Draft

Alternative Menominee River Sediment Removal Plan

Prepared for

Tyco Fire Products LP

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CH2MHILL®

Alternative Menominee River Sediment Removal Plan

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Acronyms and Abbreviations

AMRSRP	Alternative Menominee River Sediment Removal Plan
AOC	Administrative Order on Consent
BMP	best management practice
BWGWP	*Barrier Wall Groundwater Monitoring Plan*
CAA	Clean Air Act
CWA	Clean Water Act
gpd	gallons per day
gpm	gallons per minute
GPS	global positioning system
GWCT	groundwater collection and treatment
LWD	low water datum
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MNR	monitored natural recovery
ppm	parts per million
RCRA	Resource Conservation and Recovery Act
SESC	soil erosion and sediment control
SRWP	sediment removal work plan
TCLP	toxicity characteristic leaching procedure
TSS	total suspended solids
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
VBW	vertical barrier wall
WDNR	Wisconsin Department of Natural Resources
yd^3	cubic yards

SECTION 1

Introduction

This Alternative Menominee River Sediment Removal Plan (AMRSRP) is provided as permitted by the Administrative Order on Consent (AOC) between Tyco Fire Products LP (Tyco) and the U.S. Environmental Protection Agency (USEPA), dated February 26, 2009, and has been prepared in accordance with Section VI, Item 11, paragraph f (Page 8) of the AOC. In accordance with the AOC, Menomonee River sediments will be removed from the area adjacent to the northern boundary of the Tyco facility (Figure 1) that have concentrations equal to or greater than 50 milligrams per kilogram (mg/kg) total arsenic. More specifically, the AOC addresses contamination present at the Tyco Fire Products LP manufacturing facility in Marinette, Wisconsin (hereafter referred to as the "site" or "facility") and states that Tyco "will remove from the river all soft sediments and semi-consolidated sands and silts which contain arsenic concentrations greater than or equal to 50 ppm [parts per million][1] of arsenic. Soft sediments are those sediments that overlay more consolidated materials (i.e., semi-consolidated [sands and] silts, lacustrine clays, glacial till, and bedrock). The depth of removal will not exceed the top of the glacial till layer." A conceptual depiction of the sediment and material beneath the river and the Tyco facility is shown on Figure 2.

In Section VI, 11, paragraph e of the AOC, it is stipulated that Tyco "…will use MNR [monitored natural recovery] to remediate sediments remaining after sediment removal activities to a concentration of 20 ppm of arsenic." If the 20 ppm arsenic concentration is not met within 10 years of completing sediment removal, an MNR alternative plan will be submitted for USEPA's review (at the latest by November 1, 2023) indicating how the 20 ppm threshold will be achieved or how an equivalent level of protection (compared to 20 ppm) will be achieved. For purposes of discussion, the set of activities described in Section VI, 11, paragraphs d and e of the AOC is referred to as the Sediment Removal Work Plan (SRWP) approach (CH2M HILL 2010a).

Section VI, Item 11, paragraph f of the AOC makes allowance for an alternative sediment remediation approach. This alternative approach is detailed in this document and is referred to as the AMRSRP approach. It is The AMRSRP approach is more environmentally protective and cost effective than the SWRP approach as fully detailed in the *Sediment Remediation Work Plans Evaluation letter* dated December 1, 2010—submitted to USEPA and included as Appendix A to this document. The AMRSRP approach also addresses the technological impracticability of the SRWP approach.

For reasons that Tyco does not understand, USEPA insists that the AOC requires that Tyco submit a plan to address the Section VI, 11, paragraph d "dredge only" approach even if Tyco submits an alternative plan under Section VI, 11, paragraph f. Tyco does not agree with USEPA's interpretation, but to avoid unnecessary disagreements, Tyco has submitted the SRWP that addresses the Section VI, 11, paragraph d approach. To be clear, however,

[1] The abbreviation "ppm" refers to "parts per million." This is the terminology used in the AOC. Milligrams per kilogram (mg/kg) is the concentration unit used in the rest of this AMRSRP, which is equivalent to ppm.

Tyco is submitting that plan only because it facilitates the analysis and comparison of the SRWP to the AMRSWP. Tyco's proposal is to conduct the AMRSWP approach.

Appendix A provides the details necessary to support implementation of the AMRSRP approach. The major points are summarized below:

- Approximately 5,000 cubic yards of contaminated semi-consolidated sands and silt (the "semi-consolidated material") with arsenic concentrations significantly greater than 50 mg/kg to be removed under the SRWP approach makes the SRWP technically impracticable because this material provides necessary structural support for the existing sheet pile barrier wall that was installed to contain contamination beneath the onshore Tyco facility. The AMRSRP approach leaves this material in place and caps it, maintaining sheet pile stability.
- The AMRSRP approach eliminates an environmental risk from dredging the semi-consolidated material, which will release total and dissolved arsenic at levels that are likely to endanger ecological receptors in the Menominee River near to and downstream of the dredging areas during the period of dredging.
- Implementation of the SRWP approach is estimated to cost between $23.7 million and $50.8 million. Implementation of the AMRSRP approach is estimated to cost between $11.7 million and $25.1 million. Thus, the more environmentally protective AMRSRP approach can be implemented for half of the cost of the AOC-specified (SRWP) remedy.
- The AMRSRP approach protects human health and the environment by removing soft sediment with arsenic concentrations greater than or equal to 50 mg/kg and by capping semi-consolidated material with concentrations greater than or equal to 50 mg/kg. Capping and in-place containment of the semi-consolidated material is more environmentally protective in the short term as compared to the dredging of these materials included in the SRWP approach because it caps the semi-consolidated material and provides ongoing and immediate protection to the Menominee River fisheries and other ecological receptors.

This AMRSRP focuses on discussion of the AMRSRP approach, and does not repeat the discussion of current site conditions, analytical data, or similar items found in the SRWP (CH2M HILL 2010a).

1.1 Project Background

The background information including site description and history, previous facility investigations (including analytical data collected in 2010), sediment investigations and corrective actions, and a description of the overall site model (Figure 2) are included in the SRWP (CH2M HILL 2010a).

1.2 Project Objectives

Some components of the SRWP and AMRSRP approaches are similar, but the difference between the two approaches is that in the AMRSRP approach, none of the semi-consolidated material will be excavated. Instead, it will be capped in place. The cap placed for the semi-consolidated material will meet the following objectives:

- Be more protective of human health and the environment than removal of the semi-consolidated material
- Provide a barrier between the contaminated semi-consolidated material and benthic organisms

1.3 Proposed AMRSRP Corrective Action Plan for Semi-Consolidated Material

The AMRSRP approach is outlined below, including the components that are identical to those outlined in the SRWP approach.

Tyco will implement a dredging, stabilization, disposal, and capping corrective action (AMRSRP approach), which will consist of four phases. The elements involved in each phase are provided below. The AMRSRP design drawings in Appendix B provide additional details regarding the corrective activities.

- **Phase I (Mechanical Dredging of Contaminated Soft Sediment)** Implementation of Phase I is identical to Phase I of the SRWP. The soft sediment that contains total arsenic contamination in excess of 50 mg/kg will be mechanically dredged using an environmental clamshell bucket and stabilized onsite. The stabilization process will reduce the concentration of leachable arsenic in the sediment such that it passes the toxicity characteristic leaching procedure (TCLP) test with less than 5 milligrams per liter (mg/L) of total arsenic. The stabilized soft sediment will then be disposed offsite at a Resource Conservation and Recovery Act (RCRA) Subtitle D (nonhazardous) landfill.
- **Phase II (Capping of Semi-Consolidated Material)** A cap will be installed over the contaminated semi-consolidated material left in place. Specific details regarding the design of the cap are included in Section 4.10.1. The cross section locations are indicated on Figure 3, and Figure 4 is a cross-section showing the profile in the river after dredging of the soft sediments and placement of the cap over the semi-consolidated material. The lateral area that is to receive a cap is shown on the drawings in Appendix B.
- **Phase III (Dry Excavation of Soft Sediment from the South Channel)** Implementation of Phase III is identical to Phase III of the SRWP. Sheet piling will be installed at the western end of the South Channel, and water inside the temporary enclosure will be pumped out. Depending upon water levels in the river, a culvert on the eastern end of the channel may need to be blocked temporarily as well. Conventional excavation equipment (such as backhoes and articulated haulers) will be used to stabilize the soft sediment in situ, excavate it, and transport it back to the facility for disposal offsite at an RCRA Subtitle D landfill.
- **Phase IV (Monitoring Natural Recovery)** Sediment containing arsenic at concentrations between 20 and 50 mg/kg will be left in place. The site will be monitored, and within 10 years, a decision will be made as to what actions are necessary to complete the remediation. Monitoring activities will be described under a separate plan.

The AMRSRP activities consist of the following key components:

1.3.1 Pre-Dredging Activities

- Mobilizing equipment and personnel
- Completing minor improvements to the existing asphalt surface in the former Salt Vault area for use as a staging pad
- Demarcating roads on the existing asphalt surface for trucks to travel
- Constructing a temporary mooring structure and drip containment along the shoreline of the facility
- Installing a temporary water treatment system and other temporary infrastructure onsite at the facility
- Installing turbidity monitoring equipment in the river
- Clearing and grubbing of trees and vegetation on the City of Marinette-owned property east of the facility and constructing a temporary access road to the South Channel
- Installing sheet piling at the western end of the South Channel to facilitate dry excavation
- Performing a bathymetric survey to document the pre-dredge sediment conditions
- Installing turbidity control devices in the river

1.3.2 Phase I Activities (Mechanical Dredging of Contaminated Soft Sediment)

- Mechanical dredging of approximately 59,000 cubic yards (yd^3) of soft sediment contaminated with arsenic greater than 50 mg/kg using an environmental bucket[2], following best management practices (BMPs), and loading the sediment into watertight scows
- Transporting loaded scows to the mooring area adjacent to the facility
- Pumping free water off the dredged material to the temporary water treatment system
- Offloading dredged material from the scows
- Treating and stabilizing the contaminated dredged material with suitable reagents to reduce leachable arsenic, eliminate free water, and provide moderate strength gain
- Allowing sufficient time for reagents added to sediment to react to meet landfill acceptance criteria
- Conducting sampling and analysis to verify compliance with disposal criteria
- Placing the stabilized sediment into trucks
- Covering the truck bed and decontaminating the exterior of the trucks

[2] "Environmental bucket and best management practices (BMPs) are defined in Section 5.6.1.

- Transporting the sediment to an RCRA Subtitle D landfill
- Collecting and treating wastewater through the temporary water treatment system
- Performing ongoing monitoring activities, including turbidity monitoring in the river, and monitoring of arsenic and suspended solids concentrations in the influent to and effluent from the water treatment system
- Performing a bathymetric survey to document the post-Phase I subsurface elevations

1.3.3 Phase II Activities (Capping of Semi-Consolidated Material)

- Mobilizing equipment necessary specifically for placement of the cap materials
- Placing cap materials over semi-consolidated material with greater than or equal to 50 mg/kg total arsenic
- Performing a bathymetric survey to document the post-Phase II subsurface conditions

1.3.4 Phase III Activities (Dry Excavation of Soft Sediment from the South Channel)

- Mobilizing equipment necessary specifically for Phase III activities
- Pumping free water on top of the sediment to the river until total suspended solids (TSS) exceeds 80 mg/L
- Pumping remaining free water within the sediment to the onsite temporary water treatment system
- Installing well points to facilitate additional dewatering below the top of sediment and pumping this water to the onsite temporary water treatment system
- Stabilizing approximately 12,000 yd^3 of soft sediment contaminated with arsenic greater than 50 mg/kg in situ using an excavator, excavating the stabilized sediment, and loading the sediment into articulated trucks to transport the material back to the stabilization area on the facility (to facilitate handling, cementitious stabilization reagents may be added to the soft sediment before it is transported to the facility)
- Treating and stabilizing the contaminated dredged material with suitable reagents to reduce leachable arsenic, eliminate free water, and provide moderate strength gain
- Allowing sufficient time for reagents added to sediment to react to meet landfill acceptance criteria
- Conducting sampling and analysis to verify compliance with disposal criteria
- Placing the stabilized sediment into trucks
- Covering the truck bed and decontaminating the exterior of the trucks
- Transporting the sediment to an RCRA Subtitle D landfill
- Collecting and treating wastewater through the temporary water treatment system

- Performing ongoing monitoring activities, including turbidity monitoring in the river, monitoring of arsenic and suspended solids concentrations in the influent to and effluent from the water treatment system, and monitoring fugitive dust emissions from the stabilization activities
- Performing confirmation sampling to determine additional remedial measures necessary, if any
- Performing a survey to document the post-Phase III subsurface conditions
- Removing sheet piling and the berm required to provide access for sheet piling installation and removal equipment

1.3.5 Post-Dredging Activities

- Teardown, removing, and offsite disposal of temporary infrastructure built on the Tyco property
- Restoring the Tyco property to pre-corrective action conditions, to the extent practical
- Demobilizing equipment and personnel

1.3.6 Phase IV Activities, Monitoring Natural Recovery

Sediment containing arsenic at concentrations between 20 and 50 mg/kg will be left in place, and MNR will be allowed to occur for a period of 10 years following dredging activities. An MNR plan will be submitted in accordance with the AOC.[3]

[3] "Respondent shall submit the monitoring plans for the monitored natural recovery and barrier wall monitoring 90 days before completion of construction of these components [90 days prior to completion of sediment removal]" per Attachment 2, Section IV.A, 2nd paragraph, of the AOC.

SECTION 2

Corrective Design Components for the AMRSRP Approach

This section summarizes the preliminary technical conditions upon which the AMRSRP approach is based.

2.1 Remedial Investigation Activities

The SRWP contains a full description of historical and 2010 investigation activities. Total arsenic data generated during the 2010 sampling effort were used to depict site conditions and understanding of the nature and extent of contamination and, therefore, to estimate quantities of sediment that require removal. Refer to the SRWP for a discussion of methods used for these quantity estimates (CH2M HILL 2010a).

2.2 Groundwater Model

2.2.1 Development of Existing Model

A three-dimensional groundwater flow model was previously developed for the site to evaluate groundwater conditions after placement of the vertical barrier wall (VBW) that surrounds the facility. The VBW is composed of a sheet pile wall and slurry wall sections (Figure 1) and extends through unconsolidated materials to the top of bedrock (Figure 2). This wall was competed in the fall of 2010. The groundwater model was modified slightly and also used to evaluate the potential effectiveness of capping the semi-consolidated material. This section focuses on aspects of the model that are relevant for the AMRSRP approach.

Regional groundwater flow beneath the facility generally is northeast toward the Menominee River. The direction of groundwater flow will be affected in the vicinity of the facility because of the presence of the VBW. Regional groundwater flow outside of the facility likely will remain generally toward the river but will be diverted around the VBW directly south of the facility.

A groundwater collection and treatment (GWCT) system also was installed in 2010 with the objective of collecting enough groundwater, in conjunction with a phyto-pumping tree plantation, to prevent the water table from rising and flooding the site area encircled by the VBW (Figure 1). Based on site groundwater modeling scenarios, a total groundwater collection flow rate of between 8.5 and 30 gallons per minute (gpm) or an individual well flow rate of 3 to 6 gpm is projected to maintain the groundwater level at the facility below the ground surface.

The groundwater model was used further to evaluate what hydraulic conditions may exist outside the VBW after the VBW is built and the GWCT system is in operation. The main purpose of this effort was to evaluate the potential for continuing discharge of groundwater to the river after the Tyco facility has been enclosed by the VBW. The modeling performed and resulting figures and cross sections generated are included as Appendix C.

This modeling effort was developed without the benefit of hydrogeologic data from under the river, so it was assumed that the bedrock and aquifer properties under the river are the same as the properties found under the Tyco site. Calibration of the model was based on groundwater levels measured in upland areas south of the river. The results of the model have not yet been validated from actual measurements. (See, "Collection of Additional Groundwater Data", below).

Recognizing these limitations, the model was used to simulate two different flow scenarios. The objective was to gain a conceptual understanding of the differences in flow patterns under the river that would result from the VBW and GWCT system. The modeled scenarios considered a completed VBW with the head control wells in operation at the pumping rates predicted to be sufficient for groundwater control beneath the river. Six interior head control wells were included in their as-built locations, with a total estimated pumping rate of 22.5 gpm.

2.2.2 Results

Figure 5 shows simulation results as a cross-sectional groundwater elevation contour map for a north-to-south section extending through the main facility property, and out into the Turning Basin. As shown on the figure, groundwater flow is significantly affected by the presence of the VBW and the interior pumping. On the south (left) side of the cross section, the simulation shows that the VBW diverts the flow downward into the bedrock. (It is important to note that existing physical data including groundwater quality data does not currently indicate offsite migration through bedrock is occurring). After passing under the VBW, the flow turns upward because of the reduced potentiometric head caused by the interior head control wells. Under the river, the vertical flow component has been reversed, with flow derived from the river going downward under the northern segment of the VBW. It is possible that such a lowering of onsite heads could result in reversal of flow to the river, as suggested by the model, and this possibility will be evaluated during future groundwater monitoring.

2.2.3 Collection of Additional Groundwater Data

Tyco will collect additional hydraulic head information for the AMRSRP approach at varying depths and from within the key geologic units upgradient, downgradient (beneath the river), and within the area encircled by the VBW to determine the effect of the GWCT's operation on groundwater flow paths between the site and the river.

Existing and proposed groundwater monitoring wells and staff gauges for this site are depicted on Figure 6. A number of new groundwater monitoring well locations are noted on the figure and were proposed in the *Barrier Wall Groundwater Monitoring Plan* (BWGMP) submitted to USEPA on October 26, 2010 (CH2M HILL 2010b). As of the date of this AMRSRP, final USEPA approval of the proposed well network has not been received; however, it is anticipated the overall network substantially will be as shown on Figure 6.

Additional hydraulic head data will be collected at a subset of monitoring wells as indicated on Figure 6 and from Staff Gauge 2. Hydraulic head data collection will involve a combination of manual measurements and pressure transducer data logging (at select locations). In addition, it is proposed that hydraulic data collection wells or well nests be installed beneath the surface of the river within the semi-consolidated material to support data collection for the AMRSRP approach. Two data collection wells or well nests are proposed. Data collection wells or well nests would be situated beneath the Turning Basin and would consist of piezometers placed at varying depths within the semi-consolidated material and glacial till above bedrock. Details on the installation of the piezometers and the methods for hydraulic head data collection will be refined, but it is anticipated that dataloggers would be installed in the wells to record piezometric head over time. A field instruction plan would refine the measures to be used for installing hydraulic monitoring equipment and methods for data collection and evaluation.

Evaluation of collected data will be performed to supplement the existing groundwater model at the site and confirm or invalidate the groundwater modeling results obtained with the assumptions stated herein.

2.3 Design Components

This section describes the major components of the AMRSRP approach design.

2.3.1 Bathymetric and Sediment Thickness Surveys

A bathymetric survey of the 2010 sediment investigation area within the Menominee River, including the Main Channel, Turning Basin, Transition Areas, 6th Street Slip, and the South Channel areas, was completed in April 2010. Additionally, water depth and sediment thickness data were collected during the May-June 2010 sediment sampling events.

Before performing mechanical dredging work, the dredging contractor will be required to retain a bathymetric surveying contractor to perform a pre-dredge bathymetric survey that covers areas to be dredged. A post-dredge bathymetric survey will be performed at the conclusion of dredging activities to document final conditions and establish payment quantities. Since the South Channel will be dewatered, a terrestrial-based survey will be performed after dredging in Phase III is completed to document final conditions and establish payment quantities.

2.3.2 Bulkhead/Shoreline Stability

The VBW installed along the shoreline adjacent to the Tyco property consists of steel sheet piling, most of which was installed in 2010. Some of the sheet piling is supported with tieback anchors, and other segments are entirely cantilever-supported. A sheet piling stability assessment will be performed as part of the final design to determine the impact, if any, of capping activities on the structural integrity of the sheet pile wall.

2.3.3 Utilities

Thew Associates performed a utility survey in April 2010 prior to CH2M HILL conducting subsurface investigation activities. A buried high-density polyethylene waterline crossing the South Channel was identified at two spots during the April-May 2010 work, as well as an electrical line associated with the bridge at Ogden Street. It is unlikely that soft sediment removal in the South Channel will come close to these utilities, but this will be verified during development of the final design. The dredging contractor will be required to verify the presence/locations of utilities before beginning work.

SECTION 3

Corrective Action Design—Project Delivery Strategy

3.1 Preliminary Design

The objectives of the preliminary design are to define, in detail, the technical parameters upon which the design will be based, develop the conceptual strategies and ideas that compose the framework of the remediation project, review the strategies and ideas with the agencies, and, to the extent possible, finalize the strategies and ideas so that the final design may proceed with minimal changes (for example, minimal cost and schedule impacts).

3.2 Final Design

Once the conceptual strategies and ideas and supporting technical details have been developed, reviewed, finalized, and approved by the agencies in the preliminary design, the final design activities will commence. The conceptual strategies and ideas developed during the preliminary design will be expanded into a set of final design documents consisting of the following:

- Basis of design report
- Specifications
- Drawings
- Cost estimate
- Site-specific plans
- Contract award documents
- Biddability, operability, and constructability reviews
- Revised project delivery strategy
- Construction quality assurance plan

Detailed design drawings and specifications will be prepared for the majority of the selected components. The successful bidder of the work will become the dredging contractor. The contractor will be required to develop a detailed work plan, describing how the work will be executed.

SECTION 4

Preliminary Design Approach, Assumptions, and Parameters

A general conceptual description of the mechanical dredging and capping support facilities, equipment, and activities is included in this AMRSRP. During the bid process, bidders for the work will be required to provide a general description of their proposed site layout, dredging equipment, water treatment system, and procedures, so significant proposed modifications can be discussed and evaluated before award of the contract. In addition, before starting the work, the contractors will provide a detailed work plan that will describe the specifics of the proposed methodologies.

4.1 Placement of Cap Material Above Authorized Federal Navigation Channel Dredge Depth

Portions of the Main Channel and Turning Basin fall within the federally authorized navigation channel. Authorized dredging depth in the federal navigation channel is 21 feet below the Lake Michigan low water datum (LWD) of 577.5 feet above mean sea level referenced to the International Great Lakes Datum of 1985. The approximate lateral limits of the federally authorized navigation channel are shown on Figure 1.

Tyco has initiated conversations with the U.S. Army Corps of Engineers (USACE) regarding the feasibility of placing a cap over contaminated semi-consolidated material that would result in channel depths more shallow than -21 feet LWD. Borings advanced within the Turning Basin indicate the depths in the southern and southeastern portions of the federal navigation channel have always been less than -21 feet LWD, as evidenced by the presence of native materials (semi-consolidated sands and silts and glacial till) shallower than -21 feet LWD. Depths in the central portion of the Turning Basin would remain compliant with the currently authorized dredge depth of -21 feet LWD or would be deeper. The *Sediment Remediation Work Plans Evaluation Letter* in Appendix A contains more detail regarding post-cap placement water depths in the Turning Basin.

Initial discussions with USACE indicate permission to place a cap above the currently-authorized dredge depth is approvable. The main factors that would weigh into USACE's final decision appear to be current and future needs of local interests. Tyco will initiate further discussions with USACE and local interests.

4.2 Minimizing Environmental and Public Impacts

One of the primary objectives of the completing the proposed remedial actions is to minimize the environmental and public impacts. This is achieved through permitting and planning during the design phase, as well as adherence to environmental controls and monitoring during the execution of the project.

4.2.1 Planning and Permitting

Permits related to the following items will be completed by Tyco, as necessary (these items are identical to those identified in the SRWP):

- Section 10 of the Rivers and Harbor Act of 1899, Section 404 of the Clean Water Act (CWA), and Section 401 of the CWA for dredging
- Revision of Tyco's existing Wisconsin Pollution Discharge Elimination System (WPDES) industrial permit, if necessary
- Chapter NR 347 of the Wisconsin Administrative Code for sediment sampling and analysis, monitoring protocol, and disposal criteria for dredging projects
- RCRA permit for onsite sediment handling and treatment
- Clean Air Act (CAA) permit
- Endangered and threatened species review and Natural Historic Preservation Act permit, if necessary
- Coordination with the U.S. Coast Guard regarding a Notice to Mariners and waterway markers permit
- Building permit from the City of Marinette for temporary facilities
- Soil erosion and sediment control (SESC) permit
- Chapter 30 and NR 216 of the Wisconsin Administrative Code for Stormwater Erosion Control and Post-Construction Stormwater Permit
- Access agreements for use of property not owned by Tyco, if necessary

4.2.2 Execution of Dredging Activities

Project information will be communicated with local property owners and other general members of the public before and during the corrective activities to limit the impacts of the project to residents and commercial and recreational activities.

During the dredging activities, BMPs will be employed to control the resuspension of sediment; BMPs are described later in this section. Turbidity will be continuously monitored, and exceedances will be communicated to the dredging contractor so modifications to the process or equipment can be made as necessary, as described in Section 6.

Air monitoring, post-dredging confirmation sampling, and post-dredging bathymetric surveys will be conducted as described in Section 6.

4.3 Site Preparation and Mobilization

4.3.1 Site Preparation and Mobilization Activities

Before mobilization to the site, the contractors will verify they have obtained or are in compliance with the requirements of necessary permits. In addition, the contractors will deliver necessary preconstruction submittals to Tyco for approval before mobilization.

The contractor will perform site preparation activities at the Tyco property (the term "site" refers to the portion of the Tyco property used for the mechanical dredging and stabilization activities as shown on the drawings in Appendix B). These activities are necessary to allow heavy equipment to access all of the portions of the site and to ensure protection of the environment during remedial activities. The former Salt Vault area (asphalt pad) and the former 8th Street Slip will be used as the staging and treatment area. Mobilization and site preparation activities will include the following:

- Mobilization of equipment and personnel
- Clearing and grubbing of vegetation and implementation of erosion control measures in the areas disturbed
- Establishment of physical construction limits at the site with temporary fencing or other means of demarcation
- Establishment of staging area(s) for construction equipment and capping materials
- Set up of site trailers for the dredging contractor and oversight contractor
- Construction of temporary partitions on the existing asphalt surface in the former Salt Vault to create areas for staging, stabilization, stockpiling, and water treatment
- Construction of a temporary mooring structure and drip containment at the shoreline of the site
- Construction of a temporary water treatment system
- Installation of turbidity monitoring equipment in the river
- Construction of temporary access roads near the existing boat landing on City of Marinette property to access the South Channel for the dry excavation activities

4.3.2 Asphalt Pad and Site Access Roadways

The mechanical dredging of river sediments requires modifying the existing asphalt pad and installing temporary access roads to reach the South Channel for the dry excavation activities. The drawings (Appendix B) include an overview of the conceptual plan and cross-section details. Separate areas will be established on the asphalt surface near the former Salt Vault to accommodate the reagent storage, temporary onsite water treatment plant, dredged material stabilization, stabilized material storage, capping material stockpiles, and decontamination for trucks hauling stabilized sediment offsite. Temporary access roads will be built in areas where no roadways currently exist, and in other cases, designated haul routes will be demarcated on the existing asphalt areas. A description of each of these items is included below.

Asphalt Concrete Pad

The existing asphalt surface in the former Salt Vault (and the former 8th Street Slip) area will be used as the staging area. There is an existing 250-foot x 250-foot asphalt concrete staging pad with 2-foot-high sealed concrete sidewalls along with a 1 percent slope toward the drain outlet on the west sidewall. The pad area consists of a 6-inch-thick asphalt concrete layer constructed over a compacted fill and a gravel layer. The former 8th Street Slip area consists of a 4-inch-thick asphalt concrete layer constructed over a layer of compacted imported sand. A 10-foot x 10-foot x 2-foot asphalt concrete-lined outfall sump with a maximum holding capacity of approximately 1,200 gallons will be constructed outside of the asphalt pad as shown in the drawings (Appendix B). The bottom of the outfall sump will be constructed at least 2 feet below the existing asphalt concrete pad surface level. A pipe will be installed to connect the drain outlet located on the east sidewall of the asphalt pad to the outfall sump. It is expected that free water from the offloaded dredged material and the stormwater runoff will be collected in the outfall sump through the drain outlet, prior to pumping it out to the temporary water treatment system.

The southwestern corner of the pad will be used as the reagent storage and handling area, and the northwestern corner of the pad will be used for the temporary water treatment system. The remaining portion of the pad will be used as the sediment stabilization and storage area, with temporary berms separating the sediment stabilization and storage area from the water treatment system and reagent storage and handling areas. Water that seeps through the asphalt concrete pad will be contained onsite by the VBW and extracted and treated by the permanent site GWCT system.

Temporary Access Roads

Since the working area within the Tyco facility is covered with asphalt concrete, no construction of temporary access roads will be necessary in the vicinity of the staging area. Traffic cones, barrels, or signage will be used to demarcate travel areas for trucks hauling materials to and from the site to keep truck traffic confined to these areas for the safety of site personnel.

Some temporary access roadways will need to be constructed on the property east of the site as shown on the drawings in Appendix B to facilitate the truck hauling and transportation. After clearing and grubbing, the existing surface will be leveled and prepared, and a mid-weight geosynthetic fabric of 6- to 10-ounce/square yard will be laid to separate and stabilize the foundation. Over the geosynthetic fabric, a 6-inch-thick crushed stone aggregate layer will be placed and compacted. This layer of aggregate shall meet the requirements of Wisconsin Department of Transportation Series 21 Class AA or Series 22 Class A. The gravel access roadways will minimize the tracking of loose soil.

Asphalt Concrete Pad and Temporary Access Road Removal and Disposal

Once the dredging and capping activities are completed, the asphalt concrete surfaces will be washed off, and the resulting wastewater will be captured and treated in the temporary onsite water treatment system. Areas where a permanent asphalt concrete surface has been damaged by the corrective activities will be repaired and resurfaced. Access roads constructed on the property east of the site will be tested for leachable arsenic, broken up, removed, and disposed offsite at a nearby nonhazardous landfill or recycled as appropriate (assuming the leachable arsenic results indicate the material is nonhazardous and/or meets regulations for recycling). Areas where the access roads were constructed outside the VBW will be restored by reseeding it with native vegetation and planting new trees to replace those which were removed.

4.4 Mechanical Dredging

Approximately 59,000 yd^3 of soft sediment containing arsenic greater than 50 mg/kg (including estimated overdredge volumes) will be mechanically dredged from the river as shown on the drawings in Appendix B.

The volume targeted for mechanical dredging does not include 12,000 yd^3 of soft sediment in the South Channel that will be removed by dry excavation. The thickness of soft sediments to be mechanically dredged ranges from less than 1 foot to a maximum of 8 feet. Water depth within the mechanical dredging areas is up to 21 feet deep adjacent to the Main Channel. The water depth in the South Channel is approximately 1 to 2 feet, which is too shallow for mechanical dredging.

The performance standards for the mechanical dredging consist of the following:

- Removing soft sediment to specified elevations
- Minimizing sediment resuspension below the specified turbidity standard

The dredging contractor will perform bathymetric surveys before and after dredging. These bathymetric surveys will be used to determine if the specified dredge cuts have been achieved as well as providing a final dredged sediment volume for payment. Calculations of soft sediment include an average of 6 inches overdredge depth.

4.4.1 Dredging Equipment

Mechanical dredging of contaminated soft sediments will be performed with a crane and environmental clamshell bucket having the following capabilities and characteristics:

- Provides a level cut during the closing cycle
- Completely encloses the dredged sediment and water captured
- Has escape valves or vents that close when the bucket is withdrawn from the water
- Has a smooth cut surface, with no teeth
- Is controlled by the operator using global positioning system (GPS) equipment with integrated software that allows:
  - The bucket position to be monitored in real time
  - The specified horizontal and vertical accuracy requirements to be met
  - The operator to control bucket penetration to avoid overfilling and minimize sediment resuspension

4.4.2 Dredging Process

The mechanical dredging, offloading, and stabilization process described here is conceptual and will be more specifically defined during design. The dredging contractor will be allowed to propose and utilize a different process if, after an evaluation, the proposed process is cost-effective and can reasonably be expected to meet performance criteria such as production rates and turbidity standards.

The mechanically dredged material will be loaded into watertight scows that will be transported to the temporary docking platform to be constructed near the former 8th Street Slip. The dredged material will be offloaded using a material handler with a clamshell bucket and transferred onto a screen to separate oversized debris. The material passing the screen will fall onto a conveyor belt and be transported to the sediment stabilization and storage area on the asphalt pad. The material will then travel through a pugmill where stabilization reagents will be added. Following reagent addition, the material will be moved by conveyors and/or a front-end loader(s) to a storage area where the mixture will cure for approximately 1 week. Once the material has cured sufficiently, it will be sampled and analyzed for TCLP arsenic to confirm it is nonhazardous. The landfill might require additional analyses to meet disposal requirements. Then, the material will be picked up with a front-end loader and loaded into a truck for transportation offsite. The top of the truck will be covered with a tarp, the exterior of the truck will be decontaminated (if necessary), and the stabilized sediment will be transported to an off-site RCRA Subtitle D (nonhazardous) landfill for disposal.

Free water from the dredged material, decontamination water, and water from rain events will gravity drain to the outfall sump located adjacent to the asphalt pad. Water collecting in the sump will be pumped directly to the temporary water treatment system. Suspended solids and dissolved contaminants in the water will be removed by the water treatment system, which will consist of equalization, chemical feed, microfiltration (MF), two-stage reverse osmosis (RO) filtration, filter press dewatering, and, if cost-effective, mechanical evaporative concentration (see Section 4.7.2).

4.4.3 Debris

Debris encountered during mechanical dredging will be segregated as much as possible on the material scow and handled separately once the scow is moved to the offloading area. If significant debris is encountered while dredging soft sediment (Phase I) that would potentially cause damage to the environmental bucket, a conventional clamshell bucket may be used until the debris is removed.

4.4.4 Stabilization Reagents

A treatability study is currently being conducted to determine a cost-effective reagent mixture to stabilize the dredged material. The stabilized dredged material must meet three criteria:

- No free water (must pass paint filter test for disposal at the landfill)
- Leachable arsenic is less than 5 mg/L, as measured by the TCLP test
- Minimum strength of 12 pounds per square inch at 7 days of curing, as measured by the unconfined compression test

Preliminary treatability testing results indicate reagents needed to stabilize dredged materials may include a cementitious reagent to provide moderate strength gain and other reagents such as an oxidizing agent and an iron-based compound to create an insoluble arsenic compound and reduce leachability.

4.4.5 Dredging Production Rate and Duration

The expected mechanical dredging rate for the soft sediments is estimated to be 1,300 yd^3 per day up to 24 hours per day/7 days per week. The mobilization, setup, and demobilization phases of the project cumulatively may take approximately 7 weeks. A total duration of 7 weeks of soft sediment dredging (not including soft sediment dry excavation from the South Channel) are anticipated based on these production rates.

4.4.6 Debris Handling

Oversized debris from the screen at the offloading area will be removed using a front-end loader and set aside for decontamination. Debris encountered during dredging that was segregated on the material scows will be offloaded separately from the other dredged material and also set aside for decontamination. After being washed with a pressure washer to remove significant sediment from the debris, the debris will be placed in a rolloff container for eventual transportation and disposal offsite at a RCRA Subtitle D landfill for disposal.

4.4.7 Dredging Positioning System

A system that continuously locates and records the horizontal and vertical position of the cutting face will be required. A real-time kinematic positioning system, or an alternative positioning system that can meet the specified tolerance requirements, will be used to provide the horizontal and vertical positioning for the dredge system. The positioning system shall employ software capable of monitoring the x, y, and z position of the dredge bucket in real time. The software will be required to provide the following:

- A real-time view of the barge and clamshell bucket position
- A display indicating the surface derived from the pre-dredge hydrographic survey data
- A display that provides real time feedback showing current depth, final project depth, target depth, and current bucket depth

The following tolerances shall be met:

- Horizontal position accuracy shall be plus or minus 2 feet
- Vertical tolerance shall be plus zero, minus 0.5 foot

4.5 Dry Excavation – South Channel

Approximately 12,000 yd^3 of soft sediment with arsenic contamination exceeding 50 mg/kg are present in the South Channel. The water depth in the South Channel is typically 1 to 2 feet, meaning barge-based mechanical dredging equipment cannot be floated into the area. In addition, the South Channel is fairly wide (100 to 200 feet), and the shoreline is heavily vegetated, so using a crane from the shoreline would be problematic for the entire width of the channel. Underwater sediment removal is further complicated by the presence of woody debris from historical activities in the area. The physical setting of the South Channel allows for cost-effectively dewatering the channel. Therefore, dry excavation was selected as the best option for removing contaminated sediment from the South Channel in Phase III.

4.5.1 Site Preparation and Dewatering

In order to perform dry excavation, access must be obtained to the South Channel directly from land. Since the South Channel does not border the facility, an access agreement would need to be reached with the City of Marinette to use the property south of the South Channel where the boat landing is located. An access road, approximately 220 feet long, 20 feet wide, and 12 inches thick, would need to be built by first clearing and grubbing the existing trees and other vegetation, and then laying down geotextile and gravel. Once the road is built, sheet piling would need to be installed across the west end of the South Channel as shown on the drawings in Appendix B. The existing road through the wetlands area on the Tyco property that adjoins the City of Marinette property will need to be improved as well to handle the truck traffic.

A vibratory hammer will be used to install approximately 300 linear feet of sheet piling across the west end of the South Channel. The sheets are estimated to be 25 feet long.

Once the sheet piling is installed, free water on top of the sediment will be directly discharged to the river until turbidity in the water exceeds 80 mg/L TSS. Water exceeding this threshold will be routed to the onsite temporary water treatment system.

4.5.2 Excavation Activities

Standard excavation equipment will be used to remove the materials from the South Channel. A track-mounted backhoe will be used to stabilize the soft sediment in situ, excavate the stabilized sediment, and load it into articulated trucks for transport back to the staging area on the Tyco property. Debris that interferes with soft sediment removal will be removed with the backhoe and transported to the site to be staged and eventually disposed offsite. In situ stabilization will be accomplished by dumping loads of fly ash and cement next to the mixing operation, using the backhoe to pick up and add the reagents to the soft sediment, and mixing the reagents into the sediment with the backhoe bucket. Once the reagents have been mixed into the sediment, the backhoe will be used to load the sediment into articulated hauling trucks which will transport the material back to the staging area onsite.

The estimated production rate is 600 yd^3 per day, so a total of 20 days is estimated to remove the 12,000 yd^3 of soft sediment.

4.6 Dredged Material Disposal

As stated previously, the stabilized dredged material will be tested to verify that it passes the paint filter test and leachable arsenic has been reduced to less than 5 mg/L. The stabilized material will then be directly loaded into trucks and hauled offsite for disposal at an approved facility. It is assumed that the stabilized dredged material will be disposed at a RCRA Subtitle D landfill within 40 miles of the project site.

4.7 Water Quality

4.7.1 River Water Quality

Turbidity Control through Implementation of Best Management Practices

The potential to create turbidity and impact river water quality during mechanical dredging will be minimized by the dredging contractor's adherence to mechanical dredging BMPs. A list of BMPs for the dredging of soft sediment is provided below:

- Scows shall be watertight and inspected to confirm water tightness prior to dredging operations and dredged material transport.
- An environmental clamshell bucket shall be used for mechanical dredging of soft sediment.
- "Sweeping" to contour the bottom of the dredge cut shall not be permitted.
- Dredging of slopes shall proceed from top of slope to toe of slope.
- The dredging contractor shall utilize positioning devices (such as GPS) to allow the operator to be aware of the location of the dredge bucket in relation to the top of the sediment.
- The contractor shall use an experienced environmental dredging operator who is capable of implementing appropriate BMPs to limit resuspension of sediment.
- The operator shall minimize overfilling of the dredge bucket.
- The operator shall reduce the rate of bucket descent and retrieval as necessary.
- The operator shall perform single bites with the bucket, and each bucket shall be brought to the surface and emptied between bites.
- The operator shall release excess water at surface slowly.
- The operator shall not overfill scows with dredged material.
- Oil booms shall be available for emergency use.

Silt curtains will be used for the mechanical dredging work. The silt curtains will be placed around the contiguous dredging areas as shown on the drawings in Appendix B. Silt curtains will not be needed during placement of cap materials because the material will be washed to remove fines.

The success of the contractor's efforts to control release of turbidity will be evaluated through river water monitoring activities as described in Section 6.1. If a turbidity exceedance is noted, the dredging contractor will be consulted and the source of the turbidity will be identified. If dredging activities are suspected, the dredging process or equipment will be modified so the turbidity criterion is met.

Release of Dissolved Phase Arsenic during Dredging Activities

The release of particulate arsenic during mechanical dredging operations will be minimized by using BMPs to minimize dredging-induced turbidity. However, turbidity control measures such as turbidity curtains will not be successful in limiting release of dissolved-phase arsenic during dredging activities. For a complete description of the concerns with arsenic release during dredging activities, refer to the *Sediment Remediation Work Plans Evaluation Memorandum* in Appendix A.

4.7.2 Wastewater from Stabilization and Decontamination Activities

Wastewater Sources

Wastewater will be generated from several sources during the handling, stabilization, and disposal of the dredged material. The following wastewater sources will be routed to the onsite temporary water treatment system:

- Free water from the dredged sediment that is gravity drained (Phase I)
- Decontamination water (Phases I, II, and III)
- Precipitation on the staging pad (Phases I, II, and III)
- Direct discharge of water from the South Channel prior to and during dry excavation once the concentration of TSS exceeds 80 mg/L (Phase III)

The water treatment system itself will generate process wastewater, which will need to be hauled offsite and disposed.

Wastewater Volumes

The rate of water generation and treatment was calculated over a 24 hours per day, 7 days per week period since dredging activities also are assumed to occur over the same period. Volumes given below might not add up precisely because of rounding.

Free Water Removed from Sediment (Phase I)
During Phase I, the dredging rate is estimated to be 1,300 yd^3 per day. The estimated volume of water draining from sediment dredged with an environmental bucket is 11,000 gallons per day (gpd), or 7.4 gallons per minute (gpm).

Total free water generated from dredging will be as follows:

- During Phase I: (11,000 gpd)*(46 days) = 0.5 million gallons

Decontamination Water (Phases I, II, and III)
A 4 gpm pressure washer is assumed to be used for decontamination activities. Decontamination activities performed during the dredging work will include decontamination of debris, equipment, and trucks. Total volume is estimated to be 1,400 gpd, or 1.0 gpm. The wastewater generated from decontamination activities will be collected in the sump along with the other wastewater sources and sent to the water treatment system.

Total water generated will be as follows:

- During Phase I: (1,400 gpd)*(46 days) = 0.07 million gallons
- During Phase II: (1,400 gpd)*(57 days) = 0.08 million gallons
- During Phase III: (1,400 gpd)*(20 days) = 0.03 million gallons

Water from Precipitation on Pad (Phases I, II, and III)

Average monthly rainfall for the Green Bay, Wisconsin, area during the potential construction season is as follows (rssweather.com 2010):

- May: 2.75 inches
- June: 3.43 inches
- July: 3.44 inches
- August: 3.77 inches
- September: 3.11 inches
- October: 2.17 inches

A monthly rainfall of 3 inches was used to calculate rainwater that falls on the process pad and requires treatment. Using a proportionate average daily rate, the total volume is estimated to be 18,000 gpd, or 13 gpm. Total water generated will be as follows:

- During Phase I: (18,000 gpd)*(46 days) = 0.8 million gallons
- During Phase II: (18,000 gpd)*(57 days) = 1.0 million gallons
- During Phase III: (18,000 gpd)*(20 days) = 0.4 million gallons

Direct Discharge of Water from the South Channel (Phase III)

The volume of wastewater generated from dewatering the South Channel cell will be comprised of two components. The first source of wastewater will be the water remaining after the initial phase of dewatering, direct discharge of water to the river, is completed. Approximately 0.5 foot of water over the footprint of the entire cell will need to be pumped to the water treatment system, and this volume is estimated as 1.3 million gallons, which will be pumped out over 14 days, for an average flowrate of 93,000 gpd, or 64 gpm. Maintenance dewatering is estimated to be 65 gpm for the 20 days of active sediment excavation in the South Channel. This is an estimated 94,000 gpd. Total water generated by dewatering activities during Phase III will be 1.3 million gallons + (94,000 gpd)*(20 days) = 3.2 million gallons.

Summary of Wastewater Generated (Phases I through III)

During Phase I, wastewater generated will be 0.5 million gallons (free water in sediment) plus 0.07 million gallons (decontamination water) plus 0.8 million gallons (precipitation), for a total of 1.4 million gallons, and an average flow rate of 21 gpm over 24 hours.

During Phase II, wastewater generated will be 0.08 million gallons (decontamination water) plus 1.0 million gallons (precipitation), for a total of 1.1 million gallons, and an average flow rate of 14 gpm over 24 hours.

During Phase III, wastewater generated will be 0.03 million gallons (decontamination water) plus 0.4 million gallons (precipitation) plus 3.2 million gallons (direct discharge for South Channel cell dewatering activities) for a total of 3.6 million gallons, and an average flow rate of 123 gpm over 24 hours.

Total wastewater generated during the corrective activities is estimated to be 6.0 million gallons. Estimated flow to the water treatment system will vary, but will be at a maximum of 123 gpm during Phase III. Therefore, the treatment system should be designed to handle a peak flow of approximately 150 gpm.

RO process waste will be approximately 20 percent of the total flow to the treatment system. Therefore, total volume of rejectate water requiring disposal at an offsite hazardous waste facility will be 1.2 million gallons.

Wastewater Treatment

The conceptual design for the temporary onsite water treatment system is shown on the drawings in Appendix B. This conceptual design is provided as a possible configuration, but the dredging contractor can propose an alternative water treatment system design. The treated water will be considered for reuse onsite.

The water treatment system will be set up on the northern portion of the asphalt pad. Wastewater sources will be combined in an equalization tank and pumped into an MF unit. The rejectate from the MF unit will be run through a filter press and the filter cake will be added to the dredged materials for stabilization. The filtrate from the filter press will be routed back to the wastewater stream before the MF unit. Water passing through the MF unit will have sulfuric acid added to inhibit scaling before passing through a dual phase RO unit. The treated water from the RO unit will be stored in holding tanks for reuse at the Tyco facility.

Influent and effluent samples will be collected from the water treatment system to monitor performance. If not all of the treated water can be used at the Tyco facility, a WPDES permit will be obtained for discharge to the Menominee River, and discharge and sampling will be done in compliance with the permit.

4.8 Working Season and Hours of Operation

Most activities associated with the dredging or capping work will be performed up to 24 hours per day, and 7 days per week. Water treatment operations will be performed up to 24 hours per day, 7 days per week. The contractor will determine the actual hours of operation.

Mobilization is anticipated to start in late winter in 2012 (refer to the project schedule in Appendix D). It will be necessary to schedule activities to accommodate the current commercial and industrial uses of the Menominee River. The dredging schedule will be coordinated with USEPA, Wisconsin Department of Natural Resources (WDNR), and the U.S. Fish and Wildlife Service (USFWS) to minimize potential disturbance of fish spawning during the spring and fall seasons. The construction contractor will be responsible to coordinate with local industrial facilities to accommodate the arrival and departure of commercial ships delivering raw materials and with the local agencies as necessary.

4.9 Decontamination and Site Restoration

After dredging and capping activities have been completed, decontamination activities will be performed. Equipment to be removed from the river will be power-washed in place or over the river with water, prior to transport, to remove sediment and invasive species such as mussels.

Land-based equipment will be washed on the asphalt pad with the wash water being captured and treated. Rinse water will be collected in the sump through the outfall pipeline and will be pumped to the water treatment system. Following equipment decontamination, the asphalt pad will be washed to remove visible residual sediment.

Once decontamination has been completed, the temporary infrastructure built for the mechanical dredging work will be removed from the site. The docking platform, drip protection, and access walkway will be disassembled and taken offsite. The water treatment equipment will be decommissioned and taken offsite. Temporary access roadway materials will be sampled and taken offsite for reuse if not contaminated or disposed at an appropriate landfill if contaminated. Previously vegetated areas that were impacted by corrective activities will be restored to pre-construction conditions to the extent practical and replanted with native species.

4.10 Cap Placement

Phase II of the AMRSRP approach involves placing a subaqueous cap over arsenic-contaminated materials. An estimated 149,000 yd^3 of contaminated semi-consolidated material will be left in place (based on an arsenic concentration of 50 mg/kg).

4.10.1 Construction of Cap

The proposed cap plan and profile view are shown on the drawings in Appendix B. The profile view also is shown on Figure 4. Soft sediment overlying semi-consolidated material to be capped will be dredged, including a 4:1 (horizontal to vertical) slope to prevent sloughing of the soft sediment. The area to be capped is estimated to be 400,000 square feet.

Once the dredging to this elevation is confirmed, a minimum of 12 inches of granular fill will be placed over the exposed contaminated semi-consolidated material, not including overplacement. After placement of the granular fill, a minimum of 16 inches of riprap will be placed, not including overplacement. Gradations of these materials are included on the drawings in Appendix B. An estimated 17,000 yd^3 of granular fill and 22,000 yd^3 of riprap will be required. Using an estimated placement rate of 700 yd^3 per day, this equates to a total duration of 57 days for Phase II.

4.10.2 Environmental Protectiveness of Cap

The cap as constructed in this AMRSRP approach will provide a permanent barrier between the contaminated semi-consolidated material and benthic organisms. Over time, soft sediment from upriver will settle into the cap crevices and cover the material comprising the cap.

The material comprising the cap will be subject to erosion from river flows and propeller wash from vessels. Therefore, the riprap design will consider these forces, which will likely be the critical condition for the cap design. Peak river flows should not be problematic, because (1) the majority of the cap will be located in the Turning Basin outside the river's Main Channel, where peak flows will be reduced, and (2) the portion of the cap in the Main Channel will be significantly deeper than in the Turning Basin, which means the water velocity at the cap surface will be lower. Periodic monitoring of the cap will be performed to check for erosion and sediment deposition. If significant eroded areas are identified, the cap can be repaired in the future. Finally, regardless of erosion of the cap materials, the underlying semi-consolidated material is sufficiently cohesive that they will not erode significantly even if unprotected from the infrequent vessel propeller wash. For additional details on environmental protectiveness of the AMRSRP, please see Appendix A.

SECTION 5

Compliance with Applicable Requirements

This list of applicable requirements was developed based on the review of recent site data and specific components of this design. The requirements that have unique aspects affecting the implementation of the mechanical dredging corrective action at this site are based on the specific components of the project and are discussed below.

5.1 Rivers and Harbors Act

Section 10 of the Rivers and Harbors Act of 1899, 33 U.S. Code (USC) §401 et seq. and 33 Code of Federal Regulations (CFR) Parts 403 and 322, prohibits the creation of obstructions to the capacity of (that is, the excavation or fill within the limits of) the navigable waters of the United States. This includes typical requirements to be met for dredging and filling within a navigable waterway such as measures to minimize resuspension of sediments and erosion of sediments and stream banks during excavation. The project will be designed to meet the requirements of Section 10 of the Rivers and Harbors Act.

5.2 Clean Air Act

The CAA, 40 CFR Parts 50 through 99, is intended to protect the quality of air and promote public health. Title I of the Act directs USEPA to publish national ambient air quality standards for "criteria pollutants." The National Ambient Air Quality Standards, Section 109 provides specific requirements for air emissions including, but not limited to, particulates, volatile organic compounds, and hazardous air pollutants. USEPA also has provided national emission standards for hazardous air pollutants under Title III of the CAA. Hazardous air pollutants are designated hazardous substances under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The CAA Amendments of 1990 greatly expanded the national emission standards for hazardous air pollutants by designating 179 new hazardous air pollutants and directing USEPA to attain maximum achievable control technology standards for emission sources. Such emission standards are potential requirements for remedial actions producing air emissions or regulated hazardous air pollutants.

The CAA is considered applicable for activities that have the potential of causing particulate emissions, such as handling the dewatered sediment. Although significant amounts of airborne particulates are not likely to be generated, stabilization activities may cause some airborne particulates. Therefore, best available practices will be used, as necessary, to control potential particulate emissions. A plan to measure and mitigate air emissions during the implementation of the remedy will be included as part of the site management plan.

5.3 Clean Water Act

The CWA, 33 USC §1251 to 1376 and 33 CFR Part 323, provides regulations for the discharge of pollutants into the waters of the United States. It requires USEPA to set water quality standards for all contaminants in surface waters, and requires that permits be obtained for discharging pollutants from a point source into navigable waters such as the Menominee River. The CWA also regulates dredged and fill discharges. Although actual discharge of the dredged material back into the river is not anticipated, excavation within the river constitutes discharge of dredged material.

Regulations promulgated under the authority of the CWA require permits for dredging or excavating sediments in navigable water. The applicable permits include the Section 404 permit, authorized by USACE, and the Section 401 Water Quality Certification issued by WDNR. A Section 401 certification is necessary for all projects requiring a Section 404 permit and is part of the Section 404 permit review process. Because the Menominee River is designated as a navigable waterway, the requirements and conditions of the Section 404 permit and Section 401 certification will be met. Typical requirements include actions to minimize resuspension of sediment and control erosion during dredging operations.

5.4 Soil Erosion and Sediment Control (SESC) Permit

The SESC permit will be obtained for the dredging activities and construction of support structures. The SESC permit will require implementation and maintenance of soil erosion and sedimentation control measures, which will be included in the design. A notice of coverage will need to be submitted to WDNR and local agencies.

5.5 Endangered Species Act

The Endangered Species Act of 1973, 16 USC §1531 et seq. and 15 CFR Part 930, requires that federal agencies ensure that any action authorized, funded, or carried out by the agency is not likely to jeopardize the continued existence of any threatened or endangered species or destroy or adversely modify critical habitat. USFWS lists four species/habitats known to occur in Marinette County: the gray wolf *(Canis lupus),* Kirtland's warbler *(Dendroica kirtlandii),* piping plover *(Charadrius melodus)* [critical habitat], and the Canada lynx *(Lynx Canadensis)*. The gray wolf and Kirtland's warbler are listed as endangered and the Canada lynx is listed as threatened (USFWS 2010).

A Wisconsin Natural Heritage Inventory (NHI) request will be performed prior to sediment dredging, and coordination with WDNR will occur based on the results of the NHI request.

Based on the location of dredging and capping activities that will be conducted during this project and where the dewatering process will occur at the Tyco property, it is not anticipated that federal or state listed species or critical habitats will be affected. To comply with these requirements, Tyco will consult with WDNR to obtain concurrence that no critical habitat will be adversely affected during implementation of the dredging operations.

5.6 National Historic Preservation Act

The National Historic Preservation Act, 16 USC §661 et seq. and 36 CFR Part 65, establishes procedures for preserving scientific, historic, and archaeological data that might be destroyed through alteration of terrain as a result of a federal construction project or a federally licensed activity or program. If scientific, historic, or archaeological artifacts are discovered at the project site, work that could impact discovered artifacts will be halted pending the completion of any data recovery and preservation activities required pursuant to the Act.

The likelihood for unanticipated discovery of scientific, historic, or archaeological artifacts during implementation of the corrective action is small. However, if such a discovery is made, appropriate and necessary measures will be implemented to ensure adherence to the Act.

5.7 RCRA Regulations and Administrative Order on Consent

As previously mentioned, the sediment removal action is being conducted pursuant to a RCRA 3008(h) AOC, administered by USEPA Region 5. The work described herein complies with the AOC, as well as the applicable RCRA regulations that govern the management and disposal of remediation waste.

The regulatory considerations associated with the sediment removal and disposal work are outlined below:

- In accordance with 40 CFR Section 261.4, because sediment removal is being done under a Section 404 permit, the dredged material exclusion states that the sediments are not considered a hazardous waste. The exclusion states:

    (g) Dredged material that is not a hazardous waste. Dredged material that is subject to the requirements of a permit that has been issued under Section 404 of the Federal Water Pollution Control Act (33 USC 1344) or Section 103 of the Marine Protection, Research, and Sanctuaries Act of 1972 (33 USC 1413) is not a hazardous waste. For this paragraph (g), the following definitions apply:

    (1) The term dredged material has the same meaning as defined in 40 CFR 232.2.

    (2) The term permit means:

    (i) A permit issued by USACE or an approved state under Section 404 of the Federal Water Pollution Control Act (33 USC 1344);

    (ii) A permit issued by USACE under Section 103 of the Marine Protection, Research, and Sanctuaries Act of 1972 (33 USC 1413); or

    (iii) In the case of USACE civil works projects, the administrative equivalent of the permits referred to in paragraphs (g)(2)(i) and (ii) of this section, as provided for in USACE regulations (for example, see 33 CFR 336.1, 336.2, and 337.6); in this case, the exemption is limited to the Section 404 permit activities.

- Since the dredged materials are not at this point considered a hazardous waste, per the exclusion, they can be transported back onsite without being considered a hazardous waste.

- Once the sediments dry out and are ready to be moved, the materials become a new waste stream that needs to be characterized and profiled for the offsite disposal. Under RCRA, a generator does not have the responsibility to characterize their material until it is generated, so characterization samples of the dredge spoils will be taken when they are onsite to determine next steps. If analytical results indicate the material passes TCLP criteria, the material will be stabilized to the extent necessary to pass a paint-filter test and be accepted at an appropriately permitted Subtitle D facility. If sampling results indicate the materials fail TCLP criteria and would be considered as characteristic, the materials will need to be treated prior to transport to the disposal facility. In order to perform onsite treatment, the site, including the river sediment area and the uplands area, will be defined as an area of contamination.

5.8 Coastal Zone Management Act

The Coastal Zone Management Act (CZMA), under 16 USC §1451 et seq. and 15 CFR Part 930, states that all federal agency activities affecting any coastal use, resource, or zone will be conducted in a manner that is consistent, to the maximum extent possible, with the enforceable policies of approved management programs.

The State of Wisconsin – Department of Administration Wisconsin Coastal Management Program (WCMP) was established in 1978 under the federal CZMA. Through its federal consistency review authority, the WCMP has broad opportunities to influence federal government activities, construction, funding, permitting, and other actions proposed within the coastal zone. It promotes coordination between state and federal policies, programs, and agencies. The boundaries of the coastal zone subject to the WCMP extend to the state boundary on the waterward side and, on the inland side, include the 15 counties with frontage on Lake Superior, Lake Michigan, or Green Bay. The dredging and capping activities will be located entirely within the designated Wisconsin Coastal Zone area of the Menominee River.

In order to be subject to federal consistency review, a project must meet the following basic criteria. The project must:

- Be located within or affect Wisconsin's coastal zone;
- Involve the federal government through funding, permitting or direct action; and
- Meet certain thresholds. (The state will focus on projects that involve a state-managed use and meet associated thresholds established under the Wisconsin Environmental Policy Act, which determine if they require detailed environmental review.)

Evaluation of federal consistency with the WCMP is based upon the following criteria:

- Is the activity consistent with the federally approved state coastal policies (set forth in Chapter I.C., including approved county shoreland ordinances and approved floodplain ordinances)?
- Is the activity consistent with specific management policies for designated state managed special coastal areas?
- Does the activity allow for an opportunity for full public participation?

The proposed remediation project meets the criteria established by the WCMP; therefore, a federal consistency review will be initiated.

5.9 Wisconsin Chapter 30 permit

Chapter 30 of Wisconsin Statutes declares all lakes, streams, sloughs, bayous, and marsh outlets which are navigable-in-fact for any purpose whatsoever to be navigable and public waters. Placement of structures, dredging, and similar activities in or adjacent to navigable waters are regulated under Chapter 30 of Wisconsin Statutes, and often require permits from WDNR. A Chapter 30 permit will be obtained from WDNR for dredging activities as well as impacts to any jurisdictional wetlands within the project area.

5.10 NPDES Stormwater Permit

The National Pollutant Discharge Elimination System (NPDES) is a federal program that originated in the CWA, but has since been delegated to the states. WDNR is authorized to administer the NPDES permit program, which requires permits for the discharge of stormwater associated with construction activities. The Tyco facility has an existing WPDES permit for industrial and manufacturing purposes. A Notice of Intent (NOI) will be submitted to WDNR more than 30 days prior to construction to negotiate use of the temporary treatment system during sediment removal and stabilization activities.

Under 40 CFR Parts 122 and 125, the requirements for the development and implementation of a stormwater pollution prevention plan or a stormwater best management plan are outlined, along with the monitoring and reporting requirements for facilities. The stormwater pollution prevention plan will be submitted along with the NOI 30 days prior to construction.

5.11 City of Marinette Building Permit

A temporary building permit is required from the City of Marinette for the support structures at the Tyco property. A permit application will be prepared and submitted to the City of Marinette to obtain a temporary building permit before implementation of the corrective action.

5.12 OSHA Requirements

A health and safety plan for construction activities that is in accordance with the Occupational Safety and Health Administration (OSHA) requirements listed in 20 CFR 1910 and 20 CFR 1926 will be required.

5.13 Waterway Markers Permit

Waterway markers have to meet U.S. Coast Guard requirements and are also regulated by WDNR through Section 30.74(2), Wisconsin Statutes and Chapter NR 5.09, Wisconsin Administrative Code. Any waterway markers must be in compliance with the U.S. Coast Guard requirements.

A brief summary of Chapter 30.74(2) and 30.77 is that a town, village, or city may adopt an ordinance, in the interest of public health, safety or welfare applicable on waters of the state within the local unit of government's jurisdiction. WDNR assists the community in enforcing the ordinance (30.74(3)).

Under Chapter 30.77(3)(b), it appears that a county could also adopt an ordinance; however, the county ordinance would supercede any local ordinances that would be developed and may not be in the interest of local control or acceptable throughout the county.

WDNR has interpreted the regulation that waterway marker enforcement cannot occur unless the local jurisdiction enacts an ordinance adopting the authority granted under Chapter 30.74(2). For example, while the markers may follow U.S. Coast Guard signage requirements for marking a Slow No-Wake Zone, WDNR would not be able to enforce the Slow No-Wake Zone unless the local jurisdiction first adopted an ordinance to accept local waterway marker acceptance and, thereby, grant WDNR enforcement authority of the ordinance. A WDNR waterways marker permit will be obtained prior to installing the markers on the Menominee River.

5.14 Notice to Mariners

A Notice to Mariners will be issued through the U. S. Coast Guard once the dredging schedule is known more precisely. Tyco's corrective activities oversight contractor will coordinate with the U.S. Coast Guard in consultation with the dredging contractor once the dredging contract is awarded.

SECTION 6

Performance Monitoring and Operations and Maintenance Requirements

This section provides a brief summary of the performance monitoring and operations and maintenance (O&M) requirements for the corrective activities. Additional details regarding sample collection, sampling methods and data management will be developed as part of the final design.

6.1 Water Quality Monitoring

6.1.1 River Water Quality Monitoring

The effectiveness of the dredging contractor in performing mechanical dredging while using BMPs to minimize the associated water quality impacts will be determined through monitoring of the turbidity in the river. The proposed turbidity control standard for work during mechanical dredging activities is no more than 80 mg/L TSS above the background reading.

Surface water monitoring of TSS and/or turbidity will be performed to collect data that will be used to evaluate the potential for sediment resuspension during dredging activities. Before commencing dredging activities, two turbidity monitoring stations will be installed for measuring turbidity during dredging and located as shown on the drawings in Appendix B. The first will be located on the southern side of the Menominee River, near the western boundary of the Tyco property. This location will be approximately 800 feet upstream of the Turning Basin and will be used to determine the daily average background turbidity level.

The second turbidity monitoring location will be approximately 1,000 feet east of the eastern side of the Turning Basin and positioned near the southern side of the main river channel. This location will be used to monitor potential suspended sediment entering the river from dredging activities in the Turning Basin. The precise locations will be selected once dredging activities begin based upon observed responses of the upstream and downstream turbidity sensors to background turbidity, as well as the consideration of avoiding damage due to vessel traffic.

Turbidity sensors will be deployed at the background location and at the second location at mid-depth of the channel. Turbidity readings will be transferred by cellular modem telemetry, compiled, and made available on a password-protected Web site within 5 minutes of each reading. Data from the turbidity sensors also will be stored in an integrated data logger that can be accessed in the event the telemetry system is inoperable. The readings will be recorded once every 10 minutes at both turbidity monitoring stations. A rolling average of six consecutive readings (1 hour) for both of the locations will be used as the basis of comparison.

If the turbidity levels exceed the criterion above the background location, additional turbidity measurements between the downstream project extent and the downstream monitoring location will be performed to assess the BMPs and determine the cause for increased turbidity. If the turbidity increase is determined to be caused from non-dredging activities, the dredging will continue. If the turbidity is determined to be elevated because of the dredging activities, work will temporarily stop until implementation of corrective measures are demonstrated and turbidity levels at the downstream monitoring location are below the project turbidity criterion.

If an obvious outlier appears, it shall be eliminated from the rolling average calculation. An outlier will be defined as a reading that is outside the range of 50 to 200 percent of the average of the three previous readings. In addition, to be considered an outlier, the following reading must return to a range of 75 to 133 percent of the average of the three readings preceding the outlier. In practice, it is common to get occasional one-time spikes that cannot be tied to activities in the water. If this happens regularly (that is, more frequently than twice per day), the sensor will be inspected and cleaned, repaired, or replaced.

6.1.2 Water Treatment System Monitoring

Influent and effluent from the water treatment system will be sampled daily for total arsenic concentrations. The treated water might also be sampled for other parameters as required for reuse at the Tyco facility or for discharge in accordance with the WPDES permit, if applicable. Additional points in the treatment system might be sampled and other analyses might be run as well to monitor system performance.

Samples for total arsenic analyses will be submitted to a nearby laboratory and immediate results (or 24-hour turnaround) will be requested. Alternatively, an onsite laboratory might be set up during the corrective activities if the quantity of analyses and turnaround time justify the cost. This will be evaluated later in the design process. If sample results indicate arsenic concentrations or other chemicals above reuse or discharge criteria, discharge of water will stop immediately, and the system will be inspected and modified so that treated water is once again in compliance.

6.2 Post-Dredging Sediment Confirmation Sampling and Surveys

6.2.1 Surveys and Material Thickness Verification

A bathymetric or terrestrial survey will be performed after the completion of Phases I, II, and III to document that the dredging cut lines have been achieved and that the required thickness of cap layers has been met.

6.2.2 Confirmation Sampling

Possible confirmation sampling methods include split spoon sampling using a barge-mounted drill rig, hand coring, and probing. Confirmation sampling will be performed after material removal in Phases I and III. Limited confirmation sampling will be performed following Phase I, only where contaminated soft sediment overlies soft sediment with arsenic concentrations less than 50 mg/kg, and no contamination exceeding 50 mg/kg is present in semi-consolidated material beneath. For Phase III, confirmation sampling for arsenic analysis will be performed, except in areas where all soft sediment has been removed.

Confirmation sampling locations and other details will be provided in the comprehensive confirmation sampling plan, which will be developed after acceptance of the final design and at least 90 days before completion of construction (per Attachment 2, Section IVA, 2nd paragraph of the AOC).

6.3 Air Monitoring

Air monitoring for particulate matter will be performed because of the possibility of dust being released during dredged material and reagent handling. This will only be done during Phase III (excavation of soft sediment from the South Channel), because reagents will be directly mixed with the sediment in situ, and this activity has potential to create dust. During Phase I, reagents will be added to wet materials in a pugmill, which will reduce potential for dust emissions. Real-time monitors that measure particulate matter finer than 10 micrometers in diameter and smaller (PM_{10}) will be used for monitoring. Three locations will be used to record continuous data on the Tyco property in the west, south, and east directions between 300 and 400 feet away from the dredged material and reagent handling and operations area.

SECTION 7

Preliminary Construction Schedule

A preliminary construction schedule for the AMRSRP approach is provided in Appendix D.

SECTION 8
Cost Estimate

The cost for the AMRSRP approach is estimated to range from $11.7 million to $25.1 million. A compensation schedule is included in Appendix E. The cost estimate is provided in Appendix F. Cost estimate assumptions are based on the best available information regarding the anticipated scope of work, previous experience, and general site knowledge. Changes in the cost elements are likely to occur as a result of new information and design results. This is an order-of-magnitude cost estimate that is expected to be within +50 to -30 percent of the actual project costs.

SECTION 9

Biddability, Constructability, and Operability Review

The activities proposed in this AMRSRP have been reviewed with an emphasis on biddability, constructability, and operability. The final design will be reviewed using these criteria as well. Any concerns noted during these reviews regarding biddability, constructability, and operability will be addressed before completing the final design.

SECTION 10

References

CH2M HILL. 2010a. *Sediment Removal Work Plan for Sediment Remediation.* December.

CH2M HILL. 2010b. *Barrier Wall Groundwater Monitoring Plan.* October.

Figures

0 200 400 600
Feet

N

Figure 1
Site Map
Tyco Fire Products LP Facility
Marinette, WI

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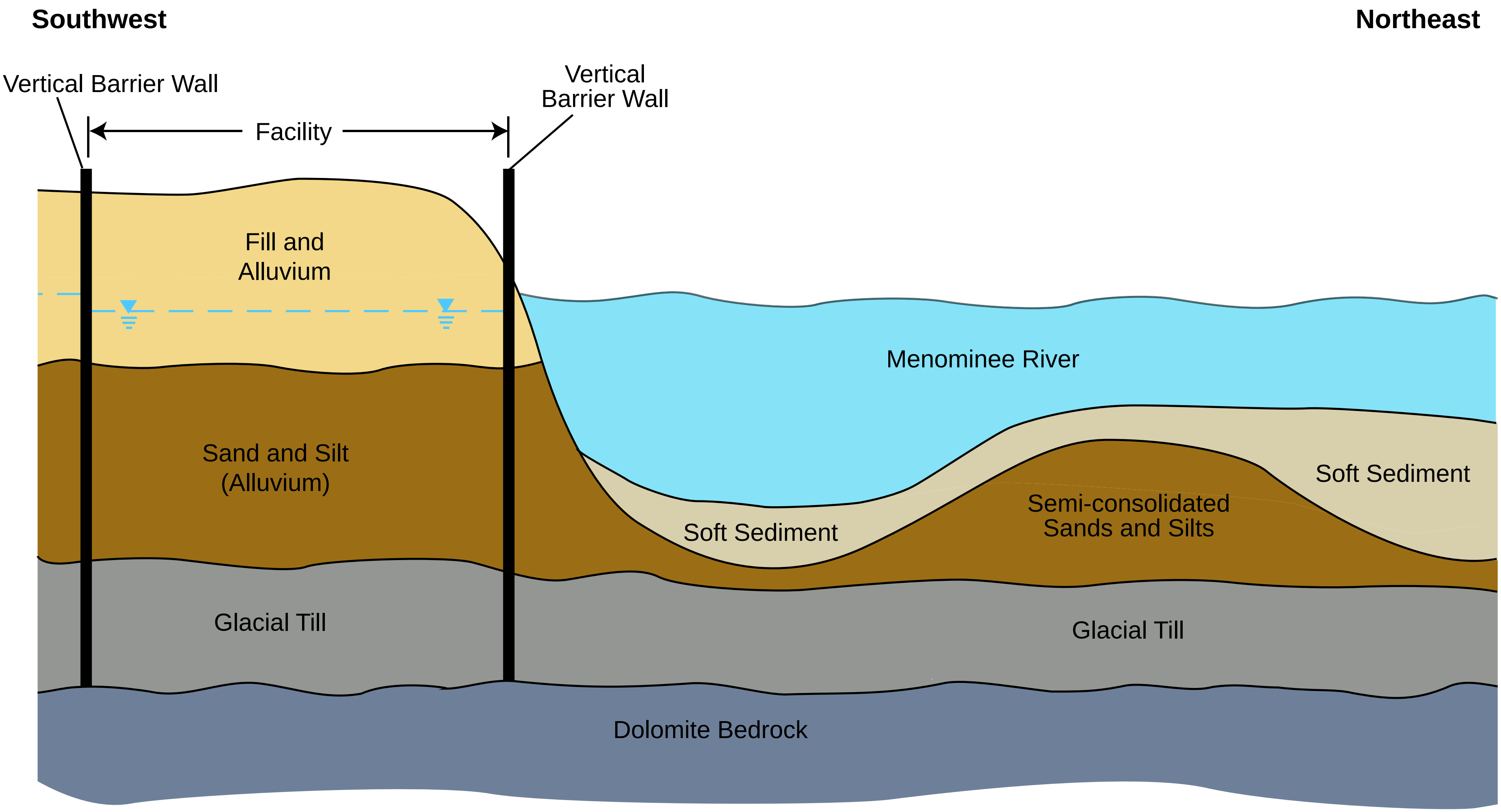
CH2MHILL



Not to scale.

FIGURE 2
Conceptual Site Model – Existing Conditions
Tyco Fire Products LP Facility
Marinette, WI

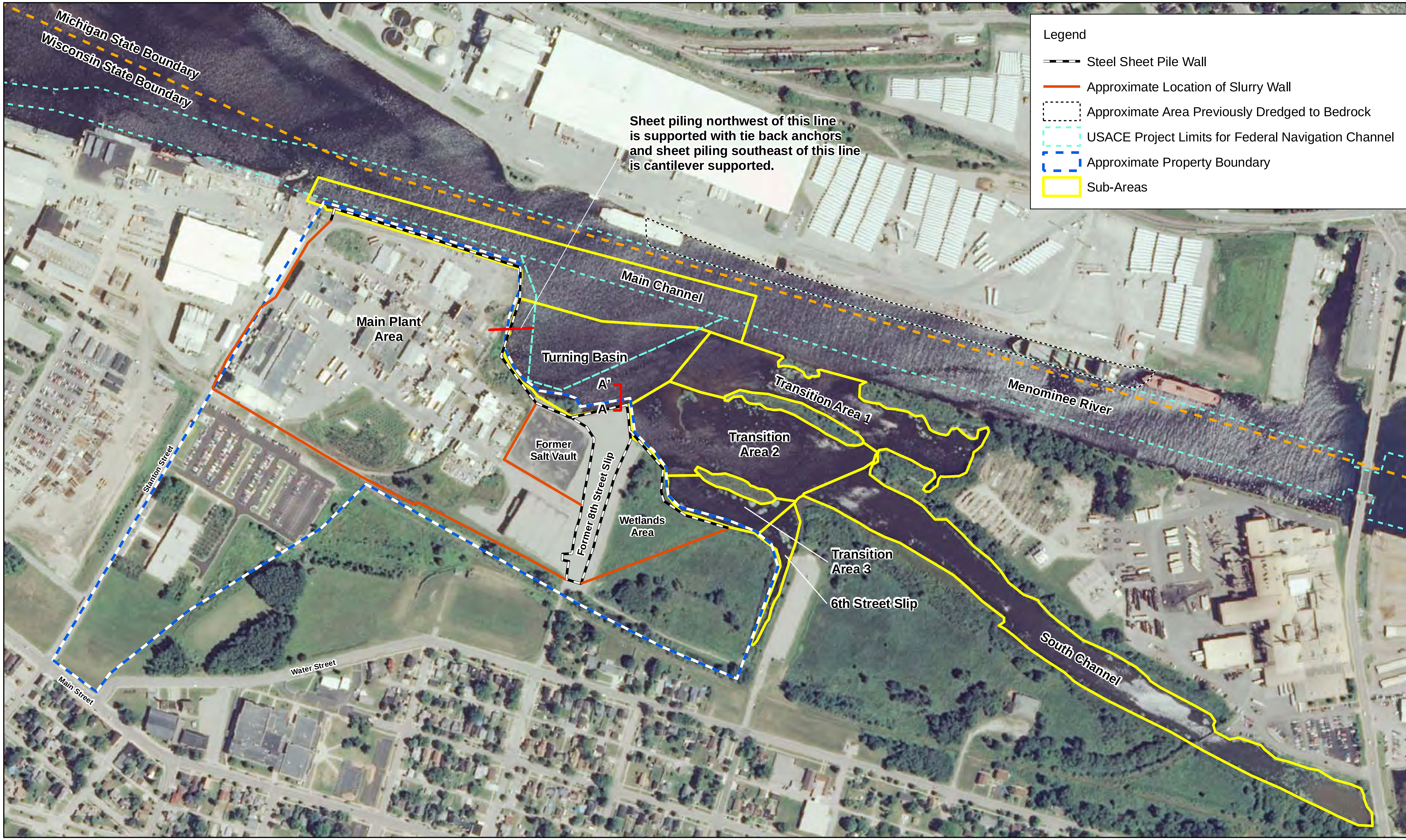


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Figure 3
Semi-consolidated Sands and Silts
Cap Cross Section Location
Tyco Fire Products LP Facility
Marinette, WI

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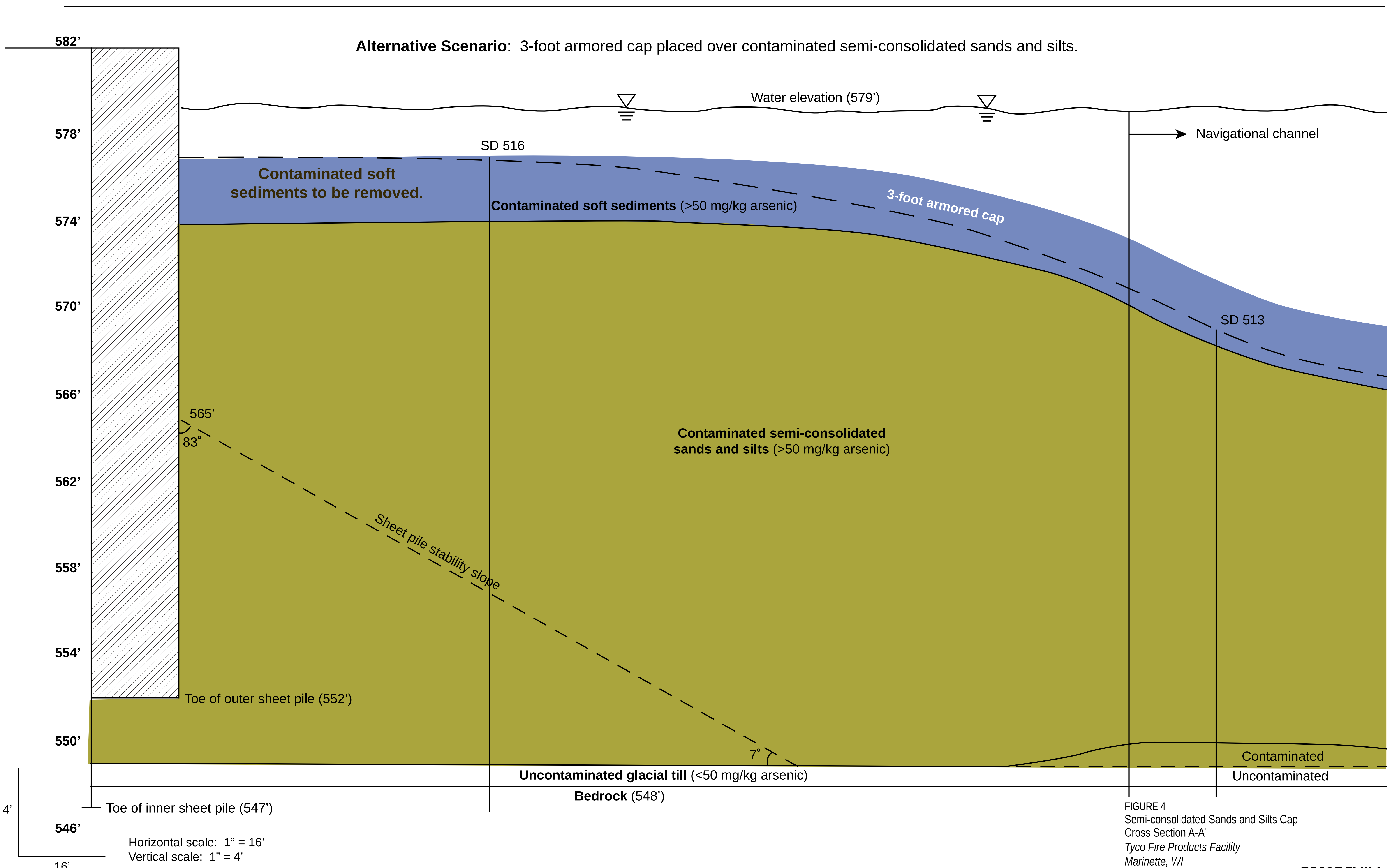

FIGURE 4
Semi-consolidated Sands and Silts Cap
Cross Section A-A'
Tyco Fire Products Facility
Marinette, WI

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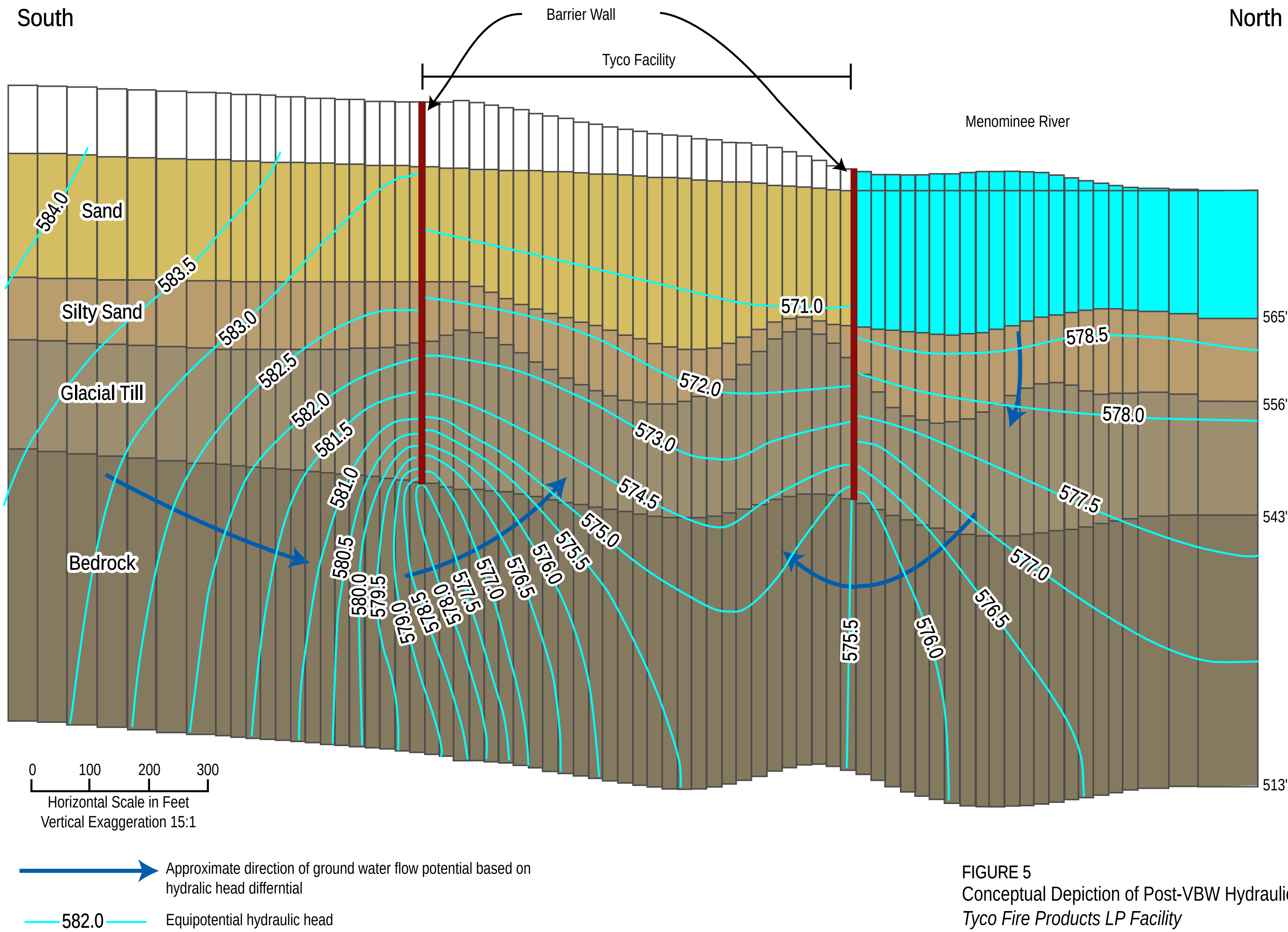

FIGURE 5
Conceptual Depiction of Post-VBW Hydraulic Conditions
Tyco Fire Products LP Facility
Marinette, Wisconsin

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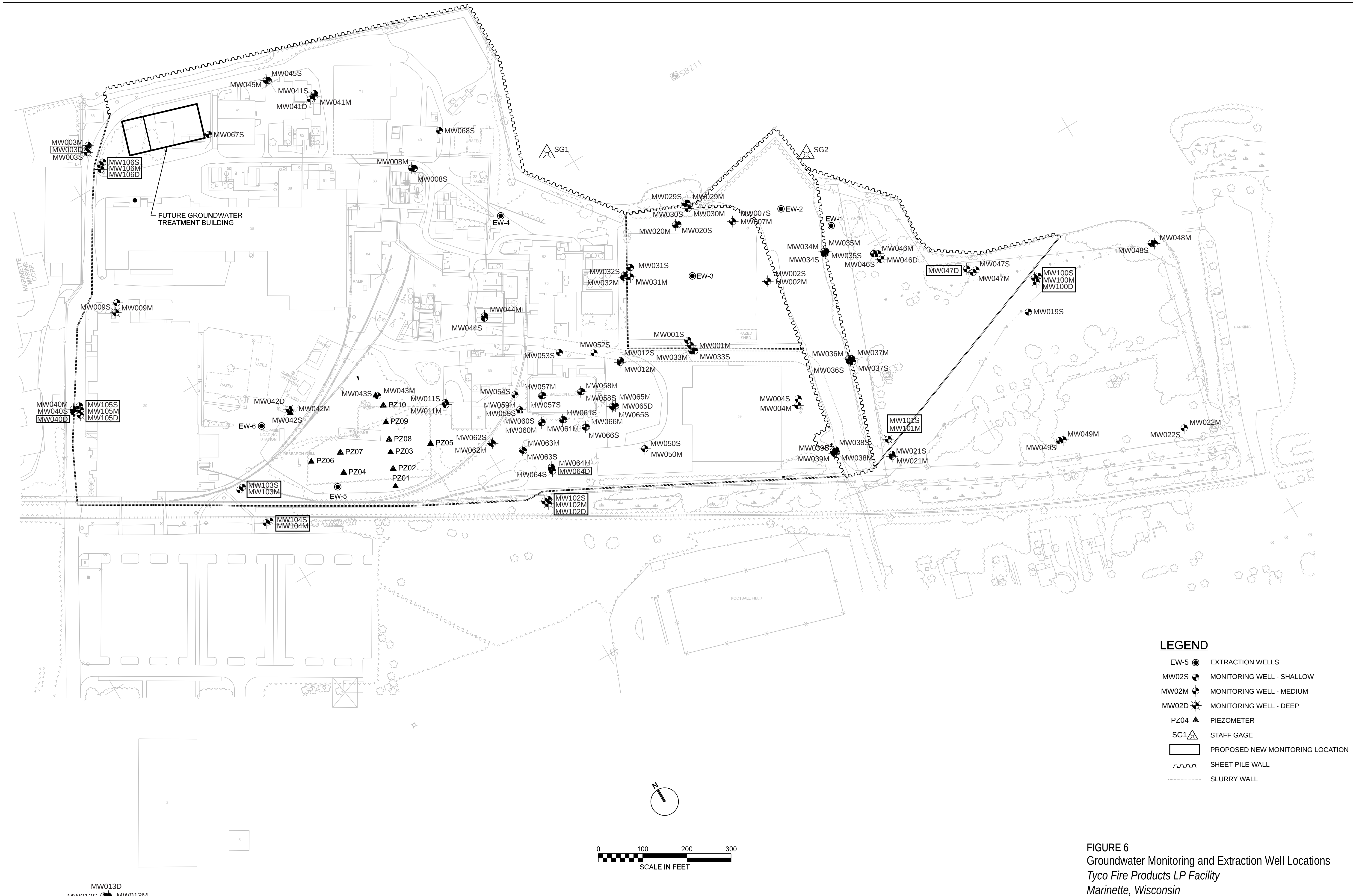

FIGURE 6
Groundwater Monitoring and Extraction Well Locations
Tyco Fire Products LP Facility
Marinette, Wisconsin

ES040810042653MKE Figure_6_Tyco_Ansul_GW_Monitoring_Network_v19.ai 11.22.10 jls/cae/sls

Appendix A

Sediment Remediation Work Plans Evaluation Letter

CH2M HILL
135 South 84th Street
Milwaukee, WI
53214
Tel 414.272.2426
Fax 414.272.4408

December 1, 2010

SUBMITTED VIA E-MAIL AND REGULAR MAIL

Mr. Gary L. Cygan
U.S. Environmental Protection Agency
77 West Jackson Blvd. DE-9J
Chicago, IL 60604-3590

Subject: Sediment Remediation Work Plans Evaluation--Tyco Fire Products LP
Stanton Street Facility
USEPA #WID 006 125 215

Dear Mr. Cygan:

On behalf of Tyco Fire Products LP (Tyco, formerly known as Ansul Incorporated), this letter is submitted to support the work plans prepared pursuant to Section VI, 11, paragraphs d, e, and f of the February 26, 2009, Administrative Order on Consent (AOC) between Tyco and the U.S. Environmental Protection Agency (USEPA).

Section VI, 11, paragraph f allows Tyco to propose an alternative to the Section VI, 11, paragraph d requirement to mechanically dredge the semi-consolidated sands and silt layer ("semi-consolidated material") between the soft sediments and the glacial till. Accordingly, an Alternative Menominee River Sediment Removal Plan (AMRSRP) that proposes to cap this layer is being submitted.

USEPA has informed Tyco that USEPA interprets the AOC as requiring Tyco to submit a work plan to mechanically dredge the semi-consolidated material, per Section VI, 11, paragraph d, even if Tyco submits an alternative plan under Section VI, 11, paragraph f. Although Tyco does not understand or agree with this interpretation, to avoid unnecessary procedural disagreements, we also have prepared a Menominee River Sediment Removal Work Plan (SRWP) that uses mechanical dredging for the semi-consolidated material. Tyco does not believe that dredging the semi-consolidated material is technically or economically implementable. As explained in the remainder of this letter and in the work plans to be submitted under separate cover, dredging the semi-consolidated material threatens the structural integrity of the sheet pile barrier wall, will cause a substantial release of arsenic which is likely to endanger populations of aquatic receptors including game fish, and will cost approximately twice as much as the alternative approach detailed in the AMRSRP.

As a result, Tyco proposes to implement the AMRSRP. The remainder of this letter evaluates and compares the approaches for the semi-consolidated material that are provided in the SRWP and AMRSRP. We believe that dredging the semi-consolidated material is technically and economically impracticable, and this letter and separately filed work plans provide the details necessary to support the approval and implementation of the AMRSRP. The SRWP is submitted only to accommodate USEPA's interpretation of the AOC.

Summary

Dredging the semi-consolidated material that exists between the soft sediments and the glacial till, as required by Section VI, 11, paragraph d of the AOC, will destabilize and threaten the integrity of the sheet pile barrier wall that was installed pursuant to Section VI, 11, paragraph b of the AOC. Thus, the SRWP approach as described in paragraph d of the AOC is technically impracticable.

In addition, the SRWP approach will cause uncontrollable releases of arsenic when dredging semi-consolidated material in the Turning Basin and in other areas of the river. The amount of arsenic released from these semi-consolidated materials is likely to result in substantial exceedances of Wisconsin's acute toxicity water quality criterion (WQC) for arsenic in surface water (340 micrograms per liter [µg/L] [Wisconsin Administrative Code NR105]). The AMRSRP approach avoids both of these problems by capping the semi-consolidated material.

Section VI, 11, paragraph f of the AOC allows Tyco to propose "an alternative to removal of the sediment layer…between the soft sediments and the glacial till [i.e., the semi-consolidated material]" if the following conditions are met:

1. **Removal of semi-consolidated material beneath soft sediment is economically and technologically impractical.**

   - Approximately 5,000 cubic yards (yd^3) of contaminated semi-consolidated material with arsenic concentrations significantly greater than 50 milligrams per kilogram (mg/kg) cannot be removed because this material provides required structural support for the existing sheet pile barrier wall that was installed to contain contamination beneath the Tyco facility. The AMRSRP approach caps these semi-consolidated materials, eliminating the risk to the sheet pile barrier structural integrity and reducing arsenic releases from the semi-consolidated materials during and after active remediation.

   - The AMRSRP approach eliminates environmental risks from the release of particle-associated and dissolved arsenic that will be caused by dredging the semi-consolidated material. The arsenic released during dredging will be at levels that are likely to endanger ecological receptors in the Menominee River near to and downstream of the dredging areas.

   - Implementation of the SRWP is estimated to cost between $23.7 million and $50.8 million. Implementation of the AMRSRP approach is estimated to cost between $11.7 million and $25.1 million. Thus, the more environmentally protective alternative approach can be implemented for approximately half the cost of the AOC-specified (SRWP) remedy.

2. **The proposed alternative protects human health and the environment.**

   - The AMRSRP approach protects human health and the environment by removing soft sediment with arsenic concentrations greater than or equal to 50 mg/kg and by capping semi-consolidated material with concentrations greater than or equal to 50 mg/kg[1]. The capping and in-place containment approach for the semi-consolidated material under the AMRSRP is more environmentally protective in the short term as compared to dredging these materials because the AMRSRP reduces the mass of arsenic that will be released during SRWP dredging. The AMRSRP approach also is more environmentally protective in the long term because the SRWP requires removal of contaminated semi-consolidated material that must remain in place to support the existing sheet pile barrier wall, while the AMRSRP caps this material, retains the structural integrity of the barrier wall, and provides ongoing and immediate protection to the Menominee River fisheries and other ecological receptors.

3. **The proposed alternative is legally implementable.**

   - The approach in the AMRSRP is legally implementable with the required state, local, and federal authorizations, including the U.S. Army Corps of Engineers (USACE). Permits and authorizations will be required to implement the approaches in either the SRWP or AMRSRP.

4. **The proposed alternative achieves an equivalent level of protection to monitored natural remediation (MNR).**

   - The AMRSRP approach, capping those portions of the semi-consolidated material with arsenic concentrations greater than 50 mg/kg, provides superior protection as compared to MNR of these areas because the cap will reduce arsenic released from these areas.

Project Background

Tyco prepared a corrective measures study (CMS; URS Corporation [URS] 2003a) and an addendum to the CMS (EarthTech 2007) that evaluated the technical and economic feasibility of remedial options for addressing the onshore contamination that exists at the Tyco facility. Corrective measures for the onshore facility included installing a vertical barrier wall (VBW) system and a groundwater collection and treatment system within the VBW.

A CMS was not conducted for the Menominee River sediment.

Tyco prepared and submitted a site-specific baseline risk assessment (URS 2003b) that concluded that the arsenic in the sediment potentially posed an unacceptable risk of adverse effects only to benthic organisms and only at concentrations greater than 89 parts per million (ppm).

In addition, at USEPA's request, Tyco prepared a cost/benefit analysis that compared the dredging costs and arsenic removal benefits of dredging ***the soft sediments only*** over a range of cleanup levels from 5 to 1,000 ppm total arsenic (URS 2003c). That analysis

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[1] Tyco's site-specific baseline risk assessment (URS 2003b) concluded that the arsenic in the Menominee River sediments as currently configured poses no threat to human health and threatens benthic organisms and ecosystems only at concentrations greater than 89 mg/kg.

concluded that the cost/benefit point of diminishing returns for dredging the soft sediment was approximately 50 ppm.

USEPA's September 12, 2007 Statement of Basis (SOB) relied on the cost/benefit analysis and evaluated costs, feasibility, and risks of options to address the estimated 74,000 cubic yards of soft sediments that the cost/benefit report identified as containing arsenic contamination greater than 50 ppm. The SOB selected mechanical dredging as the preferred alternative for remediating these soft sediments, see SOB pp. 17 and 23, and both work plans that Tyco is submitting specify mechanical dredging to address contaminated soft sediments. The SOB did not address or consider the costs, feasibility and impacts of alternatives to address contamination in the semi-consolidated sand and silt layer between the soft sediments and the glacial till.

Accordingly, the impacts, feasibility and costs associated with alternatives for addressing contamination in the semi-consolidated materials were not considered in the SOB, or anywhere else, and the public was not provided the opportunity to review and comment on remedial options for the semi-consolidated material.

Instead, without the support of a cost or technical feasibility analysis, Section VI, 11, paragraph d of the AOC specifies a dredging-only remedy for the semi-consolidated material (the SRWP). The presumptive selection of dredging contradicts USEPA guidance as outlined in USEPA Office of Solid Waste and Emergency Response (OSWER) Directives 9200.1-90 (USEPA 2008) and 9285.6-08 (USEPA 2002), ("dredging is not the 'presumptive' remedy, but should be considered on an equal footing with other remedial options").

Tyco did not object to the dredging-only remedy in the AOC because the AOC specifically provided for an alternative (Section VI, 11, paragraph f) if during design development it was determined that the dredging-only remedy was technically and economically impracticable. In fact, this is what has happened. Our evaluation has shown that the presumptive remedy should not be implemented because it will jeopardize the sheet piling structure, it is less environmentally protective, and it is twice as costly as implementing the alternative approach outlined in the AMRSRP.

Work Plan Approaches

Both the SRWP and the AMRSRP approaches include a plan to remove soft sediment containing arsenic concentrations greater than or equal to 50 mg/kg using mechanical dredging. (Dry excavation is used for removing the soft sediment but only in the South Channel area.) Various dredging technologies were evaluated but have been eliminated from further consideration as detailed in Attachment 1.

The VBW design prepared by AECOM, and implemented by Tyco in 2010, requires that at least 13 feet of semi-consolidated material and glacial till must remain in place adjacent to the sheet pile portion of the VBW to maintain the structural stability of the wall. Based on the 2010 sediment investigation results, much of the semi-consolidated material adjacent to the sheet piling contains arsenic concentrations exceeding 50 mg/kg. The SRWP requires mechanical dredging of this area. If these semi-consolidated materials are removed, the sheet pile barrier wall will likely fail, which would result in direct long-term release of contamination.

Both the SRWP and AMRSRP use MNR "to remediate sediments remaining after sediment removal activities to a concentration of 20 ppm of arsenic." The 20 ppm goal must be met within 10 years of completing the sediment removal.

The AMRSRP caps all of the semi-consolidated material that contains arsenic concentrations greater than or equal to 50 mg/kg including the semi-consolidated material that must remain in place to maintain stability of the VBW. In addition, the AMRSRP includes an evaluation of groundwater flow beneath the river following completion of the VBW to verify the elimination of groundwater gradients in the river in the areas proposed to be capped. If it is determined via collection of additional hydraulic data that groundwater continues to discharge to the river, additional measures (such as lowering the onshore groundwater elevation) will be undertaken to eliminate the possibility of groundwater upwelling through the semi-consolidated material. The AMRSRP includes a description of additional hydraulic information to be collected in support of the groundwater flow evaluation.

RCRA Corrective Measures Alternatives Evaluation

The SRWP and AMRSRP approaches each were evaluated against USEPA's performance standards and balancing criteria for the evaluation of Resource Conservation and Recovery Act (RCRA) corrective measure alternatives (USEPA 2000).

USEPA Performance Standards

USEPA has established three performance standards for corrective measures:

- Protect human health and the environment
- Achieve media cleanup objectives
- Remediate the sources of releases

An evaluation against the performance standards for the corrective measures described in the SRWP and AMRSRP is detailed below.

Protection of Human Health and the Environment

The removal of semi-consolidated material using mechanical dredging as required by Section VI, 11, paragraph d of the AOC and as detailed in the SRWP will release substantially more arsenic into the river during dredging than capping the semi-consolidated materials as described in the AMRSRP. The SRWP will cause greater environmental impacts in the short term as compared to leaving the semi-consolidated material in place and capping them as described in the AMRSRP.

The release of particle-associated and dissolved arsenic from <u>the soft sediments</u> during mechanical dredging operations can be minimized by using best management practices (BMPs). One of the BMPs is using an "environmental bucket" to minimize dredging-induced turbidity and, as a result, the release of arsenic to the environment. Because the corrective measures described in both the SRWP and AMRSRP include mechanical dredging of the soft sediments using an environmental bucket, the environmental protection for dredging soft sediment under both approaches is identical.

Although using an environmental bucket is feasible for mechanical dredging of soft sediments, an environmental bucket cannot be used when dredging the semi-consolidated material. Based on data obtained during the 2010 sediment investigation, experience from previous mechanical dredging projects, and discussions with a dredging equipment supplier, an environmental bucket cannot be used to remove the semi-consolidated sands and silts because of the material's physical properties (Standard Penetration Test "N" value of 20 to 50 blows per foot). Instead, a conventional "clamshell" bucket with teeth or an open bucket must be used to remove these materials. According to research conducted by USACE (http://el.erdc.usace.army.mil/resbrief/drbucket/drbucket.html), mechanical dredging with a conventional clamshell bucket releases twice the suspended solids and, therefore, twice the arsenic that is in the solid phase, as compared to mechanical dredging with an environmental bucket. Much of the arsenic associated with these suspended solids will be desorbed and/or resolubilized when the suspended solids pass through the water column and come into contact with the oxidizing environment.

Unlike most contaminated sediment dredging projects which have hydrophobic contaminants that are strongly sorbed to solid particles, the sediments and semi-consolidated material in the Menominee River project area has a substantial dissolved arsenic component. As discussed in the conceptual site model included in the SRWP, the dissolved arsenic present in the semi-consolidated material is primarily the result of groundwater transport. Not only will the dissolved arsenic in the semi-consolidated material be released during dredging, but the particle-associated arsenic in these materials is in a more soluble form than are contaminants typically encountered at contaminated sediment sites (such as polychlorinated biphenyls and higher molecular weight polycyclic aromatic hydrocarbons). Thus, release of the dissolved as well as the soluble particle-associated arsenic cannot be controlled adequately during dredging.

Controls such as turbidity curtains will not be effective in limiting the release of dissolved-phase arsenic during dredging activities, nor do turbidity curtains prevent particulate-associated arsenic from dissociating from the particles and being dispersed in the dissolved phase to the water column. As a result, mechanical dredging of the semi-consolidated material under the SWRP approach will uncontrollably release a substantial amount of arsenic that is contained in the semi-consolidated material.

The release of arsenic during dredging of the semi-consolidated materials is very likely to cause exceedances of the Wisconsin Department of Natural Resource (WDNR) ambient acute toxicity WQC for arsenic (340 µg/L) during dredging operations in the Turning Basin and adjacent areas to the east. The supporting evaluation is presented in Attachment 2. As an example, an evaluation of the arsenic release shows that the acute toxicity WQC for arsenic would be exceeded while dredging contaminated semi-consolidated material in the Turning Basin with arsenic concentrations exceeding 1,000 mg/kg during average river flow conditions if as little as 0.88 percent of the total (particulate and dissolved) arsenic in the dredged material is released.

Moreover, these calculations assume average river flow in the Menominee River. However, the Turning Basin is physically offset from the main channel of the river and therefore is more quiescent. Because the Turning Basin does not experience the dilution and mixing that occurs with average channel river flows, releases of less than 0.88 percent of the total arsenic in the dredged material is likely to cause the acute toxicity WQC for arsenic to be exceeded.

Results of a National Resource Council (NRC 2007) review of data available from various dredging projects concludes that as high as 10 percent (with a median of 1 percent) of the dredged sediment mass is released into a water body as resuspended sediment. This same study notes that the contaminant mass released to the water column is likely even higher because of dissolved releases from freshly exposed and redeposited sediment (NRC 2007).

The studies cited in the NRC review that support the above statistics are from sites where contaminants typically are more hydrophobic than arsenic. Therefore, it is reasonable to expect, and a preliminary evaluation has concluded, that the mass of arsenic released by dredging the semi-consolidated material likely will be in the upper end of the range (close to 10 percent) presented in the NRC report (NRC 2007).

The AMRSRP proposes to cap rather than dredge the semi-consolidated material. Capping will greatly reduce the release of arsenic from this material, which will eliminate the risk that the acute toxicity WQC for arsenic will be exceeded during and after remediating the semi-consolidated material.

The cap used in the AMRSRP also immediately eliminates direct exposure to the environment of the contaminated semi-consolidated material that must remain in place to maintain VBW stability, thereby eliminating this exposure to ecological receptors in both the short term and long term.

In summary, capping the semi-consolidated material using the AMRSRP approach is more protective of the environment than implementation of the SRWP.

Achieve Media Cleanup Objectives

As required by the AOC, arsenic concentrations greater than or equal to 50 mg/kg are to be removed, or an alternative plan may be proposed. Achieving cleanup objectives, however, does not necessarily mean removal or treatment of all contaminated material above specific constituent concentrations. Standards may be achieved through a combination of removal, treatment, and engineering and institutional controls (USEPA 2003). Implementation of the remedial approach presented in the AMRSRP will result in semi-consolidated material greater than or equal to 50 mg/kg remaining in place, but these materials will be below a protective cap, thus limiting the mobility of the arsenic. With the elimination of a vertical gradient resulting from groundwater discharge, the only transport mechanism acting on the arsenic left under the cap is diffusion. However, diffusion is a slow process.

The estimated time required for the arsenic mass in the upper 4 feet of the semi-consolidated material to diffuse through the cap into the river would be between

960 and 120,000 years (Attachment 3)[2]. The average release rate is so small that, even at the most conservative estimate of 960 years, the average arsenic concentration in the water will be 0.037 µg/L and at no time will the concentration approach Wisconsin's chronic toxicity WQC for arsenic in surface water (148 µg/L [Wisconsin Administrative Code NR105]). From a risk perspective, placing a clean cap over the semi-consolidated material is equivalent to achieving the cleanup objective.

Remediate the Sources of Releases

Sediment remediation is one part of a comprehensive approach to address soil, groundwater, and sediment impacts resulting from historical practices at the site. The required remedial actions include placing the VBW around the site to contain impacted soil and groundwater. In addition, groundwater management within the barrier system is accomplished through phyto-pumping and operation of a groundwater extraction system. These remedial actions were completed in 2010 and effectively address the primary source of impacts associated with the site.

Under the AMRSRP, sediment remediation will be accomplished through a combination of removal and source control as allowed by USEPA guidance (USEPA 2003, 2005). The AMRSRP approach achieves source control by capping those areas of the semi-consolidated material with arsenic concentrations exceeding 50 mg/kg that must remain in place adjacent to the VBW to prevent failure of the VBW, which would allow new releases of contaminants from the site. The AMRSRP approach also reduces exposure and contains the remaining arsenic located beyond the sheet pile wall. In addition, measures will be implemented under the AMRSRP approach to control groundwater flux through the semi-consolidated material if further evaluation indicates this is required. **Although total source "removal" is not achieved under the AMRSRP approach, effective remediation and "source control" are achieved. Thus, the AMRSRP is more protective than the SRWP approach.**

Evaluation versus USEPA's Balancing Criteria

If more than one remedial approach meets USEPA performance standards, balancing criteria are considered to select the approach to be implemented. These balancing criteria include (USEPA 2000):

- Long-term reliability and effectiveness
- Reduction of toxicity, mobility, or volume of wastes
- Short-term effectiveness
- Implementability
- Cost
- State and community acceptance

Under RCRA, balancing criteria are not ranked in terms of relative importance; any one of the balancing criteria may prove to be the most important based on site conditions. This section focuses on comparing SRWP and AMRSRP with reference to these balancing criteria.

[2] Two processes occur with groundwater flow—an advective and a diffusive process. This estimate was performed assuming there are no advective forces producing groundwater flow upward through the remaining semi-consolidated material. In other words, a combination of engineering controls, including the onshore vertical sheet pile barrier wall will prevent advective groundwater flow through this area. See Attachment 3.

Long-Term Reliability and Effectiveness

The approach presented in the SRWP includes removing sediment and semi-consolidated materials with arsenic concentrations greater than or equal to 50 mg/kg. Removing the semi-consolidated materials will result in a substantial, uncontrollable release of arsenic into the Menominee River that is expected to exceed acute toxicity WQC and threaten ecological receptors, including fish that inhabit or move through the Turning Basin and the shallower area to the east. In addition, removing the semi-consolidated materials adjacent to the VBW likely will result in structural failure of the wall.

Although semi-consolidated material containing arsenic concentrations greater than or equal to 50 mg/kg will remain in place following implementation of the AMRSRP approach, these materials will not be disturbed further. Instead, these contaminated materials will be capped, reducing the release of arsenic and resulting risks to the environment. Assuming upward groundwater gradients that may exist in the river are properly controlled as part of the AMRSRP (if required), it is estimated that the time required for arsenic mass remaining in the upper 4 feet of the semi-consolidated material to diffuse through the cap into the river will be between 960 and 120,000 years (Attachment 3). This equates to an average release of approximately 42 pounds per year of arsenic into the environment over the course of 960 years, assuming the most conservative (rapid) diffusion. This rate of release of arsenic will not cause an exceedance of the WQC in the Menominee River.

As a point of comparison, successful implementation of the AOC's MNR component could release as much as 700 pounds of arsenic per year.

Therefore, implementation of the approach presented in the AMRSRP is more effective in the long term than the approach presented in the SRWP.

Reduction of Toxicity, Mobility, and Waste Volume

The corrective measure approach presented in the SRWP includes removing soft sediment and semi-consolidated materials with arsenic concentrations greater than or equal to 50 mg/kg. The material removed and landfilled during the SRWP will have reduced toxicity and mobility. Approximately 380,000 tons of waste material will be generated by the SRWP approach for land disposal.

The approach presented in the AMRSRP will reduce the mobility of dissolved arsenic in the semi-consolidated materials because the groundwater recharge through these materials will be eliminated either through engineering controls already applied onshore (VBW and groundwater extraction) or through additional measures if hydraulic data indicate this is required. By eliminating this gradient and capping the semi-consolidated material, the only transport mechanism potentially affecting arsenic mobility is diffusion. As discussed above, diffusion is a slow process. The AMRSRP approach eliminates the release of arsenic that would occur during the dredging of semi-consolidated materials and precludes generation of an estimated 270,000 tons of waste material. Lastly, the mobility of arsenic in the semi-consolidated material that remains following implementation of the AMRSRP is low. As previously stated, it is estimated to take between 960 and 120,000 years for arsenic mass contained in the upper 4 feet of the remaining material to diffuse to the river (Attachment 3).

Since the AMRSRP cap will eliminate exposure of ecological receptors to media that exceed 50 mg/kg arsenic, potential impacts from arsenic in Menominee River sediment will be reduced significantly. From a risk perspective, placement of the clean cap over the semi-consolidated material prevents exposure of ecological receptors to the remaining arsenic and, therefore, is equivalent to a reduction in toxicity.

Short–Term Effectiveness

Arsenic released during dredging of the semi-consolidated material in the SRWP approach is likely to exceed Wisconsin's acute toxicity WQC for arsenic even if as little as 1 percent of the arsenic in these materials is released. As discussed above, it is likely that substantially more than 1 percent of the mass of arsenic in the semi-consolidated materials may be released during dredging of the semi-consolidated material.

Implementation of the SRWP approach uses engineering controls to protect site workers and the community during the estimated 10 months of construction. The SRWP approach will generate an estimated 380,000 tons of waste materials that will require treatment and offsite disposal and increases the risks associated with offsite transportation (an estimated 19,000 roundtrips by trucks between the Tyco facility and the offsite landfill). As described previously, the SRWP approach will result in a release of arsenic to the environment that likely will exceed acute toxicity WQC, which presents a short-term risk.

Implementation of the AMRSRP approach also uses engineering controls to protect site worker and the community during the estimated 4 months of construction. This approach will generate an estimated 108,000 tons of waste materials (an estimated 5,400 roundtrips by trucks between the Tyco facility and the offsite landfill) that require treatment and offsite disposal and eliminates the release of arsenic from the semi-consolidated materials into the environment during remediation.

Thus, implementation of the AMRSRP provides for better short-term effectiveness than the SRWP approach through a significant reduction in the construction duration, an increase in protection to the community (decrease in traffic-related risk because of decrease in waste generation), and a reduction in environmental impacts (that is, arsenic released into the Menominee River) related to dredging activities.

Implementability

The remedial approach specified in Section VI, 11, paragraph d of the AOC and detailed in the SRWP is not implementable because removing the semi-consolidated material adjacent to the VBW likely will result in failure of the wall. Conversely, the AMRSRP approach of a mixed dredging and capping remedy is implementable. The use of capping to control source material has been approved at more than 30 other river remediation sites across the United States since 1990 (Attachment 4). Mixed remedies are routinely being approved and implemented recently as a more cost-effective alternative to a dredging-only remedies both in USEPA Region 5 (for example, Lower Fox River in Wisconsin) and other areas of the United States.

As described under "Short-Term Effectiveness" above, implementing the AMRSRP approach uses engineering controls to protect site workers and the community during the estimated 4 months of construction. Because a 3-foot-thick cap is proposed under the AMRSRP approach, it also is necessary to address navigation channel depth in the river as part of the AMRSRP. Figures 1 through 4 show depth below low water datum (LWD) of the current top of soft sediment (Figure 1), depth below LWD of the top of semi-consolidated materials (Figure 2), depth below LWD of the top of a 1-foot-thick cap placed after soft sediment removal (Figure 3), and depth below LWD of a 3-foot-thick cap placed after soft sediment removal (Figure 4). As indicated on the figures, the placement of a 3-foot-thick cap in the Turning Basin will result in final water depths in the Federal Channel portion of the Turning Basin ranging between 4 and 25 feet below LWD. It should be noted that under the AMRSRP, the majority of the central portion of the Turning Basin will be greater than 20 feet deep.

Tyco has initiated discussions with USACE and navigation channel users to determine the impacts of remediation plans, under either the SRWP or the ASRWP, on commercial navigation. USACE has stated that the channel depths that would remain if the AMRSRP were implemented will require consultation with channel users. Ultimately, either the SRWP or AMRSRP will be subject to USACE's permitting authority.

Cost

The estimated cost to implement the AMRSRP approach is approximately one-half the cost for implementing the SRWP approach and provides for greater overall protection of the environment. The cost of implementing the SRWP approach is estimated to range from $23.7 million to $50.8 million, while the cost to implement the AMRSRP approach is estimated to range from $11.7 million to $25.1 million. For both the SRWP and AMRSRP approaches, these cost estimates were prepared in accordance with USEPA guidance and at this stage of conceptual design have an uncertainty range of -30/+50 percent. Under USEPA guidance, cost estimates at this stage are developed primarily for comparing the approaches and not for establishing project budgets.

Community and State Acceptance

These criteria typically are evaluated formally following the public comment period, although they can be factored into identifying a preferred approach. From the perspective of source control, implementation of either the SRWP or AMRSRP is expected to be viewed positively from the community. However, the SRWP approach of dredging the semi-consolidated material likely will encounter opposition because of the potential acute WQC toxicity impacts to the Menominee River's walleye and other fisheries from arsenic releases.

Conclusions

Based on an evaluation of site conditions, and the information presented herein, Tyco strongly recommends that the approach presented in the AMRSRP be implemented. The following support this opinion:

- Approximately 5,000 yd^3 of contaminated semi-consolidated material with arsenic concentrations significantly greater than 50 mg/kg cannot be removed because this material provides structural support for the existing sheet pile barrier wall. The AMRSRP proposes to cap these areas to reduce released arsenic and protect the structural integrity of the sheet pile wall.

- Capping and in-place containment of the semi-consolidated material as described in the AMRSRP is more environmentally protective in both the short and long term than dredging of these materials as described in the SRWP. Dredging the semi-consolidated material as proposed in the SRWP will release arsenic at levels likely to expose ecological receptors in the Menominee River adjacent to and downstream of the dredging areas to unacceptable levels of arsenic. The AMRSRP capping of the semi-consolidated materials eliminates the uncontrollable release of arsenic associated with semi-consolidated materials dredging.
- The SRWP scope is estimated to cost between $23.7 million and $50.8 million versus $11.7 million and $25.1 million for the AMRSRP.

In conclusion, a greater level of environmental protectiveness can be achieved for approximately one-half the cost by implementing the alternative plan. This is the essence of USEPA's contaminated sediment management principles and the specific objective of Section 11, paragraph f of the AOC; that is, to select and implement protective, scientifically sound, and cost-effective remedies (USEPA OSWER Directive 9285.6-08).

Please contact me at 414-847-0386 or John Perkins at 561-912-6197 if you have any questions or require additional information about the concepts included in this document.

Very truly yours,

CH2M HILL

Jeffrey Danko
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Enclosure

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John Perkins, Tyco Safety Products
Doug Clark, Foley & Lardner
Weldon Bosworth, Ph.D., URS Corporation
Brenda Allen-Johnson, Foley & Lardner

Enclosures: Figures 1 through 4
Attachments 1 through 4

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Figures

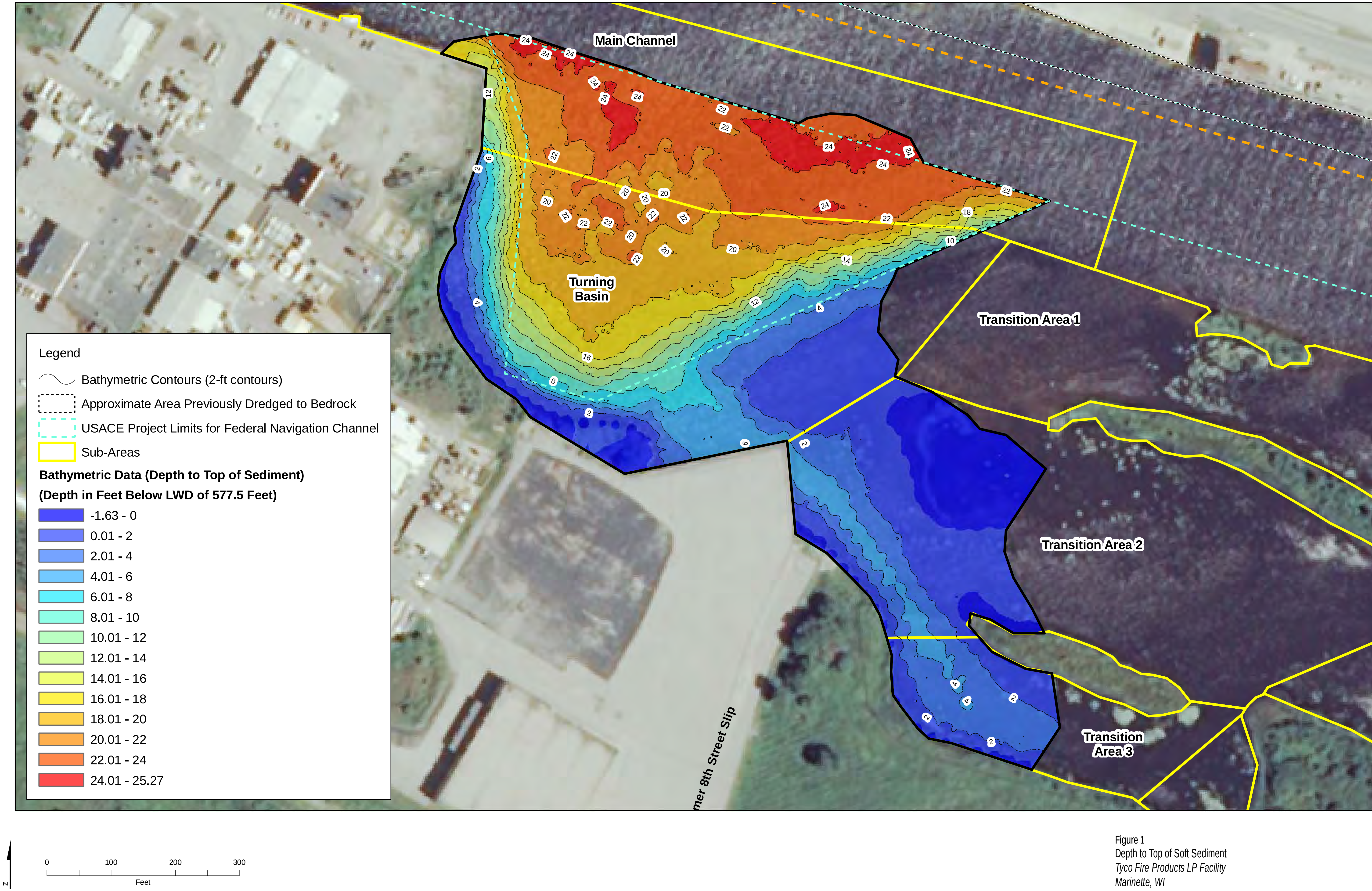

Figure 1
Depth to Top of Soft Sediment
Tyco Fire Products LP Facility
Marinette, WI

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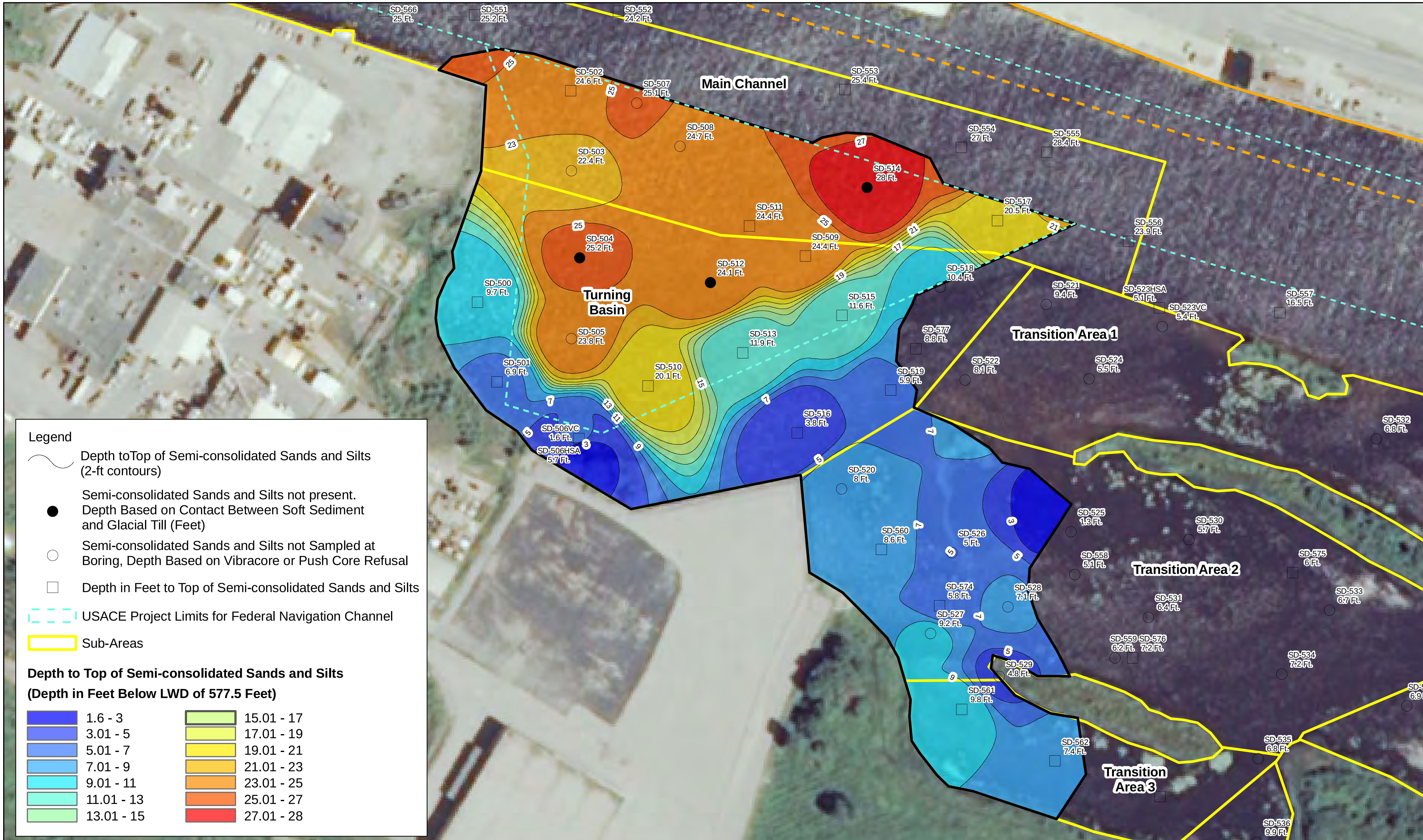

N

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Feet

Figure 2
Depth to Top of Semi-consolidated Sands and Silts
2010 Investigation Area
Tyco Fire Products LP Facility
Marinette, WI

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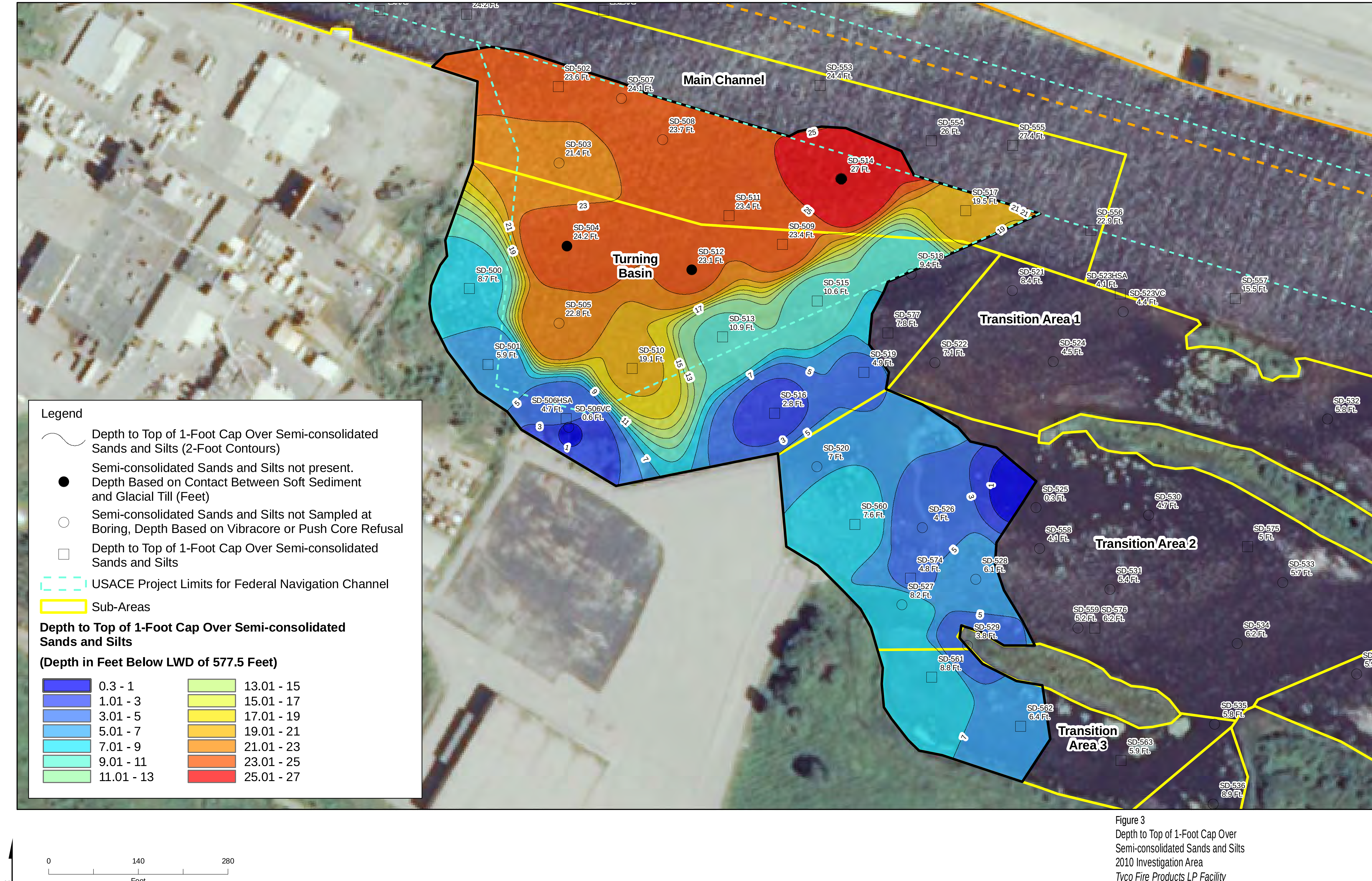

Figure 3
Depth to Top of 1-Foot Cap Over
Semi-consolidated Sands and Silts
2010 Investigation Area
Tyco Fire Products LP Facility
Marinette, WI

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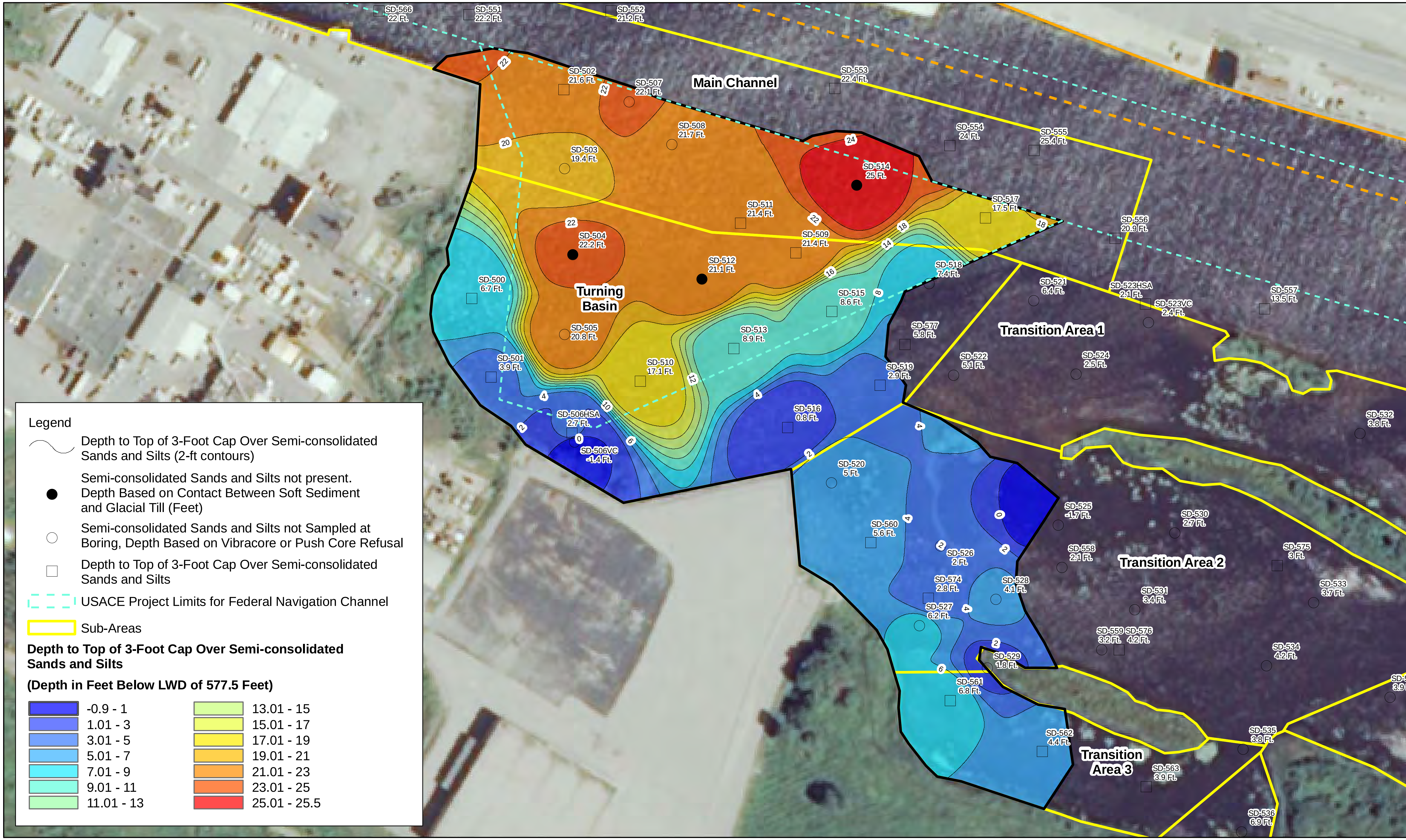

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Figure 4
Depth to Top of 3-Foot Cap Over
Semi-consolidated Sands and Silts
2010 Investigation Area
Tyco Fire Products LP Facility
Marinette, WI

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Attachment 1

Alternate Technologies Evaluation

ATTACHMENT 1

Alternate Technologies Evaluation

Additional discussion is provided herein to address miscellaneous issues that have arisen regarding technologies not identified within the AOC or the Statement of Basis.

Clamshell Bucket Types

A conventional clamshell bucket, as opposed to an environmental bucket, must be used during dredging of the semi-consolidated sands and soils because of their physical properties (20-50 blows per foot). This decision is based on information and experience from/at the following projects:

- Kinnickinnic River Great Lakes Legacy Act Sediment Removal Project in Milwaukee, Wisconsin for U.S. EPA Great Lakes National Program Office (the standard operating procedure was to switch from an environmental bucket to a conventional bucket when sand was encountered rather than soft sediment.)
- Contaminated river sediment removal project for a confidential CH2M HILL client in Australia. Excerpt from the dredge contractor's Dredge Plan:
  - *"The clamshell bucket will not be able to remove dense sands or debris at all, therefore if this material is encountered when the clamshell is in use the dredge will have to stop work and change over to an open bucket."* (The "clamshell bucket" referred to in the dredge plan was a piston-operated environmental bucket.)

Hydraulic Dredging

Hydraulic dredging of contaminated materials involves removing sediment and soil by recovering them, along with a significant volume of water (carriage water) through a pipeline, dewatering and stabilizing the dredged materials, and disposing of the materials. A cutterhead is typically used to breakup consolidated materials. The carriage water generated during hydraulic dredging is typically between 5 and 12 percent solids, meaning a significant volume of water would be generated during the process and must be treated. For a project of this scale, a likely water volume flow rate is around 1,500 gallons per minute (gpm), requiring dewatering infrastructure and a water treatment facility with equivalent capacity. For comparison, the mechanical dredging processes currently described in the SRWP and AMRSRP require water treatment facilities to handle less than 150 gpm. Estimated costs for water treatment are included in Table A1-1, including mechanical dredging and hydraulic dredging. Supporting data for the estimated costs in Table A1-1 for mechanical dredging will be included in the respective work plans. The water treatment costs for hydraulic dredging costs were estimated by scaling up the costs of water treatment for the SRWP to the 1,500-gpm value.

TABLE A-1
Estimated Remediation Water Treatment Costs with Two Dredging Technologies
Tyco Fire Products LP, Marinette, Wisconsin

	Mechanical Dredging	Hydraulic Dredging
SRWP	$ 6.6 million	$ 97 million*
AMRSRP	$ 5.3 million	$ 39 million*

*Includes geotextile tube dewatering and water treatment.

Hydraulic dredging would only be effective for removing semi-consolidated sands and silts if a cutterhead was used. Using such a cutterhead could cause an increase in arsenic release to the river beyond what would be generated using a conventional clamshell bucket, as currently described in the SRWP. Therefore, the arsenic release could be just as significant for hydraulic dredging as mechanical dredging. Hydraulic dredging with plain suction instead of a cutterhead would potentially be effective in limiting release of solids during dredging, but this technology could not be used in the denser semi-consolidated sand and silt material.

Hydraulic dredging was rejected in the AOC's Statement of Basis because of the high cost of treatment of generated wastewater as well as the potential release of arsenic during use of the cutterhead.

Additional Excavation Technologies

Consideration was given to other technologies that could be employed to limit the release of dissolved arsenic to the river during dredging operations. Two such technologies considered were dry excavation using sheet pile cofferdams and excavation using much smaller sheet pile cells.

Dry Excavation

Dry excavation has been used at numerous sites to remove contaminated materials from bodies of water. Temporary cofferdams, or cells, are created around the contaminated materials, usually with sheet piling, but in shallow water other products such as water-inflated plastic barriers (such as Aqua-Barriers) can be used. The cell is then dewatered, and the material is excavated using conventional equipment (excavators and articulated hauling trucks). Stabilization of the material can be done either in situ before excavation is performed or on a staging area outside of the dewatered cell.

Because of the significant excavation depths required to remove the semi-consolidated sands and silts for the SRWP, sheet piling would need to be used as the barrier to form cells if dry excavation were to be used in the Turning Basin area of the Menominee River. However, there is not sufficient thickness of semi-consolidated materials and glacial till above bedrock in the Main Channel north of the Turning Basin to support a sheet pile wall (sheet piling driven to form the northern wall of the cell would meet refusal on bedrock only a few feet into the till). Therefore, dry excavation using cofferdams is not a feasible technology for removal of Menominee River sediments.

Small Sheet Pile Cells

Another potential technology that could be used to remove contaminated sediment and semi-consolidated materials are small sheet pile cells. This process would involve installation of sheet piling to form a relatively small enclosed cell (perhaps 30 feet wide by 30 feet long). The material within the cell is dredged mechanically down to the target elevation, and the water in the cell is pumped out and treated by a temporary water treatment system. The treated water is returned to the cell so that no differential hydraulic pressure is created against the sheet piling. Therefore, a shallow embedment depth would not be problematic for the sheet piling.

It is likely that the water within the cell will need to be treated between three and five times to lower the arsenic to acceptable levels before releasing it to the river. Once this is done, the sheet piling can be extracted and reinstalled at another location to continue the dredging process. The process would probably proceed with three cells being used simultaneously–one being installed, one being dredged, and the last one undergoing treatment of the water after dredging has been completed.

While dredging using small sheet pile cells is technical feasible, and practically no arsenic would be released if they were used, this technology was eliminated from consideration due to the significant cost. The surface area of the dredge area in the river (not including the South Channel) is estimated to be 630,000 square feet (sf). Using cells that are 900 sf, this means that cell removal and installation will need to be done 700 times. If, on average, one of the four sides is common with a previous cell and doesn't need to be installed, this still leaves 700 x 3 x 30 ft = 63,000 linear feet of sheet piling installation and removal in total. Assuming a cost of $500 per linear foot to install and remove one linear foot of sheet piling, this is $31,000,000 for sheet piling work alone.

Average water depth is estimated to be 18 ft in the dredge area. Total water volume is 18 ft X 630,000 sf = 11 million cubic feet, or 85 million gallons. If treatment of three volumes of water is necessary before a cell can be removed, this equates to 260 million gallons of water that must be treated. Treatment of 260 million gallons is going to cost on the order of $55 million. With the combined cost of sheet piling installation and water treatment being $86 million, the entire project cost will exceed $100 million.

In addition to the excessive cost to implement the technology, use of small sheet pile cells will preclude the use of the Turning Basin by maneuvering vessels while the dredging activities are taking place. Therefore, small sheet pile cells were eliminated from further consideration.

Attachment 2

Estimate of Percentage of Total Arsenic Released during Dredging to Exceed Acute Toxicity Standard

ATTACHMENT 2

Estimate of Percentage of Total Arsenic Released during Dredging to Exceed Acute Toxicity Standard

Introduction

An Administrative Order on Consent (AOC) has been signed between Tyco Fire Products LP (Tyco) and the U.S. Environmental Protection Agency (USEPA), dated February 26, 2009, that requires the mechanical dredging of sediments from the Menominee River adjacent to the north boundary of the Tyco facility in Marinette, Wisconsin. Material must be removed that has concentrations equal to or greater than 50 milligrams per kilogram (mg/kg) total arsenic. Mechanical dredging of soft sediments can be performed using an environmental bucket, but mechanical dredging of semi-consolidated sands and silts ("semi-consolidated materials") will require the use of a conventional clamshell bucket because of the material's physical properties (Standard Penetration Test "N" value of 20 to 50 blows per foot). The use of a conventional clamshell bucket will release a higher amount of solids (and therefore arsenic) into the water column during mechanical dredging than an environmental bucket will release.

Arsenic concentrations in the surface water during dredging activities cannot be calculated with any accuracy without performing a field pilot study due to the myriad of assumptions that must be made and parameters that need to be estimated. The objective of this memorandum is to estimate what percentage of the total mass of arsenic in contaminated sediments has to be released into the water column during mechanical dredging to cause an exceedance of Wisconsin's acute toxicity water quality criterion (WQC) for arsenic in surface water (340 micrograms per liter [µg/L] [Wisconsin Administrative Code NR105]). Once the percentage of total arsenic is estimated, a semi-quantitative evaluation can be done to determine if a release of that amount of arsenic is likely during mechanical dredging activities.

Methodology

Samples collected of soft sediment and semi-consolidated materials were analyzed for total arsenic without separating the liquid fraction of the sample from the solids. Therefore, analytical results for total arsenic from these samples includes both dissolved arsenic in the porewater as well as arsenic adhered to solid particles, and can be used to estimate total arsenic present in the soft sediment and in the semi-consolidated materials. The estimation method is summarized below with the full calculation included as Table A2-1.

Step 1 – Determine areas with high concentrations of arsenic in semi-consolidated sands and silts.

Three-dimensional visualization software (Environmental Visualization System -EVS) was used to create a model of the arsenic concentrations using analytical data from samples collected during 2010 in the river. The highest arsenic concentrations were detected in the Turning Basin. Screening values of 1,000 mg/kg and 2,000 mg/kg were used to isolate areas within the Turning Basin with high concentrations of arsenic that were of a sizeable quantity and would take at least several days to excavate. The screening level of 1,000 mg/kg was selected: 5,353 cubic yards (yd^3) of soft sediment and 5,521 yd^3 of semi-consolidated materials were present in the Turning Basin with at least 1,000 mg/kg total arsenic. Figures A2-1 and A2-2 show the locations of these materials. The average arsenic concentration for the soft sediment was 2,900 mg/kg and for the semi-consolidated sands and silts was 1,694 mg/kg.

Step 2 – Determine the total mass of arsenic in materials that can be dredged in one day

The estimated dredging production rate is 1,300 yd^3 per day for soft sediment and 1,000 yd^3 per day for semi-consolidated materials. Estimated in situ dry density is 70 pounds per cubic foot (pcf) for soft sediment and 100 pdf for semi-consolidated materials. Average concentrations listed in step 1 are used (note that mg/kg is the same as pounds per million pounds).

For soft sediment:

1,300 yd^3/day X (2,900 lbs arsenic/1,000,000 lbs) X 70 lbs/ft^3 X 27 ft^3/yd^3

= 7,125 lbs of arsenic in the soft sediment dredged in one day

For semi-consolidated materials:

1,000 yd^3/day X (1,694 lbs. arsenic/1,000,000 lbs) X 100 lbs/ft^3 X 27 ft^3/yd^3

= 4,574 lbs. of arsenic in the semi-consolidated materials dredged in one day

Step 3 – Determine the volume of water flowing through the path of the bucket in one day

The average flow rate of the river was estimated to be 3,500 cubic feet per second based on the 25 year average flow (URS 2003). The cross sectional area of the river was determined to be 12,000 square feet (sf) for the soft sediment, using an estimated dredge depth of 15 feet and a width of 800 feet near the dredging area. For the semi-consolidated materials, the average dredge depth was estimated to be 20 feet, and the width was estimated to be 800 feet, so the cross sectional area was determined to be 16,000 sf. Average stream velocities were 0.292 and 0.219 feet per second for the soft sediment and semi-consolidated materials dredging, respectively. Estimate bucket widths for the soft sediment (environmental bucket) and semi-consolidated materials (conventional clamshell) were 8 and 5 feet, respectively. The volume of water flowing through the path of the environmental bucket travel for the soft sediment dredging was calculated as follows:

Quantity of water per day = Stream velocity X cross sectional area of bucket travel

= 0.292 ft/sec X 15 ft X 8 ft

= 35.0 ft^3/sec

= 22,650,000 gallons/day

= 188,900,000 lbs./day

For semi-consolidated materials, the quantity of water per day is calculated as follows:

Quantity of water per day = Stream velocity X cross sectional area of bucket travel

= 0.219 ft/sec X 20 ft X 5 ft

= 21.9 ft^3/sec

= 14,160,000 gallons/day

= 118,100,000 lbs/day

Step 4 – Determine the hypothetical concentration of arsenic in the surface water if all arsenic in the dredged material was released.

For soft sediment:

[As] in river = 7,125 lbs. As / 188,900,000 lbs. river water = 37,760 µg/L

For semi-consolidated materials:

[As] in river = 4,574 lbs. As / 118,100,000 lbs. river water = 38,787 µg/L

Step 5 – Determine what percentage of the total mass in the sediment would need to be released to equal the WDNR acute toxicity standard of 340 µg/L

For soft sediment:

% of total mass = (340 µg/L) / (37,760 µg/L) = 0.900%

For semi-consolidated materials:

% of total mass = (340 µg/L) / (38,787 µg/L) = 0.877%

Reference

URS Corporation (URS). 2003. *Baseline Risk Assessment, Tyco Suppression Systems – Ansul Stanton Street Site, Marinette Wisconsin*. February 28.

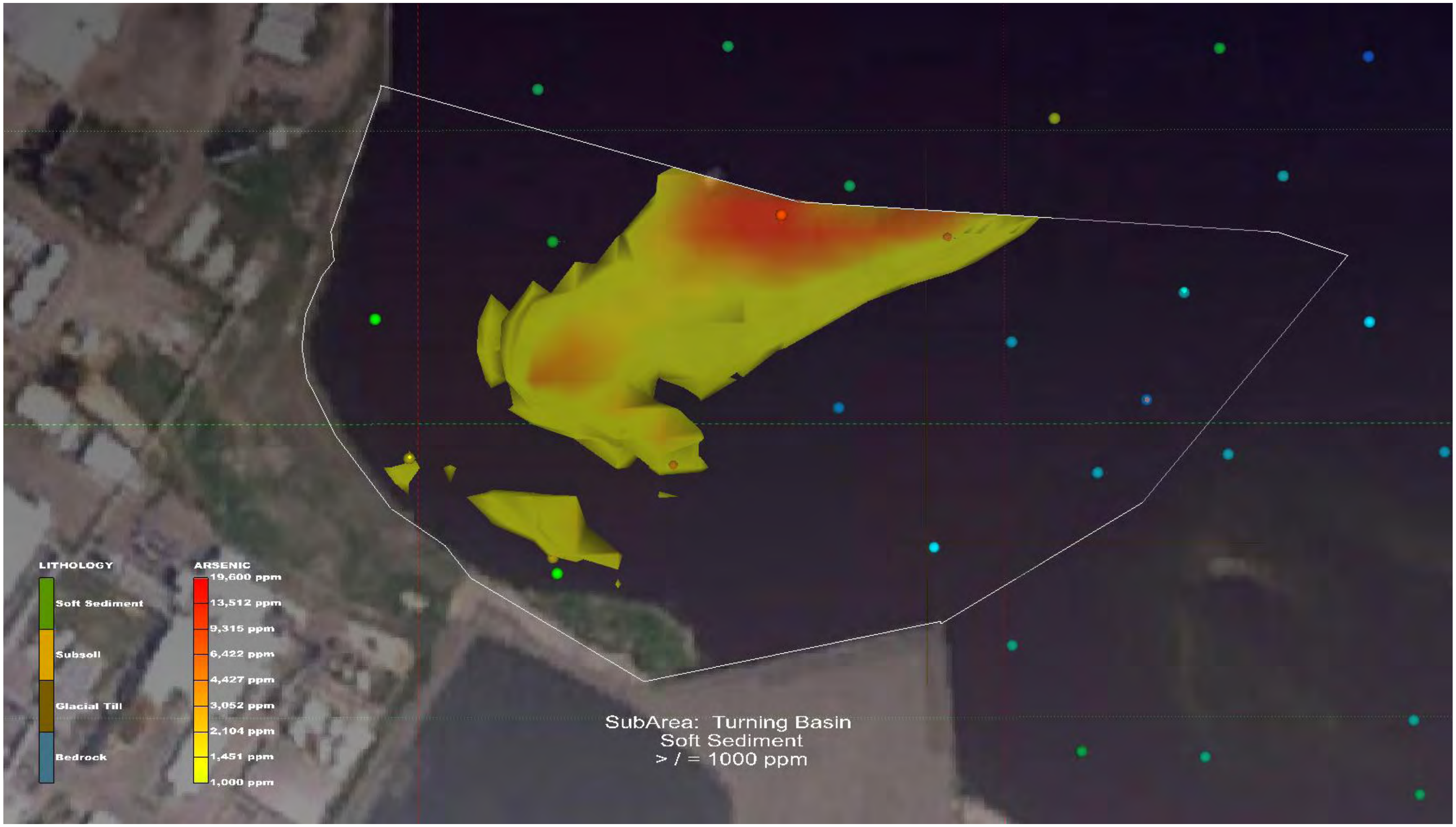


Figure A2-1. Location of soft sediment in the Turning Basin with arsenic contamination greater than 1,000 mg/kg.

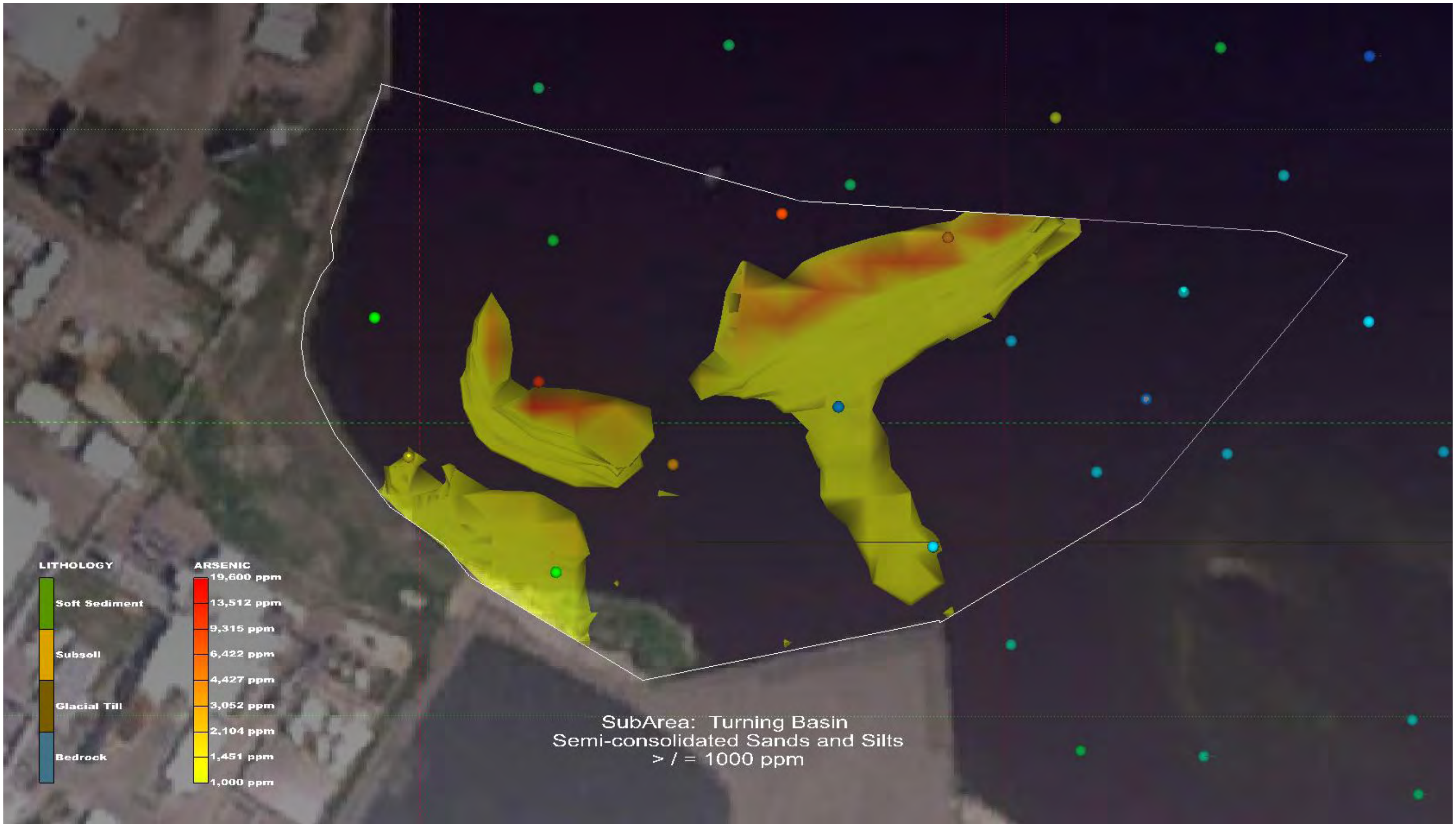


Figure A2-2. Location of Semi-consolidated Sands and Silts in the Turning Basin with arsenic contamination greater than 1,000 mg/kg.

Table A2-1
Dissolved Arsenic Released Calculations
Sediment Removal Work Plan

Sub-Area	Lithology	Screened Value (ppm)	Volume (CY)	Total Arsenic Mass (pounds)	Total Soil Mass (pounds)	Average Arsenic Conc. (ppm)	Notes
Turning Basin	Soft Sediment	1000.00	5,353.10	48,411.00	10,117,239.59	2,900.20	Most conc. vol. of soft sediments as calc. by EVS
Turning Basin	SC Sands and Silts	1000.00	5,520.60	29,165.00	14,906,052.47	1,694.20	Most conc. vol. of SC sands & silts as calc. by EVS

For Soft Sediments, assume 1,300 CY can be dredged in average day:

1,300	CY dredged from turning basin
2,900	mg/kg average arsenic concentration
70	lbs./ft3 in situ dry density
7,125	lbs. arsenic released through water column in one day if all arsenic is released

Average flow rate of the river, cfs	3,500	(Based on 25 yr average flow, URS Risk Evaluation Report, February 2003)
Minimum flow rate of the river, cfs	538	(Based on records, Oct 6 1946, URS Risk Evaluation Report,February 2003)
Cross sectional area of the river	12000	Estimated dredge depth = 15 ft and width = 800 ft near the dredging area
Average stream velocity, ft/sec	0.29	
Minimum stream velocity, ft/sec	0.04	
X-sec. area of vertical path of bucket travel, ft2	120	Estimated dredge depth = 15 ft and environmental bucket width of 8 ft

	Ave. Flowrate	Min. Flowrate
water flowing through x-sectional area of vertical path of bucket travel in one day, ft3	3,024,000	464,832
water flowing through x-sectional area of vertical path of bucket travel in one day, lbs.	188,697,600	29,005,517
concentration of arsenic downstream of dredging assuming all released, µg/l	37,760	245,653

The Wisconsin Department of Natural Resources' ambient water quality standards for arsenic are 340 µg/L for acute toxicity and 148 µg/L for chronic toxicity.

	Ave. Flowrate	Min. Flowrate
Percentage of total arsenic in sediment that can be released to equal standard for acute toxicity	0.900%	0.138%
Percentage of total arsenic in sediment that can be released to equal standard for chronic toxicity	0.392%	0.060%

For semi-consolidated sands and silts, assume 1,000 CY can be dredged in average day:

1,000	CY dredged from turning basin
1,694	mg/kg average arsenic concentration
100	lbs./ft3 in situ dry density
4,574	lbs. arsenic released through water column in one day if all arsenic is released

Average flow rate of the river, cfs	3,500	(Based on 25 yr average flow, URS Risk Evaluation Report, February 2003)
Minimum flow rate of the river, cfs	538	(Based on records, Oct 6 1946, URS Risk Evaluation Report,February 2003)
Cross sectional area of the river	16000	Estimated dredge depth = 20 ft and width = 800 ft near the dredging area
Average stream velocity, ft/sec	0.22	
Minimum stream velocity, ft/sec	0.03	
X-sec. area of vertical path of bucket travel, ft2	100	Estimated dredge depth = 20 ft and clamshell bucket width of 5ft

	Ave. Flowrate	Min. Flowrate
water flowing through x-sectional area of vertical path of bucket travel in one day, ft3	1,890,000	290,520
water flowing through x-sectional area of vertical path of bucket travel in one day, lbs.	117,936,000	18,128,448
concentration of arsenic downstream of dredging assuming all released, µg/l	38,787	252,329

The Wisconsin Department of Natural Resources' ambient water quality standards for arsenic are 340 µg/L for acute toxicity and 148 µg/L for chronic toxicity.

	Ave. Flowrate	Min. Flowrate
Percentage of total arsenic in sediment that can be released to equal standard for acute toxicity	0.877%	0.135%
Percentage of total arsenic in sediment that can be released to equal standard for chronic toxicity	0.382%	0.059%

Attachment 3

Arsenic Diffusion Calculation

ATTACHMENT 3

Arsenic Diffusion Calculation

A calculation was performed to estimate a range of potential time periods over which it would take diffusive transport mechanisms to deplete the mass of arsenic that will remain in the semi-consolidated sands and silts unit once the overlying soft sediments are removed as described in the Alternative Menominee River Sediment Removal Work Plan (AMRSRP). The calculation spreadsheet is included as Table A3-1.

Transport of arsenic from the remaining semi-consolidated material will occur through both advective and diffusive flow. Advective flow is the major contributor to transport of dissolved solutes, as it is driven by the movement of subsurface water under a hydraulic gradient. Generally, the diffusive contribution to transport is relatively small, as it is driven only by the concentration gradient and subject to the influence of other geochemical factors as mentioned below. However, groundwater modeling performed for the site has indicated that the hydraulic gradients driving the advective flux of arsenic to the river will be mitigated (and possibly reversed) as a result of implementation of the upland remedy, which involves the placement of a vertical hydraulic barrier wall (VBW) down to the top of the bedrock, and the operation of groundwater extraction wells for flood control within the VBW alignment. Given the results of the modeling, this exercise focuses on estimating the diffusive transport of arsenic and assumes that the advective component of flux is non-existent.

In the case of arsenic, the dissolution from sediments and the subsequent diffusive flux are also affected by a number of other factors, including the organic carbon content, pH and redox conditions, the availability of adsorptions sites, and the presence of other competing ions. Once in the dissolved phase, arsenic species, including the relatively mobile dimethylarsonic acid (DMA) which is present at the site, will likely be subjected to additional attenuation through sorption processes that will retard the rate at which they may be transported through the pore space. Quantification of these factors requires a myriad of assumptions or detailed site-specific studies, and the formulation of geochemical transport models. However, the objective of this exercise was to provide a rough order-of-magnitude range of hypothetical times that it might take for remaining sediment sources to be depleted. A conservative approach was used to meet this objective that concentrated on physical transport properties and the reported soil-water partition coefficient range for arsenic (a more generalized chemical attenuation factor).

The diffusive flux of total arsenic (all observed species including arsenate, arsenite, monomethyarsonic acid [MMA] and DMA) was estimated for three separate scenarios. Parameter assumptions were varied between the ranges reported in literature to estimate low, medium, and high mobility scenarios. The calculations and assumed parameter values are included on Table A3-1. The total mass of arsenic in the top four feet of the semi-consolidated material (40,290 lbs) and a volume of 78,000 cubic yards was used to back-calculate an average sediment concentration of 157 mg/kg. Using this concentration along with a range of partition coefficients (K_ds) available in EPA Guidance[1] and other available literature[2], pore water concentrations for the top four feet of the semi-consolidated materials were estimated to be between 5.4 and 8.7 mg/L.

Using the dissolved concentrations of arsenic measured in the river water samples during the 2010 investigation and a range of diffusion coefficients, assumed porosities, and tortuosity factors presented in the available literature for sandy freshwater sediments, diffusion rates of $1.8x10^{-3}$, $5.9x10^{-2}$, and $6.9x10^{-1}$ lbs of arsenic per day were calculated for the low, medium and high mobility scenarios, respectively. Conservatively assuming that the calculated diffusion rates would be constant over time it was estimated that the time it would take to remove only the mass of arsenic in the top 4 feet of the semi-consolidated materials (40% of all semi-consolidated arsenic) could range between 960 and 120,000 years with an estimate of 5,000 years for the medium mobility scenario. (Because of the combination of all the ultra conservative assumptions used for the high mobility number, the medium mobility scenario diffusion time probably represents a more realistic estimate). The calculations and assumptions used to develop these rough order-of-magnitude estimates are provided in Table A3-1.

[1] US EPA, 2001. Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites, OSWER 9355.4-24. March.

[2] US EPA, 2006. Reregistration Eligibility Decision for MSMA, DSMA, CAMA, and Cacodylic Acid EPA 738-R-06-021. July; Sanchez et. al, 2003 *Environmental Assessment of Waste Matrices contaminated with arsenic in The Journal of Hazardous Materials* B96 2003 (pp 229-257; C.W. Fetter, Contaminant Hydrogeology 2nd edition,1999.

Table A3-1

Partitioning (sediment to pore water)

Tyco Fire Products LP

Need to assume linear isotherm given complexity of system and contaminant (Kd - Partitioning Coefficient)

$Kd = C_s/C_{pw}$

when:	Sediment Conc.(Cs) =	157 mg/kg	Back-calculated average concentration for top 4 feet of subsoils given calculated mass of As in interval				
							Source of Assumed Kd
and:	Assumed Kd =	29 L/kg		then:	Pore water Conc (C_{pw}) =	5.41 mg/L	EPA Soil Screening Guidance (EPA, 2001) (at pH of 6.8)
	Assumed Kd =	18 L/kg		then:	Pore water Conc (C_{pw}) =	8.72 mg/L	Mean of Kd for DMA reported in EPA (Aug. 10, 2006 document)

Diffusion (Adaptation of Fick's Law - 1st Order [Berner 1980])

Fick's Law

$$J_j = -D_j \frac{\partial c_j}{\partial x}$$

Berner (1980) - for porous media

$$J_s = -\phi \cdot D_s \cdot \frac{\partial C}{\partial x},$$

Where:	Low Mobility	Medium Mobility	High Mobility	
	Assumption Scenarios			
Φ	0.5	0.6	0.7	relative pore water volume in sediments assumed sands and gravel (unitless)
D_s =	5.45E-11	6.87E-10	1.85E-09	effective diffusion (m^2/s) (D_j/θ^2) (Berner, 1980)
D_j =	1.13E-10	1.06E-09	2E-09	molecular diffusion in water (m^2/s) (Diffusion Coefficient)[1]
θ =	1.44	1.24	1.04	tortuousity[2] (unitless)
C_{pw}	5414	7068	8722	conc at position 1 (mg/m^3) (pore water) (see above for high and low, medium is avg. of high and low)
C_{sw}	5.6	3.8	1.9	conc at position 2 (ug/L or mg/m^3) (surface water) (high and low from river water dissolved As concentration analysis performed for elutriate sampling event
x =	1.52439	1.219512	0.9146341	Distance between position 1 and position 2 (m) (low =depth from surf water to middle of top 4 feet of subsoil + 3.0 ft. cap, high = thickness of proposed cap; med = average of low and high values)
$\partial C_j/\partial x$ =	3548	5793	9534	Concentration Gradient ($mg/m^3/m$)
J =	-9.7E-08	-2.4E-06	-1.2E-05	Diffusive Flux (mg/m^2-s)
A =	4.89E+04	4.89E+04	4.89E+04	Surface area over which flux is occurring (m^2) or 526255 ft^2
Total Flux Rate:	-0.00473	-0.11676	-0.603355	mg/s
	-0.0009	-0.02224	-0.114927	lbs/day

Results

	Low	Medium	High	
Total Mass in All Subsoils	98818	98818	98818	lbs
Total mass of As in top 4 feet of subsoils =	40290	40290	40290	lbs
No. of years of linear diffusive flux required to remove mass currently present in top 4 feet =	122,617	4,963	960	years
No. of years of linear diffusive flux required to remove total mass in all subsoils =	300,740	12,173	2,356	years

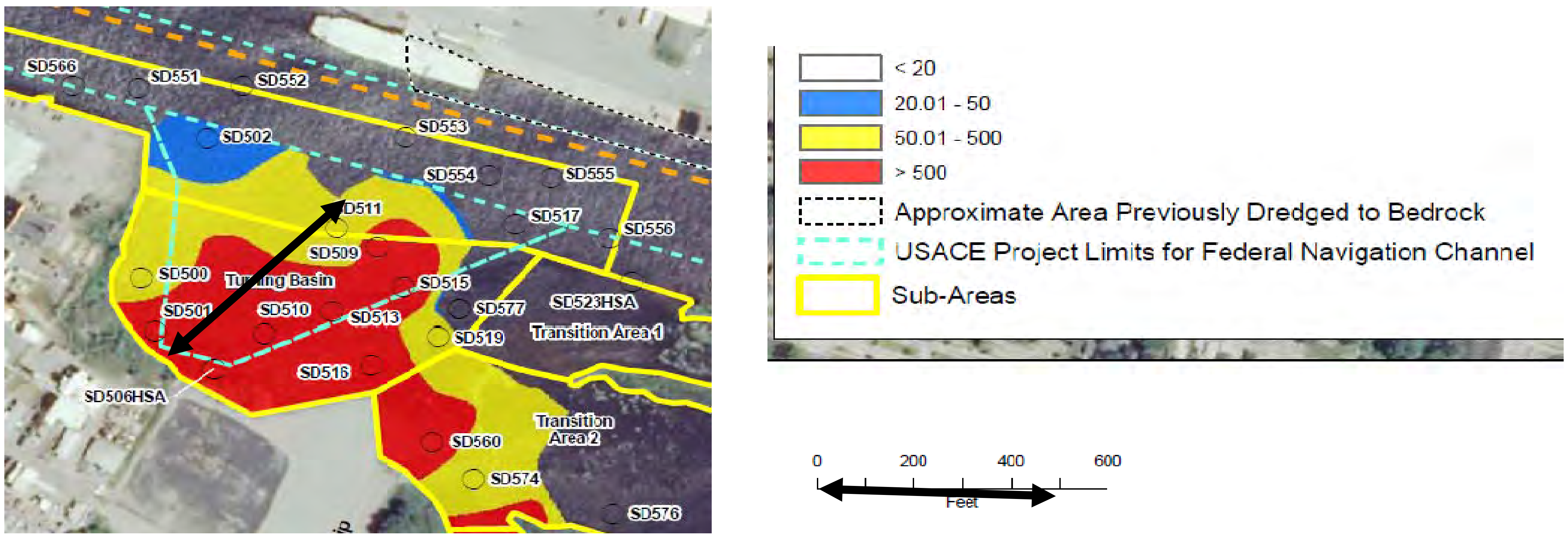
Very conservatively assumes top 4 feet of sediments are replenished w/arsenic from below at a rate equal to their diffusive flux to the surface water.

Notes:

1. Low end estimate taken from Sanchez et. al, 2003 (Environmental Assessment of Waste Matrices contaminated with arsenic in The Journal of Hazardous Materials B96 2003 (pp 229-257). High-End estimate based on the values for similar anions sulfate and bicarbonate (1.07x10-9m2/sec and 1.18x10-9m2/sec, respectively)--from C.W. Fetter, Contaminant Hydrogeology 2nd edition,1999. Arsenic is expected to be in a similar anionic form as these ions.
2. Tortuosity if the ratio of the distance an ion or molecule travels around particles and the direct path towards the lower concentration) [Swerts (1991) experimentally determined values for freshwater seds of a variety of porosities. Values reported for sandy freshwater sediments in Swerts (1991) were used here as an estimate for toruosity.

Table A3-1
Estimate of Concentration of Dissolved Arsenic in River Water from Diffusion
Tyco Fire Products LP

Total mass of arsenic in top 4' of semi-consoldiated materials	40,290	lbs.
Minimum years of linear diff. flux required to remove mass currently present in top 4 feet	960	years
Mass of arsenic released per year, average	41.9	lbs/yr
Mass of arsenic released per day, average	0.115	lbs/day
Average flow rate of the river, cfs	3,500	(Based on 25 yr average flow, URS Risk Evaluation Report, February 2003)
Cross sectional area of the river, ft^2	12000	Estimated depth = 15 ft and width = 800 ft near the dredging area
Average stream velocity, ft/sec	0.29	
Width of area >50 ppm, ft	500.00	See sketch below
Volume of water flowing by daily within 4' of top of cap	50,400,000	ft^3/day
Mass of water flowing by daily within 4' of top of cap	3,144,960,000	lbs/day
Concentration of arsenic in river water within 4' of top of cap	0.037	micrograms per liter (parts per billion)



Attachment 4

US River Sediment Remediation Projects with Capping Components

ATTACHMENT 4

US River Sediment Remediation Projects with Capping Components

Date: 11/8/2010

A list was compiled (Table A4-1) of remediation sites where capping was an approved and/or constructed component. List is included as Table 1 to this memorandum. Used the following procedure to compile the list:

- Only included sediment sites within rivers/creeks/channels throughout all regions of the U.S. using USEPA website and knowledge of more recent projects where CH2MHILL was directly involved.
- Only included United States projects—no international projects
- Only included projects that had components or construction dated 1990 or later (also included earlier phases of a project if the most recent phase was 1990 or later)
- Reviewed and cross checked the list for each of the USEPA regions on the Sediment Management Work Group (SMWG) website: (http://www.smwg.org/MCSS_Database/MCSS_Database_Docs.html)
- Attempted to identify whether the site implemented capping as the part of the "remedy" to deal with in-situ contaminated material or if capping was done to cover residuals after dredging

Table A4-1
Summary of Contaminated Sediment Capping Projects in Rivers within the U.S.*
Tyco Fire Products LP Facility
Marinette, Wisconsin

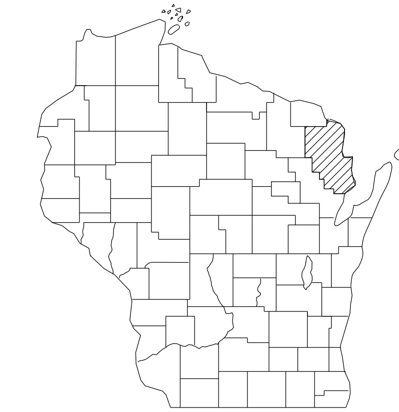
Site	Location	Contaminants of Concern	Capping Construction Date	Capping Remedy	Capping Residuals	Remedy/Residuals Not Specified
Thea Foss Waterway	Tacoma, WA	PAH, phthalate esters, metals, PCB, dioxin	Not indicated - after 2002	X		
Hylebos Waterway	Tacoma, WA	Metals, PAH	Late 1990s	X		
Williamette River	Portland, OR	Heavy metals; PAHs	2004?	X		
Upper Sheboygan River	Sheboygan, WI	PCBs	1989-90	X		
Manisitque Capping Project	Manistique, MI	PCBs	1993	X		
Ottawa River	Toledo, OH	PCBs	1999	X		
Mill-Quinnipiac River	CT	Metals; PAHs	1981-82; 1982-83; 1993-94			X
S-90-1 Harbor Village	Branford River	not specified	1989-90			X
General Motors Superfund Site	St. Lawrence River, Massena, NY	PCBs	1995	X		
ALCOA	Upper Grasse River, Massena, NY	PCBs	2001	X		
Providence River and Harbor Maintenance Dredging	Rhode Island	Metals?	2002 or 2003?		X	
Pine Street Barge Canal	Burlington, VT	PAHs; Metals; VOCs	2003	X		
Housatonic River, GE Site	Pittsfield, MA	PCBs	?	X		
Messer Street Gas Plant	Winnipesaukee River, Laconia, NH	PAHs	2000-01		X	
Rahway River	Linden, NJ	DDT; Metals	?	X		
Koppers Superfund Site	Ashley River, Charleston, SC	PAHs; PCP; dioxin, lead, arsenic	2001	X		
Calhoun Park/Aquarium	Cooper River, Charleston, SC	PAHs (former MGP site)	1996		X	
Gasse River Project 2	St. Lawrence, NY	PCBs	2001	X		
Sheboygan River Project 2	Sheboygan, WI	PCBs; PAHs	1989-1991	X		
Crotty Street Channel	Bay City, MI	PCBs	1999-2000	X		
McCormick & Baxter (Stockton Plant)	Old Morman Slough, Stockton Deepwater Channel, Stockton, CA	Dioxin/furans; PCBs	2003-04	X		
McCormick & Baxter (Portland Plant)	Williamette River, Portland, OR	PAHs	2004	X		
Lower Duwamish Waterway	Norfolk CSO, Duwamish River, Seattle, WA	??	1999		X	
	Duwamish/Diagonal CSO/Storm Drain within the Duwamish River, Seattle, WA	PCBs; BEHP	2003-04		X	
	Duwamish River/Elliott Bay	As, Pb, Hg, Zn, Cu, PCB, PAH	possibly 2003 - 2004		X	
	Duwamish River/Elliott Bay	As above plus TBT	possibly 2003 - 2004		X	
Kinnickinic River	Milwaukee Wisconsin	PCBs, PAHs	2009		X	
Fox River OU1	Appleton, Wisconsin	PCBs	2007-09	X	X	
Velsicol OU2	Pine River, St. Louis, MI	DDT	2000-06		X	
Ashtabulah River	Ashtabula, OH	PCBs	2007	X	X	

*Information compiled from USEPA Sediment Work Group material available on the internet (http://www.smwg.org/MCSS_Database/MCSS_Database_Docs.html) and from CH2MHILL's direct site experience

Appendix B

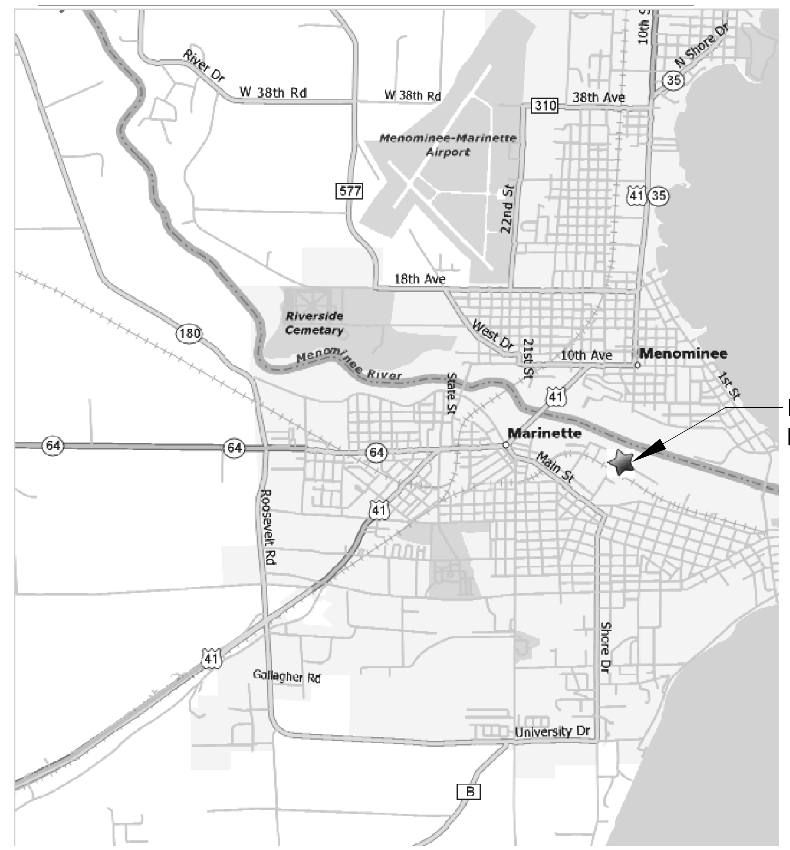
Alternative Menominee River Sediment Removal Plan Design Drawings

TYCO FIRE PRODUCTS LP
ALTERNATIVE MENOMINEE RIVER
SEDIMENT REMOVAL DESIGN



MARINETTE, WISCONSIN
OCTOBER 2010

AERIAL VIEW



PROJECT LOCATION

INDEX OF DRAWINGS

SHEET NO.	DWG NO.	DESCRIPTION
GENERAL		
1	G-1	COVER, PROJECT LOCATION, AND INDEX OF DRAWINGS
2	G-2	ABBREVIATIONS
3	G-3	CIVIL LEGENDS AND DESIGNATION LEGENDS
INSTRUMENTATION AND CONTROL		
4	N-1	CONCEPTUAL TEMPORARY WATER TREATMENT SYSTEM PROCESS FLOW DIAGRAM
CIVIL		
5	C-1	OVERALL SITE PLAN
6	C-2	DREDGING PLAN
7	C-3	WATER QUALITY MONITORING PLAN
8	C-4	ACCESS ROADWAYS, STAGING AND OFFLOADING AREA CONCEPTUAL PLAN AND SECTIONS
9	C-5	SEMI-CONSOLIDATED SANDS AND SILTS CAP PLACEMENT - PLAN AND DETAIL

PREPARED FOR

TYCO FIRE PRODUCTS LP
ONE STANTON STREET
MARINETTE, WI 54143-2542

CH2MHILL

ABBREVIATIONS

@	AT
AB	ANCHOR BOLT
ABDN	ABANDONED
ACBD	ACOUSTICAL BOARD
ACCU	AIR-COOLED CONDENSING UNIT
ACST	ACOUSTICAL TILE
ACT	ACOUSTICAL
ACU	AIR CONDITIONING UNIT
AD	AREA DRAIN
ADDL	ADDITIONAL
ADJ	ADJACENT
AHR	ANCHOR
AHU	AIR HANDLING UNIT
AL	ALUMINUM
ALTN	ALTERNATE
ANOD	ANODIZED
APPROX	APPROXIMATE
APVD	APPROVED
ARCH	ARCHITECTURAL
ARD	ACID RESISTANT DRAIN
ASSY	ASSEMBLY
ASU	AIR SUPPLY UNIT
AVG	AVERAGE
BC	BOOSTER HEATING COIL
BETW	BETWEEN
BF	BOTTOM FACE
BG	LOW WALL GRILLE
BLDG	BUILDING
BM	BEAM
BOD	BOTTOM OF DUCT
BOD_5	BIOCHEMICAL OXYGEN DEMAND (5 DAY TEST)
BOT	BOTTOM
BRG	BEARING
CAB.	CABINET
C/C	CHLORINE CONTACT
CD	CEILING DIFFUSER
CEM PLAS	CEMENT PLASTER
CF	CEILING FAN
CG	CEILING GRILLE
CHEM	CHEMICAL
CHKD	CHECKERED
CFM	CUBIC FEET PER MINUTE
CJ	CONSTRUCTION JOINT
CI	CAST IRON
CISP	CAST IRON SOIL PIPE
CL	CENTER LINE
CL_2	CHLORINE
CLDI	CEMENT LINED DUCTILE IRON
CLG	CEILING
CLP	CLAY PIPE
CLR	CLEAR
CMP	CORRUGATED METAL PIPE
CMU	CONCRETE MASONRY UNITS
COL	COLUMN
CONC	CONCRETE
CONN	CONNECTION
CONST	CONSTRUCTION
CONT	CONTINUOUS
COR	CORNER
CP	CONCRETE PIPE
CPLG	COUPLING
CPVC	CHLORINATED POLYVINYL CHLORIDE
CR	CEILING REGISTER
C TO C	CENTER TO CENTER
CTR	CENTER
CTRD	CENTERED
CU FT	CUBIC FEET
C/W	COMPLETE WITH
△	CENTRAL ANGLE
DBA	DEFORMED BAR ANCHOR
DBL	DOUBLE
DECHLOR	DECHLORINATION
DEG °	DEGREE
DET	DETAIL
DG	DOOR GRILLE
DIA	DIAMETER
DIAG	DIAGONAL
DIM	DIMENSION
DIP	DUCTILE IRON PIPE
DIR	DIRECTION
DISCH	DISCHARGE
DS	DOWNSPOUT
DN	DOWN
DRWR	DRAWER
DWG	DRAWING
DWL	DOWEL
E	EAST
E	EXTERNAL
EA	EACH
ELB	ELBOW
EC	ELECTRIC CONVECTOR
ECC	ECCENTRIC
EDH	ELECTRIC DUCT HEATER
EF	EACH FACE OR EXHAUST FAN
EFL	EFFLUENT
EL	ELEVATION
ELEC	ELECTRICAL
EQL	EQUAL
EQL SP	EQUALLY SPACED
EQPT	EQUIPMENT
EW	EACH WAY
EXA	EXHAUST AIR
EXP JT	EXPANSION JOINT
EXT	EXTERIOR
EXST	EXISTING
FAB	FABRICATION
F FL EL	FINISHED FLOOR ELEVATION
FACIL	FACILITY
FC	FLEXIBLE CONNECTION
FCA	FLANGED COUPLING ADAPTER
FCTY, FACT.	FACTORY
FEXT	FIRE EXTINGUISHER
FD	FLOOR DRAIN OR FIRE DAMPER
FDN	FOUNDATION
FLEX	FLEXIBLE
FLG	FLANGE
FLR	FLOOR
FNSH	FINISH
FTC	FIN TUBE CONVECTOR
G	GAS
GA	GAUGE
GB	GRAB BAR
GBD	GRAVITY BACKDRAFT DAMPER
GAL	GALLON
GALV	GALVANIZED
GALVS	GALVANIZED STEEL
GIV	GRAVITY INTAKE VENTILATOR
GPD	GALLONS PER DAY
GPM	GALLONS PER MINUTE
GRV	GRAVITY RELIEF VENTILATOR
GUH	GAS UNIT HEATER
GVL	GRAVEL
GW	GROUNDWATER
GWB	GYPSUM WALLBOARD
GYP PLAS	GYPSUM PLASTER
H.A.S	HEADED ANCHOR STUD
HCR	HIGH CAPACITY REGISTER
HD	HUB DRAIN
HDNR	HARDENER
HDPE	HIGH DENSITY POLYETHYLENE
HDR	HEADER
HGT	HEIGHT
HORIZ	HORIZONTAL
HM	HOLLOW METAL
HR	HOUR
HTR	HIGH THROW REGISTER
HV	HOSE VALVE
I&C	INSTRUMENTATION AND CONTROL
ID	INSIDE DIAMETER
IF	INSIDE FACE
INDOT	INDIANA DEPARTMENT OF TRANSPORTAION
INFL	INFLUENT
INSTL	INSTALL
INSUL	INSULATION
INVT	INVERT
ITG	INSULATED TEMPERED GLASS
JT	JOINT
L	LENGTH OF CURVE
LB	POUNDS
LB/D	POUNDS PER DAY
LG	LONG
LLV	LONG LEG VERTICAL
LNTL	LINTEL
LONG	LONGITUDINAL
LR	LONG RADIUS
LT	LIGHT
MATL	MATERIAL
MAU	MAKE UP AIR UNIT
MAX	MAXIMUM
MB	MACHINE BOLT
MCC	MOTOR CONTROL CENTER
MD	MOTORIZED DAMPER
MECH	MECHANICAL
MFR	MANUFACTURER
MGD	MILLION GALLONS PER DAY
MG/L	MILLIGRAMS PER LITER
MH	MANHOLE
MIN	MINIMUM
MISC	MISCELLANEOUS
MO	MASONRY OPENING
MON	MONUMENT
MTG	MOUNTING
MTL	METAL
MTRG	METERING
N	NORTH
NIC	NOT IN CONTRACT
NO.	NUMBER
NOM	NOMINAL
NORM	NORMAL
NTS	NOT TO SCALE
OA	OUTSIDE AIR
OC	ON CENTER
OD	OUTSIDE DIAMETER OR OVERFLOW DRAIN
OF	OUTSIDE FACE
O/H	OVERHEAD
O TO O	OUT TO OUT
OPNG	OPENING
OPP	OPPOSITE
PC	POINT OF CURVATURE
PE	POLYETHYLENE
PI	POINT OF INTERSECTION
P&ID	PROCESS AND INSTRUMENTATION DIAGRAM
PJF	PREMOLDED JOINT FILLER
PL	PLATE
PLAM	PLASTIC LAMINATE
PLYWD	PLYWOOD
POC	POINT ON CURVE
POT	POINT ON TANGENT
PR	PAIR
PRCST	PRECAST
PS	PUMP STATION
PSF	POUNDS PER SQUARE FOOT
PSI	POUNDS PER SQUARE INCH
PT	POINT OF TANGENCY
PTD	PAPER TOWEL DISPENSER
PTD/R	PAPER TOWEL DISPENSER/RECEPTACLE
PVC	POLYVINYL CHLORIDE OR POINT OF VERTICAL CURVATURE
PVI	POINT OF VERTICAL INTERSECTION
PVMT	PAVEMENT
PVT	POINT OF VERTICAL TANGENCY
QDRNT	QUADRANT
R OR RAD	RADIUS OR RISER
RC	REINFORCED CONCRETE
RCP	REINFORCED CONCRETE PIPE
RD	ROOF DRAIN
RDCR	REDUCER
REHAB	REHABILITATION/REHABILITATED
REINF	REINFORCE
REQD	REQUIRED
RESIL	RESILIENT
RM	ROOM
RO	ROUGH OPENING
RR	REDUCER
RST	REINFORCING STEEL
S	SOUTH
SA	SUPPLY AIR
SAT	SUSPENDED ACOUSTICAL TILE
SCHED	SCHEDULE
SD	SOAP DISPENSER OR SLOT DIFFUSER
SECT	SECTION
SG	SAFETY GLASS
SH	SHEET
SHTG	SHEETING
SIM	SIMILAR
SLV	SHORT LEG VERTICAL
S.O.	SHUTOFF
SPECD	SPECIFIED
SPECS	SPECIFICATIONS
SPG	SPACING
SQ	SQUARE
SST, SS	STAINLESS STEEL
STA	STATION
STD	STANDARD
STIF	STIFFENER
STOR	STORAGE
STR	STRAIGHT
STRUCT	STRUCTURAL
STL	STEEL
SYMM	SYMMETRICAL
T	TREAD OR TANGENT LENGTH
TAR	TRANSFER AIR REGISTER
T&B	TOP AND BOTTOM
TC	TOP OF CONCRETE
TCU	TERMINAL CONTROL UNIT
TEMP	TEMPERED
TF	TOP FACE
TG	TONGUE AND GROOVE
THK	THICK
THRD	THREADED
T.O.	TOP OF
TPD	TONS PER DAY
TPI	TURNOUT POINT OF INTERSECTION
TRANSV	TRANSVERSE
TSS	TOTAL SUSPENDED SOLIDS
TST	TOP OF STEEL
TTD	TOILET TISSUE DISPENSER
TW	TOP OF WALL
TYP	TYPICAL
UH	UNIT HEATER
UON	UNLESS OTHERWISE NOTED
V	VENT
VAT	VINYL ASBESTOS TILE
VERT	VERTICAL
VCP	VITRIFIED CLAY PIPE
VD	VOLUME DAMPER
VOC	VOLATILE ORGANIC COMPOUND
VTR	VENT THRU ROOF
VWC	VINYL WALL COVERING
W	WEST
W/	WITH
WD	WOOD
WG	WIRE GLASS
WH	WATER HEATER
WK	WEEK
WR GWB	WATER RESISTANT GYPSUM WALLBOARD
WR	WASTE RECEPTACLE
WS	WATER STOP OR WATER SURFACE OR WELDED STEEL
WSG	WALL SUPPLY GRILLE
WSR	WALL SUPPLY REGISTER
WWM	WELDED WIRE MESH
XFMR	TRANSFORMER
YR	YEAR

NOTES:

1. CONTACT THE CONTRACTOR FOR ABBREVIATIONS NOT LISTED.
2. THIS IS A STANDARD ABBREVIATION SHEET. SOME ABBREVIATIONS MAY APPEAR ON THIS SHEET, BUT NOT ON THE PLANS.

NO.	DATE	REVISION	BY	APVD

DSGN S RAMAMURTHY | DR | CHK DA KIERZEK | APVD

TYCO FIRE PRODUCTS LP
ALTERNATIVE MENOMINEE RIVER
SEDIMENT REMOVAL DESIGN
MARINETTE, WISCONSIN

CH2MHILL

GENERAL
ABBREVIATIONS

NOT TO SCALE
VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	OCTOBER 2010
PROJ	405439
DWG	G-2
SHEET	2

PRELIMINARY

CIVIL LEGEND

EXISTING	THIS CONTRACT	
157.7	158.5	SPOT ELEVATION
155	155	CONTOUR LINE
	3:1	EMBANKMENT AND SLOPE
		DRAINAGEWAY OR DITCH
	CB OR CB	CATCH BASIN OR INLET
		TRENCH DRAIN
	OR	SIGN
	D OR S	MANHOLE
	E	ELECTRICAL MANHOLE
	H	ELECTRIC HANDHOLE
		POST OR GUARD POST
		GUY ANCHOR
		FIRE HYDRANT
		UTILITY POLE
		LIGHT POLE
	BM	BENCH MARK
		SURVEY CONTROL POINT OR POINT OF INTERSECTION
		BRUSH/TREE LINE
		TREE
		PROPERTY LINE
		CENTER LINE, BUILDING, ROAD, ETC.
		STAGING OR WORK AREA LIMITS
	N 1000.00 E 1000.00	STRUCTURE, BUILDING OR FACILITY LOCATION POINT - COORDINATES
	B-1	BORING LOCATION AND NUMBER
	TP-2	TEST PIT LOCATION AND NUMBER
	P-3	PIEZOMETER LOCATION AND NUMBER
OR	OR	DEMOLITION
OR	OR	STRUCTURE, BUILDING OR FACILITY
		ASPHALT CONCRETE PAVEMENT
		GRAVEL SURFACING
		CONCRETE PAVEMENT
		CURB
		CURB AND GUTTER
		SINGLE SWING GATE
		DOUBLE SWING GATE
		SLIDING GATE
		GUARD RAIL
		CHAIN LINK FENCE
		ARCHITECTURAL FENCE
		WIRE FENCE
		CULVERT

YARD PIPING LEGEND

EXISTING	THIS CONTRACT	
		NOMINAL PIPE DIAMETER
		PIPE USE IDENTIFICATION
8" PE	8" PE	PIPING < 30" DIAMETER
		PIPING ≧ 30" DIAMETER
		EXISTING PIPE TO BE ABANDONED
		EXISTING PIPE TO BE REMOVED
		NON-FREEZE HOSE VALVE (V-X) X = NO. IN SPECIFICATIONS
		NON-FREEZE HOSE VALVE WITH HOSE RACK (V-X) X = NO. IN SPECIFICATIONS
		INDICATOR POST VALVE
		GATE VALVE AND VALVE BOX
		BUTTERFLY VALVE AND VALVE BOX
		PLUG VALVE AND VALVE BOX
		FLEXIBLE COUPLING
		90° ELBOW UP
		90° ELBOW DOWN
		BEND < 90° UP
		BEND < 90° DOWN
		CONCENTRIC REDUCER
		CAP OR PLUG
		CLEANOUT
		FIRE HYDRANT

EROSION CONTROL LEGEND

COVER PRACTICES	SYMBOL
TEMPORARY SEEDING	TS
MULCHING AND MATTING	MU
CLEAR PLASTIC COVERING	CPC
BUFFER ZONES	BZ
PERMANENT SEEDING AND PLANTING	PS
CONSTRUCTION ENTRANCE	
INTERCEPTOR DIKE	ID
INTERCEPTOR SWALE	IS
CHECK DAMS	
OUTLET PROTECTION / RIPRAP	
FILTER FENCE	
STRAW BALE BARRIER (BIOFILTER)	
SEDIMENT TRAP (OR SUMP)	
SEDIMENT POND OR BASIN	

SECTION / DETAIL DESIGNATIONS

1 / C-1 — ON DRAWING WHERE SECTION OR DETAIL IS TAKEN: SHEET/DRAWING NUMBER WHERE SHOWN

B SECTION SCALE — ON DRAWING WHERE SECTION IS SHOWN:

2 DETAIL SCALE — ON DRAWING WHERE DETAIL IS SHOWN:

DRAWING TITLE SCALE — ON DRAWING WHERE ONLY A TITLE IS REQUIRED WITH NO REFERENCE (eg: ELEVATIONS)

B / C-001 — SECTION CALLOUT WHERE SECTION IS ON THE SAME SHEET AND CUT EXTENDS TO A FIXED LIMIT

B / C-001 — B / C-001 — SECTION CALLOUT WHERE SECTION IS ON ANOTHER SHEET AND CUT EXTENDS THROUGHOUT ENTIRE SHEET

1 — KEYED NOTES

DRAWING NUMBER DESIGNATION

S-002
- INDICATES DRAWING NUMBER
- INDICATES DISCIPLINE(S) OR CATEGORY:

C CIVIL
E ELECTRICAL
G GENERAL
N INSTRUMENTATION AND CONTROL

GENERAL NOTES:

1. * SYMBOL - ONLY WHERE REQUIRED FOR CLARITY.
2. EXISTING STRUCTURES AND FACILITIES ARE SHOWN AS SCREENED BACKGROUND. NEW STRUCTURES ARE SHOWN IN HEAVY LINE WEIGHTS.
3. EXISTING PIPING AND EQUIPMENT IS SHOWN SCREENED. NEW PIPING AND EQUIPMENT IS SHOWN HEAVY-LINED.
4. THIS IS A STANDARD LEGEND SHEET. SOME SYMBOLS MAY APPEAR ON THIS SHEET AND NOT ON THE PLANS.

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CHK
APVD

TYCO FIRE PRODUCTS LP
ALTERNATIVE MENOMINEE RIVER
SEDIMENT REMOVAL DESIGN
MARINETTE, WISCONSIN

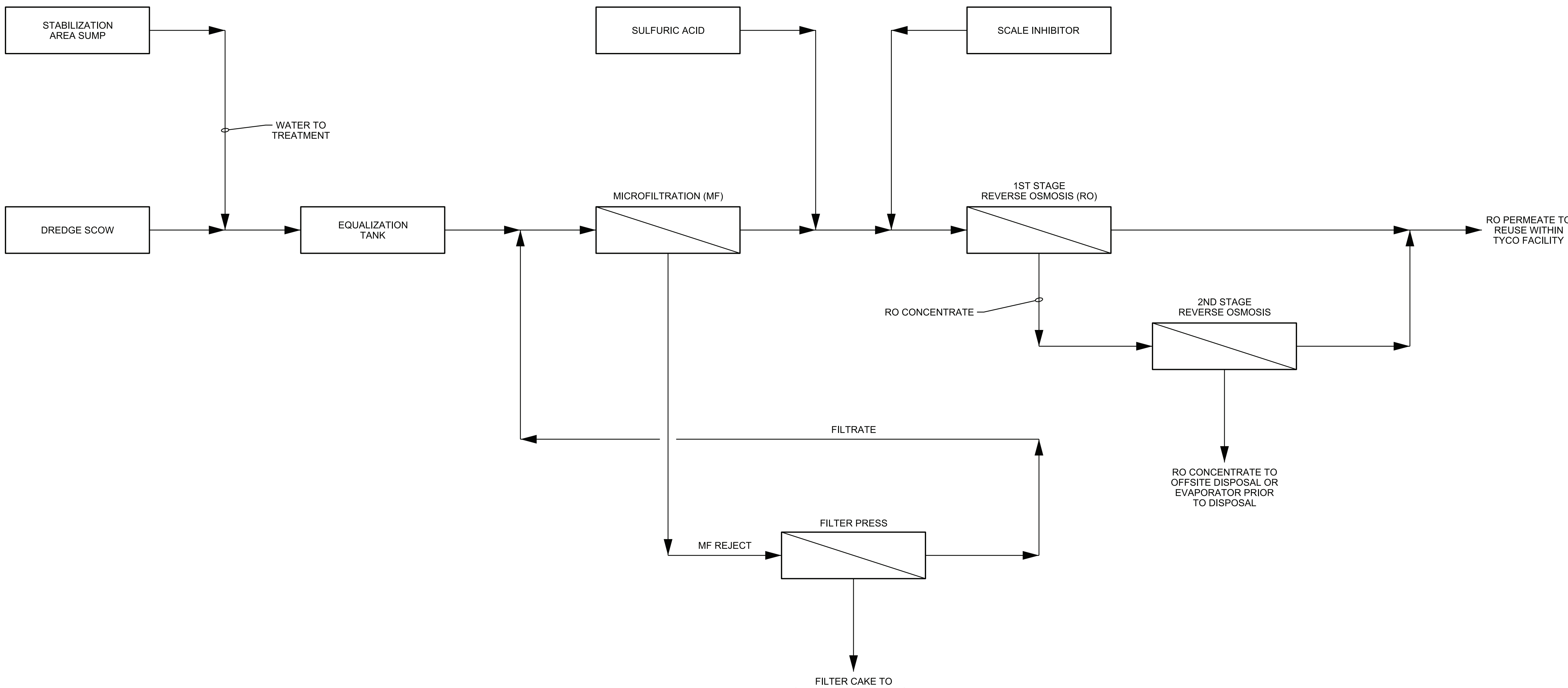
CH2MHILL

GENERAL
CIVIL LEGENDS AND DESIGNATION LEGENDS

NOT TO SCALE
VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	OCTOBER 2010
PROJ	405439
DWG	G-3
SHEET	3

PRELIMINARY



PROCESS FLOW DIAGRAM

NTS

NO.	DATE	REVISION	BY	APVD

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ALTERNATIVE MENOMINEE RIVER
SEDIMENT REMOVAL DESIGN
MARINETTE, WISCONSIN

CH2MHILL

GENERAL
CONCEPTUAL TEMPORARY
WATER TREATMENT SYSTEM
PROCESS FLOW DIAGRAM

NOT TO SCALE
VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	OCTOBER 2010
PROJ	405439
DWG	N-1
SHEET	4

PRELIMINARY

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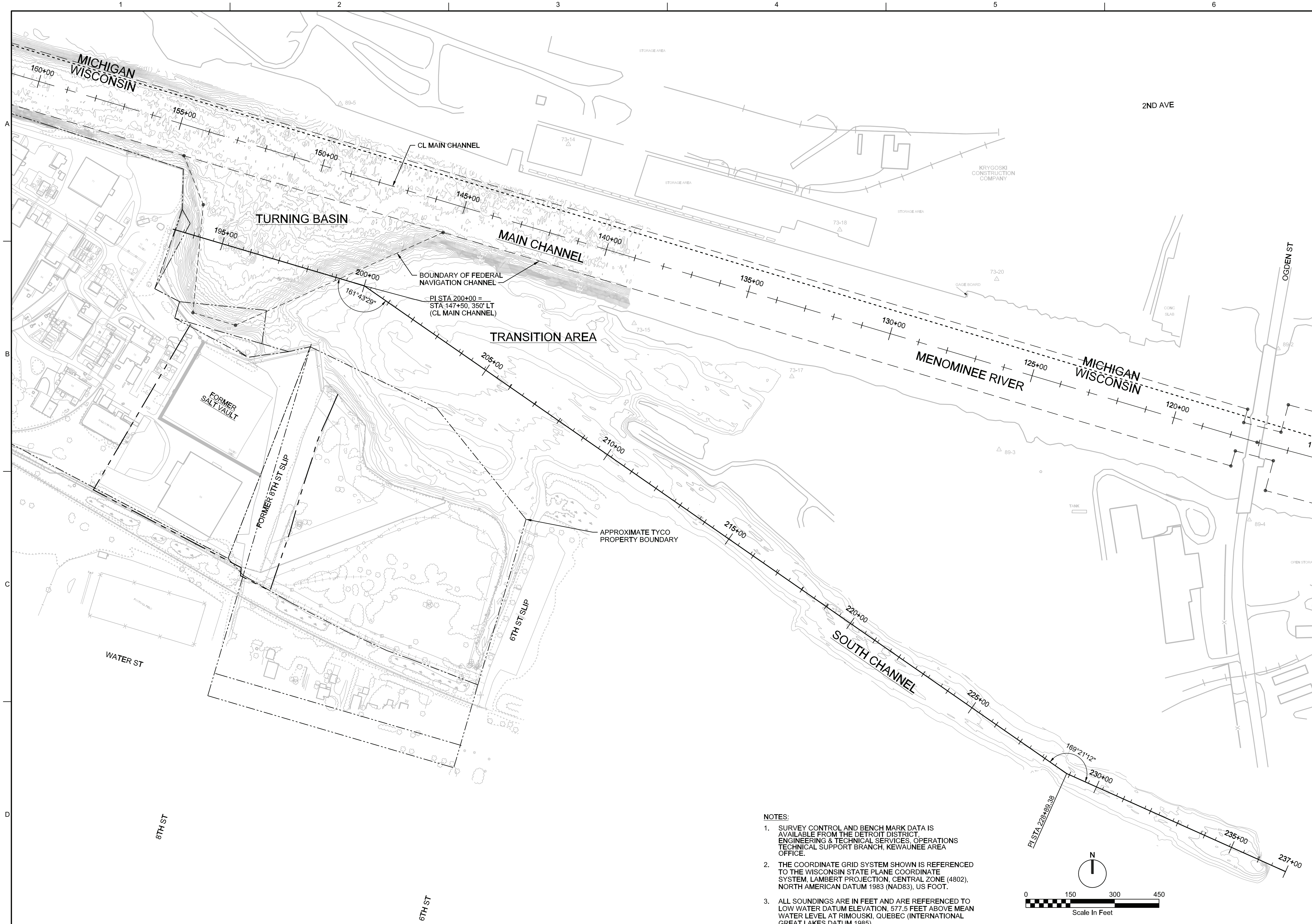

NOTES:

1. SURVEY CONTROL AND BENCH MARK DATA IS AVAILABLE FROM THE DETROIT DISTRICT, ENGINEERING & TECHNICAL SERVICES, OPERATIONS TECHNICAL SUPPORT BRANCH, KEWAUNEE AREA OFFICE.
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3. ALL SOUNDINGS ARE IN FEET AND ARE REFERENCED TO LOW WATER DATUM ELEVATION, 577.5 FEET ABOVE MEAN WATER LEVEL AT RIMOUSKI, QUEBEC (INTERNATIONAL GREAT LAKES DATUM 1985).

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TYCO FIRE PRODUCTS LP
ALTERNATIVE MENOMINEE RIVER
SEDIMENT REMOVAL DESIGN
MARINETTE, WISCONSIN

CH2MHILL

CIVIL

OVERALL SITE PLAN

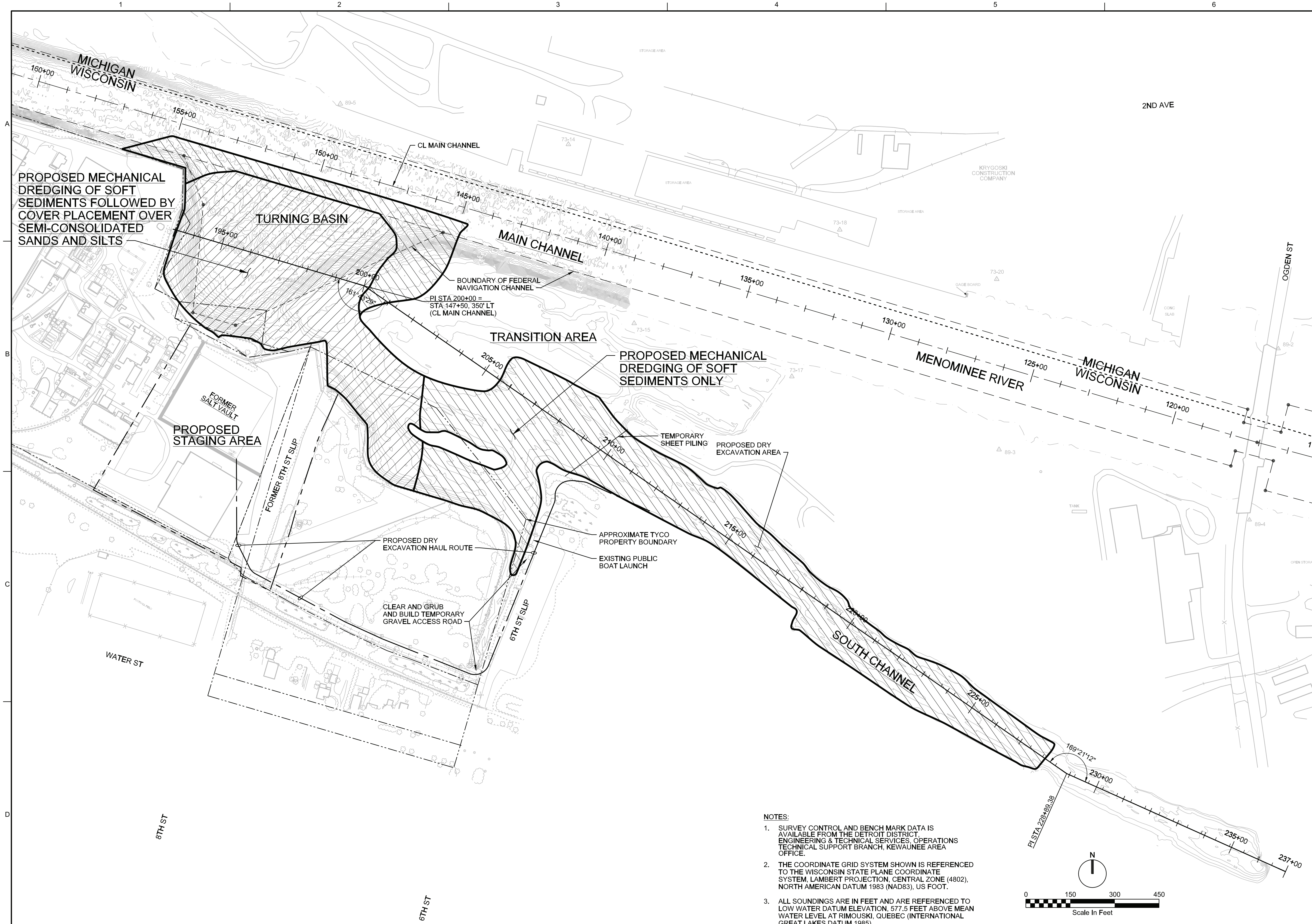
1"=150'

VERIFY SCALE

BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	OCTOBER 2010
PROJ	405439
DWG	C-1
SHEET	5

PRELIMINARY



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TYCO FIRE PRODUCTS LP
ALTERNATIVE MENOMINEE RIVER
SEDIMENT REMOVAL DESIGN
MARINETTE, WISCONSIN

CH2MHILL

CIVIL

DREDGING PLAN

1"=150'

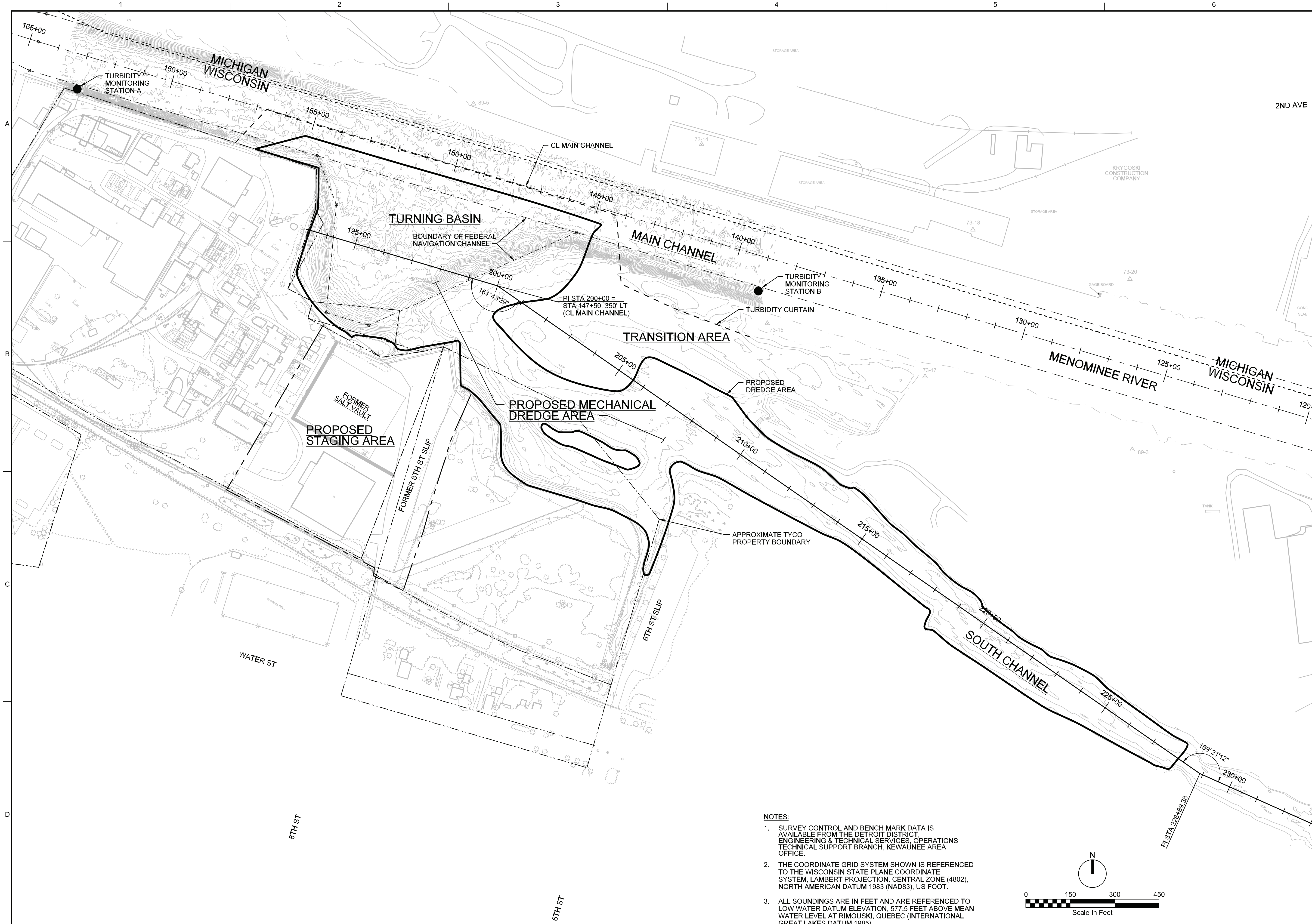
VERIFY SCALE

BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	OCTOBER 2010
PROJ	405439
DWG	C-2
SHEET	6

PRELIMINARY

FILENAME: 401c132_388522.dgn PLOT DATE: 10/18/2010 PLOT TIME: 4:48:38 PM



NOTES:

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ALTERNATIVE MENOMINEE RIVER
SEDIMENT REMOVAL DESIGN
MARINETTE, WISCONSIN

CH2MHILL

CIVIL

WATER QUALITY MONITORING PLAN

1"=150'

VERIFY SCALE

BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	OCTOBER 2010
PROJ	405439
DWG	C-3
SHEET	7

PRELIMINARY

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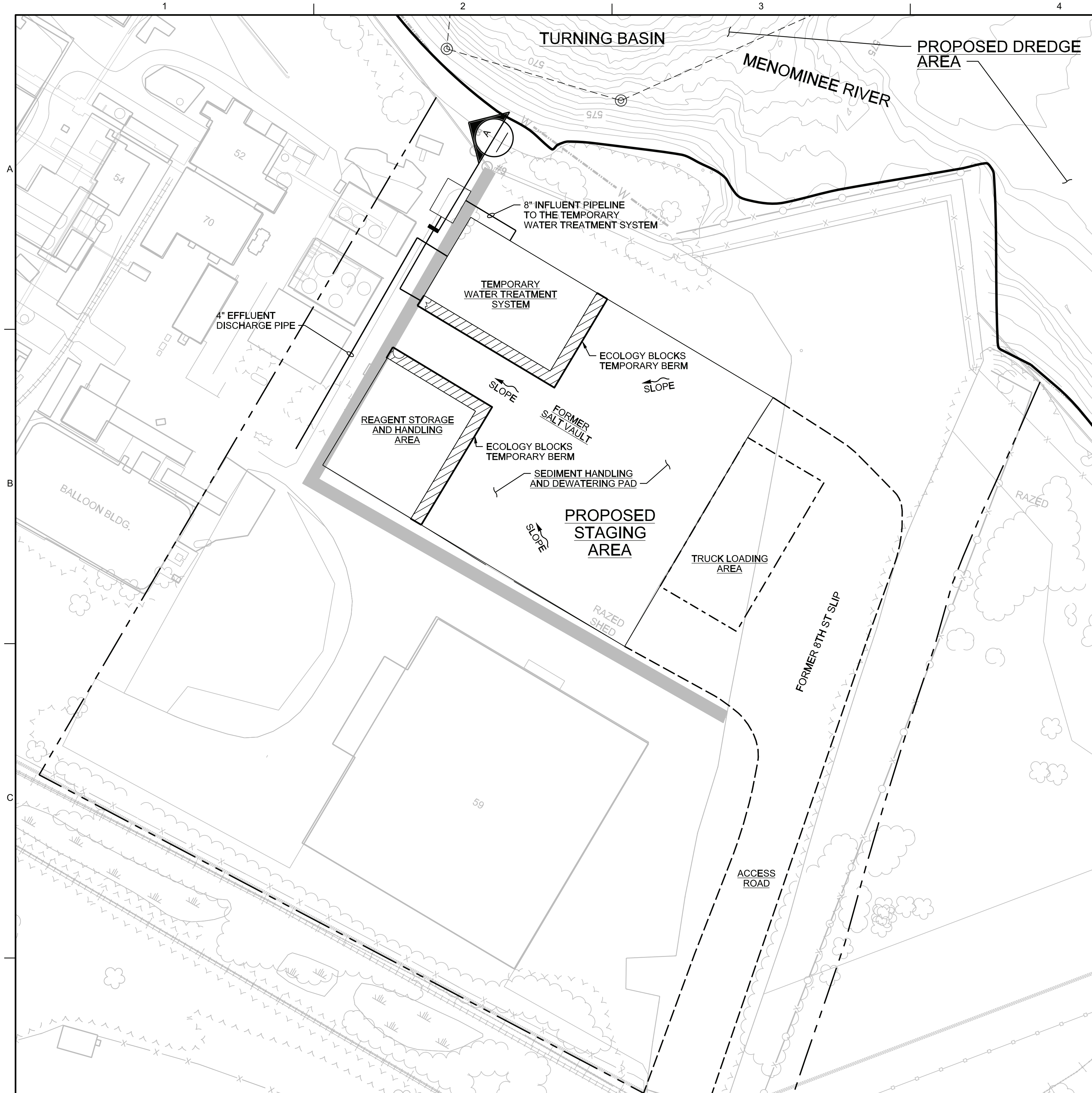

PLAN
1"=50'-0"

N

0 50 100 150
Scale In Feet

NOTES:
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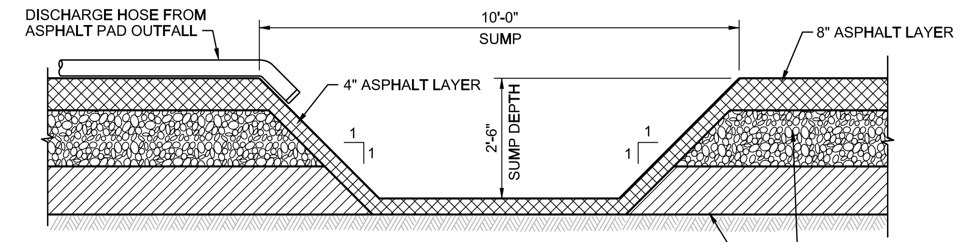
3. ALL SOUNDINGS ARE IN FEET AND ARE REFERENCED TO LOW WATER DATUM ELEVATION, 577.5 FEET ABOVE MEAN WATER LEVEL AT RIMOUSKI, QUEBEC (INTERNATIONAL GREAT LAKES DATUM 1985).



A SUMP SECTION
1/2"=1'-0"

NO.	DATE	REVISION	BY	APVD

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TYCO FIRE PRODUCTS LP
ALTERNATIVE MENOMINEE RIVER
SEDIMENT REMOVAL DESIGN
MARINETTE, WISCONSIN

CH2MHILL

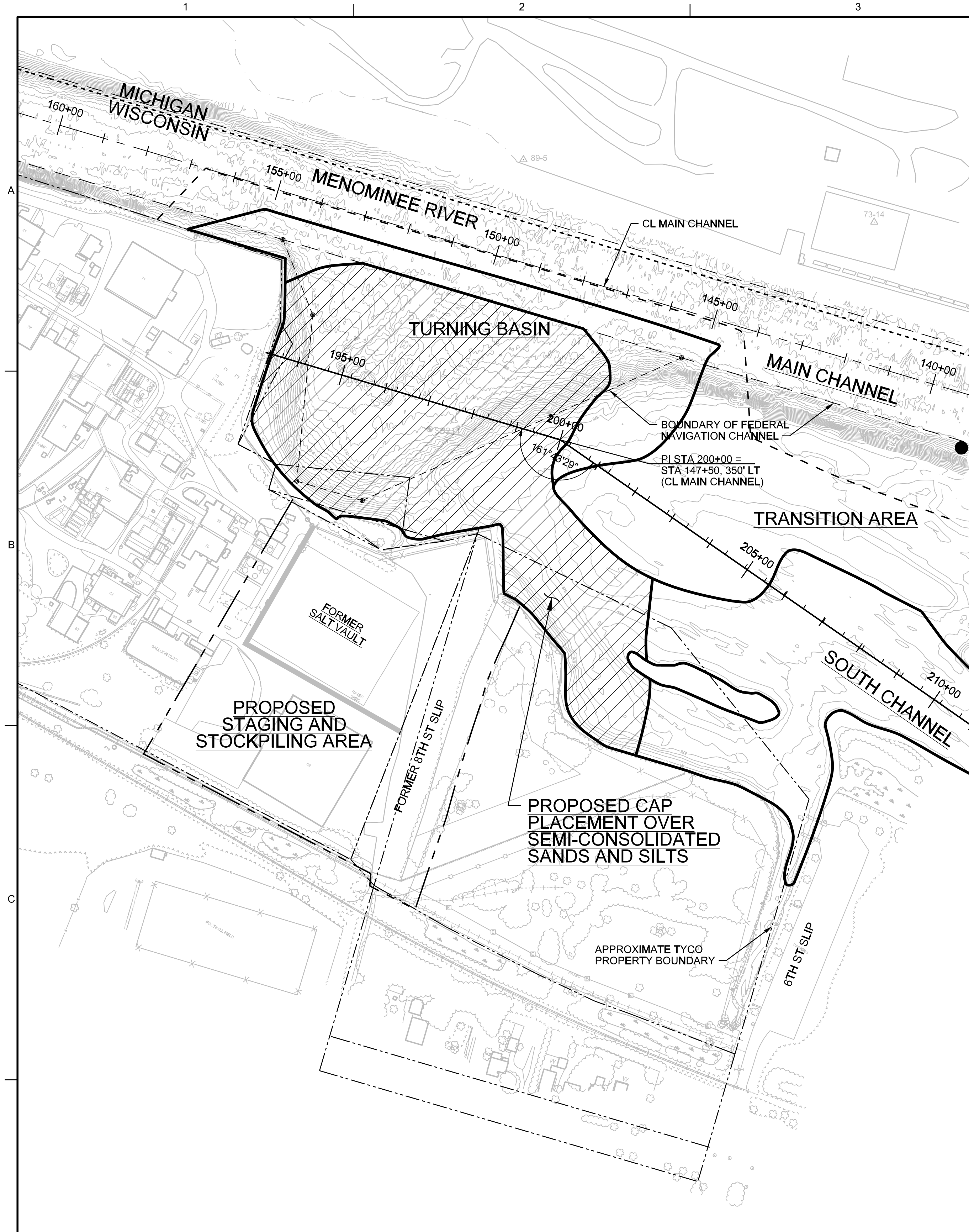
CIVIL
ACCESS ROADWAYS, STAGING AND OFF-LOADING AREA
CONCEPTUAL PLAN AND SECTIONS

VERIFY
VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	OCTOBER 2010
PROJ	405439
DWG	C-4
SHEET	8

PRELIMINARY

FILENAME: 401c134_388522.dgn PLOT DATE: 10/18/2010 PLOT TIME: 4:53:58 PM



NOTES:

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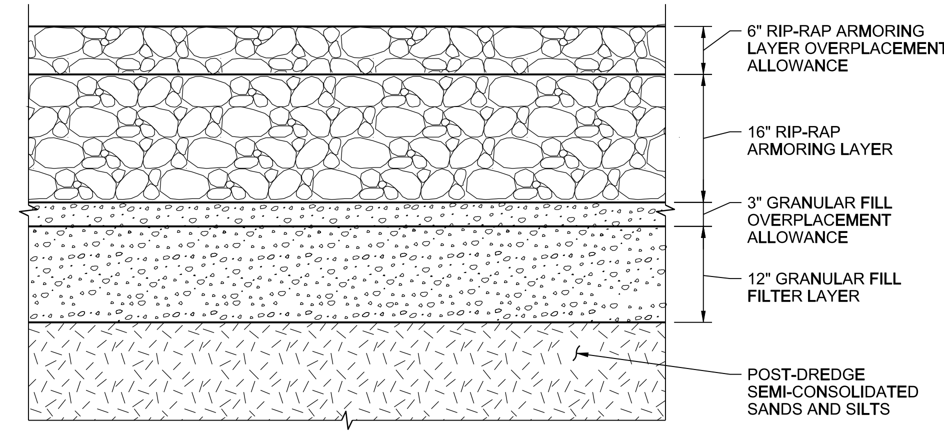
N

0 150 300 450
Scale In Feet



SECTION

NOTES:

1. GRANULAR FILL FILTER LAYER MATERIAL SHALL MEET THE FOLLOWING GRADATION REQUIREMENTS (THIS CAN BE ACHIEVED WITH A BLEND OF 25% WI DOT NO. 1 COARSE AGGREGATE AND 75% WI DOT NO. 2 COARSE AGGREGATE):

SIEVE SIZE	PERCENT FINER
2"	100
1 1/2"	92-100
1"	40-66
3/4"	22-36
3/8"	5-18
NO. 4	0-3
NO. 8	0-2

2. MATERIAL FOR THE RIP-RAP ARMORING LAYER SHALL BE WI DOT LIGHT RIP-RAP.

1 ARMORED CAP DETAIL

NTS

NO.	DATE	REVISION	BY	APVD

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TYCO FIRE PRODUCTS LP
ALTERNATIVE MENOMINEE RIVER
SEDIMENT REMOVAL DESIGN
MARINETTE, WISCONSIN

CH2MHILL

CIVIL

SEMI-CONSOLIDATED SANDS AND SILTS CAP PLACEMENT PLAN AND DETAIL

1"=150'

VERIFY SCALE

BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	OCTOBER 2010
PROJ	405439
DWG	C-5
SHEET	9

PRELIMINARY

Appendix C

Technical Memorandum - Groundwater Modeling

APPENDIX C

Technical Memorandum—Simulations of Groundwater Interactions with the River at the Tyco Facility, Marinette, Wisconsin

Background and Purpose

In 2009, a three-dimensional groundwater flow model of the Tyco facility and surrounding area was transferred to CH2M HILL from the original developer, Earth Tech, Inc. CH2M HILL reviewed the model, modified it slightly by combining the top two grid layers into one unconfined layer, and used the simplified model to simulate various pumping scenarios to control water levels within and around a proposed vertical barrier wall (VBW) to be installed around the periphery of the site. These activities are described in greater detail in the "Basis of Design" report and in several internal memoranda (CH2MHILL, 2010a).

A new question regarding Tyco site groundwater interaction with the Menominee River was realized during discussion of the remedial approach detailed in the *Alternative Menominee River Sediment Removal Plan* (CH2MHILL, 2010b). Contaminated soft sediments in the river bed are to be excavated and remaining semi-consolidated sands and silts are to be covered with a subaqueous cap. If there is a continued discharge of groundwater from the bedrock beneath the site to the river, even after the VBW is complete in fall 2010, there could be additional flux through the semi-consolidated material that remains.

It was suggested that the groundwater model that was originally developed to simulate the effects of the VBW and head control wells beneath the Tyco site could also be used to simulate their effects on groundwater flow to the river. The Menominee River is represented in the model as a constant-head boundary in the top layer of the grid. The four model layers extend approximately 200 feet north of the Tyco facility to about the middle of the river, with no-flow boundary conditions applied at the northern edge of the grid (see Figure C1). This arrangement permits the model to simulate vertical flow of groundwater from the bedrock to the river. However, the model was developed without the benefit of any data from hydrogeologic investigation under the river, so it can only be theorized that the bedrock and aquifer properties under the river are similar to those found under the Tyco site. Calibration of the model was based only on groundwater levels measured south of the river, beneath the land surface. Therefore, the nature of the flow that takes place under the river can only be inferred and has not been validated by actual measurements.

Recognizing the limited ability of this model to accurately represent flow under the river, it was used to simulate two different flow scenarios. The first scenario was the model calibration condition representing conditions prior to construction of the peripheral barrier wall and the interior head control wells. The second scenario represents the completed barrier walls with the head control wells in operation at their expected pumping rates. The objective was to gain a conceptual understanding of the qualitative differences in flow patterns under the river that may be generated by the remedial measures presently being constructed at the Tyco facility.

Baseline Scenario Simulation Results

The Baseline Scenario simulation for this modeling demonstration was the same as the model calibration condition. Under this condition, the Tyco site had existing barrier walls around two interior site features, the Salt Vault area and the 8th Street Slip Area. These are sheet-pile walls that have been driven to bedrock. They are represented in the model using the horizontal flow barrier (HFB) package with HFB segments in the top three (unconsolidated) model layers. The HFB segments are not impermeable, but were simulated with a low hydraulic conductance corresponding to a barrier 2 feet thick with a hydraulic conductivity of 2.8×10^{-5} feet per day. The fourth layer represents bedrock and contains no HFB segments.

Figure C2 shows model results for the Baseline Scenario simulation in the form of a cross-sectional piezometric head map based on the model output. Flows in all four layers are from south to north. In the southernmost (left) part of the cross section, a slight downward gradient can be seen. This is an area of groundwater recharge. As the river is approached, the equipotentials begin to show an upward component indicating groundwater discharge to the river. Flow at the northern (right) edge of the model is vertically upward into the river because that edge is simulated as a no-flow boundary.

Design Scenario Simulation Results

The Design Scenario for this model demonstration represents conditions after completion of the VBW surrounding the site. Six interior head-control wells are included, with a total pumping rate of 22.5 gallons per minute (gpm). Two of the six wells are situated within the individually-enclosed former Salt Vault and Eighth Street Slip areas. Well locations for the Design Scenario are illustrated in Figure C3. No other changes were made in the model inputs for this scenario. The boundary conditions and recharge rates remain the same as in the model calibration run.

Figure C4 shows Design Scenario simulation results as a cross-sectional piezometric head map at the same location as in Figure C2. Because of the presence of the VBW and the interior pumping wells, the flow in this cross section is significantly different that for the Baseline Scenario. On the south side of the cross section, the upgradient edge of the VBW diverts the flow downward into the bedrock. After passing under the wall, the flow turns upward because of the reduced potentiometric head caused by the interior head-control wells. Beyond the site to the north, the vertical flow component has been reversed beneath the river, with flow derived from the river going downward under the northern segment of the barrier wall. Note that the simulated water table elevation in the portion of the site enclosed within the barrier wall has been reduced by 9 to 10 feet by the wall and the head-control wells. It is conceptually reasonable that such a lowering of onsite heads could result in reversal of flow to the river, as suggested by the model. The actual amount of lowering of the water table required to lead in a reversal would need to be modeled with additional information.

A plan view of the simulated design scenario for model Layer 2 (lacustrine silt above glacial tll) is shown in Figure C5. Spatial variations in the direction of vertical flow are indicated by the contours of simulated potentiometric head in Layer 2 minus the constant simulated river level of 579.00 feet above mean sea level (amsl). Where the contour values are positive, the simulated head is higher than the river level. In some areas under the river, the contour values are negative. Simulated vertical flow in these areas is downward indicating that groundwater there will not discharge to the river. In this simulation, flow is downward in all parts of the river bed that are directly north of the barrier wall, but the natural upward flow under the river persists east and west of the site boundaries.

Modeling Uncertainty and Sensitivity Analysis

Uncertainty is always associated with groundwater modeling because the model is a mathematical representation of a simplified version of the actual site conditions. Calibration and verification of the model are intended to reduce the level of uncertainty by showing that the model accurately predicts conditions that have actually been observed. However, uncertainty increases when the model is used to simulate conditions that have not been observed. In the simulations reported here, the model was used to estimate flow conditions under the Menominee River that may occur after the peripheral barrier wall has been completed and the interior head-control wells are put into operation. This is a situation that differs significantly from the conditions for which the model was calibrated. Although the simulation results are reasonable estimates of the expected changes in flow under the river, there are likely to be quantitative differences between the predictions and the actual events as observed after they take place.

A sensitivity analysis was conducted to see how changes in the simulated aquifer flow properties would affect the predictions of vertical flow directions under the river. The analysis was conducted by systematically changing selected model input parameters, one at a time, and monitoring the resulting changes in simulated vertical head differences at five locations under the river. The five locations are shown in Figure C5 as vertical flow monitoring points. The following input parameters were varied:

- Vertical component of hydraulic conductivity of the alluvium (Model Layer 1)
- Vertical component of hydraulic conductivity of the lacustrine silt (Model Layer 2)
- Vertical component of hydraulic conductivity of the glacial till (Model Layer 3)
- Horizontal component of hydraulic conductivity of the bedrock (Model Layer 4)
- Hydraulic conductance of the peripheral VBW (model layers 1 – 3)

These parameters were chosen for sensitivity analysis because they each control a part of the hydraulic linkage between water levels inside the VBW and water levels under the river bed. Each of these parameters was varied by applying a multiplier ranging from $1/10^{th}$ to 10 to the calibrated parameter value. The calibrated parameter values are listed in Table C1. To illustrate the results of the sensitivity analysis, the simulated head differences at the five vertical flow observation points were graphed versus the parameter multiplier for each varied parameter, as shown in Figures C6 through C10.

TABLE C1
Calibrated Model Hydraulic Conductivity Values

Model Layer	Number of Zones	Zone	Simulated K_x (ft/day)	Simulated K_z (ft/day)
1	2	1*	66.0	0.01254
		2	120.0	0.0228
2	1	1	0.66	0.00178
3	1	1	0.3	0.006
4	1	1	0.5	0.005

*Hydraulic Conductivity Zone 1 occupies only the extreme northwest corner of the Tyco Facility in the top model layer. See the Basis of Design Report for a more detailed description of the calibrated model.

Figure C6 shows the effects of varying Layer-1 (fill and alluvium) vertical hydraulic conductivity on simulated vertical flow under the river. Since the head difference was calculated by subtracting the river level from the simulated heads at points in Layer 2 (below the river), negative values indicate downward flow. Model testing showed that downward flow would be maintained at all of the observation points as long as this parameter was between 0.2 and 10 times the calibrated value. When the Layer-1 vertical hydraulic conductivity was decreased to 1/10th of the calibrated value, upward flow was predicted for the easternmost location, Observation Point 1.

Figure C7 shows the sensitivity results for the vertical hydraulic conductivity of Layer 2 (lacustrine silt). Again, the simulated flows were all downward, except at Point 1 when the hydraulic conductivity was 1/10th of the calibrated value.

Figure C8 shows the results of variations in Layer 3 (glacial till) vertical hydraulic conductivity. They are very similar to the results for the two overlying layers. In each of these cases, reductions in the vertical components of hydraulic conductivity inhibit the vertical transmission of potentiometric drawdown from the head-control wells inside the barrier wall to the bedrock. This makes it more difficult for the wells to reduce potentiometric levels under the river bed.

Figure C9 illustrates the effects of changing the simulated horizontal hydraulic conductivity of the bedrock on simulated heads under the river at the observation points. In this case, increases in the input value by multipliers of 5 or more resulted in simulated upward flow at the observation points.

Figure C10 shows the effects of changing the hydraulic conductance of the peripheral barrier wall on simulated vertical flow under the river. The vertical flow direction remained downward at all five observation points throughout the range of tested values for this parameter.

In general, the sensitivity analysis suggests that the ability of the head control wells inside the VBW to maintain downward flow under the river bed was fairly robust. The parameter having the greatest potential to interfere with gradient reversal was the horizontal hydraulic conductivity of the bedrock. The calibrated model uses a spatially uniform value of 0.5 feet per day for this parameter. Given the characteristics of flow in fractured rock, it is unlikely that a spatially uniform value is realistic at the scale in question. However, no information is presently available to indicate how the bedrock flow properties vary with location.

Conclusions and Limitations

This modeling demonstration suggests the possibility that the groundwater remediation activities being constructed on the Tyco facility could result in significant reduction and even elimination of groundwater discharges from the site to the river. The reversal of groundwater flow directions under the river would be the combined result of the hydraulic effectiveness of the peripheral barrier wall and the operation of the interior head-control wells.

Because of the limitations of the model's ability to accurately simulate flow under the river, these results must only be considered qualitative. While it is reasonable to believe that groundwater discharge to the river directly north of the VBW could be reversed, the exact pumping rates needed achieve this result cannot be accurately predicted with the current model. Operation and real world monitoring of the system would be required to confirm the effects of the head control and VBW system on the water table within the area enclosed by the VBW and flow to the river and to determine the long-term pumping rates required to achieve a condition of minimal or no discharge. Some of the major modeling assumptions that are critical to this conclusion are:

- The installed VBW is as effective as expected in the design specifications.
- The head control wells will have the expected productivity and the expected hydraulic effects on groundwater levels within the VBW.
- The aquifer materials under the river bed are essentially the same, and have the same properties, as the aquifer materials in the area directly beneath the Tyco site where the hydrogeologic investigation was conducted.
- The river level used as a constant-head boundary condition in the model is unchanging.
- The aquifer recharge rates applied in model calibration are correct and unchanging.
- The flow properties assigned to the fractured bedrock are spatially uniform and correct. This is an especially tenuous assumption, because the flow properties of fractured rock are inherently variable with position. The assumption is particularly important for analyzing this question because the presence of effective barrier walls should tend to concentrate flow in the bedrock.

Reference

CH2MHILL, 2010a. *Final Groundwater Collection and Treatment System Basis of Design,* Ansul Facility. January.

CH2MHILL, 2010b. *Alternative Menominee River Sediment Removal Plan.* November.

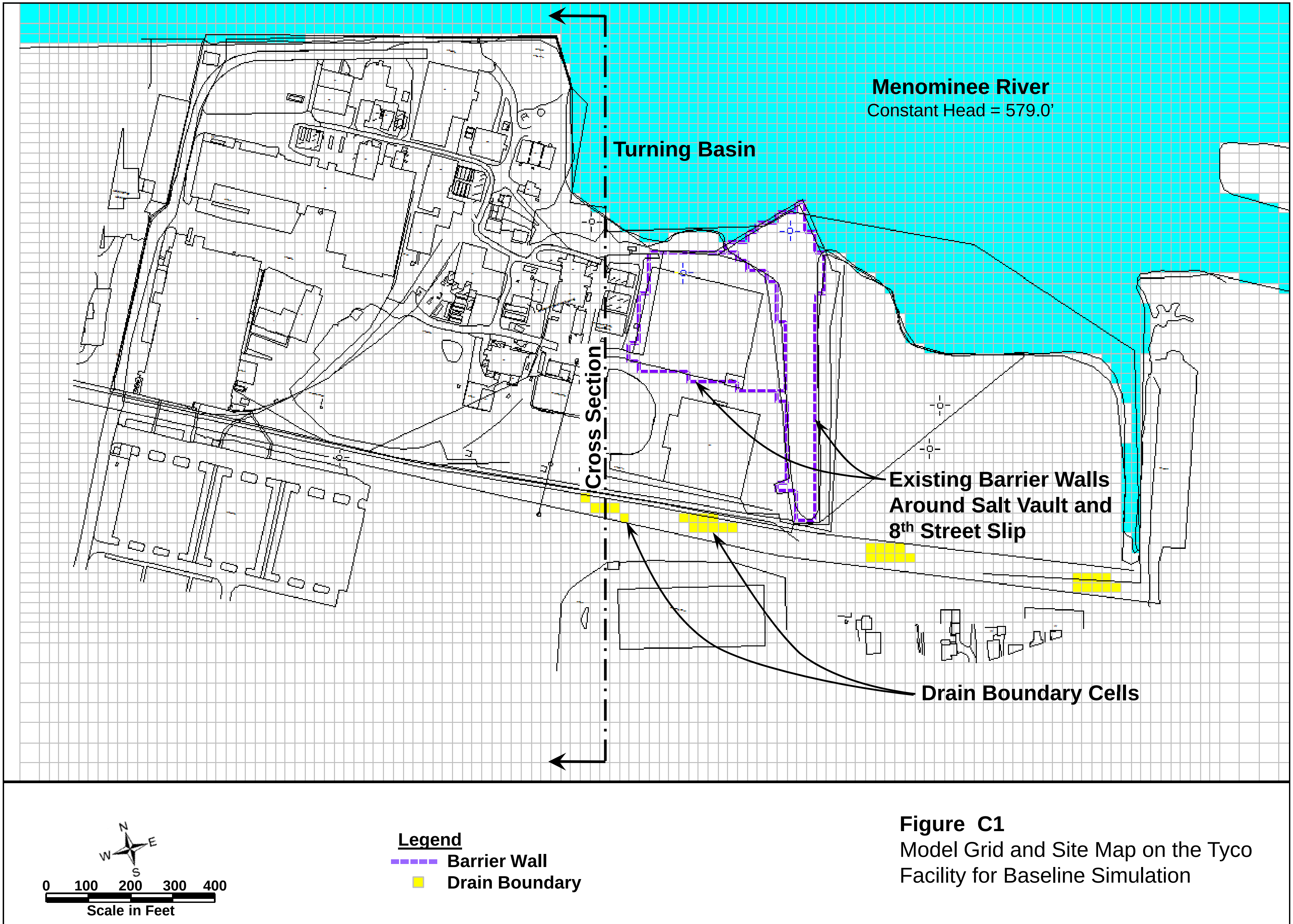

Figure C1
Model Grid and Site Map on the Tyco Facility for Baseline Simulation

CH2M HILL

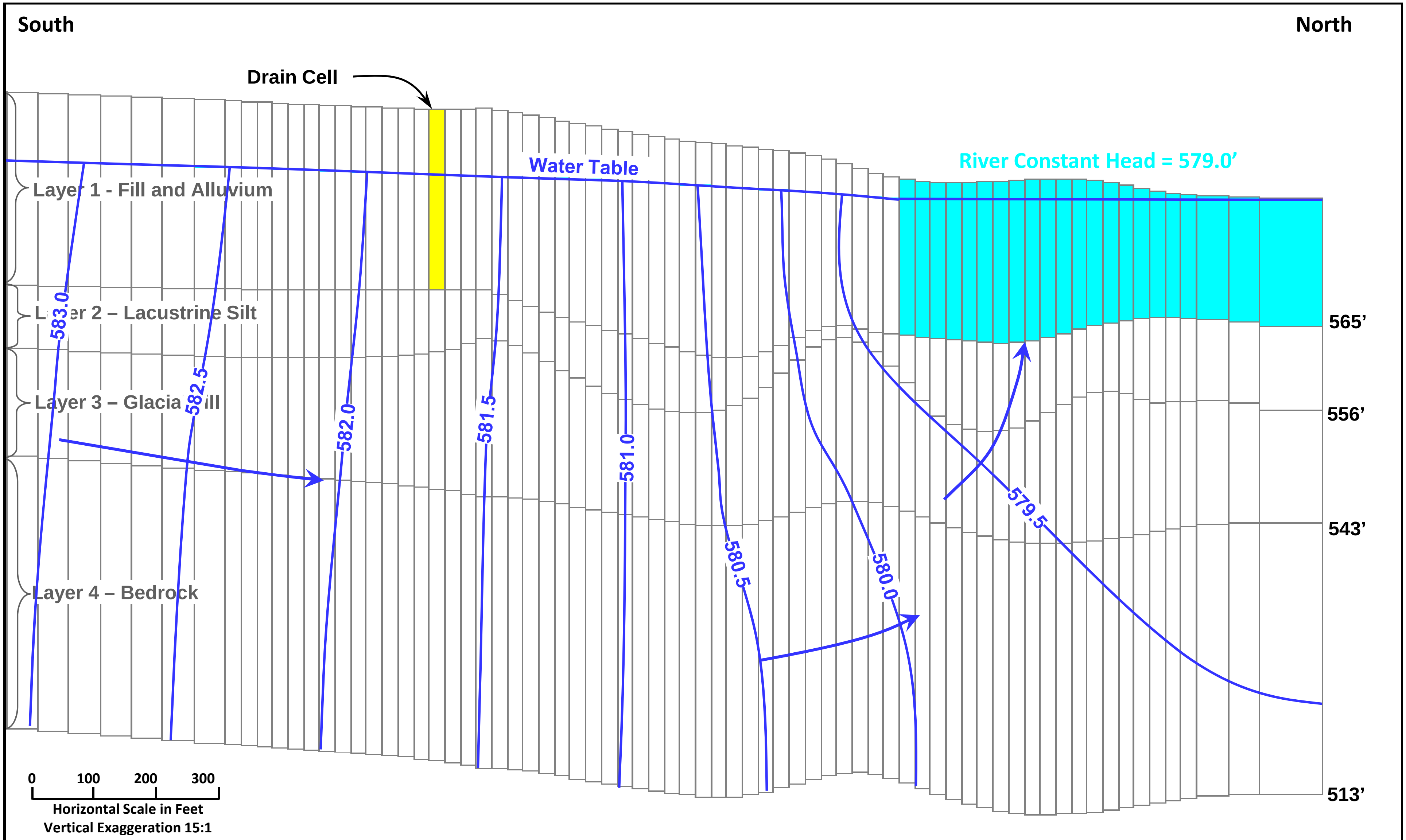

Figure C2
Cross-Sectional Contours of Simulated Piezometric Head for the Baseline Scenario

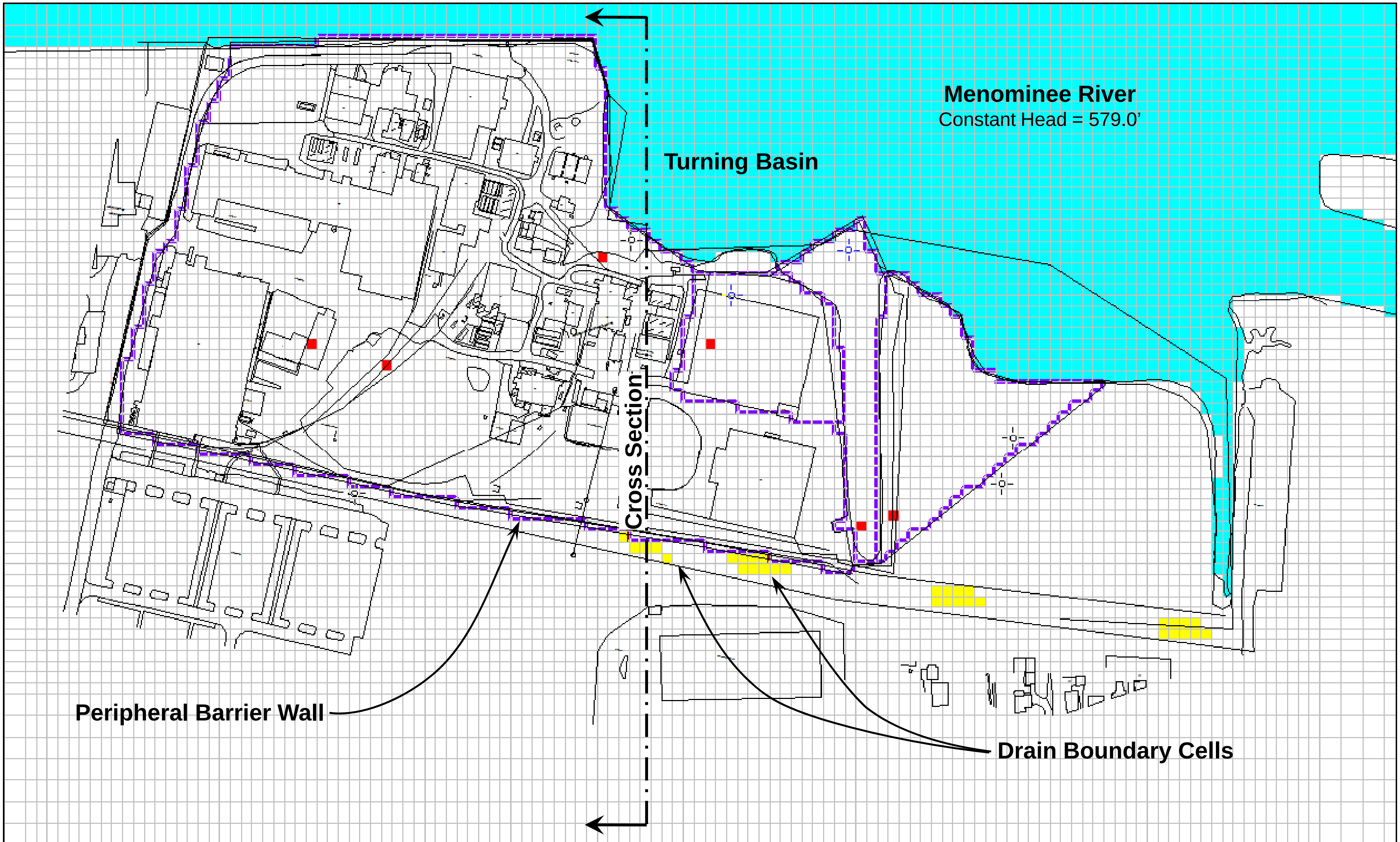

Figure C3
Model Grid and Site Map on the Tyco Facility for Design Simulation

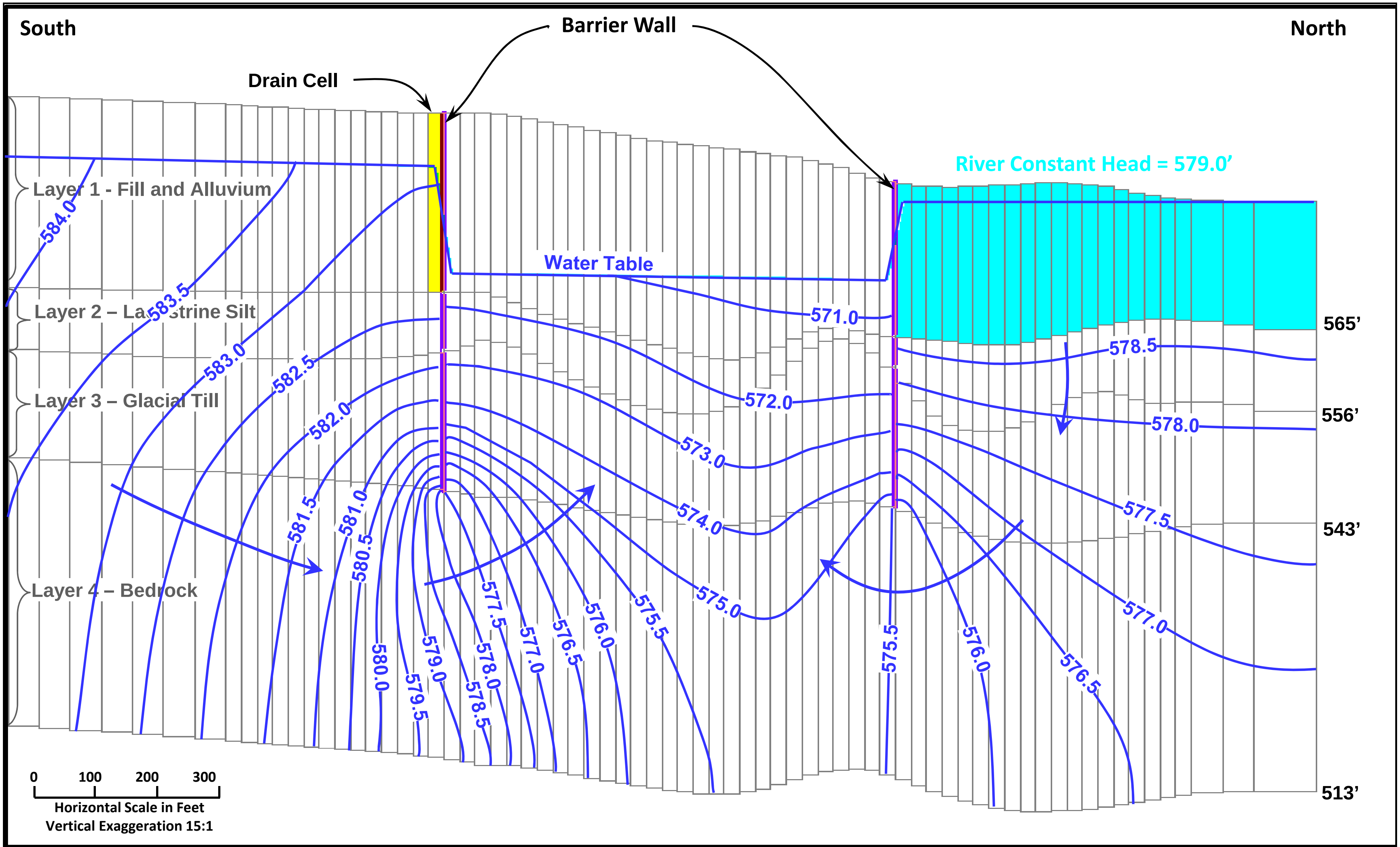

Figure C4
Cross-Sectional Contours of Simulated Piezometric Head for the Design Scenario With Six Head-Control Wells Pumping at A Total Rate of 22.5 gpm

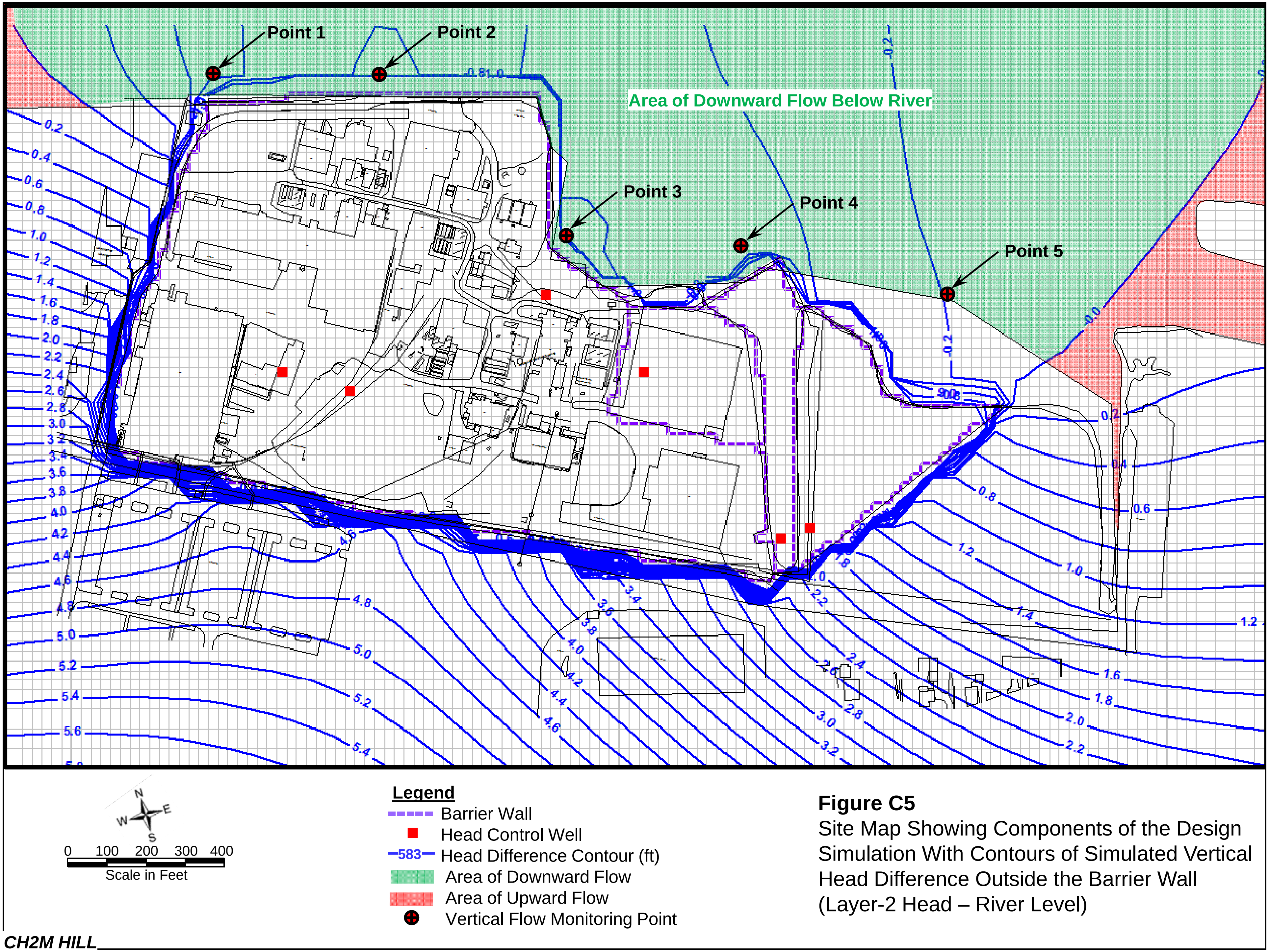

Figure C5
Site Map Showing Components of the Design Simulation With Contours of Simulated Vertical Head Difference Outside the Barrier Wall (Layer-2 Head – River Level)

CH2M HILL

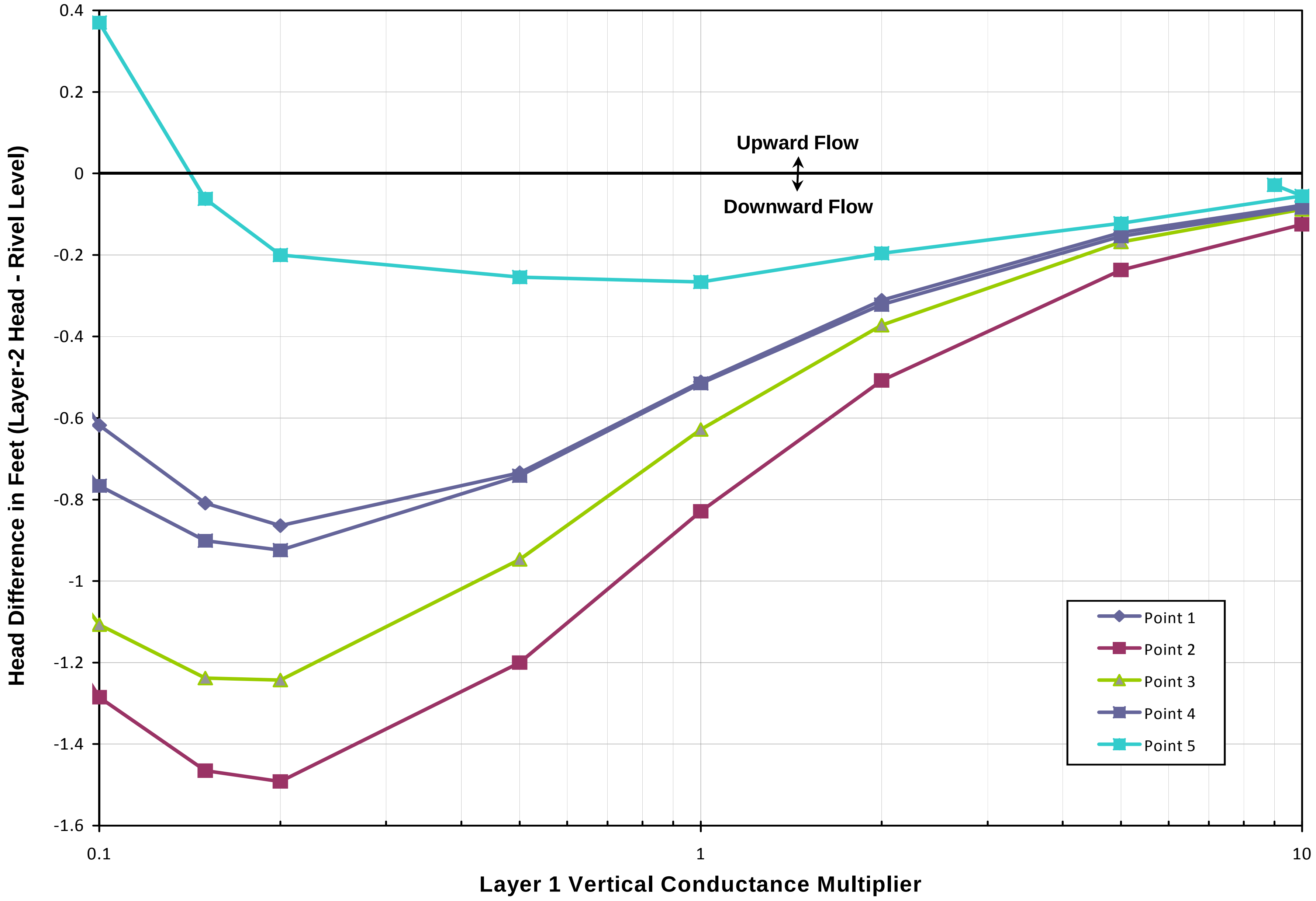

Figure C6
Sensitivity of Vertical Flow Under the River to Changes in Vertical Hydraulic Conductivity of Layer 1 (Fill and Alluvium)

CH2M HILL

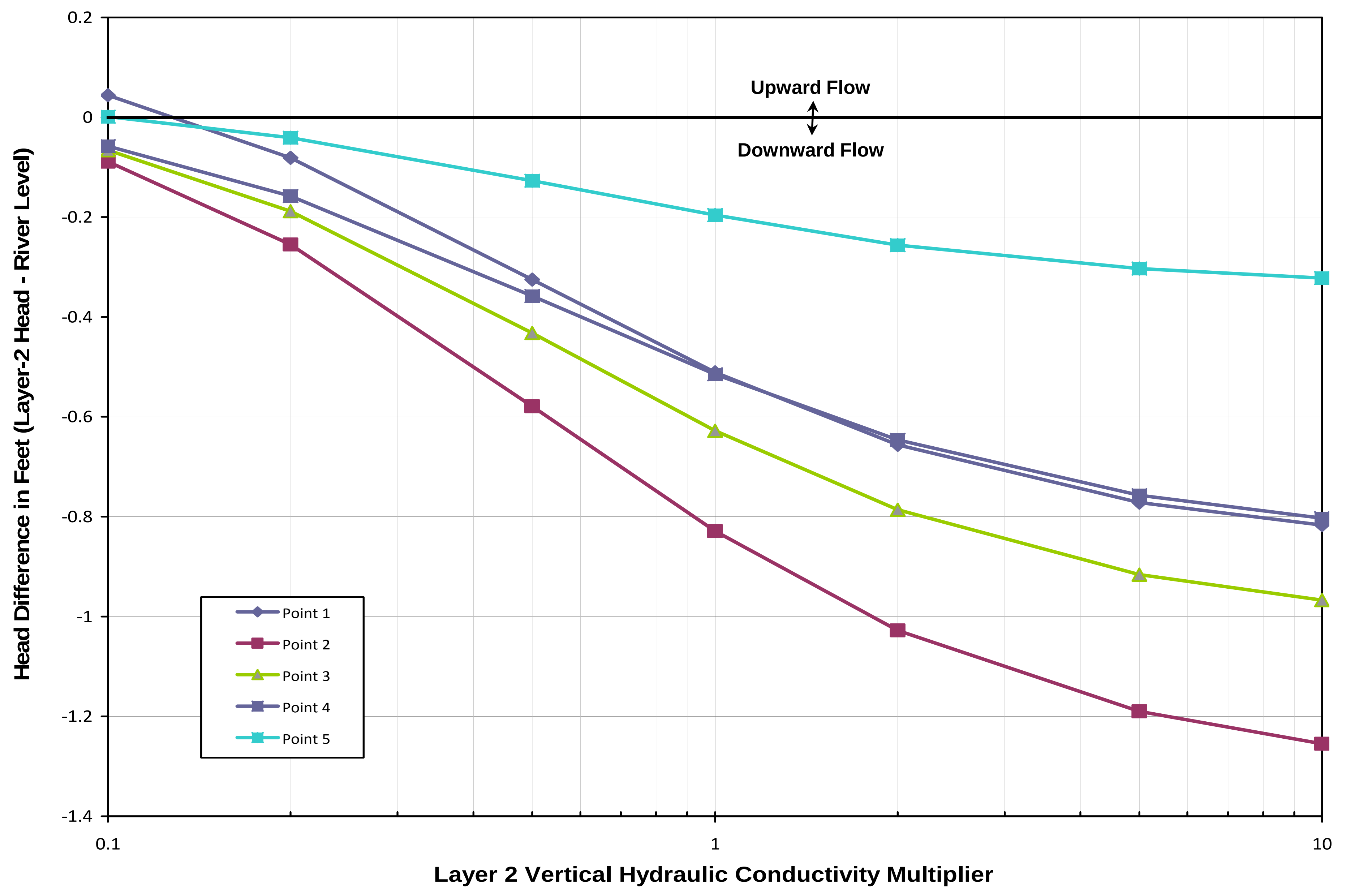

Figure C7
Sensitivity of Vertical Flow Under the River to Changes in Vertical Hydraulic Conductivity of Layer 2 (Lacustrine Silt)

CH2M HILL

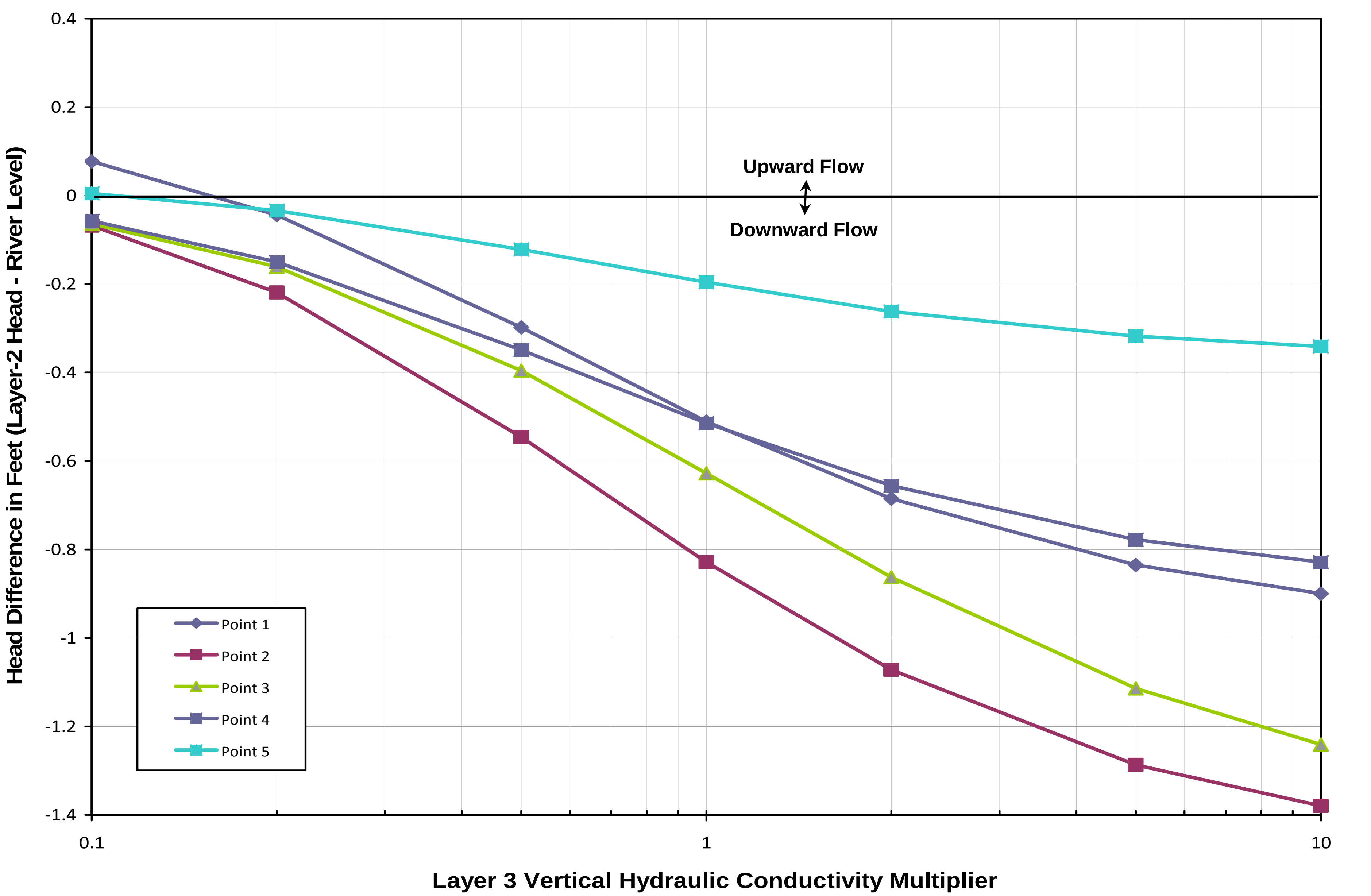

Figure C8
Sensitivity of Vertical Flow Under the River to Changes in Vertical Hydraulic Conductivity of Layer 3 (Glacial Till)

CH2M HILL

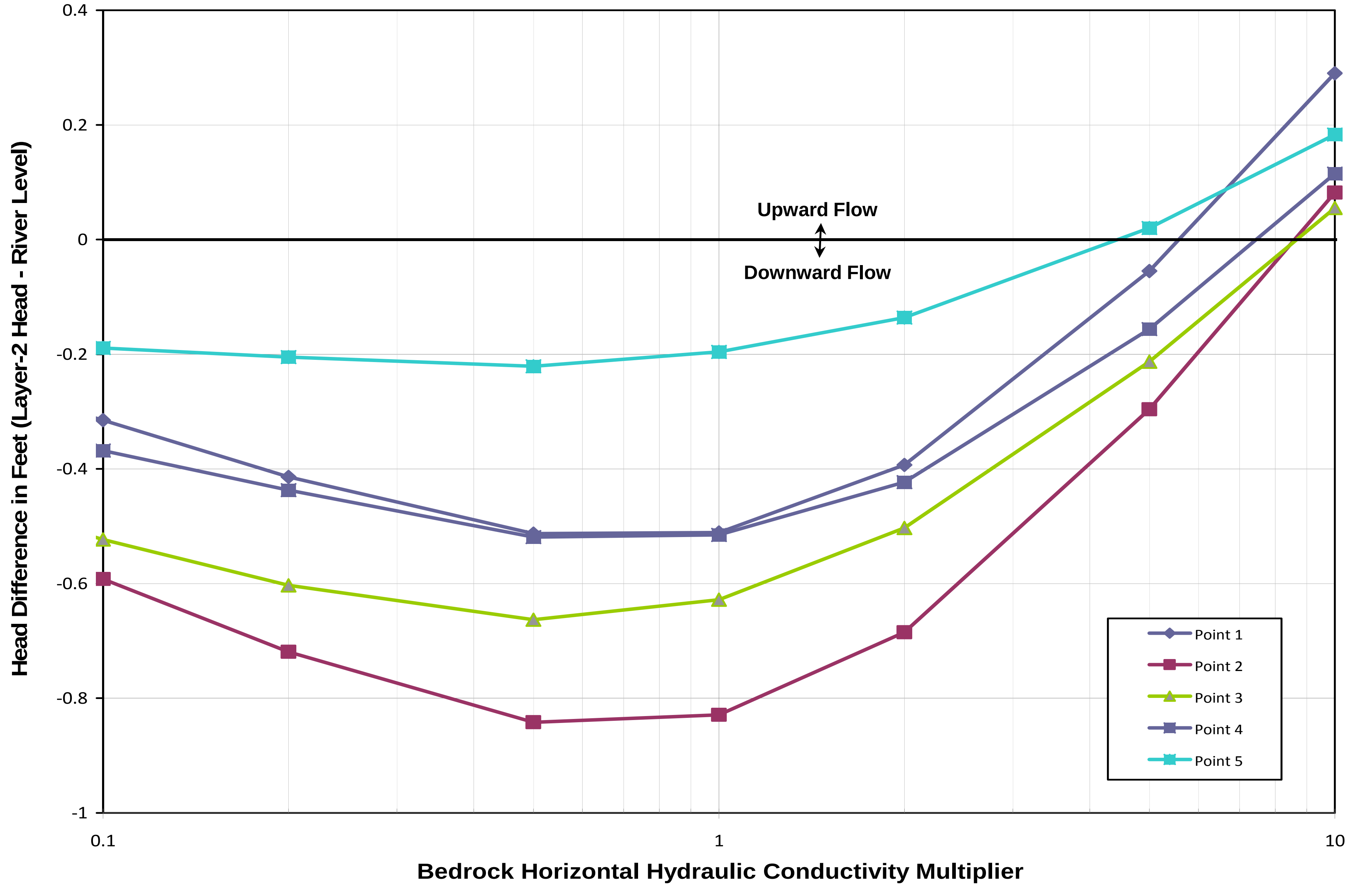

Figure C9
Sensitivity of Vertical Flow Under the River to Changes in Horizontal Hydraulic Conductivity of Layer 4 (Bedrockk)

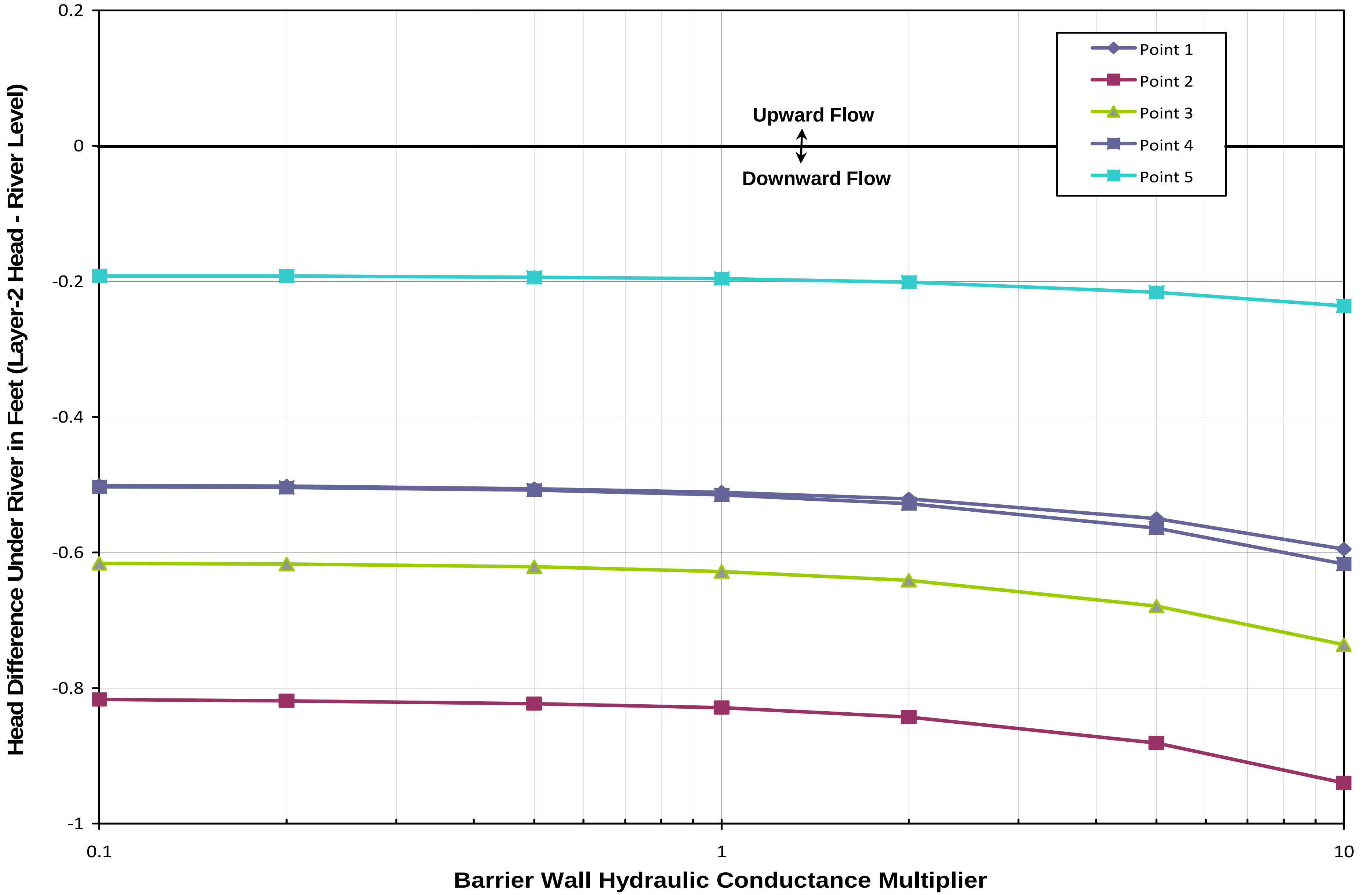

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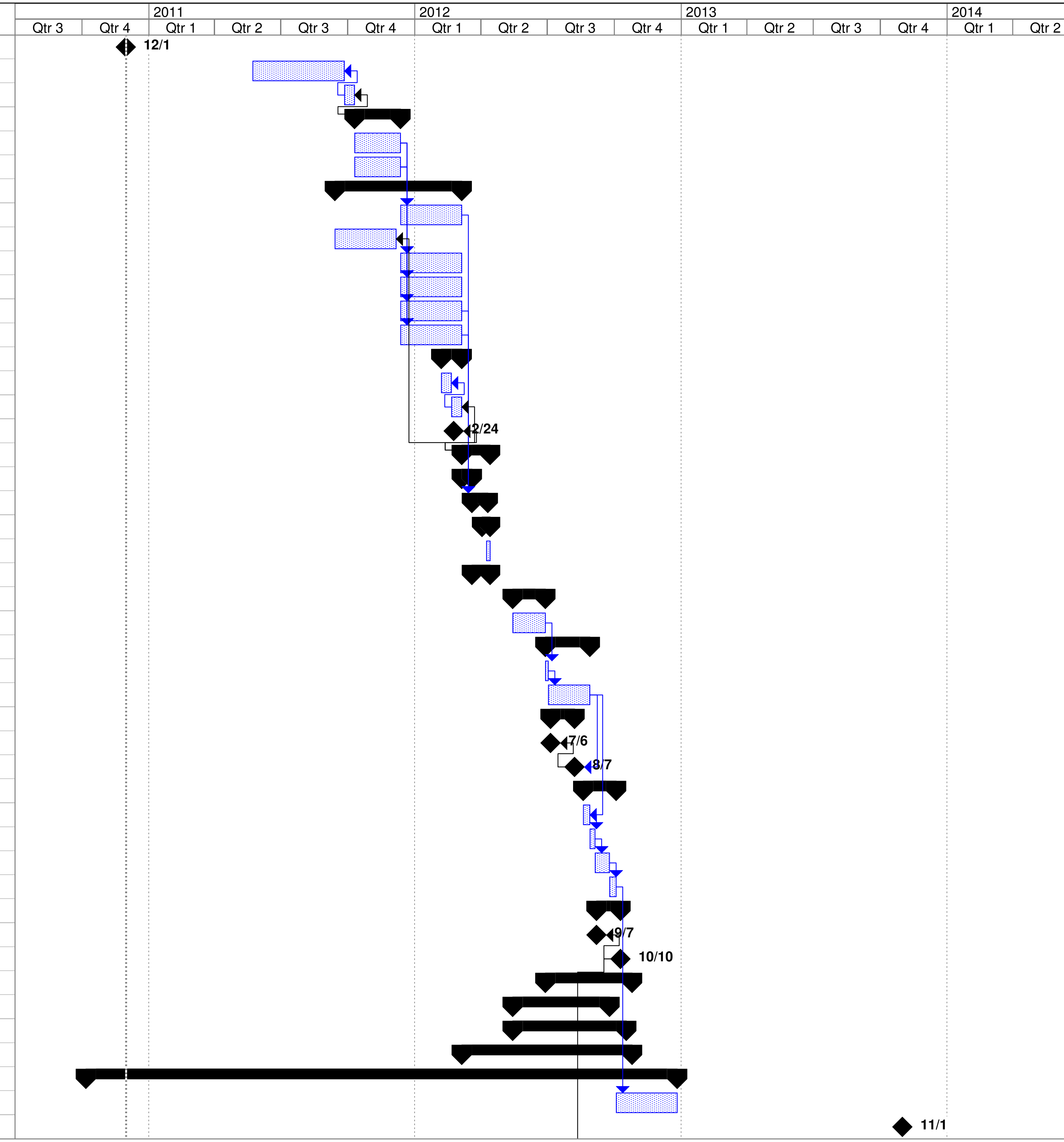
Figure C10
Sensitivity of Vertical Flow Under the River to Changes in Hydraulic Conductance of the Peripheral Barrier Wall

Appendix D

Preliminary Construction Schedule

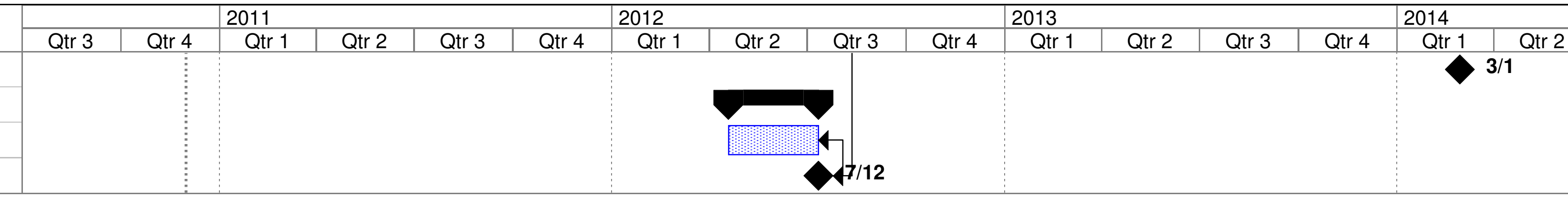
ID		Task Name	Duration	Start	Finish	Predecessors
1		Submittal of SRWP, AMRSRP, & Schedule	0 days	Wed 12/1/10	Wed 12/1/10	
2		Development of Design Plans & Specs	90 days	Tue 5/24/11	Tue 9/27/11	3SF
3		Prepare Bid Package	10 days	Tue 9/27/11	Tue 10/11/11	4SF
4		**Procurement**	**45 days**	**Tue 10/11/11**	**Mon 12/12/11**	
5		Dredger	45 days	Tue 10/11/11	Mon 12/12/11	
6		Landside Operation Subcontractor	45 days	Tue 10/11/11	Mon 12/12/11	
7		**Prepare Plans and Fact Sheets**	**124 days**	**Wed 9/14/11**	**Tue 3/6/12**	
8		Project Manual	60 days	Tue 12/13/11	Mon 3/5/12	5,6
9		Confirmation Sampling Plan	60 days	Wed 9/14/11	Wed 12/7/11	18SF-64 days
10		Construction Quality Assurance Plan	60 days	Tue 12/13/11	Mon 3/5/12	5,6
11		O & M Plan	60 days	Tue 12/13/11	Mon 3/5/12	5,6
12		H&S Plan	60 days	Tue 12/13/11	Mon 3/5/12	5,6
13		QA/QC Plan	60 days	Tue 12/13/11	Mon 3/5/12	5,6
14		**Fact Sheet**	**20 days**	**Tue 2/7/12**	**Tue 3/6/12**	
15		Distributed to USEPA	10 days	Tue 2/7/12	Tue 2/21/12	16SF
16		Distributed to Public	10 days	Tue 2/21/12	Tue 3/6/12	18SF
17		Pre-construction Inspection Meeting	0 days	Fri 2/24/12	Fri 2/24/12	18SF-7 days
18		**Mobilization**	**29 days**	**Tue 3/6/12**	**Fri 4/13/12**	
19		**Set up Solidification Pad**	**10 days**	**Tue 3/6/12**	**Mon 3/19/12**	
22		**Mobilize WWT System**	**16 days**	**Tue 3/20/12**	**Tue 4/10/12**	**8,12,13**
26		**Mobilize Solidification Equipment**	**9 days**	**Tue 4/3/12**	**Fri 4/13/12**	
32		Place Bin Blocks	5 days	Mon 4/9/12	Fri 4/13/12	30FF
33		**Mobilize Dredge**	**19 days**	**Tue 3/20/12**	**Fri 4/13/12**	
38		**Dredging Tasks**	**33 days**	**Tue 5/15/12**	**Thu 6/28/12**	
39		Dredge Soft Sediment	33 days	Tue 5/15/12	Thu 6/28/12	
40		**Placement of Cap**	**43 days**	**Fri 6/29/12**	**Tue 8/28/12**	
41		Changeover of Dredge for Cap Placement	2 days	Fri 6/29/12	Mon 7/2/12	39
42		Placement of Cap Materials	41 days	Tue 7/3/12	Tue 8/28/12	41
43		**Pre-final Constr. Inspection (at 80% compl.)**	**23 days**	**Fri 7/6/12**	**Tue 8/7/12**	
44		Notification of USEPA (30 days prior)	0 days	Fri 7/6/12	Fri 7/6/12	45SF-23 days
45		Pre-final Inspection	0 days	Tue 8/7/12	Tue 8/7/12	42FF-15 days
46		**South Channel Dredging**	**33 days**	**Mon 8/20/12**	**Wed 10/3/12**	
47		Install Sheet Pile	7 days	Mon 8/20/12	Tue 8/28/12	42FF
48		Pump Free Water	5 days	Wed 8/29/12	Tue 9/4/12	47
49		In-situ Stabilization	14 days	Wed 9/5/12	Mon 9/24/12	48
50		Remove Sheet Pile	7 days	Tue 9/25/12	Wed 10/3/12	49
51		**Final Construction Inspection (at completion)**	**23 days**	**Fri 9/7/12**	**Wed 10/10/12**	
52		Notification of USEPA (30 days prior)	0 days	Fri 9/7/12	Fri 9/7/12	53SF-23 days
53		Final Construction Inspection	0 days	Wed 10/10/12	Wed 10/10/12	61SF-2 days
54		**Demobilization**	**85 days**	**Fri 6/29/12**	**Thu 10/25/12**	
65		**Transportation and Disposal**	**95 days**	**Tue 5/15/12**	**Mon 9/24/12**	
72		**Water Treatment**	**112 days**	**Tue 5/15/12**	**Wed 10/17/12**	
79		**Project Oversight**	**168 days**	**Tue 3/6/12**	**Thu 10/25/12**	
82		**Project Management**	**580 days**	**Thu 10/7/10**	**Wed 12/26/12**	
85		Final Report	60 days	Thu 10/4/12	Wed 12/26/12	50
86		AOC Deadline for Sediment Removal Completion	0 days	Fri 11/1/13	Fri 11/1/13	



Project: Tyco AMRSRP Approach
Date: Tue 11/30/10

Task		Progress		Summary		External Tasks		Deadline	
Split		Milestone		Project Summary		External Milestone			

ID		Task Name	Duration	Start	Finish	Predecessors
87		AOC Deadline for Sediment Construction Report	0 days	Sat 3/1/14	Sat 3/1/14	
88		**MNR Plan**	**60 days**	**Thu 4/19/12**	**Thu 7/12/12**	
89		Development of MNR Plan	60 days	Thu 4/19/12	Thu 7/12/12	90FF
90		Submittal of MNR Plan	0 days	Thu 7/12/12	Thu 7/12/12	53SF-64 days



Project: Tyco AMRSRP Approach
Date: Tue 11/30/10

Task | Split | Progress | Milestone | Summary | Project Summary | External Tasks | External Milestone | Deadline

Appendix E
Compensation Schedule

TYCO AMRSRP Approach Compensation Schedule
Tyco Fire Products, LP
Marinette, Wisconsin

Item	Task	Estimated Quantity	Unit	Unit Price	Extended Total
A	**Lump Sum Items**				
A.1	Insurance Premiums	1	LS	$	$
A.2	Performance and Payment Bonds	1	LS	$	$
A.3	Mobilization	1	LS	$	$
A.4	Infrastructure Construction	1	LS	$	$
A.5	Site Maintenance (includes pumping wastewater to water treatment system)	1	LS	$	$
A.6	Surveys	1	LS	$	$
A.7	Site Restoration	1	LS	$	$
A.8	Demobilization	1	LS	$	$
A.9	Subcontract Closeout	1	LS	$	$
A.10	Interim Demobilization	1	LS	$	$
B	**Unit Price Items**				
B.1	Mechanical Dredging of Soft Sediment	59,300	CY	$	$
B.2	Mechanical Dredging of Semi-consolidated Sands and Silts	0	CY	$	$
B.3	Dry Excavation of Soft Sediment in South Channel	12,000	CY	$	$
B.4	Supply Fluidized Bed Boiler Ash Reagent	11,243	TON	$	$
B.5	Supply Portland Cement Reagent	0	TON	$	$
B.6	Supply Sodium Polyacrylate (SAP) Reagent	0	TON	$	$
B.7	Supply 60% Ferric Sulfate Solution Reagent	0	TON	$	$
B.8	Supply Calcium Hypochlorite Reagent	0	TON	$	$
B.9	Mix Reagents, stockpile on pad (staged for 7 days)	71,300	CY	$	$
B.10	Load Stabilized Materials into Trucks, Transport and Dispose at RCRA Subtitle D Landfill	104,936	TON	$	$
B.11	Load Stabilized Materials into Trucks, Transport and Dispose at RCRA Subtitle C Landfill	0	TON	$	$
B.12	Water Treatment	6,042,533	GAL	$	$
B.13	Debris Removal and RCRA Subtitle D Disposal	169	TON	$	$
B.14	Mechanical Dredge Standby Time	50	HR	$	$
B.15	Cap Placement	44,400	SY	$	$
				Total:	**$**

Appendix F
Cost Estimate

TYCO AMRSRP Approach Cost Estimate 2010-11-30
Tyco Fire Products, LP
Marinette, Wisconsin

Item	Task	Estimated Quantity	Unit	Unit Price	Extended Total
A	**Lump Sum Items**				
A.1	Insurance Premiums	1	LS	$ 186,235.38	$ 186,235
A.2	Performance and Payment Bonds	1	LS	$ 186,235.38	$ 186,235
A.3	Mobilization	1	LS	$ 517,427.13	$ 517,427
A.4	Infrastructure Construction	1	LS	$ 283,433.84	$ 283,434
A.5	Site Maintenance (includes pumping wastewater to water treatment system)	1	LS	$ 40,000.00	$ 40,000
A.6	Surveys	1	LS	$ 61,449.18	$ 61,449
A.7	Site Restoration	1	LS	$ 50,000.00	$ 50,000
A.8	Demobilization	1	LS	$ 363,191.25	$ 363,191
A.9	Subcontract Closeout	1	LS	$ 11,000.00	$ 11,000
A.10	Interim Demobilization	1	LS	$ -	$ -
B	**Unit Price Items**				
B.1	Mechanical Dredging of Soft Sediment	59,300	CY	$ 24.36	$ 1,444,475
B.2	Mechanical Dredging of Semi-consolidated Sands and Silts	0	CY	$ -	$ -
B.3	Dry Excavation of Soft Sediment in South Channel	12,000	CY	$ 19.82	$ 237,875
B.4	Supply Fluidized Bed Boiler Ash Reagent	11,243	TON	$ 60.50	$ 680,208
B.5	Supply Portland Cement Reagent	0	TON	$ -	$ -
B.6	Supply Sodium Polyacrylate (SAP) Reagent	0	TON	$ -	$ -
B.7	Supply 60% Ferric Sulfate Solution Reagent	0	TON	$ -	$ -
B.8	Supply Calcium Hypochlorite Reagent	0	TON	$ -	$ -
B.9	Mix Reagents, stockpile on pad (staged for 7 days)	71,300	CY	$ 10.93	$ 779,601
B.10	Load Stabilized Materials into Trucks, Transport and Dispose at RCRA Subtitle D Landfill	104,936	TON	$ 33.79	$ 3,545,885
B.11	Load Stabilized Materials into Trucks, Transport and Dispose at RCRA Subtitle C Landfill	0	TON	$ -	$ -
B.12	Water Treatment	6,042,533	GAL	$ 0.53	$ 3,192,016
B.13	Debris Removal and RCRA Subtitle D Disposal	169	TON	$ 121.62	$ 20,608
B.14	Mechanical Dredge Standby Time	50	HR	$ 1,196.48	$ 59,824
B.15	Cap Placement	44,400	SY	$ 82.63	$ 3,668,691
				Total:	**$ 15,328,155**

Total Contingency (Included in Estimate Range)		**$ -**
TOTAL WITH CONTINGENCY		**$ 15,328,155**
Project Management	**0%**	$ -
Remedial Design	**2%**	$ 306,563
Construction Management	**7%**	$ 1,072,971
Total Estimated COST		**$ 16,707,689**
Estimate Range		
Top estimate range +50%	**50%**	**$ 25,061,533**
Bottom estimate range -30%	**-30%**	**$ 11,695,382**

This estimate is offered as an opinion of cost to perform the work and is not an offer to contract for construction services, procure and/or provide such services