APPENDIX A

RECORD OF DECISION

Lower 8.3 Miles of the Lower Passaic River
Part of the Diamond Alkali Superfund Site
Essex and Hudson Counties, New Jersey

U.S. Environmental Protection Agency
Region II
New York, New York
March 3, 2016

396055

DECLARATION FOR THE RECORD OF DECISION

SITE NAME AND LOCATION

Diamond Alkali Superfund Site
Essex and Hudson Counties, New Jersey
Operable Unit Two (OU2): Lower 8.3 Miles of the Lower Passaic River
Superfund Site Identification Number: NJD980528996

STATEMENT OF BASIS AND PURPOSE

This Record of Decision (ROD) presents the selected remedy to address contaminated sediments found in the lower 8.3 miles of the Lower Passaic River, a part of the Diamond Alkali Superfund Site. This action addresses the Lower Passaic River in Essex and Hudson Counties, from the river's confluence with Newark Bay to River Mile (RM) 8.3 near the border between the City of Newark and Belleville Township, New Jersey. The lower 8.3 miles of the Lower Passaic River comprise OU2 of the Site, also referred to in the Proposed Plan as the Focused Feasibility Study Area (FFS Study Area). The selected remedy was chosen by the U.S. Environmental Protection Agency (EPA) in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended, 42 U.S.C. §§9601-9675, and, to the extent practicable, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). This decision is based on the Administrative Record file for this Site (see Appendix III).

The New Jersey Department of Environmental Protection (NJDEP) was consulted on the remedy for sediments of the lower 8.3 miles of the Lower Passaic River in accordance with CERCLA §121(f), 42 U.S.C. §9621(f), and it concurs with the selected remedy (see Appendix IV). In addition, EPA and NJDEP have consulted with the U.S. Army Corps of Engineers (USACE), National Oceanic and Atmospheric Administration (NOAA) and U.S. Fish and Wildlife Service (USFWS), key federal stakeholders in the Lower Passaic River, Newark Bay and New York-New Jersey Harbor Estuary.

ASSESSMENT OF THE SITE

Actual or threatened releases of hazardous substances from the Site, if not addressed by implementing the response action selected in this ROD, may present an imminent and substantial endangerment to public health, welfare, or the environment.

DESCRIPTION OF THE SELECTED REMEDY

The response action selected in this ROD addresses the risks associated with the contaminated sediments of the lower 8.3 miles of the Lower Passaic River. EPA is selecting a remedy for the lower 8.3 miles that is a final action for the sediments and an interim action for the water column. It represents the second of four planned remedial actions for the Site. The first operable unit (OU1) addressed, through an interim remedy, contaminated soils, groundwater and materials at the former Diamond Alkali facility at 80-120 Lister Avenue in Newark, New Jersey. The third operable unit (OU3) will comprehensively address the 17 miles of the Lower Passaic River Study Area (LPRSA); a remedial investigation and feasibility study (RI/FS) for OU3 will serve as the basis for selecting a remedy for the sediments above RM 8.3 and a river-wide remedy for surface water. The fourth operable unit (OU4) will address the Newark Bay Study Area.

The major components of this selected remedy include the following:

- An engineered cap will be constructed over the river bottom of the lower 8.3 miles, except in areas where backfill may be placed because all contaminated fine-grained sediments have been removed. The engineered cap will generally consist of two feet of sand and may be armored where necessary to prevent erosion of the sand.

- Before the engineered cap is installed, the river will be dredged bank to bank (approximately 3.5 million cubic yards) so that the cap can be placed without increasing the potential for flooding. Depth of dredging is estimated to be 2.5 feet, except in the 1.7 miles of the federally authorized navigation channel closest to Newark Bay.

- The remedy will include sufficient dredging and capping to allow for the continued commercial use of a federally authorized navigation channel in the 1.7 miles of the river closest to Newark Bay and to accommodate reasonably anticipated future recreational use above RM 1.7.

- Dredged materials will be barged or pumped to a sediment processing facility in the vicinity of the Lower Passaic River/Newark Bay shoreline for dewatering. Dewatered materials will be transported to permitted treatment facilities and landfills in the United States or Canada for disposal.

- Mudflats dredged during implementation of the remedy will be covered with an engineered cap consisting of one foot of sand and one foot of mudflat reconstruction (habitat) substrate.

- Institutional controls will be implemented to protect the engineered cap. In addition, New Jersey's existing prohibitions on fish and crab consumption will remain in place and will be enhanced with additional community outreach to encourage greater awareness of the prohibitions until the concentrations of contaminants of concern (COCs) in fish and crab tissue reach protective concentrations corresponding to remediation goals. EPA will share the data and consult with NJDEP about whether the prohibitions on fish and crab consumption can be lifted or adjusted to allow for increased consumption as contaminant levels decline.

- Long-term monitoring and maintenance of the engineered cap will be required to ensure its stability and integrity. Long-term monitoring of fish, crab and sediment will also be performed to determine when interim remediation milestones, remediation goals and remedial action objectives are reached. Other monitoring, such as water column sampling, will also be performed.

In the Proposed Plan, EPA specifically requested public comments on two aspects of its preferred alternative, dredged material management (DMM) scenarios and dredging depths for the federally authorized navigation channel. Three scenarios for dredged material management were under consideration: confined aquatic disposal (CAD) in Newark Bay; off-site disposal with treatment as necessary; and local decontamination and beneficial use. The navigation channel issue addressed whether shallower depths than those incorporated into the preferred alternative might accommodate reasonably anticipated future uses in the lower 2.2 miles of the river. As discussed in the Decision Summary, the comments received on the navigation channel depths led EPA to adjust the preferred alternative identified in the Proposed Plan.

DECLARATION OF STATUTORY DETERMINATIONS

Part 1: Statutory Requirements

The selected remedy is protective of human health and the environment, complies with Federal and State requirements that are applicable or relevant and appropriate to the remedial actions (unless justified by a waiver), is cost effective, and uses permanent solutions and treatment technologies to the maximum extent practicable.

Part 2: Statutory Preference for Treatment

Although CERCLA §121(b) expresses a preference for selection of remedial actions that use permanent solutions and treatment technologies to the maximum extent practicable, there are situations that may limit the use of treatment, including when treatment technologies are not technically feasible or when the extraordinary size or complexity of a site makes implementation of treatment technologies impracticable. The selected remedy would generate approximately 3.5 million cubic yards of contaminated sediments, which is clearly an extraordinary volume of materials; and the sediment treatment technologies investigated under Dredged Material Management Scenario C (Local Decontamination and Beneficial Use) have not been constructed or operated in the United States on a scale approaching the capacity needed for this project, so their technical ability to handle such an extraordinary volume of highly contaminated sediments is uncertain. The selected remedy is estimated to provide treatment of approximately 130,000 cubic yards of contaminated sediment through incineration (the only technology available at this time) off-site to comply with applicable Resource Conservation and Recovery Act (RCRA) standards.

Part 3: Five-Year Review Requirements

The selected remedy will result in hazardous substances, pollutants or contaminants remaining above levels in sediments that allow for unlimited use and unrestricted exposure. Therefore, statutory reviews will be conducted every five years after the initiation of the remedial action to ensure the remedy continues to provide adequate protection of human health and the environment.

DATA CERTIFICATION CHECKLIST

The following information is included in the Decision Summary section of this ROD. Additional information can be found in the Administrative Record file for this Site.

- COCs and their respective concentrations are in Section 5, "Summary of Site Characteristics."

- Baseline risks for human health and the environment represented by the COCs are in Section 7, "Summary of Site Risks."

- Cleanup levels established for COCs and the basis for these levels are in Section 8, "Remedial Action Objectives."

- Current and reasonably anticipated future use assumptions used in the baseline risk assessment and ROD are in Section 6, "Current and Potential Future Site and Resource Uses."

- Estimated capital, operation and maintenance (O&M), and total present value costs, discount rate, and the number of years over which the remedy cost estimates are projected are in Section 10.7, "Cost."

- Key factors that led to selecting the remedy (i.e., how the selected remedy provides the best balance of tradeoffs with respect to the balancing and modifying criteria, highlighting criteria key to the decisions) are in Section 10, "Comparative Analysis of Alternatives," and Section 13, "Statutory Determinations."

AUTHORIZING SIGNATURE:

Walter E. Mugdan

Walter E. Mugdan, Director
Emergency & Remedial Response Division
U.S. Environmental Protection Agency, Region 2

March 3, 2016
Date

DECISION SUMMARY

Lower 8.3 Miles of the Lower Passaic River
Part of the Diamond Alkali Superfund Site
Essex and Hudson Counties, New Jersey

U.S. Environmental Protection Agency
Region II
New York, New York
March 3, 2016

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<u>Appendices</u>

1. SITE NAME, LOCATION AND BRIEF DESCRIPTION

The Diamond Alkali Site, U.S. Environmental Protection Agency (EPA) ID# NJD980528996, consists of the former Diamond Alkali facility at 80-120 Lister Avenue in Newark, New Jersey, the Lower Passaic River Study Area (LPRSA), the Newark Bay Study Area and the areal extent of contamination. The LPRSA is located in (flows through) Essex, Hudson, Passaic and Bergen Counties (see Figure 1 in Appendix I). This Record of Decision (ROD) addresses the risks associated with contaminated sediments of the lower 8.3 miles of the LPRSA, which was also referred to in the Proposed Plan as the Focused Feasibility Study Area (FFS Study Area).

The lower 8.3 miles of the Lower Passaic River in northeastern New Jersey extends from the river's confluence with Newark Bay at River Mile (RM) 0 to RM 8.3 near the border between the City of Newark and Belleville Township. The lower 8.3 miles of the Lower Passaic River is part of the LPRSA, which is the 17-mile, tidal portion of the Passaic River, from RM 0 to Dundee Dam (RM 17.4), and its watershed, including the Saddle River (RM 15.6), Third River (RM 11.3) and Second River (RM 8.1). (See Figure 1.)

The 17-mile LPRSA, which is the subject of an ongoing study, is bounded at the upper end by the Dundee Dam, which isolates the Upper Passaic River from the tidal mixing of sediments that influences the lower portions of the river, and at the lower end by the confluence of the Lower Passaic River and Newark Bay. Within the Lower Passaic River, the sediments of the lower 8.3 miles have been identified as a major source of contamination to the rest of the Lower Passaic River and Newark Bay. Unlike rivers that flow in one direction, the tides in the Lower Passaic River move water and suspended sediments back and forth twice a day, meaning that there is no flow-based starting point for cleanup. This supports addressing the most highly contaminated areas first within an overall remediation framework. For these reasons, EPA completed the lower 8.3-mile remedial investigation and focused feasibility study (RI/FFS) to evaluate taking action to address these sediments, while the comprehensive study of the 17-mile LPRSA is completed.

The sediments of the lower 8.3 miles of the Lower Passaic River pose an unacceptable risk to human health and the environment due to the presence of a variety of contaminants, most of which stay in the environment for a long time and bioaccumulate in fish and crab. These contaminants include polychlorinated dibenzo-*p*-dioxins and furans (dioxins and furans), polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), Total DDx[1] and other pesticides, mercury, lead and other metals.

The lower 8.3 miles of the Lower Passaic River are located in a highly developed urban area, with approximately 1.4 million people living in Essex County (west bank) and Hudson County (east bank). At the mouth of the river (RM 0) and around Newark Bay, the near-shore land uses

[1] DDT is a common name that refers to an industrially produced, chlorinated pesticide, dichlorodiphenyl-trichloroethane. DDT breaks down in the environment to form 4,4'-dichlorodiphenyldichloroethane (DDD) and 4,4'-dichlorodiphenyldichloroethylene (DDE). The term Total DDx used in this document refers to the sum of DDT, DDD and DDE concentrations.

are commercial and industrial, in part to take advantage of the transportation infrastructure (rail, air and marine). Farther upriver, beginning near RM 4, commercial uses of near-shore properties begin to be mixed with more residential and recreational uses as well. There are narrow bands of park and open space along the river, surrounded by commercial and dense urban residential development. Near RM 7, there are marinas and boat launches along with park land surrounded by more suburban residential neighborhoods. Hard shorelines, such as bulkhead and riprap (some with overhanging vegetation) make up approximately 95 percent of the banks of the lower 8.3 miles, while aquatic vegetation predominates along about 5 percent of the banks. Approximately 100 acres of the 650-acre lower 8.3 miles consist of mudflats. Intertidal mudflats and the associated shallow-water subtidal areas are important habitats for estuarine organisms, providing valuable foraging habitat for fish, blue crab and waterbirds.

The Lower Passaic River has a federally authorized navigation channel which, when it was first constructed in the 1880s, extended to RM 8.1. It was expanded to its maximum length, to RM 15.4, in 1915, with depths ranging from 30 feet (from RM 0 to RM 2.6) to 10 feet at the farthest upstream reaches. After construction, the U.S. Army Corps of Engineers (USACE) dredged the channel regularly to maintain navigation and prevent infilling with sediments. The channel below RM 1.9 was regularly maintained until 1983. The channel above RM 1.9 was dredged periodically through the 1950s, with one segment maintained as late as 1976 (from RM 9.0 to RM 10.2).

As maintenance dredging declined and eventually stopped, this channel filled with sediments. At the same time, industries and municipalities disposed of wastewaters in the river. The coincidence of chemical disposal in the river and the filling-in of the navigation channel created ideal conditions for the accumulation of contaminated sediments in the Lower Passaic River (see Section 5.3 for further discussion).

The Lower Passaic River's cross-sectional area declines steadily moving upstream from RM 0 to RM 17.4, with a pronounced constriction at RM 8.3 (see Figure 2). At that location, there is also a pronounced change in sediment texture. The river bed below RM 8.3, from bank to bank, is dominated by fine-grained sediments (primarily silts) with pockets of coarser sediments (sand and gravel). Above RM 8.3, the river bed is dominated by coarser sediments with smaller areas of fine-grained sediments, often located outside the channel. About 85 percent of the fine-grained sediment surface area of the Lower Passaic River bed is located below RM 8.3 and, by volume, about 90 percent of fine-grained sediments in the Lower Passaic River are located below RM 8.3. Due to a combination of a wider cross-section and a deeper navigation channel below RM 8.3 (16 to 30 feet) than above RM 8.3 (10 feet), thicker and wider beds of contaminated sediments accumulated below RM 8.3 than above it. The total estimated inventory of contaminated fine-grained sediments in the lower 8.3 miles (surface and deeper sediments combined) is approximately 9.7 million cubic yards (cy).

The contaminants of concern (COCs), discussed in Section 5.2, tend to bind tightly to fine-grained sediment particles. Therefore, the majority of the contamination tends to be found in areas that are predominantly comprised of fine-grained sediments which, for the Lower Passaic River, are the lower 8.3 miles.

2. SITE HISTORY AND ENFORCEMENT ACTIVITIES

The Passaic River was one of the major centers of the American industrial revolution starting two centuries ago. Early manufacturing, particularly textile mills, developed in the area around Great Falls in the city of Paterson, which is eight miles upriver of the Dundee Dam. The Dundee Dam, constructed along with a canal and locks in the mid-nineteenth century on top of an earlier dam, was originally conceived to provide water power to nearby businesses, supporting further industrialization along the banks of the river. By the end of the nineteenth century, a multitude of industrial operations, such as manufactured gas plants, paper manufacturing and recycling facilities, petroleum refineries, shipping, tanneries, creosote wood preservers, metal recyclers and manufacturers of materials such as rubber, rope, textiles, paints and dyes, pharmaceuticals and chemicals, had located along the river's banks as cities such as Newark and Paterson grew. Industrial operations and municipalities used the river for wastewater disposal. To date, over 100 industrial facilities have been identified as potentially responsible for discharging contaminants into the river including, but not limited to, dioxins and furans, PCBs, PAHs, DDT and other pesticides, mercury, lead and other metals.

Along with the Dundee Dam, which physically isolates Dundee Lake and the upper river from lower river influences, another defining component of the development and urbanization of the Lower Passaic River was the construction of a navigable channel for commercial vessels. Between 1884 and 1915, dredging projects authorized by Congress and constructed by USACE created a federally authorized navigation channel from RM 0 to RM 15.4 (at Wallington, New Jersey). Further deepening of the channel was authorized by Congress in 1930.[2] In 1932, the navigation channel was constructed to its maximum dredged depth: 30 feet from RM 0 to RM 2.6; 20 feet from RM 2.6 to RM 4.6; 16 feet from RM 4.6 to RM 8.1; and 10 feet from RM 8.1 to RM 15.4. USACE performed dredging to maintain the channel through the 1950s above RM 1.9 and until 1983 below RM 1.9. Further details of the federally authorized navigation channel can be found in Section 6.

2.1. Superfund History

The Lower Passaic River is a part of the Diamond Alkali Superfund Site. EPA's response at the Site began at a former manufacturing facility located at 80-120 Lister Avenue in Newark, New Jersey, at RM 3.4. Manufacturing of DDT and other products began at this facility in the 1940s. In the 1950s and 1960s, the facility was operated by the Diamond Alkali Company (later purchased by and merged into Occidental Chemical Corporation, or OCC). Between March 1951 and August 1969, the Diamond Alkali Company manufactured the chemical 2,4,5-trichlorophenol (2,4,5-TCP) and the herbicides 2,4-dichlorophenoxyacetic acid (2,4-D) and 2,4,5-trichlorophenoxyacetic acid (2,4,5-T), ingredients in the defoliant "Agent Orange." A by-

[2] Rivers and Harbors Act of 1930, Pub. L. 520.

product of the manufacturing was 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (2,3,7,8-TCDD), the most toxic form of dioxin. These substances have all been found in Lower Passaic River sediment and fish/crab tissue.

2.1.1. Preliminary Actions

Based on investigations by NJDEP and EPA, the Diamond Alkali Site was placed on the National Priorities List in 1984. After further investigations and several emergency response actions that addressed dioxin found on nearby properties, EPA issued a ROD in 1987 to select an interim containment remedy for the Lister Avenue facility. The remedy consisted of capping, subsurface slurry walls, and a groundwater collection and treatment system to prevent exposure to contaminated soil (that originated at the facility and that was brought back to the facility from neighboring lots), and prevent further releases to the river.

Construction of the remedy at the 80-120 Lister Avenue facility was carried out by OCC and the owner of the facility, Chemical Land Holdings, Inc., now Tierra Solutions, Inc. (Tierra), under EPA oversight. Construction was completed in 2001. Maintenance of the facility is performed by Tierra on OCC's behalf, under EPA oversight. EPA performs periodic reviews of the remedy.

2.1.2. The Six-Mile Study

In 1994, OCC agreed to an administrative order on consent (AOC) with EPA to investigate a six-mile stretch of the Lower Passaic River (RM 1 to RM 7), with the work performed by Tierra on OCC's behalf. This investigation found COCs that originated from the Diamond Alkali facility, in particular, 2,3,7,8-TCDD and pesticides, throughout the six miles, with the highest concentrations adjacent to the 80-120 Lister Avenue facility. This investigation also found many other COCs not clearly linked to Diamond Alkali's operations, and indicated that contaminated sediments moved into and out of the six-mile stretch, leading to the conclusion that a more comprehensive study was required. In 2002, EPA expanded the scope of the investigation to include the entire 17-mile Lower Passaic River.

2.1.3. The 17-Mile Study

While working with OCC and Tierra on the Lister Avenue facility and the first studies of the river, EPA also identified other potentially responsible parties (PRPs) for the Lower Passaic River. A number of companies that owned or operated facilities from which hazardous substances were potentially discharged to the river formed the Cooperating Parties Group (CPG). In 2004, EPA signed a settlement agreement with CPG members in which the settling parties agreed to pay for EPA to perform the 17-mile LPRSA remedial investigation and feasibility study (RI/FS). The settlement agreement was amended in 2005 and 2007, adding more parties to reach a total of over 70 settling parties. From 2004 to 2007, EPA investigated contamination in sediments and water of the Lower Passaic River, and investigated the major tributaries, combined sewer overflows (CSOs) and stormwater outfalls (SWOs) to the river. In 2007, CPG members entered into a new AOC with EPA, in which the settling parties agreed to take over the performance of the 17-mile LPRSA RI/FS from EPA. Since 2007, the membership of the CPG has continued to change. EPA understands that some of the settling parties that signed the AOC are no longer members of the CPG and, also, that the CPG may include members that are not signatories to the AOC.

The CPG performed sampling for the RI between 2008 and 2014, and has submitted to EPA draft human health and ecological risk assessments, and draft RI and FS reports. These documents are currently under review. While EPA cannot predict with precision the timing for completion of the 17-mile LPRSA RI/FS, selection of a remedy for the 17-mile LPRSA likely will not occur before 2017. However, the lower 8.3-mile RI/FFS prepared by EPA to support this ROD did incorporate data collected by EPA and the CPG for the 17-mile LPRSA RI/FS, among other datasets, and EPA has shared its lower 8.3-mile findings with the CPG to support the 17-mile RI/FS.

2.1.4. The Newark Bay Study

In 2004, EPA and OCC signed an AOC in which OCC agreed to conduct a separate RI/FS of the Newark Bay Study Area (Newark Bay and portions of the Hackensack River, Arthur Kill and Kill van Kull), investigating the extent of dioxin contamination and co-located contaminants, under EPA oversight. As with the 1994 agreement, Tierra is performing the work on OCC’s behalf. This study of Newark Bay is ongoing.

2.1.5. The Tierra Removal

In June 2008, EPA, OCC and Tierra signed an AOC for a non-time-critical removal action to remove 200,000 cy of contaminated sediment from the river (from RM 3.0 to RM 3.8) adjacent to the 80-120 Lister Avenue facility. This action is referred to as the "Tierra Removal." Sediment at depth adjacent to the facility has been found to have the highest levels of 2,3,7,8-TCDD measured in the river. Dredging, dewatering and transport off site of the first 40,000 cy of sediment (known as Phase 1 of the Tierra Removal) was completed in 2012. The AOC contemplates that Phase 2 (160,000 cy) will undergo a separate engineering study and proposal that will be submitted to the public for review and comment at a later date. In 2015, Tierra, on behalf of OCC, collected additional samples in the Phase 2 area. As of the date of this ROD, EPA and OCC are in discussions with respect to Phase 2. Both phases of this removal action are considered “source removal” projects.

2.1.6. The RM 10.9 Removal

In June 2012, EPA and the CPG signed an AOC for a time-critical removal action to address the risks posed by high concentrations of dioxins, PCBs and other contaminants found at the surface of a mudflat on the east bank of the river at RM 10.9 in Lyndhurst, New Jersey. This action is referred to as the "RM 10.9 Removal." The action involved placing an engineered cap over contaminated sediments, thereby reducing exposure and preventing migration of the contamination to other parts of the river. In order to ensure that the action did not exacerbate flooding, a sufficient volume of surface sediments was first dredged from the area to make space for the cap. The CPG began work in 2013 and substantially completed it in 2014, with the exception of a relatively small area of contaminated sediments located above a utility pipeline that runs under the river. An investigation of this area is ongoing. The AOC also required a Long Term Monitoring Plan, which, as of the date of this ROD, has not been completed. This time-critical removal action is not a final remedy; a final decision for the RM 10.9 Removal area will be made by EPA as part of the 17-mile LPRSA ROD.

2.1.7. The Lower 8.3-Mile Study

Concurrent with these river studies and removal actions, EPA concluded that since the lower 8.3 miles of the river contain the bulk of the contaminated sediment which is the source of most of the risk associated with the Lower Passaic River, addressing this portion of the river first would better support the overall protection of human health and the environment than would awaiting the outcome of the 17-mile LPRSA RI/FS to make a decision for the entire Lower Passaic River. Because about 90 percent of the fine-grained (and, therefore, more heavily contaminated) sediment is below RM 8.3, EPA undertook a targeted RI and FFS of the lower 8.3 miles, which led to this ROD. The nature and extent of the contamination in the lower 8.3 miles of the Lower Passaic River and the remedial alternatives summarized in this ROD are described in greater detail in two documents: the *Remedial Investigation Report for the Focused Feasibility Study of the Lower Eight Miles of the Lower Passaic River* (RI Report) and the *Focused Feasibility Study Report for the Lower Eight Miles of the Lower Passaic River* (FFS Report). Both documents are available in the Administrative Record.

2.1.8. The Lower Passaic River Restoration Project

In 2002, at the time that the 17-mile LPRSA RI/FS was being developed, EPA also formed a partnership with USACE, the State of New Jersey, the National Oceanic and Atmospheric Administration (NOAA) and U.S. Fish and Wildlife Service (USFWS) [referred to as "the Partner Agencies"], to conduct a joint study that would bring each agency's authorities to bear on the complex environmental problems of the Lower Passaic River. The goal of the Lower Passaic River Restoration Project is to remediate contaminated sediments, improve water quality, restore degraded shorelines, restore and create new habitats and enhance human use along the 17-mile Lower Passaic River and in several tributaries from Dundee Dam near Garfield, to Newark Bay. Actions by EPA to address contaminated sediments under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended, is one aspect of the Project.

3. HIGHLIGHTS OF COMMUNITY PARTICIPATION

The Diamond Alkali Site has generated a high level of public interest since it was first identified, beginning with EPA's actions in the 1980s to remove dioxins from the neighborhoods around the Lister Avenue facility, which is located in the Ironbound section of Newark, a community that has experienced a number of other negative environmental consequences from multiple industrial and commercial operations, giving rise to environmental justice concerns. With the expansion of the scope of the project to encompass the 17-mile tidal portions of the river and Newark Bay, EPA's community outreach efforts have also expanded. A more detailed history of community involvement at the Site is provided in the *Lower Passaic River Restoration Project and Newark Bay Study Community Involvement Plan*, dated June 2006. In order to foster community involvement at the Site, beginning in 2004, EPA convened quarterly meetings with stakeholders including the Partner Agencies, municipalities, PRPs and other interested parties and members of the public called Project Delivery Team (PDT) meetings. At the PDT meetings, EPA reported on progress on various aspects of the Lower Passaic River investigation and cleanup work that was underway, including the focused study of the lower 8.3 miles of the river. In 2011, PDT meetings were replaced by Community Advisory Group (CAG) meetings.

In 2009, EPA facilitated the formation of a CAG, comprised of stakeholders with a broad range of interests. Representatives of EPA, NJDEP and the other Partner Agencies routinely attend CAG meetings, which are open to the public and generally held on a monthly basis, at which any stakeholder may be invited by the CAG chairs to share Diamond Alkali/Passaic River-related information with the community. In 2014, at the CAG's request, EPA provided the CAG with a Technical Assistance Services for Communities (TASC) contractor to respond to the CAG's technical questions related to the lower 8.3-mile RI/FFS.

In 2004, EPA awarded a Technical Assistance Grant (TAG) to the Passaic River Coalition (PRC) to assist the community in the interpretation of technical documents generated by the study of the Lower Passaic River, including the lower 8.3-mile RI/FFS. The PRC was the TAG recipient until 2013. In 2013, the New York/New Jersey Baykeeper applied for and was awarded the TAG, and continues to be the TAG recipient. The TAG advisor also provides technical assistance to the CAG.

EPA's early outreach efforts included alerting the public about New Jersey's prohibitions and advisories on fish and crab consumption for the tidal Passaic River and Newark Bay. Exposure to even low levels of contaminants through fish and crab consumption may have long-lasting health effects on people. The New Jersey prohibitions on fish and crab consumption are based on the levels of mercury, PCBs and dioxins in fish and crab. These contaminants can be especially harmful to women of childbearing age, pregnant women and nursing mothers. Children are also at risk of developmental and neurological problems if exposed to these chemicals. The NJDEP and New Jersey Department of Health have issued consumption advisories (available on the agencies' web sites) to guide anglers and other members of the public if fish and crab are harvested from within New Jersey State waters.

EPA's community participation responsibilities include soliciting community and stakeholder information, needs and opinions related to ongoing and reasonably anticipated future uses of the Lower Passaic River, including the lower 8.3 miles. EPA published an early draft FFS on its website in June 2007, inviting comment from any and all stakeholders. Written comments were submitted by the CPG, Sediment Management Workgroup, Ironbound Community Corporation, Natural Resources Defense Council and New York/New Jersey Baykeeper (jointly), Passaic

River Coalition, Biogenesis Enterprises, and Friends of the Passaic River. Further outreach efforts included convening PDT workgroup meetings to discuss formulating remedial alternatives, discussing current and future uses of the river with the CAG, convening a meeting of a broad range of stakeholders (from PRPs to municipal officials to environmental and community groups) in February 2011 to share views about remedial alternatives, discussing recreational uses of the river below Dundee Dam with rowing clubs, and consulting with USACE on current and future uses of the federally authorized navigation channel. This is discussed in more detail in Section 6.

While developing its remedial plan for the lower 8.3 miles of the Lower Passaic River, EPA's Region 2 office consulted with EPA's Contaminated Sediments Technical Advisory Group (CSTAG) and National Remedy Review Board (NRRB), each of which provides an opportunity for community participation. The work at the Diamond Alkali Site has been extensively reviewed by the CSTAG, a technical advisory group that monitors the progress of and provides advice regarding large, complex or controversial sediment sites being addressed by the Superfund program. For the February 2008 CSTAG meeting, eight stakeholder groups associated with the Site were invited to present to the CSTAG their views of how the Region had applied EPA's 11 sediment management principles (Office of Solid Waste and Emergency Response [OSWER] Directive 9285.6-08) to this project. Four invitees made presentations to the CSTAG, including the City of Newark, Ironbound Community Corporation, Passaic River Coalition, and CPG. Written comments were submitted by the CPG, Natural Resources Defense Council and New York/New Jersey Baykeeper (jointly), and Passaic River Coalition. The February 2008 CSTAG meeting and subsequent progress calls in 2009 were held during the development of the FFS for the lower 8.3 miles of the Lower Passaic River. In 2012, prior to the NRRB/CSTAG joint review of the lower 8.3-mile RI/FFS, EPA Region 2 prepared a summary of the RI/FFS that would be presented to the NRRB and CSTAG, so that stakeholders could provide meaningful input to the NRRB and CSTAG. Written comments were submitted to the NRRB and CSTAG by the Passaic River Coalition, Volcano Partners, Tierra, the New York/New Jersey Baykeeper, CPG, the CAG, the State of New Jersey, USACE, and the Ironbound Community Corporation.

The RI and FFS Reports for the lower 8.3 miles of the Passaic River, and EPA's Proposed Plan for remediation of this portion of the Site were released to the public for comment on April 11, 2014 via the web site www.ourPassaic.org. These documents were also made available to the public in the Administrative Record file maintained at the Newark Public Library, 5 Washington Street, Newark, New Jersey, the Elizabeth Public Library, 11 South Broad Street, Elizabeth, New Jersey, and in the EPA Region 2 Records Center at 290 Broadway, New York City. A notice of availability of the Administrative Record was published in the Star Ledger and Luso Americano on April 25, 2014. EPA also developed fact sheets summarizing the Proposed Plan in Spanish and Portuguese to support its outreach to those communities. In addition, select documents from the Administrative Record were made accessible online at:

http://www.ourPassaic.org
http://www.epa.gov/region02/superfund/npl/diamondalkali

A public comment period for the Proposed Plan and supporting documents was originally scheduled to extend from April 21, 2014 through June 20, 2014. EPA received requests to extend the public comment period to allow additional time for consideration of and comment on the Proposed Plan. In response to these requests, EPA extended the public comment period to July 21, 2014, then to August 20, 2014, at which time the comment period closed. EPA accepted comments by mail and also established a web mail box to accept emailed public comments.

In addition, EPA held a series of public meetings to present the findings of the RI, the FFS and EPA's Proposed Plan to the public, including local residents and officials, those who use the river for recreational or commercial purposes, and any other interested parties. Meetings were held in three communities: on May 7, 2014, at 7:00 pm at the Portuguese Sports Club, 55 Prospect Street, Newark, New Jersey; on May 21, 2014, at 6:00 pm at the Franklin School Auditorium, 100 Davis Avenue, Kearny, New Jersey; and on June 23, 2014, at 2:00 pm at the Belleville Senior Citizens Recreation Center, 125 Franklin Avenue, Belleville, New Jersey. At these meetings, representatives of EPA answered questions concerning the remedial alternatives developed as part of the FFS. Transcripts of these meetings are included in Appendix V of this ROD. Responses to comments received by EPA at these public meetings and in writing during the public comment period are included in the Responsiveness Summary (also in Appendix V).

Although not part of the formal public comment process, EPA also participated in two public forums, as follows: a "Morning Dialogue" on June 2, 2014, sponsored by Montclair State University to present information and answer questions about the RI/FFS and Proposed Plan from local government representatives; and a "Restoring Our River" forum on June 10, 2014, sponsored by the Ironbound Community Corporation to present information about the Proposed Plan to the local community. EPA also attended two Passaic River CAG meetings and a New York-New Jersey Harbor and Estuary Program Citizens Advisory Committee meeting, all open to the public, to present information and answer questions about the RI/FFS and Proposed Plan.

While EPA anticipated and accepted public comments on all of the alternatives discussed in the Proposed Plan, EPA sought public comments on two specific aspects of its preferred alternative: dredged material management (DMM) scenarios (choice of off-site disposal versus a confined aquatic disposal [CAD] site in Newark Bay) and navigational depths (whether shallower depths might accommodate reasonably anticipated future uses in the lower 2.2 miles of the river). The goal of this focused request for public comments was to ensure that community and stakeholder positions on these two issues and any new relevant information would be included in the Administrative Record and considered in the selection of the remedy. EPA's focused outreach occurred during its public meetings, but beyond these formal meetings (that are required under the Superfund statute), EPA also participated in a forum sponsored by the New Jersey Institute of Technology on July 22, 2014 that focused on dredged material disposal and navigation channel issues in the Proposed Plan.

EPA's assessment of the public comments solicited for the DMM scenarios and for the navigation depths are further discussed in Section 10.9.

4. SCOPE AND ROLE OF OPERABLE UNIT

As discussed in EPA's December 2005 *Contaminated Sediment Remediation Guidance for Hazardous Waste Sites*, EPA is employing three strategies to address the risks posed by the contamination at the Site: a phased approach, early actions and adaptive management.

4.1. Phased Approach and Early Actions

EPA often divides cleanup activities at complex sites into different areas or operable units (OUs), so that cleanup of environmental media or areas that have been characterized can occur while the nature and extent of contamination at the remainder of the site is still being investigated. Such a phased approach provides for site contamination to be addressed in a more expeditious manner, generally prioritizing response actions to accelerate risk reduction and to provide additional technical site information on which to base long-term risk management decisions. This includes taking removal actions to address imminent threats to human health while also pursuing a long-term cleanup strategy.

The Diamond Alkali Site, which includes the Lower Passaic River, has been divided by EPA into four operable units:[3]

> **Operable Unit 1 (OU1)** includes the 80-120 Lister Avenue facility and is addressed by the 1987 ROD. This is an interim containment remedy, which consists of capping, subsurface slurry wall and flood wall, and a groundwater collection and treatment system, completed in 2001. The interim remedy prevents exposure to contaminated soil (including soil that originated at the facility and that was brought back to the facility from neighboring lots), and prevents further releases to the river and groundwater. Tierra (on behalf of OCC) performs operation and maintenance of the OU1 remedy, and continues to monitor the performance of the remedy to assure the protectiveness of the actions taken to date. Based upon facility monitoring data, this OU is no longer an ongoing source of contamination to the Passaic River. Pursuant to CERCLA's requirements for remedy review, EPA has been evaluating the protectiveness of this interim remedy at least every five years since it was complete. Beginning in 2015, EPA expects to evaluate the performance of the interim remedy and the current availability of technologies that may be appropriate to address the on-site contamination over the long term. A final remedy for OU1 will be selected in the future.
>
> **Operable Unit 2 (OU2)** includes the lower 8.3 miles of the Lower Passaic River. The remedy selected in this document addresses the sediments of the lower 8.3 miles, the most contaminated segment of the river and a primary ongoing contaminant source to the rest of the river and Newark Bay. After considering comments on the Proposed Plan,

[3] EPA uses OU numbers for managing its investigation and remediation in phases. The second five-year review (June 8, 2011) identified OU2 as the Lower Passaic River and OU3 as the Newark Bay Study. EPA has concluded that renumbering the OUs as they are described here will best support the management of the project from this point forward.

EPA is selecting a remedy for the lower 8.3 miles that is a final action for the sediments and an interim action for the water column.

Operable Unit 3 (OU3) includes the 17-mile LPRSA. After completion of the on-going RI/FS, EPA expects to select a remedy that addresses the entire Lower Passaic River, consisting of the contaminated sediments above RM 8.3 and the water column for the entire study area. The CPG performed sampling for this RI between 2008 and 2014, and has submitted to EPA draft human health and ecological risk assessments, and draft RI and FS reports[4]. These are currently under review by EPA. The lower 8.3-mile RI/FFS relied upon data collected by EPA and the CPG for the 17-mile RI/FS, and EPA has shared its lower 8.3-mile findings with the CPG to support the 17-mile RI/FS. EPA has concluded that addressing the sediments of the lower 8.3 miles first will be consistent with any remedy selected for OU3. The basis for this conclusion is further discussed in Sections 4.2 and 5.

Operable Unit 4 (OU4) The on-going Newark Bay Study Area RI/FS is expected to be completed following the 17-mile LPRSA RI/FS.

In addition to these implemented and planned remedial activities, the Diamond Alkali Site is being addressed by a series of other early response actions (called “removal actions” under CERCLA) that address highly contaminated areas of the river, namely, the Tierra Removal and the RM 10.9 Removal discussed previously in Section 2.1.

4.2. Basis for Selecting the OU2 Remedy First

As discussed in the Proposed Plan, EPA has determined that selecting a final remedy at this time for the sediments of the lower 8.3 miles of the Lower Passaic River is consistent with the EPA’s approach of using operable units when a phased analysis is necessary or appropriate given the size or complexity of a site. EPA considered awaiting the conclusion of the 17-mile LPRSA RI/FS rather than selecting a remedy for only part of the Lower Passaic River. EPA concluded that the remedy for the lower 8.3 miles will be consistent with any remedy selected for the remainder of the Diamond Alkali Site, including the Lower Passaic River and Newark Bay Study Areas, for reasons discussed below.

EPA investigated potential COC sources to the Lower Passaic River, including atmospheric deposition, groundwater, industrial point sources, the Upper Passaic River (above Dundee Dam), Newark Bay, major tributaries, CSOs and SWOs. Data and screening-level analyses show that contaminated sediments that are already present on the river bottom in the lower 8.3 miles and that are resuspended and then resettle as a result of natural processes are, by a large margin, the biggest component of recently deposited sediment in the Lower Passaic River (see Section 5.3).

[4] Under a separate AOC, an investigation of potential discharges of hazardous substances from CSOs and SWOs into the 17-mile LPRSA is being conducted by Tierra on behalf of OCC.

In comparison, Upper Passaic River and Newark Bay contributions of COCs are small and all other sources are minor.

The COCs tend to bind tightly to fine-grained sediment particles. Therefore, the highest concentrations of COCs tend to be found in areas that are predominantly comprised of fine-grained sediments, which, for the Lower Passaic River, are the lower 8.3 miles. As described in Section 5, sediment sampling data show that concentrations of COCs at levels that far exceed the remediation goals (described in Section 8.1.4) are found throughout the surface sediments (generally considered to be the top six inches) of the lower 8.3 miles, bank to bank. Data further show that median concentrations of COCs in surface sediments of the lower 8.3 miles have remained almost unchanged in the last 18 years (1995-2013), indicating that additional time will not result in meaningful improvements in surface sediment conditions. The selected remedy for the lower 8.3 miles: (1) addresses the part of the 17-mile Lower Passaic River that contains the vast majority of the sediments to which COCs tend to bind; and (2) is based on the physical characteristics of sediment texture, supported by chemical data on the spatial and temporal extent of contamination. EPA concluded that the selected remedy will be consistent with the remedial alternatives likely to be developed and considered for a 17-mile LPRSA, because, with about 90 percent of the contaminated fine-grained sediments located in the lower 8.3 miles and elevated concentrations of COCs found throughout the surface sediments of the lower 8.3 miles, a bank-to-bank remedy is the only way to achieve risk-based goals. Furthermore, these findings, coupled with the tidal nature of the water body, necessitate addressing the “worst” portions of the river first (as opposed to beginning at the farthest upstream point as would be the likely approach with a nontidal system). Therefore, any remedy selected for the 17-mile LPRSA would necessarily begin with the lower 8.3 miles, and include bank-to-bank remediation in the lower 8.3 miles.

4.3. Adaptive Management

Given the complexity and uncertainty involved with remediating sediment sites, especially at such a large scale, EPA supports the use of an adaptive management approach to addressing a site. As discussed in the EPA guidance titled “Contaminated Sediment Remediation Guidance for Hazardous Waste Sites” (December 2005): “Project managers are encouraged to use an adaptive management approach, especially at complex sediment sites to provide additional certainty of information to support decisions. In general, this means testing of hypotheses and conclusions and reevaluating site assumptions as new information is gathered. This is an important component of updating the conceptual site model. For example, an adaptive management approach might include gathering and evaluating multiple data sets or pilot testing to determine the effectiveness of various remedial technologies at a site. The extent to which adaptation is cost-effective is, of course, a site-specific decision.”

EPA’s phased approach to addressing the Site has allowed EPA to update and adjust the conceptual site model during the investigation of the Lower Passaic River.

EPA expects that during implementation of the selected remedy for the lower 8.3 miles of the Passaic River, information and experience gained as a result of earlier stages of the implementation will inform later stages of the remedial action. Further, this action will inform and be integrated with subsequent remedies selected after completion of the 17-mile LPRSA RI/FS and the Newark Bay Study Area RI/FS. This will allow for appropriate adjustments or modifications to enable efficient and effective remedy implementation, providing a means to address uncertainties promptly and inform specific design decisions. Any remedy modifications will be made and documented in accordance with the CERCLA process and EPA's "A Guide to Preparing Superfund Proposed Plans, Records of Decision, and Other Remedy Selection Decision Documents" (July 1999), through a memorandum to the Site file, an Explanation of Significant Differences or an Amendment to the ROD.

4.4. Lower Passaic River Restoration Project

With the selection of this remedy, EPA is furthering the goals of the Lower Passaic River Restoration Project consistent with its authority under CERCLA. EPA expects that selection of this remedy will be a necessary step towards the partnership's broader (CERCLA and non-CERCLA) goals for the river, with additional steps to be taken under other authorities. For instance, the USACE's Hudson Raritan Estuary-Lower Passaic River Ecosystem Restoration program[5] may be able to move ahead with habitat restoration projects that had been deferred pending remediation of the lower 8.3 miles of the river.

5. SUMMARY OF SITE CHARACTERISTICS

5.1. Summary of Sampling Results and Other Investigations

The lower 8.3-mile RI and FFS Reports evaluated contamination in the Lower Passaic River and Newark Bay using data from field investigations that were conducted from the 1990s through 2013 by federal and state agencies, PRPs (such as the CPG and OCC) under EPA oversight, and academic institutions. The investigations that support this ROD include: bathymetric, geophysical and geotechnical surveys; river flow and sediment transport studies; sediment erosion studies; sediment sampling for contaminants; water quality studies; fish and crab tissue sampling; habitat surveys; a dredging pilot study; and sampling at CSOs and SWOs. Additional investigations and modeling were conducted to study the fate and transport of the COCs in the lower 8.3 miles of the Lower Passaic River. In addition to other information, the lower 8.3-mile RI/FFS incorporated the following data from the 17-mile LPRSA RI/FS:

- 2005 sediment bed erosion tests (Sedflume and Gust Microcosm)
- 2005-2007 high resolution sediment coring program
- 2005 small volume water column sampling program
- 2006 low resolution sediment coring program
- 2007-2008 berylium-7 bearing sediment collection program
- 2008 tributary, CSO and SWO sampling program

[5] Available at:
http://www.nan.usace.army.mil/Missions/Navigation/NewYorkNewJerseyHarbor/HudsonRaritanEstuary.aspx

- 2008 low resolution sediment coring program
- 2009-2010 benthic and surface sediment program
- 2009-2010 physical water column monitoring program
- 2010 high-flow water column suspended solids sampling
- 2011-2012 chemical water column monitoring program
- 2009-2010 fish community and tissue collection surveys
- 2010 habitat identification survey
- 2010 summer/fall avian community survey
- 2007 through 2012 single and multi-beam bathymetric surveys
- 2011-2012 RM 10.9 characterization sampling
- 2012 background benthic sediment sampling
- 2012 low resolution supplemental sediment sampling program

More detail can be found in the RI Report for the lower 8.3 miles and other documents in the Administrative Record file. Subsequent to the close of the public comment period, EPA conducted additional evaluations during the preparation of the Responsiveness Summary (Appendix V), in order to fully respond to comments received on the Proposed Plan, reviewing the following additional data, which had not been available to EPA at the time the RI/FFS was prepared: 2012 background fish tissue survey; 2013 chemical water column sampling; and 2013 low resolution second supplemental sampling program. These studies are also included in the Administrative Record file.

5.2. Contaminants of Concern

EPA has identified many hazardous substances in the lower 8.3-mile sediments. The following eight COCs[6] pose the greatest potential risks to human health and the environment in the lower 8.3 miles of the Lower Passaic River. COC concentrations in surface sediments and at depth in the lower 8.3 miles are shown in Tables 1 and 2, respectively, in Appendix II.

Dioxins and furans are human health and ecological COCs. They are by-products of chemical manufacturing, combustion (either in natural or industrial settings), metal processing and paper manufacturing. The dioxin congener[7] 2,3,7,8-TCDD is the most toxic form of dioxin. 2,3,7,8-TCDD and other dioxin congeners were by-products in manufacturing processes at the former Diamond Alkali facility and elsewhere. The herbicides manufactured at the former Diamond

[6] This section identifies whether a chemical was identified as a human health and/or an ecological COC for the lower 8.3 miles of the Lower Passaic River in the risk assessments, as discussed in Section 7. While all of the ecological COCs cause unacceptable risks to some or all of the receptors evaluated, risk-based preliminary remediation goals (PRGs) were developed for dioxins, PCBs, mercury and Total DDx, because they are representative COCs and because there were multiple lines of evidence developed to evaluate how the alternatives would achieve PRGs for these four COCs after remediation (see Section 8.1.2).

[7] The “dioxins and furans” referred to in this ROD describe 75 individual polychlorinated dibenzo-p-dioxins and 135 polychlorinated dibenzofurans that are considered related compounds, or “congeners.” Tetrachlorodibenzo-p-dioxin (TCDD), refers to a group of dioxin congeners with four chlorine atoms, and 2,3,7,8-TCDD is a congener with a specific arrangement of those chlorine atoms in its molecular structure.

Alkali facility included “Agent Orange,” a defoliant manufactured for military purposes and shipped in drums with an orange stripe. Dioxins stay in the environment for a long time and bioaccumulate in fish and crab. Dioxins are classified as a probable human carcinogen. Toxic effects in humans include reproductive problems, problems in fetal development or early childhood, immune system damage and cancer. In birds and mammals, effects include developmental and reproductive problems, hemorrhaging and immune system problems.

PCBs are human health and ecological COCs. They are manmade chemicals that were banned in the late 1970s. PCBs refers to a group of 209 congeners. Some of the congeners are referred to as dioxin-like PCBs, because they have chemical structures, physico-chemical properties and toxic responses similar to 2,3,7,8-TCDD. Some commercial PCB mixtures are known in the United States by an industrial trade name, Aroclor. Because they do not burn easily and are good insulating materials, PCBs were used widely as coolants and oils, and in the manufacture of paints, caulking and building material. PCBs stay in the environment for a long time and bioaccumulate in fish and crab. PCBs are classified as probable human carcinogens. Children exposed to PCBs may develop learning and behavioral problems later in life. PCBs are known to impact the immune system and may cause cancer in people who have been exposed to them over a long time. In birds and mammals, PCBs can cause adverse effects such as anemia and injuries to the liver, stomach and thyroid gland. PCBs also can cause problems with the immune system, behavioral problems and impaired reproduction.

Mercury is a human health and ecological COC. It is a metal that is released to the environment through a variety of processes, including metals processing, burning of coal, improper disposal of medical and other wastes, industrial effluent discharge, and atmospheric deposition. Mercury stays in the environment for a long time and bioaccumulates in fish and crab. Once mercury is released to the environment, it can be converted to the biologically toxic form of methyl mercury. Most of the mercury in fish and crab tissue is present as methyl mercury, so the RI/FFS risk assessments evaluated all of the mercury detected in fish and crab as methyl mercury. Toxic effects in humans include developmental and reproductive problems, and effects on the brain, nervous system and kidney. In birds and mammals, mercury can cause adverse effects in the central nervous system.

DDT (dichlorodiphenyltrichloroethane) and its primary breakdown products, dichlorodiphenyldichloroethane (DDD) and dichlorodiphenyldichloroethylene (DDE), are ecological COCs. DDT is a pesticide that was banned for use in the United States in 1972. It was used widely to control insects on crops and to control mosquitoes that spread malaria. These compounds bioaccumulate in fish and crab, are persistent in the environment and can cause adverse reproductive effects such as eggshell thinning in birds. The concentrations of these three forms of DDT are summed together for evaluation and collectively referred to as Total DDx throughout the ROD and associated documents.

Copper is an ecological COC. It is a metal that enters the environment through releases from factories that make or use copper metal or compounds, leachate from landfills, combustion of fossil fuels, wood processing, fertilizer production and from natural sources such as dust from soils, volcanoes and forest fires. Although copper is an essential dietary element at low levels, at higher levels it is highly toxic in aquatic environments and bioaccumulates in fish and crab. Copper can cause adverse effects in fish, invertebrates and amphibians. Copper impacts growth, development and causes organ problems in birds and mammals.

Dieldrin is an ecological COC. It is a pesticide that is no longer produced or used, but was once used extensively as an insecticide on crops or to control termites. It bioaccumulates in fish and crab, and is persistent in the environment. Dieldrin is highly toxic to aquatic crustaceans and fish. Dieldrin also causes liver damage, central nervous system effects and suppression of the immune system in mammals and eggshell thinning in birds.

PAHs are ecological COCs. These chemicals are a major component of petroleum products, and are formed during incomplete burning of coal, oil, gas, wood or other substances. PAH molecules are composed of two or more carbon and hydrogen rings. Low molecular weight (LMW) PAHs have two or three rings, while high molecular weight (HMW) PAHs have more than three rings. There are more than 100 different PAHs, which generally occur as complex mixtures. Typically, PAHs are readily metabolized by fish and wildlife, and do not bioaccumulate in aquatic food webs. They can persist in the environment under certain conditions. PAHs are toxic to invertebrates and cause inhibited reproduction, delayed emergence, sediment avoidance and mortality. In fish, PAHs cause liver abnormalities and impairment of the immune system. PAHs can cause adverse effects on reproduction, development and immunity in birds and mammals.

Lead is an ecological COC. Lead occurs naturally in the environment, but most of the higher levels found in the environment come from mining or factories that use lead compounds. Lead is also released into the air during the burning of coal, oil or waste. Lead is persistent in the environment, but does not bioaccumulate in aquatic organisms. Lead can cause muscular and neurological effects in fish. It is also toxic to invertebrates and can cause damage to the nervous system in birds and mammals.

5.3. Sediment Conceptual Site Model

The Lower Passaic River is a partially-stratified estuary. The tides drive a wedge of denser salt water from Newark Bay north into the river along the bottom part of the water column, under a top layer of fresher water flowing in from the Upper Passaic River over Dundee Dam. The upstream limit of the salt wedge is called the salt front. Near the salt front, where the salt wedge first meets the freshwater flow, estuarine circulation creates a cloud of suspended sediments called the estuarine turbidity maximum (ETM), resulting in elevated suspended sediment concentrations in part or all of the water column, depending on flow conditions. During low flow conditions, the salt front and ETM can reach as far upstream as approximately RM 12, while during storm events they may be pushed out to Newark Bay. Under typical flow conditions, the salt front and ETM are located between RM 2 and RM 10 and move back and forth along about four miles of the river each tidal cycle (twice a day). The movement of the salt wedge, as reflected by the movements of the salt front and ETM, causes surface sediments in the river to resuspend and redeposit on each tidal cycle, resulting in longitudinal mixing of the surface sediments. This results in median surface sediment concentrations of COCs that do not vary significantly with river mile from RM 2 to RM 12 (see Figures 3, 4 and 5 in Appendix I; similar figures for other COCs are available in RI Report Figures 4-17a, 4-18a, 4-32a, 4-45a and 4-46a).

As discussed in Section 1, the Lower Passaic River's cross-sectional area declines steadily from RM 0 to RM 17.4, with a pronounced constriction at RM 8.3, where there is also a pronounced change in sediment texture (shown in Figure 2). The river bed below RM 8.3, from bank to bank, is dominated by fine-grained sediments with pockets of coarser sediments (sand and gravel). Since most of the COCs are hydrophobic and tend to bind tightly to the organic carbon on fine-grained sediment particles, elevated concentrations of COCs are found bank to bank in the lower 8.3 miles. Data show that, between RM 0 and RM 8.3, surface sediments in the navigation channel are as highly contaminated as those in the shoals, based on median concentrations (see Figures 6, 7 and 8 in Appendix I; similar figures for other COCs are available in RI Report Figures 4-23a, 4-24a, 4-38a, 4-55a, 4-56a). In other words, data show that elevated concentrations of COCs are ubiquitous in surface sediments of the lower 8.3 miles, bank to bank.

Maintenance of the navigation channel ended in some reaches in the 1930s and in much of the rest of the river after 1950 (except for the lower 1.9 miles, which were maintained until 1983), at which time the formerly dredged channel began to fill in with sediments. During the same period, industrial activities along the river grew, and industries and municipalities disposed of wastewaters in the river. The coincidence of chemical disposal in the river and the filling-in of the navigation channel created ideal conditions for the accumulation of contaminated sediments in the Lower Passaic River. When maintenance dredging was significantly curtailed after 1950, sediment infilling rates in the navigation channel were relatively high (approximately four inches per year). This process coincided with a period when industries and municipalities most actively disposed of wastewaters in the river, so the deepest sediments are the most highly contaminated (see Table 2 in Appendix II). Beginning in the 1970s and 1980s, industrial discharges declined as a result of Clean Water Act regulations, and the channel began to fill with less contaminated sediment, leading to a slow decline in concentrations over several feet of sediment. Recently much of the dredged channel has filled in and the river has begun to reach a quasi-steady state.

The surface sediments have the most direct consequences on risks to human health and the environment, so understanding current conditions in the surface sediments and predicting future conditions was a central focus of the FFS. Sediment erosion studies were performed to assess the degree to which more contaminated deeper sediments influence conditions in shallow sediments. These studies show that the critical shear stress (the minimum force exerted by water flowing along the river bed needed to cause sediment particles to start to erode) typically increases with depth, so that shallow sediments are more easily erodible, but sediments become less and less erodible deeper in the river bed. This is due to the consolidation or compression of deeper sediments over time caused by the weight of overlying sediments.

In recent years, overall infilling has slowed considerably and alternates with some scouring during high flow events, resulting in a quasi-steady state condition, so that the river is no longer steadily filling with "cleaner" sediments from elsewhere. Daily tidal action resuspends and redeposits the contaminated surface sediments, while occasional scouring during high flow events (storms) uncovers and resuspends deeper, more highly-contaminated sediments contributing additional contamination to the surface sediments and slowing the natural recovery process. Based on five multi-beam bathymetry surveys conducted between 2007 and 2012, erosion of 0 to 12 inches occurred in 40 percent to 47 percent of the lower 8.3 miles in each of the survey intervals. Erosion of more than 18 inches occurred in 2 percent to 4 percent of the lower 8.3 miles in each of the survey intervals.

The RI and FFS assessed the degree to which filling with newer, "cleaner" sediments from elsewhere, a natural recovery process, might allow the river to improve on its own. Dated high resolution sediment cores show that contaminant concentrations in approximately the top two feet of sediments have declined extremely slowly in recent years. In addition, sampling from 1995 through 2013 confirms that lower 8.3-mile surface sediment median contaminant concentrations have remained almost unchanged over that 18-year period (see Figures 9, 10 and 11 in Appendix I; similar figures for other COCs are available in RI Report Figures 4-26, 4-27, 4-41, 4-60 and 4-61). COC concentrations in surface sediments are summarized in Table 1 in Appendix II.

Based on analyses discussed in the RI Report for the lower 8.3 miles, direct atmospheric deposition, groundwater discharge and industrial point sources of contaminants currently are not significant contributors of COC mass (i.e., sediment particles and the COCs bound to them) to the recently deposited sediments[8] of the Lower Passaic River. The Upper Passaic River, Newark Bay, the three main tributaries, and CSOs and SWOs were sampled between 2005 and 2011. Results of a mass balance[9] show that the tributaries, CSOs and SWOs are minor contributors of COCs, since they are minor contributors of sediment particles compared to the Upper Passaic River and Newark Bay, and the mass of contaminants delivered by those particles is low compared to the sediments of the Lower Passaic River main stem. For COCs such as 2,3,7,8-TCDD, Total PCBs and mercury, concentrations on sediment particles from the tributaries, CSOs and SWOs are clearly lower than those on Lower Passaic River surface sediments. Current contributions to the recently deposited sediments of the Lower Passaic River are summarized in Table 3 in Appendix II. Resuspension of Lower Passaic River sediments contributes well over 90 percent of the dioxin in recently deposited sediments of the Lower Passaic River, followed by Newark Bay (approximately 5 percent) and the Upper Passaic River (3 percent or less). Resuspension of Lower Passaic River sediments contributes approximately 80 percent of PCBs and DDE in recently deposited sediments, followed by the Upper Passaic River (approximately

[8] As described in RI/FFS Appendix C, recently deposited sediments are beryllium-7 (Be-7) bearing sediments. Be-7 is a naturally occurring radioisotope with a short half-life (53 days) that binds to sediment particles. The presence of Be-7 in surface sediments indicates that the associated solids were deposited on the sediment bed within approximately the last six months.

[9] A "mass balance" assesses inputs to and outputs from a "system" (in this case, recently deposited sediments within the Lower Passaic River) understanding that all the mass must be accounted for. For this mass balance, the change in contaminant mass in recently deposited sediments equals the difference between the sum of contaminants coming into the system from various sources and the sum of contaminants going out of system to other places.

10 percent) and Newark Bay (less than 10 percent). Similar trends are shown for copper, mercury and lead, further supporting the conclusion that resuspension of highly contaminated surface sediments already in the lower 8.3 miles of the river is the predominant contributor to COC mass in the water column, and thus to COC concentrations in fish and crab tissue. As discussed in Section 10.1, these percentage contributions would be altered dramatically through active remediation of the lower 8.3 miles. For example, bank-to-bank replacement of the highly contaminated riverbed with effectively clean material would greatly reduce the component of the mass balance that comes from resuspension of Lower Passaic River sediments. This would reduce the overall contaminant levels in surface sediment, but it would also have the effect of increasing the relative percentage contribution of the Upper Passaic River, Newark Bay and the Lower Passaic River above RM 8.3 to COCs depositing on top of the newly replaced lower 8.3-mile riverbed.

Under current conditions, the daily movement of contaminated surface sediments combined with the occasional uncovering and resuspension of deeper, more highly contaminated sediments in the lower 8.3 miles are the primary ongoing source of COCs to the water column and surface sediments of the Lower Passaic River.

5.4. Fish and Crab Tissue

In the lower 8.3 miles of the Lower Passaic River, contaminant concentrations in fish[10] and blue crab tissue have similar patterns and trends to those observed in the surface sediments. Spatially, there is a broad range of contaminant concentrations in fish and crab tissue (more than an order of magnitude), but there is little or no trend in COC median concentrations with river mile (see Figures 12, 13 and 14 in Appendix I; similar figures for other COCs and species are available in RI/FFS Appendix A, Data Evaluation Report No. 6, Figures 2-1 through 2-4).

Lipid-normalized contaminant concentrations[11] in fish and crab tissue have not consistently increased or decreased with time from 1999 to 2010, consistent with surface sediment COC concentrations, which also have remained almost unchanged over approximately the same time period (see Figures 15 and 16 in Appendix I; similar figures for other COCs and species are available in RI/FFS Appendix A, Data Evaluation Report No. 6, Figures 2-8 through 2-11).

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[10] In order to account for the various types of fish that may be consumed by anglers on the lower 8.3 miles, white catfish, white perch, white sucker, common carp, smallmouth bass and American eel were collected during the 17-mile LPRSA RI/FS. In the ecological risk assessment, brown bullhead were added to the above six species to represent piscivorous and omnivorous life histories characteristic of the lower 8.3 miles, and mummichog were collected to represent forage fish.

[11] Tissue contaminant concentrations were normalized by lipid concentrations (i.e., each tissue contaminant concentration was divided by the lipid concentration of the fish analyzed) in order to focus on changes in tissue contaminant concentrations over time that are not related solely to changes in lipid concentrations over time. Lipid content is a measure of the amount of fats and oils in the fish and crab tissue.

6. CURRENT AND POTENTIAL FUTURE SITE AND RESOURCE USES

The New Jersey Surface Water Quality Standards classify the Lower Passaic River from its mouth to the Second River (RM 0 to RM 8.1) as saline-estuarine 3 (SE3), with designated uses including secondary contact recreation (activities where the probability of water ingestion is minimal, including, but not limited to, boating and fishing). The Lower Passaic River from Second River to Dundee Dam (RM 8.1 to RM 17.4) is classified as freshwater 2 non-trout (FW2-NT) and saline-estuarine 2 (SE2). Designated uses for FW2-NT and SE2 include secondary contact recreation. Designated uses for FW2-NT also include primary contact recreation (activities that involve a significant ingestion potential, including, but not limited to, wading, swimming, diving, surfing and water skiing).

The Clean Water Act, as revised in 1972, set a national goal to restore and maintain the chemical, physical and biological integrity of the Nation's waters, with interim goals that all waters be fishable and swimmable where possible. Currently, the Lower Passaic River is not fishable and swimmable due to chemical contamination and other factors. CERCLA does not supplant the Clean Water Act, which addresses pollutants in the water column through various mechanisms such as permitting programs and the water quality implementation plan. This ROD, issued under CERCLA to address contaminated sediment in the lower 8.3 miles, will support the Clean Water Act goals by addressing a source of contamination to the water column.

New Jersey prohibits the consumption, and sale for consumption, of fish and crab from the Lower Passaic River (RM 0 to RM 17.4) due to contamination by PCBs, dioxin and mercury. Eating, selling or taking (harvesting) blue crab from the Newark Bay Complex and tidal Passaic River is prohibited (N.J.A.C. 7:25-14.11).

As discussed in Sections 1 and 2, the Lower Passaic River has a federally authorized navigation channel from RM 0 to RM 15.4 that was constructed beginning in the 1880s and maintained by USACE through the 1950s in most of the lower 8.3 miles (except in the lowest 1.9 miles, which were maintained through 1983). As discussed in Section 10.2, Section 10 of the Rivers and Harbors Act (33 U.S.C. § 403) is a location-specific Applicable or Relevant and Appropriate Requirement (ARAR) with which the remedy for the lower 8.3 miles will comply. Section 10 prohibits creation of any obstruction to the navigable capacity of any waters of the United States without Congressional authorization, subject to the permitting authority provided to the Department of the Army. As described in Section 2, the navigation channel for the Lower Passaic River is currently authorized by federal law at depths ranging from 30 feet (RM 0 to 2.6) to 10 feet (RM 8.1 to 15.4). Only Congress can change these current authorized channel depths, and it has not done so, nor is EPA aware that any de-authorization process is underway.

In addition, according to Superfund guidance, reasonably anticipated future land and waterway uses in the lower 8.3 miles of the Lower Passaic River should be considered during the development of remedial alternatives and remedy selection. USACE is responsible for the operation and maintenance of the nation's waterway system to ensure efficient and safe passage of commercial and recreational vessels. USACE also has the Federal responsibility for establishing and maintaining a variety of U.S. water transportation information systems and thus is qualified to assess current and anticipated future uses for the Lower Passaic River navigation channel.

In a 2010 Lower Passaic River Commercial Navigation Analysis report, USACE identified various physical constraints such as shallow depths, narrow widths and low vertical clearance bridges that potentially limit commercial use of the navigation channel above RM 1.2. A berth-by-berth analysis for 1997-2006 included in the report documented that the lower 1.7 miles of the channel are still in use for commercial navigation by a number of companies. These waterway users have responded to the depth constraints resulting from the lack of maintenance dredging in recent years by moving barges in and out at high tide, by moving barges in and out less than fully loaded or by using smaller barges. A 2009 USACE survey of commercial users, also included in the 2010 report, showed potential future commercial use of the channel up to RM 2.2. However, EPA has not identified or received any information of actual commercial use of the channel above RM 1.7. In a February 6, 2014 letter, USACE confirmed that 2011 Waterborne Commerce data, the last year analyzed as of the writing of the letter, indicated a significant volume of waterborne commerce was transported that year within the Lower Passaic River, and concluded that “The current and projected future level of commercial traffic is sufficient to justify maintenance dredging of the channel should it be required, subject to budget limitations.”

Many of the municipalities with river frontage on the lower 8.3 miles have published master plans that call for the expansion and improvement of parks and open space along the river that will lead to greater access to the river and improved ecological habitat. The opening of Riverfront Park in Newark at approximately RM 4 in 2013 is a prime example of how implementation of the city’s master plan is leading to greater access to and use of the river. Throughout the Lower Passaic River, particularly between RM 2 and RM 12, college, high school and community rowing clubs use the river for recreation and competition.

7. SUMMARY OF SITE RISKS

As part of the RI/FFS, baseline human health and ecological risk assessments were conducted to estimate the current and future effects of contaminants in sediments of the lower 8.3 miles of the Lower Passaic River on human health and the environment. A baseline risk assessment is an analysis of the potential adverse human health and ecological effects of releases of hazardous substances from a site or operable unit in the absence of any actions or controls to mitigate such releases, under current and future land and resource uses. The baseline risk assessment includes a human health risk assessment (HHRA) and an ecological risk assessment (BERA). They provide the basis for taking action and identify the contaminants and exposure pathways that need to be addressed by the remedial action. The baseline risk assessments are detailed in RI/FFS Appendix D. This section of the ROD summarizes the results of the baseline risk assessments.

As discussed in Section 5.3, risks are mainly posed by contaminants that are in the sediments of the lower 8.3 miles as a result of historical discharges from former industrial operations and municipalities along the Lower Passaic River. In addition, some contaminants are also coming into the lower 8.3 miles from the Upper Passaic River above Dundee Dam, from Newark Bay and from the Lower Passaic River above RM 8.3. In accordance with EPA's policies and guidance, the baseline risk assessments quantified risks and health hazards as the total exposure to contaminants in the lower 8.3 miles, without consideration of the contribution of background or other incoming contaminants to those exposures.

7.1. Human Health Risk Assessment

The Site-specific HHRA estimated cancer risks and noncancer health hazards from exposures to a set of chemicals in the lower 8.3 miles of the Lower Passaic River. While other exposure scenarios were considered, as discussed in Section 7.1.2.1, the HHRA focused primarily on angler/sportsman and other family members consuming self-caught fish and crab.

A four-step process is used for assessing site-related human health risks:

- *Hazard Identification* – uses the analytical data collected to identify the contaminants of potential concern (COPC) at the site for each medium, with consideration of a number of factors explained below;
- *Exposure Assessment* - estimates the magnitude of actual and/or potential human exposures, the frequency and duration of these exposures, and the pathways by which humans are potentially exposed;
- *Toxicity Assessment* - determines the types of adverse health effects associated with chemical exposures, and the relationship between magnitude of exposure (dose) and severity of adverse effects (response); and
- *Risk Characterization* - summarizes and combines outputs of the exposure and toxicity assessments to provide a quantitative assessment of site-related cancer risks and noncancer hazards. The risk characterization also identifies contamination with concentrations which exceed acceptable levels, identified in the NCP and EPA guidance as an excess lifetime cancer risk greater than 10^{-6} to 10^{-4} or a noncancer Hazard Index (HI) greater than 1; contaminants at these concentrations are considered COCs and are typically those that will require remediation at the site. Also included in this section is a discussion of the uncertainties associated with these risks.

Based on the results of Superfund HHRAs conducted for other river sites with bioaccumulative COCs, EPA concluded that consumption of fish and crab is associated with the highest cancer risks and noncancer health hazards compared to other exposure pathways such as ingestion, dermal contact or inhalation of chemicals in surface water or sediment during recreational activities. Despite New Jersey's prohibitions on fish and crab consumption, and harvesting blue crab in the Newark Bay Complex (Newark Bay and its tributaries, including the tidal Lower Passaic River), numerous published studies undertaken in recent decades (see RI/FFS Appendix D for a list of studies) show that people are catching and eating fish and crab along the banks of the Lower Passaic River and Newark Bay. Therefore, the only pathway of exposure evaluated quantitatively in the HHRA was the consumption of self-caught fish or crab from the lower 8.3

miles of the Lower Passaic River by the adult angler/sportsman and other family members (i.e., under the assumption, consistent with EPA guidance and site-specific information, that the angler shares his or her catch with an adolescent and a child). Other exposure pathways will be evaluated in the 17-mile LPRSA RI/FS.

7.1.1. Hazard Identification

The HHRA was conducted using the analytical results of the fish and blue crab tissue samples collected throughout the lower 8.3 miles of the Lower Passaic River during the late summer/early fall 2009 by the CPG for the 17-mile LPRSA RI/FS. The fish/crab data included species from different feeding guilds that are commonly caught and abundant in the lower 8.3 miles. Tissue chemistry data from six fish species (American eel, common carp, smallmouth bass, white catfish, white perch, and white sucker) were used to derive an equal-weighted average concentration to represent chemical concentrations to which someone eating fish would be exposed. The blue crab was selected to assess exposures of people eating crab because it is commonly caught and consumed in the lower 8.3 miles. Crabs were evaluated based on total tissue including the edible white meat (or muscle) from the thoracic cavity, claws, and legs, and the hepatopancreas, based on well-documented eating and cooking practices that result in a reasonable percentage of New Jersey anglers being exposed to both tissue types.

COPCs evaluated in the HHRA consisted of those contaminants considered to be most bioaccumulative, most persistent in the environment, and most toxic to human beings. Those COPCs identified in the HHRA as posing the greatest risk are referred to as COCs, and are the primary focus of the response action proposed in this ROD. Table 4 in Appendix II identifies the COCs and their chemical-specific characteristics (e.g., range of concentrations, frequency of detection, exposure point concentration [EPC] and associated statistical basis) for fish and crab tissue.

The COCs are:

- Dioxin/furans[12]

[12] Dioxin/furan congeners were evaluated as TCDD toxicity equivalence (TEQ) based on individual congener toxicity equivalence factors (TEFs). Dioxin-like compounds (including 2,3,7,8-TCDD, other dioxin/furan congeners and dioxin-like PCBs) typically occur as mixtures in the environment. The toxicity of dioxin-like compounds can be assessed by considering their toxicity relative to 2,3,7,8-TCDD. 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-TCDD. By convention, 2,3,7,8-TCDD is assigned a TEF of 1.0, and the TEFs for other compounds with dioxin-like effects range from 0 to 1. The consensus TEF values published in 2005 by the World Health Organization and recommended by EPA in the 2010 guidance "Recommended Toxicity Equivalence Factors (TEFs) for Human Health Risk Assessments of 2,3,7,8-Tetrachlorodibenzo-p-Dioxin-like Compounds" (EPA/100/R-10/005) are used in the risk evaluations. For a single dioxin-like compound, TCDD TEQ is the product of the concentration of the dioxin-like compound in the environment and its corresponding TEF; total TEQ for a mixture of dioxin-like compounds is the sum of the individual TCDD TEQs across those compounds. The TCDD TEQ provides a means for determining the toxicity of a mixture of dioxin-like compounds, in the absence of toxicity values for those compounds.

- PCBs[13]
- Mercury[14]

7.1.2. Exposure Assessment

Consistent with Superfund policy and guidance, the HHRA is a baseline human health risk assessment and therefore assumes no remediation or institutional controls to mitigate or remove hazardous substance releases. Cancer risks and noncancer HIs were calculated based on estimates of reasonable maximum exposures (RME) and central tendency exposures (CTE) to describe the magnitude and range of exposures that might be incurred by receptor groups under current and future conditions at the site. The RME is defined as the highest exposure that is reasonably expected to occur at a site, whereas the CTE is intended to reflect central (more typical) estimates of exposure. 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. The receptors and exposure scenarios that were identified as potentially complete and evaluated in the HHRA are the angler/sportsman and other family members consuming self-caught fish and crab (adult, adolescent and child), as summarized in Table 5 of Appendix II.

7.1.2.1. Conceptual Site Model (CSM)

The CSM for the HHRA (Figure 17 in Appendix I) considered current and future conditions in the lower 8.3 miles of the Passaic River to describe the magnitude and range of exposure by various receptors and age ranges (i.e., adults, adolescents and children). As discussed in Section 7.1, the only pathway of exposure evaluated quantitatively in the HHRA was the consumption of self-caught fish or crab from the lower 8.3 miles of the Lower Passaic River by the adult angler/sportsman and other family members (i.e., under the assumption, consistent with EPA guidance and site-specific information, that the angler shares his or her catch with an adolescent and a child). Table 5 in Appendix II provides the rationale for inclusion of the receptors and exposure pathway. Other exposure pathways, such as recreational exposures, will be evaluated in the 17-mile LPRSA RI/FS.

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[13] PCBs were evaluated as the sum of 12 dioxin-like congeners (TCDD TEQ based on individual congener TEFs) and the sum of non-dioxin-like congeners. The PCB contribution to the TCDD TEQ was separately evaluated in the risk assessments, and to avoid “double-counting” of exposures and risks, the 12 dioxin-like PCB congeners were excluded from quantification of Total PCBs. As a result, the term “Total PCBs” has a slightly different meaning in the risk assessments compared to the RI/FFS. However, the mass of dioxin-like congeners is a trivial fraction of the aggregate concentration and the two approaches to quantifying Total PCBs result in very similar concentration estimates.

[14] Due to a lack of methylmercury 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 methylmercury. Data for total mercury and methylmercury were assumed to be equivalent and treated as if all were methylmercury; however, mercury data may slightly overestimate the methylmercury concentration and thus, may result in a potential slight overestimate of noncancer health hazards.

7.1.2.2. Exposed Population

Adults (over 18 years), adolescents (aged 7 to 18 years) and young children (1 to 6 years) can be exposed to COCs in the lower 8.3 miles as a result of catching and consuming fish or crab. The FFS evaluated exposures to the adult angler/sportsman and other immediate family members (i.e., young child) who consume fish or crab provided by an adult angler. The HHRA also considered the adolescent as another possible angling receptor who may catch fish or crab and consume their catch, or consume fish or crab caught by their angling parent.

7.1.2.3. Ingestion Rates of Self-Caught Fish or Crab (IR)

The Ingestion Rate (IR) is the amount of fish or crab an individual catches in the lower 8.3 miles and consumes on a daily basis based on averaging the reported consumption rate in 1 year over 365 days. IRs for fish and crab are annualized and are presented in grams eaten per day (g/day). For purposes of the HHRA, it was assumed that an RME individual consumed either crab or fish but not both.

Fish IRs for the HHRA were developed from a detailed evaluation of LPRSA-pertinent angler and creel surveys and related literature, as documented in EPA Region 2 Technical Memorandum, “Fish and Crab Consumption Rates for the LPRSA Human Health Risk Assessment” dated February 2012. This analysis provided fish consumption rates for the RME individual of 35 g/day (or 56 eight-ounce fish meals/year) and 3.9 g/day (or 6.2 eight-ounce fish meals/year) for the CTE.

IRs for the child and adolescent consuming fish were based on the assumption that the intake for the child will be approximately one-third that of the adult and intake for the adolescent will be approximately two-thirds that of the adult. The RME IR of 12 g/day is used for the child receptor and 23 g/day is used for the adolescent receptor. For the CTE, an IR of 1.3 g/day is used for the child receptor and 2.6 g/day is used for the adolescent receptor.

The crab IRs for the adult angler were calculated as 21 g/day for the RME (or 34 eight-ounce crab meals per year) and 3.0 g/day (or 4.9 eight-ounce crab meals per year) for the CTE. IRs for the child and adolescent receptors were estimated assuming rates one third and two thirds those of the adult IR, respectively, as was assumed for fish ingestion. Thus, for the RME, an IR of 7.0 g/day is used for the child receptor and 14 g/day is used for the adolescent receptor. For the CTE, an IR of 1.0 g/day is used for the child receptor and 2.0 g/day is used for the adolescent receptor.

7.1.2.4. Exposure Duration (ED)

In the RI/FFS HHRA, for the adult angler/sportsman, exposure was assumed to occur for 6 years as a child and 24 years as an adult, for a total RME ED of 30 years, consistent with EPA human health risk assessment guidance in use at the time. For the adolescent angler/sportsman, exposure was assumed to occur for 12 years (from ages 7 through 18 years) for the RME. The CTE ED for adult receptors was 9 years, based on the 50th percentile value for years living in the current home from EPA's 2011 *Exposure Factors Handbook*. For the adolescent and child CTE exposures, 6 years and 3 years were assumed, respectively, based on EPA's 1991 Standard Default Exposure Assumptions. In response to comments, EPA evaluated the 2014 updated Standard Default Exposure Assumptions (OSWER Directive 9200.1-120), released after the RI/FFS was completed. The updated assumptions changed the adult ED from 24 years to 20 years and the total ED from 30 years to 26 years. As shown in the Responsiveness Summary in Appendix V, incorporating the updated assumptions does not significantly affect the calculated cancer risks and does not alter noncancer values at all. The risk estimates calculated with the updated EDs are presented in Tables 8 through 11 in Appendix II.

7.1.2.5. Cooking Loss for Fish

Contaminant losses from cooking may be a function of the cooking method (*e.g.*, baking, frying or broiling), cooking duration, temperature during cooking, preparation techniques (*i.e*., trimmed versus untrimmed, with or without skin), lipid content of the fish, fish species, magnitude of contamination in the raw fish, extent to which lipids separated during cooking are consumed, reporting method, and/or experimental study design. In addition, personal preferences for various preparation and cooking methods and other related habits (such as consuming pan drippings) may result in consumption of contaminants "lost" from the fish upon cooking. Based on these uncertainties and the variability in cooking methods, a zero percent cooking loss was assumed for the RME individual. Chemical-specific cooking losses were developed for individual chemicals and evaluated in the CTE assessment.

7.1.2.6. Other Exposure Assumptions

In the RI/FFS HHRA, the body weight of the adult was assumed to be 70 kilograms (kg, 154 pounds) based on EPA's 1991 Standard Default Exposure Assumptions, the guidance in use at the time of RI/FFS completion. In response to comments, EPA evaluated the 2014 updated Standard Default Exposure Assumptions, released after the RI/FFS was completed. The updated assumptions changed the adult body weight to 80 kg (176 pounds). As shown in the Responsiveness Summary (Appendix V), incorporating this updated assumption does not significantly affect the calculated risks and health hazards. The risk/hazard estimates calculated with the updated body weight are presented in Tables 8 through 17 in Appendix II. None of the other exposure assumptions were affected by the 2014 updated Standard Default Exposure Assumptions. The body weight for the young child used in the HHRA was 15 kg (33 pounds), consistent with EPA's 2014 Standard Default Exposure Assumptions. The mean body weight for the adolescent was assumed to be 52 kg (115 pounds), consistent with EPA's 2011 *Exposure Factors Handbook* (a factor unaffected by the 2014 updates). The value for lifetime used in the RI/FFS HHRA cancer calculations was 70 years, consistent with EPA's 2014 Standard Default Exposure Assumptions.

7.1.3. Toxicity Assessment

The toxicity assessment determines the types of adverse health effects associated with exposure to COCs and the relationship between the magnitude of exposure (dose) and severity of adverse effects (response). Potential health effects include increased risk of developing cancer over a lifetime. Other noncancer health effects, such as changes in the normal function of organs within the body (e.g., changes in the effectiveness of the immune response), are also evaluated.

Potential cancer effects are expressed as the probability that an individual will develop cancer over a lifetime based on the exposure assumptions described in Section 7.1.2. 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.

Noncancer health effects were evaluated using reference doses (RfDs). An 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. Chronic RfDs are specifically developed to be protective against long-term exposure to COCs.

7.1.3.1. Sources of Toxicity Information

Toxicity criteria were selected according to 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) EPA's Integrated Risk Information System (IRIS); 2) EPA's Provisional Peer-Reviewed Toxicity Values (PPRTVs); and 3) other sources of information such as the California Environmental Protection Agency (CalEPA) and EPA's Health Effects Assessment Summary Tables (HEAST). This information is presented in Appendix II, Table 6 (cancer toxicity data summary) and Table 7 (noncancer toxicity data summary). Additional toxicity information for the COCs is presented in the RI/FFS HHRA.

7.1.3.2. Cancer Assessment

Table 6 in Appendix II provides a summary of the CSFs used in the assessment along with the source of the information. EPA has determined that dioxins and PCBs are probable human carcinogens. For the fish/crab ingestion route, the CSF for Total PCBs is 2 milligrams per kilograms per day (mg/kg-day) based on the bioaccumulation of this contaminant in fish and crab and was obtained from IRIS.

For dioxins/furans (TCDD TEQ [D/F]) and dioxin-like PCBs 9TCDD TEQ [PCBs]), the HHRA used toxicity information for dioxin (2,3,7,8-TCDD) provided in EPA's 1997 Health Effects Assessment Summary Tables, a Tier 3 toxicity value. The CSF for dioxin of 150,000 mg/kg-day is also consistent with the recommendation in the EPA 1996 PCB reassessment, "PCBs: Cancer Dose-Response Assessment and Application of Environmental Mixtures." The HHRA also identified several other CSFs for dioxins that meet the Tier 3 Toxicity Hierarchy criteria. The other Tier 3 toxicity values are discussed further in Section 7.1.5.3.

7.1.3.3. Noncancer Assessment

Table 7 in Appendix II provides the chronic oral RfDs for the COCs and the source of the toxicity information for mercury, PCBs and dioxins/furans. The oral RfD for total PCBs was based on Aroclor 1254. The oral RfD for total PCBs is 2 x 10^{-5} and the critical effects include effects on the immune system and eyes. The oral RfD for dioxins/furans is 7 x 10^{-10} mg/kg-day and exposure is associated with dermal, developmental, immunological and reproductive critical effects. The oral RfD for mercury, assumed to be methyl mercury, is 1 x 10^{-4} mg/kg-day and the critical effect is on the central nervous system.

7.1.3.4. Dioxin TEF Approach

For dioxins/furans (TCDD TEQ [D/F]) and dioxin-like PCBs (TCDD TEQ [PCBs]), the consensus TEF values published in 2005 by the World Health Organization and recommended by EPA in the 2010 TEF guidance (EPA/100/R-10/005) were used in the risk evaluations.

7.1.4. Risk Characterization

Risk characterization involves estimating the magnitude of the potential adverse health effects associated with the COCs. It also involves making 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 accordance with EPA's guidelines, this assessment assumes that the effects of all contaminants are additive through a specific pathway within an exposure scenario.

For carcinogens, risks are generally expressed as the incremental probability of an individual developing cancer over a lifetime as a result of exposure to the carcinogen. Excess lifetime cancer risk (a unitless probability of an individual's developing cancer) is calculated by multiplying the chronic daily intake averaged over 70 years (mg/kg-day) and the slope factor (per mg/kg-day).

These risks are probabilities that usually are expressed in scientific notation (e.g., 1 x 10^{-6}). An excess lifetime cancer risk of 1 x 10^{-6} indicates a probability that the RME individual has a 1 in 1,000,000 chance of developing cancer as a result of site-related exposure. This is referred to as an "excess lifetime cancer risk" because it would be in addition to the risks of cancer individuals face from other exposures. The upper-bound excess lifetime cancer risks derived in this assessment are compared to the risk range of 10^{-4} (one in ten thousand) to 10^{-6} (one in one million) established in the NCP. EPA's goal of protection for cancer risk is 10^{-6} and risks greater than 10^{-4} typically will require remedial action.

The potential for noncancer health effects is estimated by comparing the average daily dose (ADD) of a chemical for adult, adolescent and child 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 the hazard quotient (HQ). When an RfD is available for the chemical, these ratios are calculated for each chemical that elicits a noncancer health effect. Typically, chemical-specific HQs are summed to calculate an HI value for each exposure pathway. EPA's goal of protection for noncancer health effects is an HI equal to 1. When the HI exceeds 1, there may be a concern for health effects. 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. If any of the separate HI values exceed 1, adverse, noncancer health effects are possible. It is important to note, however, that an HI exceeding 1 does not predict a specific disease.

7.1.4.1. Cancer Assessment

The HHRA shows that all of the risks associated with the RME are greater than the goal of protection established in the NCP of 10^{-6} (i.e., one additional cancer in 1,000,000 people). All of the risks associated with the RME are also greater than the 10^{-4} cancer risk that typically would require remedial action at a site or operable unit (see Tables 8 and 9 in Appendix II). In addition, cancer risks to the average exposed (CTE) individual associated with ingestion of fish and crab are above EPA's goal of protection of 10^{-6} (see Tables 10 and 11 in Appendix II).

For the RME adult and child combined receptor (Table 8), a cancer risk of 4×10^{-3} for consumption of fish or 1×10^{-3} for consumption of crab indicates that eating fish or crab from the lower 8.3 miles may cause four additional cancers in a population of 1,000 people or one additional cancer in a population of 1,000 people, respectively, under the stated exposure assumptions. For the adolescent receptor (Table 9), a cancer risk of 2×10^{-3} for consumption of fish or 6×10^{-4} for consumption of crab indicates that eating fish or crab from the lower 8.3 miles may cause two additional cancers in a population of 1,000 people or six additional cancers in a population of 10,000 people, respectively, under the stated exposure assumptions.

The primary contributors to the excess risk are dioxins/furans (70 percent for fish consumption and 82 percent for crab consumption), dioxin-like PCBs (11 percent for fish consumption and 12 percent for crab consumption) and non-dioxin-like PCBs (16 percent for fish consumption and 5 percent for crab consumption). The other COPCs contributed a combined 3 percent to the excess cancer risk.

7.1.4.2. Noncancer Health Hazards

The results for noncancer health hazards from the HHRA are summarized in Tables 12 through 14 in Appendix II for the RME scenarios and Tables 15 through 17 in Appendix II for the CTE scenarios. For the RME child who eats fish or crab from the lower 8.3 miles, the HIs are 196 and 67, respectively, which are above EPA's goal of protection of an HI equal to 1. RME results for the adult and adolescent also are above EPA's goal of protection of an HI equal to 1. In addition, noncancer HIs for the CTE individual associated with ingestion of fish and crab are above EPA's goal of protection.

Dioxin/furans and PCBs combined contribute more than approximately 98 percent of the excess hazard, while the remaining excess hazard is associated with methyl mercury for all receptors for ingestion of both fish and crab. The total noncancer HI exceeded the goal of protection and the individual HQs based on critical effect also exceeded a threshold of 1 for these contaminants.

7.1.5. Uncertainties

The HHRA was conducted consistent with EPA risk assessment guidance, guidelines and policies. The application of these procedures is designed to reduce potential uncertainty and ensure consistency. The process of evaluating cancer risks and noncancer health hazards involves multiple steps. Significant uncertainties are discussed in this section; a full discussion of uncertainties is included in RI/FFS Appendix D.

The procedures and inputs used to assess risks in EPA's evaluation, as in all such assessments, are subject to a wide variety of uncertainties. In general, the main sources of uncertainty include:

- Environmental chemistry sampling and analysis
- Environmental parameter measurement
- Exposure parameter estimation
- Toxicological data

Environmental sampling and parameter measurement uncertainties may be introduced through sample collection and preparation methods. Laboratory uncertainties include both random and systematic errors which affect the precision and accuracy of the sample results. Data were collected under EPA-approved QAPPs and the data were validated to reduce the uncertainties involved with laboratory measurement of COCs in environmental samples. Only validated data were used in the risk assessment, which reduced potential uncertainties.

7.1.5.1. Hazard Identification Uncertainties

The HHRA focused on the evaluation of COPCs in fish and crab that were the most bioaccumulative, persistent in the environment and most toxic to human receptors. As a result, other COPCs found in fish and crab were not evaluated in the HHRA, resulting in a potential underestimate of risks and hazards. Since the most persistent contaminants were evaluated, the impact of this uncertainty is most likely limited.

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, consistent with EPA guidance. Therefore, EPCs derived using mercury data may slightly overestimate the methyl mercury concentration and thus result in a potential slight overestimate of noncancer health hazards.

7.1.5.2. Exposure Assessment Uncertainties

Uncertainties in the exposure assessment are related to estimates of how often an individual would actually come in contact with the COCs, the period of time over which such exposure would occur and the models used to estimate the concentrations of the COCs at the point of exposure.

Exposure to dioxin, dioxin-like compounds, PCBs and other bioaccumulative compounds in sensitive subpopulations, such as breast-fed children of mothers who consume contaminated fish, 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.

Individuals may be exposed to COCs from eating game (e.g., turtles, waterfowl) found in the lower 8.3 miles. Waterfowl may contain high concentrations of dioxins and PCBs in their fat and internal organs. However, because there are no historical data on chemical concentrations in the tissues of these organisms, consumption of waterfowl, turtles, and other species is qualitatively evaluated in the HHRA and identified as an area of uncertainty. For individuals who consume these animals in addition to fish and crab, cancer risks and noncancer health hazards would be expected to be higher.

The HHRA evaluated exposure from fish or crab consumption. For those individuals who consume fish or crab and also engage in other activities that result in other types of exposure to COCs in sediment and surface water (such as sculling, wading or swimming in the lower 8.3 miles), the cancer risks and noncancer hazards may be underestimated. Such exposures are not expected to meaningfully increase the risk or hazards, because the fish/crab ingestion pathway has been found to outweigh all other pathways at other sites where both fish ingestion and recreational uses were evaluated. Other exposure pathways in addition to fish/crab ingestion will be evaluated in the 17-mile HHRA.

There is uncertainty in the fish and crab ingestion rates used due to inherent uncertainties in how creel-angler surveys are conducted and how survey results are converted to consumption rates. The potential exists that the risks may be either underestimated or overestimated. EPA’s analysis relied on published information and EPA obtained the raw survey data to calculate the IRs for fish and crab. EPA’s analysis was consistent with other regional and national surveys, supporting the conclusion that the selected IRs for fish and crab are consistent with an RME.

The ingestion rate for crab consumption was based on a survey conducted over a 3-month period during which individuals reported catching and consuming 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 for crab may be underestimated for individuals who catch crab for periods longer than three months.

The potential exists that the risks may be either underestimated or overestimated based on the ingestion rate. The ingestion rates used in the HHRA showed consistency with other surveys both regionally and nationally. This assessment supports the conclusion that the selected consumption rates for fish and crab are consistent with an RME.

The HHRA evaluated exposure from fish or crab consumption. Cancer risks and noncancer health hazards for individuals that consume both fish and crab may potentially be underestimated depending on the frequency with which an individual consumed both fish and crab.

EPCs for fish were based on tissue samples including both skinless and skin-on fillet samples, consistent with EPA guidance (Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories, Volume 2 – Risk Assessment and Fish Consumption Limits, Third Edition [EPA 823-B-00-008]). EPCs derived for organic COCs in fish may be overestimated for those individuals consuming only skinless fillets since fatty tissues concentrate many organic compounds. Conversely, the EPC derived for methyl mercury in fish may be underestimated for those individuals consuming only skinless fillets (mercury concentrates in muscle tissue). EPCs for all COPCs may be underestimated for those individuals consuming whole fish.

EPCs for crab were based on samples including both muscle and hepatopancreas tissue. Incorporating hepatopancreas results is a potential overestimate of the EPC concentration for chlorinated COCs for those individuals who remove the hepatopancreas before cooking the crab. However, consumption surveys conducted by NJDEP have found that 15 percent of respondents indicate they consumed the hepatopancreas and that even those consumers who do not deliberately eat the hepatopancreas are likely to be exposed to its contents due to its fluid nature and its dispersion in cooking liquid.

Use of an equal-weighted average concentration to represent the EPC for fish ingestion in the HHRA assumes that individuals consume only the six fish species caught during the late summer/early fall 2009 sampling event (American eel, common carp, smallmouth bass, white catfish, white perch and white sucker) and that each of these species is equally consumed. This assumption is reasonable, because the six species are commonly caught and abundant in the lower 8.3 miles; in the absence of site-specific information about fish species consumption preferences and consumption patterns, the use of six species that account for distinct ecological groups of fish consumed by anglers is more representative than use of a single species. The assumption of equal intake of the representative species may under or overestimate risks and hazards for those individuals with specific fish preferences.

Reported cooking losses vary considerably among the numerous studies reviewed and little information is available to quantify personal preferences among anglers for various preparation and cooking methods, and other related habits (such as consumption of pan drippings). The assumption that there is no loss during cooking or preparation used in the RME estimate of cancer risk and noncancer health hazard is consistent with the RME individual, but may overestimate risks and hazards for individuals depending on their cooking method preferences.

The HHRA used a 30-year default value for ED for the angler, representing an upper bound residential tenure at a single location. The angler was assumed to be a fairly permanent resident in the area. An evaluation was conducted using 2000 U.S. Census data for Essex and Hudson Counties which quantified (1) how long residents are staying within their county and (2) how long residents stay within the two-county area. The results of this evaluation indicated that, at the 95th percentile, the number of years that an individual stayed in the two-county area was about 95 years and the number of years that an individual stayed in each county was about 55 to 60 years. Therefore, risks and hazards may be underestimated based on the assumption of a 30-year ED by a factor of 1.5 to 2.

7.1.5.3. Toxicity Assessment Uncertainties

Uncertainties in toxicological data occur in extrapolating both from animals to humans and from high to low doses of exposure, as well as from the difficulties in assessing the toxicity of a mixture of chemicals. These uncertainties are addressed by making conservative assumptions concerning risk and exposure parameters throughout the assessment. As a result, the risk assessment provides upper-bound estimates of the risks to populations near a site or operable unit and thus it is highly unlikely to underestimate actual risks related to the site.

One area of uncertainty is related to the CSF used in the calculations. For dioxin, a Tier 3 value was used in the calculation of the cancer risks and an IRIS RfD was used to calculate the non-cancer hazards. As indicated in the HHRA, the currently available Tier 3 cancer slope factor values are comparable to the HEAST value of 150,000 per mg/kg-day (e.g., CalEPA 130,000 per mg/kg-day, EPA's Office of Health and Environmental Assessment (OHEA) value of 156,000 per mg/kg-day). The recalculation of risks using these comparable HEAST, CalEPA or EPA OHEA values would not significantly change the calculated risks.

Another area of uncertainty is related to the TEFs. The HHRA was conducted in accordance with EPA's 2010 TEF guidance. In addition, the primary contributor to the risk at the operable unit is 2,3,7,8-TCDD which is the basis for the other TEFs.

At sites with PCB contamination, the cancer risks and noncancer hazards from PCB exposure are typically evaluated based on a mixture of PCB congeners. However, the presence of the 12 dioxin-like PCBs at concentrations greater than the non-dioxin-like PCBs typically found at a site can result in greater impacts from PCBs at lower concentrations. In the lower 8.3 miles of the LPR, for fish ingestion as an example, the RME cancer risk of 5×10^{-4} for dioxin-like PCBs [TCDD TEQ (PCBs)] is approximately equivalent to the RME cancer risk calculated without consideration of the dioxin-like PCB congeners (*i.e.*, 6×10^{-4} for total PCBs) as shown on Table 8 in Appendix II. Therefore, there was no evidence of enhanced exposure to dioxin-like PCBs.

7.1.5.4. Uncertainty Assessment Conclusion

Overall, the HHRA found that the cancer risks and noncancer health hazards for the RME individual consuming fish or crab exceeded the acceptable cancer risk range and goal of protection of an HI of 1 for the RME individual including all age groups. EPA would not expect any potential overestimate or underestimate of risk based on the identified uncertainties to significantly change the calculated cancer risks and noncancer health hazards.

7.2. Ecological Risk Assessment

The site-specific baseline ecological risk assessment (BERA) evaluated ecological risks associated with exposure to chemicals in the lower 8.3 miles of the Lower Passaic River. Ecological receptors evaluated include aquatic organisms (including benthic macroinvertebrates and fish) and aquatic-dependent wildlife.

The approach used in the BERA to assess site related ecological risks consists of the following four components:

- **Problem Formulation** is a qualitative evaluation of contaminant release, migration, and fate; identification of COPECs, receptors, exposure pathways, and known ecological effects of the contaminants; and selection of endpoints for further study.
- **Exposure Assessment** is a quantitative evaluation of contaminant release, migration, and fate; characterization of exposure pathways and receptors; and measurement or estimation of exposure point concentrations.
- **Ecological Effects Assessment** includes literature reviews, field studies, toxicity tests and linking contaminant concentrations to effects on ecological receptors.
- **Risk Characterization** includes measurement or estimation of both current and future adverse effects.

7.2.1. Problem Formulation

Sediment and fish tissue data collected by EPA, USACE and NOAA within the 17-mile Lower Passaic River from 1990 to 2001 (latest available at the time the initial screening was conducted) were evaluated for quality and used in a screening process to identify COPECs. Any bioaccumulative chemical that was detected in the samples was identified as a COPEC and any essential nutrient was excluded as a COPEC. Then, the maximum detected concentration of each analyte in sediment and fish tissue was compared to effects-based screening values (Effects Range Low [ER-L], Threshold Effect Levels [TELs] and sediment quality threshold concentrations) from NOAA and other widely used, published sources. The screening process, which incorporates Steps 1 and 2 of the ecological risk assessment process, is documented in the *Lower Passaic River Restoration Project Pathways Analysis Report*, July 2005. All COPECs evaluated in the BERA were retained as COCs because all exceeded a Hazard Quotient (HQ) of 1 for one or more receptor categories evaluated (Table 18 in Appendix II). The COCs that were the largest contributors to total ecological risk were selected for evaluation in the BERA, as follows:

- TCDD TEQ
    - Dioxin/furans (as TCDD TEQ)
    - PCB congeners (sum of 12 dioxin-like congeners as TCDD TEQ)
    - 2,3,7,8-TCDD
- Total PCBs (sum of nondioxin-like congeners)
- Total DDx (sum of DDE, DDD and DDT)
- Dieldrin
- PAHs
    - High molecular weight PAHs (HMW PAHs)
    - Low molecular weight PAHs (LMW PAHs)
- Mercury
- Copper
- Lead

TEQs based separately on the dioxin/furan and PCB congeners were evaluated in order to quantify their relative importance to the total TCDD TEQ risks in the BERA. Ecological risks associated with exposure to 2,3,7,8-TCDD alone were also evaluated for invertebrates which lack aryl hydrocarbon receptors.[15] Other COPECs are being evaluated in the 17-mile LPRSA RI/FS.

The ecological effects of the COCs are profiled in RI/FFS Appendix D and summarized in Section 5.2.

Although the lower 8.3 miles of the Lower Passaic River is in a densely-populated urban area, a wide range of ecological receptors may be exposed to the COCs, including the following:

- Benthic invertebrates (represented by invertebrates that live in/on the sediment) and blue crab
- Forage fish (represented by mummichog)
- Piscivorous fish (represented by white perch and American eel)
- Aquatic-dependent birds (represented by great blue heron)
- Aquatic-dependent mammals (represented by mink)

The receptors listed above were evaluated for exposure to COCs through direct contact with and incidental ingestion of sediments, as well as ingestion of contaminated prey. Table 19 in Appendix II summarizes the ecological exposure pathways of concern evaluated in the ERA. To assess exposures to early life stages (the most sensitive to dioxin-like effects), fish and herring gull embryo viability was also evaluated. The assessment endpoints evaluated in the BERA were protection and maintenance (i.e., survival, growth and reproduction) of each community of ecological receptors listed above.

[15] The TEF additive risk approach is not appropriate for organisms that lack aryl hydrocarbon receptors, because aryl hydrocarbon receptor activation is necessary for expression of toxic responses following exposure to dioxin-like compounds.

7.2.2. Exposure Assessment

The BERA, which encompasses Steps 3 to 8 of the EPA eight-step ecological risk assessment guidance (EPA 540-R-97-006), estimated risks to ecological receptors based on sediment and fish and crab tissue data collected during the 17-mile LPRSA RI/FS.

Sediment exposures experienced by ecological receptors were represented by COC concentrations (i.e., 95 percent upper confidence level [UCL]) in the top six inches of sediment. Since the conceptual site model shows that elevated concentrations of COCs are ubiquitous in surface sediments of the lower 8.3 miles, bank-to-bank, the entire lower 8.3 miles was considered a single exposure point for a majority of the evaluated receptors. A subset of the aquatic environment that is periodically exposed during low tide (*i.e.*, mudflats or "shoals") was also considered as a second exposure point for the sediment medium because some ecological receptors reside primarily in this habitat.

Two fish EPCs (for the mummichog and generic fish[16] categories) were used so that potential trophic levels (i.e., piscivorous versus forage) could be considered in the BERA. Concentrations were based on the 95 percent UCL. In addition, inclusion of forage fish, which are typically found in shoals rather than a channel environment, provides a more realistic estimate of modeled dietary exposures for wading birds such as the heron. The generic fish category was used in the BERA to evaluate potential bioaccumulation hazards to the piscivorous and omnivorous fish species that use the Lower Passaic River for at least part of their life cycles as well as aquatic-dependent wildlife that rely on this resource. COC concentrations in the generic fish were calculated using a combination of whole body and reconstituted whole body tissue data for the fish species caught in the sampling programs.

Since there were no site-specific egg residue data available to evaluate early life stages, fish and avian egg tissue concentrations were estimated by applying uptake factors to adult fish tissue concentrations to model transfer from either maternal tissue (fish egg analysis) or fish prey tissue (piscivorous bird egg analysis).

Exposure models were developed for both the heron and mink receptors to estimate the daily intake rate (i.e., daily dose) of each COC; each model incorporated natural history information and species characteristics, such as diet composition, ingestion rates, body weights and foraging ranges.

[16] A number of fish species were collected for the 17-mile LPRSA RI/FS, including American eel, brown bullhead, common carp, smallmouth bass, white catfish, white perch and white sucker. These species are representative of the primary piscivorous and omnivorous life histories characteristic of the Lower Passaic River and their tissue data were combined into a "generic fish" to estimate EPCs.

7.2.3. Ecological Effects Assessment

The effects data linking contaminant concentrations to effects on ecological receptors were derived from published literature (see Table 20 in Appendix II). They are consistent with and supported by laboratory toxicity and benthic community data collected during the 17-mile LPRSA RI/FS.

The primary source of sediment benchmarks used to evaluate direct-contact exposures to sediment for benthic macroinvertebrates was an EPA 2005 study of marine macroinvertebrate survival in laboratories after exposure to field-collected sediments with a range of contaminant levels from various benthic habitats in coastal North America ("Predicting Toxicity to Amphipods from Sediment Chemistry," EPA/600/R-04/030). Chemical concentrations corresponding to a 20 percent and 50 percent probability of observing toxicity (termed "T20" and "T50" models, respectively) were selected to provide lower- and upper-bound sediment benchmarks for the BERA. The study determined that the magnitude of the toxic effect (i.e., decreased survival) predicted by the models was strongly correlated with the predicted probability of toxicity. The study provided T20 and T50 values for copper, lead, mercury, dieldrin and Total PCBs that were used in the BERA as sediment benchmarks. For those COCs lacking T20/T50 values, NOAA ER-L and Effects Range-Median (ER-M) values were used to identify the range of contaminant concentrations over which an adverse toxicological response is increasingly likely to occur. ER-L and ER-M values were selected as lower- and upper-bound sediment benchmarks for LMW PAHs, HMW PAHs and Total DDx. Finally, a site-specific sediment benchmark for 2,3,7,8-TCDD was developed in 2007 by USFWS based on sediment and suspended solids analytical data collected from the Arthur Kill and oyster effect data (see RI/FFS Appendix D for more details). The oyster is an appropriate endpoint species, since its occurrence in the lower 8.3 miles of the Lower Passaic River was documented by the 17-mile LPRSA RI/FS and it was historically an important resource.

To evaluate whether exposure to COCs that have bioaccumulated in fish and crab tissues, and in fish and bird embryos, is likely to cause adverse effects, critical body residues (CBRs) were developed from published literature for each COC and each ecological receptor. Selection of each CBR, including rationale for application of extrapolation factors where appropriate, is discussed in detail in RI/FFS Appendix D. As discussed in Section 7.2.1, dioxin CBRs were compared to crab and fish tissue EPCs based on 2,3,7,8-TCDD and TCDD-TEQ concentrations, respectively.

To evaluate the potential effects to wildlife associated with exposure to COCs through incidental sediment ingestion and consumption of contaminated prey, Toxicity Reference Values (TRVs) were developed from published literature for each COC and each ecological receptor (great blue heron and mink). Selection of each TRV, including the rationale for application of extrapolation factors where appropriate, is discussed in detail in RI/FFS Appendix D.

7.2.4. Risk Characterization

The risk characterization combines the exposure and effects assessments to derive quantitative estimates of risk for each endpoint. Risks were calculated based on both the low and high estimates of toxicity to provide lower and upper bound estimates of risk, respectively. Each individual risk estimate for a given receptor for each chemical was calculated as an HQ, which is the ratio of the EPC to a given toxicological benchmark. If the HQ is equal to or less than 1, then no adverse health effects are expected as a result of exposure. If the HQ is greater than 1, then adverse health effects are possible.

Risks to benthic invertebrates were evaluated in two ways. First, for invertebrates other than crabs, lower 8.3-mile sediment contaminant concentrations (from the exposure assessment described in Section 7.2.2) were compared to sediment benchmarks (from the ecological effects assessment in Section 7.2.3). In the lower 8.3 miles, sediment concentrations for all COCs exceeded the sediment benchmarks (see Table 21 in Appendix II). Based on the magnitude of exceedances of sediment benchmarks, 2,3,7,8-TCDD, Total DDx, Total PCBs, PAHs, dieldrin and mercury were found to contribute most substantially to risks to invertebrates other than crabs. Second, for crab, a comparison was made between crab tissue concentrations and CBRs. Lower 8.3-mile crab tissue concentrations were found to be higher than CBRs for copper, mercury, Total PCBs and 2,3,7,8-TCDD. Based on the magnitude of exceedances of CBRs, 2,3,7,8-TCDD and Total PCBs were found to contribute most substantially to risks to crabs.

Risks to piscivorous fish and forage fish were evaluated by comparing lower 8.3-mile tissue concentrations (from the exposure assessment) to CBRs (from the ecological effects assessment). (See Table 22 in Appendix II.) Fish tissue concentrations were found to be higher than CBRs for copper, PCBs and dioxins/furans. Estimates of fish egg concentrations were greater than egg CBRs for dioxins/furans.

Risks to aquatic-dependent birds and mammals were evaluated by comparing modeled daily doses of COCs (from the exposure assessment) to TRVs (from the ecological effects assessment), and by comparing estimated contaminant concentrations in eggs from fish-eating birds to CBRs (see Tables 23a and 23b in Appendix II). For the heron consuming fish, only dioxins/furans modeled daily doses exceeded the TRVs. The estimated bird egg concentrations substantially exceeded CBRs for PCBs, dioxins/furans and Total DDx. For the mink, modeled daily doses were higher than toxicological reference values for dioxins/furans, PCBs and mercury.

7.2.5. Uncertainties

BERAs are based on calculations using sample data collected to represent the nature and extent of contamination, toxicological information on COCs from laboratory and field studies, and conservative assumptions regarding the exposure of sensitive ecological receptors. There is a degree of uncertainty associated with exposure modeling and HQ calculations even when available site-specific information is used in the assessment. Significant uncertainties are discussed in this section; a full discussion of uncertainties is included in RI/FFS Appendix D.

7.2.5.1. Problem Formulation

The BERA focused on a subset of COPECs that were the largest contributors to total ecological risk, as discussed in Section 7.2.1. As a result, other COPECs found in sediment, fish and crab were not evaluated in the BERA, resulting in a potential underestimate of ecological risks.

The BERA also did not evaluate all potentially complete exposure pathways or ecological receptors, so overall risks may be underestimated.

7.2.5.2. Exposure Assessment

The fish tissue sampling program was designed to meet objectives for both the HHRA and BERA. As a consequence, the size and age of the fish collected could not be specific to the ecological wildlife modeled. Although larger prey can be speared and brought to shore for dismemberment and consumption, typical fish prey for the great blue heron tends to be less than 25 centimeters according to EPA's 1993 *Wildlife Exposure Factors Handbook*. Inclusion of larger fish prey in the sample set used to calculate the generic fish EPCs for the BERA would tend to overestimate exposures to piscivorous birds that feed on forage fish and smaller size categories of other fish because fish body burdens generally increase with size and age.

The great blue heron exposure scenario may lead to overestimates of Site-related risk, because it is assumed that 100 percent of risk to the population is resulting from exposures in the lower 8.3 miles. It is possible that piscivorous birds like the great blue heron may selectively feed in locations with lower concentrations of contaminants during some portion of their time in the lower 8.3 miles, although the concentrations of COCs at or exceeding the EPCs are broadly distributed across the lower 8.3 miles of the Lower Passaic River. Also, in this urbanized region, elevated exposures to at least some of the COCs outside of the lower 8.3 miles are also possible.

Published values for exposure parameters for wildlife receptors were assumed to represent wildlife in the Lower Passaic River. Parameters used included smallest home ranges, smallest average body weights (adult females), and typical sediment and food ingestion rates. Overall, these are conservative assumptions that potentially result in the exposures (and risks) encountered by typical individuals being overestimated. However, these assumptions do not consider juvenile receptors that may have higher ingestion rates relative to body weight, and exposures for these more sensitive life stages are likely to have been underestimated.

7.2.5.3. Ecological Effects Assessment

The T20/T50 sediment benchmarks are based on a narrow subset of the benthic and epibenthic soft bottom estuarine community and may not be robust predictors of effects for organisms with different life histories, exposures and/or toxicological sensitivities. Despite this concern, single species toxicity test results and benthic community metrics appear to be reasonably well correlated for most sediment-borne chemical stressors evaluated.

Use of the most sensitive species to select CBRs likely resulted in an overestimate of risks for the residue-based analysis. Species such as salmon and trout are not found in the Lower Passaic River, and the risks quantified in the residue-based analysis for the generic fish category were likely conservatively estimated. Use of tissue residue effect data for species such as the domesticated chicken, which is known to be particularly sensitive to PCBs and 2,3,7,8-TCDD, also resulted in conservative risk estimates. Further, selective breeding of the domesticated chicken for egg production could have affected overall sensitivities. Recently published work (see Responsiveness Summary in Appendix V for a list) categorized various avian species according to their relative sensitivity to dioxins and dioxin-like compounds. Three general categories of decreasing sensitivity have been identified, with the domesticated chicken and four other species categorized as Type 1, the ring-necked pheasant as Type 2 and species such as herring gull, double-crested cormorant and great blue heron (all potential avian receptors in the Lower Passaic River) as Type 3. The lack of obvious evolutionary relationships among the bird species in each of the categories suggests that taxonomic relatedness is not necessarily a strong predictor of relative sensitivity to compounds with dioxin-like effects. Because fewer than half of the bird species documented in the lower 8.3 miles have been categorized in this way, it is prudent to be conservative in selecting toxicity thresholds. In general, the procedures employed in the selection of CBRs tended to result in conservative risk estimates; however, this is appropriate, because suitable tissue residue data for certain COCs were limited and may not have been based on relevant sensitive species or life stages.

TRVs are typically based on results of tests performed on test animals under laboratory conditions and extrapolated to wildlife species in their natural habitat; selected values are generally conservatively developed as the lowest of the lowest observed adverse effects levels for well-conducted studies that evaluated ecologically relevant endpoints (survival, growth and reproduction). Results are then used to develop TRVs as daily dietary exposures. 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. Risks are also likely to be overestimated because researchers typically attempt to minimize the variability in contaminant exposure when conducting laboratory toxicity studies and use more bioavailable forms of chemicals in the prepared diets.

7.2.5.4. Uncertainty Assessment Conclusion

Overall, the BERA found that the ecological risks to a wide range of receptors (benthic invertebrates, forage fish, piscivorous fish, and aquatic-dependent birds and mammals) exceeded EPA’s goal of an HQ equal to 1. The finding of unacceptable ecological risk would not change even when the range of uncertainties is considered.

7.3. Basis for Remedial Action

The response action selected in this ROD is necessary to protect public health or welfare and the environment from actual or threatened releases of hazardous substances into the environment. A response action is necessary for the sediments of the lower 8.3 miles of the Lower Passaic River portion of the Diamond Alkali Superfund Site at this time because:

Human Health Risk: The risk of an RME individual developing cancer or noncancer health effects as a result of COC exposure from ingestion of fish or crab in the lower 8.3 miles of the Lower Passaic River exceeds the acceptable risk range identified in the NCP. Specifically, fish and crab consumption risks and HIs for the RME scenarios exceed CERCLA-acceptable risk levels of an excess cancer risk of 10^{-6} to 10^{-4} and a noncancer goal of protection of an HI of 1.

Ecological Risk: Risks to all ecological receptors (benthic invertebrates, fish, aquatic birds and aquatic mammals) exceed acceptable levels (HQ equal to 1).

8. REMEDIAL ACTION OBJECTIVES

Remedial action objectives (RAOs) describe what a remedial action is expected to accomplish. The following RAOs have been established for the lower 8.3 miles of the Lower Passaic River:

- Reduce cancer risks and noncancer health hazards for people eating fish and crab by reducing the concentrations of COCs in the sediments of the lower 8.3 miles.

- Reduce the risks to ecological receptors by reducing the concentrations of COCs in the sediments of the lower 8.3 miles.

- Reduce the migration of COC-contaminated sediments from the lower 8.3 miles to upstream portions of the Lower Passaic River and to Newark Bay and the New York-New Jersey Harbor Estuary.

These RAOs address human exposure through fish and/or crab consumption, and ecological exposures. The unacceptable exposures identified in the risk assessments are primarily derived from elevated COC concentrations in surface sediments that result in bioaccumulation of COCs in fish and crab. Addressing these sediments will reduce COC concentrations in biota, including fish and crab tissue, thereby significantly reducing potential human health risks and hazards, and ecological risks. By addressing exposure to and mobility of the surface sediments, the remedial action is expected to achieve the RAOs.

Reasonably anticipated future land and waterway uses in the lower 8.3 miles include the continued use of the federally authorized navigation channel for commercial navigation. Except for the two miles closest to Newark Bay, the federally authorized navigation channel in the lower 8.3 miles has not been regularly maintained in recent years. Based on EPA's analysis of USACE's 2010 Lower Passaic River Commercial Navigation Analysis report and comments submitted to EPA on the Proposed Plan, EPA does not anticipate that the channel above RM 1.7 is likely to be used for commercial navigation in the foreseeable future. The lowest 1.7 miles are currently used for commercial navigation, and USACE has indicated that maintaining the channel for this stretch is consistent with its current and reasonably anticipated future use. USACE has advised that based on current information about reasonably anticipated future use of the channel, it will support a recommendation for Congressional action to deauthorize the federal navigation channel from RM 1.7 to RM 8.3.

The communities along the banks of the lower 8.3 miles currently use the river for recreational purposes, and have provided their master plans for future increased recreational access, which can be anticipated to increase the recreational use. Thus, the reasonably anticipated future uses above RM 1.7 will be similar to if not greater than the current recreational uses.

8.1. Preliminary Remediation Goals

There are no chemical-specific federal or State of New Jersey standards for the COCs in sediment. Therefore, EPA developed Site-specific, risk-based preliminary remediation goals (PRGs) for the lower 8.3-mile sediments. Below is a discussion of how the PRGs were developed in the RI/FFS, and what led EPA to select the final remediation goals.

8.1.1. Human Health PRGs

Risk-based sediment concentrations to protect human health were developed based on fish or crab tissue concentrations of COCs (dioxins, PCBs and mercury) that would allow adult anglers to eat self-caught fish or crab from the lower 8.3 miles of the Lower Passaic River at a 10^{-6} cancer risk level or a noncancer HI of 1 as the goal of protection (see Table 24 in Appendix II[17]). Protective concentrations in tissue were also developed for risk levels of 10^{-5} and 10^{-4} (the last of which is typically the level that triggers the need for remedial action at a site). Protective concentrations in fish and crab tissue were calculated based on the site-specific adult consumption rates of 35 g/day for fish or 21 g/day for crab used in the HHRA. These consumption rates are equivalent to 56 eight-ounce fish meals per year or 34 eight-ounce crab meals per year. Additional tissue concentrations were developed for 12 eight-ounce fish or crab meals per year (or one meal per month), for use as interim remediation milestones (Table 24, columns 8-10). Interim remediation milestones are fish and crab tissue concentrations to be used during monitoring after remedy implementation to evaluate if contaminant concentrations in fish and crab tissue are decreasing as expected. EPA will share monitoring data and consult with NJDEP about whether the prohibitions on fish and crab consumption can be lifted or adjusted to allow for increased consumption as contaminant levels decline.

Sediment concentrations needed to meet protective fish and crab tissue concentrations were estimated using site-specific biota-sediment accumulation relationships developed from the COC

[17] All PRGs in Table 24 reflect were adjusted from the Proposed Plan based upon the updated ED and BW metrics discussed in Section 7.1.2.

concentrations in sediments and co-located fish or crab tissue concentrations. These relationships between sediment and tissue concentrations take into account the possibility that some of the fish or crab may have been exposed to contamination outside of the lower 8.3 miles of the Lower Passaic River, and are consistent with research showing that tissue concentrations may not decline at the same rate as sediment concentrations after sediments are remediated. These risk-based sediment PRGs for human health are presented in Table 25 in Appendix II, columns 3-8 and 12-13, along with the interim remediation milestones (columns 9-11 and 14).

8.1.2. Ecological PRGs

While all of the COCs discussed in Section 7.2 cause unacceptable risks (HQ greater than 1) to some or all of the receptors evaluated, risk-based PRGs were developed for dioxins, PCBs, mercury and Total DDx, because they are representative COCs (based on the magnitude of HQs and number of receptors affected) and because there were multiple lines of evidence developed to evaluate how the alternatives would achieve PRGs for these four COCs after remediation. In addition, most active alternatives (i.e., alternatives other than No Action) designed to address these COCs would also address the other COCs.

Sediment PRGs that would be protective of benthic invertebrates were developed based on the sediment benchmarks used to evaluate risks in the BERA. The benchmarks are published literature values shown through independent research to be good predictors of toxicity.

Tissue concentrations that would be protective of crab and fish were developed based on the CBRs used to evaluate risks in the BERA. Prey tissue concentrations that would be protective of birds and mammals were developed based on the TRVs used to evaluate risks in the BERA. The corresponding sediment concentrations needed for each species to meet the protective tissue concentrations were then estimated using the site-specific non-linear regressions described in Section 8.1.1.

Table 25 in Appendix II (column 2) presents the overall ecological risk-based sediment PRGs for the representative COCs. The overall ecological risk-based PRG for each COC is the lowest of the PRGs developed for each category of receptor, so that all of the organisms, including the most sensitive species, will be protected.

8.1.3. Background Concentrations and other Potential Contributors of COCs

The Dundee Dam (RM 17.4) physically isolates Dundee Lake and other Upper Passaic River sediments from Lower Passaic River influences. Conditions above Dundee Dam meet EPA's definition of "background" as constituents or locations that are not influenced by releases from the Site, including both anthropogenic and naturally derived substances. The concentrations of the COCs detected in recently deposited sediments collected from the Upper Passaic River immediately above Dundee Dam are representative of current background conditions for the lower 8.3 miles of the Lower Passaic River and are listed in Table 26 in Appendix II. While the Superfund program generally does not clean up to concentrations below natural or anthropogenic background levels, in the Lower Passaic River, the flow of suspended sediment over Dundee Dam is just one of many contributors to sediment contamination in the lower 8.3 miles. Sediment particles coming from above Dundee Dam make up about one third of recently deposited sediment in the lower 8.3 miles. When, after remediation, these particles flow to the lower 8.3 miles, they will mix with the other particles in the system (including cleaner particles in the water column that would result from a remediated lower 8.3 miles); after they are deposited, they also will mix with the clean cap or backfill material. So contamination in the top six inches (the bioactive zone) can end up being less than the background concentrations coming over Dundee Dam, as predicted by the mechanistic model developed by EPA to support its analyses in the RI/FFS and Proposed Plan and the model updated in response to comments for EPA's final decision-making in the ROD (see Section 10.3).

While COCs (particularly PCBs) entering the lower 8.3 miles from above the dam and other incoming COCs, such as from Newark Bay and the Lower Passaic River above RM 8.3, are relatively small contributors of COCs to the recently deposited surface sediments of the lower 8.3 miles, as compared to the resuspension of lower 8.3-mile sediments, they will be more important contributors to recontamination of an implemented remedy for the lower 8.3 miles, particularly in the case of the bank-to-bank alternatives described in Section 9. EPA expects that overall COC concentrations will decline over time as the Lower Passaic River above RM 8.3 and Newark Bay are remediated through actions selected after the completion of the 17-mile RI/FS and Newark Bay RI/FS, respectively. Furthermore, EPA expects that programs developed under the Clean Water Act will address PCBs and other COCs above Dundee Dam by working with NJDEP to identify and mitigate these loadings. Such actions, taken while the remedy for the lower 8.3 miles is being designed and implemented, will reduce the incoming COCs, minimize the degree of recontamination and allow the selected remedy to achieve RAOs.

8.1.4. Selected Remediation Goals

PRGs become final remediation goals when EPA selects a remedy after taking into consideration all public comments. The NCP identifies a 10^{-6} cancer risk level or a noncancer hazard of 1 as the goal of protection for determining remediation goals for alternatives when applicable or relevant and appropriate requirements (ARARs) are not available or are not sufficiently protective. EPA has concluded that a 10^{-6} cancer risk for the fish and crab consumption exposure pathway cannot be attained through remediation, given the Site's urban setting and the ubiquity of Site COCs in the environment. However, a remedy that includes active remediation and natural recovery provides the conditions for eventually achieving protective levels within EPA's risk range of 10^{-4} and 10^{-6} and an HI of 1 for the lower 8.3 miles of the Lower Passaic River (see Section 10.1 for further discussion). For the COCs with human health PRGs, remediation goals within the risk range and at an HI equal to 1 were selected, so they are protective of human health. For mercury and Total DDx, remediation goals at an HQ equal to 1 were selected, so they are protective of the environment. The remediation goals for the lower 8.3 miles are summarized in Table 25 in Appendix II (bolded numbers).

Nearly all surface sediment samples in the lower 8.3 miles have COC concentrations that exceed one or more of the PRGs, which has led to the development of remedial alternatives that address the lower 8.3 miles bank to bank (Alternatives 2 and 3, described in Section 9.2). EPA's analysis indicates that a combination of active remediation in the lower 8.3 miles and natural recovery would result in surface sediment concentrations of dioxins/furans at or near the remediation goals based on human health PRGs in the lower 8.3-miles under these two alternatives.[18] For the other COCs, a combination of active remediation in the lower 8.3 miles and natural recovery will be needed to achieve surface sediment concentrations in the lower 8.3 miles approaching the remediation goals based on human health PRGs, with additional actions in the Lower Passaic River above RM 8.3, in Newark Bay, and above Dundee Dam needed to reduce recontamination from incoming COCs and maintain the lower surface sediment concentrations achieved by the lower 8.3-mile remediation. For dioxins and PCBs, it is unlikely that the ecological PRGs could be met under any of the alternatives, even with natural recovery processes. However, given that bank-to-bank remediation of the lower 8.3 miles is necessary to achieve protection of human health (see Section 10.1), ecological PRGs for dioxin and PCBs would not result in any additional remediation in the sediments of the lower 8.3 miles and were not selected as remediation goals.

9. DESCRIPTION OF REMEDIAL ALTERNATIVES

CERCLA §121(b)(1), 42 U.S.C. §9621(b)(1), mandates that remedial actions must be protective of human health and the environment, be cost-effective, and use permanent solutions and alternative treatment technologies and resource recovery alternatives to the maximum extent practicable. CERCLA §121(b)(1) also establishes a preference for remedial actions which employ, as a principal element, treatment to permanently and significantly reduce the volume, toxicity, or mobility of the hazardous substances, pollutants and contaminants at a site. CERCLA §121(d), 42 U.S.C. §9621(d), further specifies that a remedial action must require a level or standard of control of the hazardous substances, pollutants, and contaminants, which at least attains ARARs under federal and state laws, unless a waiver can be justified pursuant to CERCLA §121(d)(4), 42 U.S.C. §9621(d)(4). Detailed information about the remedial alternatives is provided in the FFS Report.

9.1. Common Elements of the Active Alternatives

Four remedial alternatives were evaluated in detail (described in Section 9.2). All of the active alternatives (i.e., alternatives other than "No Action") contain some common elements, as described below. In addition, the cost of each of the active alternatives has been estimated considering each of the three DMM scenarios separately in turn, also described below.

[18] This does not preclude evaluation of remedial actions in the LPR above RM 8.3 upon completion of the 17-mile RI/FS.

9.1.1. Institutional Controls

New Jersey's prohibitions on fish and crab consumption currently in place would continue under all of the alternatives. To increase the awareness of the prohibitions and reduce the number of anglers and family members consuming their catch, each active alternative would include enhanced outreach efforts conducted by EPA and NJDEP in every municipality on both shores of the lower 8.3 miles of the Lower Passaic River. The enhanced outreach would educate community members about the NJDEP consumption prohibitions and advisories and emphasize that they will remain in place during and after remediation until remedial action objectives are reached.

For the active alternatives that rely on an engineered cap for protectiveness, additional institutional controls would be necessary to maintain cap integrity in perpetuity. Such institutional controls to protect the engineered cap might include:

- Restrictions on construction and dredging in the lower 8.3 miles except in the federally authorized navigation channel, implemented by NJDEP Tidelands Commission through existing regulatory provisions;
- Restrictions on construction and dredging below the depths of the federally authorized navigation channel, implemented by USACE through existing permitting requirements;
- Restrictions on bulkhead maintenance in the lower 8.3 miles, implemented by NJDEP Tidelands Commission and USACE through existing regulatory and permitting requirements;
- Additional institutional controls to protect the cap could be developed during remedial design.

9.1.2. Dredging

Dredging is an element of all of the active alternatives. Prior to dredging, large debris would be removed. The FFS assumed that dredging would occur using a mechanical dredge fitted with an environmental clamshell bucket, although costs for a hydraulic dredge were also estimated. The most appropriate and effective equipment for dredging and dredged-material transport will be determined during the design phase. The FFS assumed use of two primary mechanical dredges equipped with 8-cy environmental clamshell buckets. The production rate for each of the two dredges was conservatively estimated to be 2,000 cy per 24-hour day, based on the results of a pilot study of environmental dredging conducted in the lower 8.3 miles of the Lower Passaic River by USACE and NJDOT in 2005. A smaller secondary dredge would operate at a lower production rate around obstructions such as bridge abutments and bulkheads. Dredging was assumed to occur for 32 weeks per year to account for equipment maintenance, weather and a period during which work may halt to allow for fish migration (known as a "fish window"). Analyses developed by EPA since issuing the Proposed Plan identified engineering solutions to minimize bridge openings during dredged materials transport, and added time to the schedule to more fully account for equipment downtime and for fish windows during which construction may be curtailed to accommodate fish migration or spawning. As discussed in Section 14, changes to the schedule to accommodate these additions did not increase the total remedy duration substantially from that estimated in the Proposed Plan and did not change the relative durations among alternatives, so did not change EPA's comparative analysis results from the Proposed Plan. The revised durations are presented in the alternative descriptions in Section 9.2. During the remedy design, a fish migration study will be conducted to better define the fish window.

9.1.3. Engineered Capping

Engineered capping is a key element of two of the active alternatives. The term "engineered capping" refers to placing materials of known characteristics in specifically designed thicknesses over contaminated sediments to sequester them in place (i.e., isolate them from the environment). The engineered cap is planned to consist of sand with varying grain sizes and amounts of organic carbon, designed to provide chemical isolation and to protect against disturbance from bioturbation (mixing of clean cap materials with contaminated sediment by burrowing organisms), erosion, and consolidation and settling of underlying sediments.

During remedial design, other capping technologies (i.e., materials used for capping and how they are applied) that are shown to be equivalently protective may be evaluated. Based on observed sediment bed erosion trends and modeling results, certain areas of the river may need to be armored to reduce the erosion of the sand material, particularly after high flow events. The exact areas and armoring methods will be determined during remedy design. The engineered cap must be monitored and maintained in perpetuity. For cost-estimation purposes, the FFS assumed a 2-foot thick engineered sand cap with six inches of armor stone in some areas. Dredged mudflats would be reconstructed with a layer of sand (or equivalent material) under approximately one foot of habitat substrate.

During remedial design, EPA will evaluate enhanced capping technologies, such as the use of additives (e.g., activated carbon or organoclay) to create a reactive cap or thin-layer capping technologies where conditions are conducive to such approaches. USACE habitat restoration plans for the New York-New Jersey Harbor Estuary could provide additional information on appropriate habitat reconstruction techniques. EPA anticipates that re-deposition of fine-grained material over capped and armored areas will occur over time, making these areas similar in grain size to non-capped areas. Based on studies at other dredged sites, it is expected that, over time, the re-colonized benthic community will likely be similar to the benthic community currently found in the Lower Passaic River, or exhibit greater diversity and abundance than current conditions due to reduced surface sediment contamination.

9.1.4. Removal Actions

All alternatives assume that the Tierra Removal (Phases 1 and 2) and RM 10.9 Removal will have been completed, since they are governed by existing agreements. The agreement for Phase 2 of the Tierra Removal, which EPA entered into with OCC and Tierra in 2008, contemplated the siting and use of a confined disposal facility[19] (CDF) as a receptacle for the dredged materials. However, this has not occurred and may no longer be practicable, in which case alternate disposal options would be considered. If the approach for addressing the Phase 2 sediments has not been determined by the time the lower 8.3-mile remedial design is underway, EPA expects that this work will be integrated with the lower 8.3-mile remedy in a coordinated and consistent manner.

9.1.5. Five-Year Reviews

Five-year reviews will be required for any of the active remedial alternatives that result in some hazardous substances, pollutants or contaminants remaining in sediments above levels that would allow for unlimited use and unrestricted exposure. This is the case for all except Alternative 2 with DMM Scenarios B and C. In addition, EPA conducts five-year reviews at sites where the time required to achieve the RAOs exceeds five years, as is expected for all the active alternatives.

9.1.6. Dredged Material Management (DMM) Scenarios

9.1.6.1. DMM Scenario A: Confined Aquatic Disposal (CAD)

CAD cells have been shown to be a viable disposal option at other Superfund sediment sites. They can be a technically feasible and cost effective means to dispose of contaminated sediments. The bottom of Newark Bay consists of approximately 60 feet of clay beneath a few feet of silts. In the context of the lower 8.3-mile action, CAD cells would be containment pits excavated into the clay bottom that could serve as disposal sites for contaminated sediments dredged out of the lower 8.3 miles of the Lower Passaic River. In this DMM Scenario, one to three CAD cells approximately 50 feet deep would be excavated into the Newark Bay bottom (see FFS Report Figure 4-1). For cost-estimation purposes, it was assumed that the clay excavated to create the CAD cells would be disposed of in an ocean disposal area, such as the Historic Area Remediation Site in the New York Bight east of Sandy Hook. Final disposal locations would be determined during remedy design. The CAD site would be surrounded by a temporary sheet pile and silt curtain containment system to minimize impacts to Newark Bay during construction and dredged material placement.

The dredged materials would be barged directly to the CAD site in a split hull or bottom dump barge and disposed of in the CAD cells under water. Resource Conservation and Recovery Act (RCRA) regulations exclude dredged material that is subject to the requirements of Clean Water Act Section 404 from the definition of hazardous waste. Dredged material under DMM Scenario A would meet this exclusion, so there would be no requirement that lower 8.3-mile sediments be characterized and/or treated prior to disposal in CAD cells. After each CAD cell is filled, an

[19] A confined disposal facility (CDF) is an engineered structure, built on land or in the water (on the sediment bed) to hold contaminated dredged material, isolating it from the surrounding environment. An in-water CDF may be constructed with sheet pile walls or other containment structures, either against the shore or as an island. Once an in-water CDF is filled, it would be capped, converting open water to dry land.

engineered cap would be placed over the dredged material as final cover, restoring the Bay bottom.

9.1.6.2. DMM Scenario B: Off-Site Disposal

Off-Site Disposal includes two possible components: incineration and landfilling. In the off-site disposal scenario, some lower 8.3-mile sediments have the potential to be characterized as hazardous under RCRA regulations. Based on waste characterization sampling of sediment removed from the river during Phase I of the Tierra Removal, EPA identified that some sediments may be considered hazardous, resulting in a requirement to treat those sediments prior to land disposal; however, RCRA regulations require treatment not just for chemicals that caused the sediments to be classified as hazardous, but for all "underlying hazardous constituents" (i.e., any other chemicals exceeding RCRA's land disposal standards). At this time, incineration is the only technology known to be able to treat sediments if those sediments are characterized as hazardous under RCRA and contain dioxin as an underlying hazardous constituent at concentrations requiring treatment. The ash generated by incineration under this scenario would be disposed of in a RCRA Subtitle C (hazardous waste) landfill. Dredged materials characterized as non-hazardous may be disposed of directly in a landfill without treatment. Since the private parties that performed the Phase 1 Tierra Removal and the RM 10.9 Removal disposed of dredged material in RCRA Subtitle C facilities, EPA expects that the dredged material generated by this action will also go to Subtitle C facilities; and for cost-estimation purposes, placement in a RCRA Subtitle C landfill outside of New Jersey (because there are no RCRA Subtitle C landfills operating in New Jersey) was assumed. Further, the State of New Jersey has no permitted Subtitle D landfills that are authorized to accept dredged materials from coastal or tidal waters for disposal as solid waste, as such materials are specifically excluded from the definition of solid waste under New Jersey regulations.

The dredged materials would be barged or pumped to an upland sediment processing facility in the vicinity of the Lower Passaic River or Newark Bay shorelines. Debris and sand would be separated for disposal or potential beneficial use. The remaining fine-grained material would be actively dewatered using filter presses or another technology to be determined during remedy design. The contaminated water generated from dewatering would be treated at a wastewater treatment plant at the processing facility to meet NJDEP water quality standards and discharged to the Lower Passaic River or Newark Bay. For cost-estimation purposes, EPA assumed that the dewatered dredged material would be transported by rail for disposal, with less than 10 percent requiring incineration and the other approximately 90 percent going directly to permitted landfills. Facilities qualified to accept the materials for treatment and/or disposal have been identified in the United States and Canada.

9.1.6.3. DMM Scenario C: Local Decontamination and Beneficial Use

Local Decontamination and Beneficial Use includes three components: thermal treatment, sediment washing and solidification/stabilization. In this scenario, some lower 8.3-mile sediments have the potential to be characterized as hazardous under RCRA standards. According to pilot tests of the decontamination technologies, only thermal treatment technologies were able to treat sediments to the applicable RCRA standards if those sediments are characterized as hazardous and contain dioxin as an underlying hazardous constituent. Fine-grained dredged materials characterized as non-hazardous could be treated with a sediment washing technology. Approximately one to two percent of lower 8.3-mile sediments may meet New Jersey standards for beneficial use with little or no treatment. In the FFS, it was assumed that this small percentage would be solidified and stabilized with a binding material such as Portland cement, and then be beneficially used in an industrial setting.

The dredged materials would be barged or pumped to an upland sediment processing facility in the vicinity of the Lower Passaic River or Newark Bay shorelines. Debris and sand would be separated for disposal or potential beneficial use. The portion of the fine-grained material to be decontaminated using thermal treatment and solidification/stabilization would be actively dewatered using filter presses or other technology to be determined during remedy design. The portion of the fine-grained material to be decontaminated using sediment washing would be dewatered after treatment. Water used in sediment washing and generated from dewatering would be treated at a water treatment plant at the processing facility to meet NJDEP water quality standards and discharged to the Lower Passaic River or Newark Bay. For cost-estimation purposes, EPA assumed that less than 10 percent of the dredged materials would require thermal treatment and would generate beneficial use end-products, approximately 90 percent would undergo sediment washing (and potential solidification/stabilization if necessary) for use as RCRA Subtitle D landfill cover in or out of New Jersey, and the remaining few percent would be used for industrial beneficial use with only stabilization.

9.2. Remedial Alternatives

9.2.1. Alternative 1: No Action

Present Value:	$0
Construction Time:	0 years

The Superfund program requires that the No Action alternative be considered as a baseline for comparison with the other alternatives. The No Action alternative would not include any remedial measures, although the Tierra and RM 10.9 Removals are assumed to have been implemented. New Jersey's prohibitions on fish and crab consumption would remain in place.

9.2.2. Alternative 2: Deep Dredging with Backfill

Present Value:	
With DMM Scenario A	$1.21 Billion
With DMM Scenario B	$2.84 Billion
With DMM Scenario C	$2.57 Billion
Construction Time:	14 years

Deep Dredging with Backfill is a bank-to-bank remedy that would involve dredging all contaminated fine-grained sediments throughout the lower 8.3 miles of the Lower Passaic River (9.7 million cy) and placing a layer of backfill[20] over the dredged area to mitigate the effect of residuals[21] remaining after dredging. Backfill would not be maintained after placement, since the intent is that dredging would remove the inventory of contaminated sediments that could become mobile. This alternative is intended to remove the contaminated sediment inventory causing the current and potential future risks in the lower 8.3 miles. This alternative would result in the dredging of the federally authorized navigation channel over its full length within the lower 8.3 miles, since the contaminated sediment inventory is coincident with historic in-filling of the authorized navigation channel.

Within the horizontal limits of the authorized navigation channel, the depth of contaminated fine-grained sediment corresponds well with the depth of historical dredging. Therefore, the depth of dredging under Alternative 2 is assumed to be the historically constructed channel depth plus an additional three feet to account for historical dredging accuracy and over-dredging.[22] The resulting sediment removal depths (all in mean low water [MLW]) are shown in Table 27 in Appendix II.

Outside the horizontal limits of the navigation channel (in the shoals), the depth of contaminated fine-grained sediment to be dredged varies from 3 feet to 20 feet below the sediment surface. Final dredging depths would be refined in the remedy design. Mudflats dredged during implementation of Alternative 2 would be reconstructed to their original grade and would include one foot of mudflat reconstruction (habitat) substrate. USACE habitat restoration plans for the New York-New Jersey Harbor Estuary could provide additional information on appropriate habitat reconstruction techniques.

Dredged materials removed would be managed in accordance with one of three DMM scenarios described in Section 9.1.6.

The construction time estimate (14 years) includes time for dredging, backfilling and dredged material disposal. The construction duration is driven by the time required for dredging and is not influenced by the choice of DMM scenario, because EPA assumes that DMM facilities would be designed and constructed to manage the dredged material throughput without adding to the time needed.[23]

[20] For cost-estimation purposes, the FFS assumed an average 2-foot backfill layer.
[21] Dredging residuals are the small amounts of contaminated sediments that are inevitably left behind after dredging.
[22] Given the inherent inaccuracies of dredging equipment used for navigational dredging, dredge operators are allowed to "over-dredge," or dredge to depths beyond the project design depth, to make sure that the design depth is achieved. Dredges are more accurate today than historically, so over-dredge allowances are smaller today.
[23] Construction duration for DMM Scenario C is more uncertain than for the other two scenarios, because the decontamination technologies evaluated in DMM Scenario C have not been constructed and operated in the United States on a scale approaching the capacity needed for this alternative.

New Jersey's fish and crab consumption prohibitions and advisories would remain in effect (with enhanced outreach to increase awareness) until the remedial action objectives are met.

Because Alternative 2 with DMM Scenario A would result in hazardous substances, pollutants or contaminants remaining in the sediments above levels that would allow for unlimited use and unrestricted exposure (in Newark Bay CAD cells), CERCLA would require that five-year reviews be conducted. In addition, Alternative 2 under all DMM scenarios would require more than five years to achieve the remedial action objectives. Therefore, in accordance with EPA policy, five-year reviews would be conducted for Alternative 2, DMM Scenario B or C until the RAOs are achieved.

9.2.3. Alternative 3: Capping with Dredging for Flooding and Navigation

Present Value:	
With DMM Scenario A	$0.85 Billion
With DMM Scenario B	$1.38 Billion
With DMM Scenario C	$1.36 Billion
Construction Time:	6 years

Capping with Dredging for Flooding and Navigation is a bank-to-bank remedy that would place an engineered cap over the entire river bottom throughout the lower 8.3 miles of the Lower Passaic River. Before placement of the engineered cap, enough contaminated fine-grained sediment (3.5 million cy, based on an assumed cap thickness of 2 feet) would be dredged so that the cap could be placed without causing additional flooding and to allow for the continued use of the federally authorized navigation channel between RM 0 and RM 1.7.

This alternative includes dredging in portions of the 300-foot wide, federally authorized navigation channel to reasonably anticipated future use depths. The extent and depths of the navigation channel included in Alternative 3 as presented in the Proposed Plan were based on EPA's analysis of USACE's 2010 Lower Passaic River Navigation Analysis report and extensive consultation with USACE and NJDEP. In response to comments on the Proposed Plan, EPA reexamined available information pertaining to current and future commercial uses of the navigation channel submitted and obtained during the public comment period, as documented in the Responsiveness Summary (Appendix V). In further consultation with USACE and NJDEP, EPA has adjusted the extent and depths of the navigation channel included in Alternative 3 to the following: 30 feet MLW from RM 0 to RM 0.6 and 20 feet MLW from RM 0.6 to RM 1.7. Associated adjustments in dredging volume, construction duration and project costs were made and are presented in the ROD.

Where dredging depths coincide with the federally authorized navigation channel (RM 0 to RM 0.6), an additional 3 feet would be dredged to account for historical dredging accuracy and over-dredging. Because this action is expected to dredge all contaminated fine-grained sediments within the channel below RM 0.6, an engineered cap may not be required and a layer of backfill would be placed to mitigate the effect of dredging residuals. Between RM 0.6 and RM 1.7, where dredging depths are shallower than the current federally authorized channel, an estimated 5.5 feet of sediment below the proposed channel depth would be dredged to accommodate an engineered cap; the additional depth provides for a cap protection buffer and allowance for future maintenance dredging. Resulting dredging depths (all in MLW) are shown in Table 28 in Appendix II.

Since some of the capped areas would be shallower than the federally authorized channel depths, it would be necessary to pursue both modification of the authorized depth (from RM 0.6 to RM 1.7) and deauthorization (from RM 1.7 to RM 8.3) of the federal navigation channel through Congressional action. USACE has advised that it will support such modification of authorized depths, and deauthorization of navigation channel.

Between RM 1.7 and RM 8.3, dredging would be performed to allow for the installation of an engineered cap without additional flooding and to accommodate reasonably anticipated recreational future uses. While commercial navigation is not an expected future use above RM 1.7, additional dredging is included in this alternative to account for the recreational uses discussed in Sections 6 and 8. Between RM 1.7 and RM 8.3, sufficient dredging would be performed to provide a depth of at least 10 feet below MLW over a designated 200-foot width (reduced to a 150-foot width between RM 8.1 and RM 8.3) to accommodate reasonably anticipated future recreational uses. Between RM 1.7 and RM 8.3, this would mean dredging approximately 2.5 feet below the existing sediment surface, with most of that depth necessary to prevent additional flooding due to the placement of the engineered cap and some smoothing of a few areas to achieve at least 10 feet below MLW. Final dredging depths may be refined in the remedial design to better account for flooding and recreational use, but still allow for enough dredging to ensure cap stability and integrity.

Dredged materials removed would be managed in accordance with one of three DMM scenarios described in Section 9.1.6. The construction time estimate (6 years) includes time for dredging, backfilling and dredged material disposal. The construction duration is driven by the time required for dredging and is not influenced by the choice of DMM scenario, because EPA assumes that the DMM facilities could be designed and constructed to manage the dredged material throughput without adding to the time needed.[24]

Mudflats dredged during implementation of Alternative 3 would be reconstructed to their original grade. The engineered cap over the mudflats would consist of 1 foot of sand and 1 foot of mudflat reconstruction substrate (but can vary depending on conditions) that would provide a suitable habitat to support current and expected future ecological uses. USACE habitat restoration plans for the New York-New Jersey Harbor Estuary could provide additional information on appropriate habitat reconstruction techniques.

[24] Construction duration for DMM Scenario C is more uncertain than for the other two scenarios, because the decontamination technologies evaluated in DMM Scenario C have not been constructed and operated in the United States on a scale approaching the capacity needed for this alternative.

Institutional controls and monitoring would be implemented after construction. New Jersey's fish and crab consumption prohibitions and advisories would remain in effect (with enhanced outreach to increase awareness) until the remedial action objectives are met. Other permanent institutional controls are likely to include restrictions on activities that might disturb the engineered cap, as discussed in Section 9.1.1.

Because Alternative 3 would result in hazardous substances, pollutants or contaminants remaining in the sediments of the lower 8.3 miles above levels that would allow for unlimited use and unrestricted exposure, CERCLA would require that five-year reviews be conducted.

9.2.4. Alternative 4: Focused Capping, with Dredging for Flooding

Present Value:	
With DMM Scenario A	$0.36 Billion
With DMM Scenario B	$0.56 Billion
With DMM Scenario C	$0.59 Billion
Construction Time:	2.5 years

Focused or "hotspot" remedies are commonly considered for large sediment sites. To allow for an evaluation of whether a more focused approach to addressing the contaminated sediments of the lower 8.3 miles could meet the remedial action objectives, EPA evaluated an alternative consisting of dredging and capping the discrete areas of the lower 8.3 miles that EPA identified as releasing the most contaminants into the water column. Focused Capping with Dredging for Flooding includes dredging of contaminated fine-grained sediments (1 million cy) in selected portions of the lower 8.3 miles of the Lower Passaic River (cumulatively, approximately 220 acres or about one third of the lower 8.3-mile sediment surface) with the highest gross and net fluxes of COCs (see Figure 18[25] in Appendix I). These areas are those that have high surface concentrations of COCs and experience high erosional forces (i.e., shear stresses), so that this alternative accounts for the stability of the sediment bed and the mobility of contaminants within it, in accordance with EPA's December 2005 *Contaminated Sediment Remediation Guidance for Hazardous Waste Sites*. Dredging would occur to a depth of about 2.5 feet to allow for installation of an engineered cap without causing additional flooding, as discussed in Alternative 3.

Alternative 4 would not include any dredging to accommodate the continued use of the channel for navigation, or to accommodate future recreational uses. Since some of the capped areas would be shallower than the federally authorized channel depths, it would be necessary to pursue deauthorization of those portions of the federal navigation channel through Congressional action.

[25] In response to comments, EPA made various changes to the sediment transport and organic carbon-contaminant fate and transport models, as discussed in the Responsiveness Summary (Appendix V) and Attachment E. The updated models were used to identify areas in the lower 8.3 miles with the highest gross and net fluxes of COCs that are shown in Figure 18.

Dredged materials removed would be managed in accordance with one of three DMM scenarios described in Section 9.1.6. The construction time estimate (2.5 years) includes time for dredging, capping and dredged material disposal. The construction duration is driven by the time required for dredging and is not influenced by the choice of DMM scenario, because EPA assumes that the DMM facilities could be designed and constructed to manage dredged material throughput without adding to the time needed.

Mudflats dredged during implementation of Alternative 4 would be reconstructed to their original grade. The engineered cap over the mudflats would consist of 1 foot of sand and 1 foot of mudflat reconstruction (habitat) substrate, but can vary depending on conditions.

Institutional controls and monitoring would be implemented after construction. New Jersey's fish and crab consumption prohibitions and advisories would remain in effect (with enhanced outreach to increase awareness) until remedial action objectives are met. Other institutional controls would include restrictions on activities that could result in contact with uncapped sediments, or restrictions on activities that could disturb the engineered caps, as discussed in Section 9.1.1.

Because Alternative 4 would result in hazardous substances, pollutants or contaminants remaining in the sediments of the lower 8.3 miles above levels that would allow for unlimited use and unrestricted exposure, CERCLA would require that five-year reviews be conducted.

10. COMPARATIVE ANALYSIS OF ALTERNATIVES

In selecting a remedy, EPA considered the factors set out in CERCLA §121, 42 U.S.C. §9621, by conducting a detailed analysis of the viable remedial response measures pursuant to the NCP, 40 CFR §300.430(e)(9) and OSWER Directive 9355.3-01. The detailed analysis in the FFS Report consisted of an assessment of the individual response measures against each of the evaluation criteria. This section profiles the relative performance of each alternative against the nine criteria, noting how it compares to the other alternatives under consideration.

Threshold Criteria - *The first two criteria are known as "threshold criteria" because they are the minimum requirements that each response measure must meet to be eligible for selection as a remedy.*

10.1. Overall Protection of Human Health and the Environment

Overall protection of human health and the environment addresses whether each alternative provides adequate protection of human health and the environment and describes how risks posed through each exposure pathway are eliminated, reduced, or controlled, through treatment, engineering controls, and/or institutional controls.

A primary requirement of CERCLA is that the selected remedial action be protective of human health and the environment. An alternative is protective if it reduces current and potential future risks associated with each exposure pathway at a site to acceptable levels for the human health and ecological receptors.

Alternative 1 (No Action) would not be protective of human health and the environment. Under Alternative 1, the resuspension and redeposition of contaminated sediments in the lower 8.3 miles of the Lower Passaic River would continue to contaminate the surface sediments and biota in the lower 8.3 miles, so that the unacceptable risks to humans and the environment calculated in the baseline risk assessment would continue in the future. Sediment data show that some decline in surface sediment concentrations is occurring over time due to natural recovery processes, although these processes have slowed considerably over approximately the past 15 to 20 years as the navigation channel has filled in and the river has begun to reach a quasi-steady state. Computer modeling results[26] for Alternative 1 show that the decline in concentrations is extremely slow, so that in the period of 2020 to 2046 (26-year period[27] chosen to allow comparison to the 26-year period after construction for the active alternatives), human health total cancer risk (sum for the adult and child for all COCs) would be 4×10^{-3} and 2×10^{-3} for fish and crab consumption, respectively; these levels exceed the acceptable risk range. The total noncancer health hazards for the adult would be 100 and 44 for fish and crab consumption, respectively, and for the child would be 194 and 84 for fish and crab consumption, respectively; these levels exceed the goal of protection of an HI equal to 1. By the end of the period 2020 to 2049 (30-year period chosen to allow comparison to the 30-year period after construction for the active alternatives), ecological HQs for benthic invertebrates would range from 0.1 to 200, with HQs for copper, mercury, Total PCBs and 2,3,7,8-TCDD exceeding 1; for fish would range from 0.1 to 200, with HQs for copper, Total PCBs and dioxins/furans exceeding 1; and for wildlife would range from 0.07 to 200, with HQs for lead in birds exceeding 1 and HQs for mercury, total PCBs, dioxin-like PCBs and dioxins/furans in mammals exceeding 1.

Alternative 2 and 3 would replace the highly contaminated riverbed of the lower 8.3 miles with effectively clean material (sand), bank to bank. There is no more comprehensive way to remediate the sediments of the lower 8.3 miles. EPA's modeling results show that, after the sand is placed bank-to-bank in the lower 8.3 miles, incoming COCs from above Dundee Dam, from Newark Bay and from the Lower Passaic River above RM 8.3 will gradually recontaminate the new riverbed surface. EPA's model underestimates the effectiveness of the bank-to-bank remedies because, while the model assumes that the incoming COCs will remain constant until

[26] As noted in footnote 25, in response to comments, EPA made various changes to the sediment transport and organic carbon-contaminant fate and transport models, as discussed in the Responsiveness Summary (Appendix V) and Attachment E. Throughout the ROD, where model results are discussed, EPA is referring to the updated model results.

[27] As discussed in Section 7.1.2.4, the 2014 updated Standard Default Exposure Assumptions, released after the RI/FFS was completed, changed the adult ED from 24 years to 20 years and the total ED from 30 years to 26 years. In response to comments, EPA updated the risk estimates and other related analyses with the updated EDs, including the modeling period over which future human health risk reductions are compared. The 2014 updates did not affect the ecological risk assessment, so that the modeling period over which future ecological risk reductions are compared remains 30 years, the same as used in the Proposed Plan.

the end of the simulation period (until the early 2060s), EPA expects that those COCs will decline over time as the Lower Passaic River above RM 8.3 and Newark Bay are remediated through actions selected under CERCLA. Furthermore, EPA expects that Clean Water Act programs will address COCs coming in from above Dundee Dam. Such actions, taken while the remedy for the lower 8.3 miles is being designed and implemented, will reduce the incoming COCs and minimize the degree of recontamination, allowing the bank-to-bank remedies (Alternatives 2 and 3) to achieve protectiveness by achieving the cancer risk range of 10^{-4} to 10^{-6}, noncancer HIs equal to or less than 1 and ecological HQs equal to or less than 1.

Alternative 2 (Deep Dredging with Backfill) and Alternative 3 (Capping with Dredging for Flooding and Navigation) would both protect human health and the environment to approximately to the same degree, because both would result in the remediation of surface sediments bank to bank in the lower 8.3 miles, and those lower 8.3-mile surface sediments would be subjected to similar levels of recontamination from the influx, mixing and deposition of sediment that enters from above Dundee Dam, from between the dam and RM 8.3, and from Newark Bay. The sediments of the lower 8.3 miles of the Lower Passaic River are currently a major source of COCs to the river above RM 8.3 and to Newark Bay. Addressing the sediments in the lower 8.3 miles by dredging or capping bank to bank would eliminate a major source of contamination to the rest of the Lower Passaic River and Newark Bay, thereby reducing the contamination brought back into the lower 8.3 miles from those areas over time.

Alternative 2 would address the unacceptable risks and hazards due to COCs in the lower 8.3-mile sediments by removing the extensive inventory of contaminated fine-grained sediments from RM 0 to RM 8.3 (approximately 9.7 million cy). Dredging residuals that remain in the lower 8.3 miles after construction would be covered by a 2-foot layer of backfill.

- For just dioxins/furans, computer models predict that implementation of Alternative 2 would reduce risks so that in the 26-year period after construction (2034 to 2059), the human health total cancer risk (for the adult and child) would be 5×10^{-5} and 2×10^{-5} for fish and crab consumption, respectively. The noncancer health hazard for the adult would be 1 and 0.4 for fish and crab consumption, respectively, and for the child would be 2 and 0.8 for fish and crab consumption, respectively.
- For all human health COCs (dioxins/furans, PCBs and mercury) combined, computer models predict that the human health total cancer risk (for the adult and child for all COCs) would be 5×10^{-4} and 4×10^{-4} for fish and crab consumption, respectively, in the 26-year period after construction. The noncancer health hazard for the adult would be 13 and 9 for fish and crab consumption, respectively, and for the child would be 24 and 17 for fish and crab consumption, respectively. The computer models show that recontamination from dioxin-like PCBs is a primary reason that risks and hazards rise gradually over time from the lowest levels achieved upon construction completion, such that in the 26-year period after construction, risks and hazards exceed the acceptable risk range and HI of 1. The risks and hazards would be above EPA's goals, so Alternative 2 would incorporate institutional controls such as fish and crab consumption prohibitions and advisories enhanced by additional outreach to ensure protectiveness.

For the ecological COCs, thirty years after construction (2063), ecological HQs for benthic invertebrates would range from 0.05 to 8, with HQs for mercury, Total PCBs and 2,3,7,8-TCDD exceeding 1; for fish would range from 0.08 to 8, with HQs for copper and dioxins/furans exceeding 1; and for wildlife would range from 0.02 to 7, with HQs for mercury, total PCBs, dioxin-like PCBs and dioxins/furans in mammals exceeding 1.

Alternative 3 would address the unacceptable risks due to COCs in the sediments of the lower 8.3 miles of the Lower Passaic River by sequestering the extensive inventory of contaminated sediments in the lower 8.3 miles under a bank-to-bank engineered cap.

- For just dioxins/furans, computer models predict that implementation of Alternative 3 would reduce risks so that in the 26-year period after construction (2026 to 2051), the human health total cancer risk (for the adult and child) would be 6 x 10^{-5} and 2 x 10^{-5} for fish and crab consumption, respectively. The noncancer health hazard for the adult would be 1 and 0.5 for fish and crab consumption, respectively, and for the child would be 2 and 1 for fish and crab consumption, respectively.
- For all human health COCs (dioxins/furans, PCBs and mercury) combined, computer models predict that the human health total cancer risk (for the adult and child for all COCs) would be 5 x 10^{-4} and 4 x 10^{-4} for fish and crab consumption, respectively. The noncancer health hazard for the adult would be 14 and 10 for fish and crab consumption, respectively, and for the child would be 29 and 20 for fish and crab consumption, respectively. The computer models show that recontamination from dioxin-like PCBs is a primary reason that risks and hazards rise gradually over time from the lowest levels achieved upon construction completion, such that in the 26-year period after construction, risks and hazards exceed the acceptable risk range and HI of 1. Risks and hazards would be above EPA’s goals, so Alternative 3 would incorporate institutional controls such as fish and crab consumption prohibitions and advisories enhanced by additional outreach to ensure protectiveness.

For ecological COCs, thirty years after construction (2055), ecological HQs for benthic invertebrates would range from 0.05 to 9, with HQs for mercury, Total PCBs and 2,3,7,8-TCDD exceeding 1; for fish would range from 0.08 to 10, with HQs for copper and dioxins/furans exceeding 1; and for wildlife would range from 0.02 to 9, with HQs for mercury, total PCBs, dioxin-like PCBs and dioxins/furans in mammals exceeding 1.

As discussed above, EPA’s model underestimates the effectiveness of the bank-to-bank remedies because it does not account for any reduction in incoming COCs over time as the Lower Passaic River above RM 8.3 and Newark Bay are remediated under the Superfund program and COCs from above Dundee Dam are addressed under Clean Water Act programs. Such actions, taken while the remedy for the lower 8.3 miles is being designed and implemented, will reduce the incoming COCs and minimize the degree of recontamination, allowing the bank-to-bank remedies (Alternatives 2 and 3) to achieve protectiveness.

Alternative 4 (Focused Capping with Dredging for Flooding) would address the unacceptable risks due to COCs in lower 8.3-mile sediments to some extent by capping the areas that contribute the most contaminant flux to the water column; the discrete areas of sediments to be capped would add up to about one-third of the surface of the lower 8.3 miles of the Lower Passaic River. Computer models predict that implementation of Alternative 4 would reduce risks, so that in the 26-year period after construction (2023 to 2048), human health total cancer risk (for adult and child for all COCs) would be 1 x 10^{-3} and 7 x 10^{-4} for fish and crab consumption, respectively. The noncancer health hazard for the adult would be 33 and 17 for fish and crab consumption, respectively, and for the child would be 68 and 34 for fish and crab consumption, respectively. The noncancer health hazards would be above EPA's goal of an HI of 1, so Alternative 4 would incorporate institutional controls such as fish and crab consumption prohibitions and advisories enhanced by additional outreach to ensure protectiveness. Thirty years after construction (2052), ecological HQs for benthic invertebrates would range from 0.08 to 20, with HQs for mercury, Total PCBs and 2,3,7,8-TCDD exceeding 1; for fish would range from 0.09 to 30, with HQs for copper and dioxins/furans exceeding 1; and for wildlife would range from 0.04 to 30, with HQs for mercury, total PCBs, dioxin-like PCBs and dioxins/furans in mammals exceeding 1.

EPA's computer model predicts that, 26 to 30 years post-remediation, the cancer risks, noncancer health hazards and ecological risks achieved by Alternative 4 are higher than those achieved by Alternatives 2 and 3. Those predictions are consistent with the body of data collected over the past 20 years and the conceptual understanding of the river system presented under Section 5. The data show that lower 8.3-mile surface sediments have average COC concentrations that are almost 100 times higher than the remediation goals. Given the ubiquitous nature of highly contaminated sediments in the lower 8.3 miles, capping discrete areas totaling about one-third of the lower 8.3 miles is unlikely to lead to decreases in COC concentrations equal to or greater than those that would be achieved by bank-to-bank remediation. Even though the sediment areas evaluated for capping in Alternative 4 are those that contribute the most contaminant flux to the water column, the contaminated sediments in the remaining two-thirds of the lower 8.3 miles not addressed by Alternative 4 still include elevated concentrations of COCs that would contribute to risk by remaining in place, potentially being resuspended with the tide or in storm events to recontaminate the adjacent capped areas. While EPA's model also underestimates the effectiveness of Alternative 4, because it does not account for any reduction in incoming COCs over time, the effect of recontamination on the protectiveness of Alternative 4 includes and is greatly exacerbated by the resuspension of highly contaminated sediments from the unremediated two-thirds of the lower 8.3-mile riverbed redepositing on adjacent capped areas. While EPA actions under the Superfund and Clean Water Act programs may reduce the incoming COCs in the future, the resuspension of highly contaminated sediments from the unremediated two-thirds of the lower 8.3 miles will continue unabated.

Under Alternatives 2, 3 and 4, for DMM Scenario A (CAD), an engineered cap would be placed over the CAD cells in Newark Bay and the cap would be monitored and maintained in perpetuity. In consultations prior to the release of the Proposed Plan, the State of New Jersey, NOAA and USFWS, in their roles as natural resource trustees, expressed serious concerns about the disposal of highly contaminated sediment from the Lower Passaic River into a CAD cell in Newark Bay and the associated potential impacts to the aquatic environment. An additional concern of the Trustees was the scale and footprint of the CAD cells that would be required, which would be substantially larger than other CAD cells sited for environmental remediation in other waters of the United States.

These concerns are discussed further in Section 10.5, because EPA has analyzed these impacts as short-term, temporary impacts during remedy construction. However, NOAA has advised EPA that the presence of open CAD cells in Newark Bay for 2.5 to 14 years, as EPA calculated would be necessary under the three active alternatives, could have long-term impacts on some species that are dependent on limited bay bottom habitat for critical life stages. In contrast, DMM Scenarios B (Off-Site Disposal) and C (Local Decontamination and Beneficial Use) have no comparable environmental impact on the aquatic environment of Newark Bay.

10.2. Compliance with Applicable or Relevant and Appropriate Requirements (ARARs)

Section 121 (d) of CERCLA and NCP §300.430(f)(1)(ii)(B) require that remedial actions at CERCLA sites at least attain legally applicable or relevant and appropriate Federal and State requirements, standards, criteria, and limitations which are collectively referred to as "ARARs," unless such ARARs are waived under CERCLA section 121(d)(4). <u>Applicable requirements</u> are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under Federal environmental or State environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site. Only those State standards identified by a state in a timely manner and that are more stringent than Federal requirements may be applicable.

<u>Relevant and appropriate requirements</u> are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under Federal environmental or State environmental or facility siting laws that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well-suited to the particular site. Only those State standards that are identified in a timely manner and are more stringent than Federal requirements may be relevant and appropriate.

Compliance with ARARs addresses whether a remedy will meet all of the applicable or relevant and appropriate requirements of other Federal and State environmental statutes or provides a basis for invoking a waiver.

Any alternative considered by EPA must comply with all federal and state environmental standards, requirements, criteria or limitations, unless they are waived under certain specific conditions.

Alternative 1 (No Action) would not contribute toward eventual achievement of federal and state surface water ARARs. Since there is no active remediation associated with this alternative, action-specific and location-specific ARARs do not apply.

Compliance with surface water quality ARARs is both a short-term requirement during remediation and a long-term requirement after the remediation at the Diamond Alkali Site, including in the Lower Passaic River and Newark Bay, is completed. In the short term, actions would be taken during the implementation of Alternatives 2 (Deep Dredging with Backfill), 3 (Capping with Dredging for Flooding and Navigation) and 4 (Focused Capping with Dredging for Flooding) to reduce construction-related surface water quality impacts. Alternatives 2, 3 and 4 are designed to address sediment contamination in the lower 8.3 miles of the Lower Passaic River. Although remediation of contaminated sediment would contribute to improved water quality, implementation of any of these alternatives, by itself, would be unlikely to achieve compliance with ARARs in the water column. However, because this ROD only addresses the sediment portion of the lower 8.3 miles and is an interim action for the water column, and is only part of the remedial activities under consideration for the 17-mile Lower Passaic River and Newark Bay, compliance with surface water ARARs would more likely be achieved and therefore more appropriately addressed after additional response actions have been implemented.

Alternatives 2, 3 and 4 would satisfy the location-specific and action-specific ARARs, such as the requirements of the Clean Water Act that would apply to dredging and the RCRA requirements that would apply to management of dredged materials. Alternatives 2, 3 and 4, which include placement of material on the river bottom, would need to be implemented in compliance with the Clean Water Act, 33 U.S.C. §404(b)(1) and 40 CFR Part 230, which require that disturbance to aquatic habitat be minimized to the extent possible. Compliance with the substantive elements of New Jersey Flood Hazard Control Act Rules, including those addressing placement of material in the flood hazard area and impacts to riparian zones would also be required.

Alternative 3 includes capping within the federally authorized navigation channel without enough dredging to accommodate the authorized depth from RM 0.6 to RM 8.3. In order to comply with Section 10 the Rivers and Harbors Act (33 U.S.C. § 403), which is a location-specific ARAR, as well as the navigation channel depths authorized by Congress, Alternative 3 would require both modification of the Congressionally-authorized navigation channel depths (from RM 0.6 to RM 1.7) and deauthorization of the navigation channel (from RM 1.7 to RM 8.3) through Congressional action. As discussed in Section 8, USACE has advised that it will support recommendations to Congress to accomplish these changes.

Alternative 4 includes capping within portions of the federally authorized navigation channel, without any dredging to accommodate the authorized depth in areas of the river between approximately RM 2.7 to RM 8.3. In order to comply with Section 10 of the Rivers and Harbors Act, Alternative 4 would require de-authorization of the federal navigation channel from approximately RM 2.7 to RM 8.3 through Congressional action. Since USACE has advised that it will support a recommendation for Congressional action to deauthorize the federal navigation channel from RM 1.7 to RM 8.3, USACE would likely also support the recommendation for Congressional action required for Alternative 4.

A complete list of ARARs can be found in Table 29 in Appendix II.

***Primary Balancing Criteria** - The next five criteria, criteria 3 through 7, are known as "primary balancing criteria." These criteria involve the assessment of factors between response measures so that the best option will be chosen, given site-specific data and conditions.*

10.3. Long-Term Effectiveness and Permanence

Long-term effectiveness and permanence refers to expected residual risk and the ability of a remedy to maintain reliable protection of human health and the environment over time, once clean-up levels have been met. This criterion includes the consideration of residual risk that will remain on site following remediation and the adequacy and reliability of controls.

Alternative 1 (No Action) would not be effective in addressing the contaminated sediments that are causing the unacceptable risks identified in the baseline risk assessments. Natural recovery processes would cause some decline in surface sediment concentrations over time. Computer modeling results (see Figures 19, 20, 21 and 22 in Appendix I) for Alternative 1 show that, by the early 2060s (end of the model simulation period), surface sediment concentrations in the lower 8.3 miles of the Lower Passaic River would remain above all of the remediation goals for any COC.

- For dioxin, by the early 2060s, lower 8.3-mile surface sediment concentrations are predicted to reach approximately 0.5 ug/kg or ppb (micrograms per kilogram or parts per billion), which is over 60 times higher than the remediation goal.
- For PCBs, by the early 2060s, lower 8.3-mile surface sediment concentrations are predicted to reach approximately 920 ug/kg or ppb, which is almost 20 times higher than the remediation goal.
- For mercury, by the early 2060s, lower 8.3-mile surface sediment concentrations are predicted to reach approximately 2000 ug/kg or ppb, which is almost 30 times higher than the remediation goal.
- For Total DDx, by the early 2060s, lower 8.3-mile surface sediment concentrations are predicted to reach approximately 90 ug/kg or ppb, which is approximately 300 times higher than the remediation goal.

Alternative 1 (No Action) would not include any containment systems and would not rely on institutional controls to address COC contamination in lower 8.3-mile sediments.

Under Alternative 2 (Deep Dredging with Backfill), approximately 9.7 million cy of contaminated sediments covering approximately 650 acres of river bottom between RM 0 and RM 8.3 would be permanently removed from the ecosystem of the Lower Passaic River after construction is completed. Dredging residuals remaining in the lower 8.3 miles would be covered by a layer of backfill. Under Alternative 3 (Capping with Dredging for Flooding and Navigation), approximately 3.5 million cy of contaminated sediments covering approximately 650 acres of river bottom between RM 0 and RM 8.3 would be permanently removed from the ecosystem of the Lower Passaic River, followed by construction of a two-foot engineered cap (or placement of backfill where appropriate) over the entire lower 8.3 miles. A significant decline in surface sediment concentrations in the lower 8.3 miles is predicted for COCs under both alternatives (see Figures 19, 20, 21 and 22 in Appendix I).

- For dioxin, by the early 2060s, lower 8.3-mile surface sediment concentrations are predicted to reach approximately 0.01 ppb for Alternatives 2 and 3, which is approximately at the remediation goal.
- For PCBs, by the early 2060s, lower 8.3-mile surface sediment concentrations are predicted to reach approximately 200 ppb (Alternative 2) and 260 ppb (Alternative 3), which are approximately four and six times higher than the remediation goal, respectively.
- For mercury, by the early 2060s, lower 8.3-mile surface sediment concentrations are predicted to reach approximately 700 ppb for Alternatives 2 and 3, which is approximately ten times higher than the remediation goal.
- For Total DDx, by the early 2060s, lower 8.3-mile surface sediment concentrations are predicted to reach approximately 30 ppb for Alternatives 2 and 3, which is approximately 100 times higher than the remediation goal.

Alternatives 2 and 3 would incorporate fish and crab consumption prohibitions and advisories to ensure protectiveness of human health. EPA's modeling predicts that for dioxin and PCBs, shortly after construction completion, lower 8.3-mile surface sediment concentrations would reach the interim remediation milestones that correspond to interim protective fish and crab tissue concentrations, sufficiently protective to potentially allow NJDEP to consider lifting or relaxing the stringency of prohibitions on fish and crab consumption (e.g., allowing one fish meal per month, as opposed to the current prohibitions on consumption of fish or crab from the Lower Passaic River).

EPA's modeling of each of the alternatives predicted that in order to achieve COC concentrations approaching as closely as possible to remediation goals, bank-to-bank remediation in the lower 8.3 miles is necessary. Modeling results also predicted that bank-to-bank alternatives would reduce surface sediment concentrations for some of the COCs to below background levels in the future. This is because sediment particles coming over Dundee Dam make up only about one third of recently deposited sediment in the lower 8.3 miles, and when those particles flow down to the lower 8.3 miles, they mix with the other particles in the system (including cleaner particles in the water column that would result from a remediated lower 8.3 miles). The model took into consideration this mixing of newly arriving background contamination with clean material introduced as part of the remedy and predicted that the top six inches (the bioactive zone) could be less contaminated post-remediation than the background concentrations coming over Dundee Dam.

EPA's modeling results also show that, after bank-to-bank remediation of the lower 8.3 miles, incoming COCs from above Dundee Dam, from Newark Bay and from the Lower Passaic River above RM 8.3 will gradually recontaminate the new riverbed surface. EPA's model underestimates the effectiveness of the bank-to-bank remedies because, while the model assumes that the incoming COCs will remain constant until the end of the simulation period (until the early 2060s), EPA expects that those COCs will decline over time as the Lower Passaic River above RM 8.3 and Newark Bay are remediated through actions selected after the completion of the 17-mile RI/FS and Newark Bay RI/FS, respectively, and Clean Water Act programs will address COCs from above Dundee Dam. Such actions, taken while the remedy for the lower 8.3 miles is being designed and implemented, will reduce the incoming COCs and minimize the degree of recontamination, allowing the bank-to-bank remedies (Alternatives 2 and 3) to achieve protectiveness.

Alternative 2 would not rely on a containment system to maintain protectiveness in the lower 8.3 miles of the Lower Passaic River over the long term, since the contaminated fine-grained sediments would be removed. Note that a containment system (i.e., CAD cells in Newark Bay) was considered as one of the DMM scenarios for this alternative (see below).

Alternative 3 would be effective in the long term in limiting exposure to risks posed by COCs in the lower 8.3-mile sediments provided the integrity of the engineered cap is maintained. Therefore, the cap would need to be monitored and maintained in perpetuity. Engineered caps have been demonstrated to be effective over the long term in sequestering contaminated sediments at other Superfund sites, when they are properly designed and maintained. For cost-estimation purposes, the engineered cap for the lower 8.3 miles was assumed to consist of sand with a grain size large enough to withstand a 100-year storm with less than 3 inches of erosion (a fraction of the cap's thickness), thus minimizing the likelihood that cap integrity would be compromised during a storm event or season. Certain areas of the river were assumed to need armoring for further protection against erosion. The cost estimate also assumed periodic cap inspections and necessary maintenance at regular intervals and after storm events.

For Alternative 4 (Focused Capping with Dredging for Flooding), approximately 1.0 million cy of contaminated sediments in discrete areas totaling approximately 220 acres of river bottom between RM 0 and RM 8.3 would be permanently removed, followed by placement of a two-foot engineered cap over those areas dredged. As discussed in Section 10.1, Alternative 4 would not achieve as much risk reduction as Alternatives 2 and 3, because the contaminated surface sediments in the two-thirds of the lower 8.3 miles of the Lower Passaic River that remain unaddressed would contribute to risk by remaining in place and would recontaminate adjacent capped areas. Computer modeling results (see Figures 19, 20, 21 and 22 in Appendix I) show that, by the early 2060s (end of the model simulation period), lower 8.3-mile surface sediment concentrations would remain above the remediation goals.

- For dioxin, by the early 2060s, lower 8.3-mile surface sediment concentrations are predicted to reach approximately 0.05 ppb, over six times higher than the remediation goal.
- For PCBs, by the early 2060s, lower 8.3-mile surface sediment concentrations are predicted to reach approximately 400 ppb, approximately 8 times higher than the remediation goals.
- For mercury, by the early 2060s, lower 8.3-mile surface sediment concentrations are predicted to reach approximately 1200 ppb, almost 20 times higher than the remediation goal.
- For Total DDx, by the early 2060s, lower 8.3-mile surface sediment concentrations are predicted to reach approximately 45 ppb, approximately 150 times higher than the remediation goals.

EPA's modeling predicts that, for dioxin and PCBs, shortly after construction completion for Alternative 4, lower 8.3-mile surface sediment concentrations would be reduced below the first interim remediation milestone corresponding to tissue concentrations that would allow adult anglers to eat 12 eight-ounce fish or crab meals per year at a 10^{-4} cancer risk level. However, the noncancer hazard would still be too great for NJDEP to consider lifting or relaxing the stringency of prohibitions on fish and crab consumption. Although, by the early 2060s, dioxin surface sediment concentrations are predicted to reach the interim remediation milestone corresponding to tissue concentrations that would allow adult anglers to eat 12 eight-ounce fish or crab meals per year at an HI equal to 1, PCB surface sediment concentrations are not predicted to be reduced enough to achieve any other interim remediation milestones or remediation goals.

The protectiveness of Alternative 4 depends on the ability to accurately identify the discrete areas that release the most contaminants into the water column and need to be addressed by dredging and capping. A great degree of uncertainty is associated with this process, as a result of the complex estuarine environment of the lower 8.3 miles. In addition, while EPA's model also underestimates the effectiveness of Alternative 4, because it does not account for any reduction in incoming COCs over time, the effect of recontamination on the protectiveness of Alternative 4 includes and is greatly exacerbated by the resuspension of highly contaminated sediments from the unremediated two-thirds of the lower 8.3-mile riverbed redepositing on adjacent capped areas. While EPA actions under the Superfund and Clean Water Act programs may reduce the incoming COCs in the future, the resuspension of highly contaminated sediments from the unremediated two-thirds of the lower 8.3 miles will continue unabated.

For Alternatives 2, 3 and 4, under DMM Scenario A (CAD), the engineered caps over the CAD cells would have to be monitored and maintained in perpetuity in order to ensure that this disposal method remained protective of human health and the environment over time. In contrast, there is no such requirement for DMM Scenario B (Off-Site Disposal) or DMM Scenario C (Local Decontamination and Beneficial Use), because existing landfills already have provisions for long-term monitoring and maintenance by landfill owners and operators.

DMM Scenario B relies on off-site treatment facilities (at this time, incinerators) and landfills which are in operation and have proven to be reliable technologies. The reliability of local decontamination technologies (DMM Scenario C), such as thermal treatment and sediment washing, is more uncertain since they have not been built and operated in the United States on a scale approaching the capacity needed for this project. In addition, sediment washing may be less effective when the matrix contains multiple contaminants and consists of a large proportion of finer particles like silts and clays as is true of Lower Passaic River sediments. Multiple treatment passes may be needed under such conditions.

10.4. Reduction of Toxicity, Mobility, or Volume of Contaminants Through Treatment

Reduction of toxicity, mobility, or volume through treatment refers to the anticipated performance of the treatment technologies that may be included as part of a remedy.

This criterion addresses the statutory preference for selecting remedial actions that employ treatment technologies that permanently and/or significantly reduce the toxicity, mobility or volume of hazardous substances as their principal element.

For Alternative 1 (No Action), there would be no reduction of toxicity, mobility or volume through treatment.

For the active alternatives, reduction of mobility and volume of contaminated sediments in the lower 8.3 miles of the Lower Passaic River would be achieved by dredging and capping, not through treatment. The ultimate reduction of toxicity, mobility and volume for the sediments removed from the lower 8.3 miles depends on the DMM Scenario selected. Alternative 2 (Deep Dredging with Backfill), would result in removal of 9.7 million cy of contaminated sediments by dredging, followed by 3.5 million cy for Alternative 3, and 1 million cy for Alternative 4. By removing nearly three times as much sediment volume from the riverbed as the next nearest alternative, Alternative 2 will result in substantially more treatment overall under either of the DMM scenarios that include treatment. If, as discussed in Section 9.1.3, EPA were to identify an enhanced capping technology that included additives to create a reactive cap for use in some areas of the lower 8.3 miles, Alternatives 3 and 4 might include some *in situ* treatment.

For Alternatives 2, 3 and 4, under DMM Scenario A (CAD), the mobility of the COCs removed from the lower 8.3 miles of the Lower Passaic River would be effectively eliminated not through treatment, but by sequestering the dredged sediments in CAD cells under an engineered cap that would need to be monitored and maintained in perpetuity. There would be no reduction in toxicity, mobility or volume of the COCs through treatment.

Under DMM Scenario B (Off-Site Disposal), RCRA land disposal requirements will result in treatment of some dredged sediment through incineration that would reduce the toxicity, mobility and volume of the COCs removed from the lower 8.3 miles of the Lower Passaic River. Under DMM Scenario B, Alternative 2 is expected to treat the largest volume of Site contaminants, followed by Alternative 3, then Alternative 4. Amounts to be incinerated or landfilled are estimated in Table 30 in Appendix II, although actual distributions between the two categories would depend on the results of characterization for disposal.

Under DMM Scenario C (Local Decontamination and Beneficial Use), thermal treatment and sediment washing would reduce the toxicity, mobility, and volume of the COCs removed from the lower 8.3 miles of the Lower Passaic River through treatment, while stabilization would reduce mobility through treatment without reducing toxicity or volume. Because DMM Scenario C anticipates treatment for nearly all the dredged sediments (regardless of which alternative is selected), it performs best under this evaluation criterion. Amounts to be treated under each technology are estimated in Table 31 in Appendix II, although actual distributions between the three treatment categories would depend on the results of characterization for disposal.

10.5. Short-Term Effectiveness

Short-term effectiveness addresses the period of time needed to implement the remedy and any adverse impacts that may be posed to workers, the community and the environment during construction and operation of the remedy until cleanup levels are achieved.

This criterion addresses the effects of each alternative during construction and implementation until RAOs are met. It considers risks to the community, on-site workers and the environment, available mitigation measures and time frame for achieving the response objectives.

10.5.1. Short-Term Effectiveness: Potential Adverse Impacts on Communities and Workers During In-River Construction

The impacts due to construction in the river are mainly driven by the volume dredged and duration of construction for each alternative. Alternative 1 would not involve any construction that would present a risk to the community or workers. Implementation of Alternative 2 would have larger impacts on the community and workers than Alternative 3, because construction would last longer (14 years) and would involve handling of a larger volume of contaminated sediments (9.7 million cy). Implementation of Alternative 3 would have less of an impact on the community, workers and the environment than Alternative 2, although those impacts would still be important to mitigate, since the construction period would last 6 years and would involve handling of 3.5 million cy of contaminated sediments. Alternative 4 would also cause adverse impacts on the community, workers and the environment during construction, but those impacts would be smaller than those caused by Alternatives 2 and 3, because of the relatively short construction period (2.5 years) and smaller volume of contaminated sediments handled (1.0 million cy) relative to Alternatives 2 and 3.

Impacts to communities from construction of Alternatives 2, 3 and 4 would include temporary noise, light, odors, blocked views, traffic, potential air quality impacts and disruptions to commercial and recreational river users in the lower 8.3 miles of the Lower Passaic River (operating for a few months at a given location). These impacts could be lessened through use of best management practices documented in community health and safety plans, but disruptions would still be significant, since dredging and backfilling or capping is expected to proceed 24 hours a day, six days per week and 32 weeks per year.

Potential occupational risks to site workers from construction of Alternatives 2, 3 and 4 could include direct contact, ingestion and inhalation of COCs from the surface water and sediments and routine physical hazards associated with construction work and working on water. Measures to minimize and mitigate such risks would be addressed in worker health and safety plans, by the use of best management practices and by following properly approved health and safety procedures.

10.5.2. Short-Term Effectiveness: Potential Adverse Impacts on the Environment During In-River Construction

Under Alternatives 2, 3 and 4, dredging would result in resuspension of contaminated sediments, which would cause fish and other organisms in the water to be exposed to higher concentrations of contaminants than are usually present in the water column. Studies have shown that dredging can result in resuspension loss of 1 percent to 3 percent of the material removed. The volume dredged under each alternative and the concentrations of contaminants on the resuspended sediments drive this adverse impact. Alternative 2 would have the most impact on the environment when compared to Alternatives 3 and 4, because Alternative 2 would have the largest volume dredged, and the deepest dredging into the sediment bed where contaminant concentrations are highest, leading to the greatest mass of COCs released through dredging over the longest construction period (14 years, as opposed to 6 years for Alternative 3 and 2.5 years for Alternative 4). Alternative 3 would have less impact on the environment than Alternative 2, but more than Alternative 4.

Risks due to resuspension could be minimized through proper equipment selection, control of sediment removal rates (through careful operation of the dredging equipment) and the application of best management practices in all in-river operations. Environmental impacts from construction would include temporary loss of benthos and habitat for the ecological community in dredged areas and in areas affected by resuspension of contaminated sediments during dredging. Habitat replacement measures would be implemented to mitigate these impacts. Since the remedial action would improve and replace existing open water, mudflat and intertidal habitat, no additional compensatory mitigation measures would be necessary for this aspect of the remediation. Natural benthic re-colonization following a disturbance is usually fairly rapid, and can begin within days after perturbation. In many cases, full recovery to pre-disturbance species composition and abundance occurs within a few years.

10.5.3. Short-Term Effectiveness: Impacts on Communities, Workers and the Environment from Disposal Options

The impacts associated with the disposal options are mainly driven by the mode of transportation for the dredged materials and amount of local processing of dredged materials.

For Alternatives 2, 3 and 4, under DMM Scenario A (CAD), EPA assumed that the CAD cells would be sited in the part of Newark Bay where the thickest layer of clay (approximately 60 feet) is likely to be found. Dredged materials from the lower 8.3 miles of the Lower Passaic River would be barged to the Newark Bay CAD site so an upland sediment processing facility on the banks of the Lower Passaic River or Newark Bay would not be necessary. This would minimize on-land impacts to the community, but increase traffic in the bay. Since major container terminals are located in Newark Bay near the CAD sites that EPA considered in the FFS, increased barge traffic to and from the CAD site may interfere with existing port commercial traffic and increase the potential for waterborne commerce accidents. Depending on the alternative, EPA estimates that approximately 2 to 4 barges a day would be needed to transport dredged materials from the lower 8.3 miles of the Lower Passaic River to a CAD site in Newark Bay, which would increase vessel traffic from the Lower Passaic River to Newark Bay by approximately 50 percent compared to current conditions documented in USACE's *Waterborne Commerce Statistics*.

While dredged materials would also have to be barged or pumped to an upland processing facility under DMM Scenarios B (Off-Site Disposal) or C (Local Decontamination and Beneficial Use), an FFS-level survey of land along the shoreline of the lower 8.3 miles of the Lower Passaic River and Newark Bay showed a number of locations suitable for an upland processing facility. Siting the upland processing facility adjacent to the shoreline within the area to be dredged would minimize the impact of increased in-water traffic associated with DMM Scenarios B and C and avoid interference with the major container terminals in Newark Bay to the extent possible.

DMM Scenarios B and C would cause more on-land impacts to the local community and workers compared to DMM Scenario A. These disposal options would require the siting of a 29- to 38-acre (depending on the alternative and scenario) upland sediment processing facility on or near the banks of the Lower Passaic River or Newark Bay. For cost and schedule-estimation purposes, the facility was assumed to operate for 24 hours a day, 6 days a week, 32 weeks[28] each year for 2.5 to 14 years (depending on the alternative). Best efforts to minimize impacts on the local community and workers would be implemented; however, operation of the facility would still result in more odors, noise, light pollution, potential air quality impacts, greater risk of accidents from equipment operation and increased traffic on local roads than DMM Scenario A, which does not need an upland sediment processing facility. DMM Scenario B would have less impact on the local community and workers than DMM Scenario C, because DMM Scenario B involves less processing of dredged materials at the upland processing facility than DMM Scenario C. For DMM Scenario B, only coarse material separation and dewatering would need to be performed at the upland processing facility before materials are loaded onto rail cars and shipped off site to a RCRA permitted disposal facility. For DMM Scenario C, material

[28] For cost and schedule estimation purposes, dredging and capping or backfill was assumed to occur for 32 weeks a year. Within the 35-week construction season discussed in the Responsiveness Summary (Appendix V), three non-consecutive weeks of downtime for equipment maintenance and weather-related downtime were assumed, since such events cannot be predicted.

separation, dewatering, thermal treatment, sediment washing and solidification/stabilization would occur at the upland processing facility before the beneficial use end-products are loaded into trucks or railcars to be sent to their final destination. Less processing of dredged materials at the upland processing facility means less equipment operating for the duration of the project and a smaller footprint for the upland processing facility. Measures to minimize and mitigate impacts on the community would be addressed in community health and safety plans, and by the use of best management practices.

Under DMM Scenario A, construction and operation of the CAD site could have substantial impacts on the aquatic environment, some of which could be lessened through engineering controls. Computer simulations of CAD cells placed in Newark Bay and operated without any dissolved- and particulate-phase controls were modeled over short time periods. Modeling results indicated contaminant losses from the CAD cells of approximately 1 percent of the mass placed, even over the short time period modeled (seven days), and assuming placement of a small amount of dredged materials in the CAD site (approximately 38,400 cy). Based on these modeling results, the CAD site conceptual design used for developing DMM Scenario A in the FFS includes sheet pile walls on all sides and a silt curtain across the entrance channel, intended to lessen the migration of dissolved and particulate-phase contaminants out of the CAD cells during construction and operation. Even with the use of sheet pile walls and a silt curtain, some of the dissolved-phase contamination could still escape during dredged material disposal.

Intertidal and subtidal shallows, such as those where CAD cells would be located, provide valuable habitat for various aquatic species, including areas designated by NOAA as Essential Fish Habitat.

In a letter dated March 10, 2014, the Federal Trustees urged EPA not to consider alternatives that include disposal of contaminated sediment into the waters of Newark Bay. They explained that a CAD cell in this situation would be unprecedented in terms of the potential for adverse effects to aquatic habitat, the high concentrations of contaminants, the volume of sediment and the footprint (acres) of the CAD cell. They observed that some species (particularly winter flounder) use the Bay bottom to lay their eggs and will not spawn if those areas are disturbed or not accessible. Young-of-the-year flounder tend to burrow in the sediment rather than swim away from threats; they are not likely to swim away from a dredge and run a high risk of being entrained during construction, operation and closing of the CAD site. The Trustees distinguished Newark Bay in this regard from the species and locations involved in Superfund CAD cells at Puget Sound and New Bedford Harbor. The Trustees also concluded that other species that use the Bay (such as juvenile *Alosines*, bay anchovy and silverside) are prey species for federally managed species such as bluefish, summer flounder and windowpane. Therefore, adverse impacts on the prey species would result in reduction in prey and would be considered an adverse impact to Essential Fish Habitat. In addition, the Trustees observed that several species in Newark Bay have special status, including Atlantic sturgeon, which is federally listed as an endangered species.

The State of New Jersey has expressed similar concerns, including in a letter dated March 12, 2014, from NJDEP Commissioner Bob Martin to EPA Administrator Gina McCarthy. The Commissioner noted that use of a CAD cell for disposal of the required volume and concentration of dioxin-contaminated dredged material is unprecedented. He noted that dioxins are highly persistent, bio-accumulative and toxic chemicals that are highly resistant to degradation from biotic or abiotic processes. Consequently, NJDEP is not willing to support disposal of dioxin-contaminated sediment in Newark Bay.

In a November 30, 2012, letter, USACE stated that CAD cells can be constructed and operated with only localized short-term impacts and with the least impacts to the surrounding communities. CAD cells have been implemented all over the country, including the construction, use and recent capping of the Newark Bay Confined Disposal Facility. They noted that conditions in Newark Bay are favorable based on natural presence of a thick impermeable red-clay shelf over bedrock in a Bay with a well-established, already impacted, depositional environment (i.e., very low potential for erosion due to storm events) ensuring the secured and consolidated disposal of contaminated sediment in the long-term.

Operation of the CAD site would involve discharging dredged materials into waters of the United States for 14 years under Alternative 2, 6 years under Alternative 3 and 2.5 years under Alternative 4. The area of the open waters subject to temporary impacts from construction and operation of the CAD site would be approximately 171 acres for Alternative 2, 80 acres for Alternative 3 and 19 acres for Alternative 4. In addition to restoring the bay bottom at the completion of the project, compensatory mitigation for the CAD site would be required; that is, provision of a separate mitigation site to offset the temporal ecological losses to habitat and their functional value while the habitat is being restored. For FFS cost estimation purposes, local mitigation banks have been tentatively identified to provide the mitigation necessary to offset the temporal losses associated with the Alternatives 3 and 4 CAD site. Existing mitigation banks could only provide about 55 percent of the total mitigation acreage necessary to offset the temporal losses associated with the Alternative 2 CAD site. Additional acres could be provided through restoration of sites identified in USACE's Hudson-Raritan Estuary Comprehensive Restoration Plan and Lower Passaic River Ecosystem Restoration Plan. The cost of mitigation is included in the cost of the alternatives that include DMM Scenario A. Furthermore, in addition to habitat loss, there is the potential for fish and semi-aquatic birds moving into the open CAD cells during their 2.5- to 14-year operation and being exposed to highly concentrated contamination by direct contact or ingestion of prey.

DMM Scenarios B and C would have much less impact on the aquatic environment than DMM Scenario A, because they would not involve the discharge of contaminated sediments through the water column and into CAD cells. While DMM Scenarios B and C have greater on-land impacts (discussed above) due to the need for an upland processing facility, those impacts can be mitigated through proven technologies such as air pollution control technology and buffer zones around construction sites.

10.5.4. Short-Term Effectiveness: Time Until Remedial Response Objectives are Achieved

See Figures 19 through 22 in Appendix I for modeling results for Alternatives 1 through 4. Under Alternative 1 (No Action), lower 8.3-mile surface sediment concentrations would still be approximately 20 to 300 times higher than any of the remediation goals by the early 2060s (end of the model simulation period). Under Alternative 4 (Focused Capping with Dredging for Flooding), surface sediment concentrations would be approximately 6 to 150 times higher than any of the remediation goals by the early 2060s. For dioxin and PCBs, shortly after construction completion for Alternative 4, lower 8.3-mile surface sediment concentrations are predicted to be reduced below the first interim remediation milestone corresponding to tissue concentrations that would allow adult anglers to eat 12 eight-ounce fish or crab meals per year at a 10^{-4} cancer risk level, although lifting or relaxing prohibitions on fish and crab consumption would not be recommended because of still-elevated noncancer hazard.

For Alternatives 2 (Deep Dredging with Backfill) and 3 (Capping with Dredging for Flooding and Navigation), lower 8.3-mile surface sediment concentrations would reach levels approximately at remediation goals for dioxin and approximately four to 100 times higher than the remediation goals for PCBs, mercury and Total DDx by the early 2060s. For dioxin and PCBs, shortly after construction completion, lower 8.3-mile surface sediment concentrations are predicted to reach the interim remediation milestones that correspond to interim protective fish and crab tissue concentrations, potentially allowing NJDEP to consider lifting or relaxing the prohibitions on fish and crab consumption. Alternative 3 would achieve significant reductions in surface sediment concentrations sooner than Alternative 2 because of the shorter construction period (6 versus 14 years).

As discussed in Section 10.1, EPA's model underestimates the effectiveness of the bank-to-bank remedies because it does not account for any reduction in incoming COCs over time as the Lower Passaic River above RM 8.3 and Newark Bay are remediated under CERCLA and COCs from above Dundee Dam are addressed under Clean Water Act programs. Such actions, taken while the remedy for the lower 8.3 miles is being designed and implemented, will reduce the incoming COCs and minimize the degree of recontamination, allowing the bank-to-bank remedies (Alternatives 2 and 3) to achieve protectiveness. In contrast, while EPA's model also underestimates the effectiveness of Alternative 4 in the same way, the effect of recontamination on the protectiveness of Alternative 4 includes and is greatly exacerbated by the resuspension of contaminated sediments from the unremediated two-thirds of the lower 8.3-mile riverbed and deposition on adjacent capped areas. While EPA actions under the Superfund and Clean Water Act programs discussed above may reduce incoming COCs in the future, the resuspension of highly contaminated sediments from the unremediated two-thirds of the lower 8.3 miles will continue unabated.

10.6. Implementability

Implementability addresses the technical and administrative feasibility of a remedy from design through construction and operation. Factors such as availability of services and materials, administrative feasibility, and coordination with other governmental entities are also considered.

There are no implementability issues for Alternative 1 (No Action), which does not involve any active remediation.

For Alternatives 2 (Deep Dredging with Backfill) and 3 (Capping with Dredging for Flooding and Navigation), every step of the in-river construction (debris removal, dredging, backfilling, engineered capping and dredged material transport) would be technically implementable, although careful planning would be needed to overcome the substantial challenges involved in the handling of such large volumes of dredged materials. Equipment and technical expertise for dredging and backfill/cap placement are available through several commercial firms. While a large amount of backfill and cap material would be needed, adequate resources have been preliminarily identified at several local borrow sources.

The lower 8.3-mile river bed is crossed by utilities of various sizes and depths, in a number of locations. The much deeper dredging for Alternative 2 would affect more utilities than the shallower dredging for Alternatives 3 or 4. The remedy design will include procedures to more precisely locate utilities in the lower 8.3 miles and determine appropriate dredging off-sets, if necessary.

The lower 8.3 miles of the Lower Passaic River is crossed by 13 bridges of various heights. Some of the bridges can only be opened with extreme difficulty to allow the passage of river vessels, because they are heavily used for commuter rail (e.g., Dock Street Bridge) or automobile traffic, or because of their age and infrastructure condition. All of the active alternatives would be affected by the need to open the bridges occasionally to allow construction equipment and dredged materials through. During dredging, low profile barges exist that can pass beneath all but two of the bridges and other engineering options, such as bypass pumping, are available to transport dredged materials under the remaining two bridges, so that bridge openings are expected to be infrequent events that can be timed to minimize transportation disruptions. This issue is not expected to pose an undue hardship to bridge operators or users. The FFS incorporates the assumption that the necessary coordination, which may include assisting bridge authorities with engineering evaluations and maintenance of the bridges, would occur during the remedial design phase of the project.

In-river construction of Alternative 4 (Focused Capping with Dredging for Flooding) could be seen as more easily implementable than Alternatives 2 and 3, because smaller volumes of dredged materials would need to be handled and less capping material would be involved. However, under Alternative 4, the process of reliably identifying discrete areas that release the most contaminants into the water column would involve a great degree of uncertainty given the complex estuarine environment of the lower 8.3 miles. The river bottom changes constantly as the tides move back and forth twice a day and unpredictably as storm events scour different areas depending on intensity, location and direction of travel.

For the in-river work of Alternatives 2, 3 and 4, no insurmountable administrative issues are anticipated in getting the necessary regulatory approvals for sediment removal or engineered cap and backfill placement. Since a large number of the activities are expected to occur on site (as defined under CERCLA §121(e)(1) and 40 CFR 300.5), federal, state and local permits would not be required. However, as discussed in Section 13.2, all substantive requirements will be met, unless there is a documented basis for a waiver. Permits are expected to be obtained from the appropriate local, state and federal agencies for actions that occur off site.

For Alternative 3, since some of the capped areas would be shallower than the federally authorized channel depths, it would be necessary to pursue both modification of the authorized depth (from RM 0.6 to RM 1.7) and deauthorization (from RM 1.7 to RM 8.3) of the federal navigation channel through Congressional action. USACE has advised that it will support those modification and deauthorization recommendations to Congress. For Alternative 4, since some of the capped areas would be shallower than the federally authorized channel depths (above approximately RM 2.7), it would be necessary to pursue deauthorization of the federal navigation channel from RM 2.7 to RM 8.3 through Congressional action. Since USACE has advised that it will support a recommendation for Congressional action to deauthorize the federal navigation channel from RM 1.7 to RM 8.3, USACE would likely also support the recommendation for Congressional action required for Alternative 4. However, as discussed above, the process of reliably identifying discrete areas that release the most contaminants into the water column involves a high degree of uncertainty given the complex estuarine environment of the lower 8.3 miles. If, during design, such discrete areas are identified in the navigation channel below RM 1.7, Alternative 4 may face an administrative implementability hurdle with respect to obtaining deauthorization or modification of the navigation channel in the lower 1.7 miles of the river. Given the current and reasonably anticipated future use of the navigation channel, such Congressional action might not be obtained.

The technical and administrative implementability of the DMM Scenarios vary. Every step involved in DMM Scenarios A (dredged material placement in CAD cells) and B (dewatering, dredged material transport and off-site disposal) is technically implementable with proper planning. The technologies have been successfully implemented at other Superfund sites. For the processing site that is eventually selected, based on EPA's analysis during the FFS and in response to comments, EPA expects that dewatering, water treatment and transfer facilities with good rail access and suitable wharf facilities can be developed. The large volume of sediments to be handled would need significant logistical coordination. For DMM Scenario B, several incinerators and landfills have been identified as potentially having capacity to receive lower 8.3-mile dredged material by rail.

The decontamination technologies involved in DMM Scenario C (thermal treatment and sediment washing) have not been constructed and operated in the United States on a scale approaching the capacity needed for this project, so their technical ability to handle large volumes of highly contaminated sediments is more uncertain.

- At least four thermal treatment technologies were identified as potentially able to treat lower 8.3-mile dredged sediments. Pilot demonstrations were conducted by USACE for three of these technologies with Passaic River-Newark Bay sediments and for one technology with Lower Fox River (Wisconsin) sediments. All achieved over 99 percent removal efficiencies for a variety of COCs, including dioxins, PCBs, PAHs and metals, although the demonstrations involved relatively small volumes and short durations.

- At least four vendors have developed sediment washing technologies. In 2005-2006, one vendor conducted a pilot demonstration with Passaic River-Newark Bay sediments that involved sufficiently high processing rates for a limited period of time to be considered equivalent to commercial scale operation. The technology achieved variable removal efficiencies (ranging from less than 10 percent to 80 percent depending on the contaminant) for dioxins and furans, PCBs, PAHs and metals. While data from the demonstration did not conclusively establish that the system would be effective in treating all contaminants to New Jersey standards so as to allow the end product to be used beneficially without restrictions, it is possible that sediment washing, combined with solidification and stabilization technology, would enable the end product to be used as RCRA Subtitle D landfill cover. However, most recently, in mid-2012, bench-scale studies by two sediment washing technology vendors showed that their technologies were unable to reduce Lower Passaic River sediment contamination to levels low enough for beneficial use.

DMM Scenario A (CAD) is a technically viable, cost-effective solution that has been constructed and maintained in a protective manner in other locations, including Newark Bay, and Superfund sites such as New Bedford Harbor and Puget Sound Naval Shipyard. From 1997 to 2012, a CAD cell with a capacity of 1.5 million cy was operated in Newark Bay by the Port Authority of New York and New Jersey and USACE for the disposal of navigational dredged material from the Newark Bay watershed (not for disposal of sediment dredged for environmental remediation).

However, in this case, DMM Scenario A (CAD) faces unique and significant administrative and legal impediments, because the State of New Jersey has asserted ownership of the bay bottom and strongly opposes construction of a CAD site in Newark Bay, citing the high concentrations of dioxin in Lower Passaic River sediments and unprecedented volume of contaminated sediment as a primary reason it should not be disposed of in the aquatic environment. The State's position is articulated in letters dated November 28, 2012, from Governor Chris Christie to former EPA Administrator Lisa Jackson and March 12, 2014, from NJDEP Commissioner Martin to EPA Administrator Gina McCarthy. While EPA has authority to acquire property interests when needed to conduct a remedial action under Section 104(j)(1) of CERCLA, including by condemnation if necessary, Section 104(j)(2) requires prior State assurance that the State will accept the property interest when the remedial action is complete. In the March 12, 2014 letter, NJDEP stated that it will not provide the assurance required by Section 104(j)(2). Therefore, the State's opposition is likely to make DMM Scenario A administratively infeasible. Given the State's position, DMM Scenario A (CAD) is unlikely to satisfy the NCP balancing criterion of implementability and the modifying criterion of state acceptance, discussed below.

For DMM Scenario B (Off Site Disposal), administrative feasibility is less of a concern, although siting a 29- to 38-acre (depending on the alternative) upland processing facility may be challenging in the dense urban areas around the Lower Passaic River and Newark Bay. For DMM Scenario C (Local Decontamination and Beneficial Use), administrative feasibility is less of a concern than for DMM Scenario A but more of a concern than for DMM Scenario B, because Scenario C involves more upland area for dredged material processing (32 to 38 acres depending on the alternative). It also involves the construction of a thermal treatment plant, which may be subject to more stringent limitations on air emissions. In Governor Christie's November 28, 2012, letter, the State of New Jersey also expressed opposition to siting a thermal treatment facility near densely populated urban areas that are already burdened with environmental impacts, particularly from air pollutants. However, the letter acknowledged that decontamination technologies such as those described in DMM Scenario C should be considered in conjunction with off-site disposal.

10.7. Cost

Includes estimated capital and long-term operation and maintenance (O&M) present value costs.

Cost estimates are summarized in Table 32 in Appendix II. A discount rate of 7 percent was used in the present value calculations, consistent with EPA guidance.

The primary cost drivers for each remedy are the quantity of sediments to be dredged and the method of disposal. Thus, the Alternative 2 capital cost under each DMM scenario is greater than the Alternative 3 capital cost under the corresponding DMM scenario, which in turn is greater than the Alternative 4 capital cost under the corresponding DMM scenario, because Alternative 2 involves dredging and managing the largest volume of contaminated sediments, while Alternative 4 involves dredging and managing the least. All Alternative 3 and 4 operation and maintenance (O&M) costs are greater than Alternative 2 O&M costs, because Alternatives 3 and 4 would involve long-term monitoring and maintenance of an engineered cap in the lower 8.3 miles, while Alternative 2 does not involve any maintenance of the backfill (because contaminated inventory is not left behind). Annual average O&M costs for Alternative 3 and 4 over the 30 year post-construction period are comparable, at estimated present values of approximately $1.4 to $1.6 million for both Alternatives 3 and 4.

Costs for DMM Scenario B were developed with the assumption that in addition to dredged material characterized as hazardous, dredged materials that do not require treatment prior to land disposal will be placed in a RCRA Subtitle C (hazardous waste) landfill outside of New Jersey (because there are no RCRA Subtitle C landfills operating in New Jersey). EPA believes that use of RCRA Subtitle C landfills for disposal is likely since the private parties that performed the Phase 1 Tierra Removal and the RM 10.9 Removal disposed of dredged material in RCRA Subtitle C facilities. Further, the State of New Jersey has no permitted Subtitle D landfills that are authorized to accept dredged material as solid waste for disposal. Dredged materials from coastal or tidal waters otherwise regulated under New Jersey law are specifically excluded from the definition of solid waste under New Jersey regulations.

Costs associated with local decontamination technologies (DMM Scenario C) are somewhat uncertain, since these technologies have not been built and operated in the United States on a scale approaching the capacity needed for this project. In particular, sediment washing may be less effective when the matrix contains multiple contaminants and consists of a large proportion of finer particles like silts and clays. Multiple treatment passes might be needed, which would increase cost.

Modifying Criteria - *The final criteria 8 and 9, are known as "modifying criteria." Community and support agency acceptance are factors that are assessed by reviewing comments received during the public comment period, including new information made available after publication of the proposed plan that significantly changes basic features of the remedy with respect to scope, performance, or cost.*

10.8. State Acceptance

Indicates whether based on its review of the RI/FFS reports and the Proposed Plan, the state supports, opposes, and/or has identified any reservations with the selected response measure.

The State of New Jersey concurs with the selected remedy. A letter of concurrence is attached as Appendix IV.

10.9. Community Acceptance

Summarizes the public's general response to the response measures described in the Proposed Plan and the RI/FFS reports. This assessment includes determining which of the response measures the community supports, opposes, and/or has reservations about.

Community acceptance of the selected remedy for the sediments of the lower 8.3 miles of the Lower Passaic River was evaluated based upon the comments received during the public comment period. There was overwhelming support for a remediation of the Lower Passaic River. Opinions on how that remediation should take place were more diverse. Several paper petitions sponsored by environmental, labor, university and local community groups generated over two thousand signatures in favor of the preferred alternative in the Proposed Plan (Capping with Dredging for Flooding and Navigation, with Off-Site Disposal). EPA also received almost two hundred form e-mails and pre-printed post cards supporting a concept suggested by the CPG in its comments, which the CPG describes as a "Sustainable Remedy,"[29] an option not evaluated in the Proposed Plan. An additional 30-40 post cards expressed concern over the construction impacts of a bank-to-bank remedy.

Some elected officials on the federal, state and local levels expressed support for the preferred alternative and others expressed opposition to the preferred alternative. The CAG, which is composed of approximately 20 members representing local citizens and businesses, environmental and recreational groups, municipalities and educators, supported the preferred alternative, with two minority opinions supporting Alternative 2 (Deep Dredging with Backfill) with off-site disposal or CAD. Some environmental groups supported the preferred alternative, while others supported Alternative 2 with off-site disposal or local decontamination. Groups representing businesses and economic development generally expressed support for the CPG's "Sustainable Remedy." Many local boating and rowing clubs expressed concern over the impacts on their ability to use the river during the construction of a bank-to-bank remedy. Companies that have received notices of potential responsibility that submitted comments all opposed a bank-to-bank remedy, and most supported the CPG's "Sustainable Remedy." Each of the active alternatives (i.e., alternatives other than "No Action") received support from various individual stakeholders, and many local residents expressed concern over the construction impacts of any remediation, even if they wrote to support some form of remediation.

While requesting comments on all aspects of the Proposed Plan, EPA provided focused public outreach on two aspects of the preferred alternative: the choice of off-site disposal versus a CAD site in Newark Bay and the dredging depths for the federally authorized navigation channel from RM 0 to RM 2.2. Of the commenters who specifically commented on off-site disposal versus CAD, more expressed support for than opposition to off-site disposal and conversely, more expressed opposition to than support for CAD, for reasons that are described in the Responsiveness Summary. Note that many of those who expressed opposition to a CAD site in Newark Bay identified themselves as residents of the Ironbound in Newark, a community with a number of potential environmental justice concerns.

Of those who specifically commented on the navigation channel, some supported dredging the navigation channel to the maximum extent while others expressed the opinion that deeper dredging in the navigation channel should not have been included in any of the alternatives. Some commenters stated that the analysis in the 2010 USACE report should be updated to include the latest information on navigation in the Lower Passaic River. Entities who identified themselves as operating within the lower 0.6 miles of the Passaic River supported dredging and

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[29] During the development of the RI/FFS and Proposed Plan, and in their comments on the Proposed Plan, the CPG did not submit enough information for EPA to evaluate the conceptual remedy that the CPG calls a "Sustainable Remedy." EPA did develop and include a less than bank-to-bank, or focused, remedial alternative (Alternative 4) in the RI/FFS and Proposed Plan. Alternative 4 includes dredging and capping discrete areas of the lower 8.3 miles that release the most contaminants into the water column. Those areas cumulatively total approximately 220 acres of the surface of the lower 8.3 miles. The CPG's "Sustainable Remedy" would address discrete areas of highest surface sediment concentrations in the 17-mile stretch of the Lower Passaic River that would cumulatively total approximately 150 acres of the surface of the 17 miles.

maintaining the navigation channel as critical to their businesses or operations. Commenters' reasons for supporting or opposing deeper dredging in the navigation channel are described in the Responsiveness Summary.

Appendix V, the Responsiveness Summary, addresses the comments received at the public meetings and written comments received during the public comment period.

11. PRINCIPAL THREAT WASTE

The NCP establishes an expectation that EPA will use treatment to address the principal threats posed by a site wherever practicable (NCP §300.430(a)(1)(iii)(A)). Principal threat wastes are source materials that include or contain hazardous substances, pollutants or contaminants that act as a reservoir of contaminants that can migrate to groundwater, surface water or air, or act as a source for direct exposure. Contaminated groundwater generally is not considered to be a source material; however, non-aqueous phase liquids in groundwater may be viewed as source material. Principal threat wastes are those source materials considered to be highly toxic or highly mobile that generally cannot be reliably contained, or would present a significant risk to human health or the environment should exposure occur. Low-level threat wastes are those wastes that generally can be reliably contained and present only a low risk in the event of exposure. The identification of principal and low level threats is made on a site-specific basis to help streamline and focus waste management options by categorizing the suitability of the waste for treatment or containment.

The dioxin, PCB and other COC concentrations in sediments throughout the lower 8.3 miles of the Lower Passaic River are present at levels contributing to 10^{-3} risks for humans consuming fish and crab caught in the lower 8.3 miles, a risk level that can be used as a basis for identifying principal threat waste. Although the engineering and sediment transport modeling work done as part of the FFS has determined that the deeper sediment, despite its toxicity, can be reliably contained, EPA nevertheless considers the most highly contaminated sediments as principal threat wastes at the site. As such, EPA has considered treatment as a component of dredged material management. EPA does not believe that additional treatment of all the sediment in the lower 8.3 miles is practicable or cost effective, given the high volume of sediment, the number of COCs that would need to be addressed, and the lack of applicable treatment technologies.

12. SELECTED REMEDY

Based upon an evaluation of the results of Site investigations, input from the NRRB and the CSTAG, the detailed analysis of the various remedial alternatives, and public comments, EPA has selected Alternative 3 (Capping with Dredging for Flooding and Navigation) with DMM Scenario B (Off-Site Disposal) as the remedy for OU2, the sediments of the lower 8.3 miles of the Lower Passaic River.

The major components of the selected remedy include the following:

- An engineered cap will be constructed over the river bottom of the lower 8.3 miles, except in areas where backfill may be placed because all contaminated fine-grained sediments have been removed. The engineered cap will generally consist of two feet of sand and may be armored where necessary to prevent erosion of the sand.

- Before the engineered cap is installed, the river will be dredged bank to bank (approximately 3.5 million cubic yards) so that the cap can be placed without increasing the potential for flooding. Depth of dredging is estimated to be 2.5 feet, except in the 1.7 miles of the federally authorized navigation channel closest to Newark Bay.

- The remedy will include sufficient dredging and capping to allow for the continued commercial use of a federally authorized navigation channel in the 1.7 miles of the river closest to Newark Bay and to accommodate reasonably anticipated future recreational use above RM 1.7.

- Dredged materials will be barged or pumped to a sediment processing facility in the vicinity of the Lower Passaic River/Newark Bay shoreline for dewatering. Dewatered materials will be transported to permitted treatment facilities[30] and landfills in the United States or Canada for disposal.

- Mudflats dredged during implementation of the remedy will be covered with an engineered cap consisting of one foot of sand and one foot of mudflat reconstruction (habitat) substrate.

- Institutional controls will be implemented to protect the engineered cap. In addition, New Jersey's existing prohibitions on fish and crab consumption will remain in place and will be enhanced with additional community outreach to encourage greater awareness of the prohibitions until the concentrations of COCs in fish and crab tissue reach protective concentrations corresponding to remediation goals. EPA will share the data and consult with NJDEP about whether the prohibitions on fish and crab consumption advisories can be lifted or adjusted to allow for increased consumption as contaminant levels decline.

- Long-term monitoring and maintenance of the engineered cap will be required to ensure its stability and integrity. Long-term monitoring of fish, crab and sediment will also be performed to determine when interim remediation milestones, remediation goals and remedial action objectives are reached. Other monitoring, such as water column sampling, will also be performed.

[30] At this time, incineration is the only technology known to be able to treat sediments to the applicable RCRA standards if those sediments are characterized as hazardous under RCRA and contain dioxin as an underlying hazardous constituent at concentrations requiring treatment.

This is the first of three remedies to be selected for the Lower Passaic/Newark Bay waterway: separate RI/FSs are being conducted for the full 17-mile LPRSA and for the Newark Bay Study Area, and EPA expects the three remedies to be integrated into a comprehensive response action.

Further details on the selected remedy for the sediments of the lower 8.3 miles of the Lower Passaic River include:

12.1. Dredging to Allow For Engineered Capping

Prior to installing an engineered cap bank to bank in the lower 8.3 miles of the Lower Passaic River, dredging to approximately 2.5 feet below the existing sediment surface will be performed to prevent the engineered cap from causing additional flooding. That is, when the remedy is complete, the elevation of the bottom of the river will approximate its current depth. While the FFS evaluated dredging using a mechanical dredge fitted with an environmental clamshell bucket, hydraulic dredging may also be used for some or all of the work if this is determined to be appropriate during design. If, during design, other dredging methods are identified, they will be evaluated as well.

Except as discussed in Section 12.2, the depth of dredging will be governed by the thickness of the cap. An engineered cap will be installed to provide chemical isolation, and protect against disturbance from natural processes (e.g., bioturbation) and weather events. Areas of the river that are subject to higher erosion potential may need armoring to reduce loss of cap material. The cap thickness is expected to be, on average, 2 feet, although it may be determined during remedy design that the cap thickness can vary in segments of the lower 8.3 miles as long as protectiveness is maintained.

Dredging and capping will proceed in sequence to minimize the period in which deeper contaminated sediments are exposed. The final amount to be dredged, thickness of the engineered cap and material to be used for the cap will be determined during remedy design.

Dredging/capping are assumed to occur for 32 weeks per year to account for equipment maintenance, weather-related delays and the fish window. During the remedy design, a fish migration study will better define the fish window.

The selected remedy also includes the reconstruction of dredged mudflats to their original grade, with an engineered cap that would consist of 1 foot of sand and 1 foot of mudflat reconstruction (habitat) substrate.

12.2. Navigation Channel Capping/Dredging

The selected remedy includes dredging the 300-foot wide federal navigation channel from RM 0 to RM 1.7 to accommodate continued and reasonably anticipated future use as shown in Table 33 in Appendix II.

12.3. Dredging for Recreational Use

Above RM 1.7, dredging will provide for at least 10 feet below MLW to accommodate reasonably anticipated future recreational uses, as shown in Table 33 in Appendix II.

12.4. Dredged Materials Management

This action will result in the dredging of approximately 3.5 million cy of contaminated sediments, which will be disposed of in the following way:

- Dredged materials will be barged or pumped to an upland sediment processing facility in the vicinity of the Lower Passaic River/Newark Bay shorelines for debris screening, sand separation and active dewatering using filter presses. The upland sediment processing facility will include a water treatment plant to treat contaminated water generated from sediment dewatering to meet NJDEP water quality standards before discharging it to the Lower Passaic River or Newark Bay.

- Non-hazardous coarse-grained materials (sand) separated during processing will be disposed of at a local landfill, or be beneficially used in compliance with applicable regulations.

- Dewatered dredged materials will be transported to permitted landfills in the United States or Canada for disposal.

- Some lower 8.3-mile sediments have the potential to be characterized as hazardous under RCRA standards. At this time, incineration is the only technology known to be able to treat sediments to the applicable RCRA standards if those sediments are characterized as hazardous under RCRA and contain dioxin as an underlying hazardous constituent at concentrations requiring treatment. The ash generated by incineration will be disposed of in a RCRA Subtitle C landfill.

- Dredged materials characterized as non-hazardous may be disposed of directly in a landfill without treatment. For cost-estimation purposes, placement in a RCRA Subtitle C (hazardous waste) landfill outside of New Jersey was assumed, since that was the disposal method selected by private parties performing both Phase 1 of the Tierra Removal and the RM 10.9 Removal.

12.5. Performance Standards

Performance standards related to remedy implementation will be developed during the remedy design in consultation with the State of New Jersey and federal Natural Resource Trustees, based on environmental and scientific criteria. These performance standards will be incorporated in design documents. The standards will promote accountability and ensure that the remedy meets the action-specific ARARs.

12.6. Habitat Restoration

Measures to reconstruct habitat impacted by the dredging and capping will be implemented, including habitat assessment and surveys during remedy design. The design will address placement of habitat recovery material and aquatic vegetation and is discussed further in Section 9.2.3.

12.7. Monitoring, Engineered Cap Maintenance and Institutional Controls

During construction (i.e., dredging, capping and upland sediment processing facility operations), water, air and biota monitoring will be conducted to evaluate whether the project is being managed efficiently to mitigate releases of contaminants to the environment. In instances where water or air quality standards are exceeded, the construction activity that caused the exceedance will be evaluated and additional mitigation measures will be implemented. After construction, monitoring of fish, crab and sediment will be conducted to determine when interim remediation milestones and remedial action objectives are reached.

During and after construction, New Jersey's prohibitions on fish and crab consumption, with enhanced community outreach to improve awareness, will remain in place until RAOs are met. EPA and NJDEP will share data and evaluate whether and when New Jersey may lift prohibitions on fish and/or crab consumption, replacing them with advisories that can be adjusted to allow for increased consumption as contaminant levels decline.

After construction, monitoring and maintenance of the engineered cap will be required both on a regular basis and after significant storm events. Institutional controls prohibiting disturbance of the engineered cap will be necessary to maintain cap integrity.

Frequency of monitoring during and after construction activities will be identified in monitoring plans developed during remedial design.

12.8. Adaptive Management

As discussed in EPA's "Contaminated Sediment Remediation Guidance for Hazardous Waste Sites" (December 2005) Section 2.7, adaptive management is encouraged in addressing large and complex contaminated sediment sites. Further, in its 2007 report on sediment dredging at Superfund sites, the National Research Council (NRC) noted the "difficulty in predicting dredging effectiveness and the limited number of available alternative technologies." The NRC also noted that environmental responses to remediation are complex and difficult to predict. The NRC recommended an "adaptive management approach" which it defined as "[t]he use of a structured process of selecting a management action, monitoring the effects of the action, and applying those lessons to optimize a management action…." The NRC noted that adaptive management is "context-specific" and involves an active learning process. The NRC also noted that adaptive management is not a means to permit or sanction a less rigorous cleanup or avoid public input, and stressed the importance of working in concert with site stakeholders so they can contribute to adapting the remedy if necessary. The NRC also stated that it is important not only to evaluate new information as it becomes available, but also to document deviations from the plan, if any.

Given the complexity and uncertainty involved with remediating sediment sites, especially at such a large scale, as recommended by the NRC, EPA expects to employ an adaptive management approach during the remedial design and implementation of the remedy. This will allow for appropriate adjustments to ensure efficient and effective remediation. Information critical to the successful implementation of the remedy will be evaluated; for example, models may be reviewed and updated and new projections made which may provide the opportunity for modifications to the remedial action to be considered, if appropriate. As discussed in Section 9.1.3, during remedy design, EPA will evaluate enhanced capping technologies, such as the use of additives (e.g., activated carbon or organoclay) to create a reactive cap or thin-layer capping technologies where conditions are conducive to such approaches. As appropriate, remedy modifications will be made and documented in accordance with the CERCLA process, through a memorandum to the Site file, an Explanation of Significant Differences or an Amendment to the ROD.

Furthermore, EPA will evaluate remedy implementation and modify activities as appropriate to attain remediation goals and remedial action objectives more effectively. This ensures that uncertainties are promptly and effectively addressed, informs specific design decisions, and addresses concerns about how this action will be integrated with the ongoing 17-mile LPRSA RI/FS being carried out by the CPG under EPA oversight.

12.9. Staging Remedy Implementation

The selected remedy will be implemented over an estimated 6 years of active dredging and capping. Accordingly, there will be opportunities to use experience gained, and monitoring data, to influence the implementation and performance of later stages of the remedy. EPA anticipates that, during implementation, some aspects of the remedy can be optimized, improving efficiency and potentially reducing costs. For most of the lower 8.3 miles (outside channel-dredging areas discussed in Section 12.2), the need for dredging prior to capping is derived from information about system stresses that may result from changing the river bottom bathymetry and sediment grain size (affecting the erosional stresses on the cap and the amount of flood-storage capacity within the river). As the cost of the remedy is substantially driven by the cost of dredging and dredged material management, earlier stages of dredging followed by capping can inform later stages, potentially reducing the cost by allowing EPA to evaluate opportunities to potentially reduce the amount of dredging while still allowing for installation of a protective and stable engineered cap.

In addition, EPA expects to select remedies for the Lower Passaic River above RM 8.3 and Newark Bay under the Superfund program and, working with New Jersey, to address COCs from above Dundee Dam under Clean Water Act programs. Such actions, taken while the selected remedy is being designed and implemented, will reduce the incoming COCs and minimize the degree of recontamination, allowing the selected remedy to achieve protectiveness.

12.10. Future Changes to the Navigation Channel

Capping the navigation channel at a depth other than the currently authorized depth will depend on coordination with USACE and the State of New Jersey, and successful completion of the process to obtain Congressional action to modify the depths and deauthorize portions of the navigation channel. Accordingly, the actual channel dredging depths may be refined further prior to implementation of the remedy.

12.11. Upland Sediment Processing Facilities and Local Decontamination and Beneficial Reuse

There may be adaptive management opportunities in the construction of an upland sediment processing facility, including the construction of smaller sediment dewatering and management units that can be expanded as necessary. In addition, while DMM Scenario C has not been selected, primarily for implementability reasons (e.g., the challenges of constructing and operating a sediment decontamination and beneficial reuse facility on a scale approaching the capacity needed for the selected remedy), EPA plans to follow an adaptive management approach to dredged materials management that seeks opportunities for on-site treatment that allows for beneficial reuse, as discussed in more detail in Section 12.13.

12.12. Green Remediation

The environmental benefits of the selected remedy may be enhanced by consideration of technologies and practices during the design of the remedy that are sustainable in accordance with EPA Region 2's Clean and Green policy. This will include consideration of green remediation technologies and practices.

12.13. Rationale For Selection of Alternative 3, DMM Scenario B

The selection of a remedy is accomplished through the evaluation of the nine criteria as specified in the NCP. The preference for the selected alternative and DMM scenario is based upon these principal factors:

Alternative 3 with DMM Scenario B meets the threshold criteria of Overall Protection of Human Health and the Environment and Compliance with ARARs. This alternative, which relies on an engineered cap bank-to-bank over the entire lower 8.3 miles of the Lower Passaic River to isolate the contaminated sediment in the lower 8.3 miles, achieves substantial risk reduction and controls a major source of contamination to the rest of the Lower Passaic River and Newark Bay. EPA will share data and consult with NJDEP about whether New Jersey's prohibitions on fish and crab consumption, incorporated to ensure protection of human health, can be lifted or adjusted to allow for increased consumption as contaminant levels decline. The selected remedy will meet all of the RAOs for the lower 8.3 miles and will accommodate the reasonably anticipated future use in the federally authorized navigation channel, as well as future recreational use. Following are the key factors that led EPA to select this alternative-DMM scenario combination over the others:

- Alternative 3 achieves substantial risk reduction and controls a major source of contamination to the rest of the Lower Passaic River and Newark Bay by sequestering all of the contaminated sediments remaining in the lower 8.3 miles of the Lower Passaic River at the completion of the remedy under a bank-to-bank engineered cap. While engineered caps must be monitored and maintained in perpetuity, they have been demonstrated to be effective for well over 30 years at multiple Superfund sites around the country.

- Alternative 3 reduces the contaminant volume in the lower 8.3 miles of the Lower Passaic River by removing 3.5 million cy of contaminated sediments. Alternative 3 reduces mobility in the lower 8.3 miles by sequestering the remaining 6.2 million cy of contaminated sediments under an engineered cap that will be maintained in perpetuity. Overall toxicity and volume are reduced by incinerating the 5 percent of dredged materials estimated to be characterized as hazardous under RCRA (with dioxin concentrations elevated such that incineration is needed), while overall mobility is effectively eliminated by disposing of the remaining volume (and the ash from incineration) into landfills.

- While both Alternatives 2 and 3 meet the threshold criterion of protectiveness, Alternative 3 will do so in less than half the construction time of Alternative 2 and with a smaller volume dredged than Alternative 2. This means that there will be significantly less short-term impact on the community, workers and the environment.

- DMM Scenario B has less of an on-land impact than DMM Scenario C, since off-site disposal will involve fewer acres for, and less processing at, the upland processing facility than local decontamination. DMM Scenario B has significantly less impact on the aquatic environment than DMM Scenario A, since CAD cells, unlike off-site disposal, would involve managing the placement of dredged materials on 80 acres of Newark Bay bottom over 6 years, potentially impacting species that are dependent on limited bay bottom habitat for critical life stages. In addition, CAD cells could increase the potential that fish and birds could be exposed to highly concentrated contamination in the CAD cells, and increase the potential for waterborne commerce accidents in the busy port.

- The cost estimate for the selected remedy assumes that dredged materials that do not require treatment prior to land disposal will be placed in a RCRA Subtitle C landfill. Because the private parties that performed the Phase 1 Tierra Removal and the RM 10.9 Removal disposed of dredged material in RCRA Subtitle C facilities, EPA believes it likely that the dredged material for this action will also go to Subtitle C facilities. Further, because dredged materials from coastal or tidal waters, otherwise regulated under New Jersey law, are specifically excluded from the definition of solid waste under New Jersey regulations, the State of New Jersey has no permitted Subtitle D landfills that are authorized to accept dredged material as solid waste for disposal.

- The dredging and engineered cap components in Alternative 3 have been demonstrated to be technically and administratively feasible at other Superfund sites. Alternative 3 is more implementable than Alternative 2, because Alternative 3 involves a significantly smaller dredging volume and shallower dredging depths than Alternative 2, which means less challenging logistics for sediment handling and fewer utilities to be located and evaluated. Alternative 3 is more implementable than Alternative 4, because Alternative 3 does not rely on identifying discrete areas of the river that release high fluxes of contaminants into the water column. The river bottom changes constantly as the tides move back and forth twice a day and unpredictably as storm events scour different areas depending on intensity, location and direction of travel, making the identification of the discrete areas that would be remediated under Alternative 4 highly uncertain.

- While the final decisions regarding treatment and disposal locations will be made during remedy design and implementation, for DMM Scenario B, existing incinerators and landfills were identified that are permitted to handle lower 8.3-mile dredged materials, are proven to be reliable technologies and already have provisions for long-term monitoring and maintenance by their owners/operators. In contrast, because the State of New Jersey strongly opposes construction of a CAD site in Newark Bay, DMM Scenario A is likely to face such severe legal and administrative impediments as to make it administratively infeasible. The sediment washing technologies evaluated in DMM Scenario C failed in demonstration tests to reliably reduce Lower Passaic River sediment contamination to levels low enough to allow for beneficial re-use, and thermal treatment technology vendors have not sited or constructed commercial-scale facilities with the demonstrated ability to process the large volumes of sediment that would be dredged under Alternative 3.

- At a present value of $1.38 billion, Alternative 3-DMM Scenario B is less costly than the two most costly alternative-DMM scenario combinations, although more costly than three others (excluding Alternatives 1 and 4, which do not meet the protectiveness threshold criterion).

- The State of New Jersey has concurred with the combination of Alternative 3 and DMM Scenario B.

- On balance, the comments received on the Proposed Plan, particularly from local residents and many community organizations, supported the combination of Alternative 3 and DMM Scenario B.

DMM Scenario C would offer some advantages in terms of permanence and reduction of toxicity, mobility and volume through treatment. However, none of the decontamination technologies tested during the FFS development period proved implementable on a commercial scale, particularly with the large volumes of sediment that would require management under the active alternative evaluated. Several sediment decontamination vendors are continuing to develop their technologies and continue to express interest in handling Lower Passaic River sediments. It is possible that one or more vendors might succeed in demonstrating that their technology could decontaminate Lower Passaic River sediments and might be able to site and construct a local decontamination technology facility. Should this happen during the remedy design phase, EPA could modify the selected remedy through a ROD amendment or Explanation of Significant Differences in such a way as to allow for local decontamination and beneficial use (DMM Scenario C) of all or a portion of the sediment.

Based on information currently available, EPA concludes that the selected remedy meets the threshold criteria and provides the best balance of tradeoffs among the alternatives with respect to the balancing and modifying criteria. The selected remedy will satisfy the statutory requirements of CERCLA §121(b) by being protective of human health and the environment; complying with ARARs; and being cost-effective. Although CERCLA §121(b) also expresses a preference for selection of remedial actions that use permanent solutions and treatment technologies to the maximum extent practicable, there are situations that may limit the use of treatment, including when treatment technologies are not technically feasible or when the extraordinary size or complexity of a site makes implementation of treatment technologies impracticable. The selected remedy would generate approximately 3.5 million cy of contaminated sediments, which is an extraordinary volume of material; and the sediment treatment technologies investigated under DMM Scenario C have not been constructed or operated in the United States on a scale approaching the capacity needed for this project, so their technical ability to handle such an extraordinary volume of highly contaminated sediments is uncertain. The selected remedy is estimated to provide treatment of approximately 130,000 cy of contaminated sediment through incineration off-site to comply with applicable RCRA standards.

12.14. Summary of the Estimated Cost of the Selected Remedy

The estimated capital, long-term O&M and total present value costs, as well as construction time, for the selected remedy are summarized below and detailed in Tables 34 and 35 in Appendix II. The cost estimates, which are based upon estimates developed for similar projects, engineering judgment and construction bids, are order-of-magnitude engineering cost estimates that are expected to be within +50 percent to -30 percent of the actual cost for implementation of the remedy.

Total Present Value Capital Cost:	$1,338,000,000
Average Annual Present Value O&M Cost:	$ 1,468,000
Total Present Value Cost:	$1,382,000,000
Construction Duration:	6 Years

12.15. Expected Outcomes of the Selected Remedy

The selected remedy, Alternative 3 combined with DMM Scenario B, addresses a major source of contamination to the Lower Passaic River and Newark Bay. Risks to humans through fish and crab consumption, risks to ecological receptors due to direct contact and ingestion of contaminated sediments and prey, and resuspension of contaminated sediment acting as an ongoing source of contamination will be mitigated through the installation of an engineered cap over the lower 8.3 miles of the Lower Passaic River, bank to bank (except in areas where backfill may be placed, because all contaminated fine-grained sediments have been removed). To prevent the engineered cap from exacerbating flooding, removal of approximately 2.5 feet of surface sediments will be necessary. This is the first stage of a multi-phased action to address human health and ecological risks posed by contaminated sediments, water and biota in the entire 17 miles of the Lower Passaic River and in Newark Bay. The installation of an engineered cap will address exposures by remediating contaminated sediments in the lower 8.3 miles, thereby improving water column concentrations and lowering fish and crab tissue concentrations. Modeling predicts that fish and crab tissue concentrations may be reduced sufficiently after remedy implementation to allow for some adjustments of the current prohibitions on fish and crab consumption to allow for some consumption. Actions taken to reduce the incoming COCs and minimize the degree of recontamination will result in further improvements in fish and crab tissue concentrations. EPA does expect that some level of fish and crab consumption prohibitions or advisories will be needed during construction of the remedy and after construction completion to maintain the protectiveness of the remedy.

The model-projected outcomes for the lower 8.3 miles of the Lower Passaic River, described above, underestimate the effectiveness of the selected remedy, because they do not account for any reduction in incoming COCs over time as the Lower Passaic River above RM 8.3 and Newark Bay are remediated under the Superfund program and COCs from above Dundee Dam are addressed under Clean Water Act programs. Such actions, taken while the selected remedy is being designed and implemented, will reduce the incoming COCs and minimize the degree of recontamination, allowing the selected remedy to achieve protectiveness. This action for the sediments of the lower 8.3 miles of the Lower Passaic River will effectively eliminate the sediments of the lower 8.3 miles as an ongoing source of contamination to the other study areas. The upper nine miles of the Lower Passaic River and Newark Bay, which cover a greater surface area than the lower 8.3 miles of the Lower Passaic River, but account for less of the contaminant loading into the system, may see risk reduction from the implementation of the lower 8.3-mile remedy alone. At the same time, because the vast majority of the contaminated sediments are present in the lower 8.3 miles, and bank-to-bank remediation is necessary to address the unacceptable risk associated with these sediments, any remedy for the 17-mile Lower Passaic River that includes the lower 8.3 miles would necessarily have to address these contaminated sediments. For these reasons, EPA expects that the selected remedy for the sediments of the lower 8.3 miles will be consistent with any remedy selected for Lower Passaic River and Newark Bay.

Except for the two miles closest to Newark Bay, the federally authorized navigation channel in the lower 8.3 miles has not been regularly maintained in recent years. Based on EPA's analysis of USACE's 2010 Lower Passaic River Commercial Navigation Analysis report and comments submitted to EPA on the Proposed Plan, EPA does not anticipate that the channel above RM 1.7 is likely to be used for commercial navigation in the foreseeable future. The lowest 1.7 miles are currently used for commercial navigation, and USACE has indicated that maintaining the channel from RM 0 to RM 1.7 is consistent with its current and reasonably anticipated future use. USACE has advised that based on current information about reasonably anticipated future use of the channel, it will support recommendations for Congressional action to: 1) deauthorize the federal navigation channel from RM 1.7 to RM 8.3; and 2) modify the authorized depths of the federal navigation channel from RM 0.6 to RM 1.7 to the depths identified in the selected remedy. Thus, the final capping depths for the federally authorized navigation channel between RM 0 and RM 1.7 that are part of the selected remedy, including those between RM 0.6 and RM 1.7 that are less than the currently authorized channel depths, are consistent with reasonably anticipated future use including commercial navigational use.

Long-term monitoring of the remedy and maintenance of the engineered cap will be conducted to ensure the integrity of the engineered cap and the protectiveness of this remedy. Any identified deficiencies in the engineered cap will be addressed in an expeditious fashion in accordance with an O&M plan, to be developed during remedial design to ensure the continued protectiveness of the selected remedy.

13. STATUTORY DETERMINATIONS

CERCLA §121(b)(1) mandates that a remedial action must be protective of human health and the environment, cost-effective, and utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable. CERCLA §121(b)(1) also establishes a preference for remedial actions which employ treatment to permanently and significantly reduce the volume, toxicity or mobility of the hazardous substances, pollutants, or contaminants at a site. CERCLA §121(d) further specifies that a remedial action must attain a degree of cleanup that satisfies ARARs under federal and state laws, unless a waiver can be justified pursuant to CERCLA §121(d)(4).

13.1. Protection of Human Health and the Environment

The selected remedy's components will be protective of human health and the environment by removing or capping principal threat waste from the areas encompassed by this OU, removing and/or reducing the availability of the contaminated sediment throughout the lower 8.3 miles of the Lower Passaic River through surface dredging followed by capping, so that in time, surface sediment will approach remediation goals as closely as possible. Actions selected after the completion of the 17-mile RI/FS and Newark Bay RI/FS will reduce incoming COCs from the Lower Passaic River above RM 8.3 and Newark Bay, respectively, and Clean Water Act programs are expected to address COCs from above Dundee Dam. Such actions, taken while the selected remedy is being designed and implemented, will reduce the incoming COCs and minimize the degree of recontamination, allowing the selected remedy to achieve protectiveness by achieving the cancer risk range of 10^{-4} to 10^{-6}, noncancer HIs equal to or less than 1 and ecological HQs equal to or less than 1.

The selected remedy for the sediments of the lower 8.3 miles of the Lower Passaic River will be protective of human health and the environment. The selected remedy, Alternative 3, will prevent exposure and ingestion risks to humans and ecological receptors associated with contaminated sediments by containing this material under an engineered cap. Because the time frame required to achieve remedial action objectives is long, further risk reduction will be attained in the short-term through enhanced outreach to increase awareness of existing fish and crab consumption prohibitions and advisories, including complementary education efforts to reduce the consumption of self-caught fish and crab while contaminant concentrations remain above remediation goals in the fish and crab tissue.

The extensive dredging, sediment processing and off-site transportation of contaminated material associated with this remedy have the potential for significant impacts on the community and workers during its implementation. Measures to minimize and mitigate the impacts associated with these activities will be addressed in community and worker health and safety plans, by the use of best management practices and by following approved health and safety procedures.

13.2. Compliance with ARARs

CERCLA §121(d) and NCP §300.430(f)(1)(ii)(B) require that remedial actions at CERCLA sites at least attain legally applicable or relevant and appropriate Federal and State requirements, standards, criteria, and limitations which are collectively referred to as "ARARs," unless such ARARs are waived under CERCLA §121(d)(4). Applicable requirements are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under Federal environmental or State environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site. Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under Federal environmental or State environmental or facility siting laws that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well-suited to the particular site (or operable unit).

The selected remedy sequesters contaminated sediments under an engineered cap over the entire river bottom, throughout the lower 8.3 miles of the Lower Passaic River. EPA expects that during implementation, this remedy will be implemented consistent with identified action-specific and location-specific ARARs and performance standards, and once implemented, will comply with all ARARs. A complete list of the ARARs, and to-be-considered (TBCs) criteria associated with the selected remedy is presented in Table 29 in Appendix II.

Highlights of ARARs:

- Action Specific ARARs -
  - Clean Water Act, 33 U.S.C. §404(b)(1); 40 CFR Part 230
  - New Jersey Pollutant Discharge Elimination System rules, N.J.A.C. 7:14A-12
  - Resource Conservation and Recovery Act, 42 U.S.C. §6921; 40 CFR Parts 262, 264, 268
  - New Jersey Solid Waste Management Act, N.J.S.A. §13:1E-1, et seq., New Jersey Solid and Hazardous Waste Rules, N.J.A.C. 7:26 and 7:26G

- Chemical-Specific ARARs (none)

- Location-Specific ARARs
  - Section 10, Rivers and Harbors Act of 1899, 33 U.S.C. §403
  - Coastal Zone Management Act, 16 U.S.C.§1456; 15 CFR 930.30
  - New Jersey Tidelands Act, N.J.S.A. 12:3
  - New Jersey Waterfront Development Law, N.J.S.A 12:5-3
  - New Jersey Coastal Zone Management Rules N.J.A.C. 7:7
  - New Jersey Flood Hazard Control Act Rules, N.J.A.C. 7:13
  - New Jersey Freshwater Wetlands Protection Act Rules, N.J.A.C. 7:7A.

13.3. Cost Effectiveness

EPA has determined that the selected remedy is cost-effective and represents a reasonable value. In making this determination, the following definition was used: "A remedy shall be cost-effective if its costs are proportional to its overall effectiveness" (NCP §300.430(f)(1)(ii)(D)). EPA evaluated the "overall effectiveness" of those alternatives that satisfied the threshold criteria (*i.e.*, were protective of human health and the environment and ARAR-compliant). Overall effectiveness was evaluated by assessing three of the five balancing criteria in combination (long-term effectiveness and permanence; reduction in toxicity, mobility, or volume through treatment; and short–term effectiveness). Overall effectiveness was then compared to costs to determine cost-effectiveness. The relationship of the overall effectiveness of the selected remedy was determined to be proportional to costs and hence, the selected remedy represents reasonable value.

Please refer to Tables 34 and 35 in Appendix II for a summary of costs for the selected remedy.

13.4. Use of Permanent Solutions and Alternative Treatment Technologies

EPA has determined that the selected remedy represents the maximum extent to which permanent solutions and treatment technologies can be utilized in a practicable manner. Of those alternatives that are protective of human health and the environment and comply with ARARs to the extent practicable, EPA has determined that the selected remedy provides the best balance of trade-offs in terms of the five balancing criteria, while also considering the statutory preference for treatment as a principal element and State and community acceptance.

The selected remedy will provide adequate long-term control of risks to human health and the environment through eliminating and/or preventing exposure to the contaminated sediment and preventing movement of contaminated sediment. The selected remedy is protective with respect to short-term risks.

13.5. Preference for Treatment as a Principal Element

Although CERCLA §121(b) also expresses a preference for selection of remedial actions that use permanent solutions and treatment technologies to the maximum extent practicable, there are situations that may limit the use of treatment, including when treatment technologies are not technically feasible or when the extraordinary size or complexity of a site makes implementation of treatment technologies impracticable. The selected remedy would generate approximately 3.5 million cy of contaminated sediments, which is clearly an extraordinary volume of materials; and the sediment treatment technologies investigated under DMM Scenario C have not been constructed or operated in the United States on a scale approaching the capacity needed for this project, so their technical ability to handle such an extraordinary volume of highly contaminated sediments is uncertain. The selected remedy is estimated to provide treatment of approximately 130,000 cy of contaminated sediment through incineration (the only technology available at this time) off site to comply with applicable RCRA standards. If, during remedial design, EPA identifies an enhanced capping technology that includes additives to create a reactive cap for use in some areas of the lower 8.3 miles, the selected remedy may provide some *in situ* treatment.

13.6. Five-Year Review Requirements

Because the selected remedy will result in hazardous substances, pollutants, or contaminants remaining in sediments above levels that allow for unlimited use and unrestricted exposure, reviews will be conducted every five years after initiation of the remedial action to ensure that the remedy is, or will be, protective of human health and the environment.

14. DOCUMENTATION OF SIGNIFICANT CHANGES

In response to comments received on the Proposed Plan, EPA has altered some aspects of the preferred alternative (Alternative 3 with DMM Scenario B) in the Proposed Plan in formulating the selected remedy. This section briefly describes the changes, which are discussed in more detail in the Responsiveness Summary in Appendix V.

<u>Selected Remediation Goals</u>. EPA received comments that the human health risk assessment supporting the Proposed Plan should have been updated to reflect the 2014 Updated Default Exposure Assumptions (released after the RI/FFS was completed). In response to these comments, EPA used the updated assumptions to calculate risk and hazard estimates used to support remedy selection as set forth in this ROD:

- The updated assumptions changed the adult exposure duration from 24 years to 20 years and the total exposure duration from 30 years to 26 years. As shown in the Responsiveness Summary in Appendix V, incorporating the updated assumptions does not significantly affect the calculated cancer risks and does not alter noncancer values.
- The updated assumptions changed the adult body weight from 70 kg (154 pounds) to 80 kg (176 pounds). As shown in the Responsiveness Summary, incorporating this updated assumption does not significantly affect the calculated risks and health hazards.
- In addition to recalculating the risk and hazard estimates, EPA also used the updated assumptions to recalculate the human health PRGs, which resulted in the dioxin and PCB remediation goals, both based on human health PRGs, changing by 14 percent (from 7.1 ppt to 8.3 ppt) and 17 percent (from 44 ppb to 50 ppb), respectively.

Navigation Channel. EPA received comments on the depths and extent of dredging in the federally authorized navigation channel included in Alternative 3. In response to those comments, EPA, in consultation with USACE and NJDEP, reexamined available information pertaining to current and future land use and commercial uses of the Lower Passaic River navigation channel submitted and obtained during the public comment period:

- In 1930, Congress authorized the navigation channel depth for the portion of the Passaic River from RM 0 to RM 2.6 to be 30 feet, and has not modified this authorized navigation channel depth since that time.
- Section 10 of the Rivers and Harbors Act of 1899 (33 U.S.C. § 403) is a location-specific ARAR with which the remedy for the lower 8.3 miles will comply. In addition, it is EPA policy to consider reasonably anticipated future land and waterway uses during the remedy selection process in general, and in the development of remedial alternatives in particular.
- In developing a preferred alternative that included capping that would not permanently obstruct the navigable capacity of the Lower Passaic River in contravention of the Congressionally authorized navigational depth and Section 10 of the Rivers and Harbors Act and that would accommodate reasonably anticipated future commercial navigational use, EPA evaluated USACE's 2010 Lower Passaic River Commercial Navigation Analysis report, which assessed the current and potential future status of commercial navigation on the Lower Passaic River.
- During the comment period, commenters stated that the analysis in the 2010 USACE report should be updated to include the latest data on navigation (waterborne commerce statistics) in the Lower Passaic River. By letter dated February 6, 2014, USACE confirmed that 2011 Waterborne Commerce Data (the last year analyzed as of the writing of the letter) indicated a significant volume of waterborne commerce was transported that year within the Lower Passaic River, consistent with its prior analysis of 1997-2006 data. The letter also stated that "The current and projected future level of commercial traffic is sufficient to justify maintenance dredging of the channel should it be required, subject to budget limitations."

- Based on EPA's reexamination of information pertaining to commercial navigation in recent years, EPA adjusted the depths of the navigation channel included in the selected remedy to better reflect current commercial use, as follows: 30 feet from RM 0 to RM 0.6 and 20 feet from RM 0.6 to RM 1.7. The selected remedy does not include any dredging above RM 1.7 except as needed to accommodate the engineered cap and to smooth some areas prior to cap placement to achieve a minimum final water depth of approximately 10 feet for reasonably anticipated future recreational uses.
- Since the selected remedy anticipates that from RM 0.6 to RM 8.3, the Lower Passaic River will be permanently capped at depths shallower than the federally authorized navigation channel depths, it will be necessary to obtain Congressional authorization to: 1) modify the authorized depth from RM 0.6 to RM 1.7; and 2) deauthorize the federal navigation channel from RM 1.7 to RM 8.3. USACE has advised that it will support those modification and deauthorization recommendations to Congress.
- The adjustment to the depths of the navigation channel, as well as a few other minor volume adjustments made in response to other comments, resulted in a change to the estimated dredging volume for the selected remedy of less than 20 percent, from 4.3 million cubic yards to 3.5 million cubic yards. Changes in construction time and cost are discussed below.

Opening and Closing of Bridges. EPA received comments expressing concern that implementation of the preferred alternative would require the bridges over the Passaic River to be opened and closed many times a day, disrupting road, rail and pedestrian traffic, adversely impacting businesses, interfering with emergency response and stressing aging infrastructure to the point of breakage. In response to these comments, EPA re-evaluated the bridges in the lower 8.3 miles:

- EPA concluded that out of 13 bridges, low profile barges exist that can pass beneath all but two of the bridges without opening them.
- The two bridges that present the greatest challenges to navigation as a result of vertical clearance handle vehicular traffic. They are located in the upper portion of the lower 8.3 miles, at RM 5.7 and RM 6.1. Accordingly, the amount of dredged material that will be moved past these bridges will be far less than the total of 3.5 million cubic yards addressed by the selected remedy. EPA concluded that there are a number of engineering options available to transport materials under these two bridges without opening them, and evaluated bypass pumping between RM 5.7 and RM 6.1 in detail in the Responsiveness Summary for inclusion in the cost estimate that supports the ROD. The final decision on the approach to be taken will be addressed during the remedial design phase.
- Although any of the bridges may still need to be opened to allow construction equipment through, such openings are expected to be infrequent events that can be timed to minimize transportation disruptions. This issue is not expected to pose an undue hardship to bridge operators or users. Necessary coordination, which may include assisting bridge authorities with engineering evaluations and maintenance of the bridges, will occur during the remedial design phase of the project.

Construction Time and Cost. EPA received comments stating that the construction time for the preferred alternative was underestimated. In response to these comments, EPA re-evaluated the following factors affecting dredging productivity raised by commenters:

- EPA added time to the schedule to more fully account for fish windows, allow for an additional three weeks of downtime for extreme weather events and equipment breakdown; and EPA revised construction sequencing to account for the engineering solutions discussed above that significantly reduced the need for bridge openings. EPA also made revisions to account for the adjustments in the depths of the navigation channel included in the selected remedy, as discussed above.
- These revisions did not substantially increase the total construction time for the active remedies. Changes were from 11 to 14 years for Alternative 2, from 5 to 6 years for Alternative 3 (the selected remedy) and from 2 to 2.5 years for Alternative 4. These increases did not change the relative durations among alternatives, and so did not change EPA's comparative analysis results from the Proposed Plan.
- These revisions also resulted in changes to the costs of the active remedies that did not change the relative costs among alternatives, and so did not change EPA's comparative analysis results from the Proposed Plan. Updated costs are presented in Section 9.2. For the selected remedy, present value costs changed approximately 20 percent, from $1.73 billion to $1.38 billion.

All of these estimates are based on limited data and will be refined during remedial design. All changes are within the expected accuracy of feasibility study cost estimates of +50 percent to -30 percent. They are within the range of adjustments that would normally be made during remedial design, and do not significantly change the selected remedy.