Feasibility Study
Lincoln Park/Milwaukee River Channel Sediments Site
Phase II Feasibility Study/Remedial Design
Milwaukee Estuary Area of Concern, Glendale, Wisconsin

Great Lakes Architect-Engineer Services
Contract: EP-R5-11-10

Prepared for

U.S. Environmental Protection Agency
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TABLE OF CONTENTS

LIST OF APPENDICES

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS AND ABBREVIATIONS

°F	Degrees Fahrenheit
AOC	Area of Concern
BLM	U.S. Bureau of Land Management
bss	Below sediment surface
BUI	Beneficial use impairment
CDF	Confined disposal facility
CFR	Code of Federal Regulations
cfs	Cubic feet per second
CSM	Conceptual Site Model
cy	Cubic Yard(s)
EA	EA Engineering, Science, and Technology, Inc.
EPA	U.S. Environmental Protection Agency
FEMA	Federal Emergency Management Agency
FS	Feasibility Study
ft	Foot or Feet
GLLA	Great Lakes Legacy Act
GLNPO	Great Lakes National Program Office
in.	Inch(es)
mg/kg	Milligram(s) per kilogram
MNR	Monitored natural recovery
NAPL	Non-aqueous phase liquid
NRT	Natural Resource Technology
PAH	Polycyclic aromatic hydrocarbon
PCB	Polychlorinated biphenyl
PCT	Project Coordination Team
ppb	Part(s) per billion
PPE	Personal protective equipment
ppm	Part(s) per million
PRG	Preliminary remedial goal
RAO	Remedial action objective
RD	Remedial Design
RI	Remedial Investigation

SWAC	Surface-weighted average concentration
TCAC	Technical and Citizen's Advisory Committees
TSCA	Toxic Substances Control Act
USACE	U.S. Army Corps of Engineers
WDNR	Wisconsin Department of Natural Resources
WPDES	Wisconsin Pollutant Discharge Elimination System
ZVI	Zero-valent iron

1. INTRODUCTION

EA Engineering, Science, and Technology, Inc. (EA) has been contracted by the U.S. Environmental Protection Agency (EPA) Great Lakes National Program Office (GLNPO) to perform the Feasibility Study (FS) and Remedial Design (RD) for the Phase II area of the Lincoln Park/Milwaukee River Channel Sediments Site under the Great Lakes Architect-Engineer Services Contract No. EP-R5-11-10. This FS presents an evaluation of remedial and restoration alternatives for sediments in the Phase II area. Development of the FS has been a multi-step process led by the Lincoln Park/Milwaukee River Channel Sediments Site Project Coordination Team (PCT), which includes EPA GLNPO, the Wisconsin Department of Natural Resources (WDNR), and Milwaukee County Parks. The purpose of this FS is to document the identification, development, and evaluation of remediation alternatives and restoration options for managing contaminated sediments in the Phase II area of the Lincoln Park/Milwaukee River Channel Sediments Site.

1.1 SITE BACKGROUND

The Lincoln Park/Milwaukee River Channel Sediments Site (the Site) is part of the Milwaukee Estuary Area of Concern (AOC), Glendale and Milwaukee, Wisconsin (Figure 1-1). This FS focuses on the Phase II area of the Site, which encompasses the main stem of the Milwaukee River north of its bend, an oxbow located east of the main stem, and the main stem from the bend to the dam (Figure 1-1). The Phase II area is the last of three areas identified for remediation at the Site.

The Site encompasses portions of Lincoln Creek and the Milwaukee River upstream of the Estabrook Park Dam including the impoundment area behind the Estabrook Park Dam. The contaminated sediment within the impoundment area is recognized as a major contributor to beneficial use impairments (BUIs) within the AOC by both the EPA GLNPO and Milwaukee Remedial Action Plan Technical and Citizen's Advisory Committees (TCAC 1994). BUIs in the AOC include fish consumption advisories, such as those in effect from Grafton to the mouth of the Milwaukee River, because of contamination from polychlorinated biphenyls (PCBs). Remediation of contaminated sediment in the impoundment is expected to result in a long-term reduction in PCB mass transport in the Milwaukee River of up to 70 percent (Baird and Associates 1997). Remediation of the Site has been divided into two primary areas: Phase I and Phase II. Remedial construction in the Phase I area of the Site, which includes Lincoln Creek and an oxbow located west of the main stem of the Milwaukee River, was completed in 2012 and consisted of sediment removal by dry excavation followed by offsite disposal. Additionally, a small area adjacent to Blatz Pavilion was remediated prior to the Phase I remediation.

The Phase II area has been previously investigated as part of several efforts, including the Phase II Remedial Investigation (RI) conducted in 2010 (CH2M Hill 2011a); sampling performed in support of studies of the Estabrook Dam (AECOM 2010; Himalayan Consultants 2008); and investigation specifically designed to support the FS, which is discussed in **Section 1.3**. The primary chemicals of concern for the Site are PCBs, non-aqueous phase liquid (NAPL) hydrocarbons, and polycyclic aromatic hydrocarbons (PAHs). PCBs are suspected to have originated from industrial sources upstream in Lincoln Creek. Elevated PCB and PAH concentrations, and isolated occurrences of NAPL, are present in soft sediment deposits scattered throughout the Phase II area.

1.2 PURPOSE AND SCOPE

The overall purpose of this project is to address contaminated sediments within the Site that are contributing to BUIs within the Milwaukee River. The scope of the project includes both remediation of sediments within the Site and habitat restoration of areas affected by that remediation.

The specific purpose of this FS is to document the identification, development, and evaluation of remediation alternatives and restoration options for managing contaminated sediments in the Phase II area of the Site. Development of the FS has been a multi-step process involving the Site PCT, which includes EPA, WNDR, and Milwaukee County. This process has included preparation of interim documents leading up to the FS that served as an initial focus for review, comment, and revision. These documents have included the Remedial Alternatives Screening (EA 2013a), Remedial Alternatives Evaluation (EA 2013b), and Sediment Remediation Targets memorandum (Appendix A). The updated and refined content of these documents has been included in this FS.

The ultimate goal of the FS is to provide the information necessary to select a remedial alternative and associated restoration options that can be implemented at the site to achieve remedial objectives. To achieve this goal, the FS includes the following components:

- **Introduction** – Background information is presented in Chapter 1 to provide a context for the FS and to document the sources of data upon which it is based. This includes the definition of purpose and a description of supporting investigations.

- **Conceptual Site Model (CSM)** – Remedial alternatives for the Phase II area have been developed based on an understanding of the site gained from past investigations and surveys. This understanding is captured in the CSM, which defines the site setting, sources of chemicals, and fate and transport pathways. The CSM also discusses the BUIs for the site and identifies preliminary remedial goals (PRGs). It includes a discussion of habitat quality to support the evaluation of restoration options. The CSM is presented in Chapter 2.

- **Screening of Remedial Technologies** – There are many remediation technologies that can be applied to manage contaminated sediments; not all of these technologies are relevant or appropriate for application at Lincoln Park. Therefore, technologies are screened in Chapter 3 based on their potential to effectively and efficiently address the remedial action objectives (RAOs). In screening, technologies are retained for consideration or eliminated based on their potential effectiveness, implementability, and cost to implement at the Site.

- **<u>Development of Remedial Alternatives and Restoration Options</u>** – The central focus of the FS is developing and evaluating remedial alternatives. Therefore, Chapter 4 identifies viable alternatives for remediation based on technologies that were retained during screening. The remediation at Lincoln Park includes habitat restoration for areas affected by remediation. Chapter 5 defines the goals of restoration and identifies techniques that can be used to accomplish the restoration goals.

- **<u>Evaluation of Remedial Alternatives and Restoration Options</u>** – Evaluation of remedial alternatives and restoration options begins in Chapter 6, which defines the evaluation criteria. Remedial alternatives were evaluated in two stages. The alternatives for the site are based on different combinations of three primary technologies: dry excavation, hydraulic excavation, and particle size separation. Therefore, Chapter 7 presents a discussion of how each of these three technologies may be implemented using representative process options, and an independent evaluation of each technology. Chapter 8 presents the evaluation of each alternative, drawing from the discussion in Chapter 7. Options for restoration are evaluated in Chapter 9, which includes a discussion of implementability and range of costs associated with different restoration components.

- **<u>Recommended Alternative</u>** – The FS concludes in Section 10.0 with recommendation of a remedial alternative and restoration options to be selected and implemented at the Site. The recommendation will be carried forward into the remedial design (RD).

It should be noted that the FS utilizes the general framework and terminology presented in guidance for preparing FS documents under the Comprehensive Environmental Response, Compensation, and Liability Act (EPA 1988), with the understanding that the Phase II area is not a National Priorities List (NPL) site and, thus, is not subject to the requirements of CERCLA. Therefore, some steps and considerations that are specific to CERCLA have been modified to meet the specific needs of the project. Specifically, modifications have been made in association with consideration of restoration alternatives, definition of alternative evaluation criteria, and discussion of permitting requirements.

1.3 INFORMATION SOURCES SUPPORTING THE FEASIBILITY STUDY

The FS for the Phase II area of the Site is based upon numerous sources of information. These include previous investigations, studies, and reports, including the following:

- **<u>Phase I Investigation and Remediation:</u>** Information regarding site conditions and implementation considerations gathered from the FS (CH2M Hill 2009), remedial design (CH2M Hill 2011b), and construction completion report (CH2M Hill 2013) for the Phase I remediation. Key data from these sources included permitting requirements, site setting information, and information regarding the distribution and composition of NAPL bordering the Phase II area.

- **<u>Sediment Remedial Targets:</u>** Remediation of the Phase I area of the Site included development of remedial goals for PAHs and PCBs (CH2M Hill 2013). Drawing from the success of these goals, WDNR prepared a memorandum summarizing the remedial goals, the logic involved in the development, and their potential application to serve as a guide for Phase II remediation. With EPA and PCT approval and input, this memorandum was used as the basis for PRGs in the Phase II area. The memorandum is included as Appendix A.

- **<u>Phase II Remedial Investigation:</u>** The Phase II RI (CH2M Hill 2011a) provided a substantial quantity of sediment chemistry, physical characteristic, bathymetric, and lithologic data for the Phase II area. These data, including concentration data for PCBs and PAHs, were incorporated into spatial models of chemical distribution that form the basis for the CSM and the remedial volumes utilized in the FS.

- **<u>Investigation to Support the FS:</u>** Planning for the FS included a field effort to collect additional chemical analytical data; bathymetric, lithologic, and sediment thickness data; and geotechnical data (EA 2013c). A key focus was delineating the extent of NAPL deposits in the Phase II area. Investigation included confirmation of past bathymetric results to determine if flood events have changed bottom topography since preparation of the RI. Sediment sample locations are shown in Figure 1-2 and Figure 1-3. Additionally, a habitat evaluation of the Phase II area and its immediately adjacent land was conducted to define and evaluate the existing habitats throughout the study area (EA 2013d). The findings were used in this FS to determine potential impacts associated with the proposed remedial activities and assess habitat restoration activities that could be conducted in conjunction with the remedial activities.

  A memorandum summarizing field activities and analytical results field effort to support the FS is included in Appendix B. The results of the habitat evaluation are presented in Appendix C. Methods and results of spatial modeling using chemistry data are presented in Appendix D. A data usability report, including assessment of the chemical data collected in support of the FS as well as the full analytical data reports, has been provided under separate cover (EA 2013e).

- **<u>Studies related to Estabrook Dam and Milwaukee County Parks:</u>** Data are available from engineering and environmental conditions studies associated with planning efforts for Estabrook Dam (AECOM 2010; Himalayan Consultants 2008; Southeastern Wisconsin Regional Planning Commission 2011) and park infrastructure (RMT, Inc. 2009). These studies provide lithologic, bathymetric, and chemical analytical data as well as delineation of wetlands near the dam. Analytical data for PCBs were incorporated into spatial models utilized in the FS, and wetland maps were considered in habitat evaluation.

Data from the above sources were used to develop the CSM presented in Chapter 2 and form the basis for decisions made in the FS.

2. CONCEPTUAL SITE MODEL

The CSM describes the site setting and habitats, BUIs, PRGs, sources of chemicals, fate, transport, and exposure pathways for the Phase II area. Based on the results of past RIs and remediation efforts, as well as the investigation conducted in 2013 in conjunction with this FS (Appendix B), the primary chemicals of concern for the Phase II area are PCBs, NAPL, and PAHs.

2.1 SITE SETTING

The Site includes Lincoln Creek downstream of Green Bay Road and approximately 1.25 miles of the river main stem upstream of the Estabrook Park Dam (Figure 2-1). It also includes two oxbows—one west of the river, and one east of the river—that were bypassed by joining the upstream and downstream portions of the main channel as part of past flood control efforts (CH2M Hill 2011a). The river flows north to south between the oxbows, and then bends at a right angle to flow west to east.

The Phase II area, which is the focus of this FS, is the target of the third and final planned phase of investigation and remediation at the Site. Together, these remedial efforts will greatly reduce the Site's contribution of PCBs to the Milwaukee River AOC. The Phase II area encompasses the eastern oxbow (Zone 6), the main stem of the river north of its bend (Zones 3b and 7), and the main stem from the bend to the dam (Zones 4 and 5), as shown in Figure 2-1. A small area immediately adjacent to Blatz Pavilion was remediated as an initial effort by WDNR and Milwaukee County. After this was completed, Phase I was initiated which encompassed Lincoln Creek and the western oxbow (referred to in previous documents as Zones 1, 2, and 3a) from the North Bridge to downstream confluence of the oxbow with the main stem. The Phase I area has been investigated and remediated using sediment removal by dry excavation. Thus no additional remediation is planned for Zones 1, 2, and 3a.

2.1.1 Land Use

The Site is located in Milwaukee County, Wisconsin. The Site and adjacent uplands consist largely of Milwaukee County Parks property. Park property includes the islands within and between the oxbows; the land along both shorelines of the north-south portion of the river; and the land along the north bank of the east-west portion. Land use includes recreation and park maintenance. Recreation in the waterbody includes canoeing, kayaking, and fishing. Recreational land use in upland areas includes a golf course, picnic areas, sports fields, a playground, a swimming pool, and walking trails. The Milwaukee County Parks Department controls portage and launch access of nonmotorized watercraft across park land, and provides three designated access sites for canoeing and kayaking in Estabrook Park and one along the east bank of the western oxbow, north of Hampton Avenue (CH2M Hill 2011a).

The land along the south shore of the east-west portion of the river represents a mixture of residential and commercial land use. Residences occupy much of the land between the river bend and the I-43 Bridge. Downstream of the I-43 Bridge and the North Port Washington Road Bridge, land use transitions to commercial properties, including a hotel and health care facility.

2.1.2 Climate

Climate data from nearby Milwaukee Mitchell Airport indicate that average temperatures in the area fluctuate from 28.0 degrees Fahrenheit (°F) in January to 81.1 °F in July, with an average of 55.9 °F annually (Midwest Regional Climate Center 2013). Average temperatures are near or below freezing in December, January, and February. The monthly average amount of precipitation varies from a minimum of 1.65 inches (in.) in April to maximum of 3.78 in. in April and 4.03 in. in August, with a yearly average of 34.81 in. Average monthly snowfalls of at least 0.1 in. have been recorded October through May, with the greatest monthly average of 15.2 in. in January. Winter conditions often lead to formation of ice on the river, although field observations indicate that temperatures may fluctuate rapidly. Ice formation, thickness, and stability are dependent upon temperature, flow rates, water levels, freeze-thaw cycles, and precipitation type, and may vary weekly even in winter months.

2.1.3 Hydrology

Flow of the Milwaukee River runs from north to south to the bend south of W. Hampton Avenue, and from west to east from the bend towards Estabrook Park Dam. The drainage area for the Milwaukee River upstream of the Estabrook Dam is approximately 696 square miles (CH2M Hill 2011a). Hydrology of the Milwaukee River in the vicinity of the Phase II area has historically been controlled by the Estabrook Park Dam, which was used to raise water levels by 4 to 8 feet (ft) in summer months to provide navigable waters for recreation. In 2009, WDNR issued a Repair or Abandon Order to Milwaukee County based on the need for repair and maintenance work. Since that time, the dam has remained open and will remain open until a decision is made regarding repair work. Milwaukee County is currently seeking to prepare an Environmental Assessment under the National Environmental Policy Act (NEPA) evaluating alternatives for repair or abandon of the dam. The eventual outcome of decision-making regarding the dam will heavily influence site hydrology and habitats.

Flow rates within the Milwaukee River at Lincoln Park are highly variable. U.S. Geological Survey stream gauge data from immediately downstream of the site indicate predicted flows of approximately 100 to 1,000 cubic feet per second (cfs). Flow for the 2-year storm discharge event is approximately 4,730 cfs; for the 100-year storm event, flow is 14,770 cfs (Walker and Krug 2003). Flows over the last 3.5 years have demonstrated a broad range of variability, with instantaneous flows over 18,000 cfs observed in June 2010, and flows below 60 cfs observed in October 2012. Highest flows are expected in association with spring thaw and episodic summer storm events. Flow variability has the potential to affect both the distribution of habitats and topographic features within the Milwaukee River channel and floodplain as well as the potential to affect planning of remediation techniques. Many of the point bars and side bars formed in the river channel are exposed during low flow and submerged during high flows.

2.1.4 Geology and Sediment Lithology

Milwaukee County geology is dominated by deposits of material remaining from past glacial advance and retreat. Soils and sediments in the region are dominated by limestone materials that are similar to the underlying Devonian dolomite bedrock of the Milwaukee Formation. The Milwaukee River occupies a former glacial outwash channel. The composition and thickness of sediment deposits within and along the channel varies dependent upon patterns of flow and deposition. Section 2.4.2 provides a deposit-by-deposit discussion of sediment characteristics and lithology, for deposits targeted for remediation.

In general, sediment deposits in the north-to-south flowing portion of the channel (Zones 3b and 7) are underlain by compacted silts and clays. Sediment thickness near the North Bridge ranges from only a few inches to almost 10 ft, with thicker sediments located in deposits associated with the island and bankside deposits, and thinner sediments associated with areas of scour in the channel. Sediments are thicker in deposits between the oxbows and closer to the river bend, with sediment thicknesses of over 15 ft in some areas. Deposits tend to consist of a layer of erosion-resistant coarse-grained material at the sediment surface covering layers of finer silts and sands beneath.

Sediment deposits in the west-to-east flowing portion of the channel (Zones 4 and 5) are thinner and underlain by limestone bedrock. In some areas, such as under the I-43 Bridge and in much of the central channel, sediments are less than 6 in. thick. In others, such as behind the dam fixed crest spillway, they are more than 5 ft thick. Sediments consist largely of loams, silts and fine sands.

2.1.5 Habitats

The Phase II project area of the Milwaukee River and associated riparian area is a combination of warm-water fishery, deciduous riparian buffer, and fringe emergent/scrub-shrub wetland habitats. These habitats exist in close proximity to mowed/turf areas within the maintained areas of Lincoln Park. Riparian buffer and upland deciduous habitats are primarily composed of early-successional and invasive species cover with sporadic larger maples and oaks in the upland portions. Silver maple, eastern cottonwood, and black willow dominate the wetland areas.

Aquatic warm-water habitats are generally shallow and dominated by soft sediments, as described in Section 2.1.4. Aquatic species identified by WDNR (2008) in the Thiensville section of the Milwaukee River and Cedar Creek (approximately 10 miles upstream of the Phase II area) include Bluegill, Black Crappie, Common Carp, Hornyhead Chub, Creek Chub, Common Shiner, Fathead Minnow, Northern Pike, Rock Bass, Largemouth and Smallmouth Bass, Walleye, Yellow Perch, Common White Sucker and four species of Redhorse, with seasonal migrations of rainbow trout and Chinook and Coho Salmon.

2.2 BENEFICIAL USE IMPAIRMENTS

BUIs within the Milwaukee Estuary AOC include the following:

- **Restrictions on fish and wildlife consumption**
- Eutrophication or undesirable algae
- **Degradation of fish and wildlife populations**
- Beach closings
- Fish tumors or other deformities
- Degradation of aesthetics
- Bird or animal deformities or reproduction problems
- **Degradation of benthos**
- Degradation of phytoplankton and zooplankton populations
- **Restriction on dredging activities**
- Loss of fish and wildlife habitat.

BUIs shown in bold type have been identified as specifically associated with the Lincoln Park/Milwaukee River Site. These BUIs are primarily related to the presence of PCBs in the soft sediments of the Site. The PCBs tend to bioaccumulate into aquatic and benthic organisms and to be transported downstream if disturbed. NAPL and PAHs pose less potential for bioaccumulation, but could potentially contribute to degradation of benthos and restriction of dredging activities.

2.3 REMEDIAL ACTION OBJECTIVES

The following RAOs have been developed for the Phase II area:

- Remove/manage sediments contributing to the following BUIs within the Milwaukee Estuary AOC:

  — Restrictions on fish and wildlife consumption
  — Degradation of fish and wildlife populations
  — Degradation of benthos
  — Restrictions on dredging activities

- Minimize potential risks to human health and the environment during remedial activities

- Upon completion of remedial activities, restore habitat in the remediated areas.

Inherent to supporting removal of BUIs is controlling or eliminating contaminated sediments as a source of PCBs to the Milwaukee River AOC. The Sediment Remediation Targets Memorandum (Appendix A), prepared by WDNR and approved by EPA, proposed PRGs for PCBs and PAHs, for use in the evaluation of remedial alternatives and in remedial design for the Lincoln Park Phase II area. The sediment remediation targets were selected to achieve the objective of removing/managing sediments contributing to the BUIs listed above. Remediation of sediments with concentrations exceeding the PRGs will not only help alleviate contamination within the Phase II area, but will also eliminate the source of PCBs and PAHs to downstream portions of the AOC and thus support removal of BUIs.

For PCBs, the PRG proposed for the Phase II area is a surface-weighted average concentration (SWAC) less than 1 milligram per kilogram (mg/kg), equal to 1 part per million (ppm), total PCBs, to be achieved through remediation of sediment with total PCB concentrations exceeding 1 mg/kg. This PRG is consistent with the remedial action goal established in the Phase I FS (CH2M Hill 2009) and used to guide remedial actions in that area. A remedial goal of 1 mg/kg total PCBs was also used during remediation of sediments adjacent to Blatz Pavilion, which is located in the Phase II area (Figure 1-1) (Natural Resource Technology [NRT] 2007).

For PAHs, the PRG proposed for the Phase II area is a SWAC of 20 mg/kg or less, through remediation of sediments with total PAH concentrations exceeding 20 mg/kg. If determined to be acceptable, sediments with PAH concentrations between 20 and 40 mg/kg may not be remediated, if the resulting SWAC is below 20 mg/kg. This is part of a flexible approach to the PRGs, as proposed in the memorandum, to allow the goals to be adapted for compatibility with the remedial technique selected through this FS. Given their potential to act as a source of PAHs and to produce physical impacts on sediment quality, any detection of NAPL is considered to warrant remediation.

For the purposes of this FS, it will be assumed that all sediments with a total PCB concentration of 1 mg/kg or greater, all sediments with total PAH concentration of 20 mg/kg or greater, and all sediments containing NAPL will be targeted for remediation. Additionally, any sediment containing field-identifiable NAPL material (based on staining, odor, and Sudan IV testing if necessary) will also be remediated.

2.4 CHEMICAL SOURCES

The primary chemicals of concern for the Phase II area are PCBs, NAPL, and PAHs. The PCBs are thought to be derived from unidentified industrial sources within Lincoln Creek, which flows into the Milwaukee River at Lincoln Park. The NAPL is likely derived from an event in which bunker oil was spilled into Lincoln Creek, although its exact source is uncertain. The PAHs may be associated with this NAPL, or with other hydrocarbon sources within the watershed. Previous investigations have not identified any ongoing sources (i.e. upstream or upland sources) currently contributing additional amounts of PCBs, PAHs, or NAPL to the site beyond what is currently present in on-Site sediment deposits.

Elevated PCB concentrations have been detected in soft sediment deposits located in areas of deposition along the riverbank and on bars in the Milwaukee River main channel within the Phase II area (Figure 2-2), with concentrations in two deposits exceeding the Toxic Substances Control Act regulatory limit of 50 mg/kg total PCBs (Table 2-1). The highest detected PCB concentration was 230 mg/kg in sediments immediately behind the Estabrook Park Dam spillway (Deposit 5-1), and 162 mg/kg in sediments near the North Bridge (Deposit 7-2). Sediments containing elevated concentrations of PCBs tend to be located within the top 4 ft of the sediment surface, with a few notable exceptions (Figure 2-2). The Phase II RI found that areas with higher clay and silt content generally had higher PCB concentrations, as expected based on the high surface area of fine-grained sediment for adsorption of PCBs and other contaminants (CH2M Hill 2011a). Previous investigations have not found evidence of significant potential for exposure to PCBs or PAHs in the east oxbow; therefore, no portion of the east oxbow is included in the areas specifically targeted for remediation.

Total PAH concentrations up to 469 mg/kg were reported during sampling conducted in conjunction with this FS (Appendix B). The elevated PAH concentrations were also located in depositional areas of the river (Figure 2-3), including areas with elevated PCB concentrations.

During Phase I remediation, NAPL was found in subsurface sediments in an area within the northern portion of the western oxbow. This NAPL extended to the eastern boundary of the Phase I area under the North Bridge; therefore, an investigation of potential NAPL in the Phase II area was conducted as part of this FS. NAPL was observed in four locations, including three in the area of the North Bridge and one near the South Bridge (Figure 2-4) (Appendix B).

2.4.1 Delineation of Chemical Distribution

To define the areas targeted for remediation, the total observed PCB and PAH concentrations, as well as NAPL presence, were spatially interpolated in three dimensions to develop an estimate of the concentration and/or presence of these contaminants throughout the project area. Interpolation was performed by first mapping sediment thickness using bathymetry and sediment thickness probe data, and then using a spatially explicit statistical method called krigging to analyze chemistry data from sediment core samples. The methods used for this analysis are presented in additional detail in Appendix D. From these interpolation results, the sediment was segmented into deposits where one or more of the following conditions exist: (1) a total PCB concentration of 1 mg/kg or greater, (2) total PAH concentration of 20 mg/kg or greater, or (3) presence of NAPL. The volume and surface area of each of these deposits was computed from the three-dimensional model and are presented in Table 2-1. Characteristics of each deposit based on both interpretation and review of sediment core data are presented in Section 2.4.2. Depth of contaminated material below the sediment surface is indicated in Figure 2-3, Figure 2-4, and Figure 2-5, with the volume of estimated overlying sediments presented in Table 2-1.

It is important to note that there are three cases in which individual isolated samples demonstrated concentrations above PRGs, but these concentrations were not considered indicative of deposits warranting remediation. PCBs were detected in one sample at location SD-23N-C in the east oxbow at a total concentration of 1.01 mg/kg, at a depth of 1.5-2.5 ft bss. PAHs were detected in one sample at location SD30W-B in the east oxbow at a total concentration of 36.103 mg/kg (at 0.5-1.5 ft bss) and in one sample at location SD-17E-D in the main channel at a total concentration of 20.15 mg/kg (at 1.5-2.5 ft bss). In both cases, detections were within less than 5 percent of the PRG value, which is within the range of uncertainty potentially associated with laboratory analysis. Also, concentrations in sediment layers immediately above and/or below the sample were well below PRGs, and samples at all nearby locations were also below PRGs. Therefore, these detections were not considered indicative of larger deposits of sediments containing PCBs or PAHs requiring remediation. This was further confirmed by statistical modeling which showed minimal volumes of sediment associated with the concentrations in these samples.

2.4.2 Deposit-Specific Discussion

The individual deposits identified as targets for remediation (Figure 2-1) are described in detail below, in order from upstream to downstream within the Phase II area, and details of the deposits are presented in Table 2-1. For each, target volumes, areas, and concentrations and masses of contaminants as well as other information useful for FS analysis are presented and discussed.

- **Deposit 7-1** – Deposit 7-1 is located at the northern end of the eastern oxbow. The maximum reported total PCB concentration in this deposit is 3 mg/kg, and the maximum reported total PAH concentration is 105 mg/kg. The sediment that composes this deposit is approximately 70 percent fines, with fine and medium sand, and less than 5 percent coarser material (Table 2-1). The modeled volume of sediments exceeding PRGs in this deposit is 92 cubic yards (cy), over an area of approximately 0.1 acre and with an average depth of 3.2 ft below sediment surface (bss). The model indicates that a total mass of approximately 0.09 kg PCBs and 2.5 kg PAHs is contained within this volume of sediment. The estimated volume of sediments overlying the contaminated material is 814 cy.

- **Deposit 7-2** – Deposit 7-2 is located at the northern end of the west oxbow, extending from the North Bridge area southeast, along the bar on the western side of the adjacent island. The maximum reported total PCB concentration in this deposit is 162 mg/kg, and the maximum reported total PAH concentration is 247 mg/kg. The sediment that composes this deposit is approximately 65 percent fines, with fine and medium sand, and less than 10 percent coarser material (Table 2-1). The modeled volume of sediments exceeding PRGs in this deposit is 2,775 cy, 121 cy of which are regulated under TSCA. The model indicates that a total mass of approximately 17 kg PCBs and 76 kg PAHs is contained within this volume of sediments. Additionally, an estimated 172 cy of this sediment is contaminated with NAPL. The deposit covers an area of approximately 1.1 acres and with an average depth of 2.2 ft bss. The estimated volume of sediments overlying the contaminated material is 2,607 cy.

- **Deposit 7-3** – Deposit 7-3 is located on the western bank of the main channel, adjacent to the island defined by the western oxbow confluences. The maximum reported total PCB concentration in this deposit is 8.1 mg/kg, and the maximum reported total PAH concentration is 44 mg/kg. The sediment that composes this deposit is approximately 70 percent fines, with fine and medium sand, and 7 percent coarser material (Table 2-1). The modeled volume of sediments exceeding PRGs in this deposit is 2,548 cy, over an area of approximately 1.1 acres and with an average depth of 2.0 ft. The model indicates that a total mass of approximately 5.1 kg PCBs and 35 kg PAHs is contained within this volume of sediments. The estimated volume of sediments overlying the contaminated material is 2,538 cy.

- **Deposit 7-4** – Deposit 7-4 is located at the southern end of the eastern oxbow. The maximum reported total PCB concentration in this deposit is 2.4 mg/kg, and the maximum reported total PAH concentration is 37 mg/kg. The sediment that composes this deposit is approximately 75 percent fines, with fine and medium sand, and 4 percent coarser material (Table 2-1). The modeled volume of sediments exceeding PRGs in this deposit is 626 cy, over an area of approximately 0.9 acres and with an average depth of 2.2 ft bss. The model indicates that a total mass of approximately 0.48 kg PCBs and 7.2 kg PAHs is contained within this volume of sediments. The estimated volume of sediments overlying the contaminated material is 2,330 cy.

- **Deposit 3b-1** – Deposit 3b-1 is located at the southern outflow of the west oxbow, near the South Bridge. The maximum reported total PCB concentration in this deposit is 1.6 mg/kg, and the maximum reported total PAH concentration is 37 mg/kg. NAPL was detected in one core within Deposit 3b-1. The sediment that composes this deposit is a mix of fine to medium sand and fines (silt and clay), with approximately 9 percent coarse sand and gravel (Table 2-1). The modeled volume of sediments exceeding PRGs in this deposit is 632 cy, over an area of approximately 0.4 acre. The model indicates that a total mass of approximately 0.52 kg PCBs and 14 kg PAHs is contained within this volume of sediments. Additionally, an estimated 21 cy of this sediment is contaminated with NAPL. Contamination extends to an average depth of 1.0 ft bss. The estimated volume of sediments overlying the contaminated material is 116 cy.

- **Deposit 4-1** – Deposit 4-1 is located along the northern bank at the bend in the river. The maximum reported total PCB concentration in this deposit is 1.5 mg/kg, and the maximum reported total PAH concentration is 117 mg/kg. The sediment that composes this deposit is mostly fines, with fine and medium sand, and less than 3 percent coarser material (Table 2-1). The modeled volume of sediments exceeding PRGs in this deposit is 181 cy, over an area of approximately 0.1 acre and with an average depth of 0.86 ft bss. The model indicates that a total mass of approximately 0.26 kg PCBs and 3.9 kg PAHs is contained within this volume of sediments. The estimated volume of sediments overlying the contaminated material is 107 cy.

- **Deposit 4-2** – Deposit 4-2 is located along the northern bank just east of Deposit 4-1. The maximum reported total PCB concentration in this deposit is 1.9 mg/kg, and the maximum reported total PAH concentration is 33 mg/kg. The grain size of sediment in this deposit was not analyzed, but is assumed to be similar to that of Deposit 4-1 based on deposit location and setting. The modeled volume of sediments exceeding PRGs in this deposit is 249 cy, over an area of approximately 0.2 acre and with an average depth of 1.1 ft. The model indicates that a total mass of approximately 0.09 kg PCBs and 2.3 kg PAHs is contained within this volume of sediments. The estimated volume of sediments overlying the contaminated material is 173 cy.

- **<u>Deposit 4-3</u>** – Deposit 4-3 is located along the southern bank, under the I-43 bridge over the river. The maximum reported total PCB concentration in this deposit is 3.7 mg/kg, and the maximum reported total PAH concentration is 115 mg/kg. The sediment that composes this deposit is more than 70 percent coarse sand and gravel, with some finer sand and fines (Table 2-1). The modeled volume of sediments exceeding PRGs in this deposit is 83 cy, over an area of approximately 0.1 acre and with an average depth of 0.46 ft bss. The model indicates that a total mass of approximately 0.08 kg PCBs and 2.3 kg PAHs is contained within this volume of sediments. The estimated volume of sediments overlying the contaminated material is 90 cy.

- **<u>Deposit 5-1</u>** – Deposit 5-1 is located along the southern bank, just upstream of the Estabrook Park Dam fixed crest spillway. The maximum reported total PCB concentration in this deposit is 230 mg/kg, and the maximum reported total PAH concentration is 469 mg/kg. The sediment that composes this deposit is approximately 70 percent fines, with fine and medium sand, and less than 3 percent coarser material (Table 2-1). The modeled volume of sediments exceeding PRGs in this deposit is 2,775 cy, 50 cy of which are regulated under the Toxic Substances Control Act (TSCA). The model indicates that a total mass of approximately 26 kg PCBs and 132 kg PAHs contained within this volume of sediments. The deposit covers an area of approximately 1.4 acres and with an average bottom depth of the deposit of 2.2 ft bss. The estimated volume of sediments overlying the contaminated material is 1,206 cy.

In summary, sediments containing PCBs and/or PAHs exceeding PRGs, and/or containing NAPL, occupy approximately 5.3 acres of the Site with average deposit depths ranging from 0.46 to 3.2 ft bss. The total volume of material targeted for remediation is 10,845 cy of sediments containing PCBs, PAHs, and/or NAPL, with 171 cy regulated under TSCA because they have PCB concentrations greater than or equal to 50 mg/kg. An additional 9,881 cy of material overlay the contaminated sediments would need to be removed as overburden. If all the sediments in these deposits where PRGs are exceeded were removed, this would result in removal of a total of 50 kg of PCBs and 275 kg of PAHs from the AOC. Together, Deposits 5-1, 7-2, and 7-3 contain the majority of the volume of contaminated sediments as well as the majority of the contaminant mass (97 percent of the PCB mass and 88 percent of the PAH mass); however, the other six deposits together contain an estimated 1.5 kg of PCBs and 32 kg of PAHs.

Most deposits have a large proportion of fine grained material, with a site-wide average of 58 percent for the fraction of fines, and an average of 14 percent for coarse sand and gravel. This is significant for alternative evaluation because some remedial technologies are more effective for coarse-grained sediments. Percent moisture averages 28 percent across the site; this is useful information for computing percent solids as an input to quantity estimation. Core sediment recovery averaged 75 percent. Because core sediment recovery affects the accuracy of volume estimates, it must be considered as a factor in assigning contingency to FS-level calculations.

2.5 FATE, TRANSPORT, AND EXPOSURE MECHANISMS

Primary mechanisms of fate and transport of PCBs and NAPL/PAHs are expected to be erosion, deposition, and bioaccumulation. PCBs bind to soft sediment particles and are not expected to solubilize significantly. Therefore, transport is expected to occur when fine-grained sediment particles are eroded from the riverbed, carried downstream, and deposited in lower energy environments. The potential for bioaccumulation has been documented in studies of fish tissue concentrations that have resulted in fish consumption advisories within the Site boundaries.

The majority of the Site and surrounding uplands is owned by Milwaukee County and is managed as park land for recreational use. Notable exceptions are areas of residential and commercial properties that back up to the shoreline along the south shore of the west-east portion of the main channel. There is also an island located between the dam and its spillway that is owned by the U.S. Bureau of Land Management (BLM).

People may come into contact with sediments directly during recreational activities. People may also contact PCBs by consuming fish they have caught, although fish consumption advisories are in place. Ecological receptors that may be exposed to contaminants in the sediments include benthic and aquatic organisms and wildlife.

3. IDENTIFICATION AND SCREENING OF REMEDIAL TECHNOLOGIES

This section describes technologies that are applicable to remediation of sediments contaminated with PCBs, NAPL, and PAHs. The technologies are screened for their ability to achieve the RAOs for the Phase II area, based on their likely effectiveness, implementability, cost, and public acceptability. Technologies that are retained as a result of the screening are carried through to the remedial alternatives presented in Chapter 4.

Six primary categories of technologies that may be applicable to remediation in Lincoln Park Phase II were identified:

- No action
- Monitored Natural Recovery (MNR)
- Containment
- Sediment Removal and Related Technologies
- *In Situ* Treatment and Other Innovative Technologies
- Supporting technologies.

A screening level evaluation of each technology identified within these categories was performed, using the following criteria:

Effectiveness

Effectiveness is a measure of the ability of a technology to: (1) reduce toxicity, mobility, or volume of contamination; (2) minimize residual risks; (3) afford long-term protection; (4) comply with applicable regulations; (5) minimize short-term impacts; and (6) achieve protectiveness in a limited duration. Technologies that offer significantly less effectiveness than other proposed technologies were eliminated from the alternative development process. Technologies that do not provide adequate protection of human health and the environment likewise were eliminated from further consideration.

Implementability

Implementability is a measure of the technical feasibility and availability of the technology and the administrative feasibility of implementing it. Technologies that are technically or administratively infeasible or that would require equipment, specialists, or facilities that are not available within a reasonable period were eliminated from further consideration.

Cost

Qualitative relative costs for implementing the remedy were considered. Technologies that cost more to implement, but that offer no benefit in effectiveness or implementability over other technologies, were excluded from the alternative development process.

Public Acceptance

The likelihood of public acceptance of the remedy was considered. Among technologies with similar effectiveness and implementability, those expected to receive a more favorable response from the public were given preference.

As part of the screening, each technology was either retained or not retained for further analysis. Table 3-1 summarizes the identified technologies and the results of the screening-level evaluation. More detailed discussion of the technologies is provided in the sections below.

3.1 NO ACTION

A No Action alternative is typically considered as part of the alternatives screening process, and is retained for consideration to allow comparison with the identified technologies. There are no technologies associated with this response action. This alternative includes no institutional controls to prevent exposure to impacted media, nor efforts to contain, remove, treat, or dispose of any media at the Phase II area. A No Action response may be appropriate at a site with minimal risks to human health and the environment, but is not acceptable for the Lincoln Park Phase II Site. No Action will be carried forward as an alternative only because it is standard to evaluate this as a baseline for comparison.

3.2 MONITORED NATURAL RECOVERY

Many natural systems have the ability to break down, sequester, or otherwise diminish the availability and toxicity of chemicals.

3.2.1 Monitored Natural Recovery

MNR is a technology in which contaminant concentrations are monitored with no other actions to assess natural attenuation of contaminants by physical, chemical, and biological processes. Mechanisms by which natural processes could decrease the potential for exposure to contaminants at a site include biodegradation of contaminants and burial or mixing of contaminated sediments with clean sediments, which can reduce exposure levels for aquatic and benthic organisms.

To be accepted as a remedial alternative, MNR must achieve the required reductions in toxicity and risk associated with elevated contaminant concentrations within an acceptable timeframe. Therefore, a key component of MNR is a long-term, comprehensive monitoring program to confirm the expected decreases in risk to human health and the environment. With such a monitoring program as its primary component, MNR can be a highly implementable and low-cost option.

Typically, MNR is implemented as the primary technology at sites where the source of contaminants is controlled, current risks are low and/or decreasing, institutional controls address any potential risks to human health, natural processes for natural attenuation are occurring and expected to continue, downstream transport of contaminated sediments is not expected, and concerns regarding the effectiveness or implementability of other technologies make MNR the most appropriate option.

Conditions contradicting the use of MNR in the Phase II area include a lack of evidence for substantial decreases in PCB concentrations associated with contaminant burial or mixing, sediment instability in some areas under high flow conditions, the stated goal of preventing downstream transport of contaminated sediments, and the presence of PCBs which drive the BUIs and which biodegrade very slowly under natural conditions. MNR bears more applicability for PAHs, which break down more quickly in sediments than PCBs. However, MNR for both PCBs and PAHs in this situation would not prevent transport of contaminants. Additionally, it would require long-term monitoring and potentially contingency remedies should it prove ineffective, and there is currently no mechanism of funding these long-term operations. MNR is also not expected to easily achieve public acceptance due to its failure to support removal of BUIs in a reasonable timeframe compared to other technologies. Based on these conditions and the expected feasibility of other technologies, MNR is not retained for consideration.

3.3 CONTAINMENT

Sediment containment would be accomplished through placement of a cap of clean material over the contaminated areas to limit sediment transport and eliminate exposure to contaminants.

3.3.1 Isolation Cap

An isolation cap would consist of one or more layers of coarse-grained material (e.g., stone, sand, or aggregate) and fill installed over sediments known to exceed remedial goals, and would be the primary technology in areas where it is implemented. The cap would be designed to minimize contact with and transport of contaminated sediments. Stone size would be selected based on the magnitude of shear stress and other factors in the capping location, with higher flow channel areas requiring larger stone. Fabric could be installed under the cap to provide further stabilization of the contaminated sediments, especially in areas of shallow water. The cap would be keyed upstream, downstream, and into the channel bed, to form a protective barrier over existing contaminated sediments.

An isolation cap would largely prevent exposure and transport, and thus would support removal of BUIs relating to fish and wildlife exposure to PCBs, and is an accepted technology for remediation of contaminated sediments at a variety of sites. However, the effectiveness of a cap relies on its permanence, which is a function of hydrological conditions, future site uses (e.g., no dredging or other excavation activities), and monitoring and maintenance efforts. Caps located in low-shear-stress areas, with lower surface water flow velocities, require less maintenance, and therefore are both more effective and more implementable. Ice scour or propeller wash could also result in additional required cap maintenance in shallow areas. A lower potential for release of contaminated sediments is generally present under low-flow conditions, and in areas with minimal groundwater seepage. The capped surface could provide high or low quality habitat, depending on the capping material. Stone armoring used to maintain cap integrity could result in habitat degradation for some benthic species that rely on soft sediments; however, such a cap could also provide hard substrate, refugia, and foraging habitat for fish and benthic species. The cap would need to be designed to minimize its impacts on the potential for flooding associated with increases in the elevation of the river bottom, and also to minimize flow diversions that could affect the stability of the cap itself or nearby riverbank areas. One way to address these concerns would be to remove a layer of sediment equal to the thickness of the cap, prior to construction of the cap, so that the final elevation is at a stable grade.

PCB contamination in sediments is compatible with capping because PCBs are largely insoluble and will not diffuse through the cap in the dissolved phase; therefore, a cap preventing erosion of contaminated sediments should also prevent contaminant transport as long as the cap is maintained. Although PAHs can be somewhat more soluble than PCBs and some NAPL can mobilize through caps, an isolation cap would also be effective for preventing transport of PAH-contaminated sediments. However, because the contaminated sediments would be left in place, there would be the possibility of sediment transport downstream if the cap were disturbed. Sediment disturbance could occur by a variety of possible mechanisms, including storm events, ice scour, changes in the flow and sediment transport regime (as might occur due to dam removal or operation with fluctuating water levels), or activities such as dredging. Human activities that would disturb the cap, such as dredging and prop wash, can be controlled through restrictions and signage. A cap would not be appropriate for areas where dredging or other disturbance is planned. If changes in the hydraulic regime are anticipated, the cap would be designed to withstand both current and future conditions.

An isolation cap would be moderately implementable in the Phase II area from a logistical perspective, requiring transportation of a potentially large volume of capping material and in-water placement. Following installation, the cap would need to be monitored regularly for thickness, and would require periodic maintenance. However, the implementability of a cap would be negatively impacted by various other considerations, many of which were also identified during the Phase I FS (CH2M Hill 2009), resulting in the decision not to implement capping in the Phase I area. Use restrictions, beyond the restrictions on dredging activities, could be required to prevent cap disturbance by recreational users and by activities occurring on private properties along the capped areas of the river. The owners of riverfront private property would also likely be required to approve the cap and any maintenance activities, as state law indicates that riparian landowners generally own the bed and bank of the waterway to the center of the steam channel. The need to remove debris and sediment from behind the fixed crest spillway as part of standard dam maintenance activities would likely preclude capping in that area. Perhaps most significantly, funding for long-term cap maintenance is not an option under the Great Lakes Legacy Act (GLLA), under which this work is being performed. Without long-term maintenance, any cap installed would be expected to undergo significant decreases in effectiveness and may therefore not support removal of the BUIs.

Capping above the current elevation of the sediment surface could also impact the Federal Emergency Management Agency (FEMA) 100-year floodplain. Compliance with applicable local ordinances would be required for any changes in the 100-year floodplain. Additionally, a letter of map revision, and possibly easements, may be required if it is determined that the cap would cause an increase in the elevation of the 100-year floodplain. Activities required to address floodplain impacts would therefore cause extensive delays to schedule and permitting. Limited capping alternatives that do not impact the floodplain, as demonstrated by a suitable hydraulics model, could be possible in limited areas. However, extensive implementation of isolation capping would likely be hindered by requirements associated with floodplain impacts.

The cost of an isolation cap is expected to be moderate, associated mostly with the capital investments during cap installation and also with subsequent monitoring and maintenance.

An isolation cap is not retained for further evaluation as part of remedial alternatives, because of the disturbance it would pose to hydrologic conditions and river usage, because contaminated sediments would remain in place with the potential for release in the event of a cap disturbance, and because long-term maintenance of the cap could not be assured under the GLLA.

3.3.2 Reactive Cap

A cap of reactive material could be placed at the sediment surface, to both physically isolate contaminated sediments and chemically treat contaminants transported up through the cap. A reactive cap could be constructed using a variety of materials, including sulfide complex minerals (mackinawite, gypsum, or phosphogypsum), biopolymers (chitin/chitosan), zeolites, organoclays, or apatite, which could be mixed with sand or incorporated into engineered capping materials such as Reactive Core Mat™ (permeable) and AquaBlok® (impermeable).

The selected reactive material would be chosen for its ability to adsorb PCBs and/or PAHs under site conditions, and would be placed in a thin layer over the existing sediment surface. Contaminants flowing upward through the cap, driven primarily by the local groundwater gradient, would be removed prior to entering the water column. This reactive cap would likely be less thick than an isolation cap, because it would not need to contain the contaminants through purely physical means. An appropriately designed cap would be expected to effectively contain contaminants.

A reactive cap would decrease contaminant exposure and transport at the sediment surface. However, it would not address contamination in sediments at depth, and would require maintenance for long-term effectiveness. Also, the cap would have a limited timeframe of effectiveness, as it would not remove contaminants after all the reactive sites are used.

Treatability testing during the design phase could be used to design a cap with the desired lifetime of effectiveness. As with an isolation cap, installation of a reactive cap would temporarily disturb habitat, and could increase flooding risk by increasing the elevation of the river bottom, although likely to a smaller degree than an isolation cap. The cap surface could also be of lower habitat quality than the existing sediment surface; however, this could be mitigated through placement of natural material over the cap to serve as substrate.

A reactive cap would be more difficult to install than an isolation cap, due to the technical requirements associated with the reactive material. A reactive cap would also require transportation of capping material to the Site, and monitoring with periodic maintenance.

The cost of a reactive cap is expected to be relatively high, due to the relatively expensive capping materials, the requirement of detailed design procedures possibly including treatability testing, and the specialized cap placement procedures required.

A reactive cap is not retained for further evaluation, due to challenges to implementability and high costs, with only moderate effectiveness.

3.4 SEDIMENT REMOVAL AND RELATED TECHNOLOGIES

3.4.1 Sediment Removal Technologies

Sediment removal is a common technology used to eliminate exposure to and transport of contaminated sediments. Physical removal of contaminated sediment can be conducted by dry excavation or by mechanical or hydraulic dredging, using standard equipment to remove material from the riverbed and load it into transport mechanisms (e.g., trucks) for treatment and/or disposal. Regardless of the technology used, removal causes temporary destruction of the benthic habitat. Compared to capping, sediment removal requires no maintenance, and monitoring is often required for a shorter period of time. The goal of these technologies is to remove the bulk of the contaminated sediment mass.

Contaminant concentrations in sediment from areas where removal is performed would be analyzed following implementation of the selected remedial alternative, to assess the effectiveness of the removal action. If necessary to meet remedial goals, a residual cover of clean material could be placed following sediment removal. After removal, the area would also be restored to a riparian corridor with stable stream and floodplain, although the final grades may not match the existing grades (see Section 5.1).

The three primary technologies under consideration for sediment removal (dry excavation, hydraulic dredging, and mechanical dredging) are discussed below. The effectiveness of these technologies is dependent on design considerations, and their costs may be of a similar magnitude. Therefore, the decision of which technology to use in a given area will be based primarily on implementability, which will be assessed further during the design phase, as necessary.

3.4.1.1 Dry Excavation

Prior to dry excavation, the targeted area of contaminated sediments would be dewatered using flow diversions and pumping. Sediments would then be excavated to meet the RAOs.

Sediment removal by dry excavation would effectively decrease contaminant mass through removal. Dry excavation is expected to be the most effective technology for complete removal of sediments exceeding remedial goals, with minimal residual contamination left after sediment removal. Therefore, dry excavation would minimize the likelihood of needing a residual cover following removal. Dry excavation was used in the Phase I Area, and no unacceptable residuals were observed. Mobilization and transport of contaminated sediments by resuspension during removal activities is more easily controlled with dry excavation than with dredging.

Implementation of dry excavation would require a method for diverting the flow of the river away from the targeted area and then dewatering the sediments. However, this is an established sediment removal procedure, and is expected to be implementable in the shallow conditions of the Site and under average Site flow conditions. A nearby facility along the banks of the river would be needed for sediment handling and for treatment of the water removed from the excavation area. Sediments removed by dry excavation are expected to have lower water content than sediments removed by either mechanical or hydraulic dredging. Therefore, the sediments would require less effort in dewatering after excavation, although addition of amendments could be necessary to meet landfill requirements. The costs of dry excavation are expected to be moderate, associated only with the dewatering and excavation activities, as no long-term maintenance would be required.

Dry excavation is retained for further evaluation as a technology to effectively remove the contaminated sediments, and thus control both exposure and downstream transport.

3.4.1.2 Hydraulic Dredging

Hydraulic dredging would entail pumping of contaminated sediments from the river bottom to a facility for collecting and processing the resulting slurry. Sediments would be removed to meet the RAOs.

Sediment removal by hydraulic dredging would effectively decrease contaminant mass through removal. It would require measures to limit sediment resuspension and transport during dredging. Hydraulic dredging would likely leave somewhat more residual contaminated sediment than dry excavation, and therefore placement of a residual cover could be required following dredging.

Implementation of hydraulic dredging would require securing access of dredging equipment to the immediate vicinity of the contaminated sediments. An in-water barrier would be needed to limit resuspension and transport of disturbed sediment, and a facility to which the sediment slurry could be pumped for dewatering would need to be established. The slurry would contain a high percentage of water, which would need to be removed prior to disposal. This water removed from the slurry would also require treatment prior to disposal, separate from any treatment performed on the sediment. The presence of rocks or debris in the contaminated sediments could cause additional challenges to implementation of hydraulic dredging. However, hydraulic dredging may be the most implementable technology in some areas, due to site logistical considerations related to access to and removal of the contaminated sediments. The costs of hydraulic dredging are expected to be higher than the costs of dry excavation, due to costs associated with dewatering of the dredged slurry and treatment of the large volume of water removed.

Hydraulic dredging is retained for further evaluation as a technology to effectively remove the contaminated sediments, and thus control both exposure and downstream transport.

3.4.1.3 Mechanical Dredging

For mechanical dredging, contaminated sediments would be removed from the river (without dewatering the area), using equipment such as an excavator bucket or clam shell bucket down to a specified PCB concentration or to refusal.

Mechanical dredging would effectively decrease contaminant of concern mass through removal. Like hydraulic dredging, it would require measures to limit sediment resuspension and transport during dredging, and would likely leave somewhat more residual contaminated sediment than dry excavation, possibly requiring a residual cover.

Implementation of mechanical dredging would require that the excavator have access to the contaminated, submerged sediments, either from a nearby shoreline, from a tracked vehicle in shallow water (approximately 2 ft or less), or from a barge in locations where the depth of water is sufficient (approximately 3-4 ft or more). A nearby staging area for excavated sediments would also be required. An in-water barrier would be needed to limit resuspension and transport of disturbed sediment. In the Phase II area, inconsistent water depths in areas where contaminated sediments are located would be expected to make implementation of mechanical dredging difficult. Mechanical dredging would be most implementable along the shoreline; however, dry excavation is expected to be more easily implemented in these areas, due to easier staging and dewatering of the lower-water content material. The presence of rocks or debris in the contaminated sediments could also present challenges to mechanical dredging using buckets, particularly behind the fixed crest spillway. The costs of mechanical dredging are expected to be higher than the costs of dry excavation, due to additional costs associated with staging, transporting, and processing the higher-water-content dredged material.

Mechanical dredging is not retained for further evaluation, due to the challenges associated with access to many of the contaminated sediments in the Phase II area, and the additional staging and dewatering it would require relative to dry excavation.

3.4.2 Residuals Management

As noted above, no unacceptable residuals were observed following dry excavation in the Phase I area. However, some residual contaminated material could remain in the river following sediment removal, due to site conditions and technical limitations. Examples of such limitations include incomplete removal of sediment overlying bedrock and resuspension and subsequent settling of sediments disturbed during hydraulic dredging. If residual contamination is present, potential exposure to the contaminants in these residuals can be decreased by implementing additional technologies following removal.

3.4.2.1 Residual Cover

A residual cover is a clean cover placed in limited areas where the contaminant concentrations are just above remedial goals, and could be implemented in areas where sediment removal is performed, in order to act as a dilution layer to decrease exposure to residual contaminants that remain following removal of as much of the contaminated material as technically feasible. Cover placement would be considered in areas where unacceptable residual contamination is left following removal. Residual contamination, and the need for a cover, is expected to be more likely following subaqueous sediment removal than dry excavation. If a residual cover is determined to be necessary following removal, a cover of clean material (stone and/or sand) would be installed to a stable grade following the sediment removal action, with design parameters appropriate to decrease contact with and transport of any residual contamination remaining in sediment following the removal action. Stone size would be chosen to be consistent with natural materials in riffles.

The residual cover would be designed to further mitigate any remaining risk associated with residual contaminants following sediment removal. Such a cover would be more stable than a cover installed above the existing sediment surface and would not create flow constrictions or increased risk of flooding because it would not be installed above the existing sediment surface elevation.

Installation of a residual cover following sediment removal is expected to be implementable in the Phase II area. Cover material would need to be transported to the Site and placed in-water in the location of dredging. It would not require excavation beyond the sediment removal action. A flow diversion (coffer dam, silt curtain, or similar) would likely be required during cover placement, but the same diversion could be used during both sediment removal and placement of the cover. Follow-up monitoring and maintenance would not be anticipated. Based on these factors, the cost of a residual cover would also be relatively low.

Residual cover is retained for further evaluation as a technology to further decrease potential exposure following sediment removal activities.

3.4.3 Sediment Handling and *Ex Situ* Treatment Technologies

As discussed above, sediments removed from a lake or river typically require dewatering prior to disposal. The sediment removal technology determines the water content of the removed material, and also affects the choice of dewatering technologies and the design of the dewatering system. *Ex situ* sediment treatment technologies can also be used to remove or stabilize contaminants in excavated or dredged sediments. Such treatment can allow additional disposal options for the sediment. For example, treated sediment may be appropriate for reuse as fill material. This can decrease the volume of sediments requiring containment in a disposal facility.

Six treatment technologies were identified for possible application to sediments from the Phase II area, and are discussed below.

3.4.3.1 Chemical Dewatering – Stabilization

Addition of fly ash, Portland cement, Calciment®, or similar binding material to the sediment can partially or completely solidify the sediment mass, thus promoting dewatering of moist sediments and decreasing the leachability of contaminants.

Chemical stabilization is expected to be highly effective as a fast dewatering solution for sediments removed using dry excavation, which have a relatively low water content following removal. For these sediments, chemical stabilization could be used as a dewatering technology, and could also improve the physical properties of the sediment for disposal. Addition of an appropriate percentage of binding material to the sediment mixture could occur *in situ* at the excavation site or at the dewatering pad prior to loading for disposal, and thus would be highly implementable.

Chemical stabilization of sediments through addition of cement or similar material is retained as a dewatering and treatment technology, primarily for sediments removed by dry excavation.

3.4.3.2 Passive Dewatering – Geotubes

Geotubes are constructed of permeable geotextiles that allow passage of water but not sediment. They are typically used with hydraulic dredging and in conjunction with a thickening or flocculating agent to promote drying of the sediment. Dredged sediment slurry is pumped into such geotubes, and the water flows out of the thickened slurry and passes through the geotextile, leaving dewatered sediment within the tube.

The timeframe for dewatering using geotubes is substantially shorter than the timeframe for dewatering in a settling pond. The water that passes through the geotextiles also tends to be of lower turbidity than water pumped out of a settling pond.

Use of geotubes would require that sediment slurry be pumped from a hydraulic dredge to the dewatering area or area(s), likely on the park property adjacent to the river. The placement of the dewatering areas would likely be chosen to decrease transport distance through the pipelines. The area required for dewatering using geotubes would be smaller than that required to dewater a similar amount of sediment slurry in a settling pond, although the area required to dewater using geotubes would still be large, due to the volume of the dredged sediment slurry. The large volume of water removed from the sediment slurry would also require a relatively large-footprint water treatment facility. Passive dewatering using geotubes will be considered as a possible dewatering technology for sediments removed by hydraulic dredging.

3.4.3.3 Passive Dewatering – Settling Pond

A lined settling pond for removed sediments could be established onsite or nearby. Removed sediments would be trucked or otherwise transported to the pond, and water would be pumped out as the sediment settles. Technologies such as wick drains could be used to promote separation of water from the sediments.

Dewatering of removed sediments in a settling pond would be expected to achieve the degree of dewatering required for sediment disposal. The timeframe for dewatering would likely be longer than required for other technologies, including dewatering using geotubes or solidification. Therefore, it is most likely to be used for sediments removed by dry excavation or mechanical dredging, which are expected to have a water content that is too low to allow pumping into geotubes, and may have too high a water content to allow dewatering by solidification. The water removed would require treatment prior to discharge back to the waterway.

Construction of settling ponds would require a large area, likely on the park property adjacent to the river. Transport of sediments removed by mechanical dredging would likely require trucks, which would need to have access to the areas where dredging is performed and to roads leading to the settling pond. Hydraulically dredged sediment slurries could likely be pumped directly through a pipeline to the settling pond from the dredging area. However, direct pumping to the pond could restrict placement of the pond, to minimize distance from the dredging areas.

Passive dewatering in a settling pond will be considered as a possible dewatering technology for sediments removed by dry excavation or small-scale hydraulic dredging.

3.4.3.4 Particle Size Segregation

Particle size segregation entails separation of fine particles, which are typically more highly contaminated, from coarse particles (coarse sand and gravel), which typically have lower contaminant concentrations. The results of the Phase II RI (CH2M Hill 2011a) indicated that a variety of particle sizes are present in contaminated areas of the Site. The segregation can be performed on dried or wet sediments, and enables the coarse material to be disposed of separately or used in another manner at the Site or elsewhere.

Particle size segregation is expected to be highly effective for providing separate size fractions of sediment, if this is determined to be advantageous for the project. However, its effectiveness as a treatment technology would depend on test results showing that the contaminants are associated with a specific, fine size fraction. The Phase II RI provides preliminary findings to this effect. If this is further confirmed, segregation could be performed to provide coarse sediments for reuse. The required technology is available. Segregation may be implementable following bench or pilot testing to establish methods, but is also dependent on the ability to establish designated staging and treatment facilities at the Site. The implementability of segregation may also be limited if coarse-grained material contains residual concentrations of PCBs and PAHs which, though low, are still considered unacceptable to return to the Site as cover material. The cost of the segregation is expected to be moderate, although removal of the coarse material may increase the disposal costs of the fine remainder, due to higher concentrations and altered geotechnical properties. Segregation would likely only be selected for use if the cost is offset by savings associated with transportation and disposal, or a decreased volume of cover material requiring purchase.

Particle size segregation is retained as a potential technology for treating removed sediments and providing coarse cover material, if needed, for habitat restoration or residual cover.

3.4.3.5 Sediment Washing

In sediment washing, fine particles, which preferentially accumulate PCBs and PAHs, are washed from the excavated sediment in an aqueous system, allowing separate disposal of the high-contaminant material. The resulting low-contaminant material is returned to the Site or put to other uses.

Sediment washing would likely not be as effective as particle size segregation for separating high-contaminant from low-contaminant material, assuming that the PCBs and PAHs are preferentially associated with fine particles. Efficient separation would be required to allow separate disposal; if contaminant concentrations in both fractions remained above remedial goals, the potential cost savings would not be realized. Sediment washing would also be more difficult than particle size segregation to implement at the Site, as it requires specialized treatment, treatability testing, and establishment of designated staging and treatment areas. The cost of sediment washing would be relatively high, driven by the specialized equipment and intensive utility usage during washing.

Sediment washing is not retained as a potential technology for treating removed sediments, because it is not expected to be sufficiently effective or implementable to provide a net benefit.

3.4.3.6 Vitrification

Vitrification would entail heating of excavated and dewatered sediments to a temperature sufficient to transform them to a glass state, and destroy contaminants.

Vitrification would be highly effective for destroying PCBs, PAHs, and/or NAPL in excavated sediments, but would be difficult and expensive to implement. It would require that sediments be dewatered and transferred to a specialized facility outfitted to collect and treat the offgas that results from vitrification of PCB-contaminated sediments. The costs of vitrification would also be high, due to these requirements.

Vitrification is not retained as a potential technology for treating removed sediments, because its benefits are not expected to be sufficient to justify the high cost, when compared to other options for sediment disposal.

3.4.4 Disposal Options

Following removal by excavation or dredging, contaminated sediments would require disposal in a manner that prevents future exposure to PCBs and PAHs. Options for disposal include offsite disposal in a facility appropriate for the concentration of contaminants present, or onsite disposal in a confined disposal facility (CDF).

3.4.4.1 Offsite Disposal

Removed sediments could be disposed of at an offsite facility. Sediments with PCB concentrations less than 50 mg/kg would be transferred to a facility approved for non-TSCA, PCB-contaminated sediments. Sediments with PCB concentrations 50 mg/kg or greater would be transferred to a TSCA-approved facility for permanent disposal.

Offsite disposal is a common disposal option that would permanently remove contaminant mass from the Site. Facilities for disposal of non-TSCA (<50 mg/kg) PCB sediments are available in the Milwaukee area. TSCA materials (≥50 mg/kg PCBs) could be transferred to out-of-state, regional facilities. Dewatering and/or amendments would likely need to be used to stabilize the sediment to facilitate handling and disposal. Offsite disposal can be expensive depending on the location of a site relative to disposal facilities, the volume of sediment involved, the nature of contamination, and the availability of different treatment or disposal options in the area. The overall costs of offsite disposal are expected to be relatively high, associated with transportation and disposal fees, particularly for TSCA materials.

Offsite disposal is retained for further evaluation in remedial alternatives, because of its effectiveness and implementability in combination with sediment removal activities.

3.4.4.2 Onsite Disposal

Another option for disposal of contaminated sediments is containment within an onsite CDF. CDFs can permanently contain contaminated sediments in an upland or in-water landfill onsite, effectively preventing future exposure and transport of the contaminants. In some cases, an in-water CDF can be sited in a location of contaminated sediments, such that those sediments do not require removal and transport. Disposal in a CDF rather than at an offsite facility would decrease the requirements for transport of sediments, and could therefore offer cost savings relative to the offsite disposal option.

A CDF at the Lincoln Park Phase II site would need to be sited outside of the floodplain in order to achieve regulatory approval. However, sufficient space is not available on nearby County lands to contain the contaminated sediments in an upland area above the floodplain. Therefore, a CDF is not expected to be implementable for the Phase II remediation.

Based on the evaluation performed in Section 3.4.4.1 and Section 3.4.4.2, onsite disposal is not retained for further evaluation as part of remedial alternatives.

3.5 *IN SITU* TREATMENT AND INNOVATIVE TECHNOLOGIES

In situ treatment addresses contamination in place using processes that alter the state of the contamination, transform it to innocuous forms, or immobilize it. Technologies for *in situ* treatment that were identified for potential use at the Phase II area are discussed below.

3.5.1 Stabilization

In stabilization, treatment is accomplished by the addition of amendments to solidify the contaminated sediments within the bed of the waterway, resulting in a reduction in their toxicity and/or mobility. Potential amendments for solidifying the sediment include Portland cement and lime. The contaminated sediments would be dewatered and then mixed with the selected amendment for stabilization.

Stabilization would decrease contaminant mobility and could also decrease exposure, depending on the nature of the sediment surface following stabilization. However, the permanence of stabilization may be negatively impacted by erosion, and the stabilized surface would likely be of lower habitat quality than the existing sediment surface. The dewatering of sediments required prior to addition of amendments would necessitate dewatering portions of the river channel.

Stabilization is not retained for incorporation into remedial alternatives for evaluation, due to its low implementability, high cost, and uncertain effectiveness.

3.5.2 Activated Carbon Sequestration

Sequestration by activated carbon, which is an effective adsorbent for PCBs, PAHs, and other contaminants, decreases the bioavailability of the contaminants. In this technology, activated carbon would be added to the sediment surface, and then bioturbation by organisms living within the sediment would mix the carbon throughout the uppermost, biologically active sediment layer, where it would absorb contaminants and decrease their bioavailability.

Sequestration is best suited for areas with low-level contamination, and would decrease bioavailability to some degree in areas where it is added. However, it would not stabilize the sediments and therefore would not prevent downstream transport of contaminants. Sediment disturbance that removes the upper sediment layer would expose untreated sediments. The effectiveness of this technology would also be limited by the degree of mixing achieved by bioturbation, and significant volume of unsequestered contaminants could remain even in the active layer, especially in the short term. The long-term effectiveness of this technology is uncertain, as contaminants could become more bioavailable over time. The long-term stability of carbon-sequestered PCBs and PAHs is still being assessed in the laboratory and in the field by researchers and remediation professionals.

Sequestration by activated carbon would be moderately implementable at the Site, requiring import of activated carbon, placement in water, and periodic monitoring, and costs are also expected to be moderate.

Activated carbon sequestration is not retained for further evaluation, because it is expected to be less effective than other technologies, and would not prevent downstream transport of contaminants, which is a primary component of the RAOs for the Site.

3.5.3 Innovative Technologies

A number of innovative technologies are currently in development for *in situ* or *ex situ* treatment of PCBs. Some of these technologies have reached the stage of pilot testing while others have been used only in bench-scale tests. Examples include the following:

- **Phytoremediation:** Studies of both wetland and upland plants have shown the ability to uptake PCBs as a means of concentrating contamination and facilitating disposal. Studies have found that emergent wetland plants are capable of taking up PCBs (Smith et al. 2007), which bears potential as a means of *in situ* extraction from sediments. *In situ* phytoremediation of PAHs has also been shown to occur, by a different mechanism, in which plants increase the rate of degradation of the PAHs in soils and sediments (Van Epps 2006). However, these technologies are limited to shallow areas that can support such plants and is dependent on plant growth rates and the use of multiple growing seasons to achieve sufficient extraction or degradation. Members of the family of plants that includes pumpkins and squash have been shown to uptake PCBs (Whitefield et al. 2008) and bear potential for use in *ex situ* treatment through phytoextraction. However, such processes may be limited by PCB bioavailability, require large areas for land farming, and require multiple growing seasons. Additionally, the plants (including fruits) must be harvested and landfilled as appropriate given their level of contamination. Therefore, phytoremediation technologies are considered infeasible for use in the Phase II area.

- **Bioremediation:** Bioremediation has been identified as a possible means of remediating sediments *in situ*. Several strains of bacteria have been identified that can reductively dechlorinate PCBs, and processes for promoting their growth identified; however, a lack of field testing and limits on implementability constrain the utility of this technology (Mikszewski 2004). Although a wide variety of bacteria can degrade PAHs, particularly in combination with other hydrocarbons, this is not expected to be a feasible technology for the Phase II area, due to its limitations for treatment of the co-located PCBs.

- **Zero-valent iron (ZVI) treatment:** ZVI amendment has been identified as an emerging technology for treatment of PCBs and PAHs in soils and sediments (Mikszewski 2004; Chang et al. 2005). Addition of ZVI can promote bioremediation of PCBs through reductive dechlorination and can directly degrade PAHs. As part of a technology assessment, EPA evaluated multiple bench-scale studies and determined that, while ZVI bears some potential to degrade PCBs in sediments, it is not an effective *in situ* amendment (Mikszewski 2004).

- **Thermal treatment:** Thermal desorption and degradation of PCBs and PAHs have been demonstrated in field projects where sediments were remediated *in situ* or *ex situ* (Lonie et al. 1998, Baker et al. 2006). While this technology is promising, permitting requirements for onsite treatment of TSCA-level PCB waste and area requirements for a treatment facility are considered prohibitively expensive and infeasible within the project timeframe.

In summary, these and other technologies are in various stages of development, and they are unlikely to be implementable or cost effective alternatives for PCB remediation at Lincoln Park. Therefore, none of these innovative technologies is retained for further evaluation as part of remedial alternatives.

3.6 SUPPORTING TECHNOLOGIES

3.6.1 Institutional Controls

Institutional controls are used to limit risk by controlling exposure to contaminated media. These controls can include deed restrictions limiting the use of properties, fences, or other barriers to limit access to a contaminated site; water use restrictions such as no anchor or no wake zones; limitations on dredging; and maintenance agreements or advisories issued to the public notifying them of the risks associated with contacting contaminated media. Due to the size, configuration, and uses of the Phase II area, deed restrictions and barriers to access are not considered feasible.

Currently, fish consumption advisories and restrictions on dredging are in place at the Site. The fish consumption advisory provides guidance to members of the public regarding risks associated with consumption of fish with elevated contaminant concentrations in their tissues. Signs along the river warn the public about both fish consumption and contact with sediments. The effectiveness of these advisories depends on the response of the public in terms of a change in behavior to limit exposure, which in turn is dependent on effective communication. However, advisories are a moderately effective, easily implementable, and low-cost option for controlling some human health risks in the short term, before RAOs are met.

Institutional controls are not retained for incorporation into remedial alternatives, because one of the primary RAOs of the remedial action to be performed in the Phase II area is to support the removal of the BUIs and thus eliminate the need for institutional controls. However, fish consumption advisories will likely remain in place following remediation, until further testing and evaluation indicate that a change in the advisories is appropriate.

4. REMEDIAL ALTERNATIVES

The retained remedial technologies were combined into seven remedial alternatives. These alternatives are presented in Table 4-1. Detailed evaluation of these remedial alternatives is presented in Chapters 7 and 8.

4.1 ALTERNATIVE 1: NO ACTION

Alternative 1, in which no remedial actions are taken, is retained for comparison with the other identified remedial alternatives.

4.2 ALTERNATIVE 2: DRY EXCAVATION AND DISPOSAL OF SEDIMENTS

Alternative 2 would entail removing sediments containing contamination in excess of remedial goals from the river using dry excavation technologies. The sediments would then be dewatered to the extent required, likely using a dewatering pad and/or chemical stabilization due to the low water content of sediments excavated in the dry, and transported offsite for disposal. Widespread residual cover would not be expected to be necessary, but cover could be implemented in limited areas if residual contamination remains following excavation.

4.3 ALTERNATIVE 2A: DRY EXCAVATION AND DISPOSAL OF SEDIMENTS, WITH PARTICLE SIZE SEGREGATION

Alternative 2a would include all the elements of Alternative 2, with the addition of particle size segregation to separate the fine and coarse fractions of the excavated sediments. After segregation, the coarse fraction could be used for some acceptable reuse, and the fine fraction, which is expected to have higher contaminant concentrations, would be disposed offsite.

4.4 ALTERNATIVE 3: HYDRAULIC DREDGING AND DISPOSAL OF SEDIMENTS

Alternative 3 would entail removing sediments containing contamination in excess of remedial goals from the river using hydraulic dredging technologies. The resulting sediment slurry would then be dewatered to the extent required, likely using passive dewatering in settling ponds or geotubes, and transported offsite for disposal. Placement of residual cover could be necessary in areas where residual contamination remains following dredging.

4.5 ALTERNATIVE 3A: HYDRAULIC DREDGING AND DISPOSAL OF SEDIMENTS, WITH PARTICLE SIZE SEGREGATION

Alternative 3a would include all the elements of Alternative 3, with the addition of particle size segregation to separate the fine and coarse fractions of the dredged sediments. After segregation, the coarse fraction could be used as residual cover or for some other acceptable use, and the fine fraction, which is expected to have higher contaminant concentrations, would be disposed offsite.

4.6 ALTERNATIVE 4: DRY EXCAVATION, HYDRAULIC DREDGING, AND DISPOSAL OF SEDIMENTS

Alternative 4 would entail removing sediments containing contamination in excess of remedial goals from the river using a combination of dry excavation and hydraulic dredging technologies, with excavation or dredging selected as the technology to remove contaminated sediments from each area requiring remediation. This alternative would be selected if it is determined that dry excavation is more implementable in some areas, while hydraulic dredging is more implementable in other areas. Dewatering would likely include a combination of passive dewatering and chemical stabilization. Placement of residual cover would be most likely in areas of hydraulic dredging, where residual contamination is more likely to remain following dredging.

4.7 ALTERNATIVE 4A: DRY EXCAVATION, HYDRAULIC DREDGING, AND DISPOSAL OF SEDIMENTS, WITH PARTICLE SIZE SEGREGATION

Alternative 4a would include all the elements of Alternative 4, with the addition of particle size segregation to separate the fine and coarse fractions of the removed sediments. After segregation, the coarse fraction could be used as residual cover or for some other acceptable use, and the fine fraction, which is expected to have higher contaminant concentrations, would be disposed offsite.

5. HABITAT RESTORATION GOALS AND TECHNIQUES

The remediation of contaminated sediments represents but one aspect of restoring habitat to this reach of the Milwaukee River. The sediment remediation activity and compatibility with future uses can be simultaneously addressed in the habitat restoration approach.

Habitat restoration focuses on goals specific to the remediation, and restoration must be compatible with the remedial goals for the project. Habitat restoration must not increase the potential for human or environmental exposure to contaminants or limit the effectiveness of the selected remedial actions. While the goals of habitat restoration for this project focus on those associated with the remediation, restoration may have broader benefits that apply to the waterbody and watershed as a whole, especially with regard to watershed implementation plans and addressing beneficial use impairments. The intersection of these interests for habitat restoration comes in achieving the goals discussed below for upland and aquatic habitat restoration.

5.1 HABITAT GOALS IN SUPPORT OF THE REMEDIATION

A variety of habitat goals can be coupled with the remedial actions proposed for Lincoln Park. These goals represent broad, project-wide objectives. Much as the remedial design will vary for each individual area of contamination, restoration goals will be met with a diverse set of actions and multiple technologies, tailored individually to each area of excavation, dredging, construction laydown, or other construction support.

5.1.1 Restore Habitat Affected by Sediment Remediation Activities

The primary goal habitat goal of the Lincoln Park Phase II remedial action is "*restoration of the habitat to a system that is self-sustaining, but which may be unlike pre-remedial conditions*."

The restoration of this system may include the restoration of wetlands in their present or nearby locations, the removal of invasive species, or the stabilization of bed and banks following disturbance from the remedial action.

Similarly, this goal encompasses the restoration or stabilization of upland or riparian areas to stable self-maintaining slopes, re-vegetation (be that in turf, forested buffer, or wetland vegetation), and restoration of aesthetic elements. This may include enhancements, such as the removal of invasive non-native vegetation and replacement with native vegetation, or elements which improve park utilization, park access, or aesthetics.

5.1.2 Minimize Potential for Erosion

A separate but closely related goal is "*the establishment of self-maintaining river and habitats with limited bank and bed erosion or aggregation*."

The restored river reach should not be subject to any greater probability of bank erosion, bed scour, or accretion of sediments than the river is presently subject to. Closely related to this, the channel thalweg (or deepest portion) should be maintained in approximately the same position, and be as stable in its position as it presently.

This goal directly relates to protecting infrastructure and maintaining the present recreational uses within the limits of the existing depositional regime.

5.1.3 Regulatory Compatibility of Habitat

Various requirements may arise through local, state, and federal permitting requirements. Therefore, the "*restoration of habitats such that they comply with relevant requirements for natural resources permitting*" is a necessary goal in order to ensure no regulatory or civil actions are taken against the project or sponsors.

An important part of this regulatory compliance goal is ensuring that the 100-year floodplain elevation is not increased, that channel velocities for flood events are not increased, and that the flood impact footprint is not expanded. While flooding in the river is inevitable, the remedial action and its restoration should not in any way increase the magnitude or frequency of flooding.

Wetlands restoration is a potentially significant component of federal and state regulatory compliance. Under wetlands restoration requirements, any impacted wetlands must be restored to their existing condition, or re-located within the project footprint. When this is accomplished, wetlands impacts are regarded as temporary, or the project is self-mitigating with no net loss of jurisdictional wetlands. Although offsite mitigation may be an option for permanent wetlands impacts that cannot be mitigated within the project footprint, this option is costly and less favorable in a regulatory context than temporary impacts to wetlands or a self-mitigating project.

5.2 RESTORATION TECHNIQUES IN SUPPORT OF HABITAT GOALS

There are multiple compatible techniques which will support the goals of habitat restoration at this site. Each of these techniques can be implemented singly, or in combination as appropriate in each area impacted by the remediation construction to support these goals. They key techniques are outlined below and in Table 5-1; the details of how each is implemented and where are to be determined through the remedial design.

5.2.1 Benthic/Substrate Restoration

Options for restoration of the river bottom substrate and benthic habitat include the placement of substrates suitable for benthic utilization. The substrate mix is chosen to match the sizes and geologic materials of the native sands and gravels of the river, which includes both mobile and immobile fractions of material. The configuration of these substrates may mimic point bars, side bars, or other river facet features. These materials not only contribute to the restoration of stable river bed geometry, but contribute to the formation of stable flow regimes as discussed later in this section. Depending on the size and distribution of these materials, these materials also may increase the utilization of river substrates by targeted species of concern within the river.

Benthic/substrate restoration can be effective and highly implementable following sediment removal. It is typically compatible with most remedial technologies, except those which involve hard armoring. Hard armor can be incorporated within the context of substrate restoration, however, forming a stable sub-pavement of bed materials below an active benthic bed.

The restoration of benthic habitats is most effective when they are restored in accordance to the existing deposition and aggregation zones, without creating obstructions which may destabilize the river bed and banks. Placed and sized correctly, benthic substrate restoration is an effective restoration alternative which removes much of the uncertainty and instability associated with a natural substrate recovery.

Another benthic restoration strategy includes the placement of woody debris structures to provide diversity in benthic substrate as well as flow diversity. These structures would differ from the existing floating woody debris in that they would be anchored close to the channel banks, in shallow submerged locations. These structures would not contribute to the collection of floatable debris or as obstructions to boating. These structures could be installed only in specific portions of the bed and bank which are hydraulically compatible with their placement, and in conjunction with substrate restoration. Coupled with boulder clusters, these features can provide reliably available fish habitat while also enhancing recreational access and aesthetics, and improving recreational fishing utility of the river.

The implementability of benthic habitat restoration depends on installing the restoration materials in a timely fashion, and using the same erosion and sediment controls, flow diversions, and site controls utilized as part of the remedial alternative. Placing these materials shortly after the remediation can help minimize the cost, effort, and difficulty in achieving a successful implementation.

The costs of benthic/substrate restoration are typically low compared to the costs of remedial technologies, and similar to the cost of other restoration technologies. This restoration technique is retained in combination with remediation by sediment removal.

5.2.2 Flow Regime Restoration Following Remediation

Restoration of the flow regime following remedial activities allows the channel to safely convey flood and base flows, and also allows restoration of natural sediment transport patterns and flow diversity. Flow regime restoration can include re-sizing the channel bed and banks to allow stable flow regimes following the remedial action. It is an essential element to minimize impacts on the 100-year floodplain elevation, and that flooding magnitude and frequency are not increased as a result of project implementation. These factors are critical in creating and maintaining diverse benthic habitats as well as potentially preventing substrate restoration areas from being blanketed in fine sediments.

Flow regime restoration is most effective when coupled with a combined natural channel design and hydraulics model, to accurately predict hydraulic effects of grading, bank shaping, dredging, and channel substrate restoration. Additionally, this alternative is most effective when combined with the remedial alternative, implementing the restoration of flow regime concurrently with the remedial action rather than implementing it as a separate exercise.

The implementability of flow regime restoration depends on the ability of the remedial alternative to be compatible with the channel slope and dimension required to convey flows safely and non-destructively. This means that remedial alternatives which create large channel obstructions would typically be incompatible with flow regime restoration. Flow regime restoration may also combine the re-use of segregated uncontaminated cobble and gravel fractions which are excavated during the remediation. In addition to aiding in implementability, this option may reduce costs for disposing of material, and provides a washed substrate free of fine material, suitable for benthic habitat restoration as well as flow regime restoration.

The costs of flow regime restoration are typically low compared to the costs of remedial technologies, and similar to the cost of other restoration technologies. This restoration technique is retained in combination with any remediation alternative that alters the geometry of the river bottom.

5.2.3 Bank, Riparian, and Upland Restoration

The restoration of bank, riparian, and upland areas can be paired with remedial technologies to improve bank stability, decrease erosion potential, and improve overall habitat quality. The restoration can include grading the banks to appropriate stable angles, installation of bank armoring and woody debris structures, and planting riparian vegetation or turf grasses in order to regain a pre-existing or desired land usage.

These techniques are most effective when combined with site controls or management which would prevent disturbances or the growth of non-native invasive or otherwise incompatible species. Additionally, this alternative is most effective when combined with flow regime restoration, which will stabilize banks through the reduction of shear stress and flow turbulence.

The implementability of bank, riparian, and upland restoration depends upon the successful implementation of a remedial alternative. Riparian planting should occur following site disturbance from the remedial action; bank grading and stabilization is best implemented concurrent with remedial actions. Restoration of haul roads, laydown or dewatering areas must occur following the remedial alternative implementation.

The costs of bank and riparian restoration are typically low compared to the costs of remedial technologies, and are also low compared to the cost of other restoration technologies. This restoration technique is retained in combination with all remediation alternatives.

6. ALTERNATIVES EVALUATION CRITERIA

The remedial and restoration alternatives developed in Chapters 4 and 5 were evaluated using the criteria described below, to support selection of a recommended remedy. The criteria fall into three groups: (1) Threshold Criteria, which must be met for any alternative selected as a remedy for the Phase II area; (2) Balancing Criteria, for which rankings are assigned to each alternative to provide a technical basis for comparing the advantages and disadvantages of the alternatives; and (3) Modifying Criteria, which can be used to distinguish between alternatives that meet the threshold criteria and have similar rankings for the balancing criteria. The evaluation of alternatives according to these criteria are presented in Chapters 7 and 8 (remedial alternatives) and Chapter 9 (restoration alternatives).

6.1 THRESHOLD CRITERIA

Compliance With Federal, State, and Local Permits and Applicable Regulatory Requirements

Compliance with regulatory requirements is the only threshold criterion for this Site. Each alternative is evaluated to determine whether it can perform its intended function and meet the RAOs in accordance with applicable regulatory requirements, with the appropriate permits. Applicable regulatory requirements include requirements for contaminant remedial goals, waste disposal criteria and regulations, procedures for addressing changes to the river channel, and habitat quality and mitigation for habitat disturbance. The permitting and regulatory requirements identified as potentially associated with each alternative are discussed as part of the evaluation of the alternatives.

6.2 BALANCING CRITERIA

Long-Term Effectiveness in Protecting Human Health and the Environment and Achieving Remedial Action Objectives

This criterion evaluates the adequacy of the alternative to protect human health and the environment while meeting and maintaining compliance with the RAOs over the long term. This includes evaluation of the timeframe to meet RAOs and achieve removal of BUIs in the Phase II area, the amount of residual contamination anticipated to be left in place, the reliability of long-term controls, and the potential for transport of contaminated sediment following the remedial action.

Short-Term Effectiveness in Protecting Human Health and the Environment

This criterion evaluates the risks that would be expected to persist or to arise in the short term, during remedy implementation. Potential risks to workers and the community during implementation of the alternative are considered, along with potential negative short-term environmental impacts.

Engineering Implementability, Reliability, Constructability, and Technical Feasibility

This criterion evaluates the implementability of the alternative, including constructability, ease of implementation, availability of materials and workers, and reliability for achieving RAOs.

Cost

This criterion considers engineering, capital, and operation and maintenance costs for each alternative, as appropriate. The cost estimates are based on conventional cost estimating guides, vendor information, and engineering judgment. The preparation of the estimated costs presented in this FS was conducted in sufficient detail to provide costs with an accuracy of plus 50 percent to minus 30 percent for the alternative as described, while identifying the key uncertainties for each alternative. The costs are intended to support comparison of alternatives, and actual costs of implementation of the alternatives are expected to vary based on factors such as actual material and labor costs, additional information regarding site conditions, and technological details as identified during the design process.

6.3 MODIFYING CRITERIA

Stakeholder and Community Acceptance

This criterion considers the extent to which a given alternative is acceptable to the project stakeholders and the local community. This evaluation is performed for each alternative, based on the public input received during the public information session for Phase II (held on 20 August 2013) and input received relative to the remedial action performed in the Phase I area.

7. EVALUATION OF PRIMARY REMEDIAL ALTERNATIVE TECHNOLOGIES

Chapter 4 described seven remedial alternatives to be further evaluated as options for meeting RAOs for the Lincoln Park Phase II area:

- Alternative 1: No Action
- Alternative 2: Dry Excavation and Disposal of Sediments
- Alternative 2a: Dry Excavation and Disposal of Sediments, with Particle Size Segregation
- Alternative 3: Hydraulic Dredging and Disposal of Sediments
- Alternative 3a: Hydraulic Dredging and Disposal of Sediments, with Particle Size Segregation
- Alternative 4: Dry Excavation, Hydraulic Dredging, and Disposal of Sediments
- Alternative 4a: Dry Excavation, Hydraulic Dredging, and Disposal of Sediments, with Particle Size Segregation.

Each of these alternatives except Alternative 1 is composed of a combination of one or more of the following primary remedial alternative technologies:

- Dry Excavation and Supporting Technologies
- Hydraulic Dredging and Supporting Technologies
- Particle Size Segregation.

(Note that Alternative 1, No Action, does not include implementation of any technologies.)

This section presents detailed descriptions and evaluations of these primary technologies, as they would be implemented in the Phase II area, including evaluation of each according to the criteria described in Chapter 6. The Phase II area is divided into multiple Zones (3, 4, 7, and 5) and within each Zone there are multiple contaminated sediment deposits (e.g. Deposit 7-1, 7-2, 3b-1, etc.). These Zone and deposit designations are used throughout this document to describe locations and sequencing of sediment removal activities. Concept plans showing the site layout for implementation of remedial technologies are provided in Appendix E. This section also includes a discussion of potential opportunities for green remediation associated with each technology. Evaluation of the combined alternatives composed of these technologies is presented in Chapter 8.

It is important to note that assumptions regarding specific process options and field implementation were selected to allow costing and evaluation of the remedial alternatives. Actual means and methods of remediation may differ and will be determined as part of the remedial design and construction process.

7.1 DRY EXCAVATION AND SUPPORTING TECHNOLOGIES

Dry excavation involves diverting water flow from a portion of the Milwaukee River so that construction equipment can access the river bottom and remove sediments for handling, transport, and disposal. The following sections present a description of the process and component steps required for implementing this technology and evaluate it based on the criteria described in Chapter 6.

7.1.1 Description

Dry excavation requires four main processes/components: excavation, sediment dewatering and solidification, water treatment, and offsite disposal.

7.1.1.1 Excavation

Removal of the contaminated sediment would be accomplished using standard excavating equipment in the dry after construction of staging area(s) and temporary infrastructure (haul roads, decontamination areas, construction entrances, fences, dewatering pad, water treatment facilities, etc.) (Appendix E, Figures 1 through 3). The staging location and dewatering area would be constructed in the park directly west of Deposit 7-3 (Appendix E, Figure 1). This area would serve as the single staging and sediment dewatering location for the project. Sequencing of the deposit removal will be further evaluated during the design; however, one possible sequence is listed below.

Removal of deposits in Zones 3 and 7 (Appendix E, Figure 1) would be accomplished using steel sheet pile walls installed in two configurations at multiple locations in the river to allow for staging of excavation and to maintain hydraulic capacity of the river during a flood event. Sheet pile would be used to create in-river containment dams, also known as coffer dams, in this area due to its relatively deep sediment deposits likely allowing for sheet pile stability. The first configuration of containment walls at Zones 3 and 7 would allow simultaneous dewatering and excavation of the northern portion of Deposit 7-2, southern portion of Deposit 7-4 and Deposit 3b-1. This configuration would direct river flows through the main channel. The second configuration of containment walls would include removal of the configuration 1 sheet pile walls except for the wall dividing Deposit 7-2 and the reused portion of the wall dividing Deposit 7-4. Deposits 7-1, 7-3, 7-2 (southern portion), and 7-4 (northern portion) would be simultaneously dewatered and excavated. This configuration would direct river flows through the east and west oxbows. Sheet pile walls that contacted contaminated sediments would be decontaminated at the staging area. Other containment methods will be evaluated during design to minimize damage to completed Phase 1 areas adjacent to the Phase II removal areas.

Removal of contaminated sediments at Deposits 4-1, 4-2, and 4-3 would be accomplished by creating dewatered areas parallel to the riverbanks on which the contaminated sediments are located (Appendix E, Figure 2). Temporary coffer dams would be constructed using either super sack sand bags, water bladders, portable A-frame dam system, or other similar methods evaluated during design. These coffer dam technologies would be used in this area due to the shallow sediment depths and hard pan bedrock found in the deposit locations. For Deposits 4-1 and 4-2, the riverbank would be cleared and grubbed to create site access and haul roads (Appendix E, Figure 2). At Deposit 4-3, an access point would be constructed in the area directly north of the I-43 exit ramp to North Port Washington Street down to the riverbank. The northern lane of the exit ramp would be closed to allow construction traffic into and out of the area. A haul road would be constructed extending under I-43 to the deposit area. All sediments removed from the areas would be transported to the staging/dewatering area located in the park adjacent to Deposit 7-3 (Appendix E, Figure 1).

The final area of sediment removal would occur behind the Estabrook Park Dam spillway. A temporary coffer dam constructed using either super sack sand bags, water bladders, portable A-frame dam system, or other similar methods would be constructed from the island at the north end of the spillway extending roughly diagonal to the south across the river to the upstream extent of Deposit 5-1 (Appendix E, Figure 3). The temporary coffer dam would direct river flow through the Estabrook Park Dam and allow Deposit 5-1 to be dewatered and excavated. The south riverbank adjacent to Deposit 5-1 would be cleared and grubbed to provide site access. A haul road would be constructed running along the south riverbank to an existing access road that leads to River Woods Parkway, after the County gains private landowner approval for this action. All material would be removed and taken to the staging/dewatering area for treatment and handling.

Following excavation, confirmation sampling of the sediment in the excavated areas would be conducted to confirm that contaminant concentrations in the remaining sediments are below remedial goals prior to removal of the containment systems. The site infrastructure would be removed, subgrade tested for contamination, and the disturbed areas would undergo restoration.

7.1.1.2 Sediment Dewatering and Solidification

If sediments removed by dry excavation have an unacceptably high water content, they would be placed on a dewatering pad, composed of an area surrounded by berms, lined with geotextile and crushed rock, and graded to facilitate collection of water. Separate areas for TSCA and non-TSCA material would be provided. Following passive dewatering, or following excavation if the water content is acceptably low, solidification of the sediments by addition of amendments (e.g., fly ash or Portland cement) would still likely be required to meet the disposal facility’s strength requirements. The sediment would be mechanically mixed either in the excavation area or at a staging/dewatering area. The size of the staging/dewatering area would depend on several factors that include the volume of sediment to be removed, sediment amendment cure time, rate of removal versus rate of loading and transport to offsite disposal facilities, required frequency of waste confirmation sampling, and overall project schedule.

7.1.1.3 Water Treatment

Water that may require treatment would be generated from the following sources:

- Water within coffer dam areas

- Dewatering pad drainage from sediment
- Decontamination water
- Precipitation on the dewatering pad and in the coffer dam areas.

The components needed to treat the collected water before discharge would be determined during the design. However, to evaluate cost and comparison to other alternatives, it was assumed for this evaluation that the water treatment system would be sized for 300 gallons per minute and include frac tanks, bag filters, a granular activated carbon treatment system, an effluent holding tank, and a discharge pump. The influent would be pumped to the frac tanks for storage and solids removal. Effluent from the frac tank would be pumped through bag filters for additional solids removal and through granular activated carbon vessels for treatment. Finally, the treated water would flow into effluent holding tanks that would provide capacity for a small volume of treated water. Water would be held in these tanks as needed, particularly during the initial testing of the treatment system, while awaiting sampling results confirming that the treatment meets the requirements for discharge back to the river. Regular sampling would be conducted to verify that the requirements for discharge are met.

7.1.1.4 Offsite Disposal

Trucks used to transport contaminated materials offsite would be covered, and tires and exteriors decontaminated after loading and before leaving the site. Sediments would be characterized for disposal before transportation, and would be disposed of at either a facility licensed to accept TSCA waste, or a Subtitle C or Subtitle D landfill, depending on sampling results. Beneficial use of the sediment is not anticipated, but would be further evaluated during design (see also Section 7.3, Particle Size Segregation). Temporary haul route(s) would be constructed onsite to facilitate truck traffic. After completing the project, the pad materials and temporary haul route materials would be transported by truck to an offsite facility for disposal and the disturbed areas would be restored.

7.1.2 Evaluation of Threshold Criteria

Compliance With Permits and Applicable Regulatory Requirements

Dry excavation and the associated dewatering, water treatment, and offsite disposal would need to be conducted in accordance with federal, state, and local permitting and regulatory requirements, as described below. The project will be conducted in compliance with all appropriate permits.

7.1.2.1 State Requirements

WDNR Waterways Permit

A WDNR permit would be required for the installation of water flow control structures, sediment removal, placement of material within the river, and any onshore activities within adjacent wetlands. The permit would be granted by WDNR under statutes that may include the following (listed in numerical order):

- Wisconsin Statute Section 30.20(2), Removal of Material From Beds of Navigable Waters
- Wisconsin Statute Section 30.12(3m), Structures and Deposits in Navigable Waters
- Wisconsin Statute Section 30.19 Enlargement and Protection of Waterways
- Wisconsin Statute Section 281.15, Water Quality Standards
- Wisconsin Statute Section 281.36, Wetlands; Compensatory Mitigation
- Wisconsin Statute Section 283, Pollution Discharge Elimination
- Wisconsin Statute Section 1.11, Governmental Consideration of Environmental Impact
- United States Clean Water Act Section 401, State Certification.

The application for WDNR permits for Chapter 30 compliance would require an Alternatives Analysis to assess ways to minimize adverse impacts to wetlands under NR 103, Water Quality Standards for Wetlands.

Conditions of this permit would likely include erosion control measures, specifications for installation of the flow control structures and for implementation of the excavation, limitations on the area and timeframe of wetland disturbances, and wetland restoration requirements. Under this permit, it would likely be necessary to implement erosion control measures to minimize erosion into the river, in accordance with WDNR's Stormwater Construction Technical Standards (http://dnr.wi.gov/topic/stormwater/standards/const_standards.html)..

7.1.2.2 Federal Requirements

Clean Water Act Section 404 Permit

Section 404 of the Clean Water Act requires permit authorization from the U.S. Army Corps of Engineers (USACE) for the discharges of dredged or fill material into Waters of the United States. The USACE St. Paul District has issued a General Permit (GP-002-WI) for activities within Wisconsin that discharge dredged and/or fill material into waters of the United States, according to the provisions of the United States Clean Water Act (40 Code of Federal Regulations [CFR] 230), Section 404. Remedial activities in the Phase II area, including dry excavation and handling of any material contaminated with TSCA-level PCBs, would need to be authorized under the following sections of this General Permit.

- Section 2(a)(5) Clean-up of Hazardous and Toxic Waste
- Section 2(a)(7) Temporary Construction Access and Dewatering.

Rivers and Harbors Act Permit

Section 10 of the Rivers and Harbors Act states that any work in or affecting navigable waters of the United States (commercially navigable waters) requires a permit from USACE. Such work includes dredging, channelization, excavation, filling, construction of piers, breakwaters, bulkheads, revetments, power transmission lines, aids to navigation, and sewer outfalls over commercially navigable waters.

7.1.2.3 Local Requirements

7.1.2.3.1 Milwaukee County Permits

Construction/Right-of-Entry Permit

A permit from the Milwaukee County Department of Parks, Recreation and Culture would be required for access of construction equipment to Lincoln Park and the Milwaukee River.

7.1.2.3.2 City of Milwaukee

Stormwater Permit

The City of Milwaukee would need to be consulted regarding the need for a stormwater permit from the City, under Chapter 120 of the City of Milwaukee Ordinance, Stormwater Management Regulations. During planning for the Phase I remediation, the City indicated that a City permit was not necessary in addition to the state permits.

Temporary Noise Variation

During Phase I excavation, a temporary noise variation was obtained from the City of Milwaukee, under Section 80-66 of the Milwaukee Code of Ordinances.

Floodplain Permits

For any construction activities occurring within the boundaries of the City of Milwaukee, including temporary water diversions and changes to the bed and banks of the Milwaukee River, Floodplain Permits may be required to comply with floodplain management ordinances.

7.1.2.3.3 City of Glendale

Stormwater Permit

A permit for stormwater management may be required under Title 6, Chapter 5 of the City of Glendale Ordinance, Storm-Water Management System.

Notice for Construction Near or On Lakes, Streams, or Wetlands

For any construction activity occurring within the boundaries of the City of Glendale, a Notice for Construction Near or on Lakes, Streams or Wetlands would be required.

Floodplain Permits

For any construction activities occurring within the boundaries of the City of Glendale, including temporary water diversions and changes to the bed and banks of the Milwaukee River, Floodplain Permits may be required to comply with floodplain management ordinances.

7.1.3 Evaluation of Balancing Criteria

Long-Term Effectiveness in Protecting Human Health and the Environment and Achieving Remedial Action Objectives

Dry excavation offers many advantages for environmental remediation projects, and is expected to be the most effective technology for maximizing removal of sediments exceeding remedial goals, with minimal residual contamination, and thus minimal residual risk, remaining after sediment removal. Excavating in the dry is also expected to cause less sediment to become suspended during removal activities, and thus may cause relatively less redeposition of contaminated material on remediated areas following excavation and less downstream transport of contaminated material during the sediment removal.

By permanently and efficiently removing sediments that exceed remedial goals from the Phase II area and allowing disposal in a permitted offsite facility, dry excavation would minimize onsite exposure risks and would be protective of human health and the environment. Excavation would also stop downstream migration of these sediments and thus decrease contaminant exposure throughout the AOC. Dry excavation would therefore support removal of the BUIs identified as associated with the Site.

Confirmation sampling would be used to confirm the effectiveness of the dry excavation. Based on results obtained during the Phase I remediation, dry excavation is expected to meet remedial goals in most excavation areas without placement of a residual cover over the excavated surface.

Short-Term Effectiveness in Protecting Human Health and the Environment

Potential short-term risks to human health associated with dry excavation include direct contact of workers with contaminants during sediment excavation, transport, and dewatering operations. These risks would be minimized using safety procedures and appropriate personal protective equipment (PPE). Dust monitoring and control measures may also be necessary, both at the excavation and in the staging/dewatering area, to control inhalation risk among workers and the nearby community. Decontamination of equipment would be conducted before it leaves the excavation area and the staging/dewatering area, to prevent contaminated material from being transported into the Park and other nearby properties that are located along sediment transport routes. Sediments in open truckbeds would also be covered prior to leaving the site to prevent loss of material.

Transporting the sediments by truck from the staging/dewatering area to the disposal facility would cause an increase in heavy truck traffic along the haul route(s). Construction of onsite temporary haul routes and/or repair of some city streets along the haul route(s) may be necessary to counter the effects of the increased heavy truck traffic.

Dry excavation would cause temporary impacts to the local environment. Dewatering of the contaminated areas and sediment excavation would temporarily eliminate areas of aquatic and benthic habitat. However, these short-term impacts would be followed by long-term benefits associated with the contaminant removal, such as reduced PCB concentrations in fish tissue. Onshore areas would also be disturbed by construction of haul roads, construction access points, and the staging/dewatering area. Areas that are already degraded would be selected for these activities where possible, allowing an improvement in habitat and recreational value following restoration.

Engineering Implementability, Reliability, Constructability, and Technical Feasibility

Dry excavation is most feasible in shallow water areas that can be easily dewatered using temporary coffer dams to redirect water. This technology is therefore expected to be highly implementable throughout the Phase II area, which typically has water depths of less than 5 ft. Dry excavation would allow optimization of the quantity of material removed, because it enables better control over excavation (to avoid overdredging). This would reduce disposal quantities and thus costs. Transport of sediments to a staging/dewatering area near Deposit 7-3 would also be highly implementable. Dry excavation would also experience fewer impacts associated with debris than would hydraulic dredging.

Onsite treatment of water removed during dewatering, decontamination water, and water that falls as precipitation into the dewatered area, would also be highly implementable. Sediments removed by dry excavation are expected to have much lower water content than sediments removed by dredging; therefore, dry excavation would minimize the amount of wastewater treatment required and would likely reduce the amount of area required for staging/dewatering, relative to hydraulic dredging, due to *in situ* dewatering activities. Addition of sediment amendments would be fast and would serve a dual purpose as both a dewatering technology, and also a method to improve the physical properties of the sediment for disposal.

Offsite disposal is a common disposal option that would permanently remove contaminant mass from the Site. Facilities for disposal of non-TSCA (<50 mg/kg) PCB sediments are available in the Milwaukee area. TSCA materials (≥50 mg/kg PCBs) would be transferred to out-of-state, regional facilities. As described above, sediment amendments would be used to modify the physical properties of the sediment to meet disposal facility moisture and strength requirements.

Cost

The total average cost for dry excavation and associated technologies is estimated at approximately $690 per cubic yard of dredged sediment (including both targeted sediments and overburden). Detailed costing for this technology as incorporated into combined alternatives is provided in Appendix F.

7.1.4 Evaluation of Modifying Criteria

Stakeholder and Community Acceptance

Based on positive stakeholder and community response to the dry excavation and offsite disposal conducted in the Phase I area, this remedial option is expected to be accepted. Project operations would be conducted in ways that address possible concerns associated with issues such as short-term disturbance of the river and onshore areas, including temporary flow disturbances associated with placement of coffer dams; the use of park land for a staging and dewatering facility and security requirements for the facility; short-term disturbance (noise, etc.) associated with operations conducted adjacent to private property; possible long-term impacts to the flow regime (expected to be minimal); and transport routes for trucks carrying sediment.

7.2 HYDRAULIC DREDGING AND SUPPORTING TECHNOLOGIES

Hydraulic dredging involves the use of hydraulic equipment to remove sediments for handling, transport, and disposal. The following sections present a description of the process and component steps required for implementing this technology and evaluate it based on the criteria described in Chapter 6.

7.2.1 Description

Hydraulic dredging requires four main processes/components: hydraulic dredging, sediment dewatering and solidification, water treatment, and offsite disposal.

7.2.1.1 Hydraulic Dredging

Removal of contaminated sediment would be accomplished using hydraulic dredging equipment. Hydraulic dredging is best suited for areas that have a constant minimum water elevation of 2.5 to 3 ft and minimal currents. Environmental hydraulic dredging typically uses small (6- to 12-in.) conventional cutting head dredges, because smaller cutting heads typically reduce the amount of resuspension of contaminated sediments. For purposes of this remedial evaluation, it was assumed that one 8-in. conventional cutting head dredge would be utilized to complete the dredging.

Hydraulic dredging of contaminated sediments from the Phase II area using a boat-mounted dredge would require measures to ensure that a minimum of 3 ft of water depth can be maintained in the dredging area at all times. To maintain elevated water levels, since the Estabrook Park dam is inoperable, a temporary coffer dam consisting of super sack sand bags, water bladders, or portable A-frame dam systems would be installed directly upstream of the ice breakers located upstream of the dam. These coffer dam technologies would be used due to the shallow bedrock in the area, which prevents the use of sheet pile dams. The coffer dam would be built to the height of the spillway, to create a 4- to 5-ft-deep impoundment extending upstream past Zone 7. This impoundment area would allow smaller pontoon or barge-mounted hydraulic dredges to access all contaminated sediment locations. One 8-in. conventional cutting head dredge would be used to meet production rates that would allow for project completion within one construction season. Work would proceed from upstream to downstream to minimize the amount of contaminated sediments resuspended during dredging that re-contaminate already-dredged areas. Silt curtains, coffer dams, or similar measures would also be used to contain sediments suspended during dredging. A dewatering pad would be constructed in the park adjacent to Zone 7, and the dredged material from all dredging areas would be pumped to that location for treatment (Appendix E, Figures 4 and 5).

An alternative method of hydraulic dredging, most appropriate for small sediment volumes with land access to contaminated areas, involves use of a vacuum truck, high solids pump, or specialty dredge. For purposes of this remedial alternative evaluation, it was assumed that a vacuum truck could be used to dredge sediments from near-shore deposits. Sediments dredged using a vacuum truck would be transported to the staging/dewatering area by truck.

Following dredging, confirmation sampling of the sediment in the dredged areas would be conducted to confirm that contaminant concentrations in the remaining sediments are below remedial goals. If residual contamination remains following dredging, a discussion of the need for residuals management techniques or additional dredging, such as placement of a residual cover (Section 7.2.1.4), would be appropriate.

7.2.1.2 Sediment Dewatering and Solidification

Hydraulic dredging would require a larger area for dewatering per cubic yard of sediment than would dry excavation, due to the large volume of water contained in the sediment slurry and the resulting longer timeframe for dewatering. Most likely, the slurry material would be pumped into geotubes located in the dewatering area, for passive dewatering. Depending on the nature of the dredged sediments, it would also be necessary to dose the pumped slurry with polymer additives to complete the passive dewatering. After the geotube dewatering is complete, the sediments would be assessed to determine whether they meet disposal facility moisture and strength requirements. If the dewatered sediments do not meet disposal requirements, soil amendments would be required. For purposes of this evaluation, it was assumed that polymer additives would be mixed into the slurry before it is pumped to the large geotubes and that the passive dewatering would yield material with 55 percent solids by mass that would pass the paint filter test; however, such materials could still require additional dewatering or solidification to meet landfill strength requirements. For small volumes of sediments removed by vacuum truck, it could be possible to perform the necessary dewatering on the dewatering pad, without geotubes or polymers. Sediments removed in this manner could also require soil amendments to meet disposal requirements. The size of the dewatering area would depend on several factors that include the volume of sediment to be removed, dredge pumping rate, geotube dewatering rate, geotube fill and disposal sequencing, sediment amendment cure time, rate of removal versus rate of loading and transport to offsite disposal facilities, required frequency of waste confirmation sampling, and overall project schedule. Before final design is completed, a rapid dewatering test and sediment composition test would be required to verify the appropriateness of the polymer addition, geotube sizing, and dewatering rate assumptions presented in this evaluation.

7.2.1.3 Water Treatment

Water that may require treatment would be generated from the following sources:

- Dewatering pad drainage from sediment
- Decontamination water
- Precipitation on the dewatering pad.

Hydraulic dredging would require multiple levels of wastewater treatment. Based on calculated production rates for an 8-in. dredge (Appendix F, cost backup), it was assumed that an average of approximately 550,000 gallons per day would require treatment. The components needed to treat the collected water before discharge would be determined during the design. However, to evaluate cost and allow for comparison to other alternatives, it is assumed that the water treatment system would be sized for 600 gallons per minute to meet peak surges in dredging production. The system would include frac tanks, bag filters, a granular activated carbon treatment system, effluent holding tanks, and a discharge pump. The influent would be pumped to the frac tanks for storage and solids removal. Effluent from the frac tanks would be pumped through bag filters for additional solids removal, granular activated carbon vessels for treatment, and effluent holding tanks for sampling before discharge back to the river. Regular sampling would be conducted to verify that the requirements for discharge are met.

7.2.1.4 Offsite Disposal

Offsite disposal will be similar to that for dry excavation. Trucks used to transport contaminated materials offsite would be covered, and tires and exteriors decontaminated after loading and before leaving the site. Sediments would be characterized for disposal before transportation, and would be disposed of at either a facility licensed to accept TSCA waste, or a Subtitle C or Subtitle D landfill, depending on sampling results. Beneficial use of the sediment is not anticipated, but would be further evaluated during the remedial design (see also Section 7.3, Particle Size Segregation). Temporary haul route(s) would be constructed onsite to facilitate truck traffic. After completing the project, the pad materials and temporary haul route materials would be transported by truck to an offsite facility for disposal and the disturbed areas would be restored.

7.2.1.5 Residual Cover

If confirmation sampling indicates concentrations exceeding remedial goals following dredging, then a thin residual cover consisting of clean cover material would be placed within the dredged area, to contain and prevent exposure to residual contamination. For this evaluation, it is assumed that the residual cover would be 6 in. thick. Sizing of the clean cover material would be done during design to provide a long-term effective residual cover.

7.2.2 Evaluation of Threshold Criteria

Compliance With Permits and Applicable Regulatory Requirements

The permitting and regulatory requirements associated with hydraulic dredging and associated technologies are consistent with the list presented in Section 7.1.2, for dry excavation.

7.2.3 Evaluation of Balancing Criteria

Long-Term Effectiveness in Protecting Human Health and the Environment and Achieving Remedial Action Objectives

Hydraulic dredging would remove contaminated sediments from the Phase II area, prevent their transport downstream, and thus decrease contaminant exposure throughout the AOC. By permanently and efficiently removing sediments that exceed remedial goals from the Phase II area and allowing disposal in a permitted offsite facility, dredging would decrease onsite exposure risks and would be protective of human health and the environment. Dredging would also prevent future downstream migration of these sediments and thus decrease contaminant exposure throughout the AOC. Dredging would therefore support removal of the BUIs identified as associated with the Site. However, hydraulic dredging is expected to be less effective than dry excavation for achieving thorough removal of sediments exceeding the remedial goals, for the reasons discussed below.

Environmental hydraulic dredging techniques, including small cutting heads, would be used to reduce the amount of resuspension of contaminated sediments. However, some degree of off-site losses would occur, as fine sediments disturbed during dredging settle back to the river bottom. Silt curtains, coffer dams, or similar measures would be used to contain the suspended, contaminated sediments and thus minimize their downstream transport; therefore, most resuspension and settling would be expected to occur within the dredged area. Hydraulic dredges also have limited efficiency for removing contaminated sediments that are located adjacent to uneven hard pan bedrock surfaces. Thus, residual contamination is likely to remain after dredging, as a result of both re-deposition of suspended sediment following dredging, and the sediments left atop hard pan and bedrock surfaces at the bottom of the dredging volume.

Confirmation sampling would be used to assess the effectiveness of the hydraulic dredging for meeting the remedial objectives. Residual concentrations exceeding remedial goals, associated with the residuals described above, are more likely following hydraulic dredging than following dry excavation. In cases where contamination exceeding remedial goals remains, placement of a residual cover would be used to limit exposure to the remaining contaminated material.

Short-Term Effectiveness in Protecting Human Health and the Environment

Potential short-term risks to human health associated with hydraulic dredging include direct contact of workers with contaminants during dredging, transport, and dewatering operations. These risks would be minimized using safety procedures and appropriate PPE. Dust monitoring and control measures may also be necessary at the staging/dewatering area, to control inhalation risk among workers and the nearby community. Decontamination of equipment would be conducted before it leaves the staging/dewatering area, to prevent contaminated material from being transported into the Park and other nearby properties that are located along sediment transport routes. Sediments in open truckbeds would also be covered prior to leaving the site to prevent loss of material.

Transporting the sediments by truck from the dewatering/staging pad to the disposal facility would cause an increase in heavy truck traffic along the haul route(s). Construction of onsite temporary haul routes and/or repair of some city streets along the haul route(s) may be necessary to counter the effects of the increased heavy truck traffic.

Dredging would cause temporary impacts to the local environment. During dredging, the benthic habitats within the dredging areas would be dramatically disrupted. Short-term impacts to the aquatic habitats would be associated with dredging activities as well as short-term exposure risks associated with resuspension of contaminated sediments into the water column. However, these short-term impacts would be followed by long-term benefits associated with the contaminant removal, such as lower fish tissue concentrations. Onshore areas would also be disturbed by construction of haul roads, construction access points, and the staging/dewatering area. Areas that are already degraded would be selected for these activities where possible, allowing an improvement in habitat following restoration.

Engineering Implementability, Reliability, and Constructability, and Technical Feasibility

Hydraulic dredging requires a constant minimum water elevation of 2.5 to 3 ft, and therefore would require construction of a temporary dam to raise water levels. Construction of such a dam along the Estabrook Park Dam would be highly implementable. Pumping the sediment slurry to a staging/dewatering area near Zone 7 would also be highly implementable. However, the reliability of the dredging, especially behind the fixed crest spillway, would likely be decreased by the presence of debris, particularly because the smaller dredges used for environmental dredging are more susceptible to becoming clogged by small debris in the sediments.

The horizontal and vertical accuracy of hydraulic dredging is less than the accuracy of dry excavation, and results in increased quantities and costs. For typical dredge sites, the actual dredge prism can be up to 1.5 times larger than the neat dredge prism; because the Phase II area site has shallow underlying bedrock in some areas, a 1.25 dredge prism factor would be expected.

Hydraulic dredging also produces large amounts of wastewater, as the pumped slurry averages 15 percent solids by mass. The dredged sediment would therefore need to be dewatered, and all waste water would require treatment. The dewatering in geotubes is expected to be implementable, although it would require fill sequencing through the use of a flow distribution manifold, sequencing of geotube bursting and disposal, and possible geotube stacking to reach the goal of 55 percent solids by mass within the available dewatering pad area. Addition of polymers to promote dewatering would facilitate the dewatering; however, the dewatered sediments may also require addition of soil amendments in order to meet disposal facility requirements.

Due to the probability of residual contamination, areas may require placement of a residual cover after dredging to meet final residual concentration requirements. Placement of a residual cover is expected to be highly implementable following sediment removal. Unless provided by particle size segregation (Section 7.3), clean cover material would need to be transported to the Site and placed in-water in the location of dredging. The silt curtains used during dredging also would be required during placement of the cover. Cover placement may not be appropriate for areas where disturbance is planned in the near future.

Offsite disposal is a common disposal option that would permanently remove contaminant mass from the Site. Facilities for disposal of non-TSCA (<50 mg/kg) PCB sediments are available in the Milwaukee area. TSCA materials (>50 mg/kg PCBs) would be transferred to out-of-state, regional facilities. As described above, sediment amendments would be used to modify the chemical and physical properties of the dewatered sediment to meet disposal facility moisture and strength requirements.

Cost

The total average cost for hydraulic dredging and associated technologies is estimated at approximately $830 per cubic yard of dredged sediment (including both targeted sediments and overburden). Detailed costing for this technology as incorporated into combined alternatives is provided in Appendix F.

7.2.4 Evaluation of Modifying Criteria

Stakeholder and Community Acceptance

Based on positive stakeholder and community response to the sediment removal conducted in the Phase I area, and because hydraulic dredging would be expected to cause somewhat fewer site impacts than dry excavation (due to less overland transport in trucks), this remedial option is also expected to be accepted. Project operations would be conducted in ways that address possible concerns associated with issues such as short-term disturbance of the river and onshore areas, including the impacts of the temporary dam used to raise water levels during dredging; possible impacts to the flow regime (expected to be minimal); the use of park land for a staging and dewatering facility and security requirements for the facility; short-term disturbance (noise, etc.) associated with operations conducted adjacent to private property; and transport routes for trucks carrying sediment. Some concerns would likely arise in association with the possible need for a residual cover. These concerns could be addressed by using minimal volumes of material and designing the cover to ensure minimal impact to the river's flow regime.

7.3 PARTICLE SIZE SEGREGATION

Particle size segregation involves the use of equipment to separate sediments by particle size into separate waste streams for handling, transport, and disposal. The following sections present a description of the process and component steps required for implementing this technology and evaluate it based on the criteria described in Chapter 6.

7.3.1 Description

Segregation requires two main processes/components: segregation and offsite disposal.

7.3.1.1 Segregation

Segregation would include physical separation (at the staging area) of the excavated or dredged material of the excavated material to separate clays, silts, and fine to medium sand (particles that PCBs tend to adhere to) from coarse sand and gravel particles. The fine material would be analyzed and disposed at an offsite facility, as described above, and the coarse sand and gravel would be analyzed to confirm that it is appropriate for onsite disposal or reuse. If determined to be of sufficient quality, this coarse fraction would then either be returned to the Milwaukee River (potentially as part of a residual cover) or used for clean fill material at another location, to reduce the cost of offsite disposal. Any coarse material found not to meet requirements for reuse would need to be disposed offsite, with the fine material. The segregation system would be designed to accommodate the anticipated rate of sediment production/dewatering, as well as the characteristics of the sediments as determined during a pilot study of the technology. For this evaluation, it is assumed that up to 10 percent of the excavated sediment could be segregated, and that this coarse fraction would not be contaminated with PCBs or NAPL and could therefore be beneficially reused. A value of 10 percent is based on the site-wide average of 14 percent for coarse sand and gravel assuming some loss of material due to limitations in processing.

7.3.1.2 Disposal

For the purposes of the FS, it was assumed that the 10 percent of the total excavated sediment volume would be segregated as coarse material for beneficial re-use in lieu of disposal. Therefore, disposal volumes and disposal cost would decrease.

7.3.2 Evaluation of Threshold Criteria

Compliance With Permits and Applicable Regulatory Requirements

Permitting requirements associated with the process of particle size segregation are anticipated to be covered in the permits associated with sediment removal activities, as described in Section 7.1.2.

7.3.3 Evaluation of Balancing Criteria

Long-Term Effectiveness in Protecting Human Health and the Environment and Achieving Remedial Action Objectives

Particle size segregation is an *ex situ* treatment technology used to process sediments after they have been removed, to decrease the volume of sediment requiring offsite disposal and provide material for reuse. Therefore, this technology would not affect the long-term protectiveness of the sediment removal remedy and is not required for removal of BUIs in the AOC. If any segregated material were to be used as cover, it would need to meet high quality standards to ensure no added risk to human health or the environment.

Short-Term Effectiveness in Protecting Human Health and the Environment

Potential short-term risks to human health associated with particle size segregation are similar to those associated with dry excavation and hydraulic dredging. Direct contact of workers with contaminants during the segregation process would be minimized using safety procedures and appropriate PPE. Dust monitoring and control measures may also be necessary to control inhalation risk among workers and the nearby community.

Particle size segregation would cause minimal impacts to the local environment, associated with disturbance within the footprint of the onsite segregation facility.

Engineering Implementability, Reliability, and Constructability, and Technical Feasibility

Particle size segregation can be a highly effective and implementable technology for sites with large sediment volumes and large fractions of coarse material in the contaminated sediments, and the required technology is available. However, the implementability and efficiency of particle size segregation following sediment removal from the Phase II area would likely be negatively impacted by a high proportion of fine-grained material in the contaminated sediments. Past analyses indicate that sediments in the Phase II area are primarily fine-grained, with a large fraction of silt and clay. The sediments contain an average of approximately 14 percent coarse sand and gravel. Although PCBs generally adhere to fine-grained material, the implementability of segregation would also be negatively impacted if the segregated coarse material contained residual contaminant concentrations that make the material unacceptable for reuse. Additional study would be required before the design of a particle segregation system, to determine its feasibility for this project. However, if the coarse material is found to have sufficiently low contaminant concentrations, use of segregated material as a residual cover, where necessary, would be highly implementable.

Cost

The cost of particle size segregation is estimated to average a minimum of $100 per cubic yard of recovered coarse material beyond the cost of removal and handling. Note that this is substantially more than the estimated cost of approximately $40-45 for clean cover material purchased from offsite. Detailed costing for this technology as incorporated into combined alternatives is provided in Appendix F.

7.3.4 Evaluation of Modifying Criteria

Stakeholder and Community Acceptance

Particle size segregation is expected to be accepted by stakeholders and the community. Community outreach activities would seek to address any possible concerns associated with construction and operation of the segregation system. The reuse of segregated material would likely encounter more skepticism, and would require the assurance that only material meeting stringent beneficial use requirements would be utilized in residual cover or otherwise returned to the river.

7.4 GREEN REMEDIATION CONSIDERATIONS

As discussed in sections above, the RAOs for the project are to address contaminated sediments and to perform restoration for areas affected by the remediation. EPA recognizes that the process of remediation uses energy, water, and other natural materials or resources, and that much can be done to conserve natural resources, minimize waste generation, and reduce energy consumption (EPA 2010). When applied to clean-up, conservation and impact minimization concepts are often referred to as “green remediation.” EPA guidance identifies many concepts for making remediation greener. Examples include:

- Conservation of natural resources;
- Re-using materials otherwise considered waste;
- Maximizing energy efficiency;
- Decreasing air emissions;
- Conserving water resources;
- Planning work to include consideration of green practices; and
- Helping to increase the understanding and awareness of green technologies.

These and other green remediation components can produce environmental benefits, if their use is balanced with remedy protectiveness and implementability. Careful consideration must be given to where and how green components can be incorporated, while maintaining compatibility with the RAOs, with regulations, and with project schedule and budget.

The technologies retained as part of remedial alternatives for this FS offer various opportunities for incorporating green remediation principles. The greatest potential for green remediation as part of the Phase II remediation is associated with conservation of natural resources, minimization of waste, and conserving water resources. Specific opportunities for green remediation will be incorporated into the Remedial Design as appropriate. These may include methods for increasing energy efficiency, decreasing air emissions, planning with green concepts in mind, and increasing awareness.

7.4.1 Conservation of Natural Resources

All three of the primary remedial alternative technologies discussed in Sections 7.1, 7.2, and 7.3 provide opportunities for conservation of natural resources. As discussed in Chapter 5, this project includes goals for restoration in addition to remediation. Thus the overall impact of the project will be to conserve and/or enhance natural resources in any areas affected by remediation using the specific restoration options presented in Chapter 9. While the project will involve some disturbance of natural resources at the site, it will produce overall benefits for fish and wildlife and improve plant communities. Additional consideration of conservation in the design will likely include minimizing the impacts of remedial construction by placing haul roads and staging facilities in existing disturbed or open areas that can be easily restored; the preliminary description of alternatives presented above includes using existing open and disturbed ground to the extent currently considered feasible.

7.4.2 Waste Minimization

Another opportunity for incorporating green remediation concepts into the clean-up at Lincoln Park is waste stream segregation and minimization. Minimizing the amount of waste requiring disposal can decrease the amount of space consumed at landfills and reduce the amount of energy used and air emissions produced in excavating and transporting materials. Waste minimization can be conducted by carefully segregating waste so that as little waste as possible requires specialized offsite disposal, and as much as possible can be disposed routinely or even re-used. Waste minimization must be balanced with requirements to meet disposal regulations and to ensure that the RAOs are achieved.

7.4.3 Water Conservation

Opportunities for water conservation vary between the remedial alternatives. All alternatives require transport of water, either water removed from the river to allow excavation or water entrained by hydraulic dredging. Opportunities to optimize water conservation for the alternative selected will be assessed in the Remedial Design.

7.4.4 Green Remedy Recommendations

Opportunities for green remediation were considered as part of the Lincoln Park Phase II FS. Among the many concepts associated with green remediation, conservation of natural resources, waste minimization, and water conservation were identified as bearing the greatest potential for relevance to alternative development. All alternatives include restoration components that result in conservation of natural resources. Segregation of coarse material for potential re-use was incorporated into the FS as an alternative; its effectiveness is likely to be limited by the small relative proportion of coarse-grained materials in targeted sediments. All alternatives include measures to conserve water quality. The remedial design for Lincoln Park may consider other aspects of green remediation related to energy efficiency, reduced air emissions, planning, and awareness. Green remedy concepts are a part of the FS and thus are part of ongoing efforts to increase awareness and understanding of their application and benefits.

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8. EVALUATION OF REMEDIAL ALTERNATIVES

This section presents an evaluation of the combined remedial alternatives. With the exception of Alternative 1, No Action, the alternatives and sub-alternatives evaluated are composed of combinations of three primary components. The evaluation below presents an abbreviated evaluation of the combination alternatives, based on the detailed evaluation of these primary components that is presented in Chapter 7. Table 8-1 provides a summary of the evaluation of the remedial alternatives and sub-alternatives. This table also provides relative ratings of the alternatives, based on the criteria outlined in Chapter 6, to aid in comparison of the alternatives.

It is important to note that, for purposes of the FS, volumes of sediment requiring removal were estimated based on the contaminated sediment and overburden volumes presented in the CSM (Chapter 2) with the addition of contingency. As noted in sediment remediation guidance (Palermo et al. 2008), numerous factors make it necessary to consider contingencies on volume for environmental dredging of sediments. Contingencies applied in this FS have been limited to known factors that may increase the volume of target sediment requiring excavation and removal. These include:

- **Core recovery:** Contingency associated with the average percent recovery for sediment cores in each deposit. When the core extracted from the sediment is less than the depth the core was advanced, there is the possibility that sediments were compressed, lost, or not captured. This introduces uncertainty as to the exact depth and concentration of chemicals. A contingency equal to the inverse of the average core recovery was applied on a deposit-specific basis.

- **Overdredge:** Dredging and excavation are subject to limitations in precision associated with the size and type of equipment; unavoidable differences in geometry of implementable cut lines and the shape of sediment deposits; and the need to dredge an area more than once to deal with debris, obstacles, or residuals. All of these factors require inclusion of adjustments for overdredging, especially in the case of hydraulic dredging. A 25 percent contingency was applied to deposit volumes for scenarios involving hydraulic dredging to account for overdredging based on knowledge of the configuration of deposits and limitations of expected equipment.

- **Spatial extent of chemicals:** The studies upon which the FS is based provide an extensive set of data for estimating volumes and making decisions. However, factors such as small scale variability and the changing nature of river sediments cause uncertainty as to the exact extent of elevated chemical concentrations. Field duplicates at the site indicate that small scale variability is a factor affecting the ability to accurately predict the extent of sediment deposits. The Phase I remediation at the Site encountered a volume increase of approximately 20 percent between the design phase and final construction quantities, with small scale variability and changing river conditions among the suspected causes. Therefore, a contingency of 20 percent has been applied to sediment volumes to account for uncertainties in chemical distribution.

Target sediment volumes and volumes modified using contingencies are presented in Appendix F. Volumes are used in calculations to estimate costs throughout Chapter 8.

8.1 REMEDIAL ALTERNATIVE 1: NO ACTION

The No Action alternative does not include implementation of any remedial technologies at the Site, and is evaluated to allow comparison of the identified technologies with a no-action scenario.

8.1.1 Evaluation of Threshold Criteria

Compliance With Permits and Applicable Regulatory Requirements

The No Action alternative would not be subject to any permitting or regulatory requirements, because it would not involve any site activities.

8.1.2 Evaluation of Balancing Criteria

Long-Term Effectiveness in Protecting Human Health and the Environment and Achieving Remedial Action Objectives

The No Action alternative would not be protective of human health and the environment, because it would leave contaminated sediments in place in the river, and would not impact current exposure pathways for these contaminants. Although fish consumption advisories would remain in effect, the effectiveness of these advisories depends on effective communication and public responsiveness, and thus does not minimize risk. This alternative also would not affect the downstream migration of PCB-contaminated sediments from the Phase II area, which is recognized as the major contributor to BUIs within the AOC due to downstream transport of PCBs, and thus would not support removal of the BUIs.

Short-Term Effectiveness in Protecting Human Health and the Environment

The No Action alternative would not present additional risks to human health and the environment in the short term, beyond the long-term risks already associated with the presence of the contaminated material.

Engineering Implementability, Reliability, Constructability, and Technical Feasibility

The No Action alternative would be highly implementable from a logistical and technical perspective, because it does not involve any remedial activities at the site.

Cost

There would be no financial costs associated with implementation of a No Action alternative.

8.1.3 Evaluation of Modifying Criteria

Stakeholder and Community Acceptance

The No Action alternative is not expected to be acceptable to stakeholders and the community, because it would not meet the RAOs for the site or support the removal of BUIs in the AOC.

8.2 REMEDIAL ALTERNATIVE 2: DRY EXCAVATION AND DISPOSAL OF SEDIMENTS

Alternative 2 would include dry excavation of all sediments exceeding remedial goals in the Phase II area, using the processes described in Section 7.1.1. Concept plans for this alternative are provided in Figures 1, 2, and 3 in Appendix E. The estimated total volume of sediments excavated would include approximately 35,400 cy of contaminated non-TSCA sediments (1-50 mg/kg PCBs) and overburden, and 330 cy of TSCA sediments (>50 mg/kg PCBs). Coffer dams would be used to dewater each deposit to be excavated, and the sediments would be removed and transported by truck to a staging/dewatering area located adjacent to Deposit 7-3. Sediments would be dewatered using the dewatering pad and/or addition of amendments, and transported by truck for offsite disposal. The estimated total tonnage for disposal includes approximately 58,800 tons for non-TSCA sediments and overburden, and 540 tons of TSCA sediments.

8.2.1 Evaluation of Threshold Criteria

Compliance With Permits and Applicable Regulatory Requirements

The anticipated permitting and regulatory requirements associated with this alternative are presented in Section 7.1.2, and include compliance with requirements addressing sediment removal, water quality, erosion control, stormwater control and discharge, construction access, dewatering of the river channel, dust control, floodplain and wetland disturbances, and handling and disposal of excavated sediments. Obtaining and complying with the requirements of the necessary permits during implementation of this alternative is expected to be highly feasible. Because similar activities occurred during remediation of the Phase I area, the permitting procedures and requirements are expected to be similar for implementation of this alternative in the Phase II area.

8.2.2 Evaluation of Balancing Criteria

Long-Term Effectiveness in Protecting Human Health and the Environment and Achieving Remedial Action Objectives

A detailed evaluation of the effectiveness of the dry excavation and the associated technologies that would be used as part of this alternative is presented in Section 7.1.3. Dry excavation would permanently remove contaminated sediments from the Phase II area and is expected to be highly effective for removing sediments exceeding remedial goals from the Phase II area. Dry excavation is also not expected to leave significant amounts of residual contaminated material. Thus, Alternative 2 is expected to be protective of human health and the environment, achieve RAOs, prevent downstream transport of contaminated material, and support removal of BUIs.

Short-Term Effectiveness in Protecting Human Health and the Environment

Dry excavation and associated technologies would be associated with various short-term risks to human health and impacts to the local environment, as described in Section 7.1.3. Human health risks would be controlled through use of PPE and appropriate site controls. Disturbance of aquatic habitats would be outweighed by improved habitat quality following removal of contaminants. The project will avoid, where possible, disturbance to high quality habitat. Restoration efforts will provide an opportunity to improve disturbed areas to a higher quality relative to conditions before initiation of the project. The short-term risks to human health and the environment are expected to be similar for all sediment removal alternatives.

Engineering Implementability, Reliability, Constructability, and Technical Feasibility

Considerations affecting the implementability, reliability, constructability, and technical feasibility of dry excavation and associated technologies are presented in Section 7.1.3. Overall, dry excavation would be highly implementable in the shallow-water environment of the Phase II area. It would minimize the volume of sediment requiring offsite disposal by enabling better control over excavation. It would also produce less water requiring treatment than would hydraulic dredging, and would require less time for dewatering.

Note that the concept plan presented in this FS for dry excavation in the Phase II area is based on the estimated sediment quantities listed in Appendix F. The quantities are based on limited analytical data. Future data may reveal that it is necessary to excavate a larger than estimated volume of sediment in order to achieve remedial goals. If additional sediment excavation is required, Alternative 2 as described in the FS should provide sufficient room for dewatering. This alternative is more flexible for increased volumes than are alternatives that rely solely on hydraulic dredging, due to the relatively short time required to dewater and dispose of excavated sediments (relative to, for example, dredged sediments).

Cost

The estimated cost of Alternative 2 is approximately $14,328,000. Details on the derivation of this cost are provided in Appendix F.

8.2.3 Evaluation of Modifying Criteria

Stakeholder and Community Acceptance

Based on input received, dry excavation and offsite disposal are acceptable to stakeholders and the community. Input from the Public Information Session (Appendix G) indicates stakeholder and community support for an approach similar to the one used in the Phase I area.

8.3 REMEDIAL ALTERNATIVE 2A: DRY EXCAVATION AND DISPOSAL OF SEDIMENTS, WITH PARTICLE SIZE SEGREGATION

Alternative 2a would include dry excavation of all sediments exceeding remedial goals in the Phase II area, using the processes described in Section 7.1.1. Concept plans for this alternative are provided in Figures 1, 2, and 3 in Appendix E. As in Alternative 2, the estimated total volume of sediments excavated would include approximately 35,400 cy of contaminated non-TSCA sediments (1-50 mg/kg PCBs) and overburden, and 330 cy of TSCA sediments (>50 mg/kg PCBs). Coffer dams would be used to dewater each deposit to be excavated, and the sediments would be removed and transported by truck to a staging/dewatering area located adjacent to Deposit 7-3. Sediments would be dewatered using the dewatering pad and/or addition of amendments. Following dewatering, the sediments would be sieved to segregate coarse material from the fine-grained materials that PCBs tend to adhere to, and the coarse fraction would be tested for suitability for reuse. Fine sediments and any contaminated coarse sediments would be transported by truck for offsite disposal. For this study it was assumed that 10 percent of the material could be segregated and reused. This would decrease the estimated total tonnage of non-TSCA sediments and overburden for disposal from 58,800 tons (see Alternative 2) to approximately 52,900 tons, and would decrease the total tonnage of TSCA sediments for disposal from 540 tons to 490 tons.

8.3.1 Evaluation of Threshold Criteria

Compliance With Permits and Applicable Regulatory Requirements

The anticipated permitting and regulatory requirements associated with this alternative are presented in Section 7.1.2, and include compliance with requirements addressing sediment removal, water quality, erosion control, stormwater control and discharge, construction access, dewatering of the river channel, dust control, floodplain and wetland disturbances, and handling and disposal of excavated sediments. Obtaining and complying with the requirements of the necessary permits during implementation of this alternative is expected to be highly feasible. Because similar excavation and disposal activities occurred during remediation of the Phase I area, the permitting procedures and requirements are expected to be similar for implementation of this alternative in the Phase II area.

8.3.2 Evaluation of Balancing Criteria

Long-Term Effectiveness in Protecting Human Health and the Environment and Achieving Remedial Action Objectives

A detailed evaluation of the effectiveness of the dry excavation and associated technologies that would be used as part of this alternative is presented in Section 7.1.3. Dry excavation would permanently remove contaminated sediments from the Phase II area and is expected to be highly effective for removing sediments exceeding remedial goals from the Phase II area. Dry excavation is also not expected to leave significant amounts of residual contaminated material.

Particle size segregation of the excavated sediments would not impact the protectiveness or achievement of RAOs (see Section 7.3.3). Thus, Alternative 2a is expected to be protective of human health and the environment, achieve RAOs, prevent downstream transport of contaminated material, and support removal of BUIs.

Short-Term Effectiveness in Protecting Human Health and the Environment

Dry excavation and associated technologies, and particle size segregation, would be associated with various short-term risks to human health and impacts to the local environment, as described in Sections 7.1.3 and 7.3.3. Human health risks would be controlled through use of PPE and appropriate site controls. Disturbance of aquatic habitats would be outweighed by improved habitat quality following removal of contaminants. The project will avoid, where possible, disturbance to high quality habitat. Restoration efforts will provide an opportunity to improve disturbed areas to a higher quality relative to conditions before initiation of the project. The short-term risks to human health and the environment are expected to be similar for all sediment removal and segregation alternatives.

Engineering Implementability, Reliability, Constructability, and Technical Feasibility

Considerations affecting the implementability, reliability, constructability, and technical feasibility of dry excavation and associated technologies, and particle size segregation, are presented in Sections 7.1.3 and 7.3.3. Overall, dry excavation would be highly implementable in the shallow-water environment of the Phase II area. It would minimize the volume of sediment requiring offsite disposal by enabling better control. Dry excavation would also produce less water requiring treatment than would hydraulic dredging, and would require less time for dewatering. Particle size segregation is therefore expected to be more easily paired with dry excavation than with hydraulic dredging, because the time for dewatering required prior to segregation would be substantially shorter. However, overall, the implementability and efficiency of particle size segregation for sediments removed from the Phase II area is expected to be negatively impacted by a high proportion of fine-grained material in the contaminated sediments, and uncertainties resulting from the amount of coarse material that would be suitable for reuse. Additional assessment would be required to determine its feasibility for this project.

Note that the concept plan presented in this FS for dry excavation in the Phase II area is based on the estimated sediment quantities listed in Appendix F. The quantities are based on limited analytical data. Future data may reveal that it is necessary to excavate a larger than estimated volume of sediment in order to achieve remedial goals. If additional sediment excavation is required, Alternative 2a as described in the FS should provide sufficient room for dewatering. This alternative is more flexible for increased volumes than are alternatives that rely on hydraulic dredging, due to the relatively short time required to dewater and dispose of excavated sediments (relative to, for example, dredged sediments).

Cost

The estimated cost of Alternative 2a is approximately $14,600,000. Details on the derivation of this cost are provided in Appendix F.

8.3.3 Evaluation of Modifying Criteria

Stakeholder and Community Acceptance

Based on input received, dry excavation and offsite disposal are acceptable to stakeholders and the community. Input from the Public Information Session (Appendix G) indicates stakeholder and community support for an approach similar to the one used in the Phase I area. Particle size segregation is also expected to be acceptable, although reuse of the segregated material onsite would require that stringent requirements for reuse be met.

8.4 REMEDIAL ALTERNATIVE 3: HYDRAULIC DREDGING AND DISPOSAL OF SEDIMENTS

Alternative 3 would include hydraulic dredging of all sediments exceeding remedial goals in the Phase II area, using the processes described in Section 7.1.1. The estimated total volume of sediments excavated would include approximately 44,200 cy of contaminated non-TSCA sediments (1-50 mg/kg PCBs) and overburden, and 410 cy of TSCA sediments (>50 mg/kg PCBs) (approximately 25 percent higher quantities than dry excavation due to an estimated 25 percent over-dredging due to the dredge prism). The estimated total tonnage for disposal includes approximately 109,200 tons for non-TSCA sediments and overburden, and 1,000 tons of TSCA sediments. This disposal tonnage is higher than Alternative 2 due to over-dredging and additional water that is unable to be removed in the sediments in a reasonable time frame.

A coffer dam would be installed just upstream of the dam, to ensure a minimum of 3 ft of water depth can be maintained throughout the areas to be dredged. Environmental dredging techniques would be used to minimize sediment resuspension during dredging of the sediment slurry, which would then be pumped to a staging/dewatering area located adjacent to deposit 7-3. Sediments would be dewatered using polymer and geotubes, and transported by truck for offsite disposal. If confirmation sampling indicates residual contamination exceeding remedial goals in any areas, a residual cover would be placed to contain and prevent exposure to the contaminated material.

8.4.1 Evaluation of Threshold Criteria

Compliance With Permits and Applicable Regulatory Requirements

The anticipated permitting and regulatory requirements associated with this alternative are presented in Section 7.1.2, and include compliance with requirements addressing sediment removal, water quality, erosion control, stormwater control and discharge, construction access, dust control, floodplain and wetland disturbances, and handling and disposal of dredged sediments. Obtaining and complying with the requirements of the necessary permits during implementation of this alternative is expected to be highly feasible.

8.4.2 Evaluation of Balancing Criteria

Long-Term Effectiveness in Protecting Human Health and the Environment and Achieving Remedial Action Objectives

A detailed evaluation of the effectiveness of hydraulic dredging and the associated technologies that would be used as part of this alternative is presented in Section 7.2.3. Hydraulic dredging would permanently remove contaminated sediments from the Phase II area. It is expected to be less effective than dry excavation for removing sediments exceeding remedial goals from the Phase II area, due to its limited efficiency for removing material overlying uneven bedrock or hard pan and the tendency for contaminated sediments to become suspended during dredging, both of which lead to residual contamination. Although the placement of a residual cover as necessary would help to minimize risk associated with this residual contamination, Alternative 3 is expected to be slightly less effective for protecting human health and the environment, achieving RAOs, preventing downstream transport of contaminated material, and supporting removal of BUIs, than alternatives that utilize dry excavation.

Short-Term Effectiveness in Protecting Human Health and the Environment

Hydraulic dredging and associated technologies would be associated with various short-term risks to human health and impacts to the local environment, as described in Section 7.2.3. Human health risks would be controlled through use of PPE and appropriate site controls. Disturbance of aquatic habitats would be outweighed by improved habitat quality following removal of contaminants. The project will avoid, where possible, disturbance to high quality habitat. Restoration efforts will provide an opportunity to improve disturbed areas to a higher quality relative to conditions before initiation of the project. The short-term risks to human health and the environment are expected to be similar for all sediment removal alternatives.

Engineering Implementability, Reliability, Constructability, and Technical Feasibility

Considerations affecting the implementability, reliability, constructability, and technical feasibility of hydraulic dredging and associated technologies are presented in Section 7.2.3. Overall, hydraulic dredging would be implementable in the Phase II area. However, its reliability would be decreased by debris, especially behind the fixed crest spillway, which may clog the dredge. The lower accuracy of hydraulic dredging versus dry excavation, would lead to larger volumes of sediment requiring offsite disposal. The dredged slurry would require large amounts of area and time for dewatering, and would produce large volumes of water requiring treatment. The greater likelihood of residual contamination following hydraulic dredging could also necessitate placement of a residual cover.

Note that the concept plan presented in this FS for hydraulic dredging in the Phase II area is based on the estimated sediment quantities listed in Appendix F. The quantities are based on limited analytical data. Future data may reveal that it is necessary to dredge a larger than estimated volume of sediment in order to achieve remedial goals. If additional sediment excavation is required, the planned area for dewatering may not be sufficient to allow for additional quantities. Required modifications to the plans resulting from the added sediment volume could affect project schedule, logistics, and/or cost.

Cost

The estimated cost of Alternative 3 is approximately $17,323,000. Details on the derivation of this cost are provided in Appendix F.

8.4.3 Evaluation of Modifying Criteria

Stakeholder and Community Acceptance

Although hydraulic dredging and offsite disposal differs somewhat from the approach used in the Phase I remediation, input received (Appendix G) did not indicate major concerns among stakeholders or the community. However, the community has expressed concerns regarding changes in the river's flow regime and changes to the floodplain. The design and placement of the temporary dam used to raise water levels during dredging would need to be conducted so as to minimize potential impacts in high-water conditions. Similarly, if a residual cover is needed, careful design would be required to ensure that the cover does not impact the river's flow regime.

8.5 REMEDIAL ALTERNATIVE 3A: HYDRAULIC DREDGING AND DISPOSAL OF SEDIMENTS, WITH PARTICLE SIZE SEGREGATION

Alternative 3a would include hydraulic dredging of all sediments exceeding remedial goals in the Phase II area, using the processes described in Section 7.1.1. As in Alternative 3, the estimated total volume of sediments excavated would include approximately 44,200 cy of contaminated non-TSCA sediments (1-50 mg/kg PCBs) and overburden, and 410 cy of TSCA sediments (>50 mg/kg PCBs) (approximately 25 percent higher quantities than dry excavation due to an estimated 25 percent over-dredging due to the dredge prism). For this study it was assumed that 10 percent of the material could be segregated and reused. This would decrease the estimated total tonnage of non-TSCA sediments and overburden for disposal from approximately 109,200 tons (see Alternative 3) to 98,200 tons, would decrease the total tonnage of TSCA sediments for disposal from 1,000 to 900 tons.

A coffer dam would be installed just upstream of the dam, to ensure a minimum of 3 ft of water depth can be maintained throughout the areas to be dredged. Environmental dredging techniques would be used to minimize sediment resuspension during dredging of the sediment slurry, which would then be pumped to a staging/dewatering area located adjacent to Deposit 7-3. The sediment slurry would be pumped directly through a package treatment system that would segregate the sand and gravel using soil washing, hydro-cyclones, and gravity thickening technologies. Following segregation, the coarse material would be tested for suitability for reuse.

Fine sediments and any contaminated coarse sediments would be transported by truck for offsite disposal. If confirmation sampling indicates residual contamination exceeding remedial goals in any areas, a residual cover (potentially using the segregated coarse material) would be placed to contain and prevent exposure to the contaminated material.

8.5.1 Evaluation of Threshold Criteria

Compliance With Permits and Applicable Regulatory Requirements

The anticipated permitting and regulatory requirements associated with this alternative are presented in Section 7.2.2, and include compliance with requirements addressing sediment removal, water quality, erosion control, stormwater control and discharge, construction access, dust control, floodplain and wetland disturbances, and handling and disposal of dredged sediments. Obtaining and complying with the requirements of the necessary permits during implementation of this alternative is expected to be highly feasible.

8.5.2 Evaluation of Balancing Criteria

Long-Term Effectiveness in Protecting Human Health and the Environment and Achieving Remedial Action Objectives

A detailed evaluation of the effectiveness of hydraulic dredging and the associated technologies that would be used as part of this alternative is presented in Section 7.2.3. Hydraulic dredging would permanently remove contaminated sediments from the Phase II area. It is expected to be less effective than dry excavation for removing sediments exceeding remedial goals from the Phase II area, due to its limited efficiency for removing material overlying uneven bedrock or hard pan and the tendency for contaminated sediments to become suspended during dredging, both of which lead to residual contamination. Particle size segregation of the excavated sediments would not impact the protectiveness or achievement of RAOs (see Section 7.3.3). Although the placement of a residual cover as necessary would help to minimize risk associated with this residual contamination, Alternative 3a is expected to be slightly less effective for protecting human health and the environment, achieving RAOs, preventing downstream transport of contaminated material, and supporting removal of BUIs, than alternatives that utilize dry excavation.

Short-Term Effectiveness in Protecting Human Health and the Environment

Hydraulic dredging and associated technologies, and particle size segregation, would be associated with various short-term risks to human health and impacts to the local environment, as described in Sections 7.2.3 and 7.3.3. Human health risks would be controlled through use of PPE and appropriate site controls. Disturbance of aquatic habitats would be outweighed by improved habitat quality following removal of contaminants. The project will avoid, where possible, disturbance to high quality habitat. Restoration efforts will provide an opportunity to improve disturbed areas to a higher quality relative to conditions before initiation of the project. The short-term risks to human health and the environment are expected to be similar for all sediment removal and segregation alternatives.

Engineering Implementability, Reliability, Constructability, and Technical Feasibility

Considerations affecting the implementability, reliability, constructability, and technical feasibility of hydraulic dredging and associated technologies, and particle size segregation, are presented in Sections 7.2.3 and 7.3.3. Overall, hydraulic dredging would be implementable in the Phase II area. However, its reliability would be decreased by debris, especially behind the fixed crest spillway, which may clog the dredge. The lower accuracy of hydraulic dredging versus dry excavation would lead to larger volumes of sediment requiring offsite disposal. The greater likelihood of residual contamination following hydraulic dredging could also necessitate placement of a residual cover. The dredged slurry would require large amounts of area and time for dewatering, and would produce large volumes of water requiring treatment. Particle size segregation of hydraulic dredge slurry is therefore expected to be more difficult than with dry excavation, because the multiple processes and equipment would be substantially more complex, and the sediment following dewatering would likely still have a higher water content than with dry excavation. Overall, the implementability and efficiency of particle size segregation for sediments removed from the Phase II area is expected to be negatively impacted by a high proportion of fine-grained material in the contaminated sediments, and uncertainties resulting from the amount of coarse material that would be suitable for reuse. Additional assessment would be required to determine its feasibility for this project.

Note that the concept plan presented in this FS for hydraulic dredging in the Phase II area is based on the estimated sediment quantities listed in Appendix F. The quantities are based on limited analytical data. Future data may reveal that it is necessary to dredge a larger than estimated volume of sediment in order to achieve remedial goals. If additional sediment excavation is required, the planned area for dewatering may not be sufficient to allow for additional quantities. Required modifications to the plans resulting from the added sediment volume could affect project schedule, logistics, and/or cost.

Cost

The estimated cost of Alternative 3a is approximately $17,941,000. Details on the derivation of this cost are provided in Appendix F.

8.5.3 Evaluation of Modifying Criteria

Stakeholder and Community Acceptance

Although hydraulic dredging and offsite disposal differs somewhat from the approach used in the Phase I remediation, input received (Appendix G) did not indicate major concerns among stakeholders or the community. Particle size segregation is also expected to be acceptable. However, the community has expressed concerns regarding changes in the river's flow regime and changes to the floodplain. The design and placement of the temporary dam used to raise water levels during dredging would need to be conducted so as to minimize potential impacts in high-water conditions. Similarly, if a residual cover is needed, careful design would be required to ensure that the cover does not impact the river's flow regime. Reuse of the segregated material onsite would also require that stringent requirements for reuse be met.

8.6 REMEDIAL ALTERNATIVE 4: DRY EXCAVATION, HYDRALIC DREDGING, AND DISPOSAL OF SEDIMENTS

Alternative 4 would include dry excavation (Section 7.1.1) of sediments exceeding remedial goals in Deposits 7-1, 7-2, 7-3, 7-4 (northern portion), 4-1, 4-2, and 5-1, and vacuum truck removal (Section 7.2.1) of sediments exceeding remedial goals in Deposits 7-4 (southern portion) and 4-3. Concept plans for this alternative are provided in Figures 6 and 7 in Appendix E. The estimated total volume of sediments removed by dry excavation would include approximately 35,500 cy of contaminated non-TSCA sediments (1-50 mg/kg PCBs) and overburden, and 330 cy of TSCA sediments (>50 mg/kg PCBs) (the vacuum excavation quantity is approximately 25 percent higher than dry excavation due to an estimated 25 percent over-removal estimate similar to hydraulic dredging). The total volume of sediment removed by vacuum truck would be approximately 570 cy of non-TSCA sediment. The estimated total tonnage for disposal includes approximately 59,400 tons for non-TSCA sediments and overburden, and 540 tons of TSCA sediments. This disposal tonnage is slightly higher than Alternative 2 due to disposal of additional water in the sediments removed by vacuum truck. However, this additional disposal cost is more than offset by the reduction in cost of the access infrastructure as discussed below.

This alternative is the same as Alternative 2 except the containment system for Deposits 7-4 (southern portion) and 4-3 are not required. Also, the access infrastructure (haul road, decontamination area, construction entrance, and access ramp) are not required for Deposit 7-4 (southern portion), but may be required for Deposit 4-3. Deposit 4-3 access would be evaluated during design to determine feasibility and permitting to remove the deposit with a vacuum truck or high solids pump from the bridge. For costing purposes, it is assumed that the deposit can be removed with a vacuum truck from the bridge and the access infrastructure is not required.

If confirmation sampling indicates residual contamination exceeding remedial goals in any areas, particularly those where removal by vacuum truck was performed, additional removal or a residual cover would be placed to cover the contaminated material.

8.6.1 Evaluation of Threshold Criteria

Compliance With Permits and Applicable Regulatory Requirements

The anticipated permitting and regulatory requirements associated with this alternative are presented in Section 7.1.2, and include compliance with requirements addressing sediment removal, water quality, erosion control, stormwater control and discharge, construction access, dewatering of the river channel, dust control, floodplain and wetland disturbances, and handling and disposal of excavated sediments. Obtaining and complying with the requirements of the necessary permits during implementation of this alternative is expected to be highly feasible. Because similar activities occurred during remediation of the Phase I area, the permitting procedures and requirements are expected to be similar for implementation of this alternative in the Phase II area.

8.6.2 Evaluation of Balancing Criteria

Long-Term Effectiveness in Protecting Human Health and the Environment and Achieving Remedial Action Objectives

Detailed evaluations of the effectiveness of the dry excavation, vacuum truck removal, and the associated technologies that would be used as part of this alternative are presented in Sections 7.1.3 and 7.2.3. Both dry excavation and removing by vacuum truck would permanently remove contaminated sediments from the Phase II area. Dry excavation is expected to be somewhat more effective for removing sediments exceeding remedial goals than is vacuum truck removal, and is also expected to leave less residual contaminated material than vacuum truck removal. However, the lower effectiveness of vacuum truck removal could be partially addressed using a residual cover and would not have major implications as implemented only in a small portion of Deposit 3b-1 and in Deposit 4-3. Thus, Alternative 4 is expected to be protective of human health and the environment, achieve RAOs, prevent downstream transport of contaminated material, and support removal of BUIs.

Short-Term Effectiveness in Protecting Human Health and the Environment

Dry excavation, vacuum truck removal, and associated technologies would be associated with various short-term risks to human health and impacts to the local environment, as described in Sections 7.1.3 and 7.2.3. Human health risks would be controlled through use of PPE and appropriate site controls. Disturbance of aquatic habitats would be outweighed by improved habitat quality following removal of contaminants. The project will avoid, where possible, disturbance to high quality habitat. Restoration efforts will provide an opportunity to improve disturbed areas to a higher quality relative to conditions before initiation of the project. The short-term risks to human health and the environment are expected to be similar for all sediment removal alternatives.

Engineering Implementability, Reliability, Constructability, and Technical Feasibility

Considerations affecting the implementability, reliability, constructability, and technical feasibility of dry excavation, vacuum truck removal, and associated technologies are presented in Sections 7.1.3 and 7.2.3. Overall, dry excavation would be highly implementable in the shallow-water environment of the Phase II area. It would minimize the volume of sediment requiring offsite disposal by enabling better control over excavation. Dry excavation would also produce less water requiring treatment than would hydraulic dredging, and would require less time for dewatering. Vacuum truck removal would be implementable in Deposits 7-4 (southern portion) and 4-3, where the truck could access the contaminated sediments via the dewatered portion of 7-4 and the bridge over 4-3, respectively. Although the use of this technology would result in a larger volume of sediment removed and would also increase the amount of water requiring removal during dewatering, the impact on the overall project would be minimal due to the small total volume of contaminated sediment to be removed by vacuum truck.

Note that the concept plan presented in this FS for dry excavation and vacuum truck removal of sediments in the Phase II area is based on the estimated sediment quantities listed in Appendix F. The quantities are based on limited analytical data. Future data may reveal that it is necessary to excavate a larger than estimated volume of sediment in order to achieve remedial goals. If additional sediment excavation is required, Alternative 4 as described in the FS should provide sufficient room for dewatering. This alternative is more flexible for increased volumes than are alternatives that rely only on hydraulic dredging, due to the relatively short time required to dewater and dispose of excavated sediments relative to dredged sediments.

Cost

The estimated cost of Alternative 4 is approximately $13,427,000. Details on the derivation of this cost are provided in Appendix F.

8.6.3 Evaluation of Modifying Criteria

Stakeholder and Community Acceptance

Based on input received, dry excavation, vacuum truck removal, and offsite disposal are acceptable to stakeholders and the community. Input from the Public Information Session (Appendix G) indicates stakeholder and community support for an approach similar to the one used in the Phase I area, and no comments received expressed concerns regarding limited hydraulic dredging. Placement of a residual cover over the areas of vacuum truck removal, if needed, would be designed to ensure that the cover does not impact the river’s flow regime.

8.7 REMEDIAL ALTERNATIVE 4A: DRY EXCAVATION, HYDRAULIC DREDGING, AND DISPOSAL OF SEDIMENTS, WITH PARTICLE SIZE SEGREGATION

Alternative 4a would include dry excavation (Section 7.1.1) of sediments exceeding remedial goals in Deposits 7-1, 7-2, 7-3, 7-4 (northern portion), 4-1, 4-2, and 5-1, and vacuum truck removal (Section 7.2.1) of sediments exceeding remedial goals in Deposits 7-4 (southern portion) and 4-3. Concept plans for this alternative are provided in Figures 3, 6, and 7 in Appendix E. As in Alternative 4, the estimated total volume of sediments removed by dry excavation would include approximately 35,500 cy of contaminated non-TSCA sediments (1-50 mg/kg PCBs) and overburden, and 330 cy of TSCA sediments (>50 mg/kg PCBs) (the vacuum excavation quantity is approximately 25 percent higher than dry excavation due to an estimated 25 percent over-removal estimate similar to hydraulic dredging). The total volume of sediment removed by vacuum truck would be approximately 570 cy of non-TSCA sediment. For this study it was assumed that 10 percent of the material could be segregated and reused. This would decrease the estimated total tonnage of non-TSCA sediments and overburden for disposal from approximately 59,400 tons (see Alternative 4) to 53,500 tons, and would decrease the total tonnage of TSCA sediments for disposal from 540 tons to 490 tons.

This alternative is same as Alternative 2a except the containment system for Deposits 7-4 (southern portion) and 4-3 are not required. Also, the access infrastructure (haul road, decontamination area, construction entrance, and access ramp) are not required for Deposit 7-4 (southern portion), but may be required for Deposit 4-3. Deposit 4-3 access would be evaluated during design to determine feasibility and permitting to remove the deposit with a vacuum truck or high solids pump from the bridge. For costing purposes, it is assumed that the deposit can be removed with a vacuum truck from the bridge and the access infrastructure is not required.

Following dewatering, the sediments would be sieved to segregate coarse material from the fine-grained materials that PCBs tend to adhere to, and the coarse fraction would be tested for suitability for reuse. Fine sediments and any contaminated coarse sediments would be transported by truck for offsite disposal. If confirmation sampling indicates residual contamination exceeding remedial goals in any areas, particularly those where removing by vacuum truck was performed, a residual cover would be placed to contain and prevent exposure to the contaminated material.

8.7.1 Evaluation of Threshold Criteria

Compliance With Permits and Applicable Regulatory Requirements

The anticipated permitting and regulatory requirements associated with this alternative are presented in Section 7.1.2, and include compliance with requirements addressing sediment removal, water quality, erosion control, stormwater control and discharge, construction access, dewatering of the river channel, dust control, floodplain and wetland disturbances, and handling and disposal of excavated sediments. Obtaining and complying with the requirements of the necessary permits during implementation of this alternative is expected to be highly feasible. Because similar activities occurred during remediation of the Phase I area, the permitting procedures and requirements are expected to be similar for implementation of this alternative in the Phase II area.

8.7.2 Evaluation of Balancing Criteria

Long-Term Effectiveness in Protecting Human Health and the Environment and Achieving Remedial Action Objectives

Detailed evaluations of the effectiveness of the dry excavation, hydraulic dredging, and the associated technologies that would be used as part of this alternative are presented in Sections 7.1.3 and 7.2.3. Both dry excavation and removing by vacuum truck would permanently remove contaminated sediments from the Phase II area. Dry excavation is expected to be somewhat more effective for removing sediments exceeding remedial goals than is vacuum truck removal, and is also expected to leave less residual contaminated material than dredging. However, the lower effectiveness of vacuum truck removal could be partially addressed using a residual cover and would not have major implications as implemented only in a small portion of Deposit 7-4 (southern portion) and in Deposit 4-3. Particle size segregation of the excavated sediments would also not impact the protectiveness or achievement of RAOs (see Section 7.3.3). Thus, Alternative 4a is expected to be protective of human health and the environment, achieve RAOs, prevent downstream transport of contaminated material, and support removal of BUIs.

Short-Term Effectiveness in Protecting Human Health and the Environment

Dry excavation, hydraulic dredging, particle size segregation, and associated technologies would be associated with various short-term risks to human health and impacts to the local environment, as described in Sections 7.1.3, 7.2.3, and 7.3.3. Human health risks would be controlled through use of PPE and appropriate site controls. Disturbance of aquatic habitats would be outweighed by improved habitat quality following removal of contaminants. The project will avoid, where possible, disturbance to high quality habitat. Restoration efforts will provide an opportunity to improve disturbed areas to a higher quality relative to conditions before initiation of the project. The short-term risks to human health and the environment are expected to be similar for all sediment removal alternatives.

Engineering Implementability, Reliability, Constructability, and Technical Feasibility

Considerations affecting the implementability, reliability, constructability, and technical feasibility of dry excavation, hydraulic dredging, particle size segregation, and associated technologies are presented in Sections 7.1.3, 7.2.3, and 7.3.3. Overall, dry excavation would be highly implementable in the shallow-water environment of the Phase II area. It would minimize the volume of sediment requiring offsite disposal by enabling better control over excavation. Dry excavation would also produce less water requiring treatment than would hydraulic dredging, and would require less time for dewatering. Removal by vacuum truck would be implementable in Deposits 7-4 (southern portion) and 4-3, where the truck could access the contaminated sediments via the dewatered portion of 7-4 and the bridge over 4-3, respectively. Although the use of this technology would result in a larger volume of sediment removed and would also increase the amount of water requiring removal during dewatering, the impact on the overall project would be minimal due to the small total volume of contaminated sediment to be removed by vacuum truck. The overall implementability and efficiency of particle size segregation for sediments removed from the Phase II area is expected to be negatively impacted by a high proportion of fine-grained material in the contaminated sediments, and uncertainties resulting from the amount of coarse material that would be suitable for reuse. Additional assessment would be required to determine its feasibility for this project.

Note that the concept plan presented in this FS for dry excavation and vacuum truck removal of sediments in the Phase II area is based on the estimated sediment quantities listed in Appendix F. The quantities are based on limited analytical data. Future data may reveal that it is necessary to excavate a larger than estimated volume of sediment in order to achieve remedial goals. If additional sediment excavation is required, Alternative 4a as described in the FS should provide sufficient room for dewatering. This alternative is more flexible for increased volumes than are alternatives that rely only on hydraulic dredging, due to the relatively short time required to dewater and dispose of excavated sediments relative to dredged sediments.

Cost

The estimated cost of Alternative 4a is approximately $13,684,000. Details on the derivation of this cost are provided in Appendix F.

8.7.3 Evaluation of Modifying Criteria

Stakeholder and Community Acceptance

Dry excavation, vacuum truck removal, and offsite disposal are expected to be acceptable to stakeholders and the community, based on positive stakeholder and community response to the implementation of similar technologies in the Phase I area. Particle size segregation is also expected to be acceptable. However, placement of a residual cover, if needed, is expected to require careful communication and design to ensure that the cover does not impact the river's flow regime. Reuse of the segregated material onsite would also require that stringent requirements for reuse be met.

8.8 COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES

Table 8-1 summarizes the findings of the evaluations presented in Chapter 7 and Sections 8.1 through 8.7, and also presents relative ratings for the seven remedial alternatives evaluated, according to the six criteria outlined in Chapter 6. This section provides a narrative summary of the relative attributes of the alternatives.

8.8.1 Threshold Criteria

Compliance With Permits and Applicable Regulatory Requirements

Obtaining and complying with the necessary permits is expected to be highly feasible for all seven remedial alternatives evaluated. Alternative 1, No Action, would not be associated with any specific permitting or regulatory requirements. The anticipated permitting and regulatory requirements for the other six alternatives are expected to be similar, and relate to protecting water quality during sediment removal, handling necessary disturbances to the current flow regime, minimizing erosion and dust and addressing stormwater during sediment transport activities, minimizing and mitigating floodplain and wetland disturbances, and properly handling and disposing of excavated sediments (including TSCA requirements).

8.8.2 Balancing Criteria

Long-Term Effectiveness in Protecting Human Health and the Environment and Achieving Remedial Action Objectives

Either hydraulic dredging or dry excavation would remove contaminated sediments from the Phase II area, prevent their transport downstream, protect human health and the environment by decreasing contaminant exposure throughout the AOC, and thus support removal of the BUIs identified as associated with the Site. Hydraulic dredging tends to leave more residual contaminated sediment than dry excavation, and is therefore expected to be moderately less effective than dry excavation for removing contaminated sediments in the Phase II area. Residuals left after hydraulic dredging result from both the limited ability of the technology to remove material adjacent to uneven hard pan bedrock surfaces, and the potential for resuspension and redeposition of contaminated material during subaqueous dredging operations. Excavating in the dry, which does not involve disturbance of subaqueous material, is expected to cause less sediment to become suspended and thus may result in fewer residuals associated with redeposition.

Based on these considerations, Alternatives 2, 2a, 4, and 4a (which include dry excavation of some or all sediments requiring removal) are expected to be somewhat more effective in the long term than Alternatives 3 and 3a (which involve hydraulic dredging of all sediments requiring removal). Although Alternatives 4 and 4a involve vacuum truck removal of small volumes of sediment, use of this technology in targeted areas is not expected to significantly decrease the long-term effectiveness of these alternatives relative to Alternative 2 and 2a. Alternative 1, No Action, would not protect human health and the environment, prevent downstream transport of contaminants, or support removal of BUIs, and therefore would be the least effective alternative. Overall, the order of rankings for long-term effectiveness is as follows:

Alternatives 2, 2a, 4, and 4a > Alternatives 3 and 3a >> Alternative 1

Short-Term Effectiveness in Protecting Human Health and the Environment

Short-term risks currently present at the site are associated with elevated concentrations of PCBs and PAHs in sediments and with isolated occurrences of NAPL. Alternative 1, No Action, would not address these risks, and therefore has low short-term effectiveness. The other six alternatives would address these risks, but would also create additional short-term risks associated with sediment removal and related activities. All six would create similar potential short-term risks, resulting from construction activities and contact with contaminated material. These potential risks would be mitigated using design to minimize impacts, PPE, site controls including decontamination of equipment, and restoration activities following completion of the remedial action. Overall, the order of rankings for short-term effectiveness is as follows:

Alternatives 2, 2a, 3, 3a, 4, 4a > Alternative 1

Engineering Implementability, Reliability, Constructability, and Technical Feasibility

Alternative 1, No Action, would be highly implementable from a logistical and technical perspective, as it would not require any design or implementation.

Dry excavation is expected to be the most implementable technology for sediment removal in most parts of the Phase II area. Excavation in the dry is easily implemented in a shallow-water environment like the Phase II area, where temporary coffer dams can be used to redirect water and allow dewatering of the stream channel. Dry excavation would also produce a smaller volume of removed material than would hydraulic dredging, and the removed material would have a lower water content, therefore requiring smaller staging/dewatering areas and less water treatment. Hydraulic dredging would also be implementable, but in addition to the larger volumes and higher water content, would be more likely to encounter problems with debris present in the sediments, especially behind the dam. A residual cover is also more likely to be required following hydraulic dredging, to mitigate residual contamination. Although particle size segregation can be implementable at sites with large fractions of coarse material, the sediments to be removed from the Phase II area contain only approximately 10 percent coarse sand and gravel, on average. Therefore, particle size segregation is not expected to be implementable for the majority of the site. Overall, the order of rankings for engineering implementability, reliability, constructability, and technical feasibility is as follows:

Alternatives 1, 2, and 4 > Alternatives 2a, 3, 4a > Alternative 3a

Cost

Generally, the cost of removing sediments by dry excavation, expressed per cubic yard of contaminated sediment, is somewhat less than the cost of hydraulic dredging. The marginal cost of added sediment removal volume, if determined to be necessary to achieve remedial goals, would also be lower for dry excavation, as this technology is less costly per cubic yard after the fixed price for containment is considered. However, in some locations, targeted use of hydraulic dredging can be less expensive, due to logistical challenges associated with dewatering and access. The cost of particle size segregation is significantly less than the cost of removal, but is higher than the cost of the clean cover material, which it seeks to replace. The order of rankings for cost (with the highest ranking representing the lowest cost) is as follows:

Alternative 1 > Alternative 2 ≈ 2a ≈ 4 ≈ 4a > Alternative 3 ≈ 3a

8.8.3 Modifying Criteria

Stakeholder and Community Acceptance

Stakeholder and community acceptance is expected to be primarily contingent upon compliance with permitting and regulatory requirements, achievement of RAOs, protection of human health and the environment, and minimization of short-term impacts. Alternatives 2, 2a, 4, and 4a are thought to be the most acceptable, because they would be protective and effective for achieving RAOs, and based on the positive response to similar activities implemented in the Phase I area of the Site. Input received at and after the Public Information Session (Appendix G) confirms public support for such an approach. Alternative 1, No Action, is the least acceptable of the alternatives evaluated, because it would not achieve RAOs and would not be protective. The hydraulic dredging alternatives (Alternatives 3 and 3a) are expected to be moderately acceptable, with some concerns regarding placement of a residual cover and temporary changes to the floodplain. The order of rankings for stakeholder and community acceptance, assessed based on overall input received, is as follows:

Alternatives 2, 2a, 4, 4a > Alternative 3, 3a > Alternative 1

9. EVALUATION OF HABITAT RESTORATION TECHNIQUES

As restoration techniques are likely to vary with each individual area disturbed as part of the remedial action, typical practices and techniques are presented in a best management practice approach. In order to meet the prescribed goals, a variety of technologies and practices would be utilized at individual remediation locations, rather than a set of prescribed alternatives which broadly encompass the entire site limit of disturbance. This section presents an evaluation of these restoration alternatives, according to the criteria described in Chapter 6.

9.1 BOUNDARY CONDITIONS FOR RESTORATION

Key boundaries have been established for restoration relating to the remedial action. These form the basic assumptions which establish the scope and extents of this work. They include:

- The restoration boundary will only include the areas of disturbance from the remedial action.
- The timeframe for restoration and construction shall be coordinated to occur shortly following remediation in each area to help minimize the cost, effort, and difficulty of implementation.
- Restoration must account for the downstream dam, highway infrastructure, existing revetments, utilities, and other facilities. Modification of these facilities for the purposed of restoration will not be included.

These boundaries preclude a widespread watershed or river reach restoration.

9.2 BASIS OF DESIGN FOR RESTORATION

The primary basis of design for restoration practices stems from the habitat evaluation conducted in 2013 (Appendix C). This evaluation documents the existing resources at the site, including specific habitats, jurisdictional wetlands, and specific habitat resources which will be identified for restoration through the stakeholder coordination process. The ensuing design of these restoration sites will adhere to the boundary conditions established for restoration, as well as meet with the overriding goals for the remediation.

9.3 RESTORATION BEST MANAGEMENT PRACTICES AND APPROXIMATE COSTS

The following techniques are anticipated to be utilized in multiple locations or in combination as part of the restoration. They include:

- **Wetland Restoration:** Wetland restoration includes those wetlands which must be restored to prevent permanent jurisdictional wetland impacts. These typically occur to wetlands which are impacted above the ordinary high water mark. Although prices are highly variable depending on site conditions and where restoration may occur, typical prices range between $25,000 and $60,000 per acre of wetland restoration.

- **Substrate Restoration:** Substrate restoration would occur in locations where point bars, gravel beds, and other bottom features would benefit habitat. These locations would be typically in side channel/shallows areas and not the open river channel. These would be appropriate native geologic materials, of size and shape to be utilized by benthos or fish species. Typical prices of restored substrates are approximately $260 per cubic yard of substrate installed.

- **Boulder Clusters:** Boulder clusters are features which provide flow diversity, overhead in-channel cover, and bank stability. These features can also be utilized for recreation and river access by fishermen, and aid in river aesthetics. These features are typically approximately $25,000 per installed grouping.

- **Bank Stabilization:** Bank stabilization practices would occur in areas in close proximity to ordinary high water and sloping down into the channel. They are to provide resistance to bank erosion forces and maintain the position of the river channel in place. Although the extent of protection is not yet designed, a typical bank protection structure can cost between $400 and $700 per linear foot installed. For large scale stabilizations, this price may be higher.

- **Tree and Shrub Planting:** Individual trees and shrubs would be installed as part of restoration of a riparian buffer. The clearing and invasive species removal associated with this would be part of the remedial design, and not part of the restoration costs. Typical tree and shrub planting, with tree protection, can run between $20 and $300 per installation, depending on the size and type of the planting material. It would be anticipated that some larger 2- to 3-in. caliper trees may be installed as part of restoring buffer to fit with the park setting at this site. Minimal restoration with saplings at 8-ft spacing costs approximately $2.25 per square yard.

- **Turf and Seeding:** Turf and seeding costs would be approximately $2-4 per square yard, and could include a variety of native forbs and herbs as well as standard turf mixes of seed. Site preparation is excluded as part of this cost as those costs would be part of the remedial action.

- **Log and Woody Debris Structures:** These structures would be placed as permanent enhancements providing submerged aquatic habits. They are best coupled, for habitat and stability reasons, with boulder clusters. They consist of submerged logs and root wads, pinned under stones or otherwise anchored. They are positioned in areas with sufficient shear stress to allow them to be maintained clean of fine sediments to allow for consistent overhead cover habitat. They are typically approximately $7,000 per instance installed.

9.4 EVALUATION OF RESTORATION TECHNIQUES

Restoring the Phase II area to meet the goals established in Chapter 5 would involve restoring jurisdictional wetland impacts, ensuring bank and bed stability, and installing habitat elements which provide benthic and fish habitat as well as recreational opportunity. Basic erosion and sediment control restoration would be employed including riparian plantings, turf establishment, and associated management practices. The limit of restoration would include only the footprint of the remedial action and the footprints of associated facilities including haul roads, dewatering pads, etc.

Restoration as a whole was evaluated using the criteria described below to ensure compatibility with RAOs. The criteria fall into three groups: (1) Threshold Criteria, which must be met for any restoration option; (2) Balancing Criteria, which are useful for characterizing the advantages and disadvantages of restoration options; and (3) Modifying Criteria, which characterize other factors affecting the relevance of specific restoration options.

9.4.1 Evaluation of Threshold Criteria

Only one threshold criterion was evaluated; this is compliance with permits and applicable regulatory requirements, which is a stated goal of restoration and must be met to ensure project success. Permitting would likely be required for restoration activities, in conjunction with the permitting requirements associated with the remedial actions. The following subsections describe different permitting agencies and requirements for coordination.

9.4.1.1 WDNR

Under Chapter NR 353 of the Wisconsin Administrative Code, wetland restoration projects require waterway and wetland permits. Wetland Conservation projects should be designed and constructed according to the following the Wisconsin Natural Resources Conservation Service Field Office Technical Guide Standard Conservation Practices: 657 − Wetland Restoration, 638 − Water and Sediment Control, 410 − Grade Stabilization, and 378 − Pond.

9.4.1.2 USACE

The USACE St. Paul District has issued a General Permit (GP-002-WI) for activities within Wisconsin that discharge dredged and/or fill material into waters of the United States, according to the provisions of the United States Clean Water Act (40 CFR 230), Section 404. Remedial activities in the Phase II area would need to be authorized under the following sections of this General Permit.

- Section 1(a)(7) Stream and Wetland Restoration Activities
- Section 1(a)(11) Bank Stabilization.

9.4.1.3 Other Regulations

Additional regulations that may apply include the following:

- Rivers and Harbors Act Permits (33 United States Code 403 Section 10)

- Waterway and Wetland Permits: Grading (Wisconsin Statute Section 30.19 and Chapter NR 341 Wisconsin Administrative Code)

- Wetland Restoration Permits (Wisconsin Statute Section Various, Chapter NR 353 Wisconsin Administrative Code)

- Wisconsin Floodplain Management Program (Wisconsin Statute Section 87.30 (1) and NR 116, Wisconsin Administrative Code)

- Stormwater Erosion Control (NR 216, Wisconsin Administrative Code).

9.4.2 Evaluation of Balancing Criteria

Four balancing criteria were evaluated. These include long- and short-term effectiveness, implementability/feasibility, and cost, all of which aid in characterizing the ability of specific options to achieve restoration goals.

Long-Term Effectiveness in Protecting Human Health and the Environment and Achieving Remedial Action Objectives

All of the restoration options would have no significant impacts on human health. Long-term improvements in habitat would be expected. These improvements would be significantly longer time frame than the restoration work or remedial work, and source jointly from the improvements made as part of restoration as well as the chemical improvements in the habitat through the remedial action.

Short-Term Effectiveness in Protecting Human Health and the Environment

Short-term impacts of the restoration options described above would cause a disruption in existing available habitat. Human health effects in the short term would be no different than those already caused by the remedial action.

Engineering Implementability, Reliability, and Constructability, and Technical Feasibility

Implementability and Constructability: The restoration options described above are all standard techniques that are commonly implemented as part of restoration projects. Although it is anticipated that restoration work would take place using the same limit of disturbance, flow diversions, etc. as the remedial action, certain specialized equipment would be required for the successful implementation of restoration enhancements. This equipment may not be utilized during the remedial alternative and includes low ground pressure equipment, excavators with hydraulic thumbs, or tracked haul trucks. Although this equipment is specialized, it is available and utilized by specialized contractors.

Reliability: Many of the restoration options described above are designed to be self-sustaining, either by biological or geological mechanisms. Some may be prone to weathering or change over time. The design of habitat enhancements such as habitat boulders, woody debris, and substrates would include consideration of long-term stability. Substrates in some areas may be ineffective due to burial. Woody debris that does not remain submerged or is subjected to extreme flows may, however, be prone to dislodging or decomposing. Ice and floating debris may exacerbate this issue. Although through careful design and placement most of these issues can be negated, the reliability of the restoration alternative is lower than that of no action or existing conditions alternatives.

Cost

Overall restoration costs are anticipated in the $550,000 to $1.5 million in cost range, depending on the amount of wetland restoration, channel enhancements, and planting proposed.
Costs are presented by technique, with a low and high range, in Appendix F.

9.4.3 Evaluation of Modifying Criteria

One modifying criterion was identified for evaluation. Stakeholder and community acceptance of restoration options is an important determinant of their relevance, especially given that restoration will occur in a waterbody subject to heavy recreational use. The restoration options above are expected to have positive impacts on aesthetics, and no negative recreational, boating, water surface, or other associated impacts are anticipated aside from those which may arise from the remedial action itself. Long-term park usage is not anticipated to be negatively impacted, and recreational utilization of the fishery is expected to be positively impacted.

10. RECOMMENDED REMEDIAL ALTERNATIVE AND RESTORATION OPTIONS

The recommended alternative for remediation of the Phase II area is Alternative 4, Dry Excavation, Hydraulic Dredging, and Disposal of Sediments. This alternative incorporates dry excavation and disposal technologies similar to those used in remediation of the Phase I area of the Site, with the addition of limited hydraulic dredging for flexibility in removing sediments in areas that are difficult to dewater or difficult to access with dry excavation equipment.

Alternative 4 will effectively remove sediments with contaminant concentrations exceeding remedial goals from the Site, and thus will protect human health and the environment, further decrease downstream transport of contaminated material (in combination with the remedial actions already completed at the Site), and ultimately support removal of BUIs. This alternative will also be highly implementable in the shallow-water environment of the Phase II area. This alternative is recommended rather than Alternative 4a, which includes particle size segregation, due to logistical concerns related to the small volume of sediments to be removed and the relatively small fraction of coarse material within those sediments, and uncertainties regarding how much of the coarse material would be suitable for reuse. Alternative 4 is therefore the most efficient and effective alternative for meeting the RAOs for the project.

Restoration technologies recommended to be implemented in combination with the selected alternative include wetland restoration, substrate restoration, and turf and seeding. Other restoration activities may also be performed as determined appropriate to meet the restoration goals for the project. Restoration techniques appropriate to each area disturbed during remediation will be refined and developed during the design process.

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FIGURES

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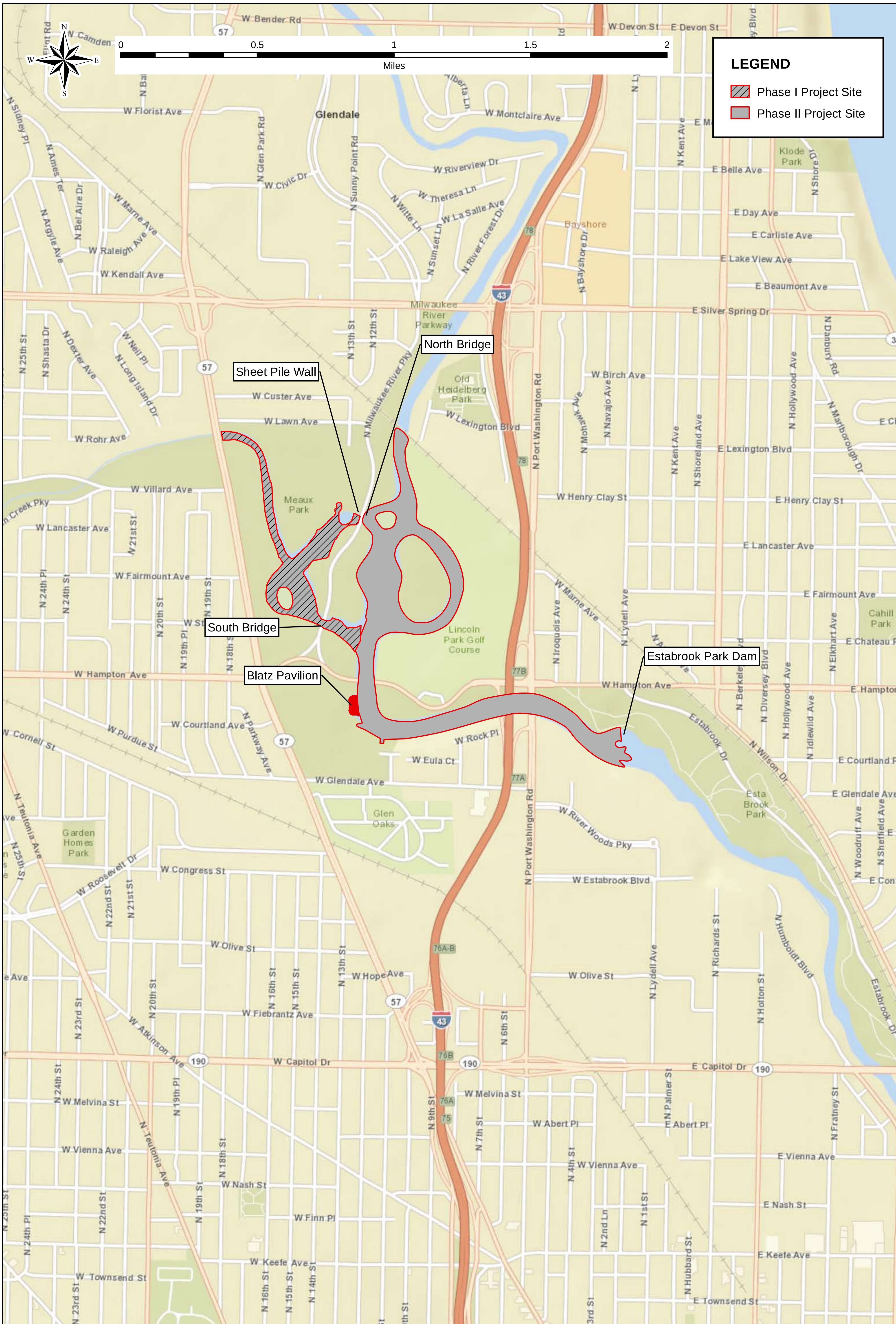

LINCOLN PARK/
MILWAUKEE RIVER
CHANNEL SEDIMENTS SITE
PHASE II FS/RD
GLENDALE, WISCONSIN

FIGURE 1-1
Site Location Map

Source: Imagery: ArcGIS Online 2012
Project Boundary from CH2M Hill 2011,
Phase II Remedial Investigation

Date:..July 2013
Prepared By:.....................EA Engineering, Science, and Technology, Inc.

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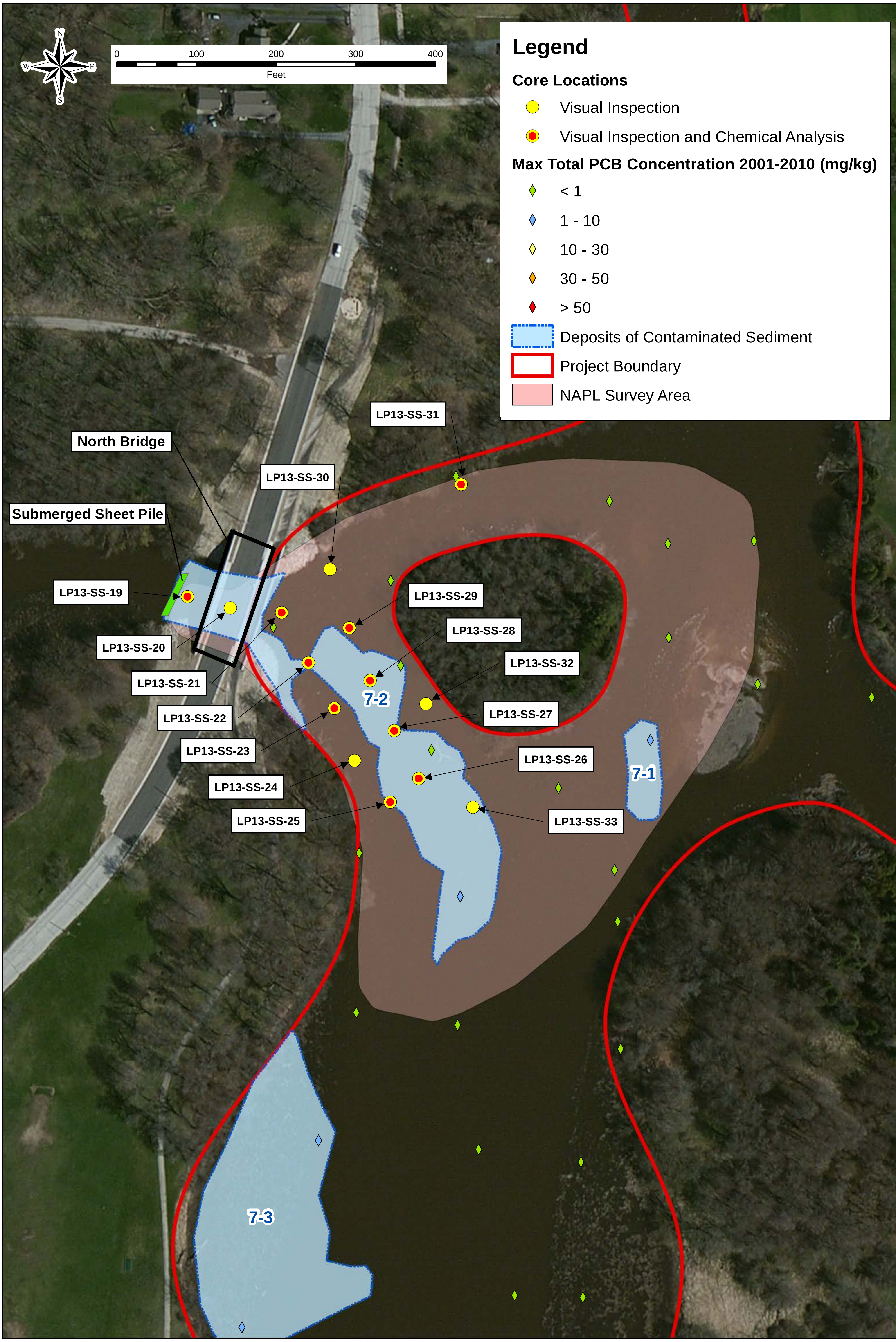

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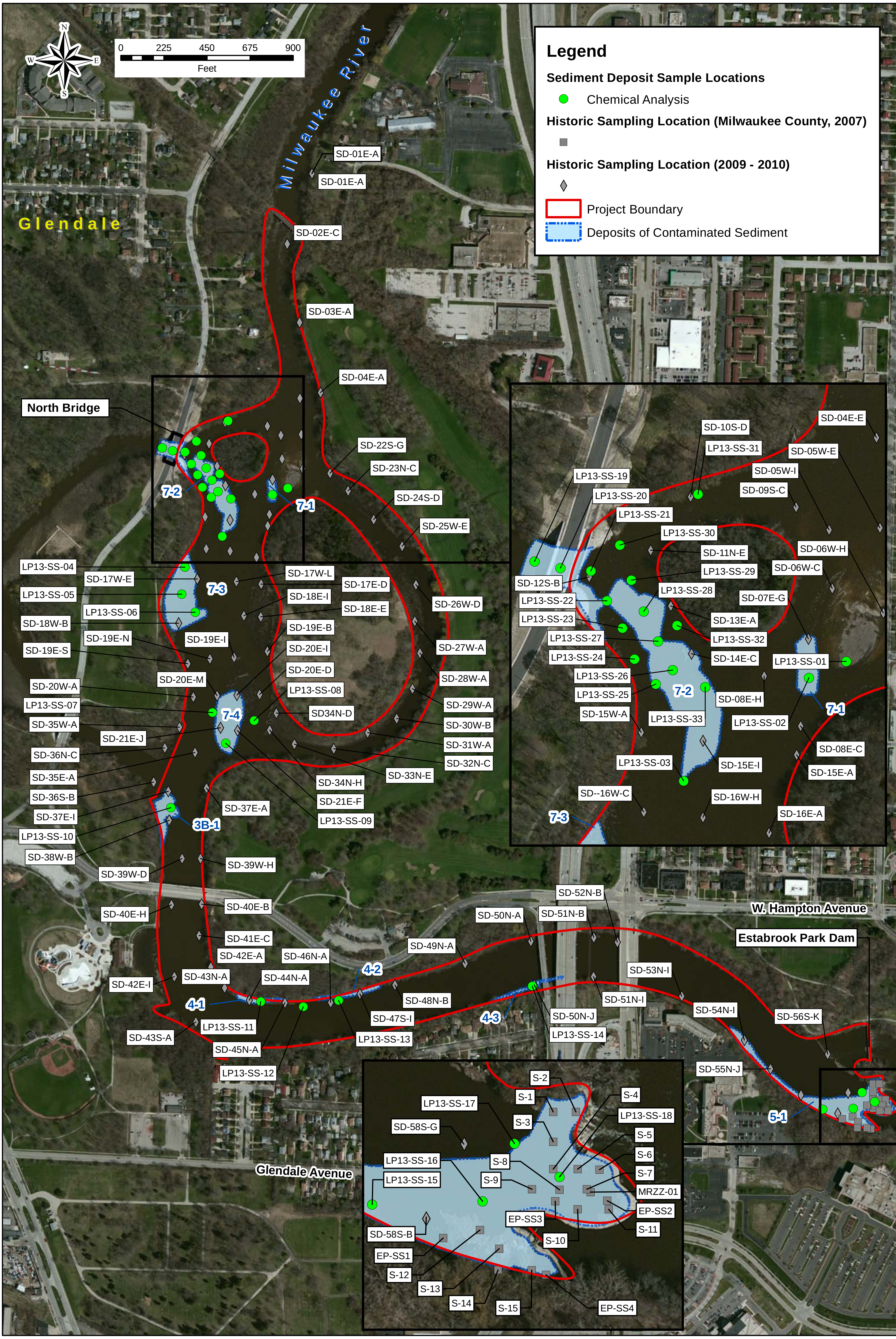
LINCOLN PARK/
MILWAUKEE RIVER
CHANNEL SEDIMENTS SITE
PHASE II FS/RD
GLENDALE, WISCONSIN

FIGURE 1-2
NAPL Survey Locations from the 2013 Investigation of Phase II Area Sediments

Source: ArcGIS Online Map Service 2012,
Total PCB data from CH2M Hill 2011,
Phase II Remedial Investigation

Date:...July 2013
Prepared By:......................EA Engineering,Science, and Technology, Inc.



LINCOLN PARK/
MILWAUKEE RIVER
CHANNEL SEDIMENTS SITE
PHASE II FS/RD
GLENDALE, WISCONSIN

FIGURE 1-3
Sediment Coring Locations from the 2013 Investigation of Phase II Area Sediments

Source: Imagery: ArcGIS Online 2012
Total PCB data from CH2M Hill 2011,
Phase II Remedial Investigation

Date:..June 2013
Prepared By:......................EA Engineering,Science, and Technology, Inc.

LINCOLN PARK/
MILWAUKEE RIVER
CHANNEL SEDIMENTS SITE
PHASE II FS/RD
GLENDALE, WISCONSIN

FIGURE 2-1
Remediation-Related Features of the Lincoln Park/Milwaukee River Channel Sediments Site

Source: Imagery: ArcGIS Online 2012

Date:....................July 2013
Prepared By:....................EA Engineering, Science, and Technology, Inc.

LINCOLN PARK/
MILWAUKEE RIVER
CHANNEL SEDIMENTS SITE
PHASE II FS/RD
GLENDALE, WISCONSIN

Figure 2-2

Total PCB Concentrations Detected in the Phase II Area of the LincolnPark/Milwaukee River Channel Sediments Site

Source: Imagery: ArcGIS Online 2012
Total PCB data from CH2M Hill 2011,
Phase II Remedial Investigation

Date:..July 2013
Prepared By:......................EA Engineering,Science, and Technology, Inc.

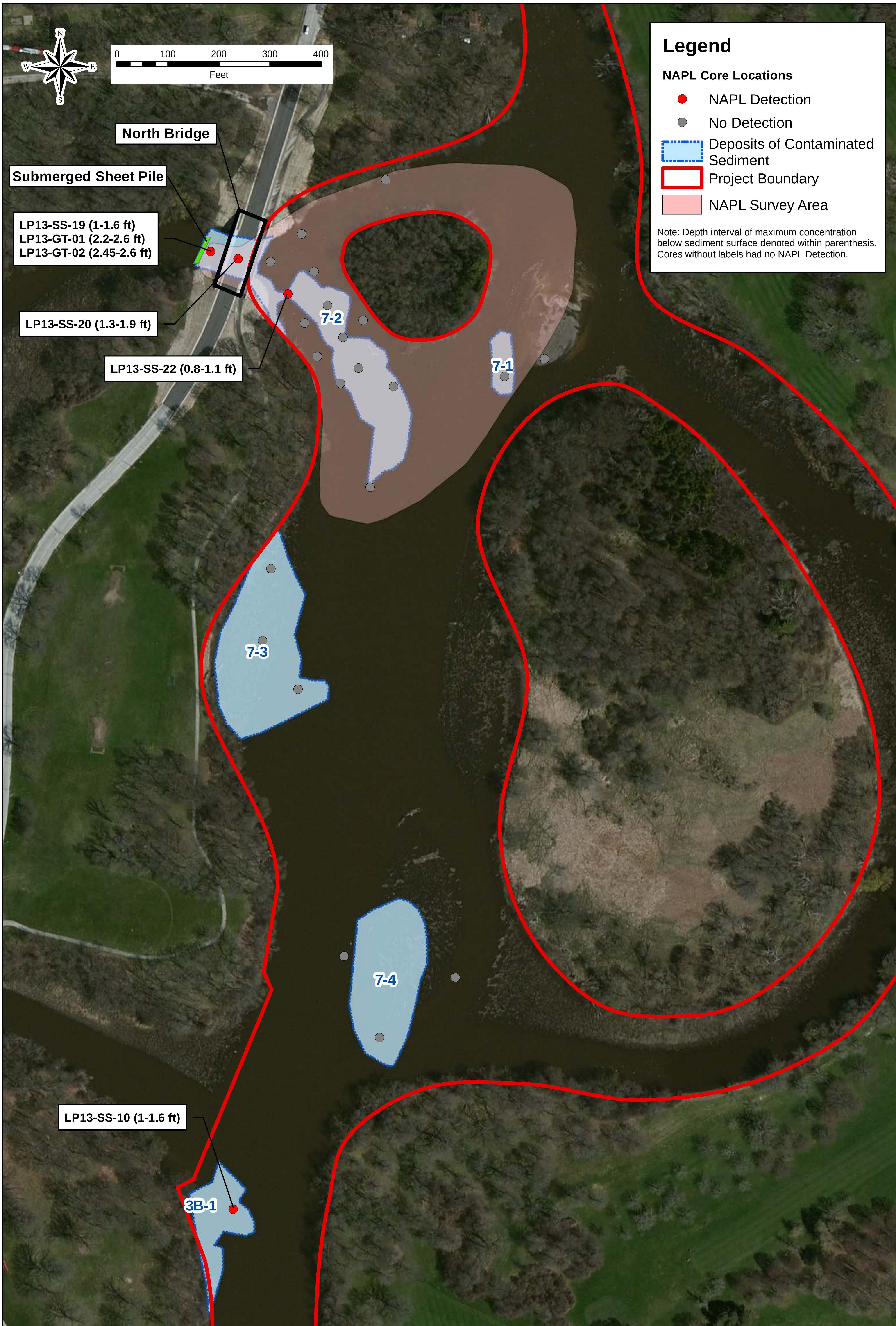
LINCOLN PARK/
MILWAUKEE RIVER
CHANNEL SEDIMENTS SITE
PHASE II FS/RD
GLENDALE, WISCONSIN

Figure 2-3

Total PAH Concentrations Detected in the Phase II Area of the Lincoln Park/Milwaukee River Channel Sediments Site

Source: Imagery: ArcGIS Online 2012
Total PCB data from CH2M Hill 2011,
Phase II Remedial Investigation

Date:...July 2013
Prepared By:......................EA Engineering,Science, and Technology, Inc.



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LINCOLN PARK/
MILWAUKEE RIVER
CHANNEL SEDIMENTS SITE
PHASE II FS/RD
GLENDALE, WISCONSIN

Figure 2-4

Locations Containing NAPL in the Phase II Area of the Lincoln Park/Milwaukee River Channel Sediments Site

Source: ArcGIS Online Map Service 2012, Total PCB data from CH2M Hill 2011, Phase II Remedial Investigation

Date:..........July 2013
Prepared By:..........EA Engineering,Science, and Technology, Inc.

TABLES

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TABLE 2-1
SUMMARY OF SEDIMENT DEPOSITS TARGETED FOR REMEDIATION[A]
LINCOLN PARK/MILWAUKEE RIVER CHANNEL SEDIMENTS SITE PHASE II AREA

Sediment Deposit Name	Chemicals of Concern	Maximum Detected Concentrations (mg/kg)		Estimated Total Mass of Contaminants (kg)		Sediment Volume (cubic yards)						Area & Depth of Contaminated Sediment (acres)		Geotechnical Information				
		PCBs	PAHs	PCBs	PAHs	Contaminated Material[B]	Estimated Volume Containing NAPL	Overburden[C]	Combined Contaminated & Overburden	Non-TSCA Regulated	TSCA Regulated[D]	Area (acres)	Average Depth to Bottom of Deposit (ft bss)	Core Sediment Recovery (%)[E]	Fraction of Coarse Sand and Gravel (%)	Fraction of Fine and Medium Sand (%)	Fraction of Fines (%)	Moisture[F] (%)
Deposit 7-1	PCBs, PAHs	3.0	105	0.09	2.5	92	--	814	906	906	0	0.1	3.2	70	5	26	70	13
Deposit 7-2	PCBs, PAHs, NAPL	162	247	17	76	2,775	172	2,607	5,382	5,332	50	1.1	2.2	71	10	25	65	27
Deposit 7-3	PCBs, PAHs	8.1	44	5.1	35	2,548	--	2,538	5,086	5,086	0	1.1	2.0	71	7	23	69	38
Deposit 7-4	PCBs, PAHs	2.4	37	0.48	7.2	626	--	2,330	2,956	2,956	0	0.9	2.2	84	4	20	76	41
Deposit 3b-1	PCBs, PAHs, NAPL	1.6	37	0.52	14	632	21	116	748	748	0	0.4	1.0	81	9	43	49	27
Deposit 4-1	PCBs, PAHs	1.5	117	0.26	3.9	181	--	107	288	288	0	0.1	0.86	77	3	39	58	28
Deposit 4-2	PCBs, PAHs	1.9	33	0.09	2.3	249	--	173	422	422	0	0.2	1.1	73				19
Deposit 4-3	PCBs, PAHs	3.7	115	0.08	2.3	83	--	90	173	173	0	0.1	0.46	84	70	18	12	18
Deposit 5-1	PCBs, PAHs	230	469	26	132	3,659	--	1,206	4,865	4,744	121	1.4	2.2	60	3	28	69	45
Overall	**PCBs, PAHs, NAPL**	**230**	**469**	**50**	**275**	**4,804**	**193**	**1,692**	**6,496**	**6,375**	**121**	**2.2**	**1.1**	**75**	**21**	**32**	**47**	**27**

A - Volume and area estimates are based on spatial modeling. Geotechnical values are based on average results across all samples from cores associated with a deposit. Concentrations are based on maximum results across all samples from cores associated with a deposit.
B - Volume is based on sediments containing one or more of the following: presence of NAPL, PCB concentrations over 1 mg/kg, or PAH concentrations over 20 mg/kg.
C - Volume is based on the average depth of the top of the contaminated sediment deposit below the sediment surface and the assumption that removal would require side slopes at a 3:1 ratio.
D - Volume is based on sediments containing PCB concentrations over 50 mg/kg.
E - Percent recovery averages were calculated using 100% for any recovery greater than 100%. Value was calculated for all cores where both penetration (sediment depth) and core length (recovery) were available.
F - Ratio of water mass to solids mass, expressed as a percentage.

TABLE 3-1. REMEDIAL TECHNOLOGY SCREENING SUMMARY

Technology	Description	Effectiveness	Implementability	Relative Cost	Public Acceptance	Screening Comment
No Action						
None	No further actions to address contamination in sediment.	Low, although slow attenuation via biodegradation and sediment redistribution is expected.	High.	None	Unfavorable, due to the presence of unacceptable risk under current conditions.	The No Action option is carried forward for comparison with other remedial alternatives.
Monitored or Enhanced Natural Recovery						
Monitored Natural Recovery	Monitor contaminant concentrations with no other actions, to assess natural attenuation of contaminants by physical, chemical, and biological processes.	Low. Evidence indicates that sediment redistribution and burial have not sufficiently decreased contamination at the site, and rates of expected attenuation by PCB and PAH biodegradation are slow.	High. Requires only periodic monitoring and assessment.	Low, associated primarily with monitoring.	Unfavorable, due to long timeframe to meet remedial goals.	Not retained, due to continued potential for contaminant transport during extended remedial timeframe.
Containment						
Isolation Cap	Installation of a cap of stone or sand (in the case of dam restoration) at the sediment surface, with design parameters appropriate to minimize contact with and transport of contaminated sediments. Larger stone would be needed in channels. Fabric could be installed under the cap to provide additional sediment stability. The cap would be keyed upstream, downstream, and into channel bed, to form a protective cap over existing contaminated sediments.	Low-Moderate. Would decrease transport of contaminated sediments Would prevent exposure and transport, but contaminated sediments would remain in-place. Disturbance of the cap and/or underlying sediments could therefore result in downstream transport, and BUI for restrictions on dredging activities would need to remain in-place. Flow restrictions could cause degrading secondary circulations that destabilize the cap in the long term. Could provide high or low quality habitat following capping, and would likely increase flooding risk. Would support removal of fish and wildlife consumption advisories and BUIs for degradation of fish and wildlife populations, degradation of benthos, and restrictions on downstream dredging activities.	Low. Ensuring long-term effectiveness would require transportation of capping material and placement in water, monitoring of cap thickness, and periodic maintenance. Long-term monitoring and maintenance is not expected to be implementable, due to restrictions on funding of Great Lakes Legacy Act projects. Would likely require establishment of no-wake zones or anchoring restrictions.	Moderate, associated mostly with capital investment, followed by lower long-term monitoring and maintenance costs.	Uncertain, likely unfavorable due to concerns related to use restrictions, increased potential for flooding, and habitat degradation.	Not retained for further evaluation, due to low implementability, with low to moderate effectiveness. PCB-contaminated sediments would remain in-place. To ensure long-term effectiveness would require monitoring and maintenance, which cannot be provided for under the Great Lakes Legacy Act. Would also disturb the existing hydrologic regime and floodplain and necessitate use restrictions.
Reactive Cap	Installation of a cap of reactive material at the sediment surface, to both physically isolate contaminated sediments and chemically treat contaminants transported up through the cap. Likely less thick than an Isolation Cap.	Moderate. Would provide a small degree of additional protectiveness relative to isolation capping, as it would prevent flow of pore water containing low concentrations of the low-solubility contaminants from the sediments to the water column. Same problems as isolation capping, associated with leaving contaminated material in place, disturbing and potentially degrading habitat, and increasing flooding risk. Would support removal of fish and wildlife consumption advisories and BUIs for degradation of fish and wildlife populations, degradation of benthos, and restrictions on downstream dredging activities.	Low. More difficult to install than an Isolation Cap, with same issues related to funding for long-term monitoring and maintenance, and the need for implementation of additional use restrictions.	Moderate to High, associated with relatively expensive capping materials and installation procedures.	Uncertain, likely unfavorable due to concerns related to use restrictions, increased potential for flooding, and habitat degradation.	Not retained for further evaluation, due to low implementability and high cost, with moderate effectiveness. PCB-contaminated sediments would remain in-place. To ensure long-term effectiveness would require monitoring and maintenance, which cannot be provided for under the Great Lakes Legacy Act. Would also disturb the existing hydrologic regime and necessitate use restrictions.

TABLE 3-1. REMEDIAL TECHNOLOGY SCREENING SUMMARY

Technology	Description	Effectiveness	Implementability	Relative Cost	Public Acceptance	Screening Comment
Sediment Removal and Related Technologies						
Sediment Removal Technologies						
Dry Excavation	Dewatering of the targeted area of contaminated sediments, likely using temporary barriers, followed by excavation of the sediments down to a specified contaminant concentration, or refusal.	High. Would effectively decrease contaminant mass through removal, and could support removal of all the BUIs that apply to the site (fish and wildlife consumption advisories, degradation of benthos, restrictions on dredging activities, and degradation of fish and wildlife populations), in a shorter timeframe than other technologies. Expected to leave less residual contamination than other sediment removal technologies.	Moderate. Requires construction of structures to divert flow away from the area to be excavated. Would require multiple nearby staging areas for excavated sediments. Yields low-water-content material, minimizing the need for sediment staging and dewatering.	Moderate, associated with capital investment, with no long-term monitoring or maintenance costs.	Favorable, due to permanent removal of contaminant material and lack of use restrictions; potential concern related to increased traffic and noise, habitat disturbance	Retained for further evaluation.
Hydraulic Dredge	Pumping of contaminated sediments from the river bottom in a slurry, using hydraulic dredging equipment. Sediments would be dredged down to a specified contaminant concentration or the bottom of soft sediments.	High. Would effectively decrease contaminant mass through removal, and could support removal of all the BUIs that apply to the site (fish and wildlife consumption advisories, degradation of benthos, restrictions on dredging activities, and degradation of fish and wildlife populations), in a shorter timeframe than other technologies. Expected to leave more residual contaminated sediment than dry excavation.	Moderate. Hydraulic dredge would likely access the contaminated sediments via pontoon boat or similar, and the sediment slurry would be pumped to an onshore facility for dewatering. Large volumes of water removed from the slurry would likely require treatment, due to the presence of PCBs in sediment. Would require measures to limit resuspension and transport of disturbed sediment. Buried debris including rocks may present challenges.	Moderate, associated with capital investment, with no long-term monitoring or maintenance costs.	Favorable, due to permanent removal of contaminant material and lack of use restrictions; potential concern related to increased traffic and noise, habitat disturbance	Retained for further evaluation.
Mechanical Dredge	Removal of contaminated sediments using an excavator bucket, down to a specified contaminant concentration or refusal. Partial dewatering could be performed prior to dredging.	High. Would effectively decrease contaminant mass through removal, and could support removal of all the BUIs that apply to the site (fish and wildlife consumption advisories, degradation of benthos, restrictions on dredging activities, and degradation of fish and wildlife populations), in a shorter timeframe than other technologies. Like hydraulic dredging, expected to leave residual contamination following dredging.	Low. Access to contaminated sediments by barge would be difficult due to variable water levels at the site. Access to contaminated sediments along the river would be possible, but would yield higher water content than dry excavation along the shoreline. Nearby staging areas for excavated sediments would be required. Would also require implementation of an in-water barrier to limit resuspension and transport of disturbed sediment. Buried debris including rocks may also present challenges.	Moderate, associated with capital investment, with no long-term monitoring or maintenance costs.	Favorable, due to permanent removal of contaminated material and lack of use restrictions; potential concern related to increased traffic and noise, habitat disturbance, and sediment resuspension.	Not retained for further evaluation, due to low implementability associated with challenges in accessing contaminated sediments, relative to hydraulic dredging, and staging and dewatering requirements as compared to dry excavation.
Residuals Management						
Residual Cover	Installation of a cover of clean material (stone and/or sand) to original or stable grade, if residual contamination remains after a sediment removal action. Stone size would be chosen to be consistent with natural materials. Fabric could be installed prior to placement of the cover to provide stabilization of the residual material.	Moderate. If residual contamination is present following sediment removal, could provide an additional level of protectiveness. Less prone to erosion than a clean cover placed above the current, stable grade, and would not increase the elevation of the river bottom relative to current conditions. Would create good habitat if designed to mimic natural conditions. Where needed, could provide additional support for removal of BUIs that apply to the site (fish and wildlife consumption advisories, degradation of benthos, restrictions on dredging activities, and degradation of fish and wildlife populations).	Moderate. Does not require excavation or flow diversion beyond that required for the sediment removal action. Requires transportation and possible in-water placement of cover material. No significant follow-up monitoring of the cover itself or use restrictions would be anticipated.	Low, associated mostly with capital investment.	Uncertain. Acceptance would require good justification, including necessity to support BUI removal or ensure stability of the river, and a lack of use restrictions.	Retained for further evaluation.

TABLE 3-1. REMEDIAL TECHNOLOGY SCREENING SUMMARY

Technology	Description	Effectiveness	Implementability	Relative Cost	Public Acceptance	Screening Comment
Sediment Handling and *Ex Situ* Treatment Technologies						
Chemical Dewatering - Stabilization	Addition of fly ash, Portland cement, or similar binding material to the sediment to promote dewatering of moist sediments and decrease the leachability of contaminants.	High for sediments removed using dry excavation, which have relatively low water content following removal. For these sediments, solidification could be used as the primary dewatering technology, and could also improve the chemical properties of the sediment for disposal.	High. Requires mixing amendments into the sediment following excavation and prior to disposal.	Moderate	Favorable	Retained for further evaluation.
Passive Dewatering - Geotubes	Pumping of dredged sediment slurry into geotubes, containing a thickening agent, to promote drying. Water flows out of the thickened slurry, through the geotextile that composes the tube, leaving dewatered sediment within the tube.	High. Expected to be substantially faster than passive dewatering in a settling pond. Removed water is also often of lower turbidity, which may be beneficial to the water treatment process if required.	High for sediment slurry removed using hydraulic dredging, which would have sufficiently high water content to allow pumping of the slurry into the geotubes. Would require less area for the dewatering facility than would a settling pond.	Moderate	Uncertain	Retained for further evaluation.
Passive Dewatering - Settling Pond	Transport of removed sediments to a nearby lined pond where dewatering occurs through natural settling. Sediment would be trucked to such a facility, and water would be pumped out as the sediment settles.	Moderate. Would effectively dewater sediment, although not as quickly as other options.	High for mechanically dredged or excavated sediments, low for hydraulically dredged sediments. Simplest option for dewatering. Requires relatively large area and long timeframe for dewatering, particularly for sediments dredged hydraulically.	Low	Uncertain	Retained for further evaluation.
Particle Size Segregation	Separation of particles in the excavated sediment by size, allowing separate disposal of fine-grained material with higher contaminant concentrations.	High. Would provide separate size fractions, and could prepare sediments for use as cover material, either onsite or offsite.	High, once sediment is excavated and bench or pilot tests are performed.	Moderate	Favorable	Retained for further evaluation.
Sediment Washing	Separation of small particles, which preferentially accumulate PCBs and PAHs, from the excavated sediment, in an aqueous system, allowing separate disposal of the fine-grained material with higher contaminant concentrations.	Low-Moderate. Would likely be difficult to separate enough contaminated material such that the remaining material is below site cleanup levels and appropriate for alternative disposal options.	Moderate, once sediment is excavated. Would require treatability testing, and specialized equipment.	High, associated largely with the specialized equipment and utility usage during washing.	Uncertain	Not retained for further evaluation, because of uncertain effectiveness, challenges to implementation, and relatively high cost.
Vitrification	Heating of excavated and dewatered sediments to a temperature sufficient to transform them to a glass state, and destroy contaminants.	High. Would destroy contaminant mass in excavated sediments.	Low. Requires dewatering of sediments. A specialized facility, with systems for collection and treatment of offgas, is required for vitrifying PCB-contaminated sediments.	High, associated with the cost of dewatering and vitrification.	Uncertain	Not retained for further evaluation, because of low implementability and high cost.
Disposal Options						
Offsite Disposal	Disposal of removed (excavated or dredged) sediments at an offsite facility. Sediments with PCB concentrations less than 50 mg/kg would be transferred to a facility approved for non-TSCA, PCB-contaminated sediments. Sediments with PCB concentrations greater than 50 mg/kg would be transferred to a TSCA-approved facility for permanent disposal.	High. Would permanently remove contaminant mass from the site.	High. Facilities for disposal of non-TSCA sediments are available in the Milwaukee area. TSCA materials could be transferred to out-of-state, regional facilities.	Moderate-High, associated with transportation and disposal fees, particularly for TSCA materials.	Favorable	Retained for further evaluation.

TABLE 3-1. REMEDIAL TECHNOLOGY SCREENING SUMMARY

Technology	Description	Effectiveness	Implementability	Relative Cost	Public Acceptance	Screening Comment
Onsite Disposal	Disposal of removed (excavated or dredged) sediment in an onsite confined disposal facility. If sited in a location of contaminated sediments, those sediments would not require removal and transport. Non-TSCA sediments from other areas of the site could be disposed in the facility. Any TSCA sediments removed from their current location would likely require offsite disposal.	Moderate. Would permanently contain contaminants in a landfill onsite, but onsite disposal of excavated or dredged TSCA materials would likely not be allowed. The facility would be designed to prevent any releases of contaminants, and would be monitored to ensure that contaminants remain contained.	Low-Moderate. Would require siting, permitting, construction, and monitoring of an onsite confined disposal facility. May be difficult to obtain approval, due to stakeholder concerns regarding contaminated sediments left onsite. Would decrease the requirements for transport of sediments to an offsite facility.	Moderate, associated with construction and monitoring of the facility. Expected to be less expensive than offsite disposal, due to savings on transportation and disposal fees.	Unfavorable.	Not retained for further evaluation, because contaminated sediments would remain onsite.
***In Situ* Treatment and Innovative Technologies**						
Sediment Stabilization	Addition of amendments that physically and/or chemically contain the contaminants in-place.	Moderate. Would decrease contaminant mobility and exposure, and could support removal of fish and wildlife consumption advisories and BUIs for degradation of fish and wildlife populations and restrictions on downstream dredging activities. Would not support removal of the BUIs for degradation of benthos, as it would create a solid mass of sediment left in-place.	Low. Would require dewatering of sediments prior to addition of amendments. Would likely also require use restrictions to prevent disturbance of the solidified sediments.	High, associated with amendment materials and infrastructure for dewatering and mixing.	Uncertain, but likely unfavorable due to contaminants left in-place and resulting use restrictions.	Not retained for further evaluation, due to low implementability and high cost.
Contaminant Fixation	Addition of activated carbon or similar sorbent to the sediment surface, where it can be mixed into contaminated sediments by bioturbation. The activated carbon would then absorb PCBs or PAHs, decreasing their bioavailability.	Low. Would decrease bioavailability in limited areas, and therefore could support removal of fish and wildlife consumption advisories and BUIs for degradation of benthos and degradation of fish and wildlife populations. However, this technology would require a longer timeframe for initial effectiveness, due to time needed for mixing. Because long-term stability of contaminants sequestered on sorbents is unknown and because some bioavailable PCBs and PAHs would remain in surface sediments, this technology may not significantly accelerate BUI removal relative to natural recovery. Would not prevent downstream transport of contaminants.	Moderate. Requires import of the sorbent material, placement in water, and periodic monitoring.	Moderate, associated primarily with capital investment.	Uncertain	Not retained for further evaluation, due to low expected effectiveness.
Innovative Technologies	Includes the following technologies, which are currently under development as remedial options for treatment of PCBs: phytoremediation using plants to uptake PCBs, bioremediation using addition of zero-valent iron or other amendments to sediments to promote biodegradation, and thermal treatment of sediments to degrade contaminants.	Unknown/Low. These technologies have been assessed using bench scale tests and/or pilot studies, but their effectiveness in the field has not been sufficiently demonstrated to allow estimation of their efficiency for destroying PCBs or PAHs in the Phase II area.	Unknown, due to the lack of full-scale implementation at other sites to provide comparison. Likely not highly implementable, due to limited availability of required materials and technology.	Unknown, likely high due to use of specialized materials and technologies and lack of widespread implementation.	Uncertain	Not retained for further evaluation, because the technologies are still in development, with unproven effectiveness and implementability, and likely high costs.
Supporting Technologies						
Institutional Controls	Signs are currently in place to warn the public about both fish consumption and contact with sediments. Use restrictions could be required for implementation of certain remedial technologies.	Moderate. In the case of advisories, effectiveness depends on communication and public response to advisories. In the case of restrictions preventing sediment disturbance, likely effective in preventing organized human disturbances (e.g., dredging).	High. Already implemented at the site, and additional controls could be implemented with agreement from stakeholders.	Low, associated primarily with organization and communication.	Moderate.	Not retained for further evaluation.

NOTES:
BUI = Beneficial use impairment
PAH = Polycyclic Aromatic Hydrocarbons
PCB = Polychlorinated biphenyl
TSCA = Toxic Substances Control Act

TABLE 4-1. REMEDIAL ALTERNATIVES SUMMARY

Technology	Retained in Screening?	Remedial Alternative						
		1) No Action	2) Dry Excavation	2a) Dry Excavation with Particle Size Segregation	3) Hydraulic Dredging	3a) Hydraulic Dredging with Particle Size Segregation	4) Mixed Technology	4a) Mixed Technology with Particle Size Segregation
No Action								
None	NA	X						
Monitored or Enhanced Natural Recovery								
Monitored Natural Recovery	No							
Containment								
Isolation Cap	No							
Reactive Cap	No							
Sediment Removal and Related Technologies								
Sediment Removal Technologies								
Dry Excavation	Yes		X	X			X	X
Hydraulic Dredge	Yes				X	X	X	X
Mechanical Dredge	No							
Residual Management								
Residual Cover	Yes				X	X	X	X
Sediment Handling and *Ex Situ* Treatment Technologies								
Passive Dewatering - Settling Pond	Yes		X	X			X	X
Passive Dewatering - Geotubes	Yes				X	X		
Stabilization/Chemical Dewatering	Yes		X	X			X	X
Particle Size Segregation	Yes			X		X		X
Sediment Washing	No							
Vitrification	No							
Disposal Options								
Offsite Disposal	Yes		X	X	X	X	X	X
Onsite Disposal	No							
***In Situ* Treatment and Innovative Technologies**								
Sediment Stabilization	No							
Contaminant Fixation	No							
Innovative Technologies	No							
Supporting Technologies								
Institutional Controls	No							

TABLE 5-1. RESTORATION OPTION SCREENING SUMMARY

Restoration Option	Description	Effectiveness	Implementability	Relative Cost	Public Acceptance	Screening Comment
Benthic/ Substrate Restoration	Restoration of the river bottom substrate and benthic habitat by replacement of removed sediments with a suitable benthic habitat bed. The substrate mix is chosen to match the sizes and geologic materials of the native sands and gravels of the river. Woody debris structures may also be added.	High. Placed and sized correctly, benthic substrate restoration is an effective restoration alternative and removes much of the uncertainty and instability associated with sediment disturbance during remediation.	High, in combination with sediment removal or sediment cover.	Moderate.	Favorable.	Retained for further evaluation.
Flow Regime Restoration	Restoration of the flow regime following remedial activities by re-sizing the channel bed and banks to allow stable flow regimes, or restoring the river bottom to pre-existing grades.	High, when combined with remedial actions and effectively designed to create the desired flow patterns.	Moderate, in combination with sediment removal or sediment cover. Can be combined with residual cover. Less implementable with remedial actions, such as isolation capping, that create channel obstructions.	Moderate.	Favorable.	Retained for further evaluation.
Bank, Riparian, and Upland Restoration	The river bank restoration can be paired with remedial technologies, to improve bank stability, decrease erosion potential, and improve habitat quality. The restoration can include grading the banks to appropriate stable angles, and planting riparian vegetation.	High, when combined with flow regime restoration. Most effective if disturbance of the bank is prevented.	Moderate, in combination with remedial actions. Restoration is likely required following bank disturbance that may result from remedial activities.	Low.	Favorable.	Retained for further evaluation.

TABLE 8-1: REMEDIAL ALTERNATIVES EVALUATION SUMMARY

	Threshold Criteria		Balancing Criteria								Modifying Criteria		
Alternative	Compliance with Permits and Applicable Regulatory Requirements		Long-Term Effectiveness in Protecting Human Health and the Environment and Achieving RAOs		Short-Term Effectiveness in Protecting Human Health and the Environment		Engineering Implementability, Reliability, Constructability, and Technical Feasibility		Cost		Stakeholder and Community Acceptance		Summary Rating
	Rating	Rationale	Rating	Rationale	Rating	Rationale	Rating	Rationale	Rating	Estimate	Rating	Rationale	
Alternative 1: No Action	3 No Requirements		0 Worst	Would not offer additional protectiveness relative to current conditions, would not prevent downstream transport of contaminants, and would not support removal of BUIs.	1 Low	Would not create short-term impacts to human health or the environment, but would not address current risks in the short-term or the long-term.	3 High	No action would be highly implementable from a logistical and technical perspective.	3 Lowest Cost	$0	1 Worst	Not acceptable because does not achieve RAOs	11
Alternative 2: Dry Excavation and Disposal	3 Meets Criteria	Required permits would be obtained and remedial activities performed in compliance with their requirements, which are expected to be similar to those for dry excavation in the Phase I area.	3 High	Dry excavation with offsite disposal is expected to be the most effective technology for complete removal of sediments exceeding cleanup goals.	2 Moderate	Short-term risks to human health and the environment are similar for all sediment removal alternatives, and would be mitigated using PPE, site controls, and restoration activities following completion of the remedial action.	3 High	Highly implementable in the shallow water environment of the Phase II area. Would produce the smallest volume of material for offsite disposal and involve faster and easier dewatering and water treatment.	2 Moderate Cost	$14,328,000	3 High	Acceptable; public comments indicate support for an approach similar to the Phase I remediation.	16
Alternative 2a: Dry Excavation and Disposal with Particle Size Segregation	3 Meets Criteria	Required permits would be obtained and remedial activities performed in compliance with their requirements. Requirements are expected to be similar to those for dry excavation in the Phase I area.	3 High	See rationale for high effectiveness of Alternative 2a. Particle size segregation would not affect long-term protectiveness.	2 Moderate	Short-term risks to human health and the environment are similar for all sediment removal alternatives, and would be mitigated using PPE, site controls, and restoration activities following completion of the remedial action.	2 Moderate	Although dry excavation is highly implementable in the shallow water environment of the Phase II area, the implementability and efficiency of particle size segregation is undetermined due to a high proportion of fine sediments.	2 Moderate Cost	$14,600,000	3 High	Acceptable; public comments indicate support for an approach similar to the Phase I remediation.	15
Alternative 3: Hydraulic Dredging and Disposal	3 Meets Criteria	Required permits would be obtained and remedial activities performed in compliance with their requirements.	2 Moderate	Hydraulic dredging and offsite disposal would be generally effective, but with limited efficiency for removing material overlying hard surfaces, and tendency for suspension and redeposition of contaminated material.	2 Moderate	Short-term risks to human health and the environment are similar for all sediment removal alternatives, and would be mitigated using PPE, site controls, and restoration activities following completion of the remedial action.	2 Moderate	Generally implementable, but would produce larger volumes of sediment for disposal, and larger amounts of water to be removed and treated. Dredge is also likely to encounter problems with debris behind the dam.	1 High Cost	$17,323,000	2 Moderate	Acceptable; potential concerns regarding temporary dam and possible residual cover.	12

TABLE 8-1: REMEDIAL ALTERNATIVES EVALUATION SUMMARY

Alternative	Threshold Criteria: Compliance with Permits and Applicable Regulatory Requirements		Balancing Criteria: Long-Term Effectiveness in Protecting Human Health and the Environment and Achieving RAOs		Balancing Criteria: Short-Term Effectiveness in Protecting Human Health and the Environment		Balancing Criteria: Engineering Implementability, Reliability, Constructability, and Technical Feasibility		Balancing Criteria: Cost		Modifying Criteria: Stakeholder and Community Acceptance		Summary Rating
	Rating	Rationale	Rating	Rationale	Rating	Rationale	Rating	Rationale	Rating	Estimate	Rating	Rationale	
Alternative 3a: Hydraulic Dredging and Disposal with Particle Size Segregation	3 Meets Criteria	Required permits would be obtained and remedial activities performed in compliance with their requirements.	2 Moderate	See rationale for high effectiveness of Alternative 2b. Particle size segregation would not affect long-term protectiveness.	2 Moderate	Short-term risks to human health and the environment are similar for all sediment removal alternatives, and would be mitigated using PPE, site controls, and restoration activities following completion of the remedial action.	1 Low	The implementability of hydraulic dredging is limited by the factors outlined for Alternative 2b, and the implementability and efficiency of particle size segregation is undetermined due to a high proportion of fine sediments.	1 High Cost	$17,941,000	2 Moderate	Acceptable; potential concerns regarding temporary dam and possible residual cover.	11
Alternative 4: Dry Excavation, Hydraulic Dredging, and Disposal	3 Meets Criteria	Required permits would be obtained and remedial activities performed in compliance with their requirements.	3 High	Dredging of small volumes of sediment with a vacuum truck would not make this alternative significantly less effective than Alternative 2a.	2 Moderate	Short-term risks to human health and the environment are similar for all sediment removal alternatives, and would be mitigated using PPE, site controls, and restoration activities following completion of the remedial action.	3 High	Dredging of small volumes of sediment with a vacuum truck would not make this alternative significantly less implementable than Alternative 2a.	2 Low Cost	$13,427,000	3 High	Acceptable, based on public input received.	16
Alternative 4a: Dry Excavation, Hydraulic Dredging, and Disposal with Particle Size Segregation	3 Meets Criteria	Required permits would be obtained and remedial activities performed in compliance with their requirements.	3 High	See rationale for high effectiveness of Alternative 2c. Particle size segregation would not affect long-term protectiveness.	2 Moderate	Short-term risks to human health and the environment are similar for all sediment removal alternatives, and would be mitigated using PPE, site controls, and restoration activities following completion of the remedial action.	2 Moderate	Dry excavation is highly implementable, and the implementability and efficiency of particle size segregation is undetermined due to a high proportion of fine sediments. Dredging of a small volume of sediments using a vacuum truck would only slightly decrease implementability, due to the factors outlined under Alternative 2b.	2 Low Cost	$13,684,000	3 High	Acceptable, based on public input received.	15

Note: Ratings are relative and intended to facilitate comparison of alternatives. 1 = worst; 3 = best.