AECOM

Remedial Alternatives Screening Evaluation

C Street Slip

Prepared for:
Wisconsin Department of Natural Resources
USEPA GLRI Grant No. GL-00E03068

Project reference: WDNR Superior Slips RAOR
Wisconsin Contract/PO Number 37000-0000021216
BRRTS# 11-16-591446
AECOM Project number: 60685299

Revision: 0

June 28, 2023

Delivering a better world

Quality information

Prepared by	Checked by	Verified by	Approved by
Brian Mastin, Ph.D. Senior Technical Coordinator	Kasia Dick Geologist	Brian Mastin, Ph.D. Senior Technical Coordinator	Kim Elias Project Manager

Revision History

Revision	Revision date	Details	Authorized	Name	Position
0	12/13/2022	Draft	Yes	Kim Elias	Proj. Manager
0	6/20/2023	Response to Comments	Yes	Kim Elias	Proj. Manager
0	6/28/2023	Final	Yes	Kim Elias	Proj. Manager

Distribution List

# Hard Copies	PDF Required	Association / Company Name
None	Yes	WDNR

Prepared for:

Wisconsin Department of Natural Resources

Prepared by:

AECOM
1555 N. RiverCenter Drive
Suite 214
Milwaukee, WI 53212

T: +1-414-944-6080
aecom.com

Table of Contents

Figures

Tables

Appendices

Glossary of Acronyms

µg/kg	micrograms per kilogram
3D	three-dimensional
95% UCL	95 percent upper confidence limit of the arithmetic mean
AECOM	AECOM Technical Services, Inc.
ARAR	Applicable, Relevant, and Appropriate Requirements
ASTM	ASTM International
BCC	bioaccumulative chemicals of concern
BMP	Best Management Practices
BRRTS	Bureau for Remediation and Redevelopment Tracking System
BTV	Background Threshold Value
BUI	beneficial use impairments
CDF	confined disposal facilities
COC	constituent of concern
COEC	Chemicals of ecological concern
CSM	Conceptual Site Model
CSTP2	combined sewer treatment plant #2
CY	cubic yards
d	day
DC	direct contact
EMNR	enhanced monitored natural recovery
ERA	Ecological Risk Assessment
EVS	Earth Volumetric Studio, cTech Software version 2022.10.2
ft	feet
Foth	Foth Infrastructure & Environmental, LLC
gal	[United States] gallons
GIK	Geologic Indicator Kriging
GIS	Geographical Information System
GLLA	Great Lakes Legacy Act
GLRI	Great Lakes Restoration Initiative
GLWQA	Great Lakes Water Quality Agreement
GPS	Geographic Positioning System
h	hours
H&H	hydrologic and hydraulic
HDPE	high-density polyethylene
HHRA	Human Health Risk Assessment
HQ	hazard quotient
IC	institutional controls
ISS	in-situ solidification and stabilization
ITRC	Interstate Technology & Regulatory Council’s
lb	[United States] pound
L	liter
lf	linear feet

MEC	Midpoint Effect Concentration
mg	milligrams
MGP	Manufactured gas plant
mL	milliliters
MPCA	Minnesota Pollution Control Agency
NAPL	non-aqueous phase liquid
NOAA	National Oceanic and Atmospheric Administration
NTE	not-to-exceed
O&M	operations and maintenance
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyls
PEC	Probable Effect Concentration
PFT	paint filter test
PID	photoionization detector
ppm	parts per million
PRG	preliminary remediation goal
RAO	remedial action objective
RAOR	Remedial Action Options Report
RAP	Remedial Action Plan
RCL	Residual Contaminant Level
RFP	request for proposal
RR	Remediation and Redevelopment Program
s/s	solidification/stabilization
Slip	C Street Slip
SLRAOC	St. Louis River Area of Concern
SMA	sediment management area
SOW	scope of work
SPLP	Synthetic Precipitation Leaching Procedure
SQG	Sediment Quality Guidelines
SVOC	semi-volatile organic compound
SWL&P	Superior Water Light & Power
TCLP	Toxicity Characteristic Leaching Procedure
TEC	Threshold Effect Concentration
TIN	triangulated irregular network
TOC	total organic carbon
TPAH	total polycyclic aromatic hydrocarbon
UCS	unconfined compressive strength
USEPA	United States Environmental Protection Agency
VOC	volatile organic compound
WDNR	Wisconsin Department of Natural Resources
WWTP	Wastewater Treatment Plant

1. Introduction

AECOM Technical Services, Inc. (AECOM) prepared this Remedial Alternatives Screening Evaluation of the C Street Slip (Slip) in accordance with remedial option evaluation guidelines provided in the Wisconsin Department of Natural Resources' (WDNR) request for proposal (RFP) and Scope of Work (WDNR RFP and SOW) (WDNR, 2022), the Wisconsin Administrative Code (Wis. Admin. Code) Department of Natural Resources Chapter NR 722, Standards for Selecting Remedial Options, the Contaminated Sediment Remediation Guidance for Hazardous Waste Sites (United States Environmental Protection Agency [USEPA], 2005), and the Interstate Technology & Regulatory Council's (ITRC) Guidance Document on Remedy Selection for Contaminated Sediments (ITRC, 2014). This report was prepared for the WDNR under a USEPA Great Lakes Restoration Initiative (GLRI) grant (USEPA GLRI Grant No. GL-00E03068), which includes a 35% nonfederal cost share from WDNR. Remedial alternatives were defined, screened, and selected to address impacted sediment within four project sites (i.e., C Street Slip, Tower Avenue Slip, General Mills Slip, and Oil Barge Dock Slip) within the St. Louis River Area of Concern (SLRAOC) in Superior, Wisconsin. This report focuses on the identification and screening results of potential remedial alternatives for the C Street Slip (**Figure 1-1**). Remedial alternatives screened for the other project sites are summarized in subsequent reports as detailed in the WDNR RFP and SOW.

Site investigation and remediation of the C Street Slip are regulated under Chapters NR 700-799 (collectively referred to as the "NR 700 series" or "NR 700 process") of the Wis. Admin. Code administered by the Remediation and Redevelopment (RR) Program of the WDNR. Potential remedial options were screened based on site-specific conditions, and only those design alternatives that are most likely to be effective were selected as viable options to achieve the remedial action goals and remove beneficial use impairments for the SLRAOC. A weighted consideration was given to those remedial action options that were expected to meet the remedial performance goals of the project, that consider long-term funding criteria and provide options that maintain DNR funding eligibility requirements outlined in Wis. Admin. Code paragraph NR 722.05(2)(c) and Wisconsin Statute section 281.87.

Potential remedial alternatives were screened based on technical, economic, and regulatory feasibility, and other site conditions to address total polynuclear aromatic hydrocarbons[1] (tPAHs) and mercury present in sediment within the C Street Slip above preliminary remediation goals (PRGs). As part of this evaluation, remedial alternatives were screened based on effectiveness and restoration time frame, implementability, and cost. Remedial alternatives retained based on the screening evaluation will be evaluated in a detailed evaluation to be presented in a subsequent report for the C Street Slip. Results of the detailed evaluation will serve as the basis for the selection of the preferred remedy to be documented in a future Remedial Action Options Report (RAOR) for the C Street Slip (to be developed by others).

2. Site Background

2.1 Site Description and Historical Use

The Slip is located in the City of Superior, Douglas County, on the Wisconsin side of the St. Louis River near the confluence with Lake Superior. It is located along the right descending bank of the federal navigation channel in Superior Bay adjacent to the City of Superior Wastewater Treatment Plant (WWTP) and the Former Superior Water Light & Power (SWL&P) Manufactured Gas Plant (MGP) along the St. Louis River in Superior, Wisconsin. The Slip is approximately 1,200-feet (ft) long and 175 to 200-ft wide. The west side of the Slip is maintained, as well as dredged for navigation for deep draft bulk cargo vessels, while the east side contains the toe of the berm for the combined sewer treatment plant #2 (CSTP2) located at the Superior WWTP. Present uses include the WWTP, lime and cement production,

[1] Total PAHs (18 tPAHs): 2-methylnaphthalene, acenaphthene, acenaphthylene, anthracene, benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(e)pyrene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, fluoranthene, fluorene, indeno(1,2,3-Cd)pyrene, naphthalene, phenanthrene, and pyrene

and bulk material handling and storage (coal and limestone). The Slip has two municipal outfalls: a stormwater outfall and an overflow from CSTP2. **Figure 2-1** presents the current Slip layout and surrounding properties.

The Slip has been impacted by industrial and maritime activities since the late 1800s. Various aliases have been used for the Slip in documents such as the SWL&P MGP Slip, Graymont-LaFarge Boat Slip, WWTP Slip, Gas Plant, and Cutler-LaLibert-McDougall Slip. WDNR has chosen the name “C Street Slip” based on 1894 and 1952 maps which depicted a street located near the middle of the slip (WDNR, 2022).

The area has historically included a lumber mill, coal dock, MGP, shipyard, and bulk petroleum storage facilities. SWL&P is the responsible party for contamination associated with the former MGP according to Bureau for Remediation and Redevelopment Tracking System (BRRTS) Case #02-16-275446. SWL&P and USEPA have an existing Great Lakes Legacy Act (GLLA) project agreement to conduct feasibility and design for the MGP-impacted sediment at the head of the Slip. SWL&P hired Foth Infrastructure & Environmental, LLC (Foth) as its consultant for feasibility and remedial design for upland source control and adjacent sediment impacts. The upland site, which was a part of the former MGP southwest of the Slip, has had extensive site investigations and remedial actions.

2.2 Site Investigations and Remedial Actions

Site assessments, investigations and remedial actions at the C Street Slip conducted from 1993 through 2022 are summarized herein and discussed in detail in the *C Street Slip Historical Data Review Technical Memorandum* (AECOM, 2022b).

Generally, sediment data collected from the Slip has been compared to Wisconsin’s Consensus-Based Sediment Quality Guidelines (SQG) Threshold Effect Concentration (TEC), Midpoint Effect Concentration (MEC), and Probable Effect Concentration (PEC) to assess potential ecological effects. Sample results were also compared to Chapter NR 720 of the Wis. Admin. Code soil cleanup standards default for non-industrial and industrial direct contact (DC) not-to-exceed (NTE) residual contaminant levels (RCLs) to assess direct contact risk for human health, namely industrial and recreational use and soil-to-groundwater RCLs to evaluate restrictions for disposal of dredged material in an upland setting, which includes direct contact and soil to groundwater levels. These comparisons to the RCLs help identify additional requirements, such as cost for dredged material management based on contamination levels and applicability of the Beneficial Use Impairment (BUI) for restrictions on dredging activity. Additionally, samples were compared to the 2022 SLRAOC specific background values. Site assessments and investigations that have been conducted to date at the C Street Slip are summarized in the following sections.

1997 Sediment Assessment of Hotspot Areas in the Duluth/Superior Harbor

Minnesota Pollution Control Agency (MPCA, 1997) performed a general desktop assessment of the SLRAOC in 1994 to identify hotspot areas, which included an area adjacent to the City of Superior WWTP. An in-depth sediment investigation also occurred in 1994 that included an assessment of sediment contamination, toxicity and benthic community assessment.

Two sediment sample locations assessed during this investigation pertain to C Street Slip (STP-1 and STP-2). Sediment cores were advanced to a maximum of 1.5 feet below the sediment-water interface. Observations noted a slight oil sheen in the recovered material at STP-1 and a “strong sulfide odor with oil” in the recovered material for STP-2. These two samples were analyzed for polychlorinated biphenyls (PCBs), mercury, ammonia, total organic carbon (TOC), and particle size. The MPCA noted in this report that the Duluth portion of the harbor was generally more contaminated than the Superior portion of the harbor and that the area adjacent to the City of Superior WWTP outfall was listed as medium priority.

2001 Preliminary Evaluation of the Sediment Sampling Results from the Superior Harbor Inlet Potentially impacted by the Former Operations of the Superior Manufactured Gas Plant

WDNR collected sediment samples from the C Street Slip in 2000 to assess the potential migration of contamination from the MGP site though a four-foot storm sewer that outfalls into the Slip (WDNR, 2001).

Six sediment sample locations (SPG-1 through SPG-6) were assessed during this investigation to a maximum of 1.95 feet below the sediment-water interface and analyzed for 8 metals and 19 PAHs.

The WDNR concluded that results of the 2000 investigation suggested a “no to minimal exposure risk” to benthic organisms on an individual metal basis for all metals except mercury. Mercury concentrations exhibited a “moderate to high exposure risk” to benthic organisms. WDNR also concluded that the synergistic effect of metals on the benthic organisms had a “low to moderate” exposure risk and the synergistic effect of PAHs had a moderate to high exposure risk. Concentrations of metals were generally higher in the deeper horizons of the cores compared to surface sediments; concentrations of lead, mercury and zinc were consistently greater in deeper horizons at all sample locations; the highest concentrations of arsenic, chromium and copper were detected at the two sample locations closest to the head of the Slip (SPG-1 and SPG-3); and the highest mercury concentrations were detected at the mouth of the Slip (SPG-4 and SPG-6).

2004 Sediment Investigation Report Former Manufactured Gas Plant Superior, Wisconsin

On behalf of the SWL&P, ENSR collected sediment samples from three locations (SD1 through SD3) within the C Street Slip, one sediment sample from the storm sewer at the point of discharge into C Street Slip (SS-Outfall), and one composite storm sewer sediment sample from a location upstream of the SWL&P site (SS-Upstream) (ENSR, 2004). The sediment samples within the C Street Slip were collected to a maximum depth of two feet below the sediment-water interface. The purpose of the investigation was to collect samples for PAHs and perform fingerprint analysis to determine if the MGP site was a potential source of PAHs measured in the sediments at the head of C Street Slip.

Sediment cores were collected from below the ice that had formed over the Slip. The ice was approximately 2.5 feet thick and black flecks of coal-like material were observed throughout the ice. The sediment-water interface ranged from approximately 2.5 to 4-feet below the top of the ice. Analytical results indicated tPAH concentrations were substantially lower than those detected in the previous investigation performed by WDNR during the 2000 investigation. ENSR concluded from the fingerprint analysis that the source of the PAHs could be from typical urban runoff and there was insufficient data to definitively characterize the source of the PAHs.

2010 Sediment Investigation Results, Former MGP Site, Superior, Wisconsin

AECOM (2010) collected sediment samples from four locations (SedB-1 through SedB-4) within the C Street Slip and advanced the cores to the underlying clay deposits. The depth from the top of the ice to the sediment-water interface ranged from three feet to 17-feet. The clay deposits ranged from 11 to 24-feet below the top of sediment.

A photoionization detector (PID) was used to measure organic vapors of the sediment cores. Elevated PID readings were not encountered. A slight petroleum odor was noted in the surficial samples collected at location SedB4. No oil or tar-like material was observed. Additionally, no sheen, or obvious waste materials of any kind were observed in sediment cores. Based on the analytical results of the samples collected, AECOM concluded that there were no MGP-derived constituents detected in the C Street Slip sediments and that the hydrocarbons detected were likely derived from vessels operating in the Slip, discharge from the WWTP, and/or storm sewer discharges.

2016 Site Characterization Report Assessment of Contaminated Sediments Superior Waterfront Characterization, St. Louis River and Bay Area of Concern, Superior Wisconsin

The primary objective of this field investigation performed by EA (2016) was to obtain data necessary to assess the sediment quality in the Superior Waterfront area and to “evaluate the priority of each area for further assessment or remediation.” Sampling took place from 10 sediment sampling locations (SW15-SB04 through SW15-SB11, SW15-SB14, and SW15-SB17) within the C Street Slip.

Sediment sample depths ranged from 0 to 8-feet below the sediment-water interface. Locations SW15-SB04, SW15-SB05, SW15-SB06 SW15-SB07, and SW15-SB11 exceeded the respective PEC for PAHs, volatile organic compounds (VOCs), SVOCs, and metals. Additionally, the toxicity testing conducted at location SW15SB04 (28-d *Hyalella azteca* and 10-d *Chironomus riparius* bioassays) indicated an adverse effect on *C. riparius*.

2017 Supplemental Site Investigation Report for the Former Manufactured Gas Plant

Summit (2017) summarized an additional subsurface investigation completed at the MGP site in 2016 to 2017. The primary objectives of the investigation included:

- Delineating the extent of tarry source materials near C Street Slip, including determining if remedial actions are necessary to prevent future migration of contaminants into the C Street Slip sediments and water from sources related to the SWL&P MGP;
- Delineating the extent of PAHs, metals, and VOCs in the C Street Slip sediments;
- Determining if a deeper aquifer system is present and assessing groundwater for PAH and VOC contamination;
- Delineating PAH and VOC concentrations in soil adjacent to monitoring wells MW3 and MW4; and
- Investigating vapor intrusion.

Sediment sampling took place at 25 core locations (S1 through S25) in 2016 within the C Street Slip utilizing a barge-mounted Geoprobe rig. Summit measured metals and PAHs in the sediment samples, but VOC detections were infrequent. They also added that concentrations of constituents of concern (COCs) exceeding sediment quality guidelines were contained to sediment deposited above the red clay layer and that the red clay layer created a sharp delineation of sediment contamination.

2019 Site Investigation Report, Former Manufactured Gas Plant

This report includes a summary of previous investigations that have occurred regarding the SWL&P MGP site and historical use (Foth, 2019). No new data was collected or presented in this report and Foth requested approval to proceed with preparation of a RAOR.

2021 Pre-Design Investigation Results

Foth completed an additional investigation in 2020 to fill data gaps and collect additional data to support the development of viable remedial alternatives for MGP-impacted sediments. Specific data gaps were not referenced in this document. Of the samples analyzed for PAHs, 48 samples exceeded the TEC of 1.6 mg/kg, 25 samples exceeded the MEC of 12.205 mg/kg, and 18 samples exceeded the PEC of 68.4 mg/kg. The highest tPAH concentration of 251 mg/kg was detected in sediment sample MGP-C-1 within the 1 to 2 feet interval below mudline (Foth, 2022a). The greatest single PAH concentration of 45.1 mg/kg phenanthrene was detected at sediment core location MGP-C-1 within the 1 to 2 feet interval below mudline. The deepest sediment interval with a tPAH MEC exceedance occurred at location MGP-C-1 in the 11 to 12-feet below mudline interval. PAH impacts were not measured in the Miller Creek Formation.

2022 C Street Slip Site Investigation

The purpose of the 2022 site investigation by AECOM was to delineate the nature and extent of mercury and PAHs across the entire C Street Slip area and to delineate VOCs at the head of the Slip. Additionally, a limited geotechnical investigation was conducted at the Slip for inclusion in site stability evaluations. Sediment samples were also collected for a treatability study to evaluate efficacy of potential ex situ sediment management alternatives and refine full-scale design assumptions including process flow and mass balance calculations. Tables, figures, and appendices of the *C Street Slip Remedial Investigation Report* present the geotechnical and treatability results, comparisons to human health assessment thresholds, and ecological assessment thresholds (AECOM, 2023b).

3. Conceptual Site Model

A Conceptual Site Model (CSM) generally includes information on known contaminant sources and impacted media, potential other sources, transport pathways, exposure pathways, and receptors. A preliminary CSM of the C Street Slip was largely obtained from the *Draft Remedial Action Options Report – Sediment Area Former Manufactured Gas Plant, St. Louis River Area of Concern (*Foth, 2022b*)* (referred to as the 2022 Draft RAOR*)*, which describes a CSM that includes the head of the C Street Slip and surrounding upland site. The following description of the CSM has been updated, as necessary, as additional information has been reviewed. A depiction of the CSM for the Slip is presented on **Figures 3-1 and 3-2** as described in the *C Street Slip Remedial Investigation Report* (AECOM, 2023b).

3.1 Physical Site Characteristics

Regional Geology consists of surficial Quaternary glacial deposits overlying bedrock. Quaternary deposits consist primarily of red clay with minor discontinuous silt and sand lenses approximately 200 feet thick. The deposits are associated with the Lake Superior lobe of Late Wisconsinian glaciation. Local bedrock consists of Mesoproterozoic rocks of the Keewanawan Supergroup, consisting of the Hinkley and Fond du Lac formations. The bedrock is sandstone and feldspathic sandstone (ET, 1999).

Subsurface conditions at the C Street Slip have been substantially reworked by dredging activities over the course of the industrial development near the Slip. According to recent intrusive site investigations, the Slip consists of 5 to 20 feet of sediment overlying the “red clay”, formally known as the Douglas Member of the Miller Creek Formation. The Miller Creek Formation overlies the Copper Falls Formation, which consists of fluvial sand and gravel, and till with a highly variable amount of sand, silt, and clay and a few pebbles and boulders (Foth, 2019). According to the Bedrock Geology of Wisconsin map, the bedrock at the site consists of the Keweenawan sandstone, which is a part of the Orienta Formation, approximately 100-300 feet below the unconsolidated material (WGNHS, 1982).

Site Hydrogeology consists of localized water bearing silt and sand lenses occasionally utilized as an aquifer for industrial purposes. Bedrock aquifers include the Hinkley and Fond du Lac formations, which are utilized as a water supply source (EA, 2021). Monitoring wells from past site investigation reports around the Slip portray the near-surface groundwater flow towards the Slip/Superior Bay. The Miller Creek Formation has a low hydraulic conductivity (10-6 centimeters per second or less) and would be expected to provide a confining boundary for vertical migration in the surficial aquifer (Foth, 2019). The National Oceanic and Atmospheric Administration (NOAA) Gauge Station (9099064 in Duluth, MN) located 3.3 miles northwest up Superior Bay has recorded average surface water levels around 602 feet above msl (NOAA, 2022). The water levels at the Slip vary slightly due to seasonal changes in the region, and the Slip does ice over during the winter. The low water datum stage is 601.45 feet above msl.

A **bathymetric survey** of C Street Slip was performed by AECOM following Standard Operating Procedure SS-03 Single-Beam Bathymetric Surveying (AECOM, 2022a). Manual survey poling provided ground elevations where water depths did not allow for survey collection. HYPACK hydrographic software was used to represent the survey output in XYZ and geographical information system (GIS) triangulated irregular network (TIN) formats as detailed in the *Supplemental Site Investigation Report; Survey Memo* (AECOM, 2023a).

A sediment thickness survey was performed using sub-bottom profiling (echo-sounder) of the project area following SOP SS-04 Sub-bottom Profiling in Shallow Water Conditions (AECOM, 2022a). Sounding pole methods were used to obtain elevations of the water and sediment surface and repeated at numerous designated locations to establish sufficient project data.

3.2 Potential Sources of Contamination

The C Street Slip has been impacted historically by maritime and industrial activities. SWL&P is an identified responsible party for contamination associated with the former MGP, according to BRRTS Case #02-16-275446. Current uses at the C Street Slip include a WWTP, lime and cement production, and bulk material handling and storage of coal and limestone. Additionally, the Slip has two municipal outfalls: a stormwater outfall and an overflow from CSTP2. Sediment within the Slip contains elevated PAH concentrations, dibenzofuran, VOCs, metals, and PCBs. WDNR and other parties have documented the presence of sediment toxicity, bioaccumulation of mercury, an impaired benthic macroinvertebrate community, and previous restrictions on the disposal of material dredged from the Slip.

3.3 Impacted Media and Transport Pathways

Sediments are the primary media of concern in the C Street Slip, as well as the potential groundwater to surface water pathway via sediment. Potential contaminant transport pathways to sediments include (Foth, 2022b):

- **Groundwater:** Dissolved phase plumes of contaminants in upland groundwater have the potential to migrate into the Slip either directly or via preferential flow paths (e.g., permeable base materials or fill along the sewer and storm sewer conveyance systems and/or historic channels) and impact surface sediment contaminant concentrations within the Slip. The migration of contaminants within the groundwater to the surface sediment is driven by chemical and physical processes such as degradation, diffusion, dispersion, and sorption. To the extent that contaminated sediment remains in place within the Slip, groundwater advection through contaminated sediment is also a potentially relevant exposure medium for surface sediment contamination via partitioning into porewater from subsurface sediment, and further partition from porewater into surface sediment.
- **Stormwater:** Contaminants in stormwater have the potential to impact surface sediment contaminant concentrations within the Slip. Runoff of precipitation falling onto industrial and commercial properties south of Highway 53 is transported to surface water in the Slip via the City's storm sewer conveyance system. If there are upland sources within the drainage area that have not been sufficiently controlled and are contacted by the stormwater, they may be sources of contaminants that may be transported to Superior Bay in both dissolved and suspended form via these conveyance systems.
- **CSTP2 Pond:** Immediately adjacent to the Slip is the City of Superior's main sewage treatment plant and CSTP2 wastewater pond. Contaminants typically associated with wastewater include total suspended solids, phosphorous, nitrogen-ammonia, fecal coliform, *E. coli*, and metals. Potential pathways for contaminant transport from the pond to the Slip include lateral seepage of wastewater through the berm and direct discharge of treated wastewater through the overflow discharge pipe.
- **Overwater Activities:** Spills or releases associated with waterfront or overwater activities, including commercial vessel loading and offloading and fueling, are a potential source of recontamination to sediment within the Slip.
- **Shoreline Erosion:** Contaminants within the shoreline soils and debris have the potential to erode or be transported onto surface sediment within the Slip via overland flow, wind, wave erosion, propeller wash, or mass wasting of the slope.
- **Resuspension and Redistribution of Bedded Sediments:** Resuspension of bedded sediments within the Slip has potential to occur via natural (e.g., seiche fluctuation, waves, and flood events) and/or anthropogenic processes (e.g., scour from marine vessel propeller wash). Contaminants can be resuspended and redeposited repeatedly due to these events.

3.4 Potential Current and Future Sources of Contamination

The area surrounding the C Street Slip is heavily industrial. Due to the highly industrialized nature of the surrounding area, it is unlikely that direct human contact due to recreational use will occur. Potential receptors are discussed in the following subsections.

3.4.1 Current Receptors

- **Maintenance Workers –** Direct contact scenarios with shallow near-shore sediments could potentially occur during maintenance activities from bordering industrial sites (Foth, 2022b). There is potential for limited exposure to dock or ship workers from chains, ropes, anchors, or other equipment that comes into contact with sediment. Potential exposures could occur via dermal contact or incidental ingestion of sediments. These potential exposure scenarios are assumed to be potentially complete, but infrequent and insignificant, and are not considered further.

- Potential exposures may also occur during dredging maintenance activities via dermal contact or incidental ingestion of sediments. Although inhalation is not considered complete while sediments remain in situ, inhalation could potentially be considered complete during dredging activities when sediments are removed and are no longer below water. It is assumed that any dredging that may occur would be conducted under appropriate health and safety plans that prevent or minimize potential exposure.
- **Anglers –** Anglers may consume fish that have accumulated sediment-associated contaminants from the Slip. Due to the industrialized nature of the Slip, angling is likely very limited but is considered a potential exposure pathway where bioaccumulative chemicals of concern (BCCs) are present.
- **Recreational Use** – Recreational boat traffic is unrestricted in this area and access could potentially occur on an infrequent basis. There is the potential for limited exposure to anchor lines, anchors, and fishing tackle that comes into contact with the sediment. These exposure scenarios are assumed to be potentially complete, but infrequent and insignificant, and were not considered further.

Potential ecological receptors and exposure pathways include the following:

- **Aquatic macroinvertebrates** – Exposures may occur via direct contact and/or ingestion of sediment.
- **Fish** – Exposures may occur via direct contact with or ingestion of sediment or ingestion of prey that contain contaminants in tissues via bioaccumulative processes.
- **Birds and mammals** – Exposures may occur via ingestion of forage or prey that contain contaminants in tissues via bioaccumulative processes. Given the heavy industrial nature of the surrounding area, it is unlikely that aquatic-associated mammals would forage within the Slip. Although dermal exposure represents a potential exposure pathway for birds (or mammals), this is relatively minor relative to ingestion exposure pathways and is considered insignificant.

3.4.2 Potential Future Receptors

The industrial character of the site is expected to remain unchanged for the foreseeable future. Potential future receptors are anticipated to remain the same as the current receptors.

3.5 Chemicals of Concern

Assessments of potential ecological effects and human health were completed in the *Remedial Investigation Report, C Street Slip (2023b)* using the analytical results of sediment samples from the 2015 and 2020 sampling events. VOCs (benzene, toluene, xylenes, 1,4-dichlorobenzene, and naphthalene) SVOCs (dibenzofuran), TPAHs, and metals (arsenic, copper, iron, lead, mercury, silver, and zinc) exceeded their respective MECs throughout the Slip. Mercury, benzo(a)pyrene, benzo(a)anthracene, benzo(b)fluoranthene, dibenzo(a,h)anthracene, indeno(1,2,3-cd)pyrene, and naphthalene exceeded industrial DC NTE RCLs throughout the Slip. Concentrations of arsenic exceeded the Wisconsin Soil background threshold value (BTV).

Figure 3-3 presents the extent of contamination based on any compound exceedance above reporting concentrations for MEC and the BUI No 1,4, and 5 evaluations discussed in the following section.

4. Remedial Action Objectives

The remedial action objectives (RAOs) and preliminary remediation goals (PRGs) consider the minimization or elimination of risks, or potential risks, from contaminants to human health and the environment and elimination of the contribution of contaminants to BUIs and contributions towards BUI removal for the SLRAOC. Risk management assessments for the protection of human health and the environment were performed to evaluate analytical and other investigative data collected at the C Street

Slip. The detailed risk assessment is discussed in the *C Street Slip Remedial Investigation Report* (AECOM, 2023b).

4.1 Human Health Risk Assessment (HHRA)

An HHRA was performed to evaluate potential human exposure associated with fish ingestion. The CSM indicated potential exposures to an angler fishing within the slip and ingestion of fillets of captured fish. Although other pathways were considered in development of the CSM (incidental dermal or ingestion of sediments), they were considered as potentially complete but insignificant. Chemicals of potential concern (COPCs) consisted of BCCs identified in sediments: specifically, these included Aroclors and mercury. Cumulative carcinogenic risk associated with PCBs did not exceed 1E-05. It is concluded that there are no unacceptable risks to humans related to PCBs sediment exposure in the C Street Slip. However, noncarcinogenic hazards exceeded 1 for mercury in all sediment intervals. Therefore, it is appropriate to establish RAOs relative to human health exposures to mercury.

4.2 Ecological Risk Assessment (ERA)

An ERA was performed to evaluate potential ecological exposures to sediments in the C Street Slip. The CSM indicated potential direct exposures for benthic invertebrates and bioaccumulation of BCCs into fish tissue and prey of birds. No unacceptable risks attributable to PCBs were identified for any of the ecological receptors evaluated.

However, potential risks were identified with respect to the benthic invertebrate community. In surface sediments, PEC hazard quotients (HQs) exceeded one for dibenzofuran (2) and tPAHs (2). Mercury (2) also exceeded a PEC HQ of one in subsurface sediments. In addition to constituents of ecological concern (COECs) exceeding PEC HQs of one, MEC HQs exceeded one for BaP (2) and mercury (2) in surface sediments. In subsurface sediments MEC HQs exceeded one for total xylenes (2) and BaP (2).

The contaminants for establishing RAOs and PRGs are focused on tPAHs and mercury. Although dibenzofuran and BaP also exceeded PEC and/or MEC risk thresholds, these constituents are co-located with PAHs. In addition, the maximum concentrations of total xylenes were also observed in samples with the higher tPAH concentration. Thus, establishing RAOs and PRGs for tPAHs and mercury will concomitantly address any potential risks associated with other COCs.

4.3 Restriction on Dredging Activity Assessment

Contaminant concentrations in the Slip warrant additional costs for water quality controls during dredging, material handling and disposal. The Remedial Action Plan (RAP) for the SLRAOC identifies remediation of contaminated sediments in the C Street Slip as management action 5.03, removal of the restrictions on the dredging BUI (Minnesota Pollution Control Agency [MPCA] and WDNR, 2022). Additional evaluations of data included comparison of constituent concentrations to RCLs to identify any additional requirements for potential BUI No. 5 restrictions on dredging activities. The following constituents exceeded applicable RCLs pertaining to BUI No. 5 and will subsequently limit opportunities for ex situ sediment management and therefore disposal may be limited to a commercial landfill or other regulated confined disposal facility (CDF):

Measured constituents (above detected concentrations) that exceed the industrial DC NTE RCL: Arsenic[2], Mercury, Benzo(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Dibenzo(a,h)anthracene, Indeno(1,2,3-cd)pyrene, Naphthalene

- **Table 4-1** presents a summary of samples that exceed Industrial DC NTE RCLs and soil background values for BUI No. 5. As previously discussed in Section 3, **Figure 3-3** presents the footprint of BUI No. 5 exceedances.

[2] Arsenic is shown where concentrations exceeded the Wisconsin soil background threshold value of 8.3 ppm at select sample points.

4.4 Remedial Action Objectives

The RAOs identified for C Street Slip based on the risk assessments are:

- Reduce mercury sediment concentrations to acceptable levels and minimize potential human health risks from fish consumption and support achieving fish tissue concentrations that are not significantly elevated compared to reference samples or fish advisories for mercury, advised for other waterbodies in the region.
- Reduce sediment concentrations of mercury and total PAHs to acceptable levels to minimize or eliminate risks to the benthic invertebrate community.
- Reduce, minimize, or eliminate the degree and extent of COCs in the slip that necessitate special handling procedures during dredging or dredged material disposal.
- Minimize or eliminate the potential for contaminated sediment within the C Street Slip to act as a source of contamination in the St. Louis River Estuary beyond the Slip.

The Remedial Action Plan (RAP) (MPCA and WDNR, 2022) identified nine beneficial uses that were impaired in the SLRAOC under the Great Lakes Water Quality Agreement (GLWQA). The most recent update to the RAP in 2022 for the SLRAOC is listed and defined in the *C Street Slip Remedial Investigation Report* (2023b), with five of the nine BUIs linked to contaminated sediment. The key focus of RAOs based on results from the Risk Assessments of the C Street Slip relate to the following BUIs and specific key drivers:

- BUI No. 1 – Fish Consumption Advisories – mercury
- BUI No. 4 – Degradation of Benthos – tPAHs and mercury
- BUI No. 5 – Restrictions on Dredging – Arsenic, Benzo(a)pyrene, Mercury

4.5 Preliminary Remedial Goals

There were two risk drivers pertinent to developing PRGs: mercury and tPAHs. Proposed PRGs are as follows:

Constituent	PRG = 1x MEC (µg/Kg)	SLRAOC BTV (mg/Kg)
Mercury	--	**0.59**
Total PAHs	**12,205**	--

Green shading indicates selected PRG values moving forward.

These are proposed as the final PRGs for evaluation in the feasibility study. Note that all suggested PRGs are based on the 95 percent upper confidence limit of the arithmetic mean (95% UCL) to be consistent with the approach used in the risk assessment (or statistical comparisons with background).

4.6 Remediation Target Area Development

Based on the screening levels presented, potential areas of interest were selected for remediation by reviewing the data from both historical investigations and the 2022 investigation, which were subsequently compared to PRGs to develop potential remediation target areas. These target areas were developed such that mitigation results in the ability to achieve the RAOs (elimination of potential Fish Consumption Advisories, BUI No. 1 and Degradation of Benthos, BUI No. 4). For mercury, the most stringent RAO was relative to BUI No. 1 and was also indicated as a potential issue for BUI No 4.

The MEC (12,205 µg/kg) was selected for remediation target development for tPAH. While remediation for exceedances with a value greater than 1x MEC or 1x PEC is justified based on uncertainties discussed in the *C Street Slip Remedial Investigation Report* (AECOM, 2023b), the MEC was selected as the PRG since it is the more conservative value for the analytes evaluated. Mercury was evaluated based on the SLRAOC background threshold value (BTV) (0.59 mg/kg).

Remedial areas were evaluated using EVS (Earth Volumetric Studio version 2022.10.2), and GIS software ArcGIS (Esri, version 10.8.1, and ArcPro (Esri, version 2.9). The contaminated sediment results represent a three-dimensional (3D) model of the analytes limited to below the bathymetric surfaces surveyed in July 2022. The 3D plumes were generated with an interpolation process called Kriging. The resulting plumes were also cut to above a confining clay layer (Miller Creek) using lithology field samples in a variation of Kriging called Geologic Indicator Kriging (GIK). Results were used in EVS volumetric tools to provide the volume of contaminated sediment in cubic yards. The clay layer is the minimum elevation, excluding the model bottom at 570 feet, or any overlapping or non-overlapping clay lithology plume. A detailed summary of assumptions, EVS methods, interpolation, and validation is provided in **Appendix A.**

4.7 Summary of Remediation Target Areas

The remediation areas for the Site are presented on **Figures 4-1 and 4-2**. These areas represent locations where tPAH concentrations exceeds the MEC and mercury concentrations exceeds the SLRAOC BTV based upon Site characterization activities. In general, these remediation areas can be described as the areas at the head of the Slip extending along the bulkhead wall adjacent to Graymont-LaFarge. Remediation in these areas, as described in the remedial alternatives in Section 6, is expected to meet the RAOs for the Site. The volumes of targeted sediment for remediation based on PRG concentrations are presented in the table below:

Constituents	Volume (CY)
Total PAHs	3,212
Mercury	12,548
TOTAL	**16,500**

The collocation overlap volume of targeted sediment for remediation based on tPAH and mercury was 1,108 CY. The total sediment volume used for process flow calculations was 16,500 CY. If dredging is the selected alternative, this sediment volume estimate does not account for overburden, slope stability, over dredge and other sediment removed as part of the dredge prism development.

5. Bench-Scale Treatability Investigation

Bulk sediment samples were collected for a treatability study to refine efficacy assumptions for potential ex situ sediment management alternatives. This supplemental data collection was necessary to help achieve WDNR's primary objective of evaluating and recommending remedial actions for the C Street Slip. A brief description of the scope of work for the treatability study and results is presented below. Details of the methodology and results of the bench-scale treatability investigation is available in the *Data Gap Treatability Report* (AECOM, 2022c).

5.1 Treatability Test Approach

5.1.1 Passive Dewatering Methods

A bench-scale sediment management treatability test program was conducted to assess the efficacy of various dewatering technologies and subsequently develop the specified criteria for sediment management, effluent discharge and refine full-scale treatment system design parameters (AECOM, 2022c). Polymer selection was based on the effectiveness of each chemical condition program to generate dry cake solids after 24-hours, greatest release of filtrate volume after 5-minutes, and filtrate with low total suspended solids concentration. Geotextile tube pillow testing was also conducted by conditioning a 40-L slurry sample and pouring it through a 40-L geotextile tube pillow in two fill events (0-hour [h] and 48-h). Dewatered sediment retained within the pillow was collected over a 7-day period to evaluate solids content as function of dewatering time. Filtrate volume and quality were also evaluated after each fill event.

5.1.2 Solidification/Stabilization Methods

Solidification/stabilization (s/s) treatability tests were performed to identify reagents and mix ratios that may be used to successfully dewater and/or stabilize the dewatered sediment for loadout, transportation and disposal. S/S tests used to support the feasibility study include stacking/gravity dewatering of bulk sediment (24-h), reagent screening with 20% admixtures and 96-h cure time (evaluated by penetrometer measurements), and optimized mix development with 5% and 10% admixtures and 96-h cure time (evaluated by unconfined compressive strength [UCS] via ASTM International [ASTM] D2216) measurements).

5.2 Treatability Test Results

5.2.1 Passive Dewatering Results

Based on an estimated dredge volume of 16,500 CY (51.6% solids in situ), a hydraulic dredge will slurry and discharge 17.2 MG [million gallons] at approximately 10% solids for chemical conditioning and subsequent containment and consolidation in geotextile tubes (**Table 1**). Approximately 2,300 linear feet (lf) of 60-ft circumference geotextile tube will dewater the 16,500 CY to 14,214 CY at 59.9% solids in 7-day (d) (**Table 1**). The recommended chemical conditioning program is 208-parts per million (ppm) ChemTreat P822L followed by 177-ppm ChemTreat P816E which equals approximately 6,600 gallons (gal) (66,000 pounds [lbs]) of total polymer.

Table 1. Dewatering of 16,500 CY of C Street Slip Sediment with Geotextile Tubes.

C Street sediment - Geotextile tube dewatering	Units	
In situ volume at 51.6% solids	CY	**16,500**
In situ volume at 51.6% solids	US gals	**3,333,000**
Volume pumped @ 10% solids for chemical conditioning	US gals	**17,200,000**
Volume of sediment in geotextile tubes, 59.9% solids	US gals	**2,900,000**
Volume of sediment in geotextile tubes, 59.9% solids	CY	**14,200**
60' circumference geotextile tubes (6.1 yd^3/lf)	linear ft	**2,330**

Additional stabilization of the dewatered material was evaluated and 5% Calciment™ admixture was recommended, increasing the filter cake strength from 0.0 to 4,786 lb/ft^2 after 96-h cure time (**Table 2**). With addition of Calciment™, the dewatered 14,200 CY contained in the geotextile tubes will continue to dewater to 9,050 CY @ 94.1% solids after 96-h cure time, 13,000 tons remaining for transportation and disposal (**Table 3**).

Table 2. Filter cake from geotextile tubes was stabilized with 5% Calciment™ to increase UCS for loadout and landfill disposal.

C Street dewatered sediment amended with 5% Calciment™	Units	
In situ volume at 59.9% solids	CY	**14,200**
In situ volume at 59.9% solids	US gals	**2,900,000**
Volume of stabilized sediment, 94.1% solids	US gals	**1,800,000**
Volume of stabilized sediment, 94.1% solids	CY	**9,050**

Table 3. Mass of geotextile tube dewatered and stabilized (5% Calciment™) C Street sediment for loadout, transportation, and disposal.

bulk density = 1.36	5% Calciment™	disposal
tons	tons	tons
12,300	**615**	**13,000**

5.2.2 Solidification/stabilization Results

In order to expedite dewatering and strengthening of mechanically dredged sediment from C Street Slip, 5% Calciment™ admixture was recommended. Calciment™ dewatered and consolidated the C Street sediment (51.6%) from 16,500 CY to 10,600 CY (80.4% solids) after 96-h cure time and increased the strength of the dewatered sediment to 2,970 lb/ft^2 (**Table 4**). With a bulk density of 1.36, sediment dewatered and stabilized equals approximately 15,100 tons for disposal including 720 tons of Calciment™ (**Table 5**).

Table 4. Calciment™ (5%) was used to dewater and stabilize C Street sediment (51.6% solids) to 80.4% solids after 96-h cure time.

C Street sediment amended with 5% Calciment™	Units	
In situ volume at 51.6% solids	CY	**16,500**
In situ volume at 51.6% solids	US gals	**3,333,000**
Volume of stabilized sediment, 80.4% solids	US gals	**2,150,000**
Volume of stabilized sediment, 80.4% solids	CY	**10,600**

Table 5. C Street sediment (14,400 tons) stabilized with 5% Calciment™ for disposal after 96-h cure time.

bulk density = 1.36	5% Calciment™	disposal
tons	tons	tons
14,400	**720**	**15,100**

6. Description and Screening of Remedial Alternatives

6.1 Description of Remedial Alternatives

Based upon the RAOs for the Site and the Site characterization described above, a general remedial approach has been developed for the in-water portion of the Site and will be considered for the remedial options that are evaluated in the following sections.

Remedial alternatives developed to address sediment impacted with tPAHs and mercury are detailed in this section. The remedial alternatives developed for the C Street Slip incorporate one or more passive approaches (e.g., Institutional Controls [ICs]) and active remedial approaches and technologies (e.g., dredging, capping, enhanced monitored natural recovery [EMNR]) and include the following:

- Alternative 1 - No-Action
- Alternative 2 - ICs
- Alternative 3 - EMNR
- Alternative 4 - Capping - Unamended
- Alternative 5 - Capping - Amended
- Alternative 6 - Mechanical Dredging

- Alternative 6A - Mechanical Dredging with Sediment Slurry Dewatering
- Alternative 6B - Mechanical Dredging with Ex-Situ Solidification/Stabilization
- Alternative 7 – Hydraulic Dredging
- Alternative 7A - Hydraulic Dredging with Passive Sediment Slurry Dewatering
- Alternative 7B - Hydraulic Dredging with Mechanical Sediment Slurry Dewatering
- Alternative 8 - In-Situ Solidification/Stabilization
- Alternative 9 – Dredging followed by Capping

Descriptions of the remedial alternatives developed for the C Street Slip and included as part of this screening evaluation are discussed below.

6.1.1 Alternative 1 - No-Action

Under Alternative 1, no action would be implemented to address the impacted sediment in the C Street Slip. Sediment containing COCs at concentrations greater than the PRGs would remain in place. This alternative is included for baseline comparison to other alternatives and does not allow for RAOs to be met.

6.1.2 Alternative 2 - ICs

Under Alternative 2, ICs would be implemented to decrease human exposure to sediments remaining in place with COCs at concentrations greater than the PRGs or to protect the integrity of engineering controls. Examples of ICs include fish advisories, commercial fishing bans, and waterway restrictions to prevent anchoring, dredging and/or excessive wakes. ICs are commonly implemented to address impacts within deeded properties. For the C Street Slip, which is located within Lake Superior, ICs would be imposed by WDNR under existing authorities and recorded in the WDNR Geographic Information System (GIS) Registry. ICs cannot be implemented as a standalone remedial alternative where potential ecological risks exist at a site. Rather ICs are implemented in combination or post-installation with other remedial alternatives. For example, ICs may be implemented to minimize disturbance or damage to a cap (with or without amendment) until the RAO(s) is achieved. Long-term monitoring will be required as part of this remedial alternative.

6.1.3 Alternative 3 – EMNR

Bioremediation (e.g., biodegradation, biostimulation and/or bioaugmentation) or enhanced deposition could be implemented within the remediation target areas to enhance natural processes (e.g., biotic and abiotic degradation and/or physical burial) so that RAOs can be met within an acceptable timeframe. This alternative would include permitting, preparation of the sediment surface, amending the biological active zone by applying or injecting bioremediation products across the impacted area and subsequently implementing ICs to protect human health until the RAO(s) is achieved.

Amendment materials can be applied using land-based or water-based methods typically involving a combination of land-based staging, mixing plants to activate and/or dilute amendments and/or a barge or boat system to expedite delivery. Amendment types and dosages will be considered as part of a detailed evaluation if this alternative is retained during this screening evaluation.

Some level of mechanical dredging may be required to remove surficial debris prior to implementation of this alternative. Work is assumed to be performed in the wet. A cofferdam or turbidity curtains (or other suitable hydraulic control) are not required to isolate the Slip from Lake Superior as these alternatives do not pose a risk if materials escape outside the application zone, but should be implemented as a best management practice (BMP). Turbidity controls or other BMPs as well as water quality monitoring will be installed during remedial activities whether work is conducted in the wet or the dry to manage suspended sediment that may be generated during remedy implementation.

A long-term monitoring program would be required following the introduction of biological amendments and/or supplements to assess recovery and to document compliance with the RAOs. Implementation of ICs would also be required as part of this remedial alternative to protect human health until the RAO(s) is achieved.

6.1.4 Alternative 4 – Unamended Sediment Cap

Remedial Alternative 4 is installation of an unamended cap (i.e., stone, sand, fines and/or a blended fill) to physically isolate impacted sediment from the aquatic environment to subsequently decrease potential for COC(s) transfer into the water column from the sediment porewater. Sediment capping is generally appropriate for locations where future construction or disturbances (e.g., dredging, prop wash, current, waves, ice scour) are minimal or can be mitigated in the cap design (e.g., armoring). Cap material(s) selection, modeling, treatability tests, recontamination potential, ebullition, potential for natural deposition and cap thickness will be considered as part of a detailed evaluation of remedial alternatives if unamended capping is retained as part of this screening evaluation.

Cap installation is assumed to be performed in the wet. Cap materials can be applied using mechanical and/or hydraulic methods involving a combination of land-based staging, mixing plants to activate and/or dilute cap materials and/or a barge or boat system to expedite delivery. Turbidity controls and water quality monitoring would be installed during remedial activities to manage suspended sediment that may be generated during remedy implementation. Some level of mechanical dredging may be required to remove debris and/or level the sediment surface that may interfere with construction of the cap. Sediment dredging may also be required prior to cap installation to accommodate any potential loss of water depth in the Slip.

Habitat restoration or engineering with nature components can be implemented as part of a capping remedy to provide habitat quality improvements for benthos, fish and other aquatic biota. A long-term monitoring program would be implemented following installation of the unamended cap to assess the stability and long-term effectiveness of the remedy and to document compliance with the RAO(s). Implementation of ICs would be required as part of this remedial alternative to protect the integrity of the remedy.

6.1.5 Alternative 5 – Amended Sediment Cap

Remedial Alternative 5 is installation of a cap (i.e., stone, sand, fines and/or a blended fill) amended with activated carbon, activated carbon-based products (e.g., SediMite or AquaGate), organoclays, or other engineered materials to sequester COCs, decrease COC concentrations in sediment porewater as well as physically isolate impacted sediment from the aquatic environment. Sediment capping is generally recommended for locations where future construction or disturbances (e.g., dredging, prop wash, current, waves, ice scour) are minimal or can be mitigated in the cap design (e.g., armoring). Amendment selection and mix ratio, cap material(s) selection, modeling, treatability tests, recontamination potential, ebullition, potential for natural deposition and cap thickness will be considered as part of a detailed evaluation of remedial alternatives if unamended capping is retained as part of this screening evaluation.

Cap installation is assumed to be performed in the wet. Cap materials can be applied using mechanical and/or hydraulic methods involving a combination of land-based staging, mixing plants to activate and/or dilute cap materials and/or a barge or boat system to expedite delivery. Turbidity controls and water quality monitoring would be installed during remedial activities to manage suspended sediment that may be generated during remedy implementation. Some level of mechanical dredging may be required to remove debris and/or level the sediment surface that may interfere with construction of the cap. Sediment dredging may also be required prior to cap installation to accommodate any potential loss of water depth in the Slip.

Habitat restoration or engineering with nature components can be implemented as part of a capping remedy to provide habitat quality improvements for benthos, fish and other aquatic biota. A long-term monitoring program would be implemented following installation of the amended cap to assess the stability and long-term effectiveness of the remedy and to document compliance with the RAO(s).

Implementation of ICs would be required as part of this remedial alternative to protect the integrity of the remedy.

6.1.6 Alternative 6 – Mechanical Dredging

Mechanical dredges excavate material at almost in situ densities using some form of bucket to carry dredged material up through the water column and place it into a barge, scow, hopper barge or other disposal transport for off-site processing and/or disposal. Backhoe, bucket (e.g., clamshell, orange-peel, and dragline), bucket ladder, bucket wheel, and dipper dredges are types of mechanical dredges. Mechanical dredges are engineered to remove loose to hard, compacted materials. Mechanical dredges may be used to excavate most types of materials except for the most cohesive consolidated sediments and solid rock. Mechanical dredges are typically used in areas where hydraulic dredges cannot work because of the proximity of the dredge cut to piers, docks, and other structures, or where the disposal area is too far from the dredge site for it to be feasible for a hydraulic dredge to pump the dredged material. Examples of various mechanical dredging equipment types are provided in **Attachment B**.

Clamshell Dredges are the most common type of bucket dredges, consisting of a clamshell bucket operated from a crane or derrick mounted on a barge or other floating structure. The clamshell dredge usually leaves an irregular, cratered bottom. Although the dredging depth is practically unlimited, because of production efficiency and accuracy clamshell dredges are usually used in water not deeper than 30 meters. The dredged material is subsequently placed in barges or scows for transportation to the sediment management and/or disposal area. Due to longer turn times for moving the bucket up and down through deep water and multiple material re-handling steps, production rates of mechanical dredging are relatively low compared to cutterhead dredges. Variations of the clamshell dredge have been developed in recent years to improve precision and minimize loss of sediment, water, and associated contaminants.

An example of an environmental bucket, the cable arm bucket, works on a two-cable system. One cable is attached to four spreader cables, which control opening and closing of the bucket. The second cable draws the clams together and lifts, thus creating a level-cut in the sediment that is essential for precision dredging. Other features such as one-way vents in the top of the dredge to reduce downward pressure during deployment and rubber seals to prevent loss of sediments have been added to further reduce sediment resuspension.

Backhoe Dredges are typically barge-mounted, cannot propel themselves, and usually have a moderate production rate. Backhoe dredges employ an articulated excavation bucket mounted on an articulated boom. They use hydraulically operated rams for movement, positioning and excavating. The material (i.e., sand, clays, gravel, cobbles and rock) is excavated, brought to the surface and placed in barges for transport to the placement area. They have radius and depth limitations, but some newer models excavate to depths more than 30 yards. These dredges are generally stationary and require spuds, or occasionally anchors to fix them at the dredging location.

6.1.6.1 Alternative 6A - Mechanical Dredging with Sediment Slurry Dewatering

Mechanically dredged sediments may be transported via a watertight scow or hopper barge to an onshore dewatering facility, where the sediments would be slurried and pumped to the landside processing system for subsequent dewatering using geotextile tubes, belt presses, plate-and-frame presses, centrifuges and/or a combination of all of the above. The nature and extent of dewatering depends on the sediment characteristics and the type of dredging, transport and disposal methods planned for the removed material.

Some form of dewatering of sediments is required prior to final disposition of the sediments. The objective of dewatering is to increase the solid content (decrease the content of water) which has the following benefits:

- Reduces volume and weight of sediments;
- Reduces transportation and disposal costs;
- Improves handling properties;

- Reduces the cost of many treatment processes; and
- Meets regulatory requirements (e.g., land disposal).

Gravity or passive dewatering is commonly used on sediment management sites where land area is available and/or hydraulic dredging is the practical/cost effective removal approach. Passive dewatering separates water by gravity and requires space to spread out or stack sediments. Geotextile tubes are another form of gravity dewatering. Geotextile tubes are a commonly used gravity sediment dewatering method. They are manufactured from a woven, high-strength polypropylene geotextile. With the aid of a chemical conditioning agent(s), sediment in the tubes consolidates releasing filtrate through the geotextile tube while retaining solids within it. Excavation of the dried materials from the tubes (which are cut open) and subsequent disposal occur when retained solids meet dryness goals (e.g., pass a paint filter test). Geotextile tubes can also be integrated into long-term consolidation and management units. Geotextile tube dewatering generally includes construction of a lined laydown area, chemical storage and feed systems, power and fuel, and limited operations and maintenance requirements. Typical advantages of dewatering sediments using geotextile tubes in comparison to mechanical dewatering include:

- Lower capital/operating cost compared to mechanical dewatering methods;
- Less infrastructure required (no buildings);
- No separation of sand prior to dewatering; and
- Lower concentration of suspended solids in the filtrate.
- Typical disadvantages of passive dewatering techniques compared to mechanical dewatering include:
- Larger sediment processing area;
- Lower percent solids resulting in higher transportation and disposal costs and/or the potential need for solidification reagent addition to pass free liquids testing for transportation;
- Longer dewatering duration; and
- Potential air/odor emission impacts.

Mechanical dewatering techniques have been commonly used at water, wastewater, and industrial facilities, including sediment management sites, to remove water from liquid residuals (sludges) using pressure to produce a non-liquid material. Some of the most common means include presses (both plate and frame and belt filter), centrifuges, and thickeners. Mechanical dewatering options generally include construction of an enclosure, conveyor/conveyance, chemical storage and feed system(s), power and fuel, material set down and loading area, and facility for attending staff/operators. Typical advantages of dewatering sediments with mechanical techniques compared to gravity dewatering methods include:

- Reduced mass and volume of filter “cake” to be loaded, transported and disposed;
- More uniform cake solids for transportation and disposal;
- Smaller footprint required for equipment;
- Filtrate collected from dewatering is contained at that location;
- Reduce or eliminate air drying and/or other solidification processes; and
- Lower transportation and disposal costs.

Typical disadvantages of the mechanical dewatering techniques compared to gravity methods may include:

- Dependence upon slurry quality, consistency and removal rate that can affect equipment operation and production;
- High concentration of suspended solids in the filtrate;

- Dependent upon operator knowledge and experience;
- High operation and maintenance (O&M) labor/costs; and
- Infrastructure and environmental controls are required to manage daily operations in addition to potential nuisance conditions, including noise and odors.

During active mechanical dewatering, equipment or materials are used to apply external pressure and can sometimes achieve a solids content of up to 70% by weight. Typical equipment used includes plate-and-frame presses, which are effective but operate in batch mode, and belt filter presses and centrifuges, which may be less effective but can be operated continuously. Water removed during mechanical dewatering must also be addressed. If the removed water contains contaminants at concentrations below regulatory thresholds, it can be discharged or disposed. Most likely, filtrate water will be contained and treated prior to discharge.

Disposal of dredged or excavated sediment is the placement of materials into a controlled site or facility (e.g., sanitary landfills, hazardous material landfills, CDFs, or confined aquatic disposal facilities). Off-site landfills are generally used for dredged material disposal when on-site disposal is not feasible or when off-site disposal is more cost effective. Alternatively, off-site landfilling is favored for smaller or moderately sized sites, where transportation to the site is feasible via truck or barge. The associated hazards and cost of transporting and landfilling large volumes of sediment make offsite disposal a less desirable solution for large sediment volumes.

Turbidity control and water quality monitoring would be implemented as part of this remedy to prevent suspended sediment from migrating outside of the project area during water-based activities. Fugitive odor and dust emissions would need to be controlled during sediment processing.

6.1.6.2 Alternative 6B - Mechanical Dredging with Ex-Situ Solidification/Stabilization

Mechanical dredging/removal of sediments “in the wet” includes use of a barge-mounted clamshell (e.g., crane or derrick) or backhoe dredge (e.g., articulated, long-reach excavator). The dredge will excavate sediment from the dredge prism using Geographic Positioning System (GPS) guidance (e.g., DredgePak) and transfer the material to a temporary and/or bermed shoreline staging area, scows or hopper barges for subsequent transfer to a nearshore sediment management area (SMA). The lined SMA will be designed to accommodate all of the excavated material as well as contain a sump to manage filtrate and precipitation during the project period. Excavated sediments will be mechanically stacked to facilitate gravity drainage. Methods such as turning, mechanical augers, windrowing, and/or addition of s/s reagents may be used to enhance the dewatering process. A temporary cover system may also be used over the dried sediments to limit re-saturation until the material is transloaded for disposal.

Solidification/stabilization (S/S) includes processes that mix inorganic cementitious/pozzolanic reagents into dredged material to transform it into a durable, solid, low–hydraulic conductivity material. Although solidification and stabilization are defined separately, they are often implemented simultaneously through a single treatment process. Ex situ solidification and stabilization are defined as follows:

- Solidification involves the processes that encapsulate dredged material to form a solid material and restricts contaminant migration by decreasing the surface area exposed to leaching and/or by coating the contaminated material with low-permeability materials. Solidification entraps the material within a granular or monolithic matrix. Solidification can be accomplished by mechanical processes that mix the material with one or more reagents.
- Stabilization involves the processes where chemical reactions occur between the reagents and dredged material to reduce the leachability of contaminated material into a stable insoluble form. Stabilization chemically binds free liquids and immobilizes contaminated materials or reduces their solubility through a chemical reaction. The physical nature of the contaminated material may or may not be changed significantly by this process.

Dredge material is usually stabilized and/or dewatered with a reactive pozzolanic reagent like Portland cement. Cementitious reagents are the most common commercially employed S/S process options due, in part, to low cost and availability. Cementitious and/or pozzolanic reagents include Portland cement, Calciment™, fly ash, ground granulated blast furnace slag, silica fume, cement kiln dust, various forms of lime, and lime kiln dust. These reagents may be used singly or in various combinations. In low admixture concentrations, cement (and other pozzolanic reagents) is used for dewatering, consolidation and geotechnical stability of the sediment. Most soil stabilization treatment ranges from 5 to 10% admixture; sediment can be more (5 to 20%) depending on the percent moisture of the sediment matrix.

Implementation costs vary widely based on reagent availability, transportation costs for delivery to the site, and mixing technique (in situ or ex situ). The S/S process typically involves either the addition of reagents to water (to form a grout or paste) or the addition of dry reagents to the dredge material and using the in-situ water for activation. The selection of the type of reagent is influenced by sediment characteristics and site conditions such as depth of mixing and moisture content. In situ dry addition is typically feasible for only relatively shallow, ex situ mixing operations; however, the generation of fugitive dust may be a concern unless it is mitigated by use of suitable equipment and controls. Recommendations for s/s reagent types and mix ratios were provided as part of the *Data Gap Treatability Test Report* (AECOM, 2022c) and will be considered as part of a detailed evaluation of remedial alternatives retained as part of this screening evaluation.

Disposal of dredged or excavated sediment is the placement of materials into a controlled site or facility (e.g., sanitary landfills, hazardous material landfills, CDFs, or confined aquatic disposal facilities). Off-site landfills are generally used for dredged material disposal when on-site disposal is not feasible or when off-site disposal is more cost effective. Alternatively, off-site landfilling is favored for smaller or moderately sized sites, where transportation to the site is feasible via truck or barge. The associated hazards and cost of transporting and landfilling large volumes of sediment make offsite disposal a less desirable solution for large sediment volumes.

Excess water generated from dredged sediments in the scow barges and during sediment processing will be collected and pumped into either an onsite water treatment system or transported to the nearby municipal wastewater treatment facility. Turbidity control and water quality monitoring would be implemented as part of this remedy and fugitive odor and dust emissions would need to be controlled during sediment processing.

6.1.7 Alternative 7 – Hydraulic Dredging

Hydraulic dredges are typically used for unconsolidated sediment, such as those typically found in waterway maintenance removal projects. Some types of hydraulic dredges are modified such that they can be used to excavate more consolidated sediments. Hydraulic dredges use diesel or electric-powered centrifugal pumps with discharge pipes ranging in diameter from 150 millimeters to 1,200 millimeters. The pump produces a vacuum on its intake side, which forces water and sediment through the suction pipe. In a hydraulic dredge the material to be removed is first loosened and mixed with water by cutterheads or by agitation with water jets and then pumped as a fluid. Sediments are directed into the suction end of a hydraulic pipeline by various methods (e.g., rotating cutterhead) and transported to the water surface inside a pipeline and then to a selected discharge point.

Hydraulically operated dredges can be classified into four main categories: pipeline (e.g., plain suction, cutterhead, auger, dustpan), hopper (e.g., trailing suction), bucket wheel, and side casting. Hydraulic dredges are self-contained units that handle both the dredge and disposal phases of dredging operations. They not only dig the material up, but also convey the sediment slurry to a placement or management area by pumping the material through a pipeline, or by storing it in hoppers that can be subsequently emptied over the disposal area. Examples of various hydraulic dredging equipment types are provided in **Attachment C**.

Cutterhead Suction Dredge is the most common hydraulic dredge used in North America and is generally the most efficient and versatile. With this type of dredge, a rotating cutter at the end of a ladder excavates the bottom sediment and guides it into the suction. The excavated material is lifted and pumped by a centrifugal pump to a designated disposal area through a pipeline as slurry with a typical solids content of 10% to 20% by weight. The typical cutterhead dredge is swung in an arc from side to side by alternately pulling on port and starboard swing wires connected to anchors through pulleys mounted on the ladder just behind the cutter. Pivoting on one of two spuds at the stern, the dredge "steps" or "sets" forward.

Jet-Suction Dredges are hydraulic suction dredges that use a widely flared dredge head along which water jets are mounted. The jets loosen and agitate sediment particles, which are then captured in the dredge head as the dredge moves forward. This type of dredge works best in free-flowing granular material and is not generally used to dredge fine-grained sediment. Similar to a cutter suction dredges, jet-suction dredges agitate and slurry the sediment with fine water jets at the end of the ladder and subsequently suction the slurry into the pipeline for conveyance and disposal at the sediment processing facility.

6.1.7.1 Alternative 7A - Hydraulic Dredging with Sediment Slurry Dewatering

Hydraulic dredging may be performed using a swinging-ladder, cutterhead hydraulic dredge connected to a high-density polyethylene (HDPE) dredge pipeline to remove sediments containing COCs at concentrations greater than the PRGs from the Slip. The sediment slurry generated during hydraulic dredging would be conveyed directly into watertight scows, hopper barges or directly to an onshore dewatering facility where the sediments would be conditioned, contained, dewatered and consolidated using geotextile tubes, belt presses, plate-and-frame presses, centrifuges and/or a combination of all of the above. The nature and extent of dewatering depends on the sediment characteristics and the type of dredging, transport and disposal methods planned for the removed material. Passive and mechanical dewatering technologies were previously defined in Section 6.1.6.1

Disposal of dredged or excavated sediment is the placement of materials into a controlled site or facility (e.g., sanitary landfills, hazardous material landfills, CDFs, or confined aquatic disposal facilities). Off-site landfills are generally used for dredged material disposal when on-site disposal is not feasible or when off-site disposal is more cost effective. Alternatively, off-site landfilling is favored for smaller or moderately sized sites, where transportation to the site is feasible via truck or barge. The associated hazards and cost of transporting and landfilling large volumes of sediment make offsite disposal a less desirable solution for large sediment volumes.

Turbidity control and water quality monitoring would be implemented as part of this remedy to prevent suspended sediment from migrating outside of the project area during water-based activities. Fugitive odor and dust emissions would need to be controlled during sediment processing.

6.1.7.2 Alternative 7B - Hydraulic Dredging with Ex-Situ Solidification/Stabilization

Hydraulic dredging may be conducted to remove sediments containing COCs at concentrations greater than the PRGs. The dredge slurry would be transported via a scow, hopper barge or directly pumped to an onshore dewatering facility where the sediments would be contained, settled and consolidated. Overlying water in the scow or barges and during sediment processing will be collected and pumped to an onsite water treatment system for treatment or transported to the nearby municipal wastewater treatment facility. Settled and consolidated sediment may undergo s/s treatment through the mixing of reagents (e.g., Calciment™, Portland cement, CKD, fly ash, lime, etc.) to further dewater and stabilize sediments to meet loadout, transportation and disposal facility requirements. Ex-situ solidification/stabilization technologies were previously defined in Section 6.1.6.2.

Addition and amendment of the sediment may occur directly in the scows or barges prior to loadout or after transfer of the dewatered sediment to a lined SDA. Stacked sediment can be amended and left to cure in the SDA prior to loadout. Following s/s, the amended sediments would be disposed of at a licensed off-site landfill or CDF. Recommendations for s/s reagent types and mix ratios were provided as part of the *Data Gap Treatability Test Report* (AECOM, 2022c) and will be considered as part of a detailed evaluation of remedial alternatives retained as part of this screening evaluation.

Turbidity control and water quality monitoring would be implemented as part of this remedy to prevent suspended sediment from migrating outside of the project area during water-based activities. Fugitive odor and dust emissions would need to be controlled during sediment processing.

6.1.8 Alternative 8 - In-Situ Solidification and Stabilization

In-situ solidification and stabilization (ISS) of sediments within the C Street Slip may be used to isolate COCs detected at concentrations greater than PRG values from transferring to porewater and surface water. ISS involves the mixing of reagents (e.g., Portland cement, kiln dust, quicklime, and/or fly ash) with in-place sediments to reduce the permeability of treated sediments and leachability of contaminants thus reducing contaminant mobility and bioavailability. Ex-situ solidification/stabilization technologies were previously defined in Section 6.1.6.2.

ISS technology is applicable for a relatively broad range of organic and inorganic contaminants and may be feasible when limitations to other technologies are imposed by site or contaminated material conditions. General non-site-specific advantages and challenges of ISS technology are listed below. As with use of any technology, site-specific conditions determine the potential feasibility and effectiveness of ISS.

ISS technology advantages include:

- Effective in treating many inorganic and organic contaminated materials;
- May be an option for treating recalcitrant or mixed contaminants;
- May address non-aqueous phase liquid (NAPL) through ISS treatment process;
- Often reaches fixed treatment end point in a relatively short period of time;
- Can improve structural property of soil, sediment, and sludge (e.g., strength) to facilitate consideration of land beneficial reuse;
- Can be applied in dry or wet conditions, reducing dewatering and waste management issues;
- Uses simple, readily available equipment and materials;
- On-site management of contaminated materials conserves landfill space and does not require transportation off site; and
- May be more cost-effective than ex situ strategies and off-site disposal.

ISS technology challenges include:

- Contaminants are not destroyed or removed, and long-term stewardship may be required;
- Effectiveness of ISS for certain contaminants (such as some organics or highly mobile species) may require additional measures in testing, treatment and design;
- Potential changes in groundwater flow, mounding, and swell may need to be assessed;
- Uncertainties associated with long-term behavior;
- Treatment or post-treatment modifications limited by time for field performance testing;
- Volume increases that occur in the treated mass may require additional BMPs; and
- ISS requires removal of debris or underground obstructions prior to treatment.

A significant challenge in applying ISS for contaminated sediments is achieving complete and uniform mixing of the reagent with the contaminated matrix at a sufficient admixture ratio. Three basic approaches are used for mixing: vertical auger mixing, shallow in-place mixing and injection grouting. In-place mixing involves the spreading and mixing of reagents with waste by conventional earth-moving equipment, such as draglines, backhoes or clamshell buckets. An auger rig can also be employed for in-place mixing. The technology is applicable only to surface or shallow deposits of contamination. Injection grouting involves forcing a reagent containing dissolved or suspended reagents into the matrix under pressure, thereby permeating the sediment. Grout injection may be applied to contaminated formations lying well below the surface. The injected grout cures in place, producing an in situ treated mass.

The selection of the mixing equipment is influenced by contaminant characteristics and site conditions, such as the depth and geometry of the impacted media; the presence of subsurface debris or very dense soil; and the proximity of utilities and other marine structures. When the contaminated material is at depths greater than approximately 20 feet the ISS project is a candidate for deep soil mixing applications using a single large-diameter auger or a multiple auger tool. If mixing occurs in situ, the treated material is left in place to “cure” or “set.” Assuming the reagents and water are adequately mixed into the contaminated material, the ultimate physical and chemical properties of the treated material are determined largely by the ratio of the dry weight of reagent (content or dosage) to the initial in-place soil mass before mixing.

Turbidity control and water quality monitoring would be implemented as part of this remedy and a periodic monitoring program would be implemented following treatment to assess the stability and long-term effectiveness of the remedy and to document compliance with the RAOs. Implementation of ICs would be required as part of this remedial alternative to protect the integrity of the remedy until RAOs are achieved and potentially for perpetuity to protect the installation.

6.1.9 Alternative 9 - Dredging and Capping

Remedial Alternative 9 includes a combination of dredging and capping to meet the RAOs. For this alternative, dredging would be conducted to remove sediment “hot spots” containing COC concentrations greater than the PRG values. There may be data gaps in the vertical and lateral delineation of these hotspots and thus sediment impacted by targeted COCs may remain at concentrations greater than the PRGs after dredging, which would be mitigated by placement of the cap (unamended or amended) and implementation of ICs. Dredging can be conducted either mechanically or hydraulically as previously described in Sections 6.1.6 and 6.1.7, respectively. Sediment management strategies are described in Sections 6.1.6.1, 6.1.6.2 and capping described in Sections 6.1.4 and 6.1.5. If a combination of dredging and capping are retained as part of this screening evaluation, additional site-specific concepts will be assessed as part of the detailed remedial alternatives evaluation for inclusion in this remedial alternative.

Under this scenario, a periodic monitoring program would be implemented following installation of the amended cap to assess the stability and long-term effectiveness of the remedy and to document compliance with the RAOs. Implementation of ICs would be required as part of this remedial alternative to protect the integrity of the capping remedy. Under this scenario, periodic repairs/maintenance measures may also be required over time.

6.2 Screening of Alternatives

During the process of identifying remedial alternatives, alternatives are discussed and screened, with some alternatives not carried forward for evaluation. Typically, a short list of alternatives is retained for evaluation. The alternatives are initially evaluated against criteria including technical feasibility (i.e., long-term effectiveness, short-term effectiveness, restoration time frame, and implementability), economic feasibility and other considerations (e.g., onsite engineering controls) as defined in Wis. Admin. Code NR 722.07.

6.2.1 Criteria

Technologies were evaluated based on the COCs, impacted media, and Site characteristics and to subsequently comply with the requirements of Wis. Admin. Code NR 722.07 and NR 722.09. Section 4.3 summarizes the preliminary screening for technologies listed in Section 6.1 using the following Technical Feasibility criteria:

A. Long-Term Effectiveness

The evaluation of remedial options for long-term effectiveness assesses the residual risk that remains after the remedial alternative has been implemented. This assessment includes an analysis of the magnitude of residual risk and the adequacy and reliability of engineering controls or continuing obligations to control that risk. The magnitude of residual risk analysis considers the following:

- Residual risk, expressed in cancer risk levels, volumes, or concentrations, remaining from untreated waste or treatment residuals at the conclusion of remedial activities.
- The volume, toxicity, and mobility of residuals remaining after remedial activities.
- The degree of adequacy and reliability the remedial option will provide to the overall protection of human health and the environment over time.

The adequacy and reliability of engineering controls, or continuing obligations, is evaluated in terms of the long-term reliability of controls used to manage treatment residuals or untreated waste remaining at the Site, and considers the following:

- The likelihood that the technology would meet required process efficiencies or performance specifications.
- The type and degree of long-term management and monitoring.
- O&M functions required to maintain process efficiencies or performance specifications.
- Difficulties of long-term maintenance, including the potential need for replacement of technical components and the degree of confidence that controls can adequately handle potential problems.

B. Short-Term Effectiveness

Short-term effectiveness addresses the effects of the remedial alternative during the construction and implementation phases until RAOs are met and considers the following:

- The risks to Site remediation workers and building occupants and the methods used to mitigate the risks, which could not be readily controlled during the remedial action.
- The risks to the community during the remedial action and how the risks would be mitigated.
- Environmental impacts, which can be expected during construction and implementation, the mitigation measures and their reliability, and the impacts which cannot be avoided or controlled.
- The duration of time until remedial objectives are met.

C. Implementability

This criterion addresses the technical and administrative feasibility of implementing a remedial option and the availability of various services and materials required during its implementation. Assessment of this criterion relies heavily on previous evaluations of technologies described in Section 4. Specific considerations include the following:

- The ability to construct and operate the remedial option, the difficulties and uncertainties that may be encountered during construction, and the likelihood of technical problems that may lead to schedule delays.
- The ease of undertaking additional remedial action and what those additional actions may be.
- The coordination required between agencies over the long term, and the ability to obtain permits for the remedial activities.
- The availability of capacity at treatment, storage, and/or disposal services, and the measures required to ensure that capacity is available.
- The availability of necessary equipment and specialists, and whether a lack of equipment and specialists prevents implementation.
- The degree to which technologies are available and sufficiently demonstrated for the specific full-scale application.

D. Restoration Time Frame

This screening criterion evaluates the time for the remedy to meet the RAOs. This criterion also considers the disturbance to the community and ecosystem over time. In addition, the volume, mobility, and toxicity of contamination including the degradation potential of the COCs is considered as part of the restoration potential of the alternative. Specific considerations include the following:

- Proximity of contamination to receptors identified.
- Risk of remedy to sensitive receptors as well as threatened or endangered species or habitats.
- COC fate and transport and the degree of natural attenuation of residual contaminants considering the post-remedy geologic and hydrogeologic conditions.
- The effectiveness and enforceability of continuing obligations by the stakeholders and/or community.

Economic Feasibility

Cost analysis includes estimates of capital costs (both direct and indirect initial costs) and annual O&M costs associated with each component of a remedial option. The target level of accuracy is +50% to -30%.

The cost may play a significant role in comparing remedial options, which are similar in long-term effectiveness or when treatment methods provide a similar performance. The remedial options with costs that are high when compared to the overall effectiveness of the remedial option will not be selected as the final remedy. Similarly, non-treatment options that have low initial capital costs may be more costly overall than a treatment option when long-term O&M costs are considered. An improved performance or greater long-term risk reduction may justify higher costs. The preferred remedial option is generally the one that satisfies the criteria at the most reasonable cost.

Additional Requirements

Additional requirements may include engineering controls, continuing obligations or other requirements as deemed necessary on a site-specific basis as described in NR 722.07(5)(c). For the Site, additional requirements include continuing obligations for groundwater monitoring and WDNR GIS Registry, per NR 714.05(1). This category also includes the evaluation of stakeholder and community acceptance of the remedial option as well as State Acceptance of the design per NR 722.15.

6.2.2 Pre-Screening

The following options were assessed at the screening stage and were not carried forward for further analysis:

- Alternative 2 - ICs
- Alternative 3 - EMNR
- Alternative 8 - In-Situ Solidification and Stabilization

A brief description of these is provided in the sub-sections below.

6.2.1.1 Alternative 2 - ICs

ICs are used to reduce the risk of contaminant exposure to human receptors by restricting access and/or notices are posted on the properties containing impacted media. ICs are typically considered as a necessary component of the post-remedy implementation phase of other alternatives. For example, ICs may be developed post-installation of a cap to ensure the installation is not disturbed through future dredging, marine construction, recreational activities and/or anchoring. Additionally, ICs (e.g., signs, public advisories) may be developed to minimize exposure due to swimming, fishing, and other recreational activities in the impacted area until RAOs are met and confirmed via monitoring.

Technical Feasibility

ICs will not be effective in mitigating the RAOs (i.e., BUI No. 1 – Fish Consumption Advisories and BUI No. 4 – Degradation of Benthos) for C Street Slip. ICs by themselves may minimize disturbance of the area by workers and recreational activities as well as limit direct and indirect human exposure. However, natural recovery processes would be relied upon to mitigate exposure pathways (e.g., sediment deposition and/or mixing to form a natural sediment cap) and/or biodegradation of organic COCs (e.g., tPAHs) to decrease risk to the benthic macroinvertebrate community and bioaccumulation in fish. By themselves, ICs are not effective for these RAOs and the timeline to measure/observe natural recovery is potentially decades. ICs are typically easy to implement and maintain but difficult to impose 24/7 compliance unless the impacted area is isolated with fencing or another barrier to restrict access.

Economic Feasibility

ICs are low cost for implementation and maintenance compared to all other alternatives.

Additional Requirements

The identification of an O&M manager and a sufficient annual budget are required to ensure compliance.

As ICs are not effective in mitigating bioaccumulation of mercury in fish (BUI No. 1) and risk to benthos (BUI No. 4), ICs are not retained for further consideration as a standalone option.

Evaluation Criteria	Alternative - 2
Threshold Criteria	
Overall Protectiveness of Public Health and the Environment	X
Compliance with Applicable, Relevant, and Appropriate Requirements (ARARs)	X
Evaluation Criteria	
Long-term Effectiveness	○
Short-term Effectiveness	○
Implementability	◑
Restoration Time Frame	○
Economic Feasibility	$
Additional Requirements	○

Legend	**Balancing Criteria**:	
Threshold Criteria:	○ = Low	◕ = Moderate to High
X = Does not Satisfy Criterion	◔ = Low to Moderate	● = High
✓ = Satisfies Criterion	◑ = Moderate	$$$ = Cost Ranking

6.2.1.2 Alternative 3 - EMNR

EMNR relies upon naturally occurring physical, chemical and/or biological processes to decrease the bioavailability and/or toxicity of contaminants to fish and the benthic macroinvertebrate community to acceptable levels. Preferential processes may be accelerated by enhancing those processes (EMNR). For example, sediment deposition rate can be accelerated by redirecting deposition from other areas or introducing deposition materials to target areas. Exposure concentrations may decrease in surficial sediments of C Street Slip through scour, burial, and/or mixing-in-place with clean sediment introduced by barge or excavator. Additionally, biological degradation rates of tPAHs may be accelerated through localized bioaugmentation and/or biostimulation. Nutrients, water quality improvements and/or additional oil-degrading bacteria may be introduced to the sediment surface and/or injected into the pore space in order to increase tPAH degradation rates.

Technical Feasibility

EMNR is not applicable for the C Street Slip as a standalone option because the mechanisms for decreasing this mixture of COCs will not occur in a timely manner even with enhancement of preferential transfers and transformations. Measurable sediment deposition and biodegradation rates are predicted to take years before results are observed. Additionally, the C Street Slip is a high-traffic, industrial waterway with high scour, prop wash and recontamination potential that would interfere with effective sediment deposition and biodegradation within the Slip.

Economic Feasibility

Costs of EMNR are significantly lower than most sediment removal or capping alternatives.

Additional Requirements

EMNR may be implemented as part of a larger remedial strategy incorporating sediment removal alternatives, such as post-dredging deposition, biostimulation and/or biodegradation to address residual tPAHs.

As EMNR is not effective in mitigating bioaccumulation of mercury in fish (BUI No. 1) and risk to benthos (BUI No. 4), EMNR is not retained for further consideration as a standalone option.

Evaluation Criteria	Alternative - 3
Threshold Criteria	
Overall Protectiveness of Public Health and the Environment	X
Compliance with (ARARs	X
Evaluation Criteria	
Long-term Effectiveness	○
Short-term Effectiveness	○
Implementability	◑
Restoration Time Frame	◔
Economic Feasibility	$
Additional Requirements	◑

Legend	**Balancing Criteria**:	
Threshold Criteria:	○ = Low	◕ = Moderate to High
X = Does not Satisfy Criterion	◔ = Low to Moderate	● = High
✓ = Satisfies Criterion	◑ = Moderate	$$$ = Cost Ranking

6.2.1.3 Alternative 8 - In-Situ Solidification and Stabilization

ISS involves applying and mixing a reagent(s) (e.g., Calciment™, Portland cement or fly ash) with in place contaminated sediment to decrease exposure to the benthic macroinvertebrate community and bioaccumulation by fish to acceptable levels (BUI No. 1 – Fish Consumption Advisories and BUI No. 4 – Degradation of Benthos). Mixing may be achieved either passively through natural biological processes such as bioturbation or actively through mechanical means (e.g., excavators and augers). ISS can achieve risk reduction in environmentally sensitive environments such as wetlands and submerged aquatic vegetation habitats where sediment removal or containment by capping might do more harm than good. ISS reagents immobilize or encapsulate the contaminants that are sorbed to the sediment, limiting bioavailability as well as the ability of COCs to transfer to the biologically active zone of the surficial sediment. The treated area will require ICs in order to limit visitors, future dredging and/or construction activities that may disturb the amended sediment and recovery and recolonization of the surficial sediment by macroinvertebrates.

Bench-scale treatability tests identified that a 10% Calciment™ admixture mixed and cured (96-h) in situ or ex situ with sediment will stabilize the sediment to eliminate leaching of tPAHs and mercury. Dry weight solids of stacked and amended sediment samples increased from 51.6% to 83.6% and 90.6% for 10% Calciment™ and 10% Portland cement, respectively, demonstrating the effective reaction that occurs between the sediment and the reagents.

Technical Feasibility

ISS may be an effective alternative for mitigating the RAOs of the C Street Slip as a standalone option as potential exposure of fish and benthos to contaminated sediment would be eliminated or minimized. ISS admixtures may be effective in both the short- and long-term allowing for natural recovery processes to occur. ISS amendments may be applied only to hotspot areas that are either difficult to remove or areas where more harm than good would occur if the sediment was removed. Additionally, recovery and recolonization of the amended surficial material may occur quickly if surface chemistry is not antagonistic to the benthic community. A disadvantage related to in situ treatment is that the contamination remains in the aquatic environment and could cause changes in the physical characteristics of the surface sediments down through the depth of application. ICs would be required in perpetuity in order to eliminate dredging, construction, prop wash and scour to limit damage to the stabilized area. Additionally, C Street Slip is an industrial waterway and the alternative will not eliminate the potential for recontamination of surficial sediment if contaminant sources were not identified and eliminated.

ISS would be difficult to implement through the vertical extent of sediment contamination, lithology and in this unpredictable waterbody off Lake Superior without significant engineering controls (e.g., sheet piling).

Economic Feasibility

Cost of ISS implementation for C Street Slip sediment is predicted to be comparable to sediment removal alternatives due to the additional costs of the admixture and extended time for project completion in a deep sediment application.

Additional Requirements

ISS may be implemented in C Street Slip with a few engineering controls and best management practices. Bench-scale treatability testing identified that a 10% Calciment™ or Portland cement admixture may be sufficient to stabilize the sediment ex situ. Additional bench-scale testing is required to evaluate whether the 10% admixture is sufficient to limit contaminant leaching (i.e., toxicity characteristic leaching procedure [TCLP] or synthetic precipitation leaching procedure [SPLP]) as there is a mixture of organic and inorganic COCs.

Although ISS may be an effective alternative in the short-term, long-term effectiveness and impacts to the benthos and fish communities (BUI Nos. 1 and 4) are unpredictable in C Street Slip. ISS would be difficult to implement in C Street Slip in deep water and deep sediment, does not permanently remove the potential for future exposure of contaminants to aquatic organisms and is not retained for further consideration as a standalone option.

Evaluation Criteria	Alternative - 8
Threshold Criteria	
Overall Protectiveness of Public Health and the Environment	X
Compliance with ARARs	X
Evaluation Criteria	
Long-term Effectiveness	◔
Short-term Effectiveness	◑
Implementability	◔
Restoration Time Frame	◑
Economic Feasibility	$$$
Additional Requirements	◔

Legend	**Balancing Criteria**:	
Threshold Criteria:	○ = Low	◕ = Moderate to High
X = Does not Satisfy Criterion	◔ = Low to Moderate	● = High
✓ = Satisfies Criterion	◑ = Moderate	$$$ = Cost Ranking

6.3 Screening of Remedial Alternatives Retained for Detailed Evaluation

As previously described (Section 6.2.1), remedial alternatives were evaluated against the following screening criteria: 1) effectiveness and restoration time frame, 2) implementability, and 3) cost. Additional factors that may be considered during development and screening of these remedial alternatives included contaminant sources, contaminant fate and transport, exposure pathways, receptors, current and future uses of the Slip, structural integrity of adjacent infrastructure, site conditions (e.g., scour, erosion, and long-term sustainability).

Remedial alternatives retained based on the results of this screening evaluation will be included in a detailed evaluation where alternatives will be evaluated against a more thorough set of criteria. The results of the detailed evaluation will be presented in a separate report for the C Street Slip. The following sediment management alternatives were identified to have the potential to achieve the RAOs for sediments in C Street Slip:

- Alternative 1 – No Action
- Alternatives 4 &5 – Sediment Cap (unamended and amended)
- Alternative 6 – Mechanical Dredging
- Alternative 7 – Hydraulic Dredging
- Alternative 9 – Dredging and Capping

A short description of each remedial alternative is provided in Sections 6.3.1 to 6.3.8 below. Water treatment is assumed to be required for all ex situ sediment management alternatives, including filtrate water from sediment dewatering as well as contact water generated from precipitation, requiring treatability testing prior to final design. Design details and costs of the water treatment system are not evaluated as part of this screening-level document. Additional assumptions include but are not limited to access to the Slip is available for marine equipment for dredging and/or capping. Also, suitable space within a mile of the Slip is available for equipment and material staging, sediment or cap material processing and loadout of dewatered sediment, as necessary.

6.3.1 Alternative 1 - No Action

The no action alternative is a baseline alternative for comparison of other alternatives that assumes no remedial activities or site monitoring of the C Street Slip in either the short- or long-term.

Technical Feasibility

No action would be implemented under this alternative and therefore is not an effective remedy to address impacted sediment in the C Street Slip.

From both technical and administrative perspectives, this alternative is highly implementable.

Economic Feasibility

No capital or O&M costs are associated with this alternative since no actions are proposed as part of this remedy.

Additional Requirements

No additional requirements. Alternative 1 is only included for baseline comparison to other alternatives.

Evaluation Criteria	Alternative - 1
Threshold Criteria	
Overall Protectiveness of Public Health and the Environment	X
Compliance with ARARs	X
Evaluation Criteria	
Long-term Effectiveness	○
Short-term Effectiveness	○
Implementability	●
Restoration Time Frame	○
Economic Feasibility	$
Additional Requirements	○

Legend	Balancing Criteria:	
Threshold Criteria:	○ = Low	◕ = Moderate to High
X = Does not Satisfy Criterion	◔ = Low to Moderate	● = High
✓ = Satisfies Criterion	◑ = Moderate	$$$ = Cost Ranking

6.3.2 Alternative 4 – Unamended Sediment Cap

Remedial Alternative 4 includes installation of an unamended cap to physically isolate impacted sediment from the aquatic environment to subsequently decrease potential for COC(s) adsorbed to sediments to transfer into the water column. Cap installation in C Street Slip is assumed to be performed in the wet. Requisite design and construction steps and assumptions for this screening-level evaluation are detailed below. Turbidity controls and water quality monitoring would be installed during remedial activities to manage suspended sediment that may be generated during remedy implementation.

- Pre-design Investigation

  - Bathymetric survey of the sediment surface of the target area prior to cap placement.
  - Hydrologic and hydraulic (H&H) modeling to evaluate stability of cap material, requirements for armoring (if necessary) and requirements for venting for ebullition and other flux in the C Street Slip.
  - Measure sediment deposition rate and perform sediment transport modeling.
- Mechanical placement of a three-foot sand cap or cap composed of blended construction fill across the target area with a cable arm bucket or hydraulic placement of the cap by slurring and pumping from a mix tank or hopper barge.
- Confirmation sampling and surveying to verify cap thickness and coverage across the target area.
- Stone armoring if required.
- Long-term monitoring for cap and armor stone stability and integrity as well as benthos community recolonization.
- ICs may be required for all or part of the Slip.

Assumptions

- Upland and groundwater sources of future contamination have been identified and mitigated.
- The addition of a sediment cap will not require dredging of sediment to accommodate for any potential loss of water depth in the Slip.
- Removal of debris is not required prior to cap placement.
- Infrastructure and other debris will not interfere with cap placement and stability.
- Prop wash, scour and other Slip activities will not impact cap integrity.
- Materials for cap construction are locally available.
- Potential for recontamination of the cap is low.
- Potential for flux from groundwater sources is low.
- Natural sediment deposition of fine sediment occurs quickly in the Slip such that recolonization occurs.

Technical Feasibility

An unamended sediment cap may be an effective alternative for mitigating the RAOs of the C Street Slip as a standalone option as potential exposure of fish and benthos to contaminated sediment would be eliminated or minimized in the long-term. In the short-term, capping would simultaneously eliminate the exposure pathway from sediment to the aquatic community as well as eliminate the existing benthos community. Capping would be effective in the long-term allowing for natural recovery processes to occur, sediment deposition and benthic community recolonization.

Based on the assumptions described under **Additional Requirements** for this alternative, an unamended cap would be relatively easy to install and armor across the target area if suitable construction materials were locally available. No specialized equipment or long-lead items have been identified. Qualified contractors and equipment are located throughout the Great Lakes region.

Economic Feasibility

Costs of sediment capping implementation for C Street Slip sediment is predicted to be lower than sediment removal alternatives due to the additional costs associated with ex situ sediment management and disposal. However, ICs and long-term monitoring will be in place for perpetuity.

Additional Requirements

Sediment capping may be implemented in C Street Slip with a few engineering controls and best management practices to manage resuspension of contaminated sediments and cap materials. Additionally, a pre-design investigation will be required prior to a full design of the cap installation project including but not limited to a bathymetric survey, H&H modeling and/or sediment transport modeling.

A disadvantage related to sediment capping is that the contamination remains in the aquatic environment and potential for future risk remains. ICs would be required in perpetuity in order to eliminate dredging, construction, prop wash and scour to limit damage to the capped area. Additionally, C Street Slip is an industrial waterway and the alternative will not eliminate the potential for recontamination of surficial sediment if contaminant sources were not identified and eliminated.

Although an Unamended Sediment Cap may be a cost-effective, short-term alternative, long-term effectiveness and impacts to the RAOs (BUIs Nos. 1 and 4) are unpredictable in C Street Slip. Capping with sand or blended fill removes the potential for exposure of sediment contaminants to the fish and benthos communities and is retained for further consideration as a standalone option.

Evaluation Criteria	Alternative - 4
Threshold Criteria	
Overall Protectiveness of Public Health and the Environment	✓
Compliance with (ARARs	✓
Evaluation Criteria	
Long-term Effectiveness	◔
Short-term Effectiveness	◑
Implementability	◑
Restoration Time Frame	◑
Economic Feasibility	$$
Additional Requirements	◑

Legend	**Balancing Criteria**:	
Threshold Criteria:	○ = Low	◕ = Moderate to High
X = Does not Satisfy Criterion	◔ = Low to Moderate	● = High
✓ = Satisfies Criterion	◑ = Moderate	$$$ = Cost Ranking

6.3.3 Alternative 5 – Amended Sediment Cap

Remedial Alternative 5 includes installation of an amended sediment cap to physically isolate impacted sediment from the aquatic environment to subsequently decrease potential for COC(s) adsorbed to sediments to transfer into the water column. An amendment layer (i.e., activated carbon, carbon-based products, organoclay, or other engineered materials) is added between the sediment cap and the target area or blended with the cap material in a 0.5 to 1-ft lift to provide additional adsorption potential to sequester COCs that transfer from the sediment pore water and migrate towards the aquatic environment. In many cap applications, the use of amendments in the initial layer may decrease the overall thickness of the rest of the cap. Cap installation in C Street Slip is assumed to be performed in the wet.

Requisite design and construction steps and assumptions for this screening-level evaluation are detailed below. Turbidity controls and water quality monitoring would be installed during remedial activities to manage suspended sediment that may be generated during remedy implementation.

- Pre-design Investigation
  - Bathymetric survey of the sediment surface of the target area prior to cap placement.
  - H&H modeling to evaluate stability of cap material, requirements for armoring (if necessary) and requirements for venting for ebullition and other flux in the C Street Slip.
  - Measure sediment deposition rate and perform sediment transport modeling.
  - Treatability tests to identify amendment(s), mix ratios and cap thickness.
- Mechanical or hydraulic placement of amendment layer or sand/amendment blended layer from a mix tank or hopper barge.
- Confirmation sampling and surveying to verify amendment thickness and coverage across the target area.
- Mechanical placement of a sand cap or cap composed of blended construction fill (engineered cap materials) across the target area with a cable arm bucket or hydraulic placement of the cap by slurring and pumping from a mix tank or hopper barge.
- Confirmation sampling and surveying to verify cap thickness and coverage across the target area.
- Stone armoring if required.
- Long-term monitoring for cap and armor stone stability and integrity as well as benthos community recolonization.
- ICs may be required for all or part of the Slip.

Assumptions

- Upland and groundwater sources of future contamination have been identified and mitigated.
- The addition of a sediment cap will not require sediment dredging to accommodate for any potential loss of water depth in the Slip.
- Dredging of sediment or removal of debris is not required prior to cap placement.
- Infrastructure and other debris will not interfere with cap placement and stability.
- Prop wash, scour and other Slip activities will not impact cap integrity.
- Materials for cap construction are locally available.
- Potential for recontamination of the cap is low.
- Potential for flux from groundwater sources is low.
- Natural sediment deposition of fine sediment occurs quickly in the Slip such that benthos recolonization occurs.

Technical Feasibility

Amended sediment capping may be an effective alternative for mitigating the RAO of the C Street Slip as a standalone option as potential exposure of fish and benthos to contaminated sediment would be eliminated or minimized in the long-term. In the short-term, capping would simultaneously eliminate the exposure pathway from sediment to the benthic community as well as eliminate the existing benthos community. Capping would be effective in the long-term allowing for natural recovery processes to occur, sediment fines deposition and benthic community recolonization.

Based on the assumptions described under **Additional Requirements** for this alternative, an amended cap would be relatively easy to install and armor across the target area if suitable construction materials were locally available. No specialized equipment or long-lead items have been identified. Qualified contractors and equipment are located throughout the Great Lakes region.

Economic Feasibility

Costs of amended sediment cap implementation for C Street Slip is predicted to be lower than sediment removal alternatives due to the additional costs associated with ex situ sediment management and disposal. However, ICs and long-term monitoring will be in place for perpetuity.

Additional Requirements

Amended capping may be implemented in C Street Slip with a few engineering controls and best management practices to manage resuspension of contaminated sediments and cap materials. Additionally, a pre-design investigation will be required prior to a full design of the cap installation project including but not limited to a bathymetric survey, H&H modeling and/or sediment transport modeling.

A disadvantage related to capping is that the contamination remains in the aquatic environment and potential for future risk remains. ICs would be required in perpetuity in order to eliminate dredging, construction, prop wash and scour to limit damage to the capped area. Additionally, C Street Slip is an industrial waterway and this alternative will not eliminate the potential for recontamination of surficial sediment if contaminant sources were not identified and eliminated.

Although an Amended Sediment Cap may be a cost-effective, short-term alternative, long-term effectiveness and impacts to the fish and benthos communities (BUIs Nos. 1 and 4) are unpredictable in C Street Slip. Capping with sand or blended fill amended with reactive material removes the potential for COC flux and exposure of contaminants to the fish and benthos communities and is retained for further consideration as a standalone option.

Evaluation Criteria	Alternative - 5
Threshold Criteria	
Overall Protectiveness of Public Health and the Environment	✓
Compliance with ARARs	✓
Evaluation Criteria	
Long-term Effectiveness	◔
Short-term Effectiveness	◑
Implementability	◑
Restoration Time Frame	◑
Economic Feasibility	$$
Additional Requirements	◑

Legend	**Balancing Criteria**:	
Threshold Criteria:	○ = Low	◕ = Moderate to High
X = Does not Satisfy Criterion	◔ = Low to Moderate	● = High
✓ = Satisfies Criterion	◑ = Moderate	$$$ = Cost Ranking

6.3.4 Alternative 6 - Dredging – Mechanical

This alternative consists of mechanical dredging of the contaminated sediments with an environmental, clam shell bucket and transferring the material into a designated onsite sediment management area via trucks or hopper barges where sediments would be stacked, dewatered and processed. Dredging progress and productivity will be tracked and monitored real-time with GIS-based surveying technology (e.g., HyPack, DredgePack). The partially dewatered sediments would be dewatered and/or stabilized with a reagent (e.g., Calciment™, Portland cement or fly ash) for a prescribed cure period and subsequently transported for offsite disposal. Alternatively, sediment contained in hopper barges may be slurried and pumped to a sediment management area if a suitable riverfront footprint is not available for transloading mechanically excavated sediment from barges to land.

By removing the contaminated sediments from C Street Slip that are greater than PRG values, the risk of contaminated sediment exposure to fish and benthos communities are eliminated. The remedial activities for Alternative 6 are:

- Pre-design Investigation
  - Bathymetric survey of the sediment surface of the target area prior to cap placement.
  - Dewatering and S/S treatability tests to identify sediment management strategies and associated efficacy to refine design assumptions.
- Mechanical dredging of the contaminated sediment with a clam shell bucket mounted on a spudded-barge conveyed into a hopper barge.
- Transportation of dredge material to waterside offloading area.
- Transload dredged sediment from hopper barges to a lined sediment management area with either mechanical or hydraulic processes.
- Sediment is dewatered through 1) mechanical stacking or 2) pumping to geotextile tubes or mechanical dewatering equipment (e.g., presses or centrifuges). Pumping options will require polymer conditioning to facilitate solids/water separation and consolidation.
- Addition of a stabilization reagent to the sediment may be required to enhance dewatering processes as well as improve the compaction potential and/or strength of the dewatered sediment prior to transportation and disposal in a commercial landfill.
- Filtrate water is collected in a sump and pumped to the water treatment plant prior to discharge.
- Confirmation sampling and surveying to verify contaminated sediment was removed and target depths were reached, respectively.

Assumptions

- The dredge prism is easily accessible.
- A nearby footprint with water access is available for construction of the sediment management area.
- Removal of debris is not required prior to mechanical dredging.
- All dredged sediment will be processed simultaneously, and sand separation and collection provides no advantages.
- No long lead items have been identified.
- Experienced contractors are regionally located, and dredging equipment is readily available.
- Capping or ICs are not required post-dredging as recontamination is not expected. Natural sediment deposition and sediment mixing (bioturbation and prop wash) is expected within the Slip.
- Potential for recontamination is low.
- Potential for flux from groundwater sources is low.
- Natural sediment deposition of fine sediment occurs quickly in the Slip such that benthos recolonization occurs.

Gravity stacking tests performed with C Street Slip sediment (51.6% solids) passed paint filter tests (PFTs) at 0-h and 24-h indicating the material may be sufficiently consolidated to mechanically dredge, stack and transport to an offsite facility for disposal. The UCS of this material was insufficient for receipt at a commercial landfill. Bench-scale treatability tests subsequently identified that a 5% Calciment™ admixture mixed and cured (96-h) with stacked sediment will exceed the 1,000 lb/ft2 UCS threshold for most landfills. Additionally, 10% Portland cement and Calciment™ admixtures stabilized contaminated sediment and eliminated leachability of mercury and tPAHs from amended sediment. Dry weight solids of these amended sediment samples increased from 51.6% to 83.6% and 90.6% for 10% Calciment™ and 10% Portland cement, respectively.

Technical Feasibility

Mechanical dredging is an effective alternative mitigating for the RAOs of C Street Slip as potential exposure of fish and benthos to contaminated sediment would be eliminated in both the short- and long-term. In the short-term, dredging would simultaneously eliminate the contaminated source material as well as the existing benthos community. As long as the contaminated sediment and associated contact water were processed appropriately and transported to a licensed commercial landfill, the risk of future risk is eliminated. Mechanical dredging is effective for dredging clay and/or other consolidated sediment layers compared to hydraulic dredging methods. If vertical delineation is incomplete or it's unclear if the target COCs have contaminated the confining clay layer, confirmation sampling may be recommended prior to a polishing pass or additional dredging until "clean" sediment is reached.

No specialized equipment or long-lead items have been identified. Qualified contractors and equipment are located throughout the Great Lakes region. The construction window for the site is small and thus mobilization efficiency will be crucial to make the most of the time for dredging and sediment processing.

Economic Feasibility

Costs of mechanical dredging and ex situ sediment management for C Street Slip is predicted to be high compared to other sediment removal alternatives due to the additional costs associated with ex situ sediment management and disposal. ICs will not be required but long-term monitoring may be required.

Additional Requirements

Mechanical dredging may be implemented in C Street Slip with engineering controls and best management practices (e.g., turbidity curtains) to manage resuspension of contaminated sediments during dredging. Additionally, a pre-design investigation will be required prior to a full design of the project including but not limited to a bathymetric survey, H&H modeling and/or sediment transport modeling.

Natural recovery processes and benthos recolonization of surficial sediment would occur quickly. ICs would not be required. C Street Slip is an industrial waterway and this alternative does not eliminate the potential for recontamination of surficial sediment if contaminant sources were not identified and eliminated. Monitoring of the Slip is assumed to be required to track recovery and confirm recontamination does not occur over time.

Mechanical Dredging is a long-term effective alternative, mitigating fish consumption advisories (BUI No. 1) and risk to the benthos community (BUI No. 4) in C Street Slip. Removing the contaminated sediment removes the potential for exposure of contaminants to fish and benthos communities and is retained for further consideration as a standalone option.

Evaluation Criteria	Alternative - 6
Threshold Criteria	
Overall Protectiveness of Public Health and the Environment	✓
Compliance with ARARs	✓
Evaluation Criteria	
Long-term Effectiveness	◕
Short-term Effectiveness	◑
Implementability	◑
Restoration Time Frame	◕
Economic Feasibility	$$$
Additional Requirements	◕

Legend	**Balancing Criteria**:	
Threshold Criteria:	○ = Low	◕ = Moderate to High
X = Does not Satisfy Criterion	◔ = Low to Moderate	● = High
✓ = Satisfies Criterion	◑ = Moderate	$$$ = Cost Ranking

6.3.5 Alternative 7 - Dredging – Hydraulic

This alternative consists of hydraulic dredging of the contaminated sediments with a cutterhead and subsequently pumping the material to a designated onsite sediment management area where sediments would be dewatered and processed. Dredging progress and productivity will be tracked and monitored real-time with GIS-based surveying technology (e.g., HyPack, DredgePack). The dredge either: 1) slurries the sediment and pumps it directly via pipeline (with or without booster pumps) to the sediment management area; or 2) pumps the sediment slurry to a hopper barge(s) and subsequently from the barge(s) to the sediment management area if a suitable riverfront footprint is available for transloading barges. In both scenarios, the sediment slurry would require additional dewatering using passive (e.g., geotextile tubes) or mechanical (e.g., belt-filter presses, plate-and-frame presses, centrifuges) equipment to contain, dewater and consolidate the slurry to generate filter cake suitable for transportation and disposal. Additional s/s of the dewatered sediment may be required to further dewater and strengthen the sediment to meet transportation and disposal requirements. By removing the contaminated sediments from C Street Slip that are greater than PRG values, the risk of contaminated sediment exposure to the fish and benthos communities are eliminated. The remedial activities for Alternative 7 are:

- Pre-design Investigation
  - Bathymetric survey of the sediment surface of the target area prior to cap placement.
  - Dewatering and S/S treatability tests to identify sediment management strategies and associated efficacy to refine design assumptions.
- Hydraulic dredging of the contaminated sediment with a cutterhead or jet-suction head with pipeline conveyance or hopper barge conveyance to the sediment management area.
- If necessary, transportation of dredge material to waterside offloading area via hopper barge.

- If necessary, transload dredged sediment from hopper barges to a lined sediment management area with either mechanical or hydraulic processes.
- Sediment is dewatered with geotextile tubes or mechanical dewatering equipment (e.g., presses or centrifuges). Both passive and mechanical dewatering options will require polymer conditioning to facilitate solids/water separation and consolidation.
- Addition of a stabilization reagent to the sediment may be required to enhance dewatering processes as well as improve the compaction potential and/or strength of the dewatered sediment prior to transportation and disposal in a commercial landfill.
- Filtrate water is collected in a sump and pumped to the water treatment plant prior to discharge.
- Confirmation sampling and surveying to verify contaminated sediment was removed and target depths were reached, respectively.

Assumptions

- The dredge prism is easily accessible.
- A nearby footprint with water access is available for construction of the sediment management area.
- Removal of debris is not required prior to hydraulic dredging.
- All dredged sediment will be processed simultaneously, and sand separation and collection provides no advantages.
- Clay or another confining sediment layer is not within the dredge prism.
- No long lead items have been identified.
- Experienced contractors are regionally located, and dredging equipment is readily available.
- Capping or ICs are not required post-dredging as recontamination is not expected. Natural sediment deposition and sediment mixing (bioturbation and prop wash) is expected within the Slip.
- Potential for recontamination is low.
- Potential for flux from groundwater sources is low.
- Natural sediment deposition of fine sediment occurs quickly in the Slip such that benthos recolonization occurs.

A dual polymer program of ChemTreat coagulant P822L (208 ppm) followed by ChemTreat anionic flocculant 816E (177 ppm) was identified as the best performer for a 5% sediment slurry bast on release of filtrate volume and clarity. Geotextile tube pillow tests dewatered C Street sediment slurries (5% solids) to greater than 59.9% solids in 7-d dewatering time with a filtrate total suspended solids of 147 mg/L. Although the filter cake passed a PFT, 5% Calciment admixture was required to increase UCS to greater than 3,000 lb/ft2 (96-h cure time). Filtrate collected from the geotextile tube did not have detectable concentrations of VOCs and mercury. Four SVOCs were detected at concentrations less than 0.04 µg/L. Dry weight solids of these amended sediment samples increased from 59.9% to 94.1% and 90.9% for 5% Calciment™ and 10% Portland cement admixtures, respectively.

Technical Feasibility

Hydraulic dredging is an effective alternative mitigating for the RAOs of the C Street Slip as a standalone option as potential exposure of fish and benthos to contaminated sediment would be eliminated in both the short- and long-term. In the short-term, dredging would simultaneously eliminate the contaminated source material as well as the existing benthos community. As long as the contaminated sediment and associated contact water were processed appropriately and transported to a licensed commercial landfill, the risk of future risk is eliminated. Hydraulic dredging is not an effective approach for dredging clay and/or other consolidated sediment layers and would not be recommended for retention if significant clay is targeted within the dredge prism. If vertical delineation is incomplete or it's unclear if the target COCs have contaminated the confining clay layer, confirmation sampling may be recommended prior to a polishing pass or additional dredging until "clean" sediment is reached.

No specialized equipment or long-lead items have been identified. Qualified contractors and equipment are located throughout the Great Lakes region. The construction window for the site is small and thus mobilization efficiency will be crucial to make the most of the time for dredging and sediment processing.

Economic Feasibility

Costs of hydraulic dredging and ex situ sediment management for C Street Slip are predicted to be high compared to other sediment removal alternatives due to the additional costs associated with ex situ sediment management and disposal. ICs will not be required but long-term monitoring may be required.

Additional Requirements

Hydraulic dredging may be implemented in C Street Slip with engineering controls and best management practices (e.g., turbidity curtains) to manage resuspension of contaminated sediments during dredging. Additionally, a pre-design investigation will be required prior to a full design of the project including but not limited to a bathymetric survey, H&H modeling and/or sediment transport modeling.

Natural recovery processes and benthos recolonization of surficial sediment would occur quickly. ICs would not be required. C Street Slip is an industrial waterway and this alternative does not eliminate the potential for recontamination of surficial sediment if contaminant sources were not identified and eliminated. Monitoring of the Slip is assumed to be required to track recovery and confirm recontamination does not occur over time.

Hydraulic Dredging is a long-term effective alternative, mitigating impacts to the fish and benthos communities (BUIs Nos. 1 and 4) in C Street Slip. Removing the contaminated sediment removes the potential for exposure of contaminants in the future and is retained for further consideration as a standalone option.

Evaluation Criteria	Alternative - 7
Threshold Criteria	
Overall Protectiveness of Public Health and the Environment	✓
Compliance with ARARs	✓
Evaluation Criteria	
Long-term Effectiveness	◕
Short-term Effectiveness	◑
Implementability	◑
Restoration Time Frame	◕
Economic Feasibility	$$$
Additional Requirements	◕

Legend	Balancing Criteria:	
Threshold Criteria:	○ = Low	◕ = Moderate to High
X = Does not Satisfy Criterion	◔ = Low to Moderate	● = High
✓ = Satisfies Criterion	◑ = Moderate	$$$ = Cost Ranking

6.3.6 Alternative 9 - Dredging and Capping

This alternative consists of dredging (mechanical or hydraulic) contaminated sediment hot spots, processing the material in a designated onsite sediment management area (dewatering and/or stabilizing) and capping the entire target area with an amended or sand cap. Dredging progress and productivity will be tracked and monitored real-time with GIS-based surveying technology (e.g., HyPack, DredgePack). Either hydraulically dredge the sediment and pump it directly via pipeline (with or without booster pumps) to the sediment management area for dewatering using passive (e.g., geotextile tubes) or mechanical (e.g., belt-filter presses, plate-and-frame presses, centrifuges) equipment to contain, dewater and consolidate the slurry or mechanically dredge with an environmental, clam shell bucket and transfer the material into the sediment management area via trucks or hopper barges. Hopper barge(s) may transport the sediment to the sediment management area if a suitable riverfront footprint is available for transloading barges. In both scenarios, the sediment needs to be dewatered and stabilized to generate filter cake suitable for transportation and disposal. Although the risk of fish and benthos exposure to contaminated sediment is eliminated by dredging, it is possible that residual contaminants are missed and remain in the target area. Amended or unamended sediment capping is used to further isolate the impacted area and further reduce the risk of exposure.

By removing the contaminated sediments from C Street Slip that are greater than PRG values, the risk of contaminated sediment exposure to the fish and benthos community is eliminated. Sediment capping is subsequently used to cover the target area and further eliminate the potential for exposure to residual COCs missed during the investigation or subsequent dredging. The remedial activities for Alternative 9 are:

- Pre-design Investigation
  - Bathymetric survey of the sediment surface of the target area prior to cap placement.
  - Dewatering and S/S treatability tests to identify sediment management strategies and associated efficacy to refine design assumptions.
  - Measure sediment deposition rate and perform sediment transport modeling.
  - Treatability tests to identify amendment(s), mix ratios and cap thickness.
- Hydraulic or mechanical dredging of the contaminated sediment hot spots and conveyance to the sediment management area.
- If necessary, transportation of mechanically dredged material to waterside offloading area via hopper barge. Transload dredged sediment from hopper barges to a lined sediment management area with either mechanical or hydraulic processes.
- If necessary, pumping of hydraulically dredged material to the sediment management area. Sediment is dewatered with geotextile tubes or mechanical dewatering equipment (e.g., presses or centrifuges).
- Addition of a stabilization reagent to the sediment may be required to enhance dewatering processes as well as improve the compaction potential and/or strength of the dewatered sediment prior to transportation and disposal in a commercial landfill.
- Filtrate water is collected in a sump and pumped to the water treatment plant prior to discharge.
- Mechanical or hydraulic placement of sand/amendment blended layer from a mix tank or hopper barge.
- Confirmation sampling and surveying to verify cap thickness and coverage across the target area.
- Stone armoring if required.
- Long-term monitoring for cap and armor stone stability and integrity as well as benthos community recolonization.
- ICs may be required for all or part of the Slip.

Assumptions

- The dredge prism is easily accessible.
- A nearby footprint with water access is available for construction of the sediment management area.
- Removal of debris is not required prior to dredging.
- All dredged sediment will be processed simultaneously, and sand separation and collection provide no advantages.
- No long lead items have been identified.
- Experienced contractors are regionally located, and dredging equipment is readily available.
- ICs are required post-capping as recontamination is not expected. Natural sediment deposition and sediment mixing (bioturbation and prop wash) is expected within the Slip.
- Potential for recontamination is low.
- Potential for flux from groundwater sources is low.
- Natural sediment deposition of fine sediment occurs quickly in the Slip such that benthos recolonization occurs.
- Infrastructure and other debris will not interfere with cap placement and stability.
- Prop wash, scour and other Slip activities will not impact cap integrity.
- Materials for cap construction are locally available.

Technical Feasibility

Hot spot dredging followed by sediment capping of the target area is an effective alternative mitigating for the RAOs of C Street Slip as a standalone option as potential exposure of fish and benthos to contaminated sediment would be eliminated in both the short- and long-term. In the short-term, dredging would eliminate the contaminated source material as well as the existing benthos community. If residual contaminants remain after dredging, sediment capping would eliminate the risk of potential exposure from these residual materials.

No specialized equipment or long-lead items have been identified. Qualified contractors and equipment are located throughout the Great Lakes region. The construction window for the site is small and thus mobilization efficiency will be crucial to make the most of the time for dredging, sediment processing, and capping in one construction season.

Economic Feasibility

Costs of dredging, ex situ sediment management and cap placement for C Street Slip are predicted to be high compared to other sediment removal alternatives due to the additional costs associated with ex situ sediment management and disposal. Costs associated with the cap design and placement may be reduced if the thickness of the cap can be reduced as the highest concentrations of COCs have been removed. ICs and long-term monitoring may be required.

Additional Requirements

Dredging and capping may be implemented in C Street Slip with engineering controls and best management practices (e.g., turbidity curtains) to manage resuspension of contaminated sediments during dredging and cap material placement. Additionally, a pre-design investigation will be required prior to a full design of the project including but not limited to a bathymetric survey, H&H modeling and/or sediment transport modeling.

Natural recovery processes and benthos recolonization of surficial sediment would occur quickly. ICs may be required to limit damage to the cap. C Street Slip is an industrial waterway and this alternative does not eliminate the potential for recontamination of surficial sediment or the cap material if contaminant sources were not identified and eliminated. Monitoring of the Slip is assumed to be required to track recovery and confirm recontamination does not occur over time.

Dredging followed by sediment capping is a long-term effective alternative, mitigating impacts to the fish and benthos communities (BUIs Nos. 1 and 4) in C Street Slip. Removing and capping the contaminated sediment removes and eliminates the potential for exposure of contaminants in the future and is retained for further consideration as a standalone option.

Evaluation Criteria	Alternative - 9
Threshold Criteria	
Overall Protectiveness of Public Health and the Environment	✓
Compliance with ARARs	✓
Evaluation Criteria	
Long-term Effectiveness	◕
Short-term Effectiveness	◕
Implementability	◑
Restoration Time Frame	◕
Economic Feasibility	$$$
Additional Requirements	◑

Legend	**Balancing Criteria**:	
Threshold Criteria:	○ = Low	◕ = Moderate to High
X = Does not Satisfy Criterion	◔ = Low to Moderate	● = High
✓ = Satisfies Criterion	◑ = Moderate	$$$ = Cost Ranking

7. Conclusions

Potential remedial alternatives were evaluated and compared to one another based on effectiveness, restoration time, implementability and cost (**Table 7-1**). The following sediment management alternatives were identified to have the potential to achieve the RAOs for sediments in C Street Slip and effectively address tPAH and mercury measured in sediment concentrations greater than PRGs and were retained for further evaluation (**Table 7-2**):

- Alternative 1 – No Action
- Alternatives 4&5 – Sediment Cap (unamended and amended)
- Alternative 6 – Mechanical Dredging
- Alternative 7 – Hydraulic Dredging
- Alternative 99
- – Dredging and Capping

There are typically multiple process options within a remedial strategy that can be applied within the project area. Definitive alternatives evaluation using a more thorough set of criteria and cost estimation will be used to conceptually engineer and design several viable process option flows for mitigating impacted sediments in C Street Slip.

8. References

AECOM, 2010. *Sediment Investigation Results, Former MGP Site*, Superior, Wisconsin. April 2010.

AECOM, 2022a. *Field Sampling Plan for Superior Slip*. Prepared by AECOM Technical Services, Inc. for Wisconsin Department of Natural Resources. Revision 3. August 12, 2022.

AECOM, 2022b. *C Street Slip Historical Data Review Technical Memorandum*. Prepared by AECOM Technical Services, Inc. for Wisconsin Department of Natural Resources. August 1, 2022.

AECOM, 2022c. *Data Gap Treatability Report*. Prepared by AECOM Technical Services, Inc. for Wisconsin Department of Natural Resources. October 20, 2022.

AECOM, 2023a. *Supplemental Site Investigation Report*, Characterization of Sediments in the C Street Slip St. Louis River and Bay Area of Concern, Superior, Wisconsin. February 27, 2023. Revision 2.

AECOM, 2023b. *C Street Slip Remedial Investigation Summary*. Prepared by AECOM Technical Services, Inc. for Wisconsin Department of Natural Resources. April 12, 2023. Revision 2.

EA, 2016. *Site Characterization Report Assessment of Contaminated Sediments Superior Waterfront Characterization, St. Louis River and Bay Area of Concern, Superior Wisconsin*, prepared for the U.S. Environmental Protection Agency. February 12, 2016.

EA, 2021. Site Investigation Report, Characterization of Sediments in the North End District and Clough Island, St. Louis River and Bay Area of Concern, Superior, Wisconsin. June 2021.

ENSR, 2004. *Sediment Investigation Report, Former Manufactured Gas Plant, Superior Water, Light & Power, Superior, Wisconsin*, Document Number 09413-098-500. March 2004.

ET, 1999. *Site Investigation Report, Midwest Energy Backup Generator Site, Superior, Wisconsin*. October 1999.

Foth, 2019. *Site Investigation Report – Former Manufactured Gas Plant*. BRRTS # 02-16-275446. Prepared by Foth for Superior Water Light & Power. March 2019.

Foth, 2022a. *Summary of 2020 Pre-Design Investigation Results*. Prepared for Superior Water Light & Power. March 2022.

Foth, 2022b. *Draft Remedial Action Options Report – Sediment Area Former Manufactured Gas Plant, St. Louis River Area of Concern*. Prepared for Superior Water Light & Power. April 2022.

ITRC, 2014. Interstate Technology & Regulatory Council's (ITRC) Guidance Document on Remedy Selection for Contaminated Sediments. August 2014. (https://projects.itrcweb.org/contseds_remedy-selection/)

MPCA, 1997. *Sediment Assessment of Hotspot Areas in the Duluth/Superior Harbor*. Prepared for US Environmental Protection Agency. December 1997.

MPCA and WDNR, 2022. St. Louis River Area of Concern 2022 Remedial Action Plan. Minnesota Pollution Control Agency and Wisconsin Department of Natural Resources. Available at https://dnr.wisconsin.gov/topic/GreatLakes/StLouis.html

NOAA, 2022. Duluth, MN Superior Lake Gauge Station 9099064. (https://tidesandcurrents.noaa.gov/stationhome.html?id=9099064)

Summit, 2017. *Supplemental Site Investigation Report for the Former Manufactured Gas Plant*. Prepared by Summit Envirosolutions, Inc. for Superior Water Light & Power. October 2017.

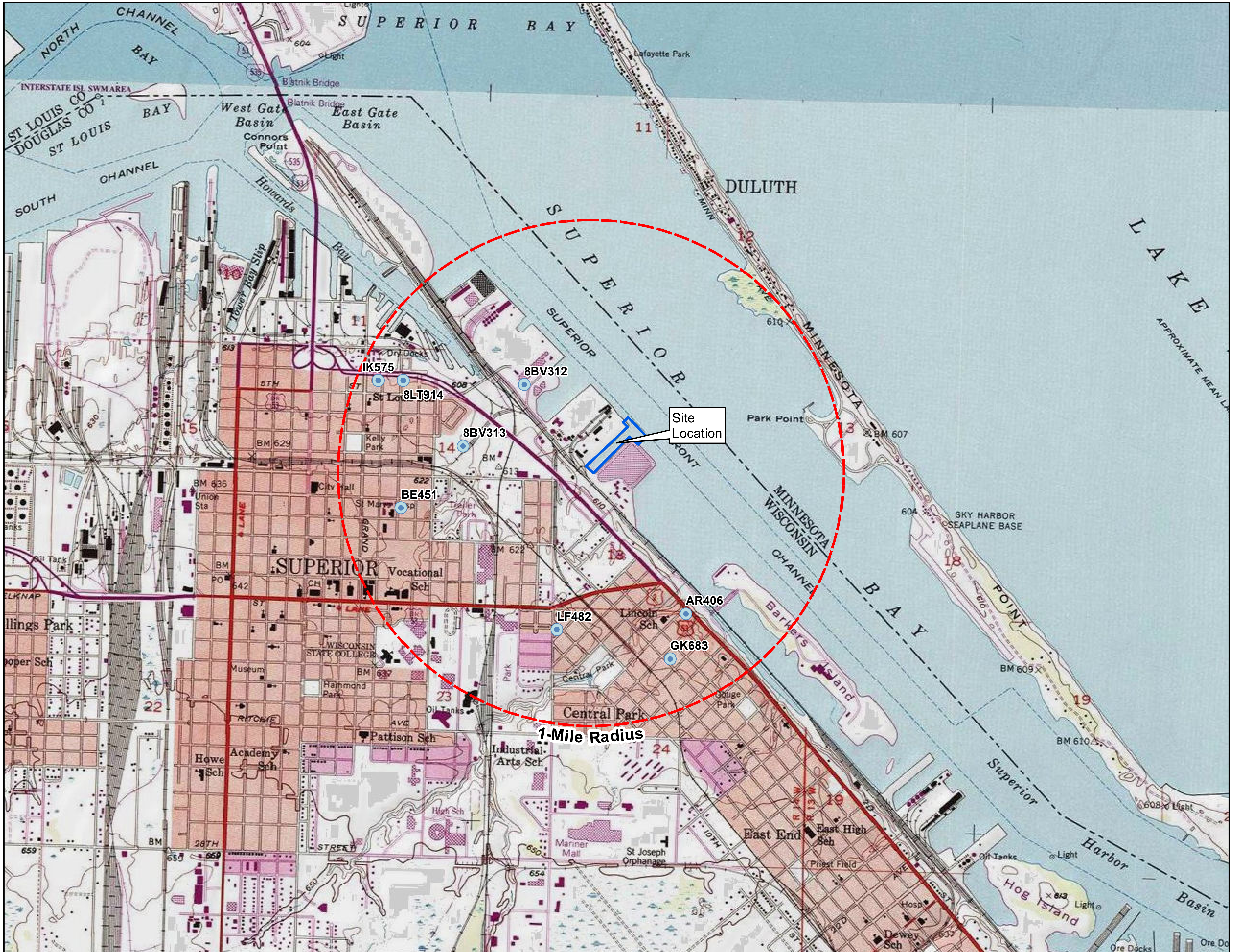
USEPA, 2005. United States Environmental Protection Agency, Office of Solid Waste and Emergency Response, Contaminated Sediment Remediation Guidance for Hazardous Waste Sites, EPA-540-R-05-012. December 2005. (https://semspub.epa.gov/work/HQ/174471.pdf)

WDNR, 2001. Internal memorandum from Tom Janisch to Jim Hosch regarding "Preliminary Evaluation of the Sediment Sampling Results From Cores Taken From the Superior Harbor Inlet Potentially Impacted by the Former Operations of the Superior Manufactured Gas Plant," File Ref. 3200. January 11, 2001.

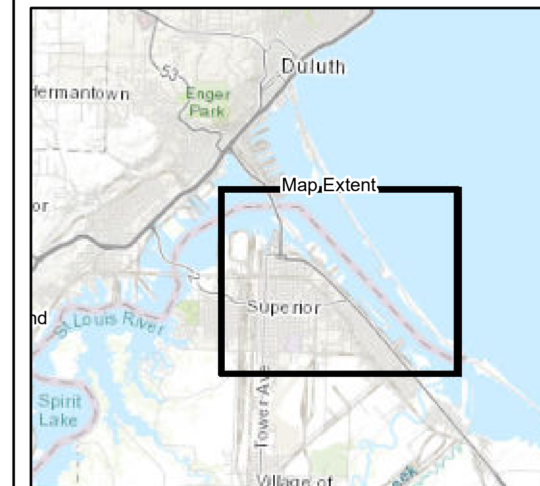
WDNR. 2022. Wisconsin Department of Natural Resources. 2022. Professional Services Request for Proposals (RFP) and Scope of Work (SOW) for Feasibility Studies & Preliminary Designs for Contaminated Sediment Remediation in the Superior Slips Revision 1. April 20, 2022.

Wisconsin Geological and Natural History Survey [WGNHS], 1982. Mudrey, M.G., Jr.; Brown, B.A.; Greenberg, J.K.; *Bedrock Geologic Map of Wisconsin*. WGNHS. 1982. (https://wgnhs.wisc.edu/catalog/publication/000390/resource/m078paper)

Figures



VICINITY MAP



Legend

- Water Supply Well
- C-Street Slip
- 1-Mile Radius

Source:
USGS 7-5 Minute Topographica Map
Superior and Duluth Quadrangles

Wisconsin Department of Natural Resources -
Bureau of Drinking Water and Groundater

N

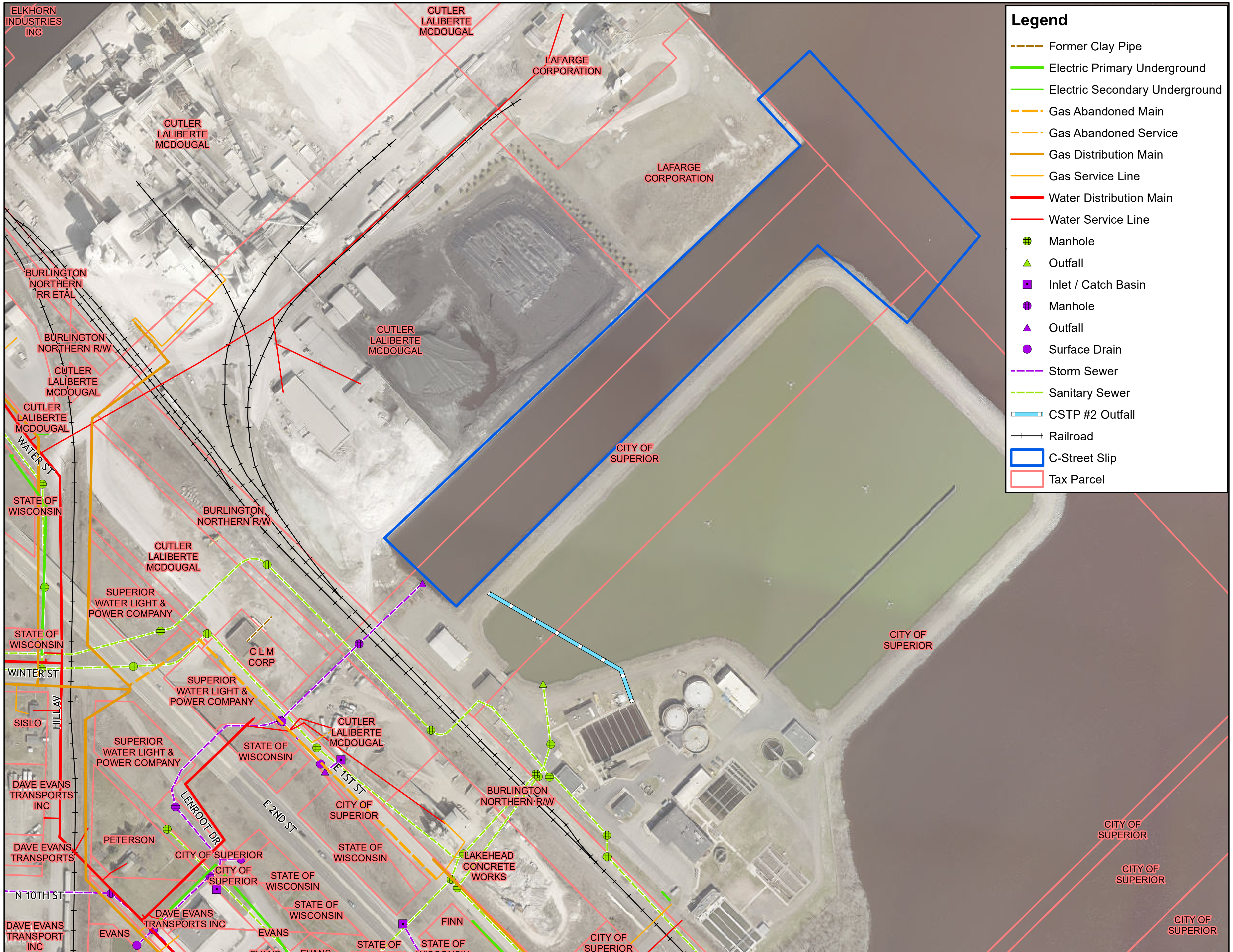
0 1,000 2,000 4,000
Feet

AECOM

Title:	Site Location C-Street Slip
Project:	Remedial Alternatives Report Superior, Wisconsin
Client:	Wisconsin DNR
File Name:	Site Map C Street.mxd

Project No.:	Date:	Figure:
60685299	4/22/2023	1-1

Path: L:\DCS\GIS\Projects\Superior\MXD\C Street\Site Map C Street.mxd



Legend

- Former Clay Pipe
- Electric Primary Underground
- Electric Secondary Underground
- Gas Abandoned Main
- Gas Abandoned Service
- Gas Distribution Main
- Gas Service Line
- Water Distribution Main
- Water Service Line
- Manhole
- Outfall
- Inlet / Catch Basin
- Manhole
- Outfall
- Surface Drain
- Storm Sewer
- Sanitary Sewer
- CSTP #2 Outfall
- Railroad
- C-Street Slip
- Tax Parcel

VICINITY MAP

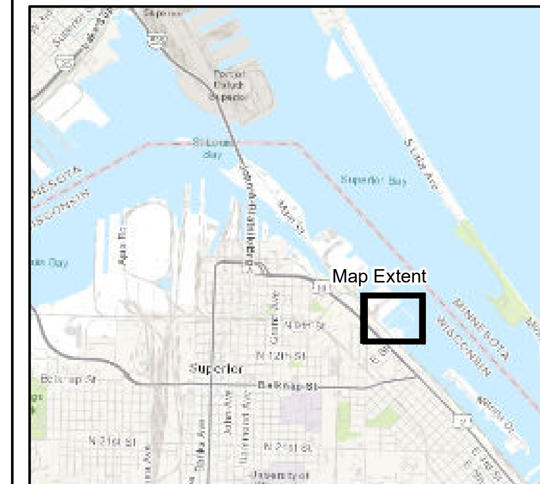


Image Source: Douglas County
Image Date: 2022

Storm and Sanitary Sewer Data
The City of Superior

Utility data from Superior Water, Light & Power

Parcel data from the City of Superior/Douglas County

N

0 100 200 400
Feet

AECOM

Title: **Current Site Layout C-Street Slip**

Project: Remedial Alternatives

Superior, Wisconsin

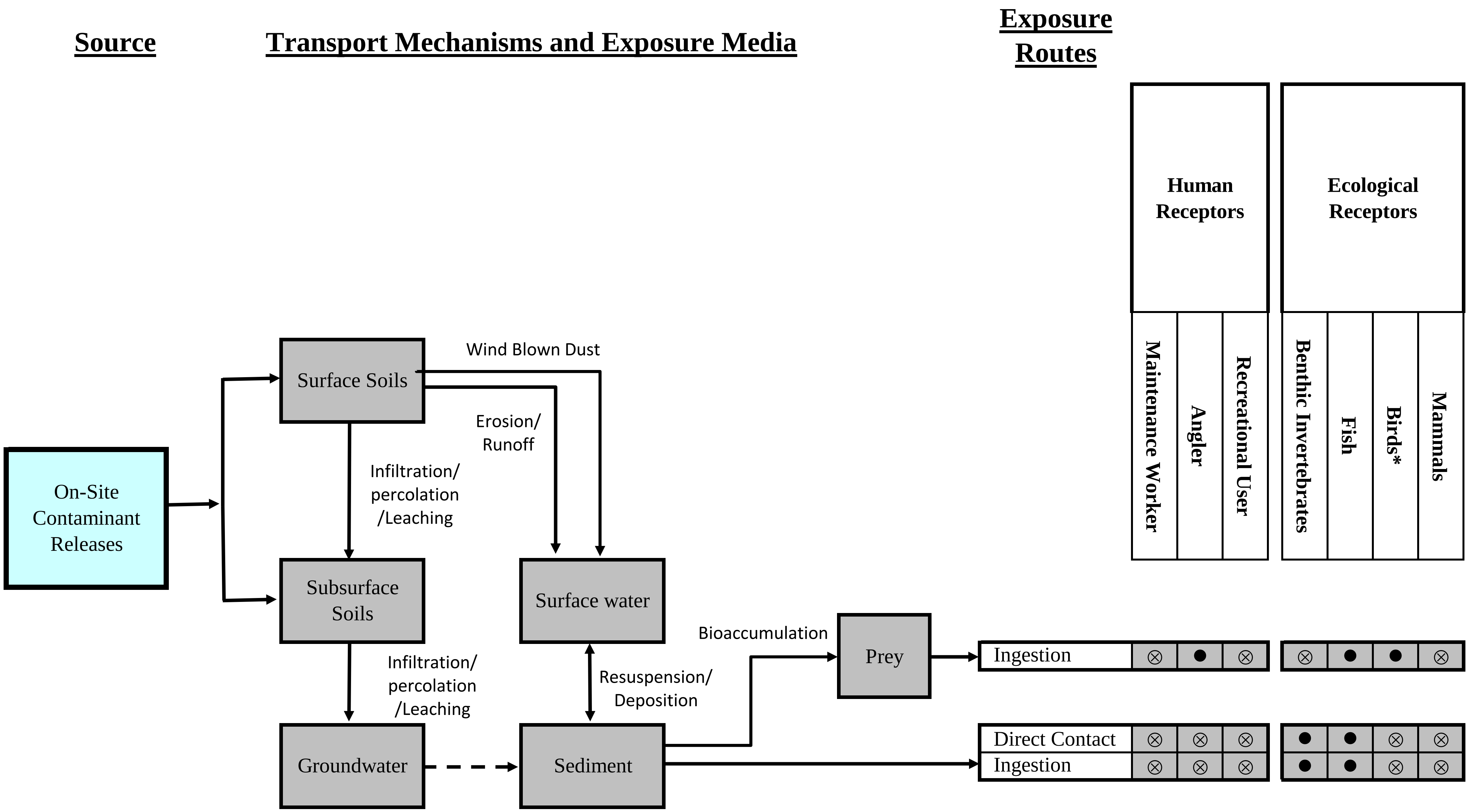
Client: Wisconsin DNR

File Name: Site Layout C Street.mxd

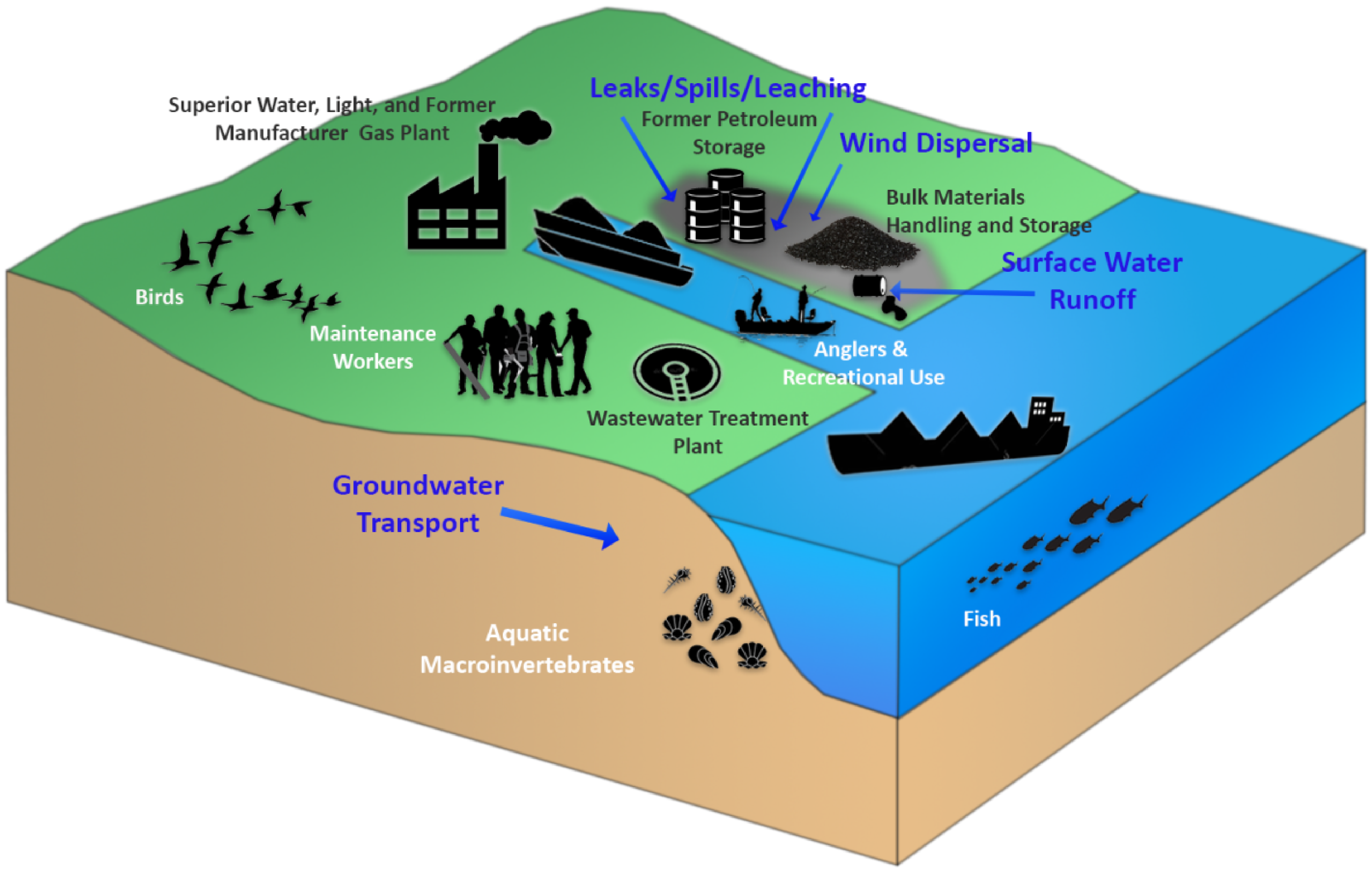
Project No.:	Date:	Figure:
60685299	5/15/2023	2-1

Path: L:\DCS\GIS\Projects\Superior\MXD\C Street\Site Layout C Street.mxd

FIGURE 3-1: Conceptual Site Model
C Street Slip Sediments
Superior, Wisconsin



NOTEs:
——— Potentially complete pathway
– – – – Incomplete, or potentially complete but insignificant pathway
* - invertivores, carnivores
● = Potentially complete exposure pathway
⊗ = Potentially complete but insignificant or not assessed



TITLE

C Street Conceptual Site Model (graphic)

AECOM

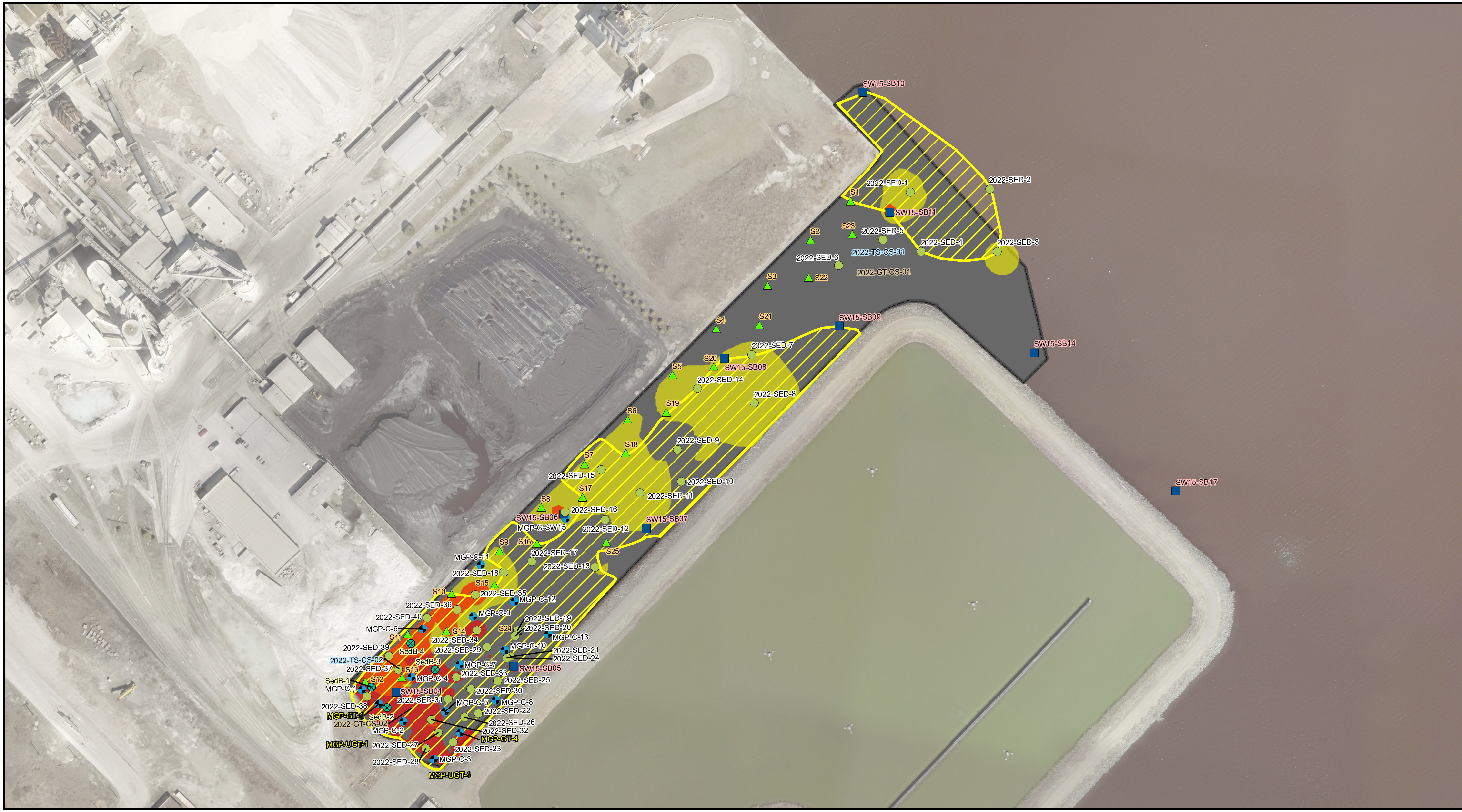
AECOM TECHNICAL SERVICES, INC.
SOUTHFIELD, MI., 248-204-5900

FINAL

NOTE: FOR INFORMATIONAL PURPOSES ONLY

NOT A PROFESSIONAL SURVEY
ALL LOCATIONS/DIMENSIONS ARE APPROXIMATE

DATE 3/08/23	JOB NO 60685299
DR DW	SKETCH NO.
CK KD	FIG. 3-2



Path: \\na.aecomnet.com\lfs\AMER\Houston-USHOU2\DCS\GIS\Projects\Superior\MXD\C Street\3-3 C St_Extent of Contamination.mxd

Legend

- 2022 Sediment Sample Location (AECOM)
- 2020 Sediment Sample Location (Foth)
- 2017 Sediment Sample Location (Summit)
- 2015 Sediment Sample Location (EA)
- 2010 Sediment Sample Location (AECOM)
- Total PAH Plume (12,205 ug/kg)
- Mercury Plume (590 ug/kg)
- BUI No.5 Exceedance Footprint
- Estimated extent of contamination above MEC for any detected analyte

NOTES:

1. SQG exceedances presented are for any COC (PAHs, SVOCs, TPAHs, metals, and organotins) analyzed and detected above MEC for the site.
2. The plumes for Total PAHs and Mercury was developed in EVS software.

N

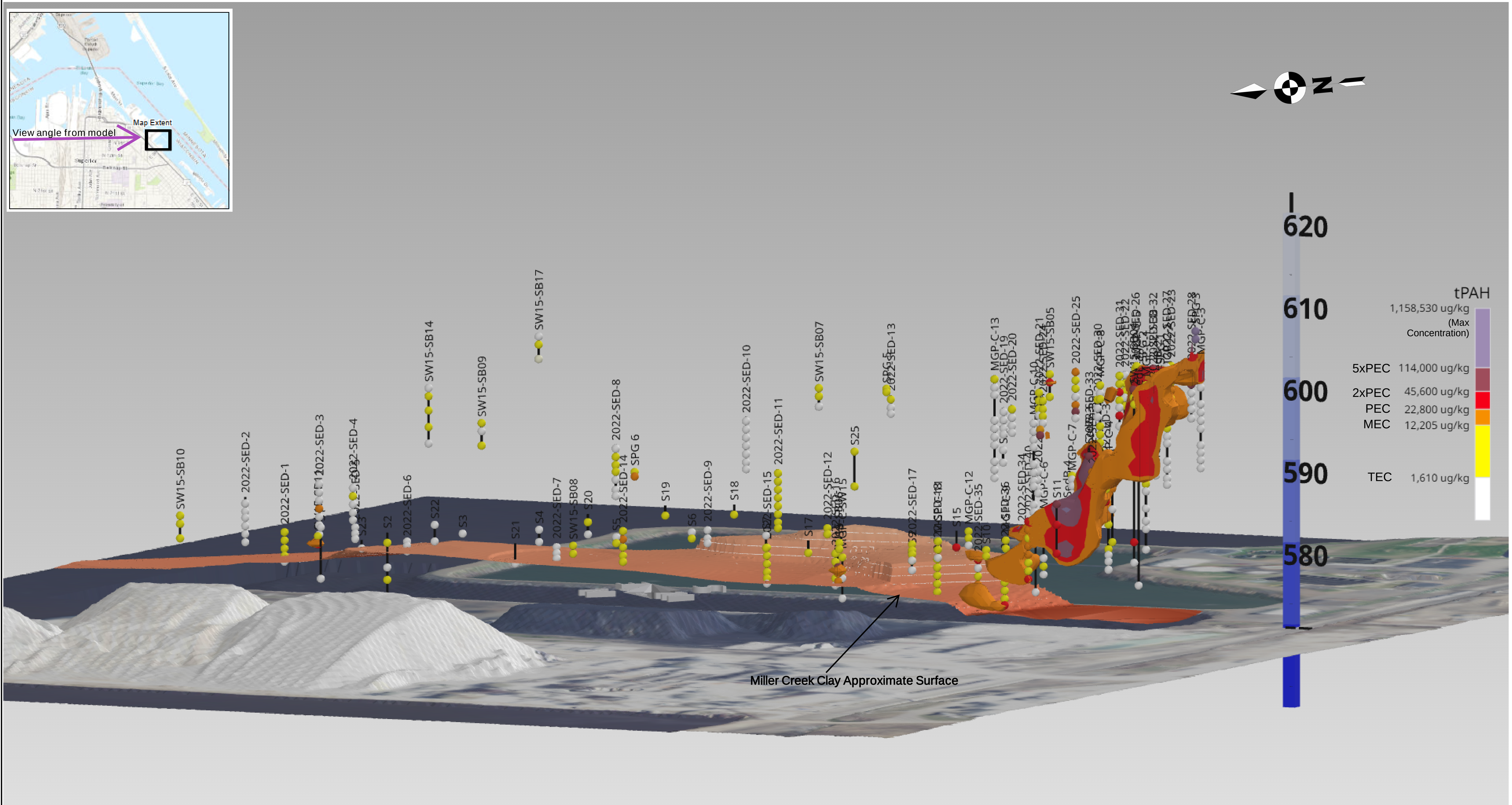
0 75 150 300

Feet

AECOM

Title:	Extent of Contamination
Project:	C-Street Slip Superior, Wisconsin
Client:	Wisconsin DNR

Scale:	Drawn by:	Date:	Project No.:	File Name:	Figure:
As Shown	AA	6/20/2023	60685299	3-3 C St_Extent of Contamination.mxd	3-3
	Chk'd by: KD	Date: 6/20/2023			



Aerial image is displaced downward for spatial reference.

TITLE

TOTAL PAHs, SURFACE AND SUBSURFACE ANALYTICAL SUMMARY, C STREET

AECOM

AECOM TECHNICAL SERVICES, INC.
SOUTHFIELD, MI., 248-204-5900

FOR INFORMATIONAL PURPOSES ONLY

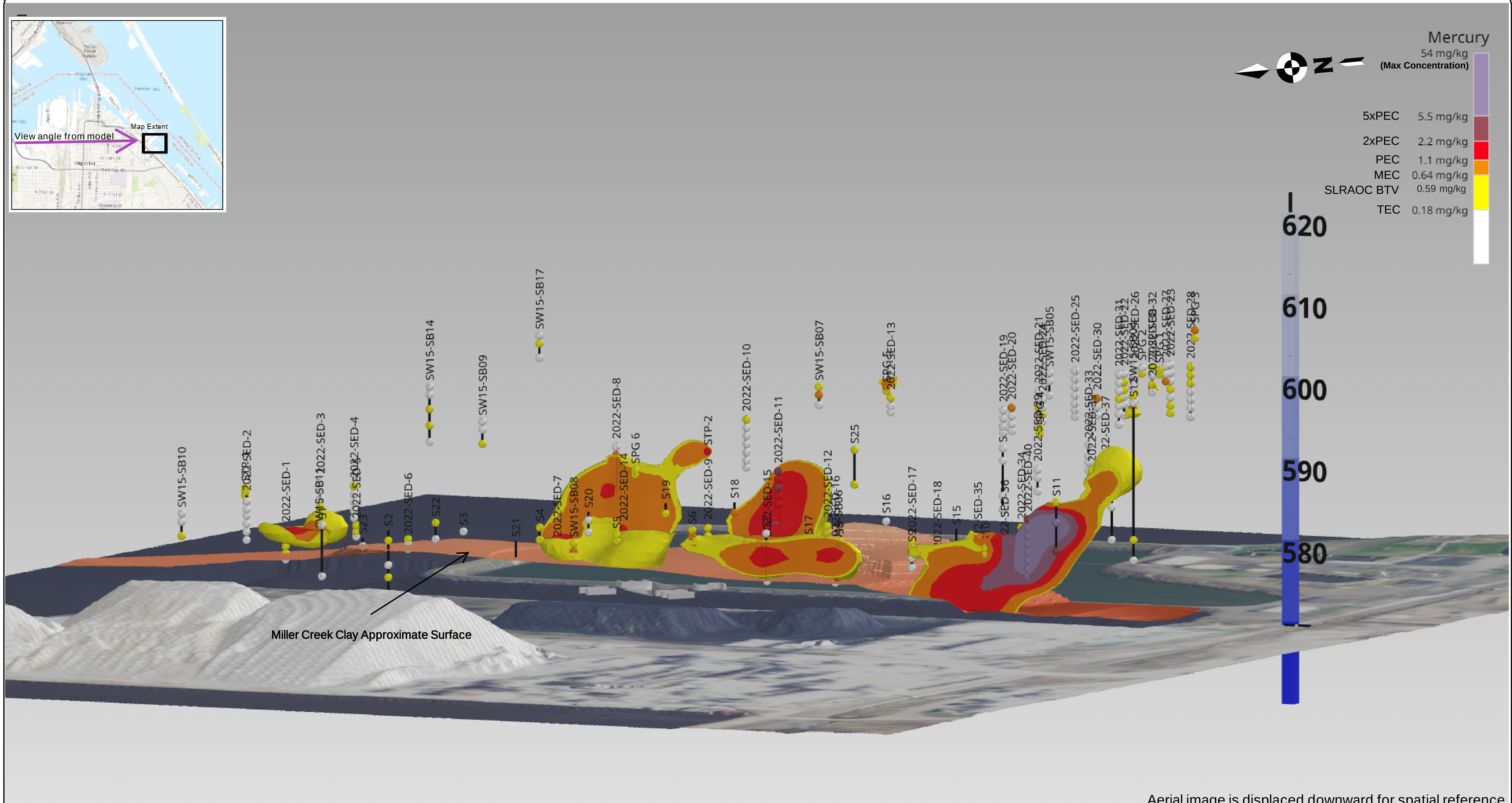
NOTE: THE PLUME REPRESENTS CONTAMINATION ABOVE 12,205 µg/kg (1 X MEC)

Constituent	PRG = 1x MEC	
	µg/kg	yd^3
Total PAHs	12,205	3,212

NOT A PROFESSIONAL SURVEY
ALL LOCATIONS/DIMENSIONS ARE APPROXIMATE

DATE 06/01/23	JOB NO 60685299
DR KD	SKETCH NO.
CK JS	FIG. 4-1

Y:\Projects\WDNR\SaintLouisBaySlips\MXDs\C Street Total PAH.mxd



TITLE

MERCURY SURFACE AND SUBSURFACE ANALYTICAL SUMMARY, C STREET

AECOM

AECOM TECHNICAL SERVICES, INC.
SOUTHFIELD, MI., 248-204-5900

FOR INFORMATIONAL PURPOSES ONLY

NOTE: THE PLUME REPRESENTS CONTAMINATION ABOVE THE PRG OF 0.59 mg/kg (SLRAOC BACKGROUND BTV)

Constituent	PRG = SLRAOC	
	mg/kg	yd^3
Mercury (Hg)	0.59	12,548

NOT A PROFESSIONAL SURVEY
ALL LOCATIONS/DIMENSIONS ARE APPROXIMATE

DATE 06/01/23	JOB NO 60685299
DR KD	SKETCH NO.
CK JS	FIG. 4-2

Y:\Projects\WDNR\SaintLouisBaySlips\MXDs\C Street Mercury.mxd

Tables

Table 4-1
Sediment Analytical Results-BUI #5 Assessment
C Street Slip - Superior, WI

Samples that Exceed BUI #5 Criteria				Chemical Name							
Location ID	Sample ID	Start Depth (ft bss)	End Depth (ft bss)	Arsenic	Benzo (a) anthracene	Benzo (a) pyrene	Benzo (b) fluoranthene	Dibenz (a,h) anthracene	Indeno (1,2,3-cd) pyrene	Mercury	Naphthalene
2022-SED-1	2022-SED-1(0-1)	0	1							X	
2022-SED-11	2022-SED-11 (7-7.4)	7	7.4							X	
2022-SED-15	2022-SED-15(4-4.5)	4	4.5							X	
2022-SED-23	2022-SED-23(5-6)	5	6			X					X
2022-SED-23	2022-SED-23(6-6.9)	6	6.9			X					
2022-SED-25	2022-SED-25 (5-5.6)	5	5.6			X					
2022-SED-28	2022-SED-28(1-2)	1	2			X					
2022-SED-28	2022-SED-28(2-3)	2	3			X					
2022-SED-32	2022-SED-32(0-1)	0	1			X					
2022-SED-32	2022-SED-32(1-2)	1	2			X					
2022-SED-33	2022-SED-33(1.5-2)	1.5	2			X					
2022-SED-34	2022-SED-34(0-1)	0	1			X					
2022-SED-36	2022-SED-36(1-2)	1	2			X					
2022-SED-36	2022-SED-36(2-3)	2	3							X	
2022-SED-37	2022-SED-37 (0-1)	0	1			X					
2022-SED-37	2022-SED-37 (1-2)	1	2			X					
2022-SED-38	2022-SED-38 (0-1)	0	1			X					
2022-SED-39	2022-SED-39(1-2)	1	2								X
2022-SED-39	2022-SED-39(2-3)	2	3								X

Table 4-1
Sediment Analytical Results-BUI #5 Assessment
C Street Slip - Superior, WI

Samples that Exceed BUI #5 Criteria				Chemical Name							
Location ID	Sample ID	Start Depth (ft bss)	End Depth (ft bss)	Arsenic	Benzo (a) anthracene	Benzo (a) pyrene	Benzo (b) fluoranthene	Dibenz (a,h) anthracene	Indeno (1,2,3-cd) pyrene	Mercury	Naphthalene
2022-SED-40	2022-SED-40(0-1)	0	1							X	
2022-SED-40	2022-SED-40(1-2)	1	2							X	
2022-SED-40	2022-SED-40(2-3)	2	3							X	
2022-SED-40	2022-SED-40(3-4)	3	4							X	
2022-SED-40	2022-SED-40(4-5)	4	5							X	
2022-SED-40	2022-SED-40(5-6)	5	6							X	
2022-SED-40	2022-SED-40(6-7)	6	7							X	
2022-SED-40	2022-SED-40(6-7)DUP	6	7							X	
2022-SED-40	2022-SED-40(7-8)	7	8							X	
SedB-2	B2-1-3	1	3			X					
SedB-3	B3-0-2	0	2			X					
SedB-3	B3-2-4	2	4			X					
SedB-4	B4-0-2	0	2		X	X	X	X	X		X
SedB-4	B4-6-7	6	7		X	X	X	X			
MGP-C-1	MGP-C-1-10-11	10	11			X					
MGP-C-1	MGP-C-1-11-12	11	12			X					
MGP-C-1	MGP-C-1-1-2	1	2			X		X			
MGP-C-1	MGP-C-1-2-3	2	3			X					
MGP-C-1	MGP-C-1-3-3.5	3	3.5			X					
MGP-C-1	MGP-C-1-5-6	5	6			X					
MGP-C-1	MGP-C-1-7-8.3	7	8.3			X					
MGP-C-2	MGP-C-2-5-6	5	6			X					

Table 4-1
Sediment Analytical Results-BUI #5 Assessment
C Street Slip - Superior, WI

Samples that Exceed BUI #5 Criteria				Chemical Name							
Location ID	Sample ID	Start Depth (ft bss)	End Depth (ft bss)	Arsenic	Benzo (a) anthracene	Benzo (a) pyrene	Benzo (b) fluoranthene	Dibenz (a,h) anthracene	Indeno (1,2,3-cd) pyrene	Mercury	Naphthalene
MGP-C-3	MGP-C-3-1-2	1	2			X					
MGP-C-3	MGP-C-3-2-3	2	3			X					
MGP-C-4	MGP-C-4-2-3	2	3			X					
MGP-C-4	MGP-C-4-5-6	5	6			X					
MGP-C-4	MGP-C-4-6-7	6	7			X					
MGP-C-6	MGP-C-6-3-3.8	3	3.8			X					
S11	S11_17.5-18	17.5	18			X					
S11	S11_18-22.5	18	22.5							X	
S11	S11_22.5-25	22.5	25			X					
S14	S14_28-30	28	30	X							
S7	S7_23.5-26DUP	23.5	26							X	
S9	S-9_24.5-25	24.5	25							X	
SD3	SD3-0-1	0	1			X					
SPG 1	SPG-1D	Unknown-Deep	Unknown-Deep	X							
SPG 1	SPG-1S	Unknown-Shallow	Unknown-Shallow	X		X					
SPG 2	SPG-2D	Unknown-Deep	Unknown-Deep	X		X					
SPG 2	SPG-2S	Unknown-Shallow	Unknown-Shallow	X							
SPG 3	SPG-3D	Unknown-Deep	Unknown-Deep	X		X					X
SPG 3	SPG-3S	Unknown-Shallow	Unknown-Shallow	X		X					X
SPG 4	SPG-4D	Unknown-Deep	Unknown-Deep	X		X					
SPG 5	SPG-5S	Unknown-Shallow	Unknown-Shallow	X							
SPG 6	SPG-6D	Unknown-Deep	Unknown-Deep	X							

Table 4-1
Sediment Analytical Results-BUI #5 Assessment
C Street Slip - Superior, WI

Samples that Exceed BUI #5 Criteria				Chemical Name							
Location ID	Sample ID	Start Depth (ft bss)	End Depth (ft bss)	Arsenic	Benzo (a) anthracene	Benzo (a) pyrene	Benzo (b) fluoranthene	Dibenz (a,h) anthracene	Indeno (1,2,3-cd) pyrene	Mercury	Naphthalene
SPG 6	SPG-6S	Unknown-Shallow	Unknown-Shallow	X							
SW15-SB04	SW15-SB04-2040	2	4			X					
SW15-SB04	SW15-SB04-SURF	0	0.5			X					
SW15-SB06	SW15-SB06-0520	0.5	2			X					
SW15-SB06	SW15-SB06-0520-FD	0.5	2			X					

Footnotes:
BUI #5 Criteria = Must exceed WDNR-SO-IND-RCL and WDNR-SO-BKG (if available)
BUI = Beneficial Use Impairment
WDNR = Wisconsin Department of Natural Resources
RCL = Residual Contaminent Level
WDNR-SO-IND-RCL = The Industrial Soil Direct Contact RCL (Wis. Admin. Code NR 720)
WDNR-SO-BKG = The Soil Background RCL (Wis. Admin. Code NR 720)
ft bss = feet below sediment surface

Table 7-1. Comparison of potential remedial alternatives for mitigating sediment RAOs in C Street Slip contaminated with tPAHs and/or mercury.

Evaluation Criteria	Alternative 1	Alternative 4	Alternative 5	Alternative 6	Alternative 7	Alternative 9
	No Action	Unamended Sediment Cap	Amended Sediment Cap	Mechanical Dredge	Hydraulic Dredge	Dredge and Cap
Threshold Criteria						
Overall Protectiveness of Public Health and the Environment	X	✓	✓	✓	✓	✓
Compliance with Applicable, Relevant, and Appropriate Requirements (ARARs)	X	✓	✓	✓	✓	✓
Evaluation Criteria						
Long-term Effectiveness	○	◔	◔	◕	◕	◕
Short-term Effectiveness	○	◑	◑	◑	◑	◕
Implementability	●	◑	◑	◑	◑	◑
Restoration Time Frame	○	◑	◑	◕	◕	◕
Economic Feasibility	$	$$	$$	$$$	$$$	$$$
Additional Requirements	○	◑	◑	◕	◕	◑

<u>Threshold Criteria:</u>
X = Does not Satisfy Criterion
✓ = Satisfies Criterion

<u>Balancing Criteria:</u>
○ = Low
◔ = Low to Moderate
◑ = Moderate
◕ = Moderate to High
● = High
$$$ = Cost Ranking

Table 7-2. Nine general remedial alternative processes were compared, retained and/or eliminated for future evaluation based on effectiveness, restoration time, implementability and cost.

Process Options	Screening Status	Long-Term & Short-Term Effectiveness	Restoration Time Frame	Implementability	Economic Feasibility	Additional Requirements
No Action (Alternative 1)	**Required for Evaluation**	Does not meet the RAOs for this project. Minimal natural attenuation possible due to biodegradation.	Years to decades	Not applicable	None	None
Institutional Controls (Alternative 2)	**Eliminated**, not effective in mitigating for RAOs.	Does not meet the RAOs for this project.	Years to decades to observe minimal degradation or sediment deposition.	Easy to implement. Used in conjunction with other alternatives.	Low	A qualified person who is responsible for O&M is required to ensure ICs impose 24/7 compliance.
Enhanced Monitored Natural Recovery (Alternative 3)	**Eliminated**, not effective in mitigating for RAOs.	EMNR (biodegradation or sediment deposition) may be effective in meeting RAOs but requires a long period of time to be effective.	Biodegradation and attenuation rates are slow.	EMNR may be implemented as part of a larger remedial strategy such as post-dredging deposition, biostimulation and/or biodegradation to address residual tPAHs.	Low	EMNR may be implemented as part of a larger remedial strategy incorporating sediment removal alternatives, such as post-dredging deposition, biostimulation and/or biodegradation to address residual tPAHs.
Unamended Sediment Capping (Alternative 4)	**Retain**	Meets the RAOs for this project. Dredging prior to installation may be required to maintain navigation depth. Armoring and ICs required.	Years to observe recolonization; contamination remains in place, exposure pathways eliminated initially	Engineering controls and BMPs required to manage resuspension. Assumes cap materials are locally available.	Moderate	Sediment capping may be implemented with a few engineering controls and best management practices. A pre-design investigation will be required prior to a full design of the cap installation project including but not limited to a bathymetric survey, H&H modeling and/or sediment transport modeling. ICs would be required in perpetuity to eliminate dredging, construction, prop wash and scour to limit damage to the capped area.
Amended Sediment Capping (Alternative 5)	**Retain**	Meets the RAOs for this project. Use of an amendment layer will help mitigate upwelling of soluble COCs through the sediment and cap to surficial sediment. Dredging may be required to maintain navigation depth. Armoring and ICs required.	Years to observe recolonization; contamination remains in place, exposure pathways eliminated initially	Engineering controls and BMPs required to manage resuspension. Assumes cap materials are locally available.	Moderate	Amended capping may be implemented in C Street Slip with a few engineering controls and best management practices A pre-design investigation will be required prior to a full design of the cap installation project including but not limited to a bathymetric survey, H&H modeling and/or sediment transport modeling. ICs would be required in perpetuity to eliminate dredging, construction, prop wash and scour to limit damage to the capped area.
Mechanical Dredging (Alternative 6)	**Retain**	Meets the RAOs for this project. Removal of the sediment contaminated with tPAH and mercury concentrations greater than PRGs will eliminate risk in short- and long-term. ICs not required after dredging. Dredging does not protect from recontamination due to landside, surface water and/or groundwater sources.	Sustainable restoration is expected in a season or two	Contractors and equipment for this project are regionally available. The project is dependent on nearby, suitable land available for sediment processing or receipt of hopper barges for transloading.	High	Mechanical dredging may be implemented with engineering controls and best management practices (e.g., turbidity curtains). A pre-design investigation will be required prior to a full design of the project including but not limited to a bathymetric survey. Monitoring of the Slip is assumed to be required to track recovery and confirm recontamination does not occur over time.
Hydraulic Dredging (Alternative 7)	**Retain**	Meets the RAOs for this project. Removal of the sediment contaminated with tPAH and mercury concentrations greater than PRGs will eliminate risk in short- and long-term. Assumes dredging of clay or other confining sediment layers are not expected. ICs not required after dredging. Dredging does not protect from recontamination due to landside, surface water and/or groundwater sources.	Sustainable restoration is expected in a season or two	Contractors and equipment for this project are regionally available. The project is dependent on nearby, suitable land available for sediment processing or receipt of hopper barges for transloading.	High	Hydraulic dredging may be implemented with engineering controls and best management practices (e.g., turbidity curtains). A pre-design investigation will be required prior to a full design of the project including but not limited to a bathymetric survey, H&H modeling and/or sediment transport modeling. Monitoring of the Slip is assumed to be required to track recovery and confirm recontamination does not occur over time.
In situ Solidification and Stabilization (Alternative 8)	**Eliminated**, Target COCs remain in sediment, unpredictable effectiveness and restoration time.	Does not meet the RAOs for this project as the COCs remain in the sediment. Mixing of the sediment with a reagent potentially causes more harm than good.	The time to restoration is unpredictable but will take several seasons.	Contractors and equipment for this project are regionally available. The project is dependent on nearby, suitable land available for s/s admixture preparation.	Moderate to high depending on admixture and mix ratio	Bench-scale treatability testing identified that a 10% Calciment™ or Portland cement admixture may be sufficient to stabilize the sediment ex situ. Additional bench-scale testing is required to evaluate whether the 10% admixture is sufficient to limit contaminant leaching (i.e., toxicity characteristic leaching procedure [TCLP] or synthetic precipitation leaching procedure [SPLP]) as there is a mixture of organic and inorganic COCs.
Hot-spot Dredging and Capping (Alternative 9)	**Retain**	Meets the RAOs for this project. Removal of tPAH and mercury hot-spots will eliminate risk in short- and long-term. Dredging alone does not protect from recontamination due to landside, surface water and/or groundwater sources. Additional use of an engineered cap will decrease future exposure and mitigate risk due to potential recontamination.	Sustainable restoration is expected in a season or two	Contractors and equipment for this project are regionally available. The project is dependent on nearby, suitable land available for dredge sediment processing or receipt of hopper barges for transloading.	High	Dredging and capping may be implemented with engineering controls and best management practices (e.g., turbidity curtains). A pre-design investigation will be required prior to a full design of the project including but not limited to a bathymetric survey, H&H modeling and/or sediment transport modeling. ICs may be required to limit damage to the cap. Monitoring of the Slip is assumed to be required to track recovery and confirm recontamination does not occur over time.

Appendix A C Street Slip Sediments with Mercury or tPAH Concentrations Greater than PRG Values Based on EVS Model Interpolation

Appendix A – C Street Slip Sediments with Mercury or tPAH Concentrations Greater than PRG Values Based on EVS Model Interpolation

Constituents of concern (COCs) for C Street, mercury (Hg) and total polynuclear aromatic hydrocarbons (tPAH), were evaluated with EVS (Earth Volumetric Studio version 2022.10.2), geographic information system (GIS) software ArcGIS (Esri, version 10.8.1), and ArcPro (Esri, version 3.0).

EVS is a Windows program developed by C Tech Development Corporation that provides 3D modeling and advanced interpolation techniques, including 3-D Kriging and geologic indicator kriging (GIK), volumetric calculations, geostatistical analysis, and advanced visualization tools for environmental science disciplines using a graphical icon-driven environment of modules (component programs) that combine to create customized EVS applications, and provides automation using Python 3 (Python programming) scripts. The contamination results (referred to in EVS terminology as "3D Fields" and colloquially as "plumes") represent a 3D model of the analytical field data.

Data Sources

The C Street model was generated from 103 parent sample locations collected between 1994 and 2022, with chemical data obtained from mercury samples (1994-2022) and tPAH (2000-2022). The data utilized in the model originated from the EQuIS database and exported for EVS use. The average sample interval length spans from 0.20 feet to 8.0 feet, averaging approximately 1 foot. In the EVS model, the vertical sample locations were generated from the midpoint of each interval. A total of 42 lithologic samples that were collected during the 2022 field investigation were modeled independently from the chemical data in order to provide the limits of the low-plasticity clay layer necessary for planning the excavation prism. A bathymetric surface developed from three bathymetric survey datasets collected on July 18, 2022 by Affiliated Researchers was generated in ArcGIS as a raster with a 3-foot cell size that is the maximum point spacing of the surveys. The resulting surface was used in to confine the results to below the bathymetric surface.

Modeling Approach

The 3D plumes were generated with an interpolation process called Kriging, which employs a statistical expression called a semi-variogram. The semi-variogram models the spatial correlation of field sample data with distance and is typically conveyed in graphical form as points (Figures 1 and 2). This statistical expression can also be portrayed as a change in spatial variance with distance and is where the term "semi-variogram" originated. Because the modeling process is data-driven, it cannot address COC distribution based on historical knowledge in localized areas, but is useful for understanding the contamination in a general context.

For natural phenomena, the spatial correlation between samples is typically higher at smaller sample distances and decreases with increasing sample distances, i.e. concentrations are more similar when closer together than further apart. In graphical form, a higher degree of spatial correlation is reflected by points that are comparatively close in distance and are visibly aligned with each other, rather than points that are farther apart, which typically have decaying spatial correlation and high variance. This is shown in Figure 1 for mercury, where the spatial correlation points on the x-axis are aligned on an ascending curve below approximately 245 feet.

To model the correlations, a best-fit curve was adapted to the semi-variogram graph by adjusting the parameters "range," "sill," "vertical and horizontal anisotropy," and "nugget" to a semi-variogram model type that establishes the shape of the curve. This is related to regression analysis curve-fitting where a curve function is fitted to sample points. These parameters are defined below.

The range parameter is the distance beyond which sample values are not spatially correlated and is reflected in the semi-variogram where the point alignment decays, and the fitted curve becomes flat (Figures 1 and 2). The range value is the distance where sample values express a continuous unit (such as a connected plume). Beyond the range value, the samples are not correlated, have a high variance, and correspond to the dissolution or dissociation of a plume at its outer boundary. The “vertical anisotropy” value influences the horizontal spread of the modeled values, where increasing the values will stretch the model laterally. Both parameters have a significant influence on the resulting plume shape, where the vertical anisotropy value is guided by consideration of the history of the deposition and hydrodynamics in the slip. Mercury and tPAH contamination at the C Street Slip has occurred over a prolonged period of industrial activity and bathymetric changes. As a result, the contamination plume shapes in the model are assumed to be spatially broad because of persistent mixing dynamics, and a vertical anisotropy ratio was selected to provide connectivity in the output model between the sample data. Using a low anisotropy value will render “bull’s eyes” where the output model is locally limited to around each sample value.

The vertical anisotropic ratio section of 15 was established by increasing the value iteratively for mercury until sufficient connectivity was generated between the sample points at the midpoint effect concentration (MEC) value of 640 µg/kg. The same vertical anisotropic ratio was used for tPAH since it is assumed that the value represents similar hydrologic sedimentation processes that affect the horizontal connectivity of all analytes.

The “sill” is an expression of the total variance of the data and is where the semi-variogram curve flattens.

The “nugget” value is an expression of the small-scale variability of the data or noise. It is declared as zero in this modeling scheme to reduce the subjectively defined parameters and to simplify the modeling process.

The semi-variogram range value of 250 ft for mercury in comparison to 150 feet for tPAH, indicates that the tPAH plume’s shape is generally smaller compared to mercury. Variations in the Kriging model parameters of the range and the horizontal to vertical anisotropy have a significant effect on the output plume’s geometries.

Figure 1 – C Street Mercury semi-variogram

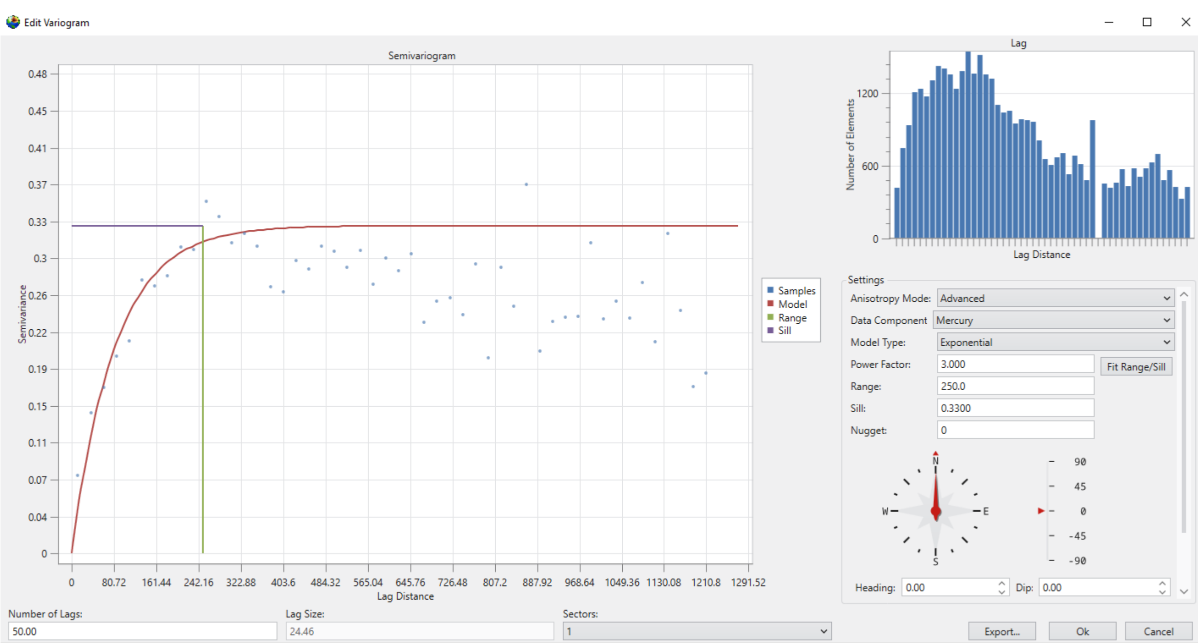
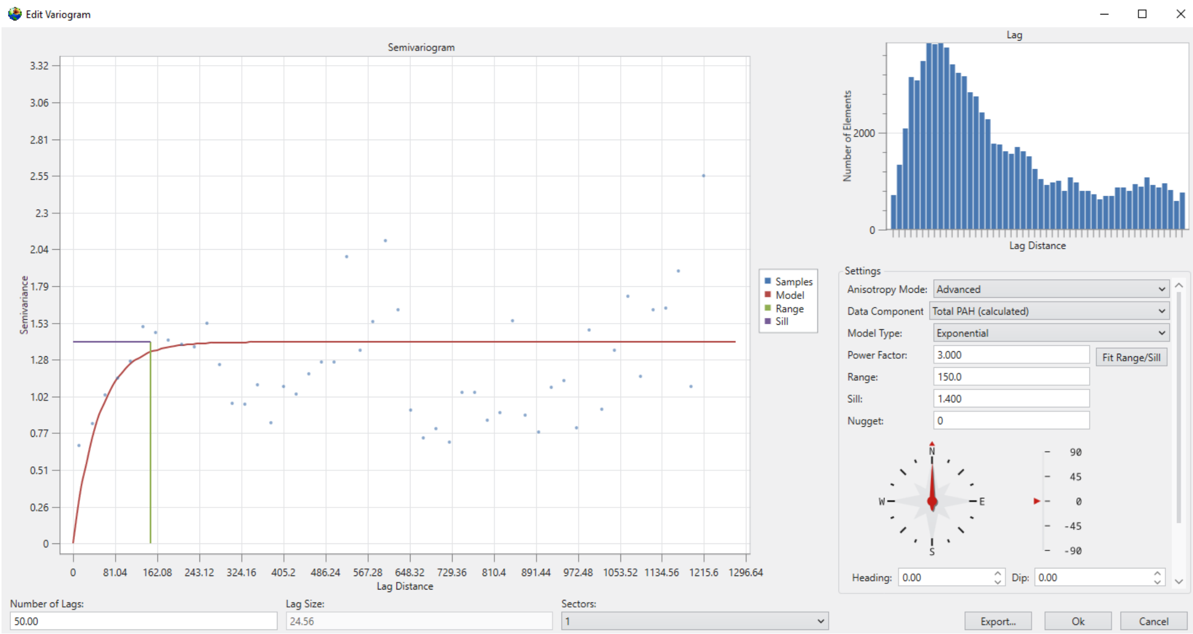


Figure 2 C Street tPAH semi-variogram 1



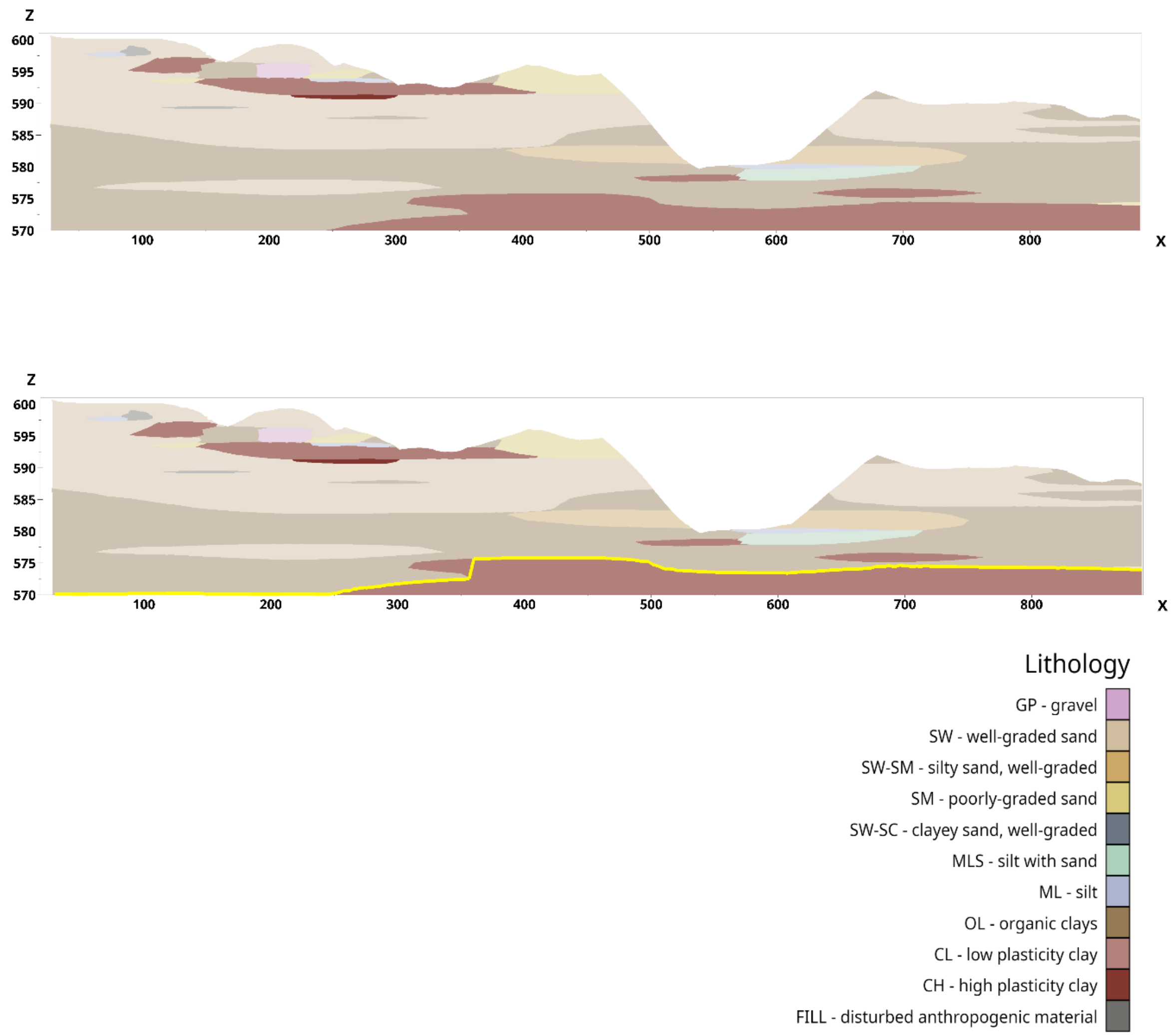
Since tidal patterns and industrial activity may elongate the plumes parallel to the long axis of the slip, the horizontal anisotropy parameter could potentially be used to generate that effect in the model. However, this parameter was not used because it is difficult to establish using the field data and is not appropriate to use a uniform value over a dynamically changing sedimentary environment with locally varying conditions.

The model has been reviewed by technical staff. Independent modeling by Foth, Inc., has developed kriging parameters that are very similar to AECOM's.

<u>Lithology</u>

An additional lithology model was generated in EVS from field samples using a form of Kriging called GIK (Geologic Indicator Kriging), that uses a variation of the Kriging algorithm specialized for discontinuous data such as geologic or lithologic boundaries.

Figure 3 - Derivation of Clay Surface



The lithologic model was used to assess the top elevation of the deepest low-plasticity clay layer to determine the maximum depth for dredging. This is because dredging below the low-plasticity clay deposits is not feasible. The generated surfaces were exported from EVS into ArcGIS and post-processed to calculate the lowest non-overhanging top of clay horizon and is represented by the yellow line in Figure 3. The GIS post-processing also included extrapolating the top of clay surface to the head of the slip (Figures 4 and 5).The mercury, and tPAH plumes were cut to above the clay surface using EVS tools. The result was used in EVS volumetric tools to provide the soil contamination volume in cubic yards.

Figure 4 – Example of Clay Surface Gap Coverage

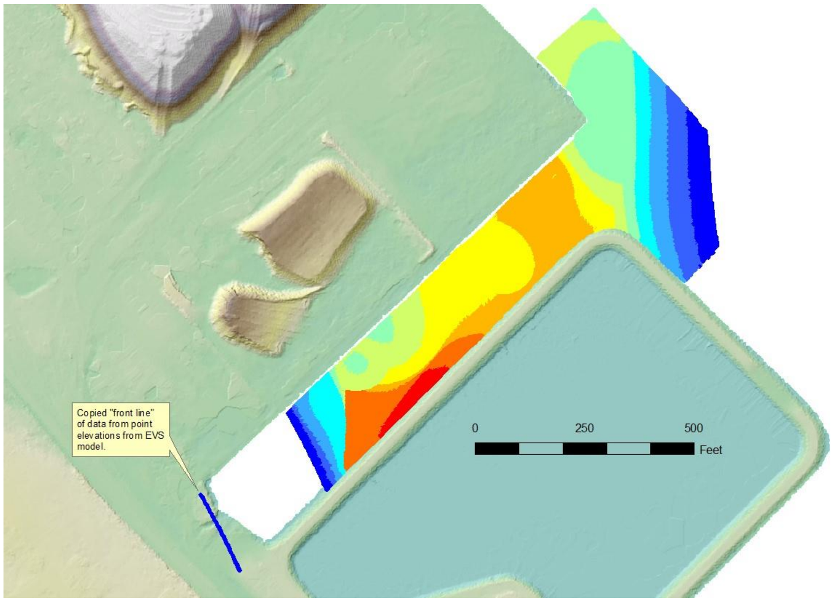
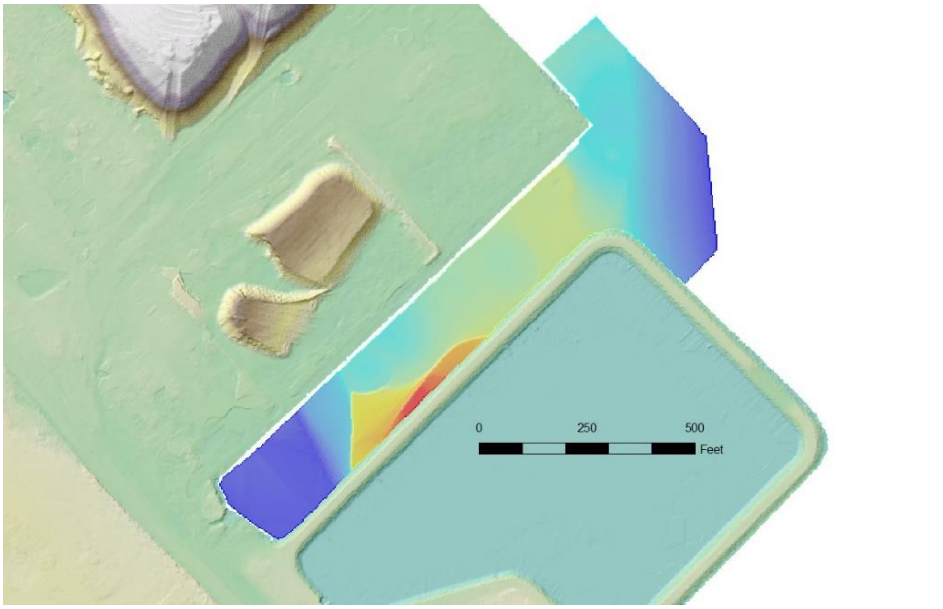


Figure 5 – Example of Resulting Clay Surface with Extrapolated Gap



Model Validation and Data Uncertainty

The major data uncertainties associated with 3D modeling center around the input data, parameter assumptions made by the modeler, and model validation to real-world conditions. Chemical and lithological data utilized in the model has been previously validated upon their imports into EQuIS. Data uncertainties previously discussed in the C Street Slip Remedial Investigation Report (AECOM, 2023) are appliable to the data. Modeling requires parameter assumptions about the behavior, properties, or interactions of the data being modeled. As mentioned above, the model is data driven and can aid to understanding the contamination in a general context. Validation of the model for C Street Slip was completed by reviewing any previous modeling produced by previous consultants and evaluating the model’s accuracy in practical settings via a geologist’s review of the stratigraphy and plume characterization.

Appendix B Mechanical Dredging Equipment Types

A clamshell bucket is operated from a crane or derrick mounted on a barge or other floating structure. Sediment and water are transferred to a hopper or scow for transportation to the sediment processing or disposal location.

Environmental buckets have been developed to improve precision dredging, prevent loss of sediment during deployment, and sedimentation during withdrawal through the water column.

Backhoe dredges employ an articulated excavation bucket mounted on an articulated boom to excavate sand, clays, gravel, cobbles and rock, brought to the surface, and placed in barges for transport to the placement area.

Appendix C Hydraulic Dredging Equipment Types

With a cutterhead dredge, sediment is first loosened and mixed with water and directed into the suction end of a hydraulic pipeline for conveyance to the disposal area.

Horizontal auger dredge loosens sediment with the action of the cutterhead and subsequently uses the auger to push the material to the center where the suction of the centrifugal pump moves slurried material to the discharge pipeline.

Jet-suction dredges agitate and slurry the sediment with fine water jets at the end of the ladder and subsequently suction the slurry into the pipeline for conveyance and disposal at the sediment processing facility.

aecom.com