APPENDIX B

RECORD OF DECISION
FOR AN INTERIM REMEDY IN THE
UPPER 9 MILES OF THE
LOWER PASSAIC RIVER STUDY AREA
OU4 OF THE DIAMOND ALKALI SUPERFUND SITE
ESSEX, BERGEN AND PASSAIC COUNTIES, NEW JERSEY

U.S. Environmental Protection Agency

Region 2

September 2021

630399

DECLARATION FOR THE RECORD OF DECISION

FACILITY NAME AND LOCATION

Diamond Alkali Superfund Site
Operable Unit 4 – Lower Passaic River Study Area
Upper 9 Miles
Essex, Bergen and Passaic Counties, New Jersey

EPA Superfund Site Identification Number ~~NJD980529879~~ NJD980528996

STATEMENT OF BASIS AND PURPOSE

This Record of Decision (ROD) documents the U.S. Environmental Protection Agency's (EPA's) selection of an interim remedy (IR) for source control to address contamination in the Lower Passaic River Study Area (LPRSA), which is Operable Unit 4 (OU4) of the Diamond Alkali Superfund Site (the Site). The IR was chosen in accordance with the requirements of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, as amended, 42 U.S.C. §§ 9601-9675, and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), 40 C.F.R. Part 300. This decision document explains the factual and legal basis for selecting the IR. The Administrative Record Index (Appendix 3) identifies the items that comprise the Administrative Record upon which the selected IR is based.

The State of New Jersey was consulted on the IR in accordance with CERCLA Section 121(f), 42 U.S.C. § 9621(f). The State of New Jersey concurs with EPA's selection of the IR alternative documented in this ROD (Appendix 4).

ASSESSMENT OF THE SITE

The response action selected in this ROD is necessary to protect the public health or welfare or the environment from actual or threatened releases of hazardous substances into the environment.

DESCRIPTION OF THE SELECTED REMEDY

The IR selected in this ROD is a source control IR in the upper 9 miles of the LPRSA. The objective of the IR for the upper 9 miles of the LPRSA is to remediate sediment source areas, focusing on 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (2,3,7,8-TCDD) and total polychlorinated biphenyls (PCBs) as contaminants of concern (COCs). The IR will also address collocated contaminants in the areas of remediation. EPA determined that, for this IR, surface weighted average concentration (SWAC)-based goals will be used to determine if the sediment source areas have been remediated.

The major components of the selected IR include the following:

- A comprehensive pre-design investigation (PDI) will be implemented to assess baseline conditions, inform the IR design, and facilitate post-IR confirmatory sampling and response and recovery assessment.
- Areas where surface sediments (0 to 0.5 ft) have elevated concentrations of 2,3,7,8-TCDD and/or total PCBs between river mile (RM) 8.3 and RM 15 will be targeted through dredging and capping, achieving a post-IR 2,3,7,8-TCDD SWAC of 75 parts per trillion (ppt) and implementing a total PCB surface remedial action level (RAL) of 1 part per million (ppm).
- Areas between RM 8.3 and RM 15 that are vulnerable to erosion and have elevated subsurface concentrations of 2,3,7,8-TCDD and/or total PCBs will be dredged and capped.
- Dredging will be performed to the depth(s) necessary to construct a sediment cap that is designed to isolate underlying contamination, prevent contaminant migration, resist erosion, and will not diminish water depth or exacerbate flooding.
- Dredged material will be processed, stabilized, and then disposed of off-site.
- The specific composition and thickness of the cap will be determined in the IR design, and dredge depth and cap composition/thickness may vary in portions of the remediation footprint.
- Some areas may be dredged to native (uncontaminated) sediments based on a cost-effectiveness review. In these areas, there would be no need for an engineered cap and associated operation and maintenance (O&M). Dredging without capping in these areas could enhance the overall long-term effectiveness and permanence of the IR.
- The area above RM 15 will be assessed carefully during the IR design based on the PDI data to identify potential source areas.
- Appropriate and necessary institutional controls (ICs) will be implemented in conjunction with the IR.
- Monitoring and sampling will be performed to evaluate the IR during construction and to assess post-IR conditions.
- Adaptive management will be applied to evaluate IR performance, assess the response of the system to the IR and the long-term recovery of the system, and to inform selection of a final risk-based remedy in a final ROD.

The cost of the IR is $441 million.

DECLARATION OF STATUTORY DETERMINATIONS

This response action (1) is protective of human health and the environment in the short term and is intended to provide adequate protection until a final ROD for the LPRSA is signed and the final remedy implemented, (2) complies with those federal and state requirements that are applicable or relevant and appropriate for this limited-scope action, and (3) is cost-effective. Although the IR is not intended to address fully the statutory mandate for permanence it will provide remedy elements (e.g., the engineered cap) that are permanent and will not be incompatible with nor preclude a final remedy.

Through the IR, the mobility of the COCs removed from the upper 9 miles of the LPR will be effectively eliminated not through treatment, but by shipping the dredged sediments to disposal facilities. There would be no reduction in toxicity, mobility or volume of the COCs specifically through treatment. However, an amendment (e.g., Portland cement) will be added (as needed) to stabilize the removed material and meet transportation and disposal requirements. The addition of an amendment will reduce the mobility of contaminants contained within the sediments compared to unamended sediments. In addition, the engineered cap will effectively isolate the remaining sediments that are not removed, and a carbon amendment will be incorporated into the cap to prevent the migration of contamination through the cap. While the IR will not meet the statutory preference for utilizing treatment to the maximum extent practicable, a degree of treatment is a secondary benefit of ex situ amendment addition during sediment processing (for transportation and disposal requirements) and for the activated carbon component of the isolation cap.

Because the IR will result in hazardous substances, pollutants, or contaminants remaining on-site above levels that allow for unlimited use and unrestricted exposure, five-year reviews will be required to ensure that the remedy is, or will be, protective of human health and the environment. The schedule for the five-year reviews for the Diamond Alkali Superfund Site was initially set by the on-site mobilization of contractors in 2000 to initiate the remedial action at OU1 of the Site (i.e., the 80-120 Lister Avenue facility); the submittal of each successive five-year review is triggered by signature of the prior five-year review. In addition, because the selected remedy is an IR, review of this remedy will be ongoing as EPA continues to develop final remedial alternatives for the LPRSA.

ROD DATA CERTIFICATION CHECKLIST

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 the LPRSA.

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

• 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."

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

• Remedial Action Objectives, which provide a basis for determining if the IR has been conducted as described by this ROD, are in Section 8, "Remedial Action Objectives."

• Estimated capital, O&M, and total present value costs (the applied discount rate and the number of years over which the IR cost estimates are projected) are in Section 10, "Comparative Analysis of Remedial Alternatives."

• Key factors that led to selecting the IR (i.e., how the selected IR provides the best balance of tradeoffs with respect to the balancing and modifying criteria and highlighting factors key to the selection) are also in Section 10, "Comparative Analysis of Remedial Alternatives."

AUTHORIZING SIGNATURE

Michael S. Regan, Administrator

SEP 2 8 2021

Date

DECISION SUMMARY
Upper 9 Miles of the
Lower Passaic River Study Area
Diamond Alkali Superfund Site – Operable Unit 4

Essex, Bergen, and Passaic Counties, New Jersey

U.S. Environmental Protection Agency
Region 2
September 2021

TABLE OF CONTENTS

SECTION **PAGE**

APPENDICES

APPENDIX 1: FIGURES

APPENDIX 2: TABLES

1. SITE NAME, LOCATION AND DESCRIPTION

The Lower Passaic River Study Area (LPRSA) is Operable Unit (OU) 4 of the Diamond Alkali Superfund Site (the Site) and encompasses the entire Lower Passaic River (LPR) from Newark Bay at River Mile (RM) 0 to the Dundee Dam at approximately RM 17.7. The LPR and Newark Bay are part of the New York/New Jersey Harbor Estuary. The LPR specifically refers to the approximate 17-mile tidal portion of the river and its watershed, which includes the major tributaries of Saddle River, Third River, and Second River (Figure 1-1 in Appendix 1). Dundee Dam isolates the Upper Passaic River (UPR) from the tidal mixing that influences the LPR.

Notably, two RM systems have been developed for the LPRSA (Figure 1-2 in Appendix 1). A RM system was developed by the U.S. Army Corps of Engineers (USACE) that follows the navigation channel of the LPR. RM 0 in the USACE system is just offshore of Newark, New Jersey at Delancey Street, and RMs continue upriver to the Dundee Dam, which is located at RM 17.7 in this system. RM 8.3, which designates the upriver extent of OU2 and the downriver extent of the upper 9-mile reach of the LPRSA covered by this Record of Decision (ROD), is named in the USACE RM system. The second system, the Remedial Investigation (RI) RM system (which was developed by the U.S. Environmental Protection Agency [EPA] and used for the RI evaluations), follows the geographic centerline of the river. In the RI RM system, RM 0 is defined by an imaginary line between two marker lighthouses at the confluence of the LPR and Newark Bay: one in Essex County just offshore of Newark, and one in Hudson County just offshore of Kearny Point. RMs in the RI RM system then continue upriver to Dundee Dam (at RM 17.4 in the RI RM system). The two RM systems are about 0.2 to 0.3 mile apart. RM designations in this ROD are in the USACE system unless otherwise specified.

The LPR is in a highly developed urban area. The predominant adjacent land uses from the mouth of the LPR (RM 0) to RM 4 are industrial and commercial. Adjacent land use above RM 4 begins to also include residential and recreational uses. Hard shorelines, such as bulkheads and riprap, make up approximately 95 percent of the banks of the lower 8.3 miles of the LPR, with vegetation comprising the remainder of the banks. Moving upriver from RM 8.3, land use increasingly transitions to commercial and recreational, with pockets of residential use. The upper portions of the LPR generally feature steeper and hardened shorelines on the west bank with limited areas of riparian vegetation. A four-lane highway (Highway 21) runs parallel to the river along the western bank between RM 7 and RM 14. A strip of parkland runs along much of the eastern shoreline between RM 7 and RM 14, with six parks and recreation areas of note and four boathouses/crew facilities. The east bank tends to be less modified, consisting of more natural shoreline, residential areas, and parks. In the parks on the eastern shore, access to the riverbank is possible in some clearings and areas where vegetation growth is limited, and the riverbank is not too steep. Above RM 14, the river becomes narrower and shallower, and the adjacent uses become more residential. Pulaski Park is located on the western bank between RM 15.5 and 16. Much of the shoreline between RM 16 and Dundee Dam is vegetated with several points of public access to the water.

The lower 8.3 miles of the LPR comprises approximately 716 acres, while the upper 9 miles comprises approximately 344 acres. Mudflats (areas of fine-grained sediments exposed at lower tides) are present throughout the entire LPR and are typically composed of fine-grained sediments, and these fine-grained sediments generally have higher contaminant concentrations than coarser materials found elsewhere in the river. Fine-grained sediments also comprise the majority of the LPR surface sediments below RM 8.3.

The LPR's cross-sectional area declines steadily moving upstream from RM 0 to Dundee Dam, with a pronounced constriction at RM 8.3. At RM 8.3, there is a pronounced change in sediment texture within the riverbed. As stated above, the riverbed from RM 0 to RM 8.3 is dominated by fine-grained sediments, while coarser sediments (sand and gravel) with smaller areas or pockets of fine-grained sediments generally comprise the riverbed above RM 8.3. About 85 percent of the fine-grained sediment surface area (90 percent by volume) of the LPR is located below RM 8.3. As discussed in the March 3, 2016 ROD for the lower 8.3 miles of the LPRSA, which is OU2 of the Diamond Alkali Superfund Site, wider and thicker beds of contaminated sediments accumulated below RM 8.3 due to a combination of a wider cross section and a deeper historical navigation channel.

The primary continuing contaminant sources to the LPR are the internal sediment inventory (e.g., resuspended contaminated sediments within the LPR), tidal exchange with Newark Bay, and flows from above Dundee Dam. Combined Sewer Overflows (CSOs), overland flow, groundwater, and various other point and non-point sources also contribute contaminants to the LPR, but not at the same magnitude as the primary sources.

The inside bends of the LPR generally accumulate finer sediments, while the outside bends generally experience little or no sediment accumulation and (in some cases) experience erosion due to higher shear stresses. In the vicinity of structures such as bridge abutments and at tributary confluences, sediments tend to be coarse or absent owing to associated turbulence that prevents long-term accumulation of fine sediments (or any sediments). The contaminated fine-grained sediments already within the LPR are the most significant continuing contaminant source and will be addressed to a large degree by the planned bank-to-bank dredging and subsequent capping of RM 0 to RM 8.3, in accordance with the OU2 ROD. This dredging and capping of the lower 8.3 miles will substantially reduce the potential for recontamination of the rest of the LPR and is currently being designed by Occidental Chemical Corporation (OCC), working with its affiliated entity Glenn Springs Holdings (GSH), under EPA oversight. The interim remedy (IR) described in this ROD, which focuses on source control and targets removal of sediments with higher contaminant concentrations in the upper 9 miles of the LPR, is based on the RI/Feasibility Study (FS) prepared by a group of companies that owned or operated facilities from which hazardous substances were potentially discharged to the LPR, called the Cooperating Parties Group (CPG), under EPA oversight. Newark Bay is being addressed as OU3 of the Diamond Alkali Superfund Site and is currently in the RI/FS stage. The Newark Bay RI/FS is being conducted by OCC-GSH, also under EPA oversight.

Sediments in Dundee Lake and other UPR sediments are isolated from hydrodynamic impacts and sediment transport from the LPR by Dundee Dam. Sediments from above Dundee Dam are transported downriver into the LPR. The concentrations of the contaminants of concern (COCs) detected in recently deposited sediments collected from the UPR immediately above Dundee Dam and transported downriver into the LPR, are representative of current background conditions for the LPR.

2. SITE HISTORY AND ENFORCEMENT ACTIVITIES

The Passaic River was one of the major centers of the American industrial revolution that started two centuries ago. Early manufacturing, particularly textile mills, developed in the area around Great Falls in the City of Paterson, which is 8 miles upriver of Dundee Dam. 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 waterpower 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 facilities, 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, more than 100 industrial facilities have been identified as potentially responsible for discharging contaminants into the river, including (but not limited to) dioxins and furans, polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), dichlorodiphenyltrichloroethane (DDT) and other pesticides, mercury, lead, and other metals.

Along with Dundee Dam, which physically isolates Dundee Lake and the UPR from LPR influences, another defining component of the development and urbanization of the LPR 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.[1] 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. The federal navigation channel above RM 1.7 was deauthorized by Congress in 2018, and the depth from RM 0.6 to RM 1.7 was reauthorized from 30 feet to 20 feet.[2]

[1] Rivers and Harbors Act of 1930.
[2] America's Water Infrastructure Act of 2018.

2.1 Site History

The LPRSA 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, now known as OU1. Manufacturing of DDT and other products, including phenoxy herbicides, 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 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), which are ingredients in the defoliant "Agent Orange." A byproduct 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 LPR sediments and in fish/crab tissue.

2.1.1 Preliminary Actions

Based on investigations by the New Jersey Department of Environmental Protection (NJDEP) and EPA, the Diamond Alkali Superfund Site was placed on the National Priorities List in 1984. After further investigations and several emergency response actions that addressed dioxin contamination 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 demolishing a warehouse and other on-site structures, capping contaminated soils (including soils brought back to the facility from nearby properties), installing subsurface slurry walls on three sides and a sheet-pile flood wall along the river, and constructing 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 performed by OCC and the owner of the facility, Chemical Land Holdings, Inc., later known as Tierra Solutions, Inc. (Tierra), under EPA oversight. Construction was completed in 2001. Operation and maintenance (O&M) of the OU1 remedy continues to be performed by OCC under EPA oversight, and EPA performs periodic reviews of the remedy. The facility property is now owned by Mariana Properties, Inc., an affiliate of OCC.

2.1.2 Six-Mile Study

In 1994, OCC agreed to an administrative order on consent (AOC) with EPA to investigate a 6-mile stretch of the LPR (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 6 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 6-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 LPR.

2.1.3 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), under EPA oversight, to investigate the extent of dioxin contamination and collocated contaminants. This study of the Newark Bay Study Area, now known as OU3, is ongoing.

2.1.4 Tierra Removal

In June 2008, EPA, OCC, and Tierra signed an AOC for a non-time-critical removal action to remove 200,000 cubic yards (cy) of contaminated sediments from the river (from RM 3.0 to RM 3.8) adjacent to the 80-120 Lister Avenue facility. This source removal action is referred to as the “Tierra Removal.” Sediments at depth adjacent to the facility were 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 sediments (known as Phase 1 of the Tierra Removal) was completed in 2012. The AOC contemplated that Phase 2 (160,000 cy) would undergo a separate engineering study and proposal that would be submitted to the public for review and comment. In 2015, Tierra, on behalf of OCC, collected additional samples in the Phase 2 area. The Phase 2 area is being incorporated into the final remedial action for the sediments of the lower 8.3 miles of the LPRSA, which is currently under design.

2.1.5 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/furans, PCBs, and other contaminants found at the surface of a mudflat on the east bank of the river at RM 10.9 next to a recreational park 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. 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. Approximately 16,000 cy of sediments were removed during the RM 10.9 Removal. The RM 10.9 Removal area is subject to a monitoring program under which the long-term performance of the engineered cap is evaluated. This area will be incorporated into the IR described in this ROD (as needed) to attain the objectives of the source removal action in the upper 9 miles of the LPRSA.

2.1.6 Lower 8.3 Miles of the LPRSA

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 sediments, which in turn is the source of most of the risk associated with the LPR, 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 LPR. Because about 90 percent (by volume) of the fine-grained (and, therefore, more heavily contaminated) sediments are below RM 8.3, EPA undertook a targeted RI and Focused Feasibility Study (FFS) of the lower 8.3 miles. In March 2016, EPA selected a remedy for the sediments of the lower 8.3 miles, which includes the construction of an engineered cap bank-to-bank over the river bottom of the lower 8.3 miles of the LPRSA, dredging of the river bottom prior to placement of the cap so that the cap does not increase the potential for flooding and to allow for the continued commercial use of the federally authorized navigation channel, and implementation of institutional controls (ICs) designed to protect the engineered cap. In September 2016, EPA entered into an administrative settlement and order on consent with OCC to perform the remedial design for the lower 8.3; that work is ongoing.

2.1.7 17-Mile LPRSA

While working with OCC on the Lister Avenue facility and the first studies of the river, EPA also identified other potentially responsible parties (PRPs) for the LPRSA. A number of companies that owned or operated facilities from which hazardous substances were potentially discharged to the river formed the 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 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 LPR, and investigated the major tributaries, 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.

The CPG performed sampling for the LPRSA RI between 2008 and 2013. EPA approved the Baseline Human Health Risk Assessment (BHHRA) for the LPRSA in July 2017 and the Baseline Ecological Risk Assessment (BERA) in June 2019. The final RI Report was submitted by the CPG in July 2019 and has been conditionally approved by EPA pending approval of the bioaccumulation model. The bioaccumulation model is an appendix to the RI that is still under development; the appendix, containing a summary of the calibrated model, is expected to be completed in 2021, and the calibrated model will subsequently be carried through the peer review process. The remaining components of the LPRSA model suite (hydrodynamic model, sediment transport model, organic carbon model, and contaminant fate and transport model) were approved in June 2019.

In July 2017, the CPG proposed an adaptive management approach for evaluating an IR for the sediments of the upper 9 miles of the LPRSA. EPA Region 2, NJDEP and the CPG held a series of meetings, from July 2017 until October 2018, to discuss the proposal to evaluate an IR for source control in the upper 9-mile reach. In October 2018, EPA Region 2 directed the CPG to evaluate an IR approach for source control in the upper 9 miles of the LPRSA through an FS. The CPG submitted a draft final IR FS Report in December 2020, which was conditionally approved by EPA, pending any necessary revisions related to comments from the public after the public comment period on the IR Proposed Plan. The IR for the upper 9 miles targets sediment source areas of high 2,3,7,8-TCDD and/or total PCB concentrations, as well as any other contaminants collocated with high concentrations of 2,3,7,8-TCDD and/or total PCBs. The source areas tend to be composed of fine-grained sediments and are responsible for relatively higher degrees of exposure, the redistribution of contamination through erosion and redeposition, and an overall inhibition of system recovery.

Based on the IR FS, EPA prepared a Proposed Plan for the IR, which was released on April 14, 2021 for public comment. NJDEP concurred on the preferred alternative in the Proposed Plan. The IR will significantly lower contaminant concentrations in the upper 9 miles of the LPRSA. In turn, EPA expects the IR to reduce exposures and accelerate system recovery. Once the source sediments have been addressed through the IR, the river system will be monitored to assess response to the source removal action and recovery toward risk-based cleanup goals. When sufficient data have been collected to characterize the nature and extent of contamination and when further evaluations regarding the recovery of the river and risks to human health and the environment have been completed, EPA expects to issue a final ROD selecting a final remedy addressing any remaining risks in sediments within the upper 9 miles and in surface water throughout the LPRSA.

3. HIGHLIGHTS OF COMMUNITY PARTICIPATION

The Diamond Alkali Superfund 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. With the expansion of the scope of the project to encompass the entire 17-mile tidal portion of the LPR 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. To foster community involvement at the Site, beginning in 2004, EPA convened quarterly Project Delivery Team (PDT) meetings with stakeholders, including the Partner Agencies (NJDEP, the National Oceanic and Atmospheric Administration [NOAA], the U.S. Fish and Wildlife Service [FWS] and USACE), municipalities, PRPs, and other interested parties and members of the public. At the PDT meetings, EPA reported progress on various aspects of the LPRSA investigation and cleanup work that was underway, including the focused study of the lower 8.3 miles of the river.

In 2009, EPA facilitated the formation of a Community Advisory Group (CAG), composed of stakeholders with a broad range of interests. Between 2009 and 2011, both PDT and CAG meetings occurred. In 2011, PDT meetings were phased out, replaced by CAG meetings. Representatives of EPA, NJDEP, and the other partner agencies routinely attend CAG meetings, which are open to the public and generally held every other month. Any stakeholder may be invited by the CAG to share Diamond Alkali Superfund Site/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 LPRSA. 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.

The LPR runs through several cities and towns—Passaic, Belleville, North Arlington, Lyndhurst, Rutherford, Clifton, Garfield, Nutley, Wallington, East Rutherford, Kearny, Harrison, East Newark, and Newark—all with different demographics and income levels represented. Among these are portions of Newark, including the "Ironbound" community, which is generally considered to be a community with environmental justice (EJ) concerns and is located near the site of the former Diamond Alkali facility. Overall, this community has experienced various negative environmental consequences from multiple industrial and commercial operations, giving rise to EJ concerns. According to an EJ Screen analysis of the local communities along the upper 9 miles of the Lower Passaic River, 35 percent of the population is considered low income as compared to 24 percent of the population in the State of New Jersey.

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 levels of mercury, PCBs, and dioxins/furans 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' websites) to guide anglers and other members of the public if fish and crab are harvested from within New Jersey State waters.

In early 2018, EPA approached the CAG about the concept of an IR in the upper 9 miles of the LPRSA. At the February 8, 2018 CAG meeting, EPA presented the results of the LPRSA RI, the conceptual site model (CSM), and the general idea of an IR. At that time, the CAG was invited to submit comments and/or present at a meeting with EPA's Contaminated Sediments Technical Advisory Group (CSTAG) where EPA was presenting the IR concept to CSTAG. CSTAG is 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. In a February 21, 2018 letter to CSTAG, the CAG expressed support for an IR as long as it would not "undermine the long-term achievement of cleanup levels that are necessary to protect human health and the environment". In subsequent CAG meetings, EPA presented several topics related to the IR, including the concept of surface weighted average concentration (SWAC), which is a weighted average of sample data intended to estimate a mean contaminant concentration over a specified spatial area, as well as the anticipated range of remedial alternatives and remedial action objectives (RAOs).

In its early years, the CAG's primary focus was on the lower 8.3 miles of the LPRSA, and the members were primarily from the Newark area. In 2019, EPA reached out to communities along the upper 9 miles, which include Clifton, Garfield, Passaic, Wallington, Rutherford, East Rutherford, Nutley, Lyndhurst, North Arlington, and Belleville. On April 23, 2019, EPA held a meeting with public officials from these municipalities, as well as state and county officials, to discuss the IR approach. EPA also held public availability sessions in Clifton on July 25, 2019 and in East Rutherford on October 21, 2019. Following these meetings and information sessions, EPA received letters of support for the concept of an IR from Belleville, Clifton, Garfield, Lyndhurst, Nutley, and Rutherford.

The work at the Diamond Alkali Superfund Site has been extensively reviewed by EPA's CSTAG. While developing the IR for the upper 9 miles, EPA Region 2 consulted with the CSTAG, which also provided an opportunity for community participation. For the February 2018 CSTAG meeting where Region 2 presented the concept of an IR, stakeholder groups associated with the Site were invited to present (to the CSTAG) their views of how the Region had applied EPA's sediment management principles (Office of Solid Waste and Emergency Response [OSWER] Directive 9285.6-08) to this project. Presentations were made to the CSTAG by the CAG and CPG only. However, written comments were submitted by the CPG, NJDEP, and the CAG, as well as a joint comment from NOAA and FWS.

A second CSTAG meeting was held in November 2019, which included members of the EPA's National Remedy Review Board (NRRB) where once again an opportunity for community participation was provided. The November 2019 CSTAG/NRRB meeting was held to discuss the development of the IR FS. At this meeting, written submittals and presentations were made by CPG, NJDEP, and the CAG. At the conclusion of each meeting, the CSTAG submitted a letter of recommendations and the Region responded to each letter. The CSTAG recommendations and the Region's responses to the recommendations can be found in the Administrative Record (Administrative Record Index in Appendix 3).

The RI for the 17-mile LPRSA and the IR FS Report for the upper 9 miles of the LPRSA, and EPA's IR Proposed Plan for the upper 9-mile portion of the Site were released to the public for comment on April 14, 2021 via the website www.ourPassaic.org. A virtual public meeting to present the findings of the investigations of the upper 9 miles of the LPRSA, the IR alternatives considered, and the preferred alternative, and to receive public comments, was held on April 27, 2021. Closed captioning and a Spanish-speaking translator were made available for this virtual meeting. A transcript of the meeting is included as Attachment C of Appendix 5, the Responsiveness Summary. 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 EPA Region 2 Records Center at 290 Broadway, New York City. A notice of availability of the Administrative Record was published in the Bergen Record and El Diario on April 14, 2021. EPA also developed fact sheets summarizing the IR Proposed Plan (translated into Spanish) to support its outreach to those communities. In addition, select documents from the Administrative Record were made accessible online at http://www.ourPassaic.org and http://www.epa.gov/superfund/diamond-alkali.

A public comment period for the IR Proposed Plan and supporting documents was originally scheduled from April 15, 2021 through May 14, 2021. EPA received a request to extend the public comment period to allow additional time for consideration of and comment on the Proposed Plan. In response to this request, EPA extended the public comment period to June 14, 2021, at which time the comment period closed. EPA accepted comments via mail and email, in addition to verbally at the April 27, 2021 public meeting. Responses to comments received by EPA at the public meeting and in writing during the public comment period are included in the Responsiveness Summary (Appendix 5).

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 (1) phased approach, (2) early actions, and (3) adaptive management.

4.1 Phased Approach and Early Actions

At complex sites, EPA often divides cleanup activities into different areas or 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 implementing removal actions to address imminent threats to human health while also pursuing a long-term cleanup strategy.

The Diamond Alkali Superfund Site, which includes the LPR, has been divided by EPA into four OUs (Figure 4-1 in Attachment 1):

> **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, a

subsurface slurry wall and flood wall, and a groundwater collection and treatment system, completed in 2001. The interim containment 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. OCC performs O&M of the OU1 remedy and continues to monitor the performance of the remedy to ensure 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 containment remedy at least every five years since it was complete. Beginning in 2015, EPA evaluated the performance of the interim containment remedy and the 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. A five-year review was completed in December 2020, which determined that the interim containment remedy is functioning as designed and remains protective of public health and the environment.

Operable Unit 2 (OU2) includes the lower 8.3 miles of the LPRSA. In March 2016, EPA issued a ROD for an estimated $1.38-billion cleanup plan to address the lower 8.3 miles. The plan includes installing an engineered cap bank-to-bank to isolate the contaminated sediments. Before installing the cap, sediments will be dredged so that the cap does not increase the potential for flooding and to allow for the continued commercial use of the federally authorized navigation channel. The contaminated sediments will be transported off-site to permitted disposal facilities. OU2 is currently in the remedial design phase of the project, which includes assessing specifically how the ROD will be implemented.

Operable Unit 3 (OU3) includes the Newark Bay Study Area, which is currently in the RI/FS phase. The risk assessments and data collection portion of the RI are complete.

Operable Unit 4 (OU4) includes the 17-mile LPRSA. The RI sampling was conducted for the full 17 miles from 2008 to 2013. The BHHRA was approved in July 2017 and the BERA was approved in June 2019. The final RI Report was submitted by the CPG in July 2019 and has been conditionally approved by EPA pending approval of the calibrated bioaccumulation model. The bioaccumulation model, which will be an appendix to the RI, is still under development. In July 2017, the CPG proposed moving away from the original schedule for a final OU4 ROD, and instead evaluating alternatives for an IR for source control for the upper 9 miles of the LPRSA. The IR will incorporate an adaptive management strategy into the Site cleanup that will inform the final remedy for the LPRSA. In October 2018, EPA Region 2 directed the CPG to prepare an IR FS evaluating an IR approach for source control. The IR FS was conditionally approved in December 2020, and the Proposed Plan was released in April 2021.

In addition to these implemented and planned remedial activities, the Diamond Alkali Superfund 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 an Interim Remedy for the Upper 9 Miles

In selecting a final remedy for the sediments of the lower 8.3 miles of the LPRSA in 2016, EPA determined that it would be consistent with any remedy selected for the remainder of the Diamond Alkali Superfund Site, including the upper 9 miles of the LPRSA and Newark Bay Study Area. Based on the RI data, the highest concentrations of COCs tend to be found in areas that are predominantly composed of fine-grained sediments, which, for the LPRSA, are principally in the lower 8.3 miles. Approximately 90 percent (by volume) of the fine-grained sediments in the LPR are located in the lower 8.3 miles. These findings, coupled with the tidal nature of the water body, led EPA to conclude any remedy for the 17-mile LPRSA should begin with the lower 8.3 miles and include bank-to-bank remediation in the lower 8.3 miles.

During and following the remedy selection process for the lower 8.3 miles, EPA continued to evaluate the 17-mile RI data, including assessing the 9 miles from RM 8.3 to Dundee Dam. The data indicated that, in the upper 9 miles, fine-grained sediments are not present bank-to-bank but are interspersed with areas of coarse-grained, less-contaminated sediments. When approached with the concept of an IR for the upper 9 miles, EPA determined that an IR would be beneficial to expedite the overall process of remediating the LPRSA. An IR for the upper 9 miles that includes the cleanup of areas with elevated concentrations of contaminants will result in significantly reduced contaminant SWACs. EPA expects that this will result in expedited recovery of the river. If work on the upper 9 miles takes place at the same time as the cleanup of the lower 8.3 miles, as is anticipated, the infrastructure constructed for the lower 8.3 miles (such as a dewatering facility or storage areas) may be used for the upper 9 miles IR, and the disruption to the river ecology and the many communities along the river would be minimized. An IR for the upper 9 miles does not alter the previously selected cleanup for the lower 8.3 miles of the river.

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 address these sites. As discussed in the EPA guidance *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 CSM. 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 has allowed the CSM to be updated and adjusted during the investigation of the LPRSA.

The remedial action for the upper 9 miles will be adaptively managed under a multistep process of remediation (the IR), assessment and monitoring, and additional remediation, if needed. The first step will be the design and implementation of the source control IR for the upper 9 miles. The IR will be followed by a period of response and recovery assessment monitoring to evaluate the response of the LPRSA system to the IR and to track the longer-term recovery of sediments, the water column, and biota, so that EPA can evaluate whether and when the conditions that give rise to unacceptable risk to human health and the environment have been addressed. Based on the evaluation of post-IR confirmation sampling, EPA will assess the need for any further action under the IR to fulfill the intent of the IR (i.e., source removal). In addition, risk-based preliminary remediation goals (PRGs) will be developed for COCs during/in parallel with the IR design and will be used by EPA to assess progress towards the PRGs as part of evaluating longer-term system recovery following the IR. Based on the evaluation of longer-term post-IR monitoring data, EPA will assess the need for additional action(s) to achieve final cleanup. EPA will evaluate remedial alternatives in a proposed plan and will issue a final ROD that includes final risk-based remediation goals (RGs) and specifies any additional actions beyond the IR, if any, that are needed to attain the RGs and address remaining unacceptable risks associated with the LPRSA, in both sediments and surface water. An Adaptive Management Implementation Approach was prepared during the IR FS and is included as Appendix D of the IR FS. EPA expects the Adaptive Management Implementation Approach to be revised and expanded into a more comprehensive adaptive management plan as project planning, design, and implementation progress.

5. SUMMARY OF SITE CHARACTERISTICS

5.1 Summary of Sampling Results and Other Investigations

The 17-mile RI and upper 9-mile IR FS Reports evaluated contamination in the LPRSA 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. In addition to other information collected prior to 2005, the 17-mile RI and upper 9-mile IR FS incorporated the following data from 2005 and after:

- 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 beryllium-7-bearing sediment collection program
- 2007 through 2012 single- and multi-beam bathymetric surveys
- 2008 tributary, CSO, and SWO sampling program
- 2008 low-resolution sediment coring program
- 2009–2010 benthic and surface sediment sampling program
- 2009–2010 physical water column monitoring program
- 2009–2010 fish community and tissue collection surveys
- 2010 high-flow water column suspended solids sampling
- 2010 habitat identification survey
- 2010 summer/fall avian community survey
- 2011–2013 small-volume chemical water column monitoring program
- 2011–2013 high-volume chemical water column monitoring program
- 2011 caged bivalve study
- 2011–2012 RM 10.9 characterization sampling
- 2012 background benthic sediment sampling
- 2012 background fish tissue survey
- 2012 low-resolution supplemental sediment sampling program
- 2013 low-resolution supplemental sediment sampling program 2

More detail related to individual investigation events can be found in the RI Report and other documents in the Administrative Record file (Administrative Record Index in Attachment 3).

In addition, a current conditions monitoring program (CCMP) was performed for the upper 9 miles of the LPRSA, pursuant to the 17-mile RI/FS AOC. The CCMP, which began in 2019, included bathymetric surveying and surface water and biota sampling that will also be relevant to the IR. Also, prior to the IR design, an extensive pre-design investigation (PDI) will be implemented during which a spatially extensive sediment sampling program will be performed to refine understanding of pre-IR contaminant distribution, inform the design including the final IR footprint, and provide baseline data for comparison to post-IR data.

5.2 Contaminants in the Upper 9 Miles

The IR targets two contaminants in the upper 9 miles of the LPRSA—2,3,7,8-TCDD and total PCBs. These two contaminants contribute significantly to the risk in the upper 9 miles. The objective of the IR is not risk-based, but the source control IR is expected to significantly reduce the risk associated with the targeted contaminants. The other COCs in the upper 9 miles, as identified by the risk assessments performed for the LPRSA, are total DDx,[3] other dioxins/furans, dieldrin, copper, lead, mercury (including methyl mercury), and PAHs.

[3] DDT is a common name that refers to an industrially produced, chlorinated pesticide, dichlorodiphenyltrichloroethane. DDT breaks down in the environment to form dichlorodiphenyldichloroethane (DDD) and dichlorodiphenyldichloroethylene (DDE). The term total DDx used in this document refers to the sum of DDT, DDD, and DDE (2,4’ and 4,4’ isomers) concentrations.

Contaminants other than 2,3,7,8-TCDD and total PCBs will be addressed during the IR to the extent they are collocated with areas targeted for remediation based on concentrations of 2,3,7,8-TCDD and total PCBs, or will be addressed in the final remedy, as needed. Detailed concentrations in surface sediments and at depth for 2,3,7,8-TCDD and total PCBs are shown in Tables 5-1 and 5-2, respectively, in Appendix 2. The COCs that are the focus of the IR are described below.

2,3,7,8-TCDD. Dioxins and furans are by-products of chemical manufacturing, combustion (either in natural or industrial settings), metal processing, and paper manufacturing. The dioxin congener[4] 2,3,7,8-TCDD is the most toxic form of dioxin. The 2,3,7,8-TCDD and other dioxin congeners were by-products of manufacturing processes at the former Diamond Alkali facility and elsewhere. The herbicides manufactured at the former Diamond Alkali facility included "Agent Orange," a defoliant manufactured for military purposes and shipped in drums with an orange stripe. Dioxins/furans persist in the environment for a long time and bioaccumulate in fish and crab. Dioxins/furans 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. PCBs are man-made 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, physicochemical 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 materials. PCBs persist 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 for 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 can also cause immune system problems in animals, as well as behavioral alterations and impaired reproduction.

5.3 Sediment Conceptual Site Model

The LPR and Newark Bay are part of the New York/New Jersey Harbor Estuary. The LPR refers to the approximate 17-mile tidal portion of the river (i.e., RM 0 at Newark Bay to Dundee Dam) and its watershed, which includes the major tributaries of Saddle River, Third

[4] 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." 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.

River, and Second River (Figure 1-1 in Appendix 1). Dundee Dam isolates the UPR from the tidal mixing that influences the LPR.

The 17-mile LPR exhibits characteristics typical of a highly urbanized estuarine system. Its large urban watershed includes many industrial facilities that have been sources of dioxins, PAHs, PCBs, pesticides, and metals.

The lower 8.3 miles of the LPR comprise approximately 716 acres, while the upper 9 miles comprise approximately 344 acres. Fine-grained sediments in the LPR generally have higher contaminant concentrations than coarser materials. Fine-grained sediments comprise the majority of the LPR surface sediments below RM 8.3, while fine-grained sediments are generally more interspersed with coarser sediments in the upper 9 miles. Between RM 15 and Dundee Dam, the river bottom is generally composed of coarse sediments. Mudflats are present throughout the entire LPR and are typically composed of fine-grained sediments.

The LPR's cross-sectional area declines steadily, moving upstream from RM 0 to Dundee Dam, with a pronounced constriction at RM 8.3 (Figure 5-1 in Appendix 1). At that location, there is also a pronounced change in sediment texture within the riverbed. As previously stated, the riverbed from RM 0 to RM 8.3 is dominated by fine-grained sediments, while coarser sediments (sand and gravel) with smaller areas or pockets of fine-grained sediments generally comprise the riverbed above RM 8.3 (Figure 5-2 in Appendix 1). About 85 percent of the fine-grained sediment surface area (90 percent by volume) of the LPR is located below RM 8.3. As discussed in the lower 8.3-mile ROD, wider and thicker beds of contaminated sediments accumulated below RM 8.3 rather than above it owing to a combination of a wider cross section and a deeper historical navigation channel. Figures 5-3 and 5-4 in Appendix 1 show the concentrations of 2,3,7,8-TCDD and total PCBs as a function of grain size and relative position in the LPRSA, demonstrating both the differences in grain size between the lower 8.3 miles and upper 9 miles and the general occurrence of higher levels of contamination in association with finer-grained sediments.

Hydrodynamics of the LPR is governed by the freshwater discharge, tides (approximate 5-foot diurnal tidal range at the mouth of the Passaic River), estuarine circulation, and changes in mean water level caused by storm surges in the Atlantic Ocean. From Dundee Dam to approximately RM 14, the LPR behaves like a freshwater river influenced by tides. Between approximately RM 14 and approximately RM 8.3, the LPR behaves more like a fluvial estuary with a mix of freshwater and brackish waters. Downstream of approximately RM 8.3, the LPR behaves like an upper estuary with a mixture of fresh water and saltwater and a strong influence of estuarine circulation where denser saline waters (the leading edge of which is the "salt front") tend to flow in the upstream direction (on net) beneath fresher water flowing in the seaward direction, producing a two-layer flow pattern. This net upstream flow helps provide a mechanism for water and solids originating from the lower portions of the LPR to move upstream.

The interface between the fresh and saline waters (the salt front) typically resides within the lower 10 miles of the LPR and moves several miles during each tidal cycle. The exact location depends on freshwater inflows, tides, and the definition of the salt front. The LPRSA studies (OU2 and OU4) have used two definitions for salt front, either 0.5 or 2 practical salinity units (psu). As noted in the lower 8.3-mile ROD, during low-flow conditions, the salt front, when defined as 2 psu, and the region of maximum turbidity known as the estuarine turbidity maximum (ETM), can reach as far upstream as approximately RM 12. The salt front, when defined as 0.5 psu consistent with the technical definition used by the U.S. Geological Survey and the definition used by the Delaware River Basin Commission, can extend upstream beyond RM 14 under extreme low-flow conditions such as extreme droughts. The salt front can move into Newark Bay under high-flow conditions.

The extent of upstream transport in the system extends beyond the salt front. Measurements collected at the most upstream physical water column monitoring station (RM 13.8) show semidiurnal depth-averaged current velocities in the upstream direction for most periods when the flow is less than 1,350 cubic feet per second (cfs). During the period of the LPR's maximum depth, when the historical navigation channel was maintained up to RM 15.4, the extent of upstream transport and the salt front location would likely have been shifted further upstream relative to current conditions.

Freshwater inflow and sediment import from Newark Bay due to estuarine circulation are the two major sources of solids to the LPR. There are four major freshwater discharge points to the LPR—the UPR at Dundee Dam (RM 17.7), Saddle River at RM 15.6, Third River at RM 11.3, and Second River at RM 8.4. Besides these major tributaries to the LPR, there are numerous smaller tributaries, SWOs, and CSOs that contribute freshwater flow to the LPR. Water from the UPR at Dundee Dam represents the majority of the freshwater flow entering the LPR. Inflows to the LPR are usually highest in March and lowest between July and October.

The LPR shows typical geomorphological features of a meandering river but has been influenced by navigational dredging and subsequent infilling after maintenance of the navigational channel stopped. The authorized navigational channel was constructed by the USACE from RM 0 to RM 15.4 and was maintained by the USACE until the 1950s in most of the lower 8.3 miles, although portions upstream of RM 8.3 were dredged between 1973 and 1976. The reach below RM 1.9 was last dredged in 1983. As noted in Section 2, in 2018, the federal navigation channel above RM 1.7 was deauthorized by an act of Congress.

The inside bends of the river generally accumulate finer sediments, while the outside bends generally experience little or no sediment accumulation and (in some cases) experience erosion due to higher sheer stresses. The LPR widens and deepens moving downstream towards Newark Bay and finer sediments become more common in the lower reaches, particularly downstream of RM 8.3. In the vicinity of structures such as bridge abutments and at tributary confluences, sediments tend to be coarse or absent owing to associated turbulence that prevents long-term accumulation of fine sediments (or any sediments).

The salt front typically coincides with the region of maximum turbidity known as the ETM. The ETM results from a combination of resuspension of bottom sediments by tidal current stresses and the convergence of bottom water transport around the upstream limit of estuarine circulation (at the salt front). Estuarine circulation is integral to the CSM as it increases sediment retention in the LPR and provides a mechanism for contaminant transport in the upstream direction within (and beyond) the salt wedge and in the downstream direction in fresher surface-layer waters.

Suspended sediment concentrations (SSCs) are also affected by fluctuations in flow velocities within tidal cycles and between tidal cycles. SSCs generally increase as velocity increases during both flood and ebb tides and generally decrease as sediments are deposited during slack water. The geometry and density gradients in the LPR (under normal flow conditions) result in higher resuspension rates and SSCs during flood tides compared to ebb tides (referred to as tidal asymmetry). The easily erodible fine-grained sediments that make up SSCs during tidal cycles is termed a "fluff layer" and consists of unconsolidated sediments that overlie a less erodible sediment bed. SSCs also vary between tidal cycles depending on the spring-neap tidal cycle and freshwater flow over Dundee Dam.

The estuarine circulation, tidal asymmetry, and freshwater flow affect sediment transport over time scales longer than tidal cycles. During low river flow conditions (low energy, generally at or below 750 cfs), tidal asymmetry and estuarine circulation are dominant, leading to import of sediments from Newark Bay, net upstream transport associated with the salt wedge, and trapping of sediments within the LPR. In moderate river flow conditions (moderate energy, generally between 750 and 5,000 cfs), sediment transport is more impacted by river-induced advection, and sediments accumulated in the ETM and in unconsolidated surface sediments are generally flushed downstream and into Newark Bay. During high river flow conditions (high energy, generally at or above 5,000 cfs), the riverbed may experience scour and the system as a whole exports sediments and erodes beyond the easily erodible unconsolidated surface sediments.

Multiple bathymetric surveys have been conducted in the LPR since 2004, including following high-flow events such as Hurricane Irene in August 2011, allowing for a conceptual understanding of how the LPR sediment bed changes with various flow events. Flow over Dundee Dam reached 24,700 cfs following Hurricane Irene. As a point of comparison, the annual average flow at Dundee Dam is approximately 1,200 cfs. The 2004 survey used a single-beam echosounder, which allowed the survey transects to extend into the shallow areas along the shoreline and up to Dundee Dam. Beginning in 2007, more detailed data were obtained with multibeam echosounders in the reach downstream of approximately RM 14.3; limited single-beam surveying was also performed for shallow areas. The water-depth constraint on the use of the multibeam echosounders allows for a detailed characterization of approximately 75 percent of the 224 acres between RM 8.3 and RM 14.3, with the remaining 120 acres upstream of RM 14.3 characterized by only the 2004 single-beam survey data.

Bathymetry data indicate that erosion occurs most frequently on the scale of 6 inches or less, which is within the level of uncertainty in survey differences. However, bathymetry data do show that erosion of 6 inches to 1 foot does occur over limited areas, and in very limited cases, erosion of more than 1 foot (and rarely exceeding 1.5 feet) has been observed. The higher energy events that cause more significant erosion tend to naturally armor the sediment bed against further erosion beyond that depth by removing fine-grained sediments and leaving behind a coarser, and more erosion resistant, fraction.

Contaminant concentrations in the LPR are largely driven by variations in sediment type and depositional/erosional history. The two contaminants found in fine-grained sediments throughout the LPRSA that have been shown to contribute significantly to unacceptable risk based on risk assessments and that are the focus of the sediment source control IR are 2,3,7,8-TCDD and total PCBs. Other COCs found in the LPRSA—not contributing to human health and/or ecological risk to the same degree as 2,3,7,8-TCDD and total PCBs—include total DDx, other dioxins/furans, dieldrin, PAHs, and metals (including mercury). Contaminants are generally found in greatest concentrations in fine-grained sediments. For example, the RM 10.9 mudflat was found to contain surface sediment 2,3,7,8-TCDD levels exceeding 50,000 parts per trillion (ppt) and total PCB levels exceeding 33.9 parts per million (ppm) in some instances, prior to the RM 10.9 Removal. Variations in spatial patterns for PCBs, total DDx, and mercury suggest these contaminants may also be impacted by other sources, including from the UPR, Newark Bay, tributaries, and/or watershed sources.

Contrary to the distribution of the COCs, comparable amounts of both high-molecular weight (HMW) PAHs and low-molecular weight (LMW) PAHs are found in fine-grained and coarse-grained sediments. Sources of PAHs upstream of Dundee Dam may be contributing to concentrations of PAHs observed in the LPR. Downstream sources may also explain why PAH concentrations do not decline as much as 2,3,7,8-TCDD concentrations moving from the LPR into Newark Bay.

Continuing contaminant sources to recently deposited sediments of the LPR are the internal sediment inventory (e.g., resuspended contaminated sediments within the LPR), tidal exchange with Newark Bay, flows from above Dundee Dam, CSOs and SWOs, overland flow, groundwater, and various other point and non-point sources. The contaminated fine-grained sediments already within the LPR are the most significant continuing contaminant source and will be addressed to a large degree by the bank-to-bank capping of RM 0 to RM 8.3 pursuant to the lower 8.3-mile ROD. In comparison, UPR and Newark Bay contributions of contaminants are relatively small, and all other sources are minor. The IR focusing on source control (the subject of this ROD) targets sediments with elevated contaminant concentrations in the upper 9 miles of the LPRSA.

Dundee Lake and other UPR sediments are isolated from hydrodynamic impacts and sediment transport from the LPR by Dundee Dam. The concentrations of the contaminants detected in recently deposited sediments collected from the UPR immediately above Dundee Dam are representative of current background conditions for the LPR.

EPA investigated potential sources of contaminants to the LPR, including atmospheric deposition, groundwater, industrial point sources, the UPR, Newark Bay, major tributaries, CSOs, and SWOs. Based on analyses discussed in the lower 8.3-mile RI and FFS Reports, direct atmospheric deposition, groundwater discharge, and industrial point sources of contaminants are not significant contributors of contaminant mass in the recently deposited sediments or water column of the LPR. The UPR, Newark Bay, the three main tributaries, and CSOs and SWOs were sampled between 2005 and 2011. A mass balance of suspended sediments and contaminant loads was performed with the data as part of the analysis supporting the lower 8.3-mile ROD. The results indicate that the tributaries, CSOs, and SWOs are minor contributors of contamination to recently deposited sediments, since they are minor contributors of sediment particles compared to the UPR and Newark Bay, and the mass of contaminants delivered by those particles is low compared to the sediments of the LPR main stem. For 2,3,7,8-TCDD and total PCBs, concentrations on sediment particles from the tributaries, CSOs, and SWOs are clearly lower than those on LPR surface sediments.

As presented in the lower 8.3-mile ROD (Table 3 from the lower 8.3-mile ROD), resuspension of LPR sediments contributes over 90 percent of the 2,3,7,8-TCDD in recently deposited sediments of the LPR, followed by Newark Bay (approximately 5 percent) and the UPR (3 percent or less). Resuspension of LPR sediments contributes approximately 80 percent of the PCBs in recently deposited sediments, followed by the UPR (approximately 10 percent) and Newark Bay (less than 10 percent).

A detailed discussion of the LPRSA CSM is presented in the RI Report, and other documents in the OU4 Administrative Record, as well as the lower 8.3-mile ROD.

5.4 Sediments

Surface sediment 2,3,7,8-TCDD concentrations greater than 500 ppt have rarely been observed upstream of RM 12 and are confined mainly to fine-grained sediment regions that have been influenced by upstream transport from the LPR. The influence of upstream transport can extend beyond RM 14. Outside the fine-grained sediment deposits, 2,3,7,8-TCDD concentrations above RM 12 are mostly less than 100 ppt and concentrations above RM 14.6 are less than 1 ppt, reflecting the low concentrations at the upstream boundary at Dundee Dam and the coarse-grained nature of the sediments.

Moving downstream, fine-grained sediments and 2,3,7,8-TCDD concentrations greater than 500 ppt become more prevalent. Point bars (accumulations of sediments on the inner bend of a river), such as those that formed at RM 10.1 and RM 7.3, generally have higher 2,3,7,8-TCDD concentrations in the central area of the point bar and lower concentrations in nearshore and offshore portions. Sharp transitions to lower concentrations are typically observed moving across the point bar toward the edge of the deeper river channel. The RM 10.9 area is also characterized overall as a point bar deposit, which includes the mudflat area addressed through the RM 10.9 Removal. In the RM 10.9 point bar, concentrations greater than 1,000 ppt were observed where 1960s-era sediments existed at the surface. The channel in the vicinity of the RM 10.9 point bar is characterized by concentrations generally in the range of 10 to 100 ppt, consistent with the coarse-grained nature of the sediments. Concentrations are typically less than 500 ppt in the southerly portion of the RM 10.9 point bar, which is consistent with ongoing evolution characteristic of the downstream portion of a point bar. Similar patterns are also observed 0.5 to 1.5 feet below the surface.

The concentration patterns for total PCBs, total DDx, and mercury tend to mirror those of 2,3,7,8-TCDD in the region downstream of RM 14. As noted previously, patterns of HMW PAHs and LMW PAHs vary from those of the other contaminants, with no clear difference between concentrations in fine-grained and coarse-grained sediments. Upstream of RM 14, none of these contaminants show the dramatically lower concentrations evident for 2,3,7,8-TCDD because of the greater influence of sources from above Dundee Dam. Differences between concentration patterns of 2,3,7,8-TCDD and other COCs also exist near the mouth of the river owing to influences from sources in Newark Bay and beyond.

5.5 Biota

Biota tissue collected from the lower 8.3 miles of the LPR is addressed in the lower 8.3 ROD. This section concentrates on biota collection performed for the upper 9 miles of the LPRSA.

Biota tissue, including fish and crabs that are potentially consumed by humans and some wildlife receptors (e.g., blue crab, common carp, American eel, catfish, largemouth bass, and white perch), and forage-sized fish that are only consumed by wildlife receptors (various species of small sunfish) were collected and analyzed for COCs. The COC concentrations in biota tissue collected in 2009/2010 for the RI were used to determine risks from human consumption, and to determine whether the tissue COC concentrations could pose risk to the biota themselves (through comparisons to critical body residue thresholds), or to piscivorous wildlife receptors (birds, mammals, and/or fish).

While there is variability in contaminant levels in biota tissue, spatially (as well as within and between species), a general trend was observed based on the benthic invertebrate and fish tissue data collected from the LPR. Organic contaminants, including 2,3,7,8-TCDD, other dioxins/furans, total PCBs, total DDx, and dieldrin, are generally highest in large benthic omnivorous fish, with the highest concentrations found in carp. The close association of carp and other large benthic omnivorous fish with surface sediments influences their accumulation of organic contaminants. Organic contaminants accumulate in crabs, including 2,3,7,8-TCDD, other dioxins/furans, total PCBs, methyl mercury, and total DDx. Inorganic contaminants, including arsenic, cadmium, mercury, and selenium, also accumulate in crabs. Mercury concentrations in LPR fish tissue generally increase with increasing trophic level and are similar to those measured in fish collected above Dundee Dam.

6. CURRENT AND POTENTIAL FUTURE SITE AND RESOURCE USES

The New Jersey Surface Water Quality Standards (N.J.A.C. 7:9B) classify the LPR from its mouth to the Second River (RM 0 to RM 8.4) as saline-estuarine 3 (SE3), with designated uses that include secondary contact recreation (activities where the probability of water ingestion is minimal, including boating and fishing). The LPR from Second River to Dundee Dam (RM 8.4 to RM 17.7) 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 wading, swimming, diving, and water skiing).

The federal Clean Water Act (CWA), 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 LPR is not fishable and swimmable owing to chemical contamination and other factors. New Jersey prohibits the consumption, and sale for consumption, of fish and crab from the entire LPR (RM 0 to RM 17.4) due to contamination by PCBs, 2,3,7,8-TCDD 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). CERCLA does not supplant the CWA, which addresses pollutants in the water column through various mechanisms such as permitting programs and water quality monitoring. This ROD, issued under CERCLA to address contaminated sediments in the upper 9 miles of the LPR, will support the CWA goals by addressing a source of contamination to the water column.

As discussed in Section 2, a federally authorized navigation channel historically existed from RM 0 to RM 15.4 of the LPR. In 2018, Congress deauthorized the federal navigation channel above RM 1.7, and reauthorized it to a depth of 20 feet from RM 0.6 to RM 1.7. In accordance with Superfund guidance, reasonably anticipated future land and waterway uses in the upper 9 miles of the LPR were considered during the development of IR alternatives and IR alternative selection. Currently, adjacent land use in the upper 9 miles is approximately 35 percent residential and recreational and 30 percent industrial and commercial (primarily along the east bank). The remaining 35 percent includes roads and other transportation infrastructure adjacent to the river. Various parks and recreational spaces are adjacent to the river, including Riverside County Park, Rutherford Waterfront Park, Memorial Park, Sesselman Park, and Wallington Park, all on the east side of the river, and Pulaski Park on the western bank between RM 15.5 and RM 16. The west bank of the LPR is abutted by Route 21 across much of the upper 9 miles. Future land use in the upper 9 miles is expected to remain generally consistent with current uses. Throughout the LPR, particularly between RM 2 and RM 12, college, high school, and community rowing clubs use the river for recreation and competition. It is expected that recreational uses of the river will continue in the future.

7. SUMMARY OF SITE RISKS

Baseline human health and ecological risk assessments were conducted to evaluate the potential for current and future impacts of Site-related contaminants on receptors visiting, utilizing, or inhabiting the LPRSA. The risk assessments are analyses of the potential adverse effects caused by hazardous substance exposure in the absence of any actions to control or mitigate these exposures under current and future uses. They identify the contaminants and exposure pathways that need to be addressed through remedial action and provide the basis for taking action. Sections 7.1 and 7.2 summarize the results of the BHHRA for the LPRSA and the BERA for the LPRSA, respectively. Under baseline conditions, the human health and ecological risks in the LPRSA are unacceptable. The BHHRA and BERA support the selected source control IR and the overall adaptive management approach for the LPRSA.

The BHHRA, entitled *Baseline Human Health Risk Assessment for the Lower Passaic River Study Area*, dated July 2017, and the BERA, entitled *Baseline Ecological Risk Assessment for the Lower Passaic River Study Area*, dated June 2019, are available in the Administrative Record (Administrative Record Index in Appendix 3).

7.1 Summary of the Human Health Risk Assessment

Consistent with Superfund policy and guidance, the BHHRA is a baseline risk assessment and therefore assumes no actions (remediation) to control or mitigate hazardous substance releases and no institutional controls, such as the fish consumption advisories and fishing restrictions that are currently in place, which are intended to control exposure to hazardous substances. Cancer risks and non-cancer hazard indices were calculated based on estimates of reasonable maximum exposure (RME) to individuals expected to occur under current and future conditions at the Site. EPA also estimated cancer risks and non-cancer hazard indices based on central tendency exposures (CTE), or average exposures, at the Site. A four-step process is utilized for assessing site-related human health risks, as follows:

Hazard Identification – uses the analytical data collected to identify the contaminants of potential concern (COPCs) 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 (e.g., ingesting contaminated fish) 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 effect (response).

Risk Characterization – summarizes and combines outputs of the exposure and toxicity assessments to provide a quantitative assessment of site-related risks. The risk characterization also identifies contamination with concentrations that exceed acceptable levels, defined by the

National Oil and Hazardous Substances Pollution Contingency Plan (NCP) as an excess lifetime cancer risk greater than 1×10^{-6} to 1×10^{-4} or a Hazard Index greater than 1.0; 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.

7.1.1 Hazard Identification

In this step, analytical data collected during the RI were used to identify COPCs in sediments, surface water, fish tissue, and crab tissue in the LPRSA. All RI data used in the BHHRA were validated in accordance with the approved Quality Assurance Project Plans (QAPPs) and were determined to be valid and acceptable for use in the risk assessment. The RI data provide a data set for the BHHRA, including:

- Accessible surface sediment samples from 180 nearshore and mudflat locations
- Near surface (shallow) surface water samples (144) from five stations in the river
- Fillet tissue samples (105) from nine species of fish (white perch, American eel, channel catfish, largemouth bass, white catfish, common carp, white sucker, smallmouth bass, and northern pike)
- Crab tissue samples (69), including muscle and hepatopancreas combined, muscle-only, and hepatopancreas-only tissue types

The screening process considered the concentration of the chemical and associated toxicity, carcinogen status, essential nutrient status, and the range and frequency of detection. The assessment identified a total of 62 chemicals as COPCs and these were retained for further evaluation in the BHHRA. The COPCs included dioxins/furans, PCBs, PAHs, total petroleum hydrocarbon ranges, methyl mercury, arsenic and other inorganics, various pesticides, and a limited number of semivolatile organic compounds (SVOCs) and volatile organic compounds (VOCs). Not all chemicals were identified as COPCs in every medium, and 14 were evaluated qualitatively in the uncertainty analysis. The screening process used to identify COPCs is designed to assure that chemicals not identified as COPCs are minor contributors to the overall risks and hazards from the LPRSA. A comprehensive list of all COPCs for the LPRSA can be found in Tables 3-8 through 3-11 of the July 2017 BHHRA report.

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 0.00003 to 1. The consensus TEF values published in 2005 by the World Health Organization and recommended by EPA in the 2010 guidance “Recommended Toxicity Equivalency 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 were evaluated using two separate approaches in the BHHRA. One approach evaluated total PCBs using the cancer and non-cancer toxicity values for total PCBs and Aroclor 1254, respectively. The other approach evaluated the sum of 12 dioxin-like PCB congeners (PCB TEQ) using the toxicity values for TCDD TEQ and evaluated the remaining non-dioxin-like congeners (PCB [non-DLC]) using the toxicity values for total PCBs and Aroclor 1254 (for cancer and non-cancer, respectively). Both approaches identified PCBs as COCs and resulted in very similar risk estimates. The PCB results presented herein represent the PCB TEQ/non-DLC approach, which was associated with slightly higher risk estimates.

COPCs identified at the conclusion of the BHHRA as posing the greatest risk are referred to as COCs and are the primary focus of the response action proposed in this ROD. The BHHRA identified TCDD TEQ and PCBs as COCs, primarily due to consumption of LPRSA fish and crabs.[5] The contribution of all other COPCs to total site cancer risks/non-cancer hazards was generally less than 4%. Among the dioxins/furans that are included in the TCDD TEQ, 2,3,7,8-TCDD contributes the majority of total TCDD TEQ (approximately 95%) for LPRSA fish and crab tissue, with the rest of the TCDD TEQ attributable to other dioxins/furans (approximately 5%).

7.1.2 Exposure Assessment

In this step, the different exposure scenarios and pathways (through which people might be exposed to the contaminants identified in the previous step) were evaluated. The goal of the exposure assessment is to estimate the magnitude, frequency, duration, and routes of current and future human exposure to COCs associated with the LPRSA. The receptor's exposure is estimated by identifying exposure scenarios that describe the potential pathways of exposure to COCs and the specific activities of individuals that may lead to contact with COCs at the LPRSA. The following receptors were evaluated for the LPRSA: anglers/crabbers, waders, swimmers, boaters, and workers. Workers were assumed to be adults and all other receptors were assumed to include two or more age groups (i.e., child, adolescent, adult). Potential exposure routes varied by receptor and included incidental ingestion of and dermal contact with sediments, incidental ingestion of and dermal contact with surface water, and ingestion of fish (mixed fish

[5] The BHHRA also identified TCDD-TEQ as a COC for direct exposure to accessible surface sediments in RM 6 to RM 9, and specifically the east bank of this river segment. Further analysis that included a quantitative analysis of the TCDD-TEQ data and associated risks and hazards indicates that no elevated direct contact hazard is associated with the sediments in the portion of the east bank RM 6 to RM 9 above RM 8.3.

diet) and blue crabs. Table 7-1 (Appendix 2) identifies all receptors and exposure pathways that were considered in the BHHRA and the rationale for selection or exclusion of each pathway.

COCs are associated with the consumption of LPRSA fish and crabs that have accumulated chemicals from the sediments and surface water. Recreational angler receptors evaluated in the BHHRA are defined as those individuals who consume self-caught fish and/or crabs from the LPRSA. Adults and adolescents (7 years to less than 19 years old) are expected to participate in angling and are expected to share self-caught fish and/or crabs with family members (i.e., children 1 year to less than 7 years old). Anglers can fish from bridges, boats, and a variety of locations along the shoreline, including bulkheads, highway and bridge abutments, boat launches and docks, mudflats, and park land.

The LPRSA BHHRA includes both site-specific data where possible (e.g., boating frequency and fish and crab consumption rates) and default exposure assumptions (e.g., body weight, dermal adherence, residence times) in the calculation of exposures.

The exposure point concentration (EPC) identifies the concentration of COCs in an environmental medium at the point of human contact (e.g., consumption of fish, crabs). Receptor- and chemical-specific exposure parameters are used in the BHHRA to estimate exposure doses to the potential receptors. Both RME and CTE exposure scenarios are evaluated. Tables 7-2a and 7-2b (Appendix 2) identify the COCs and their chemical-specific characteristics (e.g., range of concentrations, frequency of detection, EPCs, and associated statistical basis) in fish and crab tissue. The following subsections identify the exposure information used for fish and crab consumers. Exposure information for other receptors is provided in Section 4 of the July 2017 BHHRA.

7.1.2.1 EPCs for Fish and Crab

Based on the available data about fish species preferences and relative abundance, a mixed fish diet consisting of five species was evaluated in the BHHRA. The EPCs for the mixed fish diet are based on equal fractions (20 percent) of white perch, American eel, channel catfish, largemouth bass, and common carp. The EPCs for crab are based on the concentrations in the composite samples of edible crab tissue (i.e., muscle and hepatopancreas combined).

7.1.2.2 Angler Consumption Rates

Fish and crab ingestion rates for the BHHRA were developed from a detailed evaluation of LPRSA-pertinent angler and creel surveys and related literature, as documented in the EPA Region 2 Technical Memorandum, “Fish and Crab Consumption Rates for the LPRSA Human Health Risk Assessment” dated February 2012.

Two angler surveys were used to calculate the fish ingestion rate. The Burger (2002) data are from a survey conducted in the Newark Bay Complex. The Connelly et al. (1992) data are from the New York State-wide angler surveys. This analysis provided fish consumption rates for the adult angler of 34.6 g/day (or approximately 56 eight-ounce fish meals/year) for the RME scenario and 3.9 g/day (or 6.2 eight-ounce fish meals/year) for the CTE scenario. The fish ingestion rates for the adolescent and child were based on the assumption that the intake for the adolescent will be approximately two-thirds that of the adult and the intake rate for the child will be approximately one-third that of the adult.

Two studies were selected as data sources for crab ingestion (Burger 2002, Burger 1998) and the ingestion rate was adjusted based on the average weight of edible meat from crabs caught in the LPRSA. Based on the analysis, the crab ingestion rates for the adult angler were 21 g/day (or 34 eight-ounce crab meals/year) for the RME scenario and 3.0 g/day (or 4.9 eight-ounce crab meals/year) for the CTE scenario. Ingestion rates for the child and adolescent receptors were estimated assuming rates one-third and two-thirds those of the adult ingestion rates, respectively, as was assumed for fish ingestion.

7.1.2.3 Cooking Loss

A cooking loss factor accounts for the amount of chemical in tissue that is lost during the cooking process and thus not consumed. For the RME scenario, a cooking loss of 0 percent is used for all chemicals to account for the potential that individuals may consume cooking juices and pan drippings. The CTE scenarios included chemical-specific cooking loss factors, including 49 percent for dioxins/furans, 30 percent for PCBs, and 0 percent for mercury because cooking loss adjustments are not recommended for metals.

7.1.2.4 Other Exposure Assumptions

The Exposure Duration (ED) is the estimate of the total time (e.g., years) that a receptor engages in a particular activity that could result in exposure. Because of the differences in activity patterns and sensitivity to potential chemical exposures, various age groups were evaluated for the BHHRA receptors. The receptor- and age-group-specific EDs for fish and crab consumers are given below. Unless otherwise stated, the CTE duration is assumed to be one-half of the RME duration.

- Adult – from age 19 years through remainder of life. The RME ED for adult receptors is assumed to be 20 years, based on the standard default assumption of 26-year residential tenure at a single location minus 6 years as a non-adult. The CTE ED for adult receptors is 9 years, based on the 50th percentile for years living in current home.
- Adolescent – age 7 years to less than 19 years. The RME ED is 12 years based on the number of years in the age group.
- Child – age 1 year to less than 7 years. The RME ED is 6 years based on the number of years in the age group.

Receptor body weights are taken from EPA guidance and represent the averages for males and females in the applicable age ranges. A body weight of 80 kg is used for adults, 52 kg for the 7 years to less than 19-year-old adolescent, and 17 kg for the 1-year-old to less than 7-year-old child.

7.1.3 Toxicity

The toxicity assessment determines the types of adverse health effects associated with exposures to COCs and the relationship between the magnitude of exposure (dose) and severity of adverse effects (response). Potential health effects include the risk of developing cancer over a lifetime from PCBs and TCDD. Other non-cancer health effects, such as changes in the normal functions of organs within the body, are also associated with exposures to PCBs and TCDD. Some of the 209 PCB congeners are considered to be structurally and mechanistically similar to dioxin and exert dioxin-like effects.

Under current EPA guidelines, the likelihood of carcinogenic risks and noncancer hazards due to exposure to site chemicals are considered separately. Consistent with current EPA policy, it was assumed that the toxic effects of the site-related chemicals would be additive. Thus, cancer and non-cancer risks associated with exposures to individual chemicals were summed to indicate the potential risks and hazards associated with mixtures of potential carcinogens and non-carcinogens, respectively.

- **Cancer**: 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.
- **Non-Cancer**: Non-cancer 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.

Toxicity data for the BHHRA 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) database, (2) EPA's Provisional Peer-Reviewed Toxicity Values (PPRTVs), and (3) other sources identified as appropriate references for toxicity values consistent with EPA's directive on toxicity values.

Consistent with the toxicity hierarchy, the BHHRA used the current consensus toxicity values from IRIS in evaluating the cancer risk of PCBs (non-DLC) and the non-cancer health effects of TCDD TEQ and PCB (non-DLC). For cancer risks of TCDD TEQ and PCB TEQ, the BHHRA used toxicity information for dioxin (2,3,7,8-TCDD) provided in EPA's 1997 *Health Effects Assessment Summary Tables*. Cancer and non-cancer toxicity information for the COCs can be found in Tables 7-3 and 7-4 (Appendix 2), respectively. Additional toxicity information for all COPCs is presented in Tables 5-1 and 5-2 of the July 2017 BHHRA.

7.1.4 Risk Characterization

Risk characterization integrates exposure estimates with toxicity information to provide a quantitative estimate of the potential cancer risk and non-cancer hazard associated with the LPRSA.

For carcinogens, risks are generally expressed as the incremental probability of an individual developing cancer over a lifetime as a result of exposure to a carcinogen. Excess lifetime cancer risk (a unitless probability of an individual 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 cancer risks are probabilities that usually are expressed in scientific notation (such as 1×10^{-4}). For example, a 1×10^{-4} cancer risk means a "1 in 10,000 excess cancer risk," or 1 additional cancer may be seen in a population of 10,000 people as a result of exposure to site contaminants under the conditions described in the exposure assessment. The upper-bound excess lifetime cancer risks derived in the BHHRA are compared to the range of 10^{-4} to 10^{-6} (corresponding to a 1 in 10,000 to a 1 in 1-million excess cancer risk) established in the NCP (i.e., the "risk management range"). EPA's goal of protection for cancer risk is 10^{-6} and concentrations of COCs causing risks greater than 10^{-4} typically will require remedial action. For non-cancer health effects, a hazard index (HI) is calculated. The HI is determined by comparing expected contaminant intakes with the RfD for the specific route of exposure (e.g., oral). The ratio of the intake to the RfD for an individual chemical is the hazard quotient (HQ) for the contaminant in the particular medium. The HI is obtained by adding the HQs for all compounds within a particular medium that impacts a particular receptor population.

An HI greater than 1.0 indicates that the potential exists for non-carcinogenic health effects to occur as a result of site-related exposures, with the potential for health effects increasing as the HI increases. When the HI calculated for all chemicals for a specific population exceeds 1.0, separate HI values are then calculated for those chemicals that are known to act on the same target organ. These discrete HI values are then compared to the acceptable limit of 1.0 to evaluate the potential for non-cancer health effects on a specific target organ. The HI provides a useful reference point for gauging the potential significance of multiple contaminant exposures within a single medium or across media. It is important to note that an HI exceeding 1.0 does not predict a specific disease. The key concept for a non-cancer HI is that a "threshold level" (measured as an HI of less than or equal to 1.0) exists below which non-cancer health effects are not expected to occur.

This section highlights risks greater than 1×10^{-4} and/or the goal of protection of an HI equal to 1.0. The main COCs are TCDD TEQ and PCBs. The pathways of exposure are ingestion of fish and crabs.

<u>7.1.4.1. Fish Consumption</u>

The potential cancer risks to the RME recreational angler on the LPRSA consuming a mixed species fish diet exceed the NCP risk range of 1×10^{-6} to 1×10^{-4}. The estimated cancer risks from consuming fish in the LPRSA to the RME individual are 3×10^{-3} (3 excess incidences of cancer in a population of 1,000) for the adult, 2×10^{-3} (2 in 1,000) for the adolescent, 1×10^{-3} (1 in 1,000) for the child (younger than age 7 years), and 4×10^{-3} (4 in 1,000) for the combined child/adult. The primary contributors to the fish consumption cancer risks are dioxins/furans (68 percent) and PCBs (30 percent).

The potential non-cancer hazards to all RME recreational angler populations on the LPRSA consuming a mixed species fish diet exceed the goal of protection of an HI equal to 1.0. The non-cancer health hazards are 124 for the adult, 127 for the adolescent, and 193 for the child consuming fish caught from the LPRSA. Potential non-cancer health effects associated with the RME HI above the goal of protection of 1 are: developmental and reproductive effects (2,3,7,8-TCDD TEQ and dioxin-like PCBs) and eye, nails, and immune effects (PCBs).

Tables 7-5a and 7-5b (Appendix 2) provide the calculated cancer risks for the RME and CTE individuals, respectively.

7.1.4.2 Crab Consumption

The potential cancer risks to the RME recreational angler on the LPRSA consuming crab (including muscle and hepatopancreas) exceed the NCP risk range. The estimated cancer risks to the RME individual are 9×10^{-4} (9 in 10,000) for the adult, 5×10^{-4} (5 in 10,000) for the adolescent, 4×10^{-4} (4 in 10,000) for the child, and 1×10^{-3} (1 in 1,000) for the child/adult consuming crab caught from the LPRSA. The primary contributors to the crab consumption cancer risks are dioxins/furans (77 percent) and PCBs (20 percent).

The potential non-cancer hazards to the RME recreational angler on the LPRSA consuming crab (including muscle and hepatopancreas) exceed the goal of protection of a HI equal to 1.0. The non-cancer HQ is 32 for the adult, 33 for the adolescent, and 50 for the child consuming crab caught from the LPRSA. Potential health effects associated with the RME HI above 1.0 are: developmental and reproductive effects (TCDD TEQ and dioxin-like PCBs) and eye, nails, and immune effects (PCBs). Tables 7-6a and 7-6b (Appendix 2) provide the calculated non-cancer hazards for the RME and CTE individuals, respectively.

7.1.5. Uncertainties in the Risk Assessment

Within the BHHRA, areas of uncertainty were identified in the assessment process. The key sources of uncertainty are identified below.

- **Hazard Identification –** A comprehensive list of chemicals was evaluated. It is likely that the primary chemicals of public health concern at the LPRSA have been captured in the data set used in the BHHRA.

  Several chemicals were detected in one or more media, but not evaluated in the BHHRA because of a lack of screening levels based on toxicity information. The lack of toxicity information for these chemicals results in a potential underestimate of cancer risks and non-cancer hazards. However, PCBs and 2,3,7,8-TCDD have been extensively studied for toxicity and exposure and the lack of toxicity information for the other chemicals are not anticipated to significantly underestimate the risks and hazards.

- **Exposure Assessment** – Uncertainty in the exposure assessment is due to an incomplete knowledge of exposure, such as the ingestion rates of contaminated fish and crabs in the LPRSA by receptors. This source of uncertainty was reduced by applying the most local diet information available (e.g., surveys conducted near the LPRSA) and contacting researchers directly to determine appropriate exposure parameters for fish and crab ingestion. Additional risks estimated in the uncertainty evaluation in the BHHRA still exceeded the NCP risk range when alternate assumptions were made (e.g., fish consumption rate of one-half-pound fish meal per month, single-species diets, alternate mixed fish diets).

  The potential exists that biota other than fish and crabs may be consumed, including turtles, ducks, and frogs. Some biota, such as ducks and turtles, are fattier than fish or crabs and therefore may carry heavier contaminant burdens. However, it is unlikely that site risks and hazards have been underestimated by not quantitatively evaluating consumption of LPRSA biota other than fish and crab, since the frequency of consumption is likely less than for fish and crab.

  The data used to calculate the EPCs are assumed to be representative of general area conditions. Samples of five species of fish and crab tissue were evaluated in the BHHRA, representing different feeding guilds, habitats, and angler preferences. Nevertheless, due to the large size of the LPRSA, spatial and temporal variability in the system, as well as sampling and analytical limitations, there is uncertainty in the EPCs used to estimate current conditions in environmental media. Key uncertainties associated with each medium were evaluated in the BHHRA. Fish and crab tissue EPCs used in the BHHRA are more likely to overestimate than underestimate risk, though the overall impact on risk estimates is expected to be minor.

- **Toxicity Assessment –** Toxicity values were not identified for several chemicals analyzed at the LPRSA and the cancer risk and non-cancer hazards may be underestimated based on the lack of this information. Based on the significant toxicity of PCBs and 2,3,7,8-TCDD, the effect is not expected to be significant.

  The cancer toxicity of 2,3,7,8-TCDD does not currently provide a cancer classification for this chemical and the Health Effects Assessment Summary Table (HEAST; EPA 1997) value was used in the assessment. As noted in the July 2017 BHHRA, use of other available cancer toxicity values for dioxins/furans would result in calculated cancer risks that are comparable to those in the BHHRA.

7.2 Summary of the Baseline Ecological Risk Assessment

The BERA evaluated the potential for adverse effects to ecological receptors from exposure to contaminants within the LPRSA. The BERA was conducted in accordance with EPA's 1997 *Ecological Risk Assessment Guidance for Superfund* (ERAGS) and its updates, which describes an eight-step process for performing ecological risk assessment:

Steps 1 and 2 make up the screening-level ecological risk assessment (SLERA):

- Step 1 – Screening-level problem formulation and ecological effects evaluation. Descriptions are developed for the environmental setting, site contaminants, ecological receptors, and exposure pathways.
- Step 2 – Preliminary exposure estimates and screening risk calculation, which compares maximum detected concentrations to screening benchmarks.
- SLERA arrives at one of three conclusions: (1) ecological threats are negligible, (2) further risk assessment is warranted, or (3) there is potential for adverse ecological effects, and a BERA incorporating more site-specific information is needed. For the LPRSA, the SLERA reached the third conclusion.

Steps 3 through Step 7 comprise the BERA, necessary only when the SLERA indicates that further ecological risk evaluation is warranted:

- Step 3 – Baseline problem formulation. This step includes toxicity evaluation, development of a preliminary ecological CSM and exposure pathways, and development of assessment endpoints.
- Step 4 – Study design and data quality objective development, which includes development of the work plan and sampling and analysis plans based upon results of the previous three steps.
- Step 5 – Verification of field sampling design outlined in Step 4.
- Step 6 – Site investigation and data analysis.
- Step 7 – Risk characterization, which includes more refined and detailed quantification of potential site risks and is a more realistic evaluation of risks than the SLERA.

Step 8 is risk management, which includes selection of a remedy in the ROD. Step 8, while ultimately part of the risk assessment process, is beyond the scope of the BERA and is carried out by EPA as the agency selecting the remedy.

7.2.1 SLERA Results

The SLERA was performed using the maximum detected concentrations of contaminants from site-specific sediment and surface water data, evaluated with respect to exceedances of screening-level toxicity benchmarks.

Contaminants of Potential Ecological Concern (COPECs) across all receptor groups included metals, PAHs, organochlorine pesticides, PCDDs/PCDFs, PCBs, SVOCs, VOCs, and cyanide. These COPECs and their exceedances of screening benchmarks are detailed in the BERA appendix of the RI Report. The SLERA concluded that a BERA was warranted to provide a more site-specific and detailed assessment of chemicals that pose potential risk to ecological receptor groups.

7.2.2 BERA Results

The BERA evaluated nine assessment endpoints that addressed the protection and viability of communities of ecological receptor groups. A BERA is designed to protect communities of ecological receptors, as opposed to individual animals, and will typically evaluate receptor communities of different trophic levels using surrogate species, e.g., a heron as a surrogate for all piscivorous (fish-eating) birds. The assessment endpoints were evaluated using site-specific data within a site-specific framework that followed the ecological CSM. The potential for ecological risk was assessed using empirical and modeled data from a number of chemical and biological sampling events and surveys. The assessment endpoints were as follows (Table 7-7 in Appendix 2):

- **Assessment Endpoint 1** – Protection of the zooplankton community that serves as a food base for juvenile fish (receptor group: zooplankton)
- **Assessment Endpoint 2** – Protection (survival, growth, and reproduction) of the benthic invertebrate community (receptor group: infaunal benthic invertebrates)
- **Assessment Endpoint 3** – Protection (survival, growth, and reproduction) of blue crab and crayfish communities (receptor group: decapod crustaceans)
- **Assessment Endpoint 4** – Protection (survival, growth, and reproduction) of the mollusk community (receptor group: bivalve mollusks)
- **Assessment Endpoint 5** – Protection (survival, growth, and reproduction) of omnivorous (plant- and tissue-eating), invertivorous (invertebrate-eating), and piscivorous fish communities (receptor groups: benthic omnivore – mummichog, banded killifish/darter, common carp; invertivore – white perch, channel catfish, brown bullhead, white catfish, white sucker; piscivore – American eel, largemouth bass, northern pike, smallmouth bass)
- **Assessment Endpoint 6** – Protection (survival, growth, and reproduction) of herbivorous, omnivorous, sediment-probing, and piscivorous bird communities (receptor groups: aquatic herbivore – mallard duck, sediment-probing – spotted sandpiper, migratory piscivore – heron/egret, resident piscivore – belted kingfisher)
- **Assessment Endpoint 7** – Protection (survival, growth, and reproduction) of the aquatic mammal community (receptor group: river otter)
- **Assessment Endpoint 8** – Protection of the aquatic plant community (receptor group: multiple species of aquatic plants)

- **Assessment Endpoint 9** – Protection (survival, growth, and reproduction) of amphibian and reptile communities (receptor group: early life-stage amphibians and multiple species of reptiles)

Measurement endpoints are quantitative expressions of observed or measured biological responses to contamination relevant to the selected assessment endpoint. The measurement endpoints for each assessment endpoint included comparisons to toxicity benchmarks. Higher trophic level organisms (fish, birds, and mammals) were also evaluated using food web models (FWMs). The FWMs were used to derive an estimate of the daily dose of site-related contaminants for each of the target receptors. The daily dose calculation included estimates of prey consumption, water ingestion, and incidental sediment ingestion in milligrams per kilogram of body weight per day (mg/kg bw/day):

$$Dose = \frac{\left[(FIR \times EPC_{prey}) + (SIR \times EPC_{sed})\right]}{BW} \times SUF$$

Where:

Dose = daily ingested dose (mg/kg bw/day)
FIR = food ingestion rate (kg wet weight (ww)/day)
EPC_{prey} = exposure point concentration (EPC) in prey tissue (mg/kg ww)
SIR = incidental sediment ingestion rate (kg dry weight [dw]/day)
EPC_{sed} = EPC in sediments (mg/kg dw)
BW = body weight (kg)
SUF = site use factor (unitless); proportion of time receptor spends foraging in the LPR

The body weights, ingestion rates, and SUFs were obtained from the literature for each species and are described in the BERA appendix of the RI Report. The exposure point concentration (EPC in prey for each species was calculated from the fraction of the prey type in the species' diet and the chemical exposure concentration in that prey type, as follows:

$$EPC_{prey} = (EPC_1 \times F_1) + (EPC_2 \times F_2) + (EPC_3 \times F_3)$$

Where:

EPC_{prey} = EPC in prey items (mg COPEC/kg food dw)
$EPC_{1,2,3}$ = EPC in each individual prey type (mg COPEC/kg tissue dw)
$F_{1,2,3}$ = fraction ingested of each individual prey type (kg fish/kg food)

The dietary fraction (DF) of each component in each species' diet was based on information from the available scientific literature. The DFs assumed for each species and the assumptions used to derive them are described in detail in the BERA appendix to the RI Report. The estimated daily dose was then compared to literature-based toxicity reference values (TRVs). The TRVs covered a range of potential impacts from no observable adverse effect level (NOAEL) to the lowest observable adverse effect level (LOAEL). The NOAEL is the highest tested concentration of a chemical that does not cause significant adverse impacts (e.g., mortality, reduced growth, or reduced fecundity) to the species tested. The LOAEL is the lowest tested concentration of the chemical that causes significant adverse impact. Because of the conservatism incorporated in the derivation of TRVs, a protective concentration of the chemical likely lies between the NOAEL and the LOAEL.

The TRVs utilized in the LPRSA BERA were first proposed by the CPG, and then reviewed and verified as having been appropriately derived from the given citation by EPA. In order to ensure that the TRVs utilized in the upper 9 miles (fresh water) were consistent with the lower 8.3 miles (estuarine), EPA required the CPG to utilize a set of TRVs that had been developed by a working group (including EPA, NJDEP, NOAA, FWS, and the CPG). Those TRVs included total LMW PAHs, total HMW PAHs, 2,3,7,8-TCDD, PCDD/PCDF TEQ, total TEQ, total PCBs, dieldrin, total DDx, mercury/methyl mercury, copper, and lead. The CPG also included a less conservative set of TRVs that they proposed and to which EPA agreed. Where two sets of TRVs were used, the risk evaluations were performed for each set.

The potential for unacceptable risk was assessed using empirical and modeled data collected from a variety of chemical and biological sampling events and surveys conducted as part of the LPRSA RI. A step-by-step process included an initial SLERA, which identified media specific COPECs. Site-specific exposure data and a range of effect-level thresholds were used to derive risk estimates (expressed as hazard quotients [HQs]) to identify the potential for unacceptable ecological risk under baseline conditions using multiple lines of evidence.

The HQ method was utilized to evaluate the probability of each COPEC posing ecological risk and divide the estimated daily dose by the TRV. If the resultant HQ is greater than 1.0, risk is implied. An HQ less than or equal to 1 suggests there is a high degree of confidence that risk is not significant. Higher HQs are not necessarily indicative of more severe effects, but rather an indication that there is a higher probability of risk.

COPECs with HQs greater than 1.0, based on LOAEL-based TRVs, were identified as preliminary ecological COCs. Ecological risk drivers were identified from the list of preliminary COCs based on a comparison to background concentrations as described in the BERA and the uncertainty of the assessment used in the BERA (Table 7-8 in Appendix 2). In addition to ecological risk drivers, other ecological COCs were identified using a weight-of-evidence approach to draw conclusions about the benthic invertebrate community using a sediment quality triad (SQT) approach. The SQT approach integrates sediment chemistry, laboratory sediment toxicity studies, and benthic community assessment information.

Unacceptable risk to ecological species based on exceedances of a range of LOAEL-based thresholds for various ecological receptor groups and lines of evidence was primarily driven by exposure to PCDD/PCDFs, total dioxins and dioxin-like compound TEQ, total PCBs, PCB TEQ, and total DDx; these were the ecological risk drivers identified in the 17-mile BERA. An evaluation limited to just the upper 9 miles of the LPRSA resulted in the same list of ecological risk drivers as in the BERA for the entire LPRSA. Based on this analysis, a remedial action to address unacceptable ecological risk in the upper 9 miles of the LPRSA is warranted.

7.3 Basis for Action

The response action selected in this ROD is necessary to protect the public health or welfare or the environment from actual or threatened releases of hazardous substances into the environment. The excess cancer risk and non-cancer health hazards associated with human ingestion of fish and crab, as well as the ecological risks associated with ecological exposures, are above acceptable levels under baseline conditions. The IR will address areas of the riverbed in the upper 9 miles of the LPRSA with elevated contaminant concentrations that act as ongoing sources to the water column, the sediment bed, and biota. Remediating these sources will immediately reduce SWACs, accelerate recovery of the water column and the areas of the sediment bed outside the remediated area, and reduce biota exposure to contaminants. After the IR is complete and a period of post-IR response and recovery monitoring, EPA will evaluate final remedial alternatives in a remedy selection process ending with a final ROD, consistent with an adaptive management approach. The final ROD will include risk-based RGs and will specify any additional actions beyond the IR needed to address any remaining unacceptable risks in upper 9-mile sediments and surface water throughout the LPRSA, consistent with CERCLA and the NCP. As such, the IR for the upper 9 miles will not be incompatible with nor preclude a final remedy.

8. REMEDIAL ACTION OBJECTIVES

The RAOs describe what the IR is intended to accomplish. Development of the RAOs considered the physical characteristics of the upper 9 miles and the nature and extent of contamination in this river reach. The IR RAOs are based on control of elevated concentrations of 2,3,7,8-TCDD and PCB contamination in sediments, which are the primary source of risks to human health and the environment. RAOs will be developed for the final remedy.

The following RAOs have been developed for the upper 9-mile source control IR:

- **RAO 1—Addressing Surficial Sediment Source Areas**
  Control the sediment sources of 2,3,7,8-TCDD and total PCBs by remediating surface sediment source areas containing elevated concentrations, thereby reducing the SWACs[6] of 2,3,7,8-TCDD and total PCBs from RM 8.3 to RM 15. Achieve a post-IR 2,3,7,8-TCDD

[6] The SWACs apply to the reach of the LPRSA from RM 8.3 to RM 15 and are calculated based on sediment data representing the surface interval 0 to 6 inches below the surface of the sediment bed. For the IR FS, SWACs were calculated using RI data and the conditional simulation approach presented in the final RI Report for the LPRSA (AQEA 2019, Appendix J). SWACs will be recalculated based on PDI sediment sampling data, and the recalculated SWACs will be used in the IR design to define the IR footprint. Post-IR SWACs will be calculated based on surface sediment sampling data for 2,3,7,8-TCDD and total PCBs collected following construction of the IR, including dredging and placement of capping or backfill material.

SWAC[7] from RM 8.3 to RM 15 of not more than 85 ppt, approximately an order of magnitude higher than the OU2 (i.e., the lower 8.3 miles of the LPRSA) 2,3,7,8-TCDD sediment RG of 8.3 ppt[8], and achieve a post-IR total PCB SWAC from RM 8.3 to RM 15 that is at or below the established total PCB background concentration of 0.46 ppm.

- **RAO 2—Addressing Subsurface Sediment Source Areas**
  Control subsurface sediments (sediments greater than 6 inches below the sediment bed) from becoming a source of 2,3,7,8-TCDD and total PCBs by remediating sediments between RM 8.3 and RM 15 that have a demonstrated potential for erosion to expose subsurface concentrations above the defined subsurface remedial action levels (RALs) established for 2,3,7,8-TCDD and total PCBs.

As described in Section 3, a SWAC is a weighted average of sample data intended to estimate a mean contaminant concentration over a specified spatial area. For the IR, this spatial area is the reach of the LPR from RM 8.3 to RM 15, in consideration of the limited fine-grained sediments and significantly lower level of contamination above RM 15. A RAL is the contaminant concentration above which action is taken. For the IR, sediments will be removed if surface concentrations of 2,3,7,8-TCDD and/or total PCBs exceed the surface-sediment RALs or if subsurface concentrations of 2,3,7,8-TCDD and/or total PCBs exceed the subsurface sediment RALs in an area with demonstrated potential for erosion. Given EPA's conclusion based on numerous bathymetric surveys performed in the LPR (see Section 5.3) that the maximum depth of erosion is generally not more than 18 inches, the subsurface RALs will be applied to the depth interval from 6 inches to 18 inches below the sediment bed. Wherever sediments are removed, sediment removal will be to a uniform depth (assumed to be 2.5 feet) to accommodate the placement of a cap. Removing sediments with concentrations that exceed the RALs will lead to a reduction in the RM 8.3 to RM 15 SWACs.

In developing the IR remediation footprint for the upper 9-mile IR, the RAO 1 footprint will be identified first, followed by the RAO 2 footprint. RAO 1 and RAO 2 areas will be combined to create the IR footprint to be remediated.

Existing data suggest the source areas to be targeted by the IR are located between RM 8.3 and RM 15. However, the PDI will generate data throughout the upper 9 miles of the LPRSA. If sediment data that support IR design and are collected between RM 15 and Dundee Dam identify surface concentrations in excess of a final surface RAL (as specified in the IR design for RM 8.3 to RM 15), these areas will be evaluated as part of the IR.

[7] In evaluating the post-IR SWACs, the uncertainty in the SWAC calculations will be assessed. The post-IR sampling will be designed and performed to identify an acceptable envelope of uncertainty in the SWAC calculations to support a regulatory determination regarding whether RAO 1 has been achieved. A framework for this approach is provided in Appendix H of the IR FS Report.

[8] The 2,3,7,8-TCDD remediation goal (8.3 ppt) and total PCB background level (0.46 ppm) are documented in Appendix II, Tables 25 and 26, respectively, of the ROD for the lower 8.3 miles of the LPRSA (dated March 3, 2016).

EPA defines the source areas for the IR as sediments having elevated concentrations of 2,3,7,8-TCDD and/or total PCBs. These sediments have a low potential for recovery and act as a reservoir for potential migration of contamination to surface water and biota, thereby inhibiting overall abiotic and biotic recovery in the system. Source area sediments are those with 2,3,7,8-TCDD and/or total PCB concentrations greater than current water column particulate concentrations, which for 2,3,7,8-TCDD is a range of 200 to 400 ppt. Water column particulates influence system recovery through transport and deposition. Addressing source sediments will greatly reduce the 2,3,7,8-TCDD and total PCB SWACs (and reduce SWACs for other collocated contaminants that are coincidentally addressed by the remediation footprint). This in turn will reduce concentrations on suspended water column particulates, reduce concentrations in surface sediments where water column particulates are deposited, reduce sources to biota, and accelerate system recovery. In the IR design, source sediments will be defined based on the RALs; the RALs will be identified using the PDI data. This project-specific source definition aligns with the NCP and existing EPA guidance in terms of identifying sources that are "…a release of contaminants from direct and indirect continuing sources to the water body under investigation" (EPA 2005) and "…contaminants that act as a reservoir for ongoing migration and exposure" (EPA 1991). EPA expects that ecological exposure and tissue concentrations will be reduced over time in response to the IR, and that will result in a reduction in ecological and human health risk.

Achieving the SWAC for 2,3,7,8-TCDD of no greater than 85 ppt represents greater than 90-percent reduction compared to the current SWAC from RM 8.3 to RM 15. The 85 ppt level is approximately an order of magnitude higher than the OU2 sediment remediation goal for 2,3,7,8-TCDD of 8.3 ppt. EPA, in consultation with NJDEP, determined that the 85 ppt SWAC limit is an appropriate objective for a sediment source control IR for the upper 9 miles of the LPRSA that will be followed by longer-term monitoring and selection and implementation of a final remedy in an adaptive management approach. The final remedy will address remaining risk in sediments in the upper 9 miles and risk in surface water throughout the LPRSA. Final risk-based RGs will be determined in the final ROD for the LPRSA. The final ROD will be developed after the system response to the IR has been assessed and after a period of monitoring to evaluate longer-term system recovery following the source control action. EPA anticipates that this period of monitoring that will lead to a final remedy decision will last approximately 10 years.

9. SUMMARY OF REMEDIAL ALTERNATIVES

Section 121(b)(1) of CERCLA, 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 Section 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 Section 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 that at least attains ARARs under federal and state laws, unless a waiver can be justified pursuant to CERCLA Section 121(d)(4), 42 U.S.C. § 9621(d)(4).

Interim actions should protect human health and the environment from the threats they are addressing, be cost-effective, and be consistent with the final remedy. Five remedial alternatives were developed for the upper 9-mile IR. The remedial alternatives evaluated in the upper 9-mile IR FS report and presented in the proposed plan, except for the statutorily required No Action Alternative and Alternative 5, all protect human health and the environment from the threat addressed by the IR, comply with ARARs associated with the IR, and are cost-effective, thus satisfying the requirements of CERCLA. As discussed below, the active alternatives include the use of treatment technologies as part of dredged materials management.

The remedial alternatives evaluated for the upper 9-mile IR (except for the No Action Alternative) focus on source control. The common elements of the active alternatives are described below, followed by brief descriptions of each alternative. More detailed information regarding the alternatives is provided in the upper 9-mile IR FS Report.

9.1 Common Elements

Five remedial alternatives were evaluated in detail in the IR FS (described individually in Section 9.2), including the statutorily required No Action Alternative. In general, the active alternatives (i.e., alternatives other than No Action) are based on removing sediments and placing an engineered cap over remaining sediments to attain alternative-specific, post-removal SWAC targets. Certain common elements apply to any of the active alternatives, as described below.

9.1.1 Dredging and Sediment Management

Each active alternative evaluated includes sediment removal to the depths necessary to accommodate sediment capping. Dredge depths are anticipated to be 2 to 3 feet, including allowable overdredging. For the purpose of the IR FS (including cost estimating), EPA assumed a uniform removal depth of 2.5 feet (2-foot target dredge depth plus 0.5-foot overdredge allowance to account for typical dredge precision) for all alternatives using mechanical dredging with a conventional barge-mounted, clamshell dredge and/or environmental bucket. For areas of the river upstream of RM 13.9, it is assumed that land-based dredging will be necessary to accommodate fixed, low-clearance bridge constraints that preclude barge and tug operations. Contaminated sediments will be dredged to the depths necessary to construct a sediment cap without diminishing water depth or exacerbating flooding. Dredged sediments will be transported to a nearby commercial facility for processing. Following dewatering of the sediments and stabilization at the processing facility, sediments will be transported for off-site disposal at licensed disposal facilities determined based on the chemical constituents of the sediments and the acceptance criteria of the facilities. Water produced through dewatering will be contained, tested, treated, and disposed properly in accordance with testing results. The IR FS assumed transportation for various processes would be via barge, railcar, and/or truck. For the IR

FS (including cost estimating), EPA assumed disposal of dredged material at a landfill facility that is permitted to accept hazardous wastes under Subtitle C of the Resource Conservation and Recovery Act (RCRA). Precautions will be taken during transport to prevent the release of contamination; specific actions will be identified during design and implementation to reduce and minimize releases during transportation.

It is assumed that dredging will be feasible within the entirety of the IR footprint, and all possible efforts will be made to perform dredging throughout the IR footprint. If, during IR design, portions of the IR footprint are identified that have significant constraints (e.g., utility crossings, bridge abutments, or critical shoreline structures) limiting or precluding dredging and capping, thin-layer capping, and/or the in-situ placement of reactive amendments will be considered as alternate technologies for those areas.

Residual contaminated sediments remaining after remediation (residuals) can be categorized as undisturbed or generated (Patmont et al. 2018). Undisturbed residuals are contaminated sediments remaining at the post-dredging sediment surface that have been uncovered by dredging but not removed (USACE 2008b). Primary causes of undisturbed residuals include dredging limitations such as hardpan or structures, incomplete characterization or inappropriate dredge design elevation, inaccuracies in meeting target dredging elevations, and development of dredging plans that do not target complete removal due to engineering limitations or other factors (USACE 2008b). Generated residuals are contaminated sediments that are resuspended during dredging and subsequently redeposited. In addition to considering alternate technologies to address isolated issues of dredging feasibility, appropriate construction equipment and best management practices (BMPs) will be used during implementation to minimize the generation and transport of residuals. Mitigation of generated residuals will be managed in response to construction monitoring data.

While the IR approach is generally dredging to a uniform depth to accommodate an engineered cap, dredging without capping in specific portions of the remediation footprint will be evaluated. Dredging without capping is an approach that includes removal of sediments to a surface that does not require capping to isolate remaining sediments (i.e., to a surface that is demonstrably free of contamination). During the IR design, EPA expects to assess data using the following principles to determine if dredging without capping is appropriate:

- Will be considered within the dredge footprint developed to meet the sediment source control IR RAOs.
- Will be considered where native material (material that underlies contaminated sediments and is unimpacted) is visually observed in the sediment cores collected in the PDI.
- Will be considered where the costs associated with deeper dredging to reach native sediments and backfill placement (backfill would be placed where dredging without capping is performed; backfill would be accomplished by placing sand only and would not require long-

term performance monitoring) are not higher than the cost of dredging to the nominal dredge depth, capping, and long-term cap monitoring.[9]

- Will be evaluated where the depth to native material over an area of 0.25 or more contiguous acres yields the cost condition described in the bullet above, as determined using the depth to native material of at least two adjacent PDI cores.
- Would be implemented in a manner compatible with engineering, constructability, sediment stability, and safety constraints that may affect short-term effectiveness and implementability (e.g., dredging without capping would potentially not be possible in areas where sensitive infrastructure could be undermined by deeper dredging).

A cost comparison model will be developed prior to the PDI, so that the aforementioned principles can be applied, and so appropriate data can be collected to inform a detailed evaluation during the IR design of the potential application of dredging without capping. As part of the IR design, the cost comparison model will be updated using refined cost data (e.g., from remediation contractors and disposal facilities) and based on location-specific conditions that may vary for portions of the IR footprint area (e.g., dredging and capping costs associated with deeper and/or steeper portions of the river). The updated cost comparison model will be used to determine the cost comparison for discrete areas of remediation. Dredging without capping will be implemented for those discrete areas where dredging without capping would cost no more than dredging with capping.

9.1.2 Capping

Common sediment cap types include engineered granular caps, composite caps, and reactive caps. Typical cap configurations may include sand, armoring, geotextile, and reactive layers. The primary functions of a sediment cap are:

- Physical isolation of contaminated sediments from human and ecological receptors.
- Stabilization of contaminated sediments and prevention of resuspension and transport to other areas.
- Reduction of the flux of dissolved contaminants into the water column.

Each active alternative evaluated includes sediment capping following dredging. All capped areas will be pre-dredged to result in no net loss of water depth and/or increase in flooding potential once the cap is installed. It is assumed that cap material will be transported via barge and placed mechanically. For areas of the river upstream of RM 13.9, it is assumed that land-based cap material placement will be necessary, along with an alternate cap material delivery process, to accommodate fixed, low-clearance bridge constraints that preclude barge and tug operations upstream of RM 13.9.

[9] Dredging without capping can provide an enhanced degree of long-term effectiveness and permanence in areas where it is technically feasible. Other factors may be considered during IR design in evaluating the feasibility of implementing dredging without capping.

Consistent with the RM 10.9 Removal design (2013 *River Mile 10.9 Removal Action Final Design Report*), a 1-foot isolation layer was evaluated over a 100-year time frame in the IR FS to determine the cap composition that would be effective at limiting migration of underlying sediment contaminants. An evaluation of potential armor size and thickness was performed with flows associated with a 100-year return period, consistent with EPA guidance.[10] For the purposes of the FS-level cap stability analysis, armor (i.e., stone material) was assumed to be placed across the cap footprint, to a thickness of 1 foot. Cap armor needs will be refined in the IR design. The IR FS assumed that in shoal areas, habitat reconstruction material similar to existing substrate will be placed as the top 1 foot of the cap. Further consideration and refinement of the ecological and recreational function of the cap will be considered during the IR design, at which time its specific composition will be determined. Cap type and thickness may vary depending upon location and armoring requirements. Bathymetric data, geomorphic evaluations, and hydrodynamic and sediment transport model results will be used to determine erosional areas that will require armored cap placement. Additional design considerations, such as the addition of reactive amendments to the cap and ensuring that an engineered cap would not exacerbate erosion adjacent to the cap, will be established during IR design. Data and lessons learned from cap construction, cap construction monitoring, and physical and chemical cap performance monitoring at the RM 10.9 Removal area will be relied on to inform the cap design during the IR design phase. Placement of caps on slopes greater than 3:1 will require additional geotechnical analyses and design considerations. For the IR FS, it was assumed that cap thicknesses would vary from approximately 2 feet (in low-energy areas) to approximately 2.5 feet (in areas subject to greater erosion potential). A 2.5-foot cap was assumed throughout the IR footprint for the purpose of the IR FS cost estimate.

In addition, the IR FS assumed that residuals management cover (RMC) will be placed outside of the dredge and cap footprint for each alternative, as a mechanism to mitigate potential impacts of dredge residuals that might redeposit on the sediment bed outside the remediation area. RMC will potentially also be placed immediately following dredging if capping were to be delayed. The IR FS assumed that RMC would be placed to an extent equivalent to 20 percent of the remediated area, but specific RMC needs will be evaluated during IR design.

9.1.3 Institutional Controls

ICs refer to non-engineering measures intended to ensure the protectiveness of a remedy by affecting human activities to prevent or reduce the potential for exposure to contaminated media and/or to protect the integrity of the remedy. ICs are used at Superfund Sites when contamination is first discovered, when cleanups are ongoing and when residual contamination remains on-site at a level that does not allow for unlimited use and unrestricted exposure after cleanup. ICs will likely be needed both during and following completion of the IR, as recovery of the system is monitored in comparison to PRGs and until RGs are achieved. EPA has yet to identify PRGs,

[10] https://semspub.epa.gov/work/HQ/174471.pdf

which will be developed during/in parallel with the IR design; RGs will be documented in a final ROD. Potentially applicable ICs for each of the IR alternatives for the upper 9 miles of the LPRSA can be grouped into the following categories:

Governmental controls – Governmental controls may be implemented to protect the integrity of the IR or a specific IR element by prohibiting activities that could disturb or otherwise compromise its performance (e.g., restrictions on dredging, piling placement or removal, or other construction activities). Under the Code of Federal Regulations (22 CFR Part 165) a regulated navigation area (RNA) may be established to regulate vessel navigation by the appropriate government agency within a defined boundary. Examples of RNA restrictions include limitations on anchoring, spudding, or grounding vessels in capped areas.

Proprietary controls – A proprietary control is a private contractual mechanism contained in the deed or other document transferring a property. On privately owned lands, restrictive covenants are sometimes utilized to help maintain the long-term integrity of capping or other containment actions and to help control exposure scenarios (e.g., residential versus recreational uses of land). Proprietary controls may be considered IR components such as capped areas within private or publicly owned, leased, or used in waterway lands (i.e., tidelands or riparian grant lands). Such proprietary controls are referred to as "land use restrictions."

Informational Devices – These tools provide information or notification often as recorded notice in property records or as advisories to local communities, tourists, recreational users, or other interested persons including:

- Deed notices – A deed notice could be prepared and recorded that describes restrictions on property to protect capped areas and could remain in effect until the federal or state government states in writing that a change in site condition(s) warrants its removal.

- Public advisories – Fish and crab consumption advisories are an IC subject to informed voluntary compliance by the public. There is currently a NJDEP fish and crab consumption advisory for the LPR (Dundee Dam to Newark Bay).[11] This advisory recommends restrictions on consumption of fish and shellfish. New Jersey prohibits the consumption, and sale for consumption, of fish and crab from the LPR 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). It is assumed that the advisories and prohibitions will remain in effect during and following the IR. EPA would 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.

[11] https://www.nj.gov/dep/dsr/Fish_Advisories_2019.pdf

- Signage – Signs could be used to warn recreational users and other potential users of risks and to provide information about pertinent advisories. Also, signs to warn vessel operators of critical remedy area boundaries (e.g., a sediment cap) could be installed to provide added protection and notify vessel operators of applicable RNA restrictions.

ICs required for the upper 9-mile IR will be evaluated during design, along with an overall plan for IC communication, enforcement, and monitoring.

9.1.4 Habitat Considerations

The impact on and recovery of ecological habitat areas is an important aspect of remedial alternatives that involve construction in intertidal mudflats and wetland areas. These areas are home to communities of fish, birds, invertebrate species, and vegetation. There is expected to be a short-term impact associated with active remedial alternatives during construction and following completion of construction as disturbed benthic and near-shore habitat areas recover. The IR design will include management of these areas to approximately restore the habitat that supports ecological value equal to current conditions and avoid net loss of habitat, in accordance with ARARs.

9.1.5 Monitoring and Sampling

For each alternative, monitoring and sampling associated with the IR and overall cleanup of the upper 9 miles of the LPRSA will consist of data collection with respect to current conditions, PDI, IR construction, post-IR confirmation, O&M, and long-term monitoring. Anticipated monitoring activities are summarized below:

- Under the current conditions sampling program performed pursuant to the 2007 RI/FS AOC, the CPG collects the following data that are also relevant to the IR:
  - Continuous monitoring of surface water quality using deployed sensors
  - Periodic sampling of surface water for physical and chemical parameters across varying river flow conditions
  - Comprehensive sampling of fish and crab tissue
  - Bathymetric surveying

- EPA anticipates the PDI sampling program will include, but not be limited to:
  - Sediment sampling on a spatially dense grid (approximately 2,000 locations) from RM 8.3 to Dundee Dam to evaluate surface and subsurface conditions (the density of the sampling grid may be less in areas of coarse sediments)
  - A second round of sediment sampling to refine the delineation of the IR footprint and reduce variability in the PDI dataset, which would be based on results from the first round of sampling
  - Bathymetric surveying
  - Debris identification surveying

– Supporting surveys (e.g., geotechnical, habitat, cultural, fish spawning)

EPA anticipates that the PDI sediment sampling will include coring to a nominal depth of 4 ft. Anticipated coring intervals are 0 to 0.5 ft, 0.5 to 1.5 ft, 1.5 to 2.5 ft, and 2.5 to 4 ft. Core depths may be extended and/or core intervals may be refined during the PDI to ensure achievement of the data use objectives: characterization of the surface sediment interval; characterization of subsurface sediments for (a) assessment of subsurface contaminant concentrations in erosional areas, (b) waste characterization of sediments within the dredge area, and (c) characterization of sediments below the dredge depth for cap design; and characterization of sediments that may be removed following the cost break-even evaluation for dredging without capping (Section 9.1.1).

- Construction monitoring is anticipated to include, but not be limited to, confirmatory bathymetric surveys, water quality monitoring, and some limited scope of sediment sampling. Construction monitoring is also anticipated to include sediment coring to physically verify the thickness and composition of cap layers as prescribed by the IR design. Performance metrics will be established during the IR design to ensure achievement of dredging and capping extents and other construction requirements. Water quality and sediment sampling will be used to understand and mitigate potential issues associated with dredging releases.

- Post-IR confirmation sampling will include a sufficient number of sediment samples to provide a statistically unbiased estimate of the post-IR SWACs and is anticipated to include not less than 400 sediment sample locations at which 3-point composite samples would be collected. The calculated post-IR SWACs will be statistically assessed to verify that the RAO 1 SWAC goals have been achieved. In the event that the RAO 1 SWAC goals have not been achieved based on the statistical assessment, the construction monitoring conducted during the IR will be evaluated with respect to compliance with the construction requirements specified by the IR design (i.e., water quality monitoring, bathymetric surveys, discharge monitoring, inspection surveys, sediment monitoring) and the overall distribution of concentrations in the post-IR dataset will be evaluated to determine if any sediment sources remain. A multiple lines of evidence framework will be applied in this case to determine if the IR should be considered construction complete or if additional source removal is necessary. The statistical testing methodology and multiple lines of evidence framework for evaluating IR completion are described in Appendix H of the IR FS Report.

- O&M monitoring of cap areas will be conducted following construction to ensure long-term effectiveness. Bathymetry surveys and chemical sampling will be performed to assess the stability and chemical isolation performance of the cap and any potential need for maintenance to ensure continued performance (e.g., replacement of eroded cap material and/or armor stone). For cost-estimating purposes, EPA assumes cap O&M monitoring will continue for 30 years after the end of IR construction, and also that some amount of cap material will need to be replaced during this 30-year period.

- Long-term monitoring will be performed following IR completion. For cost-estimating purposes, EPA assumes long-term monitoring will continue for 30 years after IR construction, which will include both system response and recovery assessment monitoring following the IR (anticipated to last for approximately 10 years, at which point EPA will select a final remedy) and the portion of additional long-term monitoring that occurs within the 30-year timeframe after a final remedy is selected. The final ROD will document the monitoring required for the final remedy.

The PDI will be planned and implemented prior to the IR design. Details of other various future monitoring components will be established in the IR design, and data and lessons learned from cap construction, cap construction monitoring, and/or physical and chemical cap performance monitoring at the RM 10.9 Removal area will be relied on to inform those details. Monitoring data collected during the CCMP, PDI, and long-term monitoring has included or will include comprehensive laboratory analysis of samples so that appropriate and informed decisions can be made related to site-related residual risks following the IR and selection of a protective final remedy through the CERCLA remedy selection process.

9.1.6 Five-Year Reviews

Five-year reviews will be required, as the IR will result in hazardous substances, pollutants, or contaminants remaining in sediments above levels that would allow for unlimited use and unrestricted exposure. The five-year reviews will be conducted to ensure that the remedy continues to function as intended and remains protective of public health and the environment. In addition, because the selected remedy is an IR, review of this remedy will be ongoing as EPA continues to develop final remedial alternatives for the LPRSA

9.2 REMEDIAL ALTERNATIVES

The following summaries of the IR alternatives are based on the assumptions and analyses in the IR FS Report, which rely on the available data for the upper 9 miles of the LPRSA collected during the RI and documented in the RI Report. Alternative 1 is the statutorily required No Action alternative. The 85 ppt target 2,3,7,8-TCDD SWAC alternative (Alternative 2) directly addresses the IR RAOs. The 75 ppt (Alternative 3) and 65 ppt (Alternative 4) target 2,3,7,8-TCDD SWAC alternatives also address the RAOs, but the lower SWAC targets for 2,3,7,8-TCDD allowed EPA to assess whether a lower SWAC target would accomplish meaningfully greater sediment source control or provide meaningfully greater acceleration of system recovery.

The post-IR SWAC goal for total PCBs is the established total PCB background concentration of 0.46 ppm, and the available data suggest that a total PCB RAL of 1 ppm will result in a SWAC at or below this concentration. Therefore, the 85 ppt, 75 ppt, and 65 ppt target 2,3,7,8-TCDD SWAC alternatives all incorporate a total PCB surface RAL of 1 ppm. However, 2,3,7,8-TCDD concentrations dictate the IR footprint in all the active alternatives, except Alternative 5. The 125 ppt target 2,3,7,8-TCDD SWAC alternative (Alternative 5) was also evaluated to allow comparison to a smaller IR footprint and better frame the comparison between the other active alternatives. To ensure a smaller footprint, the 1 ppm total PCB surface RAL was not applied for the 125 ppt target 2,3,7,8-TCDD SWAC alternative, since applying the 1 ppm total PCB surface RAL would result in a remediation footprint of a size more consistent with the other active alternatives.

In developing the alternative-specific footprints in the IR FS, RAO 1 was applied first to address sediments until the target 2,3,7,8-TCDD SWAC was attained. RAO 2 was then applied sequentially after attaining the target 2,3,7,8-TCDD SWAC, addressing additional areas characterized as erosional and with subsurface concentrations exceeding subsurface RALs. The effect of this is further lowering the resulting SWAC in relation to the target SWAC. Table 9-1 in Appendix 2 provides a summary of the SWACs, RALs, and technical specifications for all active alternatives evaluated.

9.2.1 Alternative 1: No Action

Present Value (PV) Capital Cost:	**$0**
PV Annual O&M Cost:	**$0**
Total PV Cost:	**$0**
Construction Time:	**0 years**
Time to Achieve RAOs:	**Not applicable (N/A)**

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 Removal and RM 10.9 Removal are assumed to have been implemented. NJDEP's prohibitions on fish and crab consumption would remain in place.

9.2.2 Alternative 2: 2,3,7,8-TCDD SWAC of 85 ppt, Total PCB RAL of 1 ppm

PV Capital Cost:	**$392 million**
PV Annual O&M Cost[12]:	**$0.93 million**
Total PV Cost:	**$420 million**
Construction Time:	**4.3 years**
Time to Achieve RAOs:	**7.3 years**

Alternative 2 includes capping preceded by dredging between RM 8.3 and RM 15 in the remedial footprint delineated during the IR FS (the final IR footprint will be established during IR design based on the PDI). Alternative 2 targets source sediments with elevated concentrations of 2,3,7,8-TCDD and total PCBs, achieving a post-IR target 2,3,7,8-TCDD SWAC of 85 ppt and implementing a total PCB RAL of 1 ppm for surface sediments (0 to 0.5 ft) to address RAO 1.

[12] PV total annual and periodic O&M costs averaged over the 30-year post-construction monitoring period to estimate the PV annual O&M cost.

The delineation of the remedial footprint in the IR FS to attain a 2,3,7,8-TCDD SWAC of 85 ppt results in a surface RAL for 2,3,7,8-TCDD of 260 ppt.[13] Alternative 2 also includes additional dredging and capping in areas with erosional potential and elevated subsurface sediment concentrations (0.5 to 1.5 ft) to address RAO 2. Areas with elevated subsurface concentrations were delineated in the IR FS by applying subsurface RALs that are twice the surface RALs (520 ppt for 2,3,7,8-TCDD and 2 ppm for total PCBs). The inclusion of additional areas to address RAO 2 results in a 2,3,7,8-TCDD SWAC of 80 ppt and a total PCB SWAC of 0.29 ppm. Figure 9-1 (Appendix 1) shows the areas targeted under Alternative 2 (areas in red).

Alternative 2 includes the common engineering assumptions and considerations described in Section 9.1. This alternative includes processing of dredged material at one or more nearby commercial processing facilities, for off-site disposal at licensed disposal facilities. This alternative also includes implementation of system response and recovery assessment monitoring and adaptive management following completion of the IR to assess progress towards PRGs[14] developed during/in parallel with the IR design and, ultimately, RGs that will be established and documented in a final ROD.

Based on the estimated technical specifications for the IR alternatives shown in Table 9-1 (Appendix 2), Alternative 2 would target approximately 363,000 cy of contaminated sediments across a total area of approximately 90 acres. For the IR FS, it was assumed that an approximate equivalent quantity of clean fill materials would be imported for cap, armoring, backfill, and RMC placement.

The estimated construction time frame is approximately 4.3 years, considering the anticipated seasonal fish window (i.e., the annual period of time that dredging is not permitted due to fish spawning/migration), typical winter shutdown periods, and assumed production rates.

9.2.3 Alternative 3: 2,3,7,8-TCDD SWAC of 75 ppt, Total PCB RAL of 1 ppm

PV Capital Cost:	**$413 million**
PV Annual O&M Cost:	**$0.94 million**
Total PV Cost:	**$441 million**
Construction Time:	**4.6 years**
Time to Achieve RAOs:	**7.6 years**

[13] Final RALs for surface and subsurface sediments will be defined in the IR design. The application of a multiplier of 2 to the surface RALs to derive subsurface RALs is supported by an analysis of erosion potential and represents a site management decision agreed to by EPA and NJDEP for the purpose of the IR. This site management decision represents an uncertainty that could affect the rate and degree of natural recovery post-IR if subsurface sediments are exposed. The effect of this site management decision will be discerned through chemical and physical monitoring of the sediment bed post-IR. That information will be used in developing the final, risk-based remedy as part of the Site's adaptive management framework consistent with CERCLA and the NCP's nine criteria. During the IR design, the subsurface RAL multiplier will be evaluated based on more current bathymetry data and will not exceed 2.
[14] PRGs would be developed during/in parallel with the IR design; PRGs would not be used to evaluate the performance of the IR itself, but would be used to evaluate longer-term system recovery following the IR.

Alternative 3 includes capping preceded by dredging between RM 8.3 and RM 15 in the remedial footprint delineated during the IR FS (the final IR footprint will be established during IR design based on the PDI). Alternative 3 targets source sediments with elevated concentrations of 2,3,7,8-TCDD and total PCBs, achieving a post-IR target 2,3,7,8-TCDD SWAC of 75 ppt and implementing a total PCB RAL of 1 ppm for surface sediments (0 to 0.5 ft) to address RAO 1. The delineation of the remedial footprint in the IR FS to attain a 2,3,7,8-TCDD SWAC of 75 ppt results in a surface RAL for 2,3,7,8-TCDD of 205 ppt. Alternative 3 also includes additional dredging and capping in areas with erosional potential and elevated subsurface sediment concentrations (0.5 to 1.5 ft) to address RAO 2. Areas with elevated subsurface concentrations were delineated in the IR FS by applying subsurface RALs that are twice the surface RALs (410 ppt for 2,3,7,8-TCDD and 2 ppm for total PCBs). The inclusion of additional areas to address RAO 2 results in a 2,3,7,8-TCDD SWAC of 70 ppt and a total PCB SWAC of 0.27 ppm. Figure 9-1 (Appendix 1) shows the additional areas targeted under Alternative 3 (areas in green) compared with Alternative 2 (areas in red), which includes an additional 6 acres of footprint from RM 8.3 to RM 15, located mostly below RM 12.

Alternative 3 includes the common engineering assumptions and considerations described in Section 9.1. This alternative includes processing of dredged material at one or more nearby commercial processing facilities for off-site disposal at licensed disposal facilities. This alternative also includes system response and recovery assessment monitoring and adaptive management following completion of the IR to assess progress towards PRGs developed during/in parallel with the IR design and, ultimately, RGs that will be established and documented in a final ROD.

Based on the estimated technical specifications for the IR alternatives shown in Table 9-1 (Appendix 2), Alternative 3 would target approximately 387,000 cy of contaminated sediments across a total area of approximately 96 acres. For the IR FS, it was assumed that an approximate equivalent quantity of clean fill materials would be imported for cap, armoring, backfill, and RMC placement.

The estimated construction time frame is approximately 4.6 years, considering the anticipated seasonal fish window, typical winter shutdown periods, and assumed production rates.

9.2.4 Alternative 4: 2,3,7,8-TCDD SWAC of 65 ppt, Total PCB RAL of 1 ppm

PV Capital Cost:	**$440 million**
PV Annual O&M Cost:	**$0.95 million**
Total PV Cost:	**$468 million**
Construction Time:	**4.9 years**
Time to Achieve RAOs:	**7.9 years**

Alternative 4 includes capping preceded by dredging between RM 8.3 and RM 15 in the remedial footprint delineated during the IR FS (The final IR footprint will be established during IR design based on the PDI). Alternative 4 targets source sediments with elevated concentrations of 2,3,7,8-TCDD and total PCBs, achieving a post-IR target 2,3,7,8-TCDD SWAC of 65 ppt and implementing a total PCB RAL of 1 ppm for surface sediments (0 to 0.5 ft) to address RAO 1. The delineation of the remedial footprint in the IR FS to attain a post-IR 2,3,7,8-TCDD SWAC of 65 ppt results in a surface RAL for 2,3,7,8-TCDD of 164 ppt. Alternative 4 also includes additional dredging and capping in areas with erosional potential and elevated subsurface sediment concentrations (0.5 to 1.5 ft) to address RAO 2. Areas with elevated subsurface concentrations were delineated in the IR FS by applying subsurface RALs that are twice the surface RALs (328 ppt for 2,3,7,8-TCDD and 2 ppm for total PCBs). The inclusion of additional areas to address RAO 2 results in a 2,3,7,8-TCDD SWAC of 60 ppt and a total PCB SWAC of 0.24 ppm. Figure 9-1 (Appendix 1) shows the additional areas targeted under Alternative 4 (areas in blue) compared with Alternative 3 (areas in green) and Alternative 2 (areas in red), which includes an additional 8 acres of footprint from RM 8.3 to RM 15, located mostly below RM 13.

Alternative 4 includes the common engineering assumptions and considerations described in Section 9.1. This alternative includes processing of dredged material at one or more nearby commercial processing facilities for off-site disposal at licensed disposal facilities. This alternative also includes system response and recovery assessment monitoring and adaptive management following completion of the IR to assess progress towards PRGs developed during/in parallel with the IR design and, ultimately, RGs that will be established and documented in a final ROD.

Based on the estimated technical specifications for the IR alternatives shown in Table 9-1 (Appendix 2), Alternative 4 would target approximately 419,000 cy of contaminated sediments across a total area of approximately 104 acres. For the IR FS, it was assumed that an approximate equivalent quantity of clean fill materials would be imported for cap, armoring, backfill, and RMC placement.

The estimated construction time frame is approximately 4.9 years, considering the anticipated seasonal fish window, typical winter shutdown periods, and assumed production rates.

9.2.5 Alternative 5: 2,3,7,8-TCDD SWAC of 125 ppt

PV Capital Cost:	**$294 million**
PV Annual O&M Cost:	**$0.89 million**
Total PV Cost:	**$321 million**
Construction Time:	**3.2 years**
Time to Achieve RAOs:	**N/A**

Alternative 5 includes capping preceded by dredging between RM 8.3 and RM 15 in the remedial footprint delineated during the IR FS. Alternative 5 targets source sediments with elevated concentrations of 2,3,7,8-TCDD, achieving a post-IR target 2,3,7,8-TCDD SWAC of

125 ppt. For this alternative, PCBs are not specifically targeted to ensure a smaller IR footprint is achieved for comparison purposes (since applying the 1 ppm total PCB surface RAL would result in a remediation footprint of a size more consistent with the other active alternatives). Therefore, no total PCB RAL was applied in the IR FS for this alternative. The delineation of the remedial footprint to attain a post-IR 2,3,7,8-TCDD SWAC of 125 ppt in the IR FS results in a surface (0 to 0.5 ft) RAL for 2,3,7,8-TCDD of 346 ppt. Alternative 5 also includes additional dredging and capping in areas with erosional potential and elevated subsurface sediment concentrations (0.5 to1.5 ft) to address RAO 2. Areas with elevated subsurface concentrations were delineated in the IR FS by applying a subsurface RAL that is twice the surface RAL (692 ppt for 2,3,7,8-TCDD). Inclusion of these additional areas in the IR footprint results in a 2,3,7,8-TCDD SWAC of 121 ppt and a total PCB SWAC of 0.49 ppm.

Alternative 5 includes the common engineering assumptions and considerations described in Section 9.1. Dredged materials would be processed at one or more nearby commercial processing facilities, for off-site disposal at licensed disposal facilities. Following completion of the IR, system response and recovery assessment monitoring and adaptive management would be implemented to assess progress towards PRGs developed during/in parallel with the IR design and, ultimately, RGs that will be established and documented in a final ROD.

Based on the estimated technical specifications for the remedial alternatives shown in Table 9-1 (Appendix 2), Alternative 5 would target approximately 250,000 cy of contaminated sediments across a total area of approximately 62 acres. For the IR FS, it was assumed that an approximate equivalent quantity of clean fill materials would be imported for cap, armoring, backfill, and RMC placement.

The estimated construction time frame is approximately 3.2 years, considering the anticipated seasonal fish window, typical winter shutdown periods, and assumed production rates.

This alternative, with a 125 ppt target 2,3,7,8-TCDD SWAC, would not achieve the 2,3,7,8-TCDD SWAC goal of not more than 85 ppt in RAO 1 and EPA did not consider it to be a candidate alternative. It was evaluated to allow comparison to a smaller IR footprint and better frame the comparison between the other active alternatives.

10. COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES

In selecting a remedy for a site, EPA considers the factors set forth in Section 121 of CERCLA 42 U.S.C. § 9621, and conducts a detailed analysis of the viable remedial alternatives pursuant to Section 300.430(e)(9) of the NCP, 40 C.F.R. § 300.430(e)(9), EPA's Guidance for Conducting Remedial Investigations and Feasibility Studies, OSWER Directive 9355.3-01, and EPA's *A Guide to Preparing Superfund Proposed Plans, Records of Decision, and Other Remedy Selection Decision Documents*, OSWER 9200.1-23.P. The detailed analysis consists of an assessment of the individual alternatives against each of the nine evaluation criteria at 40 C.F.R. § 300.430(e)(9)(iii) and a comparative analysis focusing upon the relative performance of each alternative against those criteria. A summary of key metrics used in the Comparative Analysis is presented in Table 10-1 (Appendix 2). The cost for each alternative is also included in this table.

***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.

While all the alternatives evaluated are for an interim action, not a final action, with the exception of Alterative 1 each of the alternatives would result in conditions that would contribute to a final remedy for the LPRSA that is protective of human health and the environment. Alternatives 2, 3, and 4 would provide overall protection of human health and the environment by remediating source sediments with elevated contaminant concentrations to achieve the RAOs and accelerate the recovery of sediments, water column, and fish and crab tissue contaminant concentrations. These alternatives would reach post-IR surface sediment SWACs for 2,3,7,8-TCDD of less than 85 ppt and for total PCBs of less than 0.46 ppm and would control subsurface sediments from becoming sources. Alternative 1, the No Action alternative, would not provide overall protection of human health and the environment. Alternative 5, while it has the ability to accelerate recovery and progress towards overall protection of human health and the environment, would not accelerate recovery to the same degree as Alternative 2, 3, or 4 and would not achieve the RAO 1 requirement to reach a post-IR surface sediment SWAC for 2,3,7,8-TCDD of not more than 85 ppt. The NJDEP fish and crab consumption advisories will help ensure that human health is protected in the short term.

Remediation of sediments within the IR footprint for Alternatives 2, 3, and 4 would be anticipated to achieve the following:

- Attainment of RAO 1, post-IR target SWACs of not more than 85 ppt for 2,3,7,8-TCDD and 0.46 ppm for total PCBs (subject to post-construction confirmation of IR completion in accordance with the IR remedy completion framework).
- Remediation of sediments with elevated concentrations of 2,3,7,8-TCDD and total PCBs, reducing the potential for these contaminated sediments to resuspend and become sources of contamination to the water column, to other areas of the sediment bed, and to biota.
- Reduction of 2,3,7,8-TCDD surface sediment SWAC of greater than 90 percent and reduction of total PCB surface sediment SWAC of greater than 80 percent.
- Accelerated recovery of surface sediment concentrations of 2,3,7,8-TCDD, total PCBs, and other contaminants following IR completion.

- Accelerated recovery of surface water concentrations of 2,3,7,8-TCDD, total PCBs, and other contaminants following IR completion.
- Reduction of fish and crab tissue concentrations of 2,3,7,8-TCDD, total PCBs, and other contaminants resulting from reduced concentrations in sediments and the water column.
- Reduced potential for human health exposure to 2,3,7,8-TCDD, total PCBs, and other contaminants resulting from sediment, water column, and fish and crab tissue concentration reductions.

10.2 Compliance with 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).

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. Only those State standards identified by a state in a timely manner and that are more stringent than Federal requirements may be applicable.

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. 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. ARARs can be location-specific, action-specific, or chemical-specific. Tables 10-2 and 10-3 in Appendix 2 present the ARARs identified for this IR.

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

There are no chemical-specific ARARs for sediments. Alternatives 2, 3, 4, and 5 would satisfy location-specific ARARs (key potential location-specific ARARs include the Endangered Species Act, the Migratory Bird Treaty Act, the Coastal Zone Management Act, the Rivers and Harbors Act, and the Wetland Act of 1970/Freshwater Wetlands Protection Act) and action-specific ARARs (key potential action-specific ARARs include the requirements of the Clean Water Act that would apply to dredging and capping, the RCRA requirements that would apply to management of dredged materials, the New Jersey Water Pollution Control Act, the Clean Air Act, and the Hazardous Materials Transportation Act). The active alternatives could require one or more ARAR waivers during construction to meet the threshold criterion of compliance with ARARs. Although waivers could be required, actions will be taken to limit water quality impacts during construction.

Alternatives 2, 3, 4, and 5 are anticipated to comply with the ARARs through appropriate engineering design and agency review processes. Confirmation of ARARs compliance is typically demonstrated during remedial design and through the remedial action work plan (e.g., environmental protection plan, construction quality control plan, waste management plan, transportation and disposal plan, stormwater pollution and spill prevention plan, and BMPs) as well as monitoring during the construction period.

A final remedy for surface water throughout the LPRSA (in addition to a final remedy for sediments in the upper 9 miles) will be established in the final ROD for the 17-mile LPRSA. While Alternatives 2, 3, 4, and 5 would be anticipated to improve water quality, ARARs for water quality may not be achieved following completion of any of the active IR alternatives. It is anticipated that the final ROD for the 17-mile LPRSA will evaluate achievement of surface water ARARs.

***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 refer to expected residual risk and the ability of a remedy to maintain reliable protection of human health and the environment over time, once cleanup 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.

This criterion considers the residual risk remaining at the conclusion of remedial activities, and the adequacy and reliability of containment systems and ICs. Key parameters assessed for the comparative analysis of IR alternatives are source control and recovery potential; cap stability; and monitoring, maintenance, and ICs.

Alternatives 2, 3, and 4 achieve a high degree of performance for this criterion. All three alternatives would provide source control that would reduce concentrations in the water column and promote accelerated recovery in the unremediated areas of the sediment bed. Dredging and capping would reduce the surface SWAC from RM 8.3 to RM 15 by 91 to 94 percent for 2,3,7,8-TCDD and 81 to 84 percent for total PCBs for these three alternatives.

The surface RALs for 2,3,7,8-TCDD under Alternatives 2, 3, and 4 are (to varying degrees) within or below the range of concentrations (200 to 400 ppt) that EPA has identified for the IR to define source sediments that inhibit recovery (Figure 10-1 in Appendix 1). The 2,3,7,8-TCDD surface RAL of 164 ppt for Alternative 4 is less than the low end of this range, indicating this alternative may include areas in the active IR footprint that are currently subject to recovery on their own and not consistent with the definition of source sediments for the IR. The 2,3,7,8-TCDD surface RAL of 260 ppt for Alternative 2 is within the range of concentrations defined as source, while the 2,3,7,8-TCDD surface RAL of 205 ppt for Alternative 3 coincides with the low end of the range of concentrations defined as source. Thus, Alternative 3 provides the greatest certainty of meeting the IR source control objective, without including areas that are or may already be experiencing natural recovery.

The areas and volumes of sediment removal increase incrementally from Alternative 2 to Alternative 4 to meet the progressively lower 2,3,7,8-TCDD SWAC targets, without a commensurate degree of incremental 2,3,7,8-TCDD and PCB mass removal. While the overall remedial acreage and volume increases by more than 15 percent from Alternative 2 to Alternative 4, the increase in mass of 2,3,7,8-TCDD and PCBs removed from the top 0.5 ft of the sediment bed is much more modest, increasing by less than 2 and 4 percent, respectively.

The IR footprint and RALs are derived by addressing the highest sediment concentrations first followed by lower concentrations until the target SWAC is reached. Therefore, the highest concentrations on average are targeted by the alternative with the smallest footprint. Progressively lower concentrations are targeted as remedial area is added to achieve the lower SWACs of the alternatives with increasingly larger footprints (Figure 10-2 in Appendix 1). The average 2,3,7,8-TCDD concentration targeted in the IR footprint is 2,870 ppt for Alternative 2. It is 220 ppt in the 6 acres added for Alternative 3 (which is within the range of concentrations considered source sediments for the IR) and 170 ppt in the further 8 acres added for Alternative 4 (which is below the range of concentrations considered source sediments for the IR). The change in the distribution of post-IR concentrations relative to pre-IR concentrations is similar for Alternatives 2, 3, and 4 (i.e., the distribution of remaining concentrations is similarly skewed towards lower concentrations for each alternative).

Alternatives 2, 3, and 4 all target LPR sediments classified as fine-grained sediments. However, the additional areas of sediments targeted under Alternatives 3 and 4 (compared with Alternative 2) include sediments that are progressively coarser. Because the contamination in the LPR is closely associated with fine-grained sediments, the increasing volume of coarser sediments addressed by the alternatives with larger footprints, and particularly Alternative 4, may not represent source material.

Alternatives 2, 3, and 4 are expected to provide similar degrees of recovery potential based on numerical modeling of several recovery metrics, including average water column concentrations, total water column loads, gross and net erosion flux, and the average concentration on depositing fine sediments over the 10-year period following IR construction, and would result in similarly accelerated recovery of the sediments and water column. Reductions of erosion flux of contaminants from the sediment bed for each alternative would result in reduced concentrations on depositing fine sediments and downstream loads of 2,3,7,8-TCDD and PCBs. The projected recovery half-lives for 2,3,7,8-TCDD and PCBs (a representation of recovery trajectory) for Alternatives 2, 3, and 4 are similar, indicating they would yield similarly accelerated recovery.

The cap stability would be refined in design but is assumed to have a 1-foot isolation layer that could withstand flows associated with a 100-year return period, which is consistent with EPA guidance.

More detailed information related to the use of numerical modeling and the results of this modeling in the context of the comparative evaluation of IR alternatives under Long-Term Effectiveness and Permanence is provided in the IR FS Report.

10.4 Reduction of Toxicity, Mobility, or Volume of Contaminants via Treatment

Reduction of toxicity, mobility, or volume via 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), only natural recovery processes would potentially reduce contaminant concentrations in sediments and surface water. There would be no reduction of toxicity, mobility, or volume via treatment.

The active alternatives would use two treatment components to reduce the toxicity and/or mobility of contaminants: (1) solidification/stabilization during processing after removal, and (2) in situ sequestration via capping including a carbon amendment. The degree to which reductions would be achieved would be proportional to the contaminant mass removed and the area of the cap footprint. The mass fraction of 2,3,7,8-TCDD removed from the upper 0.5 ft of the sediment bed ranges from 92 to 94 percent of the total surface mass from RM 8.3 to RM 15 and from 80 to 85 percent of the total mass for the upper 2.5 ft of the sediment bed from RM 8.3 to RM 15 for the three alternatives (Alternatives 2, 3, and 4) that achieve the threshold criteria. The mass fraction of total PCBs removed from the upper 0.5 ft of the sediment bed ranges from

82 to 85 percent of the total surface mass from RM 8.3 to RM 15 and from 64 to 68 percent of the total mass for the upper 2.5 ft of the sediment bed from RM 8.3 to RM 15 for the three alternatives that achieve the threshold criteria. The area over which an erosion and chemical migration resistant cap that would reduce the mobility of contaminants would be placed to isolate remaining sediments would be 90 acres for Alternative 2, 96 acres for Alternative 3 (7 percent larger than Alternative 2), and 104 acres for Alternative 4 (8 percent larger than Alternative 3).

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 as well as on-site workers and the environment, available mitigation measures, and the time frame for achieving the response objectives. Key parameters assessed for the comparative analysis of IR alternatives are time to achieve RAOs, worker risk and community impact, resuspension, and downstream and upstream transport.

Alternatives 2, 3, and 4 would achieve the RAOs in approximately 7.3, 7.6, and 7.9 years, respectively, following the start of construction, based on estimated respective construction durations of 4.3, 4.6, and 4.9 years and the IR completion assessment process taking approximately 3 years for any alternative. The IR completion assessment process will include implementation of sediment sampling, validation and analysis of results, potential additional sampling to address uncertainty in the data or the need for additional data for statistical interpretation, and the decision-making process following completion of data collection activities. The 3-year time frame for the IR completion assessment process represents a period of measurement, after which it can be stated the RAOs have been achieved. Despite this 3-year time frame, Alternatives 2, 3, and 4 would be designed and implemented to attain the RAOs at the completion of construction.

The estimated construction durations vary with the area and volume of the remedial footprints, with construction activities assumed to occur 24 hours per day, 6 days per week during the construction season. Appropriate health and safety plans and contingency plans would be in place during implementation of an IR to protect workers and the community. Impacts to communities from construction of the IR would potentially include temporary noise, light, odors, blocked views, traffic, and disruptions to commercial and recreational river users.

Alternative 2, which has the smallest IR footprint (of the alternatives that achieve the threshold criteria) and the shortest estimated construction duration, would have the fewest short-term impacts on and risks to workers, communities, and the ecosystem, in a relative comparison with the alternatives with larger footprints. These impacts are expected to arise in general proportion to the size of the remedial footprint of the remedial alternatives. The extent to which habitat and ecological disturbance may increase in proportion to the IR footprint is uncertain and would depend on final delineation of the IR footprint using the PDI data. The IR design will include management of ecologically sensitive areas to approximately restore the habitat that supports ecological value equal to current conditions and avoid net loss of habitat. Alternative 4, the alternative with the largest IR footprint (approximately 14 acres larger than Alternative 2) and longest estimated construction duration (approximately 0.6 years longer than Alternative 2), would have the greatest short-term impacts.

While Alternatives 2, 3, and 4 are all estimated to be complete within approximately 5 years, the larger the footprint, the greater the potential that work would extend into another construction season if delays are encountered, which would result in another season of worker risks and community impact.

Studies have shown that dredging can result in resuspension loss of 1 percent to 3 percent of the material removed. Resuspension of contaminants during construction would be expected to be generally similar for Alternatives 2, 3, and 4, based on model projections of annual average water column concentrations. During active construction, average annual water column concentrations for Alternatives 2, 3, and 4 are projected to be higher than the No Action alternative. For all of the alternatives, annual average water column concentrations at the completion of active construction would be expected to be generally lower than pre-construction concentrations.

At RM 15, there is little projected impact of IR implementation, and the average annual and cumulative net upstream water column load would be expected to be nearly the same for Alternatives 2, 3, and 4 as compared to No Action. At RM 8.3, the implementation of an IR is projected to increase the downstream loads of 2,3,7,8-TCDD and total PCBs in the water column during construction, compared to the No Action alternative, with similar increases for Alternatives 2, 3, and 4. At the conclusion of active construction, the water column loads for Alternatives 2, 3, and 4 at RM 8.3 would be expected to be at or near the projected load under No Action. The implementation of an IR is projected to have a small impact on the water column loads at RM 0, evidenced in the projections of total load, which are generally similarly minor for all alternatives over the construction period.

More detailed information related to the evaluation of resuspension and downstream and upstream transport and the results of these evaluations in the context of the comparative evaluation of IR alternatives under the short-term effectiveness criterion is provided in the IR FS Report.

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.

This criterion considers the technical and administrative feasibility of implementing each alternative, including availability of services and materials needed during construction.

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

The technologies and methods to perform the active alternatives are well established. Necessary equipment, materials, facilities, and transportation capacity would be available for the active alternatives with sufficient lead times. The active alternatives would require BMPs during implementation to manage dredge residuals and potential recontamination. Construction of the IR would face implementability challenges in the upper 9 miles of the LPRSA owing to the urban environment. Specific challenges that could impact dredging and would need to be considered during IR design and implementation include utility crossings, existing shoreline structures, in-water bridge structures, and hard river bottom. For example, designing and implementing the IR where the footprint abuts hardened or engineered shoreline could require significant effort to avoid damaging engineered shoreline structures or to rebuild or replace failing structures, and/or result in lower production rates or unanticipated delays. Alternative 2 would abut an estimated 37,792 linear feet of hardened shoreline, compared with 39,551 and 41,454 linear feet that would be abutted by Alternatives 3 and 4, respectively. This is an increase of 5 percent (Alternative 3) and 10 percent (Alternative 4) in hardened shoreline compared to Alternative 2.

The transportation of materials up and down the LPR would also present implementability challenges owing to low clearance and/or narrow bridges, which could necessitate custom or specialized equipment, as well as transiting tugs and barges through the lower 8.3 miles during active remediation of that reach of the river. Implementation of the IR could require additional removal in and/or around the RM 10.9 Removal area, which could introduce additional implementability challenges associated with protecting the existing armored cap over that previously remediated area. The extent of remediation in and/or around the RM 10.9 area will be determined during the IR design when the IR footprint is finalized.

Among the active alternatives, the larger the remedial footprint, the greater challenges and constraints, because of the need to dredge in more areas and over a longer time frame. Although implementability challenges would be similar in type for all active alternatives, the degree of the challenges can be anticipated to increase in general proportion to the size of the remedial footprint. It is anticipated that any of the alternatives can be designed to address these challenges.

10.7 Cost

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

Cost estimates are summarized in Table 10-4 (Appendix 2). A discount rate of 7 percent was used in the PV calculations, consistent with EPA guidance.

Alternatives that achieve the RAOs (Alternatives 2, 3, and 4) are estimated to have a PV cost of $420 million, $441 million, and $468 million, respectively. There are no remedial response costs associated with Alternative 1. Costs that are assumed to be the same for the active alternatives include the PDI and IR design, long-term monitoring, and periodic sediment sampling (which includes remedy completion confirmation sampling). Other costs vary with area, volume, and construction duration. The cost estimates assume that long-term monitoring and maintenance will occur over a 30-year period following completion of construction, including both system response and system recovery assessment monitoring following the IR and additional long-term monitoring when a final remedy is selected under a final ROD.

Alternatives 2, 3, and 4 all achieve the RAOs for the IR, with an additional cost of $21 million and $48 million for Alternatives 3 and 4, respectively, compared with Alternative 2.

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/FS 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 4.

10.9 Community Acceptance

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

Community acceptance of the selected IR for source control in the upper 9 miles of the LPRSA was evaluated based upon the comments received during the public comment period. The Proposed Plan for the IR indicated that Alternative 3 was EPA's preferred alternative. There was overwhelming support for the IR Proposed Plan for the upper 9 miles, including letters from the City of Clifton, Bergen County, the Township of Nutley, the City of Garfield, and the Borough of North Arlington. In addition, resolutions of support were submitted as public comments from Belleville, East Rutherford, Garfield, Lyndhurst, Rutherford, and Wallington. EPA also received letters of support from New Jersey Senator Paul Sarlo and New Jersey Assemblyman Clinton Calabrese. The letters and resolutions generally support the tenets of the IR for the upper 9 miles of the LPRSA and the expedited schedule that aligns with the remedy for the lower 8.3 miles of the LPRSA. The letters and resolutions advised EPA to keep in mind flooding impacts, shoreline erosion issues, EJ impacts, and careful assessment of the upper 2 miles (i.e., to ensure that the area from RM 15 to Dundee Dam is appropriately investigated during the PDI and action taken in that reach as necessary).

The CAG, which is composed of approximately 20 members representing local citizens and businesses, environmental and recreational groups, and municipalities and educators, supported the preferred alternative. Some environmental groups supported the preferred alternative, while others suggest consideration of alternate remediation technologies to implement the preferred alternative. A local boating and rowing club expressed concern over the impact on their ability to use the river during the construction. Individual residents of adjacent communities expressed concern over the scale of the IR, potential impacts to drinking water, potential traffic impacts, and the cost of the IR. Appendix 5, the Responsiveness Summary, addresses the comments received at the public meetings and written comments received during the public comment period.

11. PRINCIPAL THREAT WASTES

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. 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. They include liquids and other highly mobile materials (e.g., solvents) or materials having high concentrations of toxic compounds. No "threshold level" of toxicity/risk has been established to equate to "principal threat." However, where toxicity and mobility of source material combine to pose a potential risk of 1×10^{-3} or greater, treatment alternatives should generally be evaluated. The NCP states that EPA expects to use treatment to address principal threats posed by a site whenever practicable.

The dioxin, PCB, and other contaminant concentrations in sediments throughout the LPRSA are present at levels contributing to significant risks (greater than 1×10^{-3}) for humans consuming fish and crab caught in the LPRSA. As previously stated, the IR is developed to remove and control sediments that have elevated contaminated concentrations and act as a reservoir for potential migration of contamination to the water column, other areas of the sediment bed, and biota. EPA considers the most highly contaminated sediments as principal threat wastes. However, engineering and sediment transport modeling work done as part of the IR FS determined that the source area sediments, despite their toxicity, under current conditions, may be reliably contained.

Additionally, EPA does not believe that treatment of all the sediments in the upper 9 miles of the LPRSA is practicable or cost effective given the high volume of sediments the number of contaminants that would need to be addressed and lack of applicable and mature in situ (i.e., in-place) treatment technologies. However, as discussed in this ROD, EPA has considered treatment as a component of dredged material management and capping. In addition, in the event that there are isolated limitations to the feasibility of dredging and capping, alternative technologies including the in situ placement of reactive (i.e., treatment) amendments would be considered for those areas.

12. SELECTED REMEDY

Based upon an evaluation of the results of previous site investigations, input from EPA's CSTAG and members of EPA's NRRB, the detailed analysis of the various remedial alternatives, and public comments, EPA has selected Alternative 3 (implementing sediment source control to achieve a post-IR target 2,3,7,8-TCDD SWAC of 75 ppt for RM 8.3 to RM 15, incorporating a total PCB surface sediment RAL of 1 ppm) as the IR for the upper 9 miles of the LPRSA. This is the IR alternative offered as the preferred alternative by EPA in the IR Proposed Plan, which was released for public review and comment in accordance with CERCLA and the NCP.

Following are the key factors that led EPA to select this IR alternative:

- The IR is for sediment source control. Source sediments are those with elevated concentrations, defined generally as those with concentrations of 2,3,7,8-TCDD, in the range of 200 and 400 ppt and above. The 2,3,7,8-TCDD surface RAL, based on available data, is 260 ppt for Alternative 2, 205 ppt for Alternative 3, and 164 ppt for Alternative 4. The RAL for Alternative 3 aligns with the lower end of the range of concentrations representing source. The RAL for Alternative 2 is within but not at the lower end of this range, while the RAL for Alternative 4 is below the range and therefore would be expected to capture sediments that are not source sediments and are likely to be recovering. Alternative 3 therefore will most effectively address source sediments consistent with the intent and purpose of the IR (Figure 10-1 in Appendix 2).

- Based on available data, the average 2,3,7,8-TCDD concentration addressed by the footprint for Alternative 2 is 2,870 ppt, while the average concentration addressed in the additional 6 acres included for Alternative 3 is 220 ppt, and the average concentration addressed in the yet additional 8 acres included for Alternative 4 is 170 ppt. Given the average concentration in the additional footprint area for Alternative 3 is within the range of concentrations defined as source and the average concentration in the additional footprint area for Alternative 4 is below the range, this further demonstrates that Alternative 3 is most suitable to accomplish sediment source control per the intent and purpose of the IR while Alternative 4 would go beyond that intended source control, addressing areas that may be experiencing natural recovery (Figure 10-2 in Appendix 2).

- Contaminant concentrations generally correlate with sediment type in the LPR, with higher concentrations tending to be found in finer-grained sediments. Progressively larger IR footprints would capture progressively coarser sediments. Alternative 2 would capture sediments that are on average approximately 60- to 65-percent fine-grained, while the additional sediments captured by Alternative 3 (beyond Alternative 2) are on average approximately 40-percent fine-grained and the yet additional sediments captured by Alternative 4 (beyond Alternative 3) are on average approximately 35-percent fine-grained. Based on the distribution of 2,3,7,8-TCDD concentrations in sediment samples from the upper 9 miles of the LPRSA in comparison to the grain size of the samples, relatively high concentrations are associated with sediments that are on the order of 40- to 60-percent fine-grained (resulting from higher concentrations in the fine-grained fraction of those sediments) while the likelihood of high contaminant concentrations diminishes significantly when the sediments are only 35-percent fine-grained. This indicates that implementing Alternative 3 would address additional source material beyond that addressed by Alternative 2, even if the additional sediments captured by Alternative 3 are relatively coarser, whereas Alternative 4 would include yet coarser-grained sediments not likely to exhibit elevated contaminant concentrations indicative of source sediments. This shows that the additional footprint area for Alternative 3 includes more comprehensive control of source material while minimizing inclusion of non-source material.

- Alternative 3 will be cost effective in that it provides overall effectiveness (taking into account long-term effectiveness and permanence; reduction in toxicity, mobility, or volume through treatment; and short–term effectiveness) proportional to its cost.

The major components of the selected IR include the following:

- A comprehensive PDI will be implemented to assess baseline conditions, inform the IR design, and facilitate post-IR response and recovery assessment.
- Surface sediments (0 to 0.5 ft) with elevated concentrations of 2,3,7,8-TCDD and/or total PCBs between RM 8.3 and RM 15 will be targeted through dredging and capping to address RAO 1, achieving a post-IR 2,3,7,8-TCDD SWAC of 75 ppt and implementing a total PCB surface RAL of 1 ppm.
- Areas between RM 8.3 and RM 15 that are vulnerable to erosion and have elevated subsurface concentrations of 2,3,7,8-TCDD and total PCBs will be dredged and capped to address RAO 2.
- Dredging will be performed to the depth(s) necessary to construct a sediment cap that is designed to isolate underlying contamination, prevent contaminant migration, and resist erosion, and will not diminish water depth or exacerbate flooding.
- Dredged material will be processed, stabilized, and then disposed of off-site.

- The specific composition and thickness of the cap will be determined in the IR design, and dredge depth and cap composition/thickness may vary in portions of the remediation footprint.
- Some areas may be dredged to native (uncontaminated) sediments based on a cost-effectiveness review. In these areas, there would be no need for an engineered cap and associated O&M. Dredging without capping in these areas could enhance the overall long-term effectiveness and permanence of the IR.
- The area above RM 15 will be assessed carefully during the IR design based on the PDI data and to identify potential source areas.
- Appropriate and necessary ICs will be implemented in conjunction with the IR.
- Monitoring and sampling will be performed to evaluate the IR during construction and to assess post-IR conditions.
- Adaptive management will be applied to evaluate IR performance, assess the response of the system to the IR and the long-term recovery of the system, and to inform selection of a final risk-based remedy in a final ROD.

12.1 Source Sediments Definition and Delineation

Source sediments are defined as sediments having elevated 2,3,7,8-TCDD concentrations in the range of 200 and 400 ppt and above. These sediments have a low potential for recovery, and act as a reservoir for potential migration of contamination to surface water and biota, thereby inhibiting overall recovery in the system. For purposes of the IR, EPA has defined sediments with low recovery potential as those with 2,3,7,8-TCDD and/or total PCB concentrations greater than those associated with current water column particulate concentrations. Water column particulates influence system recovery through transport and deposition. Addressing source sediments would greatly reduce the 2,3,7,8-TCDD and total PCB SWACs (and reduce SWACs for other collocated contaminants that are addressed by the IR footprint), which would in turn reduce concentrations of suspended water column particulates, reduce concentrations in surface sediments where water column particulates are deposited, reduce sources to biota, and accelerate system recovery.

The areas of source sediments to be addressed by the IR will be defined during the IR design based on the RALs identified to achieve the RAOs for the selected IR. These RALs will be identified using PDI data (Section 12.1.1) and through the footprint derivation process (Section 12.1.2). The footprint derivation process will establish the total area of source sediments to be addressed by the IR.

12.1.1 Current Conditions Monitoring Program and Pre-Design Investigation

Beginning in 2019, under the 2007 RI/FS AOC, a CCMP was performed in the upper 9 miles of the LPRSA which also provided data that will be relevant to the IR. The CCMP included bathymetric surveys,, physical and chemical water column monitoring at multiple stations in the upper 9 miles (and at times below the upper 9 miles when characterizing the area of the salt front), and contaminant monitoring in fish and crab tissue. These data will help establish pre-IR baseline conditions, facilitate post-IR evaluation of system response and recovery, and support refinement of models, to identify potential source areas used to predict system behavior. EPA anticipates that the CCMP data overall will be used in the IR design to support footprint development and construction and long-term monitoring approaches.

The PDI will be completed to support the IR design. The PDI is anticipated to include, but not be limited to:

- Sediment sampling on a spatially dense grid (approximately 2,000 locations) from RM 8.3 to Dundee Dam to evaluate surface and subsurface conditions (the spatial density of sampling may be less in areas of coarse sediments).
- A second round of sediment sampling to refine the delineation of the remedial footprint, better constrain data variability, and minimize the potential for targeting errors in the IR footprint, as needed.
- Sediment sampling is anticipated to include coring to a nominal depth of 4 ft. Anticipated coring intervals are 0 to 0.5 ft, 0.5 to 1.5 ft, 1.5 to 2.5 ft, and 2.5 to 4 ft. Core depths may be extended and/or core intervals may be refined during the PDI to ensure achievement of the data use objectives:
    - Characterization of the surface sediment interval.
    - Characterization of subsurface sediments for (a) assessment of subsurface contaminant concentrations in erosional areas, (b) waste characterization of sediments above the dredge depth, and (c) characterization of sediments below the dredge depth for cap design.
    - Characterization of sediments that may be removed following the cost break-even evaluation for dredging without capping.
- Additional bathymetry surveying.
- Debris identification surveying.
- Geotechnical evaluations.
- Supporting surveys (e.g., habitat, cultural, fish spawning).

The PDI sediment sampling program will be critical in establishing refined estimates of the pre-IR SWACs, developing the IR footprint (Section 12.1.2), and informing the statistical testing methodology to evaluate IR success (Section 12.3).

12.1.2 IR Footprint Development

Successful source control during the IR will require accurate mapping of 2,3,7,8-TCDD and total PCB concentrations in sediments, and accurate delineation of areas to be remediated.

As described in Section 12.1.1, sediments will first be sampled on a fixed grid nominally spaced at 80 feet on center from RM 8.3 to Dundee Dam (sampling density may be less above RM 15, where the sediment bed is coarser). Geostatistical interpolation will be conducted for the 0- to 6-

inch (surface) and 6- to 18-inch (subsurface) layers. A second round of PDI sampling will supplement the dataset and reduce the uncertainty of the footprint delineation. A second geostatistical interpolation will be performed with the combined data. This will be accomplished through conditional simulation.

The approach to conditional simulation, considering both total PCBs and 2,3,7,8-TCDD, will be determined after analysis of the first stage PDI data. In general, multiple conditional simulation maps (maps generated by artificially sampling from the underlying data distribution at a finer scale) will be generated and remedy footprints that yield surface sediment layer concentrations that meet the total PCB and 2,3,7,8-TCDD (RAO 1) SWAC goals will be established for each map along with targeting to meet RAO 2. These maps will be used to generate a map of the likelihood of being targeted for remediation. The second phase of sampling will be conducted where the likelihood of sediments being targeted falls in the range of 40 to 60 percent or where sharp concentration gradients are observed or predicted. After incorporating the data from the second phase of the PDI sampling, analyses of the surface sediment data will be refined to better understand spatial correlation and covariance, and the analyses will be extended to the subsurface data. These analyses will support determining an appropriate interpolation method to map both surface and subsurface sediment concentrations. Nominally, the subsurface mapping will use the data from the 6-inch to 18-inch layer, though adjustments may be incorporated if warranted based on assessments of depth of erosion from bathymetric differences and refined modeling. The preliminary delineation of the remedial footprint will be based on applying conditional simulation to these mappings.

The final delineation of the IR footprint will incorporate physical characteristics (i.e., geotechnical properties, side-scan sonar-based sediment type, bathymetry, and hydrodynamic conditions) to allow for consideration of elements that can impact where contamination may (or may not) exist based on the characteristics of the river. The geostatistical mappings will incorporate some of these features to honor patterns evident in the PDI data, but manual review, under EPA oversight, of those results to optimize the target areas and incorporate physical information will aid in developing a robust dredging prism.

To identify areas vulnerable to erosion, bank-to-bank bathymetric surveying will be conducted during the PDI and/or following a high flow (generally at or above 5,000 cfs) event, if such an event occurs and a survey can be safely performed, for comparison to the CCMP bathymetric survey and earlier surveys. Using bathymetric differencing, vulnerable areas will be defined and PDI data and geostatistical mapping (which will factor in side-scan sonar data) in those areas will be used to interpolate subsurface concentrations. The surface RAL for 2,3,7,8-TCDD will be determined specifically during the IR design through the footprint delineation process, as the lowest surface concentration that must be targeted to attain the 75 ppt post-IR SWAC.

For subsurface sediments, sediments in areas characterized as erosional and having concentrations in excess of the subsurface RALs will be remediated. Given the maximum depth of erosion is generally not more than 18 inches based on numerous bathymetric surveys performed in the LPR (see Section 5.3), the subsurface RALs will be applied to the depth interval from 6 inches to 18 inches below the sediment bed. In the IR FS, the subsurface RALs were established at twice the surface RALs, as a site management decision by EPA in consultation with NJDEP, supported by an analysis of erosion potential using available bathymetric data. . During IR design, the PDI data and newer bathymetry information will be used to establish erosional areas and verify the subsurface RAL multiplier using an analysis similar to the erosion potential analysis performed in the IR FS. The final footprint will be established by attaining RAO 1 first and then sequentially including additional area to attain RAO 2. The subsurface RAL multiplier will not exceed 2.

Combining areas addressed to attain RAO 2 with areas addressed to attain RAO 1, and based on existing data, EPA estimates that the IR will achieve a 2,3,7,8-TCDD SWAC of approximately 70 ppt (i.e., lower than the 75 ppt SWAC target because of sequentially addressing RAO 2 after RAO 1) and a total PCB SWAC of 0.27 ppm (compared to background of 0.46 ppm). Based on current estimates of SWACs from existing data, the IR will reduce the 2,3,7,8-TCDD SWAC in the upper 9 miles of the LPR by approximately 92 percent and the total PCB SWAC by approximately 82 percent. Based on existing data and the IR footprint derived in the IR FS, the IR will result in the removal of approximately 387,000 cy of contaminated sediments across approximately 96 acres.

With the development of the final IR footprint in the IR design using the PDI data, EPA anticipates that the actual post-IR 2,3,7,8-TCDD SWAC will be lower than the SWAC target of 75 ppt (70 ppt based on existing data, as described above); however, the degree to which the actual post-IR SWAC will be lower than the SWAC target will be determined in the IR design.

12.1.3 River Mile 15 to Dundee Dam

Current data suggest that the source areas to be targeted by the IR are located between RM 8.3 and RM 15. The river reach between RM 8.3 and RM 15 contains some proportion of fine-grained sediments, with which the LPRSA contaminants are associated, while the portion of the river above RM 15 tends to be overall coarser and shows a significantly lower level of contamination. However, if sediment data collected between RM 15 and Dundee Dam that support the IR design identify elevated surface concentrations in the reach of RM 15 to Dundee Dam (i.e., surface sediment concentrations in excess of the surface RAL determined for RM 8.3 to RM 15), EPA will evaluate these areas during IR design to determine whether they constitute a source that is inhibiting the recovery of the LPR. Exceedances above the RAL between RM 15 and Dundee Dam will be evaluated and any source areas identified will be remediated as part of the remedy.

12.2 Dredging and Capping

Sediments will be removed to the depths necessary to accommodate an engineered sediment cap in the remediation areas. Dredge depths are anticipated to be 2 to 3 ft, including allowable overdredging. For the purpose of the cost estimate, EPA assumes a removal depth of 2.5 ft

(2 ft nominal dredge depth plus 0.5 ft overdredge that accounts for typical dredge precision). Mechanical dredging with a conventional barge-mounted clamshell dredge and/or environmental bucket is assumed as the primary process option for the IR dredging. Other equipment (e.g., barge-mounted precision excavator) will be evaluated during IR design and implementation.

Land-based removal is assumed for the area above RM 13.9 to accommodate fixed, low-clearance bridge constraints that preclude barge and tug operations upstream of RM 13.9. It is assumed that dredging will be feasible within the entirety of the IR footprint. All possible effort to perform active dredging, where feasible, throughout the IR footprint will be undertaken. If, during IR design, portions of the IR footprint where significant constraints (e.g., utility crossings, bridge abutments, and critical shoreline structures) limit or preclude dredging and capping, EPA will consider alternate technologies (e.g., enhanced natural recovery and in situ sediment treatment) for those areas. Dredging methods will be further evaluated during IR design to support development of construction monitoring performance standards.

Following dredging, an engineered cap will be placed throughout the dredge area, restoring the sediment bed to pre-IR elevations to avoid any impact to flood storage within the river. In addition, the placement of RMC will occur outside of the dredge and cap footprint as a mechanism to mitigate potential impacts of dredge residuals that might redeposit on the sediment bed outside the remediation area. RMC will potentially also be placed immediately following dredging if capping were to be delayed.

Consistent with the RM 10.9 IR design, a 1 ft isolation layer was evaluated over a 100-year time frame to determine the cap composition that would be effective at limiting migration of underlying sediment contaminants. An evaluation of potential armor stone size and thickness was performed with flows associated with a 100-year return period, consistent with EPA guidance (USEPA 2005). In the IR FS armor is assumed to be placed throughout the cap footprint, to a thickness of 1 ft. Armoring needs will be refined in the IR design, and sediment capping will conform to current EPA guidance concerning climate change considerations and flood risk management consistent with the reinstatement of Executive Order 13690 which establishes a federal flood risk reduction standard intended to “improve the resilience of communities and Federal assets against the impacts of flooding”. In shoal areas, habitat reconstruction material similar to existing substrate is assumed to be placed throughout the shoals, as the top 1 ft of the cap. Further consideration and refinement of the ecological and recreational function of the cap will be considered during the IR design, at which time its composition will be determined. Cap types and thickness could vary depending on location and armoring requirements. Bathymetric data, geomorphic evaluations, and hydrodynamic and sediment transport model results will be used to determine erosional areas that would require armored cap placement. Additional design considerations, such as the addition of in situ reactive amendments, will be established during the IR design. EPA anticipates that one important cap design consideration will be the potential for an engineered cap to exacerbate erosion in adjacent uncapped areas. Placement of caps on slopes greater than 3:1 will require additional geotechnical analyses and design to evaluate feasibility. For cost-estimating purpose, EPA assumes that cap thicknesses will vary from approximately 2 ft (in low-energy areas) to approximately 2.5 ft (in areas subject to greater erosion potential). A 2.5 ft cap is assumed throughout the IR footprint for the purpose of the ROD cost estimate.

Some areas may be dredged to native (uncontaminated) sediments based on a cost-effectiveness review. Under this approach, discrete areas might be dredged to a clean subsurface horizon, eliminating the need to place an engineered cap in those areas (along with associated O&M). In the areas where dredging without capping is applied, remedy resiliency and climate change concerns are addressed by not requiring a cap that would need to be monitored and maintained after storm events. The following steps will determine the areas where dredging without capping will be employed:

1. Before the PDI, a cost model will be developed and used to compare the cost of (a) dredging to the nominal dredge depth, with capping and long-term cap monitoring to (b) dredging to reach native sediments and backfill placement (which includes evaluating depths deeper than the nominal dredge depth). Unit costs will be refined, as possible and necessary, and used in the cost comparison model. So that the costs are sufficiently developed for this exercise, the cost drivers associated with dredging and capping will be reviewed and possibly refined prior to using them in the cost model. Also, the backup and/or references used to establish the unit costs in the cost model will be identified. It is expected that this model will identify the depth(s) at which the costs of the two dredging options would be the same. These depths will be used to refine the termination depth of the PDI borings in each area of the river, if greater than the nominal PDI boring depth; EPA anticipates that cores will need to extend 1 ft beyond the depth at which the costs of the two dredging options are equal.

2. PDI sampling will be conducted to the depths established, with the depth at which native material is encountered in each boring (up to the termination depth for the area in the river the boring is located) to be recorded. The depth of native material will be determined from visual observation of the sediment cores.

3. Preliminary dredge management units (DMUs) where two or more adjacent borings intersect native material will be identified.

4. As part of the IR design program, the cost comparison model will be updated using cost data from remediation contractors, disposal facilities, etc., and location-specific conditions that may vary among the DMUs. The updated model will be used by EPA to determine the cost comparison for each preliminary DMU. Dredging without capping will be selected for those DMUs where dredging without capping would cost no more than dredging and capping.

It is assumed that dredged material will be transported via barge. It is assumed that cap (or RMC or backfill) material will be transported via barge and placed with a mechanical bucket. Upstream of

RM 13.9, land-based cap material placement is assumed to accommodate fixed, low-clearance bridge constraints that preclude barge and tug operations. Specific materials transportation and removal/placement methods will be determined in the IR design.

EPA will continue to assess RM 10.9 construction and performance-monitoring data to inform the dredging and capping approach for the IR. The remediation contractor will identify means and methods to satisfy the performance requirements in the IR design documents, including selection of appropriate dredging/capping equipment and methods.

12.2.1 Dredged Material Management

It is assumed that dredged sediments will be transported via barge to a nearby commercial facility for processing. For example, there are three Clean Earth sediment processing facilities within a 3-mile radius of the mouth of the Passaic River (Kearney, Koppers, and Claremont). Facility capacity and accessibility evaluations will be required during the design to identify which location(s) are available and accessible. Alternative sediment processing options, including the possible use of the sediment processing facility that EPA anticipates will be constructed for the material dredged from the lower 8.3 miles, or another facility, may be evaluated during IR design.

Following dewatering of the sediments and stabilization at the processing facility, sediments will be transported via railcar and/or truck for off-site disposal. EPA assumes the sediments will be transported via rail from the sediment processing facility. Precautions will be taken during transport to prevent the release of contamination; specific actions will be identified during design and implementation.

Nonhazardous dredged material may be accepted for direct disposal in a RCRA Subtitle D facility (i.e., a facility that is permitted to accept only nonhazardous wastes and not hazardous wastes), contingent on the facility's permit, available space, and facility-specific acceptance criteria for material impacted by chlorinated dioxins and furans. Dredged material that is characterized as hazardous waste, if any, would require disposal in a RCRA Subtitle C facility following treatment, if necessary, to meet all regulatory requirements. EPA has previously determined that sediments from the LPR do not contain RCRA-listed hazardous waste (USEPA 2008c). However, during the Phase I removal action near the Lister Avenue site, sediments were encountered that had to be managed as characteristic hazardous waste, and an analysis of the Phase I removal data in the lower 8.3-mile ROD responsiveness summary estimated 5 percent of the sediments to be addressed by the selected remedy exceeded RCRA waste characterization criteria. If PCB concentrations indicate TSCA-regulated sediments are encountered during dredging, then TSCA regulations will be followed (currently available data from the upper 9 miles do not suggest TSCA-regulated sediments are likely to be encountered). Waste characterization sampling conducted preliminarily during the PDI, with final testing taking place prior to disposal and in accordance with receiving facility requirements, will be used to identify dredged material requiring management as a RCRA characteristic waste. For cost estimating, EPA assumes that all dredged material will be sent for direct disposal in a Subtitle C facility, given the uncertainty regarding acceptance of material from the LPR at a Subtitle D facility.

12.2.2 Best Management Practices During Dredging

Appropriate construction equipment and BMPs will be used during implementation to minimize sediment resuspension, residuals generation, and contaminant releases from dredging operations. The specific array of BMPs or engineering controls implemented during the IR could vary according to location-specific conditions. BMPs may include the following, although relevant BMPs will be evaluated in more detail during IR design:

- Implement construction monitoring, including chemical measurements (through surface water and limited sediment sampling), bathymetry surveys, and continuous turbidity measurements upstream and downstream of construction areas.
- Remove debris prior to dredging.
- Minimize residuals generation through operational controls, such as carefully controlling depth, location, and cutting action to maximize sediment capture and minimize dredge area sidewall sloughing and bottom impacts. Optimize dredge bucket fill efficiency to minimize both free-water capture and overfill fallback.
- Control speed of bucket through the water column to minimize loss of adhered sediments.
- Allow the sediment-filled bucket to drain before fully emerging above the water surface.
- Contain drippage during the overwater swing of a filled bucket (e.g., by placing an empty barge or apron under the swing path during offloading).
- Use an environmental or sealed bucket except where conditions require other equipment.
- Start dredging in upslope areas and move downslope to minimize sloughing.
- Plan multiple dredge cuts, limit initial cut depths to avoid sloughing of the cut bank, and plan initial cut(s) to limit resuspension.
- Use floating and/or absorbent booms to capture floating debris or sheens.
- Use conventional construction stormwater BMPs to control and reduce the silt burden in runoff from barges or rehandling areas.
- Deploy silt curtains or other suitable containment features (subject to suitable site conditions).
- Limit or suspend dredging during high flows following significant storm events.
- Sequence dredging to remove areas with the most elevated sediment contaminant concentration first to minimize recontamination.
- Placement of RMC outside the dredge/cap footprint to mitigate impacts of generated residuals that are transported beyond the dredge area .

It is assumed that 6 inches of RMC will be placed outside the dredge and cap footprint, over an area approximately equal to 20 percent of the dredge footprint. The actual area for application of RMC will be evaluated during the IR design and determined through construction quality assurance sampling during IR construction. RMC may also be placed within a dredge area if capping is delayed.

For cost-estimation purposes, the ROD assumes that capping will be performed in multiple lifts to minimize resuspension. The ROD also assumes cap material will be placed as soon as practicable following confirmation of dredge prisms to contain residuals and underlying contaminated sediments.

12.2.3 Institutional Controls

ICs will likely be needed both during and following completion of the IR, as recovery of the system is monitored in comparison to PRGs/RGs and until RGs are achieved. EPA has not yet determined PRGs or RGs. PRGs will be developed during/in parallel with the IR design to inform system recovery assessment following the IR, and until RGs are documented in the final ROD.

ICs may include a combination of governmental controls, proprietary controls, and informational devices. Possible ICs include the following:

- Governmental controls (i.e., monitoring and notification of waterway users)
  - Prohibitions on anchorage within the areas that are capped
  - Prohibitions on grounding of small vessels on the shoreline
  - Restrictions of vessel draft, horsepower, and speed
  - Restrictions on dredging, piling placement or removal, or other construction activities that may disturb sediments
- Proprietary controls (i.e., easements and restrictive covenants related to cap)
- Informational devices (i.e., deed notices, fish consumption advisories, and signage)

Specific ICs will be evaluated during the IR design process. EPA assumes that the existing NJDEP fish and crab consumption advisories for the LPR (Dundee Dam to Newark Bay), which prohibit consumption of fish and shellfish, and ban collection of blue crabs from the entire LPR, will remain in effect during and following the IR. Consistent with the lower 8.3-mile ROD, EPA will evaluate enhancing the advisories with additional community outreach to encourage greater awareness. Also consistent with the lower 8.3 ROD, EPA will share monitoring data and consult with NJDEP about whether the fish and crab consumption restrictions can be lifted or adjusted to allow for increased consumption as contaminant levels decline.

ICs will be established through an Institutional Controls Implementation and Assurance Plan (ICIAP), or equivalent, which will document the ICs and necessary implementation, monitoring, and enforcement activities along with associated responsibilities and termination criteria.

12.2.4 Monitoring

Monitoring elements associated with the IR will consist of baseline, construction, confirmatory, O&M, and long-term monitoring.

Building on the CCMP data (evaluating bathymetry, surface water, and biota), the PDI will establish pre-remediation baseline conditions for comparison purposes and support the IR design. These monitoring elements are previously described in Section 12.1.1.

EPA anticipates that construction monitoring will include confirmatory bathymetric surveys to verify dredge depths and cap placement thicknesses, water quality monitoring, and sediment sampling to evaluate the efficacy of residuals management measures (e.g., limited sediment sampling after a dredging season, targeting newly deposited sediments, for the objective of evaluating the efficacy of and potential improvements to BMPs). Cap construction verification is also anticipated to include sediment coring to verify cap layer(s) thickness(es) and composition as prescribed by the IR design, and to evaluate potential mixing of cap layers with underlying sediments during cap placement. This information will be used to directly confirm achievement of cap layer IR design specifications. It will also help inform any future cap monitoring efforts focused on assessing the cap's performance in chemically isolating underlying contaminants. Performance metrics will be established during the IR design to ensure achievement of dredging and capping extents and other performance standards. Data and lessons learned from dredging, cap construction, cap construction monitoring, and physical and chemical cap performance monitoring at the RM 10.9 Removal area will be relied on to inform the IR construction monitoring approach.

Post-IR confirmation sampling will include sufficient samples to provide a statistically unbiased estimate of the post-IR SWACs. EPA anticipates this will include not less than 400 and not more than 800 sediment sample locations at which three closely spaced samples will be collected and composited. A multiple lines of evidence IR completion assessment process will be performed to verify that RAO 1 has been achieved. This assessment process is described in Section 12.3.

O&M monitoring of IR remediation areas will be conducted following construction to ensure long-term effectiveness. Bathymetry surveys and chemical monitoring will be performed to assess the continued stability and chemical isolation performance of the cap and any potential need for maintenance to ensure continued performance (e.g., replacement of eroded cap material and/or armor stone). Chemical monitoring to evaluate contaminant isolation may consist of sediment coring and sample analysis and/or the use of passive samplers. Data and lessons learned from cap performance monitoring at the RM 10.9 Removal area will inform the IR cap O&M monitoring approach. For cost estimating, EPA assumes cap O&M monitoring will continue until 30 years after the end of construction.

EPA expects that long-term monitoring will span two phases. The first will be a system response and recovery assessment phase to evaluate effectiveness of the IR, which will follow completion of IR construction and will continue for an estimated period of approximately 10 years. These years of monitoring data will support EPA's remedy selection decision regarding the need for additional remediation, if any, which will be documented in the final ROD. The second phase of long-term monitoring will occur following selection of a final remedy and issuance of the final

ROD. The post-IR system response and recovery monitoring activities will include assessment of sediments, surface water, and biota tissue to evaluate trends in concentrations and assess progress towards risk-based goals. Specific long-term monitoring needs for the final remedy will be documented in the final ROD. Assessing progress towards risk-based goals will initially be based on PRGs developed during/in parallel with the IR design, and later will be based on comparison to final RGs documented in the final ROD. Ultimately, monitoring may continue longer than 30 years, but 30 years is currently assumed consistent with EPA guidance for cost estimating.

Plans for all monitoring phases will be prepared for EPA approval before (the PDI) or in conjunction with the IR design. Monitoring approaches may be modified based on observed conditions in the LPRSA, in accordance with adaptive management principles (Section 12.5).

12.2.5 Habitat Considerations

There are expected to be short-term impacts to habitat (specifically intertidal mudflats and wetland areas) associated with IR construction and following completion of construction, as these habitat areas are disturbed and recover. IR design will include management of these areas to approximately restore the habitat that supports ecological value equal to current conditions and avoid net loss of habitat, in accordance with ARARs.

12.2.6 Construction Constraints

Various construction constraints may influence the proposal and selection of equipment and production rates in IR design and implementation. The possible constraints on the IR include:

- Bridges with low or limited crossing access, especially above RM 13.9
- Navigational constraints of shallow water or strong currents
- Migratory fish window limitations
- Critical structure protection (including utility corridors)

The ROD assumes a migratory fish window (i.e., when there would be a restriction on dredging) of March 1 to June 1 annually. The ROD also assumes that there will be an annual shutdown for winter weather, potentially January 1 to March 1. Further evaluation of construction constraints, including specific seasonal restrictions and physical/infrastructure impediments, and potential strategies to mitigate the associated impact on construction will be completed during IR design.

12.2.7 Green and Sustainable Remediation

A green and sustainable remediation (GSR) evaluation of a range of metrics was performed to compare the environmental, social, and economic impacts of implementing an IR. In summary, the GSR impacts are proportional to remedy size; the smallest remedial footprint has the smallest impacts, and impacts increase with increasing size of remedial footprints. The primary contributors to greenhouse gas emissions and energy consumption are equipment use during dredging and capping remediation activities, sediment dewatering, and the transportation of equipment and materials on- and off-site. Potential injuries are most influenced by the project duration and worker travel/transportation via roads and flights.

While not a formal CERCLA evaluation criterion, the GSR evaluation provides a way to measure the sustainability of an IR, with a goal of protecting the environment and minimizing community impacts. The concept of “sustainability” is not one of the NCP’s criteria, however EPA may consider “greener” activities when those can be incorporated into alternatives and evaluated under specific NCP criteria.

The environmental benefits of the selected IR may be enhanced by consideration of technologies and practices during the design of the IR that are sustainable in accordance with EPA Region 2’s Clean and Green policy.

In addition, during oversight of the IR design, EPA will closely evaluate climate change issues and climate change resiliency to ensure that climate change impacts are considered and addressed to the extent practicable and feasible, in accordance with federal and state resiliency initiatives. During IR design, capping materials will be evaluated, such as armoring, to ensure that the remedy can withstand potentially increased storm intensity due to climate change impacts. In addition, long term monitoring will be implemented to assess and maintain cap stability.

12.2.8 Selected Remedy Technologies

All active alternatives, including the selected IR for the upper 9 miles of the LPRSA, were developed by evaluating general response actions and combining remediation technologies and process options (i.e., a specific tool, method, or approach within a technology category) that were retained after a screening evaluation performed in accordance with CERCLA and the NCP. Technologies/process options were retained if they were judged to be suitable for the site, suitable for the contaminants of interest, overall effective relative to IR objectives, implementable, and appropriately cost effective.

However, certain technologies/process options were identified in the IR FS as “retained for further evaluation during IR design.” Specific technologies/process options were considered to be potentially effective and potentially implementable and may warrant further consideration during IR design, but were not incorporated directly into the IR alternatives, including the selected IR. These include enhanced natural recovery, in situ sediment treatment, ex situ sediment treatment (soil washing, thermal desorption, thermal destruction, incineration, vitrification), composite capping or reactive capping, specialty dredging, hydraulic dredging, hydraulic transport, confined aquatic disposal, off-site landfill disposal at a Subtitle D landfill, and beneficial reuse. During the IR design, alternate technologies will be considered if and as necessary to overcome identified design and implementation challenges for discrete portions of the IR footprint. EPA will document changes to the selected remedy consistent with the requirements of the NCP.

12.3 Remedy Completion

The IR will be deemed successful and complete if it achieves the RAO SWAC goals. Assessing achievement of SWAC goals will rely on interpreting post-IR sediment data, which will not yield a precise estimate of SWAC because of the expected variability of concentrations and the nature of statistical assessment of averages. PDI data will likely reduce uncertainties and a balance between SWAC precision and post-IR confirmation sampling sample size will be sought. This balance will be adequate when the rates of false negative (i.e., the IR is judged to be unsuccessful when the post-IR SWACs do in fact comply with the RAO SWAC goals) and false positive (i.e., the IR is judged to be successful when the post-IR SWACs do not in fact comply with the RAO SWAC goals) post-IR decisions are suitably controlled. For purposes of this ROD, EPA, in consultation with and NJDEP, has determined that acceptable rates of false negative and false positive decisions are 5 percent and 10 percent, respectively.

A statistical assessment of post-IR sediment concentrations will be the first line of evidence in determining IR completion. If statistical assessment demonstrates attainment of the RAO SWAC goals, EPA will judge the IR successful. If statistical assessment fails to demonstrate success in achieving the RAO SWAC goals, the IR could still be deemed complete if effective source sediments control is indicated by a weight of evidence approach using other lines of evidence (LOEs).

Before the post-IR sediment data are collected, three of the LOEs will have been fully evaluated:

1. The mapping of total PCB and 2,3,7,8-TCDD concentrations and areas vulnerable to erosion and the use of that mapping to delineate areas to be remediated.
2. The comprehensiveness of the IR design to address the identified sediment sources, including the sequential application of RAO 2 after RAO 1 to derive the IR footprint.
3. The degree to which IR implementation is judged acceptable through construction performance monitoring and a construction certification process that will evaluate IR implementation over smaller spatial scales (dredge management units).

If the statistical assessment indicates that the IR is not conclusively successful, a final LOE will be applied. This final LOE will assess whether sediment source areas remain (i.e., surface concentrations that are above a surface RAL). The absence of surface RAL exceedances would be strong evidence of IR completion. If there are surface sediment concentrations above the surface RAL, an evaluation of the overall IR implementation will occur, incorporating the aforementioned LOEs to identify and explain observed concentration patterns. If EPA concludes that the identified sediment sources are actionable and can be effectively remediated based on size, location, and bottom type, additional sediment removal/ capping of the identified areas will be performed, or an additional FS will be developed. Otherwise, if there are no such actionable sediment sources, EPA will deem the IR complete by weight of evidence. A weight of evidence assessment protocol was developed in the IR FS, and is included in as Appendix H to the IR FS document. During the IR design, the weight of evidence approach will be refined to select specific statistical testing parameters and to provide a more detailed basis for characterizing sediments as actionable following IR implementation and post-IR sediment sampling, as needed.

12.4 Summary of the Estimated Cost of the Selected IR

The estimated capital, long-term O&M and total present value costs, as well as construction time and time to achieve RAOs for the selected remedy are summarized below. The cost estimate details are presented in Table 12-1 (Appendix 2). The cost estimate assumes that long-term monitoring and maintenance will occur throughout a 30-year period following completion of construction, including both response and recovery assessment monitoring following the IR, though, as explained above, additional long-term monitoring may be specified when a final remedy is selected under a final ROD.

PV Capital Cost:	**$413 million**
PV Annual O&M Cost:	**$0.94 million**
Total PV Cost:	**$441 million**
Construction Time:	**4.6 years**
Time to Achieve RAOs:	**7.6 years**

Consistent with CERCLA, the cost estimate is expected to be within +50 percent to -30 percent of the actual cost for implementation of the IR. As expected for a project of this size and nature, the cost estimate has scope and bid uncertainties. Major scope uncertainties that were identified are:

- Remedy approach changes in the IR design
- Area of the final IR footprint needed to achieve RAOs (to be evaluated following the PDI)
- Dredging depth (including over dredge allowance) needed to accommodate final cap design
- Selection of dredged material transportation options and landfill type
- Extent of operations, maintenance, and monitoring (OMM) activities (e.g., sample collection, cap maintenance)
- Additional regulatory requirements

Bid uncertainties that were identified are:

- Unforeseen dredging challenges (e.g., hardpan, debris, utilities)
- Major delays due to external factors (e.g., bridge failure, extreme weather events)
- Changes in regulatory requirements during the project
- Market condition variations that affect pricing of goods and services

Dredged materials will be processed at one or more nearby commercial processing facilities for off-site disposal at licensed disposal facilities; an additional uncertainty is the location of the sediment processing facility. A sensitivity analysis was performed to assess the response to changes in key factors, or elements, of the costs estimate. First, varying discount rates showed the total net present value costs, discounted at a rate of 7 percent (the EPA default discount rate used for the cost estimate), are approximately 20 percent lower than the undiscounted costs. Total net present value costs discounted at a rate of 1.5 percent are approximately 17- to 19-percent higher than those discounted at 7 percent. Also, increasing the total contingency from 25 percent, assumed in the cost estimate, to 35 percent, increases total net present value costs by approximately 6 to 7 percent. Additionally, two construction elements were compared in the sensitivity analysis: (1) Dredging Method (mechanical versus hydraulic), and (2) Disposal Landfills (Subtitle C versus Subtitle D). A screening-level evaluation performed for Alternative 3 (the selected remedy in this ROD) in the IR FS shows that estimated hydraulic dredging costs are approximately 16-percent higher than mechanical dredging costs and for the landfill assessment, overall costs were 15- to 17-percent lower with sediments disposed at a Subtitle D landfill compared with disposal at a Subtitle C landfill.

12.5 Expected Outcomes of the Selected IR

The selected IR, which is for sediment source control in the upper 9 miles of the LPRSA, will be designed to attain the IR RAOs, and will achieve the following:

- Removal of sediments with elevated concentrations of 2,3,7,8-TCDD, PCBs, and other contaminants that are collocated in the IR footprint, that might resuspend and become sources to the water column, other areas of the sediment bed, and biota, and that overall act to inhibit system recovery and contribute to human health and ecological risk.
- Immediate and significant reduction in SWACs for 2,3,7,8-TCDD and total PCBs in the reach RM 8.3 to RM 15, where current data suggest the source sediments to be addressed by the IR are located.
    - A SWAC of 75 ppt (or less, depending on the amount of additional area included in the IR footprint to attain RAO 2) for 2,3,7,8-TCDD, which represents a 93-percent reduction from the current SWAC based on currently available data.
    - A SWAC of 0.27 ppm for total PCBs, which represents an 83-percent reduction from the current SWAC based on currently available data and is below the PCB background level.
- Attainment of the IR RAOs, including addressing areas that might be subject to erosion that could expose buried contaminated sediments.
- Placement of an engineered cap that is resistant to erosion and chemical migration, isolates underlying contaminated sediments from exposure by receptors, and does not exacerbate flooding issues in the river.
- Accelerated recovery of surface sediment concentrations of 2,3,7,8-TCDD and PCBs, and other contaminants.
- Accelerated recovery of surface water concentrations of 2,3,7,8-TCDD and PCBs, and other contaminants.

- Accelerated recovery of fish and crab tissue concentrations of 2,3,7,8-TCDD and PCBs, and other contaminants, resulting from reduced concentrations in the sediment bed and water column.
- Reduced potential for human and ecological exposure to 2,3,7,8-TCDD and PCBs, and other contaminants, resulting from sediments, surface water, and tissue concentration reductions.
- Reduced risk to human and ecological receptors.
- Acceleration of the timeline for significant action in the upper 9 miles of the LPRSA (implementing the IR for the upper 9 miles under an adaptive management framework will lead to significant remediation and risk reduction in this reach of the river several years faster than would be realized without the IR).
- Technical and schedule synchronization with the lower 8.3-mile remedy, limiting the period of time that construction occurs in the river, effectively managing relationships between the two actions (e.g., generation and movement of dredging residuals between the upper 9 miles and lower 8.3 miles), minimizing short-term impacts to adjacent communities, and achieving economies of scale.
- Reductions of EJ burdens to adjacent communities, and the potential for opportunities for economic advancement in the LPRSA region (e.g., through promoting the use of the Superfund Job Training Initiative to the parties performing the remedy).
- Implementation, monitoring, and enforcement of ICs to ensure protection of human receptors from site risks.
- Post-IR conditions that are readily measurable, including over the long-term, to evaluate contaminant reduction trends and facilitate selection of a final risk-based remedy.

12.6 Adaptive Management

Consistent with EPA guidance, adaptive management is a formal and systematic management approach centered on rigorous planning and understanding of site conditions and uncertainties. This technique leverages continuous reevaluation and prioritization of the management of site activities and decisions to account for new learning and evolving site conditions.

For complex, large-scale sediment remediation projects such as for the LPRSA, adaptive management can play a central role in several important ways:

- Further developing and refining the CSM and quantitative models of system behavior, including transport, bioaccumulation, and recovery processes
- Reducing uncertainty in remedial decision-making by learning from new information and data that become available through site characterization, design and implementation of remedial actions, and monitoring
- Testing and evaluating the response of the system to remedial actions
- Modifying key hypotheses on system behavior and/or associated response actions, when needed, to support final site cleanup

Consistent with the goals of the EPA Superfund program, the overall objective of adaptive management for the LPRSA is to ensure the attainment of risk-protective final RGs as expeditiously and cost-effectively as possible. To meet this objective, remediation of the upper 9 miles of the LPRSA will be adaptively managed under a multistep process. The first step will be the design and implementation of the source control IR documented in this ROD for the upper 9 miles, along with expanding the Adaptive Management Implementation Approach (Appendix D of the IR FS) into a more comprehensive adaptive management plan which over time will be developed to include the decision points on remedy adaptation, the preliminary remediation goals and eventually the RAOs and remediation goals for the final actions, and general timeframes for the interim and final actions. The adaptive management plan will be periodically reviewed and updated based on new site data or information, if warranted.

The IR will be followed by a period of response and recovery assessment monitoring to evaluate the response of the system to the source removal and track the longer-term recovery of sediments, the water column, and biota. This period of monitoring is anticipated to last for approximately 10 years, during which recovery of the system will be monitored in comparison to PRGs. Based on the results of the recovery assessment monitoring, EPA will issue a final ROD for the LPRSA that finalizes risk-based RGs and specifies any additional actions beyond the IR that are needed to address remaining risks and attain the RGs. The final ROD will be risk-based and will address sediments in the upper 9 miles of the river (the IR will lead to substantial reduction in contaminant concentrations in the upper 9 miles, and thereby reduction in risk, but some risk may remain following the IR) and surface water throughout the LPRSA (the IR documented in this ROD does not explicitly focus on surface water, and the remedy for the lower 8.3 miles of the LPRSA is an interim remedy for surface water).

The data that will be collected prior to, during, and following the IR will guide the planned multistep remedial action for the upper 9 miles. The outcome of the process will answer the critical overarching question: *what actions are required to promote and attain the overall protection of human health and the environment, initially for the upper 9 miles of the LPRSA and subsequently for the entire LPRSA*.

Activities to support adaptive management of the LPRSA are currently under way, with ongoing data collection to describe current conditions and inform decision-making throughout the program. Adaptive management activities will continue through the IR design phase, when initial PRGs and expected recovery trajectories are established, and through response and recovery assessment monitoring to assess system response and track progress with respect to PRGs, issuance of a final ROD, and, ultimately, confirmation of the attainment of final RGs. More information can be found in Appendix D of the IR FS.

The three elements identified in the Adaptive Management Implementation Approach function in parallel and overlapping fashion, relying on information from the several phases of monitoring activities to be performed before, during, and following the completion of the IR. The approach (and comprehensive adaptive management plan, as available) will be refined and expanded during the IR design phase and at the initiation of recovery assessment monitoring, at minimum, as data and information become available to add details to support evaluations and decision-making or when new guidance is issued. Figure 12-1 in Appendix 1 demonstrates the adaptive management framework. As shown on this figure and discussed elsewhere in this ROD, EPA anticipates that the IR will take approximately 4.6 years to construct, followed by up to 3 years to complete the IR confirmation process. Post-IR system response and recovery monitoring will occur simultaneously and are anticipated to last for approximately 10 years. During this time, PRGs may be refined and other adaptive responses implemented, at which point EPA will make a decision regarding the trends in system recovery and the need for further action to address remaining site risks. A final FS will be developed to evaluate final remedy alternatives, and a final ROD will be developed to memorialize final RGs and a final remedy.

13. STATUTORY DETERMINATIONS

The selection of an alternative for remedial action is accomplished through the evaluation of the criteria as specified in the NCP. EPA has determined that the selected IR alternative documented in this ROD meets the threshold criteria and provides the best balance of tradeoffs relative to the other alternatives with respect to the balancing and modifying criteria. The selected IR will satisfy the following statutory requirements of CERCLA Section 121: (1) be protective of human health and the environment, (2) comply with ARARs, (3) be cost effective, (4) utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable, and (5) satisfy the statutory preference for treatment as a principal element to the extent practicable or explain why the preference will not be met. With respect to the two modifying criteria (state acceptance and community acceptance), NJDEP concurs with EPA’s preferred alternative and community acceptance has been evaluated through the public comment period associated with the Proposed Plan.

This IR is protective of human health and the environment in the short term and is intended to provide adequate protection until a final ROD is signed, complies with those federal and state requirements that are applicable or relevant and appropriate for this limited-scope action, and is cost effective. Although the IR is not intended to address fully the statutory mandate for permanence and treatment to the maximum extent practicable, it uses treatment via stabilization of dredged sediments during processing and disposal and the use of cap materials that prevent the migration of contaminants, and thus supports that statutory mandate and the statutory preference for treatment as a principal element to the extent practicable.

Because this is an IR ROD, assessment will be ongoing as EPA continues to monitor system response and recovery and develop final remedial alternatives for a risk-based remedy for the LPRSA.

13.1 Protection of Human Health and the Environment

As an interim remedy, the selected IR will provide adequate protection until a final ROD is signed. The selected IR is expected to be protective of human health and the environment from the threat it is addressing in the short term. PRGs will be developed during/in parallel with the IR design and used to assess recovery of the system after the IR, and EPA expects to evaluate final cleanup levels in the final remedy decision for the LPRSA.

The selected IR, with a post-IR target 2,3,7,8-TCDD SWAC of 75 ppt, meets the threshold criteria of overall protection of human health and the environment and compliance with ARARs. This alternative effectively achieves sediment source control based on the definition of source sediments for the IR and will yield accelerated recovery of the LPR system that will be verified. The IR will be followed by a period of system response and system recovery assessment monitoring to evaluate the response of the system to the sediment source removal and track the recovery of sediments, the water column, and biota.

13.2 Compliance with ARARs

There are no chemical-specific ARARs for sediments. The selected IR will be designed and implemented to comply with all substantive location- and action-specific ARARs. The IR could require one or more ARAR waivers during construction to meet threshold criterion of compliance with ARARs. EPA expects the IR to comply with the ARARs through appropriate engineering design and agency review processes. Confirmation of ARARs compliance is typically demonstrated during remedial design and through the remedial action work plan (e.g., environmental protection plan, construction quality control plan, waste management plan, transportation and disposal plan, stormwater pollution and spill prevention plan, and BMPs) as well as monitoring during the construction period. A final risk-based remedy for sediments in the upper 9 miles and surface water throughout the LPR will be established in the final ROD for the 17-mile LPRSA. While EPA anticipates that the IR will improve water quality, ARARs for water quality may not be achieved following completion; however, no evaluation of the potential need for a technical impracticability waiver was performed as part of the IR FS or this ROD.

13.3 Cost-Effectiveness

A cost-effective remedy is one for which costs are proportional to its overall effectiveness (NCP at 40 CFR Section 300.430(f)(1)(ii)(D)). Overall effectiveness is based on the evaluation of the following: long-term effectiveness and permanence; reduction in toxicity, mobility, or volume through treatment; and short-term effectiveness. Overall effectiveness is then compared to cost, to determine cost-effectiveness. Costs for the selected IR were evaluated in detail. Capital and annual O&M costs were estimated and used to develop present worth costs. In the present worth costs, annual O&M costs were calculated for the life of the IR using a 7-percent discount rate and a 30-year interval. Based on the comparison of overall effectiveness to cost, the selected IR meets the statutory requirement that Superfund remedies be cost effective. The selected IR will attain the IR RAOs, including achieving a post-IR 2,3,7,8-TCDD SWAC of not more than 85 ppt and a post-IR total PCB SWAC equal to or less than background, at a cost of $441 million, which is $21 million more than Alternative 2, and $27 million less than Alternative 4.

13.4 Utilization of Permanent Solutions and Alternative Treatment Technologies

The selected IR provides the best balance of tradeoffs among the alternatives considered with respect to the balancing criteria set forth in the NCP at 40 C.F.R. Section 300.430(f)(1)(i)(B), such that it represents the maximum extent to which permanent solutions and treatment technologies can be used in a practicable manner at the LPRSA. Of those alternatives that were judged to be protective of human health and the environment and to comply with ARARs, EPA has determined that the selected IR 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 IR will provide adequate long-term control of risks to human health and the environment by removing and/or preventing exposure to contaminated sediments and otherwise preventing movement of contaminated sediments. It is also protective with respect to short-term risks. Sediment dredging and capping are mature and proven technologies, along with the ancillary IR elements, and with proper design, construction, and O&M, a sediment cap is a permanently protective remedy solution. During IR design, certain alternative treatment technologies will be considered to the extent that construction limitations would prevent the implementation of the selected dredging and capping approach in isolated areas.

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 IR includes removal, disposal, and containment to reduce contaminant toxicity and mobility. Contaminants will be treated ex situ by stabilization during sediment processing, and in situ by the organic carbon content of the cap. Dredged sediments will be solidified and stabilized via treatment with a reagent admixture (e.g., Portland cement), which will reduce toxicity and mobility before disposal. The reagent will solidify the sediments by reducing the water content to levels appropriate for transportation and disposal at a permitted landfill. Chemical stabilization by the reagent will further immobilize contaminants within the dredged sediments. Solidification and stabilization are considered irreversible, but this component of treatment does not address residuals that would remain in the LPR. Based on currently available data, an in-situ sediment volume of 387,000 cy will be dewatered and processed (solidified and stabilized) ex situ at a nearby commercial processing facility. Implementation of the IR will result in the removal of approximately 610 g of 2,3,7,8-TCDD (of the approximate total of 740 g in upper 2.5 ft of the sediment bed in RM 8.3 to RM 15) and approximately 840 kg of total PCBs (of the approximate total of 1,270 kg in the upper 2.5 ft of the sediment bed in RM 8.3 to RM 15), based on currently available data.

The conceptual sediment cap design for the IR includes 5-percent organic carbon content in the sand isolation layer, which will reduce the mobility of residual contaminants in the IR footprint (96 acres based on available data and evaluations in the IR FS). Organic carbon in the cap will inhibit potential contaminant movement through the cap and the cap will be designed to prevent cap breakthrough within 100 years of placement. Capping is considered to be permanent, and the remaining residuals within the dredge footprint will be covered. Remaining contamination is expected to be effectively sequestered by this treatment action.
In situ sediment treatment options have been retained for consideration in the IR design, and, if implemented, would address contaminants in areas where active dredging and capping are not possible (e.g., utility crossings, bridge abutments, and critical shoreline structures).

13.6 Five-Year Review Requirements

Because the selected IR 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 IR to ensure that the IR is, or will be, protective of human health and the environment.

Because this is an IR ROD, review of this action will be ongoing as EPA continues to develop final remedial alternatives for the LPRSA.

14. DOCUMENTATION OF SIGNIFICANT CHANGES

The Proposed Plan identified the preferred alternative for the IR as Alternative 3: 2,3,7,8-TCDD SWAC of 75 ppt, total PCB RAL of 1 ppm. That alternative constitutes the selected remedy in this ROD. Responses have been prepared for the comments received during the public comment period from April 15, 2021 to June 14, 2021 and at the Proposed Plan public meeting on April 27, 2021. The comments and responses are provided in Appendix 5, Responsiveness Summary. Upon review of the comments, EPA has determined that no significant changes to the selected remedy, as it was presented in the Proposed Plan, are warranted.