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Focused Feasibility Study for Sediment Cleanup in Howard's Bay

Superior, Wisconsin

July 2015

Focused Feasibility Study for Sediment Cleanup in Howard's Bay

Prepared for the Great Lakes Legacy Act (GLLA) Howard's Bay Focused Feasibility Study and Remedial Design Project on behalf of the Howard's Bay Project Partners

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Acronyms and Abbreviations

AOC	Area of Concern
ARCADIS	ARCADIS U.S., Inc.
BUIs	Beneficial Use Impairments
CAD	confined aquatic disposal
CBSQG	Consensus-Based Sediment Quality Guidelines
CHS	Cenex Harvest States
CDF	confined disposal facility
CFR	Code of Federal Regulations
COCs	contaminants of concern
cy	cubic yards
DSR	Sediment Data Summary Report
ENR	enhanced natural recovery
EPRI	Electric Power Research Institute
FFS	Focused Feasibility Study for Sediment Cleanup in Howard's Bay
Fraser	Fraser Shipyards, Inc.
g	grams
GLLA	Great Lakes Legacy Act
GLNPO	Great Lakes National Program Office
GRA	general response action
HB	Howard's Bay
ID	identification
IGLD	International Great Lakes Datum
IJC	International Joint Commission

kg	kilogram
LWD	low water datum
MEC	midpoint effect concentration
mg/kg	milligrams per kilogram
mg/kg-TOC%	milligrams of organic constituent per kilogram of dry-weight sediment normalized at 1% total organic carbon
MNR	monitored natural recovery
MPCA	Minnesota Pollution Control Agency
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NEPA	National Environmental Policy Act
O&M	operation, monitoring and maintenance
PAH	polycyclic aromatic hydrocarbon
Partners	Howard's Bay Project Partners
PEC	probable effect concentration
PRG	Preliminary Remedial Goal
POTW	publicly owned treatment works
RAO	Remedial Action Objective
RAP	Remedial Action Plan
RCL	Residual contaminant level
SAMP	City of Superior's Special Area Management Plan
site	Howard's Bay
SLRAOC	St. Louis River Area of Concern
SND	strategic navigation dredging
SWPPP	Stormwater Pollution Prevention Plan

TEC	threshold effect concentration
TOC	total organic carbon
µg/kg	micrograms per kilogram
USACE	Unites States Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
WDNR	Wisconsin Department of Natural Resources
WEPA	Wisconsin Environmental Policy Act
Weston	Weston Solutions, Inc.
WPDES	Wisconsin Pollutant Discharge Elimination System

1. Introduction

Howard's Bay, located in the City of Superior in Douglas County in northwest Wisconsin (site; Figure 1-1), is a priority area for remediation within the larger St. Louis River Area of Concern (SLRAOC). A plan to clean up contaminated sediment and restore Howard's Bay is being developed through a Great Lakes Legacy Act (GLLA) project partnership including the Unites States Environmental Protection Agency (USEPA) Great Lakes National Program Office (GLNPO), the Wisconsin Department of Natural Resources (WDNR), and Fraser Shipyards (Fraser) – collectively the Howard's Bay Project Partners (Partners). The United States Army Corps of Engineers (USACE) is providing technical and engineering support to USEPA for this project. ARCADIS U.S., Inc. (ARCADIS) has prepared this Focused Feasibility Study for Sediment Cleanup in Howard's Bay (FFS), on behalf of the project Partners and in collaboration with the Partners and USACE, working under contract to Fraser, to identify and evaluate remedial alternatives based on, but not limited to: short- and long-term effectiveness for protection of human health and the environment; ability to achieve the remedial action objectives (RAOs) for the site and meet cleanup goals; compliance with applicable regulations and permit requirements; implementability; cost; and ability to make progress towards removal of beneficial use impairments (BUIs) identified for the SLRAOC. This FFS is based on sediment data available for the site that was summarized and evaluated in the Howard's Bay Sediment Data Summary Report (DSR; ARCADIS 2014), which was also prepared as part of this GLLA project. Note that several older sediment sample datasets collected prior to 2007 were not addressed in detail in the DSR, nor were they employed as a primary basis for cleanup planning in this FFS. This FFS focuses on data collected in 2007 and more recently. The alternatives developed in this FFS are based on an assumption that federal channel maintenance will be completed by the USACE as "Strategic Navigation Dredging" (SND) which is connected to the cleanup of contaminated sediment that is addressed in this FFS. The SND is utilizing funds from the Great Lakes Restoration Initiative, which is contingent on the cleanup of the contaminated sediment in Howard's Bay as a whole and will not be implemented separately.

1.1 Scope and Report Purpose

This FFS was prepared in accordance with the Scope of Work for the "Focused Feasibility Study and Remedial Design for Remediation of Howards Bay" (FFS Work Plan; Partners 2014). The FFS Work Plan was prepared to guide the development of the FFS, and identifies that the primary objective of this report is to develop and evaluate remedial alternatives and disposal options with associated cost estimates that the Partners can use, in conjunction with stakeholder consultation, to select a preferred remedy to move forward to the remedial design phase. The purpose of this FFS is to:

- Describe and evaluate the RAOs identified for the site by the project Partners;
- Identify and screen remedial technologies;
- Develop and evaluate alternatives for remediating contaminated sediment at the site; and

- Support selection of a remedy that will be developed in association with the SND project that meets the site RAOs and makes progress towards removing BUIs identified for the SLRAOC.

1.2 Report Organization

This report is organized into the following sections:

- **Section 1.0 – Introduction:** describes the scope and purpose of the report, organization of the report, and site description.
- **Section 2.0 Remedial Action Objectives and Preliminary Remedial Goals:** describes RAOs and preliminary remedial goals (PRGs) developed for the site by the project Partners based on the site sampling activities and biological assessments.
- **Section 3.0 Identification and Screening of Technologies:** summarizes remedial technology types identified for the site, preliminary remedial technology screening based on site characteristics, and identification of disposal options for contaminated material removed from the site.
- **Section 4.0 Development of Remedial Alternatives:** assembles a suite of potential alternatives for the site.
- **Section 5.0 Evaluation and Screening of Remedial Alternatives:** presents the evaluation and screening of potential remedial alternatives assembled for the site.
- **Section 6.0 Required Permits for the Preferred Remedial Alternative:** summarizes local, state, and federal permits required for the implementation of the preferred alternative selected for the site.
- **Section 7.0 Basis of Design Memorandum Requirements:** describes key activities required to develop the basis of design for the integrated remedial action and navigation dredging design.
- **Section 8.0 References:** provides references of documents used to prepare this report.

1.3 Site Description

Howard's Bay is an industrialized embayment located in the SLRAOC, in the City of Superior, Douglas County, Wisconsin (Figure 1-1). It has been the home of a series of shipyards, grain terminals, commercial fishing operations, and other industrial operations for over 100 years. It is located on the east side of the St. Louis River, and is bisected by the Interstate 535 (I-535) Bridge (the Blatnik Bridge) crossing over Howard's Bay. The Howard's Bay study area includes the bay proper and also three remaining ship slips constructed along the south shore – the Fraser Slip, Cummings Avenue Slip and Hughitt Avenue Slip; in addition to two dry docks along the south shore. The approximate area of Howard's Bay study area, inclusive of the three slips, is approximately 300 acres. A small embayment (2.6 acres), called the Baxter Avenue Embayment located on the south bank between the Cummings Avenue Slip and the Fraser Slip, is slated through a separate project to be separated from Howard's Bay by a sheetpile wall that will create additional berthing for ships. The embayment is anticipated to be eventually filled to create usable land.

A number of different shoreline types are present around the bay and the associated slips including sheet pile, rip-rap, dilapidated former wooden and concrete wharf structures, existing and former bridge approaches and abutments, and earthen banks. Water depths in Howard's Bay vary from shallow waters along the north shore to approximately 33 feet below the Lake Superior low water datum (LWD) within the federal channel that runs nearly the entire length of the bay (Figure 1-2). Harbor-wide bathymetry survey data from 2013 is available from the USACE, and bathymetric contours developed from these data are shown in Figure 1-3. The Lake Superior LWD is at an elevation of 601.1 feet using the International Great Lakes Datum of 1985 (IGLD 85).

Commercial maritime needs in the bay are met by the federal navigation channel and access to the ship slips and dock areas. They bay is open to recreational boat access and anglers fish from a city owned bridge abutment. The Wisconsin public trust doctrine protects recreational navigation and fishing activities in the Bay. However, currently there are no public access boating sites or public use boat docks in Howard's Bay, and there is limited recreational boating activity on the bay as the only recreational docking sites are located in Hughitt Slip and there are few recreational boating destinations. Public access for shoreline recreation is available along the north side of the bay, and fishermen can access the site from the north bank on property owned by Fraser Industries and the City of Superior, but the south bank is primarily industrial use and is generally is not open to public access.

The Cummings Avenue Slip, the Fraser Slip, and the Baxter Avenue Embayment are within the limits of Fraser's submerged land lease. Fraser, the City of Superior, and Cenex Harvest States (CHS) own the large majority of land bordering Howard's Bay. The federal channel ranges from approximately 175 to 450 feet wide with an authorized project depth of 27 feet below LWD. The Hughitt Avenue Slip is used for loading and unloading ships at the CHS grain elevators and the Sivertson Fisheries docks and boats are situated at the south end of the slip. The Cummings Avenue Slip has most recently been used by Fraser for long-term layup of ships, but future uses are expected to be limited to work barge and smaller craft mooring in approximately the northern one third of the slip. Large ships are not expected to use the Cummings Avenue Slip in the future. The Fraser Slip is used by Fraser and local law enforcement for docking smaller boats and this is the intended future use also.

For the purposes of this report, and based on a prior sediment summary report prepared for USEPA (Weston Solutions, Inc. [Weston] 2011), the study area for Howard's Bay was segregated into the following areas (Figure 1-4):

- Area 1 consists of Howard's Bay northwestern portion from a transect west of the entrance to Hughitt Slip to Lamborn Avenue. Area 1 was further divided into the following areas for the purpose of this report:
    - *Area 1 – Within Federal Channel* consists of the deep draft navigation area and side slopes located within Area 1.
    - *Area 1 – Outside Federal Channel* consists of the areas within Area 1 located outside of the deep draft navigation area and side slopes.
- Area 2 consists of Howard's Bay south-eastern portion from Lamborn Avenue to the easternmost extent of the bay. Area 2 was further divided into the following areas for the purpose of this report:
    - *Area 2 – Within Federal Channel* consists of the deep draft navigation area and side slopes located within Area 2.
    - *Area 2 – Outside Federal Channel* consists of the areas within Area 2 located outside of the deep draft navigation area and side slopes.
- *Baxter Avenue Embayment* consists of an area along the south shore of Howard's Bay proposed to be walled off with a sheet pile bulkhead through a separate project and then filled to create additional ship berthing space along the federal channel. Design and permitting activities are underway to install the sheet pile bulkhead.
- Private Slips and Docks located on the south side of the bay:
    - *Hughitt Avenue Slip* located west of I-535
    - *Cummings Avenue Slip* located east of I-535
    - *Fraser Slip* located toward the east end of Howard's Bay
    - *Docking Area* consists of bay area located in the east end of Howard's Bay.

1.3.1 Current Land Use Around Howard's Bay

Current land use surrounding Howard's Bay primarily consists of industrial and commercial areas including the Fraser Shipyard, the CHS grain elevators and ship loading facility, and other commercial operations along the south side of Howard's Bay (Figure 1-5 and Appendix A). The area has served industrial uses since the early 1800s and continues to be an important source of jobs and income for the City of Superior. The Fraser shipyard property along the south side of the Bay from the Blatnik Bridge east to the end of Howard's Bay are occupied and actively used by Fraser. The parcel west of the Blatnik Bridge adjacent to the Hughitt Avenue Slip is vacant property. Parcels adjoining the north side of Howard's Bay are currently vacant and are owned by Fraser and the City of Superior. Storm water drainages from the City of Superior enter into Cummings Slip and a drainage ditch at the far east end of the Bay.

Anticipated future water depth needs for the Cummings Avenue Slip, the Fraser Slip, and Hughitt Avenue Slip have been identified based on anticipated use. The Fraser Slip will continue to be used for docking smaller boats, and therefore will require 10 feet of water depth. Future use of the Cummings Avenue Slip will focus on an area approximately 200 feet from the channel, and will include docking of work barges that require 10 feet of water depth; the remainder of the slip has no intended future commercial use. The western portion of Hughitt Avenue Slip will continue to be used for loading and unloading ships and requires nominally 27 feet of water depth, and the eastern and southern portions are intended for use by smaller boats with water depth needs of 10 feet. The eastern-most dock area used by Fraser (which has been referred to as the "Frog Pond Dock") will be used for either barge mooring, or possibly temporary dock space for ships, depending on future water depths in this area. Figure 1-5 illustrates the required water depth for each slip and area, this is also summarized in the table below:

Area	Anticipated Future Water Depth Needs (feet)
Cummings Avenue Slip	10
Fraser Slip	10
Hughitt Avenue Slip (East and South)	10
Hughitt Avenue Slip (West)	27

1.3.2 Bathymetry, Federal Channel Limits and Strategic Navigational Dredging Boundaries

Bathymetric contours developed by ARCADIS based on survey conducted by the USACE in September 2013 are shown in Figure 1-3. Based on the bathymetric contour surface and the Lake Superior LWD (601.1 feet IGLD 85), a map delineating shoal areas (with bottom elevations above 27 feet below LWD) within the federal channel was developed (Figure 1-6). As part of the USACE's SND scope, USACE is responsible for dredging sediments within the federal channel to achieve the authorized project depth of 27 feet below LWD. The cleanup alternatives in this FFS address contaminated sediments that exist in some areas at elevations below the federal channel limit, and outside of the federal channel boundaries. Limits of the deep draft navigation area to be addressed by the SND, and the associated side slopes are depicted in Figure 1-6.

1.3.3 Current Beneficial Use Impairments

Impacted sediments in the study area potentially contribute to the following BUIs listed for the SLRAOC (Stage I Remedial Action Plan [RAP], Minnesota Pollution Control Agency [MPCA] and WDNR 1992):

- BUI 1: Fish Consumption Advisories
- BUI 3: Fish Tumors and Other Deformities
- BUI 4: Degradation of Benthos
- BUI 5: Restrictions on Dredging
- BUI 9: Loss of Fish and Wildlife Habitat

No formal evaluation of whether sediments in study area are actually linked to these BUIs, or the degree to which they may be linked to these BUIs has been completed.

1.4 Summary of Sediment Investigation Findings

This section summarizes the findings of sediment sampling activities conducted at the site in 2007, 2010, and 2013. A number of earlier investigations were also completed in 1993, 1994, 1995, 1996 and 2002 (USEPA 1997a, USEPA 1997b, Breneman et al. 2000, MPCA 1997, WDNR 2003a); however, due to smaller sample counts and the age of the datasets, it was determined that those data will not be used for the FFS and remedial design. Information generated from the 2007, 2010, and 2013 sediment investigation activities were compiled and incorporated into the DSR (ARCADIS 2014). The sediment data collected in 2007, 2010, and 2013 provide a refined understanding of the nature and extent of contamination at the site. The combined data sets include more than 350 sediment data points from approximately 110 attempted core or grab sample locations in Howard's Bay.

A brief summary of the supplemental sampling investigation conducted by the WDNR and USEPA in 2014 is also provided in this section.

1.4.1 Contaminants of Concern

Based on a 2011 report prepared for USEPA (Weston 2011) to summarize data collected in 2010, polycyclic aromatic hydrocarbons (PAHs), organotins (e.g., tributyltin), and lead have been identified as contaminants of concern (COCs; Partners 2014). USEPA and WDNR requested consideration of mercury as an additional COC as part of the DSR. Therefore, the nature and extent of PAHs, organotins, lead, and mercury were evaluated as part of the DSR.

1.4.2 Areas of Contamination

Concentrations of the COCs vary within Howard's Bay due to the history of various sources, dredging activity, construction projects and other activities within the bay, including but not limited to ship movements and ice breaking. As described in the DSR (ARCADIS 2014), the site sediment sample data normalized to total organic carbon (TOC) for organic chemicals, reported as µg/kg-TOC%, and the inorganic data without adjustment were compared to the WDNR recommended sediment quality guidelines (WDNR 2003b), including Threshold Effect Concentration (TEC) and Probable Effect Concentration (PEC) screening levels, which are levels at which the potential for toxicity to benthic organisms are predicted to be unlikely and probable, respectively. The Midpoint Effect Concentration (MEC) is the average of the TEC and PEC values. For this reason, some flexibility is warranted in using the MECs as cleanup numbers. In comparison to the WDNR MEC values, the largest exposures to concentrations of the project COCs in surface sediment occur as follows: in the Cummings Avenue Slip, Fraser Slip and east end of Howard's Bay for lead; in the Cummings Avenue Slip and Hughitt Avenue Slip for mercury; at the head of the Cummings Avenue Slip and near the Blatnik Bridge for PAHs; and in the Hughitt Avenue Slip, adjacent to the Hughitt Avenue Slip in the federal channel and near the head (i.e. west end) of the federal channel for tributyltin.

The COC mass and associated volume of sediment represented by each sediment core with concentrations exceeding selected comparison values (that include the WDNR screening levels) provided an indication of relative mass distribution within the site (see Figure 4-8 of the DSR). COC mass inventories are concentrated in the three slips, in the south eastern end of the bay, in the head of the federal channel, and along the immediate margins of the federal channel. In the shallower waters north of the federal channel, there are large areas with comparatively little COC mass inventory. Various aspects of the data distribution are evaluated further in Section 2 of this FFS, in particular the distribution of COCs in relation to boundaries of planned navigational dredging of the federal channel, and in relation to PRGs discussed in Section 2.1 of this report.

1.4.3 2014 Supplemental Sediment Investigation

On August 18, 2014, WDNR conducted supplemental sediment sampling at the site with assistance from USEPA. The objectives were to further define the horizontal and vertical extent of organotin and lead contamination within the federal channel deeper than 27 feet below LWD, define the horizontal and vertical extent of organotin contamination in Area 1 outside the federal channel, and define the horizontal and vertical extent of lead contamination in Area 2 shallow water areas to the north of the federal channel where lead contamination had been confirmed. In addition, samples from two cores were analyzed for PAHs based on field observations of sheens and odors. Results of this sampling effort became available after preparation of an initial draft of this FFS. Limited refinement of some management unit boundaries for certain alternatives was incorporated based on review of the WDNR's field data report in Appendix B (WDNR 2014a). Further refinement of sediment management units established for the FFS may be warranted once these data are incorporated in the design phase. A total of 13 core samples were collected using a Vibracorer and one sample was collected with a Ponar dredge. Figure 1-6 depicts the 2014 core locations.

Cores HB14-02, HB14-03, HB14-04, HB13-05, HB14-06, HB14-07, HB14-08, and HB14-09 had detected TOC-normalized tributyltin concentration above the WDNR PEC (2.94 ug/kg-TOC%). These cores are all located west of the mouth of Hughitt Avenue Slip. The maximum depth of exceedances of the tributyltin

MEC sediment quality guidelines, excluding non-detects, is 2.5 feet below sediment surface (bss), and was observed at locations HB14-03 and HB13-04. The horizontal and vertical extent of MEC exceedances is similar to the extent of PEC exceedances. Boundaries of potential dredge areas around and west of the Blatnik Bridge in particular may require refinement based on tributyltin levels in these samples.

Core HB14-14 is the only core that had a lead concentration above the WDNR PEC (130 mg/kg). For this core, maximum depth of exceedance is 3.5 feet bss. Boundaries of potential dredge areas around HB14-14 may require refinement based on lead levels in this sample. Considering the MEC, cores HB14-12 and HB14-14 had detected lead concentration above the WDNR MEC (83 mg/kg). The maximum depth of exceedance is 8.5 feet bss (HB14-14[78-102]).

The only sample that had detected TOC-normalized total PAH concentration above the WDNR MEC of 12.2 mg/kg-TOC% or the PEC of 22.8 mg/kg-TOC% is the subsurface sample HB14-14(4-6).

1.4.4 Sediment Thickness

A preliminary evaluation of sediment thickness overlying a distinct native clay layer present in most areas of Howard's Bay, was conducted as part of the DSR using sediment coring field notes and core logs. Most of the 2007 locations were sampled using a Ponar grab sediment sampler, although cores were collected at six of the 16 locations. Field notes recorded during investigation activities conducted in 2010 and 2013 indicate the thickness of soft sediment recovered in core samples, and the presence of a dense native red clay underlying sediments in many locations and in some locations a softer deposited clay layer was observed. Core stratigraphy logs indicate the thickness of the sediment layer in the core tube overlying the plug of native red clay in the bottom of the core – when it was present. Not all core samples contained a plug of native red clay at the bottom – some cores met with refusal without recovering native clay (the native clay may have been too stiff or fallen out of the core or the core tube could have encountered other dense material limiting its advancement). In general, the amount of sediment in the core samples is interpreted to be approximately equal to the thickness of soft sediment above native clay, when native clay is present. When native clay is not present, the thickness of sediment is assumed as the recovered core length.

Top of sediment elevations were assigned to 2007, 2010, and 2013 cores by measuring water depth at the location and subtracting this from the water surface elevation at the time of sampling. To calculate top of sediment elevations for 2010, the water surface elevation recorded by the National Oceanic and Atmospheric Administration staff gauge 9099064 located near Duluth, Minnesota was used. To calculate top of sediment elevations for 2013, the water surface elevation recorded by the staff gauge located within the study area was used. For the 2007 sampling data, water surface elevation and water depth records were not available from EPA; therefore, the top of sediment elevation for 2007 locations was estimated using the bathymetric contours developed by ARCADIS based on survey conducted by the USACE in the year of core collection (see Table 1-1). Based on the top of sediment surface elevations assigned to each core (shown in

Table 1-1) and core stratigraphy logs, the bottom-of-sediment/top-of-native-substrate elevation was established for each core (Figure 1-7). Based on the difference between this bottom-of-sediment/top-of-native-substrate and the bathymetry, a map showing estimated sediment thickness at each core location was developed, and is provided as Figure 1-8. This figure has high uncertainty in some areas, especially along the sides of the federal channel where bed slopes are greatest and core sampling was limited. It is likely that relatively little sediment accumulation on these slopes has occurred compared to deeper and shallower areas adjacent to the slopes.

Figure 1-9 illustrates cross-section locations that were developed based on assigned top of sediment and top of clay elevations, and chemistry results for the COCs. Cross-sections A-A', B-B', C-C', D- D', E-E', F-F' and G-G' are illustrated on Figures 1-10a to 1-10g. The cross-sections illustrate how concentrations of the COCs, and in particular levels that exceed the MEC and PEC values, are distributed across the federal channel, the steep slope sides of the federal channel (where sediment thickness information is estimated based on very limited information from the side slopes themselves), and the shallower areas of the study area. Due to the morphology, dredging history and influences of navigation (propeller scour in particular), thickness of sediment and depth of exceedances of sediment MEC and PEC screening levels for the COCs vary substantially across the study area. Some exceedances (e.g., HB10-1-14[60-66] and HB13-02[24-30] shown in Figures 1-10b and 1-10g) occur at depth with a layer of overlying non-impacted or lesser-impacted sediments having deposited and accumulated over time. Exceedances of MEC along the northern portion of the bay are limited and shallower in the sediment column with few detected exceedances of the PEC (e.g., HB10-1-15[12-16] and HB13-52[6-12] shown on Figures 1-10b and 1-10d). In a number of the shallower locations, the COC concentrations in the uppermost sediment sample are below the MEC, and exceed it in deeper depth intervals in the sediment bed.

1.4.5 Benthic Community and Toxicity Tests

Human health and ecological risk assessments have not been completed for Howard's Bay. Recreational contact with sediments as a result of wading (for example by fisherman) or other incidental contact with sediment along the north shore for the site is possible. Worker contact with sediments could occur in association with marine construction activities in the bay and also in association with shipyard activities, such as contact with anchors or other equipment, or during dry-dock cleanout activities (removal of small amounts of sediment that may come in with bay water when ships are taken into dry-dock).

Ecological exposures occur through the benthic community, and include higher level receptors that may accumulate bioaccumulative compounds through the food chain. Toxicity tests conducted with the crustacean *Hyalella azteca* and the insect *Chironomus dilutes* to determine whether chemicals were present in the Howard's Bay sediment at concentrations that would be harmful to the test organisms indicated spatially limited adverse effects on the benthic community of Howard's Bay in comparison to reference and control samples, with the exception of one sample which resulted in genotoxicity to the bacterium

Vibrio fischeri (see DSR for details of test results). This sample was at location ID DSH 31 located within Fraser Slip. A limited number of toxicity tests were conducted within the study area. Because of the variability among sample results, there is high uncertainty with respect to the data representativeness of the whole study area.

Results of the benthic sampling described in the DSR (ARCADIS 2014) showed a macroinvertebrate community that is typical of finer-grained sediments with organisms that often "burrow" in finer sediments, such as oligochaetes (39 percent [%] segmented worms), dipterans (36% fly larva) and nematodes (14% roundworms). The Project Partners decided that efforts to interpret the benthic community data relative to background, to evaluate the data with respect to need for remediation, or to use these data to develop potential remedial endpoints would not be undertaken for the purposes of this GLLA project. However, it was acknowledged that these data may be useful for post-cleanup comparisons at a future date if adequate data analysis is undertaken to control for sources of variability.

1.5 Source Control

Concentrations of the COCs vary within Howard's Bay due to various historical sources, current sources, dredging activity, construction projects and other activities within the bay, reflecting contamination that is a legacy of the urban/industrial history of Howard's Bay and the SLRAOC. Continuing sources of potential importance to achieving sustained removal of BUIs in the future include: storm water outfalls; runoff from roads, bridges, parking lots, and other impervious surfaces; atmospheric and wind-blown dust deposition; shipping operations; and other industrial/commercial activities within and around the Bay (See Figure 1-5 and Appendix A of this report, and Figure 5-1 of the DSR). Reductions in COCs from these sources have occurred since historical periods of industrial development, and further improvements under this GLLA project to address contaminated sediments can further restore the quality of Howard's Bay sediments and surface water. The phase out of organotin-containing paints, the general improvement in environmental practices, improved stormwater management, general spill prevention measures in place at most industrial/commercial operations, the changeover to use of unleaded gasoline in cars, and adoption of best management practices within the Fraser Shipyards Stormwater Pollution Prevention Plan (SWPPP) all serve to minimize the future introduction of contamination to Howard's Bay. An apparent episode of uncontrolled hull scraping and repainting of an ocean-going ship at the CHS grain elevator is documented and narrated in the PBS video *Working Waterfront: A Harbor Portrait* (PBS 1997). In August 2014, WDNR contacted CHS about painting or maintenance activities in the Hughitt Slip. CHS replied that CHS has not conducted painting or maintenance of vessels in the slip, and that they have no record of storage or use of tributyltin or mercury (WDNR 2014b). It is unknown what hull maintenance activities ships calling on the CHS docks or Hughitt Slip may have conducted over the years. So long as unpermitted spills, which are subject to regulatory enforcement, do not directly impact the study area, recontamination is unlikely to substantially diminish benefits of cleanup of sediments from the bay.

PAHs, including benzo(a)pyrene, are common contaminants of urban industrial waterways like the SLRAOC. They enter the sediments from many sources, including runoff from the Blatnik Bridge. In fact, it was noted in comparison of individual PAH compounds to dredged material disposal criteria during the development of disposal alternatives described in Section 3.3 that concentrations of benzo(a)pyrene in sediments in the vicinity of the Blatnik Bridge frequently exceeded the WDNR soil industrial direct contact residual contaminant level of 0.21 mg/kg, and thus may continue to present dredged material disposal limitations in the future if sources in this area remain.

To assess whether the potential improvements under this GLLA project would be sustainable, an assessment of the sediment recontamination potential for the study project area is being conducted separately by WDNR.

1.6 Sediment Stability

The conceptual site model for sediment stability in Howard's Bay discussed in this section addresses the processes listed below, which are then discussed further on:

- Propeller scour from tugs and ships
- River level variation and seiche activity
- Wind-wave
- Ice scour
- Storm flow discharges
- Shipyard operations
- Bioturbation

Ships and tug boats operating in Howard's Bay influence sediment mobility within the federal channel and dock areas. Propeller turbulence can impart resuspension forces serving to focus sediments to the bottom of the side slopes and in deeper areas of the main channel. This results in shallower depths along the sides of the channel. Flows in the channel resulting from ship displacement are also a likely factor influencing sediment moving and focusing along the sides of the main channel. Bathymetric cross sections and sediment core sampling results document the presence of relatively thicker sediment deposits at the toe of the channel side slopes.

Shallower areas, away from the federal channel, especially to the north are relatively isolated from direct propeller scour forces due to several factors, including the shallower water depths, distance away from the channel, and due to ships typically moving along the east-west direction with the notable exception of the turning basin to the northwest of the dry dock entrances. Ship turning operations in this area likely impart scouring forces to the sediments in these areas. Water depths in most of the area to the north of the channel are considerably less than typical ship draft and depth of the propellers – meaning that scour forces would impact the sides of the channel at depths below these shallow areas and thus propeller scour from ships and large vessels is a force mainly limited to within the federal channel, ship dock areas and ship slips.

The sediment core data shows that in many instances, cleaner sediment has accumulated over historically more impacted sediment layers north of the federal channel, consistent with these areas being depositional locations that have not been subject to significant sediment mixing events such as can occur with direct impacts by ship propeller scour.

Howard's Bay is subject to seiche effects from the western arm of Lake Superior, and water level variations in response to river flow variation and long term variation in water levels of Lake Superior. Due to the large channel cross section to convey flow, and the relatively small surface area of Howard's Bay in relation to the channel size, seiche-driven flow velocities in the channel are judged insignificant from a sediment stability perspective.

Wave action occurs within the Howard's Bay due to wind and ship traffic. Wind waves are judged to be an insignificant sediment stability factor in the bay due to the limited wind fetch distance. Vessel movement in the bay is controlled and speeds are low due to the close quarters and thus off-channel sediment stability concerns associated boat wake waves are negligible.

There is little, if any, sediment scour potential associated with advective flow through the bay, due to the small size of tributary and storm water discharges in relation to the cross-sectional area of the Bay. Sediment erosion potential in the immediate vicinity of storm water discharge locations, especially at the large outfall in Cummings Slip, and the tributary at the east end of the bay is localized around those locations. There was a major storm event in 2012 that caused flooding in the City of Superior and resulted in significant storm water runoff to Howard's Bay, and may have delivered substantial quantities of sediment also. This major storm event occurred after the 2007 and 2010 sampling activities discussed in this report, and it is uncertain what effect it may have had on sediment COC concentrations within the bay. It is likely that the storm resulted in localized scour at the immediate location of the outfall, but also additional deposition in Cummings Slip. However, changes due to the storm would be reflected in the 2013 bathymetric survey and the 2013 sampling results.

Shallow sediments are subject to bioturbation processes which mix the upper layer of sediment. As described by WDNR (2003b), the majority of benthic organisms are usually associated with the upper strata (e.g., 6 inches). Bioturbation depth depends on the species present in the sediment, and their feeding and burrowing activity. Some species may burrow to deeper depths below the well-mixed surface layer.

Based on these considerations, the conceptual site model is that sediments within the federal channel and in docking areas adjacent to the south side of the federal channel are potentially unstable. Sediments to the north of the federal channel are suspected to be stable, but no quantitative analysis of propeller turbulence has been performed.

2. Remedial Action Objectives and Preliminary Remedial Goals

RAOs are medium-specific goals that, if met, would be protective of public health and the environment relative to the environmental concerns identified at the site. Potential site-wide remedial alternatives are evaluated relative to their ability to achieve the RAOs, meet the PRGs, and be protective of public health and the environment. This section presents the RAOs for the site, which were developed by the project Partners based on the site sampling activities and biological assessments presented in the DSR (ARCADIS 2014), and summarized in Section 1.4 of this report. The site-specific RAOs below identify the potential risk, exposure routes, and receptors.

For this FFS, RAOs address sediment alone rather than multiple media such as water and biota tissue levels. The following RAOs have been developed for the COC contaminated media in Howard's Bay:

1. Reduce potential for human health risks associated with exposure to COCs through direct contact with sediments and incidental sediment ingestion.
2. Reduce potential for risks to benthic organisms.
3. Reduce potential for risks to other organisms (fish, birds, mammals, etc.).
4. Reduce sediment concentrations of COCs to ultimately meet criteria, standards, and guidelines per International Joint Commission (IJC) and AOC Remedial Action Plan documents.
5. Reduce the potential for contaminated sediment within Howards Bay to act as a source of contamination outside of Howards Bay in the St. Louis River Estuary.

2.1 Identification of Preliminary Remedial Goals

2.1.1 WDNR Sediment Quality Screening Levels

As described in the DSR (ARCADIS 2014) and summarized in Section 1.4, the project team agreed that the WDNR sediment quality guidelines (WDNR 2003b) be used for sediment data evaluations. The sediment quality guideline values apply to the biologically active zone, and include TEC and PEC screening levels, which are levels at which the potential for toxicity to benthic organisms are predicted to be unlikely and probable, respectively (WDNR 2003b) based on toxicity test results. The MEC is also included and is the average of the TEC and PEC values. For this reason, some flexibility is warranted using the MECs as PRGs. The following table summarizes screening levels recommended by WDNR for the site COCs and mercury.

COC	Unit	TEC	MEC	PEC
Total PAH17-TOC	mg/kg-TOC%	1.61	12.205	22.8
Tributyltin-TOC	mg/kg-TOC%	0.00052	0.00173	0.00294
Lead	mg/kg	36	83	130
Mercury	mg/kg	0.18	0.64	1.1

Notes: mg/kg = milligrams per kilogram; mg/kg-TOC% = milligrams of organic constituent per kilogram of dry-weight sediment normalized at 1% total organic carbon

2.1.2 Preliminary Remedial Goals

MEC values were adopted as PRGs for the project COCs.

In formulating remedial alternatives consideration was given to the degree to which PRGs were exceeded in the deeper sediments below the upper-most sample layer, specifically in comparison to whether the PEC value was also exceeded, and the depth intervals within which the exceedances were observed. The following table lists the PRG value for each COC:

COC	PRG Value
Total PAHs	12.205 mg/kg-TOC%
Tributyltin	0.00173 mg/kg-TOC%
Lead	83 mg/kg
Mercury	0.64 mg/kg

Notes: mg/kg = milligrams per kilogram; mg/kg-TOC% = milligrams of organic constituent per kilogram of dry-weight sediment normalized at 1% total organic carbon

3. Identification and Screening of Technologies

This section presents the general response actions (GRAs) identified for Howard's Bay and screening of remedial technologies and process options for each GRA for use in development of remedial alternatives. The first step in the process is to identify GRAs (broad categories that can be used alone or in combination) that can meet the RAOs and PRGs (Section 3.1). Based on these GRAs, potential remedial technologies (general categories of technologies) and process options (specific processes within each technology type) are identified and then screened (Section 3.2). The results of this screening are then used to develop the complete Howard's Bay remedial alternatives (Section 4).

3.1 Identification of General Response Actions

The following GRAs were identified to achieve the RAOs and PRGs. With the exception of the No Action GRA, all GRAs may be implemented with some other technology or combinations of technologies to satisfy the RAOs and PRGs. For example, some areas of the site may simply warrant monitoring, or institutional controls, while others may be dredged or subject to other actions.

1. No Action – No remedial actions would be taken. This GRA is typically included as a baseline against which other remedial actions may be compared in accordance with USEPA guidance (USEPA 1988).

2. Monitoring – Monitoring of natural recovery processes, which have the ability to reduce the mass, volume, and toxicity of chemicals, would be conducted. Monitored natural recovery (MNR) relies upon ongoing, naturally occurring environmental processes such as chemical transformation, reduction in contaminant mobility/bioavailability, physical isolation, and dispersion that contain and reduce the bioavailability or toxicity of contaminants in sediment and thereby reduce ecological and human health (Electric Power Research Institute [EPRI] 2008; Magar et al. 2009). Isolation and mixing of contaminants through natural sedimentation is the process most frequently relied upon for natural recovery of contaminated sediment (USEPA 2005). However, certain types of chemicals, including PAHs, are amenable to reduction in concentrations, toxicity and bioavailability through natural processes such as physical-chemical weathering.

3. Enhancement of Natural Recovery – Natural recovery can also be enhanced by certain active remedial actions, such as placing a thin layer of clean material over contaminated sediments to accelerate the natural recovery process. This is sometimes also referred to as thin layer capping. Both MNR and enhanced natural recovery (ENR) are included as process options.

4. Institutional Controls – Institutional controls would be implemented to limit human access to and use of specific areas of impacted sediments. This response involves legal, administrative, and procedural

measures intended to mitigate the risks of exposure to impacted sediments by restricting contact with impacted areas or protect the integrity of a remedy.

5. Containment – Selected areas of impacted sediment would be chemically and/or physically isolated through the placement of in situ materials to provide protection of human health and the environment by reducing mobility of contaminants and/or eliminating pathways of exposure (i.e., capping). Capping is an accepted technology for the effective remediation and management of risks posed by contaminated sediment (USEPA 2005). Caps may be constructed of sand, gravel, reactive and sorbent materials, geotextiles, etc. In Howard's Bay, these materials would be installed in situ in a controlled manner "in the wet" on top of the existing sediments. Some capping options may require removing large debris, or a portion of the sediment, prior to cap construction, and some may also involve the installation of armor components or a biological layer as the top layer of the cap. Long-term post-construction monitoring would be required for any capping options to assess if the cap is functioning as intended and whether maintenance is needed. The process options for capping include isolation capping and reactive capping. Isolation capping includes placement of a non-reactive clean material over contaminated sediments to provide an engineered physical barrier to minimize transport of COCs. Reactive capping includes application of a thin layer of reactive materials over contaminated sediments to provide a physical and chemical barrier, and simultaneously providing sequestration of constituents via the addition of reactive material.

6. Removal – Selected volumes of impacted sediments would be removed for subsequent disposal or treatment. Removal actions reduce the mass, volume, and the mobility of contaminants. Resuspension of contaminated sediment and residuals are usually associated with removal process options and must be managed to minimize its effect on the surrounding environment. Removal would be performed "in the wet". Removal process options evaluated are mechanical dredging (physical removal via dredge/bucket and conventional construction equipment) and hydraulic dredging (removal/transportation of sediment in a liquid slurry form using a hydraulic pump or compressed air).

7. Sediment Treatment – Sediment treatment would include treatment of impacted sediments in-place without transferring contaminants to upland for treatment and management. In-situ treatment process options evaluated herein include mixing of amendments and solidification/stabilization. Potential amendments could include apatite, organic carbon, or organoclay.

8. Management of Removed Material and Disposal – This response is a component of a sediment remediation system that follows removal, and includes management of associated sediments and water. Sediment management processes such as dewatering, water treatment or sediment stabilization requirements depend on the staging location and disposal location. Sediment management and disposal will be evaluated and screened separately in Section 3.3 per the FFS Work Plan requirements.

3.2 Evaluation and Screening of Remedial Technologies

Identification of potential remedial technologies and process options for GRAs 1 through 6 is provided on Table 3-1, which includes a brief description of the technology and associated process options, and an initial evaluation of the technology based on the following three screening criteria:

- *Effectiveness* – This criterion is used to evaluate the ability of a remedial technology to demonstrate short-term and long-term effectiveness to achieve the site RAOs and provide protection of human health and the environment. This criterion also considers the degree of human health and environment protection during construction and implementation of a remedial technology.
- *Implementability* – This criterion encompasses technical and administrative feasibility of designing and constructing a remedial technology under the regulatory, technical and site condition constraints, as well as the availability of specific equipment, materials, services, and technical specialists to design, install, operate, and maintain a remedial technology.
- *Relative Cost* – This criterion evaluates the overall relative cost required to implement a remedial technology. As a screening tool, relative capital and operation, monitoring, and maintenance (O&M) costs are used rather than detailed cost estimates. For each remedial technology, relative costs are presented as low, moderate, or high. Costs are estimated on the basis of engineering judgment and professional experience in the industry.

Based on the criteria described above and Table 3-1, technologies were ranked using a scoring system from low (score = L) to high (score = H) as shown in Table 3-2. Technologies or process options that are clearly not effective or implementable and technologies retained from this screening process are identified in Table 3-2. GRA 8 is evaluated in Table 3-3 (see Section 3.3). Results from the screening were used to develop the remedial alternatives identified in Section 4.

3.3 Identification and Evaluation of Dredged Material Management Options

As indicated in Section 3.1, a remedial action that includes sediment removal would require management of dredged material for disposal (GRA 8). Table 3-3 identifies five dredged material management options, four beneficial use options, and five disposal options. These options are also summarized below. Figure 3-1 depicts potential onsite staging areas for dewatering and stabilization of the dredged material prior to transport by truck for final disposal. Figure 3-2 depicts locations of the beneficial use and final disposal sites described below and in Table 3-3. Criteria and evaluations of dredged material suitable for the beneficial use options 1 and 2, and for the disposal options 1 and 3 through 6 are provided as Appendices C through K. These evaluations are preliminary, subject to agency review, and will be revised during the design phase, as necessary.

A brief description of dredged material management options and evaluation of these options considering the following two criteria is also provided in Table 3-3.

- *Implementability* – This criterion encompasses technical and administrative feasibility of disposal under the regulatory, technical and site condition constraints.
- *Relative Cost* – This criterion evaluates the overall relative cost required to implement the option under evaluation. As a screening tool, relative capital and operation, monitoring, and maintenance (O&M) costs are used rather than detailed cost estimates. For each option, relative costs are presented as low, moderate, or high. Costs are estimated on the basis of engineering judgment and professional experience in the industry.

Dredged material management options evaluated include:

1. Sediment Dewatering – Dewatering can include gravity drainage on a staging pad after removal from transport barges, pumping of free water from within transport barges, and/or hydraulic loading of Geotube® dewatering devices at a temporary dewatering/staging location by pumping from transport barges. Recovered water would be managed as described below under water treatment. Temporary staging of dredged material in stockpiles for a period of months either on-site or at a disposal location can also potentially achieve adequate dewatering needs for final disposal placement.
2. On-Site Stabilization – Addition of lime, cement, fly ash or other such amendments to reduce water content, and improve the stability of the material as needed for transportation and disposal or beneficial use.
3. On-Site Ex-Situ Treatment – Traditional treatment methods include physical, chemical, thermal and/or biological processes (e.g., thermal desorption) to reduce the COC concentrations to levels required for placement in the designated disposal location. Physical processes could include separation of sand materials from fine materials. The project Partners have decided no further evaluation of this option is warranted due to significant costs associated with this option.
4. Water Treatment – Water produced from sediment dewatering operations will either be returned to the work area or retained and potentially treated for subsequent disposal or discharge to the City of Superior sanitary sewer in accordance with any pre-treatment requirements. Any water treatment that may be required would be determined during the design phase.

For purposes of the FFS, it is assumed that dredged material requiring dewatering/stabilization would be mechanically dredged and loaded onto transport barges and then unloaded for dewatering/stabilization at a staging area immediately west of the Cummings Avenue Slip (see Figure 3-1). It is assumed that water that drains from the sediment would be collected on a temporary dredged material dewatering pad constructed at this location and filtered (and treated if necessary) prior to discharge to the City of Superior sanitary sewer. It is currently anticipated that the dredged material would be stabilized by allowing a sufficient period of drying and reworking in temporary stockpiles and/or through mixing with dry soil or an additive(s) to remove free liquids.[1] The dewatered/stabilized material would then be transported by truck to the beneficial use or disposal location.

Several beneficial use options for dredge material were identified including:

1. Shallow Water Habitat Creation with In-water Placement and Cover in Cummings Avenue Slip – Cleanup dredged material qualified as acceptable for confined aquatic disposal (CAD) by WDNR would be placed in the slip to create shallow water habitat and a wetland area to help filter contaminants in stormwater from the outfall at the head of the slip. A sinuous navigational channel for recreational use by shallow draft boats would be constructed extending from the stormwater outfall into the slip (see Appendix C). The CAD cell would be constructed by installation of a berm across the slip approximately two-thirds the distance from the south end of the slip, leaving the remaining third for use as a docking area for work boats and barges (see Figure 3-2). The CAD footprint would be adjusted according to the dredged material volume meeting the WDNR criteria and up to an area of 1.6 acres (or up to placement of about 20,500 cubic yards [cy] of material within the CAD cell). Dredged materials would be transported by barge to the CAD cell, and placed through the water column. WDNR and USACE have indicated that permitting requirements for the CAD option are significant and time consuming.
2. Reuse at the Wisconsin Point Landfill – Dredged material that meets the higher of WDNR soil industrial direct contact residual contaminant level (RCL) values[2] or background values (as available for the particular analyte) could be used for amending the cap at the closed Wisconsin Point landfill located on Wisconsin Point Road (see Figure 3-2). An additional volume is under evaluation by WDNR for placement beneath the cover material as described in Appendix D. WDNR and the City of Superior have interest in improving the slope features of the landfill. Up to 90,000 cy of material may be suitable for this purpose assuming that cleaner material could be segregated and used in the finished surface layer over higher risk material, although the amount of material needed has yet to be determined. Appropriate erosion and stormwater controls would be necessary for temporary stockpiling. These needs would be addressed as part of the permitting and design process.

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[1] Alternate methods for dredged material dewatering may include gravity dewatering or the use of sediment dewatering bags (e.g., Geotubes® or similar) if the dredged sediment is hydraulically transported. In addition, it may be feasible to dewater dredged material at the upland placement location. The final dewatering method and location will be determined during the design phase.

[2] RCL values from the WDNR RCL worksheets (http://dnr.wi.gov/topic/Brownfields/documents/tech/RCLs0115.xlsm), based on the web calculator developed for the USEPA by a group from the Oak Ridge National Laboratory.

3. Beneficial Use at Brownfield Sites in Duluth, Minnesota – This project could facilitate use of sediments currently stockpiled at the Erie Pier facility, but relocating them to make space for additional material – which would be a requirement for use of the Erie Pier facility for managing any dredge material from cleanup dredging. In this scenario, the dredged material would be transported by barge to the Erie Pier facility, dewatered at Erie Pier, and stockpiled after the existing stockpile is relocated to City of Duluth brownfield sites. The new dredged material replacing relocated dredged material that meet the MPCA tiered soil criteria could potentially also be used locally in upland areas as fill material. Tier 1 material is authorized to be used at/on sites with a residential or recreational property use category. Tier 2 material is authorized to be used on/at sites with an industrial category. The Erie Pier facility is located approximately two miles from Howard's Bay on the Minnesota side of St. Louis Bay (Figure 3-2).

4. Reuse as Landfill Daily Cover - Dredged material of suitable quality could potentially be reused as daily cover at the Moccasin Mike landfill located in Section 2, Township 28 North, Range 31 West, Douglas County, Wisconsin, operated by the City of Superior or at the VONCO V industrial landfill located in Duluth, Minnesota. This option has not been retained for detailed evaluation because interested parties indicated the volume needed for daily cover is limited to about 5,000 cy at the Moccasin Mike landfill.

Disposal options that were identified and evaluated include:

1. Baxter Avenue Embayment – Barge transport and disposal of dredged material of acceptable quality into the Baxter Avenue Embayment to be contained behind the Phase 3 dock wall being installed by Fraser that will separate the embayment from Howard's Bay. Bounded by the Phase 3 dock wall to the north, the embayment shoreline to the south, and a top elevation of 605.3 feet, it is estimated that up to 50,000 cy of material could potentially be used to fill the embayment. However, given the compaction and bearing strength requirements for material to be used in the approximately 80 foot distance immediately behind the Phase 3 dock wall, approximately 22,000 cy of fill would be required in the space behind the dock wall, resulting in a maximum capacity for placement of dredged material of approximately 28,000 cy. Any sediment disposed at Baxter Avenue Embayment would need to be approved by the WDNR and consistent with a submerged lands lease through the State of Wisconsin Board of Commissioners of Public Lands. WDNR provided guidance and criteria for a low hazard waste exemption that would achieve this in an October 20, 2014 letter memorandum that is provided in Appendix E. A preliminary evaluation of material potentially suitable for placement in the embayment compared to the WDNR (and other criteria) is provided as Appendix F. However, due to permitting requirements, concerns about impacting grant funds for the Phase 3 project, and the prevalence of benzo(a)pyrene exceeding the WDNR criteria, this option has been excluded from further consideration.

2. Confined Disposal Facility (CDF) in Cummings Avenue Slip – Barge transport and disposal of dredged material of suitable quality to a CDF constructed in the Cummings Avenue Slip. The CDF would be constructed by installation of a sheetpile bulkhead wall or soil berm/dike wall across the slip and have a

footprint similar to the CAD cell option (beneficial use option 5), but would have greater capacity due to infilling above the waterline. The storm sewer discharging to the head of the slip would be extended to an alternative discharge point beyond the extent of the CDF. Sediment disposed at a potential Cummings Avenue Slip CDF would also be subject to WDNR approval. Material would be placed at the CDF until capacity is reached, which is assumed nominally to be at an elevation two feet below the surface elevation of the land bordering the slip to allow for placement of a two-foot cover layer. It is assumed that dredged material would be placed directly into the CDF and with gravity dewatering back to the slip through filter media to remove suspended materials (and/or other treatment may be required). The CDF disposal capacity is estimated at approximately 30,000 cy. The project Partners evaluated that, based on feedback from WDNR and USACE, permitting requirements for this option would be very time consuming, and no further evaluation of this option was undertaken.

3. Disposal at Erie Pier Dredged Material Management Facility – Dredged material would be delivered to the Erie Pier facility by barge. Sediment disposed at Erie Pier would be required to meet the criteria provided in Appendix G. An evaluation of material suitable for disposal at the Erie Pier facility is provided as Appendix H. However, the available Erie Pier disposal capacity is limited, and will be used for disposal of navigational dredged material to be dredged under the SND scope by USACE. Due to limited disposal capacity, this option was not further evaluated. An option under consideration is the transportation of cleanup dredged material by barge to Erie Pier and relocation of an equivalent amount of material from an existing stock pile at Erie Pier to a brownfield site resulting in no net loss of capacity at Erie Pier (See Beneficial Use Option #3).

4. Upland Placement on Fraser Shipyards Property – Dredged material qualified as acceptable for upland placement by WDNR would be placed on Fraser's property east of Clough Avenue between East 2nd Street (Route 53; the highway) and the railroad tracks (see Figure 3-1). An evaluation of dredged material suitable for upland placement is provided as Appendix I. It is assumed that the footprint of the consolidation cell would be approximately 3.5 acres. The upland placement location has an estimated capacity of approximately 37,000 cy, assuming that dredged material is placed to a thickness of 4 feet at the perimeter of the consolidation cell with a gradual slope to a maximum dredged material thickness of 10 feet in the central portion of the consolidation cell and a 2-foot thick soil cover and an impermeable membrane cover over the dredged materials with 3:1 (horizontal:vertical) slopes at the perimeter of the cell. A wetland has been identified on portion of property where the upland placement cell is proposed (see Figure 3-1 for wetland area limits). Permitting and other considerations due to the presence of wetlands within the upland placement area are identified in Appendix I.

5. Landfill Disposal at VONCO V, Duluth, Minnesota - Disposal of dredged material at this industrial landfill. Dredged material to be disposed as waste would be required to meet the waste criteria provided in Appendix J, and pass the paint filter test.

6. Moccasin Mike Landfill, Superior, Wisconsin – Disposal of dredged material at this landfill owned by City of Superior. Dredged material to be disposed as waste would be required to meet the City of Superior Special Waste Management Plan (see Appendix K), and if over 2,000 cy would also need to be approved by WDNR. The project Partners have decided no further evaluation of this option is warranted due to significant disposal costs associated with this option.

Based on the evaluation provided in Table 3-3 and described above, three beneficial use options (*i.e.,* options 1 through 3) and two disposal options (*i.e.,* options 4 and 5) were retained for future consideration. It is likely that a combination of beneficial use and disposal options will be selected considering disposal suitability (see also Appendices C through J, and Figure 3-2), relative cost (see Table 3-3), and dredge volume and disposal capacity of various disposal options. Similarly, all management of removed material options were retained. Results from this screening were used to develop the remedial alternatives identified in Section 4.

4. Development of Remedial Alternatives

This section utilizes the retained remedial technologies and associated process options from Section 3, and assembles them into eight site-wide remedial alternatives for evaluation against the screening criteria. The Site-Wide No Action alternative is retained throughout the evaluation as a baseline for comparison to the other remedial alternatives.

Sections 4.1 through 4.9 provide specific details for each of the assembled remedial alternatives. While representative process options are included for each of the remedial alternatives, it should be noted that these may be modified during the design and implementation phases of the selected alternative due to engineering considerations, localized site-specific conditions, ongoing coordination with the USACE regarding the SND project details, and/or any new site-specific information. Further, it is anticipated that means and methods would be determined to some degree by the selected contractor; however, for purposes of the FFS assumptions have been made for cost estimating purposes to allow for an evaluation of the alternatives. Note also that some process options are common to multiple remedial alternatives, and therefore will be described once with references back to where details are provided for subsequent alternatives.

4.1 Potential Remedial Areas and Volumes

Comparison of the COC concentrations in surface and subsurface sediment samples to the PRGs described in Section 2.1.1, professional judgment was used to delineate the sediment management units for the remedial alternative A-1. The original basis for the delineations was a draft proposed by WDNR that was subsequently used to develop the boundaries in Alternative A-1. Other alternatives were then prepared through a series of efforts that included refinement of the Alternative A-1 management unit boundaries. The remedial alternatives A-2, A-3, and B-1 (described in Sections 4.4, 4.5, and 4.7) are substantially similar to Alternative A-1, with the exception of the use of other remedial technologies (*i.e.,* ENR, MNR and/or capping) in combination to dredging to address the impacted sediments within the sediment management units. Sediment management units are defined in this project as discrete areas considered for potential remedial action and are shown in Figure 4-1.

The WDNR Consensus-Based Sediment Quality Guidelines (CBSQGs, WDNR 2003b) state that "the CBSQGs should not be used on a stand-alone basis to establish cleanup levels or for sediment management decision making." However, in certain situations, with agreement of all the parties involved in overseeing remediation and those responsible for remediating a contaminated sediment site, the CBSQG values can be used as remediation objectives for a site. The Contaminated Sediment Remediation Guidance for Hazardous Waste Sites (USEPA 2005) states that "it is very important for project managers to keep in mind that screening values are not designed to be used as default cleanup levels and generally should not be used for that purpose". With these Guidelines and Guidance in mind, Alternative A-4 was developed to provide a lower cost alternative with consideration of the following:

- The degree to which PRG values were exceeded in the deeper sediments below the upper-most sample layer, specifically in comparison to whether the PEC value was also exceeded, and the depth intervals within which the exceedances were observed; and
- Sediment stability considerations including potential effects of bioturbation and potential for sediment resuspension (as discussed in Section 1.6). Preliminary refinements of the boundaries along shorelines with bulkheads and former wharf or dock structures were made to avoid creating instability, or to avoid the need to do extensive debris or piling removal – although similar adjustments would be likely be applied during the design phase to whatever preferred cleanup plan is ultimately selected.

The remedial alternatives B-2 and B-3 were then developed substantially similar to the refined alternative A-4, with the exception of the use of other remedial technologies (i.e., ENR and capping) in combination to dredging to address the impacted sediments. Remedial boundaries for the refined alternatives are provided in Figure 4-2.

Preliminary estimates of remedial areas and removal volumes associated with each remedial alternative are provided in Table 4-1. The removal volumes provided include only incremental dredge depth volumes beyond the SND project scope where appropriate. The remedial areas and volumes will ultimately be refined during the design phase with considerations such as side sloping, sloughing, overdredging tolerances, off-sets from in-water structures, pre-design investigation findings, setbacks, approach for dredging specifications in each sediment management unit, and other factors. Per USACE's Technical Guidelines for Environmental Dredging of Contaminated Sediments, it is anticipated that actual quantities addressed during remedy implementation may vary considerably from the FFS estimates in consideration of constructability issues. This uncertainty in volume will affect all alternatives similarly, and therefore allows the comparative evaluation of alternatives.

The SND activities will target an estimated 24,000 cy of sediment from the federal channel to a depth of 27 feet below the Lake Superior LWD within the areas shown in Figure 1-6 plus an assumed 1-foot over-dredge allowance for a total estimated dredge volume of up to 37,000 in-situ cy[3]. Final dredge volumes could be somewhat greater depending on side slope sloughing into the dredge cut. For purposes of the FFS, it is assumed that the SND dredged material will be placed at the Erie Pier facility (disposal option 3; see Figure

[3] Based on the 2013 single-beam bathymetric data. The total SND volume estimated by USACE based on the 2014 multi-beam bathymetry data is approximately 43,000 in-situ cy.

3-2). A volume of 11,000 in-situ cy of potential SND dredge material has been excluded from the dredged material volume estimates due to its proximity to the Blatnik Bridge – these sediments are within the setback area of the federal channel around the bridge abutments that is shown in channel limit drawings provided by the USACE. A portion of sediments in these setback areas may be considered for removal in the design phase depending on engineering considerations.

Cleanup dredging will address sediments adjacent and below the federal channel limits. The alternatives described in Sections 4.3 through 4.9 include dredging a range of 45,000 in-situ cy to 96,000 in-situ cy of sediment targeted for remediation, depending on the alternative, and not accounting for any allocation for overdredge volumes. After an initial dredging pass to remove the target cleanup material followed by post-removal sampling and testing, it is assumed a contingency of up to 20% of the cleanup volume to address uncertainties in cleanup volume based on dredging tolerance and field conditions. This estimate is derived by allowing for a dredge tolerance of 6 inches beyond the neat line volume over the entire dredging area. This 20% overdredging allowance is included in the disposal quantities for purposes of the FFS cost estimate. Thus, the total cleanup dredge volume is estimated to range from 55,000 to 115,000 in-situ cy.

Assuming a dredged material bulking factor of 15% for all cleanup dredged material, the total ex-situ cleanup volume (after addition of stabilization amendments) ranges from 63,000 to 132,000 cy.

Dredged material is anticipated to contain on average of approximately 56% silt and clay, and moisture contents of approximately 42% by weight. Sand content is anticipated to be approximately 40% (ARCADIS 2014).

4.2 Site-Wide No Action Alternative

Under the No Action alternative, no remediation or monitoring activities would be conducted in the study area. Natural recovery processes would be relied upon to reduce COC levels in sediment, but these levels would not be tracked over time, and thus BUIs associated with Howard's Bay would remain unaddressed. Future dredging needs would be addressed as needed specific to each dredging event, and potential risks associated with contaminated sediment would remain. The Site-Wide No Action alternative serves as a baseline for comparison of the other remedial alternatives.

4.3 Alternative A-1: Sediment Removal in All Subareas

Alternative A-1 includes removal of sediment targeted based on the PRGs in specific subareas of the site (Units 1- 31 require cleanup dredging, and Units 32-36 require SND only). Removal depths are based on sediment analysis results exceeding the WDNR MEC values for the four site-specific COCs or the top of the underlying native clay unit (see Figures 4-3a to 4-3d). For purposes of this FFS, the main components of Alternative A-1 are assumed to include the following:

- Mechanical dredging using in-water equipment (e.g., mechanical clamshell dredges operating from a barge) of approximately 96,000 neat in-situ cy over a remedial area of about 24 acres (or 115,000 in-situ cy with the assumed overdredge allowance). SNDTable 4-2 provides the estimated SND and cleanup dredging volume and footprint for each sediment management unit. Shallow areas to the north of the federal channel (Units 12B, 15C, 17C, 20 and 25B) would be dredged using long-reach excavators operating from shallow-draft barges or from temporary access constructed from shore, assuming that barge-mounted, crane-operated dredges will not be able to reach the full extent of these areas because of water depth limitations. Dredging of sediments targeted for cleanup would utilize an environmental dredging bucket. Turbidity controls (silt curtains and potentially other technologies such as air bubble curtains) will be assessed and determined during design with consideration given to the minimization of impacts to shipyard operations during dredging, cost, and hot spots.
- The maximum sediment excavation thickness is estimated to be 8 feet (in the Cummings Avenue Slip). The maximum depth below water that the dredging would occur to is approximately 31 feet in the federal channel. These extents are based on sampling results provided in Figures 4-3a and 4-3b.
- Dredging setbacks and/or bulkhead stabilization measures may be needed in certain areas. Appendix L provides an evaluation of the current seawall configuration and bulkhead stability conditions conducted by the USACE. This evaluation indicated that dredging near the wall along the head of Hughitt Slip (Unit 26), head of Cummings Avenue Slip (Unit 19D), and the embankment from Fraser Slip to the Docking Area (Units 1, 2 and 4) will likely affect wall stability and thus will require either application of a dredging set-back and/or wall stabilization measures in association with dredging. In addition, dredging near the wall along the east embankment of the Fraser Slip (Unit 10) could cause some instability of the wall.
- Removal of large debris from the target removal areas, to the extent needed, to allow for removal using mechanical methods (such as excavators). Any large debris encountered will be segregated from dredged material, temporarily stockpiled near the off-loading area and then hauled separately for transport to the disposal location, or an alternative location suitable to receive the materials. Debris is anticipated to consist primarily of old pilings, timber cribbing, and associated iron and concrete debris. If substantial quantities of recyclable debris is found it will be decontaminated and sent to a center for recycle, if appropriate.
- Placement of a residuals cover layer after completion of dredging would be used where needed depending on post-removal sample results. It is nominally assumed the residuals cover layer would consist of 6 inches of sand. There is a potential of redgredging in some specific areas, although redredging needs are assumed to be minimal and were not included in cost estimates.
- Dredged material handling, transport, sediment processing, and water treatment needs would be determined based on the selected disposition locations. The following approach is assumed for purposes of the FFS alternatives description and cost estimating. This plan is subject to revision during the design phase and/or based on approved methods ultimately selected by the construction contractor.

- o Navigational dredged material would be placed onto a barge and transported to the Erie Pier facility. For purposes of the FFS, it is assumed that 37,000 in-situ cy of dredged material would be disposed of at Erie Pier (including neat in-situ volume and the assumed overdredge in-situ volume).
- o Estimates of the in-situ material volumes (including neat in-situ volume and the assumed overdredge allowance) are provided in Table 4-3. The estimates were prepared based on the criteria and evaluations of sediments identified as suitable for beneficial use (*i.e.,* options 1 through 3) discussed in Appendices C, D and H. Those sediments that are not suitable for beneficial use would be placed in the onsite upland consolidation cell (*i.e.,* disposal option 4) or disposed of as waste at the VONCO V landfill located in Duluth, Minnesota (*i.e.,* disposal option 5). The anticipated volumes of dredged material that would be disposed of through these options will be refined during the design phase following selection of a preferred alternative, and will account for volume adjustment for side slopes, overdredge allowance, addition of stabilization additives[4], and other considerations.

Alternative A-1 Quantities Summary (Including Neat In-Situ Cleanup Volume and Assumed Overdredge Allowance)	
Remedial sediment dredge volume	115,000 in-situ cy over 24 acres
Erie Pier Dredged Material Management Facility	SND material only
Wisconsin Point Landfill dredged material placement	62,000 in-situ cy
Brownfield site dredged material beneficial use	46,800 in-situ cy
VONCO V Landfill dredged material disposal	6,200 in-situ cy

4.4 Alternative A-2: Sediment Removal in All Subareas, Except for ENR in Units 12B, 15C, 17C, 20 and 25B

Alternative A-2 is substantially similar to Alternative A-1, with the exception of the use of ENR instead of dredging as the remediation approach in Units 12B, 15C, 17C, 20 and 25B, all located in shallow areas to the north of the federal channel (see Figure 4-4). A primary reason for use of ENR instead of dredging is the

[4] Note that addition of stabilization additives is a high cost item for the project. For purposes of cost estimates, it is assumed that Portland cement either type 1 or 2 from Lafarge at a cost of $135/ton free on board (fob) locally available approximately 1 to 2 miles from the project staging area will be used at approximately a 10% by weight amount. This product/percent is subject to change during the design phase based upon bench scale testing to be performed on the dredge materials. Other products under evaluation for use as stabilization additives are quick lime from Graymont at a cost of $105/ton fob and lime kiln byproduct from Graymont at a cost of $30/ton fob locally available approximately 1 to 2 miles from the project staging area. It has been assumed no stabilization additive is needed for the reuse option at brownfield sites.

greater cost effectiveness of ENR, recognizing that the shallow water conditions could necessitate mobilization of different dredging equipment to access these areas, thus increasing the unit cost of removing the relatively small quantities of sediment in these management units. The cost savings would be offset somewhat by mobilization of similar equipment to these units in order to transport and place the sand cover material. The description of this alternative is consistent with the description of Alternative A-1 in Section 4.3, and is not repeated below except to describe the use of ENR and present the quantities summary specific to Alternative A-2.

- ENR in the shallow water areas (Units 12B, 15C, 17C, 20 and 25B) would be accomplished by placement of a four to six-inch sand cover layer over the targeted areas, which total approximately 1.4 acres. The cover thickness tolerances and measurement methods will be identified during the design phase. The sand (or clean dredged material) would be placed via methods left to the contractor's determination but could include spreading from small barges, broadcast methods, or use of small barge mounted excavators. Silt curtains would be placed around the ENR sites during placement of the cover layer. Monitoring activities during and following placement would be performed as necessary to provide adequate turbidity control and quality assurance of cover layer placement.

Alternative A-2 Quantities Summary (Including Neat In-Situ Cleanup Volume and Assumed Overdredge Allowance)	
Remedial sediment dredge volume (Units 1-11, 12A, 13-14, 15A-15B, 16, 17A-17B, 18-19, 21-24, 25A, and 26-31)	109,000 in-situ cy over 23 acres
Erie Pier Dredged Material Management Facility	SND material only
Wisconsin Point Landfill dredged material placement	62,000 in-situ cy
Brownfield site dredged material beneficial use	40,800 in-situ cy
VONCO V Landfill dredged material disposal	6,200 in-situ cy
ENR (Units 12B, 15C, 17C, 20 and 25B)	1.4 acres (addressing 6,000 in-situ cy) with placement of 1,200 cy of sand

4.5 Alternative A-3: Sediment Removal in All Subareas, Except for MNR in Units 12B, 15C, 17C, 20 and 25B

Alternative A-3 is substantially similar to Alternative A-2, except that the areas targeted for ENR would be subject to MNR (see Figure 4-5). MNR in those areas would entail periodic monitoring to document either the continued deposition of cleaner sediment, recovery of exposure concentrations, reductions in toxicity test metrics, and/or other indicators of sediment quality over time. A monitoring plan would be developed in association with the design phase activities.

Alternative A-3 Quantities Summary (Including Neat In-Situ Cleanup Volume and Assumed Overdredge Allowance)	
Remedial sediment dredge volume (Units 1-11, 12A, 13-14, 15A-15B, 16 17A-17B, 18-19, 21-24, 25A, and 26-31)	109,000 in-situ cy over 23 acres
Erie Pier Dredged Material Management Facility	SND material only
Wisconsin Point Landfill dredged material placement	62,000 in-situ cy
Brownfield site dredged material beneficial use	40,800 in-situ cy
VONCO V Landfill dredged material disposal	6,200 in-situ cy
MNR (Units 12B, 15C, 17C, 20 and 25B)	1.4 acres (addressing 6,000 in-situ cy)

4.6 Alternative A-4: Sediment Removal in Refined Subareas, Except for ENR in Units 15D and 25B, and No Action in Units 12B, 13B, 14B, 15B-C, 17B-C, 19A, 20, 22, 25A, 28

Alternative A-4 is similar to Alternative A-2 except that the subareas have been refined and certain units have been designated for alternative management approaches other than dredging based on more detailed consideration of the sediment profile and project cost. Specific considerations applied in development of Alternative A-4 include the following:

- Several sediment management unit boundaries east of the Blatnik Bridge were adjusted based on preliminary review of these supplemental 2014 sampling results.
- Core locations where the PRG value was not exceeded at the surface, but was exceeded deeper in the sediment column were individually reviewed with consideration of sediment stability, cost-effectiveness implications of removing overlying clean sediment, and the degree to which PRGs were exceeded, and whether by a single or multiple COCs. In this review, consideration was given to whether concentrations exceeding the PRG were also above the PEC values or not. Instances of this were primarily limited to individual COCs, mainly lead, but in a few cases also tributyltin and PAHs. No adjustments to sediment management units were made in Alternative A-4 based on mercury concentrations. Based on the development of the MEC values, (by definition) there is uncertainty as to whether concentrations below the PEC would be associated with adverse effects on populations of benthic organisms. Recognizing this uncertainty, and in consideration of balancing factors of cost and in some cases logistical limitations of dredging in shallow water – alternative management approaches were selected in Alternative A-4.
- In review of sediment manage unit assignments in development of Alternative A-1, it was recognized that in some cases the available sample network did not reliably represent conditions within certain units due to the applicable samples being positioned along the boundary, or in some cases, even outside of the units. In these cases, upon closer review, in consideration of the site morphology, sediment thickness and COC distributions, alternative management approaches to

those specified in Alternative A-1 were adopted – and in some cases the units were subdivided and alternative target depths specified.

- Refinements were also made to the boundaries along shorelines with bulkheads and former wharf or dock structures to avoid creating instability, or to avoid the need to do extensive debris or piling removal. This will ultimately be a design consideration for the selected alternative, but was applied to a limited extent in development of the refined Alternatives A-4, B-2 and B-3.

These changes result in Alternative A-4 being consistent with the description of Alternative A-2 in Section 4.4, except for:

- No action would be taken instead of dredging in Units 13B, 14B, 15B, 17B-C, 19A, 22, 25A, and 28;
- No action would be taken instead of ENR in Units 12B and 17C, and 20; and
- Refinement of selected subarea boundaries and creation of Units 15D, 17D, 19E and 19F to address portions of Units 15B-C, 17A-B, 19A, and 19B (see Figures 4-6a to 4-6d).

The quantities summary specific to Alternative A-4 is provided below.

Alternative A-4 Quantities Summary (Including Neat In-Situ Cleanup Volume and Assumed Overdredge Allowance)	
Remedial sediment dredge volume (Units 1-11, 12A, 13A, 14A, 15A, 16, 17A, 17D, 18, 19B-F, 21, 23, 24, 26, 27, and 29-31)	89,000 in-situ cy over 18 acres
Erie Pier Dredged Material Management Facility	SND material only
Wisconsin Point Landfill dredged material placement	54,100 in-situ cy
Brownfield site dredged material beneficial use	28,800 in-situ cy
VONCO V Landfill dredged material disposal	6,100 in-situ cy
ENR (Units 15D and 25B)	0.70 acres (addressing 1,000 in-situ cy) with placement of 560 cy of sand

4.7 Alternative B-1: Partial Dredge/Capping at Head of Hughitt and Cummings Avenue Slips and Sediment Removal in All Subareas, Except for ENR in Units 12B, 15C, 17C, 20 and 25B

Alternative B-1 is similar to Alternative A-2, with the exception of management of sediments at the head of the Hughitt Avenue Slip and Cummings Avenue Slip. Under this alternative, sediments at the head of these slips would be partially dredged and capped in-situ through placement of isolation caps (see Figure 4-7). . If this alternative were selected, the capping approach would be developed in the design phase, including the long term monitoring and maintenance approach. The main components of sediment removal would be consistent with the description provided in Section 4.3 (Alternative A-1) and ENR would be consistent with the description provided in Section 4.4 (Alternative A-2), and are not repeated below except to note the volume and areas associated with this alternative. Partial sediment removal would be performed as necessary at the head of Hughitt Avenue Slip to accommodate for cap placement while preserving the needed navigation depth. Sivertson Fisheries, who have continuing operations in the head of the Hughitt Avenue Slip, indicated that a depth of 10 feet would be adequate for their purposes (*pers. conv. Erin Endsley, WDNR, 8/27/14 team call)*. No specific navigational use for the southern two-thirds of the Cummings Avenue Slip has been identified by the current riparian property owner, and therefore no dredging would be necessitated for navigational purposes required prior to cap placement; however, limited hotspot dredging near the outfall of Cummings Avenue Slip has been discussed with WDNR, depending on the cap design. For purposes of this FFS, the main components of cap placement are assumed to include the following:

- Mechanical dredging to achieve a top of sediment elevation of 12 feet below low water datum prior to placement of a two-foot thick isolation cap at the head of Hughitt Avenue Slip (Unit 26). This would involve removal of approximately 300 cy from the head of Hughitt Avenue Slip prior to installation of the cap. This would ensure that the surface of the cap is a uniform elevation to allow for consistent navigational access – and aid in any future maintenance dredging of these areas, which could target a defined elevation. Institutional controls to limit future dredging depth in the cap area within Hughitt Slip may be needed. For purposes of the FFS, no dredging has been assumed at the head of Cummings Avenue Slip.
- Installation of an isolation cap over approximately 1 acre of impacted sediments at the head of Hughitt Avenue Slip in Unit 26 and over approximately 1.2 acres at the head of Cummings Avenue Slip in Units 19B through 19D to achieve the PRGs (see Figure 4-7). The cap is assumed to consist of a separation layer, followed by an isolation layer, and a habitat layer. The final configuration, thickness and composition details would be determined during the design phase. In addition to the isolation cap elements, the cap could potentially include reactive material to eliminate migration of constituents in porewater. For purposes of the FFS, it is assumed that a 2 foot sand cap layer would be placed over impacted areas for a total estimated volume of approximately 7,100 cy of sand (does not include loss or sloping factors). Stability of the cap materials addressed during remedial design. Localized armoring may be required near outfalls. Measures to minimize potential disturbance of the cap by boat propellers, such as signs, buoys or other measures could also be installed if appropriate.
- Removal of large debris from the target areas to the extent needed for cap installation.
- Cap materials would be placed from the water via mechanical equipment located on barges (e.g., excavators or telestackers). The staging area to be used for cap material preparation, stockpiling, and loading would be the same as that established for supporting the mechanical dredging activities.
- A long-term monitoring and maintenance program would be implemented to document and maintain the effectiveness of the cap. Damage to the cap observed during monitoring activities would be addressed appropriately as needed to maintain the long-term effectiveness of the cap. The long-term monitoring

and maintenance program will be developed during the design phase, if this alternative is selected as the preferred remedy.

- Impose institutional controls (i.e., no dredging or marine navigational use within cap areas) to protect the integrity of the caps.

Alternative B-1 Quantities Summary (Including Neat In-Situ Cleanup Volume and Assumed Overdredge Allowance)	
Cap head of Hughitt Avenue Slip (Unit 26)	1 acre (addressing 13,000 in-situ cy) with placement of 3,200 cy of cap material
Cap head of Cummings Avenue Slip (Units 19B-19D)	1.2 acres (addressing 7,100 in-situ cy) with placement of 3,900 cy of cap material
Remedial sediment dredge volume (Units 1-11, 12A, 13-14, 15A-15B, 16, 17A-17B, 18, 19A, 21-24, 25A, and 26-31)	89,000 in-situ cy over 20 acres
Erie Pier Dredged Material Management Facility	SND material only
Wisconsin Point Landfill dredged material placement	42,000 in-situ cy
Brownfield site dredged material beneficial use	40,800 in-situ cy
VONCO V Landfill dredged material disposal	6,200 in-situ cy
ENR (Units 12B, 15C, 17C, 20 and 25B)	1.4 acres (addressing 6,000 in-situ cy) with placement of 1,200 cy of sand

4.8 Alternative B-2: Partial Dredge/Capping at Head of Hughitt Avenue Slip and Docking Area, CAD at Head of Cummings Avenue Slip, and Sediment Removal in Refined Subareas, Except for ENR in Units 15D and 25B, and No Action in Units 12B, 13B, 14B, 15B-C, 17B-C, 19A, 20, 22, 25A, 28

Alternative B-2 is similar to Alternative A-4 for the sediment management units within Areas 1 and 2 (within and outside of the federal channel) and Cummings Slip (Units 19A and E), and similar to the Alternative B-1 approach for the slips, except that instead of a sediment cap within the head of Cummings Avenue Slip, this area would be converted to a CAD. The CAD would be filled with dredged material to create improved habitat conditions on the slip and a wetland area to help filter contaminants in stormwater from the outfall discharges at the head of the slip (Figure 4-8). The bottom of the slip is owned by Fraser, and approximately the southern two-thirds of the slip (Units 19B through 19D) is not needed by Fraser for future shipyard use. Therefore, these units would be converted to a CAD through installation of a an underwater berm across the slip to contain dredged material placed in the CAD area, the sediments within this area would be left in place, and dredged material would be placed and then covered to fill the CAD (see Section 3.3 for additional details). Under this CAD option, localized "hot-spot" removal may be needed within Unit 19D and/or a portion of Unit 19C before placement of dredged material - depending on the cover system design. Initial estimates are that approximately 2,500 cy would be removed for offsite disposal. Alternative B-2 also includes partial capping of Unit 1. Within Unit 1 the Docking Area would be dredged and the remainder would be covered with an isolation cap placed in the northern portion of Unit 1.

The main components of sediment removal and ENR are consistent with the description provided in Section 4.6 (Alternative A-4), and of capping in the head of the Hughitt Avenue Slip are consistent with the description provided in Section 4.7 (Alternative B-1), and therefore are not repeated below except to note the volume and areas associated with this alternative. Legal review and consideration of permitting issues are required to further assess feasibility of the CAD. For purposes of this FFS, the main components of the CAD installation and partial dredging/capping in the Docking Area under Alternative B-2 are assumed to include the following:

- Construction of a CAD at head of Cummings Avenue Slip in Units 19B through 19D and 19F over an area up to 1.6 acres to isolate in place COC-containing sediment and dispose of sediments meeting the WDNR criteria for placement . Under this CAD option, hot-spot removal of approximately 2,500 cy may be needed in Unit 19D and a portion of Unit 19C before placement of dredged material – depending on the cover layer design. For purposes of cost estimates for this alternative, hot spot removal prior to dredged material placement is included. It is anticipated that the capacity of this CAD would be approximately 20,000 cy. An armor layer at the head of the slip would prevent disturbance of the cap in the immediate vicinity of the stormwater outfall if unusually large runoff events occur.
- Material would be placed at the CAD until capacity is reached (see Section 3.3 for additional description)[5]. The filling process would be developed to allow the sediment to gradually settle to mitigate water quality impacts from the discharge of excess water and suspended sediment.
- Once the dredged material was placed, one foot of clean fill or dredged material over all dredged material with an organic content sufficient to support aquatic vegetation would be placed over the top to cap the dredged sediment. Other design requirements may also be necessary to achieve regulatory approval, in particular if hotspot dredging is not conducted prior to dredged material placement.
- A sinuous navigational channel would be constructed extending from the storm water outfall into the slip with a navigable water depth of at least two feet below the Lake Superior LWD. At average water levels, navigable depth would be approximately 2.5 feet.
- A berm would be constructed with clean fill and armored on the outboards side with coarse aggregate at the mouth of the CAD cell near the limits of submerged land lease (see conceptual plan view and longitudinal transect sketches in Appendix C).

[5] It has been assumed no stabilization additive is needed for the CAD reuse option.

- A long-term monitoring and maintenance program would be implemented to document and maintain the effectiveness of the CAD.
- Impose institutional controls (i.e., no excavation) to protect the integrity of the CAD.
- Mechanical dredging using in water equipment of approximately 11,000 neat in-situ cy over a remedial area of about 2.4 acres (or 13,000 in-situ cy including neat in-situ volume and overdredge allowance) with installation of an isolation cap over approximately 1 acre in Unit 1B of remaining impacted sediments to achieve the PRGs (see Figure 4-8). For purposes of the FFS, it is assumed that the cap configuration would be similar to the Alternative B-1 approach for the slips with a 2 foot sand cap layer placed over impacted areas for a total estimated volume of approximately 3,200 cy of sand (does not include loss or sloping factors). Stability of the cap materials would be verified during remedial design. Localized armoring may be required. The final cap thickness and composition details would be determined during remedial design.

Alternative B-2 Quantities Summary (Including Neat In-Situ Cleanup Volume and Assumed Overdredge Allowance)	
CAD at head of Cummings Avenue Slip (Units 19C, 19D, and portions of Units 19B and 19F) with hot-spot removal in Unit 19D and portion of Unit 19C, and removal in portion of Units 19B and 19F outside of the CAD limits	Up to 1.6 acres (addressing 2,600 in-situ cy) with placement of 2,500 cy of cap material, and removal of 3,600 cy over 0.40 acres
Cap head of Hughitt Avenue Slip (Unit 26)	0.86 acre (addressing 12,000 in-situ cy) with placement of 3,200 cy of cap material
Partial dredge (Units 1A-B) and cap of portion of the Docking Area (Unit 1B)	1 acre (addressing 4,800 in-situ cy) with placement of 3,200 cy of cap material, and removal of 13,000 cy over 2.4 acres
Remedial sediment dredge volume (Units 2-11, 12A, 13A, 14A, 15A, 16, 17A, 17D, 18, 19E, 21, 23, 24, 27, and 29-31)	72,000 in-situ cy over 17 acres (including removal in portion of Units 19B-D, 19F and 1A-B, as described above)
Erie Pier Dredged Material Management Facility	SND material only
Wisconsin Point Landfill dredged material placement	29,500 in-situ cy
Cummings Avenue Slip CAD dredged material disposal	8,800 in-situ cy
Brownfield site dredged material beneficial use	27,600 in-situ cy
VONCO V Landfill dredged material disposal	6,100 in-situ cy
ENR (Units 15D and 25B)	0.70 acres (addressing 1,000 in-situ cy) with placement of 560 cy of sand

4.9 Alternative B-3: Partial Dredge/Capping at Head of Hughitt Avenue Slip, Head of Cummings Avenue Slip, and Docking Area, and Sediment Removal in Refined Subareas, Except for ENR in Units 15D and 25B, and No Action in Units 12B, 13B, 14B, 15B-C, 17B-C, 19A, 20, 22, 25A, 28

Alternative B-3 is similar to Alternative B-2, with the exception of placement of an isolation cap to achieve the PRGs at the head of Cummings Avenue Slip instead of installation of a CAD cell, and at the Docking Area instead of partial dredging and capping (Figure 4-9).

Under this alternative, the main components of sediment removal and ENR are consistent with the description provided in Section 4.6 (Alternative A-4). Sediments at the head of the Hughitt Avenue Slip and Cummings Avenue Slip, and at the Docking Area would be partially dredged and capped in-situ through placement of isolation caps consistent with the description provided in Section 4.7 (Alternative B-1). Therefore, the components of this alternative are not repeated below except to note the volume and areas associated with this alternative.

Alternative B-3 Quantities Summary (Including Neat In-Situ Cleanup Volume and Assumed Overdredge Allowance)	
Cap head of Hughitt Avenue Slip (Unit 26)	0.86 acre (addressing 12,000 in-situ cy) with placement of 3,200 cy of cap material
Cap head of Cummings Avenue Slip (Units 19B-19D, and 19F)	1.1 acres (addressing 6,200 in-situ cy) with placement of 3,900 cy of cap material
Cap the Docking Area (Units 1A and 1B)	2.4 acres (addressing 18,000 in-situ cy) with placement of 7,800 cy of cap material
Remedial sediment dredge volume (Units 2-11, 12A, 13A, 14A, 15A, 16, 17A, 17D, 18, 19E, 21, 23, 24, 27, and 29-31)	55,000 in-situ cy over 14 acres
Erie Pier Dredged Material Management Facility	SND material only
Wisconsin Point Landfill dredged material placement	24,900 in-situ cy
Brownfield site dredged material beneficial use	24,000 in-situ cy
VONCO V Landfill dredged material disposal	6,100 in-situ cy
ENR (Units 15D and 25B)	0.70 acres (addressing 1,000 in-situ cy) with placement of 560 cy of sand

5. Evaluation and Screening of Remedial Alternatives

This section provides an evaluation of the site-wide remedial alternatives described in Section 4 considering the seven evaluation criteria defined in Section 5.1. Comparison of each alternative against the evaluation criteria are provided in tabular format on Table 5-1, and a comparative evaluation of the remedial alternatives against each other with respect to the evaluation criteria is provided in Section 5.2.

5.1 Evaluation Remedial Alternatives

Seven evaluation criteria were used for comparison of the remedial alternatives. The evaluation criteria are listed and described below. Note that while some of the criteria listed below have been grouped or categorized to facilitate alternative evaluation, the evaluation reflects the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) requirements for remedy evaluation in the feasibility study process (40 Code of Federal Regulation [CFR] 300.430).

- **Short- and long-term effectiveness in protecting human health and the environment:** This criterion refers to the ability of a remedial alternative to eliminate, reduce, or control potential exposure over the short- and long-term. Short-term specifically considers time period until RAOs are achieved and short-term effects and risks related to construction and implementation of an alternative including protection of workers and the community during remedial action implementation and short-term environmental impacts of remedial action. Long-term specifically focuses on magnitude of residual risks, current and future site use, and adequacy/reliability of control measures to provide overall protection of human health and the environment.

- **Ability to achieve RAOs and meet cleanup goals**: This criterion refers to the ability of a remedial alternative to achieve the RAOs that were identified Section 2.

- **Evaluation of applicable regulations and permit requirements**: This criterion refers to the ability of a remedial alternative to meet all appropriate federal, state, and local regulations and permits. Potential regulatory authorizations needed for the identified process options may include, but are not limited to, USACE Section 10 dredging permit, USACE Section 404 of the Federal Clean Water Act, Section 401 Water Quality Certification, Wisconsin Pollutant Discharge Elimination System (WPDES) Permits, Chapter 30 of the Wisconsin Statutes, Discharge Permit to the City of Superior publicly owned treatment works (POTW) and the City of Superior's Special Area Management Plan (SAMP) permit if applicable, landfill approval for acceptance of dredge material, WDNR and MPCA acceptance material criteria, local soil/sediment erosion control plan permits, and environmental review (National Environmental Policy Act [NEPA]/ Wisconsin Environmental Policy Act [WEPA]) including state historical society and endangered species review. Each remedial alternative would comply with regulations, so the assessment for this criterion describes the relative effort and complexity involved in complying with applicable regulations.

- **Implementability**: This criterion encompasses the technical feasibility (ease or difficulty) of designing and constructing/implementing and monitoring a remedial alternative based on site-specific constraints as applicable, as well as the availability of specific equipment, materials, services, and technical specialists need to design, install, operate, and maintain the remedial alternative.

- **Cost**: This criterion refers to the overall cost required to implement the remedial alternative including relative capital and future O&M costs. Cost estimates developed by the USACE are provided in Appendix M. Note that quantities associated with Alternatives A-1, A-2, A-3 and B-1 used for cost estimates in Appendix M were revised[6] to include preliminary refinements of the boundaries along shorelines with bulkheads and former wharf or dock structures and to avoid the need to do extensive debris or piling removal under the same approach applied to Alternatives A-4, B-2 and B-3 to allow unbiased comparison among all the alternatives. Note that remedial depths/boundaries are not identical between alternatives, as shown in Figures 4-1 and 4-2 and reflected in dredging volumes provided in this report[7]. Dredging units and volumes for the preferred alternative will undergo refinement during design.

- **Ability to contribute to removal of BUIs**: This criterion refers to the potential ability of a remedial alternative to support removal of BUIs identified for the SLRAOC. The SLRAOC BUIs are listed in Section 1.3.3.

- **State and public acceptance**: State and public acceptance is also a necessary criterion for any selected cleanup alternative. This criterion considers the acceptability of a remedial alternative to the state and the public. This criterion is not evaluated in this FFS, but will be satisfied once the Partners (including WDNR) agree on the preferred remedial alternative selected in this FFS, and a public meeting is held to provide an opportunity for public input on the preferred alternative.

The evaluation of the remedial alternatives with respect to these evaluation criteria is provided in Table 5-1.

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[6] Revised quantities are provided in Appendix M only, and have not been included in the main body of this report because the changes are minor and they will not appreciably affect the comparative analysis of alternatives, considering that they are reflected in the cost estimate comparison.

[7] As an example, Unit 1 contains eight sediment cores. Alternative A-1 mutliplied the maximum thickness from the eight cores by the area to determine the volume (17,000 CY). Alternative A-4 splits Unit 1 into two smaller units based on the varying sediment thicknesses, resulting in 13,700 CY, or a 3,300 CY reduction (19%) of Unit 1 dredge volume.

5.2 Comparative Analysis of Remedial Alternatives

A comparative analysis of the remedial alternatives is presented in Table 5-2. The analysis evaluated each alternative alongside criteria presented in Table 5-1, and the resulting scores are used to rank the alternatives. Ability to achieve RAOs and meet cleanup goals, and compliance with ARARs are threshold criteria that all alternatives must meet, therefore these criteria are not considered in the relative scoring and ranking.

It should be noted that all alternatives, except Site-Wide No Action, include mechanical dredging of impacted sediment in Areas 1 and 2 within the navigation channel and side slopes, and portions of Areas 1 and 2 outside navigation channel to south, in slips, and in docking areas (Units 1-11, 12A, 13A, 14A, 15A, 16, 17A, 17D or 17B, 18, 19A or 19E, 21, 23, 24, 27, and 29-31), except for Alternative B-3 which does not include dredging in Unit 1. Thus, dredging is the primary means by which all of the alternatives accomplish the remedial action objectives. The areas that differ in how they are addressed between the alternatives include:

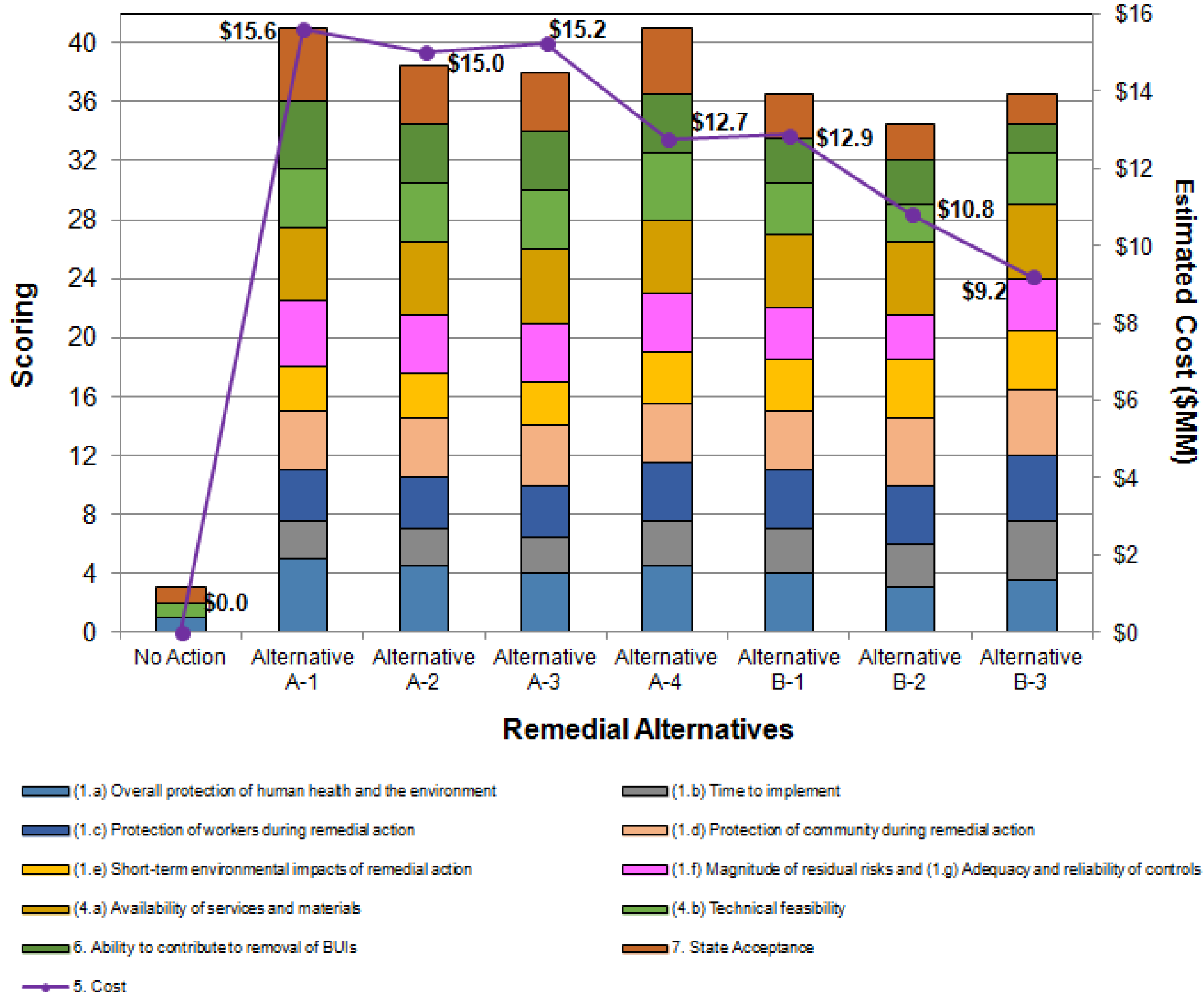
- The shallow areas to the north (Areas 1 and 2 outside navigation channel) that meet the PRGs (Units 12B, 13B, 14B, 15B, 17B-17C, 19A, 20, 22, 25A) or are between the MEC and PEC (Units 15C or 15D, 25B, and 28) in surface sediment samples. The specific alternatives vary in how these units are addressed. The PRGs would ultimately be achieved in these units where concentrations fall between the MEC and PEC through dredging in Alternative A-1, through either dredging or MNR as a result of attenuation of surface levels over time due to ongoing sedimentation and natural attenuation processes for Alternative A-3, or through dredging, ENR or no action for Alternatives A-2, A-4 and B-series.
- The head of Hughitt Avenue Slip (Unit 26). PRGs in this area would be met by partial removal and capping remaining sediments exceeding the PRGs in the B series Alternatives, whereas in the A series Alternatives, this unit would be dredged.
- The head of Cummings Avenue Slip (Units 19B through 19D, and 19F for applicable alternatives). In the B series Alternatives these units would be subject to partial removal and capping, or in the case of Alternative B-2, covered following partial removal with an in-water dredged material containment cell (i.e. the CAD). In the A series Alternatives, these units would be dredged.
- Docking Area (Unit 1). In Alternative B-3, sediments in this area exceeding the PRGs would be capped to isolate them from the water column; whereas all other alternatives identify dredging of Unit 1.

The Site-Wide No Action alternative does not seek to reduce potential risks to human health and the environment, would not facilitate BUI removal, and likely would not be accepted by the State or the public. This alternative serves only as baseline for comparison to other technologies, and is included for consistency with the NCP feasibility study process.

Estimated costs for each alternative were developed by the USACE and are presented in Appendix M. The estimated cost for each alternative is summarized in the table below. Refer to Appendix M for details.

Alternative	Description	Estimated Cost ($MM)
Alternative A-1	Sediment Removal in All Subareas	$ 15.6
Alternative A-2	Sediment Removal in All Subareas, Except for ENR in Units 12B, 15C, 17C, 20 and 25B	$ 15.0
Alternative A-3	Sediment Removal in All Subareas, Except for MNR in Units 12B, 15C, 17C, 20 and 25B	$ 15.2
Alternative A-4	Sediment Removal in Refined Subareas, Except for ENR in Units 15D and 25B, and No Action in Units 12B, 13B, 14B, 15B-C, 17B-C, 19A, 20, 22, 25A, 28	$ 12.7
Alternative B-1	Partial Dredge/Capping at Head of Hughitt and Cummings Avenue Slips and Sediment Removal in All Subareas, Except for ENR in Units 12B, 15C, 17C, 20 and 25B	$ 12.9
Alternative B-2	Partial Dredge/Capping at Head of Hughitt Avenue Slip and Docking Area, CAD at Head of Cummings Avenue Slip, and Sediment Removal in Refined Subareas, Except for ENR in Units 15D and 25B, and No Action in Units 12B, 13B, 14B, 15B-C, 17B-C, 19A, 20, 22, 25A, 28	$ 10.8
Alternative B-3	Partial Dredge/Capping at Head of Hughitt and Cummings Avenue Slips and Docking Area, and Sediment Removal in Refined Subareas, Except for ENR in Units 15D and 25B, and No Action in Units 12B, 13B, 14B, 15B-C, 17B-C, 19A, 20, 22, 25A, 28	$ 9.2

The comparative evaluation and total scoring of the alternatives presented in Table 5-2 is illustrated in the Figure below.



The remedial alternative with the highest scoring (i.e. the top-ranked alternative) at the end of the comparative analysis is Alternative A-4.

The project Partners agreed on selection of Alternative A-4 as the preferred alternative due to moderate to high scorings on all of the criteria, with the highest total comparative score of 44 including cost, or 41 excluding cost, as shown in Table 5-2 and on the graph above.

The estimated cost of Alternative A-4 is $12.7 million and is assumed to be within a +50%/-30% accuracy range, which is the same accuracy assumed for the estimated costs of the other alternatives. The associated dredge limits and costs of Alternative 4 will be refined through the remedial design phase.

6. Required Permits for the Preferred Remedial Alternative

Implementation of the preferred remedial alternative will require applicable permits and authorizations from local, state, and federal agencies. The following bullets list the anticipated permits required based on the remedial activities. This list will be refined during the design phase.

Federal Permits:

- USACE Section 404 of the Federal Clean Water Act
- USACE Section 401 Water Quality Certification
- USACE Section 10 dredging permit of the Rivers and Harbors Act of 1899
- Erie Pier material acceptance from the USACE
- Consult the U.S. Fish and Wildlife Service list of Threatened, Endangered, Sensitive Species
- Consult the National Register of Historic Places

State Permits:

- For carriage/interstitial water and stormwater from land disturbing construction activity (≥ 1 acre), discharge Permit to Superior POTW under WPDES Chapter 30 of the Wisconsin Statutes will be required, if applicable.
- Review of endangered resources under NEPA/WEPA
- Review of historical society and endangered resources
- WDNR Dredging Requirements, including WDNR Disposal of Certain Dredged Materials
- WDNR Wisconsin State Air Pollution Control Regulations

Local Permits:

- Local soil/sediment erosion control plan permits
- Discharge Permit to the City of Superior POTW

Coordination with USACE, WDNR, and USEPA will be necessary to facilitate necessary permit applications and timely review. It is anticipated that obtaining permits and authorizations for the preferred alternative will take at least 60 days, after receipt of the application submittal by applicable agencies.

7. Design Requirements

The preferred alternative will be designed and implemented concurrently with the SND project. The USACE will prepare the design drawings and specifications for the project in coordination with the Partners. The elements of the project that are unique to the cleanup requirements will be described and developed to a suitable level for USACE incorporation in the overall project design effort. This section outlines the anticipated design elements for the preferred alternative, Alternative A-4, that will need to be developed to complete the design drawings and specifications for construction.

The design is expected to address the following elements:

1. Results of the supplemental sampling conducted by WDNR and USEPA in 2014 and 2015 will be incorporated in the design data set to determine what adjustments may be needed to sediment management units in the vicinity of those sample locations. Appendix B to this FFS presents a sample location map and field notes for the 2014 samples. WDNR will provide similar documentation of the 2015 samples.

2. Extent of dredging and ENR around the abutments or piers of the Blatnik Bridge will be established in consideration of samples representing sediment management units in those locations, and in coordination with appropriate agencies to determine extent of any set back or work limitations imposed in those areas.

3. A bathymetric map of the study area will be prepared by USACE for use in the design based on a new survey to be completed in 2015 and supplemented as needed by the multi-beam survey conducted by the USACE in July 2014.

4. Refined dredge volume estimates based on the design bathymetric map (see Item #3 above), the additional sediment core data (See Item #1 above), and a selected approach for setting dredging limits and tolerances for each sediment management unit. Dredge limits may be set using a level cut, removal of a uniform thickness of sediment, removal to slopes defined based on the core data and existing bathymetry and historical bathymetric data, or 3-D modeling of COC concentrations. The available sediment probing and core logs together with the sediment core chemical profiles will be used in this analysis. The dredge limits and volumes will account for any side slopes to be dredged around the sediment management units.

5. Results of the bulkhead stability evaluation conducted by the USACE (Appendix L) will be used to identify any special measures to be taken where bulkhead stability adjacent to sediment management units is of concern. This step will include collaboration with shoreline owners to achieve their concurrence and/or any needed liability waivers.

6. Locations of debris will be reviewed to determine dredging setbacks from these areas, or whether debris removal would be conducted as part of the project for aesthetic or navigational safety improvement. Known areas of extensive debris include the far eastern end of Howard's Bay along the north bank, at the northeastern corner of the Hughitt Slip, and along the eastern perimeter of Hughitt Slip.

7. Extent of any proposed dredging on steep side slopes of the federal channel will be reviewed and a determination of dredge limits established to exclude targeting of steep slopes with minimal sediment present.

8. Specification of dredging, dredged material transport, sediment dewatering, and stabilization methods for dredged material to be sent to landfills. Specification of material conditioning requirements and amendments for disposal of cleanup dredging materials will be based on testing planned to be completed by the USACE.

9. Development of a decision tree for establishing dredging and/or residual cover placement completion in each sediment management unit. This may include: survey, probing to evaluate removal of sediment above clay, post-removal sampling, or these methods in combination.

10. Specification of over-dredge allowances based on the dredging limits and confirmation approach for each sediment management unit.

11. Final specification of the disposal location and disposal volumes for dredged material removed from each sediment management unit.

12. Specification of the dredged material offloading location(s) and staging area requirements.

13. Final estimates of sediment removal quantities and disposal quantities for cleanup material outside of the SND dredging limits.

14. Description of post-implementation testing or monitoring and maintenance requirements, if appropriate.

15. Specification of turbidity management and monitoring approach to be applied during dredging, subject to permitting requirements.

8. References

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Tables

Table 1-1
Estimation of Top of Clay/Bottom of Soft Sediment Elevation
Focused Feasibility Study for Sediment Cleanup in Howard's Bay
Superior, WI

Location ID	Collection Date	Staff Gage Reading	NOAA 9099064 Duluth, MN Staff Gage Reading	Elevation of Staff Gage Reading[2]	Water Depth (feet)	Calculated Sediment Surface Elevation[3]	2013 Bathymetry Estimated Sediment Surface Elevation[4]	2010 Bathymetry Estimated Sediment Surface Elevation[5]	2007 Bathymetry Estimated Sediment Surface Elevation[6]	Best Estimate of Sediment Surface Elevation[7]	Core Recovery (inches)	Depth to Native Clay[8] (inches)	Native Clay Surface Elevation	Sediment thickness (feet)	Sediment Core Encountered Native Clay
HB13-01	9/11/2013	8.84	--	602.22	11.7	590.55	590.73	--	--	590.6	74	74	584.4	6.2	
HB13-02	9/9/2013	9.25	--	602.63	3.7	598.96	598.10	--	--	599.0	48	48	595.0	4.0	
HB13-03	9/9/2013	9	--	602.38	16.8	585.55	585.79	--	--	585.5	50	46	581.7	3.8	X
HB13-04	9/9/2013	8.64	--	602.02	16.4	585.60	590.03	--	--	585.6	44	44	581.9	3.7	
HB13-05	9/9/2013	9.15	--	602.53	26.2	576.36	577.13	--	576.16	576.4	77	77	569.9	6.4	
HB13-06	9/9/2013	9	--	602.38	20.5	581.88	581.50	581.50	580.47	581.9	55	48	577.9	4.0	X
HB13-07	9/9/2013	9.32	--	602.70	13.3	589.45	587.81	587.88	588.99	589.5	48	48	585.5	4.0	
HB13-08	9/11/2013	8.7	--	602.08	26.7	575.41	576.38	575.75	575.57	575.4	92	92	567.7	7.7	
HB13-09	9/11/2013	8.94	--	602.32	21.2	581.15	--	--	--	581.2	0	0	581.2	0.0	X
HB13-10	9/10/2013	8.74	--	602.12	20.8	581.29	580.95	581.75	581.70	581.3	22	0	581.3	0.0	X
HB13-11A	9/11/2013	8.8	--	602.18	26.6	575.60	575.83	575.89	578.20	575.6	60	49	571.5	4.1	X
HB13-12B	9/10/2013	8.48	--	601.86	5.7	596.19	595.84	595.23	594.40	596.2	17	6	595.7	0.5	X
HB13-13	9/11/2013	8.86	--	602.24	29.7	572.57	573.02	573.14	573.42	572.6	43	1	572.5	0.1	X
HB13-14	9/12/2013	8.86	--	602.24	29.1	573.16	573.32	572.44	573.93	573.2	46	46	569.3	3.8	
HB13-15A	9/12/2013	8.68	--	602.06	26.9	575.14	575.33	575.93	574.56	575.1	19	19	573.6	1.6	
HB13-16A	9/12/2013	8.6	--	601.98	26.9	575.06	576.48	575.82	574.49	575.1	39	26	572.9	2.2	X
HB13-17	9/12/2013	8.82	--	602.20	27.3	574.95	575.34	575.93	575.35	575.0	47	47	571.0	3.9	
HB13-18	9/12/2013	8.64	--	602.02	24.3	577.77	579.05	578.69	578.22	577.8	27	10	576.9	0.8	X
HB13-19	9/13/2013	8.64	--	602.02	3.9	598.10	598.54	592.59	592.96	598.1	70	70	592.3	5.8	
HB13-20	9/12/2013	8.6	--	601.98	25.4	576.56	577.17	577.00	575.98	576.6	52	52	572.2	4.3	
HB13-21	9/13/2013	8.75	--	602.13	3.3	598.88	599.13	591.74	595.86	598.9	88	88	591.5	7.3	
HB13-22	9/12/2013	8.7	--	602.08	25.4	576.66	577.52	579.72	577.38	576.7	34	24	574.7	2.0	X
HB13-23	9/12/2013	8.74	--	602.12	28.3	573.79	574.24	573.58	574.43	573.8	32	27	571.5	2.3	X
HB13-24A	9/11/2013	8.56	--	601.94	18.6	583.36	583.67	--	--	583.4	26	26	581.2	2.2	
HB13-25	9/12/2013	8.68	--	602.06	17.3	584.73	585.06	584.97	585.19	584.7	57	57	580.0	4.8	
HB13-26	9/12/2013	8.64	--	602.02	27.0	575.02	574.82	574.54	574.96	575.0	33	33	572.3	2.8	
HB13-27A	9/13/2013	8.53	--	601.91	19.9	581.99	582.40	582.80	582.47	582.0	32	32	579.3	2.7	
HB13-28	9/12/2013	8.61	--	601.99	27.3	574.74	574.66	574.45	574.77	574.7	43	43	571.2	3.6	
HB13-29	9/12/2013	8.64	--	602.02	28.3	573.69	574.90	574.22	573.33	573.7	44	44	570.0	3.7	
HB13-30	9/10/2013	8.68	--	602.06	25.0	577.06	576.91	576.67	576.74	577.1	78	60	572.1	5.0	X
HB13-31	9/13/2013	8.7	--	602.08	28.3	573.83	574.17	573.71	573.80	573.8	41	27	571.6	2.3	X
HB13-32	9/13/2013	8.76	--	602.14	28.8	573.39	571.70	573.07	573.02	573.4	42	26	571.2	2.2	X
HB13-33B	9/13/2013	9.01	--	602.39	32.8	569.64	569.35	570.42	569.73	569.6	12	12	568.6	1.0	
HB13-34A	9/13/2013	8.85	--	602.23	34.3	567.90	571.17	569.41	568.95	567.9	7	0.5	567.9	0.0	X
HB13-35A	9/13/2013	9.01	--	602.39	32.6	569.81	570.08	--	--	569.8	16	4	569.5	0.3	X
HB13-36	9/10/2013	8.76	--	602.14	28.5	573.64	--	--	--	573.6	0	0	573.6	0.0	X
HB13-37A	9/10/2013	8.76	--	602.14	29.7	572.47	573.36	--	--	572.5	6	6	572.0	0.5	
HB13-38A	9/11/2013	8.58	--	601.96	17.0	584.96	584.78	--	--	585.0	6	6	584.5	0.5	
HB13-39	9/13/2013	8.76	--	602.14	16.8	585.39	586.77	--	--	585.4	42	28	583.1	2.3	X
HB13-40	9/13/2013	8.74	--	602.12	18.4	583.70	583.75	--	--	583.7	84	84	576.7	7.0	
HB13-41A	9/10/2013	8.74	--	602.12	19.5	582.62	582.56	--	--	582.6	29	29	580.2	2.4	
HB13-42	9/11/2013	8.8	--	602.18	15.5	586.68	587.48	--	--	586.7	36	33	583.9	2.8	X
HB13-43	9/11/2013	8.74	--	602.12	4.5	597.62	597.21	--	--	597.6	24	24	595.6	2.0	
HB13-44	9/13/2013	8.84	--	602.22	32.0	570.22	--	--	--	570.2	0	0	570.2	0.0	X
HB13-45	9/11/2013	8.78	--	602.16	14.9	587.24	588.07	--	--	587.2	21	21	585.5	1.8	
HB13-46	9/11/2013	8.91	--	602.29	20.9	581.37	--	--	--	581.4	0	0	581.4	0.0	X

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HB13-47A	9/10/2013	8.58	--	601.96	11.2	590.79	590.84	--	--	590.8	47	31	588.2	2.6	X
HB13-48B	9/10/2013	8.54	--	601.92	13.3	588.67	588.97	--	--	588.7	46	46	584.8	3.8	
HB13-49A	9/11/2013	8.7	--	602.08	14.2	587.91	587.85	--	--	587.9	30	30	585.4	2.5	
HB13-50	9/13/2013	8.75	--	602.13	23.6	578.55	578.62	577.68	578.44	578.5	47	47	574.6	3.9	
HB13-51	9/10/2013	8.78	--	602.16	2.2	599.96	--	--	--	600.0	15	15	598.7	1.3	
HB13-52	9/10/2013	8.78	--	602.16	2.5	599.66	600.93	591.71	592.04	599.7	17	17	598.2	1.4	
HB10-1-01	10/16/2010	--	601.09	--	17.2	583.92	583.69	583.70	583.98	583.9	41	41	580.5	3.4	
HB10-1-02	10/16/2010	--	601.09	--	28.3	572.84	572.58	573.28	572.84	572.8	28	28	570.5	2.3	
HB10-1-03	10/16/2010	--	601.09	--	23.3	577.76	578.06	577.61	577.43	577.8	88	88	570.4	7.3	
HB10-1-04	10/17/2010	--	600.96	--	2.5	598.46	594.97	588.87	593.21	598.5	50	50	594.3	4.2	
HB10-1-05	10/16/2010	--	601.09	--	25.2	575.92	573.43	575.94	573.86	575.9	6	NA	NA	NA	NA
HB10-1-06	10/16/2010	--	601.09	--	23.1	578.01	--	--	--	578.0	56	56	573.3	4.7	
HB10-1-07	10/17/2010	--	600.96	--	4.5	596.46	596.30	589.47	593.06	596.5	111	111	587.2	9.3	
HB10-1-08	10/17/2010	--	600.96	--	2.5	598.46	598.50	593.47	594.90	598.5	36	36	595.5	3.0	
HB10-1-09	10/17/2010	--	600.96	--	NA	--	--	--	--	NA	6	NA	NA	NA	NA
HB10-1-10	10/18/2010	--	601.00	--	27.1	573.92	573.91	573.92	574.52	573.9	6	NA	NA	NA	NA
HB10-1-11	10/16/2010	--	601.09	--	15.2	585.92	587.25	589.08	588.16	585.9	40	21	584.2	1.8	X
HB10-1-12	10/17/2010	--	600.96	--	3.0	597.96	596.91	594.44	595.66	598.0	34	34	595.1	2.8	
HB10-1-13	10/18/2010	--	601.00	--	23.8	577.17	574.32	574.22	574.53	577.2	67	67	571.6	5.6	
HB10-1-14	10/17/2010	--	600.96	--	24.4	576.56	577.54	577.57	577.38	576.6	83	83	569.6	6.9	
HB10-1-15	10/17/2010	--	600.96	--	3.3	597.71	597.71	595.24	596.21	597.7	16	16	596.4	1.3	
HB10-1-16	10/17/2010	--	600.96	--	16.1	584.86	578.08	--	--	584.9	35	35	581.9	2.9	
HB10-1-17	10/17/2010	--	600.96	--	NA		578.53	578.75	577.68	0.0	6	NA	NA	NA	NA
HB10-1-19	10/17/2010	--	600.96	--	2.5	598.46	--	--	--	598.5	NA	NA	NA	NA	NA
HB10-1-20	10/17/2010	--	600.96	--	27.1	573.86	573.51	--	--	573.9	6	NA	NA	NA	NA
HB10-1-21	10/18/2010	--	601.00	--	3.5	597.50	596.90	--	--	597.5	23	23	595.6	1.9	
HB10-1-22	10/17/2010	--	600.96	--	29.9	571.06	--	--	--	571.1	6	NA	NA	NA	NA
HB10-1-23	10/17/2010	--	600.96	--	3.3	597.71	599.07	597.08	597.06	597.7	36	36	594.7	3.0	
HB10-1-24	10/19/2010	--	600.94	--	6.0	594.94	593.76	--	--	594.9	42	42	591.4	3.5	
HB10-1-25	10/17/2010	--	600.96	--	13.2	587.76	587.25	587.52	588.86	587.8	6	NA	NA	NA	NA
HB10-1-27	10/18/2010	--	601.00	--	26.2	574.83	593.00	594.48	594.05	574.8	34	0	574.8	0.0	X
HB10-1-28	10/17/2010	--	600.96	--	13.9	587.06	587.92	--	--	587.1	105	105	578.3	8.8	
HB10-1-29	10/17/2010	--	600.96	--	8.3	592.66	593.07	--	--	592.7	101	84	585.7	7.0	X
HB10-1-30	10/18/2010	--	601.00	--	2.8	598.17	597.83	--	--	598.2	80	80	591.5	6.7	
HB10-1-31	10/18/2010	--	601.00	--	24.7	576.33	575.85	575.66	577.70	576.3	41	36	573.3	3.0	X
HB10-2-18	10/18/2010	--	601.00	--	16.3	584.67	584.21	--	583.77	584.7	6	NA	NA	NA	NA
HB10-2-26	10/16/2010	--	601.09	--	3.0	598.09	--	--	--	598.1	17	17	596.7	1.4	
HB10-2-32	10/18/2010	--	601.00	--	21.9	579.08	578.47	580.44	579.49	579.1	6	NA	NA	NA	NA
HB10-2-33	10/18/2010	--	601.00	--	2.0	599.00	600.96	592.97	593.36	599.0	22	22	597.2	1.8	
HB10-2-34	10/18/2010	--	601.00	--	27.3	573.67	572.70	574.49	573.76	573.7	14	6	573.2	0.5	X
HB10-2-35	10/18/2010	--	601.00	--	2.0	599.00	598.27	593.79	595.08	599.0	36	36	596.0	3.0	
HB10-2-36	10/18/2010	--	601.00	--	29.8	571.17	570.80	571.52	573.59	571.2	6	NA	NA	NA	NA
HB10-2-37	10/18/2010	--	601.00	--	1.0	600.00	599.38	595.41	596.53	600.0	28	28	597.7	2.3	
HB10-2-38	10/18/2010	--	601.00	--	17.8	583.25	583.60	583.55	583.78	583.3	59	38	580.1	3.2	X
HB10-2-39	10/18/2010	--	601.00	--	1.5	599.50	594.82	595.44	596.27	599.5	36	36	596.5	3.0	
HB10-2-40	10/18/2010	--	601.00	--	12.8	588.17	588.26	--	589.43	588.2	53	53	583.8	4.4	

Table 1-1
Estimation of Top of Clay/Bottom of Soft Sediment Elevation
Focused Feasibility Study for Sediment Cleanup in Howard's Bay
Superior, WI

Location ID	Collection Date	Staff Gage Reading	NOAA 9099064 Duluth, MN Staff Gage Reading	Elevation of Staff Gage Reading[2]	Water Depth (feet)	Calculated Sediment Surface Elevation[3]	2013 Bathymetry Estimated Sediment Surface Elevation[4]	2010 Bathymetry Estimated Sediment Surface Elevation[5]	2007 Bathymetry Estimated Sediment Surface Elevation[6]	Best Estimate of Sediment Surface Elevation[7]	Core Recovery (inches)	Depth to Native Clay[8] (inches)	Native Clay Surface Elevation	Sediment thickness (feet)	Sediment Core Encountered Native Clay
HB10-2-41	10/18/2010	--	601.00	--	8.0	593.00	591.42	--	--	593.0	31	31	590.4	2.6	
HB10-2-42	10/18/2010	--	601.00	--	5.0	596.00	594.10	--	--	596.0	30	30	593.5	2.5	
HB10-2-43	10/17/2010	--	600.96	--	3.5	597.46	--	--	--	597.5	22	22	595.6	1.8	
HB10-2-44	10/18/2010	--	601.00	--	12.8	588.20	587.57	--	--	588.2	16	16	586.9	1.3	
HB10-2-45	10/18/2010	--	601.00	--	12.0	589.00	590.19	--	--	589.0	19	19	587.4	1.6	
HB2A_4	5/12/2007	--	--	--	--	--	587.39	--	--	587.4	48	48	583.4	4.0	
HB2A_6	5/2/2007	--	--	--	--	--	597.13	589.22	594.22	594.2	6	NA	NA	NA	NA
HB2A_7	5/10/2007	--	--	--	--	--	585.59	584.25	584.51	584.5	6	NA	NA	NA	NA
HB2A_8	5/10/2007	--	--	--	--	--	580.41	579.96	580.25	580.3	6	NA	NA	NA	NA
HB2A_11	5/10/2007	--	--	--	--	--	591.21	590.24	595.08	595.1	6	NA	NA	NA	NA
HB2A_13	5/2/2007	--	--	--	--	--	592.44	593.57	593.32	593.3	6	NA	NA	NA	NA
HB2A_16	5/2/2007	--	--	--	--	--	574.26	573.35	572.71	572.7	6	NA	NA	NA	NA
HB2B_17	5/12/2007	--	--	--	--	--	589.23	--	--	589.2	46	46	585.4	3.8	
HB2B_18	5/7/2007	--	--	--	--	--	589.94	--	--	589.9	48	48	585.9	4.0	
HB2B_19	5/2/2007	--	--	--	--	--	586.03	--	--	586.0	24	24	584.0	2.0	
HB2B_20	5/2/2007	--	--	--	--	--	588.63	589.71	587.36	587.4	48	48	583.4	4.0	
HB2B_21	5/2/2007	--	--	--	--	--	581.41	579.55	579.31	579.3	6	NA	NA	NA	NA
HB2B_22	5/2/2007	--	--	--	--	--	587.81	586.18	588.34	588.3	6	NA	NA	NA	NA
HB2A_210	5/16/2007	--	--	--	--	--	590.24	588.51	588.75	588.7	48	48	584.7	4.0	
HB2A_GENES	5/22/2007	--	--	--	--	--	596.44	--	--	596.4	6	NA	NA	NA	NA
HB3A_GENES	9/6/2007	--	--	--	--	--	592.37	--	--	592.4	6	NA	NA	NA	NA

Notes:
NA = not available.
X = core encountered dense native clay.
1. Elevations are provided in International Great Lakes Datum 1985.
2. For 2013 samples, data for staff gage located at the site are used (staff gage reading of 10.10 is equivalent to an elevation of 603.48 feet [IGLD 85]). For 2010 samples, data for NOAA staff gage at Duluth, MN are used.
3. Sediment surface elevation based on staff gage readings and water depth.
4. Sediment surface elevation based on 2013 bathymetry and/or nearby core.
5. Sediment surface elevation based on 2010 bathymetry and/or nearby core.
6. Sediment surface elevation based on 2007 bathymetry and/or nearby core.
7. Sediment surface elevation based on best estimate between staff gage readings/water depth in the following descending order of priority:
(a) Difference between measured surface water elevation and water depth.
(b) Elevations estimated based on bathymetric contours developed by ARCADIS based on survey conducted by USACE in the year of core collection.
8. For sediment cores that did not encounter native clay (i.e., not marked with "X"), top of native clay is being inferred from core recovery. Top of native clay has not been inferred for surface grabs.

Table 3-1
Evaluation of Remedial Technologies
Focused Feasibility Study for Sediment Cleanup in Howard's Bay
Superior, WI

General Response Action/ Remedial Technology	Process Option	Description	Effectiveness	Implementability	Relative Cost [1]
			Short-Term & Long-Term Effectiveness **(1) Short-term effectiveness: Ability to protect human health and the environment in the short term until the RAOs are achieved.** **(2) Long-term effectiveness: Ability to provide reliable protection of human health and the environment and achieve the RAOs.**	**Technical and Administrative Feasibility** **(1) Feasibility of designing and constructing the technology given the site conditions.** **(2) Availability of specific equipment, materials, services, and technical specialists to design, install, operate, and maintain the remedy.**	
No Action	No Action	- Applicable to all study areas. - No remedial action or monitoring would be conducted. - Serves as baseline for comparison to other technologies.	(1) Would not reduce the concentrations of site-specific COCs, the mobility or volume of contaminated sediment, in the short term as no action would be taken. Potential risks and sediment-related BUIs would remain in the short term. (2) Could not be demonstrated to achieve the RAOs or lead to BUI removal as no monitoring would be conducted. Reduction of concentration of site-specific COCs may occur in the long term through natural recovery but without monitoring it would be undocumented.	(1) Technically feasible. Not administratively feasible given the need to address sediment in Howard's Bay for delisting of the St. Louis River Area of Concern and regulatory concerns related to sediment contamination. (2) Readily implementable with no requirement of specialty equipment, materials, services, or technical specialists.	None
Natural Recovery	Monitored Natural Recovery (MNR)	- Applicable to all study areas where sedimentation processes attenuate exposure concentrations over time. - Includes natural physical, chemical, and/or biological recovery processes that act in combination to reduce the mass, volume, and toxicity of site-specific COCs in sediments. - Requires periodic sampling and/or monitoring followed by an evaluation of the data collected to verify reduction of COC concentrations, bioavailability, and/or toxicity. - No short-term construction related disturbance of sediments, does not require disposal of sediments. - Would not remove contaminants from the site.	(1) Would not reduce the concentrations of site-specific COCs or the mobility or volume of contaminated sediment in the short term as natural recovery is anticipated to occur over a longer period of time assuming suitable environmental conditions; potential for exposure in the short term. (2) May eventually achieve the RAOs in the long term, assuming natural recovery of constituents over time, although the anticipated amount of time until the RAOs are achieved is uncertain. Continued deposition may reduce likelihood of erosion of deeper sediments in areas where prop scour is unlikely. Monitoring would be required to assess long-term effectiveness.	(1) Technically feasible. Requires periodic sampling. Would need to comply with applicable regulations. (2) Would not require specialty equipment, materials, services, or technical specialists other than those needed to conduct monitoring.	No construction costs and low O&M costs
	Enhanced Natural Recovery (ENR)	- Applicable to areas outside of Federal Channel, Private Slips, and Docking Area where prop scour resuspension is unlikely. - Not applicable to Federal Channel due to navigation dredging requirements and ship traffic causing scour. - Placement of a thin-layer of clean material (typically sand or clean sediment) over contaminated sediments to accelerate natural recovery and reduce concentrations of site-specific COCs in surface sediments. - Thin-layer natural material such as sand would be applied over the sediment surface. - Periodic sampling and/or monitoring may be needed followed by an evaluation of the data collected to verify reduction of constituent concentrations, bioavailability, and/or toxicity. - No disturbance of sediments, does not require disposal of sediments. - Would not remove contaminants from the site.	(1) Would reduce COC concentrations in surface sediments and accelerate natural recovery processes. Would reduce potential risk and mobility of contaminated sediment in the short term due to placement of the cover layer material. (2) Thin layer of non-reactive material will eventually mix with in-situ sediment resulting in lower exposure concentrations. Added material will reduce likelihood of erosion of deeper sediment. Would not provide chemical isolation of COCs from overlying water column due to potential migration in porewater and bioturbation. Monitoring could be conducted to assess long-term effectiveness.	(1) Technically feasible in site areas not subjected to scour and with no future navigation dredging requirements. Requires periodic sampling. Would need to comply with applicable regulations. (2) Equipment, materials, services, and the technical specialists necessary to install a thin-layer of clean material are available.	Low construction and O&M costs
Institutional Controls	Institutional Controls	- Applicable to Areas 1 and 2 Outside of Federal Channel, Private Slips, and Docking Area. - Institutional controls include legal and/or administrative controls (e.g., waterway and/or future dredging use restrictions, public advisory to prevent activities that may disturb sediment such as signs, floating barriers, pilings or other measures to restrict entry by boats or "no anchoring" zones, and environmental easements) to mitigate the potential for exposure to impacted sediments and/or protect the integrity of a remedy.	(1) Controls on human use would reduce potential risk associated with human exposure. Would control and limit potential for exposure if applied in conjunction with other measures (such as capping). If relied on alone, would not be effective in reducing exposure concentrations to ecological receptors of site-specific COCs. (2) Could not be demonstrated to achieve the RAO alone in the long term.	(1) Technically feasible. Would require coordination with stakeholders, agencies, and any parties with easements (e.g., utility crossings); and would need to comply with applicable permits and regulations. (2) Equipment, materials, services, and the technical specialists necessary to install institutional controls are available.	Low construction and O&M costs

Table 3-1
Evaluation of Remedial Technologies
Focused Feasibility Study for Sediment Cleanup in Howard's Bay
Superior, WI

General Response Action/ Remedial Technology	Process Option	Description	Effectiveness	Implementability	Relative Cost [1]
			Short-Term & Long-Term Effectiveness **(1) Short-term effectiveness: Ability to protect human health and the environment in the short term until the RAOs are achieved.** **(2) Long-term effectiveness: Ability to provide reliable protection of human health and the environment and achieve the RAOs.**	**Technical and Administrative Feasibility** **(1) Feasibility of designing and constructing the technology given the site conditions.** **(2) Availability of specific equipment, materials, services, and technical specialists to design, install, operate, and maintain the remedy.**	
In-Situ Treatment	Sediment Amendments	- Applicable to Areas 1 and 2 Outside of Federal Channel, Private Slips, and Docking Area. - Not applicable to Federal Channel due to future navigation dredging requirements and ship traffic causing scour of amendments. - In-situ delivery of amendments to the surface layer of sediment to reduce the mobility and bioavailability of constituents through adsorption/ absorption/ precipitation and/or enhanced rate of natural biodegradation. - Amendments considered for the study area are a mixture of organic carbon/apatite or pelletized GAC/apatite. Mixing into surface sediments would occur through natural sediment mixing processes such as bioturbation. - Post-construction monitoring and institutional controls would be required. - Less disturbance of sediments, does not require disposal of sediments. - Would not remove contaminants from the site.	(1) Would reduce the mobility of site-specific COCs (via sorption/ precipitation) in the short term and reduce future adverse exposures, assuming the proper dosage of amendment is applied and that it comes into direct contact with COCs. Would address the RAOs in the short term with reduction of bioavailability of site-specific COCs. Not expected to reduce the volume of COCs in the short term as natural biodegradation is anticipated to occur over a long period of time, assuming suitable environmental conditions. (2) Would reduce the long-term potential for exposure via sorption/ precipitation, and the volume of COCs via natural biodegradation, assuming suitable environmental conditions and adequate contact between amendments and COCs. Additional amendments might have to be applied in the future. Monitoring could be conducted to assess long-term effectiveness.	(1) Technically feasible in site areas not subjected to scour and with no future navigation dredging requirements. Additional doses may be needed due to erosion and scour. Amendments may need to be mixed into the subsurface to maximize sorptive capacity. Significant commercial navigation may pose a challenge. Would need to comply with applicable regulations. (2) Equipment, materials, services, and technical specialists necessary to apply amendments are available. Field testing is suggested to select and optimize the amendment dosage.	Moderate capital and O&M costs
	Solidification/ Stabilization	- Applicable to Areas 1 and 2 Outside of Federal Channel, Private Slips, and Docking Area. - Not applicable to Federal Channel due to future navigation dredging requirements. - Addition and mixing of materials (e.g., Portland cement) into sediments to bind COCs and reduce their transport. Materials such as GAC, organoclay (for tributyltin) or apatite (for lead) can also be added as a means of sequestering organic and inorganic constituents, thereby eliminating or greatly reducing their transport. - Post-construction monitoring and institutional controls would be required. - Less disturbance of sediments, does not require disposal of sediments. - Would not remove contaminants from the site.	(1) Would reduce the mobility of site-specific COCs (via binding) in the short term and reduce future adverse exposures, assuming an effective solidification/stabilization mix/process can be determined. Would effectively address the RAOs in the short term with reduction of bioavailability of site-specific COCs. Not expected to reduce the volume of COCs in the short term as natural biodegradation is anticipated to occur over a long period of time, assuming suitable environmental conditions. (2) Would reduce the long-term potential for exposure via binding, and the volume of COCs via natural biodegradation, assuming suitable environmental conditions and adequate contact between mix and COCs. Additional material might have to be mixed in the future. Monitoring would be required to assess long-term effectiveness. Future intrusive activities at the site may reduce the long-term effectiveness of this technology.	(1) Technically feasible in site areas with no future navigation dredging requirements. The amount of material applied to the site would have to be determined. May require sediment removal to address sediment expansion/bulking during solidification/stabilization. Significant commercial navigation may pose a challenging situation. Would need to comply with applicable regulations and permits. (2) Equipment, materials, services, and technical specialists necessary for mixing are available. Bench-scale treatability study is suggested to select additive and method of mixing in the various parts of the site.	Moderate capital and O&M costs

Table 3-1
Evaluation of Remedial Technologies
Focused Feasibility Study for Sediment Cleanup in Howard's Bay
Superior, WI

General Response Action/ Remedial Technology	Process Option	Description	Effectiveness: Short-Term & Long-Term Effectiveness (1) Short-term effectiveness: Ability to protect human health and the environment in the short term until the RAOs are achieved. (2) Long-term effectiveness: Ability to provide reliable protection of human health and the environment and achieve the RAOs.	Implementability: Technical and Administrative Feasibility (1) Feasibility of designing and constructing the technology given the site conditions. (2) Availability of specific equipment, materials, services, and technical specialists to design, install, operate, and maintain the remedy.	Relative Cost [1]
In-Situ Containment	Isolation Capping	- Applicable to Areas 1 and 2 Outside of Federal Channel, Private Slips, and Docking Area. - Not applicable to Federal Channel due to current/future navigation dredging requirements. - Application of an isolation layer of non-reactive clean material (typically sand with thickness ranging from two up to several feet) over contaminated sediments to provide an engineered physical barrier to minimize transport of COCs. - Cap materials would be installed in the wet over existing sediments. - Post-construction monitoring and institutional controls would be required. - Less disturbance of sediments, isolates COCs from overlying water column, create "clean" surface for use by benthic organisms, does not require disposal of sediments. - Would not remove contaminants from the site.	(1) Would likely achieve the RAOs. Would reduce bioavailability and toxicity of site-specific COCs (via a physical barrier) and reduce the potential for exposure to constituents in the short term. However, sand does not provide sorption of constituents, so COC transport may occur if cap does not sufficiently isolate contaminated material or if the cap is damaged. Would alter benthic habitat in short term. (2) Would reduce the potential for exposure in the long term, assuming contaminated sediments are physically isolated, the cap is not damaged, and COCs naturally degrade below the cap over time. Any future intrusive activities at the site, such as excavation, may reduce the long-term effectiveness of this technology.	(1) Technically feasible where cap placement would not interfere with maintenance dredging requirements. Pre-design investigation activities may be required to design the cap. Monitoring during construction would be required to assess achievement of cap thickness and settling. Dredging of some sediment prior to cap placement may be needed to achieve desired post-capping water depths. Not feasible in federal channel. May require armoring near stormwater outfalls or in prop-scour areas. Post-construction monitoring and maintenance would be required. Would need to comply with applicable regulations and permits. (2) Equipment, materials, services, and the technical specialists necessary to construct a cap are available.	Moderate construction and O&M costs
	Reactive Capping	- Applicable to Areas 1 and 2 Outside of Federal Channel, Private Slips, and Docking Area. - Not applicable to Federal Channel due to future navigation dredging requirements. - Application of a thin layer of reactive materials (e.g., mixture of GAC/apatite/sand, pelletized GAC, reactive core mat) over contaminated sediments to provide a physical and chemical barrier, while simultaneously providing sequestration of constituents via the addition of reactive material. AquaBlok™ could be used in combination with reactive materials provide a hydraulic barrier. - Reactive cap would be installed in the wet. - Monitoring during construction would be required to assess achievement of cap thickness and settling. - Less disturbance of sediments, isolates COCs from overlying water column, create "clean" surface for use by benthic organisms, does not require disposal of sediments. - Would not remove contaminants from the site.	(1) Would achieve the RAOs. Would reduce bioavailability and toxicity of site-specific COCs (via sorption and the presence of a physical barrier) and reduce the potential for exposure to constituents. Would alter benthic habitat in short term. (2) Would reduce the potential for exposure in the long term and meet the RAOs. Any future intrusive activities at the site, such as excavation, may reduce the long-term effectiveness of this technology.	(1) Technically and administratively feasible in site areas with no future navigation dredging requirements. Pre-design investigation activities may be required to design the cap. Monitoring during construction would be required to assess achievement of cap thickness and settling. May require armoring. Post-construction monitoring required. Would need to comply with applicable regulations and permits. (2) Equipment, materials, services, and the technical specialists necessary to construct a reactive cap are available. Field testing is suggested to select and optimize the mass of reactive material required.	Moderate construction and O&M costs

Table 3-1
Evaluation of Remedial Technologies
Focused Feasibility Study for Sediment Cleanup in Howard's Bay
Superior, WI

General Response Action/ Remedial Technology	Process Option	Description	Effectiveness: Short-Term & Long-Term Effectiveness (1) Short-term effectiveness: Ability to protect human health and the environment in the short term until the RAOs are achieved. (2) Long-term effectiveness: Ability to provide reliable protection of human health and the environment and achieve the RAOs.	Implementability: Technical and Administrative Feasibility (1) Feasibility of designing and constructing the technology given the site conditions. (2) Availability of specific equipment, materials, services, and technical specialists to design, install, operate, and maintain the remedy.	Relative Cost [1]
Removal	Mechanical Dredging	- Applicable to all study areas except along set-backs required to avoid impacting bridge piers, bulkheads, other structures, or utilities. - Physical removal of impacted sediment using dredges/ buckets (e.g., clamshell) and conventional construction equipment either using excavation equipment positioned along the shoreline and/or on barges within the bay. - Dredging will be conducted in the wet. - Monitoring during construction would be required to assess achievement of dredging depth. - Post-removal sampling and/or placement of residual cover may be required. - Handling/treatment of dredged material would be required. - May require treatment of water generated throughout the stages of sediment handling. - Does not require post-construction monitoring.	(1) Would achieve the RAOs following completion of dredging. Would disturb/remove benthic habitat. May result in short-term exposure and/or increased residual COC concentrations due to technological limitations of dredging. (2) Would achieve the RAOs; Implementation of other remedial technology (e.g., capping, MNR) may be required if contamination left behind.	(1) Technically and administratively feasible. (2) Equipment, materials, services, and the technical specialists necessary for dredging are available. Would require necessary access permissions and a plan for the management of dredged material.	Moderate to high capital costs
	Hydraulic Dredging	- Applicable to all study areas except along set-backs required to avoid impacting bridge piers, bulkheads, other structures, or utilities. - Removal and transportation of sediment in a liquid slurry form using a hydraulic pump or compressed air (e.g., horizontal auger, cutter head dredge, PNEUMA pump). - Monitoring during construction would be required to assess achievement of dredging depth. - Post-removal sampling and/or placement of residual cover may be required, depending on the dredging design. - Handling/treatment of dredged material and water would be required. - Requires management of large volumes of water generated throughout the stages of sediment handling. - Does not require post-construction monitoring.		(1) Technically and administratively feasible. (2) Equipment, materials, services, and the technical specialists necessary for dredging are available. Would require necessary access permissions and a plan for the management of dredged material and large volume of water generated during dredging.	High capital costs

Notes:
COC = Contaminant of Concern
GAC = granular activated carbon
O&M = Operation & Maintenance
RAO = remedial action objective
[1] Relative cost estimates are based on the available information regarding the site investigation and the anticipated scope of the remedial technology. Changes in cost elements are likely to occur as a result of new information and data collected during the engineering design of the remedial technology.

Table 3-2
Screening of Remedial Technologies
Focused Feasibility Study for Sediment Cleanup in Howard's Bay
Superior, WI

General Response Action	Remedial Technology	Effectiveness	Implementability	Relative Cost[1]	Retained
No Action	No Action	L - All Areas	L - All Areas	L - All Areas	Yes (for baseline screening purposes)
Monitoring	Monitored Natural Recovery (MNR)	L - All Areas	H - All Areas	L - All Areas	Yes (combined with other technologies)
	Enhanced Natural Recovery (ENR)	L - All Areas	L - Areas 1 and 2 Within Federal Channel H - Areas 1 and 2 Outside of Federal Channel, Private Slips, and Docking Area	L - All Areas	Yes (combined with other technologies)
Institutional Controls	Institutional Controls	L - All Areas	H - All Areas	L - All Areas	Yes (combined with other technologies)
In-Situ Treatment	Sediment Amendments	L - Areas 1 and 2 Within Federal Channel M - Areas 1 and 2 Outside of Federal Channel, Private Slips, and Docking Area	L - Areas 1 and 2 Within Federal Channel M - Areas 1 and 2 Outside of Federal Channel, Private Slips, and Docking Area	M - Areas 1 and 2 Within Federal Channel M - Areas 1 and 2 Outside of Federal Channel, Private Slips, and Docking Area	No
	Solidification/ Stabilization	M - All Areas	L - Areas 1 and 2 Within Federal Channel M - Areas 1 and 2 Outside of Federal Channel, Private Slips, and Docking Area	M - Areas 1 and 2 Within Federal Channel M - Areas 1 and 2 Outside of Federal Channel, Private Slips, and Docking Area	No
In-Situ Containment	Isolation Capping	M - All Areas	L - Areas 1 and 2 Within Federal Channel H - Areas 1 and 2 Outside of Federal Channel, Private Slips, and Docking Area	M - Areas 1 and 2 Within Federal Channel M - Areas 1 and 2 Outside of Federal Channel, Private Slips, and Docking Area	Yes
	Reactive Capping	H - All Areas	L - Areas 1 and 2 Within Federal Channel H - Areas 1 and 2 Outside of Federal Channel, Private Slips, and Docking Area	M/H - Areas 1 and 2 Within Federal Channel M/H - Areas 1 and 2 Outside of Federal Channel, Private Slips, and Docking Area	No
Removal	Mechanical Dredging	M - All Areas	H - All Areas	H - All Areas	Yes
	Hydraulic Dredging	M - All Areas	M - All Areas	H - All Areas	No

Notes:
H = High
L = Low
M = Moderate
Gray font - technologies ranked low, and screened out in this screening process.
Ranking of the technologies are based on the evaluation provided in Table 3-1 (effectiveness, implementation, and relative cost) in consideration of the listed technologies.
[1] Relative cost estimates are based on the available information regarding the site investigation and the anticipated scope of the project. Changes in cost elements are likely to occur as a result of new information and data collected during the engineering design of the remedial action. Utilization of this comparative cost estimate information beyond the stated purpose is not recommended. ARCADIS is not licensed to provide financial or legal consulting services; as such, this relative cost estimate information is not intended to be utilized for complying with financial reporting requirements associated with liability services.

Table 3-3
Evaluation and Screening of Management of Removed Material and Disposal Options
Focused Feasibility Study for Sediment Cleanup in Howard's Bay
Superior, WI

General Response Action	Technology	Description	Implementability	Relative Cost [1]	Retained
Management of Removed Material	Gravity Dewatering	- Sediment is dewatered by gravity drainage as pre-stabilization or disposal step. Dewatering can occur by pumping free water from transport scows or pumping from a temporary dewatering pad constructed to drain water to a collection or discharge point. Water is collected and treated on or offsite and discharged in accordance with permits. If dredged material is stockpiled for a longer period, dewatering by evaporation can be significant, and enhanced by periodic turning of the stockpile.	- Implementable	Low	Yes
	Geotube Dewatering	- Geotubes allow water to migrate through membrane retaining sediments.	- Implementable - Geotubes are used for temporary containment of the dredged material. Once dewatered, the geotubes are opened to load and haul materials for disposal.	Moderate to high	Yes
	Onsite Stabilization	- Addition of lime, cement or other potential drying agents associated with dewatering to reduce water content, as needed, for transportation and disposal. Cal-cement, Portland cement, fly ash and other similar materials are commonly used. Stabilization agents can be added in transport vessels (e.g., scows or trucks) and/or at the dewatering location.	- Technically and administratively feasible. - Treatability testing may be needed to define dosage of reagent.	Moderate	Yes
	Onsite Ex-Situ Treatment	- Applicable for sediments with concentrations of constituents exceeding disposal criteria. - Traditional treatment methods include physical, chemical, thermal and/or biological processes (e.g., thermal desorption) to produce a solidified material with low leachability that limits the solubility and mobility of constituents and/or reduce the concentrations of constituents to below disposal criteria. - Requires sampling to assess if treated sediments meet dredged material quality criteria for on or offsite disposal.	- Technically and administratively feasible, but will require monitoring and management at site to separate sediments with concentrations of constituents above disposal criteria for treatment. - Need treatability studies, space for treatment, and specialized equipment depending on selected method.	High	No
	Water Treatment	- Water generated throughout the stages of sediment handling will either be returned to the work area or retained, tested, potentially treated, and disposed appropriately in accordance with permits. - Treatment could include filtration, potentially proceeded by a flocculation stage and settling, if necessary, in order to meet the discharge requirements. - Requires sampling to assess if treated water meets discharge requirements.	- Technically and administratively feasible. Would need to comply with applicable regulations. - Any water treatment that may be required would be determined during the design phase.	Low to moderate	Yes

Table 3-3
Evaluation and Screening of Management of Removed Material and Disposal Options
Focused Feasibility Study for Sediment Cleanup in Howard's Bay
Superior, WI

General Response Action	Technology	Description	Implementability	Relative Cost [1]	Retained
Beneficial Re-use of Dredged Material	Shallow Water Habitat Creation with In-water Placement and Cover in Cummings Avenue Slip	- Cleanup dredged material meeting the criteria for in-water placement from the WDNR would be placed in water to create improved habitat conditions on the slip, and create a wetland area to help filter contaminants in stormwater from the outfall discharges at the head of the slip. - A shallow draft, small boat navigational channel would be constructed through the placement area. - Approximately 2,500 in-situ cy of material near the CSO outfall would be dredged. - Clean cover material (or clean navigational dredged material, if suitable) would be placed over the dredged material. - Dredged material would be barged to Cummings Avenue Slip.	- Technically and administratively feasible. Would need to comply with applicable regulations. - An underwater berm of coarse fill would be constructed to contain sediment behind (to south) of the berm. - Dewatering of material would not be necessary.	Low	Yes
	Reuse at the Abandoned Wisconsin Point Landfill	- Cleanup dredged material meeting the soil CW RCL criteria from WDNR would be placed as cover in the abandoned landfill (closed in 1976), and cleanup material meeting the WDNR requirements at the landfill would be placed beneath the cover. - Cleanup dredged material would be either a) barged to a location near the landfill (i.e., former US Coast Guard Station), and conditioned in the barges prior to truck transport and stockpiling for further drainage at the landfill and prior to spreading the material;, or b) offloaded and dewatered at a staging area adjacent to the site prior to transport and spreading at the landfill. - Temporary soil berms or stormwater detention features may be needed at the landfill - After placement the material would be re-graded, vegetated, and monitoring well casings extended to above grade.	- Technically and administratively feasible. Would need to comply with applicable regulations. - A closure plan modification request would be required and is subject to approval by WDNR. - Water from the dewatering process would be collected and transported to a WWTP for treatment (or pre-treated with filtration prior to discharge to the City sanitary sewer).	Low	Yes
	Reuse at Brownfield Sites in Duluth, MN	- Cleanup dredged material meeting the Tier 1 and/or Tier 2 criteria for re-use from the MPCA would be reused as fill material at brownfield sites. - Dredged material would be transported by barge to Erie Pier, and dewatered at Erie Pier. - An equivalent amount of dredged material stored at Erie Pier would be relocated to the City of Duluth brownfield sites.	- Technically and administratively feasible. Would need to comply with applicable regulations. - Suitable reuse and interested parties in taking the material have been identified.	Low	Yes
	Reuse as Landfill Daily Cover	- Dredged material of suitable quality for use as daily cover would be used either at the Moccasin Mike landfill or at the VONCO V industrial landfill located in Duluth, MN. - Dewatering and stabilization would be required prior to truck transport to a temporary stockpile site. - Sealed dump trucks would be required for transport, with trucks washed before leaving the site. - Material would be required to meet the criteria of the landfill for use as daily cover.	- Technically and administratively feasible. - Quantities that the landfills require for reuse as daily cover are limited. - Material would be delivered weekly or as needed from stockpile area to the landfill for use as daily cover.	Moderate	No

Table 3-3
Evaluation and Screening of Management of Removed Material and Disposal Options
Focused Feasibility Study for Sediment Cleanup in Howard's Bay
Superior, WI

General Response Action	Technology	Description	Implementability	Relative Cost [1]	Retained
Disposal	On-Site Disposal at Baxter Avenue Embayment	- Transport dredged material to Baxter Avenue Embayment by barge. - Dredged material would be placed wet and allowed to settle and gravity dewater over time with water drained back to Howard's Bay. - Materials to be placed are subject to WDNR approval. - Post-construction monitoring and institutional controls would be required.	- Technically feasible. - Administratively challenging due to regulatory requirements. - Placed material ultimately needs to provide sufficient bearing strength suitable for use by the shipyard. - Required to meet the criteria from WDNR for disposal in land (Appendix E). - Water draining back to the bay would need to be in compliance with applicable permits.	Moderate, low O&M	No
	On-Site Disposal in a new CDF in Cummings Avenue Slip	- A CDF would be constructed by placement of a sheetpile bulkhead or soil berm/dike wall across the slip. - The existing City stormwater outfall would be re-routed in a trench along the shoreline to a discharge point beyond the extent of the CDF. - Transport dredged material to Head of Cummings Avenue Slip by barge. - Dredged material would be placed wet and allowed to settle and gravity dewater over time. Sediments within the CDF footprint would remain in-place. - The CDF would be monitored over time to ensure adequate containment of the dredged materials, and ensure the integrity of the berm/dike wall. - Applicable to sediments meeting WDNR disposal quality criteria. - Post-construction monitoring and institutional controls would be required.	- Technically feasible. - Administratively challenging due to regulatory requirements. - Required to meet the criteria from WDNR for disposal in land (Appendix E) or alternative WDNR requirements.	Moderate, low O&M	No
	Disposal at the Erie Pier CDF	- Transport dredged material to Erie Pier CDF by barge, where it would be processed wet at the CDF to reduce the fines content and produce material that can be stockpiled for beneficial reuse. - Applicable to sediments meeting soil standards for beneficial reuse at upland sites.	- Technically and administratively feasible. - Materials from outside the federal channel may be subject to special requirements or limitations. - Required to meet the criteria from the USACE for disposal in water (Appendix G). - Limited capacity at the Erie Pier CDF available for disposal of cleanup dredged material.	Low to moderate	No
	Upland Placement on Fraser Shipyards Property	- Applicable for the entire volume of sediments removed. - Cleanup dredged material would be loaded onto transport barges and unloaded for dewatering at the upland area immediately west of the Cummings Avenue Slip. - The dewatered material would then be transported by truck and placed onsite east of Clough Avenue between the highway and the railroad tracks. - Further conditioning prior to regrading for cover placement may be needed after placement at the diposal site - Requires periodic inspection to assess the condition of the CDF.	- Technically feasible. - Requires construction of a new local CDF. - Placement of a vegetated cover or impermeable cover would be required (impermeable cover included for cost estimating purposes). - Land use restrictions would be implemented where the upland placement cell is constructed. - Water that drains from the dredged material at the initial dewatering pad would be collected and filtered prior to discharge to the City of Superior's sanitary sewer.	Moderate	Yes

Table 3-3
Evaluation and Screening of Management of Removed Material and Disposal Options
Focused Feasibility Study for Sediment Cleanup in Howard's Bay
Superior, WI

General Response Action	Technology	Description	Implementability	Relative Cost [1]	Retained
Disposal	Off-Site Disposal	- Applicable to all dredged material. - Dewatering and stabilization would be required prior to truck transport to disposal sites. - Sealed dump trucks would be required for transport, with trucks washed before leaving the site. - Dredged material would be disposed as waste at the City of Superior's Moccasin Mike landfill or at the VONCO V industrial landfill located in Duluth, MN.	- Technically and administratively feasible. - WDNR approval required for volumes in excess of 2,000 cy and dredged material is required to meet the City of Superior Special Waste Management Plan (see Appendix K) if the Moccasin Mike landfill were the disposal location.	High	Yes

Notes:

[1] Relative cost estimates are based on the available information regarding the site investigation and the anticipated scope of the project. Changes in cost elements are likely to occur as a result of new information and data collected during the engineering design of the remedial action. Utilization of this comparative cost estimate information beyond the stated purpose is not recommended. ARCADIS is not licensed to provide financial or legal consulting services; as such, this relative cost estimate information is not intended to be utilized for complying with financial reporting requirements associated with liability services.

CDF = confined disposal facility
CSO = combined sewer overflow
CW = Construction Worker
cy = cubic yards
GLLA = Great Lakes Legacy Act
MPCA = Minnesota Pollution Control Agency
O&M = Operation & Maintenance
RCL = Residual contaminant level
USACE = Unites States Army Corps of Engineers
WDNR = Wisconsin Department of Natural Resources
WWTP = wastewater treatment plant

Table 4-1
Description, Areas and Quantities of Remedial Alternatives
Focused Feasibility Study for Sediment Cleanup in Howard's Bay
Superior, WI

Sediment Management Alternative	Sub Area	Description of Approach	Dredge Footprint (acre)[1]	ENR/ MNR/ Cap/ CAD Footprint (acre)[1]	Estimated Neat In-Situ Cleanup Volume (cy)[1]	Estimated Neat In-situ Navigational Dredge Volume (cy)	Estimated Neat In-Situ Total Volume (cy)	Assumed In-Situ Cleanup Volume Overdredge Allowance (cy)[2]	Assumed Navigational Overdredge In-Situ Volume (cy)[3]	Estimated Overall Dredging Volume (cy)[4]	Estimated Overall Cleanup Dredging Volume (cy)
No Action	All Areas	No remedial action or monitoring	--	--	--	--	--	--	--	--	--
Alternative A-1	Area 1 - Within Federal Channel	Mechanical dredging and disposal of dredged material. Dredged material would be transported to disposal site identified for each dredged management unit, and managed in accordance with the disposal site requirements. Dredging would be performed with an environmental bucket. Silt curtains would be placed around the dredge in specific "hot spot" areas in slips and far end of Howards Bay to minimize redistribution of materials. Cleanup dredging will occur first in the most impacted areas, and then in the lesser impacted areas. 6-inch sand residuals cover layer to be placed after second pass based on test results. Dredging sequence and dredge material management will be defined in the Basis of Design.	4.0	--	12,000	10,000	22,000	2,400	5,900	30,300	14,400
	Area 2 - Within Federal Channel		5.1	--	16,000	14,000	30,000	3,200	7,000	40,200	19,200
	Area 1 - Outside Federal Channel		2.7	--	9,000	--	9,000	1,800	--	10,800	10,800
	Area 2 - Outside Federal Channel		4.3	--	15,000	--	15,000	3,000	--	18,000	18,000
	Hughitt Avenue Slip		1.7	--	4,100	--	4,100	900	--	5,000	5,000
	Head of Hughitt Avenue Slip		1.0	--	11,000	--	11,000	2,200	--	13,200	13,200
	Cummings Avenue Slip		0.51	--	830	--	830	200	--	1,030	1,030
	Head of Cummings Avenue Slip		1.2	--	5,900	--	5,900	1,200	--	7,100	7,100
	Fraser Slip		0.89	--	4,700	--	4,700	1,000	--	5,700	5,700
	Docking Area		2.6	--	17,000	--	17,000	3,400	--	20,400	20,400
		Summary	**24**	**0**	**96,000**	**24,000**	**120,000**	**19,000**	**13,000**	**152,000**	**115,000**
Alternative A-2	Area 1 - Within Federal Channel	Same as Alternative A-1	4.0	--	12,000	10,000	22,000	2,400	5,900	30,300	14,400
	Area 2 - Within Federal Channel		5.1	--	16,000	14,000	30,000	3,200	7,000	40,200	19,200
	Area 1 - Outside Federal Channel	Same as Alternative A-1, except ENR (6 inches sandy material - tolerance 4 to 6 inches) would be implemented in shallow areas to north of Federal Channel by spreader barges, broadcast, or similar methods	1.9	0.82	5,400	--	5,400	1,100	--	6,500	6,500
	Area 2 - Outside Federal Channel		3.8	0.55	13,600	--	13,600	2,800	--	16,400	16,400
	Hughitt Avenue Slip	Same as Alternative A-1	1.7	--	4,100	--	4,100	900	--	5,000	5,000
	Head of Hughitt Avenue Slip		1.0	--	11,000	--	11,000	2,200	--	13,200	13,200
	Cummings Avenue Slip		0.51	--	900	--	900	200	--	1,100	1,100
	Head of Cummings Avenue Slip		1.2	--	5,900	--	5,900	1,200	--	7,100	7,100
	Fraser Slip		0.89	--	4,700	--	4,700	1,000	--	5,700	5,700
	Docking Area		2.6	--	17,000	--	17,000	3,400	--	20,400	20,400
		Summary	**23**	**1.4**	**91,000**	**24,000**	**115,000**	**18,000**	**13,000**	**146,000**	**109,000**
Alternative A-3	Area 1 - Within Federal Channel	Same as Alternative A-1	4.0	--	12,000	10,000	22,000	2,400	5,900	30,300	14,400
	Area 2 - Within Federal Channel		5.1	--	16,000	14,000	30,000	3,200	7,000	40,200	19,200
	Area 1 - Outside Federal Channel	Same as Alternative A-1, except that MNR would be implemented in shallow areas to north of Federal Channel	1.9	0.82	5,400	--	5,400	1,100	--	6,500	6,500
	Area 2 - Outside Federal Channel		3.8	0.55	13,600	--	13,600	2,800	--	16,400	16,400
	Hughitt Avenue Slip	Same as Alternative A-1	1.7	--	4,100	--	4,100	900	--	5,000	5,000
	Head of Hughitt Avenue Slip		1.0	--	11,000	--	11,000	2,200	--	13,200	13,200
	Cummings Avenue Slip		0.51	--	900	--	900	200	--	1,100	1,100
	Head of Cummings Avenue Slip		1.2	--	5,900	--	5,900	1,200	--	7,100	7,100
	Fraser Slip		0.89	--	4,700	--	4,700	1,000	--	5,700	5,700
	Docking Area		2.6	--	17,000	--	17,000	3,400	--	20,400	20,400
		Summary	**23**	**1.4**	**91,000**	**24,000**	**115,000**	**18,000**	**13,000**	**146,000**	**109,000**

Table 4-1
Description, Areas and Quantities of Remedial Alternatives
Focused Feasibility Study for Sediment Cleanup in Howard's Bay
Superior, WI

Sediment Management Alternative	Sub Area	Description of Approach	Dredge Footprint (acre)[1]	ENR/ MNR/ Cap/ CAD Footprint (acre) [1]	Estimated Neat In-Situ Cleanup Volume (cy) [1]	Estimated Neat In-situ Navigational Dredge Volume (cy)	Estimated Neat In-Situ Total Volume (cy)	Assumed In-Situ Cleanup Volume Overdredge Allowance (cy) [2]	Assumed Navigational Overdredge In-Situ Volume (cy) [3]	Estimated Overall Dredging Volume (cy) [4]	Estimated Overall Cleanup Dredging Volume (cy)
Alternative A-4	Area 1 - Within Federal Channel	Similar to Alternative A-2, but with refinement of selected subarea boundaries and designation of certain subareas for either No Action or ENR based on constructability considerations, cost-effectiveness considerations, and further data evaluation vs. PRGs.	2.6	--	6,700	10,000	16,700	1,400	5,900	24,000	8,100
	Area 2 - Within Federal Channel		5.1	--	16,000	14,000	30,000	3,200	7,000	40,200	19,200
	Area 1 - Outside Federal Channel		1.3	0.29	4,700	--	4,700	1,000	--	5,700	5,700
	Area 2 - Outside Federal Channel		2.6	0.41	9,100	--	9,100	1,900	--	11,000	11,000
	Hughitt Avenue Slip		1.3	--	3,400	--	3,400	700	--	4,100	4,100
	Head of Hughitt Avenue Slip		0.85	--	9,700	--	9,700	2,000	--	11,700	11,700
	Cummings Avenue Slip		0.29	--	950	--	950	200	--	1,150	1,150
	Head of Cummings Avenue Slip		1.1	--	5,100	--	5,100	1,100	--	6,200	6,200
	Fraser Slip		0.76	--	4,100	--	4,100	900	--	5,000	5,000
	Docking Area		2.4	--	14,000	--	14,000	2,800	--	16,800	16,800
		Summary	**18**	**0.70**	**74,000**	**24,000**	**98,000**	**15,000**	**13,000**	**126,000**	**89,000**
Alternative B-1	Area 1 - Within Federal Channel	Same as Alternative A-1	4.0	--	12,000	10,000	22,000	2,400	5,900	30,300	14,400
	Area 2 - Within Federal Channel		5.1	--	16,000	14,000	30,000	3,200	7,000	40,200	19,200
	Area 1 - Outside Federal Channel	Same as Alternative A-2	1.9	0.82	5,400	--	5,400	1,100	--	6,500	6,500
	Area 2 - Outside Federal Channel		3.8	0.55	13,600	--	13,600	2,800	--	16,400	16,400
	Hughitt Avenue Slip	Same as Alternative A-1	1.7	--	4,100	--	4,100	900	--	5,000	5,000
	Head of Hughitt Avenue Slip	Dredge as necessary to accommodate placement of an isolation cap to achieve PRGs and maintain minimum water depth of 10 feet post-cap placement. Impose institutional controls to protect cap integrity. Long-term O&M required.	--	1.0	300	--	300	100	--	300	300
	Cummings Avenue Slip	Same as Alternative A-1	0.51	--	830	--	830	200	--	1,030	1,030
	Head of Cummings Avenue Slip	Place isolation cap to achieve PRGs. Armoring near outfall. Impose institutional controls to protect cap integrity. Long term O&M.	--	1.2	--	--	--	--	--	--	--
	Fraser Slip	Same as Alternative A-1	0.89	--	4,700	--	4,700	1,000	--	5,700	5,700
	Docking Area		2.6	--	17,000	--	17,000	3,400	--	20,400	20,400
		Summary	**20**	**3.6**	**74,000**	**24,000**	**98,000**	**15,000**	**13,000**	**126,000**	**89,000**

Table 4-1
Description, Areas and Quantities of Remedial Alternatives
Focused Feasibility Study for Sediment Cleanup in Howard's Bay
Superior, WI

Sediment Management Alternative	Sub Area	Description of Approach	Dredge Footprint (acre)[1]	ENR/ MNR/ Cap/ CAD Footprint (acre)[1]	Estimated Neat In-Situ Cleanup Volume (cy)[1]	Estimated Neat In-situ Navigational Dredge Volume (cy)	Estimated Neat In-Situ Total Volume (cy)	Assumed In-Situ Cleanup Volume Overdredge Allowance (cy)[2]	Assumed Navigational Overdredge In-Situ Volume (cy)[3]	Estimated Overall Dredging Volume (cy)[4]	Estimated Overall Cleanup Dredging Volume (cy)
Alternative B-2	Area 1 - Within Federal Channel	Same as Alternative A-4	2.6	--	6,700	10,000	16,700	1,400	5,900	24,000	8,100
	Area 2 - Within Federal Channel		5.1	--	16,000	14,000	30,000	3,200	7,000	40,200	19,200
	Area 1 - Outside Federal Channel		1.3	0.29	4,700	--	4,700	1,000	--	5,700	5,700
	Area 2 - Outside Federal Channel		2.6	0.41	9,100	--	9,100	1,900	--	11,000	11,000
	Hughitt Avenue Slip		1.3	--	3,400	--	3,400	700	--	4,100	4,100
	Head of Hughitt Avenue Slip	Same approach as Alternative B-1, same extent as Alternative A-4	--	0.86	300	--	300	100	--	300	300
	Cummings Avenue Slip	Same as Alternative A-4	0.29	--	950	--	950	200	--	1,150	1,150
	Head of Cummings Avenue Slip	Place suitable dredged material in a CAD to support shallow-water aquatic vegetation to improve habitat conditions on the slip, help filter contaminants in storm water from the outfall that discharges at the head of the slip, and maintain shallow draft navigational channel for small boats. Hot-spot removal in Unit 19D and a portion of Unit 19C. Dredge portion of Unit 19B and 19F not within CAD footprint.	0.40	1.6	3,000	--	3,000	600	--	3,600	3,600
	Fraser Slip	Same as Alternative A-4	0.76	--	4,100	--	4,100	900	--	5,000	5,000
	Docking Area	Dredge Unit 1 and place an isolation cap in northern portion of Unit 1 outside ship berth area to achieve PRGs	2.4	1.0	11,000	--	11,000	2,200	--	13,200	13,200
		Summary	**17**	**4.2**	**60,000**	**24,000**	**84,000**	**12,000**	**13,000**	**109,000**	**72,000**
Alternative B-3	Area 1 - Within Federal Channel	Same as Alternative B-2	2.6	--	6,700	10,000	16,700	1,400	5,900	24,000	8,100
	Area 2 - Within Federal Channel		5.1	--	16,000	14,000	30,000	3,200	7,000	40,200	19,200
	Area 1 - Outside Federal Channel		1.3	0.29	4,700	--	4,700	1,000	--	5,700	5,700
	Area 2 - Outside Federal Channel		2.6	0.41	9,100	--	9,100	1,900	--	11,000	11,000
	Hughitt Avenue Slip		1.3	--	3,400	--	3,400	700	--	4,100	4,100
	Head of Hughitt Avenue Slip		--	0.86	300	--	300	100	--	300	300
	Cummings Avenue Slip		0.29	--	950	--	950	200	--	1,150	1,150
	Head of Cummings Avenue Slip	Same approach as Alternative B-1, same extent as Alternative A-4	--	1.1	--	--	--	--	--	--	--
	Fraser Slip	Same as Alternative A-4	0.76	--	4,100	--	4,100	900	--	5,000	5,000
	Docking Area	Place isolation cap in Unit 1 to achieve PRGs. Armoring may be required. Impose institutional controls to protect cap integrity.	--	2.4	--	--	--	--	--	--	--
		Summary	**14**	**5.1**	**46,000**	**24,000**	**70,000**	**9,000**	**13,000**	**92,000**	**55,000**

Notes:

1. Preliminary estimates of areas and volumes include incremental neatline dredging volumes beyond SND scope based on assuming a constant average thickness of sediment to be removed over each dredge unit. Area of the Sediment Management Units within the federal channel that do not require cleanup (*i.e.,* Units 32 to 36, or 12.3 acres) has not been included in the dredge footprint. Side slopes from federal channel were considered as remedial dredge in this preliminary estimation; however, it is likely going to be infeasible to dredge steep side slopes and there is considerable uncertainty as to presence and thickness of sediment on the slopes as most cores are from top or bottom of slope areas. Areas and volumes will be refined during the design phase using a 3-dimensional model of the dredge prism and taking into account pre-design investigation findings, constructability factors and federal channel side slopes. ENR/MNR/Cap/CAD footprint is indicated only for those units that would implement these technologies in specific alternatives.

2. A 20% cleanup volume overdredge allowance is based on a 6-inch over dredging allowance for all dredging units.

3. The navigational overdredge volume estimate assumes a 1-foot over-dredge allowance over the footprint within the federal channel to be dredged under the SND scope, and does not account for potential volume of material that may slough into dredge cut. The 1-foot overdredge allowance is based on typical USACE contract allowances.

4. Includes neat in-situ volume, SND overdredge in-situ volume, an additional 20% cleanup volume based on 6-inch over dredge allowance.

-- = Not applicable
AOC = Area of Concern
CAD = confined aquatic disposal
cy = cubic yards
ENR = Enhanced Natural Recovery (Placement of thin layer cap or cover layer of clean fine grained material to expedite recovery of surface exposures)
MNR = Monitored Natural Recovery (Periodic testing as part of future AOC-wide monitoring activities or other AOC monitoring programs)
PRGs = Preliminary Remedial Goals
O&M = operation and maintenance
SND = strategic navigation dredging

Table 4-2
Estimated Strategic Navigation and Cleanup Dredging Volumes for Remedial Alternative A-1
Focused Feasibility Study for Sediment Cleanup in Howard's Bay
Superior, WI

Sediment Management Unit ID	Dredge Unit Location	Overall Dredge Unit Footprint (acres)	Estimated Neat In-Situ SND Volume (cy) [1]	Estimated Neat In-Situ Cleanup Volume (cy) [2,4]	Total Estimated Neat In-Situ Volume (cy) [1,2]	SND Dredge Area Footprint (acres)	Footprint where SND Dredge Area Overlaps with Cleanup Dredge Area (acres)	Overall Dredging Depth (feet) [3]	Average SND Removal Thickness (feet) [3]	Average Cleanup Removal Thickness (feet)	Assumed SND Overdredge Thickness (feet)	Assumed SND Overdredge In-Situ Volume (cy)	Assumed In-Situ Cleanup Volume Overdredge Allowance (cy) [4]	Estimated Overall Cleanup Dredging Volume (cy)	Estimated Overall Dredging Volume (cy) [5,6,7]
1	Outside FC	2.61	0	16,839	16,839	--	--	4	--	4.0	1	0	3,368	20,206	20,206
2	Outside FC	0.52	0	3,343	3,343	--	--	4	--	4.0	1	0	669	4,012	4,012
3A	Federal Channel	0.24	1,272	1,057	2,329	0.24	0.24	6	3.3	2.7	1	387	211	1,268	2,927
3B	Federal Channel	1.69	5,548	6,803	12,351	1.60	1.52	4.5	2.1	2.6	1	2,581	1,361	8,164	16,292
4	Outside FC	0.62	0	2,993	2,993	--	--	3	--	3.0	1	0	599	3,592	3,592
5	Outside FC	0.14	0	467	467	--	--	2	--	2.0	1	0	93	561	561
6	Outside FC	0.14	0	226	226	--	--	1	--	1.0	1	0	45	271	271
7	Outside FC	0.38	0	613	613	--	--	1	--	1.0	1	0	123	736	736
8	Federal Channel	0.98	3,278	3,921	7,199	0.87	0.80	4.5	2.3	2.7	1	1,407	784	4,705	9,390
9A	Outside FC	0.58	0	936	936	--	--	1	--	1.0	1	0	187	1,124	1,124
9B	Federal Channel	0.30	0	482	482	--	--	1	--	1.0	1	0	96	579	579
9C	Outside FC	0.12	0	197	197	--	--	1	--	1.0	1	0	39	236	236
10	Fraser Slip	0.45	0	2,893	2,893	--	--	4	--	4.0	1	0	579	3,472	3,472
11	Fraser Slip	0.44	0	1,764	1,764	--	--	2.5	--	2.5	1	0	353	2,117	2,117
12A	Outside FC	0.27	0	865	865	--	--	2	--	2.0	1	0	173	1,038	1,038
12B	Outside FC	0.23	0	917	917	--	--	2.5	--	2.5	1	0	183	1,100	1,100
13A	Federal Channel	0.08	45	477	523	0.04	0.04	4	0.8	3.7	1	59	95	573	677
13B	Outside FC	0.10	0	655	655	--	--	4	--	4.0	1	0	131	786	786
14A	Federal Channel	1.19	3,240	1,629	4,869	0.95	0.49	2	2.1	1.4	1	1,526	326	1,955	6,721
14B	Outside FC	0.42	0	1,367	1,367	--	--	2	--	2.0	1	0	273	1,640	1,640
15A	Federal Channel	0.58	426	1,438	1,864	0.30	0.28	2	0.9	1.6	1	483	288	1,726	2,635
15B	Outside FC	0.49	0	1,580	1,580	--	--	2	--	2.0	1	0	316	1,896	1,896
15C	Outside FC	0.32	0	516	516	--	--	1	--	1.0	1	0	103	619	619
16A	Federal Channel	0.38	739	1,263	2,001	0.31	0.27	3	1.5	2.2	1	498	253	1,515	2,752
16B	Outside FC	0.89	0	4,283	4,283	--	--	3	--	3.0	1	0	857	5,140	5,140
17A	Federal Channel	0.36	1,032	1,554	2,586	0.33	0.32	4.5	2.0	2.7	1	525	311	1,865	3,422
17B	Outside FC	0.50	0	810	810	--	--	1	--	1.0	1	0	162	972	972
17C	Outside FC	0.35	0	1,700	1,700	--	--	3	--	3.0	1	0	340	2,040	2,040
18	Federal Channel	0.42	883	668	1,551	0.30	0.18	2	1.8	1.4	1	485	134	802	2,170
19A	Cummings Ave Slip	0.51	0	826	826	--	--	1	--	1.0	1	0	165	991	991
19B	Cummings Ave Slip	0.57	0	2,780	2,780	--	--	3	--	3.0	1	0	556	3,336	3,336
19C	Cummings Ave Slip	0.48	0	1,165	1,165	--	--	1.5	--	1.5	1	0	233	1,399	1,399
19D	Cummings Ave Slip	0.15	0	1,970	1,970	--	--	8	--	8.0	1	0	394	2,364	2,364
20	Outside FC	0.34	0	1,629	1,629	--	--	3	--	3.0	1	0	326	1,955	1,955
21	Outside FC	0.19	0	301	301	--	--	1	--	1.0	1	0	60	361	361
22	Federal Channel	0.68	1,239	1,059	2,297	0.53	0.41	2	1.5	1.2	1	850	212	1,271	3,359
23	Federal Channel	0.35	834	960	1,794	0.27	0.21	3	1.9	2.1	1	437	192	1,152	2,423
24	Federal Channel	0.23	683	382	1,065	0.15	0.06	2	2.9	1.7	1	238	76	459	1,380
25A	Outside FC	0.16	0	260	260	--	--	1	--	1.0	1	0	52	312	312

Table 4-2
Estimated Strategic Navigation and Cleanup Dredging Volumes for Remedial Alternative A-1
Focused Feasibility Study for Sediment Cleanup in Howard's Bay
Superior, WI

Sediment Management Unit ID	Dredge Unit Location	Overall Dredge Unit Footprint (acres)	Estimated Neat In-Situ SND Volume (cy) [1]	Estimated Neat In-Situ Cleanup Volume (cy) [2,4]	Total Estimated Neat In-Situ Volume (cy) [1,2]	SND Dredge Area Footprint (acres)	Footprint where SND Dredge Area Overlaps with Cleanup Dredge Area (acres)	Overall Dredging Depth (feet) [3]	Average SND Removal Thickness (feet) [3]	Average Cleanup Removal Thickness (feet)	Assumed SND Overdredge Thickness (feet)	Assumed SND Overdredge In-Situ Volume (cy)	Assumed In-Situ Cleanup Volume Overdredge Allowance (cy) [4]	Estimated Overall Cleanup Dredging Volume (cy)	Estimated Overall Dredging Volume (cy) [5,6,7]
25B	Outside FC	0.13	0	215	215	--	--	1	--	1.0	1	0	43	258	258
26	Hughitt Ave Slip	0.99	0	11,153	11,153	--	--	7	--	7.0	1	0	2,231	13,383	13,383
27	Hughitt Ave Slip	0.85	0	2,736	2,736	--	--	2	--	2.0	1	0	547	3,284	3,284
28	Hughitt Ave Slip	0.24	0	389	389	--	--	1	--	1.0	1	0	78	466	466
29	Hughitt Ave Slip	0.57	0	926	926	--	--	1	--	1.0	1	0	185	1,111	1,111
30	Federal Channel	1.11	34	3,541	3,575	0.01	0.002	2	2.1	2.0	1	17	708	4,249	4,300
31A	Federal Channel	0.51	1,050	2,242	3,291	0.25	0.22	4	2.6	2.9	1	406	448	2,690	4,146
31B	Outside FC	0.15	0	241	241	--	--	1	--	1.0	1	0	48	289	289
32A	Federal Channel	0.65	184	0	184	0.15	--	0.8	0.8	--	1	238	0	0	422
32B	Federal Channel	0.26	0	0	0	0.00	--	0.1	0.1	--	1	3	0	0	3
33	Federal Channel	0.88	256	0	256	0.21	--	0.7	0.7	--	1	345	0	0	600
34	Federal Channel	2.77	1,150	0	1,150	0.45	--	1.6	1.6	--	1	731	0	0	1,881
35	Federal Channel	4.34	2,141	0	2,141	0.96	--	1.4	1.4	--	1	1,549	0	0	3,691
36	Federal Channel	3.39	245	0	245	0.09	--	1.6	1.6	--	1	149	0	0	394
Total:		**36.3**	**24,300**	**95,100**	**119,400**	**8.0**	**5.0**					**13,000**	**19,100**	**114,100**	**151,300**

Notes:
1. SND volume includes dredged material volume shallower than 27 fow within the federal channel to be dredged under the SND scope by the USACE.
2. GLLA volume includes dredged material volume deeper than 27 fow within the federal channel and all dredge material volume outside of the federal channel to be dredged under the environmental dredging scope as part of the GLLA project
3. Some portions of the federal channel have SND removal thickness greater than the required overall dredging thickness resulting in the sum of average SND removal thickness plus average cleanup removal thickness greater than the overall dredging depth for certain dredge units.
4. The neat cleanup volume estimates do not include allowance for overdredging. The cleanup volume estimates assume that the dredging tolerance for the initial dredging pass will be plus or minus 6 inches from the target cleanup elevation and that post-removal sediment sampling will be conducted after the initial dredging pass. If post-removal sampling of the initial dredging pass does not achieve the cleanup goal, it is assumed that a residual cover of 6 inches (tolerance range of 3 inches) will be placed.
5. Includes neat in-situ volume, SND overdredge in-situ volume, and a 20% additional volume for over dredge allowance.
6. Estimated dredging volumes are based on single-beam bathymetry data collected in 2013.
7. It is assumed that project specifications will provide for adjustment of removal depths if clay is encountered above the target removal elevations/depths, in order to avoid dredging native clay

cy = cubic yards
FC = Federal Channel
fow = feet of water
GLLA = Great Lakes Legacy Act
mg/kg = milligrams per kilogram
SND = strategic navigation dredging
USACE = Unites States Army Corps of Engineers

Table 4-3
Summary of Disposal Options
Focused Feasibility Study for Sediment Cleanup in Howard's Bay
Superior, WI

#	Disposal Option	Proposed Criteria [1]	Estimated Neat In-Situ Cleanup Volume Meeting Criteria [2,3,4,5] (cy)	Estimated Weight (tons)	Maximum Capacity of Disposal Location (cy)	Estimated Unit Cost		Neat In-Situ Cleanup Volume and In-Situ Cleanup Volume Overdredge Allowance for Disposal Associated with Each Alternative for Cost Estimate Purposes [8,9] (cy)							Notes/Assumptions [12]
								A-1	A-2	A-3	A-4	B-1	B-2	B-3	
								115,000	109,000	109,000	89,000	89,000	72,000	55,000	
1-A	Shallow Water Habitat Creation with In-water Placement and Cover in Cummings Avenue Slip [6]	NI-DC RCL	9,500	NA	Approx. 20,000	19.41	/in-situ cy	0	0	0	0	0	8,800	0	Cleanup dredged material would be barged to Cummings Avenue Slip. Dewatering of material would not be necessary. Approximately 2,500 in-situ cy of material near the stormwater outfall would be dredged (Units 19C and 19D). Dredged material meeting the Priority 4 criterion would be placed above the remaining sediment in the disposal area, which is approximately two-thirds the length of Cummings Avenue Slip. Dredged material meeting the NI-DC soil RCL values divided by a safety factor of 2 or background values would then be placed in the area. Clean cover material (or clean SND material, if suitable) would be placed over the dredged material (thickness of 1 foot or 2,500 cy). Approximately 8,800 in-situ cy are suitable for placement based on the Priority 4 criterion and the refined boundaries from Alternative A-4. The estimated footprint of the CAD would be 0.9 acres based on amount of material suitable for placement.
1-B		Priority 4 criterion (see Attachment X)	14,700 (or 5,200 beyond the 9,500 meeting NI-DC RCL)	NA											
2-A	Wisconsin Point Landfill [7]	CW RCL, Except for PAHs and thallium (unit-averaged) and for dredged material from slips (with material meeting CW RCL placed as cover)	67,700	NA	Likely 90,000	46.48	/in-situ cy	62,000	62,000	62,000	54,100	42,000	29,500	24,900	Cleanup dredged material meeting the CW RCL except for PAHs and thallium (unit-averaged) would be placed beneath a cover. Activities at the landfill in addition to material placement, would include re-grading, re-vegetation, extending monitoring well casing to above grade, and maintenance, if needed, to manage vegetative cover growth and any slope failure areas. Material would be either barged to a location near the landfill (i.e., former US Coast Guard Station), or hauled by truck after dewatering and stabilization at a staging area adjacent to the site. If barge transport to the Coast Guard Station, it is assume that dredged material would be conditioned in the barges prior to offloading, transport, stockpiling for further drainage at the landfill, and spreading the material. If truck transport, the material would be offloaded at the site, dewatered and stabilized and then hauled to the landfill. Water from the dewatering process would be collected and transported to a WWTP for treatment (or pre-treated with filtration prior to discharge to the City sanitary sewer, whichever is more cost-effective). A material management plan at the landfill would need to be submitted to the City for submission to WDNR for approval.
2-B		CW RCL, Except for PAHs and thallium (unit-averaged) (with material meeting CW RCL placed as cover)	90,800 (or 23,100 beyond the 67,700)	NA											
3-A	Reuse at brownfield sites in Duluth, MN	Tier 1 - MPCA	39,000	NA	Unlimited - No Net Volume Increase if <40,000 cy (replace existing stockpile)	41.36	/in-situ cy	46,800	40,800	40,800	28,800	40,800	27,600	24,000	Cleanup dredged material will be transported by barge to Erie Pier, and dewatered at Erie Pier. An equivalent amount of material up to 40,000 cy from an existing stock pile at Erie Pier would be re-located to City of Duluth brownfield sites and dumped there for spreading and grading by others. The neat in-situ cleanup volume associated with each alternative was estimated assuming the maximum volume meeting the Tier 1 criterion comparing discrete sample concentrations against the Tier 1 criterion. The overdredge allowance was added to the maximum volume meeting the Tier 1.
3-B		Tier 2 - MPCA	53,000 (or 14,000 beyond the 39,000 meeting Tier 1)	NA											
4-A	Upland Placement on Fraser Shipyards Property	CW RCL (discrete samples) [11]	22,400 [11]	NA	37,500	52.43	/in-situ cy	0	0	0	0	0	0	0	In this option, cleanup dredged material would be placed for long term containment in a constructed disposal cell at an upland area on Fraser's property. The estimated footprint would be approximately 3.5 acres. Assume dredged material would be placed to a thickness of 4 feet at the perimeter of the consolidation cell with a gradual slope to a maximum dredged material thickness of 10 feet in the central portion of the consolidation cell and a 2-foot thick cover over the dredged materials with 3:1 (horizontal:vertical) slopes at the perimeter of the cell. For cost estimating, it is assumed the dredged materials would be covered with an impermeable cover of: a non-woven geotextile marker layer, a 40-mil high-density polyethylene (HDPE) membrane liner, a 6-inch sand or granular drainage layer, a 12-inch general soil fill layer, and a 6-inch vegetated topsoil layer of material stripped from the upland area (along with imported material). Subgrade preparation would include clearing, grubbing, and grading. A non-woven geotextile marker layer will be placed above the subgrade. GLLA material would be dewatered/stabilized and then transported by truck for placement on Fraser's property between the highway and the railroad tracks. If dewatering is conducted at the placement location, drainage water from dredged material would be collected and filtered prior to discharge to the City sanitary sewer. Stormwater erosion control and drainage features would be installed. Long-term maintenance and annual inspections would be required. Land use restrictions would also need to be implemented. Wetland delineation would be needed and wetland fill permits would need to be obtained prior to using the proposed Fraser property for upland placement.
4-B		CW RCL, Except for PAHs and thallium (unit-averaged) [11]	90,800 (or 68,400 beyond the 22,400 meeting CW RCL) [11]	NA											
5	Landfill Disposal at VONCO V, Duluth, MN	TCLP results	96,000	129,600 [10]	Unlimited	63.32	/in-situ cy	6,200	6,200	6,200	6,100	6,200	6,100	6,100	In this option, dredged material would be trucked to the VONCO landfill from the site. Cleanup dredged material would need to pass TCLP testing and paint filter testing. Per landfill requirements, no other testing would be needed. It is assumed that dredged material would be offloaded from a transport barge by a shore-mounted crane at the Fraser property, dewatered, stabilized and then hauled by truck to the VONCO landfill. Alternately, subject to USACE evaluation, hydraulic transport of dredged materials and dewatering using geotubes at the Cummings Avenue Slip may be considered. Water generated from dewatering will be collected and pre-treated with filtration and discharged to the City's sanitary sewer. The assumed disposal volume includes dredged material from Units 16B and 29, which are likely the only Units exceeding the criterion proposed for the Wisconsin Point landfill disposal option based on preliminary feedback provided by WDNR.

Table 4-3
Summary of Disposal Options
Focused Feasibility Study for Sediment Cleanup in Howard's Bay
Superior, WI

Notes:
1. Criteria under evaluation. Actual volume depends on agency acceptance and design factors.
2. Neat in-situ cleanup volume meeting criteria based on Alternative A-1.
3. Cleanup volume includes dredged material volume deeper than 27 fow within the federal channel and all dredge material volume outside of the federal channel to be dredged under the environmental dredging scope as part of the GLLA project.
4. ARCADIS' estimated dredging volumes are based on bathymetric surface prepared from single-beam bathymetry data collected in 2013.
5. Volume estimates assume that clay will not be encountered above the target removal elevations/depths. It is assumed that project specifications will allow for reducing dredge depth to avoid removing clay, if it is encountered.
6. CAD extends from head of Cummings slip up to the limits of submerged land lease (see Appendix C for description of CAD).
7. It is assumed that capping material would be required to meet the CW RCL, and material for placement beneath the cap would be required to meet one of the other criteria listed for this disposal option.
8. Preliminary assumptions for cleanup dredged material for each alternative and disposal options were developed based on the status of current evaluations and cost estimates. The distribution of disposal volumes is subject to revision during the design phase.
9. A 20% cleanup volume contingency is assumed based a 6-inch overdredge allowance applied to the entire dredge area.
10. The estimated weight of cleanup dredged material for disposal at the VONCO landfill is based on an assumed unit weight of 1.35 tons per in-situ cubic yard (after material stabilization).
11. The comparison of sediment analytical data with these WDNR criteria was conducted to provide a general understanding of the constituent concentrations that may be designated for placement in the upland consolidation area. It should be noted that dredged material that exceeds these criteria would not preclude placement in the upland consolidation area, but may require additional consideration during design (e.g., cover system design to minimize direct contact and water infiltration).
12. Assumptions are preliminary based on the available information regarding the disposal options and the anticipated scope of the remedial alternatives, and are subject to change during the design phase.

BaP = benzo(a)pyrene
CAD = Confined Aquatic Disposal
CW = Construction Worker
cy = cubic yards
fow = feet of water
GLLA = Great Lakes Legacy Act
MPCA = Minnesota Pollution Control Agency
NA = not applicable
NI-DC = Non-Industrial Direct Contact
PAH = polycyclic aromatic hydrocarbons
RCL = Residual contaminant level
SND = strategic navigation dredging
TCLP = toxicity characteristic leaching procedure
WDNR = Wisconsin Department of Natural Resources
WWTP = wastewater treatment plant

Table 5-1
Evaluation of Remedial Alternatives
Focused Feasibility Study for Sediment Cleanup in Howard's Bay
Superior, WI

Criterion [1]	**Site-Wide No Action** [2]	**Alternative A-1:** Sediment Removal in All Subareas	**Alternative A-2:** Sediment Removal in All Subareas, Except for ENR in Units 12B, 15C, 17C, 20 and 25B	**Alternative A-3:** Sediment Removal in All Subareas, Except for MNR in Units 12B, 15C, 17C, 20 and 25B	**Alternative A-4:** Sediment Removal in Refined Subareas, Except for ENR in Units 15D and 25B, and No Action in Units 12B, 13B, 14B, 15B-C, 17B-C, 19A, 20, 22, 25A, 28	**Alternative B-1:** Partial Dredge/Capping at Head of Hughitt and Cummings Avenue Slips and Sediment Removal in All Subareas, Except for ENR in Units 12B, 15C, 17C, 20 and 25B	**Alternative B-2:** Partial Dredge/Capping at Head of Hughitt Avenue Slip and Docking Area, CAD at Head of Cummings Avenue Slip, and Sediment Removal in Refined Subareas, Except for ENR in Units 15D and 25B, and No Action in Units 12B, 13B, 14B, 15B-C, 17B-C, 19A, 20, 22, 25A, 28	**Alternative B-3:** Partial Dredge/Capping at Head of Hughitt and Cummings Avenue Slips, Capping in Docking Area, and Sediment Removal in Refined Subareas, Except for ENR in Units 15D and 25B, and No Action in Units 12B, 13B, 14B, 15B, 17B-C, 19A, 20, 22, 25A, 28
1. Short- and long-term effectiveness in protecting human health and the environment								
(1.a) Overall protection of human health and the environment	Does not address potential risks associated with sediment in Howard's Bay. (Potential risks have not been quantified through risk assessment.)	A properly designed and implemented dredging alternative would reduce bioavailability, exposure, and toxicity of site-specific COCs by physically/permanently removing contaminated sediment exceeding PRGs from the environment. Dredging would result in a reduction of in-place COC concentration, volume, and mass from the system. Dredging does not require OM&M of a man-made structure in a waterway. Some of the short-term limitations of dredging technology resuspension and short-term exposures to the water column, dredge residuals, worker exposure, and community impacts) are manageable with best practices. Other short term effects include removal of benthic habitat and disruption of benthic populations. Dredging is protective of human health and the environment if cleanup goals are met, and dredging permanently removes contaminants from the waterway.	Dredging: Same as Alternative A-1. ENR: Placement of a thin-layer of material would reduce COC concentrations at the surface, reduce potential remobilization of sub-surface sediments and help ensure long-term protectiveness in these locations. For units where surface sediment COCs are below the PRG, no short-term risk reduction is needed; however, would help reduce potential for long-term risks by placement of additional clean sediment over the underlying layers to buffer effects of future mixing through bioturbation or other processes. Would not reduce volume of contaminated sediment. The ENR areas are in shallow areas to north. The upper most layers of sediment in these units either already achieves the PRG or are below the PEC and thus marginally exceed the PRG. These areas contain relatively low inventories of mass and volume of site- specific COCs exceeding PRGs due to relatively thin sediment deposits in these areas compared to deeper areas of the site.	Dredging: Same as Alternative A-1. MNR areas: Would rely on natural processes to continue to provide risk reduction in these locations. The MNR areas are restricted to shallow areas to north and the upper most layer of sediment in these units already achieves the PRG or is between the MEC and PEC. These areas contain limited mass and volume of site-specific COCs exceeding the PRGs in buried sediment layers.	Dredging and ENR: Same as Alternative A-2. Refinements made to unit boundaries specific to units located outside of normally dredged areas (thus no direct impact on restrictions on dredging BUI) based on cost-effectiveness and implementability considerations. In developing this alternative, these considerations were reviewed for units where PRG exceedances occur only in subsurface (and are below the PEC), and in consideration of thickness of overburden as well as potential effects of sediment mixing on resulting exposure concentrations. Also incorporates modified unit boundaries adjacent to shoreline structures based on stability and constructability concerns. No Action: Lack of future dredging needs, depth of PRG exceedance in sediment column, level of PRG exceedance, and propensity for natural recovery processes to continue to sequester buried materials together with potential recontamination source minimization through dredging areas in marine traffic lanes indicate No Action in the designated units will be protective where applied in this alternative.	Dredging and ENR: Same as Alternative A- 2. Cap: A properly designed and implemented capping alternative would reduce bioavailability and exposure and therefore would reduce the toxicity of site-specific COCs (via a physical and chemical isolation barrier). Capping would not reduce in-place COC concentration, volume, or mass, but would reduce exposure to the COCs. Capping would require long-term monitoring and maintenance, prohibitions on intrusive activities (excavation) in these areas, and depending on the type of capping (reactive versus isolation) there may be an associated limitation on the timeframe of effectiveness (reactive media capacity). The short-term limitations of capping technology (resuspension, short-term exposures to the water column and residuals, temporary worker exposure, and community impacts are manageable with best practices. Capping also eliminates benthic habitat that is typically restored on the surface of the cap. Overall, capping would be protective of human health and the environment to the extent that the contaminated sediment remains physically isolated (i.e., the cap is not damage), but has greater long-term risks than removing contaminants from the environment.	Dredging, ENR, and No Action: Same as Alternative A-4. Cap: Same as Alternative B- 1, except for CAD at head of Cummings Slip. CAD: For cover same as B-1 Cap, In addition, CAD will create wetlands area and a navigational channel to improve habitat and recreational conditions on the slip, and help filter contaminants in stormwater from the outfall discharges at the head of the slip. Hot spot removal in head of slip (if required for permitting of the CAD) would remove a portion of COC-containing sediment in CAD footprint. Establishment, monitoring and maintenance of an abundant aquatic/wetland plant community needed to achieve and sustain wetland functions.	Dredging, ENR, and No Action: Same as Alternative A-4. Cap: Same as B-1
(1.b) Time to implement	No remedial action; therefore, not applicable.	Dredging duration could span two construction seasons, depending on specific sequencing of work and when actual dredging activities are initiated. The project activities could extend up to approximately two years depending on whether the project employs temporary staging of dredged materials for placement in a following construction season.	Implementation could be achieved within the same time period as the overall dredging project, consistent with Alternative A-1. Periodic monitoring and maintenance (as needed) over an appropriate future period could be conducted to evaluate and maintain ENR areas.	Implementation could be achieved within the same time period as the overall dredging project, consistent with Alternative A-1. Periodic monitoring over an appropriate future period would be conducted to evaluate MNR areas.	Implementation could be achieved within the same time period as the overall dredging project, consistent with Alternative A-1, or within a shorter duration due to refined removal areas and ENR footprint, and consideration of setbacks that will facilitate dredging activities near bulkheads and shorelines.	Implementation could be achieved within the same time period as the overall dredging project, consistent with Alternative A-1. Periodic monitoring and maintenance (as needed) over an appropriate future period could be conducted to evaluate and maintain ENR and capped areas.	Implementation could be achieved within the same time period as the overall dredging project, consistent with Alternative A-4; however, CAD construction would take an estimated additional 2 months, lengthening the overall duration of the project, but not more than two construction seasons in total. Periodic monitoring and maintenance (as needed) over an appropriate future period would be conducted to evaluate and maintain CAD.	Implementation could be achieved within the same time period as the overall dredging project, consistent with Alternative A-4.

Table 5-1
Evaluation of Remedial Alternatives
Focused Feasibility Study for Sediment Cleanup in Howard's Bay
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Criterion [1]	**Site-Wide No Action** [2]	**Alternative A-1:** Sediment Removal in All Subareas	**Alternative A-2:** Sediment Removal in All Subareas, Except for ENR in Units 12B, 15C, 17C, 20 and 25B	**Alternative A-3:** Sediment Removal in All Subareas, Except for MNR in Units 12B, 15C, 17C, 20 and 25B	**Alternative A-4:** Sediment Removal in Refined Subareas, Except for ENR in Units 15D and 25B, and No Action in Units 12B, 13B, 14B, 15B-C, 17B-C, 19A, 20, 22, 25A, 28	**Alternative B-1:** Partial Dredge/Capping at Head of Hughitt and Cummings Avenue Slips and Sediment Removal in All Subareas, Except for ENR in Units 12B, 15C, 17C, 20 and 25B	**Alternative B-2:** Partial Dredge/Capping at Head of Hughitt Avenue Slip and Docking Area, CAD at Head of Cummings Avenue Slip, and Sediment Removal in Refined Subareas, Except for ENR in Units 15D and 25B, and No Action in Units 12B, 13B, 14B, 15B-C, 17B-C, 19A, 20, 22, 25A, 28	**Alternative B-3:** Partial Dredge/Capping at Head of Hughitt and Cummings Avenue Slips, Capping in Docking Area, and Sediment Removal in Refined Subareas, Except for ENR in Units 15D and 25B, and No Action in Units 12B, 13B, 14B, 15B, 17B-C, 19A, 20, 22, 25A, 28
(1.c) Protection of workers during remedial action	No remedial action; therefore, not applicable.	Inherent to sediment remediation is working on or near the water and the general operational hazards of using construction equipment. Workers could potentially be exposed to COCs during sediment removal, handling, processing, and disposal activities through exposure routes of incidental ingestion, dermal contact, or dust inhalation. However, adequate controls would be in place to ensure work safety during remedial activities through use of appropriately trained personnel, engineering controls and/or PPE, decontamination, and air monitoring as specified in a site-specific HASP.	Dredging: Same as Alternative A-1. ENR: Reduces potential for worker exposure to COCs as sediments are not disturbed during placement.	Dredging: Same as Alternative A-1. MNR: Limited potential for worker exposure to COCs as sediments are minimally disturbed during monitoring.	Dredging and ENR: Same as Alternative A-2.	Dredging and ENR: Same as Alternative A- 2. Partial Dredge/Capping: Partial dredging would be the same as Alternative A-1. For capping, working on water and the general construction operational hazardous are similar to A-1. Potential for worker exposure is less than dredging as sediments are left in place. However, cap placement could release sheens that contain COCs. This sheen could coat marine vessels and workers could potentially be exposed during decontamination through exposure routes of dermal contact and incidental ingestion. Mitigation controls are same as A-1.	Dredging and ENR: Same as Alternative A-2. Partial Dredge/Capping: Same as Alternative B- 1. CAD, Wetlands and Navigational Channel (for Recreational Use) Construction: Potential for worker risk with respect to exposure to COCs, and mitigation measures would be similar to those for dredging in Alternative A-1.	Dredging and ENR: Same as Alternative A-2. Partial Dredge/Capping: Same as Alternative B-1. Capping: Limited potential for worker exposure as sediments are not disturbed during placement.
(1.d) Protection of community during remedial action	No remedial action; therefore, not applicable.	Impacts to the community would include noise, increased truck and marine vessel traffic, and potential dust emissions during sediment removal, handling, processing, and disposal activities. Measures to mitigate these impacts and protect the community would include engineering controls and plans and air monitoring to protect the community. Truck routes will be laid out to minimize traffic congestion and accident risks and also to follow appropriate road load limits. Additionally, a construction quality assurance plan will be developed with steps to protect against trucks that are overloaded, unsealed, or not in compliance with rules, regulations, or licensing. Decontamination of equipment would prevent the spread of COC-containing materials along haul routes. Dust control measures would be applied where needed to minimize wind-blown transport of dried dredged materials.	Dredging: Same as Alternative A-1. ENR: Minimal impacts resulting from material transport and placement - comparable to dredging activities, including some noise, truck and marine vessel traffic, and potential dust emissions. Measures to mitigate these impacts would include engineering controls and plans.	Dredging: Same as Alternative A-1. MNR: No remedial action; therefore, not applicable.	Dredging and ENR: Same as Alternative A-2.	Dredging and ENR: Same as Alternative A- 1. Partial Dredge/Capping: Impacts to the community during cap placement beyond those occurred by dredging would be minimal, if any. Additional traffic associated with delivering cap materials to the site via truck or barge.	Dredging and ENR: Same as Alternative A-1. Partial Dredge/Capping: Same as Alternative B- 1. CAD: Impacts to the community during CAD installation would be associated with truck traffic for delivery of cover materials.	Dredging and ENR: Same as Alternative A-1. Partial Dredge/Capping: Same as Alternative B-1. Capping would involve truck and marine vessel traffic associated with cap material delivery and placement, and potential dust emissions. Measures to mitigate these impacts would include monitoring and/or engineering controls, similar to A-1.
(1.e) Short-term environmental impacts of remedial action	No remedial action; therefore, not applicable.	Short term effects will include impacts to the water column from sediment re-suspension, alteration/destruction of existing habitat in the sediment areas targeted for removal. Monitoring, engineering controls and/or BMPs would be used to mitigate these impacts. Naturally deposited sediments would provide a surface habitat layer to eventually facilitate natural re-colonization by native biota.	Dredging: Same as Alternative A-1. ENR: Placement on a thin-layer of material would enhance natural recovery processes, but could result in temporary alteration of existing habitat. ENR surface would provide clean layer for natural re-colonization by native biota. Limited changes to bathymetry due to placement of thin-layer.	Dredging: Same as Alternative A-1 MNR: No intrusive action; therefore, not applicable.	Dredging and ENR: Same as Alternative A-2.	Dredging and ENR: same as Alternative A- 2. Partial Dredge/Capping: Partial dredging would be the same as Alternative A-1. Placement of cap material would cause temporary alteration/destruction of existing habitat, but cap surface would provide clean layer for natural re-colonization by native biota. Dredging prior to capping minimizes change/shallowing of bathymetry. Capping will change habitat. Habitat layer can be incorporated in cap design to allow recolonization.	Dredging and ENR: Same as Alternative A-2. Partial Dredge/Capping: Same as Alternative B- 1. CAD: Construction of CAD, wetlands area and navigational channel for recreational use will modify this area and create environmental, ecological and human use/enjoyment benefits.	Dredging and ENR: Same as Alternative A-2. Partial Dredge/Capping: Same as Alternative B-1. Capping: Placement of cap material would cause temporary alteration/destruction of existing habitat, but cap surface would provide clean layer for natural re-colonization by native biota. Capping would cause locally shallower conditions due to cap placement.

Table 5-1
Evaluation of Remedial Alternatives
Focused Feasibility Study for Sediment Cleanup in Howard's Bay
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Criterion [1]	**Site-Wide No Action** [2]	**Alternative A-1:** Sediment Removal in All Subareas	**Alternative A-2:** Sediment Removal in All Subareas, Except for ENR in Units 12B, 15C, 17C, 20 and 25B	**Alternative A-3:** Sediment Removal in All Subareas, Except for MNR in Units 12B, 15C, 17C, 20 and 25B	**Alternative A-4:** Sediment Removal in Refined Subareas, Except for ENR in Units 15D and 25B, and No Action in Units 12B, 13B, 14B, 15B-C, 17B-C, 19A, 20, 22, 25A, 28	**Alternative B-1:** Partial Dredge/Capping at Head of Hughitt and Cummings Avenue Slips and Sediment Removal in All Subareas, Except for ENR in Units 12B, 15C, 17C, 20 and 25B	**Alternative B-2:** Partial Dredge/Capping at Head of Hughitt Avenue Slip and Docking Area, CAD at Head of Cummings Avenue Slip, and Sediment Removal in Refined Subareas, Except for ENR in Units 15D and 25B, and No Action in Units 12B, 13B, 14B, 15B-C, 17B-C, 19A, 20, 22, 25A, 28	**Alternative B-3:** Partial Dredge/Capping at Head of Hughitt and Cummings Avenue Slips, Capping in Docking Area, and Sediment Removal in Refined Subareas, Except for ENR in Units 15D and 25B, and No Action in Units 12B, 13B, 14B, 15B, 17B-C, 19A, 20, 22, 25A, 28
(1.f) Magnitude of residual risks	Unchanged from existing conditions.	Residuals cover placement based on post-removal sampling will be used to address residual exposures that may exceed current surface sediment exposures post-removal due to the limitations of dredging technology. No institutional controls that limit water body uses.	Dredging: Same as Alternative A-1. ENR: Minimal residual risk because attenuation of surface exposures will reduce COC levels further, below levels that already are below the PRGs at the surface. Placement of additional material will reduce potential for future exposures of deeper sediment.	Dredging: Same as Alternative A-1. MNR: Some locations for MNR already have COCs below the PRGs in the upper most sediment layer, with others between the MEC and PEC. Potential for risk if the deeper sediments were exposed in the future.	Dredging: Same as Alternative A-1. ENR and No Action: Higher relative risks because s although PRGs would be met at the surface, sediments would remain above the PRGs in some depth intervals. Potential would remain for long-term re-exposure of COCs in sediments.	Dredging and ENR: same as Alternative A- 2. Partial Dredge/Capping: While existing sediment will remain in place, cap placement will physically isolate contaminated sediments, and sediments will not be disturbed provided institutional controls are employed, maintained and remain effective. Long-term monitoring and maintenance (as needed) will be performed to evaluate and ensure cap performance.	Dredging and ENR: Same as Alternative A-2. Partial Dredge/Capping: Same as Alternative B- 1. CAD: CAD cover and creation of wetlands area will be designed to physically isolate in situ contaminated sediments, and these sediments will not be disturbed in the future. Long-term monitoring and maintenance (as needed) will be needed to ensure long-term CAD performance.	Dredging and ENR: Same as Alternative A-2. Partial Dredge/Capping: Same as Alternative B-1. Capping: Cap placement will physically isolate contaminated sediments. Long-term monitoring and maintenance (as needed) will be performed to evaluate and ensure cap performance.
(1.g) Adequacy and reliability of controls	No remedial action.	Engineering controls on dredging and at the dredged material management locations to minimize release of sediment can be used to adequately minimize redistribution of contaminants. No institutional controls are needed for the areas to be dredged.	Dredging: Same as Alternative A-1. ENR: Monitoring and engineering controls if needed to minimize release of suspended material or wind-blown dust during placement.	Dredging: Same as Alternative A-2. MNR: Institutional controls would be necessary in the shallow water areas to the north to impose restrictions on contact with sediments. These would include future restrictions on dredging in these areas to prevent activities that may disturb sediments containing elevated COC at depth.	Dredging and ENR: Same as Alternative A-2.	Dredging and ENR: same as Alternative A- 2. Partial Dredge/Capping: Partial dredging would be the same as Alternative A-1. The sediment caps may need to be replenished or repaired following large storm events, though the cap can be designed to withstand such events, and cap breakthroughs would be relatively low-risk. Sediment caps have been shown to be reliable at other sites. Institutional controls would be implemented, such as controls to restrict future cap excavation and public advisories to prevent activities that may physically damage the sediment cap (i.e., anchoring).	Dredging and ENR: same as Alternative A-2. Partial Dredge/Capping: Same as Alternative B- 1. CAD: The CAD and wetlands area will be designed to contain the in place and disposed sediment, and will be monitored and maintained in the long term.	Dredging and ENR: same as Alternative A-2. Partial Dredge/Capping: Same as Alternative B-1. Capping: Sediment caps have been shown to be reliable at other sites with engineering (such as armoring where needed and physical features to minimize future disturbance) and institutional controls to prevent activities that may disturb the sediment cap.
2. Ability to achieve RAOs and meet cleanup goals	RAOs not likely to be met within a reasonable timeframe. No monitoring would be conducted to verify if RAOs would be achieved.	Would achieve the RAOs following completion of dredging and attenuation and/or covering of dredging residuals.	Dredging: Same as Alternative A-1. ENR: Existing COC levels in upper most layers of sediment are consistent with PRGs or below PEC. Helps ensure RAOs continue to be met in future.	Dredging: Same as Alternative A-1. MNR: Upper most layer of sediment is consistent with PRGs or below the PEC. Rely on natural recovery to continue to satisfy RAOs over time (as evidenced by upper most sediments in some areas already having COCs below the PRGs).	Dredging and ENR: Same as Alternative A-1. ENR and No Action: Remaining concentrations would be below the PRG at the surface, and on average over sediment column. Rely on enhanced natural recovery in ENR areas and currently low COC concentrations (less than PRG or less than PEC) in No action areas to achieve RAOs and cleanup goals in upper most sediment layers. Deeper layers outside limits of dredging and limited to relatively thin deposits of sediment.	Dredging and ENR: same as Alternative A- 2. Partial Dredge/Capping: Cap placement would achieve the RAOs through isolation of COC-containing sediment. Proper cap maintenance is required.	Dredging and ENR: same as Alternative A-2. Partial Dredge/Capping: Same as Alternative B- 1. CAD: Construction of a CAD and associated cover and wetlands area would achieve the RAOs through isolation of COC-containing materials. CAD monitoring and maintenance is required.	Dredging and ENR: same as Alternative A-2. Partial Dredge/Capping: Same as Alternative B-1. Capping: Would achieve the RAOs through isolation of COC-containing sediment. Cap monitoring and maintenance is required.
3. Evaluation of applicable regulations and permit requirements	No remedial action; therefore, not applicable.	Multiple permits would be required applicable to dredging operation, dredged material staging locations, and disposal. Anticipated that compliance would be met without significant exceptions. Administratively feasible. No significant permitting limitations. Long-term monitoring and maintenance limited to disposal site.	Dredging: Same as Alternative A-1 ENR: Permits would be required for placement of materials on ENR areas. Long-term monitoring may be needed.	Dredging Same as Alternative A-1 MNR: Long-term monitoring and may needed.	Dredging Same as Alternative A-1 ENR: Permits would be required for placement of materials on ENR areas. Long-term monitoring may be needed.	Same as Alternative A-1. Additional permit approvals needed for cap placement. Anticipated that compliance would be met without significant exceptions. Administratively feasible. Long-term OM&M of the cap would be needed, beyond activities that can be completed through the Great Lakes Legacy Act project. Responsibility for long-term OM&M of the cap would need to be identified.	Same as Alternative B-1. Permitting requirements for CAD would be potentially complex, but administratively feasible. Long-term O&M of the CAD, cap and wetlands area would be needed.	Same as Alternative B-1.

Table 5-1
Evaluation of Remedial Alternatives
Focused Feasibility Study for Sediment Cleanup in Howard's Bay
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Criterion [1]	**Site-Wide No Action** [2]	**Alternative A-1:** Sediment Removal in All Subareas	**Alternative A-2:** Sediment Removal in All Subareas, Except for ENR in Units 12B, 15C, 17C, 20 and 25B	**Alternative A-3:** Sediment Removal in All Subareas, Except for MNR in Units 12B, 15C, 17C, 20 and 25B	**Alternative A-4:** Sediment Removal in Refined Subareas, Except for ENR in Units 15D and 25B, and No Action in Units 12B, 13B, 14B, 15B-C, 17B-C, 19A, 20, 22, 25A, 28	**Alternative B-1:** Partial Dredge/Capping at Head of Hughitt and Cummings Avenue Slips and Sediment Removal in All Subareas, Except for ENR in Units 12B, 15C, 17C, 20 and 25B	**Alternative B-2:** Partial Dredge/Capping at Head of Hughitt Avenue Slip and Docking Area, CAD at Head of Cummings Avenue Slip, and Sediment Removal in Refined Subareas, Except for ENR in Units 15D and 25B, and No Action in Units 12B, 13B, 14B, 15B-C, 17B-C, 19A, 20, 22, 25A, 28	**Alternative B-3:** Partial Dredge/Capping at Head of Hughitt and Cummings Avenue Slips, Capping in Docking Area, and Sediment Removal in Refined Subareas, Except for ENR in Units 15D and 25B, and No Action in Units 12B, 13B, 14B, 15B, 17B-C, 19A, 20, 22, 25A, 28
4. Implementability								
(4.a) Availability of services and materials	No remedial action; therefore, not applicable.	Materials and services are readily available and have been used for other similar projects in the area. Suitable disposal sites and staging/material handling areas are available in the area.	Dredging: Same as Alternative A-1. ENR: Materials and services are readily available and have been used for other projects.	Dredging: Same as Alternative A-1. MNR: Monitoring equipment and services are readily available and have been used for other projects.	Dredging and ENR: Same as Alternative A-2.	Dredging and ENR: same as Alternative A- 2. Partial Dredge/Capping: Materials and services are readily available and have been used for other projects.	Dredging and ENR: same as Alternative A-2. Partial Dredge/Capping: Same as Alternative B- 1. CAD and creation of wetlands: Materials and services are available and have been used for other similar projects.	Dredging and ENR: same as Alternative A-2. Partial Dredge/Capping: Same as Alternative B-1. Capping: Materials and services are readily available and have been used for other projects.
(4.b) Technical feasibility (administrative feasibility covered under criterion 3)	No remedial action; therefore, not applicable.	Dredging has been performed in the navigation channel previously, and would be conducted again as part of the USACE strategic navigation dredging project. Clean-up dredging has been practiced at numerous sites and has been proven feasible. May be potential implementation challenges associated with removal along steep side slopes, shallow areas to north of the federal channel, presence of debris, and other obstructions (e.g., bridge piers, sheetpile walls). Remedy effectiveness can be documented through various post-implementation data collection techniques to demonstrate achievement of target dredging elevations and post-removal concentrations. Potential destabilization of shoreline structures in several areas present limitations to extent of dredging near shore (see Appendix L).	Dredge: Same as Alternative A-1. ENR: Will require placement of a thin- layer of material using equipment capable of accessing shallow water areas such as small spreader barges or other appropriate equipment. Thin-layer material placement has been successfully demonstrated at other project sites.	Dredging: Same as Alternative A-1. MNR: No implementation issues as no construction activities. Monitoring activities have been successfully performed previously in the bay.	Dredging and ENR: Same as Alternative A-2, except that technical issues with potential destabilization of structures have been addressed by modifying unit boundaries adjacent to bulkhead, shoreline and bridge pier. (These same considerations could be applied in design phase of any of the alternatives.)	Dredging and ENR: Same as Alternative A- 2. Partial Dredge/Capping: Capping has been successfully performed at other sites. Will require placement of material using equipment capable of accessing shallow water areas.	Dredging and ENR: Same as Alternative A-4. Partial Dredge/Capping: Same as Alternative B- 1. CAD: Technically feasible. An armor layer at the head of the slip would prevent disturbance of the cap in the immediate vicinity of the stormwater outfall if unusually large runoff events occur.	Dredging and ENR: Same as Alternative A-4. Partial Dredge/Capping: Same as Alternative B-1. Capping: Capping has been successfully permitted and performed at other sites.
5. Cost – "Order-of-Magnitude" (-30/+50 uncertainty range)	No remedial action; therefore, no cost.	Highest Cost and Highest Cost Uncertainty due to greater potential to encounter unknown conditions, longest duration of construction and susceptibility to weather and other factors. As with all dredging alternatives, volume estimates and costs will be refined through design, and the design will reduce the cost uncertainty. $15.6MM ($10.9MM / $23.4MM)	High Cost. Similar cost uncertainty factors to A-1, but reduced by smaller scope associated with not conducting removal operations in shallow water to north of channel. Same volume estimation method as A-1. $15.0MM ($10.5MM / $22.5MM)	High Cost; Cost uncertainty relatively lower than A-1 and A-2 due to not trying to access shallow water areas north of channel. Same volume estimation method as A-1. $15.2MM ($10.6MM / $22.8MM)	Moderate Cost. Same volume estimation method as A-1. $12.7MM ($8.9MM / $19.1MM)	Moderate Cost. Reduced potential to encounter unknown conditions during construction and shorter construction timeline reduces implementation cost uncertainty. Same volume estimation method as A-1. $12.9MM ($9.0MM / $19.4MM)	Low Cost Greater use of capping and reduction of disposal costs through construction of CAD lowers cost. Uncertainty factors include potential issues with shallow water habitat development in Cummings Slip. Same volume estimation method as A-1. $10.8MM ($7.6MM / $16.2MM)	Lowest Cost This alternative makes greatest use of capping to lower dredging costs. Same volume estimation method as A-1. $9.2MM ($6.4MM / $13.8MM)

Table 5-1
Evaluation of Remedial Alternatives
Focused Feasibility Study for Sediment Cleanup in Howard's Bay
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<table>
<tr>
<th>Criterion [1]</th>
<th>Site-Wide No Action [2]</th>
<th>Alternative A-1:
Sediment Removal in All Subareas</th>
<th>Alternative A-2:
Sediment Removal in All Subareas, Except for ENR in Units 12B, 15C, 17C, 20 and 25B</th>
<th>Alternative A-3:
Sediment Removal in All Subareas, Except for MNR in Units 12B, 15C, 17C, 20 and 25B</th>
<th>Alternative A-4:
Sediment Removal in Refined Subareas, Except for ENR in Units 15D and 25B, and No Action in Units 12B, 13B, 14B, 15B-C, 17B-C, 19A, 20, 22, 25A, 28</th>
<th>Alternative B-1:
Partial Dredge/Capping at Head of Hughitt and Cummings Avenue Slips and Sediment Removal in All Subareas, Except for ENR in Units 12B, 15C, 17C, 20 and 25B</th>
<th>Alternative B-2:
Partial Dredge/Capping at Head of Hughitt Avenue Slip and Docking Area, CAD at Head of Cummings Avenue Slip, and Sediment Removal in Refined Subareas, Except for ENR in Units 15D and 25B, and No Action in Units 12B, 13B, 14B, 15B-C, 17B-C, 19A, 20, 22, 25A, 28</th>
<th>Alternative B-3:
Partial Dredge/Capping at Head of Hughitt and Cummings Avenue Slips, Capping in Docking Area, and Sediment Removal in Refined Subareas, Except for ENR in Units 15D and 25B, and No Action in Units 12B, 13B, 14B, 15B, 17B-C, 19A, 20, 22, 25A, 28</th>
</tr>
<tr>
<td colspan="9">6. Ability to contribute to removal of BUIs</td>
</tr>
<tr>
<td>(6.a) Fish Consumption Advisories</td>
<td rowspan="4">No remedial action; unchanged from existing conditions.</td>
<td colspan="7" rowspan="2">Potentially supportive of addressing BUI</td>
</tr>
<tr>
<td>(6.b) Fish Tumors and Deformities</td>
</tr>
<tr>
<td>(6.c) Degradation of Benthos</td>
<td colspan="7">Temporary degradation of benthos due to elimination of benthic habitat as a result of dredging, thin-layer sand cover, or cap placement. Long-term recolonization post-removal, thin-layer sand cover, or cap placement, or due to ongoing natural recovery is likely to contribute to improved benthic community health.</td>
</tr>
<tr>
<td>(6.d) Restrictions on Dredging</td>
<td colspan="7">Supportive of addressing BUI.</td>
</tr>
<tr>
<td>(6.e) Loss of Fish and Wildlife Habitat</td>
<td>No remedial action; unchanged from existing conditions.</td>
<td colspan="5">Generally supportive of addressing BUI to the extent that cleanup work may ultimately lead to better quality habitat.</td>
<td>Same as other alternatives, with additional benefit of shallow water habitat creation in CAD area.</td>
<td>Same as Alternatives A-1, A-2, A-3, A-4, B-1.</td>
</tr>
</table>

Notes:
[1] State and public acceptance criterion has not been included in this table because this criterion will be satisfied once the Partners agree on selected alternative prior to remedial design.
[2] Site-wide No Action is typically carried as a point of comparison for active remedies.

BMP = Best management practices BOD = Basis of Design Document
BUIs = Beneficial Use Impairments
CAD = confined aquatic disposal
COC = contaminant of concern
ENR = Enhanced Natural Recovery
HASP = Health & Safety Plan
MEC = midpoint effect concentration
MNR = Monitored Natural Recovery
O&M = Operation & Maintenance
PEC = probable effect concentration
PPE = personal protection equipment
PRG = preliminary remedial goal RAOs = remedial action objectives

Table 5-2
Comparative Analysis of Remedial Alternatives
Focused Feasibility Study for Sediment Cleanup in Howard's Bay
Superior, WI

Criterion [1]	No Action Site-Wide [2]	Alternative A-1 Sediment Removal in All Subareas	Alternative A-2 Sediment Removal in All Subareas, Except for ENR in Units 12B, 15C, 17C, 20 and 25B	Alternative A-3 Sediment Removal in All Subareas, Except for MNR in Units 12B, 15C, 17C, 20 and 25B	Alternative A-4 Sediment Removal in Refined Subareas, Except for ENR in Units 15D and 25B, and No Action in Units 12B, 13B, 14B, 15B-C, 17B-C, 19A, 20, 22, 25A, 28	Alternative B-1 Partial Dredge/Capping at Head of Hughitt and Cummings Avenue Slips and Sediment Removal in All Subareas, Except for ENR in Units 12B, 15C, 17C, 20 and 25B	Alternative B-2 Partial Dredge/Capping at Head of Hughitt Avenue Slip and Docking Area, CAD at Head of Cummings Avenue Slip, and Sediment Removal in Refined Subareas, Except for ENR in Units 15D and 25B, and No Action in Units 12B, 13B, 14B, 15B-C, 17B-C, 19A, 20, 22, 25A, 28	Alternative B-3 Partial Dredge/Capping at Head of Hughitt and Cummings Avenue Slips and Docking Area, and Sediment Removal in Refined Subareas, Except for ENR in Units 15D and 25B, and No Action in Units 12B, 13B, 14B, 15B-C, 17B-C, 19A, 20, 22, 25A, 28	Comments
(1.a) Overall protection of human health and the environment	1.0	5.0	4.5	4.0	4.5	4.0	3.0	3.5	Alternative A-1 has highest long-term effectiveness by greatest reduction in COC mass and sediment volume. Alternative B-2 scores the lowest because of dredged material remaining in the in-water CAD.
(1.b) Time to implement	n/a	2.5	2.5	2.5	3.0	3.0	3.0	4.0	Implementation could be achieved within the same time period as the overall dredging project over all alternatives. A-1 is projected to span two construction seasons, which is the reason for the starting scoring of 2.5. B-3 was scored the highest at 4.0 because it has the lowest removal volume, and could likely be completed in one season. It was not scored a 5.0 because of potential for delays to push it into a second season.
(1.c) Protection of workers during remedial action	n/a	3.5	3.5	3.5	4.0	4.0	4.0	4.5	Cleanup sediment dredging and capping projects are routinely implemented and the COCs at this site are less of a concern for human health from exposure to ambient air concentrations or direct contact. Adequate controls would be in place to ensure worker safety during remedial activities. The relative scoring acknowledges that all alternatives would be protective of health of workers, but the dredging alternatives involve more potential for exposure than capping alternatives. Of the capping alternatives, Alternative B-2 involves the additional step of handling dredged material at the CAD and thus is scored slightly lower than Alternative B-3, although the scope of Alternative B-3 is otherwise similar.
(1.d) Protection of community during remedial action	n/a	4.0	4.0	4.0	4.0	4.0	4.5	4.5	Truck and marine vessel traffic and noise will increase as a part of all alternatives. However, the site is located in heavily industrial area were heavy marine vessel traffic is common. Marine vessels (barges, scows, and tugs) associated with this project will likely impact commercial and industrial vessel traffic more so than recreational traffic. As exemplified by the sediment sampling in 2013 in Howards Bay, ship coordination and awareness can be resolved with proper coordination and planning. As far as truck traffic impacts, this will largely depend on the disposal and quarry locations. The SND and beneficial reuse material are slotted for transport to the Erie Pier by water and will not increase truck traffic substantially, other that from Erie Pier, which is common. Material slotted for Wisconsin Point Landfill or VONCO V Landfill will have associated truck traffic, but have almost immediate access to Hwy 53 and Interstate 535 which lessens the impacts to the community. Additionally, truck traffic associated with disposal volumes are not substantially different among alternatives and are offset somewhat by capping and cover volumes. Finally, the sediment processing location is planned to occur on Fraser's private property, a substantial distance from residential areas. In total, community impacts as a part of this project are low relative to typical cleanup sediment projects in urban and industrial harbors.
(1.e) Short-term environmental impacts of remedial action	n/a	3.0	3.0	3.0	3.5	3.5	4.0	4.0	All alternatives will temporarily alter and disturb benthic habitat. All alternatives will temporarily impact the water column resulting in sediment re-suspension, alteration/destruction of existing habitat in the sediment areas, especially in shallow areas to the north where water depths limit access. Monitoring, engineering controls and/or BMPs will be used to mitigate these impacts. Naturally deposited sediments will provide a surface habitat layer to eventually facilitate natural re-colonization by native biota. All alternatives will result in a reduction in surface concentrations of COCs. However, Alternatives B-3 and B-2 were scored slightly higher followed by A-4 and B-1 due to lower removal volumes resulting in less sediment re-suspension and potential for redistribution of contamination, and also a shorter construction period of water quality disturbances.
(1.f) Magnitude of residual risks and (1.g) Adequacy and reliability of controls	n/a	4.5	4.0	4.0	4.0	3.5	3.0	3.5	Removal areas will have a residuals cover placed based on post-removal sampling to address residual exposures. No institutional controls are needed for the areas to be dredged. Engineering controls on dredging and at the dredged material management locations to minimize release of sediment can be used to adequately minimize redistribution of contaminants. Cap placement would physically isolate contaminated sediments. Long-term monitoring and maintenance (as needed) would be performed to evaluate and ensure cap performance. Sediment caps have been shown to be reliable at other sites with engineering (such as armoring where needed and physical features to minimize future disturbance) and institutional controls to prevent activities that may disturb the sediment cap. Alternative A-1 was scored the highest based on largest extent of remediation. Alternative B-2 was scored lowest of the capping alternatives due to additional controls needed for CAD.
(4.a) Availability of services and materials	n/a	5.0	5.0	5.0	5.0	5.0	5.0	5.0	Materials and services are readily available and have been used for other similar projects. This is not a distinguishable variable among alternatives.
(4.b) Technical feasibility	1.0	4.0	4.0	4.0	4.5	3.5	2.5	3.5	Boundaries of Alternatives A-4, B-2 and B-3 require less construction activities in shallow areas, and exclude setbacks to address wall and embankment stability issues and are thus scored relatively higher for implementability. Except for A-1, all alternatives do not require dredging in shallow areas to the north of the federal channel and require less space to dispose of dredged material. Alternative A-1 includes proposed dredging in areas where core samples could not be collected due to shallow refusal, and also potentially includes dredging in close proximity or immediately adjacent to dock and shoreline structures. Due to shallow water access, shoreline structural issues, and the larger scope of Alternative A-1 it is scored lower on implementability. A-4 is scored slightly higher because it reduces these potential challenges of A-1. Limited engineering evaluation and testing has been done for cap design in the dock area and other areas, and would be needed prior to design, so the capping alternatives are therefore scored lower than dredging. Limited FFS analysis on constructability issues for CAD approach in Alternative B-2 has been done, therefore because of uncertainties, it is scored lower on implementability.

Table 5-2
Comparative Analysis of Remedial Alternatives
Focused Feasibility Study for Sediment Cleanup in Howard's Bay
Superior, WI

Criterion [1]	No Action Site-Wide [2]	Alternative A-1 Sediment Removal in All Subareas	Alternative A-2 Sediment Removal in All Subareas, Except for ENR in Units 12B, 15C, 17C, 20 and 25B	Alternative A-3 Sediment Removal in All Subareas, Except for MNR in Units 12B, 15C, 17C, 20 and 25B	Alternative A-4 Sediment Removal in Refined Subareas, Except for ENR in Units 15D and 25B, and No Action in Units 12B, 13B, 14B, 15B-C, 17B-C, 19A, 20, 22, 25A, 28	Alternative B-1 Partial Dredge/Capping at Head of Hughitt and Cummings Avenue Slips and Sediment Removal in All Subareas, Except for ENR in Units 12B, 15C, 17C, 20 and 25B	Alternative B-2 Partial Dredge/Capping at Head of Hughitt Avenue Slip and Docking Area, CAD at Head of Cummings Avenue Slip, and Sediment Removal in Refined Subareas, Except for ENR in Units 15D and 25B, and No Action in Units 12B, 13B, 14B, 15B-C, 17B-C, 19A, 20, 22, 25A, 28	Alternative B-3 Partial Dredge/Capping at Head of Hughitt and Cummings Avenue Slips and Docking Area, and Sediment Removal in Refined Subareas, Except for ENR in Units 15D and 25B, and No Action in Units 12B, 13B, 14B, 15B-C, 17B-C, 19A, 20, 22, 25A, 28	Comments
5. Cost	n/a	2.0	2.0	2.0	3.0	3.0	4.0	4.5	Dredging activities have cost uncertainties associated with potential to encounter unforeseen issues, and expansion of potential dredge volumes because of limitations on the existing data set. The larger and longer the project, the greater the magnitude of cost uncertainty related to these issues. Therefore Alternative A-1, which has largest footprint, is scored lowest on cost because of its largest cost and largest cost uncertainty. Alternative B-3 has the lowest dredging volume and due to lower relative complexity of implementing capping, it is scored highest. The capping alternatives are lower cost, but have cost uncertainty associated with future monitoring and maintenance needs. Due to complexities with CAD construction, the capping alternatives are scored lower than Alternative B-3. Because Alternative B-2 has similar level of dredging as B-1, it was scored similar to B-3.
6. Ability to contribute to removal of BUIs	n/a	4.5	4.0	4.0	4.0	3.0	3.0	2.0	All alternatives are generally supportive of addressing BUIs to the extent that they all reduce potential for exposure. However, some residual concentration will remain. The capping alternatives leave sediment in place that present limitations on future dredging in these areas, and are thus scored lower than dredging. None of the alternatives are scored 5.0 because of uncertainty in how the sediment impairments relate to the various listed BUIs for the St. Louis River Area of Concern. Alternative A-1 was scored the highest because it presents the lowest limitation to future dredging considerations in Howard's Bay.
7. State Acceptance	1.0	5.0	4.0	4.0	4.5	3.0	2.5	2.0	Alternative A-1 is the most preferable by the state while no action site-wide is not acceptable by the state. Alternative B-3 is not supported by the State due to concerns about capping the volume of impacted sediment and the highest concentrations of lead in sediments in the dock area and future maintenance and monitoring concerns.
Total Scoring	**3**	**43**	**41**	**40**	**44**	**40**	**39**	**41**	(Sum of all individual scores above)
Total Scoring Value (excluding cost)	**3**	**41**	**39**	**38**	**41**	**37**	**35**	**37**	(Sum of all individual scores above except for cost)
Estimated Cost Amount ($MM)	$0.0	$15.6	$15.0	$15.2	$12.7	$12.9	$10.8	$9.2	See Cost Estimates in Appendix M

Notes:
[1] State and public acceptance criterion has not been included in this table because this criterion will be satisfied once the Partners agree on selected alternative prior to remedial design, and provide an opportunity for public comment at a public meetinç
[2] Site-wide No Action is typically carried as a point of comparison for active remedies.

BUIs = Beneficial Use Impairments
CAD = confined aquatic disposal
COC = contaminant of concern
ENR = Enhanced Natural Recovery
MNR = Monitored Natural Recovery
RAOs = remedial action objectives
SND = strategic navigation dredging

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Figures

REFERENCE: BASE MAP USGS 7.5 MIN. QUADS., SUPERIOR, WI-MN, 2013 AND DULUTH, MN, 2013.

2000' 0 2000'

Approximate Scale: 1" = 2000'

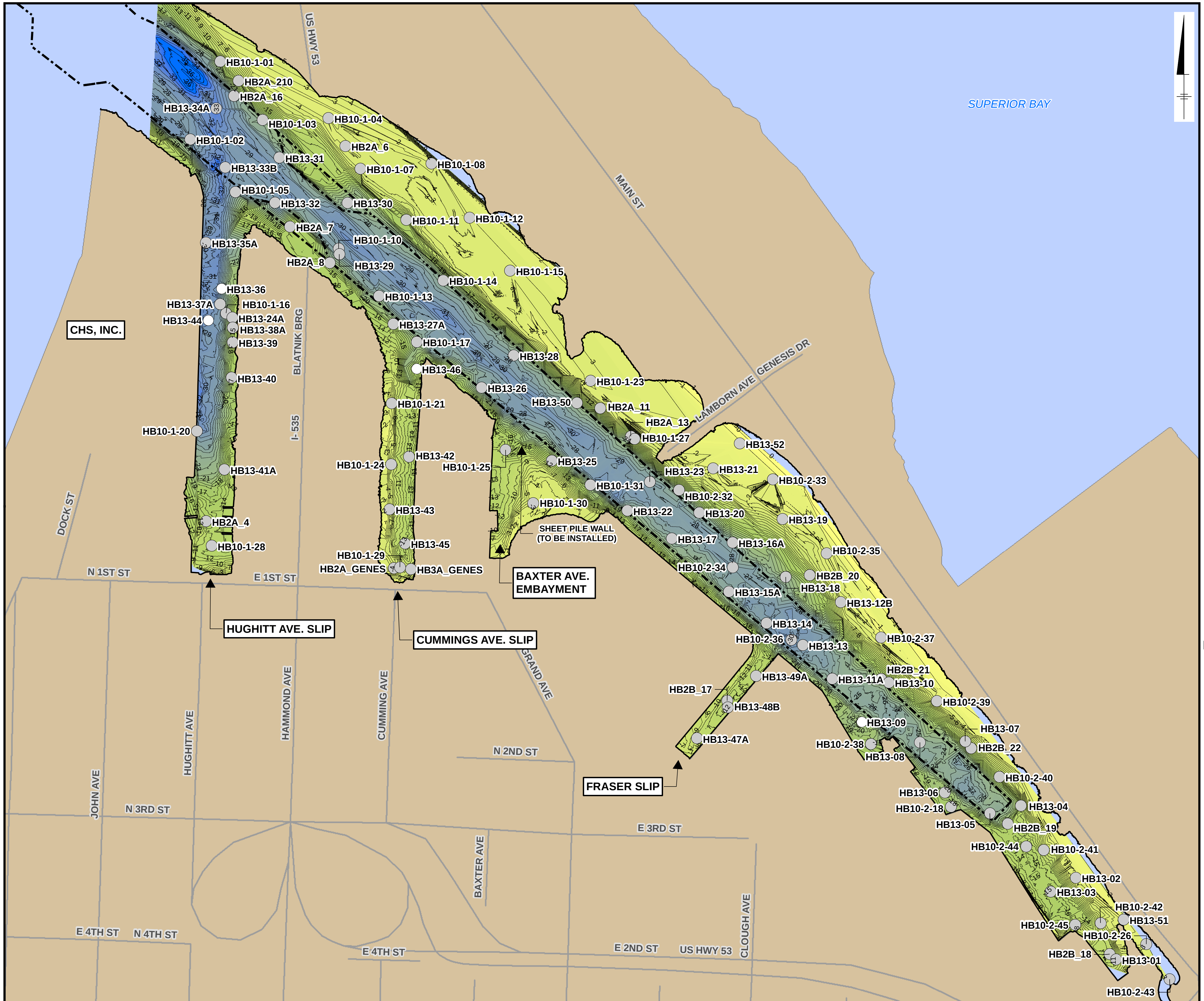
HOWARD'S BAY
SUPERIOR, WISCONSIN
FOCUSED FEASIBILITY STUDY FOR SEDIMENT CLEANUP IN HOWARD'S BAY

SITE LOCATION MAP

ARCADIS

FIGURE
1-1

01/30/2015 SYRACUSE, DIV/GROUP: ENV/IM-DV DJHOWES
CI001796/0002/00003/CDR/01796N01.CDR



LEGEND:

- 2007, 2010, OR 2013 SEDIMENT SAMPLE LOCATION
- 2013 CORE LOCATION WITH NO RECOVERY
- FEDERAL CHANNEL
- SHORELINE (APPROXIMATE)
- ROADS
- WATER DEPTH CONTOUR (1-FOOT INTERVALS)

DEPTH (IGLD 85)

0
-2
-7
-12
-17
-22
-27
-32
-37

0 400 800 Feet

GRAPHIC SCALE

NOTES:

1. SAMPLE INFORMATION FROM DATABASES PROVIDED BY WNDR ON MAY 23, 2013.
2. CHANNEL BOUNDARY AND BATHYMETRY PROVIDED BY THE US ARMY CORPS OF ENGINEERS - DETROIT DISTRICT http://www.lre.usace.army.mil
3. ALL SOUNDINGS REFERENCED TO LOW WATER DATUM ELEVATION of 601.1 (IGLD1985).
4. BATHYMETRIC CONTOURS DEVELOPED BY ARCADIS BASED ON SURVEY CONDUCTED BY USACE IN SEPTEMBER 2013.
5. CORE INFORMATION USED TO SUPPLEMENT SURVEY.

HOWARD'S BAY
SUPERIOR, WISCONSIN

FOCUSED FEASIBILITY STUDY FOR SEDIMENT CLEANUP IN HOWARD'S BAY

2013 WATER DEPTH MAP OF HOWARD'S BAY

ARCADIS

FIGURE **1-2**

City: SYR Div/Group: SWG Created By: J.RAPP Last Saved By: kives
FRASER SHIPYARD (CI001796.0001.0003)
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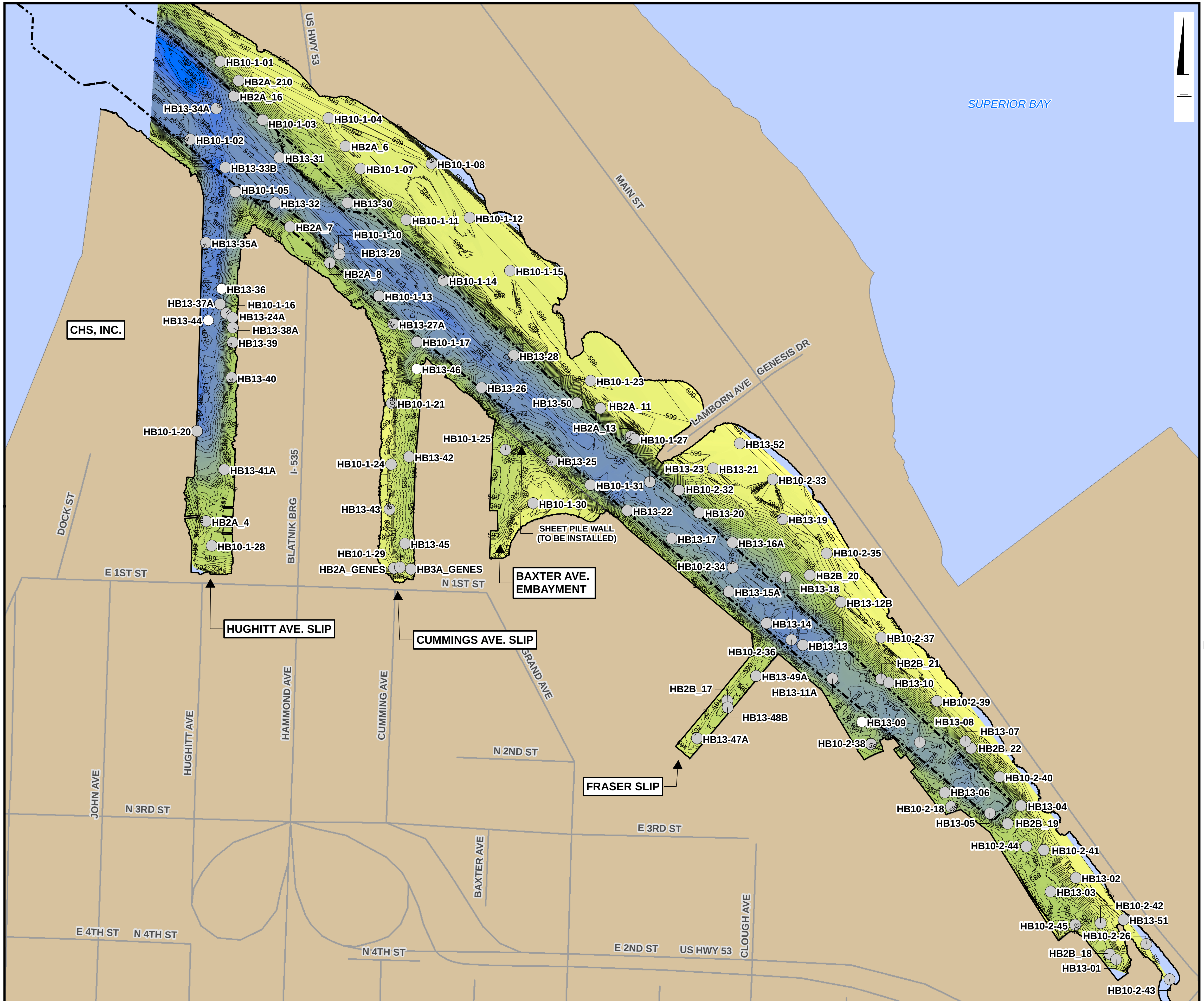


LEGEND:

- 2007, 2010, OR 2013 SEDIMENT SAMPLE LOCATION
- 2013 CORE LOCATION WITH NO RECOVERY
- FEDERAL CHANNEL
- SHORELINE (APPROXIMATE)
- ROADS
- BATHYMETRY CONTOUR (1-FOOT CONTOURS)

ELEVATION (IGLD 85)

601.8
599
594
589
584
579
574
569
564

0 400 800 Feet

GRAPHIC SCALE

NOTES:

1. SAMPLE INFORMATION FROM DATABASES PROVIDED BY WNDR ON MAY 23, 2013.
2. CHANNEL BOUNDARY AND BATHYMETRY PROVIDED BY THE US ARMY CORPS OF ENGINEERS - DETROIT DISTRICT http://www.lre.usace.army.mil
3. ALL SOUNDINGS REFERENCED TO LOW WATER DATUM ELEVATION of 601.1 (IGLD1985).
4. BATHYMETRIC CONTOURS DEVELOPED BY ARCADIS BASED ON SURVEY CONDUCTED BY USACE IN SEPTEMBER 2013.
5. CORE INFORMATION USED TO SUPPLEMENT SURVEY.

HOWARD'S BAY
SUPERIOR, WISCONSIN

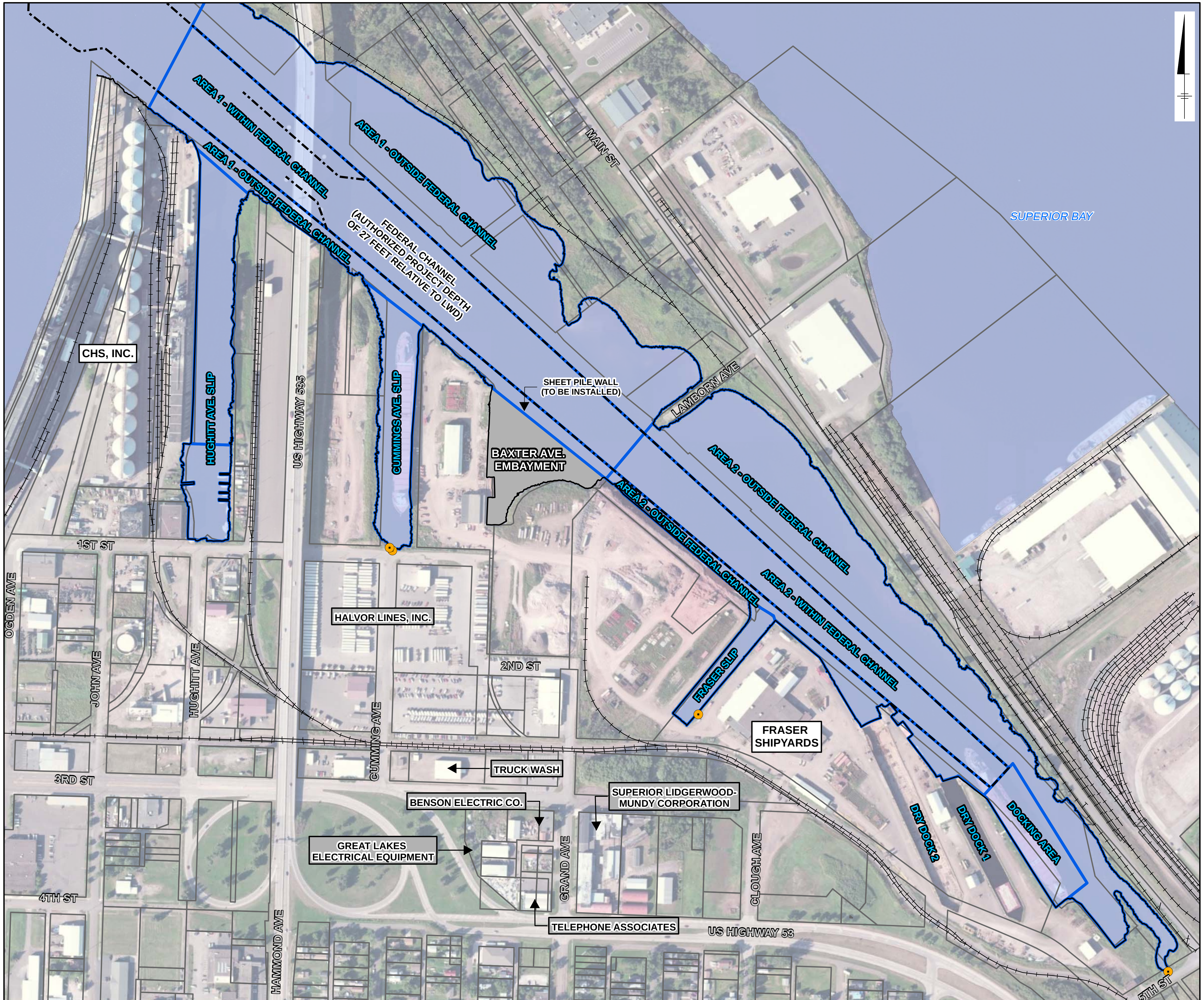
FOCUSED FEASIBILITY STUDY FOR SEDIMENT CLEANUP IN HOWARD'S BAY

2013 BATHYMETRIC MAP OF HOWARD'S BAY

ARCADIS

FIGURE **1-3**

City: SYR Div/Group: SWG Created By: J.RAPP Last Saved By: kives
FRASER SHIPYARD (CI001796.0001.0003)
Q:\FraserShipyard\SuperiorWI\FocusedFeasibilityStudy2015\mxd\SiteBathymetry2013_Elevations.mxd 2/2/2015 4:24:41 PM



SITE LOCATION

LEGEND:

- STORMWATER OUTFALL
- SHORELINE (APPROXIMATE)
- RAILROAD
- FEDERAL CHANNEL
- PARCEL BOUNDARY
- HOWARD'S BAY AREA
- BAXTER AVE EMBAYMENT

0 400 800 Feet

GRAPHIC SCALE

NOTES:

1. JULY 6, 2011 IMAGERY PROVIDED BY ESRI IMAGE SERVICE.
2. PARCELS, RAILROADS, AND OUTFALLS OBTAINED FROM http://www.ci.superior.wi.us/
3. CHANNEL BOUNDARY AND BATHYMETRY PROVIDED BY THE US ARMY CORPS OF ENGINEERS - DETROIT DISTRICT http://www.lre.usace.army.mil
4. LWD = LOW WATER DATUM OF 601.1 FEET (IGLD 85)

HOWARD'S BAY
SUPERIOR, WISCONSIN

FOCUSED FEASIBILITY STUDY FOR SEDIMENT CLEANUP IN HOWARD'S BAY

SITE SUBAREAS

ARCADIS

FIGURE **1-4**

City: SYR Div/Group: SWG Created By: J.RAPP Last Saved By: kives
FRASER SHIPYARD (CI001796.0001.0003)
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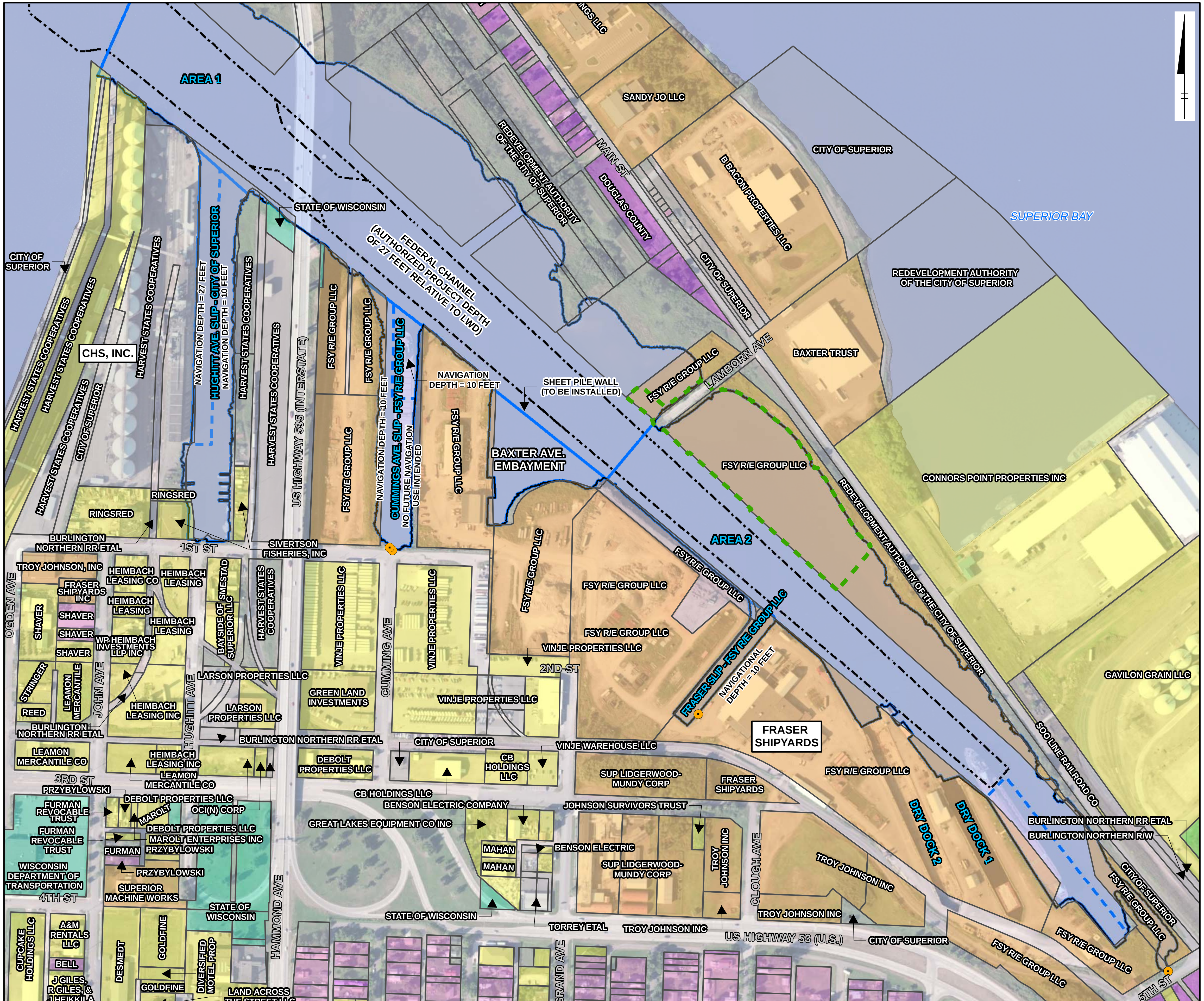

LEGEND:

- STORMWATER OUTFALL
- SHORELINE (APPROXIMATE)
- FEDERAL CHANNEL
- HOWARD'S BAY AREA
- FUTURE SHIPYARD DOCK SPACE AREA
- PARCEL BOUNDARY

LANDCLASS

- RESIDENTIAL
- COMMERCIAL/MANUFACTURING
- COMMERCIAL
- MANUFACTURING
- FEDERAL
- COUNTY
- OTHER/UNKNOWN
- POTENTIAL FUTURE SHIPYARD USE AREA

0 400 800 Feet

GRAPHIC SCALE

NOTES:

1. JULY 6, 2011 IMAGERY PROVIDED BY ESRI IMAGE SERVICE.
2. PARCELS, OUTFALLS, AND LAND CLASSES OBTAINED FROM http://www.ci.superior.wi.us/
3. CHANNEL BOUNDARY PROVIDED BY THE US ARMY CORPS OF ENGINEERS - DETROIT DISTRICT http://www.lre.usace.army.mil
4. LWD = LOW WATER DATUM OF 601.1 FEET (IGLD 85)

HOWARD'S BAY
SUPERIOR, WISCONSIN

FOCUSED FEASIBILITY STUDY FOR SEDIMENT CLEANUP IN HOWARD'S BAY

SITE USE AREAS AND PARCEL OWNERSHIP

ARCADIS

FIGURE **1-5**

City: SYR Div/Group: SWG Created By: J.RAPP Last Saved By: kives
FRASER SHIPYARD (CI001796.0001.0003)
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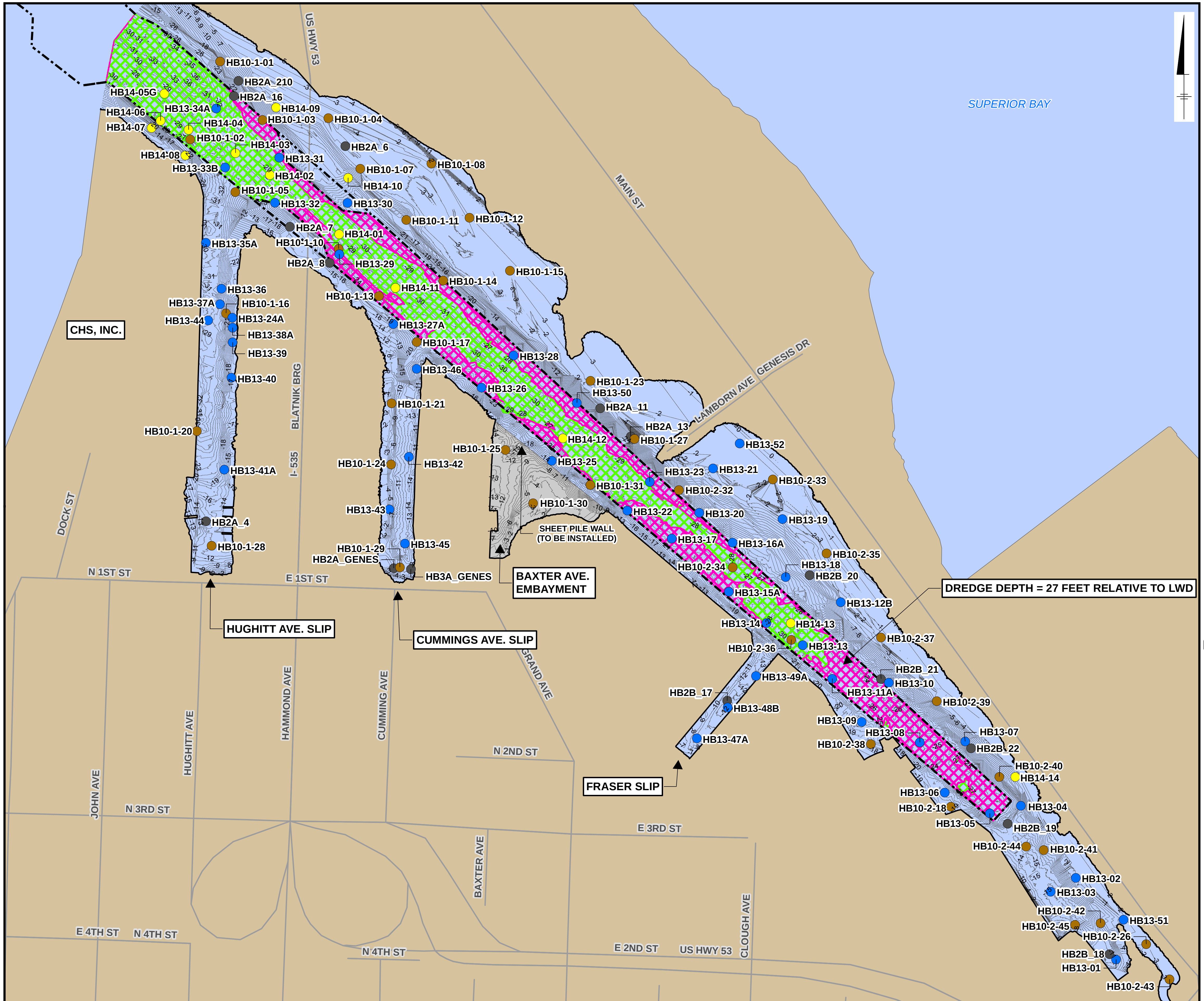

LEGEND:

- 2007 SEDIMENT SAMPLE LOCATION
- 2010 SEDIMENT SAMPLE LOCATION
- 2013 SEDIMENT SAMPLE LOCATION
- 2014 SEDIMENT SAMPLE LOCATION
- FEDERAL CHANNEL
- SHORELINE (APPROXIMATE)
- ROADS
- BATHYMETRY CONTOUR
- BAXTER AVE EMBAYMENT
- AREA WITHIN FEDERAL CHANNEL WITH WATER DEPTH ≥ 27 FEET RELATIVE TO LWD BASED ON 2013 SURVEY
- AREA WITHIN FEDERAL CHANNEL WITH SHOALING ABOVE 27 FEET RELATIVE TO LWD BASED ON 2013 SURVEY

0 400 800 Feet

GRAPHIC SCALE

NOTES:

1. SAMPLE INFORMATION FROM DATABASES PROVIDED BY WNDR ON MAY 23, 2013 AND FROM THE HOWARD'S BAY 2014 SEDIMENT SAMPLING REPORT (WDNR, 2014)
2. CHANNEL BOUNDARY AND BATHYMETRY PROVIDED BY THE US ARMY CORPS OF ENGINEERS - DETROIT DISTRICT http://www.lre.usace.army.mil
3. ALL SOUNDINGS REFERENCED TO LOW WATER DATUM ELEVATION of 601.1 (IGLD1985).
4. LWD = LOW WATER DATUM OF 601.1 FEET (IGLD 85)

HOWARD'S BAY
SUPERIOR, WISCONSIN

FOCUSED FEASIBILITY STUDY FOR SEDIMENT CLEANUP IN HOWARD'S BAY

HOWARD'S BAY 2013 SHOAL AREAS AND AVAILABLE SEDIMENT SAMPLES

ARCADIS

FIGURE **1-6**

City: SYR Div/Group: SWG Created By: J.RAPP Last Saved By: kives
FRASER SHIPYARD (CI001796.0001.0003)
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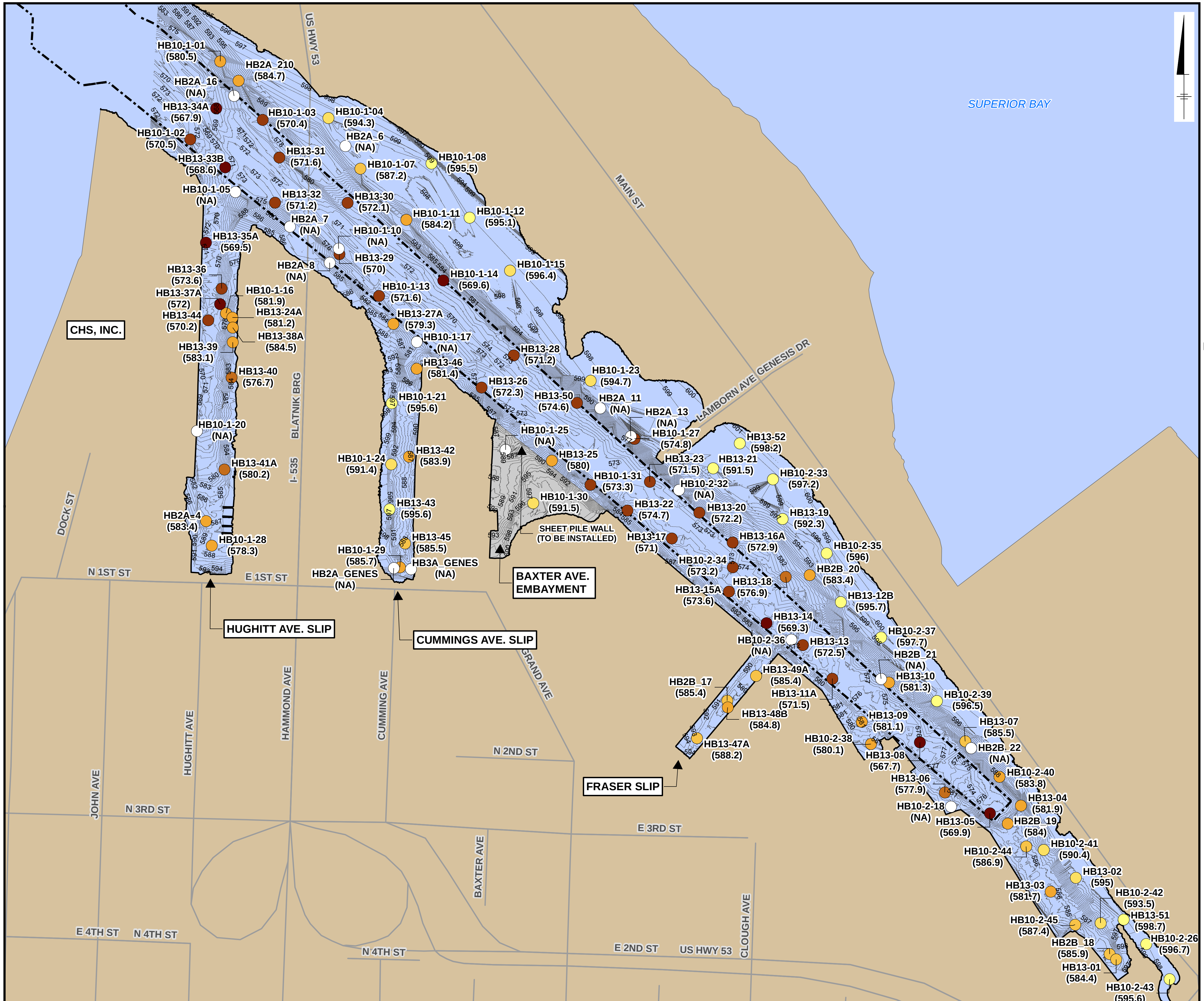

LEGEND

TOP OF CLAY ELEVATION (IGLD 85)

- NOT AVAILABLE
- > 595
- 590 - 595
- 585 - 590
- 580 - 585
- 575 - 580
- 570 - 575
- ≤ 570.0
- FEDERAL CHANNEL
- SHORELINE (APPROXIMATE)
- BATHYMETRY CONTOUR (1-FOOT CONTOURS)

HB13-33B SAMPLE ID
(576.4) TOP OF CLAY ELEVATION (IGLD 85)

(NA) NOT AVAILABLE

0 400 800 Feet

GRAPHIC SCALE

NOTES:

1. SAMPLE INFORMATION FROM DATABASES PROVIDED BY WNDR ON MAY 23, 2013.
2. CHANNEL BOUNDARY AND BATHYMETRY PROVIDED BY THE US ARMY CORPS OF ENGINEERS - DETROIT DISTRICT HTTP://WWW.LRE.USACE.ARMY.MIL
3. TOP OF CLAY ELEVATION IDENTIFIED BASED ON TOP OF SEDIMENT ELEVATION AND CORE LOGS. FOR CORES THAT DID NOT EXTEND TO NATIVE CLAY, LENGTH OF SEDIMENT RECOVERED IN CORE TUBES WAS USED. SURFACE GRAB SAMPLES WERE NOT USED TO IDENTIFY TOP OF CLAY ELEVATION.
4. BATHYMETRIC CONTOURS DEVELOPED BY ARCADIS BASED ON SURVEY CONDUCTED BY USACE IN SEPTEMBER 2013.

HOWARD'S BAY
SUPERIOR, WISCONSIN
FOCUSED FEASIBILITY STUDY FOR SEDIMENT CLEANUP IN HOWARD'S BAY

ESTIMATED TOP OF CLAY / BOTTOM OF SOFT SEDIMENT ELEVATION

ARCADIS

FIGURE **1-7**

City: SYR Div/Group: SWG Created By: J.RAPP Last Saved By: kives
FRASER SHIPYARD (CI001796.0001.0003)
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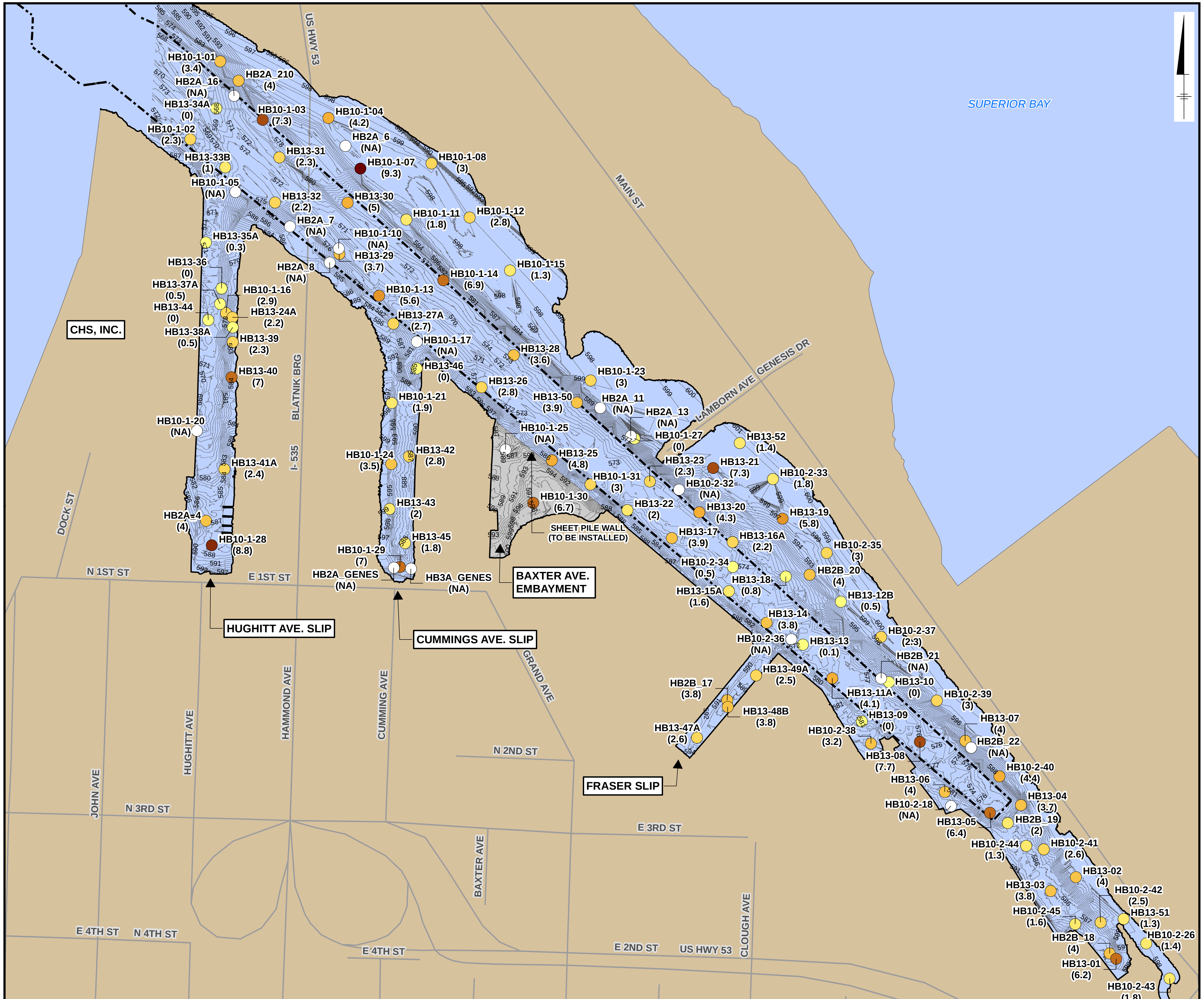

LEGEND:

SEDIMENT THICKNESS (FEET)

- NOT AVAILABLE
- < 1
- 1.0 - 2.0
- 2.1 - 3.0
- 3.1 - 4.0
- 4.1 - 5.0
- 5.1 - 6.0
- 6.1 - 7.0
- 7.1 - 8.0
- 8.1 - 9.0
- > 9.0
- FEDERAL CHANNEL
- ROADS
- SHORELINE (APPROXIMATE)
- BATHYMETRY ELEVATIONS (1-FOOT CONTOURS)

HB13-19 SAMPLE ID
(2.2) SEDIMENT THICKNESS (FEET)

(NA) NOT AVAILABLE

0 400 800 Feet

GRAPHIC SCALE

NOTES:

1. SAMPLE INFORMATION FROM DATABASES PROVIDED BY WNDR ON MAY 23, 2013.
2. CHANNEL BOUNDARY AND 2013 BATHYMETRY PROVIDED BY THE US ARMY CORPS OF ENGINEERS - DETROIT DISTRICT HTTP://WWW.LRE.USACE.ARMY.MIL
3. SEDIMENT THICKNESS WAS IDENTIFIED BASED ON TOTAL THICKNESS FROM SEDIMENT SURFACE TO DEPTH TO NATIVE CLAY. FOR CORES THAT DID NOT EXTEND TO NATIVE CLAY, LENGTH OF SEDIMENT RECOVERED IN CORE TUBES WAS USED. SURFACE GRAB SAMPLES WERE NOT USED TO ESTIMATE SEDIMENT THICKNESS.

HOWARD'S BAY
SUPERIOR, WISCONSIN

FOCUSED FEASIBILITY STUDY FOR SEDIMENT CLEANUP IN HOWARD'S BAY

ESTIMATED SEDIMENT THICKNESS DISTRIBUTIONS IN HOWARD'S BAY

ARCADIS

FIGURE **1-8**

City: SYR Div/Group: SWG Created By: J.RAPP Last Saved By: kives
FRASER SHIPYARD (CI001796.0001.0003)
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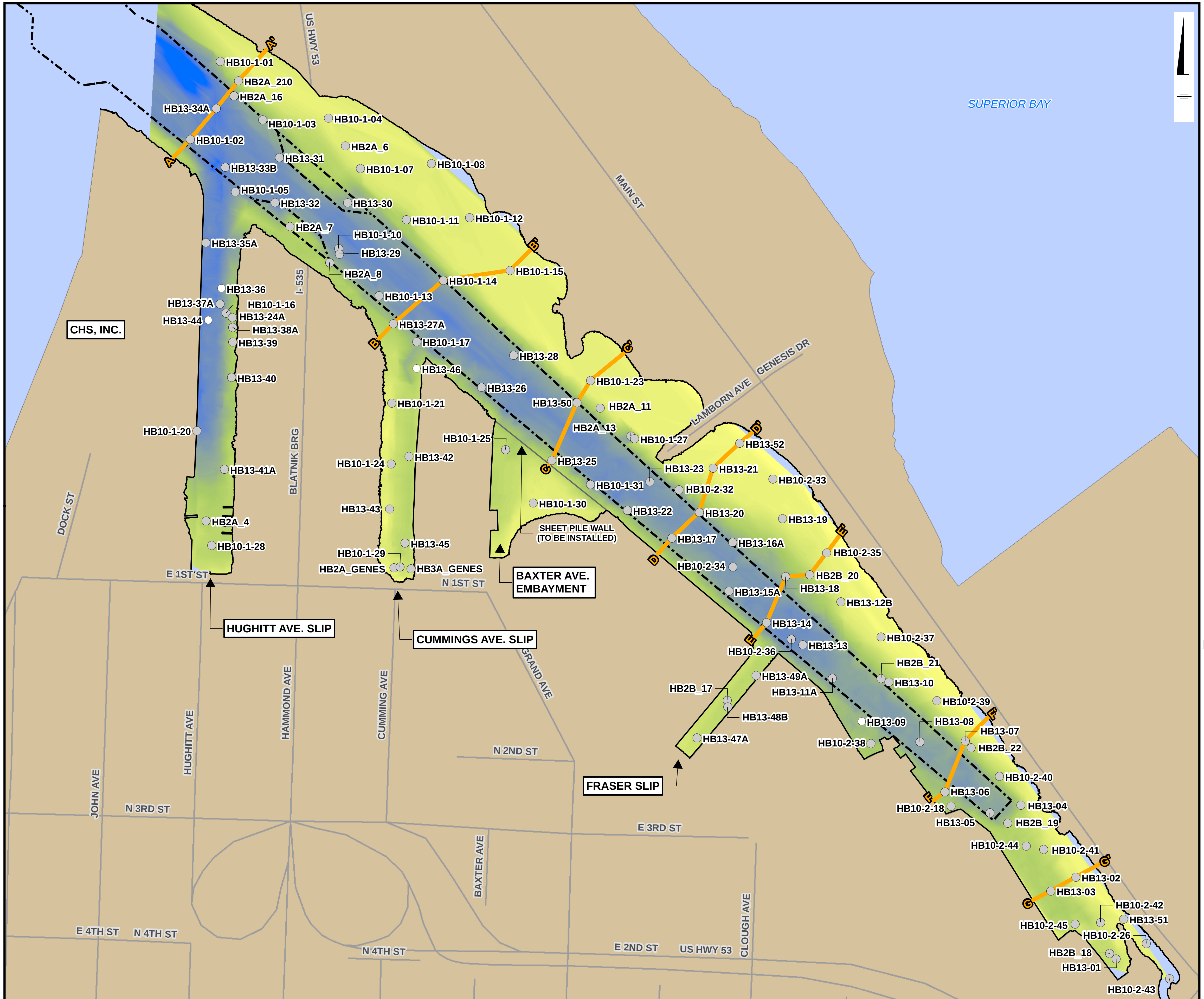


LEGEND:

- 2007, 2010, OR 2013 SEDIMENT SAMPLE LOCATION
- 2013 CORE LOCATION WITH NO RECOVERY
- CROSS SECTION LOCATION
- FEDERAL CHANNEL
- SHORELINE (APPROXIMATE)
- ROADS

ELEVATION (IGLD 85)

601.8
599
594
589
584
579
574
569
564

0 400 800 Feet

GRAPHIC SCALE

NOTES:

1. SAMPLE INFORMATION FROM DATABASES PROVIDED BY WNDR ON MAY 23, 2013.
2. CHANNEL BOUNDARY AND BATHYMETRY PROVIDED BY THE US ARMY CORPS OF ENGINEERS - DETROIT DISTRICT http://www.lre.usace.army.mil
3. ALL SOUNDINGS REFERENCED TO LOW WATER DATUM ELEVATION of 601.1 (IGLD1985).
4. BATHYMETRIC CONTOURS DEVELOPED BY ARCADIS BASED ON SURVEY CONDUCTED BY USACE IN SEPTEMBER 2013.
5. CORE INFORMATION USED TO SUPPLEMENT SURVEY.

HOWARD'S BAY
SUPERIOR, WISCONSIN

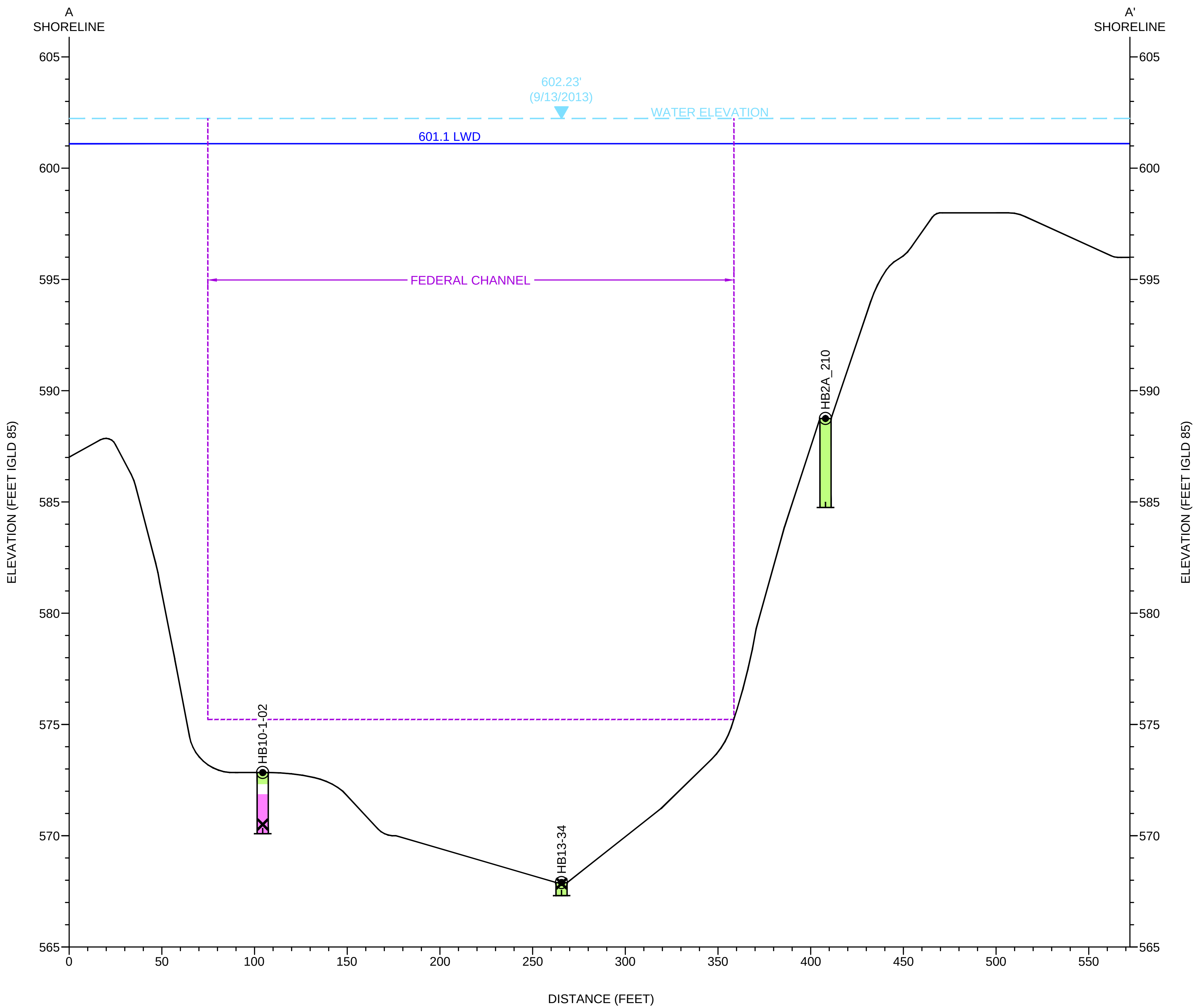
FOCUSED FEASIBILITY STUDY FOR SEDIMENT CLEANUP IN HOWARD'S BAY

CROSS SECTION LOCATIONS OF HOWARD'S BAY

ARCADIS

FIGURE **1-9**

City: SYR Div/Group: SWG Created By: J.RAPP Last Saved By: kives
FRASER SHIPYARD (CI001796.0001.0003)
Q:\FraserShipyard\SuperiorWI\FocusedFeasibilityStudy2015\mxd\SiteBathymetry2013_Elevations_CrossSection.mxd 2/2/2015 4:55:08 PM



LEGEND:

- SEDIMENT SURFACE (2013 BATHYMETRIC CONTOURS
- SEDIMENT SURFACE ELEVATION AT CORING LOCATION
- NATIVE CLAY ELEVATION AT CORING LOCATION
- BOTTOM OF SEDIMENT CORE
- LWD LOW WATER DATUM OF 601.1 (IGLD 85)

LEAD, TRIBUTYLTIN, TOTAL PAHs, AND/OR MERCURY EXCEEDANCES:

- NO SAMPLE ANALYZED
- NON-DETECT OR SMALLER OR EQUAL TO MEC
- >PEC

NOTES:

1. SAMPLE INFORMATION FROM DATABASES PROVIDED BY WNDR ON MAY 23, 2013.
2. CHANNEL BOUNDARY AND 2013 BATHYMETRY PROVIDED BY THE US ARMY CORPS OF ENGINEERS - DETROIT DISTRICT HTTP://WWW.LRE.USACE.ARMY.MIL
3. ELEVATIONS ARE PROVIDED IN INTERNATIONAL GREAT LAKES DATUM 1985.
4. FOR 2013 SAMPLES, STAFF GAGE READINGS ARE FROM GAGE LOCATED AT THE SITE. FOR 2010 SAMPLES, STAFF GAGE READINGS ARE FROM THE NOAA 9099064 DULUTH, MN STAFF GAGE.
5. SEDIMENT SURFACE ELEVATION BASED ON STAFF GAGE READINGS AND WATER DEPTH, WHEN AVAILABLE. WHEN NOT AVAILABLE, SEDIMENT SURFACE ELEVATION WAS ESTIMATED USING BATHYMETRIC CONTOURS DEVELOPED BY ARCADIS BASED ON SURVEY CONDUCTED BY USACE IN THE YEAR OF SAMPLING EVENT.
6. TOP OF CLAY ELEVATION IDENTIFIED BASED ON TOP OF SEDIMENT ELEVATION AND CORE LOGS.
7. MEC = MIDPOINT EFFECT CONCENTRATION; PEC = PROBABLE EFFECT CONCENTRATION

0 5' 10'
VERTICAL GRAPHIC SCALE

0 60' 120'
HORIZONTAL GRAPHIC SCALE

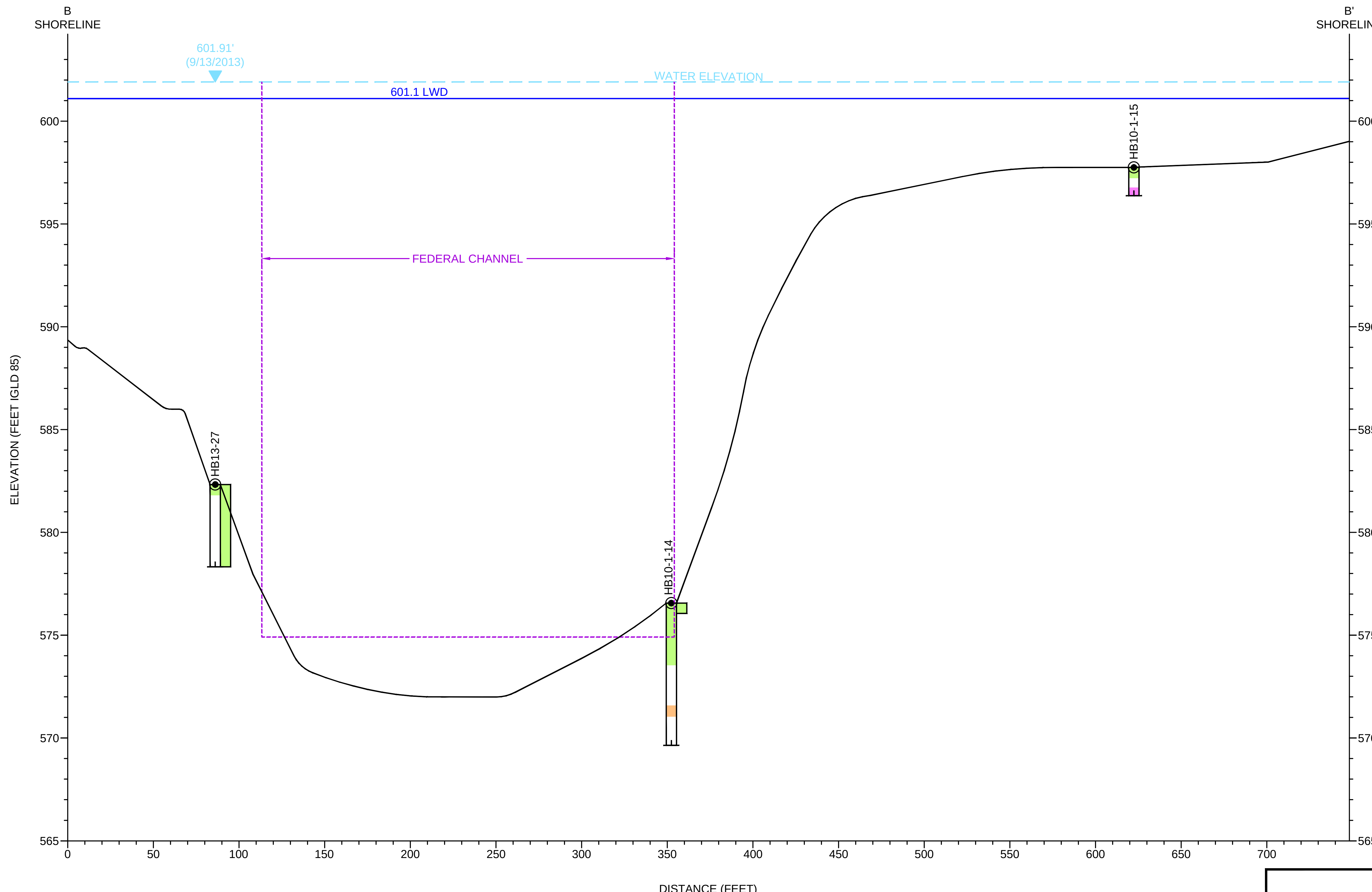
HOWARD'S BAY
SUPERIOR, WISCONSIN

FOCUSED FEASIBILITY STUDY FOR SEDIMENT CLEANUP IN HOWARD'S BAY

CROSS SECTION A-A'

ARCADIS

FIGURE
1-10a



NOTES:

1. SAMPLE INFORMATION FROM DATABASES PROVIDED BY WNDR ON MAY 23, 2013.
2. CHANNEL BOUNDARY AND 2013 BATHYMETRY PROVIDED BY THE US ARMY CORPS OF ENGINEERS - DETROIT DISTRICT HTTP://WWW.LRE.USACE.ARMY.MIL
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6. TOP OF CLAY ELEVATION IDENTIFIED BASED ON TOP OF SEDIMENT ELEVATION AND CORE LOGS.
7. IF A PARENT AND DUPLICATE SAMPLE OR A COMPOSITE SAMPLE WAS ANALYZED FOR SAME DEPTH INTERVAL, BOTH RESULTS ARE SHOWN, CONSERVATIVELY.
8. MEC = MIDPOINT EFFECT CONCENTRATION; PEC = PROBABLE EFFECT CONCENTRATION

LEGEND:

- SEDIMENT SURFACE (2013 BATHYMETRIC CONTOURS
- SEDIMENT SURFACE ELEVATION AT CORING LOCATION
- BOTTOM OF SEDIMENT CORE
- LWD LOW WATER DATUM OF 601.1 (IGLD 85)

LEAD, TRIBUTYLTIN, TOTAL PAHs, AND/OR MERCURY EXCEEDANCES:

- NO SAMPLE ANALYZED
- NON-DETECT OR SMALLER OR EQUAL TO MEC
- >MEC, SMALLER OR EQUAL PEC
- >PEC

0 5' 10'
VERTICAL GRAPHIC SCALE

0 60' 120'
HORIZONTAL GRAPHIC SCALE

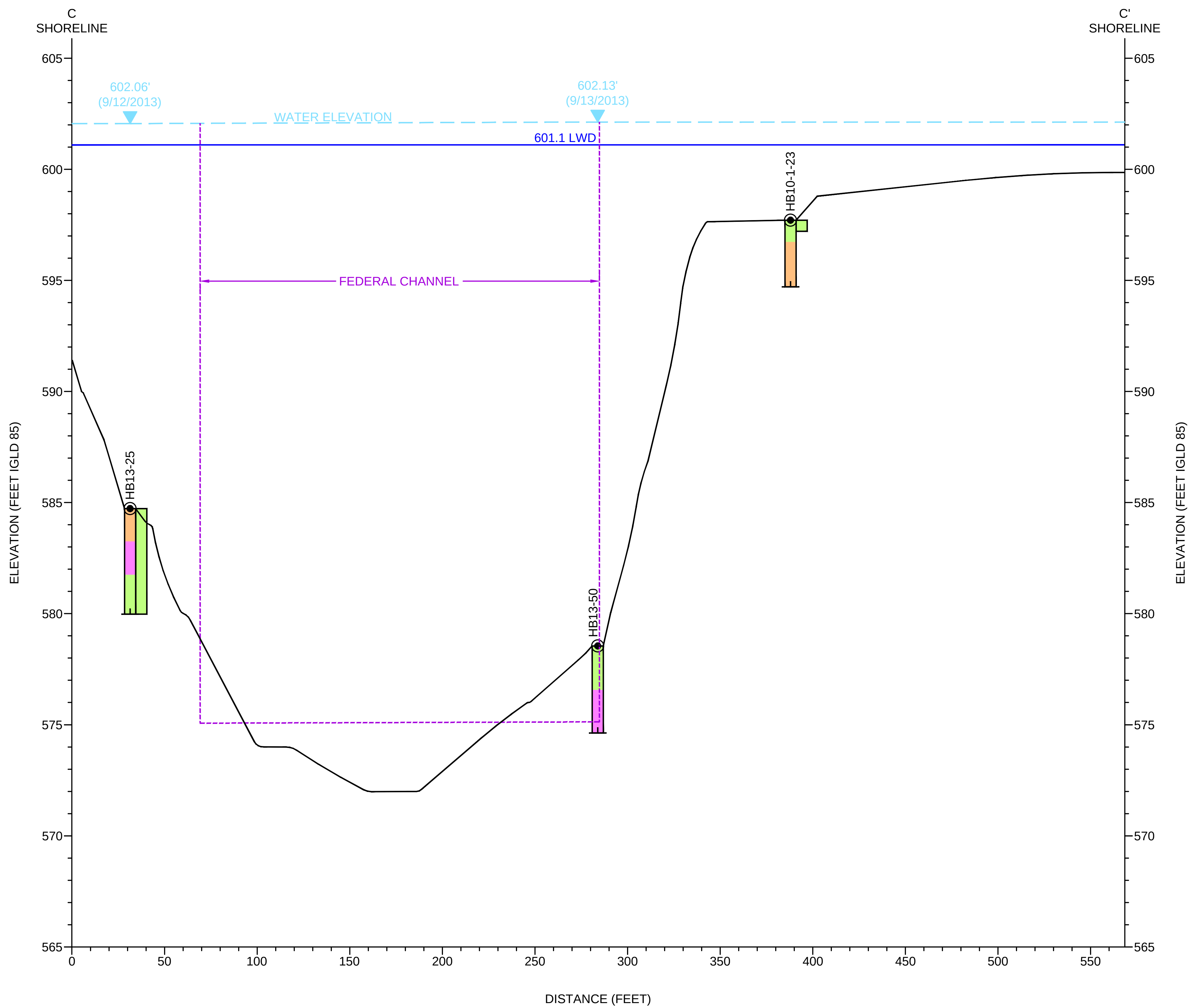
HOWARD'S BAY
SUPERIOR, WISCONSIN
FOCUSED FEASIBILITY STUDY FOR SEDIMENT CLEANUP IN HOWARD'S BAY

CROSS SECTION B-B'

ARCADIS

FIGURE
1-10b

CITY: MANCHESTER DIV/GROUP: ENVCAD DB: B.SMALL PM: TM:
G:\ENVCAD\Manchester\ACT\CI001796\0002\00003\CI0017960002-C01.dwg LAYOUT: 1-10B SAVED: 2/5/2015 10:21 AM ACADVER: 18.1S (LMS TECH) PAGESETUP: ---- PLOTSTYLETABLE: ---- PLOTTED: 2/5/2015 10:27 AM BY: SMALL, BRIAN



LEGEND:

- SEDIMENT SURFACE (2013 BATHYMETRIC CONTOURS
- SEDIMENT SURFACE ELEVATION AT CORING LOCATION
- BOTTOM OF SEDIMENT CORE
- LWD LOW WATER DATUM OF 601.1 (IGLD 85)

LEAD, TRIBUTYLTIN, TOTAL PAHs, AND/OR MERCURY EXCEEDANCES:

- NON-DETECT OR SMALLER OR EQUAL TO MEC
- >MEC, SMALLER OR EQUAL PEC
- >PEC

NOTES:

1. SAMPLE INFORMATION FROM DATABASES PROVIDED BY WNDR ON MAY 23, 2013.
2. CHANNEL BOUNDARY AND 2013 BATHYMETRY PROVIDED BY THE US ARMY CORPS OF ENGINEERS - DETROIT DISTRICT HTTP://WWW.LRE.USACE.ARMY.MIL
3. ELEVATIONS ARE PROVIDED IN INTERNATIONAL GREAT LAKES DATUM 1985.
4. FOR 2013 SAMPLES, STAFF GAGE READINGS ARE FROM GAGE LOCATED AT THE SITE. FOR 2010 SAMPLES, STAFF GAGE READINGS ARE FROM THE NOAA 9099064 DULUTH, MN STAFF GAGE.
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6. IF A PARENT AND DUPLICATE SAMPLE OR A COMPOSITE SAMPLE WAS ANALYZED FOR SAME DEPTH INTERVAL, BOTH RESULTS ARE SHOWN, CONSERVATIVELY.
7. MEC = MIDPOINT EFFECT CONCENTRATION; PEC = PROBABLE EFFECT CONCENTRATION

0 5' 10'
VERTICAL GRAPHIC SCALE

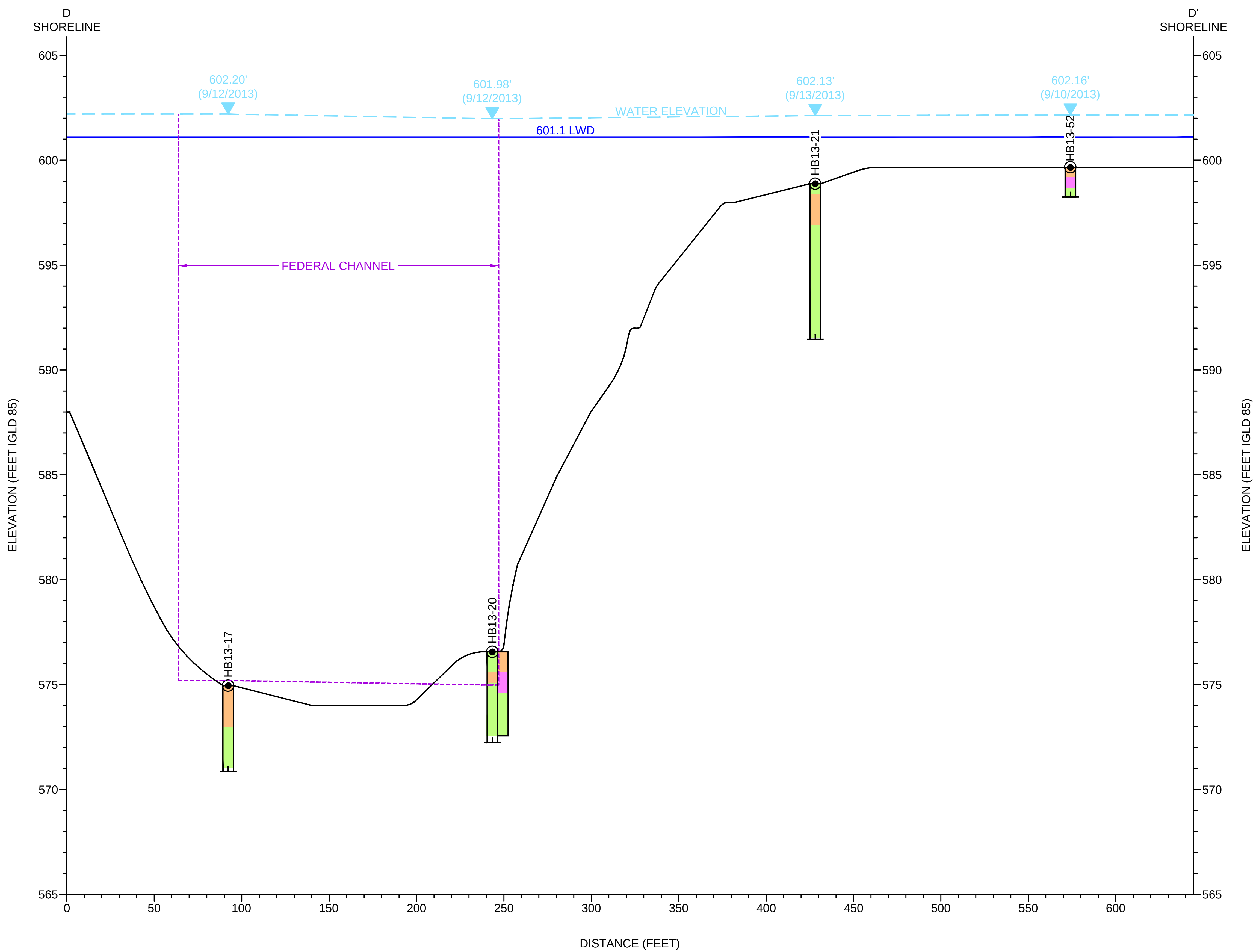
0 60' 120'
HORIZONTAL GRAPHIC SCALE

HOWARD'S BAY
SUPERIOR, WISCONSIN
FOCUSED FEASIBILITY STUDY FOR SEDIMENT CLEANUP IN HOWARD'S BAY

CROSS SECTION C-C'

ARCADIS

FIGURE
1-10c



LEGEND:

SEDIMENT SURFACE (2013 BATHYMETRIC CONTOURS

SEDIMENT SURFACE ELEVATION AT CORING LOCATION

BOTTOM OF SEDIMENT CORE

LWD LOW WATER DATUM OF 601.1 (IGLD 85)

LEAD, TRIBUTYLTIN, TOTAL PAHs, AND/OR MERCURY EXCEEDANCES:

NO SAMPLE ANALYZED

NON-DETECT OR SMALLER OR EQUAL TO MEC

>MEC, SMALLER OR EQUAL PEC

>PEC

NOTES:

1. SAMPLE INFORMATION FROM DATABASES PROVIDED BY WNDR ON MAY 23, 2013.
2. CHANNEL BOUNDARY AND 2013 BATHYMETRY PROVIDED BY THE US ARMY CORPS OF ENGINEERS - DETROIT DISTRICT HTTP://WWW.LRE.USACE.ARMY.MIL
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7. MEC = MIDPOINT EFFECT CONCENTRATION; PEC = PROBABLE EFFECT CONCENTRATION

0 5' 10'

VERTICAL GRAPHIC SCALE

0 60' 120'

HORIZONTAL GRAPHIC SCALE

HOWARD'S BAY
SUPERIOR, WISCONSIN

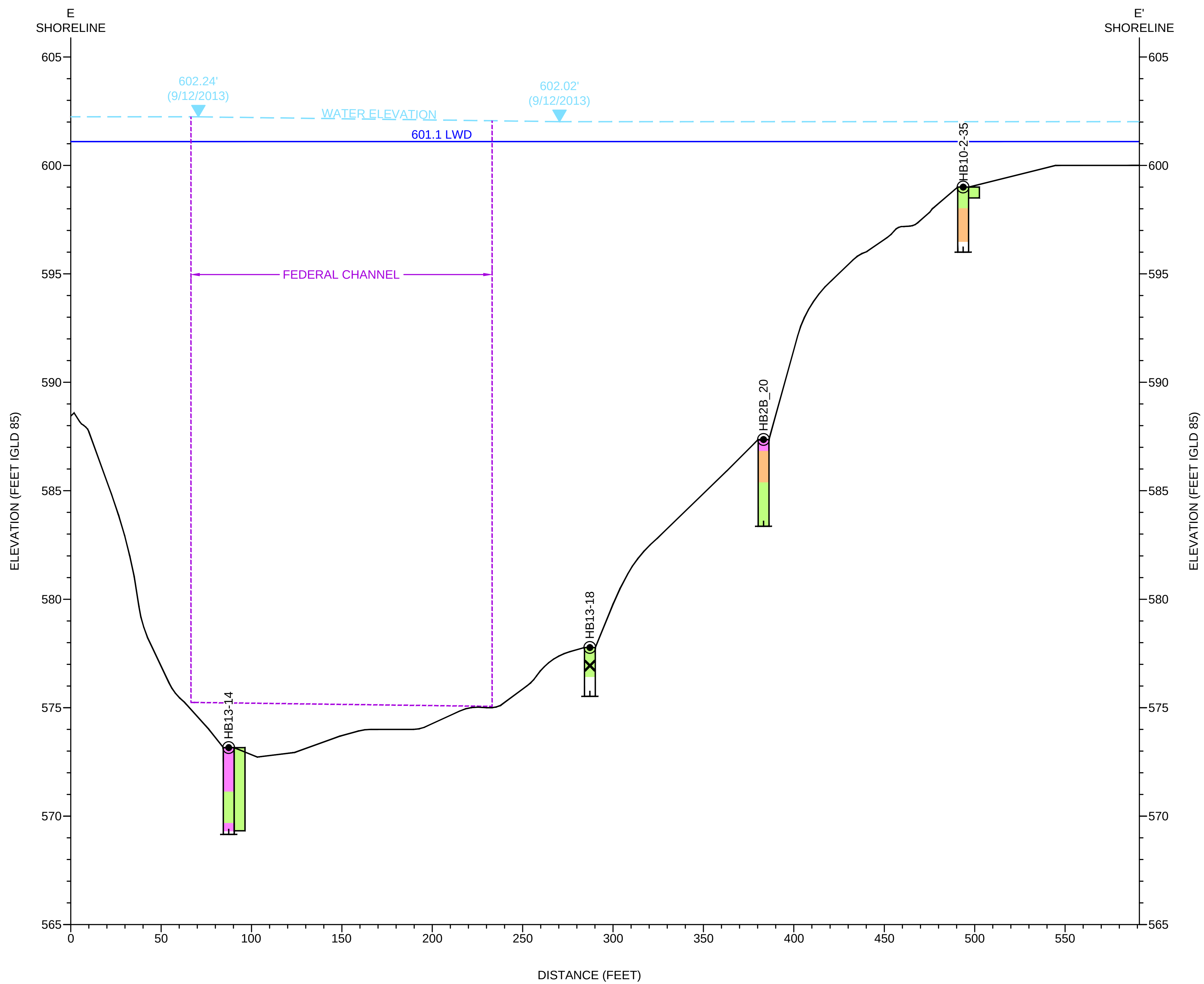
FOCUSED FEASIBILITY STUDY FOR SEDIMENT CLEANUP IN HOWARD'S BAY

CROSS SECTION D-D'

ARCADIS

FIGURE

1-10d



LEGEND:

SEDIMENT SURFACE (2013 BATHYMETRIC CONTOURS

SEDIMENT SURFACE ELEVATION AT CORING LOCATION

NATIVE CLAY ELEVATION AT CORING LOCATION

BOTTOM OF SEDIMENT CORE

LWD LOW WATER DATUM OF 601.1 (IGLD 85)

LEAD, TRIBUTYLTIN, TOTAL PAHs, AND/OR MERCURY EXCEEDANCES:

NO SAMPLE ANALYZED

NON-DETECT OR SMALLER OR EQUAL TO MEC

>MEC, SMALLER OR EQUAL PEC

>PEC

NOTES:

1. SAMPLE INFORMATION FROM DATABASES PROVIDED BY WNDR ON MAY 23, 2013.
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7. IF A PARENT AND DUPLICATE SAMPLE OR A COMPOSITE SAMPLE WAS ANALYZED FOR SAME DEPTH INTERVAL, BOTH RESULTS ARE SHOWN, CONSERVATIVELY.
8. MEC = MIDPOINT EFFECT CONCENTRATION; PEC = PROBABLE EFFECT CONCENTRATION

0 5' 10'

VERTICAL GRAPHIC SCALE

0 60' 120'

HORIZONTAL GRAPHIC SCALE

HOWARD'S BAY
SUPERIOR, WISCONSIN

FOCUSED FEASIBILITY STUDY FOR SEDIMENT CLEANUP IN HOWARD'S BAY

CROSS SECTION E-E'

ARCADIS

FIGURE **1-10e**

CITY: MANCHESTER DIV/GROUP: ENVCAD DB: B.SMALL PM: TM: LAYOUT: 1-10E SAVED: 2/5/2015 10:21 AM ACADVER: 18.1S (LMS TECH) PAGESETUP: ---- PLOTSTYLETABLE: ---- PLOTTED: 2/5/2015 10:24 AM BY: SMALL, BRIAN
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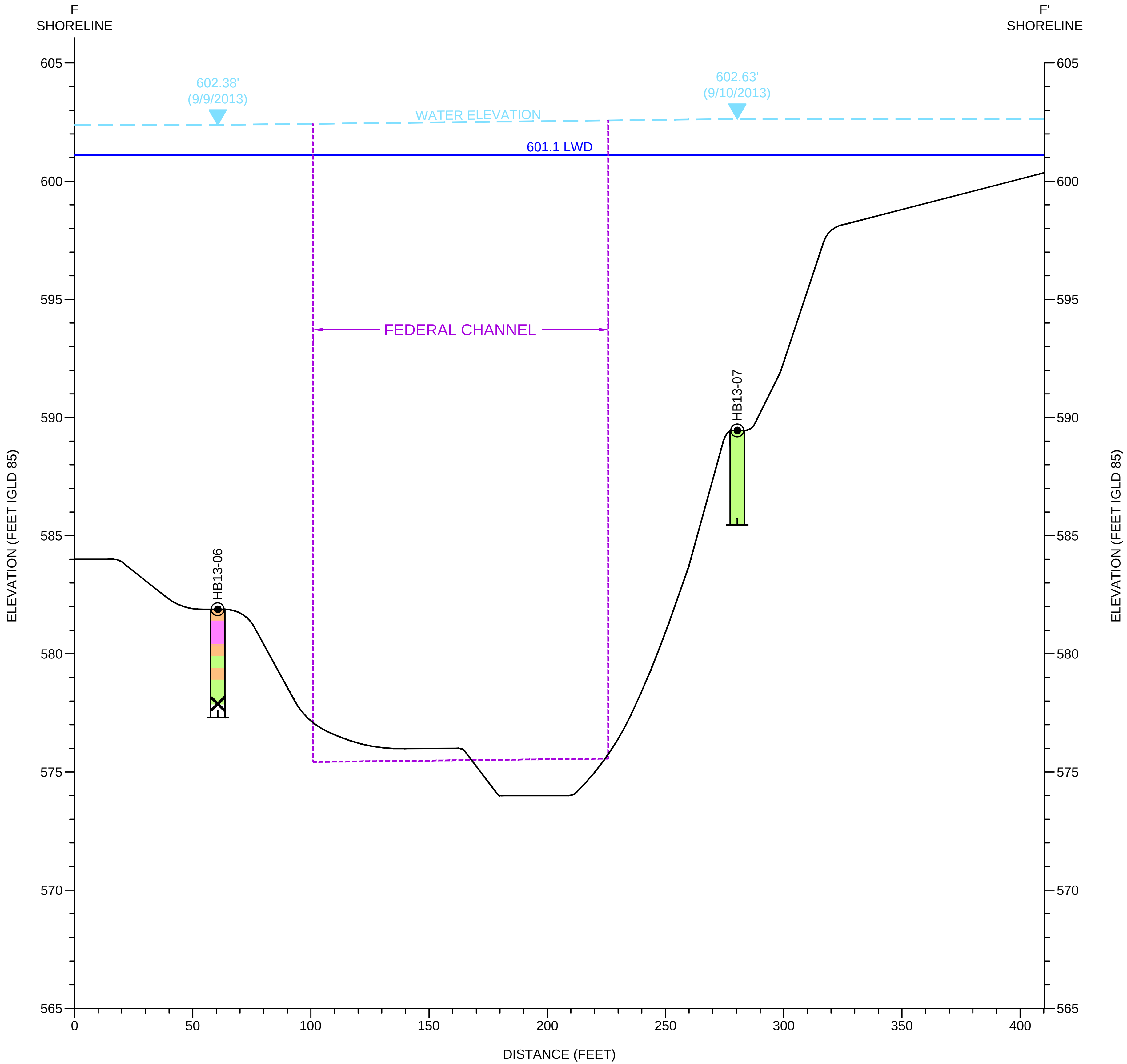

LEGEND:

- SEDIMENT SURFACE (2013 BATHYMETRIC CONTOURS
- SEDIMENT SURFACE ELEVATION AT CORING LOCATION
- NATIVE CLAY ELEVATION AT CORING LOCATION
- BOTTOM OF SEDIMENT CORE
- LWD LOW WATER DATUM OF 601.1 (IGLD 85)

LEAD, TRIBUTYLTIN, TOTAL PAHs, AND/OR MERCURY EXCEEDANCES:

- NO SAMPLE ANALYZED
- NON-DETECT OR SMALLER OR EQUAL TO MEC
- >MEC, SMALLER OR EQUAL PEC
- >PEC

NOTES:

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6. TOP OF CLAY ELEVATION IDENTIFIED BASED ON TOP OF SEDIMENT ELEVATION AND CORE LOGS.
7. MEC = MIDPOINT EFFECT CONCENTRATION; PEC = PROBABLE EFFECT CONCENTRATION

0 5' 10'
VERTICAL GRAPHIC SCALE

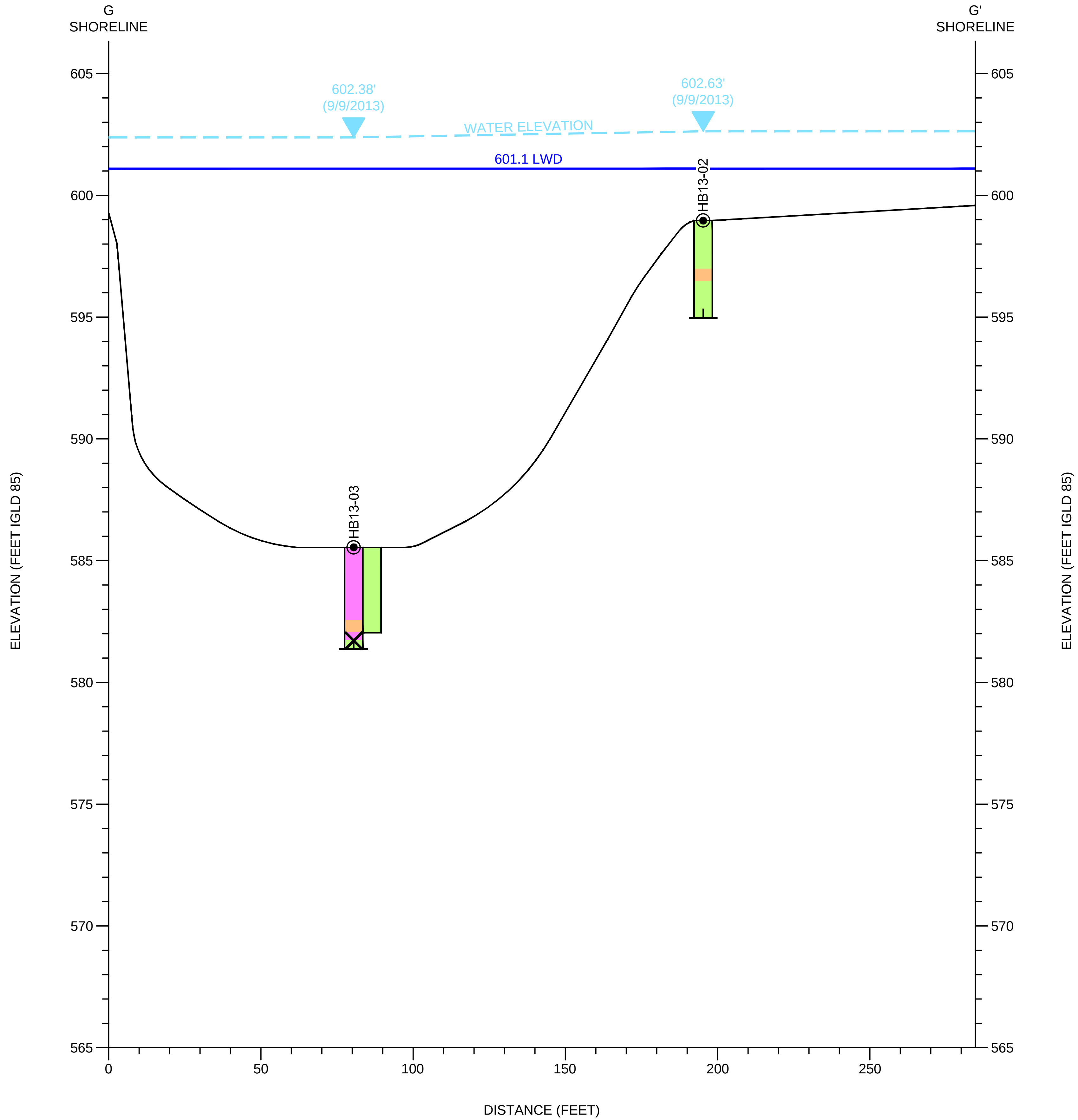
0 50' 100'
HORIZONTAL GRAPHIC SCALE

HOWARD'S BAY
SUPERIOR, WISCONSIN
FOCUSED FEASIBILITY STUDY FOR SEDIMENT CLEANUP IN HOWARD'S BAY

CROSS SECTION F-F'

ARCADIS

FIGURE
1-10f



LEGEND:

SEDIMENT SURFACE (2013 BATHYMETRIC CONTOURS

SEDIMENT SURFACE ELEVATION AT CORING LOCATION

NATIVE CLAY ELEVATION AT CORING LOCATION

BOTTOM OF SEDIMENT CORE

LWD LOW WATER DATUM OF 601.1 (IGLD 85)

LEAD, TRIBUTYLTIN, TOTAL PAHs, AND/OR MERCURY EXCEEDANCES:

NON-DETECT OR SMALLER OR EQUAL TO MEC

>MEC, SMALLER OR EQUAL PEC

>PEC

NOTES:

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2. CHANNEL BOUNDARY AND 2013 BATHYMETRY PROVIDED BY THE US ARMY CORPS OF ENGINEERS - DETROIT DISTRICT HTTP://WWW.LRE.USACE.ARMY.MIL
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7. IF A PARENT AND DUPLICATE SAMPLE OR A COMPOSITE SAMPLE WAS ANALYZED FOR SAME DEPTH INTERVAL, BOTH RESULTS ARE SHOWN, CONSERVATIVELY.
8. MEC = MIDPOINT EFFECT CONCENTRATION; PEC = PROBABLE EFFECT CONCENTRATION

0 5' 10'
VERTICAL GRAPHIC SCALE

0 40' 80'
HORIZONTAL GRAPHIC SCALE

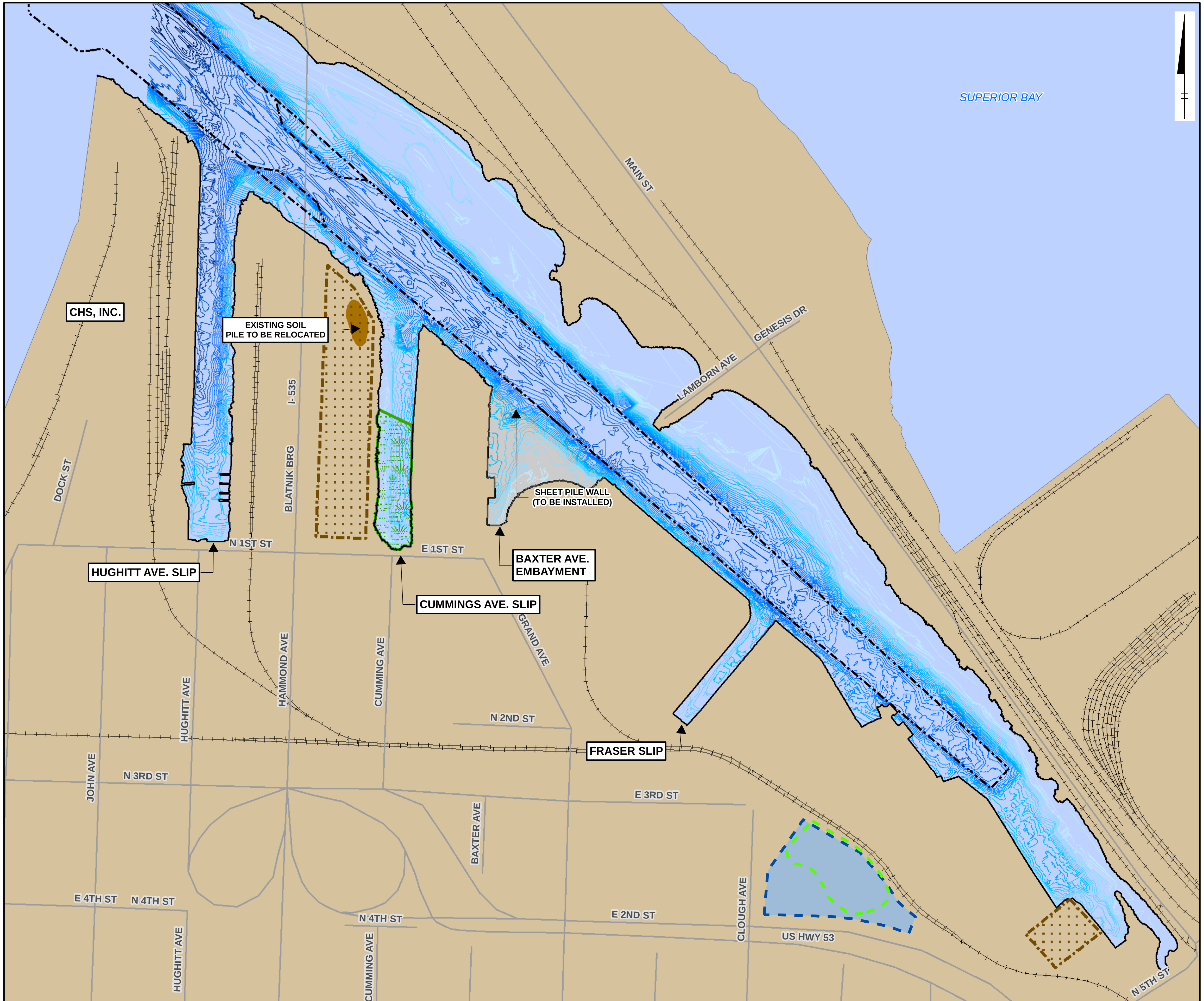
HOWARD'S BAY
SUPERIOR, WISCONSIN
FOCUSED FEASIBILITY STUDY FOR SEDIMENT CLEANUP IN HOWARD'S BAY

CROSS SECTION G-G'

ARCADIS

FIGURE
1-10g

DRAFT



LEGEND:

- FEDERAL CHANNEL
- SHORELINE (APPROXIMATE)
- ROADS
- RAILROAD
- APPROXIMATE LIMITS OF WETLAND AREA (SEE NOTE 3)
- APPROXIMATE LIMITS OF POSSIBLE UPLAND PLACEMENT OR TEMPORARY STAGING AREA
- APPROXIMATE LOCATION OF DREDGED MATERIAL HANDLING/DEWATERING AREA
- EXISTING SOIL PILE
- ESTIMATED LIMITS OF THE INWATER CAD
- BAXTER AVE EMBAYMENT

0 400 800 Feet

GRAPHIC SCALE

NOTES:

1. CHANNEL BOUNDARY PROVIDED BY THE US ARMY CORPS OF ENGINEERS - DETROIT DISTRICT HTTP://WWW.LRE.USACE.ARMY.MIL
2. THE APPROXIMATE WETLAND LIMITS SHOWN ARE BASED ON CITY OF SUPERIOR MAPPING. WETLAND ASSESSMENT/ DELINEATION FIELD ACTIVITIES WOULD BE NEEDED FOR PERMITTING

HOWARD'S BAY
SUPERIOR, WISCONSIN

FOCUSED FEASIBILITY STUDY FOR SEDIMENT CLEANUP IN HOWARD'S BAY

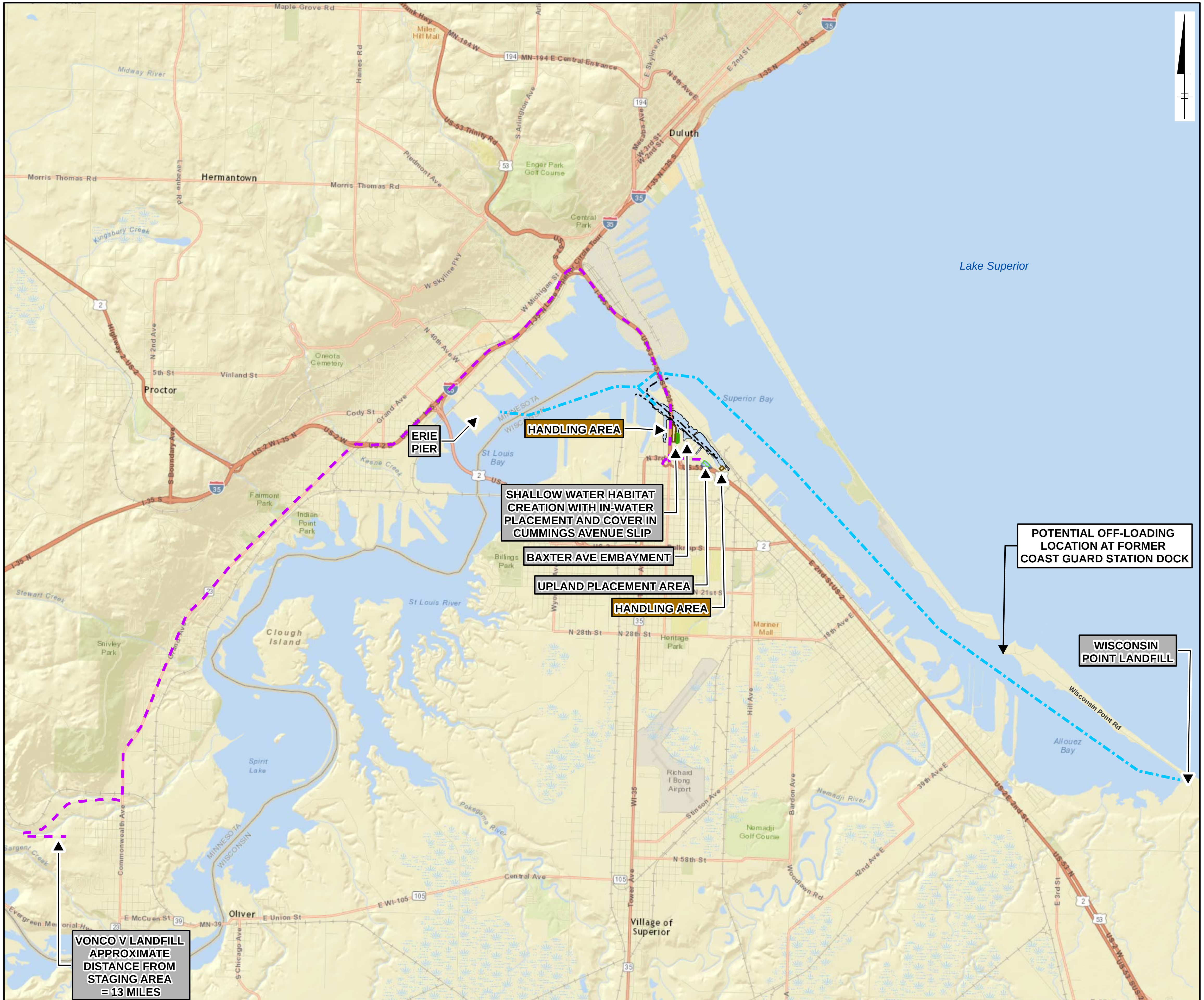
POTENTIAL STAGING AREAS AND ON-SITE PLACEMENT AREAS

ARCADIS

FIGURE **3-1**

City: SYR Div/Group: SWG Created By: J.RAPP Last Saved By: kives
FRASER SHIPYARD (CI001796.0001.0003)
Q:\FraserShipyard\SuperiorWI\FocusedFeasibilityStudy2015\mxd\SedimentSamples_SiteLayout.mxd 2/11/2015 10:43:24 AM

DRAFT



LEGEND

- BARGE ROUTE
- TRUCK ROUTE
- FEDERAL CHANNEL
- SHORELINE (APPROXIMATE)
- APPROXIMATE LIMITS OF WETLAND AREA (SEE NOTE 3)
- APPROXIMATE LOCATION OF DREDGED MATERIAL HANDLING/DEWATERING AREA
- CONFINED AQUATIC DISPOSAL TO CREATE WETLANDS (CAD)
- BENEFICIAL REUSE/DISPOSAL OPTION LOCATION
- HANDLING AREA

0 6,000 12,000 Feet

GRAPHIC SCALE

NOTES:

1. BASEMAP PROVIDED BY ESRI IMAGE SERVICE.
2. CHANNEL BOUNDARY PROVIDED BY THE US ARMY CORPS OF ENGINEERS - DETROIT DISTRICT HTTP://WWW.LRE.USACE.ARMY.MIL
3. THE APPROXIMATE WETLAND LIMITS SHOWN ARE BASED ON CITY OF SUPERIOR MAPPING. WETLAND ASSESSMENT/ DELINEATION FIELD ACTIVITIES WOULD BE NEEDED TO CONFIRM THE PRESENCE AND LOCATIONS OF THE WETLAND AREA.

HOWARD'S BAY
SUPERIOR, WISCONSIN
FOCUSED FEASIBILITY STUDY FOR SEDIMENT CLEANUP IN HOWARD'S BAY

POSSIBLE OFF-SITE DISPOSAL LOCATIONS

ARCADIS

FIGURE **3-2**

City: SYR Div/Group: SWG Created By: J.RAPP Last Saved By: kives
FRASER SHIPYARD (CI001796.0001.0003)
Q:\FraserShipyard\SuperiorWI\FocusedFeasibilityStudy2015\mxd\SedimentSamples_DisposalSiteLocations.mxd 2/11/2015 10:43:21 AM

DRAFT

City: SYR Div/Group: SWG Created By: J.RAPP Last Saved By: kives
FRASER SHIPYARD (CI001796.0001.0003)
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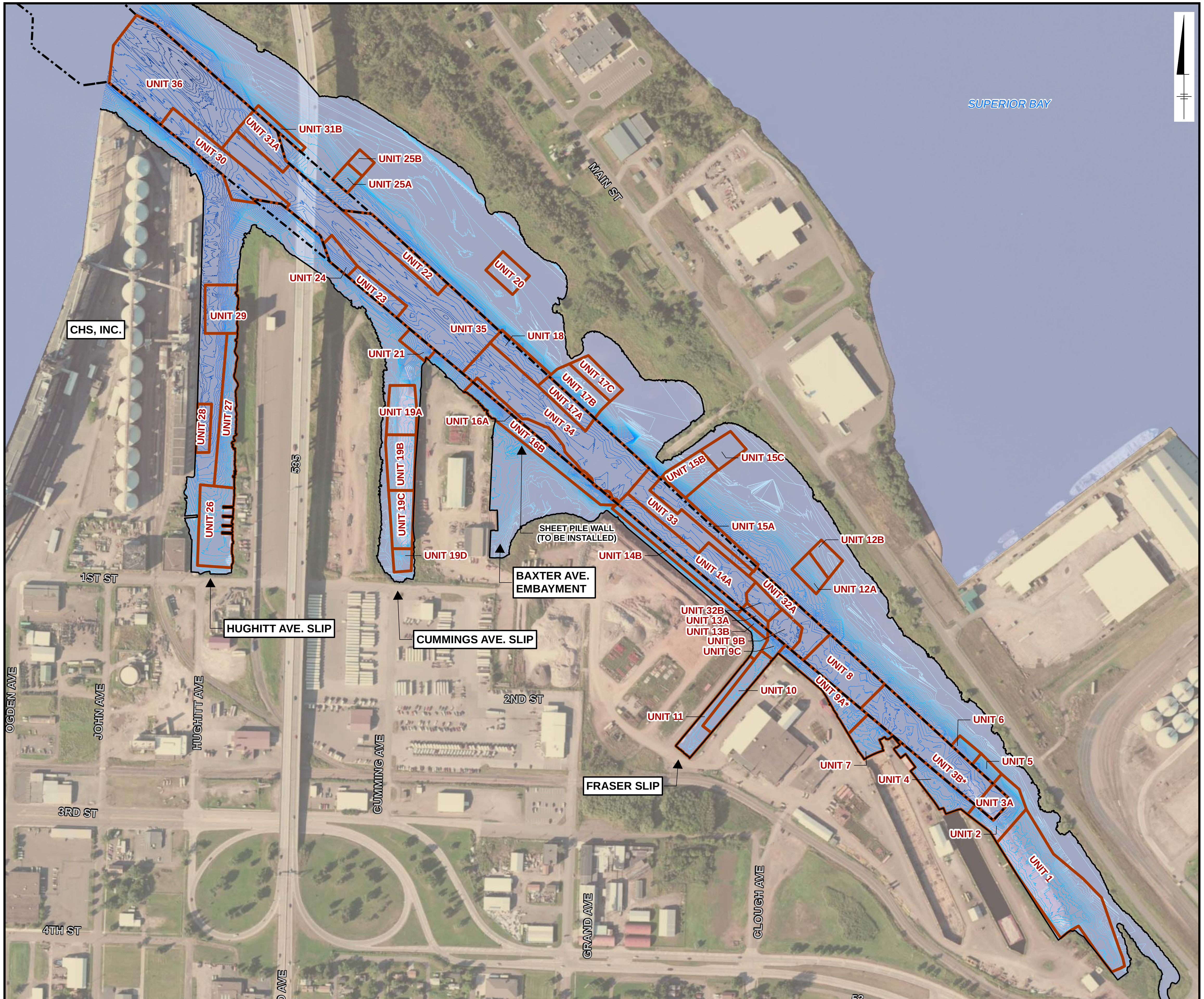


LEGEND:

- SHORELINE (APPROXIMATE)
- FEDERAL CHANNEL
- SEDIMENT MANAGEMENT UNIT

0 400 800 Feet

GRAPHIC SCALE

NOTE:

1. CHANNEL BOUNDARY AND BATHYMETRY PROVIDED BY THE US ARMY CORPS OF ENGINEERS - DETROIT DISTRICT http://www.lre.usace.army.mil

HOWARD'S BAY
SUPERIOR, WISCONSIN

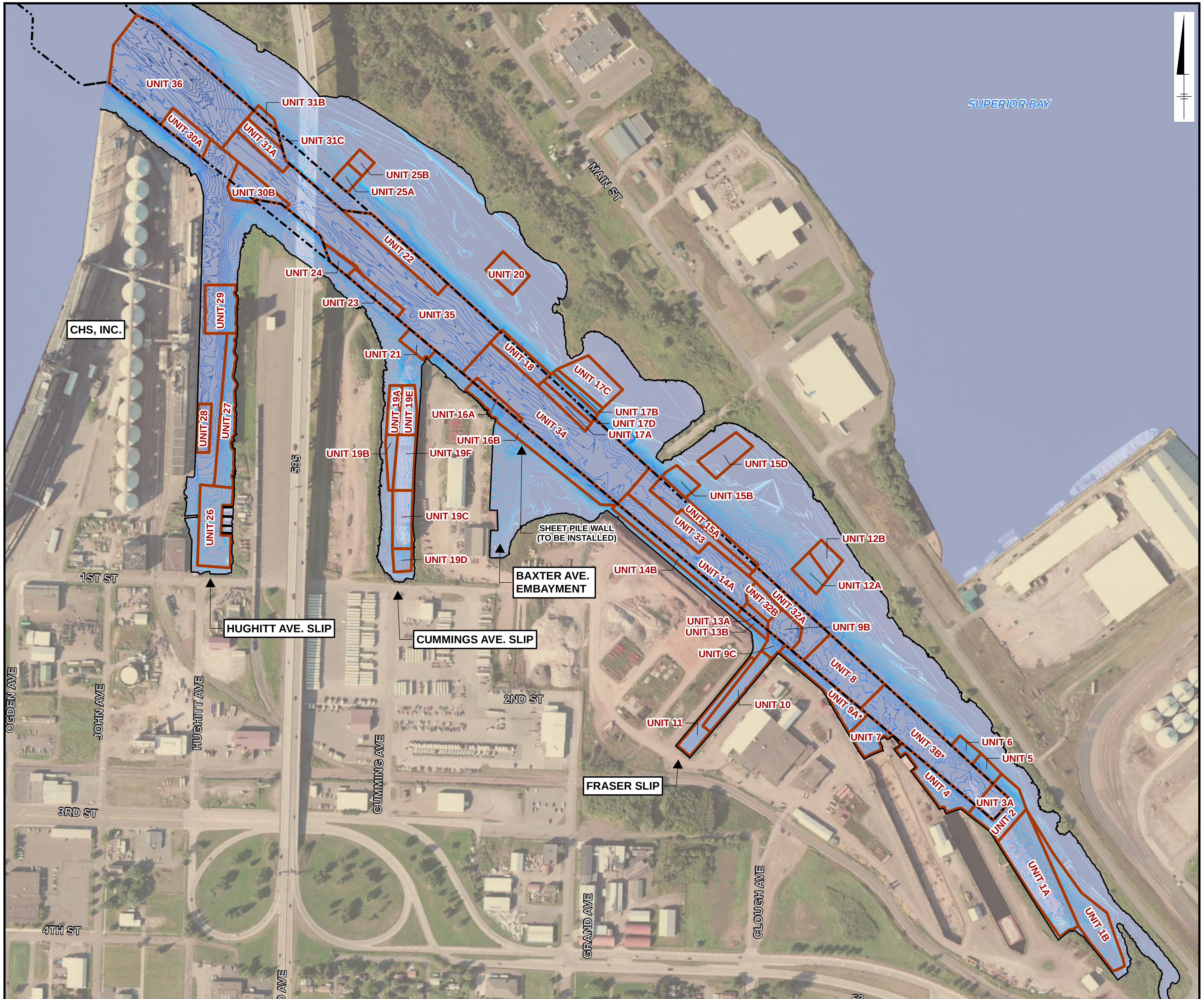
FOCUSED FEASIBILITY STUDY FOR SEDIMENT CLEANUP IN HOWARD'S BAY

REMEDIAL BOUNDARIES FOR ALTERNATIVES A-1, A-2, A-3, AND B-1

ARCADIS

FIGURE
4-1

DRAFT



LEGEND:

- SHORELINE (APPROXIMATE)
- FEDERAL CHANNEL
- SEDIMENT MANAGEMENT UNIT

0 400 800 Feet

GRAPHIC SCALE

NOTE:

1. CHANNEL BOUNDARY AND BATHYMETRY PROVIDED BY THE US ARMY CORPS OF ENGINEERS - DETROIT DISTRICT http://www.lre.usace.army.mil

HOWARD'S BAY
SUPERIOR, WISCONSIN

FOCUSED FEASIBILITY STUDY FOR SEDIMENT CLEANUP IN HOWARD'S BAY

REMEDIAL BOUNDARIES FOR ALTERNATIVES A-4, B-2, AND B-3

ARCADIS

FIGURE **4-2**

City: SYR Div/Group: SWG Created By: J.RAPP Last Saved By: kives
FRASER SHIPYARD (CI001796.0001.0003)
Q:\FraserShipyard\SuperiorWI\FocusedFeasibilityStudy2015\mxd\SiteLocationMap_RemedialBoundariesA4_B2_B3.mxd 2/11/2015 11:47:20 AM

City: SYR Div/Group: SWG Created By: K.IVES Last Saved By: kives
FRASER SHIPYARDS
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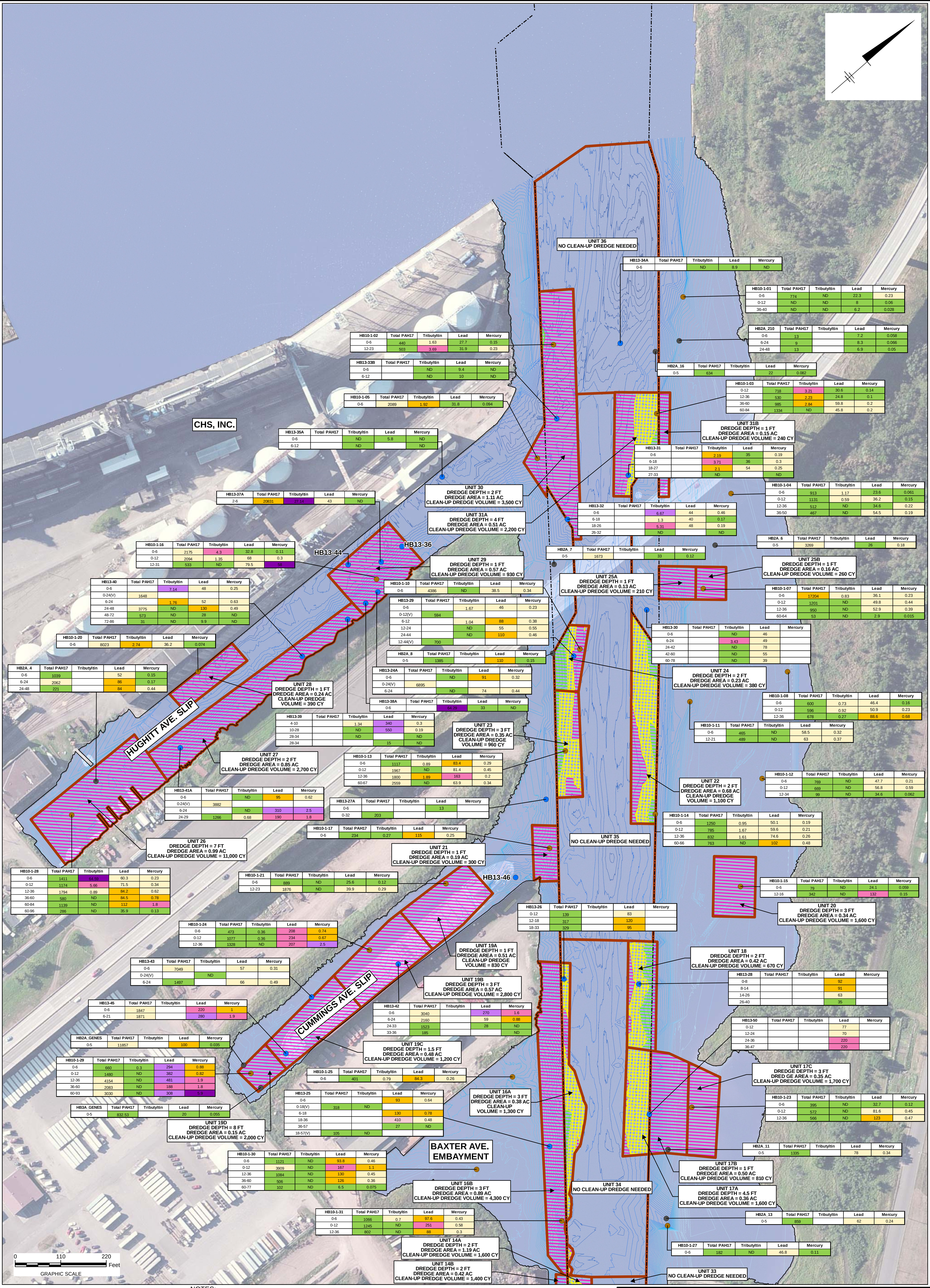

LEGEND

- 2007 SAMPLE LOCATION
- 2010 SAMPLE LOCATION
- 2013 SAMPLE LOCATION
- SHORELINE (APPROXIMATE)
- FEDERAL CHANNEL
- SEDIMENT MANAGEMENT UNIT
- STRATEGIC NAVIGATION DREDGE AREA OVERLAPPING CLEANUP DREDGE AREA
- ADDITIONAL CLEAN-UP DREDGE AREA
- STRATEGIC NAVIGATION DREDGE AREA

NOTES:

1. JULY 6, 2011 IMAGERY PROVIDED BY ESRI IMAGE SERVICE.
2. SAMPLE INFORMATION FROM DATABASES PROVIDED BY WNDR ON MAY 23, 2013.
3. CHANNEL BOUNDARY PROVIDED BY THE US ARMY CORPS OF ENGINEERS - DETROIT DISTRICT HTTP://WWW.LRE.USACE.ARMY.MIL
4. TOTAL PAHS WERE CALCULATED BY SUM OF 17 PAHS. THE ASSOCIATE VALUE TO NON-DETECT IS ½ REPORTING LIMIT.
5. ORGANIC RESULTS WERE NORMALIZED TO TOC CONTENT PRIOR TO COMPARISON TO THE CRITERIA FOR SAMPLES WITH DETECTED TOC CONTENT GREATER THAN 2 G/KG.
6. 17 TOTAL PAHS WERE CALCULATED BY SUM OF THE FOLLOWING 17 PAHS: 2-METHYLNAPHTHALENE, ACENAPHTHENE, ACENAPHTHYLENE, ANTHRACENE, BENZO(A)ANTHRACENE, BENZO(B)FLUORANTHENE, BENZO(G,H,I)PERYLENE, BENZO(K) FLUORANTHENE, BENZO(A)PYRENE, CHRYSENE, DIBENZ(A,H) ANTHRACENE, FLUORANTHENE, FLUORENE, INDENO(1,2,3-CD)PYRENE, NAPHTHALENE, PHENANTHRENE, AND PYRENE.
7. REMEDIAL BOUNDARIES ARE SUBJECT TO REFINEMENT DURING THE DESIGN PHASE FOR THE PREFERRED ALTERNATIVE
8. AC = ACRES
CY = CUBIC YARDS
FT = FEET
ND = NON-DETECT
V = VERTICALLY COMPOSITE
R = REPLICATE
A = SECOND LOCATION ATTEMPT
B = THIRD LOCATION ATTEMPT
TEC = THRESHOLD EFFECT CONCENTRATION
MEC = MIDPOINT EFFECT CONCENTRATION
PEC = PROBABLE EFFECT CONCENTRATION
µG/KG-OC = MICROGRAM PER KILOGRAM OF SEDIMENT (DRY WEIGHT) NORMALIZED TO TOTAL ORGANIC CARBON AT 1 PERCENT
TOC = TOTAL ORGANIC CARBON
PAH = POLYCYCLIC AROMATIC HYDROCARBONS

Location ID	Total PAH17 (µg/kg-OC)	Tributyltin (µg/kg-OC)	Lead (mg/kg)	Mercury (mg/kg)
Depth (inches)	NA	NA	NA	NA
	<TEC	<TEC	<TEC	<TEC
	≥TEC(1610) <MEC	≥TEC(0.52) <MEC	≥TEC(36) <MEC	≥TEC(0.18) <MEC
	≥MEC(12205) <PEC	≥MEC(1.73) <PEC	≥MEC(83) <PEC	≥MEC(0.64) <PEC
	≥PEC(22800) <2xPEC	≥PEC(2.94) <2xPEC	≥PEC(130) <2xPEC	≥PEC(1.1) <2xPEC
	≥2xPEC(45600) <5xPEC	≥2xPEC(5.88) <5xPEC	≥2xPEC(260) <5xPEC	≥2xPEC(2.2) <5xPEC
	≥5xPEC(114000)	≥5xPEC(14.7)	≥5xPEC(650)	≥5xPEC(5.5)

HOWARD'S BAY
SUPERIOR, WISCONSIN

FOCUSED FEASIBILITY STUDY FOR SEDIMENT CLEANUP IN HOWARDS BAY

REMEDIAL ALTERNATIVE A-1 - AREA 1

ARCADIS

FIGURE
4-3a

City: SYR Div/Group: SWG Created By: K.IVES Last Saved By: kives
FRASER SHIPYARDS
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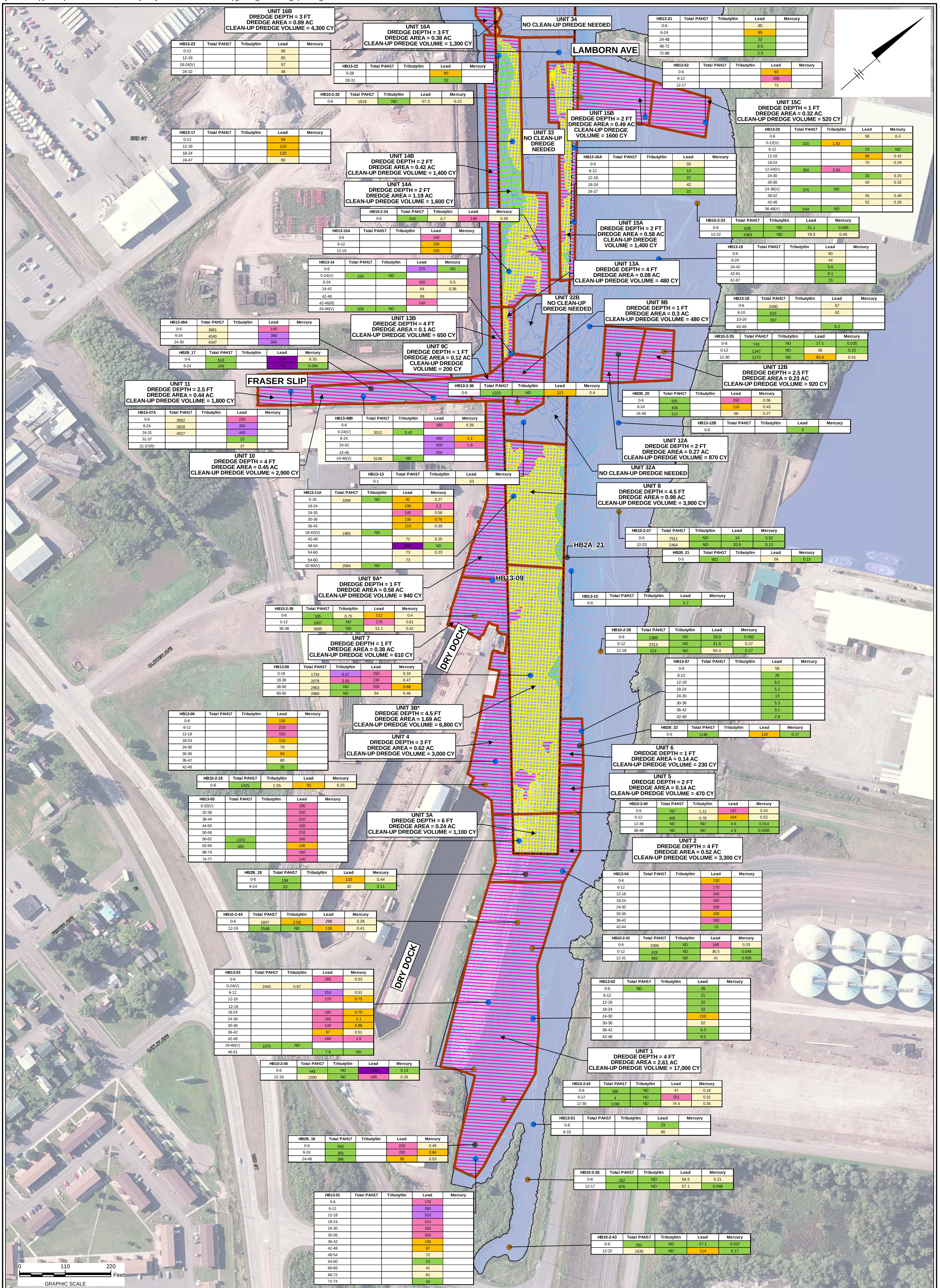

LEGEND

- 2007 SAMPLE LOCATION
- 2010 SAMPLE LOCATION
- 2013 SAMPLE LOCATION
- SHORELINE (APPROXIMATE)
- FEDERAL CHANNEL
- SEDIMENT MANAGEMENT UNIT
- STRATEGIC NAVIGATION DREDGE AREA OVERLAPPING CLEANUP DREDGE AREA
- ADDITIONAL CLEAN-UP DREDGE AREA
- STRATEGIC NAVIGATION DREDGE AREA

NOTES:

1. JULY 6, 2011 IMAGERY PROVIDED BY ESRI IMAGE SERVICE.
2. SAMPLE INFORMATION FROM DATABASES PROVIDED BY WNDR ON MAY 23, 2013.
3. CHANNEL BOUNDARY PROVIDED BY THE US ARMY CORPS OF ENGINEERS - DETROIT DISTRICT HTTP://WWW.LRE.USACE.ARMY.MIL
4. TOTAL PAHS WERE CALCULATED BY SUM OF 17 PAHS. THE ASSOCIATE VALUE TO NON-DETECT IS ½ REPORTING LIMIT.
5. ORGANIC RESULTS WERE NORMALIZED TO TOC CONTENT PRIOR TO COMPARISON TO THE CRITERIA FOR SAMPLES WITH DETECTED TOC CONTENT GREATER THAN 2 G/KG.
6. * = FINAL REMOVAL DEPTH TO BE DETERMINED BASED ON FIELD OBSERVATION AS TO PRESENCE OF SEDIMENT AND/OR SAMPLING FOR LEAD CONCENTRATIONS
7. 17 TOTAL PAHS WERE CALCULATED BY SUM OF THE FOLLOWING 17 PAHS: 2-METHYLNAPHTHALENE, ACENAPHTHENE, ACENAPHTHYLENE, ANTHRACENE, BENZO(A)ANTHRACENE, BENZO(B)FLUORANTHENE, BENZO(G,H,I)PERYLENE, BENZO(K) FLUORANTHENE, BENZO(A)PYRENE, CHRYSENE, DIBENZ(A,H) ANTHRACENE, FLUORANTHENE, FLUORENE, INDENO(1,2,3-CD)PYRENE, NAPHTHALENE, PHENANTHRENE, AND PYRENE.
8. REMEDIAL BOUNDARIES ARE SUBJECT TO REFINEMENT DURING THE DESIGN PHASE FOR THE PREFERRED ALTERNATIVE
9. AC = ACRES
   CY = CUBIC YARDS
   FT = FEET
   ND = NON-DETECT
   V = VERTICALLY COMPOSITE
   R = REPLICATE
   A = SECOND LOCATION ATTEMPT
   B = THIRD LOCATION ATTEMPT
   TEC = THRESHOLD EFFECT CONCENTRATION
   MEC = MIDPOINT EFFECT CONCENTRATION
   PEC = PROBABLE EFFECT CONCENTRATION
   µG/KG-OC = MICROGRAM PER KILOGRAM OF SEDIMENT (DRY WEIGHT) NORMALIZED TO TOTAL ORGANIC CARBON AT 1 PERCENT
   TOC = TOTAL ORGANIC CARBON
   PAH = POLYCYCLIC AROMATIC HYDROCARBONS

Location ID	Total PAH17 (µg/kg-OC)	Tributyltin (µg/kg-OC)	Lead (mg/kg)	Mercury (mg/kg)
Depth (inches)	NA	NA	NA	NA
	<TEC	<TEC	<TEC	<TEC
	≥TEC(1610) <MEC	≥TEC(0.52) <MEC	≥TEC(36) <MEC	≥TEC(0.18) <MEC
	≥MEC(12205) <PEC	≥MEC(1.73) <PEC	≥MEC(83) <PEC	≥MEC(0.64) <PEC
	≥PEC(22800) <2xPEC	≥PEC(2.94) <2xPEC	≥PEC(130) <2xPEC	≥PEC(1.1) <2xPEC
	≥2xPEC(45600) <5xPEC	≥2xPEC(5.88) <5xPEC	≥2xPEC(260) <5xPEC	≥2xPEC(2.2) <5xPEC
	≥5xPEC(114000)	≥5xPEC(14.7)	≥5xPEC(650)	≥5xPEC(5.5)

HOWARD'S BAY
SUPERIOR, WISCONSIN

FOCUSED FEASIBILITY STUDY FOR SEDIMENT CLEANUP IN HOWARDS BAY

REMEDIAL ALTERNATIVE A-1 - AREA 2

ARCADIS

FIGURE **4-3b**

City: SYR Div/Group: SWG Created By: K.IVES Last Saved By: kives
FRASER SHIPYARDS
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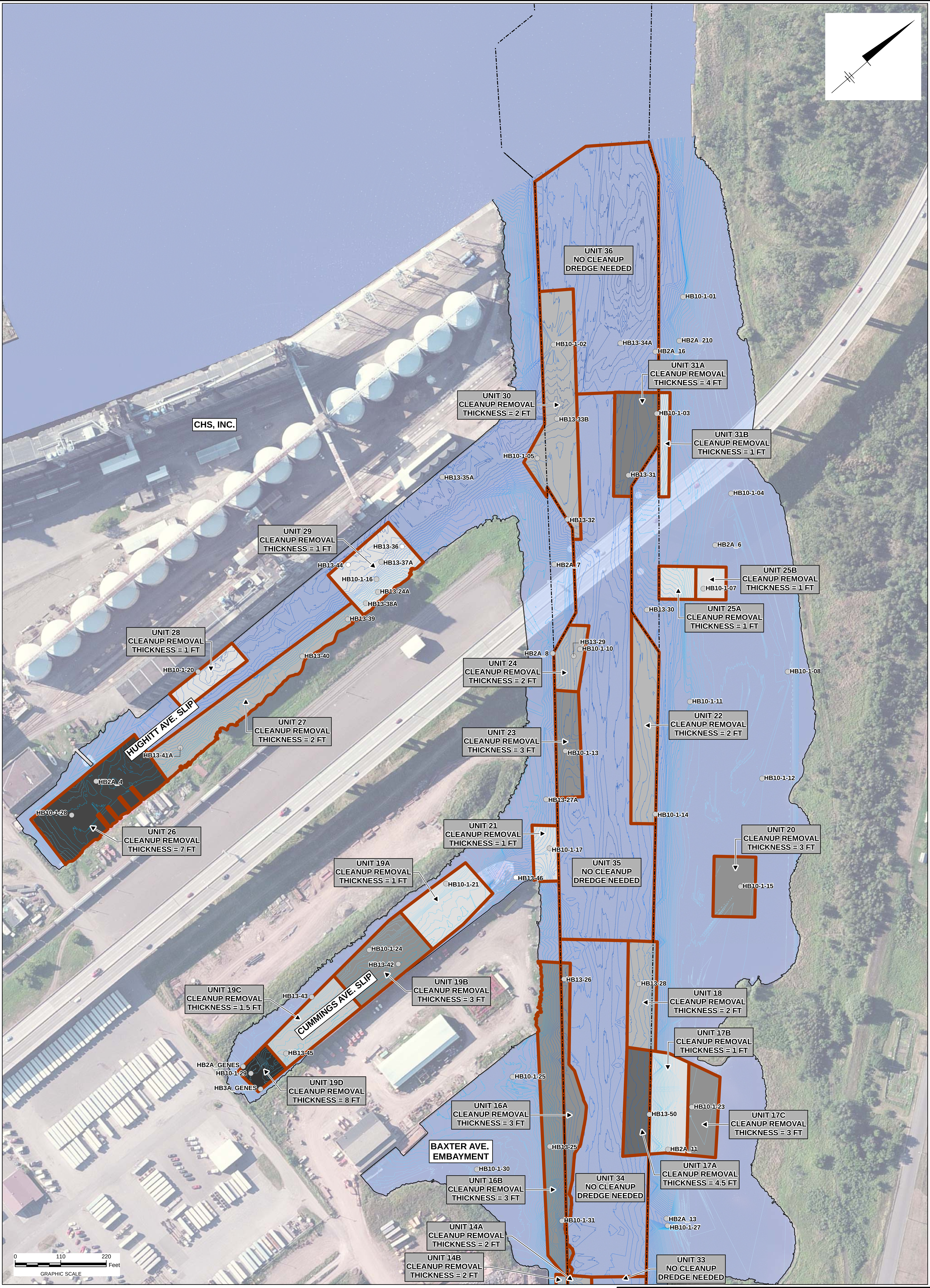


LEGEND

- 2007, 2010, OR 2013 SEDIMENT SAMPLE LOCATION
- 2013 CORE LOCATION WITH NO RECOVERY
- FEDERAL CHANNEL
- SHORELINE (APPROXIMATE)
- SEDIMENT MANAGEMENT UNIT

SEDIMENT MANAGEMENT UNIT CLEANUP DREDGE DEPTH (FT)

1
1.5
2
2.5
3
4
4.5
6
7
8

NOTES:

1. JULY 6, 2011 IMAGERY PROVIDED BY ESRI IMAGE SERVICE.
2. SAMPLE INFORMATION FROM DATABASES PROVIDED BY WNDR ON MAY 23, 2013.
3. CHANNEL BOUNDARY PROVIDED BY THE US ARMY CORPS OF ENGINEERS - DETROIT DISTRICT HTTP://WWW.LRE.USACE.ARMY.MIL
4. TARGET CLEANUP REMOVAL THICKNESS INCLUDES INCREMENTAL DREDGING DEPTH DEEPER THAN 27 FOW WITHIN THE FEDERAL CHANNEL AND OVERALL DREDGING DEPTH FOR SEDIMENT MANAGEMENT UNITS OUTSIDE OF THE FEDERAL CHANNEL TO BE DREDGED UNDER THE ENVIRONMENTAL DREDGING SCOPE AS PART OF THE GLLA PROJECT. ALL QUANTITIES AND TARGET REMOVAL DEPTHS ARE SUBJECT TO REFINEMENT DURING THE DESIGN FOR THE SELECTED ALTERNATIVE
7. A DREDGE PLAN FOR AREAS WITHIN AND AROUND BRIDGE ABUTMENT SETBACKS AND DOCKS WILL BE DEVELOPED DURING THE DESIGN PHASE.
5. FOW = FEET OF WATER
FT = FEET
GLLA = GREAT LAKES LEGACY ACT

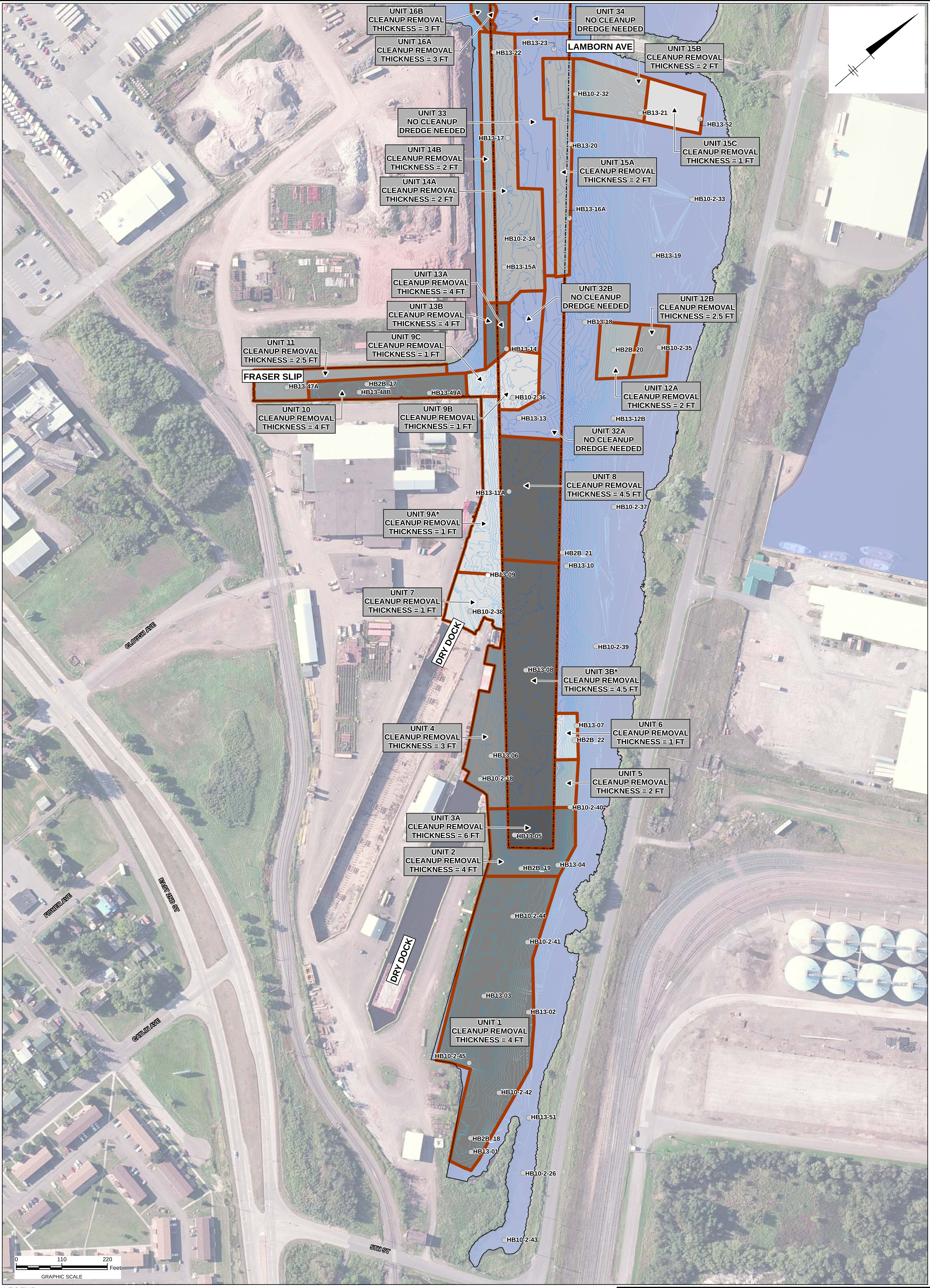
HOWARD'S BAY
SUPERIOR, WISCONSIN

FOCUSED FEASIBILITY STUDY FOR SEDIMENT CLEANUP IN HOWARDS BAY

TARGET REMOVAL DEPTHS FOR REMEDIAL ALTERNATIVE A-1 – AREA 1

ARCADIS

FIGURE
4-3c



LEGEND

- 2013 CORE LOCATION WITH NO RECOVERY
- 2007, 2010, OR 2013 SEDIMENT SAMPLE LOCATION
- FEDERAL CHANNEL
- SHORELINE (APPROXIMATE)
- SEDIMENT MANAGEMENT UNIT

SEDIMENT MANAGEMENT UNIT CLEANUP DREDGE DEPTH (FT)

- 1
- 1.5
- 2
- 2.5
- 3
- 4
- 4.5
- 6
- 7
- 8

NOTES:

1. JULY 6, 2011 IMAGERY PROVIDED BY ESRI IMAGE SERVICE.
2. SAMPLE INFORMATION FROM DATABASES PROVIDED BY WNDR ON MAY 23, 2013.
3. CHANNEL BOUNDARY PROVIDED BY THE US ARMY CORPS OF ENGINEERS - DETROIT DISTRICT HTTP://WWW.LRE.USACE.ARMY.MIL
4. TARGET CLEANUP REMOVAL THICKNESS INCLUDES INCREMENTAL DREDGING DEPTH DEEPER THAN 27 FOW WITHIN THE FEDERAL CHANNEL AND OVERALL DREDGING DEPTH FOR SEDIMENT MANAGEMENT UNITS OUTSIDE OF THE FEDERAL CHANNEL TO BE DREDGED UNDER THE ENVIRONMENTAL DREDGING SCOPE AS PART OF THE GLLA PROJECT. ALL QUANTITIES AND TARGET REMOVAL DEPTHS ARE SUBJECT TO REFINEMENT DURING THE DESIGN FOR THE SELECTED ALTERNATIVE
5. A DREDGE PLAN FOR AREAS WITHIN AND AROUND BRIDGE ABUTMENT SETBACKS AND DOCKS WILL BE DEVELOPED DURING THE DESIGN PHASE.
6. FOW = FEET OF WATER
   FT = FEET
   GLLA = GREAT LAKES LEGACY ACT

HOWARD'S BAY
SUPERIOR, WISCONSIN

FOCUSED FEASIBILITY STUDY FOR SEDIMENT CLEANUP IN HOWARDS BAY

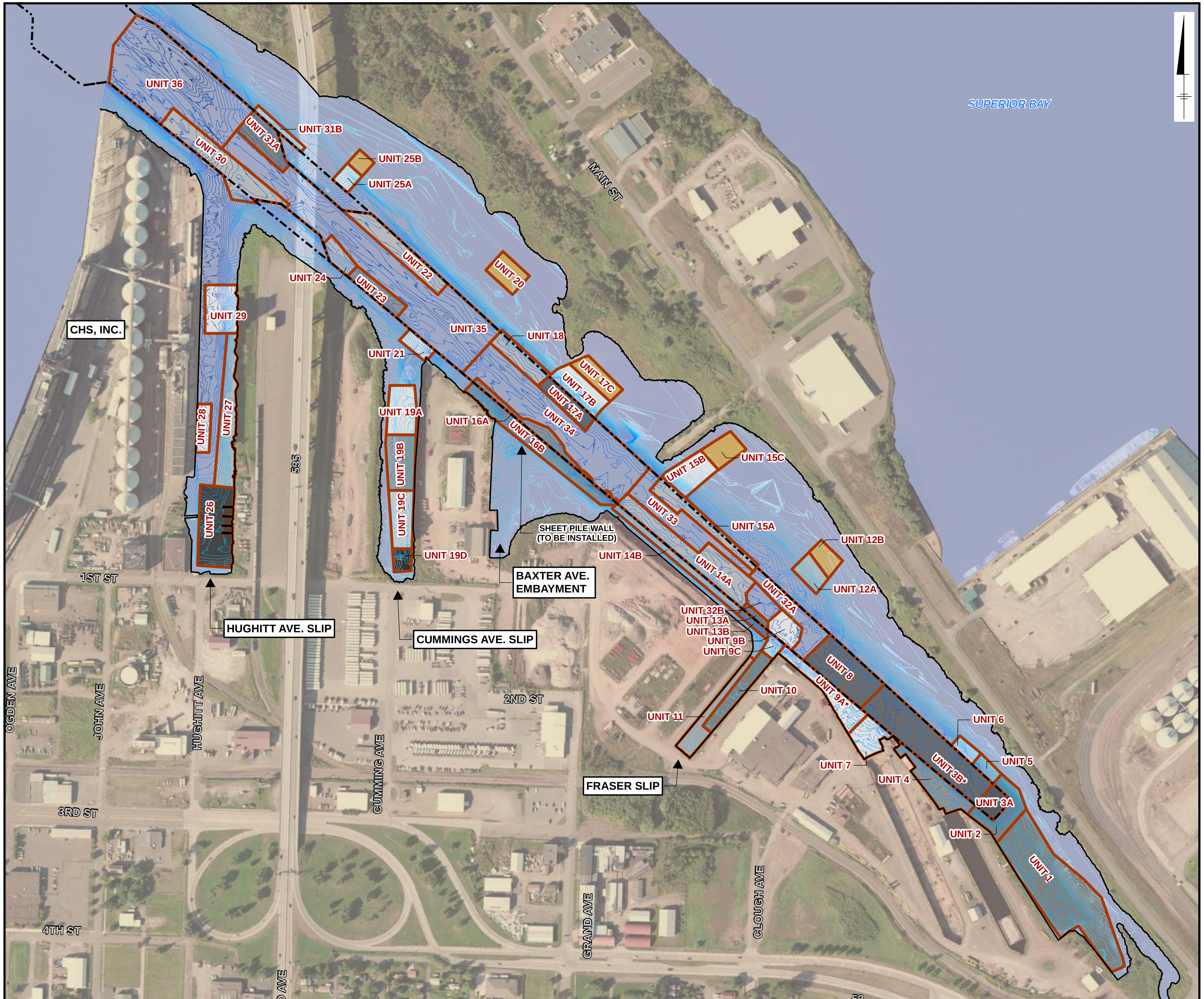
TARGET REMOVAL DEPTHS FOR REMEDIAL ALTERNATIVE A-1 – AREA 2

ARCADIS

FIGURE

4-3d

DRAFT



LEGEND:

- SHORELINE (APPROXIMATE)
- FEDERAL CHANNEL
- SEDIMENT MANAGEMENT UNIT
- ENHANCED NATURAL RECOVERY

CLEANUP DREDGE DEPTH (FT)

- 1
- 1.5
- 2
- 2.5
- 3
- 4
- 4.5
- 6
- 7
- 8

0 400 800 Feet

GRAPHIC SCALE

NOTES:

1. CHANNEL BOUNDARY AND BATHYMETRY PROVIDED BY THE US ARMY CORPS OF ENGINEERS - DETROIT DISTRICT http://www.lre.usace.army.mil
2. REMEDIAL BOUNDARIES ARE SUBJECT TO REFINEMENT DURING THE DESIGN PHASE FOR THE PREFERRED ALTERNATIVE.
3. A DREDGE PLAN FOR AREAS WITHIN AND AROUND BRIDGE ABUTMENT SETBACKS AND DOCKS WILL BE DEVELOPED DURING THE DESIGN PHASE.

HOWARD'S BAY
SUPERIOR, WISCONSIN

FOCUSED FEASIBILITY STUDY FOR SEDIMENT CLEANUP IN HOWARD'S BAY

PROPOSED APPROACH FOR REMEDIAL ALTERNATIVE A-2

ARCADIS

FIGURE **4-4**

City: SYR Div/Group: SWG Created By: J.RAPP Last Saved By: kives
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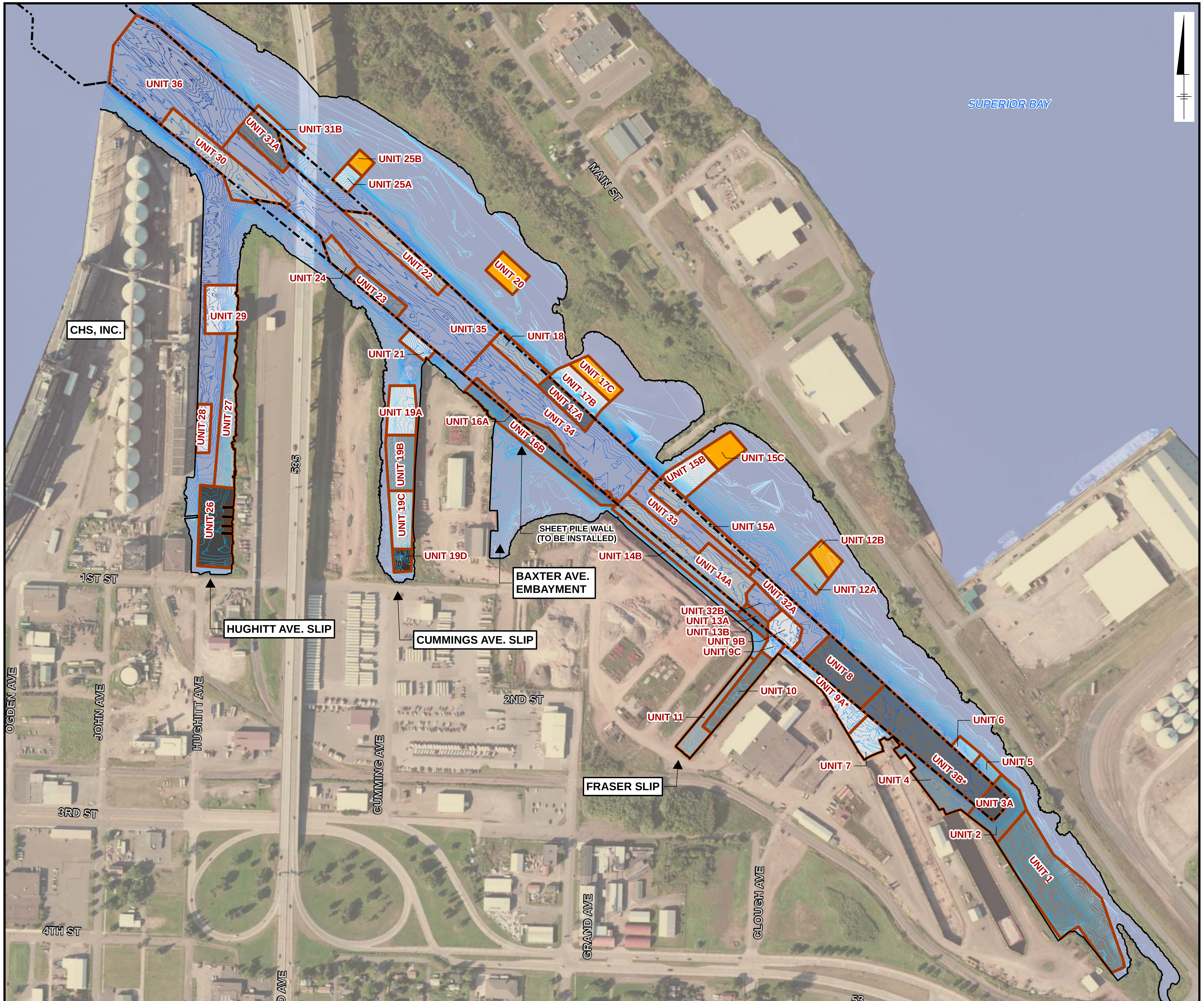

LEGEND:
- SHORELINE (APPROXIMATE)
- FEDERAL CHANNEL
- SEDIMENT MANAGEMENT UNIT
- MONITORED NATURAL RECOVERY

CLEANUP DREDGE DEPTH (FT)
1
1.5
2
2.5
3
4
4.5
6
7
8

0 400 800 Feet
GRAPHIC SCALE

NOTES:
1. CHANNEL BOUNDARY AND BATHYMETRY PROVIDED BY THE US ARMY CORPS OF ENGINEERS - DETROIT DISTRICT http://www.lre.usace.army.mil
2. REMEDIAL BOUNDARIES ARE SUBJECT TO REFINEMENT DURING THE DESIGN PHASE FOR THE PREFERRED ALTERNATIVE.
3. A DREDGE PLAN FOR AREAS WITHIN AND AROUND BRIDGE ABUTMENT SETBACKS AND DOCKS WILL BE DEVELOPED DURING THE DESIGN PHASE.

HOWARD'S BAY
SUPERIOR, WISCONSIN
FOCUSED FEASIBILITY STUDY FOR SEDIMENT CLEANUP IN HOWARD'S BAY

PROPOSED APPROACH FOR REMEDIAL ALTERNATIVE A-3

ARCADIS

FIGURE
4-5

City: SYR Div/Group: SWG Created By: J.RAPP Last Saved By: kives
FRASER SHIPYARD (CI001796.0001.0003)
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City: SYR Div/Group: SWG Created By: K.IVES Last Saved By: kives
FRASER SHIPYARDS
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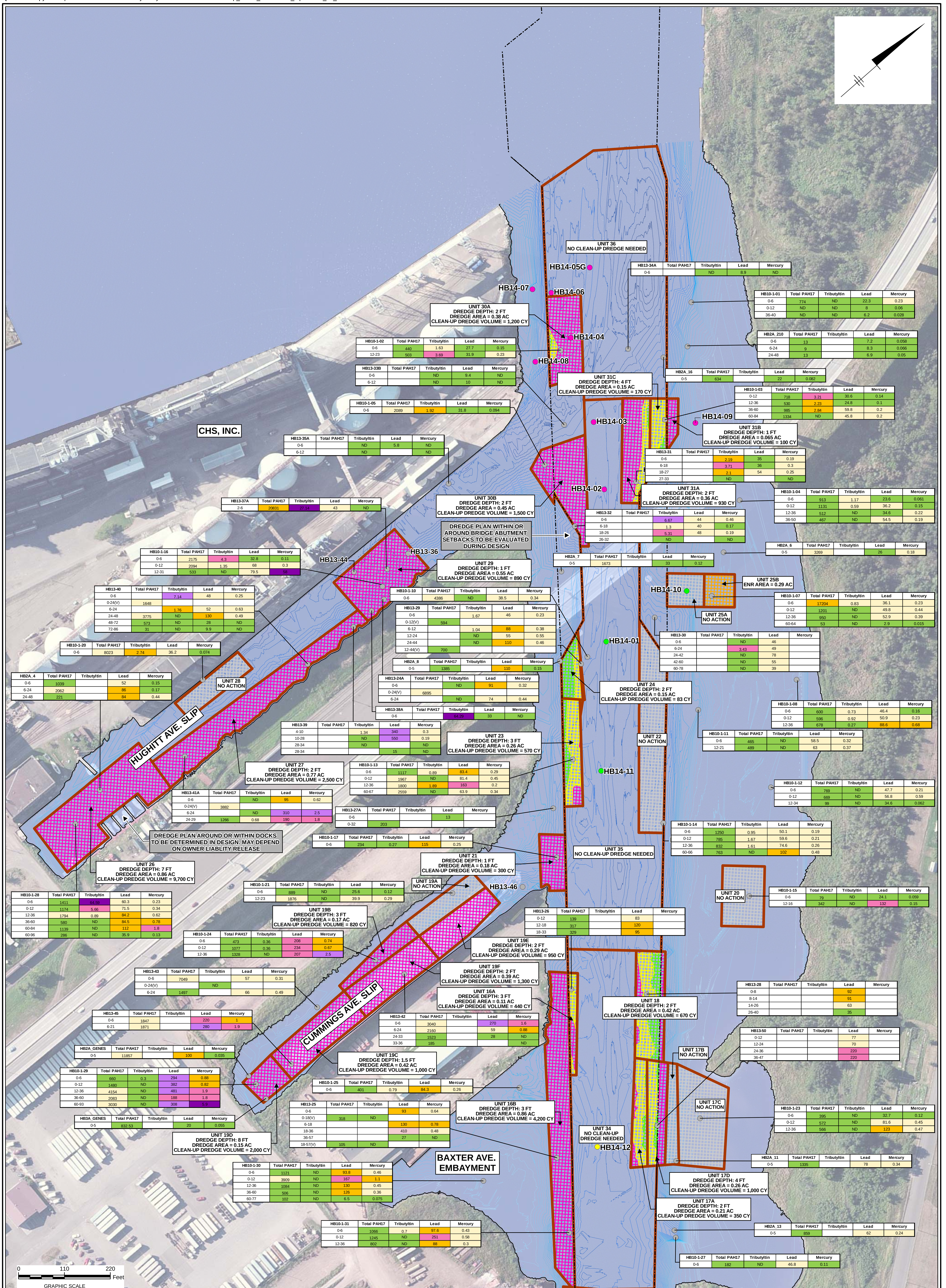

LEGEND
- 2007, 2010, OR 2013 SAMPLE LOCATION
- 2014 CORE LOCATION WITH AT LEAST ONE SAMPLE EXCEEDING THE PEC
- 2014 CORE LOCATION WITH AT LEAST ONE SAMPLE EXCEEDING THE MEC
- 2014 CORE LOCATION MEETING MEC AND PEC
- SHORELINE (APPROXIMATE)
- FEDERAL CHANNEL
- SEDIMENT MANAGEMENT UNIT
- ADDITIONAL CLEAN-UP DREDGE AREA
- STRATEGIC NAVIGATION DREDGE AREA OVERLAPPING CLEAN-UP DREDGE AREA
- STRATEGIC NAVIGATION DREDGE AREA
- NO ACTION
- ENHANCED NATURAL RECOVERY (ENR)

NOTES:
1. JULY 6, 2011 IMAGERY PROVIDED BY ESRI IMAGE SERVICE.
2. SAMPLE INFORMATION FROM DATABASES PROVIDED BY WNDR ON MAY 23, 2013.
3. CHANNEL BOUNDARY PROVIDED BY THE US ARMY CORPS OF ENGINEERS - DETROIT DISTRICT HTTP://WWW.LRE.USACE.ARMY.MIL
4. TOTAL PAHS WERE CALCULATED BY SUM OF 17 PAHS. THE ASSOCIATE VALUE TO NON-DETECT IS ½ REPORTING LIMIT.
5. ORGANIC RESULTS WERE NORMALIZED TO TOC CONTENT PRIOR TO COMPARISON TO THE CRITERIA FOR SAMPLES WITH DETECTED TOC CONTENT GREATER THAN 2 G/KG.
6. 17 TOTAL PAHS WERE CALCULATED BY SUM OF THE FOLLOWING 17 PAHS: 2-METHYLNAPHTHALENE, ACENAPHTHENE, ACENAPHTHYLENE, ANTHRACENE, BENZO(A)ANTHRACENE, BENZO(B)FLUORANTHENE, BENZO(G,H,I)PERYLENE, BENZO(K) FLUORANTHENE, BENZO(A)PYRENE, CHRYSENE, DIBENZ(A,H) ANTHRACENE, FLUORANTHENE, FLUORENE, INDENO(1,2,3-CD)PYRENE, NAPHTHALENE, PHENANTHRENE, AND PYRENE.
7. A DREDGE PLAN FOR AREAS WITHIN AND AROUND BRIDGE ABUTMENT SETBACKS AND DOCKS WILL BE DEVELOPED DURING THE DESIGN PHASE.
8. REMEDIAL BOUNDARIES ARE SUBJECT TO REFINEMENT DURING THE DESIGN PHASE FOR THE PREFERRED ALTERNATIVE
9. AC = ACRES
CY = CUBIC YARDS
FT = FEET
ND = NON-DETECT
V = VERTICALLY COMPOSITE
R = REPLICATE
A = SECOND LOCATION ATTEMPT
B = THIRD LOCATION ATTEMPT
TEC = THRESHOLD EFFECT CONCENTRATION
MEC = MIDPOINT EFFECT CONCENTRATION
PEC = PROBABLE EFFECT CONCENTRATION
µG/KG-OC = MICROGRAM PER KILOGRAM OF SEDIMENT (DRY WEIGHT) NORMALIZED TO TOTAL ORGANIC CARBON AT 1 PERCENT
TOC =TOTAL ORGANIC CARBON
PAH = POLYCYCLIC AROMATIC HYDROCARBONS

Location ID	Total PAH17 (µg/kg-OC)	Tributyltin (µg/kg-OC)	Lead (mg/kg)	Mercury (mg/kg)
Depth (inches)	NA	NA	NA	NA
	<TEC	<TEC	<TEC	<TEC
	≥TEC(1610) <MEC	≥TEC(0.52) <MEC	≥TEC(36) <MEC	≥TEC(0.18) <MEC
	≥MEC(12205) <PEC	≥MEC(1.73) <PEC	≥MEC(83) <PEC	≥MEC(0.64) <PEC
	≥PEC(22800) <2xPEC	≥PEC(2.94) <2xPEC	≥PEC(130) <2xPEC	≥PEC(1.1) <2xPEC
	≥2xPEC(45600) <5xPEC	≥2xPEC(5.88) <5xPEC	≥2xPEC(260) <5xPEC	≥2xPEC(2.2) <5xPEC
	≥5xPEC(114000)	≥5xPEC(14.7)	≥5xPEC(650)	≥5xPEC(5.5)

HOWARD'S BAY
SUPERIOR, WISCONSIN

FOCUSED FEASIBILITY STUDY FOR SEDIMENT CLEANUP IN HOWARDS BAY

REMEDIAL ALTERNATIVE A-4 - AREA 1

ARCADIS

FIGURE
4-6a

City: SYR Div/Group: SWG Created By: K.IVES Last Saved By: kives
FRASER SHIPYARDS
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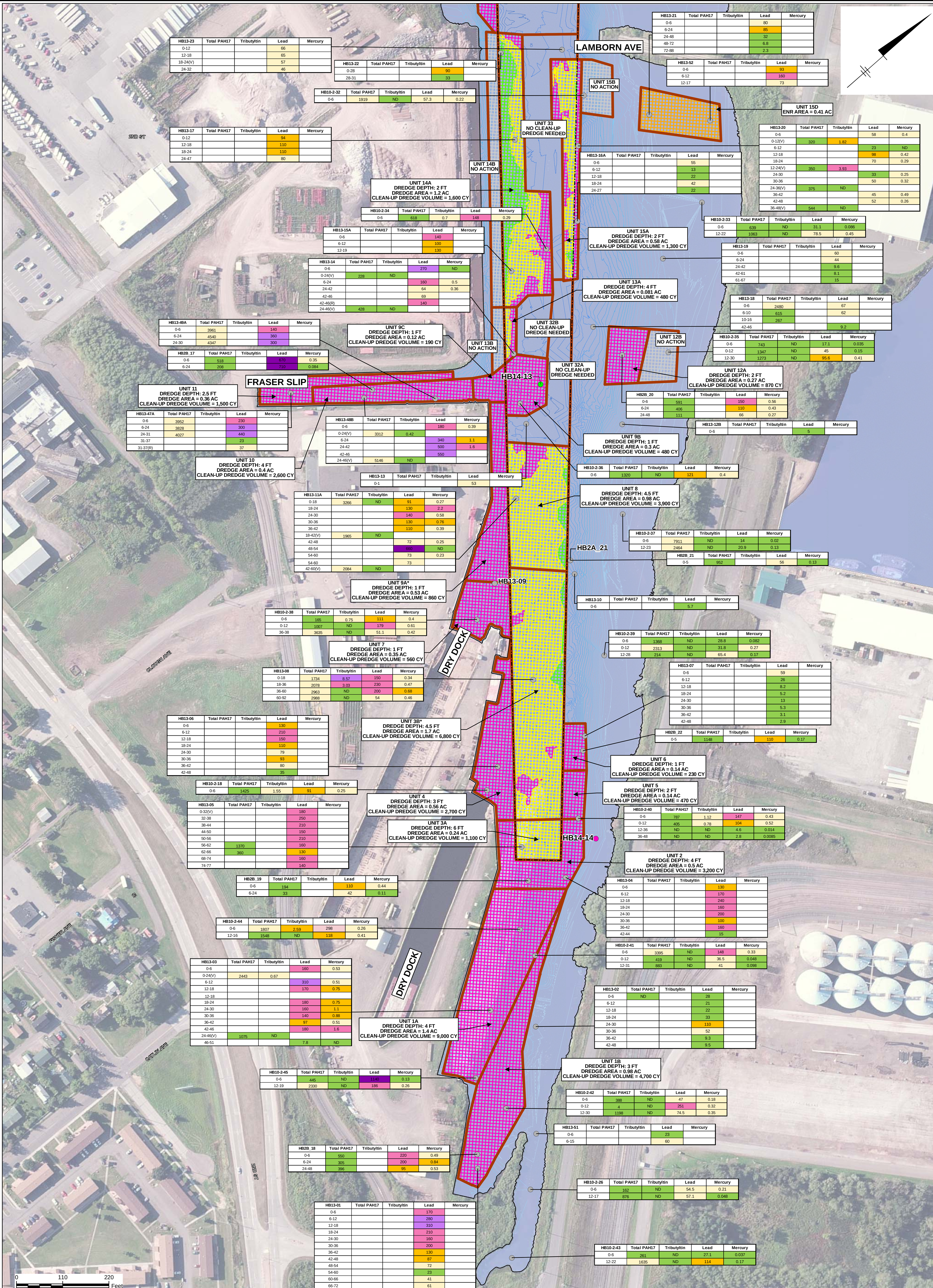


HB13-23	Total PAH17	Tributyltin	Lead	Mercury
0-12			66	
12-18			65	
18-24(V)			57	
24-32			46	

HB13-22	Total PAH17	Tributyltin	Lead	Mercury
0-28			90	
28-31			33	

HB10-2-32	Total PAH17	Tributyltin	Lead	Mercury
0-6	1919	ND	57.3	0.22

HB13-17	Total PAH17	Tributyltin	Lead	Mercury
0-12			94	
12-18			110	
18-24			110	
24-47			80	

HB13-21	Total PAH17	Tributyltin	Lead	Mercury
0-6			80	
6-24			85	
24-48			32	
48-72			6.8	
72-88			2.3	

HB13-52	Total PAH17	Tributyltin	Lead	Mercury
0-6			93	
6-12			160	
12-17			73	

HB13-20	Total PAH17	Tributyltin	Lead	Mercury
0-6			58	0.4
0-12(V)	320	1.82		
6-12			23	ND
12-18			98	0.42
18-24			70	0.29
12-24(V)	350	3.93		
24-30			33	0.25
30-36			50	0.32
24-36(V)	375	ND		
36-42			45	0.49
42-48			52	0.26
36-48(V)	544	ND		

HB13-16A	Total PAH17	Tributyltin	Lead	Mercury
0-6			55	
6-12			13	
12-18			22	
18-24			42	
24-27			22	

HB10-2-33	Total PAH17	Tributyltin	Lead	Mercury
0-6	639	ND	31.1	0.086
12-22	1063	ND	78.5	0.45

HB10-2-34	Total PAH17	Tributyltin	Lead	Mercury
0-6	618	0.7	148	0.29

HB13-15A	Total PAH17	Tributyltin	Lead	Mercury
0-6			140	
6-12			100	
12-19			130	

HB13-19	Total PAH17	Tributyltin	Lead	Mercury
0-6			60	
6-24			44	
24-42			9.6	
42-61			8.1	
61-67			15	

HB13-14	Total PAH17	Tributyltin	Lead	Mercury
0-6			270	ND
0-24(V)	228	ND		
6-24			160	0.5
24-42			64	0.36
42-46			69	
42-46(R)			140	
24-46(V)	428	ND		

HB13-18	Total PAH17	Tributyltin	Lead	Mercury
0-6	2480		67	
6-10	615		62	
10-16	267			
42-46			9.2	

HB13-49A	Total PAH17	Tributyltin	Lead	Mercury
0-6	3961		140	
6-24	4540		360	
24-30	4347		300	

HB2B_17	Total PAH17	Tributyltin	Lead	Mercury
0-6	518		670	0.35
6-24	208		710	0.084

HB10-2-35	Total PAH17	Tributyltin	Lead	Mercury
0-6	743	ND	17.1	0.035
0-12	1347	ND	45	0.15
12-30	1273	ND	95.6	0.41

HB2B_20	Total PAH17	Tributyltin	Lead	Mercury
0-6	591		150	0.56
6-24	406		110	0.43
24-48	111		66	0.27

HB13-12B	Total PAH17	Tributyltin	Lead	Mercury
0-6			5	

HB13-47A	Total PAH17	Tributyltin	Lead	Mercury
0-6	3952		230	
6-24	3828		300	
24-31	4027		440	
31-37			23	
31-37(R)			37	

HB13-48B	Total PAH17	Tributyltin	Lead	Mercury
0-6			180	0.39
0-24(V)	3312	0.42		
6-24			340	1.1
24-42			500	1.6
42-46			550	
24-46(V)	5146	ND		

HB10-2-36	Total PAH17	Tributyltin	Lead	Mercury
0-6	1320	ND	121	0.4

HB13-13	Total PAH17	Tributyltin	Lead	Mercury
0-1			53	

HB13-11A	Total PAH17	Tributyltin	Lead	Mercury
0-18	3266	ND	91	0.27
18-24			130	2.2
24-30			140	0.58
30-36			130	0.76
36-42			110	0.39
18-42(V)	1965	ND		
42-48			72	0.25
48-54			660	ND
54-60			73	0.23
54-60			73	
42-60(V)	2084	ND		

HB10-2-37	Total PAH17	Tributyltin	Lead	Mercury
0-6	7911	ND	14	0.02
12-23	2464	ND	20.9	0.13

HB2B_21	Total PAH17	Tributyltin	Lead	Mercury
0-5	952		56	0.13

HB13-10	Total PAH17	Tributyltin	Lead	Mercury
0-6			5.7	

HB10-2-38	Total PAH17	Tributyltin	Lead	Mercury
0-6	165	0.75	111	0.4
0-12	1007	ND	179	0.61
36-38	3635	ND	51.1	0.42

HB10-2-39	Total PAH17	Tributyltin	Lead	Mercury
0-6	1368	ND	28.8	0.082
0-12	2313	ND	31.8	0.27
12-28	214	ND	65.4	0.17

HB13-07	Total PAH17	Tributyltin	Lead	Mercury
0-6			59	
6-12			26	
12-18			8.2	
18-24			5.2	
24-30			13	
30-36			5.3	
36-42			3.1	
42-48			2.9	

HB13-08	Total PAH17	Tributyltin	Lead	Mercury
0-18	1734	6.57	150	0.34
18-36	2078	3.03	230	0.47
36-60	2963	ND	200	0.68
60-92	2988	ND	54	0.46

HB13-06	Total PAH17	Tributyltin	Lead	Mercury
0-6			130	
6-12			210	
12-18			150	
18-24			110	
24-30			79	
30-36			93	
36-42			80	
42-48			35	

HB2B_22	Total PAH17	Tributyltin	Lead	Mercury
0-5	1148		110	0.17

HB10-2-18	Total PAH17	Tributyltin	Lead	Mercury
0-6	1425	1.55	91	0.25

HB13-05	Total PAH17	Tributyltin	Lead	Mercury
0-32(V)			180	
32-38			250	
38-44			210	
44-50			150	
50-56			210	
56-62	1370		180	
62-66	360		130	
68-74			160	
74-77			140	

HB10-2-40	Total PAH17	Tributyltin	Lead	Mercury
0-6	787	1.12	147	0.43
0-12	405	0.78	104	0.52
12-36	ND	ND	4.6	0.014
36-48	ND	ND	2.8	0.0085

HB2B_19	Total PAH17	Tributyltin	Lead	Mercury
0-6	194		110	0.44
6-24	33		42	0.11

HB13-04	Total PAH17	Tributyltin	Lead	Mercury
0-6			130	
6-12			170	
12-18			240	
18-24			160	
24-30			200	
30-36			100	
36-42			160	
42-44			15	

HB10-2-44	Total PAH17	Tributyltin	Lead	Mercury
0-6	1807	2.59	298	0.26
12-16	1548	ND	118	0.41

HB10-2-41	Total PAH17	Tributyltin	Lead	Mercury
0-6	3395	ND	148	0.33
0-12	419	ND	36.5	0.048
12-31	883	ND	41	0.098

HB13-03	Total PAH17	Tributyltin	Lead	Mercury
0-6			160	0.53
0-24(V)	2443	0.67		
6-12			310	0.51
12-18			170	0.75
12-18				
18-24			180	0.75
24-30			160	1.1
30-36			140	0.88
36-42			97	0.51
42-46			180	1.6
24-46(V)	1075	ND		
46-51			7.8	ND

HB13-02	Total PAH17	Tributyltin	Lead	Mercury
0-6	ND		28	
6-12			21	
12-18			22	
18-24			33	
24-30			110	
30-36			52	
36-42			9.3	
42-48			9.5	

HB10-2-45	Total PAH17	Tributyltin	Lead	Mercury
0-6	445	ND	1140	0.13
12-19	2330	ND	186	0.26

HB10-2-42	Total PAH17	Tributyltin	Lead	Mercury
0-6	388	ND	47	0.18
0-12	4	ND	251	0.32
12-30	1198	ND	74.5	0.35

HB13-51	Total PAH17	Tributyltin	Lead	Mercury
0-6			23	
6-15			60	

HB2B_18	Total PAH17	Tributyltin	Lead	Mercury
0-6	550		220	0.49
6-24	305		200	0.84
24-48	396		95	0.53

HB10-2-26	Total PAH17	Tributyltin	Lead	Mercury
0-6	162	ND	54.5	0.21
12-17	876	ND	57.1	0.048

HB13-01	Total PAH17	Tributyltin	Lead	Mercury
0-6			170	
6-12			280	
12-18			310	
18-24			210	
24-30			160	
30-36			200	
36-42			130	
42-48			87	
48-54			72	
54-60			23	
60-66			41	
66-72			61	
72-74			34	

HB10-2-43	Total PAH17	Tributyltin	Lead	Mercury
0-6	261	ND	27.1	0.037
12-22	1635	ND	114	0.17

LEGEND

- 2007, 2010, OR 2013 SAMPLE LOCATION
- 2014 CORE LOCATION WITH AT LEAST ONE SAMPLE EXCEEDING THE PEC
- 2014 CORE LOCATION MEETING MEC AND PEC
- SHORELINE (APPROXIMATE)
- FEDERAL CHANNEL
- SEDIMENT MANAGEMENT UNIT
- ADDITIONAL CLEAN-UP DREDGE AREA
- STRATEGIC NAVIGATION DREDGE AREA OVERLAPPING CLEAN-UP DREDGE AREA
- STRATEGIC NAVIGATION DREDGE AREA
- NO ACTION
- ENHANCED NATURAL RECOVERY (ENR)

NOTES:

1. JULY 6, 2011 IMAGERY PROVIDED BY ESRI IMAGE SERVICE.
2. SAMPLE INFORMATION FROM DATABASES PROVIDED BY WNDR ON MAY 23, 2013.
3. CHANNEL BOUNDARY PROVIDED BY THE US ARMY CORPS OF ENGINEERS - DETROIT DISTRICT HTTP://WWW.LRE.USACE.ARMY.MIL
4. TOTAL PAHS WERE CALCULATED BY SUM OF 17 PAHS. THE ASSOCIATE VALUE TO NON-DETECT IS ½ REPORTING LIMIT.
5. ORGANIC RESULTS WERE NORMALIZED TO TOC CONTENT PRIOR TO COMPARISON TO THE CRITERIA FOR SAMPLES WITH DETECTED TOC CONTENT GREATER THAN 2 G/KG.
6. * = FINAL REMOVAL DEPTH TO BE DETERMINED BASED ON FIELD OBSERVATION AS TO PRESENCE OF SEDIMENT AND/OR SAMPLING FOR LEAD CONCENTRATIONS
7. 17 TOTAL PAHS WERE CALCULATED BY SUM OF THE FOLLOWING 17 PAHS: 2-METHYLNAPHTHALENE, ACENAPHTHENE, ACENAPHTHYLENE, ANTHRACENE, BENZO(A)ANTHRACENE, BENZO(B)FLUORANTHENE, BENZO(G,H,I)PERYLENE, BENZO(K) FLUORANTHENE, BENZO(A)PYRENE, CHRYSENE, DIBENZ(A,H) ANTHRACENE, FLUORANTHENE, FLUORENE, INDENO(1,2,3-CD)PYRENE, NAPHTHALENE, PHENANTHRENE, AND PYRENE.
8. A DREDGE PLAN FOR AREAS WITHIN AND AROUND BRIDGE ABUTMENT SETBACKS AND DOCKS WILL BE DEVELOPED DURING THE DESIGN PHASE.
9. MODEL BOUNDARIES ARE SUBJECT TO REFINEMENT DURING THE DESIGN PHASE FOR THE PREFERRED ALTERNATIVE
10. AC = ACRES
CY = CUBIC YARDS
FT = FEET
ND = NON-DETECT
V = VERTICALLY COMPOSITE
R = REPLICATE
A = SECOND LOCATION ATTEMPT
B = THIRD LOCATION ATTEMPT
TEC = THRESHOLD EFFECT CONCENTRATION
MEC = MIDPOINT EFFECT CONCENTRATION
PEC = PROBABLE EFFECT CONCENTRATION
µG/KG-OC = MICROGRAM PER KILOGRAM OF SEDIMENT (DRY WEIGHT) NORMALIZED TO TOTAL ORGANIC CARBON AT 1 PERCENT
TOC =TOTAL ORGANIC CARBON
PAH = POLYCYCLIC AROMATIC HYDROCARBONS

Location ID	Total PAH17 (µg/kg-OC)	Tributyltin (µg/kg-OC)	Lead (mg/kg)	Mercury (mg/kg)
Depth (inches)	NA	NA	NA	NA
	<TEC	<TEC	<TEC	<TEC
	≥TEC(1610) <MEC	≥TEC(0.52) <MEC	≥TEC(36) <MEC	≥TEC(0.18) <MEC
	≥MEC(12205) <PEC	≥MEC(1.73) <PEC	≥MEC(83) <PEC	≥MEC(0.64) <PEC
	≥PEC(22800) <2xPEC	≥PEC(2.94) <2xPEC	≥PEC(130) <2xPEC	≥PEC(1.1) <2xPEC
	≥2xPEC(45600) <5xPEC	≥2xPEC(5.88) <5xPEC	≥2xPEC(260) <5xPEC	≥2xPEC(2.2) <5xPEC
	≥5xPEC(114000)	≥5xPEC(14.7)	≥5xPEC(650)	≥5xPEC(5.5)

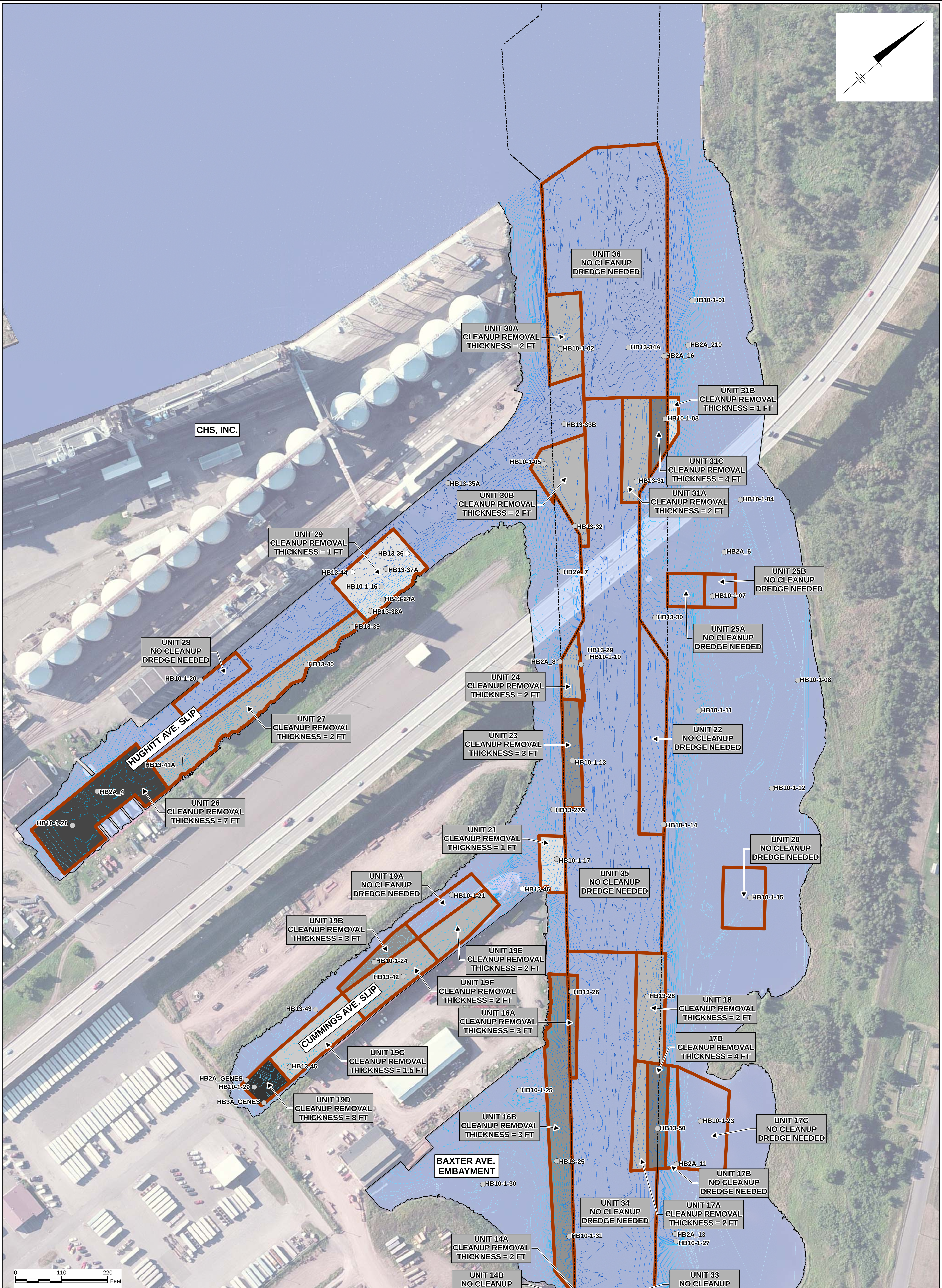
HOWARD'S BAY
SUPERIOR, WISCONSIN

FOCUSED FEASIBILITY STUDY FOR SEDIMENT CLEANUP IN HOWARDS BAY

REMEDIAL ALTERNATIVE A-4 - AREA 2

ARCADIS

FIGURE
4-6b



LEGEND

- 2007, 2010, OR 2013 SEDIMENT SAMPLE LOCATION
- 2013 CORE LOCATION WITH NO RECOVERY
- FEDERAL CHANNEL
- SHORELINE (APPROXIMATE)
- SEDIMENT MANAGEMENT UNIT

SEDIMENT MANAGEMENT UNIT CLEANUP DREDGE DEPTH (FT)

- 1
- 1.5
- 2
- 2.5
- 3
- 4
- 4.5
- 6
- 7
- 8

NOTES:

1. JULY 6, 2011 IMAGERY PROVIDED BY ESRI IMAGE SERVICE.
2. SAMPLE INFORMATION FROM DATABASES PROVIDED BY WNDR ON MAY 23, 2013.
3. CHANNEL BOUNDARY PROVIDED BY THE US ARMY CORPS OF ENGINEERS - DETROIT DISTRICT HTTP://WWW.LRE.USACE.ARMY.MIL
4. TARGET CLEANUP REMOVAL THICKNESS INCLUDES INCREMENTAL DREDGING DEPTH DEEPER THAN 27 FOW WITHIN THE FEDERAL CHANNEL AND OVERALL DREDGING DEPTH FOR SEDIMENT MANAGEMENT UNITS OUTSIDE OF THE FEDERAL CHANNEL TO BE DREDGED UNDER THE ENVIRONMENTAL DREDGING SCOPE AS PART OF THE GLLA PROJECT. ALL QUANTITIES AND TARGET REMOVAL DEPTHS ARE SUBJECT TO REFINEMENT DURING THE DESIGN FOR THE SELECTED ALTERNATIVE
5. A DREDGE PLAN FOR AREAS WITHIN AND AROUND BRIDGE ABUTMENT SETBACKS AND DOCKS WILL BE DEVELOPED DURING THE DESIGN PHASE.
6. FOW = FEET OF WATER
   FT = FEET
   GLLA = GREAT LAKES LEGACY ACT

HOWARD'S BAY
SUPERIOR, WISCONSIN

FOCUSED FEASIBILITY STUDY FOR SEDIMENT CLEANUP IN HOWARDS BAY

TARGET REMOVAL DEPTHS FOR REMEDIAL ALTERNATIVE A-4 – AREA 1

ARCADIS

FIGURE
4-6c

City: SYR Div/Group: SWG   Created By: K.IVES Last Saved By: kives
FRASER SHIPYARDS
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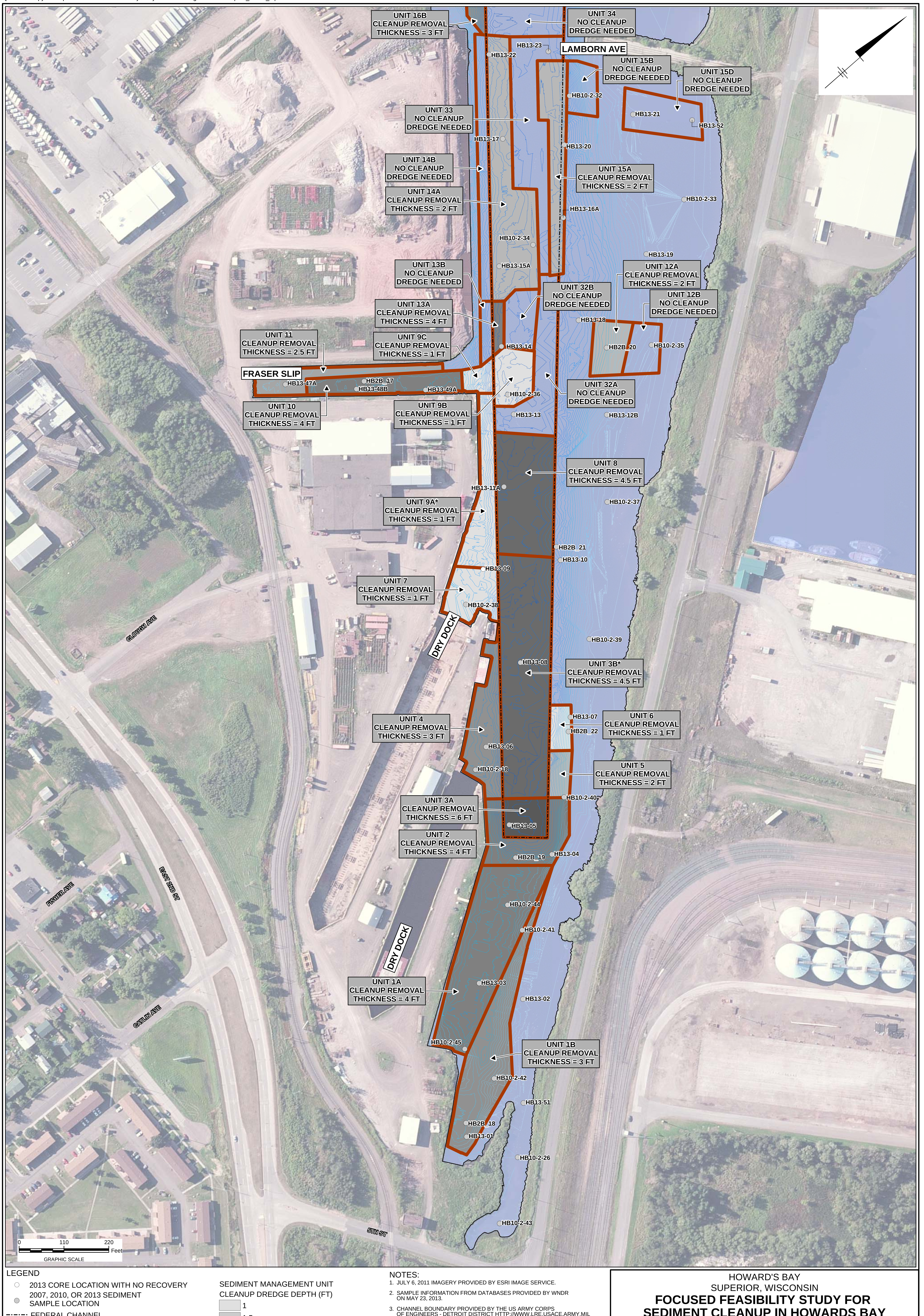

LEGEND

- 2013 CORE LOCATION WITH NO RECOVERY
- 2007, 2010, OR 2013 SEDIMENT SAMPLE LOCATION
- FEDERAL CHANNEL
- SHORELINE (APPROXIMATE)
- SEDIMENT MANAGEMENT UNIT

SEDIMENT MANAGEMENT UNIT CLEANUP DREDGE DEPTH (FT)

- 1
- 1.5
- 2
- 2.5
- 3
- 4
- 4.5
- 6
- 7
- 8

NOTES:

1. JULY 6, 2011 IMAGERY PROVIDED BY ESRI IMAGE SERVICE.
2. SAMPLE INFORMATION FROM DATABASES PROVIDED BY WNDR ON MAY 23, 2013.
3. CHANNEL BOUNDARY PROVIDED BY THE US ARMY CORPS OF ENGINEERS - DETROIT DISTRICT HTTP://WWW.LRE.USACE.ARMY.MIL
4. TARGET CLEANUP REMOVAL THICKNESS INCLUDES INCREMENTAL DREDGING DEPTH DEEPER THAN 27 FOW WITHIN THE FEDERAL CHANNEL AND OVERALL DREDGING DEPTH FOR SEDIMENT MANAGEMENT UNITS OUTSIDE OF THE FEDERAL CHANNEL TO BE DREDGED UNDER THE ENVIRONMENTAL DREDGING SCOPE AS PART OF THE GLLA PROJECT. ALL QUANTITIES AND TARGET REMOVAL DEPTHS ARE SUBJECT TO REFINEMENT DURING THE DESIGN FOR THE SELECTED ALTERNATIVE
5. A DREDGE PLAN FOR AREAS WITHIN AND AROUND BRIDGE ABUTMENT SETBACKS AND DOCKS WILL BE DEVELOPED DURING THE DESIGN PHASE.
6. FOW = FEET OF WATER
   FT = FEET
   GLLA = GREAT LAKES LEGACY ACT

HOWARD'S BAY
SUPERIOR, WISCONSIN

FOCUSED FEASIBILITY STUDY FOR SEDIMENT CLEANUP IN HOWARDS BAY

TARGET REMOVAL DEPTHS FOR REMEDIAL ALTERNATIVE A-4 – AREA 2

ARCADIS

FIGURE
4-6d

DRAFT

LEGEND:

- SHORELINE (APPROXIMATE)
- FEDERAL CHANNEL
- SEDIMENT MANAGEMENT UNIT
- PARTIAL DREDGE/ISOLATION CAP
- ENHANCED NATURAL RECOVERY

CLEANUP DREDGE DEPTH (FT)

- 1
- 1.5
- 2
- 2.5
- 3
- 4
- 4.5
- 6
- 7
- 8

0 400 800 Feet

GRAPHIC SCALE

NOTES:

1. CHANNEL BOUNDARY AND BATHYMETRY PROVIDED BY THE US ARMY CORPS OF ENGINEERS - DETROIT DISTRICT http://www.lre.usace.army.mil
2. REMEDIAL BOUNDARIES ARE SUBJECT TO REFINEMENT DURING THE DESIGN PHASE FOR THE PREFERRED ALTERNATIVE.
3. A DREDGE PLAN FOR AREAS WITHIN AND AROUND BRIDGE ABUTMENT SETBACKS AND DOCKS WILL BE DEVELOPED DURING THE DESIGN PHASE.

HOWARD'S BAY
SUPERIOR, WISCONSIN

FOCUSED FEASIBILITY STUDY FOR SEDIMENT CLEANUP IN HOWARD'S BAY

PROPOSED APPROACH FOR REMEDIAL ALTERNATIVE B-1

ARCADIS

FIGURE **4-7**

City: SYR Div/Group: SWG Created By: J.RAPP Last Saved By: kives
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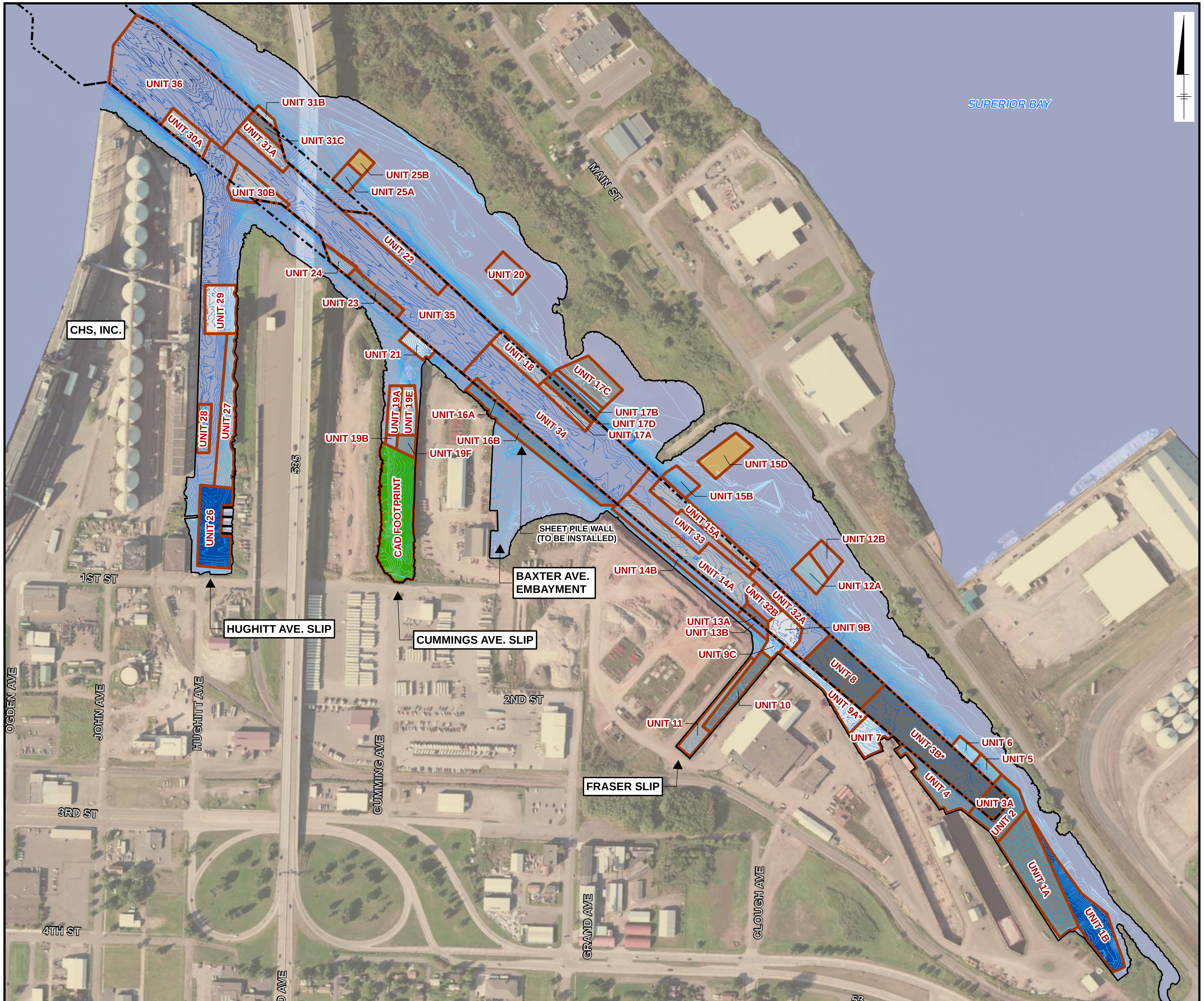

LEGEND:

- SHORELINE (APPROXIMATE)
- FEDERAL CHANNEL
- SEDIMENT MANAGEMENT UNIT
- CONFINED AQUATIC DISPOSAL TO CREATE WETLANDS (CAD)
- ENHANCED NATURAL RECOVERY (ENR)
- CAP AREA
- PARTIAL DREDGE/ISOLATION CAP

CLEANUP DREDGE DEPTH (FT)

- 1
- 1.5
- 2
- 2.5
- 3
- 4
- 4.5
- 6
- 7
- 8

0 400 800 Feet

GRAPHIC SCALE

NOTES:

1. CHANNEL BOUNDARY AND BATHYMETRY PROVIDED BY THE US ARMY CORPS OF ENGINEERS - DETROIT DISTRICT http://www.lre.usace.army.mil
2. REMEDIAL BOUNDARIES ARE SUBJECT TO REFINEMENT DURING THE DESIGN PHASE FOR THE PREFERRED ALTERNATIVE.
3. A DREDGE PLAN FOR AREAS WITHIN AND AROUND BRIDGE ABUTMENT SETBACKS AND DOCKS WILL BE DEVELOPED DURING THE DESIGN PHASE.

HOWARD'S BAY
SUPERIOR, WISCONSIN

FOCUSED FEASIBILITY STUDY FOR SEDIMENT CLEANUP IN HOWARD'S BAY

PROPOSED APPROACH FOR REMEDIAL ALTERNATIVE B-2

ARCADIS

FIGURE **4-8**

City: SYR Div/Group: SWG Created By: J.RAPP Last Saved By: kives
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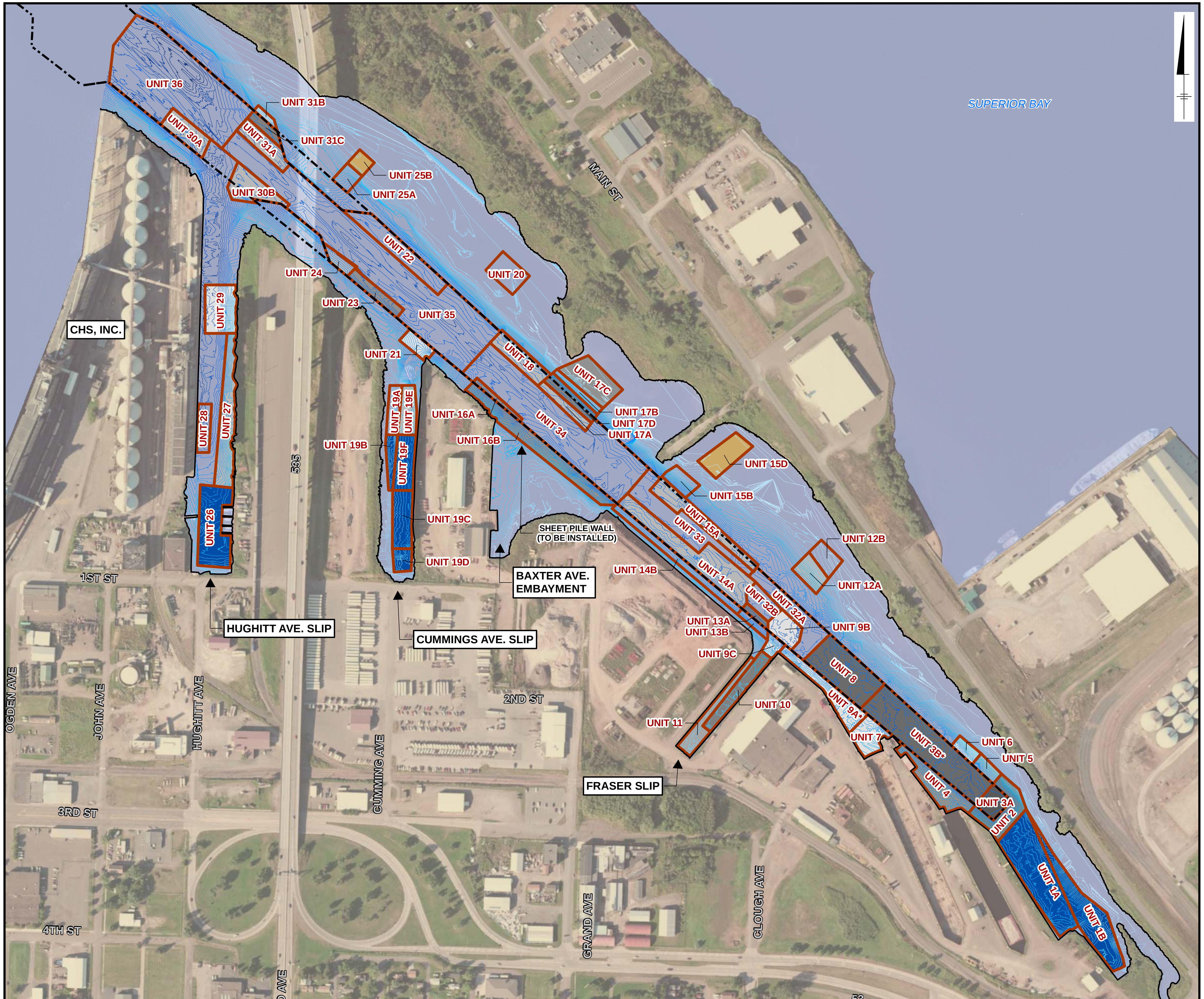

LEGEND:

- SHORELINE (APPROXIMATE)
- FEDERAL CHANNEL
- SEDIMENT MANAGEMENT UNIT
- ENHANCED NATURAL RECOVERY (ENR)
- PARTIAL DREDGE/ISOLATION CAP

CLEANUP DREDGE DEPTH (FT)

- 1
- 1.5
- 2
- 2.5
- 3
- 4
- 4.5
- 6
- 7
- 8

0 400 800 Feet

GRAPHIC SCALE

NOTES:

1. CHANNEL BOUNDARY AND BATHYMETRY PROVIDED BY THE US ARMY CORPS OF ENGINEERS - DETROIT DISTRICT http://www.lre.usace.army.mil
2. REMEDIAL BOUNDARIES ARE SUBJECT TO REFINEMENT DURING THE DESIGN PHASE FOR THE PREFERRED ALTERNATIVE.
3. A DREDGE PLAN FOR AREAS WITHIN AND AROUND BRIDGE ABUTMENT SETBACKS AND DOCKS WILL BE DEVELOPED DURING THE DESIGN PHASE.

HOWARD'S BAY
SUPERIOR, WISCONSIN

FOCUSED FEASIBILITY STUDY FOR SEDIMENT CLEANUP IN HOWARD'S BAY

PROPOSED APPROACH FOR REMEDIAL ALTERNATIVE B-3

ARCADIS

FIGURE **4-9**

City: SYR Div/Group: SWG Created By: J.RAPP Last Saved By: kives
FRASER SHIPYARD (CI001796.0001.0003)
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