7,8-HxCDD	Dioxins-Furans	pg/g	12	10 J	11 J	9 J	10 J	11	11	11
1,2,3,4,7,8-HxCDF	Dioxins-Furans	pg/g	276	279	214	201	242	241	237	241
1,2,3,6,7,8-HxCDD	Dioxins-Furans	pg/g	80	70	62 J	62 J	66 J	70	68	68
1,2,3,6,7,8-HxCDF	Dioxins-Furans	pg/g	71	76	55 J	55 J	65 J	71	64	65
2,3,4,6,7,8-HxCDF	Dioxins-Furans	pg/g	49	45 J	41 J	37 J	41 J	40	40	42
1,2,3,7,8,9-HxCDD	Dioxins-Furans	pg/g	39	34 J	33 J	30 J	36 J	33	32	34
1,2,3,7,8,9-HxCDF	Dioxins-Furans	pg/g	13	11 J	10	10 J	11 J	11	10	11
1,2,3,7,8-PeCDD	Dioxins-Furans	pg/g	71.1J Q	6 U	13 J	12 J	8 U	16 J	20	12
1,2,3,7,8-PeCDF	Dioxins-Furans	pg/g	26.6J Q	24 JQ	22 J	20 J	22 JQ	26 J	26	23
2,3,4,7,8-PeCDF	Dioxins-Furans	pg/g	112J JQ	98	90	85	90 JQ	73 J	91 J	88
2,3,7,8-TCDD	Dioxins-Furans	pg/g	2,330 JQ	704	644	589	569	571 J	994 J	914
2,3,7,8-TCDF	Dioxins-Furans	pg/g	58 JQ	2 U	39	40	36	30 J	270 J	68
OCDD	Dioxins-Furans	pg/g	12,600 JE	11,400	10,400	10,100	11,200	10,600 J	11,300 J	11,086
OCDF	Dioxins-Furans	pg/g	1,900	2,490	1,580	1,360	1,950	1,780	1,940 J	1,857
Total HpCDDs	Dioxins-Furans	pg/g	2,580	2,370	2,170	2,110	2,320	2,260 J	2,370	2,311
Total HpCDFs	Dioxins-Furans	pg/g	1,660	2,150	1,440	1,340	1,680	1,530	1,530	1,619
Total HxCDDs	Dioxins-Furans	pg/g	576 J	524	480 J	469	504 J	513 J	551	517
Total HxCDFs	Dioxins-Furans	pg/g	846 J	1,080 J	915 J	847	955 J	939 J	889 J	924
Total PeCDDs	Dioxins-Furans	pg/g	404 J	136 J	140 J	130 J	113 J	138 J	208	181
Total PeCDFs	Dioxins-Furans	pg/g	1,220 J	1,280 J	1,140 J	1,070 J	1,120 J	1,090 J	1,140 J	1,151
Total TCDDs	Dioxins-Furans	pg/g	3,550 J	944	847	766	768	806 J	1,670 J	1,336
Total TCDFs	Dioxins-Furans	pg/g	1,280 J	1,180 J	1,140 J	1,080	1,140	1,170 J	1,520 J	1,216
Total of TCDD/DF Congeners*			26,616	23,554	20,252	19,272	21,750	20,826	23,118	22,198
TEQ (Dioxin)	TEQ	ng/kg	2,543.1	844.7	771.1	709.2	694.1	696.8	1,157.0	1,059
Total TEQ	TEQ	ng/kg	2,575.4	871.2	807.0	746.7	820.1	831.6	1,274.1	1,132
METALS										
Arsenic	Metals	mg/kg	15.3	15.2	14.7	14.1	14.1	14	13.7	14
Barium	Metals	mg/kg	185	189	187	190	174	190	193	187
Cadmium	Metals	mg/kg	7.9	7.6 J	7.9 J	7.8 J	6.9 J	8.3 J	8.5 J	8 J
Chromium	Metals	mg/kg	207	210	219	212	211	204	205	210
Cobalt	Metals	mg/kg	12.7	12.2	12.7	12.4	12.2	12.6	12.7	13
Copper	Metals	mg/kg	262	269	264	274	239	247	260	259
Lead	Metals	mg/kg	395	384	399	388	358	381	379	383
Manganese	Metals	mg/kg	418	446	455	431	453	474	432	444
Mercury	Metals	mg/kg	4.8	5.3	5.6	5.5	5.4	5.4	4.9	5
Nickel	Metals	mg/kg	58.6 J	54.7 J	57.7 J	53.8 J	54.6 J	55.2 J	53.3 J	55 J
Selenium	Metals	mg/kg	3.1 U	3.2 U	3.4 U	3.2 U	3.1 U	3.3 U	3.7	3 U
Silver	Metals	mg/kg	5.6	5.8	6	5.9	5.3	5.9	6.4	6
Zinc	Metals	mg/kg	649 J	651 J	674 J	666 J	605 J	671 J	662 J	654 J

R2-0010840

TABLE 1. ANALYTICAL RESULTS OF INPUT SEDIMENT SAMPLES
PHASE 2 CEMENT-LOCK DEMONSTRATION
Bayonne, New Jersey

Compound	Class	Units	P2-SS-01	P2-SS-02	P2-SS-03	P2-SS-03 (Dup)	P2-SS-04	P2-SS-05	P2-SS-06	Average**
PESTICIDES										
4,4'-DDD	Pest	ug/kg	19.6	19	18.4	22.4	20.8	29.7	32.2 J	23
4,4'-DDE	Pest	ug/kg	32 J	31.9 J	26.7 J	34.9 J	29.1 J	47.9	46.6 J	36
4,4'-DDT	Pest	ug/kg	28.2 J	25.2 J	28	34.4 J	27.7 J	29.7 J	87.9 J	37
Dieldrin	Pest	ug/kg	0.53 U	0.54 U	0.55 U	0.54 U	0.53 U	0.54 U	0.54 U	1
SVOCs										
Acenaphthene	SVOC	ug/kg	61.9	69.3	51.1	51.3	72.2	76.8	79.9	66
Acenaphthylene	SVOC	ug/kg	178	221	236	243	283	251	292	243
Anthracene	SVOC	ug/kg	212	221	219	215	262	352	369	264
Benzo(a)anthracene	SVOC	ug/kg	643	697	700	709	790	1140	1110	827
Benzo(a)pyrene	SVOC	ug/kg	675	658	649	648	879	1120	1090 J	817
Benzo(b)fluoranthene	SVOC	ug/kg	701	751	712	700	937	1280	1200	897
Benzo(g,h,i)perylene	SVOC	ug/kg	143	140	193	170	250	484	408	255
Benzo(k)fluoranthene	SVOC	ug/kg	599	694	691	639	754	1110	1050	791
bis(2-Ethylhexyl)phthalate	SVOC	ug/kg	15700	15700	12300	12500	13200	17900	37300 J	17,800
Chrysene	SVOC	ug/kg	526	588	586	613	708	1010	985	717
Dibenzo(a,h)anthracene	SVOC	ug/kg	70.4	68.4	97.9	82.3	115	231	205	124
Di-n-octyl phthalate	SVOC	ug/kg	670	647	674	232	10 U	960	2150 J	763
Fluoranthene	SVOC	ug/kg	1190	1300	1180	1090	1460	1900	1860	1,426
Fluorene	SVOC	ug/kg	123	145	131	58.6	80.1	183	196	131
Indeno(1,2,3-cd)pyrene	SVOC	ug/kg	145	142	182	170	236	440	379	242
Naphthalene	SVOC	ug/kg	40.9	48.5	37.7	33.5	39.1	71.1	58.3	47
Phenanthrene	SVOC	ug/kg	466	523	448	423	656	717	706	563
Pyrene	SVOC	ug/kg	1410	1640	1460	1310	1710	2430	2370	1,761

Notes:
U - Analyte was not detected. The associated value is the estimated detection limit.
J - The analyte is present, but the concentration is below the quantitation limit. The concentration is estimated
UJ - The detection limit is estimated.
C - The isomer coeluted with another of its homologue group. If followed by a number, the number indicates the lowest numbered congener among the coelution set.
"-" The sample was not analyzed for that analyte.
* The total of these analytes includes non-detected values at the detection limit
** Average includes "U", "C", or "J" only if all 6 samples include the modifier

R2-0010841

TABLE 2. ANALYTICAL RESULTS ECOMELT® SAMPLES
PHASE 2 CEMENT-LOCK DEMONSTRATION
Bayonne, New Jersey

Compound	Class	Units	P2-SEM-01	P2-SEM-02	P2-SEM-03	P2-SEM-04	P2-SEM-04 (Dup)	P2-SEM-05	P2-SEM-06	Average
PCBs										
1-MoCB	Congeners	pg/g	0.499 UJ	0.33 UJ	0.586 U	0.557 U	0.454 U	1.25	0.278 UJ	0.56
2-MoCB	Congeners	pg/g	0.463 U	0.324 UJ	0.627 U	0.612 U	0.56 U	2.62	0.724 U	0.85
3-MoCB	Congeners	pg/g	0.402 U	0.297 UJ	0.922 JQ	0.367 UJ	0.652 J	0.432 U	0.25 UJ	0.47
4-DiCB	Congeners	pg/g	1.78 U	2.85 U	1.09 U	1.34 U	0.864 U	1.97 U	1.74 U	1.66 U
5-DiCB	Congeners	pg/g	0.459 U	0.54 U	0.976 U	1.45 U	0.834 U	2 U	2.62 U	1.27 U
6-DiCB	Congeners	pg/g	0.393 U	0.462 U	0.656 U	0.977 U	0.56 U	2.17 U	2.09 U	1.04 U
7-DiCB	Congeners	pg/g	0.363 U	0.426 U	0.611 U	0.91 U	0.522 U	2.06 U	1.98 U	0.98 U
8-DiCB	Congeners	pg/g	0.35 U	0.412 U	0.529 U	0.788 U	1.4	2.55 U	1.8 U	1.12
9-DiCB	Congeners	pg/g	0.441 UJ	0.518 UJ	0.838 U	-	0.715 U	2.98 U	2.86 U	1.39
10-DiCB	Congeners	pg/g	1.14 U	1.71 U	0.677 U	0.856 U	0.555 U	1.35 U	2.34 U	1.23
11-DiCB	Congeners	pg/g	0.424 U	0.498 U	0.748 U	1.11 U	0.639 U	2.52 U	66.1	10.29
12-DiCB	Congeners	pg/g	0.39 U	1.85 J	0.68 U	1.01 U	0.581 U	2.3 U	2.13 U	1.28
13-DiCB	Congeners	pg/g	C12	C12	C12	C12	C12	C12	C12	
14-DiCB	Congeners	pg/g	0.426 U	0.501 U	0.743 U	1.11 U	0.634 U	2.48 U	2.4 U	1.18
15-DiCB	Congeners	pg/g	0.504 U	0.573 U	0.769 U	1.16 U	0.669 U	2.54 U	1.28 U	1.07
16-TrCB	Congeners	pg/g	0.936 U	0.7 U	0.65 U	0.623 U	0.612 UJ	0.464 U	0.619 U	0.66
17-TrCB	Congeners	pg/g	0.907 U	0.678 U	0.778 U	0.746 U	0.733 U	0.547 U	0.803 U	0.74 U
18-TrCB	Congeners	pg/g	0.789 U	0.59 U	2.4 C	0.659 U	0.648 U	0.508 U	0.7 U	0.90
19-TrCB	Congeners	pg/g	1.13 U	0.895 U	0.821 U	0.826 U	0.759 U	0.58 U	0.476 U	0.78 U
20-TrCB	Congeners	pg/g	0.567 U	0.424 U	0.597 U	0.572 U	0.562 U	0.398 U	17.2 C	2.90
21-TrCB	Congeners	pg/g	0.549 U	0.41 U	0.559 U	2.76 CJ	2.49 C	0.376 U	0.579 U	1.10
22-TrCB	Congeners	pg/g	0.623 U	0.465 U	0.613 U	0.587 U	0.577 U	0.423 U	0.594 U	0.55 U
23-TrCB	Congeners	pg/g	0.562 U	0.42 U	0.56 U	0.536 U	0.527 U	0.402 U	0.546 U	0.51 U
24-TrCB	Congeners	pg/g	0.713 U	0.532 U	0.531 U	0.509 U	0.5 U	0.443 U	0.62 U	0.55 U
25-TrCB	Congeners	pg/g	0.466 U	0.348 U	0.602 JQ	0.47 UJ	0.462 U	0.308 UJ	1.68	0.62
26-TrCB	Congeners	pg/g	0.564 U	0.422 U	0.581 U	0.556 UJ	0.547 U	0.417 U	0.599 U	0.53 U
27-TrCB	Congeners	pg/g	0.699 U	0.522 U	0.694 U	0.664 U	0.653 U	0.451 U	0.642 U	0.62 U
28-TrCB	Congeners	pg/g	C20	C20	C20	C20	C20	C20	C20	
29-TrCB	Congeners	pg/g	C26	C26	C26	C26	C26	C20	C20	
30-TrCB	Congeners	pg/g	C18	C18	C18	C18	C18	C18	C18	
31-TrCB	Congeners	pg/g	0.595 U	0.444 U	0.606 U	0.58 U	0.57 U	0.427 U	11.5	2.10
32-TrCB	Congeners	pg/g	0.613 U	0.458 U	1.12	0.542 U	0.533 UJ	0.418 U	2.44	0.87
33-TrCB	Congeners	pg/g	C21	C21	C21	C21	C21	C21	C21	
34-TrCB	Congeners	pg/g	0.689 U	0.515 U	0.638 U	0.611 U	0.601 U	0.463 U	0.707 U	0.60 U
35-TrCB	Congeners	pg/g	0.74 U	0.524 U	0.677 U	0.632 U	0.624 U	0.683 U	0.576 U	0.64 U
36-TrCB	Congeners	pg/g	0.675 U	0.478 U	0.721 U	0.673 U	0.664 U	0.599 U	0.484 U	0.61 U
37-TrCB	Congeners	pg/g	0.78 U	0.529 U	0.693 U	0.625 U	0.648 U	0.749 U	0.281 U	0.62 U
38-TrCB	Congeners	pg/g	0.737 U	0.521 U	0.642 U	0.6 U	0.591 U	0.71 U	0.561 U	0.62 U
39-TrCB	Congeners	pg/g	0.645 U	0.456 U	0.563 U	0.525 U	0.518 U	0.59 U	0.457 U	0.54 U
40-TeCB	Congeners	pg/g	14.1 C	11.4 C	1.09 U	1.22 CJ	1.23 CJ	0.762 U	0.968 U	4.40
41-TeCB	Congeners	pg/g	0.458 U	0.84 U	1.6 U	1.27 U	1.36 U	1.16 U	1.8 U	1.21 U
42-TeCB	Congeners	pg/g	9	6.45	1.18 U	0.937 U	1 U	0.899 U	2.76	3.18
43-TeCB	Congeners	pg/g	1.74	0.776 UJ	1.03 U	0.82 U	0.877 U	0.753 U	0.906 U	0.99
44-TeCB	Congeners	pg/g	34.6 C	27.8 C	1.04 U	0.827 U	0.885 UJ	0.773 U	0.974 U	9.56
45-TeCB	Congeners	pg/g	6 C	0.782 U	1.26 U	1.1 U	1.12 U	0.827 U	0.887 U	1.71
46-TeCB	Congeners	pg/g	0.713 U	0.827 U	1.28 U	1.12 U	1.14 U	0.843 U	0.881 U	0.97 U
47-TeCB	Congeners	pg/g	C44	C44	C44	C44	C44	C44	C44	
48-TeCB	Congeners	pg/g	5.69	0.616 U	1.15 U	0.91 U	0.973 U	0.825 U	1.07 U	1.60
49-TeCB	Congeners	pg/g	20.8 C	15.9 C	2.05 C	2.28 CJ	1.84 CJ	4.17 C	8.28 C	7.90 C
50-TeCB	Congeners	pg/g	0.663 U	0.769 U	1.21 U	1.06 U	1.08 U	0.798 U	0.856 U	0.92 U
51-TeCB	Congeners	pg/g	C45	C45	C45	C45	C45	C45	C45	
52-TeCB	Congeners	pg/g	35.2	0.638 U	1.43 U	1.13 U	1.21 U	0.942 U	22.5	9.01

TABLE 2. ANALYTICAL RESULTS ECOMELT® SAMPLES
PHASE 2 CEMENT-LOCK DEMONSTRATION
Bayonne, New Jersey

Compound	Class	Units	P2-SEM-01	P2-SEM-02	P2-SEM-03	P2-SEM-04	P2-SEM-04 (Dup)	P2-SEM-05	P2-SEM-06	Average
53-TeCB	Congeners	pg/g	C50	C50	C50	C50	C50	C50	C50	
54-TeCB	Congeners	pg/g	0.691 UJ	1.02 U	0.766 U	0.7 U	0.706 U	0.397 U	0.243 U	0.65 U
55-TeCB	Congeners	pg/g	28.9	0.446 U	1.8 U	0.618 U	0.701 U	0.506 U	1.18 U	4.88
56-TeCB	Congeners	pg/g	0.569 U	0.43 U	1.46 U	0.503 U	0.916 J	0.432 U	1.01 U	0.76
57-TeCB	Congeners	pg/g	0.585 U	0.442 U	1.84 U	0.634 U	0.719 U	0.562 U	1.35 U	0.88 U
58-TeCB	Congeners	pg/g	0.553 UJ	0.418 U	1.76 U	0.605 U	0.686 U	0.519 U	1.23 U	0.82 U
59-TeCB	Congeners	pg/g	2.99 J	2.37 CJ	0.894 U	0.71 U	0.759 U	0.688 UJ	0.958 CJ	1.34
60-TeCB	Congeners	pg/g	0.543 U	0.411 U	1.61 U	1.18	0.628 U	0.488 UJ	1.13 U	0.86
61-TeCB	Congeners	pg/g	0.565 U	0.427 U	5.25 C	4.84 CJ	3.47 CJ	0.487 U	14.6 C	4.23
62-TeCB	Congeners	pg/g	C59	C59	C59	C59	C59	C59	C59	
63-TeCB	Congeners	pg/g	0.617 U	0.467 U	1.88 U	0.646 U	0.733 U	0.568 U	1.33 U	0.89 U
64-TeCB	Congeners	pg/g	13.3	0.468 U	0.86 U	0.682 U	0.73 U	0.595 U	0.798 U	2.49 U
65-TeCB	Congeners	pg/g	C44	C44	C44	C44	C44	C44	C44	
66-TeCB	Congeners	pg/g	0.57 U	0.431 U	3.08	0.605 U	2.07	0.534 U	8.22	2.22
67-TeCB	Congeners	pg/g	1.16	0.952 J	1.46 U	0.502 U	0.57 U	0.431 U	1.02 U	0.87
68-TeCB	Congeners	pg/g	0.494 U	0.373 UJ	1.56 U	0.538 U	0.61 U	0.487 U	1.12 U	0.74 U
69-TeCB	Congeners	pg/g	C49	C49	C49	C49	C49	C49	C49	
70-TeCB	Congeners	pg/g	C61	C61	C61	C61	C61	C61	C61	
71-TeCB	Congeners	pg/g	C40	C40	C40	C40	C40	C40	C40	
72-TeCB	Congeners	pg/g	0.546 U	0.413 U	1.64 U	0.564 U	0.64 U	0.535 U	1.27 U	0.80 U
73-TeCB	Congeners	pg/g	0.248 UJ	0.455 U	0.858 U	0.681 U	0.728 U	0.662 U	0.899 U	0.65 U
74-TeCB	Congeners	pg/g	C61	C61	C61	C61	C61	C61	C61	
75-TeCB	Congeners	pg/g	C59	C59	C59	C59	C59	C59	C59	
76-TeCB	Congeners	pg/g	C61	C61	C61	C61	C61	C61	C61	
77-TeCB	Congeners	pg/g	2.73	0.392	1.53 U	0.551 U	0.62 U	0.476 U	0.589 U	0.98
78-TeCB	Congeners	pg/g	0.561 U	0.424 U	1.75 U	0.603 U	0.684 U	0.499 U	1.24 U	0.82 U
79-TeCB	Congeners	pg/g	0.459 U	0.347 U	1.52 U	0.522 U	0.593 U	0.426 U	1.02 U	0.70 U
80-TeCB	Congeners	pg/g	0.502 U	0.38 U	1.54 U	0.528 U	0.6 U	0.464 U	1.04 U	0.72 U
81-TeCB	Congeners	pg/g	0.518 U	0.38 U	1.77 U	0.569 U	0.651 U	0.483 U	0.576 U	0.71 U
82-PeCB	Congeners	pg/g	3.82	0.75 U	1.36 U	1.16 U	1.5 U	0.768 U	1.91 U	1.61
83-PeCB	Congeners	pg/g	0.652 U	0.906 U	1.61 U	1.38 U	1.78 U	1.08 U	2.94 U	1.48 U
84-PeCB	Congeners	pg/g	8.22	0.679 U	1.31 U	1.12 U	1.45 U	0.812 U	4.68	2.61
85-PeCB	Congeners	pg/g	0.371 U	4.12 C	1 U	0.856 U	1.11 U	0.576 U	2.46 C	1.50
86-PeCB	Congeners	pg/g	23 C	0.548 U	1.03 UJ	3.72 CJ	1.13 UJ	0.591 U	14.8 C	6.40
87-PeCB	Congeners	pg/g	C86	C86	C86	C86	C86	C86	C86	
88-PeCB	Congeners	pg/g	5.62 C	2.01 C	2.11 U	1.8 U	2.33 U	0.773 U	1.87 U	2.36
89-PeCB	Congeners	pg/g	0.502 UJ	0.698 U	1.39 U	1.19 U	1.54 U	0.865 U	2.02 U	1.17
90-PeCB	Congeners	pg/g	30.3 C	22.2 C	1.11 U	0.948 U	1.23 U	0.642 U	12.6 C	9.86
91-PeCB	Congeners	pg/g	C88	C88	C88	C88	C88	C88	C88	
92-PeCB	Congeners	pg/g	6.68	4.41	1.31 U	1.12 U	1.44 U	0.77 U	2.73	2.64
93-PeCB	Congeners	pg/g	0.467 U	1.97 CJ	1.21 U	1.03 U	1.33 U	0.748 U	1.77 U	1.22
94-PeCB	Congeners	pg/g	0.461 UJ	0.641 U	1.25 U	1.07 U	1.38 U	0.788 U	1.82 U	1.06
95-PeCB	Congeners	pg/g	0.45 U	18.8	1.27 U	1.08 U	1.4 U	0.808 U	16.2	5.72
96-PeCB	Congeners	pg/g	0.483 UJ	0.444 U	1.29 U	1.11 U	1.3 U	1.06 U	1.68 U	1.05 U
97-PeCB	Congeners	pg/g	C86	C86	C86	C86	C86	C86	C86	
98-PeCB	Congeners	pg/g	2.3 C	1.56 J	1.07 U	0.913 U	1.18 U	0.663 U	1.59 U	1.33
99-PeCB	Congeners	pg/g	13.1	8.99	1.41	1.81	1.16 U	0.609 U	5.29	4.62
100-PeCB	Congeners	pg/g	C93	C93	C93	C93	C93	C93	C93	
101-PeCB	Congeners	pg/g	C90	C90	C90	C90	C90	C90	C90	
102-PeCB	Congeners	pg/g	C98	C98	C98	C98	C98	C98	C98	
103-PeCB	Congeners	pg/g	0.416 U	0.578 UJ	1.2 U	1.02 U	1.32 U	0.751 U	1.8 U	1.01
104-PeCB	Congeners	pg/g	0.344 UJ	0.308 U	0.893 U	0.81 U	0.859 U	0.607 U	0.555 U	0.63
105-PeCB	Congeners	pg/g	8.31	7.71	1.28	0.88 U	1.28 U	0.882 U	1.37	3.10

TABLE 2. ANALYTICAL RESULTS ECOMELT® SAMPLES
PHASE 2 CEMENT-LOCK DEMONSTRATION
Bayonne, New Jersey

Compound	Class	Units	P2-SEM-01	P2-SEM-02	P2-SEM-03	P2-SEM-04	P2-SEM-04 (Dup)	P2-SEM-05	P2-SEM-06	Average
106-PeCB	Congeners	pg/g	0.603 U	0.477 U	0.911 U	0.899 U	1.23 U	0.866 U	0.666 U	0.81
107-PeCB	Congeners	pg/g	1.02 J	0.494 U	0.908 U	0.896 U	1.23 U	0.817 U	0.69 U	0.87
108-PeCB	Congeners	pg/g	C86	C86	C86	C86	C86	C86	C86	
109-PeCB	Congeners	pg/g	2.13	0.482 U	0.926 U	0.914 U	1.25 U	0.808 U	0.669 U	1.03
110-PeCB	Congeners	pg/g	33.9 C	25.7 C	0.853 U	0.728 U	0.942 U	0.454 U	1.15 U	9.10
111-PeCB	Congeners	pg/g	0.335 U	0.466 U	0.849 U	0.725 U	0.937 U	0.472 U	1.18 U	0.71
112-PeCB	Congeners	pg/g	0.323 U	0.448 UJ	0.876 U	0.748 U	0.967 U	0.48 U	1.23 U	0.72
113-PeCB	Congeners	pg/g	C90	C90	C90	C90	C90	C90	C90	
114-PeCB	Congeners	pg/g	0.653 U	0.583 J	0.919 U	0.875 U	1.23 U	0.87 U	0.339 U	0.78
115-PeCB	Congeners	pg/g	C110	C110	C110	C110	C110	C110	C110	
116-PeCB	Congeners	pg/g	C85	C85	C85	C85	C85	C85	C85	
117-PeCB	Congeners	pg/g	C85	C85	C85	C85	C85	C85	C85	
118-PeCB	Congeners	pg/g	22.4	17	0.908 U	2.06	1.41	2.6	0.336 U	6.67
119-PeCB	Congeners	pg/g	C86	C86	C86	C86	C86	C86	C86	
120-PeCB	Congeners	pg/g	0.336 U	0.467 U	0.885 U	0.755 U	0.976 U	0.488 U	1.24 U	0.74
121-PeCB	Congeners	pg/g	0.334 U	0.464 U	0.907 U	0.774 U	1 U	0.539 U	1.31 U	0.76
122-PeCB	Congeners	pg/g	0.668 U	0.528 U	1.1 U	1.08 U	1.48 U	0.936 U	0.768 U	0.94
123-PeCB	Congeners	pg/g	0.651 U	0.491 U	0.842 U	0.844 U	1.24 U	0.78 U	0.331 U	0.74
124-PeCB	Congeners	pg/g	C107	C107	C107	C107	C107	C107	C107	
125-PeCB	Congeners	pg/g	C86	C86	C86	C86	C86	C86	C86	
126-PeCB	Congeners	pg/g	0.801 U	0.582 U	1.02 U	1.02 U	1.33 U	0.92 U	0.392 U	0.87
127-PeCB	Congeners	pg/g	0.683 U	0.541 U	0.922 U	0.91 U	1.25 U	0.764 U	0.699 U	0.82
128-HxCB	Congeners	pg/g	4.24 C	3.52 C	1.29 U	2.01 U	1.85 U	0.704 U	1.34 UJ	2.14
129-HxCB	Congeners	pg/g	26 C	21.6 C	1.28 U	2 U	2.56 J	0.708 U	8.24 C	8.91
130-HxCB	Congeners	pg/g	0.805 U	0.925 U	1.7 U	2.65 U	2.44 U	0.964 U	1.88 U	1.62
131-HxCB	Congeners	pg/g	0.746 U	0.857 U	1.72 U	2.7 U	2.48 U	1.05 U	1.83 U	1.63
132-HxCB	Congeners	pg/g	0.719 U	0.827 U	1.55 U	2.41 U	2.22 U	0.933 U	2.88	1.65
133-HxCB	Congeners	pg/g	0.702 U	0.807 U	1.68 U	2.63 U	2.42 U	0.988 U	1.77 U	1.57
134-HxCB	Congeners	pg/g	1.7	1.48	1.76 U	2.74 U	2.53 U	1.18 U	1.96 U	1.91
135-HxCB	Congeners	pg/g	9.8	0.784 U	2.32 U	2.35 U	3.36 U	0.912 U	2.71 C	3.18
136-HxCB	Congeners	pg/g	3.23	0.583 U	1.86 U	1.88 U	2.69 U	0.839 U	1.94	1.86
137-HxCB	Congeners	pg/g	1.63	1.01 J	1.44 U	2.24 U	2.06 U	0.823 U	1.58 U	1.54
138-HxCB	Congeners	pg/g	C129	C129	C129	C129	C129	C129	C129	
139-HxCB	Congeners	pg/g	0.618 U	0.711 U	1.41 U	2.21 U	2.03 U	0.838 U	1.56 U	1.34
140-HxCB	Congeners	pg/g	C139	C139	C139	C139	C139	C139	C139	
141-HxCB	Congeners	pg/g	4.74	3.76	1.4 U	2.19 U	2.01 U	0.807 U	1.47 U	2.34
142-HxCB	Congeners	pg/g	0.74 U	0.851 U	1.63 U	2.54 U	2.34 U	1.03 U	1.81 U	1.56
143-HxCB	Congeners	pg/g	1.35	0.74 U	1.54 U	2.41 U	2.22 U	0.899 U	1.65 U	1.54
144-HxCB	Congeners	pg/g	0.665 U	0.795 U	2.25 U	2.28 U	3.26 U	0.927 U	1.58 U	1.68
145-HxCB	Congeners	pg/g	0.472 U	0.564 U	1.66 U	1.68 U	2.41 U	0.796 U	1.27 U	1.26
146-HxCB	Congeners	pg/g	0.572 U	0.658 U	1.33 U	2.08 U	1.91 U	0.77 UJ	1.55	1.27
147-HxCB	Congeners	pg/g	21.6 C	16.3 C	2.82 C	2.19 C	1.96 U	0.835 U	6.76 C	7.50
148-HxCB	Congeners	pg/g	0.653 U	0.78 U	2.26 U	2.29 U	3.28 U	1.01 U	1.68 U	1.71
149-HxCB	Congeners	pg/g	C147	C147	C147	C147	C147	C147	C147	
150-HxCB	Congeners	pg/g	0.511 U	0.611 U	1.65 U	1.67 U	2.4 U	0.734 U	1.18 U	1.25
151-HxCB	Congeners	pg/g	C135	C135	C135	C135	C135	C135	C135	
152-HxCB	Congeners	pg/g	0.53 U	0.634 U	1.86 U	1.88 U	2.7 U	0.846 U	1.34 U	1.40
153-HxCB	Congeners	pg/g	22.8 C	17.5 C	3.67 C	2.36 C	2.47 C	0.692 U	7.34 C	8.12
154-HxCB	Congeners	pg/g	0.55 UJ	0.794 J	1.79 U	1.81 U	2.6 U	0.785 U	1.29 U	1.37
155-HxCB	Congeners	pg/g	0.372 U	0.399 UJ	0.899 U	0.918 U	1.29 U	0.396 U	0.369 U	0.66
156-HxCB	Congeners	pg/g	3.01 C	2.29 C	2.06 U	1.67 U	1.61 U	0.976 U	0.53 UJ	1.74
157-HxCB	Congeners	pg/g	C156	C156	C156	C156	C156	C156	C156	
158-HxCB	Congeners	pg/g	0.478 U	2.18	1.03 U	1.61 U	1.48 U	0.541 U	1.05 U	1.20

TABLE 2. ANALYTICAL RESULTS ECOMELT® SAMPLES
PHASE 2 CEMENT-LOCK DEMONSTRATION
Bayonne, New Jersey

Compound	Class	Units	P2-SEM-01	P2-SEM-02	P2-SEM-03	P2-SEM-04	P2-SEM-04 (Dup)	P2-SEM-05	P2-SEM-06	Average
159-HxCB	Congeners	pg/g	0.914 U	0.611 U	2.07 U	1.65 U	1.59 U	0.901 U	0.906 U	1.23
160-HxCB	Congeners	pg/g	0.534 U	0.614 U	1.11 U	1.73 U	1.59 U	0.623 U	1.13 U	1.05
161-HxCB	Congeners	pg/g	0.516 U	0.593 U	1.22 U	1.9 U	1.75 U	0.67 U	1.28 U	1.13
162-HxCB	Congeners	pg/g	0.853 U	0.57 U	1.85 U	1.48 U	1.43 U	0.818 U	0.829 U	1.12
163-HxCB	Congeners	pg/g	C129	C129	C129	C129	C129	C129	C129	
164-HxCB	Congeners	pg/g	1.91	0.597 U	1.07 U	1.67 U	1.54 U	0.589 U	1.13 U	1.22
165-HxCB	Congeners	pg/g	0.567 U	0.652 U	1.23 U	1.93 U	1.77 U	0.707 U	1.31 U	1.17
166-HxCB	Congeners	pg/g	C128	C128	C128	C128	C128	C128	C128	
167-HxCB	Congeners	pg/g	1.17	0.916 J	1.68 U	1.32 U	1.25 U	0.778 U	0.396 U	1.07
168-HxCB	Congeners	pg/g	C153	C153	C153	C153	C153	C153	C153	
169-HxCB	Congeners	pg/g	0.937 U	0.672 U	1.82 U	1.45 U	1.43 U	0.879 U	0.412 U	1.09
170-HpCB	Congeners	pg/g	9.08	6.38	1.49 U	1.54 U	2.41 U	0.936 U	2.55	3.48
171-HpCB	Congeners	pg/g	0.695 U	2.64 C	1.45 U	1.51 U	2.36 U	0.965 U	1.66 U	1.61
172-HpCB	Congeners	pg/g	0.674 U	2.31	1.51 U	1.57 U	2.46 U	0.932 U	1.71 U	1.60
173-HpCB	Congeners	pg/g	C171	C171	C171	C171	C171	C171	C171	
174-HpCB	Congeners	pg/g	8.93	7.33	1.4 U	1.45 U	2.27 U	0.881 U	2.19	3.49
175-HpCB	Congeners	pg/g	0.77 U	0.784 U	2.03 U	1.53 U	1.87 U	0.867 U	1.74 U	1.37 U
176-HpCB	Congeners	pg/g	0.605 U	1	1.64 U	1.24 U	1.51 U	0.748 U	1.42 U	1.17
177-HpCB	Congeners	pg/g	6.25	0.73 U	1.63 U	1.7 U	2.65 U	0.967 U	1.64 U	2.22
178-HpCB	Congeners	pg/g	0.786 U	2.37	2.13 U	1.61 U	1.96 U	0.921 U	1.81 U	1.66
179-HpCB	Congeners	pg/g	3.66	0.585 U	1.64 U	1.24 U	1.51 U	0.803 U	1.42 U	1.55
180-HpCB	Congeners	pg/g	19.2 C	13.7 C	1.9 JQ	1.2 U	1.87 U	1.79 J	4.02 C	6.24
181-HpCB	Congeners	pg/g	0.664 U	0.692 U	1.34 U	1.39 U	2.17 U	0.84 U	1.46 U	1.22 U
182-HpCB	Congeners	pg/g	0.712 U	0.725 U	1.94 U	1.47 U	1.79 U	0.83 U	1.58 U	1.29 U
183-HpCB	Congeners	pg/g	5.34 C	0.643 U	1.42 U	1.48 U	2.31 U	0.858 U	1.48 U	1.93
184-HpCB	Congeners	pg/g	0.499 U	0.508 U	1.46 U	1.1 U	1.35 U	0.653 U	1.26 U	0.98 U
185-HpCB	Congeners	pg/g	C183	C183	C183	C183	C183	C183	C183	
186-HpCB	Congeners	pg/g	0.576 U	0.587 U	1.57 U	1.19 U	1.45 U	0.685 U	1.33 U	1.06 U
187-HpCB	Congeners	pg/g	10.6	8.54	1.79 U	1.35 U	1.65 U	0.767 U	2.61	3.90
188-HpCB	Congeners	pg/g	0.508 U	0.515 U	1.34 U	1.03 U	1.2 U	0.592 U	0.583 U	0.82 U
189-HpCB	Congeners	pg/g	0.392 U	0.729 U	1.11 U	1.33 U	1.84 U	0.774 U	0.436 U	0.94 U
190-HpCB	Congeners	pg/g	2.23	0.534 U	1.12 U	1.16 U	1.81 U	0.703 U	1.2 U	1.25
191-HpCB	Congeners	pg/g	0.516 U	0.537 U	1.12 U	1.17 U	1.82 U	0.72 U	1.25 U	1.02 U
192-HpCB	Congeners	pg/g	0.547 U	0.57 U	1.12 U	1.16 U	1.82 U	0.71 U	1.2 U	1.02 U
193-HpCB	Congeners	pg/g	C180	C180	C180	C180	C180	C180	C180	
194-OcCB	Congeners	pg/g	0.575 U	4.14	2.07 U	1.74 U	2.51 U	1.19 U	1.73 U	1.99 U
195-OcCB	Congeners	pg/g	0.623 U	1.02 U	2.42 U	2.03 U	2.94 U	1.28 U	1.91 U	1.75 U
196-OcCB	Congeners	pg/g	2.29	0.787 U	2.19 U	2.28 U	1.99 U	1.1 U	1.67 U	1.76
197-OcCB	Congeners	pg/g	0.619 U	0.583 U	3.55 U	3.7 U	3.23 U	0.806 U	1.27 U	1.97 U
198-OcCB	Congeners	pg/g	5.77 C	0.788 U	2.12 U	2.21 U	1.93 U	1.07 U	2.51 C	2.34
199-OcCB	Congeners	pg/g	C198	C198	C198	C198	C198	C198	C198	
200-OcCB	Congeners	pg/g	C197	C197	C197	C197	C197	C197	C197	
201-OcCB	Congeners	pg/g	0.645 UJ	0.607 U	1.75 U	1.82 U	1.59 U	0.887 U	1.35 U	1.24 U
202-OcCB	Congeners	pg/g	0.641 U	0.659 U	1.52 U	1.65 U	1.41 U	0.766 U	0.61 U	1.04 U
203-OcCB	Congeners	pg/g	3.09	0.723 U	1.9 U	1.98 U	1.73 U	0.93 U	1.45 U	1.69
204-OcCB	Congeners	pg/g	0.652 U	0.614 U	1.79 U	1.87 U	1.63 U	0.89 U	1.38 U	1.26 U
205-OcCB	Congeners	pg/g	0.498 U	0.764 U	1.76 U	1.42 U	2.1 U	0.986 U	0.671 U	1.17 U
206-NoCB	Congeners	pg/g	3.45	2.76	2.13 U	2.51 U	2.62 U	1.23 U	0.803 U	2.21
207-NoCB	Congeners	pg/g	0.789 U	0.69 U	1.89 U	2.28 U	2.25 U	1.08 U	1.52 U	1.50 U
208-NoCB	Congeners	pg/g	1.57	0.738 U	1.73 U	2.15 U	2.01 U	0.987 U	0.709 U	1.41
209-DeCB	Congeners	pg/g	2.49	1.29 U	2.23 U	1.74 U	2.61 U	0.945 U	1.02 U	1.76
Total of PCB Congeners			591.98100	381.66800	229.68400	218.57100	238.73800	147.79300	421.55000	318.56929

TABLE 2. ANALYTICAL RESULTS ECOMELT® SAMPLES
PHASE 2 CEMENT-LOCK DEMONSTRATION
Bayonne, New Jersey

Compound	Class	Units	P2-SEM-01	P2-SEM-02	P2-SEM-03	P2-SEM-04	P2-SEM-04 (Dup)	P2-SEM-05	P2-SEM-06	Average
TEQ (PCB)	TEQ	ng/kg	0.050	0.037	0.061	0.059	0.075	0.051	0.022	0.051
DIOXINS-FURANS										
1,2,3,4,6,7,8-HpCDD	Dioxins-Furans	pg/g	1.31 JA	2.63 U	0.548 JA	0.425 U	0.394 U	0.474 J	0.31 J	0.870
1,2,3,4,6,7,8-HpCDF	Dioxins-Furans	pg/g	0.72 JA	1.38 U	0.38 U	0.425 U	0.252 JA	0.292 J	0.425 U	0.553
1,2,3,4,7,8,9-HpCDF	Dioxins-Furans	pg/g	0.887 U	1.72 U	0.454 U	0.425 U	0.394 U	0.496 U	0.425 U	0.686
1,2,3,4,7,8-HxCDD	Dioxins-Furans	pg/g	0.469 U	0.434 U	0.385 U	0.425 U	0.394 U	0.421 U	0.425 U	0.422
1,2,3,4,7,8-HxCDF	Dioxins-Furans	pg/g	0.444 U	0.434 U	0.38 U	0.425 U	0.394 U	0.108 J	0.425 U	0.373
1,2,3,6,7,8-HxCDD	Dioxins-Furans	pg/g	0.486 U	0.434 U	0.399 U	0.425 U	0.394 U	0.421 U	0.425 U	0.426
1,2,3,6,7,8-HxCDF	Dioxins-Furans	pg/g	0.444 U	0.434 U	0.38 U	0.425 U	0.394 U	0.121 J	0.425 U	0.375
1,2,3,7,8,9-HxCDD	Dioxins-Furans	pg/g	0.474 U	0.434 U	0.388 U	0.425 U	0.394 U	0.421 U	0.425 U	0.423
1,2,3,7,8,9-HxCDF	Dioxins-Furans	pg/g	0.444 U	0.434 U	0.38 U	0.425 U	0.394 U	0.421 U	0.425 U	0.418
1,2,3,7,8-PeCDD	Dioxins-Furans	pg/g	0.444 U	0.434 U	0.38 U	0.425 U	0.394 U	0.421 U	0.43 U	0.418
1,2,3,7,8-PeCDF	Dioxins-Furans	pg/g	0.444 U	0.434 U	0.38 U	0.425 U	0.394 U	0.123 J	0.425 U	0.375
2,3,4,6,7,8-HxCDF	Dioxins-Furans	pg/g	0.444 U	0.434 U	0.38 U	0.425 U	0.394 U	0.421 U	0.425 U	0.418
2,3,4,7,8-PeCDF	Dioxins-Furans	pg/g	0.444 U	0.434 U	0.38 U	0.425 U	0.394 U	0.174 J	0.425 U	0.382
2,3,7,8-TCDD	Dioxins-Furans	pg/g	0.833 U	0.625 U	0.72 U	0.338 U	0.287 U	0.461 U	0.248 U	0.502
2,3,7,8-TCDF	Dioxins-Furans	pg/g	0.502 U	0.336 U	0.369 U	0.184 U	0.15 A	0.322 U	0.189 U	0.293
OCDD	Dioxins-Furans	pg/g	8.74 A	1.13 U	5.97 A	0.851 U	0.788 U	2.08	0.851 U	2.916
OCDF	Dioxins-Furans	pg/g	1.31 U	0.932 U	1.11 U	0.851 U	0.788 U	1.24 U	0.851 U	1.012
Total HpCDDs	Dioxins-Furans	pg/g	2.84	2.63 U	1.11	0.237	0.394 U	0.958	0.31	1.211
Total HpCDFs	Dioxins-Furans	pg/g	0.72	1.72 U	0.454 U	0.425 U	0.252	0.292	0.425 U	0.613
Total HxCDDs	Dioxins-Furans	pg/g	0.486 U	0.434 U	0.399 U	0.425 U	0.394 U	0.722	0.425 U	0.469
Total HxCDFs	Dioxins-Furans	pg/g	0.522	0.434 U	0.38 U	0.425 U	0.394 U	0.686	0.425 U	0.467
Total PeCDDs	Dioxins-Furans	pg/g	0.444 U	0.434 U	0.38 U	0.425 U	0.394 U	0.951 J	0.43 U	0.494
Total PeCDFs	Dioxins-Furans	pg/g	0.444 U	0.434 U	0.38 U	0.425 U	0.394 U	1.13 J	0.425 U	0.519
Total TCDDs	Dioxins-Furans	pg/g	0.833 U	0.625 U	0.72 U	0.338 U	0.287 U	0.494	0.248 U	0.506
Total TCDFs	Dioxins-Furans	pg/g	0.502 U	0.336 U	0.369 U	0.184 U	0.15	1.83	0.189 U	0.509
Total of D/F Congener Categories*			16.84	9.11	11.27	4.59	4.24	10.38	4.58	8.72
TEQ (Dioxin)	TEQ	ng/kg	0.972	0.998	0.818	0.663	0.608	0.690	0.622	0.767
Total TEQ (D/F+PCBs)	TEQ	ng/kg	1.021	1.034	0.879	0.722	0.683	0.741	0.644	0.818
METALS										
Arsenic	Metals	mg/kg	2.3 U	2.1 U	2.1 U	2.1 U	2 U	2 U	2.2 U	2.1 U
Barium	Metals	mg/kg	159	166	235	222	216	20 U	22 U	148.6
Cadmium	Metals	mg/kg	0.66	0.58	0.83	0.8	0.77	0.51 U	0.55 U	0.7
Chromium	Metals	mg/kg	101	103	125	116	114	7.2	11.6	82.5
Cobalt	Metals	mg/kg	7.6	7.6	10.7	10.2	9.3	5.1 U	5.5 U	8.0
Copper	Metals	mg/kg	93.5	101	150	141	138	7.3	12.9	92.0
Lead	Metals	mg/kg	25.2	18	45.1	41.6	40.2	8.9	11.3	27.2
Manganese	Metals	mg/kg	242	237	315	300	290	14.7	27.9	203.8
Mercury	Metals	mg/kg	0.035 U	0.034 U	0.033 U	0.033 U	0.033 U	0.031 U	0.032 U	0.0 U
Nickel	Metals	mg/kg	29.7	27.7	38.2	36.1	34	4.1 U	4.4 U	24.9
Selenium	Metals	mg/kg	2.3 U	2.1 U	2.1 U	2.1 U	2 U	2 U	2.2 U	2.1 U
Silver	Metals	mg/kg	1.1 U	1 U	1.1 U	1 U	0.99 U	1 U	1.1 U	1.0 U
Zinc	Metals	mg/kg	88.1	79.6	220	203	200	14.1	20.9	118.0
PESTICIDES										
4,4'-DDD	Pest	ug/kg	0.36 U	0.35 U	0.33 U	0.32 U	0.32 U	0.34 U	0.33 UJ	0.336 U
4,4'-DDE	Pest	ug/kg	0.37 U	0.36 U	0.34 U	0.33 U	0.34 U	0.35 U	0.34 U	0.347 U
4,4'-DDT	Pest	ug/kg	0.45 U	0.44 U	0.42 U	0.41 U	0.41 U	0.43 U	0.42 U	0.426 U
Dieldrin	Pest	ug/kg	0.37 U	0.37 U	0.35 U	0.34 U	0.34 U	0.36 U	0.35 U	0.354 U

TABLE 2. ANALYTICAL RESULTS ECOMELT® SAMPLES
PHASE 2 CEMENT-LOCK DEMONSTRATION
Bayonne, New Jersey

Compound	Class	Units	P2-SEM-01	P2-SEM-02	P2-SEM-03	P2-SEM-04	P2-SEM-04 (Dup)	P2-SEM-05	P2-SEM-06	Average
SVOCs										
Acenaphthene	SVOC	ug/kg	0.6 U	0.59 U	0.56 U	0.56 U	0.56 U	0.57 U	0.57 U	0.57 U
Acenaphthylene	SVOC	ug/kg	0.37 U	0.37 U	0.35 U	0.35 U	0.35 U	0.36 U	0.36 U	0.36 U
Anthracene	SVOC	ug/kg	0.26 U	0.26 U	0.24 U	0.24 U	0.24 U	0.25 U	0.25 U	0.25 U
Benzo(a)anthracene	SVOC	ug/kg	0.23 U	0.22 U	0.21 U	0.21 U	0.21 U	0.22 U	0.22 U	0.22 U
Benzo(a)pyrene	SVOC	ug/kg	0.55 U	0.54 U	0.51 U	0.51 U	0.51 U	0.52 U	0.52 U	0.52 U
Benzo(b)fluoranthene	SVOC	ug/kg	1.4 UJ	1.4 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.33 U
Benzo(g,h,i)perylene	SVOC	ug/kg	0.62 U	0.61 U	0.58 U	0.58 U	0.58 U	0.59 U	0.59 U	0.59 U
Benzo(k)fluoranthene	SVOC	ug/kg	0.62 U	0.61 U	0.58 U	0.57 U	0.57 U	0.59 U	0.59 U	0.59 U
bis(2-Ethylhexyl)phthalate	SVOC	ug/kg	24 U	24 U	22 U	22 U	22 U	23 U	23 U	22.86 U
Chrysene	SVOC	ug/kg	0.41 U	0.41 U	0.38 U	0.38 U	0.38 U	0.39 U	0.39 U	0.39 U
Dibenzo(a,h)anthracene	SVOC	ug/kg	0.48 U	0.47 U	0.45 U	0.44 U	0.44 U	0.46 U	0.46 U	0.46 U
Di-n-octyl phthalate	SVOC	ug/kg	7.3 U	7.2 U	6.8 U	6.8 U	6.8 U	7 U	7 U	6.99 U
Fluoranthene	SVOC	ug/kg	0.27 U	0.26 U	0.25 U	0.25 U	0.25 U	0.26 U	0.26 U	0.26 U
Fluorene	SVOC	ug/kg	0.68 U	0.67 U	0.63 U	0.63 U	0.63 U	0.65 U	0.65 U	0.65 U
Indeno(1,2,3-cd)pyrene	SVOC	ug/kg	0.57 U	0.56 U	0.53 U	0.53 U	0.53 U	0.55 U	0.55 U	0.55 U
Naphthalene	SVOC	ug/kg	0.44 U	0.43 U	0.41 U	0.41 U	0.41 U	0.42 U	0.42 U	0.42 U
Phenanthrene	SVOC	ug/kg	0.39 U	0.39 U	0.37 U	0.37 U	0.37 U	0.37 U	0.37 U	0.38 U
Pyrene	SVOC	ug/kg	0.29 U	0.29 U	0.27 U	0.27 U	0.27 U	0.28 U	0.28 U	0.28 U
Arsenic	SPLP/Metals	mg/l	0.008 U	-	0.008 U	-	-	-	0.008 U	0.00800 U
Barium	SPLP/Metals	mg/l	1 U	-	1 U	-	-	-	1 U	1.00000 U
Cadmium	SPLP/Metals	mg/l	0.004 U	-	0.004 U	-	-	-	0.004 U	0.00400 U
Chromium	SPLP/Metals	mg/l	0.01 U	-	0.01 U	-	-	-	0.01 U	0.01000 U
Cobalt	SPLP/Metals	mg/l	0.05 U	-	0.05 U	-	-	-	0.05 U	0.05000 U
Copper	SPLP/Metals	mg/l	0.025 U	-	0.025 U	-	-	-	0.025 U	0.02500 U
Lead	SPLP/Metals	mg/l	0.01 U	-	0.017	-	-	-	0.032	0.01967
Manganese	SPLP/Metals	mg/l	0.084	-	0.021	-	-	-	0.023	0.04267
Mercury	SPLP/Metals	mg/l	0.0002 U	-	0.00029	-	-	-	0.0002 U	0.00023
Nickel	SPLP/Metals	mg/l	0.043	-	0.04 U	-	-	-	0.04 U	0.04100
Selenium	SPLP/Metals	mg/l	0.05 U	-	0.05 U	-	-	-	0.05 U	0.05000 U
Silver	SPLP/Metals	mg/l	0.01 U	-	0.01 U	-	-	-	0.01 U	0.01000 U
Zinc	SPLP/Metals	mg/l	0.13	-	0.1 U	-	-	-	0.12	0.11667
4,4'-DDD	SPLP/Pest	mg/l	0.000017 U	-	0.000017 U	-	-	-	0.000017 U	0.00002 U
4,4'-DDE	SPLP/Pest	mg/l	0.0000041 U	-	0.0000041 U	-	-	-	0.0000041 U	0.00000 U
4,4'-DDT	SPLP/Pest	mg/l	0.000018 U	-	0.000018 U	-	-	-	0.000018 U	0.00002 U
Dieldrin	SPLP/Pest	mg/l	0.000013 U	-	0.000013 U	-	-	-	0.000013 U	0.00001 U
Benzo(a)anthracene	SPLP/SVOC	mg/l	0.000019 U	-	0.000019 U	-	-	-	0.000019 U	0.00002 U
Benzo(a)pyrene	SPLP/SVOC	mg/l	0.0000039 U	-	0.0000039 U	-	-	-	0.0000039 U	0.00000 U
Benzo(b)fluoranthene	SPLP/SVOC	mg/l	0.000017 U	-	0.000017 U	-	-	-	0.000017 U	0.00002 U
Benzo(k)fluoranthene	SPLP/SVOC	mg/l	0.000021 U	-	0.000021 U	-	-	-	0.000021 U	0.00002 U
bis(2-Ethylhexyl)phthalate	SPLP/SVOC	mg/l	0.00013 U	-	0.00013 U	-	-	-	0.00013 U	0.00013 U
Chrysene	SPLP/SVOC	mg/l	0.0000093 U	-	0.0000093 U	-	-	-	0.0000093 U	0.00001 U
Indeno(1,2,3-cd)pyrene	SPLP/SVOC	mg/l	0.0000085 U	-	0.0000085 U	-	-	-	0.0000085 U	0.00001 U

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TABLE 2. ANALYTICAL RESULTS ECOMELT® SAMPLES
PHASE 2 CEMENT-LOCK DEMONSTRATION
Bayonne, New Jersey

Compound	Class	Units	P2-SEM-01	P2-SEM-02	P2-SEM-03	P2-SEM-04	P2-SEM-04 (Dup)	P2-SEM-05	P2-SEM-06	Average
Arsenic	TCLP/Metals	mg/l	0.5 U	0.5 U	0.5 U	0.5 U	-	0.5 U	0.5 U	0.5 U
Barium	TCLP/Metals	mg/l	1 U	1 U	1 U	1 U	-	1	1 U	1.0
Cadmium	TCLP/Metals	mg/l	0.0092	0.005 U	0.005 U	0.005 U	-	0.005 U	0.005 U	0.0
Chromium	TCLP/Metals	mg/l	0.01	0.01 U	0.01 U	0.01 U	-	0.014	0.011	0.0
Cobalt	TCLP/Metals	mg/l	0.05 U	0.05 U	0.05 U	0.05 U	-	0.05 U	0.05 U	0.1 U
Copper	TCLP/Metals	mg/l	0.15	0.025 U	0.025	0.025 U	-	0.034	0.026	0.0
Lead	TCLP/Metals	mg/l	0.5 U	0.5 U	0.5 U	0.5 U	-	0.5 U	0.5 U	0.5 U
Manganese	TCLP/Metals	mg/l	0.21	0.071	0.037	0.032	-	0.037	0.034	0.1
Mercury	TCLP/Metals	mg/l	0.0002 U	0.0002 U	0.0002 U	0.0002 U	-	0.0002 U	0.0002 U	0.0 U
Nickel	TCLP/Metals	mg/l	0.12	0.04	0.04 U	0.04 U	-	0.04 U	0.04 U	0.1
Selenium	TCLP/Metals	mg/l	0.5 U	0.5 U	0.5 U	0.5 U	-	0.5 U	0.5 U	0.5 U
Silver	TCLP/Metals	mg/l	0.01 U	0.01 U	0.01 U	0.01 U	-	0.01 U	0.01 U	0.0 U
Zinc	TCLP/Metals	mg/l	0.7	0.31	0.16	0.13	-	0.22	0.17	0.3
4,4'-DDD	TCLP/Pest	mg/l	0.00017 U	0.00017 U	0.000017 UJ	0.00017 U	-	0.00017 U	0.00017 U	0.000145 U
4,4'-DDE	TCLP/Pest	mg/l	0.000041 U	0.000041 U	0.000041 U	0.000041 U	-	0.000041 U	0.000041 U	0.000041 U
4,4'-DDT	TCLP/Pest	mg/l	0.00018 U	0.00018 U	0.00018 U	0.00018 U	-	0.00018 U	0.00018 U	0.000180 U
Dieldrin	TCLP/Pest	mg/l	0.000013 U	0.00013 U	0.00013 U	0.00013 U	-	0.00013 U	0.00013 U	0.000111 U
Acenaphthene	TCLP/SVOC	mg/l	0.000054 U	0.000054 U	0.000054 U	0.000054 U	-	0.000054 U	0.000054 U	0.0000540 U
Acenaphthylene	TCLP/SVOC	mg/l	0.000021 U	0.000021 U	0.000021 U	0.000021 U	-	0.000021 U	0.000021 U	0.0000210 U
Anthracene	TCLP/SVOC	mg/l	0.000029 U	0.000029 U	0.000029 U	0.000029 U	-	0.000029 U	0.000029 U	0.0000290 U
Benzo(a)anthracene	TCLP/SVOC	mg/l	0.00019 U	0.00019 U	0.00019 U	0.00019 U	-	0.00019 U	0.00019 U	0.0001900 U
Benzo(a)pyrene	TCLP/SVOC	mg/l	0.000039 U	0.000039 U	0.000039 U	0.000039 U	-	0.000039 U	0.000039 U	0.0000390 U
Benzo(b)fluoranthene	TCLP/SVOC	mg/l	0.00017 U	0.00017 U	0.00017 U	0.00017 U	-	0.00017 U	0.00017 U	0.0001700 U
Benzo(g,h,i)perylene	TCLP/SVOC	mg/l	0.000088 U	0.000088 U	0.000088 U	0.000088 U	-	0.000088 U	0.000088 U	0.0000880 U
Benzo(k)fluoranthene	TCLP/SVOC	mg/l	0.00021 U	0.00021 U	0.00021 U	0.00021 U	-	0.00021 U	0.00021 U	0.0002100 U
bis(2-Ethylhexyl)phthalate	TCLP/SVOC	mg/l	0.0013 U	0.0013 U	0.0013 U	0.0013 U	-	0.0013 U	0.0013 U	0.0013000 U
Chrysene	TCLP/SVOC	mg/l	0.000093 U	0.000093 U	0.000093 U	0.000093 U	-	0.000093 U	0.000093 U	0.0000930 U
Dibenzo(a,h)anthracene	TCLP/SVOC	mg/l	0.00012 U	0.00012 U	0.00012 U	0.00012 U	-	0.00012 U	0.00012 U	0.0001200 U
Di-n-octyl phthalate	TCLP/SVOC	mg/l	0.002 U	0.002 U	0.002 U	0.002 U	-	0.002 U	0.002 U	0.0020000 U
Fluoranthene	TCLP/SVOC	mg/l	0.0002 U	0.0002 U	0.0002 U	0.0002 U	-	0.0002 U	0.0002 U	0.0002000 U
Fluorene	TCLP/SVOC	mg/l	0.000077 U	0.000077 U	0.000077 U	0.000077 U	-	0.000077 U	0.000077 U	0.0000770 U
Indeno(1,2,3-cd)pyrene	TCLP/SVOC	mg/l	0.000085 U	0.000085 U	0.000085 U	0.000085 U	-	0.000085 U	0.000085 U	0.0000850 U
Naphthalene	TCLP/SVOC	mg/l	0.000082 U	0.000082 U	0.000082 U	0.000082 U	-	0.000082 U	0.000082 U	0.0000820 U
Phenanthrene	TCLP/SVOC	mg/l	0.000099 U	0.000099 U	0.000099 U	0.000099 U	-	0.000099 U	0.000099 U	0.0000990 U
Pyrene	TCLP/SVOC	mg/l	0.00011 U	0.00011 U	0.00011 U	0.00011 U	-	0.00011 U	0.00011 U	0.0001100 U

Notes:
U - Analyte was not detected. The associated value is the estimated detection limit.
J - The analyte is present, but the concentration is below the quantitation limit. The concentration is estimated
UJ - The detection limit is estimated.
C - The isomer coeluted with another of its homologue group. If followed by a number, the number indicates the lowest numbered congener among the coelution set.
"-" The sample was not analyzed for that analyte.
* The total of these analytes includes non-detected values at the detection limit

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TABLE 2. ANALYTICAL RESULTS ECOMELT® SAMPLES LEACHING TESTS
PHASE 2 CEMENT-LOCK DEMONSTRATION
Bayonne, New Jersey

Compound	Class	Units	P2-SEM-01	P2-SEM-02	P2-SEM-03	P2-SEM-04	P2-SEM-04	P2-SEM-05	P2-SEM-06	Average
SPLP METALS										
Arsenic	SPLP/Metals	mg/l	0.008 U	-	0.008 U	-	-	-	0.008 U	0.00800 U
Barium	SPLP/Metals	mg/l	1 U	-	1 U	-	-	-	1 U	1.00000 U
Cadmium	SPLP/Metals	mg/l	0.004 U	-	0.004 U	-	-	-	0.004 U	0.00400 U
Chromium	SPLP/Metals	mg/l	0.01 U	-	0.01 U	-	-	-	0.01 U	0.01000 U
Cobalt	SPLP/Metals	mg/l	0.05 U	-	0.05 U	-	-	-	0.05 U	0.05000 U
Copper	SPLP/Metals	mg/l	0.025 U	-	0.025 U	-	-	-	0.025 U	0.02500 U
Lead	SPLP/Metals	mg/l	0.01 U	-	0.017	-	-	-	0.032	0.01967
Manganese	SPLP/Metals	mg/l	0.084	-	0.021	-	-	-	0.023	0.04267
Mercury	SPLP/Metals	mg/l	0.0002 U	-	0.00029	-	-	-	0.0002 U	0.00023
Nickel	SPLP/Metals	mg/l	0.043	-	0.04 U	-	-	-	0.04 U	0.04100
Selenium	SPLP/Metals	mg/l	0.05 U	-	0.05 U	-	-	-	0.05 U	0.05000 U
Silver	SPLP/Metals	mg/l	0.01 U	-	0.01 U	-	-	-	0.01 U	0.01000 U
Zinc	SPLP/Metals	mg/l	0.13	-	0.1 U	-	-	-	0.12	0.11667
SPLP PESTICIDES										
4,4'-DDD	SPLP/Pest	mg/l	0.000017 U	-	0.000017 U	-	-	-	0.000017 U	0.00002 U
4,4'-DDE	SPLP/Pest	mg/l	0.0000041 U	-	0.0000041 U	-	-	-	0.0000041 U	0.00000 U
4,4'-DDT	SPLP/Pest	mg/l	0.000018 U	-	0.000018 U	-	-	-	0.000018 U	0.00002 U
Dieldrin	SPLP/Pest	mg/l	0.000013 U	-	0.000013 U	-	-	-	0.000013 U	0.00001 U
SPLP SVOCs										
Benzo(a)anthracene	SPLP/SVOC	mg/l	0.000019 U	-	0.000019 U	-	-	-	0.000019 U	0.00002 U
Benzo(a)pyrene	SPLP/SVOC	mg/l	0.0000039 U	-	0.0000039 U	-	-	-	0.0000039 U	0.00000 U
Benzo(b)fluoranthene	SPLP/SVOC	mg/l	0.000017 U	-	0.000017 U	-	-	-	0.000017 U	0.00002 U
Benzo(k)fluoranthene	SPLP/SVOC	mg/l	0.000021 U	-	0.000021 U	-	-	-	0.000021 U	0.00002 U
bis(2-Ethylhexyl)phthalate	SPLP/SVOC	mg/l	0.00013 U	-	0.00013 U	-	-	-	0.00013 U	0.00013 U
Chrysene	SPLP/SVOC	mg/l	0.0000093 U	-	0.0000093 U	-	-	-	0.0000093 U	0.00001 U
Indeno(1,2,3-cd)pyrene	SPLP/SVOC	mg/l	0.0000085 U	-	0.0000085 U	-	-	-	0.0000085 U	0.00001 U
TCLP METALS										
Arsenic	TCLP/Metals	mg/l	0.5 U	0.5 U	0.5 U	0.5 U	-	0.5 U	0.5 U	0.5 U
Barium	TCLP/Metals	mg/l	1 U	1 U	1 U	1 U	-	1	1 U	1.0
Cadmium	TCLP/Metals	mg/l	0.0092	0.005 U	0.005 U	0.005 U	-	0.005 U	0.005 U	0.0
Chromium	TCLP/Metals	mg/l	0.01	0.01 U	0.01 U	0.01 U	-	0.014	0.011	0.0
Cobalt	TCLP/Metals	mg/l	0.05 U	0.05 U	0.05 U	0.05 U	-	0.05 U	0.05 U	0.1 U
Copper	TCLP/Metals	mg/l	0.15	0.025 U	0.025	0.025 U	-	0.034	0.026	0.0
Lead	TCLP/Metals	mg/l	0.5 U	0.5 U	0.5 U	0.5 U	-	0.5 U	0.5 U	0.5 U
Manganese	TCLP/Metals	mg/l	0.21	0.071	0.037	0.032	-	0.037	0.034	0.1

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TABLE 2. ANALYTICAL RESULTS ECOMELT® SAMPLES LEACHING TESTS
PHASE 2 CEMENT-LOCK DEMONSTRATION
Bayonne, New Jersey

Compound	Class	Units	P2-SEM-01	P2-SEM-02	P2-SEM-03	P2-SEM-04	P2-SEM-04	P2-SEM-05	P2-SEM-06	Average
Mercury	TCLP/Metals	mg/l	0.0002 U	0.0002 U	0.0002 U	0.0002 U	-	0.0002 U	0.0002 U	0.0 U
Nickel	TCLP/Metals	mg/l	0.12	0.04	0.04 U	0.04 U	-	0.04 U	0.04 U	0.1
Selenium	TCLP/Metals	mg/l	0.5 U	0.5 U	0.5 U	0.5 U	-	0.5 U	0.5 U	0.5 U
Silver	TCLP/Metals	mg/l	0.01 U	0.01 U	0.01 U	0.01 U	-	0.01 U	0.01 U	0.0 U
Zinc	TCLP/Metals	mg/l	0.7	0.31	0.16	0.13	-	0.22	0.17	0.3
TCLP PESTICIDES										
4,4'-DDD	TCLP/Pest	mg/l	0.00017 U	0.00017 U	0.000017 UJ	0.00017 U	-	0.00017 U	0.00017 U	0.000145 U
4,4'-DDE	TCLP/Pest	mg/l	0.000041 U	0.000041 U	0.000041 U	0.000041 U	-	0.000041 U	0.000041 U	0.000041 U
4,4'-DDT	TCLP/Pest	mg/l	0.00018 U	0.00018 U	0.00018 U	0.00018 U	-	0.00018 U	0.00018 U	0.000180 U
Dieldrin	TCLP/Pest	mg/l	0.000013 U	0.00013 U	0.00013 U	0.00013 U	-	0.00013 U	0.00013 U	0.000111 U
TCLP SVOCs										
Acenaphthene	TCLP/SVOC	mg/l	0.000054 U	0.000054 U	0.000054 U	0.000054 U	-	0.000054 U	0.000054 U	0.0000540 U
Acenaphthylene	TCLP/SVOC	mg/l	0.000021 U	0.000021 U	0.000021 U	0.000021 U	-	0.000021 U	0.000021 U	0.0000210 U
Anthracene	TCLP/SVOC	mg/l	0.000029 U	0.000029 U	0.000029 U	0.000029 U	-	0.000029 U	0.000029 U	0.0000290 U
Benzo(a)anthracene	TCLP/SVOC	mg/l	0.00019 U	0.00019 U	0.00019 U	0.00019 U	-	0.00019 U	0.00019 U	0.0001900 U
Benzo(a)pyrene	TCLP/SVOC	mg/l	0.000039 U	0.000039 U	0.000039 U	0.000039 U	-	0.000039 U	0.000039 U	0.0000390 U
Benzo(b)fluoranthene	TCLP/SVOC	mg/l	0.00017 U	0.00017 U	0.00017 U	0.00017 U	-	0.00017 U	0.00017 U	0.0001700 U
Benzo(g,h,i)perylene	TCLP/SVOC	mg/l	0.000088 U	0.000088 U	0.000088 U	0.000088 U	-	0.000088 U	0.000088 U	0.0000880 U
Benzo(k)fluoranthene	TCLP/SVOC	mg/l	0.00021 U	0.00021 U	0.00021 U	0.00021 U	-	0.00021 U	0.00021 U	0.0002100 U
bis(2-Ethylhexyl)phthalate	TCLP/SVOC	mg/l	0.0013 U	0.0013 U	0.0013 U	0.0013 U	-	0.0013 U	0.0013 U	0.0013000 U
Chrysene	TCLP/SVOC	mg/l	0.000093 U	0.000093 U	0.000093 U	0.000093 U	-	0.000093 U	0.000093 U	0.0000930 U
Dibenzo(a,h)anthracene	TCLP/SVOC	mg/l	0.00012 U	0.00012 U	0.00012 U	0.00012 U	-	0.00012 U	0.00012 U	0.0001200 U
Di-n-octyl phthalate	TCLP/SVOC	mg/l	0.002 U	0.002 U	0.002 U	0.002 U	-	0.002 U	0.002 U	0.0020000 U
Fluoranthene	TCLP/SVOC	mg/l	0.0002 U	0.0002 U	0.0002 U	0.0002 U	-	0.0002 U	0.0002 U	0.0002000 U
Fluorene	TCLP/SVOC	mg/l	0.000077 U	0.000077 U	0.000077 U	0.000077 U	-	0.000077 U	0.000077 U	0.0000770 U
Indeno(1,2,3-cd)pyrene	TCLP/SVOC	mg/l	0.000085 U	0.000085 U	0.000085 U	0.000085 U	-	0.000085 U	0.000085 U	0.0000850 U
Naphthalene	TCLP/SVOC	mg/l	0.000082 U	0.000082 U	0.000082 U	0.000082 U	-	0.000082 U	0.000082 U	0.0000820 U
Phenanthrene	TCLP/SVOC	mg/l	0.000099 U	0.000099 U	0.000099 U	0.000099 U	-	0.000099 U	0.000099 U	0.0000990 U
Pyrene	TCLP/SVOC	mg/l	0.00011 U	0.00011 U	0.00011 U	0.00011 U	-	0.00011 U	0.00011 U	0.0001100 U

Notes:
U - Analyte was not detected. The associated value is the estimated detection limit.
J - The analyte is present, but the concentration is below the quantitation limit. The concentration is estimated
UJ - The detection limit is estimated.
C - The isomer coeluted with another of its homologue group. If followed by a number, the number indicates the lowest numbered congener among the coelution set.
"-" The sample was not analyzed for that analyte.
* The total of these analytes includes non-detected values at the detection limit

R2-0010850

Appendix I

Dredged Volume Estimates

Draft Contractor Document: Subject to Continuing Agency Review

MALCOLM PIRNIE

Interoffice Correspondence

Date: April 6, 2007

To: L. Bossi (WHI)

Copy: S. Thompson (WHI), B. Fidler (NNJ)

From: D. Navon (TAM)

Re: Sediment Removal Volume Estimate Methodology

INTRODUCTION

This memorandum outlines the methodology and results of the calculation for the sediment removal volumes from river mile (RM) 0 to RM8.3 (*i.e.*, the Area of Focus) for the six remedial action alternatives considered in the Focused Feasibility Study (FFS). It is necessary to estimate sediment removal volumes to evaluate the feasibility of each remedial action alternative with respect to remedial action duration, dredged material management options, cost, and other considerations. The memorandum describes the data used for the calculations, methods used to calculate sediment volumes, and the results of the calculations for each remedial action alternative.

DATA

Bathymetric Survey

Data obtained from a bathymetric survey conducted in 2004 by Rogers Surveying, Inc. for the United States Army Corps of Engineers (USACE) were used to approximate the current sediment surface. The bathymetric data are relative to the National Geodetic Vertical Datum of 1929 (NGVD29), which is 2.4 feet above Mean Low Water (MLW). To convert the NGVD29 bathymetric data to depths relative to MLW, a depth of 2.4 feet was subtracted from each datum.

Geotechnical Borings and Chemical Core Data

Geotechnical borings were collected in 2005. The borings were logged and the depth of the fine-grained sediment (primarily silt) was estimated by a geologist by evaluating the boring logs. The depth of fine-grained sediment was used to approximate the depth of contamination. Geotechnical boring logs are provided in the *Technical Report: Geophysical Survey* (Aqua Survey, Inc., 2006).

Data from historical sediment cores collected in 1991, 1993, and 1995 were used to estimate the depth of contamination (see the Methodology section discussion below). This historical sediment core dataset is described in detail in the *Draft Geochemical Evaluation (Step 2)* (Malcolm Pirnie, Inc., 2006).

METHODOLOGY

Sampling Locations

Nineteen transects were drawn across the river (from bank to bank) to form 18 river sections (a river section is formed by two transects) between RM0 and RM8.3 (refer to the attached Figure I-1). Thirteen transects were placed where borings provided geotechnical data. Five additional transects were placed to refine the volume calculations in areas where the distance between transects was greater than approximately one-half mile. Note that the distance between transects Q (RM7.1) and R (RM8.3) is greater than one mile due to the lack of chemical core data in this area of the river. Also, three additional transects (A', B', and C') were drawn to calculate the area of the river outside of the limits of the authorized navigational channel between RM0.0 and RM0.9 for Alternative 1 (Figure I-1), which entails sediment removal from the shoals[1] at the mouth of the river. An additional transect, R', was drawn at RM8.1 for Alternatives 1, 3, 5 and 6, as the proposed depth of sediment removal changes at this river mile. Table 1 provides data regarding transect locations with respect to river miles.

[1] Shoals are defined as areas located between the navigational channel and the shoreline.

Table 1: River Transects Used for Sediment Removal Volume Estimates

Transect	River Mile
A (A')	0
B (B')	0.6
C (C')	0.9
D	1.4
E	1.7
F	2.5
G	2.9
H	3.5
I	3.8
J	4.3
K	4.7
L	5.3
M	5.8
N	6.4
O	6.7
P	7.0
Q	7.1
R’	8.1
R	8.3

Average-End Area Calculation

Sediment removal volumes for the majority of the river were estimated using average-end area calculations. This method involved determining the cross-sectional area for sediment removal at each transect based on the desired sediment depth and channel configuration for each remedial alternative (refer to the Discussion section below). Then, the cross-sectional areas for both transects comprising the river section were averaged and multiplied by the length of the river section to estimate the sediment removal volume. This calculation assumes that the change in the sediment surface between the two transects is linear. Therefore, the greater the distance between adjacent transects, the greater the likelihood that the average-end area calculation contains error due to irregularities in the sediment surface and the width of the river.

Assumptions for Alternatives

For Alternatives 1 and 6, which involve the removal of fine-grained sediment from the shoals, the depth of sediment to be removed was determined using geotechnical and chemical core data (see Figure I-1 for core locations). The geotechnical cores provided data on the depth of fine-grained sediment, which is assumed to be associated with the presence of contamination. The chemical cores provided the depth of mercury contamination. Mercury was selected as a surrogate to identify depth of contamination because mercury contamination occurs deeper in the sediment bed relative to 2,3,7,8-tetrachlorodibenzodioxin (2,3,7,8-TCDD) and polychlorinated biphenyls (Total PCB) (Malcolm Pirnie, Inc., 2006). The chemical cores included both complete cores (where mercury concentrations peaked and declined to zero above the core bottom) and incomplete cores (where a rising mercury concentration gradient or a non-zero mercury concentration exists at the core bottom).

The locations of all of the cores were plotted to determine which cores fell closest to each transect. Then, the depth of contamination indicated by each core was determined. For each type of core (*i.e.*, complete chemical core, incomplete chemical core, and geotechnical core), the average depth of contamination for each transect was estimated. The average depths of contamination indicated by the complete cores, the incomplete cores, and the depth of fine-grained sediment were compared, and the deepest depth was selected to be representative of contamination for the associated transect. One foot was added to these estimated depths to account for dredging inaccuracy (*i.e.*, overdredge allowance). Table 2 presents the average depth of sediment removal for the shoals at each transect.

Table 2: Depth for Sediment Removal from Shoals for Alternatives 1 and 6

Transect	Depth (ft) [1]
A'	10.2
B'	6
C'	12.2
D	13.4
E	14.3
F	7.4
G	10.7
H	14.9
I	7
J	17.9
K	8.7
L	13
M	13
N	6.5
O	6.5
P	4.5
Q	5
R'	2.9
R	2.9

[1] Depths are the selected depth of contamination plus a one foot to account for dredging inaccuracy

The side slopes of the cross-sectional areas to be excavated for all of the remedial action alternatives were constrained to be no greater than a 3 horizontal to 1 vertical slope (3H:1V). The resultant transect cross-sections were used to calculate sediment removal volumes using the average-end area calculation method described above.

For alternatives requiring placement of cap material, the shoals would be pre-dredged only if hydrodynamic flood modeling showed that pre-dredging prior to cap placement would result in acceptable flooding results (refer to Appendix G "Cap Erosion and Flood Modeling"). For Alternatives 3, 4, 5, and 6, it is assumed that pre-dredging in the shoals is required prior to cap placement. For these alternatives, it is assumed that three feet of sediment are pre-dredged to accommodate a two-foot thick sand cap and one foot of dredging inaccuracy.

Several alternatives assume the placement of an armor layer over a sand cap in areas of unacceptable erosion as defined by hydrodynamic modeling. As discussed in Section 4.0

of the FFS, the median stone size for the armor material has been estimated at six inches. Placement of a stone of this size would require that the thickness of the armor layer be approximately 18 inches to ensure adequate coverage of the sand, with an additional allowance of six inches for a filter material to be placed on the sand prior to stone placement. An additional one foot of sediment removal is assumed to account for dredging inaccuracies; therefore, the total depth of additional sediment removal for areas to be armored is three feet. However, for Alternatives 3, 4, 5, and 6 only two feet of sediment removal is required since dredging inaccuracies are taken into account in the dredging of the navigation channel and the pre-dredging in the shoals to make room for the cap.

Tidal Mudflat Estimation

Tidal mudflats, which are intermittently exposed and submerged based on tidal action, would be pre-dredged to three feet for each alternative to accommodate a one-foot thick sand cap, one foot of mudflat reconstruction material, and one foot to account for dredging and placement inaccuracies. The tidal mudflat areas were delineated by analyzing the 2-foot contours from the Rogers Surveying, Inc. 2004 bathymetric dataset. Based on tidal gauges, the water level of the river fluctuates between minus 2 feet elevation (relative to NGVD1929) and the shoreline during low and high tides. Areas between the -2-foot elevation and the shoreline were designated as mudflats. Areas with widths less than 50 feet were not considered mudflats and were excluded. The results of this delineation were used to calculate the sediment removal volume from the mudflats. The resulting sediment volume to be removed from the mudflats is approximately 208,000 cubic yards (CY) for each remedial alternative. The conceptual design figures in Section 4.0 of the FFS show the locations of the delineated mudflats. Table 3 presents the mudflat areas and sediment removal volumes from the mudflats per river mile.

Table 3: Mudflats Areas and Sediment Removal Volumes by River Mile

River Miles	Mudflats (acres)	Mudflats Volume (CY)
0 - 1	0.0	0
1 - 2	0.0	0
2 - 3	11.2	54,208
3 - 4	5.3	25,652
4 - 5	7.8	37,752
5 - 6	0.0	0
6 - 7	2.5	12,100
7 - 8.3	16.3	78,892
Total	**43**	**208,265**

DISCUSSION

Alternative 1: Removal of Fine-grained Sediment from Area of Focus

Alternative 1 would involve the removal of fine-grained sediment from the horizontal limits of the federally authorized navigation channel as well as from the adjacent shoal and mudflat areas. Within the horizontal limits of the federally authorized navigation channel, the depth of fine-grained sediment has been shown to correspond well with the depth of historical dredging. For this reason, the depth of dredging within the horizontal limits of the navigation channel was assumed to be the historically constructed channel depth plus an additional three feet to account for historical overdredging (two feet) and dredging accuracy (one foot). For this alternative, the resulting sediment removal depth would be 33 feet MLW for RM0.0 to RM2.5, 23 feet MLW for RM2.5 to RM4.6, 19 feet MLW for RM4.6 to RM7.1, 19 feet MLW for RM7.1 to RM8.1, and 13 feet MLW for RM8.1 to RM8.3.

The volume of sediment removal from the shoals located between transect C (RM0.9) and transect R (RM8.3) was calculated using the average-end area calculation. The area at the mouth of the river between the southern Study Area boundary and transect A' was not suited for average-end area calculations because the width of the river changes dramatically in this segment. For this portion of the river, the surface area was calculated using Geographical Information System (GIS), and the depth of sediment removal was determined to be 2.8 feet based on the average of two cores collected from this area.

Transects A', B', and C' were drawn to calculate sediment removal volumes for the areas at the mouth of the river. The length between these transects was estimated using geometrical approximations from the triangular areas formed by these transects. The depth of contamination was determined as described under the Methodology section (*i.e.*, using core data), and the average-end area method was applied using the estimated length between transects. The volume of sediment to be removed from the mudflats was estimated at 208,000 CY as described above in the Methodology section. Figure 4-1 in the text of the FFS shows the cross sections of sediment removal for each transect for Alternative 1. Table 4 (attached) presents the calculated volumes of sediment to be removed from each river section.

Alternative 2: Engineered Capping of Area of Focus

Alternative 2 would sequester the contaminated sediments in the Area of Focus by means of an engineered cap. The volume of sediment removal for Alternative 2 consists of areas to be pre-dredged for armor placement as well as mudflat areas that will be excavated for purposes of mudflat reconstruction. These areas are delineated on Figure 4-2 in the FFS. Table 5 (attached) presents the volume of sediment to be removed from each river mile for Alternative 2.

Alternative 3 – Engineered Capping of Area of Focus Following Reconstruction of Federally Authorized Navigation Channel

Alternative 3 would involve the removal of sediment from the horizontal limits of the federally authorized navigation channel as well as from the adjacent shoal and mudflat areas. The depth of dredging within these horizontal limits is assumed to be the historically constructed channel depth plus an additional three feet to account for historical overdredging (two feet) and dredging accuracy (one foot). For this alternative, the approximate depth of sediment removal in the navigation channel would be 33 feet MLW for RM0.0 to RM2.5, 23 feet MLW for RM2.5 to RM4.6, 19 feet MLW for RM4.6 to RM7.1, 19 feet MLW for RM7.1 to RM8.1, and 13 feet MLW for RM8.1 to RM8.3. A

two-foot layer of backfill would then be placed to mitigate for any remaining fine-grained sediment and/or dredging residuals.

Alternative 3 also requires the pre-dredging of shoal areas to accommodate an engineered cap as well as pre-dredging in certain areas to accommodate armoring material as discussed above in the Methodology section. Mudflat areas would be pre-dredged as discussed under the Methodology section above. The side slopes of the areas to be excavated were constrained to be no greater than 3H:1V. The conceptual design of Alternative 3 is shown on Figure 4-3 in the FFS. Table 6 (attached) presents the volume of sediment to be removed from each river section for Alternative 3.

Alternative 4 – Engineered Capping of Area of Focus Following Construction of Navigation Channel to Accommodate Current Usage

As described in Section 4.0 of the FFS, the New York District of the USACE has studied the current navigation usage of the river. The dimensions of the navigation channel necessary to accommodate current usage were estimated based on this Study. Implementation of Alternative 4 entails the construction of a channel of these dimensions followed by placement of an engineered cap over the entire Area of Focus (RM0 to RM8.3).

From RM0 to RM1.2, the depth of dredging within the horizontal limits of the federally authorized navigation channel is assumed to be the historically constructed channel depth plus an additional three feet to account for historical overdredging (two feet) and dredging accuracy (one foot). The side slope would be constructed at a slope of 3H:1V. After sediments are removed from the federally authorized navigation channel to the depth specified above (*i.e.*, 33 feet MLW), it is assumed that minimal fine-grained sediment would remain in the channel. Therefore, a two foot backfill layer would be placed to mitigate for any remaining fine-grained sediment and/or dredging residuals.

From RM1.2 to RM2.5, the depth of dredging within the horizontal limits of the federally authorized navigation channel is assumed to be the depth required by the design vessel (13 feet), plus an additional three feet for underkeel clearance, plus an additional nine feet to accommodate the necessary cap components that would be placed. The side slope would be constructed at a slope of 3H:1V. Following removal to the depth described above, it is possible that additional, un-targeted contaminant inventory would remain in place. Therefore, it is assumed that an engineered cap would be placed on the channel bottom.

In the side slope and shoals of RM0 to RM2.5, and throughout the rest of the Area of Focus from RM2.5 to RM8.3, it is likely that additional, un-targeted contaminant inventory would remain in place. Therefore, pre-dredging to accommodate an engineered cap would be necessary in these areas. In areas of unacceptable erosion, as identified in Appendix G "Cap Erosion and Flood Modeling," stone would be used as armor material, and the areas to be armored would be pre-dredged as described in the Methodology section above. Mudflat areas would be pre-dredged as discussed under the Methodology section above. The conceptual design of Alternative 4 is shown on Figure 4-4 of the FFS. Table 7 (attached) presents the volume of sediment to be removed from each river section for Alternative 4.

Alternative 5- Engineered Capping of Area of Focus Following Construction of Navigation Channel for Future Use

As described in Section 4.0 of the FFS, New Jersey Department of Transportation (NJDOT) has estimated the dimensions of the navigation channel necessary for future river traffic. Alternative 5 entails the construction of a channel of these dimensions followed by the placement of an engineered cap over the Area of Focus.

From RM0 to RM1.2, the depth of dredging within the horizontal limits of the federally authorized navigation channel is assumed to be the historically constructed channel depth plus an additional three feet to account for historical overdredging (two feet) and

dredging accuracy (one foot). The side slope would be constructed at a slope of 3H:1V. Following removal of the sediment from within the horizontal limits of the federally authorized navigation channel to the depth specified above (*i.e.*, 33 feet MLW), it is assumed that minimal fine-grained sediment would remain in the channel. Therefore, a two foot backfill layer would be placed to mitigate for any remaining fine-grained sediment and/or dredging residuals.

From RM1.2 to RM2.5, the depth of dredging within the horizontal limits of the federally authorized navigation channel is assumed to be the depth required by the design vessel (13 feet), plus an additional three feet for underkeel clearance, plus an additional nine feet to accommodate the necessary cap components that would be placed. The side slope would be constructed at a slope of 3H:1V. Following removal to the depth described above (*i.e.*, 25 feet MLW), it is possible that additional, un-targeted contaminant inventory would remain in place. Therefore, an engineered cap would be placed on the channel bottom.

From RM2.5 to RM3.6, the depth of dredging within the horizontal limits of the federally authorized navigation channel is assumed to be the depth required by the design vessel (13 feet), plus an additional three feet for underkeel clearance, plus an additional nine feet to accommodate the necessary cap components that would be placed. This alternative would require sediment removal to 25 feet MLW. However, the depth of the authorized historical channel from RM 2.5 to RM 3.6 is 20 feet. An addition of three feet to the authorized depth to account for historical overdredging (two feet) and dredging accuracy (one foot) result in a historical channel depth of 23 feet MLW (not 25 feet MLW). Since dredge depth is limited to the historical channel depth, it is assumed that sediment will be removed to a depth of 23 feet MLW, and a full cap is not required since all of the fine-grained sediment will presumably be removed (*i.e.*, two feet of backfill will be applied as opposed to placement of a full cap). The side slope would be constructed at a slope of 3H:1V.

From RM3.6 to RM8.3, the depth of dredging within the horizontal limits of the federally authorized navigation channel is assumed to be the depth required by the design vessel (seven feet), plus an additional three feet for underkeel clearance, plus an additional nine feet to accommodate the necessary cap components that would be placed. This alternative will require sediment removal to 19 feet MLW. However, the depth of the authorized historical channel from RM8.1 to RM8.3 is 10 feet. An addition of three feet to the authorized depth to account for historical overdredging (two feet) and dredging accuracy (one foot) results in a historical channel depth of 13 feet MLW (not 19 feet MLW). Since dredge depth is limited to the historical channel depth, it is assumed that sediment will be removed to a depth of 13 feet MLW from RM8.1 to RM8.3. Following removal to the depth described above (*i.e.*, 19 feet MLW from RM3.6 to RM8.1 and 13 feet from RM8.1 to RM8.3), it is possible that additional, un-targeted contaminant inventory would remain in place from RM3.6 to RM4.6; however, it is assumed that minimal fine-grained sediment would remain in the channel from RM4.6 to RM8.3. Therefore, an engineered cap would be placed on the channel bottom from RM3.6 to RM4.6 and a two foot thick backfill layer would be placed to mitigate for any remaining fine-grained sediment and/or dredging residuals from RM4.6 to RM8.3. The side slope would be constructed at a slope of 3H:1V.

In the side slope and shoal areas of RM0 to RM8.3, it is likely that additional, un-targeted contaminant inventory would remain in place. For this reason, it is assumed that an engineered cap would be placed in these areas. Alternative 5 requires the pre-dredging of shoal areas to accommodate an engineered cap, as well as pre-dredging in certain areas to accommodate armoring material as discussed above in the Methodology section. Mudflat areas would be pre-dredged as discussed under the Methodology section above. The conceptual design of Alternative 5 is shown on Figure 4-5 in the FFS. Table 8 (attached) presents the volume of sediment to be removed from each river section for Alternative 5.

Alternative 6 – Engineered Capping of Area of Focus Following Construction of Navigation Channel for Future Usage and Removal of Fine-grained Sediment from Primary Inventory Zone and Primary Erosional Zone

The conceptual design of Alternative 6 is identical to that of Alternative 5 with the exception that in the Primary Erosional Zone and the Primary Inventory Zone the depth of dredging is assumed to be the estimated depth of fine-grained sediment plus an additional one foot to account for dredging accuracy. (The delineations of the Primary Erosional and Primary Inventory Zones are discussed in Section 2.3 of the FFS.) The Primary Erosional Zone comprises approximately 68 acres located between RM3.7 and RM5.4. The Primary Inventory Zone comprises approximately 63 acres between RM2.4 and RM3.6. The estimated depth of fine-grained sediment in these zones was derived using the geotechnical and chemical core data as discussed above in the Methodology section (Table 2). The conceptual design of Alternative 6 is shown on Figure 4-6 in the FFS. Table 9 (attached) presents the volume of sediment to be removed from each river section for Alternative 6.

SUMMARY

Table 10 (attached) summarizes estimated sediment removal volumes for all of the remedial action alternatives considered in the FFS. The values have been rounded to the nearest thousand cubic yards.

REFERENCES

Aqua Survey, Inc., 2006. "Technical Report, Geophysical Survey, Lower Passaic River Restoration Project". June 2006.

Malcolm Pirnie, Inc., 2006. "Draft Geochemical Evaluation (Step 2)." Lower Passaic River Restoration Project. March 2006.

Attached Tables
(Table 4 through Table 10)

Table 4: Alternative 1 - Volumes of Sediment to be Removed

Alternative 1				
Navigation Component				
Section		**Average Cross Sectional Area [Sq Ft]**	**Length of Section [Ft]**	**Volume of Section [CY]**
N/A				
Contamination Component				
Section		**Average Surface Area [Sq Ft]**	**Average Depth of Section [Ft]**	**Volume of Section [CY]**
Area of Focus Southern Boundary - A'		3,751,863	2.8	*389,082*
Section		**Average Cross Sectional Area [Sq Ft]**	**Length of Section [Ft]**	**Volume of Section [CY]**
A' - B'	Left Shoal	1,196	2,992	132,535
	Channel	4,825		534,626
	Right Shoal	23,827	2,118	934,528
B' -C'	Left Shoal	1,215	1,687	75,884
	Channel	4,686		292,788
	Right Shoal	14,281	1,324	350,149
C' - D	Left Shoal	1,404	2,429	126,263
	Channel	4,931		443,607
	Right Shoal	10,805		972,050
D - E	Left Shoal	1,394	1,848	95,377
	Channel	5,273		360,908
	Right Shoal	3,251		222,479
E -F	Left Shoal	2,258	3,960	331,100
	Channel	5,727		839,887
	Right Shoal	1,564		229,387
F -G	Left Shoal	1,848	2,429	166,238
	Channel	3,099		278,772
	Right Shoal	723		64,993
G - H	Left Shoal	1,554	3,062	176,201
	Channel	3,560		403,726
	Right Shoal	762		86,428
H - I	Left Shoal	1,418	1,478	77,616
	Channel	3,655		200,132
	Right Shoal	799		43,722
I - J	Left Shoal	2,191	2,851	231,317
	Channel	3,827		404,131
	Right Shoal	1,306		137,861
J - K	Left Shoal	1,662	1,954	120,255
	Channel	3,344		241,957
	Right Shoal	1,176		85,054
K - L	Left Shoal	246	3,274	29,766
	Channel	2,129		258,129
	Right Shoal	736		89,236
L - M	Left Shoal	296	2,323	25,426
	Channel	1,701		146,319
	Right Shoal	719		61,823
M - N	Left Shoal	169	3,168	19,829
	Channel	949		111,291
	Right Shoal	357		41,829
N - O	Left Shoal	201	1,795	13,364
	Channel	1,938		128,822
	Right Shoal	359		23,836
O - P	Left Shoal	474	1,531	26,853
	Channel	2,744		155,587
	Right Shoal	320		18,119
P - Q	Left Shoal	599	475	10,534
	Channel	2,946		51,841
	Right Shoal	258		4,541
Q - R'	Left Shoal	520	5,227	100,672
	Channel	1,608		311,309
	Right Shoal	234		45,302
R' - R	Left	270	1,056	10,560
	Center	372		14,549
	Right	76		2,972
Total Contamination Component Volume [CY]				***10,751,562***
Pre-dredging in Armor Areas				
RM		**Area [Sq Ft]**	**Depth [Ft]**	**Volume of Section [CY]**
N/A				
Pre-dredging in Mudflats Areas				
Total Pre-dredging in Mudflats Areas Volume [CY]				***208,265***
Total Volume [CY]				***10,959,827***

Table 5: Alternative 2 - Volumes of Sediment to be Removed

Alternative 2			
Pre-Dredging Armor Areas			
RM	**Area [Sq Ft]**	**Depth [Ft]**	**Volume of Section [CY]**
0 - 1	0	3	0
1 - 2	608,563	3	67,618
2 - 3	1,190,754	3	132,306
3 - 4	1,883,172	3	209,241
4 - 5	1,346,177	3	149,575
5 - 6	1,174,942	3	130,549
6 - 7	1,336,282	3	148,476
7 - 8.3	867,005	3	96,334
Total Pre-Dredging Armor Areas Volume [CY]			***934,099***
Pre-dredging in Mudflats Areas			
Total Pre-dredging in Mudflats Areas Volume [CY]			***208,265***
Total Volume [CY]			***1,142,364***

Table 6: Alternative 3 - Volumes of Sediment to be Removed

Alternative 3			
Navigation Component			
Section	**Average Cross Sectional Area [Sq Ft]**	**Length of Section [Ft]**	**Volume of Section [CY]**
A - B	4,248	2,992	470,741
B - C	5,610	1,687	350,490
C - D	6,555	2,429	589,707
D - E	7,261	1,848	496,941
E - F	8,084	3,960	1,185,580
F - G	4,337	2,429	390,137
G - H	4,627	3,062	524,805
H - I	4,949	1,478	270,958
I - J	5,244	2,851	553,766
J - K	4,414	1,954	319,341
K - L	2,676	3,274	324,390
L - M	2,233	2,323	192,137
M - N	1,356	3,168	159,045
N - O	2,483	1,795	165,092
O - P	3,523	1,531	199,765
P - Q	3,802	475	66,915
Q - R'	2,223	5,227	430,373
R' - R	726	1,056	28,395
Total Navigation Component Volume [CY]			***6,718,578***
Contamination Component			
Section	**Average Depth of Contamination [Ft]**	**Area of Section [Sq Ft]**	**Volume of Section [CY]**
N/A			
Pre-dredging in Armor Areas			
RM	**Area [Sq Ft]**	**Depth [Ft]**	**Volume of Section [CY]**
0 - 2.5	0	2	0
2.5 - 4.6	137,546	2	10,189
4.6 - 7.1	219,382	2	16,251
7.1 - 8.1	311,125	2	23,046
8.1 - 8.3	36,885	2	2,732
Total Pre-dredging in Armor Areas Volume [CY]			***52,218***
Pre-dredging in Mudflats Areas			
Total Pre-dredging in Mudflats Areas Volume [CY]			***208,265***
Total Volume [CY]			***6,979,061***

Table 7: Alternative 4 - Volumes of Sediment to be Removed

Alternative 4			
Navigation Component			
Section	**Average Cross Sectional Area [Sq Ft]**	**Length of Section [Ft]**	**Volume of Section [CY]**
A - B	4,248	2,992	470,741
B - C	5,610	1,687	350,490
C - D	6,555	2,429	589,662
D - E	4,085	1,848	279,561
E - F	4,692	3,960	688,087
F - G	1,650	2,429	148,382
G - H	1,426	3,590	189,626
H - I	1,435	950	50,494
I - J	1,670	2,851	176,352
J - K	1,467	1,954	106,146
K - L	1,165	3,274	141,250
L - M	1,147	2,323	98,693
M - N	1,043	3,168	122,320
N - O	1,069	1,795	71,077
O - P	1,144	1,531	64,849
P - Q	1,132	475	19,923
Q - R	976	6,283	227,126
Total Navigation Component Volume [CY]			***3,794,779***
Contamination Component			
Section	**Average Depth of Contamination [Ft]**	**Area of Section [Sq Ft]**	**Volume of Section [CY]**
N/A			
Pre-dredging in Armor Areas			
RM	**Area [Sq Ft]**	**Depth [Ft]**	**Volume of Section [CY]**
0 - 2.5	0	2	0
2.5 - 3	46,565	2	3,449
3 - 4	1,877,143	2	139,048
4 - 5	1,030,083	2	76,302
5 - 6	988,757	2	73,241
6 - 7	1,181,779	2	87,539
7 - 8.3	668,203	2	49,497
Total Pre-dredging in Armor Areas Volume [CY]			***429,076***
Pre-dredging in Mudflats Areas			
Total Pre-dredging in Mudflats Areas Volume [CY]			***208,265***
Total Volume [CY]			***4,432,120***

Table 8: Alternative 5 - Volumes of Sediment to be Removed

Alternative 5			
Navigation Component			
Section	**Average Cross Sectional Area [Sq Ft]**	**Length of Section [Ft]**	**Volume of Section [CY]**
A - B	4,249	2,992	470,797
B - C	5,609	1,687	350,427
C - D	6,971	2,429	627,087
D - E	4,085	1,848	279,561
E - F	4,689	3,960	687,720
F - G	4,732	2,429	425,670
G - H	5,316	3,590	706,843
H - I	3,428	950	120,648
I - J	3,751	2,851	396,106
J - K	2,969	1,954	214,787
K - L	2,675	3,274	324,329
L - M	2,233	2,323	192,137
M - N	1,356	3,168	159,045
N - O	2,483	1,795	165,092
O - P	3,523	1,531	199,765
P - Q	3,802	475	66,915
Q - R'	2,223	5,227	430,373
R' - R	726	1,056	28,395
Total Navigation Component Volume [CY]			***5,845,697***
Contamination Component			
Section	**Average Depth of Contamination [Ft]**	**Area of Section [Sq Ft]**	**Volume of Section [CY]**
N/A			
Pre-dredging in Armor Areas			
RM	**Area [Sq Ft]**	**Depth [Ft]**	**Volume of Section [CY]**
0 - 2.5	0	2	0
2.5 - 3.6	4,322	2	320.1399073
3.6 - 4.6	704,978	2	52220.57461
4.6 - 8.3	566,568	2	41968.01073
Total Pre-dredging in Armor Areas Volume [CY]			***94,509***
Pre-dredging in Mudflats Areas			
Total Pre-dredging in Mudflats Areas Volume [CY]			***208,265***
Total Volume [CY]			***6,148,471***

Table 9: Alternative 6 - Volumes of Sediment to be Removed

Alternative 6			
Navigation Component			
Section	**Average Cross Sectional Area [Sq Ft]**	**Length of Section [Ft]**	**Volume of Section [CY]**
A - B	4,249	2,992	470,797
B - C	5,609	1,687	350,427
C - D	6,971	2,429	627,087
D - E	4,085	1,848	279,561
E - F	4,689	3,960	687,720
K - L (half)	1,996	3,274	241,973
L - M	2,233	2,323	192,137
M - N	1,356	3,168	159,045
N - O	2,483	1,795	165,092
O - P	3,523	1,531	199,765
P - Q	3,802	475	66,915
Q - R'	2,223	5,227	430,373
R' - R	726	1,056	28,395
Total Navigation Component Volume [CY]			***3,899,287***
Contamination Component			
Section	**Average Cross Sectional Area [Sq Ft]**	**Length of Section [Ft]**	**Volume of Section [CY]**
F -G Right	1,848	2,429	166,238
Center	3,099		278,772
Left	723		64,993
G - H Right	1,554	3,062	176,201
Center	3,560		403,726
Left	762		86,428
H - I Right	1,418	1,478	77,616
Center	3,655		200,132
Left	799		43,722
I - J Right	2,191	2,851	231,317
Center	3,827		404,131
Left	1,306		137,861
J - K Right	1,662	1,954	120,255
Center	3,344		241,957
Left	1,176		85,054
K - L Right	246	3,274	29,766
Center (half)	871		105,543
Left	0		0
Total Contamination Component Volume [CY]			***2,853,712***
Pre-dredging in Armor Areas			
RM	**Area [Sq Ft]**	**Depth [Ft]**	**Volume of Section [CY]**
0 - 2.5	0	2	0
2.5 - 3.6	0	2	0
3.6 - 4.6	121,953	2	9,034
4.6 - 8.3	535,085	2	39,636
Total Pre-dredging in Armor Areas Volume [CY]			***48,670***
Pre-dredging in Mudflats Areas			
Total Pre-dredging in Mudflats Areas Volume [CY]			***208,265***
Total Volume [CY]			***7,009,934***

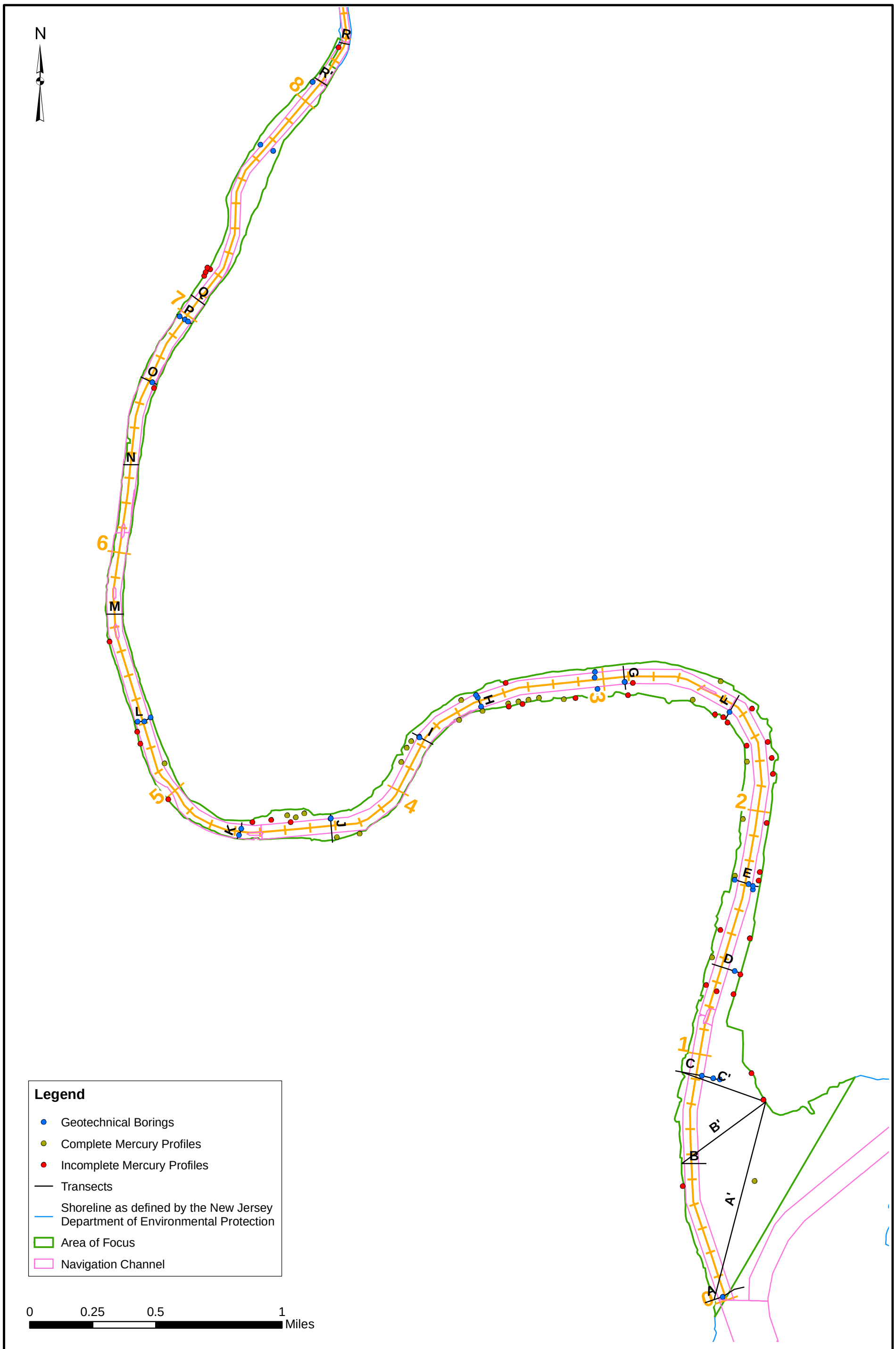
Table 10: Volumes of Sediment to be Removed for each Remedial Action Alternative

Alternative Number	Description	Nav Channel + shoals/side slopes (CY)	Room for Armor Layer (CY)	Mudflats (CY)	TOTAL VOLUME (CY) [1]
1	Dredging	10,751,562	0	208,265	10,960,000
2	Capping	0	934,099	208,265	1,142,000
3	NCC[2] - Authorized Channel	6,718,578	52,218	208,265	6,979,000
4	NCC - Current Use Channel	3,794,779	429,076	208,265	4,432,000
5	NCC - Future Use Channel	5,845,697	94,509	208,265	6,148,000
6	NCC - Future Use Channel + Dredging Primary Erosion and Inventory Zones	6,752,999	48,670	208,265	7,010,000

[1] Total Volumes are rounded to the nearest thousand

[2] NCC = Navigationally Constrained Capping

Figures



US Army Corps of Engineers

Sediment Cores RM0 to RM8.3

Lower Passaic River Restoration Project

Note:
Samples include historical and non-historical sediment cores.

Figure I-1

June 2007
Draft

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Appendix J

Cost Estimates

Summary of Cost Estimates for Remedial Alternatives on Page J-2
Cost Estimates for Remedial Alternatives on Pages J-3 to J-14
Cost Estimates Assumptions on Pages J-15 to J-36
DMM Backup Sheets on Pages J-37 to J-110

Draft Contractor Document: Subject to Continuing Agency Review

Summary of Cost Estimates for Remedial Alternatives
Focused Feasibility Study
Lower Passaic River Restoration Project

Alternative	DMM [1] Scenario	Total Capital Costs	Total DMM Costs	Total O&M [2] Costs	TOTAL COST
Alternative 1: Dredging	A [3]	$1,092,000,000	$763,000,000	$91,000,000	$1,947,000,000
	B [4]	$1,092,000,000	$1,085,000,000	$95,000,000	$2,272,000,000
Alternative 2: Capping	A	$537,000,000	$230,000,000	$96,000,000	$863,000,000
	B	$537,000,000	$477,000,000	$97,000,000	$1,111,000,000
Alternative 3: NCC [5] - Authorized Channel	A	$901,000,000	$522,000,000	$94,000,000	$1,518,000,000
	B	$901,000,000	$847,000,000	$97,000,000	$1,845,000,000
Alternative 4: NCC - Current Use Channel	A	$754,000,000	$418,000,000	$95,000,000	$1,267,000,000
	B	$754,000,000	$744,000,000	$97,000,000	$1,596,000,000
Alternative 5: NCC - Future Use Channel	A	$839,000,000	$489,000,000	$93,000,000	$1,421,000,000
	B	$839,000,000	$814,000,000	$96,000,000	$1,749,000,000
Alternative 6: NCC - Future Use Channel + Dredging Primary Erosional and Primary Inventory Zones	A	$879,000,000	$524,000,000	$93,000,000	$1,496,000,000
	B	$879,000,000	$849,000,000	$96,000,000	$1,824,000,000

Notes:

[1] DMM = Dredged Material Management

[2] O&M = Operation and Maintenance

[3] DMM Scenario A: Nearshore Confined Disposal

[4] DMM Scenario B: Nearshore Confined Disposal, Storage, Thermal Treatment, and Beneficial Use

[5] NCC = Navigationally Constrained Capping

Values are rounded to the nearest million.

Alternative 1: Dredging
DMM Scenario A
Focused Feasibility Study
Lower Passaic River Restoration Project

Component	Unit	Unit Cost	# of Units	Cost
CAPITAL COSTS				
A. Pre-Construction Activities				
Design	Percentage	8%		$53,053,672
Pre-Design Investigation - Chemical	Core	$26,241	4,874	$127,899,259
Pre-Design Investigation - Geological	Core	$5,741	1,219	$6,998,435
Pre-Design Investigation - Geotechnical	Boring	$8,470	64	$542,080
Subbottom Geophysics and Bathymetric Survey	Day	$6,500	16	$104,000
Video Survey for Debris Identification	Day	$6,500	16	$104,000
Pre-Construction Oversight	Month	$50,000	12	$600,000
Contractor Work Plans and Submittals	LS	$300,000	1	$300,000
Permitting (Equivalency) and Legal	Percentage	2%		$13,263,418
Total Pre-Construction Activities				*$202,864,864*
B. Mobilization/Demobilization				
Dredge Equipment Mobilization/Demobilization	LS	$200,000	3	$600,000
Capping Equipment Mobilization	LS	$200,000	1	$200,000
Monitoring Equipment Mobilization	LS	$16,700	1	$16,700
Debris Removal Equipment Mobilization/Demobilization	LS	$50,000	1	$50,000
Shoreline Protection Equipment Mobilization/Demobilization	LS	$200,000	1	$200,000
New Season Restart	LS	$266,675	9	$2,400,075
Total Mobilization/Demobilization				*$3,466,775*
C. Dredging				
Dredging	CY	$25	10,960,000	$274,000,000
Debris removal/transport/off-loading/disposal	Ton	$300	8,000	$2,400,000
Testing & Monitoring	EA	$4,881,105	9	$43,929,945
Utility Protection	LF	$50	280,000	$14,000,000
Bridge/Abutment/Bulkhead Protection	LF	$610	44,000	$26,840,000
Barge transport of dredged material	CY	$5	13,700,000	$68,500,000
Dredged material off-loading	CY	$7	13,700,000	$95,900,000
Total Dredging				*$525,569,945*
D. Backfilling or Capping				
Material purchase and delivery	CY	$30	2,100,453	$63,013,596
Material placement	CY	$20	2,100,453	$42,009,064
Confirmation coring	Core	$8,941	400	$3,576,500
Armor Layer Purchase and Placement	CY	$150	0	0
Mudflat reconstruction material purchase and delivery	CY	$60	208,265	$12,495,912
Mudflat reconstruction material placement	CY	$40	208,265	$8,330,608
Natural Shoreline Biostabilization	LF	$215	21,900	$4,708,500
Total Backfill and/or Sand Cap				*$134,134,180*
Subtotal Capital Costs				$866,035,764
E. Construction Management	Percentage	8%		$53,053,672
F. Contingency	Percentage	20%		$173,207,153
TOTAL CAPITAL COSTS				**$1,092,296,588**
DMM COSTS				
G. Dredged Material Management [1]				
TOTAL DMM COSTS				**$763,000,000**
O&M COSTS				
H. Annual O&M				
Mobilization/Demobilization - Monitoring Equipment	EA	$16,900	1	$16,900
Mobilization/Demobilization - Capping Equipment	EA	$40,000	0	$0
Bathymetric Surveys	Day	$6,500	16	$104,000
Surface Sediment Sampling and Analysis	Sample	$3,011	400	$1,204,300
Biological Monitoring	LS	$2,688,390	1	$2,688,390
Water column sampling & analysis	Sample	$1,051	35	$36,986
Habitat recolonization using SPI	Location	$2,000	80	$160,000
Groundwater Monitoring (Well Sampling and Testing)	Sample	$1,500	144	$216,000
Cap maintenance	CY	$30	0	$0
Monitoring reports (including lab reporting)	EA	$450,000	1	$450,000
Community Outreach	LS	$80,000	1	$80,000
Subtotal Annual O&M				$4,956,576
Contingency	Percentage	20%		$991,315
TOTAL ANNUAL O&M COSTS				**$5,947,892**
PRESENT WORTH ANNUAL O&M (5% Rate over 30 Years)				**$91,433,674**
TOTAL PRESENT WORTH COSTS				**$1,946,730,262**

Notes:
[1] See Scenario 1A DMM Backup Sheets for details.

Alternative 1: Dredging
DMM Scenario B
Focused Feasibility Study
Lower Passaic River Restoration Project

Component	Unit	Unit Cost	# of Units	Cost
CAPITAL COSTS				
A. Pre-Construction Activities				
Design	Percentage	8%		$53,053,672
Pre-Design Investigation - Chemical	Core	$26,241	4,874	$127,899,259
Pre-Design Investigation - Geological	Core	$5,741	1,219	$6,998,435
Pre-Design Investigation - Geotechnical	Boring	$8,470	64	$542,080
Subbottom Geophysics and Bathymetric Survey	Day	$6,500	16	$104,000
Video Survey for Debris Identification	Day	$6,500	16	$104,000
Pre-Construction Oversight	Month	$50,000	12	$600,000
Contractor Work Plans and Submittals	LS	$300,000	1	$300,000
Permitting (Equivalency) and Legal	Percentage	2%		$13,263,418
Total Pre-Construction Activities				*$202,864,864*
B. Mobilization/Demobilization				
Dredge Equipment Mobilization/Demobilization	LS	$200,000	3	$600,000
Capping Equipment Mobilization	LS	$200,000	1	$200,000
Monitoring Equipment Mobilization	LS	$16,700	1	$16,700
Debris Removal Equipment Mobilization/Demobilization	LS	$50,000	1	$50,000
Shoreline Protection Equipment Mobilization/Demobilization	LS	$200,000	1	$200,000
New Season Restart	LS	$266,675	9	$2,400,075
Total Mobilization/Demobilization				*$3,466,775*
C. Dredging				
Dredging	CY	$25	10,960,000	$274,000,000
Debris removal/transport/off-loading/disposal	Ton	$300	8,000	$2,400,000
Testing & Monitoring	EA	$4,881,105	9	$43,929,945
Utility Protection	LF	$50	280,000	$14,000,000
Bridge/Abutment/Bulkhead Protection	LF	$610	44,000	$26,840,000
Barge transport of dredged material	CY	$5	13,700,000	$68,500,000
Dredged material off-loading	CY	$7	13,700,000	$95,900,000
Total Dredging				*$525,569,945*
D. Backfilling or Capping				
Material purchase and delivery	CY	$30	2,100,453	$63,013,596
Material placement	CY	$20	2,100,453	$42,009,064
Confirmation coring	Core	$8,941	400	$3,576,500
Armor Layer Purchase and Placement	CY	$150	0	$0
Mudflat reconstruction material purchase and delivery	CY	$60	208,265	$12,495,912
Mudflat reconstruction material placement	CY	$40	208,265	$8,330,608
Natural Shoreline Biostabilization	LF	$215	21,900	$4,708,500
Total Backfill and/or Sand Cap				*$134,134,180*
Subtotal Capital Costs				$866,035,764
E. Construction Management	Percentage	8%		$53,053,672
F. Contingency	Percentage	20%		$173,207,153
TOTAL CAPITAL COSTS				**$1,092,296,588**
DMM COSTS				
G. Dredged Material Management [1]				
TOTAL DMM COSTS				**$1,085,000,000**
O&M COSTS				
H. Annual O&M				
Mobilization/Demobilization - Monitoring Equipment	EA	$16,900	1	$16,900
Mobilization/Demobilization - Capping Equipment	EA	$40,000	1	$40,000
Bathymetric Surveys	Day	$6,500	16	$104,000
Surface Sediment Sampling and Analysis	Sample	$3,011	420	$1,264,515
Biological Monitoring	LS	$2,688,390	1	$2,688,390
Water column sampling & analysis	Sample	$1,051	40	$41,610
Habitat recolonization using SPI	Location	$2,000	100	$200,000
Groundwater Monitoring (Well Sampling and Testing)	Sample	$1,500	144	$216,000
Cap maintenance	CY	$30	1,084	$32,525
Monitoring reports (including lab reporting)	EA	$450,000	1	$450,000
Community Outreach	LS	$80,000	1	$80,000
Subtotal Annual O&M				$5,133,940
Contingency	Percentage	20%		$1,026,788
TOTAL ANNUAL O&M COSTS				**$6,160,727**
PRESENT WORTH ANNUAL O&M (5% Rate over 30 Years)				**$94,705,480**
TOTAL PRESENT WORTH COSTS				**$2,272,002,069**

Notes:
[1] See Scenario 1B DMM Backup Sheets for details.

Alternative 2: Capping
DMM Scenario A
Focused Feasibility Study
Lower Passaic River Restoration Project

Component	Unit	Unit Cost	# of Units	Cost
CAPITAL COSTS				
A. Pre-Construction Activities				
Design	Percentage	8%		$28,879,462
Pre-Design Investigation - Chemical	Core	$7,041	1,219	$8,583,135
Pre- Design Investigation - Chemical (Pre-Dredging Areas)	Core	$9,441	979	$9,242,864
Pre-Design Investigation - Geological	Core	$5,741	1,219	$6,998,435
Pre-Design Investigation - Geotechnical	Boring	$8,470	64	$542,080
Subbottom Geophysics and Bathymetric Survey	Day	$6,500	16	$104,000
Video Survey for Debris Identification	Day	$6,500	16	$104,000
Pre-Construction Oversight	Month	$50,000	12	$600,000
Contractor Work Plans and Submittals	LS	$300,000	1	$300,000
Permitting (Equivalency) and Legal	Percentage	2%		$7,219,865
Total Pre-Construction Activities				*$62,573,842*
B. Mobilization/Demobilization				
Dredge Equipment Mobilization/Demobilization	LS	$200,000	1	$200,000
Capping Equipment Mobilization/Demobilization	LS	$200,000	2	$400,000
Monitoring Equipment Mobilization	LS	$16,700	1	$16,700
Debris Removal Equipment Mobilization/Demobilization	LS	$50,000	1	$50,000
New Season Restart	LS	$166,675	4	$666,700
Total Mobilization/Demobilization				*$1,333,400*
C. Dredging				
Dredging	CY	$25	1,142,000	$28,550,000
Debris removal/transport/off-loading/disposal	Ton	$200	2,000	$400,000
Utility protection	LF	$50	280,000	$14,000,000
Bridge/Abutment/Bulkhead Protection	LF	$610	0	$0
Barge transport of dredged material	CY	$5	1,427,500	$7,137,500
Dredged material off-loading	CY	$7	1,427,500	$9,992,500
Total Dredging				*$60,080,000*
D. Backfilling or Capping				
Material purchase and delivery	CY	$30	3,150,680	$94,520,394
Material placement	CY	$20	3,150,680	$63,013,596
Testing & monitoring during placement	EA	$4,881,105	4	$19,524,420
Confirmation coring	Core	$8,941	400	$3,576,500
Armor Layer Purchase and Placement	CY	$150	622,733	$93,409,939
Mudflat reconstruction purchase and delivery	CY	$60	208,265	$12,495,912
Mudflat reconstruction placement	CY	$40	208,265	$8,330,608
Natural Shoreline Biostabilization	LF	$215	21,900	$4,708,500
Total Backfill and/or Sand Cap				*$299,579,869*
Subtotal Capital Costs				$423,567,111
E. Construction Management	Percentage	8%		$28,879,462
F. Contingency	Percentage	20%		$84,713,422
TOTAL CAPITAL COSTS				**$537,159,994**
DMM COSTS				
G. Dredged Material Management [1]				
TOTAL DMM COSTS				**$230,000,000**
O&M COSTS				
H. Annual O&M				
Mobilization/Demobilization - Monitoring Equipment	EA	$16,900	1	$16,900
Mobilization/Demobilization - Capping Equipment	EA	$40,000	1	$40,000
Bathymetric Surveys	Day	$6,500	16	$114,000
Surface Sediment Sampling and Analysis	Sample	$3,011	420	$1,264,515
Biological Monitoring	LS	$2,688,390	1	$2,688,390
Water column sampling & analysis	Sample	$1,051	35	$46,986
Habitat recolonization using SPI	Location	$2,000	80	$170,000
Groundwater Monitoring (Well Sampling and Testing)	Sample	$1,500	144	$216,000
Cap maintenance	CY	$30	4,433	$132,995
Monitoring reports (including lab reporting)	EA	$450,000	1	$450,000
Community Outreach	LS	$80,000	1	$80,000
Subtotal Annual O&M				$5,219,786
Contingency	Percentage	20%		$1,043,957
TOTAL ANNUAL O&M COSTS				**$6,263,743**
PRESENT WORTH ANNUAL O&M (5% Rate over 30 Years)				**$96,289,090**
TOTAL PRESENT WORTH COSTS				**$863,449,084**

Notes:
[1] See Scenario 2A DMM Backup Sheets for details.

Alternative 2: Capping
DMM Scenario B
Focused Feasibility Study
Lower Passaic River Restoration Project

Component	Unit	Unit Cost	# of Units	Cost
CAPITAL COSTS				
A. Pre-Construction Activities				
Design	Percentage	8%		$28,879,462
Pre-Design Investigation - Chemical	Core	$7,041	1,219	$8,583,135
Pre- Design Investigation - Chemical (Pre-Dredging Areas)	Core	$9,441	979	$9,242,864
Pre-Design Investigation - Geological	Core	$5,741	1,219	$6,998,435
Pre-Design Investigation - Geotechnical	Boring	$8,470	64	$542,080
Subbottom Geophysics and Bathymetric Survey	Day	$6,500	16	$104,000
Video Survey for Debris Identification	Day	$6,500	16	$104,000
Pre-Construction Oversight	Month	$50,000	12	$600,000
Contractor Work Plans and Submittals	LS	$300,000	1	$300,000
Permitting (Equivalency) and Legal	Percentage	2%		$7,219,865
Total Pre-Construction Activities				*$62,573,842*
B. Mobilization/Demobilization				
Dredge Equipment Mobilization/Demobilization	LS	$200,000	1	$200,000
Capping Equipment Mobilization/Demobilization	LS	$200,000	2	$400,000
Monitoring Equipment Mobilization	LS	$16,700	1	$16,700
Debris Removal Equipment Mobilization/Demobilization	LS	$50,000	1	$50,000
New Season Restart	LS	$166,675	4	$666,700
Total Mobilization/Demobilization				*$1,333,400*
C. Dredging				
Dredging	CY	$25	1,142,000	$28,550,000
Debris removal/transport/off-loading/disposal	Ton	$200	2,000	$400,000
Utility protection	LF	$50	280,000	$14,000,000
Bridge/Abutment/Bulkhead Protection	LF	$610	0	$0
Barge transport of dredged material	CY	$5	1,427,500	$7,137,500
Dredged material off-loading	CY	$7	1,427,500	$9,992,500
Total Dredging				*$60,080,000*
D. Backfilling or Capping				
Material purchase and delivery	CY	$30	3,150,680	$94,520,394
Material placement	CY	$20	3,150,680	$63,013,596
Testing & monitoring during placement	EA	$4,881,105	4	$19,524,420
Confirmation coring	Core	$8,941	400	$3,576,500
Armor Layer Purchase and Placement	CY	$150	622,733	$93,409,939
Mudflat reconstruction purchase and delivery	CY	$60	208,265	$12,495,912
Mudflat reconstruction placement	CY	$40	208,265	$8,330,608
Natural Shoreline Biostabilization	LF	$215	21,900	$4,708,500
Total Backfill and/or Sand Cap				*$299,579,869*
Subtotal Capital Costs				$423,567,111
E. Construction Management	Percentage	8%		$28,879,462
F. Contingency	Percentage	20%		$84,713,422
TOTAL CAPITAL COSTS				**$537,159,994**
DMM COSTS				
G. Dredged Material Management [1]				
TOTAL DMM COSTS				**$477,000,000**
O&M COSTS				
H. Annual O&M				
Mobilization/Demobilization - Monitoring Equipment	EA	$16,900	1	$16,900
Mobilization/Demobilization - Capping Equipment	EA	$40,000	1	$40,000
Bathymetric Surveys	Day	$6,500	16	$114,000
Surface Sediment Sampling and Analysis	Sample	$3,011	400	$1,204,300
Biological Monitoring	LS	$2,688,390	1	$2,688,390
Water column sampling & analysis	Sample	$1,051	40	$51,610
Habitat recolonization using SPI	Location	$2,000	100	$210,000
Groundwater Monitoring (Well Sampling and Testing)	Sample	$1,500	144	$216,000
Cap maintenance	CY	$30	5,517	$165,520
Monitoring reports (including lab reporting)	EA	$450,000	1	$450,000
Community Outreach	LS	$80,000	1	$80,000
Subtotal Annual O&M				$5,236,719
Contingency	Percentage	20%		$1,047,344
TOTAL ANNUAL O&M COSTS				**$6,284,063**
PRESENT WORTH ANNUAL O&M (5% Rate over 30 Years)				**$96,601,454**
TOTAL PRESENT WORTH COSTS				**$1,110,761,448**

Notes:
[1] See Scenario 2B DMM Backup Sheets for details.

Alternative 3: NCC - Authorized Channel
DMM Scenario A
Focused Feasibility Study
Lower Passaic River Restoration Project

Component	Unit	Unit Cost	# of Units	Cost
CAPITAL COSTS				
A. Pre-Construction Activities				
Design	Percentage	8%		$42,150,773
Pre-Design Investigation - Chemical	Core	$26,241	4,874	$127,899,259
Pre-Design Investigation - Geological	Core	$5,741	1,219	$6,998,435
Pre-Design Investigation - Geotechnical	Boring	$8,470	64	$542,080
Subbottom Geophysics and Bathymetric Survey	Day	$6,500	16	$104,000
Video Survey for Debris Identification	Day	$6,500	16	$104,000
Pre-Construction Oversight	Month	$50,000	12	$600,000
Contractor Work Plans and Submittals	LS	$300,000	1	$300,000
Permitting (Equivalency) and Legal	Percentage	2%		$10,537,693
Total Pre-Construction Activities				*$189,236,240*
B. Mobilization/Demobilization				
Dredge Equipment Mobilization/Demobilization	LS	$200,000	3	$600,000
Capping Equipment Mobilization/Demobilization	LS	$200,000	2	$400,000
Monitoring Equipment Mobilization	LS	$16,700	1	$16,700
Debris Removal Equipment Mobilization/Demobilization	LS	$50,000	1	$50,000
Shoreline Protection Equipment Mobilization/Demobilization	LS	$200,000	1	$200,000
New Season Restart	LS	$316,675	6	$1,900,050
Total Mobilization/Demobilization				*$3,166,750*
C. Dredging				
Dredging	CY	$25	6,979,000	$174,475,000
Debris removal/transport/off-loading/disposal	Ton	$300	8,000	$2,400,000
Utility protection	Per LF	$50	280,000	$14,000,000
Bridge/Abutment/Bulkhead Protection	Per LF	$610	44,000	$26,840,000
Barge transport of dredged material	CY	$5	8,723,750	$43,618,750
Dredged material off-loading	CY	$7	8,723,750	$61,066,250
Total Dredging				*$322,400,000*
D. Backfilling or Capping				
Material purchase and delivery	CY	$30	2,701,743	$81,052,276
Material placement	CY	$20	2,701,743	$54,034,851
Testing & monitoring during placement	EA	$4,881,105	6	$29,286,630
Confirmation coring	Core	$8,941	400	$3,576,500
Armor Purchase and Placement	CY	$150	52,218	$7,832,636
Mudflat reconstruction purchase and delivery	CY	$60	208,265	$12,495,912
Mudflat reconstruction placement	CY	$40	208,265	$8,330,608
Natural Shoreline Biostabilization	LF	$215	21,900	$4,708,500
Total Backfill and/or Sand Cap				*$201,317,912*
Subtotal Capital Costs				$716,120,902
E. Construction Management	Percentage	8%		$42,150,773
F. Contingency	Percentage	20%		$143,224,180
TOTAL CAPITAL COSTS				**$901,495,856**
DMM COSTS				
G. Dredged Material Management [1]				
TOTAL DMM COSTS				**$522,000,000**
O&M COSTS				
H. Annual O&M				
Mobilization/Demobilization - Monitoring Equipment	EA	$16,900	1	$16,900
Mobilization/Demobilization - Capping Equipment	EA	$40,000	1	$40,000
Bathymetric Surveys	Day	$6,500	16	$104,000
Surface Sediment Sampling and Analysis	Sample	$3,011	400	$1,204,300
Biological Monitoring	LS	$2,688,390	1	$2,688,390
Water column sampling & analysis	Sample	$1,051	35	$36,986
Habitat recolonization using SPI	Location	$2,000	80	$160,000
Groundwater Monitoring (Well Sampling and Testing)	Sample	$1,500	144	$216,000
Cap maintenance	CY	$30	3,451	$103,532
Monitoring reports (including lab reporting)	EA	$450,000	1	$450,000
Community Outreach	LS	$80,000	1	$80,000
Subtotal Annual O&M				$5,100,109
Contingency	Percentage	20%		$1,020,022
TOTAL ANNUAL O&M COSTS				**$6,120,131**
PRESENT WORTH ANNUAL O&M (5% Rate over 30 Years)				**$94,081,409**
TOTAL PRESENT WORTH COSTS				**$1,517,577,265**

Notes:
[1] See Scenario 3A DMM Backup Sheets for details.

Alternative 3: NCC - Authorized Channel
DMM Scenario B
Focused Feasibility Study
Lower Passaic River Restoration Project

Component	Unit	Unit Cost	# of Units	Cost
CAPITAL COSTS				
A. Pre-Construction Activities				
Design	Percentage	8%		$42,150,773
Pre-Design Investigation - Chemical	Core	$26,241	4,874	$127,899,259
Pre-Design Investigation - Geological	Core	$5,741	1,219	$6,998,435
Pre-Design Investigation - Geotechnical	Boring	$8,470	64	$542,080
Subbottom Geophysics and Bathymetric Survey	Day	$6,500	16	$104,000
Video Survey for Debris Identification	Day	$6,500	16	$104,000
Pre-Construction Oversight	Month	$50,000	12	$600,000
Contractor Work Plans and Submittals	LS	$300,000	1	$300,000
Permitting (Equivalency) and Legal	Percentage	2%		$10,537,693
Total Pre-Construction Activities				*$189,236,240*
B. Mobilization/Demobilization				
Dredge Equipment Mobilization/Demobilization	LS	$200,000	3	$600,000
Capping Equipment Mobilization/Demobilization	LS	$200,000	2	$400,000
Monitoring Equipment Mobilization	LS	$16,700	1	$16,700
Debris Removal Equipment Mobilization/Demobilization	LS	$50,000	1	$50,000
Shoreline Protection Equipment Mobilization/Demobilization	LS	$200,000	1	$200,000
New Season Restart	LS	$316,675	6	$1,900,050
Total Mobilization/Demobilization				*$3,166,750*
C. Dredging				
Dredging	CY	$25	6,979,000	$174,475,000
Debris removal/transport/off-loading/disposal	Ton	$300	8,000	$2,400,000
Utility protection	LF	$50	280,000	$14,000,000
Bridge/Abutment/Bulkhead Protection	LF	$610	44,000	$26,840,000
Barge transport of dredged material	CY	$5	8,723,750	$43,618,750
Dredged material off-loading	CY	$7	8,723,750	$61,066,250
Total Dredging				*$322,400,000*
D. Backfilling or Capping				
Material purchase and delivery	CY	$30	2,701,743	$81,052,276
Material placement	CY	$20	2,701,743	$54,034,851
Testing & monitoring during placement	EA	$4,881,105	6	$29,286,630
Confirmation coring	Core	$8,941	400	$3,576,500
Armor Purchase and Placement	CY	$150	52,218	$7,832,636
Mudflat reconstruction purchase and delivery	CY	$60	208,265	$12,495,912
Mudflat reconstruction placement	CY	$40	208,265	$8,330,608
Natural Shoreline Biostabilization	LF	$215	21,900	$4,708,500
Total Backfill and/or Sand Cap				*$201,317,912*
Subtotal Capital Costs				$716,120,902
E. Construction Management	Percentage	8%		$42,150,773
F. Contingency	Percentage	20%		$143,224,180
TOTAL CAPITAL COSTS				**$901,495,856**
DMM COSTS				
G. Dredged Material Management [1]				
TOTAL DMM COSTS				**$847,000,000**
O&M COSTS				
H. Annual O&M				
Mobilization/Demobilization - Monitoring Equipment	EA	$16,900	1	$16,900
Mobilization/Demobilization - Capping Equipment	EA	$40,000	1	$40,000
Bathymetric Surveys	Day	$6,500	16	$104,000
Surface Sediment Sampling and Analysis	Sample	$3,011	420	$1,264,515
Biological Monitoring	LS	$2,688,390	1	$2,688,390
Water column sampling & analysis	Sample	$1,051	40	$41,610
Habitat recolonization using SPI	Location	$2,000	100	$200,000
Groundwater Monitoring (Well Sampling and Testing)	Sample	$1,500	144	$216,000
Cap maintenance	CY	$30	4,535	$136,057
Monitoring reports (including lab reporting)	EA	$450,000	1	$450,000
Community Outreach	LS	$80,000	1	$80,000
Subtotal Annual O&M				$5,237,472
Contingency	Percentage	20%		$1,047,494
TOTAL ANNUAL O&M COSTS				**$6,284,966**
PRESENT WORTH ANNUAL O&M (5% Rate over 30 Years)				**$96,615,338**
TOTAL PRESENT WORTH COSTS				**$1,845,111,194**

Notes:
[1] See Scenario 3B DMM Backup Sheets for details.

Alternative 4: NCC - Current Use Channel
DMM Scenario A
Focused Feasibility Study
Lower Passaic River Restoration Project

Component	Unit	Unit Cost	# of Units	Cost
CAPITAL COSTS				
A. Pre-Construction Activities				
Design	Percentage	8%		$37,916,799
Pre-Design Investigation - Chemical - RM 0-2.5	Core	$26,241	2,198	$57,678,000
Pre-Design Investigation - Chemical - RM 2.5-8.3	Core	$9,441	991	$9,356,158
Pre-Design Investigation - Geological	Core	$5,741	1,219	$6,998,435
Pre-Design Investigation - Geotechnical	Boring	$8,470	64	$542,080
Subbottom Geophysics and Bathymetric Survey	Day	$6,500	16	$104,000
Video Survey for Debris Identification	Day	$6,500	16	$104,000
Pre-Construction Oversight	Month	$50,000	12	$600,000
Contractor Work Plans and Submittals	LS	$300,000	1	$300,000
Permitting (Equivalency) and Legal	Percentage	2%		$9,479,200
Total Pre-Construction Activities				*$123,078,672*
B. Mobilization/Demobilization				
Dredge Equipment Mobilization/Demobilization	LS	$200,000	3	$600,000
Capping Equipment Mobilization/Demobilization	LS	$200,000	2	$400,000
Monitoring Equipment Mobilization	LS	$16,700	1	$16,700
Debris Removal Equipment Mobilization/Demobilization	LS	$50,000	1	$50,000
Shoreline Protection Equipment Mobilization/Demobilization	LS	$200,000	1	$200,000
New Season Restart	LS	$316,675	4	$1,266,700
Total Mobilization/Demobilization				*$2,533,400*
C. Dredging				
Dredging	CY	$25	4,432,000	$110,800,000
Debris removal/transport/off-loading/disposal	Ton	$300	3,500	$1,050,000
Utility protection	LF	$50	280,000	$14,000,000
Bridge/Abutment/Bulkhead Protection	LF	$610	19,800	$12,078,000
Barge transport of dredged material	CY	$5	5,540,000	$27,700,000
Dredged material off-loading	CY	$7	5,540,000	$38,780,000
Total Dredging				*$204,408,000*
D. Backfilling or Capping				
Material purchase and delivery	CY	$30	3,080,424	$92,412,724
Material placement	CY	$20	3,080,424	$61,608,483
Testing & monitoring during placement	EA	$4,881,105	4	$19,524,420
Confirmation coring	Core	$8,941	400	$3,576,500
Armor Purchase and Placement	CY	$150	429,076	$64,361,442
Mudflat reconstruction purchase and delivery	CY	$60	208,265	$12,495,912
Mudflat reconstruction placement	CY	$40	208,265	$8,330,608
Natural Shoreline Biostabilization	LF	$215	21,900	$4,708,500
Total Backfill and/or Sand Cap				*$267,018,588*
Subtotal Capital Costs				$597,038,660
E. Construction Management	Percentage	8%		$37,916,799
F. Contingency	Percentage	20%		$119,407,732
TOTAL CAPITAL COSTS				**$754,363,191**
DMM COSTS				
G. Dredged Material Management [1]				
TOTAL DMM COSTS				**$418,000,000**
O&M COSTS				
H. Annual O&M				
Mobilization/Demobilization - Monitoring Equipment	EA	$16,900	1	$16,900
Mobilization/Demobilization - Capping Equipment	EA	$40,000	1	$40,000
Bathymetric Surveys	Day	$6,500	16	$104,000
Surface Sediment Sampling and Analysis	Sample	$3,011	400	$1,204,300
Biological Monitoring	LS	$2,688,390	1	$2,688,390
Water column sampling & analysis	Sample	$1,051	35	$36,986
Habitat recolonization using SPI	Location	$2,000	80	$160,000
Groundwater Monitoring (Well Sampling and Testing)	Sample	$1,500	144	$216,000
Cap maintenance	CY	$30	4,593	$137,778
Monitoring reports (including lab reporting)	EA	$450,000	1	$450,000
Community Outreach	LS	$80,000	1	$80,000
Subtotal Annual O&M				$5,134,354
Contingency	Percentage	20%		$1,026,871
TOTAL ANNUAL O&M COSTS				**$6,161,225**
PRESENT WORTH ANNUAL O&M (5% Rate over 30 Years)				**$94,713,132**
TOTAL PRESENT WORTH COSTS				**$1,267,076,323**

Notes:
[1] See Scenario 4A DMM Backup Sheets for details.

Alternative 4: NCC - Current Use Channel
DMM Scenario B
Focused Feasibility Study
Lower Passaic River Restoration Project

Component	Unit	Unit Cost	# of Units	Cost
CAPITAL COSTS				
A. Pre-Construction Activities				
Design	Percentage	8%		$37,916,799
Pre-Design Investigation - Chemical - RM 0-2.5	Core	$26,241	2,198	$57,678,000
Pre-Design Investigation - Chemical - RM 2.5-8.3	Core	$9,441	991	$9,356,158
Pre-Design Investigation - Geological	Core	$5,741	1,219	$6,998,435
Pre-Design Investigation - Geotechnical	Boring	$8,470	64	$542,080
Subbottom Geophysics and Bathymetric Survey	Day	$6,500	16	$104,000
Video Survey for Debris Identification	Day	$6,500	16	$104,000
Pre-Construction Oversight	Month	$50,000	12	$600,000
Contractor Work Plans and Submittals	LS	$300,000	1	$300,000
Permitting (Equivalency) and Legal	Percentage	2%		$9,479,200
Total Pre-Construction Activities				*$123,078,672*
B. Mobilization/Demobilization				
Dredge Equipment Mobilization/Demobilization	LS	$200,000	3	$600,000
Capping Equipment Mobilization/Demobilization	LS	$200,000	2	$400,000
Monitoring Equipment Mobilization	LS	$16,700	1	$16,700
Debris Removal Equipment Mobilization/Demobilization	LS	$50,000	1	$50,000
Shoreline Protection Equipment Mobilization/Demobilization	LS	$200,000	1	$200,000
New Season Restart	LS	$316,675	4	$1,266,700
Total Mobilization/Demobilization				*$2,533,400*
C. Dredging				
Dredging	CY	$25	4,432,000	$110,800,000
Debris removal/transport/off-loading/disposal	Ton	$300	3,500	$1,050,000
Utility protection	LF	$50	280,000	$14,000,000
Bridge/Abutment/Bulkhead Protection	LF	$610	19,800	$12,078,000
Barge transport of dredged material	CY	$5	5,540,000	$27,700,000
Dredged material off-loading	CY	$7	5,540,000	$38,780,000
Total Dredging				*$204,408,000*
D. Backfilling or Capping				
Material purchase and delivery	CY	$30	3,080,424	$92,412,724
Material placement	CY	$20	3,080,424	$61,608,483
Testing & monitoring during placement	EA	$4,881,105	4	$19,524,420
Confirmation coring	Core	$8,941	400	$3,576,500
Armor Purchase and Placement	CY	$150	429,076	$64,361,442
Mudflat reconstruction purchase and delivery	CY	$60	208,265	$12,495,912
Mudflat reconstruction placement	CY	$40	208,265	$8,330,608
Natural Shoreline Biostabilization	LF	$215	21,900	$4,708,500
Total Backfill and/or Sand Cap				*$267,018,588*
Subtotal Capital Costs				$597,038,660
E. Construction Management	Percentage	8%		$37,916,799
F. Contingency	Percentage	20%		$119,407,732
TOTAL CAPITAL COSTS				**$754,363,191**
DMM COSTS				
G. Dredged Material Management [1]				
TOTAL DMM COSTS				**$744,000,000**
O&M COSTS				
H. Annual O&M				
Mobilization/Demobilization - Monitoring Equipment	EA	$16,900	1	$16,900
Mobilization/Demobilization - Capping Equipment	EA	$40,000	1	$40,000
Bathymetric Surveys	Day	$6,500	16	$104,000
Surface Sediment Sampling and Analysis	Sample	$3,011	420	$1,264,515
Biological Monitoring	LS	$2,688,390	1	$2,688,390
Water column sampling & analysis	Sample	$1,051	40	$41,610
Habitat recolonization using SPI	Location	$2,000	100	$200,000
Groundwater Monitoring (Well Sampling and Testing)	Sample	$1,500	144	$216,000
Cap maintenance	CY	$30	5,677	$170,303
Monitoring reports (including lab reporting)	EA	$450,000	1	$450,000
Community Outreach	LS	$80,000	1	$80,000
Subtotal Annual O&M				$5,271,717
Contingency	Percentage	20%		$1,054,343
TOTAL ANNUAL O&M COSTS				**$6,326,061**
PRESENT WORTH ANNUAL O&M (5% Rate over 30 Years)				**$97,247,061**
TOTAL PRESENT WORTH COSTS				**$1,595,610,252**

Notes:
[1] See Scenario 4B DMM Backup Sheets for details.

Alternative 5: NCC - Future Use Channel
DMM Scenario A
Focused Feasibility Study
Lower Passaic River Restoration Project

Component	Unit	Unit Cost	# of Units	Cost
CAPITAL COSTS				
A. Pre-Construction Activities				
Design	Percentage	8%		$38,588,399
Pre-Design Investigation - Chemical	Core	$26,241	4,874	$127,899,259
Pre-Design Investigation - Geological	Core	$5,741	1,219	$6,998,435
Pre-Design Investigation - Geotechnical	Boring	$8,470	64	$367,432
Subbottom Geophysics and Bathymetric Survey	Day	$6,500	16	$104,000
Video Survey for Debris Identification	Day	$6,500	16	$104,000
Pre-Construction Oversight	Month	$50,000	12	$600,000
Contractor Work Plans and Submittals	LS	$300,000	1	$300,000
Permitting or Permitting Equivalent	Percentage	2%		$9,647,100
Total Pre-Construction Activities				*$184,608,624*
B. Mobilization/Demobilization				
Dredge Equipment Mobilization/Demobilization	LS	$200,000	3	$600,000
Capping Equipment Mobilization/Demobilization	LS	$200,000	2	$400,000
Monitoring Equipment Mobilization	LS	$16,700	1	$16,700
Debris Removal Equipment Mobilization/Demobilization	LS	$50,000	1	$50,000
Shoreline Protection Equipment Mobilization/Demobilization	LS	$200,000	1	$200,000
New Season Restart	LS	$316,675	5	$1,583,375
Total Mobilization/Demobilization				*$2,850,075*
C. Dredging				
Dredging	CY	$25	6,148,000	$153,700,000
Debris removal/transport/off-loading/disposal	Ton	$300	8,000	$2,400,000
Utility protection	LF	$50	280,000	$14,000,000
Bridge/Abutment/Bulkhead Protection	LF	$610	44,000	$26,840,000
Barge transport of dredged material	CY	$5	7,685,000	$38,425,000
Dredged material off-loading	CY	$7	7,685,000	$53,795,000
Total Dredging				*$289,160,000*
D. Backfilling or Capping				
Material purchase and delivery	CY	$30	2,453,031	$73,590,932
Material placement	CY	$20	2,453,031	$49,060,621
Testing & monitoring during placement	EA	$4,881,105	5	$24,405,525
Confirmation coring	Core	$8,941	400	$3,576,500
Armor Purchase and Placement	CY	$150	94,509	$14,176,309
Mudflat reconstruction purchase and delivery	CY	$60	208,265	$12,495,912
Mudflat reconstruction placement	CY	$40	208,265	$8,330,608
Natural Shoreline Biostabilization	LF	$215	21,900	$4,708,500
Total Backfill and/or Sand Cap				*$190,344,907*
Subtotal Capital Costs				$666,963,606
E. Construction Management	Percentage	8%		$38,588,399
F. Contingency	Percentage	20%		$133,392,721
TOTAL CAPITAL COSTS				**$838,944,726**
DMM COSTS				
G. Dredged Material Management [1]				
TOTAL DMM COSTS				**$489,000,000**
O&M COSTS				
H. Annual O&M				
Mobilization/Demobilization - Monitoring Equipment	EA	$16,900	1	$16,900
Mobilization/Demobilization - Capping Equipment	EA	$40,000	1	$40,000
Bathymetric Surveys	Day	$6,500	16	$104,000
Surface Sediment Sampling and Analysis	Sample	$3,011	400	$1,204,300
Biological Monitoring	LS	$2,688,390	1	$2,688,390
Water column sampling & analysis	Sample	$1,051	35	$36,986
Habitat recolonization using SPI	Location	$2,000	80	$160,000
Groundwater Monitoring (Well Sampling and Testing)	Sample	$1,500	144	$216,000
Cap maintenance	CY	$30	1,832	$54,958
Monitoring reports (including lab reporting)	EA	$450,000	1	$450,000
Community Outreach	LS	$80,000	1	$80,000
Subtotal Annual O&M				$5,051,535
Contingency	Percentage	20%		$1,010,307
TOTAL ANNUAL O&M COSTS				**$6,061,842**
PRESENT WORTH ANNUAL O&M (5% Rate over 30 Years)				**$93,185,362**
TOTAL PRESENT WORTH COSTS				**$1,421,130,088**

Notes:
[1] See Scenario 5A DMM Backup Sheets for details.

Alternative 5: NCC - Future Use Channel
DMM Scenario B
Focused Feasibility Study
Lower Passaic River Restoration Project

Component	Unit	Unit Cost	# of Units	Cost
CAPITAL COSTS				
A. Pre-Construction Activities				
Design	Percentage	8%		$38,588,399
Pre-Design Investigation - Chemical	Core	$26,241	4,874	$127,899,259
Pre-Design Investigation - Geological	Core	$5,741	1,219	$6,998,435
Pre-Design Investigation - Geotechnical	Boring	$8,470	64	$367,432
Subbottom Geophysics and Bathymetric Survey	Day	$6,500	16	$104,000
Video Survey for Debris Identification	Day	$6,500	16	$104,000
Pre-Construction Oversight	Month	$50,000	12	$600,000
Contractor Work Plans and Submittals	LS	$300,000	1	$300,000
Permitting or Permitting Equivalent	Percentage	2%		$9,647,100
Total Pre-Construction Activities				*$184,608,624*
B. Mobilization/Demobilization				
Dredge Equipment Mobilization/Demobilization	LS	$200,000	3	$600,000
Capping Equipment Mobilization/Demobilization	LS	$200,000	2	$400,000
Monitoring Equipment Mobilization	LS	$16,700	1	$16,700
Debris Removal Equipment Mobilization/Demobilization	LS	$50,000	1	$50,000
Shoreline Protection Equipment Mobilization/Demobilization	LS	$200,000	1	$200,000
New Season Restart	LS	$316,675	5	$1,583,375
Total Mobilization/Demobilization				*$2,850,075*
C. Dredging				
Dredging	CY	$25	6,148,000	$153,700,000
Debris removal/transport/off-loading/disposal	Ton	$300	8,000	$2,400,000
Utility protection	LF	$50	280,000	$14,000,000
Bridge/Abutment/Bulkhead Protection	LF	$610	44,000	$26,840,000
Barge transport of dredged material	CY	$5	7,685,000	$38,425,000
Dredged material off-loading	CY	$7	7,685,000	$53,795,000
Total Dredging				*$289,160,000*
D. Backfilling or Capping				
Material purchase and delivery	CY	$30	2,453,031	$73,590,932
Material placement	CY	$20	2,453,031	$49,060,621
Testing & monitoring during placement	EA	$4,881,105	5	$24,405,525
Confirmation coring	Core	$8,941	400	$3,576,500
Armor Purchase and Placement	CY	$150	94,509	$14,176,309
Mudflat reconstruction purchase and delivery	CY	$60	208,265	$12,495,912
Mudflat reconstruction placement	CY	$40	208,265	$8,330,608
Natural Shoreline Biostabilization	LF	$215	21,900	$4,708,500
Total Backfill and/or Sand Cap				*$190,344,907*
Subtotal Capital Costs				$666,963,606
E. Construction Management	Percentage	8%		$38,588,399
F. Contingency	Percentage	20%		$133,392,721
TOTAL CAPITAL COSTS				**$838,944,726**
DMM COSTS				
G. Dredged Material Management [1]				
TOTAL DMM COSTS				**$814,000,000**
O&M COSTS				
H. Annual O&M				
Mobilization/Demobilization - Monitoring Equipment	EA	$16,900	1	$16,900
Mobilization/Demobilization - Capping Equipment	EA	$40,000	1	$40,000
Bathymetric Surveys	Day	$6,500	16	$104,000
Surface Sediment Sampling and Analysis	Sample	$3,011	420	$1,264,515
Biological Monitoring	LS	$2,688,390	1	$2,688,390
Water column sampling & analysis	Sample	$1,051	40	$41,610
Habitat recolonization using SPI	Location	$2,000	100	$200,000
Groundwater Monitoring (Well Sampling and Testing)	Sample	$1,500	144	$216,000
Cap maintenance	CY	$30	2,916	$87,483
Monitoring reports (including lab reporting)	EA	$450,000	1	$450,000
Community Outreach	LS	$80,000	1	$80,000
Subtotal Annual O&M				$5,188,898
Contingency	Percentage	20%		$1,037,780
TOTAL ANNUAL O&M COSTS				**$6,226,677**
PRESENT WORTH ANNUAL O&M (5% Rate over 30 Years)				**$95,719,291**
TOTAL PRESENT WORTH COSTS				**$1,748,664,017**

Notes:
[1] See Scenario 5B DMM Backup Sheets for details.

Alternative 6: NCC - Future Use Channel + Dredging Primary Erosional and Primary Inventory Zones
DMM Scenario A
Focused Feasibility Study
Lower Passaic River Restoration Project

Component	Unit	Unit Cost	# of Units	Cost
CAPITAL COSTS				
A. Pre-Construction Activities				
Design	Percentage	8%		$40,870,524
Pre-Design Investigation - Chemical	Core	$26,241	4,874	$127,899,259
Pre-Design Investigation - Geological	Core	$5,741	1,219	$6,998,435
Pre-Design Investigation - Geotechnical	Boring	$8,470	64	$542,080
Subbottom Geophysics and Bathymetric Survey	Day	$6,500	16	$104,000
Video Survey for Debris Identification	Day	$6,500	16	$104,000
Pre-Construction Oversight	Month	$50,000	12	$600,000
Contractor Work Plans and Submittals	LS	$300,000	1	$300,000
Permitting or Permitting Equivalent	Percentage	2%		$10,217,631
Total Pre-Construction Activities				*$187,635,928*
B. Mobilization/Demobilization				
Dredge Equipment Mobilization/Demobilization	LS	$200,000	3	$600,000
Capping Equipment Mobilization/Demobilization	LS	$200,000	2	$400,000
Monitoring Equipment Mobilization	LS	$16,700	1	$16,700
Debris Removal Equipment Mobilization/Demobilization	LS	$50,000	1	$50,000
Shoreline Protection Equipment Mobilization/Demobilization	LS	$200,000	1	$200,000
New Season Restart	LS	$316,675	6	$1,900,050
Total Mobilization/Demobilization				*$3,166,750*
C. Dredging				
Dredging	CY	$25	7,010,000	$175,250,000
Debris removal/transport/off-loading/disposal	Ton	$300	8,000	$2,400,000
Utility protection	LF	$50	280,000	$14,000,000
Bridge/Abutment/Bulkhead Protection	LF	$610	44,000	$26,840,000
Barge transport of dredged material	CY	$5	8,762,500	$43,812,500
Dredged material off-loading	CY	$7	8,762,500	$61,337,500
Total Dredging				*$323,640,000*
D. Backfilling or Capping				
Material purchase and delivery	CY	$30	2,367,524	$71,025,732
Material placement	CY	$20	2,367,524	$47,350,488
Testing & monitoring during placement	EA	$4,881,105	6	$29,286,630
Confirmation coring	Core	$8,941	400	$3,576,500
Armor Purchase and Placement	CY	$150	48,670	$7,300,425
Mudflat reconstruction purchase and delivery	CY	$60	208,265	$12,495,912
Mudflat reconstruction placement	CY	$40	208,265	$8,330,608
Natural Shoreline Biostabilization	LF	$215	21,900	$4,708,500
Total Backfill and/or Sand Cap				*$184,074,795*
Subtotal Capital Costs				$698,517,473
E. Construction Management	Percentage	8%		$40,870,524
F. Contingency	Percentage	20%		$139,703,495
TOTAL CAPITAL COSTS				**$879,091,492**
DMM COSTS				
G. Dredged Material Management [1]				
TOTAL DMM COSTS				**$524,000,000**
O&M COSTS				
H. Annual O&M				
Mobilization/Demobilization - Monitoring Equipment	EA	$16,900	1	$16,900
Mobilization/Demobilization - Capping Equipment	EA	$40,000	1	$40,000
Bathymetric Surveys	Day	$6,500	16	$104,000
Surface Sediment Sampling and Analysis	Sample	$3,011	400	$1,204,300
Biological Monitoring	LS	$2,688,390	1	$2,688,390
Water column sampling & analysis	Sample	$1,051	35	$36,986
Habitat recolonization using SPI	Location	$2,000	80	$160,000
Groundwater Monitoring (Well Sampling and Testing)	Sample	$1,500	144	$216,000
Cap maintenance	CY	$30	1,456	$43,693
Monitoring reports (including lab reporting)	EA	$450,000	1	$450,000
Community Outreach	LS	$80,000	1	$80,000
Subtotal Annual O&M	EA			$5,040,269
Contingency	Percentage	20%		$1,008,054
TOTAL ANNUAL O&M COSTS				**$6,048,323**
PRESENT WORTH ANNUAL O&M (5% Rate over 30 Years)				**$92,977,545**
TOTAL PRESENT WORTH COSTS				**$1,496,069,037**

Notes:
[1] See Scenario 6A DMM Backup Sheets for details.

Alternative 6: NCC - Future Use Channel + Dredging Primary Erosional and Primary Inventory Zones
DMM Scenario B
Focused Feasibility Study
Lower Passaic River Restoration Project

Component	Unit	Unit Cost	# of Units	Cost
CAPITAL COSTS				
A. Pre-Construction Activities				
Design	Percentage	8%		$40,870,524
Pre-Design Investigation - Chemical	Core	$26,241	4,874	$127,899,259
Pre-Design Investigation - Geological	Core	$5,741	1,219	$6,998,435
Pre-Design Investigation - Geotechnical	Boring	$8,470	64	$542,080
Subbottom Geophysics and Bathymetric Survey	Day	$6,500	16	$104,000
Video Survey for Debris Identification	Day	$6,500	16	$104,000
Pre-Construction Oversight	Month	$50,000	12	$600,000
Contractor Work Plans and Submittals	LS	$300,000	1	$300,000
Permitting or Permitting Equivalent	Percentage	2%		$10,217,631
Total Pre-Construction Activities				*$187,635,928*
B. Mobilization/Demobilization				
Dredge Equipment Mobilization/Demobilization	LS	$200,000	3	$600,000
Capping Equipment Mobilization/Demobilization	LS	$200,000	2	$400,000
Monitoring Equipment Mobilization	LS	$16,700	1	$16,700
Debris Removal Equipment Mobilization/Demobilization	LS	$50,000	1	$50,000
Shoreline Protection Equipment Mobilization/Demobilization	LS	$200,000	1	$200,000
New Season Restart	LS	$316,675	6	$1,900,050
Total Mobilization/Demobilization				*$3,166,750*
C. Dredging				
Dredging	CY	$25	7,010,000	$175,250,000
Debris removal/transport/off-loading/disposal	Ton	$300	8,000	$2,400,000
Utility protection	LF	$50	280,000	$14,000,000
Bridge/Abutment/Bulkhead Protection	LF	$610	44,000	$26,840,000
Barge transport of dredged material	CY	$5	8,762,500	$43,812,500
Dredged material off-loading	CY	$7	8,762,500	$61,337,500
Total Dredging				*$323,640,000*
D. Backfilling or Capping				
Material purchase and delivery	CY	$30	2,367,524	$71,025,732
Material placement	CY	$20	2,367,524	$47,350,488
Testing & monitoring during placement	EA	$4,881,105	6	$29,286,630
Confirmation coring	Core	$8,941	400	$3,576,500
Armor Purchase and Placement	CY	$150	48,670	$7,300,425
Mudflat reconstruction purchase and delivery	CY	$60	208,265	$12,495,912
Mudflat reconstruction placement	CY	$40	208,265	$8,330,608
Natural Shoreline Biostabilization	LF	$215	21,900	$4,708,500
Total Backfill and/or Sand Cap				*$184,074,795*
Subtotal Capital Costs				$698,517,473
E. Construction Management	Percentage	8%		$40,870,524
F. Contingency	Percentage	20%		$139,703,495
TOTAL CAPITAL COSTS				**$879,091,492**
DMM COSTS				
G. Dredged Material Management [1]				
TOTAL DMM COSTS				**$849,000,000**
O&M COSTS				
H. Annual O&M				
Mobilization/Demobilization - Monitoring Equipment	EA	$16,900	1	$16,900
Mobilization/Demobilization - Capping Equipment	EA	$40,000	1	$40,000
Bathymetric Surveys	Day	$6,500	16	$104,000
Surface Sediment Sampling and Analysis	Sample	$3,011	420	$1,264,515
Biological Monitoring	LS	$2,688,390	1	$2,688,390
Water column sampling & analysis	Sample	$1,051	40	$41,610
Habitat recolonization using SPI	Location	$2,000	100	$200,000
Groundwater Monitoring (Well Sampling and Testing)	Sample	$1,500	144	$216,000
Cap maintenance	CY	$30	2,541	$76,217
Monitoring reports (including lab reporting)	EA	$450,000	1	$450,000
Community Outreach	LS	$80,000	1	$80,000
Subtotal Annual O&M	EA			$5,177,632
Contingency	Percentage	20%		$1,035,526
TOTAL ANNUAL O&M COSTS				**$6,213,158**
PRESENT WORTH ANNUAL O&M (5% Rate over 30 Years)				**$95,511,474**
TOTAL PRESENT WORTH COSTS				**$1,823,602,966**

Notes:
[1] See Scenario 6B DMM Backup Sheets for details.

Cost Estimates Assumptions

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General Assumptions

- Costs do not include EPA oversight costs.
- Costs are in Calendar Year 2006.

A. Pre-Construction Activities

- Design
  - The cost of the Design is assumed to be 8% of construction phase capital costs (not including Pre-Design Investigation costs).

- Pre-Design Investigation (Chemical and Geological)
  - General:
    - Daily rate for coring vessel ($7,100) is scaled by factor of 1.5 to calculate 12 hour daily rate. [Contractor communication.]
    - Assumes four 20-foot cores taken per 12 hour day.
    - Assumes 4 staff working in existing facility to process cores (4 hours per core).
    - Assumes excess sediment will be transported/disposed at cost of $500 per cubic yard [internal database.]
    - Estimates analytical/validation cost of $2,750 per sample ($2,400 chemical and $350 geological). [Internal database.]
    - Estimates shipping cost of $75 per cooler (4 samples per cooler). [Internal database.]
  - Alternatives 1, 3, 5 and 6:
    - Assumes 20-foot cores are analyzed at 2-foot intervals for geological parameters (grain size, percent moisture, TOC), VOCs, SVOCs, Metals/Cyanide, TCL Pesticides/PCBs, and Dioxins.
    - Assumes approximate 80-foot triangular grid spacing of cores for chemical analysis and 160-foot triangular grid spacing of cores for geological parameters analysis.
  - Alternative 2:
    - Assumes 20-foot cores are analyzed at 2-foot intervals for geological parameters (grain size, percent moisture, TOC).
    - Assumes approximate 160-foot triangular grid spacing of cores for chemical and geological parameters analysis.
    - Areas without armor: assumes that the first two 2-foot core intervals are analyzed for VOCs, SVOCs, Metals/Cyanide, TCL Pesticides/PCBs, and dioxins.
    - Areas with armor and mudflats: assumes that the first three 2-foot core intervals are analyzed for VOCs, SVOCs, Metals/Cyanide,

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TCL Pesticides/PCBs, and dioxins. Also assumes approximate 80-foot triangular grid spacing of cores for chemical analysis.

- Alternative 4:

  For RM0 to RM2.5:

  - Assume 20-foot cores are analyzed at 2-foot intervals for geological parameters (grain size, percent moisture, TOC), VOCs, SVOCs, Metals/Cyanide, TCL Pesticides/PCBs, and dioxins.
  - Assumes approximate 80-foot triangular grid spacing of cores for chemical analysis and 160-foot triangular grid spacing of cores for geological parameters analysis.

  For RM 2.5 to RM8.3:

  - Assumes 20-foot cores are analyzed at 2-foot intervals for geological parameters (grain size, percent moisture, TOC).
  - Assumes approximate 160-foot triangular grid spacing of cores for chemical and geological parameters analysis.
  - Areas without armor: assumes that the first two 2-foot core intervals are analyzed for VOCs, SVOCs, Metals/Cyanide, TCL Pesticides/PCBs, and dioxins.
  - Areas with armor and mudflats: assumes that the first three 2-foot core intervals are analyzed for VOCs, SVOCs, Metals/Cyanide, TCL Pesticides/PCBs, and dioxins. Also assumes approximate 80-foot triangular grid spacing of cores for chemical analysis.

- Pre-Design Investigation – Geotechnical
  - Assumes four 80-feet deep borings will be taken at transects placed at 0.5 miles intervals.
  - Assumes one boring is taken per day.
  - Estimates 12 hour daily rate of $6,500 for auger drilling and sampling. [Contractor communications.]
  - Estimates cost of $400 per sample for undisturbed sample collection.
  - Assumes 3 samples would be taken per boring.

- Sub-bottom Geophysics and Bathymetric Survey
  - Estimates daily rate for geophysical vessel of $6,500. [Contractor communication.]
  - Assumes one river mile can be surveyed in two days.

- Video Survey for Debris Identification
  - Estimates daily rate for vessel of $6,500. [Contractor communication.]
  - Assumes one river mile can be surveyed in two days.

- Pre-Construction Oversight
  - Assumes monthly rate of $50,000 for two staff to oversee coring/processing operations.
  - Assumes pre-design investigation duration of 12 months for all alternatives.

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- Contractor Work Plans and Submittals
    - Assumes lump sum cost of $300,000 for all alternatives.

- Permitting (Equivalency) and Legal
    - The cost is assumed to be 2% of construction phase capital costs (not including Pre-Design Investigation costs).

B. Mobilization/Demobilization

- Assume a six months period to mobilize and demobilize.

- Dredge Equipment Mobilization/Demobilization
    - Lump sum of $200,000 is estimated per dredge per event. [Contractor communication.]
    - Equipment would be onsite for either the dredge duration or the capping duration (not including the armor placement duration), whichever is greater. For alternatives that pre-dredge armor areas only, the dredge equipment would be onsite for the dredging duration only.

- Capping Equipment Mobilization/Demobilization
    - Lump sum of $200,000 is estimated per clamshell per event. [Contractor communication.]
    - Assumes capping equipment would also be use for backfilling.
    - Equipment would be onsite for either the dredge duration or the capping duration (including the armor placement duration), whichever is greater.

- Monitoring Equipment Mobilization/Demobilization
    - Estimates cost of mobilization of two hydrographic survey vessels ($3,200 each), geophysical vessel ($4,800), and small vibracoring vessel ($5,500). [Contractor communication.]
    - Equipment would be onsite for the total construction duration.

- Debris Removal Equipment Mobilization/Demobilization
    - Lump sum of approximately $50,000 is assumed per event.
    - Equipment would be onsite for either the dredge duration or the capping duration (not including the armor placement duration), whichever is greater. For alternatives that pre-dredge armor areas only, the dredge equipment would be onsite for the dredging duration only.

- Shoreline Protection Equipment Mobilization/Demobilization
    - Lump sum of $100,000 is assumed per event [internal database].
    - Shoreline protection equipment will also be used to protect utilities, if necessary.

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- Equipment would be onsite for either the dredge duration or the capping duration (not including the armor placement duration), whichever is greater. For alternatives that pre-dredge armor areas only, the dredge equipment would be onsite for the dredging duration only.

- New Season Restart
  - Lump sum of 25 percent of total of equipment mobilization/demobilization costs per season is assumed.

C. Dredging

- Dredging
  - Cost of $25 per cubic yard is estimated. [Contractor communication.]
  - The assumed dredge production rate is 2,000 cubic yards per day per dredge.
  - Assume that dredging season is 40 weeks per year.
  - Assume 12 hour days, 5 work days per week.
  - Removal volumes account for overdredging of 1-foot based on dredge accuracy.
  - Once design depths are achieved, additional required dredging will be performed in one pass on average.
  - For Alternative 1, assume that dredging duration is 9 years using three dredges.
  - For Alternative 2, assume that dredging duration is 4 years using one dredge.
  - For Alternative 3, assume that dredging duration is 5 years using three dredges.
  - For Alternative 4, assume that dredging duration is 4 years using two dredge.
  - For Alternative 5, assume that dredging duration is 5 years using three dredges.
  - For Alternative 6, assume that dredging duration is 6 years using three dredges.

- Debris Removal/Off-loading/Transport/Disposal
  - Debris will be removed, off-loaded, decontaminated, and transported and disposed of at an estimated cost of $200 per ton prior to dredging operations and $400 per ton during dredging operations. [Contractor communication.]
  - Assumes that 50% of the debris will be removed prior to dredging operations and the other 50% during dredging operations.
  - Alternatives 1, 3, 5, and 6 assume that 8,000 tons will be removed.
  - Alternative 2 assumes that 25% of debris removed in Alternatives 1, 3, and 5 will be removed (2,000 tons).

- Alternative 4 assumes that 3,500 tons of debris will be removed (2000 tons from RM0 to RM2.5, where dredging would be implemented, and 1500 tons from RM2.2 to RM8, where capping would be implemented).

- Testing and Monitoring (Alternative 1)
  - Estimates daily rate for two (2) water quality vessels ($3,200) is scaled by factor of 9 to calculate monthly rate and by factor of 1.5 to calculate 12 hour daily rate. [Contractor communication.]
  - Estimates daily rate for bathymetric vessels ($3,200) is scaled by factor of 9 to calculate monthly rate and by factor of 1.5 to calculate 12 hour daily rate. [Contractor communication.]
  - Assumes 10 water column samples per day and average 22 days per month (total 220 samples per month).
  - Two rounds of bathymetric surveys will be performed after dredging is performed to the specified elevation.
  - Two sampling vessels (one located upstream and one downstream of the dredge) will be collecting water quality (i.e., TSS and limited chemistry) samples continuously during dredging operations.
  - Estimates analytical/validation cost of $350 per water column sample and $2,750 per sediment sample. [Internal database.]
  - Assumes two staff working 8 hour days to process/ship samples. Assumes 50 samples processed/shipped per day.
  - Assume an average of $186,319 would be needed for biological monitoring per year [Internal calculation/database.]
    - Assume biological monitoring includes the following surveys: habitat delineation, terrestrial vegetation, avian community, aquatic community, aquatic vegetation (SAV), fish community, benthic invertebrates, biological tissue-residual, and toxicity testing.
  - Assumes monitoring would be performed through the duration of construction.
  - Assumes lump sum lab reporting cost of $50,000 [internal database].

- Utility Protection
  - Assumes sheetpiling will be driven to 35-foot depth.
  - Estimates unit cost of $50 per square foot of sheeting. [Internal database.]
  - Assumes sheeting is removed following dredging operations.
  - Assumes one utility crossing per river mile and approximate river width of 500-feet.

- Bridge/Abutment/Bulkhead Protection
  - Estimates unit cost of $610 per foot [Internal calculation/database.]
  - Assumes that 58,700 linear feet of hard shorelines would be protected (84,500 ft of total shoreline minus 25,800 ft of natural shorelines).

- Barge Transport of Dredged Material

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- Estimates barge transport cost of $5 per cubic yard. [Contractor communications.]
- Assumes dredged material will be transported in 1500 – 4000 cubic yard hopper scows and delivered to processing site within the Port.

- Dredged Material Offloading
  - Estimates offloading cost of $7 per cubic yard. [Contractor communications.]
  - Assumes offloading via clamshell and bobcats.

D. Backfill and/or Sand Cap

- Backfill/Sand Cap Material Purchase and Delivery
  - Assumes cost of $30 per cubic yard will be applied to purchase and deliver material to site in hopper scow.

- Backfill/Sand Cap Material Placement
  - General:
    - Estimates cost of $20 per cubic yard will be applied to place material. [Contractor communications.]
    - Estimates material placement production rate of 2,000 cubic yard per day. [Contractor communications.]
  - Backfill:
    - Assume that backfill layer will only be placed when dredging depth exceeds depth of fine-grained sediments. Assumes that backfill will be used to mitigate for any remaining fine-grained sediment and/or dredging residuals.
    - Dredged area will be backfilled with nominal 2-feet of sand.
    - Assume that there will be no maintenance of the backfill layer.
  - Sand Cap:
    - Assume that capping will be necessary in areas where remedial alternatives do not remove entire depth of fine-grained sediments (Alternatives 2, 3, 4, 5, and 6).
    - Cap materials will be placed using a clam shell dredge.
    - Assumes minimum sand thickness of 2.5 feet, and average thickness of 3 feet.

- Testing and Monitoring (Alternatives 2, 3, 4, 5, and 6)
  - Estimates daily rate for two water quality vessels ($3,200) is scaled by factor of 9 to calculate monthly rate and by factor of 1.5 to calculate 12 hour daily rate. [Contractor communication.]
  - Estimates daily rate for bathymetric vessels ($3,200) is scaled by factor of 9 to calculate monthly rate and by factor of 1.5 to calculate 12 hour daily rate. [Contractor communication.]
  - Assumes 10 water column samples per day and average 22 days per month (total 220 samples per month).

- Estimates analytical/validation cost of $350 per water column sample and $2,750 per sediment sample. [Internal database.]
- Assumes two staff working 8 hour days to process/ship samples. Assumes 50 samples processed/shipped per day.
- Assume monitoring would be through the duration of construction.
- Assume an average of $186,319 would be needed for biological monitoring per year [Internal calculation/database.]
    - Assume biological monitoring includes the following surveys: habitat delineation, terrestrial vegetation, avian community, aquatic community, aquatic vegetation (SAV), fish community, benthic invertebrates, biological tissue-residual, and toxicity testing.
- Assumes lump sum lab reporting cost of $50,000.

- Confirmation Coring
    - Assumes 4-feet deep cores placed to verify thickness of backfill layer.
    - Assumes 5 cores will be taken at transects placed at 0.1 miles intervals.
    - Assumes 20 cores taken per day.
    - Estimates 12 hour daily rate of $6,300 for coring vessel. [Contractor communications.]
    - Assumes 4 staff working in existing facility to process cores (10 cores per day).
    - Estimates chemical and geological analytical/validation cost of $2,750 per sample, and three samples will be collected per core. [Internal database.]
    - Estimates shipping cost of $75 per cooler (4 samples per cooler). [Internal database.]

- Armor Layer Placement
    - Assume a stone armor layer 2-feet in thickness for areas identified as erosional by hydrodynamic modeling.
    - Estimates unit cost for armor material purchase and placement of $150 per cubic yard. [Internal database.]

- Mudflat reconstruction
    - Assumes that a 3-foot thick layer of suitable mudflat construction material will be placed in the area of all disturbed mudflats.
    - Assumes unit cost of $60 per cubic yard to purchase and deliver mudflat reconstruction material [internal database].
    - Assumes unit cost of $40 per cubic yard to place mudflat reconstruction material [internal database].
    - Estimates that approximately 43 acres of mudflats would be disturbed, requiring 208,265 cubic yard of mudflat reconstruction material. [Internal calculation/database.]

- Natural Shoreline Stabilization
    - Assumes 20 foot wide area of shoreline will be stabilized.

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- Assumes a cost of $25 per linear foot for two coir rolls, wedges, twine, and biodegradable erosion control matting.
- Assumes 20 wetland plants per linear foot at $3 per plant ($60 per linear foot).
- Assumes 2 hours of labor per linear foot for two laborers to install erosion control matting, coir roll, and plants at $65 per hour.
- Estimates that 75% of natural shorelines will be stabilized.
- Assumes that approximately 29,192 linear feet of natural shoreline exist (sum of natural shorelines and unknown shorelines). This results in approximately 21,900 linear feet of shoreline to be stabilized (i.e., 75% of 29,192). [Internal calculation/database].

E. Construction Management

- Construction Management services are assumed to be 8% of the cost of field activities. Assume multiple prime contracts held by client, not by one prime contractor.

F. Contingency

- A 20% contingency is assumed.

G. Dredged Material Management

- Site Characterization
  - Labor
    - Barge-Auger Mobilization
      - Lump sum of $10,000 is assumed [internal database.]
    - Auger Drilling and Sampling
      - Assume a daily rate of $6,500 for drilling and sampling [internal database.]
      - Assume 80 borings will be drilled (60 borings along sheeting alignment extending to a depth of approximately 80-feet and 20 borings inside CDF footprint area).
      - Assume one boring will be drilled per day.
    - Undisturbed Sample Collection
      - Assumes a cost of $400 per sample collected [internal database.]
      - Assume three samples will be collected per boring.
    - Bathymetric Survey
      - Estimates daily rate of bathymetric vessel of $6500. [Contractor communication].
      - Assumes approximately 30 acres can be surveyed in a day.
    - Field Oversight
      - Assume three engineers working 8 hour days at $110 per hour for the duration of drilling and surveying.
    - Reporting

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            - Assumes two engineers working 8 hour days at $125 per hour and one engineer working 8 hour days at $135 per hour.

            - Assumes reporting period of 4 months.
        - Project Management
            - Assumes an hourly rate of $200 for 8 hours per week for a period of 26 weeks.
        - Drilling Permits and Work Plans
            - Lump sum of $50,000 is assumed for permits and workplans.
    - Disbursements
        - Geotechnical Tests
            - Assume geotechnical testing [grain size analysis (sieve and hydrometer), Atterberg limits, and cyclic triaxial] cost is 10% of drilling costs.
        - Drillers/Surveyors Sustenance
            - Assume a cost of $500 per day for 100 field days.

- Starter Cell Construction
    - Pre-Construction Activities
        - Design
            - The cost is assumed to be 8% of construction phase capital costs (not including Pre-Design Investigation costs).
        - Contractor Work Plans
            - Assumes lump sum cost of $100,000.
        - Permitting (Equivalency), and Legal
            - The cost is assumed to be 2% of construction phase capital costs (not including Pre-Design Investigation costs).
    - Inner Sheetpile Wall Construction
        - Mobilization/Site Clean-up/Demobilization
            - Assumes a lump sum of $100,000 for barge, hammer, and crane to install sheeting [internal database].
        - Surveying
            - Assumes a daily rate of $3,000 for sheetpile wall alignment surveys [internal database].
            - Assumes surveying is required 25% of the time to install the sheeting.
        - Waterloo Sheet Piles (Material Cost)
            - Estimates unit cost of $31 per square foot of sheeting [contractor communications].
            - Assumes inner wall will be 9600-feet long and 30-feet in height (20-feet will be driven below the mudline)
        - Walers

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            - Assumes a cost of $50 per linear foot [contractor communications].
        - Installation Costs
            - Crane and Crew – with driving head
                - Estimates a cost of $12 per square foot [internal database].
            - Water Side Installation Vessels
                - Assumes daily rate of $3,500 for two barges, two boats, and one tug boat [internal database].
            - Walers Installation
                - Assumes daily rate of $1,800 for one foreman and three steel workers [internal database].
                - Assumes that required walers can be installed to approximately 192 linear feet of sheetpile wall per day.
    - Outer Bulkhead Wall Construction
        - Waterloo Sheet Piles (Material Cost)
            - Estimates unit cost of $31 per square foot of sheeting [contractor communications].
            - Assumes outer wall will be 9700-feet long and 50-feet in height (40-feet will be driven below the mudline).
        - Walers
            - Assumes a cost of $50 per linear foot [contractor communications].
        - Deadman Tiebacks and Connectors
            - Estimates a cost of $2000 per tieback [contractor communications].
            - Assumes tieback spacing of 8 feet.
        - Bumpers – Outside of Bulkhead
            - Assumes a cost of $18 per linear foot [internal database].
        - Backfill Between inner and outer walls – Material and installation
            - Estimates a cost of $32 per cubic yard for materials and installation of backfill between inner and outer walls [internal database].
            - Assumes that walls are installed 5 ft apart.
            - Assumes that walls around the shoreline will not be backfilled.
        - Installation Costs – Water Side
            - Crane and Crew – with driving head
                - Estimates a cost of $12 per square foot [internal database].
            - Water Side Installation Vessels
                - Assumes daily rate of $3,500 for two barges, two boats, and one tug boat [internal database].
            - Walers, Deadman, and Bumpers Installation

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        - Assumes daily rate of $2,000 for one foreman and three steel workers [internal database].
        - Assumes that 70 days would be necessary to attach walers, deadman, and bumpers.

    - Construction Management
        - Construction Management services are assumed to be 8% of the cost of field activities.

- Sub-grade Cell Construction
    - Pre-Construction Activities
        - Design
            - The cost is assumed to be 8% of construction phase capital costs (not including Pre-Design Investigation costs).
        - Permitting (Equivalency), and Legal
            - The cost is assumed to be 2% of construction phase capital costs (not including Pre-Design Investigation costs).
    - Sediment Veneer Dredging
        - Mobilization/Site Clean-up/Demobilization
            - Estimates the cost of two dredges ($200,000 per dredge), one debris removal vessel ($50,000), two hydrographic survey vessels ($3,200), and one geophysical vessel ($4,800) [contractor communications].
        - Debris Removal
            - Debris will be removed, off-loaded, decontaminated, and transported and disposed of at an estimated cost of $200 per ton prior to dredging operations and $400 per ton during dredging operations. [Contractor communication.]
            - Assumes that 50% of the debris will be removed prior to dredging operations and the other 50% during dredging operations.
            - Assumes that 500 tons of debris will be removed from the starter cell footprint area.
        - Environmental Dredging
            - Cost of $25 per cubic yard is estimated. [Contractor communication.]
            - The assumed dredge production rate is 2,000 cubic yards per day per dredge.
            - Assume that approximately 5 ft of material will be removed form 85 acres.
            - Assumes that Scenarios 2A and 2B do not require any dredging.
        - Barge Transport of Dredged Material
            - Estimates barge transport cost of $5 per cubic yard. [Contractor communications.]

        - Assume a 25% volume increase due to water entrainment.
        - Assumes dredged material will be transported in 1500 – 4000 cubic yard hopper scows.
    - Dredged Material Off-Loading
        - Estimates offloading cost of $7 per cubic yard. [Contractor communications.]
        - Assumes material will be offloaded onto starter cell.
    - Testing and Monitoring
        - Estimates daily rate for two (2) water quality vessels ($3,200) is scaled by factor of 9 to calculate monthly rate and by factor of 1.5 to calculate 12 hour daily rate. [Contractor communication.]
        - Estimates daily rate for bathymetric vessels ($3,200) is scaled by factor of 9 to calculate monthly rate and by factor of 1.5 to calculate 12 hour daily rate. [Contractor communication.]
        - Assumes 10 water column samples per day and average 22 days per month (total 220 samples per month).
        - Two rounds of bathymetric surveys will be performed after dredging is performed to the specified elevation.
        - Two sampling vessels (one located upstream and one downstream of the dredge) will be collecting water quality (i.e., TSS and limited chemistry) samples continuously during dredging operations.
        - Estimates analytical/validation cost of $350 per water column sample and $2,750 per sediment sample. [Internal database.]
        - Assumes two staff working 8 hour days to process/ship samples. Assumes 50 samples processed/shipped per day.
        - Assumes monitoring would be performed through the dredging duration.
        - Assumes lump sum lab reporting cost of $50,000 [internal database].
- Dredging Sub-grade cell
    - Mobilization/Site Clean-up/Demobilization
        - Assumes four dredges will be mobilized at lump sum cost of $200,000 per dredge.
    - Debris Removal
        - Debris will be removed, off-loaded, decontaminated, and transported and disposed of at an estimated cost of $200 per ton prior to dredging operations and $400 per ton during dredging operations. [Contractor communication.]
        - Assumes that 50% of the debris will be removed prior to dredging operations and the other 50% during dredging operations.

    - Assumes 1000 tons of debris will be removed.
- Dredging/Transport/Dump
    - Estimates a cost of $15 per cubic yard to dredge, transport, and dump clean dredged material into ocean for dredging to depths no greater than 50-feet [internal database].
    - Estimates a cost of $20 per cubic yard to dredge, transport, and dump clean dredged material into ocean for dredging to depths greater than 50-feet [internal database].
    - Assumes that approximately 11,279,493 cubic yards of material will be dredged for DMM Scenario 1A and 10,800,293 cubic yards for DMM Scenario 1B [internal database].
    - Assumes Scenarios 2A and 2B do not require any dredging.
    - Assumes that approximately 6,701,343 cubic yards of material will be dredged for DMM Scenario 3A and 6,222,143 cubic yards for DMM Scenario 3B [internal database].
    - Assumes that approximately 3,772,293 cubic yards of material will be dredged for DMM Scenario 4A and 3,293,093 cubic yards for DMM Scenario 4B [internal database].
    - Assumes that approximately 5,745,693 cubic yards of material will be dredged for DMM Scenario 5A and 5,266,493 cubic yards for DMM Scenario 5B [internal database].
    - Assumes that approximately 6,736,993 cubic yards of material will be dredged for DMM Scenario 6A and 6,257,793 cubic yards for DMM Scenario 6B [internal database].
    - The assumed dredge production rate is 10,000 cubic yards per day per dredge.
- Testing and Monitoring
    - Estimates daily rate for two (2) water quality vessels ($3,200) is scaled by factor of 9 to calculate monthly rate and by factor of 1.5 to calculate 12 hour daily rate. [Contractor communication.]
    - Estimates daily rate for bathymetric vessels ($3,200) is scaled by factor of 9 to calculate monthly rate and by factor of 1.5 to calculate 12 hour daily rate. [Contractor communication.]
    - Assumes 10 water column samples per day and average 22 days per month (total 220 samples per month).
    - Two rounds of bathymetric surveys will be performed after dredging is performed to the specified elevation.
    - Two sampling vessels (one located upstream and one downstream of the dredge) will be collecting water quality

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(i.e., TSS and limited chemistry) samples continuously during dredging operations.
- Estimates analytical/validation cost of $350 per water column sample and $2,750 per sediment sample. [Internal database.]
- Assumes two staff working 8 hour days to process/ship samples. Assumes 50 samples processed/shipped per day.
- Assumes monitoring would be performed through the duration of construction.
- Assumes lump sum lab reporting cost of $50,000 [internal database].

- Construction Management
  - Construction Management services are assumed to be 8% of the cost of field activities.

- CDF Construction
  - Pre-Construction Activities
    - Design
      - The cost is assumed to be 8% of construction phase capital costs (not including Pre-Design Investigation costs).
    - Contractor Work Plans
      - Assumes lump sum cost of $100,000.
    - Permitting (Equivalency), and Legal
      - The cost is assumed to be 2% of construction phase capital costs (not including Pre-Design Investigation costs).
  - Inner Sheetpile Wall Construction
    - Mobilization/Site Clean-up/Demobilization
      - Assumes a lump sum of $100,000 [internal database].
    - Surveying
      - Assumes a daily rate of $3,000 for sheetpile wall alignment surveys [internal database].
      - Assumes surveying is required 25% of the time to install the sheeting.
    - Waterloo Sheet Piles (Material Cost)
      - Estimates unit cost of $31 per square foot of sheeting [contractor communications].
      - Assumes inner wall will be 12,600-feet long and 40-feet in height (30-feet will be driven below the mudline).
    - Walers
      - Assumes a cost of $50 per linear foot [contractor communications].
    - Installation Costs
      - Crane and Crew – with driving head
        - Estimates a cost of $12 per square foot [internal database].

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        - Water Side Installation Vessels
            - Assumes daily rate of $3,500 for two barges, two boats, and one tug boat [internal database].
        - Walers Installation
            - Assumes daily rate of $1,800 for one foreman and tree steel workers [internal database].
            - Assumes that approximately 192 linear feet can be attached per day.
- Outer Bulkhead Wall Construction
    - Waterloo Sheet Piles (Material Cost)
        - Estimates unit cost of $31 per square foot of sheeting [contractor communications].
        - Assumes outer wall will be 12,700-feet long and 70-feet in height (60-feet will be driven below the mudline).
    - Additional Cost for 70' Sheet Piles
        - Assumes an additional cost of $2 per square foot for 60-foot sheeting [contractor communications].
    - Walers
        - Assumes a cost of $50 per linear foot [contractor communications].
    - Deadman Tiebacks and Connectors
        - Estimates a cost of $2000 per tieback [contractor communications].
        - Assumes tieback spacing of 8 feet.
    - Bumpers – Outside of Bulkhead
        - Assumes a cost of $18 per linear foot [internal database].
    - Backfill Between inner and outer walls – Material and installation
        - Estimates a cost of $32 per cubic yard for materials and installation of backfill between inner and outer walls [internal database].
        - Assumes that walls are installed 5 ft apart.
        - Assumes that walls around the shoreline will not be backfilled.
    - Installation Costs – Water Side
        - Crane and Crew – with driving head
            - Estimates a cost of $12 per square foot [internal database].
        - Water Side Installation Vessels
            - Assumes daily rate of $3,500 for two barges, two boats, and one tug boat [internal database].
        - Walers, Deadman, and Bumpers Installation
            - Assumes daily rate of $2,000 for one foreman and tree steel workers [internal database].
            - Assumes that 90 days would be necessary to attach walers, deadman, and bumpers.

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- Water Barrier
    - Assumes a cost of $250,000 per boom.
    - Assumes that CDF will have three interior cells separated by floating booms.

- Water Treatment
    - Mobilization/Demobilization
        - For Alternative 2, lump sum of $120,000 is assumed for mobilization and demobilization of water treatment plant [internal database].
        - For Alternative 4, lump sum of $240,000 is assumed for mobilization and demobilization of water treatment plant [internal database].
        - For Alternatives 1, 3, 5, and 6 lump sum of $480,000 is assumed for mobilization and demobilization of water treatment plant [internal database].
    - Treatment Plant
        - For Alternative 2, assume a lump sum of $500,000 for a 200 gpm water treatment plant [internal database].
        - For Alternative 4, assume a lump sum of $1,000,000 for a 400 gpm water treatment plant [internal database].
        - For Alternatives1, 3, 5, and 6 assumed a lump sum of $2,000,000 for a 600 gpm water treatment plant [internal database]
    - Piping to plant
        - Lump sum of $150,000 is assumed (based on 3000-feet of 6" steel pipes at an estimated cost of $50 per linear foot).
    - Treatment – O&M
        - Assumes O&M costs of $0.04 per gallon of flow [internal database]. Assumes that permit will be obtained for discharge of treated water to Passaic River.
        - Assumes all water contained within starter cell and CDF will be treated. An additional 20% is added to account for rainfall and passive dewatering of dredged material.
    - Testing
        - Assumes a cost of $10,000 per week [internal database].
        - Assumes water treatment will be performed for 10 years (i.e. the useful life of the CDF).

- CDF Operations
    - Monitoring wells
        - Estimates an installation cost of $750 per well.
        - Assumes wells are placed at various depths around the CDF's perimeter (i.e. installed between the CDF's inner and outer walls) at 150 ft spacing.
    - Spreading Starter Cell Mount into CDF

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        - Assumes dredged material mount over starter cell will be spread onto CDF for DMM Scenarios 1A, 2A, 3A, 4A, 5A, and 6A
        - Estimates a cost of $2 per cubic yard using two dozers [internal database].
    - Operation of CDF (including Starter Cell)
        - Lump sum based on an estimated cost of $6 per cubic yard and the assumption that dredged material above the mudline will be handled twice using backhoes.

- CDF Closing
    - Mobilization/Site Clean-up/Demobilization
        - Assume a lump sum of $75,000 [internal database].
    - Sheetpile Removal
        - Assumes a sand cap will be placed in DMM Scenarios 1B, 2B, 3B, 4B, 5B, and 6B.
        - Assumes a cost of $150 per linear foot for inner sheetpile removal [internal database].
        - Assumed a cost of $14/CY for removal of backfill between the inner and outer sheetpile walls [internal database]
        - Assumes a cost of $250 per linear foot for removal of outer sheetpile wall [internal database]
        - Assumes a cost of $90,000 for the construction of a decontamination pad to clean the sheetpile [internal database]
        - Assumed that the rate for decontamination operations and equipment is $50,000 per month [internal database]
        - Assumed off-site disposal of soil and steel sheets at $50/ton at a Subtitle D landfill (no salvage value assumed)
    - Geotextile Layer
        - Estimates a cost of $2 per square foot of geotextile.
        - Assumes that geotextile will cover 112 acres.
        - Assumes that 20% additional material will be necessary for quality assurance.
    - Compacted Clay Cover – Fill (Haul, Place, and Compact)
        - Assumes clay cover will be placed in DMM Scenarios 1A, 2A, 3A, 4A, 5A, and 6A.
        - Estimates a cost of $15 per cubic yard to place a clay cover over CDF.
        - Assume a 2 foot cover will be placed over a 112 acre area.
    - Sand Cap (Purchase, Delivery, Placement, Monitoring)
        - Assumes a sand cap will be placed in DMM Scenarios 1B, 2B, 3B, 4B, 5B, and 6B.

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- Estimates a lump sum cost of $200,000 for mobilization/demobilization of capping equipment.
- Estimates a cost of $40 to purchase and deliver sand and a cost of $20 to place sand.
- Assume a 2 foot cap will be placed over a 112 acre area.
- The assumed capping production rate is 2,000 cubic yards per day per dredge [contractor communications].
- Estimates a cost of $220,440 per month for three months for testing and monitoring.
    - Estimates daily rate for two (2) water quality vessels ($3,200) is scaled by factor of 9 to calculate monthly rate and by factor of 1.5 to calculate 12 hour daily rate. [Contractor communication.]
    - Estimates daily rate for bathymetric vessels ($3,200) is scaled by factor of 9 to calculate monthly rate and by factor of 1.5 to calculate 12 hour daily rate. [Contractor communication.]
    - Assumes 10 water column samples per day and average 22 days per month (total 220 samples per month).
    - Two rounds of bathymetric surveys will be performed after dredging is performed to the specified elevation.
    - Two sampling vessels (one located upstream and one downstream of the dredge) will be collecting water quality (i.e., TSS and limited chemistry) samples continuously during dredging operations.
    - Estimates analytical/validation cost of $350 per water column sample and $2,750 per sediment sample. [Internal database.]
    - Assumes two staff working 8 hour days to process/ship samples. Assumes 50 samples processed/shipped per day.
    - Assumes monitoring would be performed through the duration of construction.
    - Assumes lump sum lab reporting cost of $50,000 [internal database].

- Vegetation
    - Assumes vegetation will be required for DMM Scenarios 1A, 2A, 3A, 4A, 5A, and 6A.
    - Assume a cost of $1 per square yard.
    - Assume that 112 acres will be vegetated.
- Shoreline Plantings and other Trees
    - Assumes planting will be done in DMM Scenarios 1A, 2A, 3A, 4A, 5A, and 6A.
    - Estimates a lump sum cost of $75,000 for plants and trees.

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        - Surveying
            - Estimates a cost of $3,000 per day for surveying [internal database].
            - Assumes that surveying will be performed in a period of 30 days.
    - Construction Management
        - Construction Management services are assumed to be 8% of the cost of field activities.

- On-Site Thermal Treatment
    - Assume that material from Starter Cell will be treated for DMM Scenarios 1B, 2B, 3B, 4B, 5B, and 6B.
    - Pre-Construction Activities
        - Design
            - The cost is assumed to be 8% of construction phase capital costs (not including Pre-Design Investigation costs).
        - Permitting (Equivalency), and Legal
            - The cost is assumed to be 2% of construction phase capital costs (not including Pre-Design Investigation costs).

    - Dredged Material Treatment
        - Assume that all material above the mudline will be treated for DMM Scenarios 1B, 2B, 3B, 4B, 5B, and 6B.
        - Mobilization/Demobilization
            - Assume a lump sum of $25,000 for mobilization of personnel and equipment [internal database].
        - Sediment Removal and Loading onto Trucks
            - Cost of $8 per cubic yard is estimated [internal database].
            - Assume sediment will be excavated using 2-1/2 cubic yards backhoes.
            - Assume sediment will be off-loaded onto dump trucks.
        - Transport to Thermal Treatment Area
            - Estimates a cost of $4 per cubic yard [internal database].
            - Assumes six 12 cubic yards dump truck will make 2 mile roundtrips.
        - Dredged Material Off-Loading to Filter Press
            - Estimates off-loading cost of $6 per cubic yard [internal database].
        - Mechanical Sediment Dewatering
            - Assumes unit cost of $40 per ton to dewater sediment.
            - Assumes that dewatering of one cubic yard of dredged material from 30% to 60% solids generates approximately 118 gallons of water.
            - Assumes that dewatering process reduces dredged material weight by 50%.
        - Treatment – O&M

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            - Assumes O&M costs of $0.04 per gallon of flow [internal database].
        - Discharge to POTW
            - Assumes O&M costs of $666.79 per million gallons of flow, $357.34 per thousand pounds of BOD, and $213.04 per thousand pounds of TSS [internal database].
            - Assumes typical industrial wastewater effluent limitations of 300 mg BOD/L and 45 mg TSS/L.
        - On-Site Thermal Treatment
            - Assume a unit cost of $80 per ton [based on GTI cost estimate].
        - Sediment Processing Site
            - Estimates a cost of $500,000 per acre [internal database]..
            - Assumes that processing site will be 20 acres.
    - Construction Management
        - Construction Management services are assumed to be 8% of the cost of field activities

- Contingency
    - A 20% contingency is assumed.

H. Annual Operations and Maintenance (O&M)

- Mobilization/Demobilization – Monitoring Equipment
    - Assumes mobilization/demobilization rate for hydrographic survey vessel ($3,200), small coring vessel ($2,200), and SPI vessel ($11,500).
- Mobilization/Demobilization – Capping Equipment
    - Assumes mobilization/demobilization of capping equipment is not necessary for O&M activities associated with Alternative 1 – DMM Scenario 1A.
    - Assumes a lump sum of $40,000. Assumes that capping equipment for cap maintenance purposes is more conventional and readily available than precision equipment used to construct cap.
- Bathymetric Survey
    - Daily rate for vessel ($6,500).
- Surface Sediment Sampling and Analysis
    - Assumes daily rate for small coring vessel of $4,200.
    - Assumes 20 sediment samples taken per day.
    - Assumes 5 samples will be taken at transects placed at 0.1 miles intervals.
    - Assumes 20 sediment samples will be taken from CDF footprint area for DMM Scenarios 1B, 2B, 3B, 4B, 5B, and 6B.
    - Assumes analytical/validation cost of $2,750 per sediment sample.
    - Assumes shipping cost of $75 per cooler (4 samples per cooler).
    - Assumes two staff working 8 hour days to process/ship samples.
    - Assumes 50 samples processed/shipped per day.

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- Biological Monitoring
    - Assumes a lump sum cost of $2,688,390 for all alternatives [Internal calculation/database.]
        - Assume the following surveys would be performed: habitat delineation, terrestrial vegetation, avian community, aquatic community, aquatic vegetation (SAV), fish community, benthic invertebrates, biological tissue-residual, and toxicity testing.
- Water Column Sampling and Analysis
    - Assumes daily rate for water quality vessel of $6,500.
    - Assumes 10 water quality samples taken per day.
    - Assumes two samples taken for two tidal cycles per river mile.
    - Assumes two samples taken for two tidal cycles from CDF footprint area for DMM Scenarios 1B, 2B, 3B, 4B, 5B, and 6B.
    - Assume additional sampling of 10% for quality assurance.
    - Assumes analytical/validation cost of $350 per water column sample.
    - Assumes two staff working 8 hour days to process/ship samples. Assumes 50 samples processed/shipped per day.
- Habitat Recolonization using SPI
    - Assumes $2,000 per SPI location, which covers imaging, processing, and reporting.
    - SPI survey will be performed annually.
    - Approximately 10 SPI locations per mile.
    - Assumes 20 SPI locations in CDF footprint area for DMM Scenarios 1B, 2B, 3B, 4B, 5B, and 6B.
- Groundwater Monitoring (Well Sampling and Testing)
    - Estimates a cost of $1,500 per sample [internal database.]
    - Assumes 12 wells will be sample per month.
- Cap Maintenance
    - Assumes that 0.2% of placed cap material would need to be replaced per year at a cost of $30 per cubic yard.
    - Assumes that no maintenance is required in backfill and armor areas.
- Monitoring Reports
    - Assumes lump sum lab reporting cost of $150,000 for all alternatives.
    - Assumes 3,000 hours at $100 per hour to complete draft and final monitoring reports for all alternatives.
- Community Outreach
    - Assumes a lump sum of $80,000 per year [internal database].
- Contingency
    - A 20% contingency is assumed.
- Present Worth of Annual O&M Costs
    - The Net Present Worth of O&M costs is calculated using a 5% rate over 30 years.

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DMM Backup Sheets

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DMM Backup Sheets
Comparison of Scenarios
Focused Feasibility Study
Lower Passaic River Restoration Project

Alternative	DMM Scenario	Total DMM Costs	Alternative Sediment Removal (CY)	Estimated Cost per CY of Sediment ($/CY)
Alternative 1: Dredging	A	$763,000,000	10,960,000	$70
	B	$1,085,000,000	10,960,000	$99
Alternative 2: Capping	A	$230,000,000	1,142,000	$201
	B	$477,000,000	1,142,000	$418
Alternative 3: NCC - Authorized Channel	A	$522,000,000	6,979,000	$75
	B	$847,000,000	6,979,000	$121
Alternative 4: NCC - Current Use Channel	A	$418,000,000	4,432,000	$94
	B	$744,000,000	4,432,000	$168
Alternative 5: NCC - Future Use Channel	A	$489,000,000	6,148,000	$80
	B	$814,000,000	6,148,000	$132
Alternative 6: NCC - Future Use Channel + Dredging Primary Erosional and Primary Inventory Zones	A	$524,000,000	7,010,000	$75
	B	$849,000,000	7,010,000	$121

DMM Backup Sheets
Scenario 1A: Total DMM Costs
Focused Feasibility Study
Lower Passaic River Restoration Project

Component		Cost
DMM COSTS		
1A-1	Site Characterization[1]	$1,489,800
1A-2	Starter Cell Construction	$56,542,704
1A-3	Sub-grade Cell Construction	$304,861,260
1A-4	CDF Construction	$273,054,347
1A-5	On-Site Thermal Treatment	$0
	Subtotal DMM Costs	**$635,948,111**
	Contingency (20%)	$127,189,622
	TOTAL DMM COSTS	**$763,137,733**

Notes:

[1]Site Characterization limited to geotechnical investigation of proposed starter cell and CDF areas.

DMM Backup Sheets
Scenario 1A: Site Characterization
Focused Feasibility Study
Lower Passaic River Restoration Project

Component	Unit	Unit Cost	# of Units	Cost
A. Labor				
Barge-Auger Mobilization	LS	$10,000	1	$10,000
Auger Drilling and Sampling	Day	$6,500	80	$520,000
Undisturbed Sample Collection	Sample	$400	240	$96,000
Bathymetric Survey	Day	$6,500	4	$26,000
Field Oversight	Day	$2,640	100	$264,000
Reporting	Day	$3,080	120	$369,600
Project Management	Week	$1,600	26	$41,600
Drilling Permits and Work Plans	LS	$50,000	1	$50,000
Total Labor				$1,377,200
B. Disbursements				
Geotechnical Tests	Percentage	10%		$62,600
Drillers/ Surveyors Sustenance	Day	$500	100	$50,000
Total Disbursements				$112,600
TOTAL SITE CHARACTERIZATION COSTS				**$1,489,800**

DMM Backup Sheets
Scenario 1A: Starter Cell Construction
Focused Feasibility Study
Lower Passaic River Restoration Project

Component	Unit	Unit Cost	# of Units	Cost
A. Pre-Construction Activities				
Design	Percentage	8%		$3,826,624
Contractor Work Plans	LS	$100,000	1	$100,000
Permitting (Equivalency), and Legal	Percentage	2%		$956,656
Total Pre-Construction Activities				*$4,883,280*
B. Inner Sheetpile Wall Construction				
Mobilization/Site Clean-up/Demobilization	LS	$100,000	1	$100,000
Surveying	Day	$3,000	40	$120,000
Waterloo Sheet Piles (Material Cost)	SF	$31	288,000	$8,784,000
Walers	LF	$50	9,600	$480,000
Installation Costs				
Crane and Crew - with driving head	SF	$12	288,000	$3,456,000
Water Side Installation Vessels	Day	$3,500	137	$480,000
Walers Installation	Day	$1,800	50	$90,000
Total Inner Sheetpile Wall Construction				*$13,510,000*
C. Outer Bulkhead Wall Construction				
Waterloo Sheet Piles (Material Cost)	SF	$31	485,000	$14,792,500
Walers	LF	$50	9,700	$485,000
Deadman Tiebacks and Connectors	Tieback	$2,000	1,213	$2,425,000
Bumpers - Outside of Bulkhead	LF	$18	4,850	$87,300
Backfill Between inner and outer walls - Materials and installation	CY	$32	315,250	$10,088,000
Installation Costs - Water Side				
Crane and Crew - with driving head	SF	$12	485,000	$5,820,000
Water Side Installation Vessels	Day	$3,500	139	$485,000
Walers, Deadmen, and Bumpers Installation	Day	$2,000	70	$140,000
Total Outer Bulkhead Wall Construction				*$34,322,800*
Subtotal Starter Cell Construction				**$52,716,080**
D. Construction Management	Percentage	8%		**$3,826,624**
TOTAL STARTER CELL CONSTRUCTION				**$56,542,704**

DMM Backup Sheets
Scenario 1A: Sub-grade Cell Construction
Focused Feasibility Study
Lower Passaic River Restoration Project

Component		Unit	Unit Cost	# of Units	Cost
A.	**Pre-Construction Activities**				
	Design	Percentage	8%		$20,668,560
	Permitting (Equivalency), and Legal	Percentage	2%		$5,167,140
	Total Pre-Construction Activities				*$25,835,700*
B.	**Sediment Veneer Dredging**				
	Mobilization/Site Clean-up/Demobilization	LS	$461,200	1	$461,200
	Debris Removal	Ton	$300	500	$150,000
	Environmental Dredging	CY	$25	693,733	$17,343,333
	Barge Transport of Dredge Material	CY	$5	867,167	$4,335,833
	Dredged Material Off-Loading	CY	$7	867,167	$6,070,167
	Testing and Monitoring	Month	$220,440	6	$1,322,640
	Total Sediment Veneer Dredging				*$29,683,173*
C.	**Dredging Sub-grade cell**				
	Mobilization/Site Clean-up/Demobilization	LS	$800,000	1	$800,000
	Debris Removal	Ton	$300	1,000	$300,000
	Dredging/Transport/Dump	CY	$20	11,279,493	$225,589,867
	Testing and Monitoring	Month	$220,440	9	$1,983,960
	Total Dredging Sub-grade cell				*$228,673,827*
	Subtotal Sub-grade Cell Construction				**$284,192,700**
D.	**Construction Management**	Percentage	8%		$20,668,560
	TOTAL SUB-GRADE CELL CONSTRUCTION				**$304,861,260**

DMM Backup Sheets
Scenario 1A: CDF Construction
Focused Feasibility Study
Lower Passaic River Restoration Project

Component	Unit	Unit Cost	# of Units	Cost
A. Pre-Construction Activities				
Design	Percentage	8%	231,317,243	$18,505,379
Contractor Work Plans	LS	$100,000	1	$100,000
Permits	Percentage	2%	231,317,243	$4,626,345
Total Pre-Construction Activities				*$23,231,724*
B. Inner Sheetpile Wall Construction				
Mobilization/Site Clean-up/Demobilization	LS	$400,000	1	$400,000
Surveying - Assume 1/4 time required	Day	$3,000	68	$202,500
Waterloo Sheet Piles (Material Cost)	SF	$31	504,000	$15,372,000
Walers	LF	$50	12,600	$630,000
Installation Costs				
Crane and Crew - with driving head	SF	$12	504,000	$6,048,000
Four Barges, two boats, tug boat	Day	$6,500	90	$585,000
Crew for Attaching Walers	Day	$1,800	80	$144,000
Total Inner Sheetpile Wall Construction				*$23,381,500*
C. Outer Bulkhead Wall Construction				
Waterloo Sheet Piles (Material Cost)	SF	$31	889,000	$27,114,500
Additional Cost for 70' Sheet Piles	SF	$2	889,000	$1,778,000
Walers	LF	$50	12,700	$635,000
Deadman Tiebacks and Connectors	Tieback	$2,000	1,588	$3,175,000
Bumpers - Outside of Bulkhead	LF	$18	7,250	$130,500
Backfill Between inner and outer walls - Materials and installation	CY	$32	13,426	$429,630
Installation Costs - Water Side				
Crane and Crew - with driving head	SF	$12	889,000	$10,668,000
Four Barges, two boats, tug boat	Day	$6,500	190	$1,234,807
Crew for Attaching Walers, Deadmen, and Bumpers	Day	$2,000	90	$180,000
Water Barrier	Boom	$250,000	3	$750,000
Total Outer Bulkhead Wall Construction				*$46,095,436*
D. Water Treatment				
Mobilization/Demobilization	LS	$360,000	1	$360,000
Treatment Plant	LS	$1,500,000	1	$1,500,000
Piping to Plant	LS	$150,000	1	$150,000
Water Treatment	Gallon	$0.04	3,252,305,925	$130,092,237
Testing	Week	$10,000	520	$5,200,000
Subtotal Water Treatment				*$137,302,237*
E. CDF Operations				
Monitoring Wells	Well	$750	85	$63,750
Spreading Starter Cell Mount into CDF	CY	$2	462,220	$924,440
Operation of CDF (including Starter Cell)	LS	$17,347,000	1	$17,347,000
Total CDF Operations				*$18,335,190*
F. CDF Closing				
Mobilization/Site Clean-up/Demobilization	LS	$75,000	1	$75,000
Inner Sheetpile Wall Removal	LF	$150	0	$0
Removal of Backfill Between Walls	CY	$14	0	$0
Outer Sheetpile Wall Removal	LF	$250	0	$0
Decontamination Pad Construction	LS	$90,000	0	$0
Decontamination Operations and Equipment	Month	$50,000	0	$0
Off-site Disposal of Soil and Steel Sheets	Ton	$50	0	$0
Geotextile Layer	SY	$2	216,832	$379,456
Compacted Clay Cover - Fill (Haul, Place, and Compact)	CY	$15	361,387	$5,420,800
Sand Cap (Purchase, Delivery, Placement, Monitoring)	CY	$64	0	$0
Vegetation	SY	$1	216,832	$162,624
Shoreline Plantings and other Trees	LS	$75,000	1	$75,000
Surveying	Day	$3,000	30	$90,000
Total CDF Closing				*$6,202,880*
Subtotal CDF Construction				**$254,548,967**
G. Construction Management	Percentage	8%	231,317,243	$18,505,379
TOTAL CDF CONSTRUCTION				**$273,054,347**

DMM Backup Sheets
Scenario 1A: On-Site Thermal Treatment
Focused Feasibility Study
Lower Passaic River Restoration Project

Component		Unit	Unit Cost	# of Units	Cost
A.	**Pre-Construction Activities**				
	Design	Percentage	8%		$0
	Permitting (Equivalency), and Legal	Percentage	2%		$0
	Total Pre-Construction Activities				*$0*
B.	**Dredged Material Treatment**				
	Mobilization/Demobilization	LS	$25,000	0	$0
	Sediment Removal and Loading onto Trucks	CY	$8	0	$0
	Transport to Thermal Treatment Area	CY	$4	0	$0
	Dredged Material Off-Loading to Filter Press	CY	$6	0	$0
	Mechanical Sediment Dewatering	Ton	$40	0	$0
	Water Treatment	Gallon	$0.04	0	$0
	Discharge to POTW	Gallon	$0.02	0	$0
	On-Site Thermal Treatment	Ton	$80	0	$0
	Sediment Processing Site	Acre	$500,000	0	$0
	Total Dredged Material Treatment				*$0*
	Subtotal On-Site Thermal Treatment				**$0**
C.	**Construction Management**	Percentage	8%		**$0**
	TOTAL ON-SITE THERMAL TREATMENT				**$0**

DMM Backup Sheets
Scenario 1B: Total DMM Costs
Focused Feasibility Study
Lower Passaic River Restoration Project

Component		Cost
DMM COSTS		
1B-1	Site Characterization[1]	$1,489,800
1B-2	Starter Cell Construction	$56,542,704
1B-3	Sub-grade Cell Construction	$293,552,140
1B-4	CDF Construction	$305,212,040
1B-5	On-Site Thermal Treatment	$247,319,333
	Subtotal DMM Costs	**$904,116,018**
	Contingency (20%)	$180,823,204
	TOTAL DMM COSTS	**$1,084,939,221**

Notes:

[1]Site Characterization limited to geotechnical investigation of proposed starter cell and CDF areas.

DMM Backup Sheets
Scenario 1B: Site Characterization
Focused Feasibility Study
Lower Passaic River Restoration Project

Component	Unit	Unit Cost	# of Units	Cost
A. Labor				
Barge-Auger Mobilization	LS	$10,000	1	$10,000
Auger Drilling and Sampling	Day	$6,500	80	$520,000
Undisturbed Sample Collection	Sample	$400	240	$96,000
Bathymetric Survey	Day	$6,500	4	$26,000
Field Oversight	Day	$2,640	100	$264,000
Reporting	Day	$3,080	120	$369,600
Project Management	Week	$1,600	26	$41,600
Drilling Permits and Work Plans	LS	$50,000	1	$50,000
Total Labor				$1,377,200
B. Disbursements				
Geotechnical Tests	Percentage	10%		$62,600
Drillers/ Surveyors Sustenance	Day	$500	100	$50,000
Total Disbursements				$112,600
TOTAL SITE CHARACTERIZATION COSTS				**$1,489,800**

DMM Backup Sheets
Scenario 1B: Starter Cell Construction
Focused Feasibility Study
Lower Passaic River Restoration Project

Component	Unit	Unit Cost	# of Units	Cost
A. Pre-Construction Activities				
Design	Percentage	8%		$3,826,624
Contractor Work Plans	LS	$100,000	1	$100,000
Permitting (Equivalency), and Legal	Percentage	2%		$956,656
Total Pre-Construction Activities				*$4,883,280*
B. Inner Sheetpile Wall Construction				
Mobilization/Site Clean-up/Demobilization	LS	$100,000	1	$100,000
Surveying	Day	$3,000	40	$120,000
Waterloo Sheet Piles (Material Cost)	SF	$31	288,000	$8,784,000
Walers	LF	$50	9,600	$480,000
Installation Costs				
Crane and Crew - with driving head	SF	$12	288,000	$3,456,000
Water Side Installation Vessels	Day	$3,500	137	$480,000
Walers Installation	Day	$1,800	50	$90,000
Total Inner Sheetpile Wall Construction				*$13,510,000*
C. Outer Bulkhead Wall Construction				
Waterloo Sheet Piles (Material Cost)	SF	$31	485,000	$14,792,500
Walers	LF	$50	9,700	$485,000
Deadman Tiebacks and Connectors	Tieback	$2,000	1,213	$2,425,000
Bumpers - Outside of Bulkhead	LF	$18	4,850	$87,300
Backfill Between inner and outer walls - Materials and installation	CY	$32	315,250	$10,088,000
Installation Costs - Water Side				
Crane and Crew - with driving head	SF	$12	485,000	$5,820,000
Water Side Installation Vessels	Day	$3,500	139	$485,000
Walers, Deadmen, and Bumpers Installation	Day	$2,000	70	$140,000
Total Outer Bulkhead Wall Construction				*$34,322,800*
Subtotal Starter Cell Construction				**$52,716,080**
D. Construction Management	Percentage	8%		**$3,826,624**
TOTAL STARTER CELL CONSTRUCTION				**$56,542,704**

DMM Backup Sheets
Scenario 1B: Sub-grade Cell Construction
Focused Feasibility Study
Lower Passaic River Restoration Project

Component		Unit	Unit Cost	# of Units	Cost
A.	**Pre-Construction Activities**				
	Design	Percentage	8%		$19,901,840
	Permitting (Equivalency), and Legal	Percentage	2%		$4,975,460
	Total Pre-Construction Activities				*$24,877,300*
B.	**Sediment Veneer Dredging**				
	Mobilization/Site Clean-up/Demobilization	LS	$461,200	1	$461,200
	Debris Removal	Ton	$300	500	$150,000
	Environmental Dredging	CY	$25	693,733	$17,343,333
	Barge Transport of Dredge Material	CY	$5	867,167	$4,335,833
	Dredged Material Off-Loading	CY	$7	867,167	$6,070,167
	Testing and Monitoring	Month	$220,440	6	$1,322,640
	Total Sediment Veneer Dredging				*$29,683,173*
C.	**Dredging Sub-grade cell**				
	Mobilization/Site Clean-up/Demobilization	LS	$800,000	1	$800,000
	Debris Removal	Ton	$300	1,000	$300,000
	Dredging/Transport/Dump	CY	$20	10,800,293	$216,005,867
	Testing and Monitoring	Month	$220,440	9	$1,983,960
	Total Dredging Sub-grade cell				*$219,089,827*
	Subtotal Sub-grade Cell Construction				**$273,650,300**
D.	**Construction Management**	Percentage	8%		$19,901,840
	TOTAL SUB-GRADE CELL CONSTRUCTION				**$293,552,140**

DMM Backup Sheets
Scenario 1B: CDF Construction
Focused Feasibility Study
Lower Passaic River Restoration Project

Component		Unit	Unit Cost	# of Units	Cost
A.	**Pre-Construction Activities**				
	Design	Percentage	8%	258,569,526	$20,685,562
	Contractor Work Plans	LS	$100,000	1	$100,000
	Permits	Percentage	2%	258,569,526	$5,171,391
	Total Pre-Construction Activities				*$25,956,953*
B.	**Inner Sheetpile Wall Construction**				
	Mobilization/Site Clean-up/Demobilization	LS	$400,000	1	$400,000
	Surveying - Assume 1/4 time required	Day	$3,000	68	$202,500
	Waterloo Sheet Piles (Material Cost)	SF	$31	504,000	$15,372,000
	Walers	LF	$50	12,600	$630,000
	Installation Costs				
	Crane and Crew - with driving head	SF	$12	504,000	$6,048,000
	Four Barges, two boats, tug boat	Day	$6,500	90	$585,000
	Crew for Attaching Walers	Day	$1,800	80	$144,000
	Total Inner Sheetpile Wall Construction				*$23,381,500*
C.	**Outer Bulkhead Wall Construction**				
	Waterloo Sheet Piles (Material Cost)	SF	$31	889,000	$27,114,500
	Additional Cost for 70' Sheet Piles	SF	$2	889,000	$1,778,000
	Walers	LF	$50	12,700	$635,000
	Deadman Tiebacks and Connectors	Tieback	$2,000	1,588	$3,175,000
	Bumpers - Outside of Bulkhead	LF	$18	7,250	$130,500
	Backfill Between inner and outer walls - Materials and installation	CY	$32	13,426	$429,630
	Installation Costs - Water Side				
	Crane and Crew - with driving head	SF	$12	889,000	$10,668,000
	Four Barges, two boats, tug boat	Day	$6,500	190	$1,234,807
	Crew for Attaching Walers, Deadmen, and Bumpers	Day	$2,000	90	$180,000
	Water Barrier	Boom	$250,000	3	$750,000
	Total Outer Bulkhead Wall Construction				*$46,095,436*
D.	**Water Treatment**				
	Mobilization/Demobilization	LS	$360,000	1	$360,000
	Treatment Plant	LS	$1,500,000	1	$1,500,000
	Piping to Plant	LS	$150,000	1	$150,000
	Water Treatment	Gallon	$0.04	3,136,162,298	$125,446,492
	Testing	Week	$10,000	520	$5,200,000
	Subtotal Water Treatment				*$132,656,492*
E.	**CDF Operations**				
	Monitoring Wells	Well	$750	85	$63,750
	Spreading Starter Cell Mount into CDF	CY	$2	0	$0
	Operation of CDF (including Starter Cell)	LS	$22,894,000	1	$22,894,000
	Total CDF Operations				*$22,957,750*
F.	**CDF Closing**				
	Mobilization/Site Clean-up/Demobilization	LS	$75,000	1	$75,000
	Inner Sheetpile Wall Removal	LF	$150	22,200	$3,330,000
	Removal of Backfill Between Walls	CY	$14	13,426	$187,963
	Outer Sheetpile Wall Removal	LF	$250	22,400	$5,600,000
	Decontamination Pad Construction	LS	$90,000	1	$90,000
	Decontamination Operations and Equipment	Month	$50,000	3	$150,000
	Off-site Disposal of Soil and Steel Sheets	Ton	$50	12,219	$610,969
	Geotextile Layer	SY	$2	216,832	$379,456
	Compacted Clay Cover - Fill (Haul, Place, and Compact)	CY	$15	0	$0
	Sand Cap (Purchase, Delivery, Placement, Monitoring)	CY	$64	361,387	$22,964,960
	Vegetation	SY	$1	0	$0
	Shoreline Plantings and other Trees	LS	$75,000	0	$0
	Surveying	Day	$3,000	30	$90,000
	Total CDF Closing				*$33,478,348*
	Subtotal CDF Construction				**$284,526,478**
G.	**Construction Management**	Percentage	8%	258,569,526	$20,685,562
	TOTAL CDF CONSTRUCTION				**$305,212,040**

DMM Backup Sheets
Scenario 1B: On-Site Thermal Treatment
Focused Feasibility Study
Lower Passaic River Restoration Project

Component		Unit	Unit Cost	# of Units	Cost
A.	**Pre-Construction Activities**				
	Design	Percentage	8%		$16,767,412
	Permitting (Equivalency), and Legal	Percentage	2%		$4,191,853
	Total Pre-Construction Activities				*$20,959,266*
B.	**Dredged Material Treatment**				
	Mobilization/Demobilization	LS	$25,000	1	$25,000
	Sediment Removal and Loading onto Trucks	CY	$8	1,907,767	$15,262,133
	Transport to Thermal Treatment Area	CY	$4	1,907,767	$7,631,067
	Dredged Material Off-Loading to Filter Press	CY	$6	1,907,767	$11,446,600
	Mechanical Sediment Dewatering	Ton	$40	1,907,767	$76,310,667
	Water Treatment	Gallon	$0.04	225,116,467	$9,004,659
	Discharge to POTW	Gallon	$0.02	225,116,467	$3,601,863
	On-Site Thermal Treatment	Ton	$80	953,883	$76,310,667
	Sediment Processing Site	Acre	$500,000	20	$10,000,000
	Total Dredged Material Treatment				*$209,592,655*
	Subtotal On-Site Thermal Treatment				**$230,551,921**
C.	**Construction Management**	Percentage	8%		**$16,767,412**
	TOTAL ON-SITE THERMAL TREATMENT				**$247,319,333**

DMM Backup Sheets
Scenario 2A: Total DMM Costs
Focused Feasibility Study
Lower Passaic River Restoration Project

Component		Cost
DMM COSTS		
2A-1	Site Characterization[1]	$1,489,800
2A-2	Starter Cell Construction	$56,542,704
2A-3	Sub-grade Cell Construction	$0
2A-4	CDF Construction	$133,528,314
2A-5	On-Site Thermal Treatment	$0
	Subtotal DMM Costs	**$191,560,818**
	Contingency (20%)	$38,312,164
	TOTAL DMM COSTS	**$229,872,982**

Notes:

[1]Site Characterization limited to geotechnical investigation of proposed starter cell and CDF areas.

DMM Backup Sheets
Scenario 2A: Site Characterization
Focused Feasibility Study
Lower Passaic River Restoration Project

Component	Unit	Unit Cost	# of Units	Cost
A. Labor				
Barge-Auger Mobilization	LS	$10,000	1	$10,000
Auger Drilling and Sampling	Day	$6,500	80	$520,000
Undisturbed Sample Collection	Sample	$400	240	$96,000
Bathymetric Survey	Day	$6,500	4	$26,000
Field Oversight	Day	$2,640	100	$264,000
Reporting	Day	$3,080	120	$369,600
Project Management	Week	$1,600	26	$41,600
Drilling Permits and Work Plans	LS	$50,000	1	$50,000
Total Labor				$1,377,200
B. Disbursements				
Geotechnical Tests	Percentage	10%		$62,600
Drillers/ Surveyors Sustenance	Day	$500	100	$50,000
Total Disbursements				$112,600
TOTAL SITE CHARACTERIZATION COSTS				**$1,489,800**

DMM Backup Sheets
Scenario 2A: Starter Cell Construction
Focused Feasibility Study
Lower Passaic River Restoration Project

Component	Unit	Unit Cost	# of Units	Cost
A. Pre-Construction Activities				
Design	Percentage	8%		$3,826,624
Contractor Work Plans	LS	$100,000	1	$100,000
Permitting (Equivalency), and Legal	Percentage	2%		$956,656
Total Pre-Construction Activities				*$4,883,280*
B. Inner Sheetpile Wall Construction				
Mobilization/Site Clean-up/Demobilization	LS	$100,000	1	$100,000
Surveying	Day	$3,000	40	$120,000
Waterloo Sheet Piles (Material Cost)	SF	$31	288,000	$8,784,000
Walers	LF	$50	9,600	$480,000
Installation Costs				
Crane and Crew - with driving head	SF	$12	288,000	$3,456,000
Water Side Installation Vessels	Day	$3,500	137	$480,000
Walers Installation	Day	$1,800	50	$90,000
Total Inner Sheetpile Wall Construction				*$13,510,000*
C. Outer Bulkhead Wall Construction				
Waterloo Sheet Piles (Material Cost)	SF	$31	485,000	$14,792,500
Walers	LF	$50	9,700	$485,000
Deadman Tiebacks and Connectors	Tieback	$2,000	1,213	$2,425,000
Bumpers - Outside of Bulkhead	LF	$18	4,850	$87,300
Backfill Between inner and outer walls - Materials and installation	CY	$32	315,250	$10,088,000
Installation Costs - Water Side				
Crane and Crew - with driving head	SF	$12	485,000	$5,820,000
Water Side Installation Vessels	Day	$3,500	139	$485,000
Walers, Deadmen, and Bumpers Installation	Day	$2,000	70	$140,000
Total Outer Bulkhead Wall Construction				*$34,322,800*
Subtotal Starter Cell Construction				**$52,716,080**
D. Construction Management	Percentage	8%		**$3,826,624**
TOTAL STARTER CELL CONSTRUCTION				**$56,542,704**

DMM Backup Sheets
Scenario 2A: Sub-grade Cell Construction
Focused Feasibility Study
Lower Passaic River Restoration Project

Component		Unit	Unit Cost	# of Units	Cost
A.	**Pre-Construction Activities**				
	Design	Percentage	8%		$0
	Permitting (Equivalency), and Legal	Percentage	2%		$0
	Total Pre-Construction Activities				*$0*
B.	**Sediment Veneer Dredging**				
	Mobilization/Site Clean-up/Demobilization	LS	$461,200	0	$0
	Debris Removal	Ton	$300	0	$0
	Environmental Dredging	CY	$25	0	$0
	Barge Transport of Dredge Material	CY	$5	0	$0
	Dredged Material Off-Loading	CY	$7	0	$0
	Testing and Monitoring	Month	$220,440	0	$0
	Total Sediment Veneer Dredging				*$0*
C.	**Dredging Sub-grade cell**				
	Mobilization/Site Clean-up/Demobilization	LS	$800,000	0	$0
	Debris Removal	Ton	$300	0	$0
	Dredging/Transport/Dump	CY	$20	0	$0
	Testing and Monitoring	Month	$220,440	0	$0
	Total Dredging Sub-grade cell				*$0*
	Subtotal Sub-grade Cell Construction				**$0**
D.	**Construction Management**	Percentage	8%		$0
	TOTAL SUB-GRADE CELL CONSTRUCTION				**$0**

DMM Backup Sheets
Scenario 2A: CDF Construction
Focused Feasibility Study
Lower Passaic River Restoration Project

Component		Unit	Unit Cost	# of Units	Cost
A.	**Pre-Construction Activities**				
	Design	Percentage	8%	113,074,843	$9,045,987
	Contractor Work Plans	LS	$100,000	1	$100,000
	Permits	Percentage	2%	113,074,843	$2,261,497
	Total Pre-Construction Activities				*$11,407,484*
B.	**Inner Sheetpile Wall Construction**				
	Mobilization/Site Clean-up/Demobilization	LS	$400,000	1	$400,000
	Surveying - Assume 1/4 time required	Day	$3,000	68	$202,500
	Waterloo Sheet Piles (Material Cost)	SF	$31	504,000	$15,372,000
	Walers	LF	$50	12,600	$630,000
	Installation Costs				
	Crane and Crew - with driving head	SF	$12	504,000	$6,048,000
	Four Barges, two boats, tug boat	Day	$6,500	90	$585,000
	Crew for Attaching Walers	Day	$1,800	80	$144,000
	Total Inner Sheetpile Wall Construction				*$23,381,500*
C.	**Outer Bulkhead Wall Construction**				
	Waterloo Sheet Piles (Material Cost)	SF	$31	889,000	$27,114,500
	Additional Cost for 70' Sheet Piles	SF	$2	889,000	$1,778,000
	Walers	LF	$50	12,700	$635,000
	Deadman Tiebacks and Connectors	Tieback	$2,000	1,588	$3,175,000
	Bumpers - Outside of Bulkhead	LF	$18	7,250	$130,500
	Backfill Between inner and outer walls - Materials and installation	CY	$32	13,426	$429,630
	Installation Costs - Water Side				
	Crane and Crew - with driving head	SF	$12	889,000	$10,668,000
	Four Barges, two boats, tug boat	Day	$6,500	190	$1,234,807
	Crew for Attaching Walers, Deadmen, and Bumpers	Day	$2,000	90	$180,000
	Water Barrier	Boom	$250,000	3	$750,000
	Total Outer Bulkhead Wall Construction				*$46,095,436*
D.	**Water Treatment**				
	Mobilization/Demobilization	LS	$120,000	1	$120,000
	Treatment Plant	LS	$500,000	1	$500,000
	Piping to Plant	LS	$150,000	1	$150,000
	Water Treatment	Gallon	$0.04	350,356,912	$14,014,276
	Testing	Week	$10,000	520	$5,200,000
	Subtotal Water Treatment				*$19,984,276*
E.	**CDF Operations**				
	Monitoring Wells	Well	$750	85	$63,750
	Spreading Starter Cell Mount into CDF	CY	$2	0	$0
	Operation of CDF (including Starter Cell)	LS	$17,347,000	1	$17,347,000
	Total CDF Operations				*$17,410,750*
F.	**CDF Closing**				
	Mobilization/Site Clean-up/Demobilization	LS	$75,000	1	$75,000
	Inner Sheetpile Wall Removal	LF	$150	0	$0
	Removal of Backfill Between Walls	CY	$14	0	$0
	Outer Sheetpile Wall Removal	LF	$250	0	$0
	Decontamination Pad Construction	LS	$90,000	0	$0
	Decontamination Operations and Equipment	Month	$50,000	0	$0
	Off-site Disposal of Soil and Steel Sheets	Ton	$50	0	$0
	Geotextile Layer	SY	$2	216,832	$379,456
	Compacted Clay Cover - Fill (Haul, Place, and Compact)	CY	$15	361,387	$5,420,800
	Sand Cap (Purchase, Delivery, Placement, Monitoring)	CY	$64	0	$0
	Vegetation	SY	$1	216,832	$162,624
	Shoreline Plantings and other Trees	LS	$75,000	1	$75,000
	Surveying	Day	$3,000	30	$90,000
	Total CDF Closing				*$6,202,880*
	Subtotal CDF Construction				**$124,482,327**
G.	**Construction Management**	Percentage	8%	113,074,843	$9,045,987
	TOTAL CDF CONSTRUCTION				**$133,528,314**

DMM Backup Sheets
Scenario 2A: On-Site Thermal Treatment
Focused Feasibility Study
Lower Passaic River Restoration Project

Component		Unit	Unit Cost	# of Units	Cost
A.	**Pre-Construction Activities**				
	Design	Percentage	8%		$0
	Permitting (Equivalency), and Legal	Percentage	2%		$0
	Total Pre-Construction Activities				*$0*
B.	**Dredged Material Treatment**				
	Mobilization/Demobilization	LS	$25,000	0	$0
	Sediment Removal and Loading onto Trucks	CY	$8	0	$0
	Transport to Thermal Treatment Area	CY	$4	0	$0
	Dredged Material Off-Loading to Filter Press	CY	$6	0	$0
	Mechanical Sediment Dewatering	Ton	$40	0	$0
	Water Treatment	Gallon	$0.04	0	$0
	Discharge to POTW	Gallon	$0.02	0	$0
	On-Site Thermal Treatment	Ton	$80	0	$0
	Sediment Processing Site	Acre	$500,000	0	$0
	Total Dredged Material Treatment				*$0*
	Subtotal On-Site Thermal Treatment				**$0**
C.	**Construction Management**	Percentage	8%		**$0**
	TOTAL ON-SITE THERMAL TREATMENT				**$0**

DMM Backup Sheets
Scenario 2B: Total DMM Costs
Focused Feasibility Study
Lower Passaic River Restoration Project

Component		Cost
DMM COSTS		
2B-1	Site Characterization[1]	$1,489,800
2B-2	Starter Cell Construction	$56,542,704
2B-3	Sub-grade Cell Construction	$0
2B-4	CDF Construction	$165,906,635
2B-5	On-Site Thermal Treatment	$173,939,890
	Subtotal DMM Costs	**$397,879,028**
	Contingency (20%)	$79,575,806
	TOTAL DMM COSTS	**$477,454,834**

Notes:

[1]Site Characterization limited to geotechnical investigation of proposed starter cell and CDF areas.

DMM Backup Sheets
Scenario 2B: Site Characterization
Focused Feasibility Study
Lower Passaic River Restoration Project

Component	Unit	Unit Cost	# of Units	Cost
A. Labor				
Barge-Auger Mobilization	LS	$10,000	1	$10,000
Auger Drilling and Sampling	Day	$6,500	80	$520,000
Undisturbed Sample Collection	Sample	$400	240	$96,000
Bathymetric Survey	Day	$6,500	4	$26,000
Field Oversight	Day	$2,640	100	$264,000
Reporting	Day	$3,080	120	$369,600
Project Management	Week	$1,600	26	$41,600
Drilling Permits and Work Plans	LS	$50,000	1	$50,000
Total Labor				$1,377,200
B. Disbursements				
Geotechnical Tests	Percentage	10%		$62,600
Drillers/ Surveyors Sustenance	Day	$500	100	$50,000
Total Disbursements				$112,600
TOTAL SITE CHARACTERIZATION COSTS				**$1,489,800**

DMM Backup Sheets
Scenario 2B: Starter Cell Construction
Focused Feasibility Study
Lower Passaic River Restoration Project

Component	Unit	Unit Cost	# of Units	Cost
A. Pre-Construction Activities				
Design	Percentage	8%		$3,826,624
Contractor Work Plans	LS	$100,000	1	$100,000
Permitting (Equivalency), and Legal	Percentage	2%		$956,656
Total Pre-Construction Activities				*$4,883,280*
B. Inner Sheetpile Wall Construction				
Mobilization/Site Clean-up/Demobilization	LS	$100,000	1	$100,000
Surveying	Day	$3,000	40	$120,000
Waterloo Sheet Piles (Material Cost)	SF	$31	288,000	$8,784,000
Walers	LF	$50	9,600	$480,000
Installation Costs				
Crane and Crew - with driving head	SF	$12	288,000	$3,456,000
Water Side Installation Vessels	Day	$3,500	137	$480,000
Walers Installation	Day	$1,800	50	$90,000
Total Inner Sheetpile Wall Construction				*$13,510,000*
C. Outer Bulkhead Wall Construction				
Waterloo Sheet Piles (Material Cost)	SF	$31	485,000	$14,792,500
Walers	LF	$50	9,700	$485,000
Deadman Tiebacks and Connectors	Tieback	$2,000	1,213	$2,425,000
Bumpers - Outside of Bulkhead	LF	$18	4,850	$87,300
Backfill Between inner and outer walls - Materials and installation	CY	$32	315,250	$10,088,000
Installation Costs - Water Side				
Crane and Crew - with driving head	SF	$12	485,000	$5,820,000
Water Side Installation Vessels	Day	$3,500	139	$485,000
Walers, Deadmen, and Bumpers Installation	Day	$2,000	70	$140,000
Total Outer Bulkhead Wall Construction				*$34,322,800*
Subtotal Starter Cell Construction				**$52,716,080**
D. Construction Management	Percentage	8%		**$3,826,624**
TOTAL STARTER CELL CONSTRUCTION				**$56,542,704**

DMM Backup Sheets
Scenario 2B: Sub-grade Cell Construction
Focused Feasibility Study
Lower Passaic River Restoration Project

Component		Unit	Unit Cost	# of Units	Cost
A.	**Pre-Construction Activities**				
	Design	Percentage	8%		$0
	Permitting (Equivalency), and Legal	Percentage	2%		$0
	Total Pre-Construction Activities				*$0*
B.	**Sediment Veneer Dredging**				
	Mobilization/Site Clean-up/Demobilization	LS	$461,200	0	$0
	Debris Removal	Ton	$300	0	$0
	Environmental Dredging	CY	$25	0	$0
	Barge Transport of Dredge Material	CY	$5	0	$0
	Dredged Material Off-Loading	CY	$7	0	$0
	Testing and Monitoring	Month	$220,440	0	$0
	Total Sediment Veneer Dredging				*$0*
C.	**Dredging Sub-grade cell**				
	Mobilization/Site Clean-up/Demobilization	LS	$800,000	0	$0
	Debris Removal	Ton	$300	0	$0
	Dredging/Transport/Dump	CY	$15	0	$0
	Testing and Monitoring	Month	$220,440	0	$0
	Total Dredging Sub-grade cell				*$0*
	Subtotal Sub-grade Cell Construction				**$0**
D.	**Construction Management**	Percentage	8%		$0
	TOTAL SUB-GRADE CELL CONSTRUCTION				**$0**

DMM Backup Sheets
Scenario 2B: CDF Construction
Focused Feasibility Study
Lower Passaic River Restoration Project

Component		Unit	Unit Cost	# of Units	Cost
A.	**Pre-Construction Activities**				
	Design	Percentage	8%	140,514,097	$11,241,128
	Contractor Work Plans	LS	$100,000	1	$100,000
	Permits	Percentage	2%	140,514,097	$2,810,282
	Total Pre-Construction Activities				*$14,151,410*
B.	**Inner Sheetpile Wall Construction**				
	Mobilization/Site Clean-up/Demobilization	LS	$400,000	1	$400,000
	Surveying - Assume 1/4 time required	Day	$3,000	68	$202,500
	Waterloo Sheet Piles (Material Cost)	SF	$31	504,000	$15,372,000
	Walers	LF	$50	12,600	$630,000
	Installation Costs				
	Crane and Crew - with driving head	SF	$12	504,000	$6,048,000
	Four Barges, two boats, tug boat	Day	$6,500	90	$585,000
	Crew for Attaching Walers	Day	$1,800	80	$144,000
	Total Inner Sheetpile Wall Construction				*$23,381,500*
C.	**Outer Bulkhead Wall Construction**				
	Waterloo Sheet Piles (Material Cost)	SF	$31	889,000	$27,114,500
	Additional Cost for 70' Sheet Piles	SF	$2	889,000	$1,778,000
	Walers	LF	$50	12,700	$635,000
	Deadman Tiebacks and Connectors	Tieback	$2,000	1,588	$3,175,000
	Bumpers - Outside of Bulkhead	LF	$18	7,250	$130,500
	Backfill Between inner and outer walls - Materials and installation	CY	$32	13,426	$429,630
	Installation Costs - Water Side				
	Crane and Crew - with driving head	SF	$12	889,000	$10,668,000
	Four Barges, two boats, tug boat	Day	$6,500	190	$1,234,807
	Crew for Attaching Walers, Deadmen, and Bumpers	Day	$2,000	90	$180,000
	Water Barrier	Boom	$250,000	3	$750,000
	Total Outer Bulkhead Wall Construction				*$46,095,436*
D.	**Water Treatment**				
	Mobilization/Demobilization	LS	$120,000	1	$120,000
	Treatment Plant	LS	$500,000	1	$500,000
	Piping to Plant	LS	$150,000	1	$150,000
	Water Treatment	Gallon	$0.04	350,356,912	$14,014,276
	Testing	Week	$10,000	520	$5,200,000
	Subtotal Water Treatment				*$19,984,276*
E.	**CDF Operations**				
	Monitoring Wells	Well	$750	85	$63,750
	Spreading Starter Cell Mount into CDF	CY	$2	0	$0
	Operation of CDF (including Starter Cell)	LS	$17,347,000	1	$17,347,000
	Total CDF Operations				*$17,410,750*
F.	**CDF Closing**				
	Mobilization/Site Clean-up/Demobilization	LS	$75,000	1	$75,000
	Inner Sheetpile Wall Removal	LF	$150	22,200	$3,330,000
	Removal of Backfill Between Walls	CY	$14	13,426	$187,963
	Outer Sheetpile Wall Removal	LF	$250	22,400	$5,600,000
	Decontamination Pad Construction	LS	$90,000	1	$90,000
	Decontamination Operations and Equipment	Month	$50,000	3	$150,000
	Off-site Disposal of Soil and Steel Sheets	Ton	$50	12,219	$610,969
	Geotextile Layer	SY	$2	216,832	$379,456
	Compacted Clay Cover - Fill (Haul, Place, and Compact)	CY	$15	0	$0
	Sand Cap (Purchase, Delivery, Placement, Monitoring)	CY	$64	361,387	$23,128,747
	Vegetation	SY	$1	0	$0
	Shoreline Plantings and other Trees	LS	$75,000	0	$0
	Surveying	Day	$3,000	30	$90,000
	Total CDF Closing				*$33,642,134*
	Subtotal CDF Construction				**$154,665,507**
G.	**Construction Management**	Percentage	8%	140,514,097	$11,241,128
	TOTAL CDF CONSTRUCTION				**$165,906,635**

DMM Backup Sheets
Scenario 2B: On-Site Thermal Treatment
Focused Feasibility Study
Lower Passaic River Restoration Project

Component		Unit	Unit Cost	# of Units	Cost
A.	**Pre-Construction Activities**				
	Design	Percentage	8%		$11,792,535
	Permitting (Equivalency), and Legal	Percentage	2%		$2,948,134
	Total Pre-Construction Activities				*$14,740,669*
B.	**Dredged Material Treatment**				
	Mobilization/Demobilization	LS	$25,000	1	$25,000
	Sediment Removal and Loading onto Trucks	CY	$8	1,313,300	$10,506,400
	Transport to Thermal Treatment Area	CY	$4	1,313,300	$5,253,200
	Dredged Material Off-Loading to Filter Press	CY	$6	1,313,300	$7,879,800
	Mechanical Sediment Dewatering	Ton	$40	1,313,300	$52,532,000
	Water Treatment	Gallon	$0.04	154,969,400	$6,198,776
	Discharge to POTW	Gallon	$0.02	154,969,400	$2,479,510
	On-Site Thermal Treatment	Ton	$80	656,650	$52,532,000
	Sediment Processing Site	Acre	$500,000	20	$10,000,000
	Total Dredged Material Treatment				*$147,406,686*
	Subtotal On-Site Thermal Treatment				**$162,147,355**
C.	**Construction Management**	Percentage	8%		**$11,792,535**
	TOTAL ON-SITE THERMAL TREATMENT				**$173,939,890**

DMM Backup Sheets
Scenario 3A: Total DMM Costs
Focused Feasibility Study
Lower Passaic River Restoration Project

Component		Cost
DMM COSTS		
3A-1	Site Characterization[1]	$1,489,800
3A-2	Starter Cell Construction	$56,542,704
3A-3	Sub-grade Cell Construction	$156,498,637
3A-4	CDF Construction	$220,680,968
3A-5	On-Site Thermal Treatment	$0
	Subtotal DMM Costs	**$435,212,109**
	Contingency (20%)	$87,042,422
	TOTAL DMM COSTS	**$522,254,531**

Notes:

[1]Site Characterization limited to geotechnical investigation of proposed starter cell and CDF areas.

DMM Backup Sheets
Scenario 3A: Site Characterization
Focused Feasibility Study
Lower Passaic River Restoration Project

Component	Unit	Unit Cost	# of Units	Cost
A. Labor				
Barge-Auger Mobilization	LS	$10,000	1	$10,000
Auger Drilling and Sampling	Day	$6,500	80	$520,000
Undisturbed Sample Collection	Sample	$400	240	$96,000
Bathymetric Survey	Day	$6,500	4	$26,000
Field Oversight	Day	$2,640	100	$264,000
Reporting	Day	$3,080	120	$369,600
Project Management	Week	$1,600	26	$41,600
Drilling Permits and Work Plans	LS	$50,000	1	$50,000
Total Labor				$1,377,200
B. Disbursements				
Geotechnical Tests	Percentage	10%		$62,600
Drillers/ Surveyors Sustenance	Day	$500	100	$50,000
Total Disbursements				$112,600
TOTAL SITE CHARACTERIZATION COSTS				**$1,489,800**

DMM Backup Sheets
Scenario 3A: Starter Cell Construction
Focused Feasibility Study
Lower Passaic River Restoration Project

Component	Unit	Unit Cost	# of Units	Cost
A. Pre-Construction Activities				
Design	Percentage	8%		$3,826,624
Contractor Work Plans	LS	$100,000	1	$100,000
Permitting (Equivalency), and Legal	Percentage	2%		$956,656
Total Pre-Construction Activities				*$4,883,280*
B. Inner Sheetpile Wall Construction				
Mobilization/Site Clean-up/Demobilization	LS	$100,000	1	$100,000
Surveying	Day	$3,000	40	$120,000
Waterloo Sheet Piles (Material Cost)	SF	$31	288,000	$8,784,000
Walers	LF	$50	9,600	$480,000
Installation Costs				
Crane and Crew - with driving head	SF	$12	288,000	$3,456,000
Water Side Installation Vessels	Day	$3,500	137	$480,000
Walers Installation	Day	$1,800	50	$90,000
Total Inner Sheetpile Wall Construction				*$13,510,000*
C. Outer Bulkhead Wall Construction				
Waterloo Sheet Piles (Material Cost)	SF	$31	485,000	$14,792,500
Walers	LF	$50	9,700	$485,000
Deadman Tiebacks and Connectors	Tieback	$2,000	1,213	$2,425,000
Bumpers - Outside of Bulkhead	LF	$18	4,850	$87,300
Backfill Between inner and outer walls - Materials and installation	CY	$32	315,250	$10,088,000
Installation Costs - Water Side				
Crane and Crew - with driving head	SF	$12	485,000	$5,820,000
Water Side Installation Vessels	Day	$3,500	139	$485,000
Walers, Deadmen, and Bumpers Installation	Day	$2,000	70	$140,000
Total Outer Bulkhead Wall Construction				*$34,322,800*
Subtotal Starter Cell Construction				**$52,716,080**
D. Construction Management	Percentage	8%		**$3,826,624**
TOTAL STARTER CELL CONSTRUCTION				**$56,542,704**

DMM Backup Sheets
Scenario 3A: Sub-grade Cell Construction
Focused Feasibility Study
Lower Passaic River Restoration Project

Component	Unit	Unit Cost	# of Units	Cost
A. Pre-Construction Activities				
Design	Percentage	8%		$10,610,077
Permitting (Equivalency), and Legal	Percentage	2%		$2,652,519
Total Pre-Construction Activities				*$13,262,596*
B. Sediment Veneer Dredging				
Mobilization/Site Clean-up/Demobilization	LS	$461,200	1	$461,200
Debris Removal	Ton	$300	500	$150,000
Environmental Dredging	CY	$25	693,733	$17,343,333
Barge Transport of Dredge Material	CY	$5	867,167	$4,335,833
Dredged Material Off-Loading	CY	$7	867,167	$6,070,167
Testing and Monitoring	Month	$220,440	6	$1,322,640
Total Sediment Veneer Dredging				*$29,683,173*
C. Dredging Sub-grade cell				
Mobilization/Site Clean-up/Demobilization	LS	$800,000	1	$800,000
Debris Removal	Ton	$300	1,000	$300,000
Dredging/Transport/Dump	CY	$15	6,701,343	$100,520,150
Testing and Monitoring	Month	$220,440	6	$1,322,640
Total Dredging Sub-grade cell				*$102,942,790*
Subtotal Sub-grade Cell Construction				**$145,888,560**
D. Construction Management	Percentage	8%		$10,610,077
TOTAL SUB-GRADE CELL CONSTRUCTION				**$156,498,637**

DMM Backup Sheets
Scenario 3A: CDF Construction
Focused Feasibility Study
Lower Passaic River Restoration Project

Component		Unit	Unit Cost	# of Units	Cost
A.	**Pre-Construction Activities**				
	Design	Percentage	8%	186,933,024	$14,954,642
	Contractor Work Plans	LS	$100,000	1	$100,000
	Permits	Percentage	2%	186,933,024	$3,738,660
	Total Pre-Construction Activities				*$18,793,302*
B.	**Inner Sheetpile Wall Construction**				
	Mobilization/Site Clean-up/Demobilization	LS	$400,000	1	$400,000
	Surveying - Assume 1/4 time required	Day	$3,000	68	$202,500
	Waterloo Sheet Piles (Material Cost)	SF	$31	504,000	$15,372,000
	Walers	LF	$50	12,600	$630,000
	Installation Costs				
	Crane and Crew - with driving head	SF	$12	504,000	$6,048,000
	Four Barges, two boats, tug boat	Day	$6,500	90	$585,000
	Crew for Attaching Walers	Day	$1,800	80	$144,000
	Total Inner Sheetpile Wall Construction				*$23,381,500*
C.	**Outer Bulkhead Wall Construction**				
	Waterloo Sheet Piles (Material Cost)	SF	$31	889,000	$27,114,500
	Additional Cost for 70' Sheet Piles	SF	$2	889,000	$1,778,000
	Walers	LF	$50	12,700	$635,000
	Deadman Tiebacks and Connectors	Tieback	$2,000	1,588	$3,175,000
	Bumpers - Outside of Bulkhead	LF	$18	7,250	$130,500
	Backfill Between inner and outer walls - Materials and installation	CY	$32	13,426	$429,630
	Installation Costs - Water Side				
	Crane and Crew - with driving head	SF	$12	889,000	$10,668,000
	Four Barges, two boats, tug boat	Day	$6,500	190	$1,234,807
	Crew for Attaching Walers, Deadmen, and Bumpers	Day	$2,000	90	$180,000
	Water Barrier	Boom	$250,000	3	$750,000
	Total Outer Bulkhead Wall Construction				*$46,095,436*
D.	**Water Treatment**				
	Mobilization/Demobilization	LS	$360,000	1	$360,000
	Treatment Plant	LS	$1,500,000	1	$1,500,000
	Piping to Plant	LS	$150,000	1	$150,000
	Water Treatment	Gallon	$0.04	2,142,700,449	$85,708,018
	Testing	Week	$10,000	520	$5,200,000
	Subtotal Water Treatment				*$92,918,018*
E.	**CDF Operations**				
	Monitoring Wells	Well	$750	85	$63,750
	Spreading Starter Cell Mount into CDF	CY	$2	462,220	$924,440
	Operation of CDF (including Starter Cell)	LS	$17,347,000	1	$17,347,000
	Total CDF Operations				*$18,335,190*
F.	**CDF Closing**				
	Mobilization/Site Clean-up/Demobilization	LS	$75,000	1	$75,000
	Inner Sheetpile Wall Removal	LF	$150	0	$0
	Removal of Backfill Between Walls	CY	$14	0	$0
	Outer Sheetpile Wall Removal	LF	$250	0	$0
	Decontamination Pad Construction	LS	$90,000	0	$0
	Decontamination Operations and Equipment	Month	$50,000	0	$0
	Off-site Disposal of Soil and Steel Sheets	Ton	$50	0	$0
	Geotextile Layer	SY	$2	216,832	$379,456
	Compacted Clay Cover - Fill (Haul, Place, and Compact)	CY	$15	361,387	$5,420,800
	Sand Cap (Purchase, Delivery, Placement, Monitoring)	CY	$64	0	$0
	Vegetation	SY	$1	216,832	$162,624
	Shoreline Plantings and other Trees	LS	$75,000	1	$75,000
	Surveying	Day	$3,000	30	$90,000
	Total CDF Closing				*$6,202,880*
	Subtotal CDF Construction				**$205,726,327**
G.	**Construction Management**	Percentage	8%	186,933,024	$14,954,642
	TOTAL CDF CONSTRUCTION				**$220,680,968**

DMM Backup Sheets
Scenario 3A: On-Site Thermal Treatment
Focused Feasibility Study
Lower Passaic River Restoration Project

Component		Unit	Unit Cost	# of Units	Cost
A.	**Pre-Construction Activities**				
	Design	Percentage	8%		$0
	Permitting (Equivalency), and Legal	Percentage	2%		$0
	Total Pre-Construction Activities				*$0*
B.	**Dredged Material Treatment**				
	Mobilization/Demobilization	LS	$25,000	0	$0
	Sediment Removal and Loading onto Trucks	CY	$8	0	$0
	Transport to Thermal Treatment Area	CY	$4	0	$0
	Dredged Material Off-Loading to Filter Press	CY	$6	0	$0
	Mechanical Sediment Dewatering	Ton	$40	0	$0
	Water Treatment	Gallon	$0.04	0	$0
	Discharge to POTW	Gallon	$0.02	0	$0
	On-Site Thermal Treatment	Ton	$80	0	$0
	Sediment Processing Site	Acre	$500,000	0	$0
	Total Dredged Material Treatment				*$0*
	Subtotal On-Site Thermal Treatment				**$0**
C.	**Construction Management**	Percentage	8%		**$0**
	TOTAL ON-SITE THERMAL TREATMENT				**$0**

DMM Backup Sheets
Scenario 3B: Total DMM Costs
Focused Feasibility Study
Lower Passaic River Restoration Project

Component		Cost
DMM COSTS		
3B-1	Site Characterization[1]	$1,489,800
3B-2	Starter Cell Construction	$56,542,704
3B-3	Sub-grade Cell Construction	$148,016,797
3B-4	CDF Construction	$252,838,662
3B-5	On-Site Thermal Treatment	$247,319,333
	Subtotal DMM Costs	**$706,207,296**
	Contingency (20%)	$141,241,459
	TOTAL DMM COSTS	**$847,448,755**

Notes:

[1]Site Characterization limited to geotechnical investigation of proposed starter cell and CDF areas.

DMM Backup Sheets
Scenario 3B: Site Characterization
Focused Feasibility Study
Lower Passaic River Restoration Project

Component	Unit	Unit Cost	# of Units	Cost
A. Labor				
Barge-Auger Mobilization	LS	$10,000	1	$10,000
Auger Drilling and Sampling	Day	$6,500	80	$520,000
Undisturbed Sample Collection	Sample	$400	240	$96,000
Bathymetric Survey	Day	$6,500	4	$26,000
Field Oversight	Day	$2,640	100	$264,000
Reporting	Day	$3,080	120	$369,600
Project Management	Week	$1,600	26	$41,600
Drilling Permits and Work Plans	LS	$50,000	1	$50,000
Total Labor				$1,377,200
B. Disbursements				
Geotechnical Tests	Percentage	10%		$62,600
Drillers/ Surveyors Sustenance	Day	$500	100	$50,000
Total Disbursements				$112,600
TOTAL SITE CHARACTERIZATION COSTS				**$1,489,800**

DMM Backup Sheets
Scenario 3B: Starter Cell Construction
Focused Feasibility Study
Lower Passaic River Restoration Project

Component	Unit	Unit Cost	# of Units	Cost
A. Pre-Construction Activities				
Design	Percentage	8%		$3,826,624
Contractor Work Plans	LS	$100,000	1	$100,000
Permitting (Equivalency), and Legal	Percentage	2%		$956,656
Total Pre-Construction Activities				*$4,883,280*
B. Inner Sheetpile Wall Construction				
Mobilization/Site Clean-up/Demobilization	LS	$100,000	1	$100,000
Surveying	Day	$3,000	40	$120,000
Waterloo Sheet Piles (Material Cost)	SF	$31	288,000	$8,784,000
Walers	LF	$50	9,600	$480,000
Installation Costs				
Crane and Crew - with driving head	SF	$12	288,000	$3,456,000
Water Side Installation Vessels	Day	$3,500	137	$480,000
Walers Installation	Day	$1,800	50	$90,000
Total Inner Sheetpile Wall Construction				*$13,510,000*
C. Outer Bulkhead Wall Construction				
Waterloo Sheet Piles (Material Cost)	SF	$31	485,000	$14,792,500
Walers	LF	$50	9,700	$485,000
Deadman Tiebacks and Connectors	Tieback	$2,000	1,213	$2,425,000
Bumpers - Outside of Bulkhead	LF	$18	4,850	$87,300
Backfill Between inner and outer walls - Materials and installation	CY	$32	315,250	$10,088,000
Installation Costs - Water Side				
Crane and Crew - with driving head	SF	$12	485,000	$5,820,000
Water Side Installation Vessels	Day	$3,500	139	$485,000
Walers, Deadmen, and Bumpers Installation	Day	$2,000	70	$140,000
Total Outer Bulkhead Wall Construction				*$34,322,800*
Subtotal Starter Cell Construction				**$52,716,080**
D. Construction Management	Percentage	8%		**$3,826,624**
TOTAL STARTER CELL CONSTRUCTION				**$56,542,704**

DMM Backup Sheets
Scenario 3B: Sub-grade Cell Construction
Focused Feasibility Study
Lower Passaic River Restoration Project

Component	Unit	Unit Cost	# of Units	Cost
A. Pre-Construction Activities				
Design	Percentage	8%		$10,035,037
Permitting (Equivalency), and Legal	Percentage	2%		$2,508,759
Total Pre-Construction Activities				*$12,543,796*
B. Sediment Veneer Dredging				
Mobilization/Site Clean-up/Demobilization	LS	$461,200	1	$461,200
Debris Removal	Ton	$300	500	$150,000
Environmental Dredging	CY	$25	693,733	$17,343,333
Barge Transport of Dredge Material	CY	$5	867,167	$4,335,833
Dredged Material Off-Loading	CY	$7	867,167	$6,070,167
Testing and Monitoring	Month	$220,440	6	$1,322,640
Total Sediment Veneer Dredging				*$29,683,173*
C. Dredging Sub-grade cell				
Mobilization/Site Clean-up/Demobilization	LS	$800,000	1	$800,000
Debris Removal	Ton	$300	1,000	$300,000
Dredging/Transport/Dump	CY	$15	6,222,143	$93,332,150
Testing and Monitoring	Month	$220,440	6	$1,322,640
Total Dredging Sub-grade cell				*$95,754,790*
Subtotal Sub-grade Cell Construction				**$137,981,760**
D. Construction Management	Percentage	8%		$10,035,037
TOTAL SUB-GRADE CELL CONSTRUCTION				**$148,016,797**

DMM Backup Sheets
Scenario 3B: CDF Construction
Focused Feasibility Study
Lower Passaic River Restoration Project

Component		Unit	Unit Cost	# of Units	Cost
A.	**Pre-Construction Activities**				
	Design	Percentage	8%	214,185,307	$17,134,825
	Contractor Work Plans	LS	$100,000	1	$100,000
	Permits	Percentage	2%	214,185,307	$4,283,706
	Total Pre-Construction Activities				*$21,518,531*
B.	**Inner Sheetpile Wall Construction**				
	Mobilization/Site Clean-up/Demobilization	LS	$400,000	1	$400,000
	Surveying - Assume 1/4 time required	Day	$3,000	68	$202,500
	Waterloo Sheet Piles (Material Cost)	SF	$31	504,000	$15,372,000
	Walers	LF	$50	12,600	$630,000
	Installation Costs				
	Crane and Crew - with driving head	SF	$12	504,000	$6,048,000
	Four Barges, two boats, tug boat	Day	$6,500	90	$585,000
	Crew for Attaching Walers	Day	$1,800	80	$144,000
	Total Inner Sheetpile Wall Construction				*$23,381,500*
C.	**Outer Bulkhead Wall Construction**				
	Waterloo Sheet Piles (Material Cost)	SF	$31	889,000	$27,114,500
	Additional Cost for 70' Sheet Piles	SF	$2	889,000	$1,778,000
	Walers	LF	$50	12,700	$635,000
	Deadman Tiebacks and Connectors	Tieback	$2,000	1,588	$3,175,000
	Bumpers - Outside of Bulkhead	LF	$18	7,250	$130,500
	Backfill Between inner and outer walls - Materials and installation	CY	$32	13,426	$429,630
	Installation Costs - Water Side				
	Crane and Crew - with driving head	SF	$12	889,000	$10,668,000
	Four Barges, two boats, tug boat	Day	$6,500	190	$1,234,807
	Crew for Attaching Walers, Deadmen, and Bumpers	Day	$2,000	90	$180,000
	Water Barrier	Boom	$250,000	3	$750,000
	Total Outer Bulkhead Wall Construction				*$46,095,436*
D.	**Water Treatment**				
	Mobilization/Demobilization	LS	$360,000	1	$360,000
	Treatment Plant	LS	$1,500,000	1	$1,500,000
	Piping to Plant	LS	$150,000	1	$150,000
	Water Treatment	Gallon	$0.04	2,026,556,822	$81,062,273
	Testing	Week	$10,000	520	$5,200,000
	Subtotal Water Treatment				*$88,272,273*
E.	**CDF Operations**				
	Monitoring Wells	Well	$750	85	$63,750
	Spreading Starter Cell Mount into CDF	CY	$2	0	$0
	Operation of CDF (including Starter Cell)	LS	$22,894,000	1	$22,894,000
	Total CDF Operations				*$22,957,750*
F.	**CDF Closing**				
	Mobilization/Site Clean-up/Demobilization	LS	$75,000	1	$75,000
	Inner Sheetpile Wall Removal	LF	$150	22,200	$3,330,000
	Removal of Backfill Between Walls	CY	$14	13,426	$187,963
	Outer Sheetpile Wall Removal	LF	$250	22,400	$5,600,000
	Decontamination Pad Construction	LS	$90,000	1	$90,000
	Decontamination Operations and Equipment	Month	$50,000	3	$150,000
	Off-site Disposal of Soil and Steel Sheets	Ton	$50	12,219	$610,969
	Geotextile Layer	SY	$2	216,832	$379,456
	Compacted Clay Cover - Fill (Haul, Place, and Compact)	CY	$15	0	$0
	Sand Cap (Purchase, Delivery, Placement, Monitoring)	CY	$64	361,387	$22,964,960
	Vegetation	SY	$1	0	$0
	Shoreline Plantings and other Trees	LS	$75,000	0	$0
	Surveying	Day	$3,000	30	$90,000
	Total CDF Closing				*$33,478,348*
	Subtotal CDF Construction				**$235,703,837**
G.	**Construction Management**	Percentage	8%	214,185,307	$17,134,825
	TOTAL CDF CONSTRUCTION				**$252,838,662**

DMM Backup Sheets
Scenario 3B: On-Site Thermal Treatment
Focused Feasibility Study
Lower Passaic River Restoration Project

Component		Unit	Unit Cost	# of Units	Cost
A.	**Pre-Construction Activities**				
	Design	Percentage	8%		$16,767,412
	Permitting (Equivalency), and Legal	Percentage	2%		$4,191,853
	Total Pre-Construction Activities				*$20,959,266*
B.	**Dredged Material Treatment**				
	Mobilization/Demobilization	LS	$25,000	1	$25,000
	Sediment Removal and Loading onto Trucks	CY	$8	1,907,767	$15,262,133
	Transport to Thermal Treatment Area	CY	$4	1,907,767	$7,631,067
	Dredged Material Off-Loading to Filter Press	CY	$6	1,907,767	$11,446,600
	Mechanical Sediment Dewatering	Ton	$40	1,907,767	$76,310,667
	Water Treatment	Gallon	$0.04	225,116,467	$9,004,659
	Discharge to POTW	Gallon	$0.02	225,116,467	$3,601,863
	On-Site Thermal Treatment	Ton	$80	953,883	$76,310,667
	Sediment Processing Site	Acre	$500,000	20	$10,000,000
	Total Dredged Material Treatment				*$209,592,655*
	Subtotal On-Site Thermal Treatment				**$230,551,921**
C.	**Construction Management**	Percentage	8%		**$16,767,412**
	TOTAL ON-SITE THERMAL TREATMENT				**$247,319,333**

DMM Backup Sheets
Scenario 4A: Total DMM Costs
Focused Feasibility Study
Lower Passaic River Restoration Project

Component		Cost
DMM COSTS		
4A-1	Site Characterization[1]	$1,489,800
4A-2	Starter Cell Construction	$56,542,704
4A-3	Sub-grade Cell Construction	$104,134,213
4A-4	CDF Construction	$186,441,457
4A-5	On-Site Thermal Treatment	$0
	Subtotal DMM Costs	**$348,608,174**
	Contingency (20%)	$69,721,635
	TOTAL DMM COSTS	**$418,329,809**

Notes:

[1]Site Characterization limited to geotechnical investigation of proposed starter cell and CDF areas.

DMM Backup Sheets
Scenario 4A: Site Characterization
Focused Feasibility Study
Lower Passaic River Restoration Project

Component	Unit	Unit Cost	# of Units	Cost
A. Labor				
Barge-Auger Mobilization	LS	$10,000	1	$10,000
Auger Drilling and Sampling	Day	$6,500	80	$520,000
Undisturbed Sample Collection	Sample	$400	240	$96,000
Bathymetric Survey	Day	$6,500	4	$26,000
Field Oversight	Day	$2,640	100	$264,000
Reporting	Day	$3,080	120	$369,600
Project Management	Week	$1,600	26	$41,600
Drilling Permits and Work Plans	LS	$50,000	1	$50,000
Total Labor				$1,377,200
B. Disbursements				
Geotechnical Tests	Percentage	10%		$62,600
Drillers/ Surveyors Sustenance	Day	$500	100	$50,000
Total Disbursements				$112,600
TOTAL SITE CHARACTERIZATION COSTS				**$1,489,800**

DMM Backup Sheets
Scenario 4A: Starter Cell Construction
Focused Feasibility Study
Lower Passaic River Restoration Project

Component	Unit	Unit Cost	# of Units	Cost
A. Pre-Construction Activities				
Design	Percentage	8%		$3,826,624
Contractor Work Plans	LS	$100,000	1	$100,000
Permitting (Equivalency), and Legal	Percentage	2%		$956,656
Total Pre-Construction Activities				*$4,883,280*
B. Inner Sheetpile Wall Construction				
Mobilization/Site Clean-up/Demobilization	LS	$100,000	1	$100,000
Surveying	Day	$3,000	40	$120,000
Waterloo Sheet Piles (Material Cost)	SF	$31	288,000	$8,784,000
Walers	LF	$50	9,600	$480,000
Installation Costs				
Crane and Crew - with driving head	SF	$12	288,000	$3,456,000
Water Side Installation Vessels	Day	$3,500	137	$480,000
Walers Installation	Day	$1,800	50	$90,000
Total Inner Sheetpile Wall Construction				*$13,510,000*
C. Outer Bulkhead Wall Construction				
Waterloo Sheet Piles (Material Cost)	SF	$31	485,000	$14,792,500
Walers	LF	$50	9,700	$485,000
Deadman Tiebacks and Connectors	Tieback	$2,000	1,213	$2,425,000
Bumpers - Outside of Bulkhead	LF	$18	4,850	$87,300
Backfill Between inner and outer walls - Materials and installation	CY	$32	315,250	$10,088,000
Installation Costs - Water Side				
Crane and Crew - with driving head	SF	$12	485,000	$5,820,000
Water Side Installation Vessels	Day	$3,500	139	$485,000
Walers, Deadmen, and Bumpers Installation	Day	$2,000	70	$140,000
Total Outer Bulkhead Wall Construction				*$34,322,800*
Subtotal Starter Cell Construction				**$52,716,080**
D. Construction Management	Percentage	8%		**$3,826,624**
TOTAL STARTER CELL CONSTRUCTION				**$56,542,704**

DMM Backup Sheets
Scenario 4A: Sub-grade Cell Construction
Focused Feasibility Study
Lower Passaic River Restoration Project

Component		Unit	Unit Cost	# of Units	Cost
A.	**Pre-Construction Activities**				
	Design	Percentage	8%		$7,059,947
	Permitting (Equivalency), and Legal	Percentage	2%		$1,764,987
	Total Pre-Construction Activities				*$8,824,933*
B.	**Sediment Veneer Dredging**				
	Mobilization/Site Clean-up/Demobilization	LS	$461,200	1	$461,200
	Debris Removal	Ton	$300	500	$150,000
	Environmental Dredging	CY	$25	693,733	$17,343,333
	Barge Transport of Dredge Material	CY	$5	867,167	$4,335,833
	Dredged Material Off-Loading	CY	$7	867,167	$6,070,167
	Testing and Monitoring	Month	$220,440	6	$1,322,640
	Total Sediment Veneer Dredging				*$29,683,173*
C.	**Dredging Sub-grade cell**				
	Mobilization/Site Clean-up/Demobilization	LS	$800,000	1	$800,000
	Debris Removal	Ton	$300	1,000	$300,000
	Dredging/Transport/Dump	CY	$15	3,772,293	$56,584,400
	Testing and Monitoring	Month	$220,440	4	$881,760
	Total Dredging Sub-grade cell				*$58,566,160*
	Subtotal Sub-grade Cell Construction				**$97,074,267**
D.	**Construction Management**	Percentage	8%		$7,059,947
	TOTAL SUB-GRADE CELL CONSTRUCTION				**$104,134,213**

DMM Backup Sheets
Scenario 4A: CDF Construction
Focused Feasibility Study
Lower Passaic River Restoration Project

Component		Unit	Unit Cost	# of Units	Cost
A.	**Pre-Construction Activities**				
	Design	Percentage	8%	157,916,489	$12,633,319
	Contractor Work Plans	LS	$100,000	1	$100,000
	Permits	Percentage	2%	157,916,489	$3,158,330
	Total Pre-Construction Activities				*$15,891,649*
B.	**Inner Sheetpile Wall Construction**				
	Mobilization/Site Clean-up/Demobilization	LS	$400,000	1	$400,000
	Surveying - Assume 1/4 time required	Day	$3,000	68	$202,500
	Waterloo Sheet Piles (Material Cost)	SF	$31	504,000	$15,372,000
	Walers	LF	$50	12,600	$630,000
	Installation Costs				
	Crane and Crew - with driving head	SF	$12	504,000	$6,048,000
	Four Barges, two boats, tug boat	Day	$6,500	90	$585,000
	Crew for Attaching Walers	Day	$1,800	80	$144,000
	Total Inner Sheetpile Wall Construction				*$23,381,500*
C.	**Outer Bulkhead Wall Construction**				
	Waterloo Sheet Piles (Material Cost)	SF	$31	889,000	$27,114,500
	Additional Cost for 70' Sheet Piles	SF	$2	889,000	$1,778,000
	Walers	LF	$50	12,700	$635,000
	Deadman Tiebacks and Connectors	Tieback	$2,000	1,588	$3,175,000
	Bumpers - Outside of Bulkhead	LF	$18	7,250	$130,500
	Backfill Between inner and outer walls - Materials and installation	CY	$32	13,426	$429,630
	Installation Costs - Water Side				
	Crane and Crew - with driving head	SF	$12	889,000	$10,668,000
	Four Barges, two boats, tug boat	Day	$6,500	190	$1,234,807
	Crew for Attaching Walers, Deadmen, and Bumpers	Day	$2,000	90	$180,000
	Water Barrier	Boom	$250,000	3	$750,000
	Total Outer Bulkhead Wall Construction				*$46,095,436*
D.	**Water Treatment**				
	Mobilization/Demobilization	LS	$240,000	1	$240,000
	Treatment Plant	LS	$1,000,000	1	$1,000,000
	Piping to Plant	LS	$150,000	1	$150,000
	Water Treatment	Gallon	$0.04	1,432,787,074	$57,311,483
	Testing	Week	$10,000	520	$5,200,000
	Subtotal Water Treatment				*$63,901,483*
E.	**CDF Operations**				
	Monitoring Wells	Well	$750	85	$63,750
	Spreading Starter Cell Mount into CDF	CY	$2	462,220	$924,440
	Operation of CDF (including Starter Cell)	LS	$17,347,000	1	$17,347,000
	Total CDF Operations				*$18,335,190*
F.	**CDF Closing**				
	Mobilization/Site Clean-up/Demobilization	LS	$75,000	1	$75,000
	Inner Sheetpile Wall Removal	LF	$150	0	$0
	Removal of Backfill Between Walls	CY	$14	0	$0
	Outer Sheetpile Wall Removal	LF	$250	0	$0
	Decontamination Pad Construction	LS	$90,000	0	$0
	Decontamination Operations and Equipment	Month	$50,000	0	$0
	Off-site Disposal of Soil and Steel Sheets	Ton	$50	0	$0
	Geotextile Layer	SY	$2	216,832	$379,456
	Compacted Clay Cover - Fill (Haul, Place, and Compact)	CY	$15	361,387	$5,420,800
	Sand Cap (Purchase, Delivery, Placement, Monitoring)	CY	$64	0	$0
	Vegetation	SY	$1	216,832	$162,624
	Shoreline Plantings and other Trees	LS	$75,000	1	$75,000
	Surveying	Day	$3,000	30	$90,000
	Total CDF Closing				*$6,202,880*
	Subtotal CDF Construction				**$173,808,138**
G.	**Construction Management**	Percentage	8%	157,916,489	$12,633,319
	TOTAL CDF CONSTRUCTION				**$186,441,457**

DMM Backup Sheets
Scenario 4A: On-Site Thermal Treatment
Focused Feasibility Study
Lower Passaic River Restoration Project

Component		Unit	Unit Cost	# of Units	Cost
A.	**Pre-Construction Activities**				
	Design	Percentage	8%		$0
	Permitting (Equivalency), and Legal	Percentage	2%		$0
	Total Pre-Construction Activities				*$0*
B.	**Dredged Material Treatment**				
	Mobilization/Demobilization	LS	$25,000	0	$0
	Sediment Removal and Loading onto Trucks	CY	$8	0	$0
	Transport to Thermal Treatment Area	CY	$4	0	$0
	Dredged Material Off-Loading to Filter Press	CY	$6	0	$0
	Mechanical Sediment Dewatering	Ton	$40	0	$0
	Water Treatment	Gallon	$0.04	0	$0
	Discharge to POTW	Gallon	$0.02	0	$0
	On-Site Thermal Treatment	Ton	$80	0	$0
	Sediment Processing Site	Acre	$500,000	0	$0
	Total Dredged Material Treatment				*$0*
	Subtotal On-Site Thermal Treatment				**$0**
C.	**Construction Management**	Percentage	8%		**$0**
	TOTAL ON-SITE THERMAL TREATMENT				**$0**

DMM Backup Sheets
Scenario 4B: Total DMM Costs
Focused Feasibility Study
Lower Passaic River Restoration Project

Component		Cost
DMM COSTS		
4B-1	Site Characterization[1]	$1,489,800
4B-2	Starter Cell Construction	$56,542,704
4B-3	Sub-grade Cell Construction	$95,652,373
4B-4	CDF Construction	$218,599,151
4B-5	On-Site Thermal Treatment	$247,319,333
	Subtotal DMM Costs	**$619,603,361**
	Contingency (20%)	$123,920,672
	TOTAL DMM COSTS	**$743,524,034**

Notes:

[1]Site Characterization limited to geotechnical investigation of proposed starter cell and CDF areas.

DMM Backup Sheets
Scenario 4B: Site Characterization
Focused Feasibility Study
Lower Passaic River Restoration Project

Component	Unit	Unit Cost	# of Units	Cost
A. Labor				
Barge-Auger Mobilization	LS	$10,000	1	$10,000
Auger Drilling and Sampling	Day	$6,500	80	$520,000
Undisturbed Sample Collection	Sample	$400	240	$96,000
Bathymetric Survey	Day	$6,500	4	$26,000
Field Oversight	Day	$2,640	100	$264,000
Reporting	Day	$3,080	120	$369,600
Project Management	Week	$1,600	26	$41,600
Drilling Permits and Work Plans	LS	$50,000	1	$50,000
Total Labor				$1,377,200
B. Disbursements				
Geotechnical Tests	Percentage	10%		$62,600
Drillers/ Surveyors Sustenance	Day	$500	100	$50,000
Total Disbursements				$112,600
TOTAL SITE CHARACTERIZATION COSTS				**$1,489,800**

DMM Backup Sheets
Scenario 4B: Starter Cell Construction
Focused Feasibility Study
Lower Passaic River Restoration Project

Component	Unit	Unit Cost	# of Units	Cost
A. Pre-Construction Activities				
Design	Percentage	8%		$3,826,624
Contractor Work Plans	LS	$100,000	1	$100,000
Permitting (Equivalency), and Legal	Percentage	2%		$956,656
Total Pre-Construction Activities				*$4,883,280*
B. Inner Sheetpile Wall Construction				
Mobilization/Site Clean-up/Demobilization	LS	$100,000	1	$100,000
Surveying	Day	$3,000	40	$120,000
Waterloo Sheet Piles (Material Cost)	SF	$31	288,000	$8,784,000
Walers	LF	$50	9,600	$480,000
Installation Costs				
Crane and Crew - with driving head	SF	$12	288,000	$3,456,000
Water Side Installation Vessels	Day	$3,500	137	$480,000
Walers Installation	Day	$1,800	50	$90,000
Total Inner Sheetpile Wall Construction				*$13,510,000*
C. Outer Bulkhead Wall Construction				
Waterloo Sheet Piles (Material Cost)	SF	$31	485,000	$14,792,500
Walers	LF	$50	9,700	$485,000
Deadman Tiebacks and Connectors	Tieback	$2,000	1,213	$2,425,000
Bumpers - Outside of Bulkhead	LF	$18	4,850	$87,300
Backfill Between inner and outer walls - Materials and installation	CY	$32	315,250	$10,088,000
Installation Costs - Water Side				
Crane and Crew - with driving head	SF	$12	485,000	$5,820,000
Water Side Installation Vessels	Day	$3,500	139	$485,000
Walers, Deadmen, and Bumpers Installation	Day	$2,000	70	$140,000
Total Outer Bulkhead Wall Construction				*$34,322,800*
Subtotal Starter Cell Construction				**$52,716,080**
D. Construction Management	Percentage	8%		**$3,826,624**
TOTAL STARTER CELL CONSTRUCTION				**$56,542,704**

DMM Backup Sheets
Scenario 4B: Sub-grade Cell Construction
Focused Feasibility Study
Lower Passaic River Restoration Project

Component	Unit	Unit Cost	# of Units	Cost
A. Pre-Construction Activities				
Design	Percentage	8%		$6,484,907
Permitting (Equivalency), and Legal	Percentage	2%		$1,621,227
Total Pre-Construction Activities				*$8,106,133*
B. Sediment Veneer Dredging				
Mobilization/Site Clean-up/Demobilization	LS	$461,200	1	$461,200
Debris Removal	Ton	$300	500	$150,000
Environmental Dredging	CY	$25	693,733	$17,343,333
Barge Transport of Dredge Material	CY	$5	867,167	$4,335,833
Dredged Material Off-Loading	CY	$7	867,167	$6,070,167
Testing and Monitoring	Month	$220,440	6	$1,322,640
Total Sediment Veneer Dredging				*$29,683,173*
C. Dredging Sub-grade cell				
Mobilization/Site Clean-up/Demobilization	LS	$800,000	1	$800,000
Debris Removal	Ton	$300	1,000	$300,000
Dredging/Transport/Dump	CY	$15	3,293,093	$49,396,400
Testing and Monitoring	Month	$220,440	4	$881,760
Total Dredging Sub-grade cell				*$51,378,160*
Subtotal Sub-grade Cell Construction				**$89,167,467**
D. Construction Management	Percentage	8%		$6,484,907
TOTAL SUB-GRADE CELL CONSTRUCTION				**$95,652,373**

DMM Backup Sheets
Scenario 4B: CDF Construction
Focused Feasibility Study
Lower Passaic River Restoration Project

Component		Unit	Unit Cost	# of Units	Cost
A.	**Pre-Construction Activities**				
	Design	Percentage	8%	185,168,772	$14,813,502
	Contractor Work Plans	LS	$100,000	1	$100,000
	Permits	Percentage	2%	185,168,772	$3,703,375
	Total Pre-Construction Activities				*$18,616,877*
B.	**Inner Sheetpile Wall Construction**				
	Mobilization/Site Clean-up/Demobilization	LS	$400,000	1	$400,000
	Surveying - Assume 1/4 time required	Day	$3,000	68	$202,500
	Waterloo Sheet Piles (Material Cost)	SF	$31	504,000	$15,372,000
	Walers	LF	$50	12,600	$630,000
	Installation Costs				
	Crane and Crew - with driving head	SF	$12	504,000	$6,048,000
	Four Barges, two boats, tug boat	Day	$6,500	90	$585,000
	Crew for Attaching Walers	Day	$1,800	80	$144,000
	Total Inner Sheetpile Wall Construction				*$23,381,500*
C.	**Outer Bulkhead Wall Construction**				
	Waterloo Sheet Piles (Material Cost)	SF	$31	889,000	$27,114,500
	Additional Cost for 70' Sheet Piles	SF	$2	889,000	$1,778,000
	Walers	LF	$50	12,700	$635,000
	Deadman Tiebacks and Connectors	Tieback	$2,000	1,588	$3,175,000
	Bumpers - Outside of Bulkhead	LF	$18	7,250	$130,500
	Backfill Between inner and outer walls - Materials and installation	CY	$32	13,426	$429,630
	Installation Costs - Water Side				
	Crane and Crew - with driving head	SF	$12	889,000	$10,668,000
	Four Barges, two boats, tug boat	Day	$6,500	190	$1,234,807
	Crew for Attaching Walers, Deadmen, and Bumpers	Day	$2,000	90	$180,000
	Water Barrier	Boom	$250,000	3	$750,000
	Total Outer Bulkhead Wall Construction				*$46,095,436*
D.	**Water Treatment**				
	Mobilization/Demobilization	LS	$240,000	1	$240,000
	Treatment Plant	LS	$1,000,000	1	$1,000,000
	Piping to Plant	LS	$150,000	1	$150,000
	Water Treatment	Gallon	$0.04	1,316,643,447	$52,665,738
	Testing	Week	$10,000	520	$5,200,000
	Subtotal Water Treatment				*$59,255,738*
E.	**CDF Operations**				
	Monitoring Wells	Well	$750	85	$63,750
	Spreading Starter Cell Mount into CDF	CY	$2	0	$0
	Operation of CDF (including Starter Cell)	LS	$22,894,000	1	$22,894,000
	Total CDF Operations				*$22,957,750*
F.	**CDF Closing**				
	Mobilization/Site Clean-up/Demobilization	LS	$75,000	1	$75,000
	Inner Sheetpile Wall Removal	LF	$150	22,200	$3,330,000
	Removal of Backfill Between Walls	CY	$14	13,426	$187,963
	Outer Sheetpile Wall Removal	LF	$250	22,400	$5,600,000
	Decontamination Pad Construction	LS	$90,000	1	$90,000
	Decontamination Operations and Equipment	Month	$50,000	3	$150,000
	Off-site Disposal of Soil and Steel Sheets	Ton	$50	12,219	$610,969
	Geotextile Layer	SY	$2	216,832	$379,456
	Compacted Clay Cover - Fill (Haul, Place, and Compact)	CY	$15	0	$0
	Sand Cap (Purchase, Delivery, Placement, Monitoring)	CY	$64	361,387	$22,964,960
	Vegetation	SY	$1	0	$0
	Shoreline Plantings and other Trees	LS	$75,000	0	$0
	Surveying	Day	$3,000	30	$90,000
	Total CDF Closing				*$33,478,348*
	Subtotal CDF Construction				**$203,785,649**
G.	**Construction Management**	Percentage	8%	185,168,772	$14,813,502
	TOTAL CDF CONSTRUCTION				**$218,599,151**

DMM Backup Sheets
Scenario 4B: On-Site Thermal Treatment
Focused Feasibility Study
Lower Passaic River Restoration Project

Component		Unit	Unit Cost	# of Units	Cost
A.	**Pre-Construction Activities**				
	Design	Percentage	8%		$16,767,412
	Permitting (Equivalency), and Legal	Percentage	2%		$4,191,853
	Total Pre-Construction Activities				*$20,959,266*
B.	**Dredged Material Treatment**				
	Mobilization/Demobilization	LS	$25,000	1	$25,000
	Sediment Removal and Loading onto Trucks	CY	$8	1,907,767	$15,262,133
	Transport to Thermal Treatment Area	CY	$4	1,907,767	$7,631,067
	Dredged Material Off-Loading to Filter Press	CY	$6	1,907,767	$11,446,600
	Mechanical Sediment Dewatering	Ton	$40	1,907,767	$76,310,667
	Water Treatment	Gallon	$0.04	225,116,467	$9,004,659
	Discharge to POTW	Gallon	$0.02	225,116,467	$3,601,863
	On-Site Thermal Treatment	Ton	$80	953,883	$76,310,667
	Sediment Processing Site	Acre	$500,000	20	$10,000,000
	Total Dredged Material Treatment				*$209,592,655*
	Subtotal On-Site Thermal Treatment				**$230,551,921**
C.	**Construction Management**	Percentage	8%		**$16,767,412**
	TOTAL ON-SITE THERMAL TREATMENT				**$247,319,333**

DMM Backup Sheets
Scenario 5A: Total DMM Costs
Focused Feasibility Study
Lower Passaic River Restoration Project

Component		Cost
DMM COSTS		
5A-1	Site Characterization[1]	$1,489,800
5A-2	Starter Cell Construction	$56,542,704
5A-3	Sub-grade Cell Construction	$139,323,513
5A-4	CDF Construction	$209,748,470
5A-5	On-Site Thermal Treatment	$0
	Subtotal DMM Costs	**$407,104,486**
	Contingency (20%)	$81,420,897
	TOTAL DMM COSTS	**$488,525,384**

Notes:

[1]Site Characterization limited to geotechnical investigation of proposed starter cell and CDF areas.

DMM Backup Sheets
Scenario 5A: Site Characterization
Focused Feasibility Study
Lower Passaic River Restoration Project

Component	Unit	Unit Cost	# of Units	Cost
A. Labor				
Barge-Auger Mobilization	LS	$10,000	1	$10,000
Auger Drilling and Sampling	Day	$6,500	80	$520,000
Undisturbed Sample Collection	Sample	$400	240	$96,000
Bathymetric Survey	Day	$6,500	4	$26,000
Field Oversight	Day	$2,640	100	$264,000
Reporting	Day	$3,080	120	$369,600
Project Management	Week	$1,600	26	$41,600
Drilling Permits and Work Plans	LS	$50,000	1	$50,000
Total Labor				$1,377,200
B. Disbursements				
Geotechnical Tests	Percentage	10%		$62,600
Drillers/ Surveyors Sustenance	Day	$500	100	$50,000
Total Disbursements				$112,600
TOTAL SITE CHARACTERIZATION COSTS				**$1,489,800**

DMM Backup Sheets
Scenario 5A: Starter Cell Construction
Focused Feasibility Study
Lower Passaic River Restoration Project

Component	Unit	Unit Cost	# of Units	Cost
A. Pre-Construction Activities				
Design	Percentage	8%		$3,826,624
Contractor Work Plans	LS	$100,000	1	$100,000
Permitting (Equivalency), and Legal	Percentage	2%		$956,656
Total Pre-Construction Activities				*$4,883,280*
B. Inner Sheetpile Wall Construction				
Mobilization/Site Clean-up/Demobilization	LS	$100,000	1	$100,000
Surveying	Day	$3,000	40	$120,000
Waterloo Sheet Piles (Material Cost)	SF	$31	288,000	$8,784,000
Walers	LF	$50	9,600	$480,000
Installation Costs				
Crane and Crew - with driving head	SF	$12	288,000	$3,456,000
Water Side Installation Vessels	Day	$3,500	137	$480,000
Walers Installation	Day	$1,800	50	$90,000
Total Inner Sheetpile Wall Construction				*$13,510,000*
C. Outer Bulkhead Wall Construction				
Waterloo Sheet Piles (Material Cost)	SF	$31	485,000	$14,792,500
Walers	LF	$50	9,700	$485,000
Deadman Tiebacks and Connectors	Tieback	$2,000	1,213	$2,425,000
Bumpers - Outside of Bulkhead	LF	$18	4,850	$87,300
Backfill Between inner and outer walls - Materials and installation	CY	$32	315,250	$10,088,000
Installation Costs - Water Side				
Crane and Crew - with driving head	SF	$12	485,000	$5,820,000
Water Side Installation Vessels	Day	$3,500	139	$485,000
Walers, Deadmen, and Bumpers Installation	Day	$2,000	70	$140,000
Total Outer Bulkhead Wall Construction				*$34,322,800*
Subtotal Starter Cell Construction				**$52,716,080**
D. Construction Management	Percentage	8%		**$3,826,624**
TOTAL STARTER CELL CONSTRUCTION				**$56,542,704**

DMM Backup Sheets
Scenario 5A: Sub-grade Cell Construction
Focused Feasibility Study
Lower Passaic River Restoration Project

Component	Unit	Unit Cost	# of Units	Cost
A. Pre-Construction Activities				
Design	Percentage	8%		$9,445,662
Permitting (Equivalency), and Legal	Percentage	2%		$2,361,415
Total Pre-Construction Activities				*$11,807,077*
B. Sediment Veneer Dredging				
Mobilization/Site Clean-up/Demobilization	LS	$461,200	1	$461,200
Debris Removal	Ton	$300	500	$150,000
Environmental Dredging	CY	$25	693,733	$17,343,333
Barge Transport of Dredge Material	CY	$5	867,167	$4,335,833
Dredged Material Off-Loading	CY	$7	867,167	$6,070,167
Testing and Monitoring	Month	$220,440	6	$1,322,640
Total Sediment Veneer Dredging				*$29,683,173*
C. Dredging Sub-grade cell				
Mobilization/Site Clean-up/Demobilization	LS	$800,000	1	$800,000
Debris Removal	Ton	$300	1,000	$300,000
Dredging/Transport/Dump	CY	$15	5,745,693	$86,185,400
Testing and Monitoring	Month	$220,440	5	$1,102,200
Total Dredging Sub-grade cell				*$88,387,600*
Subtotal Sub-grade Cell Construction				**$129,877,851**
D. Construction Management	Percentage	8%		$9,445,662
TOTAL SUB-GRADE CELL CONSTRUCTION				**$139,323,513**

DMM Backup Sheets
Scenario 5A: CDF Construction
Focused Feasibility Study
Lower Passaic River Restoration Project

Component		Unit	Unit Cost	# of Units	Cost
A.	**Pre-Construction Activities**				
	Design	Percentage	8%	177,668,195	$14,213,456
	Contractor Work Plans	LS	$100,000	1	$100,000
	Permits	Percentage	2%	177,668,195	$3,553,364
	Total Pre-Construction Activities				*$17,866,819*
B.	**Inner Sheetpile Wall Construction**				
	Mobilization/Site Clean-up/Demobilization	LS	$400,000	1	$400,000
	Surveying - Assume 1/4 time required	Day	$3,000	68	$202,500
	Waterloo Sheet Piles (Material Cost)	SF	$31	504,000	$15,372,000
	Walers	LF	$50	12,600	$630,000
	Installation Costs				
	Crane and Crew - with driving head	SF	$12	504,000	$6,048,000
	Four Barges, two boats, tug boat	Day	$6,500	90	$585,000
	Crew for Attaching Walers	Day	$1,800	80	$144,000
	Total Inner Sheetpile Wall Construction				*$23,381,500*
C.	**Outer Bulkhead Wall Construction**				
	Waterloo Sheet Piles (Material Cost)	SF	$31	889,000	$27,114,500
	Additional Cost for 70' Sheet Piles	SF	$2	889,000	$1,778,000
	Walers	LF	$50	12,700	$635,000
	Deadman Tiebacks and Connectors	Tieback	$2,000	1,588	$3,175,000
	Bumpers - Outside of Bulkhead	LF	$18	7,250	$130,500
	Backfill Between inner and outer walls - Materials and installation	CY	$32	13,426	$429,630
	Installation Costs - Water Side				
	Crane and Crew - with driving head	SF	$12	889,000	$10,668,000
	Four Barges, two boats, tug boat	Day	$6,500	190	$1,234,807
	Crew for Attaching Walers, Deadmen, and Bumpers	Day	$2,000	90	$180,000
	Water Barrier	Boom	$250,000	3	$750,000
	Total Outer Bulkhead Wall Construction				*$46,095,436*
D.	**Water Treatment**				
	Mobilization/Demobilization	LS	$360,000	1	$360,000
	Treatment Plant	LS	$1,500,000	1	$1,500,000
	Piping to Plant	LS	$150,000	1	$150,000
	Water Treatment	Gallon	$0.04	1,911,079,713	$76,443,189
	Testing	Week	$10,000	520	$5,200,000
	Subtotal Water Treatment				*$83,653,189*
E.	**CDF Operations**				
	Monitoring Wells	Well	$750	85	$63,750
	Spreading Starter Cell Mount into CDF	CY	$2	462,220	$924,440
	Operation of CDF (including Starter Cell)	LS	$17,347,000	1	$17,347,000
	Total CDF Operations				*$18,335,190*
F.	**CDF Closing**				
	Mobilization/Site Clean-up/Demobilization	LS	$75,000	1	$75,000
	Inner Sheetpile Wall Removal	LF	$150	0	$0
	Removal of Backfill Between Walls	CY	$14	0	$0
	Outer Sheetpile Wall Removal	LF	$250	0	$0
	Decontamination Pad Construction	LS	$90,000	0	$0
	Decontamination Operations and Equipment	Month	$50,000	0	$0
	Off-site Disposal of Soil and Steel Sheets	Ton	$50	0	$0
	Geotextile Layer	SY	$2	216,832	$379,456
	Compacted Clay Cover - Fill (Haul, Place, and Compact)	CY	$15	361,387	$5,420,800
	Sand Cap (Purchase, Delivery, Placement, Monitoring)	CY	$64	0	$0
	Vegetation	SY	$1	216,832	$162,624
	Shoreline Plantings and other Trees	LS	$75,000	1	$75,000
	Surveying	Day	$3,000	30	$90,000
	Total CDF Closing				*$6,202,880*
	Subtotal CDF Construction				**$195,535,014**
G.	**Construction Management**	Percentage	8%	177,668,195	$14,213,456
	TOTAL CDF CONSTRUCTION				**$209,748,470**

DMM Backup Sheets
Scenario 5A: On-Site Thermal Treatment
Focused Feasibility Study
Lower Passaic River Restoration Project

Component		Unit	Unit Cost	# of Units	Cost
A.	**Pre-Construction Activities**				
	Design	Percentage	8%		$0
	Permitting (Equivalency), and Legal	Percentage	2%		$0
	Total Pre-Construction Activities				*$0*
B.	**Dredged Material Treatment**				
	Mobilization/Demobilization	LS	$25,000	0	$0
	Sediment Removal and Loading onto Trucks	CY	$8	0	$0
	Transport to Thermal Treatment Area	CY	$4	0	$0
	Dredged Material Off-Loading to Filter Press	CY	$6	0	$0
	Mechanical Sediment Dewatering	Ton	$40	0	$0
	Water Treatment	Gallon	$0.04	0	$0
	Discharge to POTW	Gallon	$0.02	0	$0
	On-Site Thermal Treatment	Ton	$80	0	$0
	Sediment Processing Site	Acre	$500,000	0	$0
	Total Dredged Material Treatment				*$0*
	Subtotal On-Site Thermal Treatment				**$0**
C.	**Construction Management**	Percentage	8%		**$0**
	TOTAL ON-SITE THERMAL TREATMENT				**$0**

DMM Backup Sheets
Scenario 5B: Total DMM Costs
Focused Feasibility Study
Lower Passaic River Restoration Project

Component		Cost
DMM COSTS		
5B-1	Site Characterization[1]	$1,489,800
5B-2	Starter Cell Construction	$56,542,704
5B-3	Sub-grade Cell Construction	$130,841,673
5B-4	CDF Construction	$241,906,163
5B-5	On-Site Thermal Treatment	$247,319,333
	Subtotal DMM Costs	**$678,099,673**
	Contingency (20%)	$135,619,935
	TOTAL DMM COSTS	**$813,719,608**

Notes:

[1]Site Characterization limited to geotechnical investigation of proposed starter cell and CDF areas.

DMM Backup Sheets
Scenario 5B: Site Characterization
Focused Feasibility Study
Lower Passaic River Restoration Project

Component	Unit	Unit Cost	# of Units	Cost
A. Labor				
Barge-Auger Mobilization	LS	$10,000	1	$10,000
Auger Drilling and Sampling	Day	$6,500	80	$520,000
Undisturbed Sample Collection	Sample	$400	240	$96,000
Bathymetric Survey	Day	$6,500	4	$26,000
Field Oversight	Day	$2,640	100	$264,000
Reporting	Day	$3,080	120	$369,600
Project Management	Week	$1,600	26	$41,600
Drilling Permits and Work Plans	LS	$50,000	1	$50,000
Total Labor				$1,377,200
B. Disbursements				
Geotechnical Tests	Percentage	10%		$62,600
Drillers/ Surveyors Sustenance	Day	$500	100	$50,000
Total Disbursements				$112,600
TOTAL SITE CHARACTERIZATION COSTS				**$1,489,800**

DMM Backup Sheets
Scenario 5B: Starter Cell Construction
Focused Feasibility Study
Lower Passaic River Restoration Project

Component	Unit	Unit Cost	# of Units	Cost
A. Pre-Construction Activities				
Design	Percentage	8%		$3,826,624
Contractor Work Plans	LS	$100,000	1	$100,000
Permitting (Equivalency), and Legal	Percentage	2%		$956,656
Total Pre-Construction Activities				*$4,883,280*
B. Inner Sheetpile Wall Construction				
Mobilization/Site Clean-up/Demobilization	LS	$100,000	1	$100,000
Surveying	Day	$3,000	40	$120,000
Waterloo Sheet Piles (Material Cost)	SF	$31	288,000	$8,784,000
Walers	LF	$50	9,600	$480,000
Installation Costs				
Crane and Crew - with driving head	SF	$12	288,000	$3,456,000
Water Side Installation Vessels	Day	$3,500	137	$480,000
Walers Installation	Day	$1,800	50	$90,000
Total Inner Sheetpile Wall Construction				*$13,510,000*
C. Outer Bulkhead Wall Construction				
Waterloo Sheet Piles (Material Cost)	SF	$31	485,000	$14,792,500
Walers	LF	$50	9,700	$485,000
Deadman Tiebacks and Connectors	Tieback	$2,000	1,213	$2,425,000
Bumpers - Outside of Bulkhead	LF	$18	4,850	$87,300
Backfill Between inner and outer walls - Materials and installation	CY	$32	315,250	$10,088,000
Installation Costs - Water Side				
Crane and Crew - with driving head	SF	$12	485,000	$5,820,000
Water Side Installation Vessels	Day	$3,500	139	$485,000
Walers, Deadmen, and Bumpers Installation	Day	$2,000	70	$140,000
Total Outer Bulkhead Wall Construction				*$34,322,800*
Subtotal Starter Cell Construction				**$52,716,080**
D. Construction Management	Percentage	8%		**$3,826,624**
TOTAL STARTER CELL CONSTRUCTION				**$56,542,704**

DMM Backup Sheets
Scenario 5B: Sub-grade Cell Construction
Focused Feasibility Study
Lower Passaic River Restoration Project

Component	Unit	Unit Cost	# of Units	Cost
A. Pre-Construction Activities				
Design	Percentage	8%		$8,870,622
Permitting (Equivalency), and Legal	Percentage	2%		$2,217,655
Total Pre-Construction Activities				*$11,088,277*
B. Sediment Veneer Dredging				
Mobilization/Site Clean-up/Demobilization	LS	$461,200	1	$461,200
Debris Removal	Ton	$300	500	$150,000
Environmental Dredging	CY	$25	693,733	$17,343,333
Barge Transport of Dredge Material	CY	$5	867,167	$4,335,833
Dredged Material Off-Loading	CY	$7	867,167	$6,070,167
Testing and Monitoring	Month	$220,440	6	$1,322,640
Total Sediment Veneer Dredging				*$29,683,173*
C. Dredging Sub-grade cell				
Mobilization/Site Clean-up/Demobilization	LS	$800,000	1	$800,000
Debris Removal	Ton	$300	1,000	$300,000
Dredging/Transport/Dump	CY	$15	5,266,493	$78,997,400
Testing and Monitoring	Month	$220,440	5	$1,102,200
Total Dredging Sub-grade cell				*$81,199,600*
Subtotal Sub-grade Cell Construction				**$121,971,051**
D. Construction Management	Percentage	8%		$8,870,622
TOTAL SUB-GRADE CELL CONSTRUCTION				**$130,841,673**

DMM Backup Sheets
Scenario 5B: CDF Construction
Focused Feasibility Study
Lower Passaic River Restoration Project

Component		Unit	Unit Cost	# of Units	Cost
A.	**Pre-Construction Activities**				
	Design	Percentage	8%	204,920,477	$16,393,638
	Contractor Work Plans	LS	$100,000	1	$100,000
	Permits	Percentage	2%	204,920,477	$4,098,410
	Total Pre-Construction Activities				*$20,592,048*
B.	**Inner Sheetpile Wall Construction**				
	Mobilization/Site Clean-up/Demobilization	LS	$400,000	1	$400,000
	Surveying - Assume 1/4 time required	Day	$3,000	68	$202,500
	Waterloo Sheet Piles (Material Cost)	SF	$31	504,000	$15,372,000
	Walers	LF	$50	12,600	$630,000
	Installation Costs				
	Crane and Crew - with driving head	SF	$12	504,000	$6,048,000
	Four Barges, two boats, tug boat	Day	$6,500	90	$585,000
	Crew for Attaching Walers	Day	$1,800	80	$144,000
	Total Inner Sheetpile Wall Construction				*$23,381,500*
C.	**Outer Bulkhead Wall Construction**				
	Waterloo Sheet Piles (Material Cost)	SF	$31	889,000	$27,114,500
	Additional Cost for 70' Sheet Piles	SF	$2	889,000	$1,778,000
	Walers	LF	$50	12,700	$635,000
	Deadman Tiebacks and Connectors	Tieback	$2,000	1,588	$3,175,000
	Bumpers - Outside of Bulkhead	LF	$18	7,250	$130,500
	Backfill Between inner and outer walls - Materials and installation	CY	$32	13,426	$429,630
	Installation Costs - Water Side				
	Crane and Crew - with driving head	SF	$12	889,000	$10,668,000
	Four Barges, two boats, tug boat	Day	$6,500	190	$1,234,807
	Crew for Attaching Walers, Deadmen, and Bumpers	Day	$2,000	90	$180,000
	Water Barrier	Boom	$250,000	3	$750,000
	Total Outer Bulkhead Wall Construction				*$46,095,436*
D.	**Water Treatment**				
	Mobilization/Demobilization	LS	$360,000	1	$360,000
	Treatment Plant	LS	$1,500,000	1	$1,500,000
	Piping to Plant	LS	$150,000	1	$150,000
	Water Treatment	Gallon	$0.04	1,794,936,086	$71,797,443
	Testing	Week	$10,000	520	$5,200,000
	Subtotal Water Treatment				*$79,007,443*
E.	**CDF Operations**				
	Monitoring Wells	Well	$750	85	$63,750
	Spreading Starter Cell Mount into CDF	CY	$2	0	$0
	Operation of CDF (including Starter Cell)	LS	$22,894,000	1	$22,894,000
	Total CDF Operations				*$22,957,750*
F.	**CDF Closing**				
	Mobilization/Site Clean-up/Demobilization	LS	$75,000	1	$75,000
	Inner Sheetpile Wall Removal	LF	$150	22,200	$3,330,000
	Removal of Backfill Between Walls	CY	$14	13,426	$187,963
	Outer Sheetpile Wall Removal	LF	$250	22,400	$5,600,000
	Decontamination Pad Construction	LS	$90,000	1	$90,000
	Decontamination Operations and Equipment	Month	$50,000	3	$150,000
	Off-site Disposal of Soil and Steel Sheets	Ton	$50	12,219	$610,969
	Geotextile Layer	SY	$2	216,832	$379,456
	Compacted Clay Cover - Fill (Haul, Place, and Compact)	CY	$15	0	$0
	Sand Cap (Purchase, Delivery, Placement, Monitoring)	CY	$64	361,387	$22,964,960
	Vegetation	SY	$1	0	$0
	Shoreline Plantings and other Trees	LS	$75,000	0	$0
	Surveying	Day	$3,000	30	$90,000
	Total CDF Closing				*$33,478,348*
	Subtotal CDF Construction				**$225,512,525**
G.	**Construction Management**	Percentage	8%	204,920,477	$16,393,638
	TOTAL CDF CONSTRUCTION				**$241,906,163**

DMM Backup Sheets
Scenario 5B: On-Site Thermal Treatment
Focused Feasibility Study
Lower Passaic River Restoration Project

Component		Unit	Unit Cost	# of Units	Cost
A.	**Pre-Construction Activities**				
	Design	Percentage	8%		$16,767,412
	Permitting (Equivalency), and Legal	Percentage	2%		$4,191,853
	Total Pre-Construction Activities				*$20,959,266*
B.	**Dredged Material Treatment**				
	Mobilization/Demobilization	LS	$25,000	1	$25,000
	Sediment Removal and Loading onto Trucks	CY	$8	1,907,767	$15,262,133
	Transport to Thermal Treatment Area	CY	$4	1,907,767	$7,631,067
	Dredged Material Off-Loading to Filter Press	CY	$6	1,907,767	$11,446,600
	Mechanical Sediment Dewatering	Ton	$40	1,907,767	$76,310,667
	Water Treatment	Gallon	$0.04	225,116,467	$9,004,659
	Discharge to POTW	Gallon	$0.02	225,116,467	$3,601,863
	On-Site Thermal Treatment	Ton	$80	953,883	$76,310,667
	Sediment Processing Site	Acre	$500,000	20	$10,000,000
	Total Dredged Material Treatment				*$209,592,655*
	Subtotal On-Site Thermal Treatment				**$230,551,921**
C.	**Construction Management**	Percentage	8%		**$16,767,412**
	TOTAL ON-SITE THERMAL TREATMENT				**$247,319,333**

DMM Backup Sheets
Scenario 6A: Total DMM Costs
Focused Feasibility Study
Lower Passaic River Restoration Project

Component		Cost
DMM COSTS		
6A-1	Site Characterization[1]	$1,489,800
6A-2	Starter Cell Construction	$56,542,704
6A-3	Sub-grade Cell Construction	$157,129,642
6A-4	CDF Construction	$221,088,799
6A-5	On-Site Thermal Treatment	$0
	Subtotal DMM Costs	**$436,250,945**
	Contingency (20%)	$87,250,189
	TOTAL DMM COSTS	**$523,501,134**

Notes:

[1]Site Characterization limited to geotechnical investigation of proposed starter cell and CDF areas.

DMM Backup Sheets
Scenario 6A: Site Characterization
Focused Feasibility Study
Lower Passaic River Restoration Project

Component	Unit	Unit Cost	# of Units	Cost
A. Labor				
Barge-Auger Mobilization	LS	$10,000	1	$10,000
Auger Drilling and Sampling	Day	$6,500	80	$520,000
Undisturbed Sample Collection	Sample	$400	240	$96,000
Bathymetric Survey	Day	$6,500	4	$26,000
Field Oversight	Day	$2,640	100	$264,000
Reporting	Day	$3,080	120	$369,600
Project Management	Week	$1,600	26	$41,600
Drilling Permits and Work Plans	LS	$50,000	1	$50,000
Total Labor				$1,377,200
B. Disbursements				
Geotechnical Tests	Percentage	10%		$62,600
Drillers/ Surveyors Sustenance	Day	$500	100	$50,000
Total Disbursements				$112,600
TOTAL SITE CHARACTERIZATION COSTS				**$1,489,800**

DMM Backup Sheets
Scenario 6A: Starter Cell Construction
Focused Feasibility Study
Lower Passaic River Restoration Project

Component	Unit	Unit Cost	# of Units	Cost
A. Pre-Construction Activities				
Design	Percentage	8%		$3,826,624
Contractor Work Plans	LS	$100,000	1	$100,000
Permitting (Equivalency), and Legal	Percentage	2%		$956,656
Total Pre-Construction Activities				*$4,883,280*
B. Inner Sheetpile Wall Construction				
Mobilization/Site Clean-up/Demobilization	LS	$100,000	1	$100,000
Surveying	Day	$3,000	40	$120,000
Waterloo Sheet Piles (Material Cost)	SF	$31	288,000	$8,784,000
Walers	LF	$50	9,600	$480,000
Installation Costs				
Crane and Crew - with driving head	SF	$12	288,000	$3,456,000
Water Side Installation Vessels	Day	$3,500	137	$480,000
Walers Installation	Day	$1,800	50	$90,000
Total Inner Sheetpile Wall Construction				*$13,510,000*
C. Outer Bulkhead Wall Construction				
Waterloo Sheet Piles (Material Cost)	SF	$31	485,000	$14,792,500
Walers	LF	$50	9,700	$485,000
Deadman Tiebacks and Connectors	Tieback	$2,000	1,213	$2,425,000
Bumpers - Outside of Bulkhead	LF	$18	4,850	$87,300
Backfill Between inner and outer walls - Materials and installation	CY	$32	315,250	$10,088,000
Installation Costs - Water Side				
Crane and Crew - with driving head	SF	$12	485,000	$5,820,000
Water Side Installation Vessels	Day	$3,500	139	$485,000
Walers, Deadmen, and Bumpers Installation	Day	$2,000	70	$140,000
Total Outer Bulkhead Wall Construction				*$34,322,800*
Subtotal Starter Cell Construction				**$52,716,080**
D. Construction Management	Percentage	8%		**$3,826,624**
TOTAL STARTER CELL CONSTRUCTION				**$56,542,704**

DMM Backup Sheets
Scenario 6A: Sub-grade Cell Construction
Focused Feasibility Study
Lower Passaic River Restoration Project

Component		Unit	Unit Cost	# of Units	Cost
A.	**Pre-Construction Activities**				
	Design	Percentage	8%		$10,652,857
	Permitting (Equivalency), and Legal	Percentage	2%		$2,663,214
	Total Pre-Construction Activities				*$13,316,071*
B.	**Sediment Veneer Dredging**				
	Mobilization/Site Clean-up/Demobilization	LS	$461,200	1	$461,200
	Debris Removal	Ton	$300	500	$150,000
	Environmental Dredging	CY	$25	693,733	$17,343,333
	Barge Transport of Dredge Material	CY	$5	867,167	$4,335,833
	Dredged Material Off-Loading	CY	$7	867,167	$6,070,167
	Testing and Monitoring	Month	$220,440	6	$1,322,640
	Total Sediment Veneer Dredging				*$29,683,173*
C.	**Dredging Sub-grade cell**				
	Mobilization/Site Clean-up/Demobilization	LS	$800,000	1	$800,000
	Debris Removal	Ton	$300	1,000	$300,000
	Dredging/Transport/Dump	CY	$15	6,736,993	$101,054,900
	Testing and Monitoring	Month	$220,440	6	$1,322,640
	Total Dredging Sub-grade cell				*$103,477,540*
	Subtotal Sub-grade Cell Construction				**$146,476,785**
D.	**Construction Management**	Percentage	8%		$10,652,857
	TOTAL SUB-GRADE CELL CONSTRUCTION				**$157,129,642**

DMM Backup Sheets
Scenario 6A: CDF Construction
Focused Feasibility Study
Lower Passaic River Restoration Project

Component	Unit	Unit Cost	# of Units	Cost
A. Pre-Construction Activities				
Design	Percentage	8%	187,278,644	$14,982,291
Contractor Work Plans	LS	$100,000	1	$100,000
Permits	Percentage	2%	187,278,644	$3,745,573
Total Pre-Construction Activities				*$18,827,864*
B. Inner Sheetpile Wall Construction				
Mobilization/Site Clean-up/Demobilization	LS	$400,000	1	$400,000
Surveying - Assume 1/4 time required	Day	$3,000	68	$202,500
Waterloo Sheet Piles (Material Cost)	SF	$31	504,000	$15,372,000
Walers	LF	$50	12,600	$630,000
Installation Costs				
Crane and Crew - with driving head	SF	$12	504,000	$6,048,000
Four Barges, two boats, tug boat	Day	$6,500	90	$585,000
Crew for Attaching Walers	Day	$1,800	80	$144,000
Total Inner Sheetpile Wall Construction				*$23,381,500*
C. Outer Bulkhead Wall Construction				
Waterloo Sheet Piles (Material Cost)	SF	$31	889,000	$27,114,500
Additional Cost for 70' Sheet Piles	SF	$2	889,000	$1,778,000
Walers	LF	$50	12,700	$635,000
Deadman Tiebacks and Connectors	Tieback	$2,000	1,588	$3,175,000
Bumpers - Outside of Bulkhead	LF	$18	7,250	$130,500
Backfill Between inner and outer walls - Materials and installation	CY	$32	13,426	$429,630
Installation Costs - Water Side				
Crane and Crew - with driving head	SF	$12	889,000	$10,668,000
Four Barges, two boats, tug boat	Day	$6,500	190	$1,234,807
Crew for Attaching Walers, Deadmen, and Bumpers	Day	$2,000	90	$180,000
Water Barrier	Boom	$250,000	3	$750,000
Total Outer Bulkhead Wall Construction				*$46,095,436*
D. Water Treatment				
Mobilization/Demobilization	LS	$360,000	1	$360,000
Treatment Plant	LS	$1,500,000	1	$1,500,000
Piping to Plant	LS	$150,000	1	$150,000
Water Treatment	Gallon	$0.04	2,151,340,934	$86,053,637
Testing	Week	$10,000	520	$5,200,000
Subtotal Water Treatment				*$93,263,637*
E. CDF Operations				
Monitoring Wells	Well	$750	85	$63,750
Spreading Starter Cell Mount into CDF	CY	$2	462,220	$924,440
Operation of CDF (including Starter Cell)	LS	$17,347,000	1	$17,347,000
Total CDF Operations				*$18,335,190*
F. CDF Closing				
Mobilization/Site Clean-up/Demobilization	LS	$75,000	1	$75,000
Inner Sheetpile Wall Removal	LF	$150	0	$0
Removal of Backfill Between Walls	CY	$14	0	$0
Outer Sheetpile Wall Removal	LF	$250	0	$0
Decontamination Pad Construction	LS	$90,000	0	$0
Decontamination Operations and Equipment	Month	$50,000	0	$0
Off-site Disposal of Soil and Steel Sheets	Ton	$50	0	$0
Geotextile Layer	SY	$2	216,832	$379,456
Compacted Clay Cover - Fill (Haul, Place, and Compact)	CY	$15	361,387	$5,420,800
Sand Cap (Purchase, Delivery, Placement, Monitoring)	CY	$64	0	$0
Vegetation	SY	$1	216,832	$162,624
Shoreline Plantings and other Trees	LS	$75,000	1	$75,000
Surveying	Day	$3,000	30	$90,000
Total CDF Closing				*$6,202,880*
Subtotal CDF Construction				**$206,106,508**
G. Construction Management	Percentage	8%	187,278,644	$14,982,291
TOTAL CDF CONSTRUCTION				**$221,088,799**

DMM Backup Sheets
Scenario 6A: On-Site Thermal Treatment
Focused Feasibility Study
Lower Passaic River Restoration Project

Component		Unit	Unit Cost	# of Units	Cost
A.	**Pre-Construction Activities**				
	Design	Percentage	8%		$0
	Permitting (Equivalency), and Legal	Percentage	2%		$0
	Total Pre-Construction Activities				*$0*
B.	**Dredged Material Treatment**				
	Mobilization/Demobilization	LS	$25,000	0	$0
	Sediment Removal and Loading onto Trucks	CY	$8	0	$0
	Transport to Thermal Treatment Area	CY	$4	0	$0
	Dredged Material Off-Loading to Filter Press	CY	$6	0	$0
	Mechanical Sediment Dewatering	Ton	$40	0	$0
	Water Treatment	Gallon	$0.04	0	$0
	Discharge to POTW	Gallon	$0.02	0	$0
	On-Site Thermal Treatment	Ton	$80	0	$0
	Sediment Processing Site	Acre	$500,000	0	$0
	Total Dredged Material Treatment				*$0*
	Subtotal On-Site Thermal Treatment				**$0**
C.	**Construction Management**	Percentage	8%		**$0**
	TOTAL ON-SITE THERMAL TREATMENT				**$0**

DMM Backup Sheets
Scenario 6B: Total DMM Costs
Focused Feasibility Study
Lower Passaic River Restoration Project

Component		Cost
DMM COSTS		
6B-1	Site Characterization[1]	$1,489,800
6B-2	Starter Cell Construction	$56,542,704
6B-3	Sub-grade Cell Construction	$148,647,802
6B-4	CDF Construction	$253,246,493
6B-5	On-Site Thermal Treatment	$247,319,333
	Subtotal DMM Costs	**$707,246,132**
	Contingency (20%)	$141,449,226
	TOTAL DMM COSTS	**$848,695,358**

Notes:

[1]Site Characterization limited to geotechnical investigation of proposed starter cell and CDF areas.

DMM Backup Sheets
Scenario 6B: Site Characterization
Focused Feasibility Study
Lower Passaic River Restoration Project

Component	Unit	Unit Cost	# of Units	Cost
A. Labor				
Barge-Auger Mobilization	LS	$10,000	1	$10,000
Auger Drilling and Sampling	Day	$6,500	80	$520,000
Undisturbed Sample Collection	Sample	$400	240	$96,000
Bathymetric Survey	Day	$6,500	4	$26,000
Field Oversight	Day	$2,640	100	$264,000
Reporting	Day	$3,080	120	$369,600
Project Management	Week	$1,600	26	$41,600
Drilling Permits and Work Plans	LS	$50,000	1	$50,000
Total Labor				$1,377,200
B. Disbursements				
Geotechnical Tests	Percentage	10%		$62,600
Drillers/ Surveyors Sustenance	Day	$500	100	$50,000
Total Disbursements				$112,600
TOTAL SITE CHARACTERIZATION COSTS				**$1,489,800**

DMM Backup Sheets
Scenario 6B: Starter Cell Construction
Focused Feasibility Study
Lower Passaic River Restoration Project

Component	Unit	Unit Cost	# of Units	Cost
A. Pre-Construction Activities				
Design	Percentage	8%		$3,826,624
Contractor Work Plans	LS	$100,000	1	$100,000
Permitting (Equivalency), and Legal	Percentage	2%		$956,656
Total Pre-Construction Activities				*$4,883,280*
B. Inner Sheetpile Wall Construction				
Mobilization/Site Clean-up/Demobilization	LS	$100,000	1	$100,000
Surveying	Day	$3,000	40	$120,000
Waterloo Sheet Piles (Material Cost)	SF	$31	288,000	$8,784,000
Walers	LF	$50	9,600	$480,000
Installation Costs				
Crane and Crew - with driving head	SF	$12	288,000	$3,456,000
Water Side Installation Vessels	Day	$3,500	137	$480,000
Walers Installation	Day	$1,800	50	$90,000
Total Inner Sheetpile Wall Construction				*$13,510,000*
C. Outer Bulkhead Wall Construction				
Waterloo Sheet Piles (Material Cost)	SF	$31	485,000	$14,792,500
Walers	LF	$50	9,700	$485,000
Deadman Tiebacks and Connectors	Tieback	$2,000	1,213	$2,425,000
Bumpers - Outside of Bulkhead	LF	$18	4,850	$87,300
Backfill Between inner and outer walls - Materials and installation	CY	$32	315,250	$10,088,000
Installation Costs - Water Side				
Crane and Crew - with driving head	SF	$12	485,000	$5,820,000
Water Side Installation Vessels	Day	$3,500	139	$485,000
Walers, Deadmen, and Bumpers Installation	Day	$2,000	70	$140,000
Total Outer Bulkhead Wall Construction				*$34,322,800*
Subtotal Starter Cell Construction				**$52,716,080**
D. Construction Management	Percentage	8%		**$3,826,624**
TOTAL STARTER CELL CONSTRUCTION				**$56,542,704**

DMM Backup Sheets
Scenario 6B: Sub-grade Cell Construction
Focused Feasibility Study
Lower Passaic River Restoration Project

Component	Unit	Unit Cost	# of Units	Cost
A. Pre-Construction Activities				
Design	Percentage	8%		$10,077,817
Permitting (Equivalency), and Legal	Percentage	2%		$2,519,454
Total Pre-Construction Activities				*$12,597,271*
B. Sediment Veneer Dredging				
Mobilization/Site Clean-up/Demobilization	LS	$461,200	1	$461,200
Debris Removal	Ton	$300	500	$150,000
Environmental Dredging	CY	$25	693,733	$17,343,333
Barge Transport of Dredge Material	CY	$5	867,167	$4,335,833
Dredged Material Off-Loading	CY	$7	867,167	$6,070,167
Testing and Monitoring	Month	$220,440	6	$1,322,640
Total Sediment Veneer Dredging				*$29,683,173*
C. Dredging Sub-grade cell				
Mobilization/Site Clean-up/Demobilization	LS	$800,000	1	$800,000
Debris Removal	Ton	$300	1,000	$300,000
Dredging/Transport/Dump	CY	$15	6,257,793	$93,866,900
Testing and Monitoring	Month	$220,440	6	$1,322,640
Total Dredging Sub-grade cell				*$96,289,540*
Subtotal Sub-grade Cell Construction				**$138,569,985**
D. Construction Management	Percentage	8%		$10,077,817
TOTAL SUB-GRADE CELL CONSTRUCTION				**$148,647,802**

DMM Backup Sheets
Scenario 6B: CDF Construction
Focused Feasibility Study
Lower Passaic River Restoration Project

Component		Unit	Unit Cost	# of Units	Cost
A.	**Pre-Construction Activities**				
	Design	Percentage	8%	214,530,926	$17,162,474
	Contractor Work Plans	LS	$100,000	1	$100,000
	Permits	Percentage	2%	214,530,926	$4,290,619
	Total Pre-Construction Activities				*$21,553,093*
B.	**Inner Sheetpile Wall Construction**				
	Mobilization/Site Clean-up/Demobilization	LS	$400,000	1	$400,000
	Surveying - Assume 1/4 time required	Day	$3,000	68	$202,500
	Waterloo Sheet Piles (Material Cost)	SF	$31	504,000	$15,372,000
	Walers	LF	$50	12,600	$630,000
	Installation Costs				
	Crane and Crew - with driving head	SF	$12	504,000	$6,048,000
	Four Barges, two boats, tug boat	Day	$6,500	90	$585,000
	Crew for Attaching Walers	Day	$1,800	80	$144,000
	Total Inner Sheetpile Wall Construction				*$23,381,500*
C.	**Outer Bulkhead Wall Construction**				
	Waterloo Sheet Piles (Material Cost)	SF	$31	889,000	$27,114,500
	Additional Cost for 70' Sheet Piles	SF	$2	889,000	$1,778,000
	Walers	LF	$50	12,700	$635,000
	Deadman Tiebacks and Connectors	Tieback	$2,000	1,588	$3,175,000
	Bumpers - Outside of Bulkhead	LF	$18	7,250	$130,500
	Backfill Between inner and outer walls - Materials and installation	CY	$32	13,426	$429,630
	Installation Costs - Water Side				
	Crane and Crew - with driving head	SF	$12	889,000	$10,668,000
	Four Barges, two boats, tug boat	Day	$6,500	190	$1,234,807
	Crew for Attaching Walers, Deadmen, and Bumpers	Day	$2,000	90	$180,000
	Water Barrier	Boom	$250,000	3	$750,000
	Total Outer Bulkhead Wall Construction				*$46,095,436*
D.	**Water Treatment**				
	Mobilization/Demobilization	LS	$360,000	1	$360,000
	Treatment Plant	LS	$1,500,000	1	$1,500,000
	Piping to Plant	LS	$150,000	1	$150,000
	Water Treatment	Gallon	$0.04	2,035,197,307	$81,407,892
	Testing	Week	$10,000	520	$5,200,000
	Subtotal Water Treatment				*$88,617,892*
E.	**CDF Operations**				
	Monitoring Wells	Well	$750	85	$63,750
	Spreading Starter Cell Mount into CDF	CY	$2	0	$0
	Operation of CDF (including Starter Cell)	LS	$22,894,000	1	$22,894,000
	Total CDF Operations				*$22,957,750*
F.	**CDF Closing**				
	Mobilization/Site Clean-up/Demobilization	LS	$75,000	1	$75,000
	Inner Sheetpile Wall Removal	LF	$150	22,200	$3,330,000
	Removal of Backfill Between Walls	CY	$14	13,426	$187,963
	Outer Sheetpile Wall Removal	LF	$250	22,400	$5,600,000
	Decontamination Pad Construction	LS	$90,000	1	$90,000
	Decontamination Operations and Equipment	Month	$50,000	3	$150,000
	Off-site Disposal of Soil and Steel Sheets	Ton	$50	12,219	$610,969
	Geotextile Layer	SY	$2	216,832	$379,456
	Compacted Clay Cover - Fill (Haul, Place, and Compact)	CY	$15	0	$0
	Sand Cap (Purchase, Delivery, Placement, Monitoring)	CY	$64	361,387	$22,964,960
	Vegetation	SY	$1	0	$0
	Shoreline Plantings and other Trees	LS	$75,000	0	$0
	Surveying	Day	$3,000	30	$90,000
	Total CDF Closing				*$33,478,348*
	Subtotal CDF Construction				**$236,084,019**
G.	**Construction Management**	Percentage	8%	214,530,926	$17,162,474
	TOTAL CDF CONSTRUCTION				**$253,246,493**

DMM Backup Sheets
Scenario 6B: On-Site Thermal Treatment
Focused Feasibility Study
Lower Passaic River Restoration Project

Component		Unit	Unit Cost	# of Units	Cost
A.	**Pre-Construction Activities**				
	Design	Percentage	8%		$16,767,412
	Permitting (Equivalency), and Legal	Percentage	2%		$4,191,853
	Total Pre-Construction Activities				*$20,959,266*
B.	**Dredged Material Treatment**				
	Mobilization/Demobilization	LS	$25,000	1	$25,000
	Sediment Removal and Loading onto Trucks	CY	$8	1,907,767	$15,262,133
	Transport to Thermal Treatment Area	CY	$4	1,907,767	$7,631,067
	Dredged Material Off-Loading to Filter Press	CY	$6	1,907,767	$11,446,600
	Mechanical Sediment Dewatering	Ton	$40	1,907,767	$76,310,667
	Water Treatment	Gallon	$0.04	225,116,467	$9,004,659
	Discharge to POTW	Gallon	$0.02	225,116,467	$3,601,863
	On-Site Thermal Treatment	Ton	$80	953,883	$76,310,667
	Sediment Processing Site	Acre	$500,000	20	$10,000,000
	Total Dredged Material Treatment				*$209,592,655*
	Subtotal On-Site Thermal Treatment				**$230,551,921**
C.	**Construction Management**	Percentage	8%		**$16,767,412**
	TOTAL ON-SITE THERMAL TREATMENT				**$247,319,333**