LOWER FOX RIVER REMEDIAL DESIGN
100 PERCENT DESIGN REPORT FOR
2010 AND BEYOND REMEDIAL ACTIONS

VOLUME 2 OF 2

Prepared for

Lower Fox River Remediation LLC

For Submittal to

Wisconsin Department of Natural Resources

U.S. Environmental Protection Agency

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ACES	Automated Coastal Engineering System
AM	Adaptive Management
Anchor	Anchor Environmental, L.L.C.
Anchor QEA	Anchor QEA, LLC
AOC	Administrative Order on Consent
A/OT	Agencies/Oversight Team
ARAR	Applicable or Relevant and Appropriate Requirement
ARCS	Assessment and Remediation of Contaminated Sediments
ASTM	American Society for Testing and Materials
BMP	best management practice
BOD	biological oxygen demand
BODR	Basis of Design Report
BPC	Brennan Push Corer
CCU	cap certification unit
CDF	confined disposal facility
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
Cm	centimeter
CMU	cap management unit
COMMP	Cap Operations, Maintenance and Monitoring Plan
CQAPP	Construction Quality Assurance Project Plan
CWA	Clean Water Act
cy	cubic yard
DMU	dredge management unit
DOC	depth of contamination
DRT	Design Review Tool
ESD	Explanation of Significant Differences
FIK	full indicator kriging
Fort James	Fort James Operating Company, Inc.
FRVOR	Fox River Valley Organic Recycling
GIS	geographic information system
GP	Georgia-Pacific Consumer Products LP
gpm	gallons per minute

GPS	Global Positioning System
HASP	Health and Safety Plan
H:V	horizontal to vertical
ICIAP	Institutional Control Implementation and Assurance Plan
IGLD	International Great Lakes Datum
J.F. Brennan	J.F. Brennan Company, Inc.
LFR Processing Facility	Lower Fox River Processing Facility
LHE	Low Hazard Waste Exemption
LLC	Lower Fox River Remediation LLC
LOS	level of significance
LTI	Limno Tech
LTMP	Long-Term Monitoring Plan
MAE	Mean Absolute Error
mm	millimeter
MOA	memorandum of agreement
MSW	municipal solid waste
NAD	North American Datum
NAVD88	North American Vertical Datum of 1988
NCR	NCR Corporation
NOAA	National Oceanic and Atmospheric Administration
O&M	Operation & Maintenance
Order	Administrative Order for Remedial Action, Docket Number V-W-08-C-885
OU	Operable Unit
PCB	polychlorinated biphenyl
pcf	pounds per cubic foot
PLC	programmable logic controller
ppm	part per million
PVC	polyvinyl chloride
QA	quality assurance
QC	quality control
RA	remedial action
RAL	remedial action level

RAO	Remedial Action Objective
RAWP	Work Plan for RA
RCM	Reactive Core Mat
RD	remedial design
RD Respondents	Fort James Operating Company, Inc. and NCR Corporation
Response Agencies	USEPA and WDNR
RMSE	Root Mean Squared Error
ROD	Record of Decision
RTK	Real Time Kinematic
SCCU	sand cover certification unit
SCMU	sand cover management unit
SDDP	sediment desanding and dewatering plant
SHSP	Site Health and Safety Plan
Site	Operable Units 2 to 5 of the Lower Fox River and Green Bay Site
SOW	Statement of Work
SPRI	Stuyvesant Projects Realization Inc. (formerly Stuyvesant Dredging, Inc. (SDI); a subsidiary of Boskalis Dolman Bv)
SQT	sediment quality threshold
SWAC	surface weighted average concentration
Tetra Tech	Tetra Tech, EC, Inc.
TSCA	Toxic Substances Control Act
USACE	U.S. Army Corps of Engineers
U.S.C.	United States Code
USCG	U.S. Coast Guard
USEPA	U.S. Environmental Protection Agency
VE	Value Engineering
WIDOT	Wisconsin Department of Transportation
WDNR	Wisconsin Department of Natural Resources
WRDA	Water Resources Development Act
WTP	water treatment plant

1 INTRODUCTION

This document presents the 100 Percent Design Report Volume 2 for the remediation of polychlorinated biphenyls (PCBs) in Operable Units (OUs) 2 to 5 of the Lower Fox River and Green Bay Site (Site; Figure 1-1). The accompanying 100 Percent Design Report Volume 1 (Tetra Tech, EC, Inc. [Tetra Tech] et al. 2008a) presents the remedial design (RD) of construction activities scheduled for implementation in 2009, including remedial action (RA) in OU 2, upper OU 3, a portion of OU 4, and associated material processing and staging facilities. The 100 Percent Design Report Volume 1 also describes the background of the OUs 2 to 5 RD/RA project, including a Site description, which is not repeated herein. This Volume 2 submittal presents the RD for remaining activities within OUs 2 to 5 to be performed in 2010 and beyond. Because this Volume 2 report is being submitted in 2012, it includes references to work already completed in 2010 through 2012, but the document is intended to present a design for all work from 2010 and beyond. As such, this Volume 2 document includes summaries of sampling, analysis, engineering evaluations, and RAs completed to date that form the basis for the overall RD in OUs 2 to 5.

The PCB cleanup remedy for the Lower Fox River was originally set forth in Records of Decision (RODs) for OUs 2 to 5 issued in December 2002 and June 2003 by the U.S. Environmental Protection Agency (USEPA) and the Wisconsin Department of Natural Resources (WDNR) under the authority of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), as amended, 42 U.S.C. §§ 9601-9675. The RD requirements for OUs 2 to 5 were originally set forth in the Administrative Order on Consent (AOC) and associated Statement of Work (SOW) for OUs 2 to 5 (USEPA 2004), executed in March 2004 by Fort James Operating Company, Inc.[1] (Fort James) and NCR Corporation (NCR) (collectively the "RD Respondents") in cooperation with the USEPA and WDNR (collectively the "Response Agencies"). In June 2007, a ROD Amendment was issued by the Response Agencies that made changes to parts of the remedy described in the original RODs in response to the new information gathered during the initial stages of the RD, and also from experience with prior remediation activities at the Site (USEPA and WDNR 2007). Further refinements to the design were documented in an Explanation of Significant Differences (ESD) issued in

[1] In January 2007, Fort James Operating Company, Inc. was converted to Georgia-Pacific Consumer Products LP.

February 2010 (USEPA and WDNR 2010). The Lower Fox River Remediation LLC (the LLC), an entity formed by Appleton Papers Inc. and NCR, retained Tetra Tech as the prime contractor for completion of the RD. The Tetra Tech Team performing the RD includes J.F. Brennan Company, Inc. (J.F. Brennan) for dredging and capping; Stuyvesant Projects Realization Inc. (SPRI, formerly Stuyvesant Dredging, Inc. [SDI], a subsidiary of Boskalis Dolman Bv) for sediment processing operations; Anchor QEA, LLC (Anchor QEA) for design assistance; and other specialty subcontractors. USEPA and WDNR are overseeing the RD process, and design documents prepared by the LLC are subject to review and approval by USEPA and WDNR. Follow-on RA activities are ongoing in accordance with the Administrative Order for Remedial Action, Docket Number V-W-08-C-885 (the "Order"; USEPA 2007).

This 100 Percent Design Report Volume 2 builds off of the Basis of Design Report (BODR; Shaw et al. 2006), the ROD Amendment (USEPA and WDNR 2007), the ESD (USEPA and WDNR 2010), the 30 Percent Design Report (Shaw and Anchor Environmental, L.L.C. [Anchor] 2007), the 60 Percent Design Report (Anchor et al. 2008), follow-on collaborative workgroup efforts, and the 100 Percent Design Report Volume 1 (Tetra Tech et al. 2008a). As discussed in Volume 1, the Response Agencies and the LLC have collaboratively sought to resolve key technical and implementation issues throughout the RD process through the timely use of workgroups and other communications (e.g., technical memoranda). Many of the technical memoranda and data collected during each phase of the RD have been included in the design deliverable for that phase of the work (e.g., technical memoranda produced during the 30 Percent Design phase were included with the 30 Percent Design Report). At the recommendation of the Response Agencies, each successive RD deliverable has not duplicated technical memoranda, data, or other information that were previously included in or attached to an earlier design deliverable. Rather, a "Remedial Design Anthology" was developed, which includes all information that forms the basis of the design, including the project analytical database, technical memoranda documenting key parts of the RD, and each RD submittal (e.g., BODR, 30 Percent Design, 60 Percent Design) The intent is to continually update the Remedial Design Anthology as the RD progresses to maintain a complete set of RD documents. The RD Respondents initially submitted the Remedial Design Anthology, including RD information through the 60 Percent Design phase, in July 2008 (Anchor and Tetra Tech 2008). Addenda to the Remedial Design Anthology were submitted in March 2009 (Anchor QEA and Tetra Tech 2009) and a revised

Design Anthology Remedy Change spreadsheet was submitted in December 2010 (Anchor QEA and Tetra Tech 2010).

The equipment and methods proposed by Tetra Tech Team selected to perform the RA for OUs 2 to 5 have been incorporated into the design as presented in this 100 Percent Design Report Volume 2 submittal, which includes the following:

- Determination of specific technologies for sediment capping, dredging, dewatering, transportation, and disposal of dredged sediments and associated wastewaters
- Design assumptions, parameters, and specifications, including design restrictions, process performance criteria, appropriate unit processes for the treatment train, and expected removal or treatment efficiencies during 2010 and beyond
- Plans, cross-sections, drawings, sketches, and design calculations
- Selected siting/locations of processes and construction activities
- Construction schedule for the implementation of the RA
- Adaptive Management (AM) and Value Engineering (VE) Plan to modify the cleanup plan as appropriate in response to new information and experience during initial remediation activities in OUs 2 to 5
- Construction Quality Assurance Project Plan (CQAPP), including verification plans and contingency plans to be implemented in 2010 and beyond
- Draft Capital and Operation and Maintenance Cost Estimates for the entire RA (including 2009 activities)
- Institutional Control Implementation and Assurance Plan (ICIAP)
- Cap Operations, Maintenance and Monitoring Plan (COMMP), including expected long-term monitoring and operation requirements
- Long-Term Monitoring Plan (LTMP) for surface water and biota

The design, submitted as part of this 100 Percent Design Volume 2 submittal, was developed under the oversight of the Response Agencies and their oversight team, collectively referred to as the Agencies/Oversight Team (A/OT).

1.1 Summary of OUs 2 to 5 Remedy

The ROD Amendment requires RA for all sediment with PCB concentrations exceeding the 1.0 part per million (ppm) remedial action level (RAL). Consistent with the ROD Amendment, the OUs 2 to 5 remedy described in this 100 Percent Design Report Volume 2 includes the elements listed in Section 1.3 of the 100 Percent Design Report Volume 1 submittal and the following additional elements:

- **Performance Standards.** Refer to Section 1.3 of Volume 1 for performance standards.
- **Staging Areas**. Refer to Sections 1.3 and 3 of Volume 1 for details of material processing and staging facilities that will be developed for sediment dewatering, sediment handling, water treatment, and cap/cover material staging.
- **Sediment Removal**. Sediment with PCB concentrations exceeding the 1.0 ppm RAL are targeted for removal from OUs 3 and 4, and near the river mouth in OU 5 beginning in 2010. In areas targeted for sediment removal without subsequent placement of an engineered cap, sediment removal will be performed to a neatline elevation intended to remove sediment exceeding 1.0 ppm PCBs while appropriately balancing the likelihood of removing non-target sediments or leaving undisturbed residuals behind (as determined using sampling data and geostatistical data interpolation). The dredging plan has been refined using data generated from "infill" sampling. As described below, results from infill sampling conducted in 2012 have not been incorporated into the design in time for this report. Once the 2012 infill sampling data are incorporated, the annual Work Plan for RA (RAWP) will be adjusted to reflect the 2012 data, as well as data from any future sampling that may be performed. Sediment removal will primarily be conducted using hydraulic dredging methods (e.g., swinging ladder cutterhead dredges), although in certain circumstances (such as in areas that cannot be accessed by hydraulic dredging equipment) some sediment may be removed by mechanical dredging, transported by barge to the Lower Fox River Processing Facility (LFR Processing Facility; formerly referred to as the Shell property), and mechanically unloaded. For hydraulic dredging, in-water pipelines will carry the dredged sediment from the dredge to the staging area.
- **Sediment Desanding**. Refer to Sections 1.3 and 5.4.4 of Volume 1 for details of bench-scale and pilot testing and VE to determine the potential for coarse- and fine-grained sand separation to provide material suitable for beneficial reuse.
- **Sediment Dewatering and Disposal**. Refer to Sections 1.3 and 5 of Volume 1 and Section 5 of this Volume 2 submittal for details of sediment dewatering and disposal.

- **Water Treatment**. Details of the water treatment process and associated monitoring are provided in Section 1.3 of Volume 1, Section 5.5 of this Volume 2 submittal, and the CQAPP for 2010 and beyond in Appendix F of this Volume 2 submittal.
- **Post-Dredge Residuals Management**. Refer to Section 1.3 of Volume 1 and Sections 2.7, 6, and 7 of this Volume 2 submittal for details of post-dredge residual management. In addition, alternative residuals management techniques were proposed by the Response Agencies in a memorandum dated June 14, 2012 (transmitted on June 15, 2012) outlining a "minor change to the selected remedy." These alternate techniques include reducing the overdredge allowance in areas with relatively low PCB concentrations at the base of the contaminated sediment deposit and with surface elevations relatively close to the RAL neatline (termed "Dredge Low Risk" in the memorandum dated June 14, 2012). The alternate techniques also include performing confirmation sampling in areas that were production dredged and, thus, may meet the post-dredge completion criteria with little or no additional dredging (termed "Confirm" in the memorandum dated June 14, 2012).
- **Engineered Caps**. An engineered cap, consisting of a sand layer and an armor stone layer or equivalent armor component will be installed in portions of the Site where dredging is not safe, feasible, practicable, and/or cost effective, provided the ROD Amendment eligibility criteria are satisfied. Similar to the design of the sediment removal areas, the capping plan has been refined using data generated from "infill" sampling through 2011. Once the 2012 infill sampling data are incorporated, the annual RAWPs will be adjusted to reflect the 2012 data, as well as data from any future sampling that may be performed. The following are capping eligibility criteria:
  - Minimum water depth criteria for capping as specified in the ROD Amendment
  - Capping will be performed in areas below the federally authorized navigation channel if the top of the cap is at least 2 feet below the authorized navigation depth.
  - Capping will be performed in areas outside of the federally authorized navigation channel if the top of the cap is at least 3 feet below the river's low water datum defined for the project in the BODR and 30 Percent Design Report (relative to the North American Vertical Datum of 1988 [NAVD88]; see Table 6-5).

- Engineered caps of 33 inches nominal thickness (minimum 21-inch thickness), including a surface armor layer composed of quarry spall or equivalent materials, will be used to contain contaminated sediments in: 1) areas within the OU 4B[2] federally authorized navigation channel (sediment in specific areas may be dredged as necessary to meet this criterion before the cap is installed); 2) areas with deeply buried sediment having PCB concentrations above 50 ppm (when the top three sample intervals [6 inches per interval] below the base of the cap each have PCB concentrations less than 50 ppm, unless otherwise approved by the A/OT as an exception); and 3) nearshore areas with any sediment having PCB concentrations exceeding 50 ppm, if removal of such sediment would impair the stability of shorelines, bridge piers, and utilities. Note that capping deposits with PCB concentrations in excess of 50 ppm is an exceptional case subject to Response Agencies' approval, as discussed below.
- Engineered caps of 16 or 21 inches nominal thickness (minimum 10- or 12-inch thickness), including a surface armor layer composed of gravel materials, will be used in areas outside of the federally authorized navigational channel and within the federally authorized navigational channel in OU 4A where sediment beneath the cap does not exceed 50 ppm PCBs at any depth within the sediment profile. Sediment in specific areas may be dredged as necessary to meet these criteria before the cap is installed.
- Engineered caps of 13 or 18 inches nominal thickness (minimum 7- or 9-inch thickness), including a surface armor layer composed of gravel materials, will be used in areas outside of the federally authorized navigational channel where sediment PCB concentrations beneath the cap do not exceed 50 ppm at any depth within the sediment profile and PCB concentrations in the 6-inch layer immediately beneath the cap do not exceed 10 ppm. Sediment in specific areas may be dredged as necessary to meet these criteria before the cap is installed.
- Engineered cap with Site-specific chemical isolation and/or armor designs based on unique conditions are not addressed by the cap designs discussed above.

[2] OU 4B is defined for the purposed of the RD as extending from the southern extent of the Fort Howard turning basin to the mouth of the river at Green Bay.

- **Exceptional Areas**. Modified remedial approaches will be used in exceptional areas in OU s 2 to 5. These areas were originally targeted for dredging; evaluation demonstrated that alternate remedies (primarily sand cover placement) will be sufficiently protective, more feasible, and more cost effective than the dredge-only approach for these areas as originally described in the BODR. The specific remedial approach for each exceptional area was developed through the collaborative workgroup process and is summarized in the Remedial Design Anthology (Anchor and Tetra Tech 2008). The agreed-upon approach to these exceptional areas was incorporated into this 100 Percent Design Report Volume 2**.** Additional discussion of exceptional areas continues through the collaborative workgroup process and may result in adjustment of the design, subject to the Response Agencies' review and approval.
- **Sand Covers**. A cover composed of at least 6 inches of clean sand from an off-site source will be placed over certain undredged areas that have a thin layer (12 inches or less; no more than two 6-inch sample intervals) of PCB-contaminated sediment with concentrations less than 2.0 ppm. Similar to sediment removal and engineered capping, the sand cover designs presented in this 100 Percent Design Report are based on infill sampling through 2011 and may be adjusted to reflect the 2012 data, as well as data from any future sampling that may be performed. Sand cover designs for the Site are described in Section 7 of this Volume 2 submittal.
- **Demobilization and Restoration**. Winterizing of equipment is required at the end of each remediation season. Details of specific winterizing and decontamination procedures are presented in Operation and Maintenance (O&M) Plans (J.F. Brennan 2009a; Tetra Tech et al. 2011a; Tetra Tech et al. 2011b; Tetra Tech 2011).
- **Natural Recovery**. Although the 1.0 ppm RAL performance standard or the surface (0 to 6 inches) weighted average concentration (SWAC) goal (0.28 ppm in OU 3 and 0.25 ppm in OU 4) will be met before construction of the RA can be deemed complete in an OU, the Response Agencies have concluded that it will take additional time for natural recovery before some of the remedial action objectives (RAOs) specified in the RODs and ROD Amendment are achieved. For example, though the ROD Amendment estimated that a SWAC of approximately 0.28 ppm PCBs will be achieved in OU 3 after the completion of active remediation, an additional 9 years of natural recovery were assumed to be necessary to achieve the

sediment quality threshold (SQT) for unlimited walleye consumption (i.e., 0.049 ppm PCBs). Natural recovery of both actively remediated and un-remediated areas will be necessary for certain SQTs and other RAOs discussed in the RODs and ROD Amendment to be achieved. Sediment natural recovery monitoring is discussed in the LTMP provided in Appendix I of this 100 Percent Design Report Volume 2.

- **Long-Term Monitoring of Surface Water and Biota**. Long-term monitoring of surface water and biota will be performed to assess progress in achieving RAOs and to determine remedial success. Sampling and analysis under the LTMP will continue until acceptable levels of PCBs are reached in surface water and fish. The LTMP, which specifies the types and frequency of monitoring, range of additional response actions, and outcomes triggering those actions, is provided in Appendix I of this 100 Percent Design Report Volume 2.
- **Long-Term Cap Monitoring**. Long-term monitoring will also be performed on any caps that are installed in OUs 2 to 5 to ensure their long-term integrity, protectiveness, and effectiveness. The long-term monitoring of caps will use bathymetric surveys to verify the presence of the armor layer, indicating that the cap remains in place, as described in the COMMP. If this monitoring indicates that the cap in an area no longer meets its original as-built design criteria and that degradation of the cap in the area may result in an actual or threatened release of PCBs at or from the area at levels that preclude achieving the RAOs, additional monitoring activities (potentially including physical and/or chemical sampling) may be undertaken in the affected area. If appropriate, additional remedial response actions will be performed to address the affected area. Long-term cap monitoring plans and contingency measures are presented in the COMMP (Appendix H of this 100 Percent Design Report Volume 2). In addition to the cap monitoring presented in the COMMP, the LTMP (Appendix I of this 100 Percent Design Report Volume 2) includes long-term monitoring of the chemical isolation layer effectiveness.

1.2 Summary of 2007 and 2009 Remedial Actions

Phase 1 of the OUs 2 to 5 RA was performed in 2007, pursuant to a consent decree with the Response Agencies; Phase 1 included the hydraulic dredging, dewatering, and disposal of approximately 132,000 in situ cubic yards (cy) of sediment from an approximately 22-acre area on the western shore downstream of the De Pere Dam. The Phase 1 dredging included approximately 104,000 cy of non-Toxic Substances Control Act (TSCA) sediment that was disposed of at the Veolia Hickory Meadows Landfill in Chilton, Wisconsin, and approximately 28,000 cy of in situ TSCA sediment that was disposed of at the EQ-Michigan Disposal Waste Treatment Plant in Belleville, Michigan (Shaw et al. 2008). Post-dredge sampling following the 2007 Phase 1 project indicated the presence of residual sediments, and the Response Agencies have held open the Phase 1 Consent Decree until further remediation is performed. The remediation of these sediments is planned as part of the services performed by the contractor conducting the Phase 2 RA, but the details of this remediation are not included in this 100 Percent Design Report Volume 2 because the work is governed by a separate consent decree.

Phase 2 of the OUs 2 to 5 RA began in 2009, as described in the 100 Percent Design Report Volume 1. The 2009 dredging areas described in the 100 Percent Design Report Volume 1 submittal are depicted on Figure 1-2. Additional details of the planned RA for 2009 are provided in the Phase 2B 2009 RAWP (Tetra Tech et al. 2010a)

1.3 Summary of Remedial Actions in 2010 and Beyond

This 100 Percent Design Report Volume 2 describes the RD for planned activities in 2010 and beyond including dredging, engineered capping, and sand covering. Figure 1-3 depicts planned RA areas during this period. These RA areas will be re-evaluated based on AM, VE, any future sampling, and geostatistical analyses. Depending on the results of any infill samples, the RA areas will be reassessed and reported in the annual Phase 2B RAWPs, which will be submitted in January of each year and will detail the work to be completed in the coming construction season.

Following the 2009 construction season, dredging resumed in 2010 and has continued through 2012 (at the time of this report) downstream of the De Pere Dam in OU 4 using two of Brennan's 8-inch dredges. Production dredging was, and continues to be, performed downstream of the De Pere Dam in OU 4 using J.F. Brennan's 12-inch dredge. Sequencing of 8-inch and 12-inch dredge operations will generally continue in an upstream to downstream direction. The dredge configuration will continue to be adapted based on the scope of work and the areas in which dredging is occurring to balance production, the overall project schedule, and the potential for subsequent recontamination of dredged areas.

Dredging operations to be used in 2010 and beyond are discussed in Sections 4 and 5 of this 100 Percent Design Report Volume 2, including removal of sediment subject to TSCA requirements as well as non-TSCA sediments, and appropriate segregation and handling of these materials. The Phase 2B 2009 RAWP (Tetra Tech et al. 2010a) provides additional details of the dredging operations for 2009, which are expected to be very similar to those planned for the remainder of the project.

Given the length of dredge slurry pipelines, several booster stations are necessary to convey the dredge slurry to the LFR Processing Facility located in OU 4. A series of up to six booster stations (two fewer than required in 2009) were required for the 8-inch dredge pipeline extending upstream of the LFR Processing Facility to OU 3 in 2010. For the 12-inch dredge pipeline, two boosters are necessary to facilitate dredging upstream of the LFR Processing Facility to the De Pere Dam. As dredging in OU 4 proceeds downstream, the two booster stations will be shifted downstream of the LFR Processing Facility to allow access to the mouth of Green Bay. The proposed dredging sequence allows for reducing the dredge pipeline length and number of in-line booster pumps as the dredging operations proceed north towards the LFR Processing Facility. Once removed from in-line use, the booster pumps will serve as back-ups for the other on-line boosters.

Dredging of sediments is anticipated to be substantially complete by the end of 2015. Most engineered capping and sand covering of contaminated sediment will be conducted over seven seasons, beginning in 2011 and being substantially complete by the end of 2017. Some limited capping and more significant sand covering was performed during the 2009 dredge season in OU 2 and OU 3. In-water construction work will typically be performed between early April and mid-November of each calendar year. However, this is an approximate window that is dependent on actual work plans, river conditions, and weather, resulting in expanded or reduced schedules for any given year. Within these approximately 7-month construction seasons, it is anticipated that in-water dredging operations will generally be conducted 24 hours per day, 5 days per week, with a sixth day per week planned for regular equipment maintenance and repair. Capping and sand cover placement operations are currently planned to be conducted up to 24 hours per day, 5 days per week.

Sections 1.3.1 through 1.3.3 provide brief summaries of planned annual dredging, cap and sand cover placement, and long-term monitoring activities beginning in 2010. A Phase 2B RAWP will be submitted annually detailing the planned RA for the upcoming construction season. The first of these annual work plans was submitted as a draft in January 2009 for the 2009 season and revised for final submittal in April 2009 (Tetra Tech et al. 2009c). Similar work plans were submitted for the 2011 (Tetra Tech et al. 2011c) and 2012 (Tetra Tech et al. 2011d) seasons.

1.3.1 Dredging

Figure 1-4 depicts planned 2010 to 2015 dredge areas. Table 9-1 presents the anticipated annual dredging production rates and volumes. Dredging activities for each year between 2010 and 2015 are summarized in Sections 4.1 and 4.2. Subject to AM and VE refinements, the dredging slurry transport system and dewatering/disposal operations will be as outlined in the 100 Percent Design Report Volume 1. Planned actions and production rates may be refined (upwards or downwards), depending on actual field performance, weather conditions, and other factors. The annual Phase 2B RAWPs will provide the updated schedule of actions for each year.

The two 8-inch dredges operated in 2010 and 2011 within the OU 3, continuing where 2009 dredging left off (see the 100 Percent Design Report Volume 1). These 8-inch dredges proceeded from upstream to downstream. Additionally, the 12-inch dredge continued production dredging downstream of the De Pere Dam through 2012, with target elevations set approximately 1 foot or less above the 1.0 ppm PCB concentration neatline (based on the geostatistical modeling) or required dredge-and-cap elevation, as described in the 100 Percent Design Report Volume 1.

Following completion of the OU 3 dredging, the two 8-inch dredges began the final dredging passes in OU 4 of those areas where the 12-inch dredge previously completed production passes. In addition to final pass dredging, the two 8-inch dredges will operate in shallow water areas where the dredge cuts are thin or where it is not efficient or feasible for the 12-inch dredge to operate. It is anticipated that the 12-inch production dredge will continue each year where it left off the prior dredge season in areas with thicker targeted dredge cuts remaining. The planned dredging schedule is presented in Section 9, and is subject to AM.

Coordination with U.S. Army Corps of Engineers (USACE) maintenance dredging within the OU 4B navigation channel and elsewhere in the river will occur as generally outlined in the AM and VE Plan (Appendix E of this 100 Percent Design Volume 2), and as indicated in updated dredging operations provided in annual Phase 2B RAWPs.

1.3.2 Cap and Cover Placement

Most capping and covering of contaminated sediment will be conducted over six seasons, beginning in 2011 and continuing through 2017 and excluding 2012; however, some limited capping and more significant sand covering was performed during the 2009 dredge season in OU 2 and OU 3. A broadcast spreading method will be the primary means of placing sand and gravel-sized armor materials. This broadcast spreading method, developed and refined during earlier operations in OU 1, allows for uniform placement of thin layers of cap and cover material as well as capping and sand covering in shallow waters. Typical mechanical placement equipment (e.g., clamshell bucket or excavator bucket) will be used to place larger armor stone that cannot be placed with the broadcast spreader unit.

The proposed sequence of capping and covering operations will generally proceed upstream to downstream following the completion of dredging in those areas. For the majority of the capping seasons, dredging will be conducted simultaneously downstream of capping and sand covering operations.

Figure 1-5 depicts cap and cover placement areas in OUs 2 to 5. Planned actions and production rates may be refined (upwards or downwards), depending on actual field performance, weather conditions, and other factors. The annual Phase 2B RAWPs will provide the updated schedule of actions for each year.

As construction proceeds, up to two broadcast spreading marine plants will be operated in OU 3 and OU 4. In addition, up to two mechanical plants will also be operated, as necessary, to place the larger armor. Capping and cover placement will continue each season where operations left off the prior year (except for 2012 when the placement of caps or sand covers is not planned).

The planned cap and cover placement schedule for 2010 to 2017 is presented in Section 9, and is subject to revision.

1.3.3 Long-Term Monitoring

As described in the COMMP (Appendix H), the "Year 0" trigger for post-construction cap monitoring in a given area will occur when cap construction is completed within that area. Caps in OU 2 were completed in 2009, and an initial detailed post-construction bathymetric survey of the OU 2 capped areas was performed towards the end of the 2009 construction season. Caps and sand covers in OU 3 were completed in 2011. Detailed post-construction Year 0 multi-beam hydrographic surveys were completed in OU 3 cap areas during November 2011. Similar bathymetric surveys will be completed in subsequent years following completion of cap construction in individual areas. In addition to the monitoring of caps presented in the COMMP, the LTMP includes long-term monitoring of the chemical isolation layer effectiveness (see Appendices H and I of this 100 Percent Design Report Volume 2), and also monitoring of fish tissue, sediment, and water.

As discussed in the COMMP, post-construction bathymetric surveys (and potential follow-up surveying and/or sampling) will generally be performed following completion of cap construction in individual areas. See Table 1-1 for the proposed schedule of years for post-construction surveying. In addition to routine bathymetric monitoring of all cap areas, additional event-based cap monitoring will be performed in "sentinel" areas (i.e., cap areas located in the upper 10 percentile of shear stresses) as soon as possible following peak flow or seiche events with a recurrence interval of 20 years or more, or following major river construction events (e.g., new bridge construction). If cap integrity and performance are verified under a 20-year event, a follow-on, event-based cap monitoring will occur following a 50-year event. In the event that routine or event-based monitoring indicates cap erosion or damage, the Respondents and Response Agencies will collaboratively discuss appropriate response actions as part of AM. Long-term cap monitoring plans are presented in the COMMP

(Appendix H). Long-term sediment monitoring plans for OU2 and 5 are described in the LTMP (see page 6 of COMMP Section 1.2 for clarification).

Table 1-1
Summary of Cap Monitoring Events

Area	Cap Monitoring Event Years (Following Project Completion)
OUs 2 and 3	0, 2, 6, 11, 16, 21, 26, 31
OUs 4 and 5	0, 2, 5, 10, 15, 20, 25, 30

1.4 Report Organization

Major design elements for this RA were developed during the 30 and 60 Percent Design phases. A series of collaborative workgroup discussions and technical exchanges between the RD Team and the A/OT during design activities was critical in developing and completing this 100 Percent Design. The following specific collaborative work elements were completed for the 60, 90, and 100 Percent Design Report Volume 2:

- Refinement of dredging plans including incorporation of a neatline dredge approach for dredge-only areas
- Refinement of capping plans including localized cap armor designs
- Development of design approaches in shoreline areas and adjacent to infrastructure and utilities (i.e., setback and stable slope assumptions). For this 100 Percent Design, the shoreline and transition area designs are based on the established standard design approaches (i.e., "ground rules") developed in the 60 Percent Design and refined based on Site-specific evaluations including additional sampling and investigations currently being performed. Final remedy design around each structure or section of shoreline will be documented in technical memoranda to be submitted as addenda to this 100 Percent Design.

To document the design effort, this report has been organized to provide the following:

- Summary of Site characteristics from completed RD sampling and analysis events
- Dredge plan designs (updated from 60 Percent Design)
- Beneficial reuse opportunities and landfill disposal requirements for separated sand and dewatered sediments, respectively

- Design criteria and detailed engineering plans for the staging area, sediment dredging, material handling, transportation and disposal of sediments, engineered capping, and sand covering
- Institutional controls
- Scheduling
- Monitoring, maintenance, and AM strategies
- Location-specific applicable or relevant and appropriate requirements (ARARs)

In addition, attached to this report are the following supporting appendices:

- Appendix A Dredging and Materials Handling Design Support Documentation
- Appendix B Cap Design Support Documentation
- Appendix C Specifications/Construction Work Plans for Key Design Elements
- Appendix D Engineered Plan Drawings
- Appendix E   AM and VE Plan
- Appendix F CQAPP
- Appendix G ICIAP
- Appendix H COMMP, including expected long-term monitoring and operation requirements
- Appendix I LTMP
- Appendix J Site Health and Safety Plan (SHSP)
- Appendix K Responsiveness Summary for Agency Comments on the 60, 90, and Draft 100 Percent Design Reports Volume 2
- Appendix L Operations and Maintenance Plans
- Appendix M Refinements to Previous 100 Percent Design Plans based on the A/OT's Design Review Tool (DRT)

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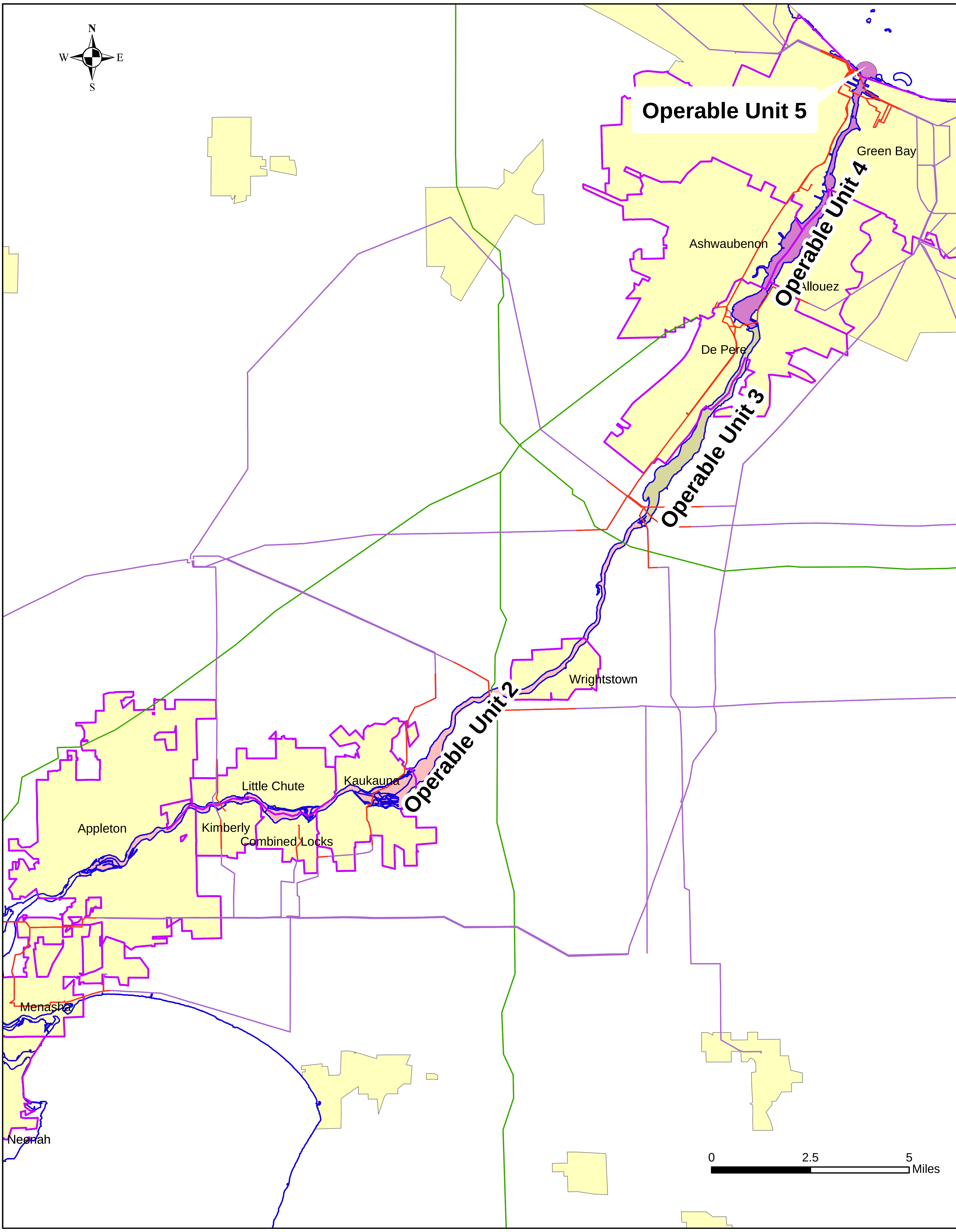


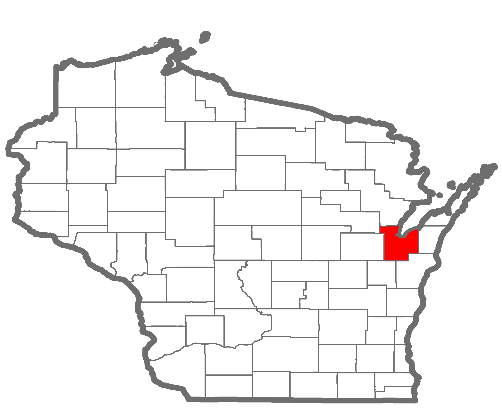
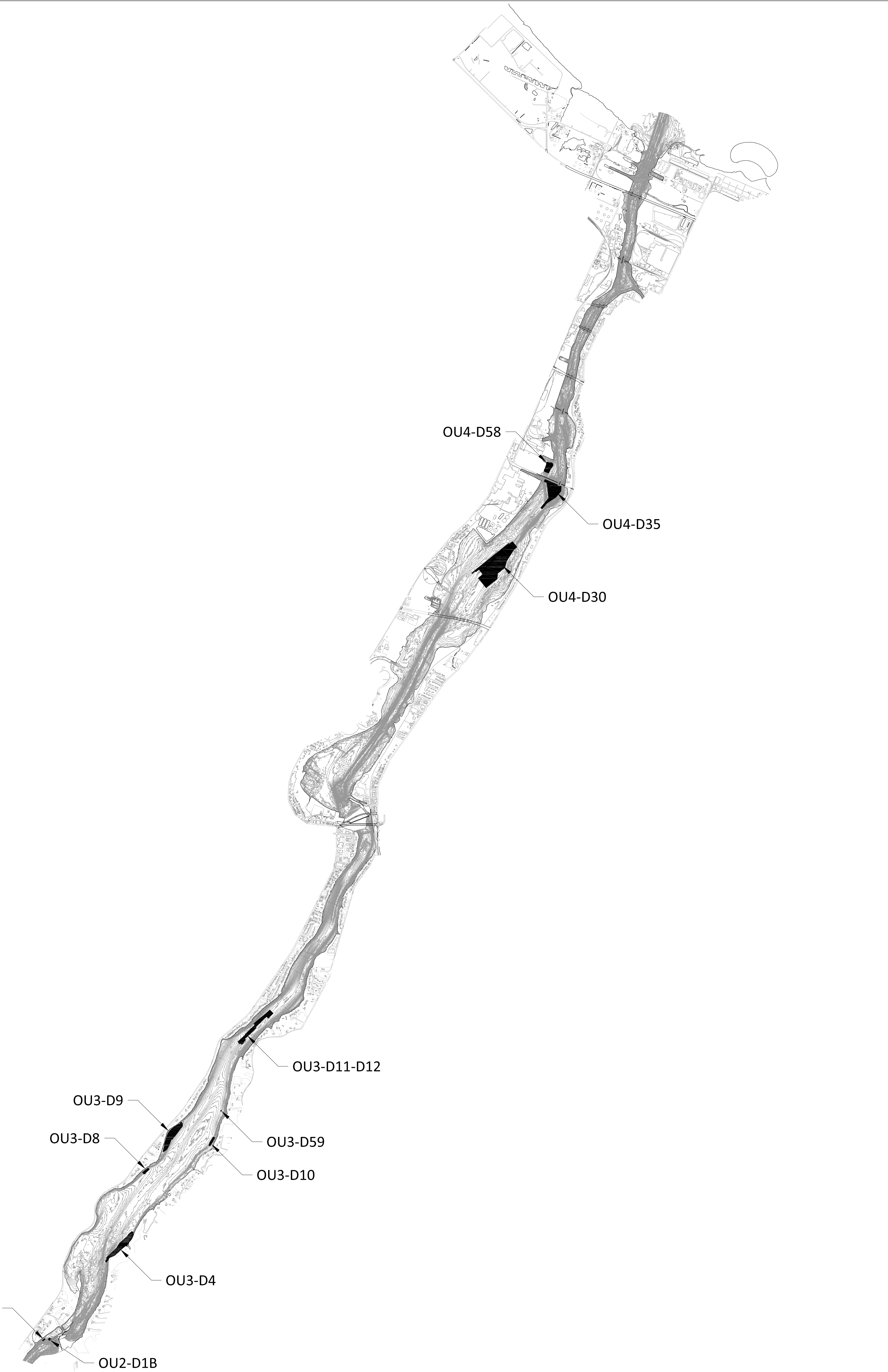


Figure 1-1
Lower Fox River
Area Location Map

Lower Fox River OU 2-OU 5



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Nov 18, 2009 9:16am dbinkney

SOURCE: Survey and mapping work performed for the WDNR by the RETEC Group circa 2004.
HORIZONTAL DATUM: Wisconsin State Plane Central Zone, NAD83, U.S. Survey Feet.
VERTICAL DATUM: North American Vertical Datum 1988 (NAVD88), U.S. Survey Feet.

LEGEND:

2009 Dredge Area

0 5000
Scale in Feet

Figure 1-2
2009 Dredge Areas
Lower Fox River - OUs 2 to 5

ANCHOR QEA

TETRA TECH

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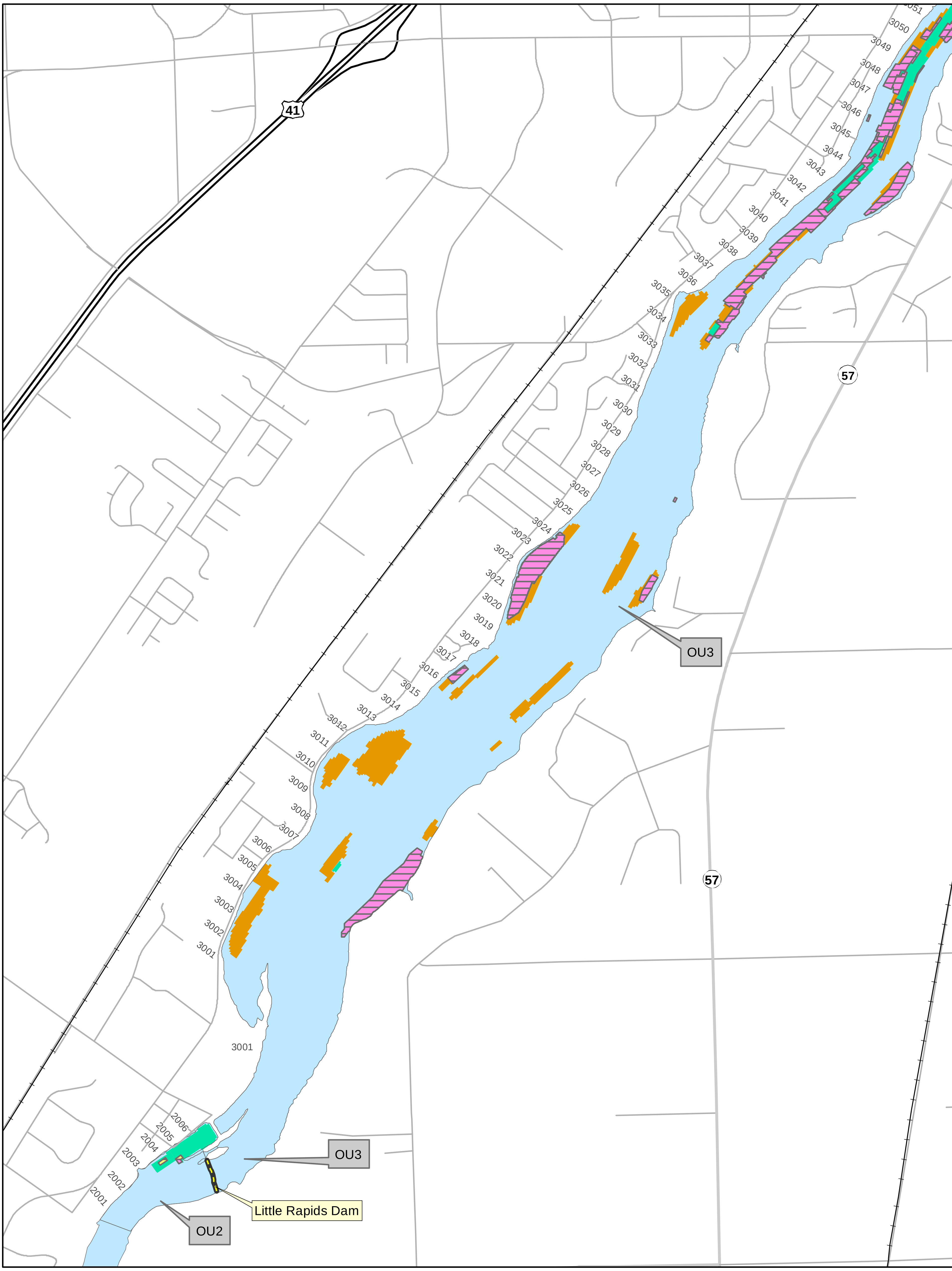
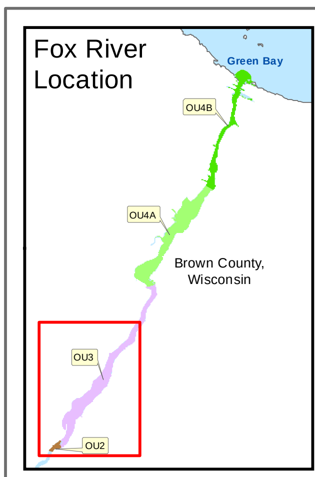


Fox River Location



US Highway | State Highway | Road | Railroad

Operable Unit / Fox River Boundary | Dam | 3001 Sample Location Row Number | Federal Navigation Channel

100% Design

Dredge and Cap | Shoreline Cap

Engineered Cap A, B or C | Sand Cover

Dredge (Volume 1 - 2009/Volume 2 - 2010/2011)

Dredge to 1 ppm (Volume 2 - 2012 and beyond)

Fox River - OUs 2 to 5
Figure 1-3a

OUs 2 to 5 Remedial Action Areas

Brown County, Wisconsin, USA

TETRA TECH

ANCHOR QEA

N E S W

Rotation 0°

Feet

0 1,000 2,000

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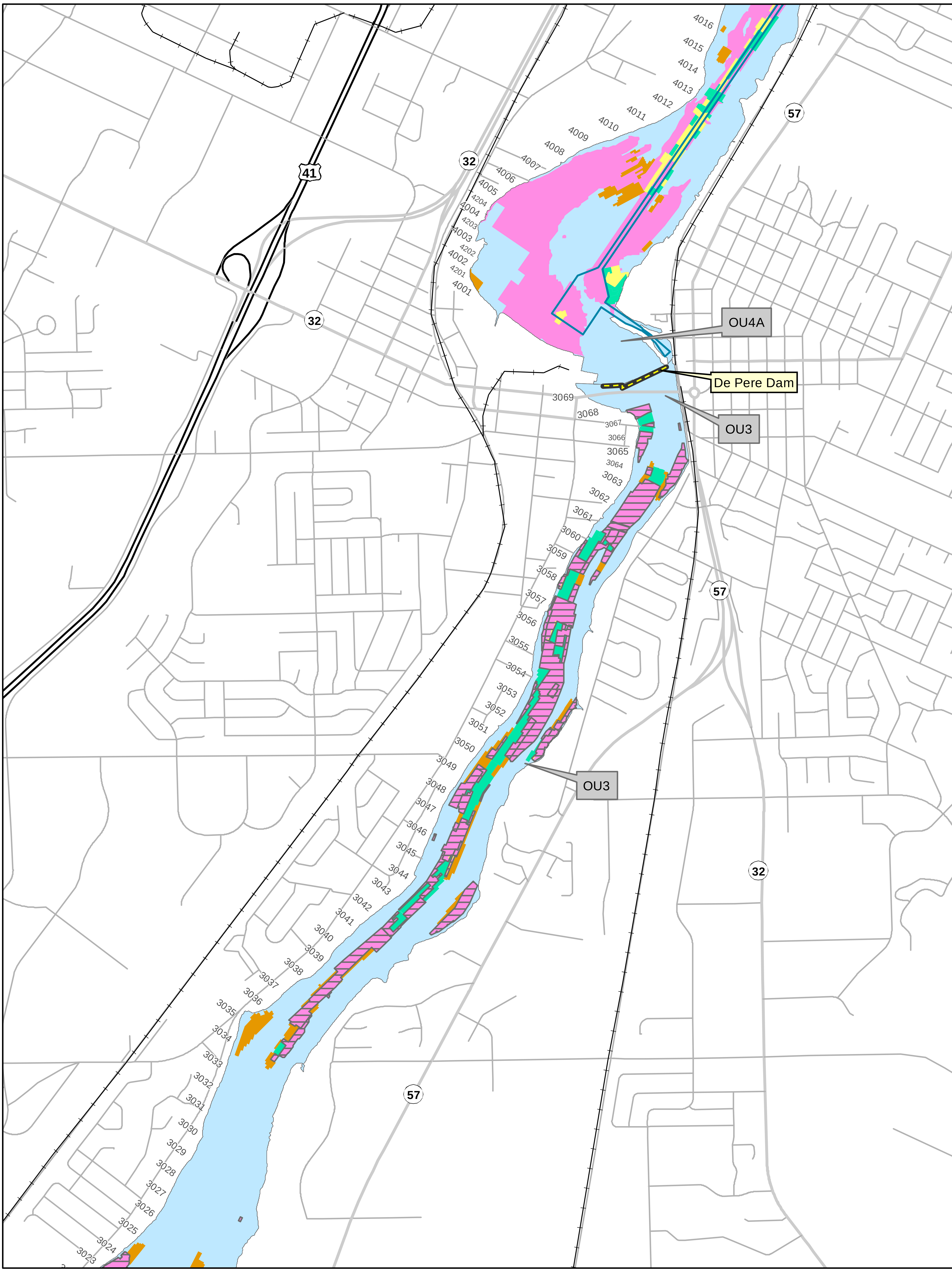
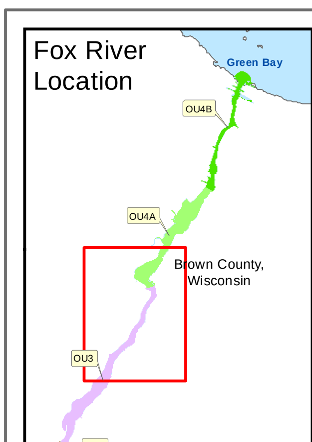


Fox River Location



US Highway	Operable Unit / Fox River Boundary
State Highway	Dam
Road	3001 Sample Location Row Number
Railroad	Federal Navigation Channel

100% Design

Dredge and Cap	Shoreline Cap
Engineered Cap A, B or C	Sand Cover
Dredge (Volume 1 - 2009/Volume 2 - 2010/2011)	
Dredge to 1 ppm (Volume 2 - 2012 and beyond)	

Fox River - OUs 2 to 5
Figure 1-3b

OUs 2 to 5 Remedial Action Areas

Brown County, Wisconsin, USA

TETRA TECH

ANCHOR QEA

N W E S

Rotation 0°

Feet

0 1,000 2,000

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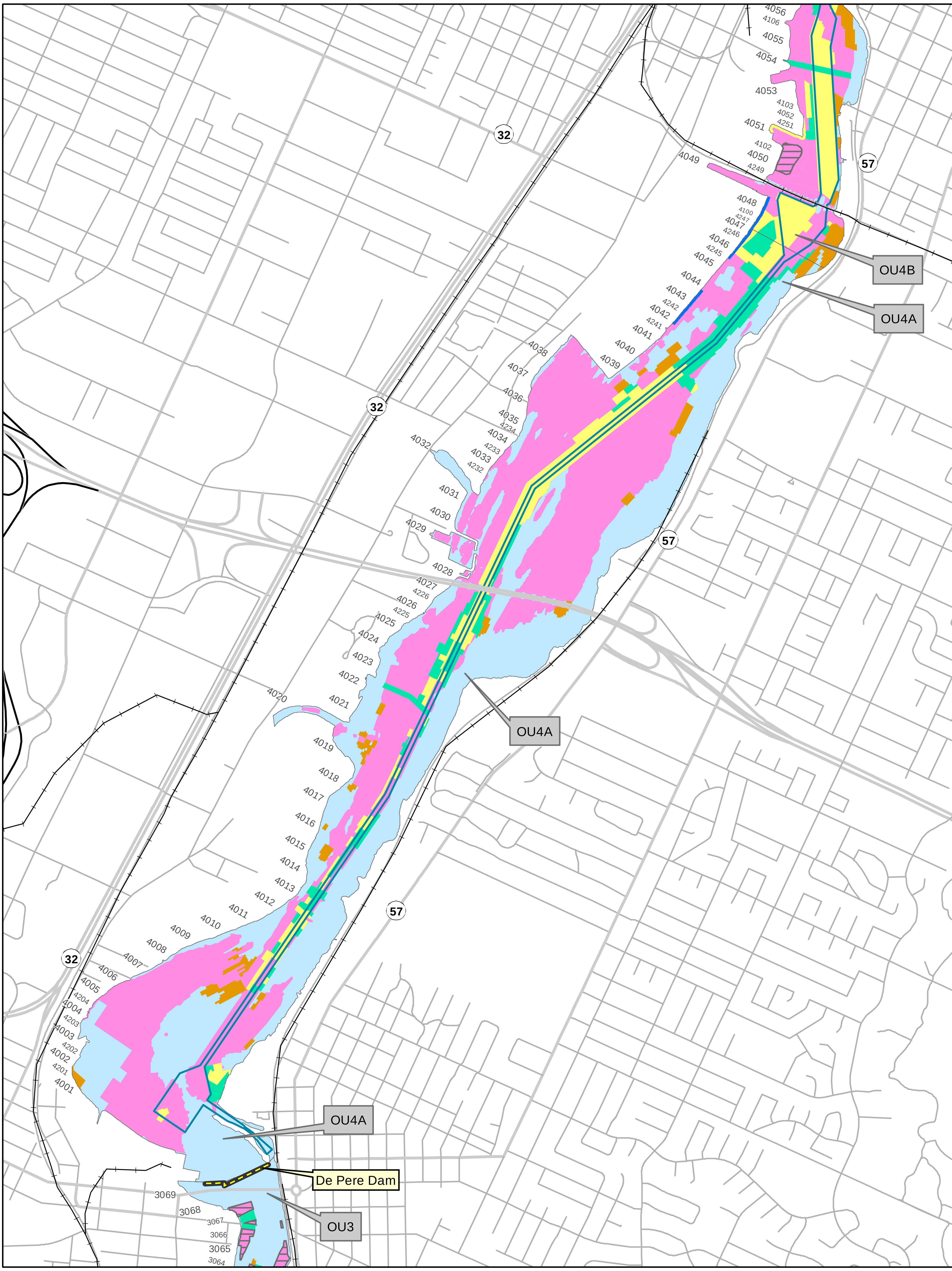

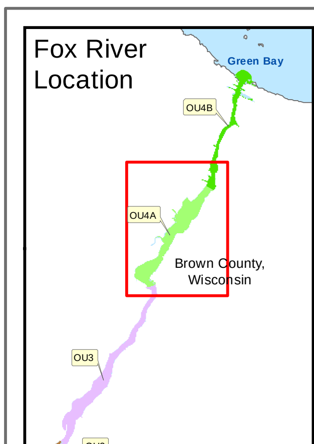

- US Highway
- State Highway
- Road
- Railroad
- Operable Unit / Fox River Boundary
- Dam
- 3001 Sample Location Row Number
- Federal Navigation Channel

100% Design

- Dredge and Cap
- Engineered Cap A, B or C
- Dredge (Volume 1 - 2009/Volume 2 - 2010/2011)
- Dredge to 1 ppm (Volume 2 - 2012 and beyond)
- Shoreline Cap
- Sand Cover

Fox River - OUs 2 to 5
Figure 1-3c

OUs 2 to 5 Remedial Action Areas

Brown County, Wisconsin, USA

Rotation 0°

Feet
0 1,000 2,000

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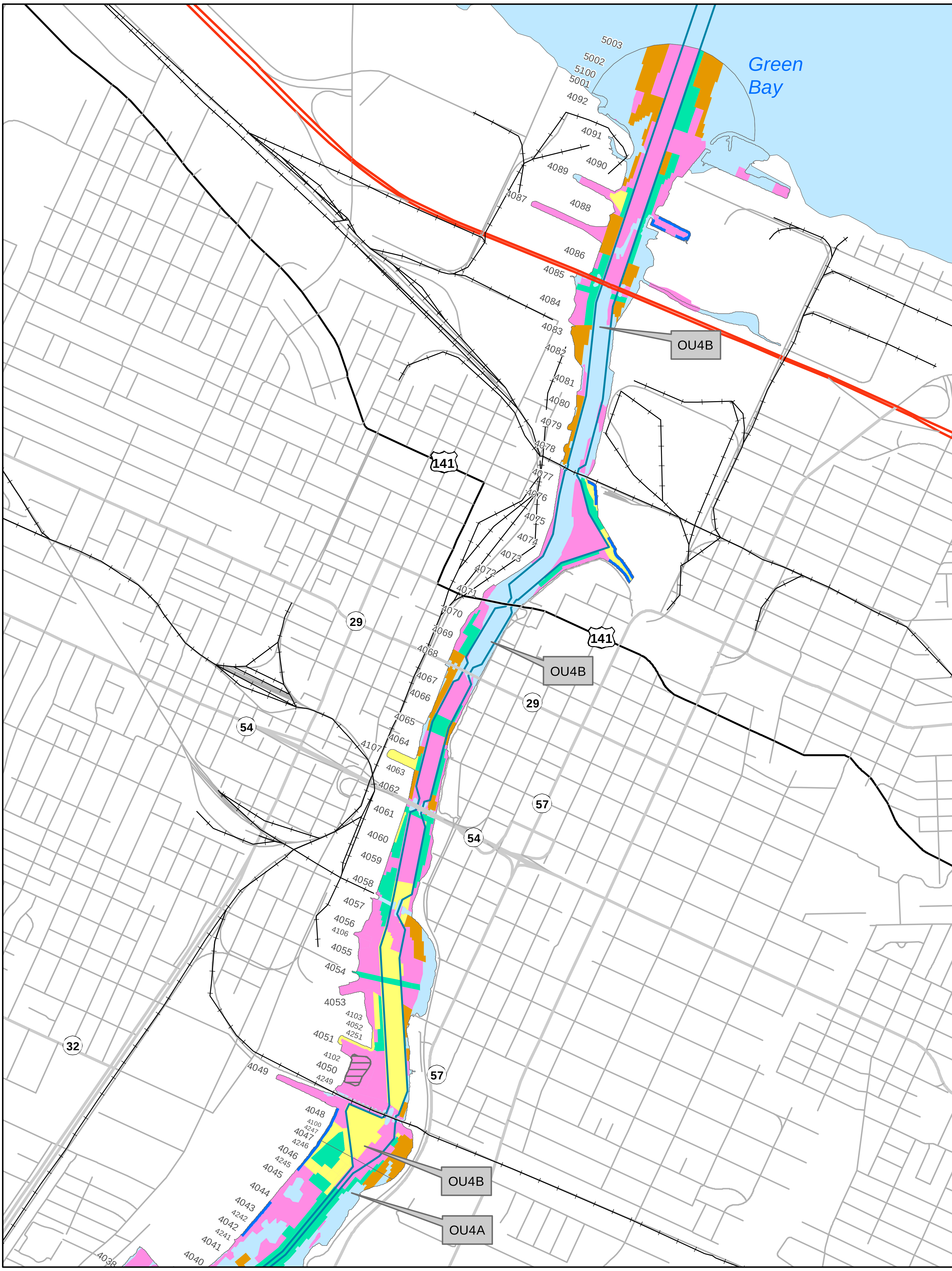
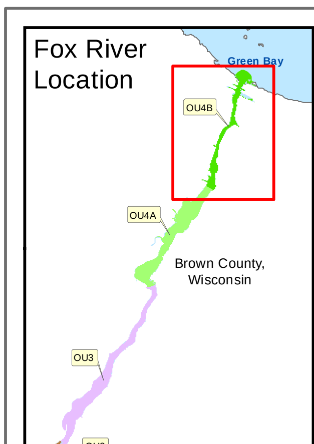




US Highway	Operable Unit / Fox River Boundary
State Highway	Dam
Road	3001 Sample Location Row Number
Railroad	Federal Navigation Channel

100% Design

Dredge and Cap	Shoreline Cap
Engineered Cap A, B or C	Sand Cover
Dredge (Volume 1 - 2009/Volume 2 - 2010/2011)	
Dredge to 1 ppm (Volume 2 - 2012 and beyond)	

Fox River - OUs 2 to 5
Figure 1-3d

OUs 2 to 5 Remedial Action Areas

Brown County, Wisconsin, USA

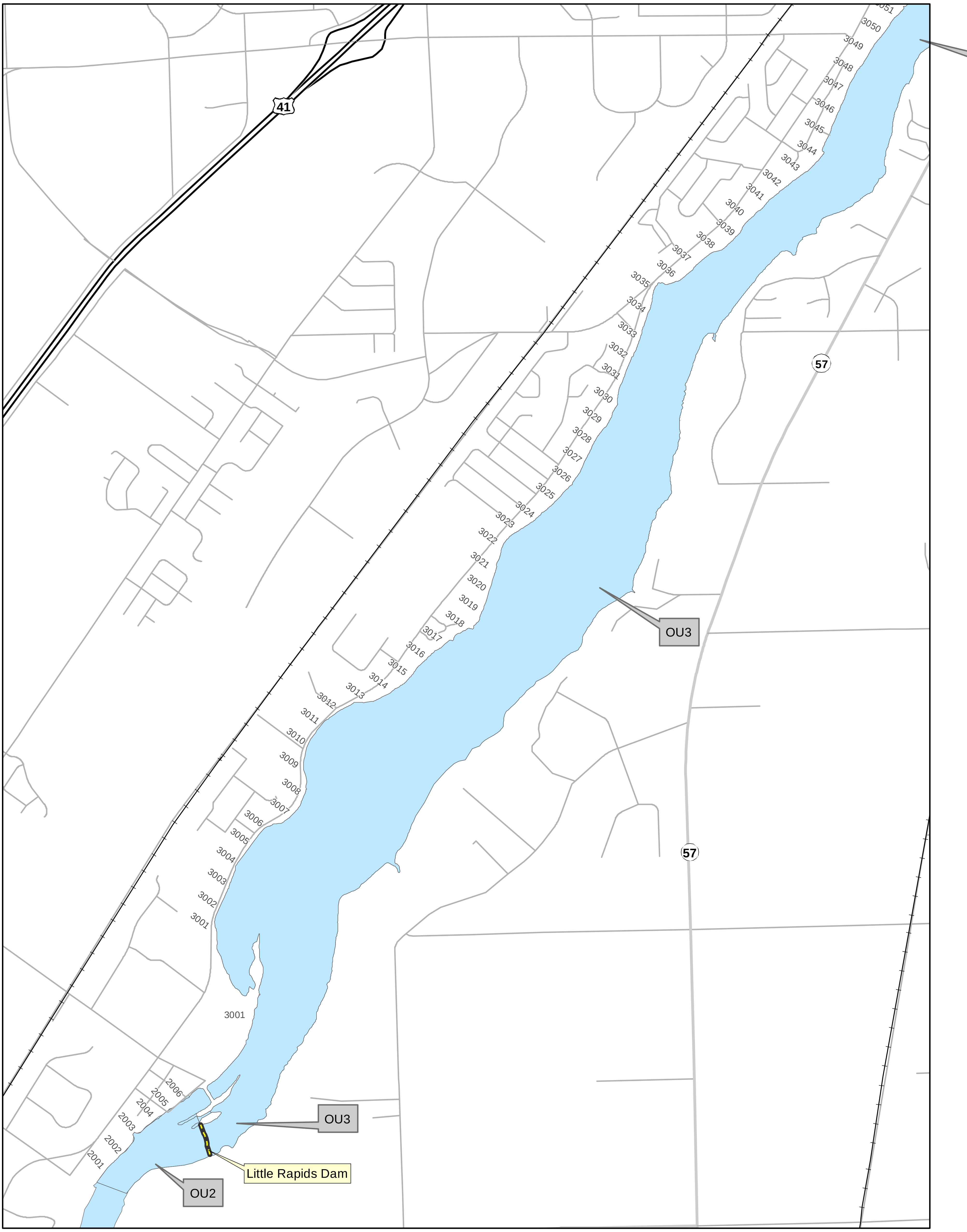
TETRA TECH

ANCHOR QEA

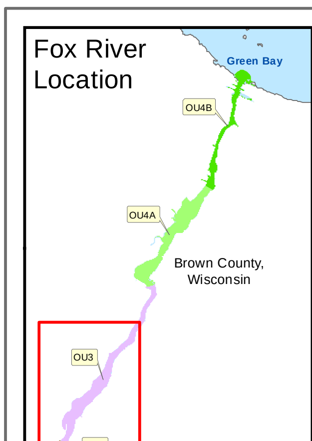
N W E S

Rotation 0°

Feet
0 1,000 2,000



Fox River Location



US Highway
State Highway
Road
Railroad
Operable Unit / Fox River Boundary
Dam
3001 Sample Location Row Number
Federal Navigation Channel

100% Design

Dredge and Cap - Years 2012 to 2017

Dredge to 1 ppm - Years 2012 to 2015

Fox River - OUs 2 to 5
Figure 1-4a

2012 to 2015 Dredging Areas

Brown County, Wisconsin, USA

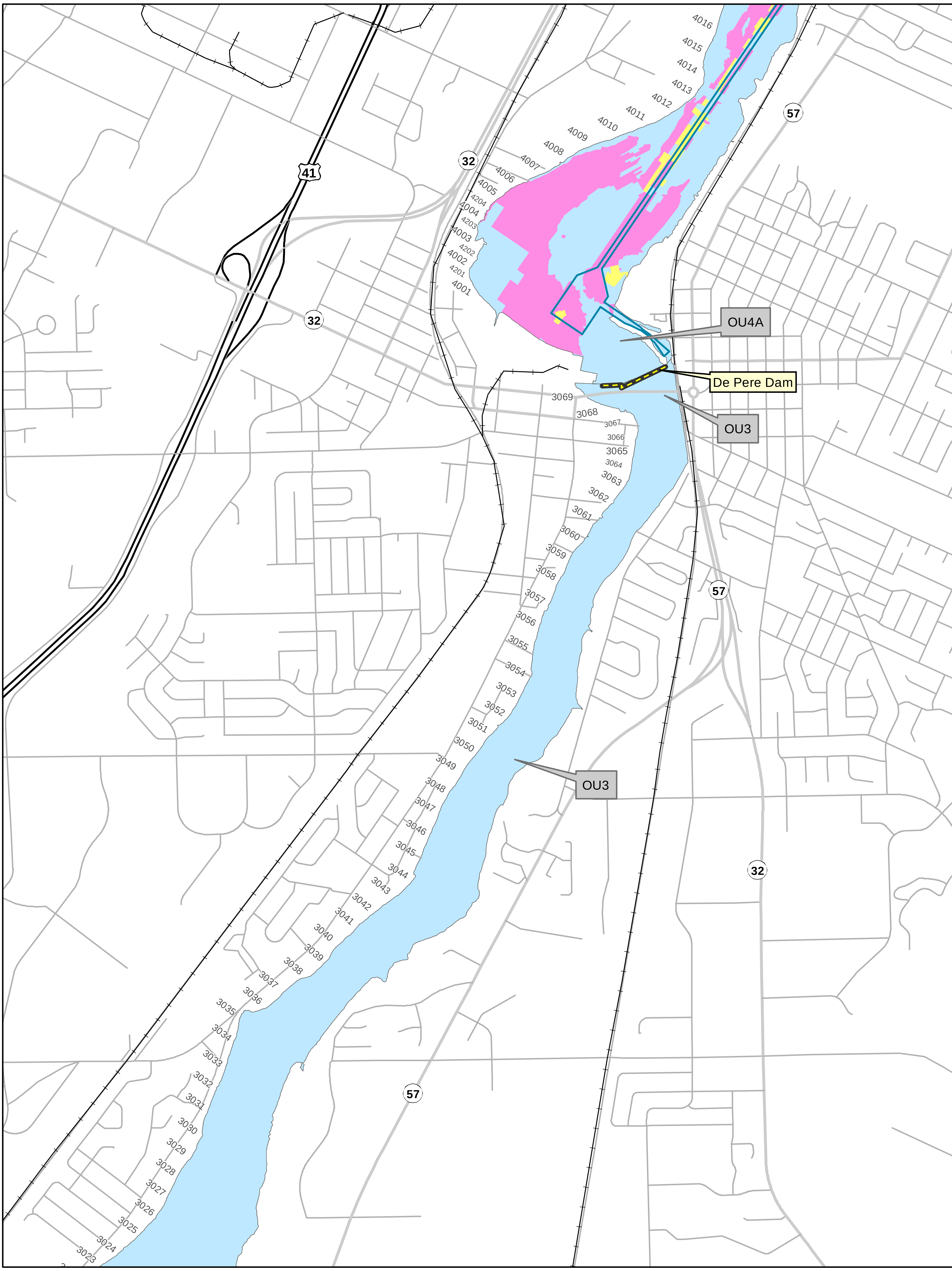
TETRA TECH

ANCHOR QEA

N W E S

Rotation 0°

Feet
0 1,000 2,000



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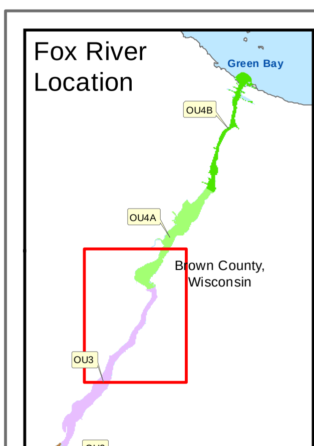


US Highway
State Highway
Road
Railroad
Operable Unit / Fox River Boundary
Dam
3001 Sample Location Row Number
Federal Navigation Channel

100% Design

Dredge and Cap - Years 2012 to 2017

Dredge to 1 ppm - Years 2012 to 2015

Fox River - OUs 2 to 5
Figure 1-4b

2012 to 2015 Dredging Areas

Brown County, Wisconsin, USA

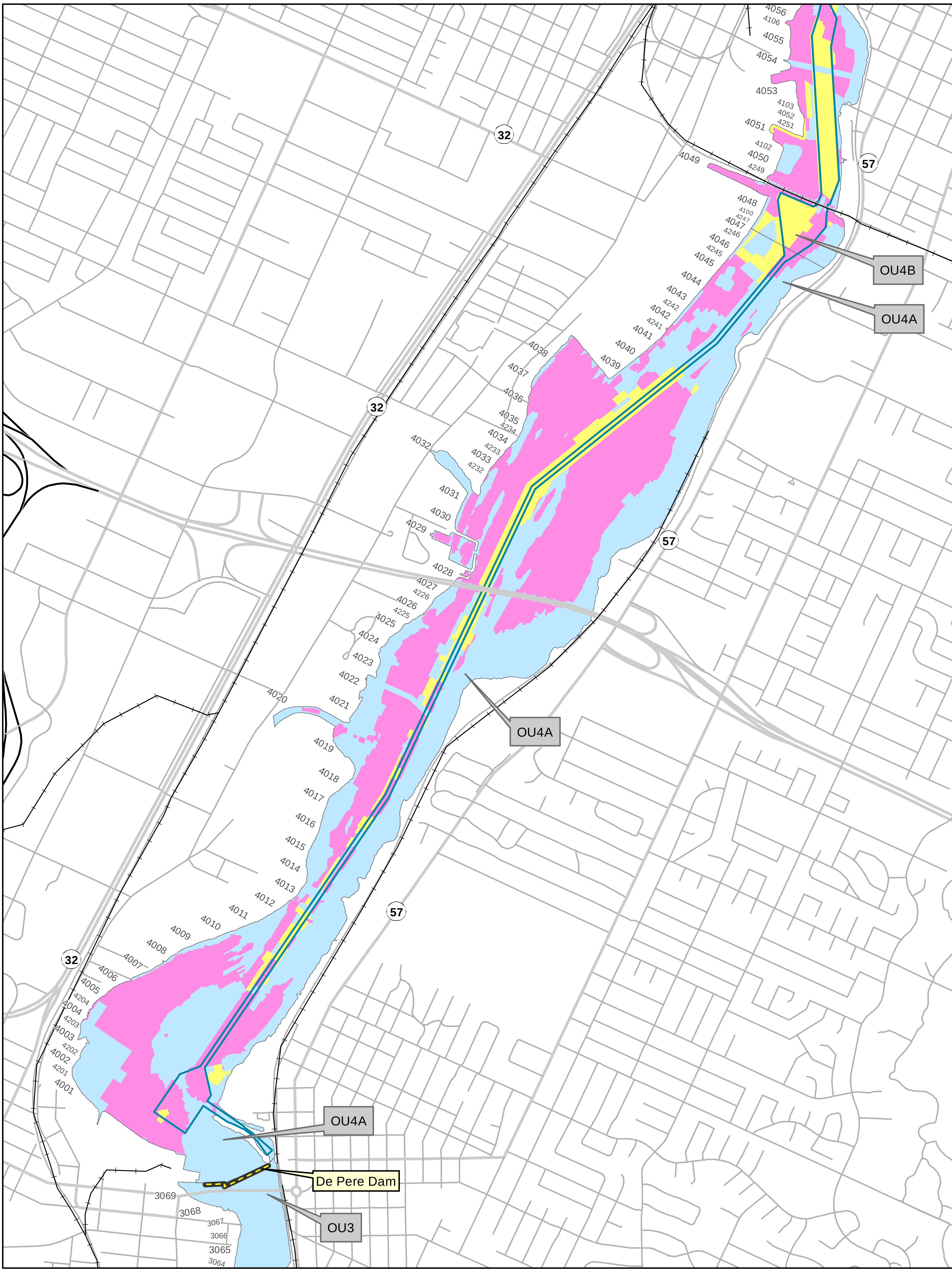
TETRA TECH

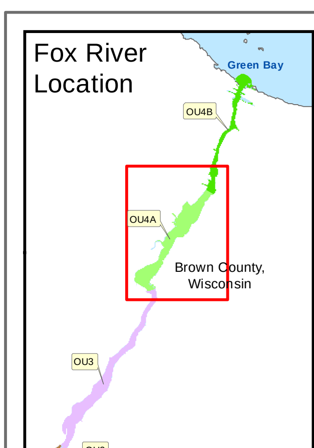
ANCHOR QEA

N S E W

Rotation 0°

Feet
0 1,000 2,000





US Highway
State Highway
Road
Railroad
Operable Unit / Fox River Boundary
Dam
3001 Sample Location Row Number
Federal Navigation Channel

100% Design

Dredge and Cap - Years 2012 to 2017

Dredge to 1 ppm - Years 2012 to 2015

Fox River - OUs 2 to 5
Figure 1-4c

2012 to 2015 Dredging Areas

Brown County, Wisconsin, USA

TETRA TECH

ANCHOR QEA

Rotation 0°

Feet
0 1,000 2,000

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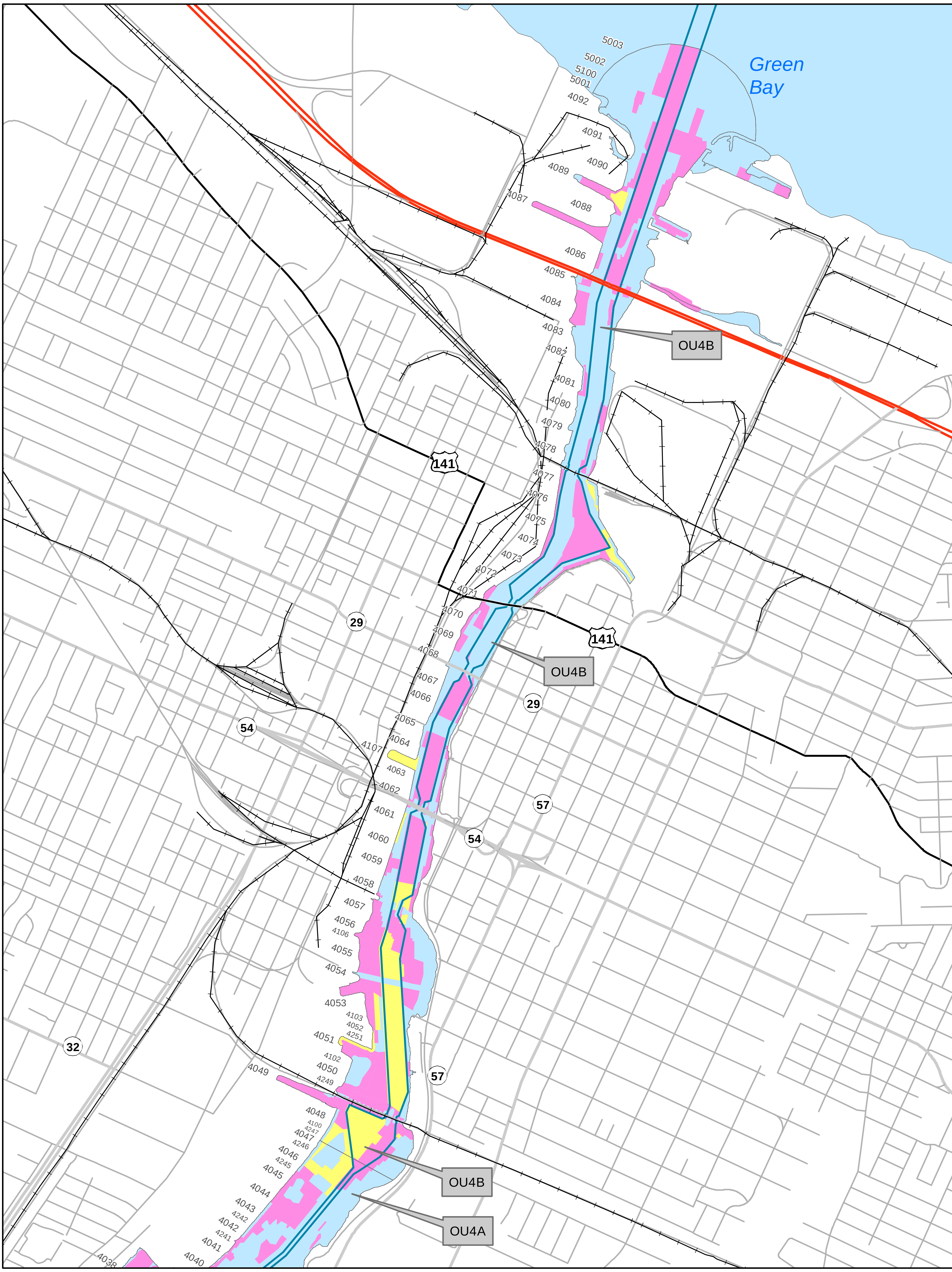
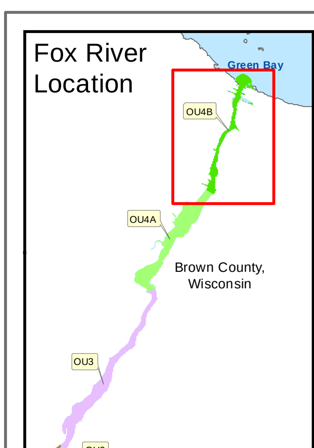


Fox River Location



Legend	
US Highway	Operable Unit / Fox River Boundary
State Highway	Dam
Road	3001 Sample Location Row Number
Railroad	Federal Navigation Channel

100% Design

- Dredge and Cap - Years 2012 to 2017
- Dredge to 1 ppm - Years 2012 to 2015

Fox River - OUs 2 to 5
Figure 1-4d

2012 to 2015 Dredging Areas

Brown County, Wisconsin, USA

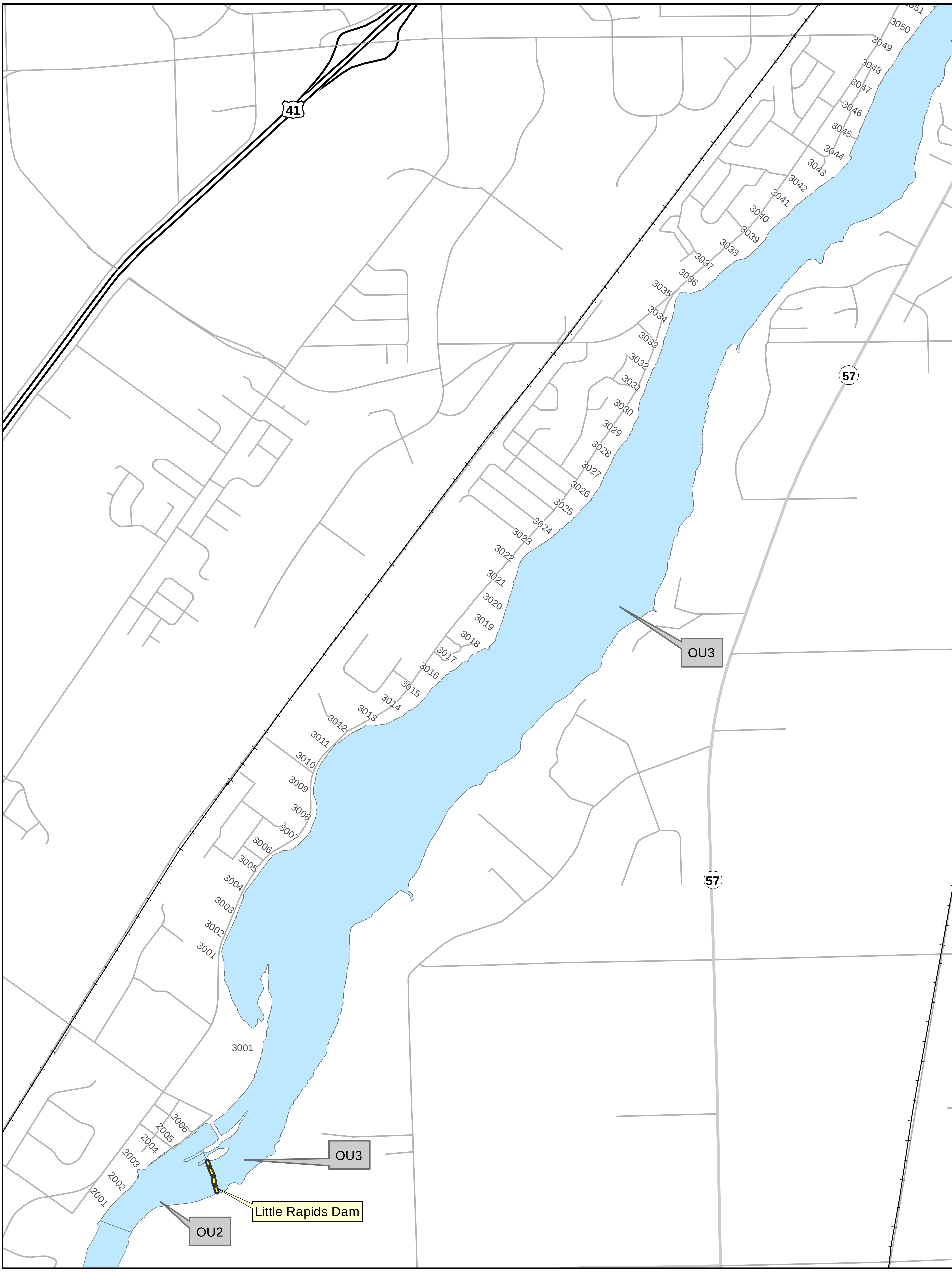
TETRA TECH

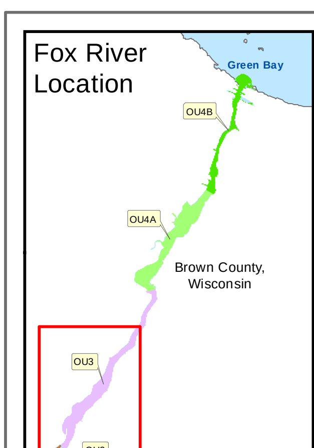
ANCHOR QEA

N / E / S / W

Rotation 0°

Feet
0 1,000 2,000





US Highway	Operable Unit / Fox River Boundary
State Highway	Dam
Road	3001 Sample Location Row Number
Railroad	Federal Navigation Channel

100% Design

- Dredge and Cap - Years 2012 to 2017
- Engineered Cap A, B or C - Years 2012 to 2017
- Shoreline Cap - Years 2012 to 2017
- Sand Cover - Years 2012 to 2017

Fox River - OUs 2 to 5
Figure 1-5a

2012 to 2017 Engineered Capping and Sand Cover Areas

Brown County, Wisconsin, USA

TETRA TECH

ANCHOR QEA

N W E S

Rotation 0°

Feet
0 1,000 2,000

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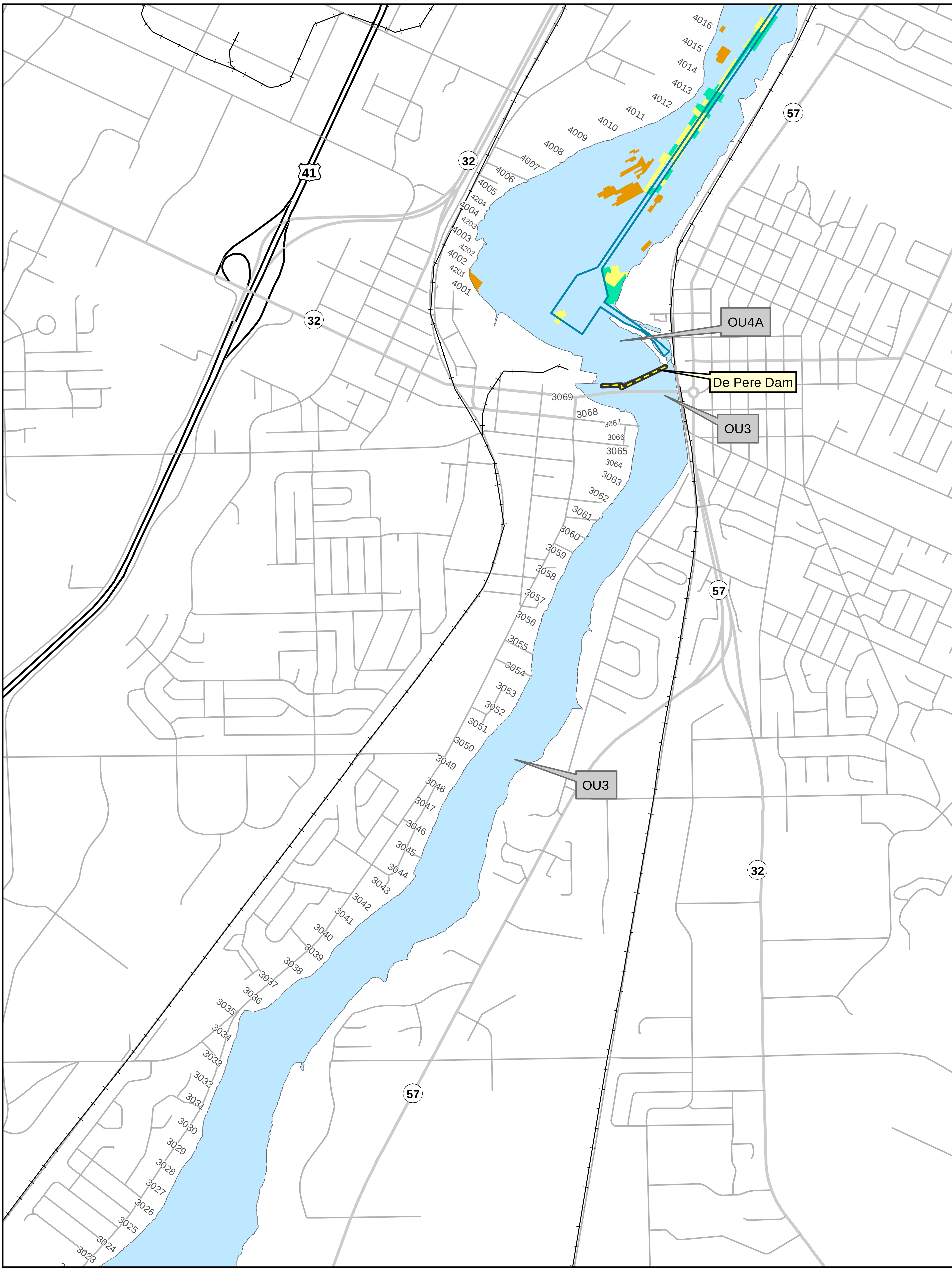

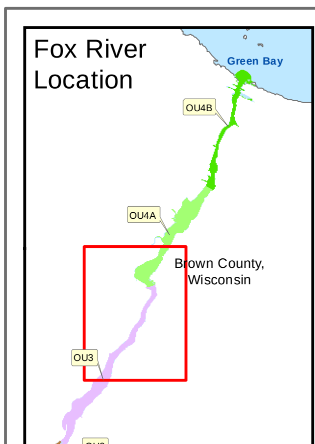

Legend	
US Highway	Operable Unit / Fox River Boundary
State Highway	Dam
Road	3001 Sample Location Row Number
Railroad	Federal Navigation Channel

100% Design

- Dredge and Cap - Years 2012 to 2017
- Engineered Cap A, B or C - Years 2012 to 2017
- Shoreline Cap - Years 2012 to 2017
- Sand Cover - Years 2012 to 2017

Fox River - OUs 2 to 5
Figure 1-5b

2012 to 2017 Engineered Capping and Sand Cover Areas

Brown County, Wisconsin, USA

TETRA TECH

ANCHOR QEA

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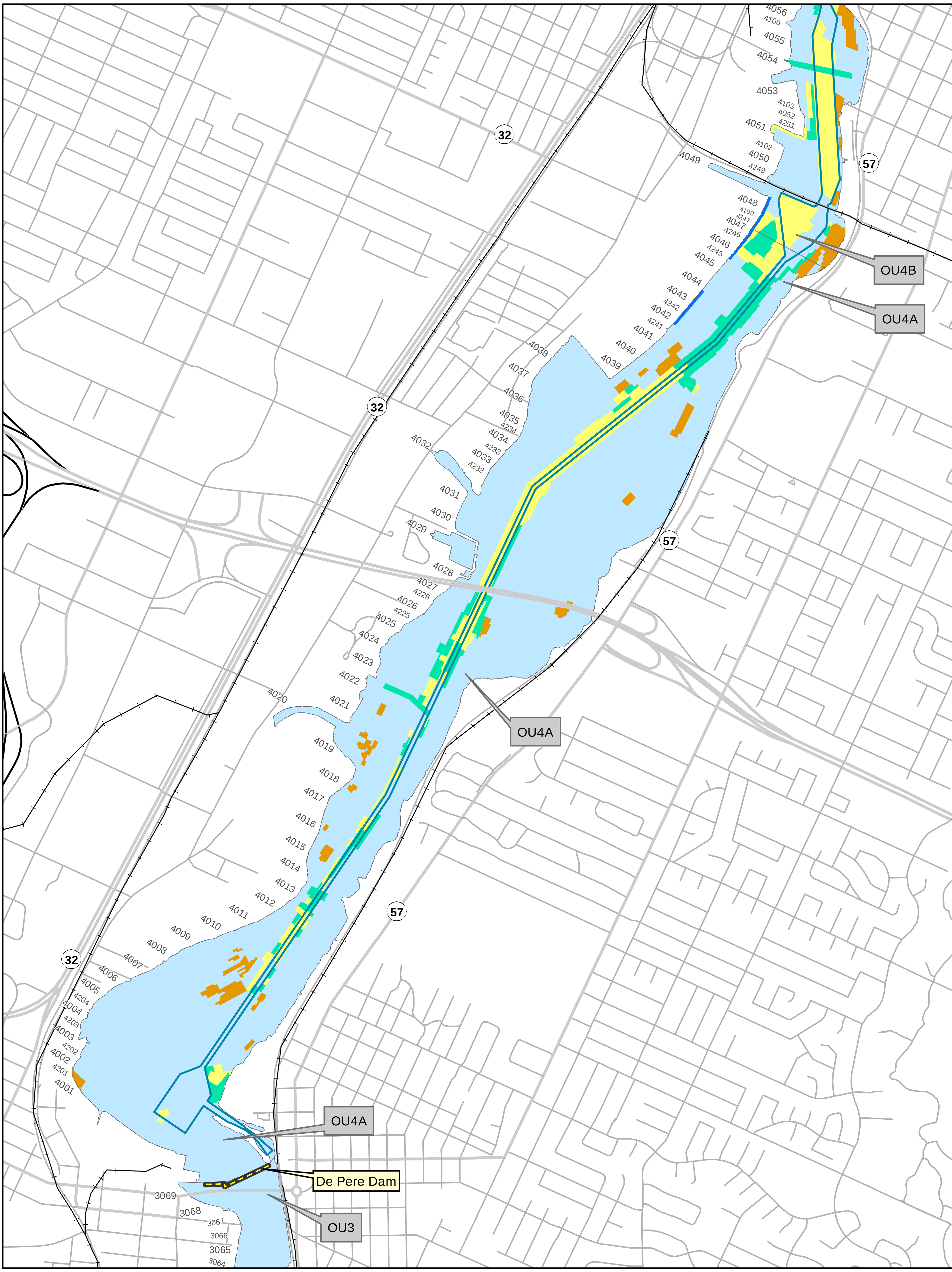
W E
S
Rotation 0°

Feet
0 1,000 2,000



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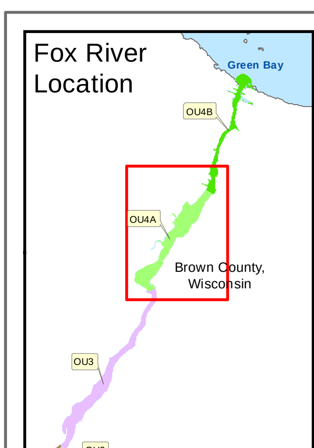


US Highway
State Highway
Road
Railroad
Operable Unit / Fox River Boundary
Dam
3001 Sample Location Row Number
Federal Navigation Channel

100% Design

Dredge and Cap - Years 2012 to 2017
Engineered Cap A, B or C - Years 2012 to 2017
Shoreline Cap - Years 2012 to 2017
Sand Cover - Years 2012 to 2017

Fox River - OUs 2 to 5
Figure 1-5c

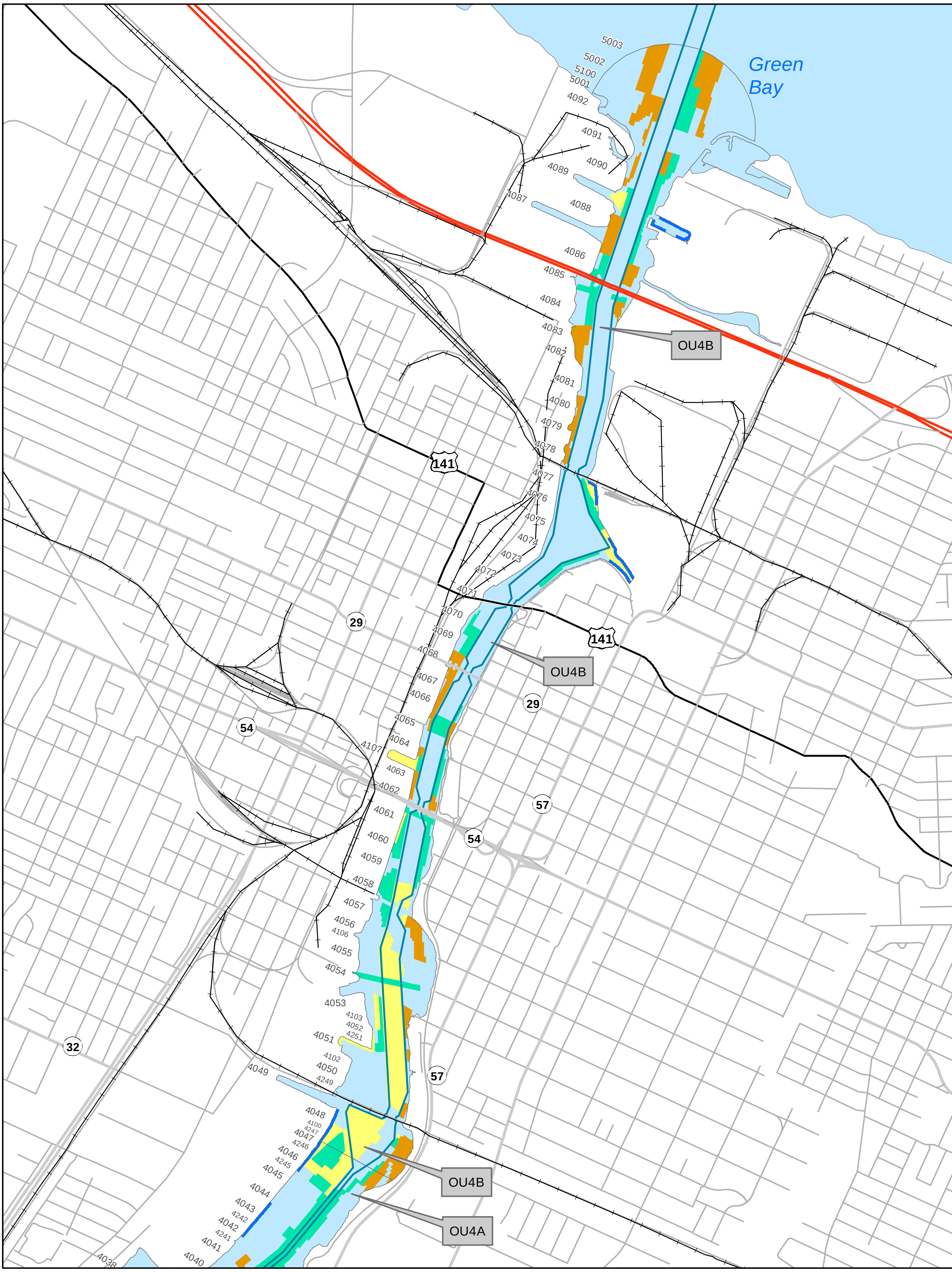
2012 to 2017 Engineered Capping and Sand Cover Areas

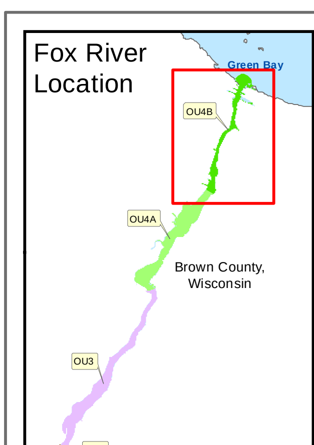
Brown County, Wisconsin, USA

TETRA TECH
ANCHOR QEA

Rotation 0°

Feet
0 1,000 2,000





US Highway	Operable Unit / Fox River Boundary
State Highway	Dam
Road	3001 Sample Location Row Number
Railroad	Federal Navigation Channel

100% Design

- Dredge and Cap - Years 2012 to 2017
- Engineered Cap A, B or C - Years 2012 to 2017
- Shoreline Cap - Years 2012 to 2017
- Sand Cover - Years 2012 to 2017

Fox River - OUs 2 to 5
Figure 1-5d

2012 to 2017 Engineered Capping and Sand Cover Areas

Brown County, Wisconsin, USA

TETRA TECH

ANCHOR QEA

N W E S

Rotation 0°

Feet

0 1,000 2,000

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2 SITE CHARACTERISTICS

2.1 Sampling and Analysis Data

The RD sampling and analysis program conducted to date includes data collection activities from 2004 through 2008, as described in the BODR; the 30, 60, and 100 Percent Design Reports (Volume 1); and the Phase 2A Site Surveys Report (Tetra Tech et al. 2008b) and associated addendum (Tetra Tech et al. 2009a). In addition, infill sampling has been conducted in 2009 and will continue through 2012 within and around remediation areas to refine the remediation footprints. Figure 2-1 presents the locations of all RD and infill samples collected between 2004 and 2012. In addition, data collected prior to 2004 have been utilized, where appropriate, to support the RD data; however, data collected in 2012 or later are not utilized in the 100 Percent Design plans but rather will be incorporated as part of annual RA Work Plans prepared in subsequent years. These data were compiled and summarized to provide an assessment of current information on the nature and extent of contamination, bathymetry and sub-bottom profiles of the river channel and side-slope areas, and the location of candidate areas for active remediation, consistent with the ROD Amendment. The review and analysis of existing data focused on the portions of the OUs requiring active remediation as identified in the RODs, as follows: OU 2 (Deposit DD), OU 3 and OU 4 (in their entirety), and OU 5 (immediately adjacent to the mouth of the Lower Fox River). The locations where samples were collected during the 2004 to 2012 RD and infill field investigations are depicted on Figure 2-1, and included collection of the following:

- Approximately 3,660 subsurface and surface sediment (0 to 10 centimeter [cm]) sampling locations
- Approximately 130 in situ vane shear measurements from selected locations
- Approximately 1,100 sediment samples collected and analyzed for selected geotechnical parameters
- Approximately 19,000 sediment samples collected and analyzed for selected physical and chemical parameters
- Fourteen composite samples from different regions of the river tested for detailed chemical mobility and desanding bench studies
- Approximately 1,750 poling locations along the shoreline to define rock and gravel areas

Detailed descriptions of sampling and analysis data are provided in the 30, 60, and 100 Percent Design Reports (Volume 1) as well as in the Phase 2A Site Surveys Report and associated addendum (Tetra Tech et al. 2008b, 2010b, and 2011e), and are not repeated herein.

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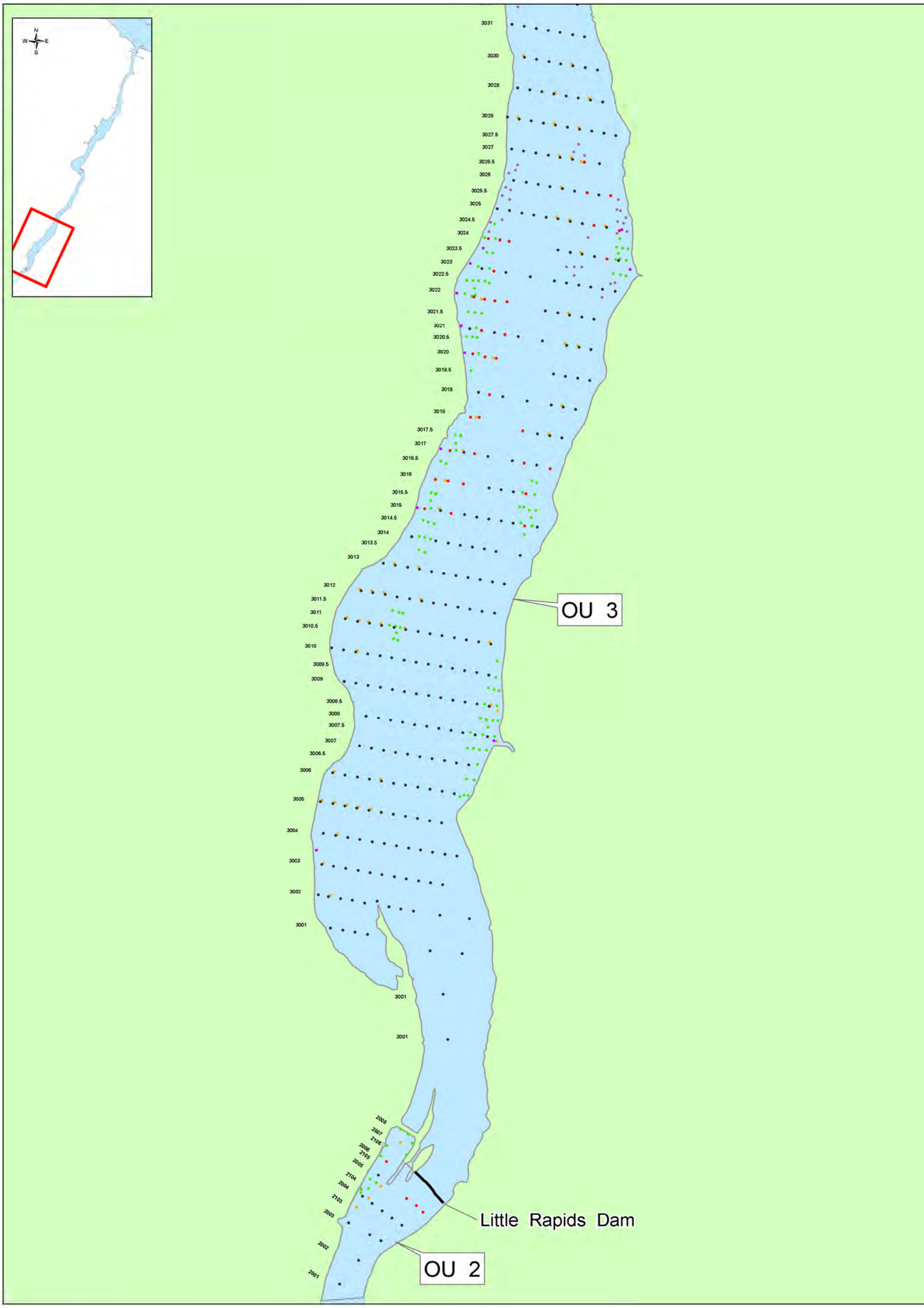


Legend

- 2008 Sample Location
- 2007 Sample Location
- 2006 Sample Location
- 2005 Sample Location
- 2004 Sample Location
- 2004 Supplemental Sample Location
- 2011 Sample Location
- 2010 Sample Location
- 2009 Sample Location
- Operable Unit Boundaries
- Dams
- Federal Navigation Channel
- 2001 Transect Number

N

25° rotation

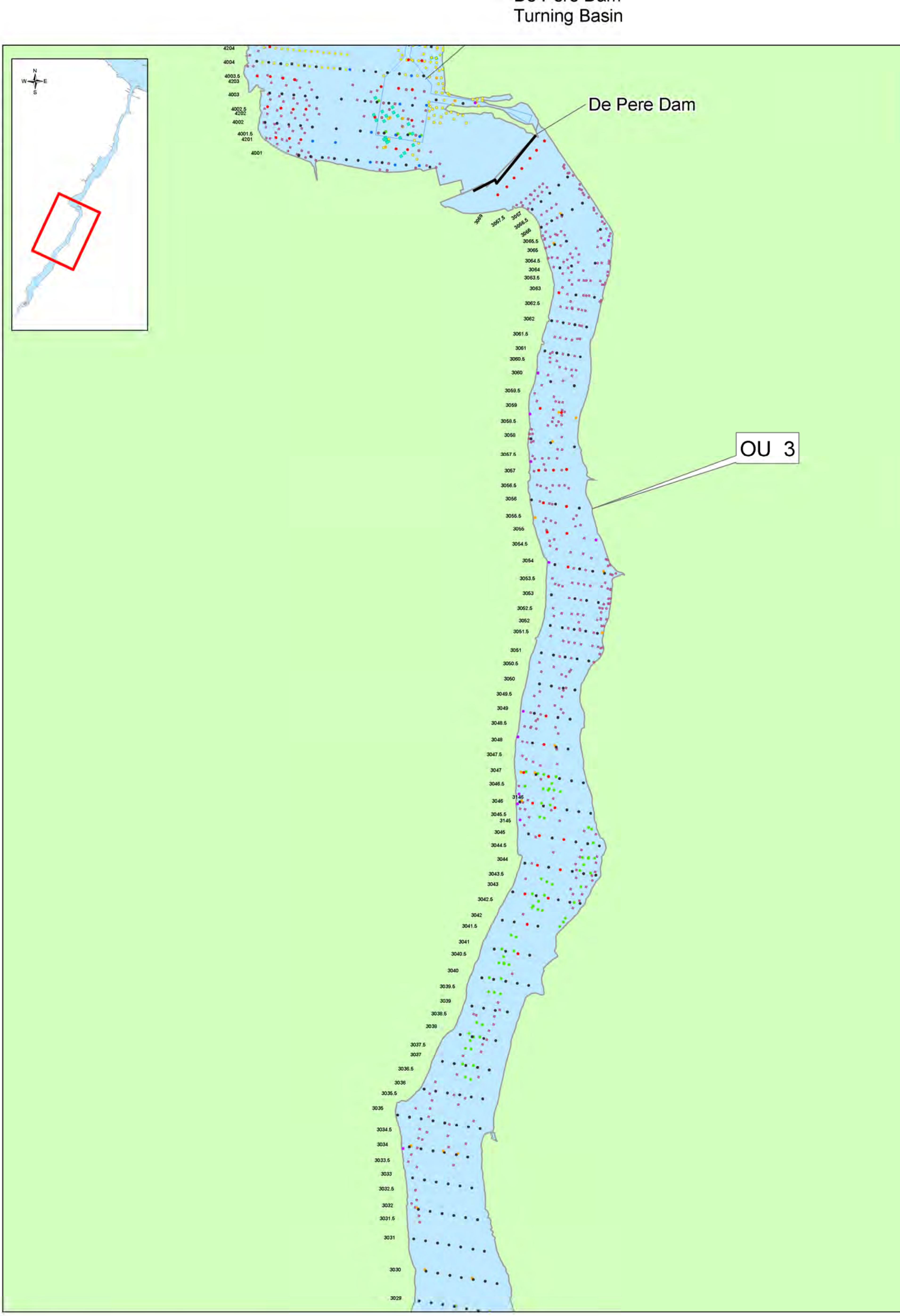
1,000 0 1,000 Feet

Figure 2-1a

Sample Location Map
Operable Units 2 - 5
2004 to 2011

TETRA TECH EC, INC.

ANCHOR QEA



Legend

- 2008 Sample Location
- 2007 Sample Location
- 2006 Sample Location
- 2005 Sample Location
- 2004 Sample Location
- 2004 Supplemental Sample Location
- 2011 Sample Location
- 2010 Sample Location
- 2009 Sample Location
- Operable Unit Boundaries
- Dams
- Federal Navigation Channel
- 2001 Transect Number

N

25° rotation

1,000 0 1,000 Feet

Figure 2-1b

Sample Location Map
Operable Units 2 - 5
2004 to 2011

TETRA TECH EC, INC.

ANCHOR QEA

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Figure 2-1c

Sample Location Map
Operable Units 2 - 5
2004 to 2011

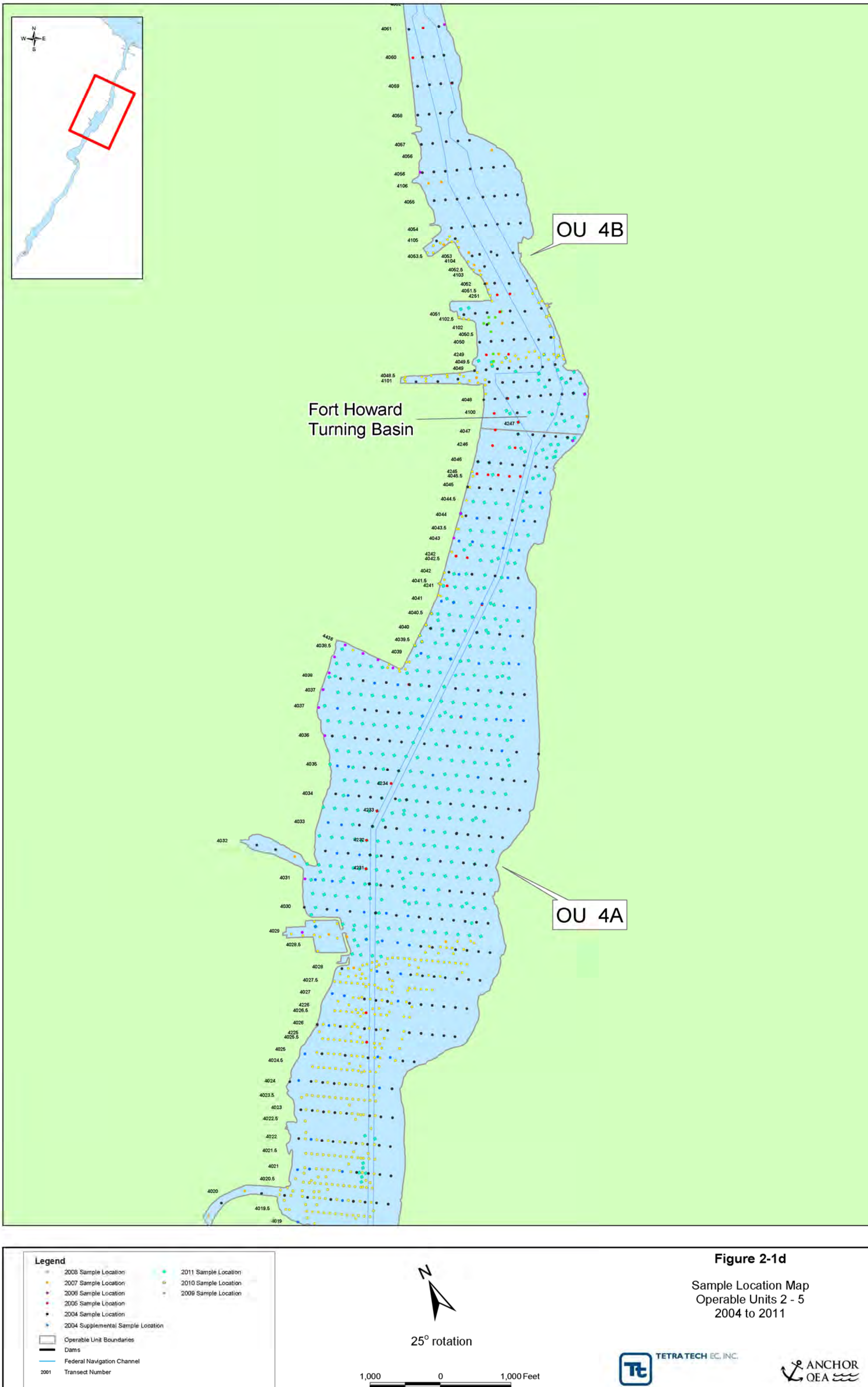

Figure 2-1d

Sample Location Map
Operable Units 2 - 5
2004 to 2011

TETRA TECH EC, INC.

ANCHOR QEA

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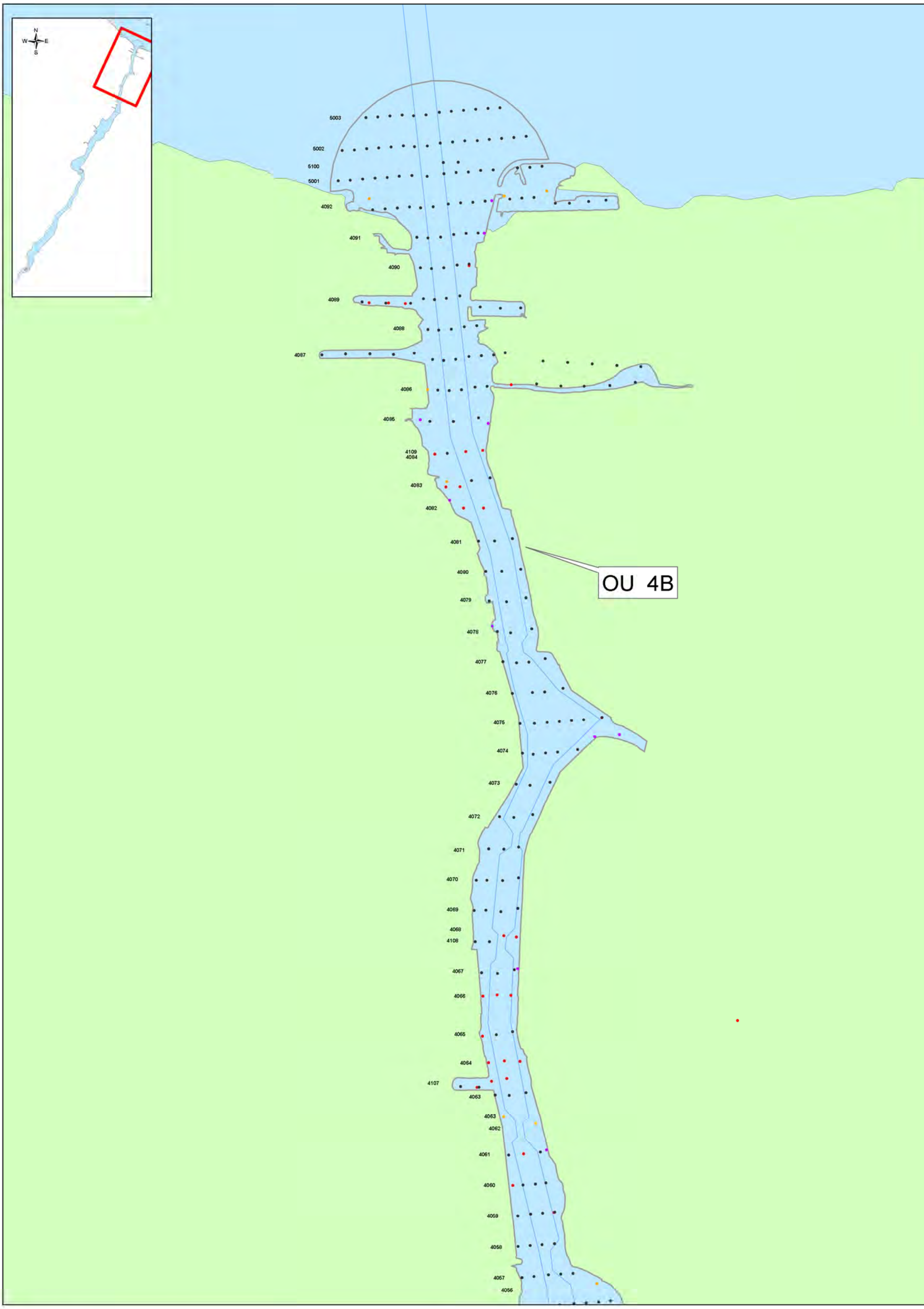

Legend

- 2008 Sample Location
- 2007 Sample Location
- 2006 Sample Location
- 2005 Sample Location
- 2004 Sample Location
- 2004 Supplemental Sample Location
- 2011 Sample Location
- 2010 Sample Location
- 2009 Sample Location
- Operable Unit Boundaries
- Dams
- Federal Navigation Channel
- 2001 Transect Number

N

25° rotation

1,000 0 1,000 Feet

Figure 2-1e

OU 4B Sample Location Map
Operable Units 2 - 5
2004 to 2011

TETRA TECH EC, INC.

ANCHOR QEA

2.2 Summary of Physical Site Characteristics

The BODR provides the physical characteristics of OUs 2 to 5, and a summary is provided in the 100 Percent Design Report Volume 1. Section 2.3 provides an updated summary of the geotechnical conditions in OUs 2 to 5, incorporating the results of sampling conducted subsequent to the BODR, including data collected in 2008 to 2010 pursuant to the Order, which was used to finalize the design and operation of the LFR Processing Facility.

2.3 Summary of Geotechnical Conditions

Section 2.2 of the BODR provided a detailed summary of the geotechnical properties of sediments sampled during the 2004 and 2005 RD field investigations. However, several supplemental field studies have been conducted since then, resulting in a refined characterization of some of the geotechnical properties of the sediments targeted for dredging as part of the OUs 2 to 5 project. Section 4.1 of the 100 Percent Design Report Volume 1 presents a summary of the recent geotechnical field studies as they relate to design of the sediment dewatering and desanding equipment. Table 2-1 presents a summary of the geotechnical properties for samples collected during the 2004 to 2007 RD investigations, as well as the 2008 Boskalis Dolman and Tetra Tech sampling (see Volume 1 Section 4.1) and 2010 infill sampling within the targeted sediment removal areas in OUs 2 to 5. The sediments targeted for dredging in OUs 2 to 5 can be generally characterized as loose to very loose, sandy silt with an average in situ percent solids content of approximately 38 percent by weight (standard deviation of 14 percent). The sediment within the overall OUs 2 to 5 sediment removal areas averages approximately 30 percent sand-sized particles (4.75 to 0.075 millimeter [mm]; standard deviation 20 percent, based on American Society for Testing and Materials [ASTM] D422), 70 percent silt- and clay-sized particles (less than 0.075 mm; standard deviation 22 percent), with the remaining trace fraction being gravel-sized particles. The data presented in Table 2-1 has been corrected for coring-induced sample compaction using the procedures described in the *Lower Fox River Operable Units 2-5 Pre-design Sampling Plan* (Shaw and Anchor 2004) and Appendix A of the BODR. Attachment A-5 of Appendix A provides a complete summary of geotechnical data collected within the targeted removal areas in OUs 2 to 5.

In addition to the 2004 to 2007 RD sampling and the 2008 Boskalis and Tetra Tech sampling, in 2007, Boskalis collected 40 samples from OUs 2 to 5 and composited the samples into six composites. Geotechnical testing (including grain size, organic content, specific gravity, bulk density, and dry density) was performed on each of the composite samples. The geotechnical test results for these samples were summarized in the Process Design Basis Technical Memorandum (Tetra Tech et al. 2009a; Attachment A-11 of Appendix A of the 100 Percent Design Report Volume 1). This sediment sampling and geotechnical testing was conducted in conjunction with bench-scale dewatering tests to evaluate sediment properties and dewatering characteristics. The results were used to develop mass balance calculations for equipment sizing based on the proposed maximum flow rate of 6,000 gallons per minute (gpm) for the sediment slurry and a maximum dredge production rate of 250 in situ cy per hour. The geotechnical test results for the Boskalis composite samples were also used in calculations to evaluate the number of presses needed for the planned dredge production rates. The average dry density of the composite sediment samples was 48.3 pounds per cubic foot (pcf), versus an average dry density of 29 pcf for samples obtained during the RD (from OUs 2 to 5). The average percent solids for the Boskalis composite samples was 50.7 percent, versus 35 percent for the samples obtained during the RD (from OUs 2 to 5). Because the Boskalis composite samples exhibited a higher dry density and percent solids, the data from these samples were utilized in the calculations performed by Boskalis to evaluate the number of presses needed. This results in a more conservative analysis because utilizing a higher density results in more solids flow through the desanding and dewatering system. Additional information on the use of these data in the desanding and dewatering system process design is presented in the Process Design Basis Technical Memorandum (Tetra Tech et al. 2009a). It should be noted that additional analyses were performed that included a range of sand content, percent solids, and bulk density, analyzed over a range of dredge production rates and press uptime to supplement the mass balance calculations performed by Boskalis. These additional analyses were used to estimate sand and filter cake production rates for the project and the resulting number of presses needed. This information is discussed in detail in the Process Design Basis Technical Memorandum (Tetra Tech et al. 2009a). The production estimates will be updated in each annual Phase 2B RAWP based on experience gained during the previous dredge seasons.

Table 2-1
Summary of RD Geotechnical Data Representative of Removal Areas Only [a]

	Moisture Content [b] (percent)	Percent Solids [b] (percent)	Percent Sand/Gravel-Sized [c] (percent)	Percent Silt/Clay-Sized (percent)	Liquid Limit (percent)	Plasticity Index (percent)	Organic Content	Specific Gravity	Dry Density [b] (pounds per cubic foot)
OUs 2 and 3									
Number of Samples	41	41	38	38	9	9	32	32	41
Average	150	43%	17	83	182	130	18	2.31	37
Standard Deviation	78	11%	14	14	22	32	11	0.09	12
OUs 4 and 5									
No. of Samples	100	100	55	55	77	77	11	13	100
Average	218	35%	39	61	167	121	10.9	2.38	29
Standard Deviation	91	14%	23	23	48	40	6.0	0.10	18
OUs 2 to 5									
Number of Samples	141	141	93	93	86	86	43	45	141
Average	198	38%	30	70	168	122	17	2.33	32
Standard Deviation	92	14%	22	22	46	40	10	0.10	17

Notes:

a. Includes 2004, 2005, 2006, and 2007 RD samples, as well as 2010 infill samples for all areas targeted for dredging in OUs 2 to 5. Samples collected in 6-inch intervals.

b. Corrected for core compaction.

c. Percent sand was determined from ASTM D422 and includes all sand-sized particles.

2.4 Summary of Spatial Extent of PCBs

Extensive sampling efforts were conducted in 2004 and 2005 to characterize the nature and extent of PCBs in OUs 2 to 5. Geostatistical methods were used to delineate the depth of contamination (DOC) boundary in OUs 2 to 5, defined as the boundary beyond which sediment PCB concentrations are predicted, with at least 50 percent confidence, to be at or below the RAL of 1.0 ppm as specified in the ROD Amendment. This geostatistical modeling formed the basis of the dredge plan designs presented in the 30 and 60 Percent Design Reports, but did not fully incorporate RD sampling data collected in 2006, 2007, and 2008. Section 2.1 of this report discusses the additional sampling conducted between 2006 and 2010 to further delineate the spatial extent of PCBs. These data have been incorporated into a refined geostatistical model for upper OU 3 and OUs 4 and 5, resulting in an updated neatline model surface for the remediation areas presented in this 100 Percent Design Report, as discussed below. Additional sampling may be conducted in subsequent years to refine the remediation area boundaries for future years of remediation. The remainder of this section discusses the refinements to the geostatistical model and the resulting updated neatline model surface. These refinements are consistent with the Geostatistics Technical Memorandum No. 4 (Anchor and LimnoTech Inc. [LTI] 2006a).

2.4.1 Geostatistical Delineation of Remediation Boundaries

A geostatistical kriging model was initially developed, as presented in the BODR, using the 2004 sampling data and evaluated with respect to a number of cross-validation metrics, which are discussed in detail in the BODR and technical memoranda (Anchor and LTI 2006b, 2006c, and 2006d). During subsequent collaborative workgroup meetings, the kriging analysis was improved by including the 2005 RD sampling data and a series of refinements such as coordinate transformation ("river straightening") based on shoreline geometry, and adjustments to reflect historical channel features. The kriging analysis using the 2004 and 2005 RD data formed the basis for the 30 and 60 Percent Design Reports. Infill sampling at various densities was simulated, using the geostatistical model, to estimate potential benefit and support planning of infill sampling for OU 3 and OU 4 (Kern et al. 2008; Wolfe et al. 2009a, 2009b, 2010a, 2010b). More recently, the geostatistical models for OU 3 and OU 4A have been further refined to incorporate the results of all sampling conducted between 2005 and 2011. The 100 Percent Design Report Volume 1 presents details of the geostatistical refinements in OU

3, which include the incorporation of 2008 infill sampling results for upper OU 3. Infill sampling for 2010 through 2012 RA areas has been incorporated into this 100 Percent Design Report Volume 2. The results of infill sampling performed in 2012 for all RA areas after 2012 will be incorporated into future annual Phase 2B RAWPs. This 100 Percent Design Report Volume 2 presents the refined geostatistical model for lower OU 3, OU 4, and OU 5, which was performed consistent with the 2005 kriging, but incorporated the additional sediment chemistry data collected through 2011, where applicable. In addition, the DOCs used in the geostatistical models for the 2011 and 2012 RA areas from the De Pere Dam to the Canadian National Railroad bridge (near the OU 4A and OU 4B boundary, at approximately transect 4049) are based on uncorrected core data, whereas the geostatistical model for all other areas of the river is based on corrected core data (OU 3 and OU 4B downstream of the Canadian National Railroad bridge). The model input for areas to be remediated in 2013 and beyond will be updated to use uncorrected core data for historical cores and for cores obtained during infill sampling performed in 2012. The updated dredging neatline determined through the 2012 kriging analysis (with infill samples collected up to approximately transect 4049) serves as the basis for final dredge plans presented herein to be implemented in 2010 and beyond. The additional infill sampling data from 2012 infill sampling and the historical core data north of approximately transect 4049 will be used to re-run the kriging model to refine the RD for annual Phase 2B RAWPs, which will be submitted for A/OT review and approval beginning with the Phase 2B RAWP in 2013.

Specifically, since the BODR, the following work has been completed:

- **Inclusion of New Data.** The updated kriging analysis incorporated initial sediment core data collected in 2004 with additional data collected during subsequent phases of fieldwork between 2005 and 2011. The primary purpose of the subsequent data collection efforts between 2005 and 2011 was to collect additional samples in areas where increased definition of PCB distribution would aid in defining the remediation areas more accurately. The secondary purpose of the subsequent collection (specifically the 2005 to 2008 investigations) was to provide additional geotechnical information in order to supplement the data that were already available. Several of the 2005 to 2011 cores were located in areas where previous sampling indicated contamination extended to the depth of core refusal, in an attempt to either collect deeper samples for delineating the DOC or to confirm that no further penetration of the sample coring device was possible.

- **Channel Segregation.** The federal navigation channel, including the recently reauthorized portion in OU 4A and the active portion in OU 4B, was segregated and kriged separately. This was done because of the distinct character of the channel and its past activities. The initial (2004) interpolations, which did not segregate channel from out-of-channel locations, had consistently underestimated DOC in the channel, whereas DOC on the nearshore benches was being overestimated. In addition, the boundaries of the channel for geostatistical purposes were extended 22 feet beyond the actual channel line on either side. It was determined by inspection that the DOC in all cores within this distance on the channel margins was consistent with cores in the channel proper, whereas further widening would have included samples with much shallower DOC outside the influence of channel activities. This suggests some disturbance and sloughing of the sidewalls occurred during channel dredging, as might be expected.
- **River Straightening.** In the 2004 kriging model, the primary correlation axis was fixed along the average direction of the OUs 3 and 4 reaches. Along river bends, however, a fixed correlation axis will sometimes deviate from the local flow direction, generating interpolations of depositional features that are oblique to the direction of the river. These artifacts were corrected in the subsequent kriging models by performing a coordinate transformation (river straightening) based on shoreline geometry. This technique allows the correlation axis to align with the local flow direction, and interpolates between data points along paths that follow the bends in the river. This type of model also conforms better with geomorphology of the Lower Fox River.

The 2005 kriging analysis was performed step-wise to evaluate the potential improvements associated with the new data and the "physical" modifications separately. The cross-validation metrics were updated for each reach and for OU 4, and are discussed in detail in Geostatistics Technical Memorandum No. 4 (Anchor and LTI 2006a). This verification process was also completed for OU 3 and presented to the

Response Agencies in a series of workgroup meetings. As noted above, the 2010 through 2012 kriging analyses performed for OU 4 utilized identical cross-validation metrics to the 2005 modeling, but incorporated the more recent data.

The 2005 data were preferentially located in areas of uncertainty based on the 2004 data, and the greater difficulty of prediction in those areas is reflected in a slight deterioration of the cross-validation metrics when the 2005 data were added to the unstraightened model. Straightening the river, however, improved most of the metrics for both OU 3 and OU 4. In Table 2-2, cross-validation results for each OU with river straightening (the columns headed "Updated With More Recent Data") are shown through the 2008 sampling in OU 3 and through the 2005 sampling in OU 4. For OU 3, extensive sampling has been done since 2004, including 2009 infill sampling in upper OU 3, and the full indicator kriging (FIK) model has been re-estimated for this OU based on the full set of 2004 to 2009 data. Similarly in OU 4, results of infill sampling conducted in 2009 through 2011 have been incorporated into the FIK models such that the re-estimated models presented in this 100 Percent Design Report Volume 2 are based on the full set of 2004 to 2011 data, where applicable. However, the OU 4 cross-validation results shown below are based only on 2004 to 2005 data, as has been previously reported. A key advantage of the model updates using more recent data (i.e., after 2004) was their ability to more accurately predict the DOC, as indicated in the summary statistics presented in Table 2-2. For example, in OU 4A, this is reflected in the reduction in the Root Mean Square Error (RMSE) and Mean Absolute Error (MAE). This is at least partly attributed to more accurate predictions of DOC in the reauthorized OU 4A navigation channel and De Pere turning basin. The DOC in these areas was consistently underestimated in the previous model. In OU 3, cross-validation of the updated model shows a particularly large improvement in sensitivity, which is the percentage of locations exceeding the RAL (at some depth) that are correctly predicted to have RAL exceedances. The geostatistical metrics are discussed in detail in the Geostatistics Technical Memorandum No. 4 (Anchor and LTI 2006a).

Table 2-2
Summary of Kriging Cross-Validation Metrics for OUs 3, 4, and 5 [a]

	2004	2004 to 2005	Updated with More Recent Data [d]				
	Unstraightened River		Straightened River and Segregated Channel [b]				
OU 3							
Significance Level	0.5	0.5	0.5	0.4	0.3	0.2	0.1
False Positives (%)	46	40	35	40	47	52	56
False Negatives (%)	21	22	21	19	18	16	13
Sensitivity (%)	49	51	65	71	79	86	93
Specificity (%)	83	84	79	72	58	44	30
Percent Correct (%)	73	73	74	72	66	60	53
RMSE (feet) [c]	0.5	0.6	0.5	0.5	0.6	0.7	0.9
MAE (feet) [c]	0.3	0.3	0.3	0.3	0.4	0.5	0.6
Bias (feet) [c]	-0.1	-0.1	-0.1	0.0	0.2	0.3	0.5
OU 4A							
Significance Level	0.5	0.5	0.5	0.4	0.3	0.2	0.1
False Positives (%)	15	15	13	17	19	21	24
False Negatives (%)	22	25	25	19	13	8	5
Sensitivity (%)	88	88	86	91	95	97	99
Specificity (%)	73	70	77	67	58	52	44
Percent Correct (%)	83	82	83	83	82	81	79
RMSE (feet) [c]	2.2	2.4	1.9	1.9	2	2.4	2.8
MAE (feet) [c]	1.3	1.4	1.1	1.1	1.3	1.5	1.8
Bias (feet) [c]	-0.3	-0.3	-0.3	0.1	0.5	1.1	1.5
OU 4B/5							
Significance Level	0.5	0.5	0.5	0.4	0.3	0.2	0.1
False Positives (%)	17	18	20	21	24	27	29
False Negatives (%)	25	29	32	27	23	21	9
Sensitivity (%)	89	88	86	90	94	96	99
Specificity (%)	64	60	58	51	43	29	19
Percent Correct (%)	80	79	77	77	77	74	72
RMSE (feet) [c]	2.5	2.6	2.6	2.8	3	3.6	4.3
MAE (feet) [c]	1.7	1.8	1.8	1.9	2.1	2.5	3.2
Bias (feet) [c]	-0.3	-0.2	-0.3	0.3	1	1.7	2.7
OU 4							
Significance Level	0.5	0.5	0.5	0.4	0.3	0.2	0.1
False Positives (%)	16	17	16	19	22	24	27
False Negatives (%)	23	26	27	23	17	13	6
Sensitivity (%)	88	88	86	90	94	97	99
Specificity (%)	70	67	70	60	51	42	33
Percent Correct (%)	82	80	80	80	79	78	76
RMSE (feet) [c]	2.3	2.4	2.2	2.3	2.5	3	3.5
MAE (feet) [c]	1.4	1.6	1.4	1.5	1.6	2	2.4
Bias (feet) [c]	-0.3	-0.3	-0.3	0.1	0.7	1.4	2

Notes:

a. Kriging analysis was not performed for OU 2 due to limited spatial area.

b. Channels were only segregated in OU 4.

c. Units for RMSE, MAE, and Bias are in feet to the DOC.

d. Cross validation metrics in OU 3 based on data collected between 2004 and 2008. Metrics in OU 4 based on data collected between 2004 and 2005.

In 2008, a program of infill sampling was undertaken in the upper portion of OU 3 for the purpose of refining and finalizing the RD for this area. The results of the 2008 infill sampling program were reported in a technical memorandum prepared in collaboration with the A/OT (Wolfe et al. 2009a). As recommended in that memorandum, additional infill sampling was undertaken in 2009 to similarly refine remediation depths and footprints. Most of this 2009 infill sampling was in lower OU 3, with some additional sampling also conducted in upper OU 3 to better delineate deposit boundaries. The 2009 program also included poling data to confirm areas suspected of having minimal soft sediment. The results of the 2009 infill program were reported in a technical memorandum (Wolfe et al. 2010a). Both memoranda report on comparisons of measured DOC in infill data to predicted DOC using the FIK model based on prior data, as a test of accuracy of the model. Both memoranda also report on the changes in estimates of contaminated OU 3 sediment volume due to infill sampling and resulting re-estimation of the FIK model. These results are summarized below, and the reader is referred to the full documents for more details.

Prior to 2008 infill sampling, FIK interpolations were based on 2004 to 2005 data because DOC was not re-estimated after the reporting of the 2006 to 2007 data. For this reason, DOCs from the 2008 infill cores were compared with FIK predictions based on 2004 to 2005 data, as a test of the accuracy of those predictions. Figure 2-2 shows the distribution of differences between DOCs observed in 2008 infill sampling and predicted DOCs, where positive values are underpredictions and negative values are overpredictions. Note that the intervals on the horizontal axis are denoted in Figure 2-2 by their upper endpoint, as is standard in Microsoft Excel histogram graphics (e.g., Figure 2-2 shows that for 55 locations, the difference between observed and predicted DOC was between -0.5 and 0 feet, shown as “0” in the figure). At the majority (i.e., 82) of the 157 infill locations, the absolute prediction error was less than 0.5 feet. At an additional 53 locations, absolute prediction error was less than 1 foot. Of the remaining locations, 11 exhibited positive prediction errors, with a maximum of 1.9 feet, and 11 showed negative prediction errors, with an extreme value of -1.6 feet. Table 2-3 shows that the average and median prediction errors were both -0.1 feet, and that the absolute value of prediction error had both a mean and median of 0.5 feet.

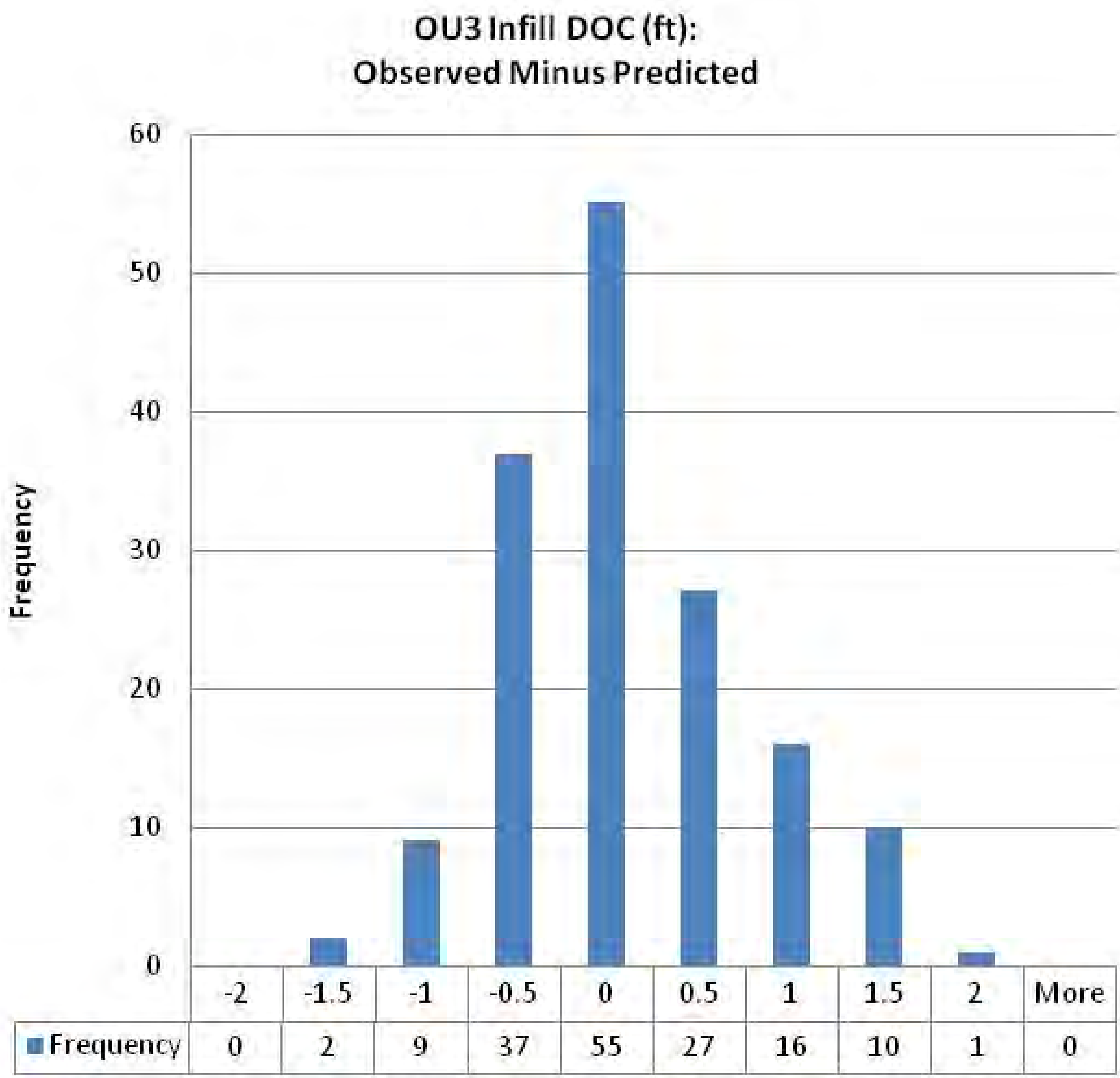

Figure 2-2
Distribution of 2008 Observed (Infill) Minus Predicted DOC, Based on Prior FIK Predictions
Lower Fox River OUs 2 to 5

Table 2-3
Summary Statistics for 2008 Observed Minus Predicted DOC, Based on Prior FIK Model

	Observed – Predicted DOC (ft)	Absolute Value DOC (Observed – Predicted) (ft)
Mean	-0.1	0.5
Median	-0.1	0.5
Maximum	1.9	1.9
Minimum	-1.6	0.0

The FIK model, as re-estimated incorporating all 2004 to 2008 data, was also used to predict DOC at 2009 infill locations. Figure 2-3 shows the distribution of differences between observed and predicted DOCs for 2009 infill coring locations in the left panel and poling locations in the right panel, where positive values are underpredictions and negative values are overpredictions. Note that the intervals on the horizontal axis are denoted in the figure by their upper endpoint (e.g., Figure 2-3 shows that for 203 locations, the difference between observed and predicted DOC was between -0.5 and 0 feet; at 79 of the stations the difference was exactly zero). At the majority (i.e., 277) of the 387 infill locations, the absolute prediction error was no greater than 0.5 feet. At an additional 49 locations, absolute prediction error was no greater than 1 foot. Of the remaining locations, 45 exhibited positive prediction errors, with a maximum of 3.5 feet, and 16 showed negative prediction errors, with an extreme value of -2.5 feet. Table 2-4 shows that the average and median prediction errors were 0.04 and 0.00 feet, respectively, and that the absolute value of prediction error had a mean and median of 0.53 and 0.49 feet, respectively. In summary, these results indicate that accuracy of the FIK model in OU 3, using 2004 to 2008 data, was approximately +/- 0.5 feet.

Poling data, in locations where little or no soft sediment (less than 0.3 feet) was encountered, provide additional information about areas with no contamination. The histogram of prediction errors for the included poling data does not include any underpredictions, due to the fact that all of the included poling locations had measured contamination depths of zero. In 11 of 45 poling locations, the predicted DOC was zero and this prediction was confirmed through the poling. In the remaining 34 locations, the predicted DOC was greater than zero, but the poling established the actual DOC to be zero. The histogram in the right panel of Figure 2-3 reflects the distribution of predicted depths (shown as negative) because the measured DOC in all cases shown was zero. In 11 locations, the predicted DOC was zero, and in 5 additional locations the predicted depth was less than 0.5 feet. Another 13 locations had predicted DOCs of 1 to 2 feet, and 16 locations had predicted DOCs of 2 to 2.5 feet. The findings indicate that there is value in incorporating poling data, especially along shorelines, to more accurately delineate deposits.

Table 2-4
Summary Statistics for 2009 Observed Minus Predicted DOC without Poling, Based on Prior FIK Model

	Observed – Predicted DOC (ft)	Observed – Predicted Absolute Value DOC (ft)
Mean	0.04	0.53
Median	0.00	0.49
Maximum	3.25	3.25
Minimum	-2.51	0.00

DOC was re-estimated for OU 3 at a level of significance (LOS) of 0.5 after each annual round of infill sampling. The effect of incorporating the 2008 data, which were primarily in upper OU 3, was that the relatively thinly contaminated dredge areas in uppermost OU 3 were better delineated and were generally reduced in size, and the more thickly contaminated dredge areas, including those found in the middle portion of OU 3, were also refined in shape. The effect these refinements had in OU 3 DOC was to re-classify 117,000 cy of sediment as less than the RAL, and also re-classify another 68,000 cy of sediment as exceeding the RAL.

After combining all 2004 to 2009 data, including the 2009 infill data, the DOC surface throughout OU 3 was once again re-estimated at an LOS of 0.5. The result was an improved delineation of deposits in dredge, cap, and sand cover areas. The contaminated footprints of a number of sand cover areas decreased substantially, and dredge and cap areas for which footprints and volumes were estimated to decrease outnumbered those for which they were estimated to increase. In terms of volume, approximately 67,500 cy of OU 3 sediment previously thought to be contaminated in excess of the RAL was reclassified as uncontaminated, based on 2009 infill data. Approximately 48,000 cy of material previously thought to be uncontaminated was identified as contaminated, based on the 2009 infill samples. The final estimate of volume contaminated above the RAL in OU 3, based on FIK kriging incorporating all of the 2004 to 2009 data, was 268,500 cy.

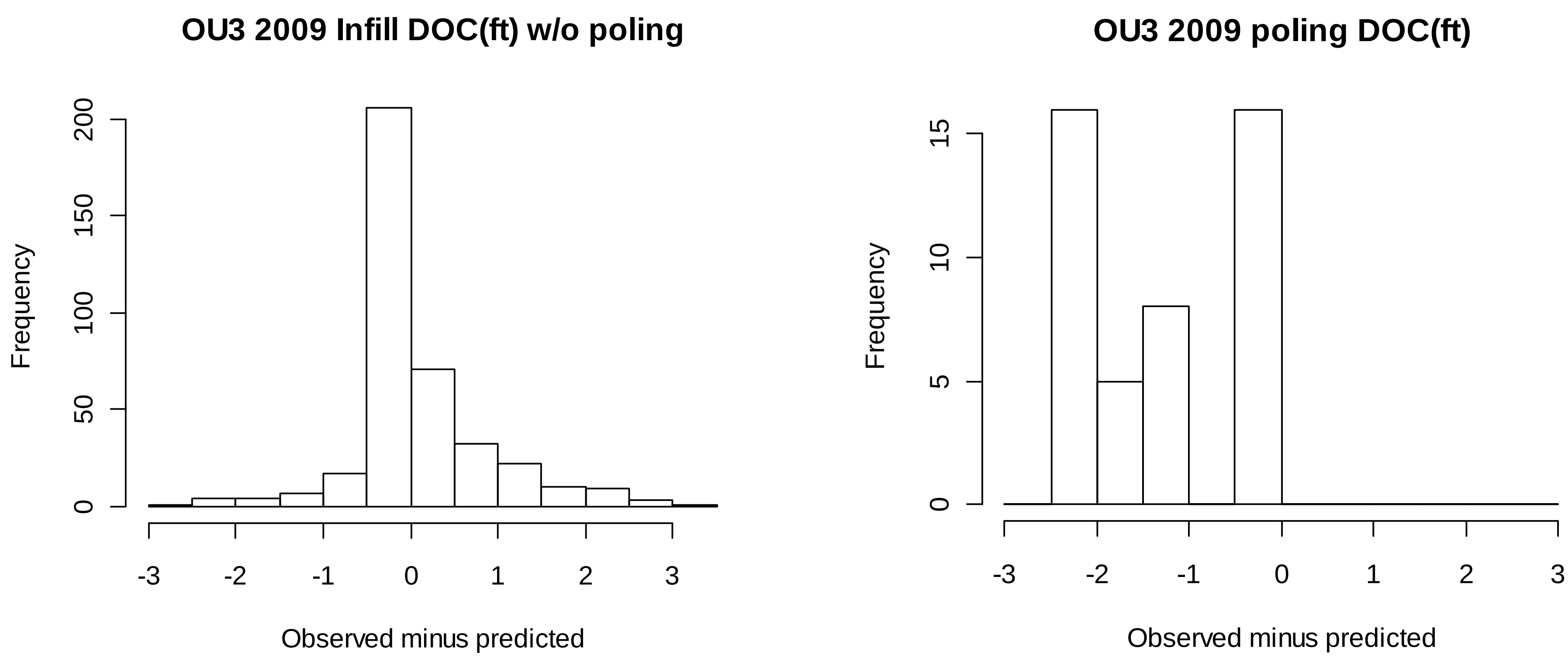

Figure 2-3

Distribution of Observed Minus Predicted DOC, Based on Prior FIK Predictions Without Zero-DOC Poling Locations and for Zero-DOC Poling Locations Only

Lower Fox River OUs 2 to 5

2.4.2 Spatial Extent of PCBs Exceeding 1.0 ppm

The modeled spatial distributions of PCB mass in OUs 3 through the active remediation portion of OU 5 are presented on Figures 2-4 and 2-5, respectively. Although these estimates of PCB mass are subject to uncertainty based on the density of RD sampling, the distribution of PCB mass is nonetheless useful in delineating appropriate RA. The DOC in OUs 3 and 4 is presented on Figures 2-6 and 2-7, respectively, using the refined FIK model with an LOS of 0.5. The surface represented in DOC maps was subtracted from the mudline elevation measured during the 2008 bathymetry survey (Tetra Tech et al. 2008b) to generate an elevation surface of the bottom of contamination, and used to develop the dredge plans, as described in Attachment A-7 of Appendix A.

Figures 2-4 through 2-7 provide important information on the PCB mass inventory in the sediments because indicator kriging discretizes data in terms of whether or not the RAL is exceeded, but does not convey information on the magnitude of the exceedance (i.e., how high the PCB concentrations are relative to the RAL). Together, these various sets of maps characterize the spatial distribution of PCBs in the project area.

In an effort to reduce or eliminate the engineering judgment used during earlier phases of the design to define the vertical and horizontal extent of remedial footprints in OUs 2 to 5 relative to the LOS 0.5 footprint, technical memoranda were prepared collaboratively by the RD Team and the A/OT that outline a set of ground rules for interpreting geostatistical outputs (see Attachments A-5 and A-8 of Appendix A of the 100 Percent Design Report Volume 1 as well as Attachment A-7 of Appendix A of this 100 Percent Design Report Volume 2). These ground rules had been applied to the RD for 2009, as presented in Volume 1 and the RD for 2010 and beyond, as presented in this Volume 2. Similar application of these ground rules will be incorporated into the RA plans for each subsequent construction season, following the completion of any infill sampling in the year prior and following development of any proposed changes due to AM or VE activities. These refinements will be presented in the annual Phase 2B RAWPs.

2.4.3 Planned Refinements after Follow-On Sampling

Consistent with the 100 Percent Design Report Volume 1 (Section 2.4.1), the neatline will be refined using the FIK model based on infill sampling. In addition, results from infill sampling conducted during 2012 have not been incorporated into the FIK model as of the date of this report. Tetra Tech and Anchor QEA (the Design Team) will incorporate the results of the 2012 infill sampling, as well as the results of any future sampling, into the design for particular areas. These designs may be changed based on the sampling; any changes will be documented in future annual Phase 2B RAWPs.

2.5 Characterization of Material for Beneficial Use and Disposal Purposes

The methodology for making characterization determinations for dredged material and debris generated from work performed in 2010 and beyond are included in the 100 Percent Design Report Volume 1.

2.6 Project Datum

A discussion of project datums is included in the 100 Percent Design Report Volume 1.

2.7 Sequential Remedial Design Anthology

Since submittal of the BODR, a number of OUs 2 to 5 RD refinements have been implemented to address additional data collection, engineering evaluations, and collaborative workgroup activities. These refinements are summarized in Attachment A-6 of Appendix A (Table 2) and Attachment B-9 of Appendix B (Table 2), for dredge and cap areas, respectively. In addition, the Remedial Design Anthology summarizes the basis of design and design refinements. The Remedial Design Anthology was initially submitted to the Response Agencies on July 31, 2008 and addenda were submitted in March 2009 and December 2010. Additional addenda will be submitted following approval of this 100 Percent Design Report Volume 2.

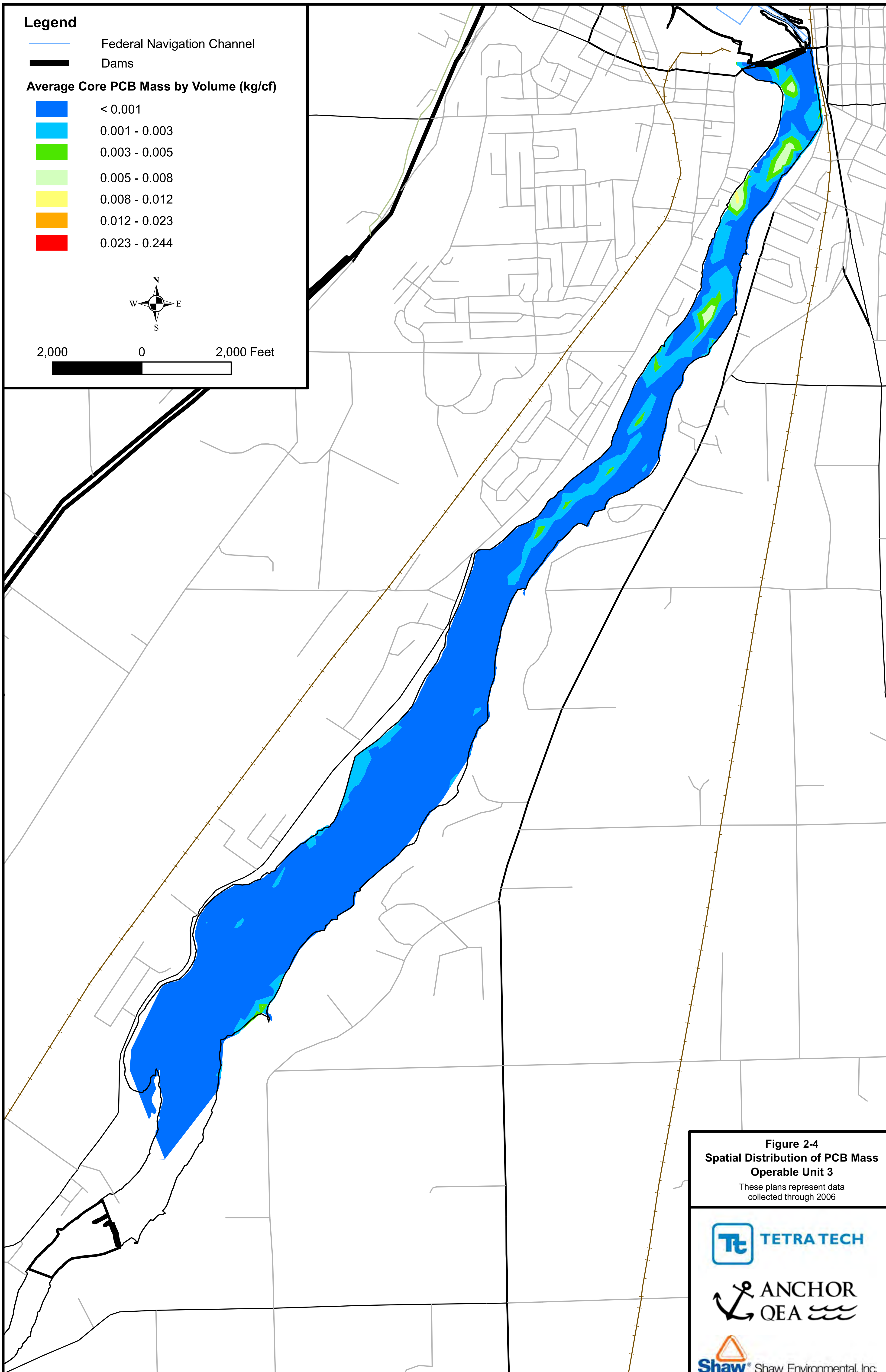

Figure 2-4
Spatial Distribution of PCB Mass
Operable Unit 3
These plans represent data collected through 2006

TETRA TECH

ANCHOR QEA

Shaw® Shaw Environmental, Inc.

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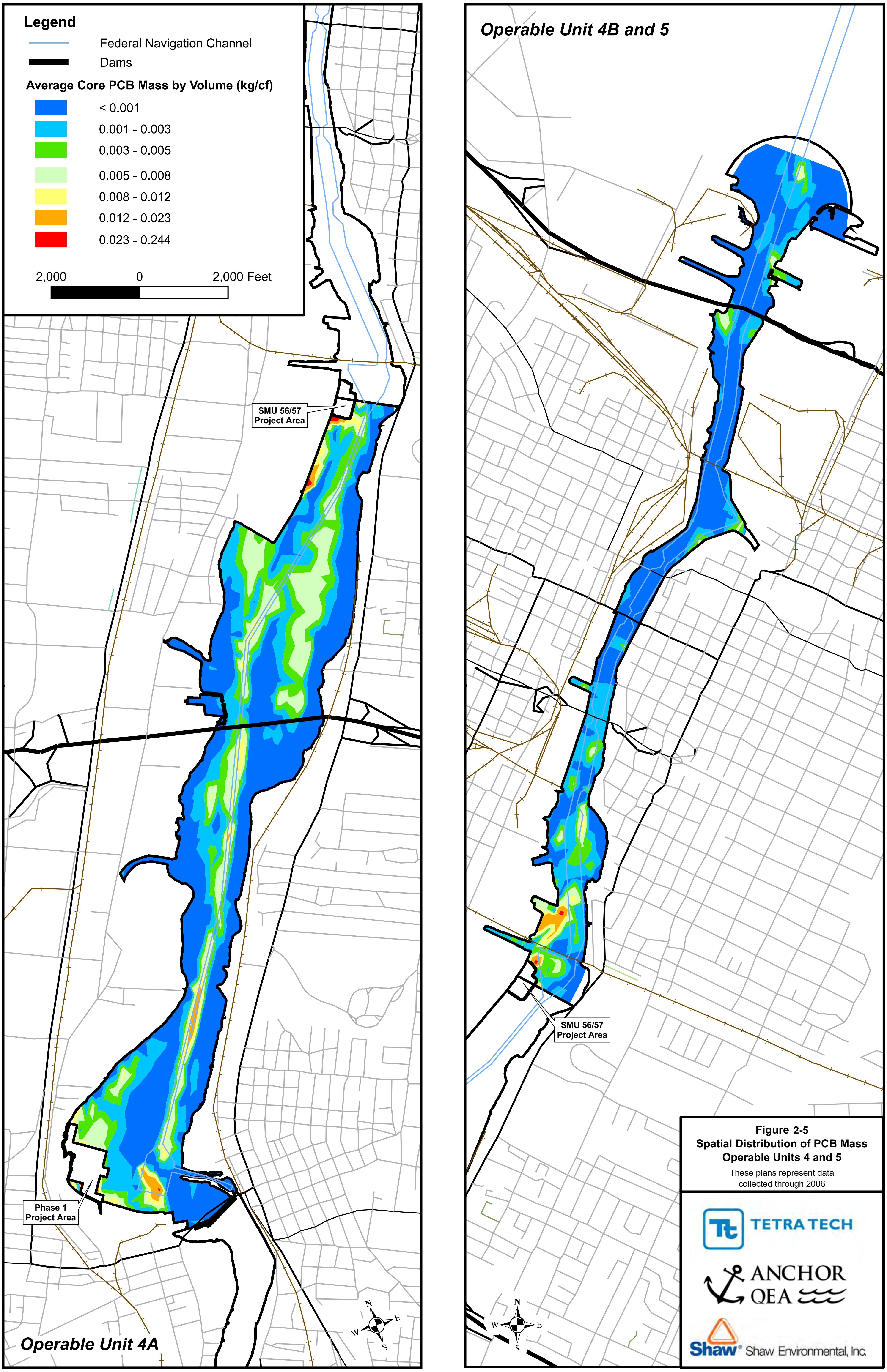

Figure 2-5
Spatial Distribution of PCB Mass
Operable Units 4 and 5

These plans represent data collected through 2006

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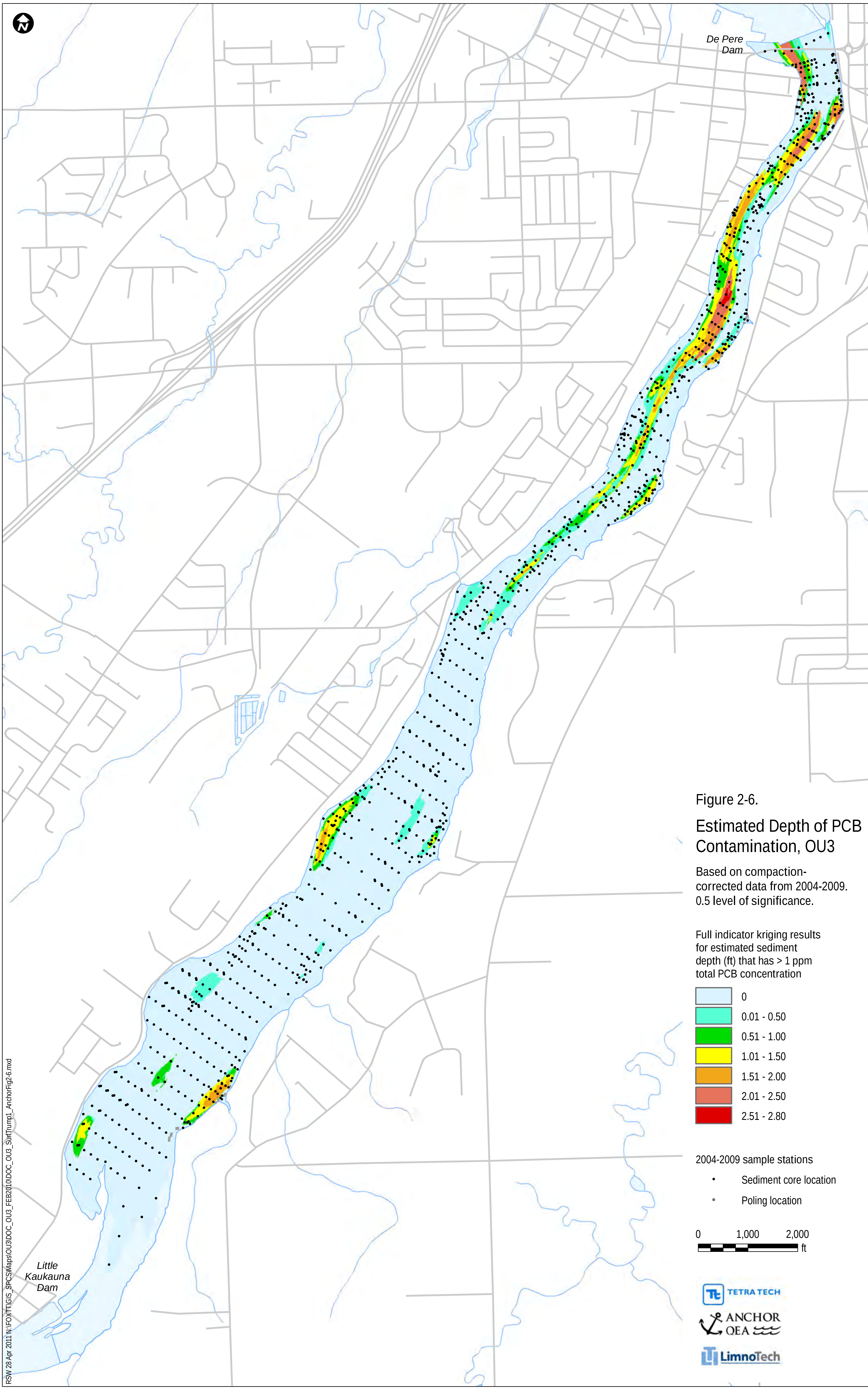


Figure 2-6.

Estimated Depth of PCB Contamination, OU3

Based on compaction-corrected data from 2004-2009.
0.5 level of significance.

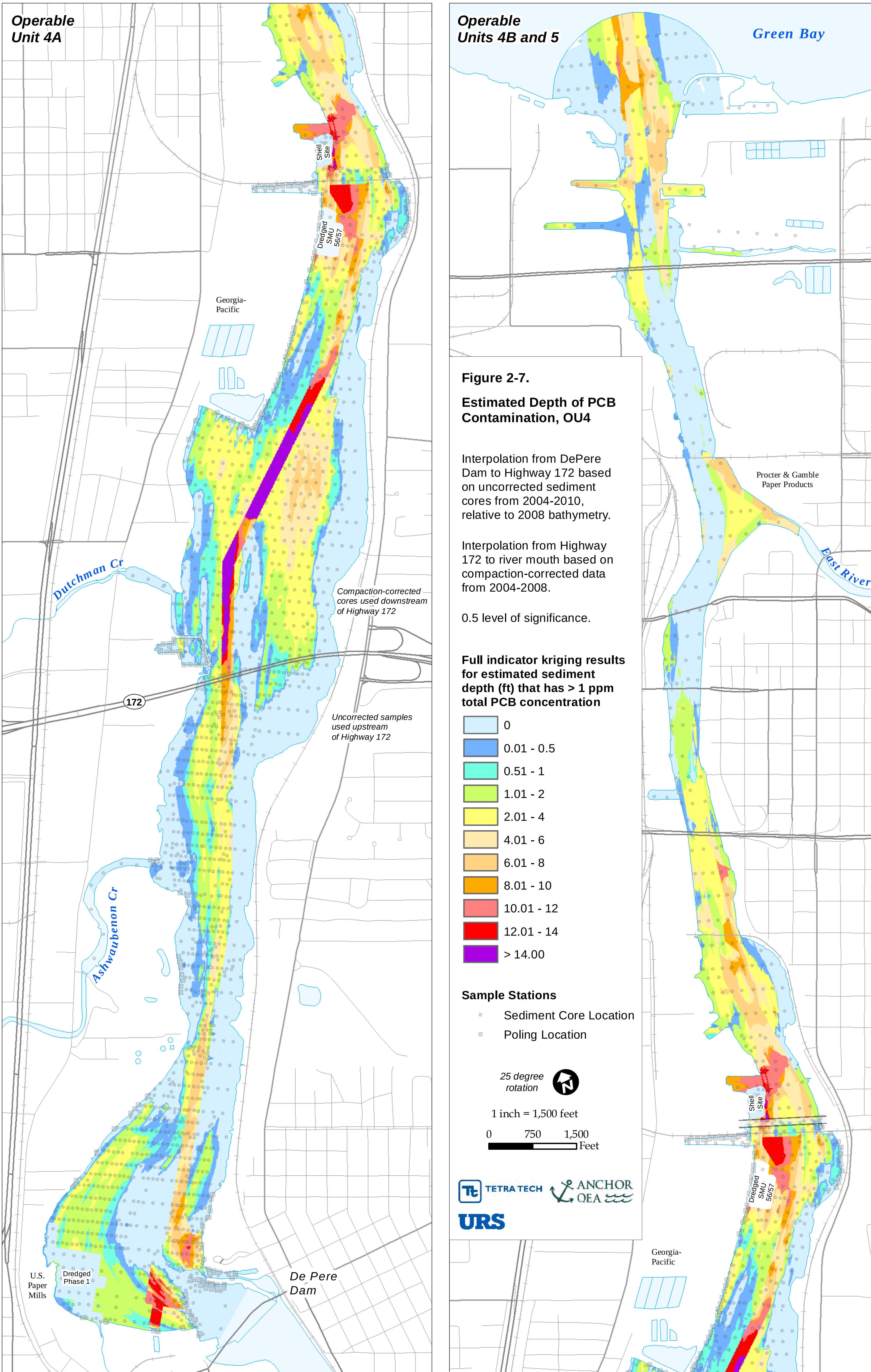


Figure 2-7.

Estimated Depth of PCB Contamination, OU4

Interpolation from DePere Dam to Highway 172 based on uncorrected sediment cores from 2004-2010, relative to 2008 bathymetry.

Interpolation from Highway 172 to river mouth based on compaction-corrected data from 2004-2008.

0.5 level of significance.

3 SITE PREPARATION AND STAGING AREA DEVELOPMENT

3.1 Staging Area Requirements

A discussion of the staging area requirements and the staging area selection process is included in the 100 Percent Design Report Volume 1.

3.2 Staging Area Layouts and Site Development Plans (2010 and Beyond)

3.2.1 OU 2/3 – Secondary Staging Facility

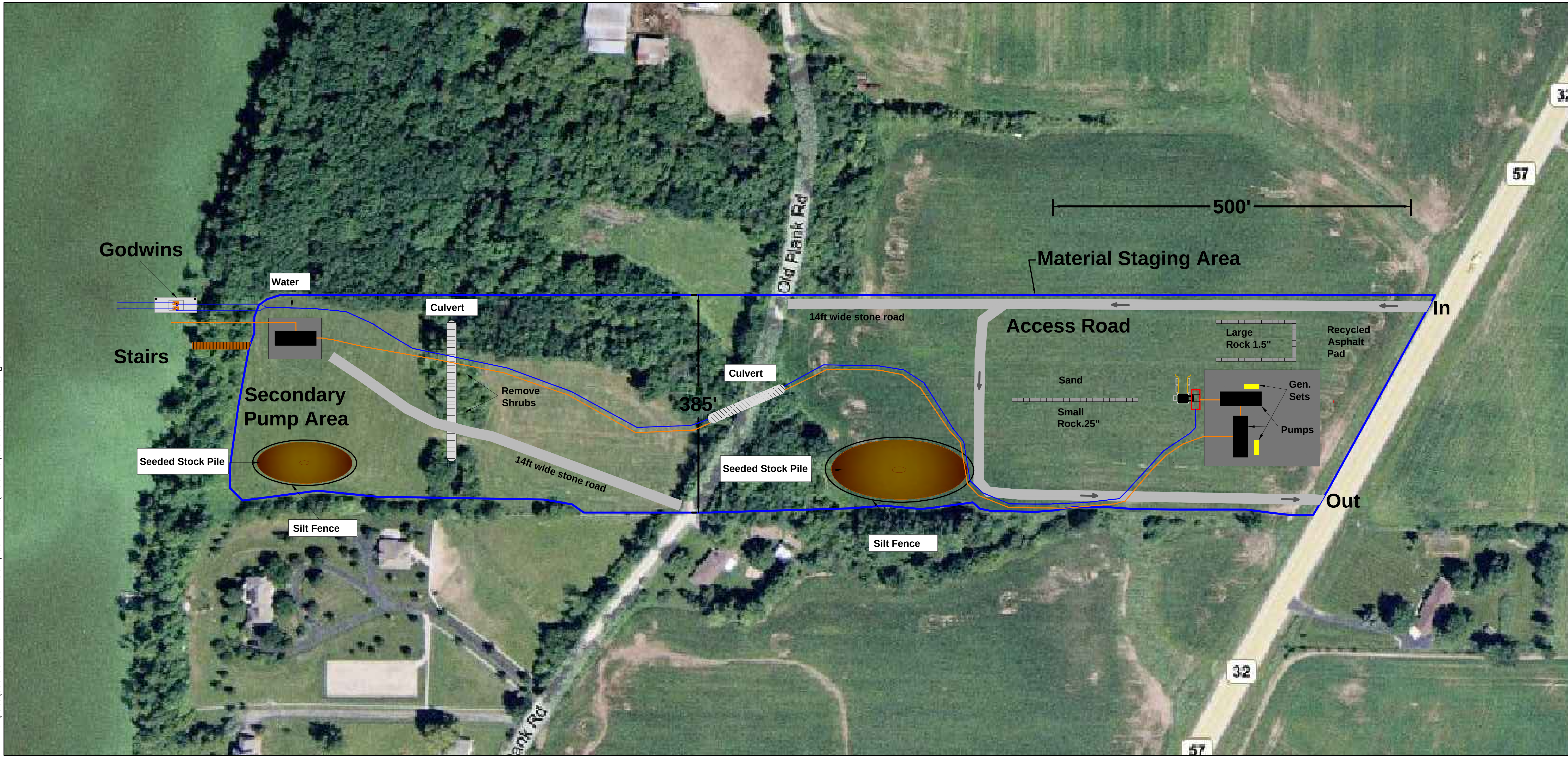
The OU 2/3 secondary staging facility is a privately owned parcel located on the east side of the Fox River in the city of De Pere, Wisconsin, which can be accessed from Old Plank Road (see Figure 3-2 of the 100 Percent Design Report Volume 1). Figure 3-1 of this report depicts the preliminary site layout for the OU 2/3 secondary staging area. A more detailed site development plan for the OU 2/3 secondary staging facility was submitted under separate cover (J.F. Brennan 2009b). This secondary staging facility will be in active use receiving capping materials in the years 2009 and 2011, to support capping and cover activities in OUs 2 and 3. At the end of 2012, the Site use will be complete and the area will be demobilized, restored, and returned to the property owner in early 2013. The final Site condition will be determined by the leasing agreement with the property owner.

3.2.2 OU 4 – LFR Processing Facility, and Staging Area

The LFR Processing Facility, OU 4 staging area, and buildings for filter cake storage and offices were initially constructed in 2008 and early 2009. Completion of construction of the OU 4 staging area is planned to occur in late 2012. Site preparation began in 2008 with debris removal. Bulkhead wall installation was scheduled to begin in 2010 and continue through the 2010 construction season, but the schedule for capping areas in OU 4A was delayed to 2013. In addition, the bulkhead wall was re-evaluated and for several reasons a decision was made not to proceed with its installation. As a result, a more cost-effective plan for materials handling was developed that eliminated the need to construct the bulkhead wall. Figure 3-2 depicts the revised design for Phase 2 development of the LFR Processing Facility property, to accommodate the new material staging plan for staging cap and sand cover materials to be used in OU 4 . The shoreline will be used for docking of material barges that will be used for loading sand and gravel materials from the upland stockpile area into the pipeline that will convey the material to the spreader barge used to place the cap or sand cover layers in designated areas.

Operations will continue to support the dredging and debris disposal activities on the river, the disposal of TSCA and non-TSCA wastes from the LFR Processing Facility through 2015, and capping and covering activities into 2017.

Demobilization of the LFR Processing Facility site should begin the year dredging is completed (currently scheduled for 2015). A Demobilization and Lay-Up Plan will be prepared and completed under separate cover approximately a year prior to completion of dredging (plan preparation currently scheduled for 2014) to address the actions required to turn over the property to owner. This could include modifications to the site for a more limited use of the property to support the RA (currently scheduled for 2016) and a total return of the property the year after RA is completed (currently RA is scheduled for completion in 2017).



SOURCE: Prepared from electronic file provided by Brennan dated 2-13-09.

0 140
Scale in Feet

K:\Jobs\080295-03 FOX RIVER OU2-OU4\100% DESIGN\FIGURES\080295-03-RP-02.dwg F3-1

Oct 11, 2012 10:39am heriksen

ANCHOR QEA

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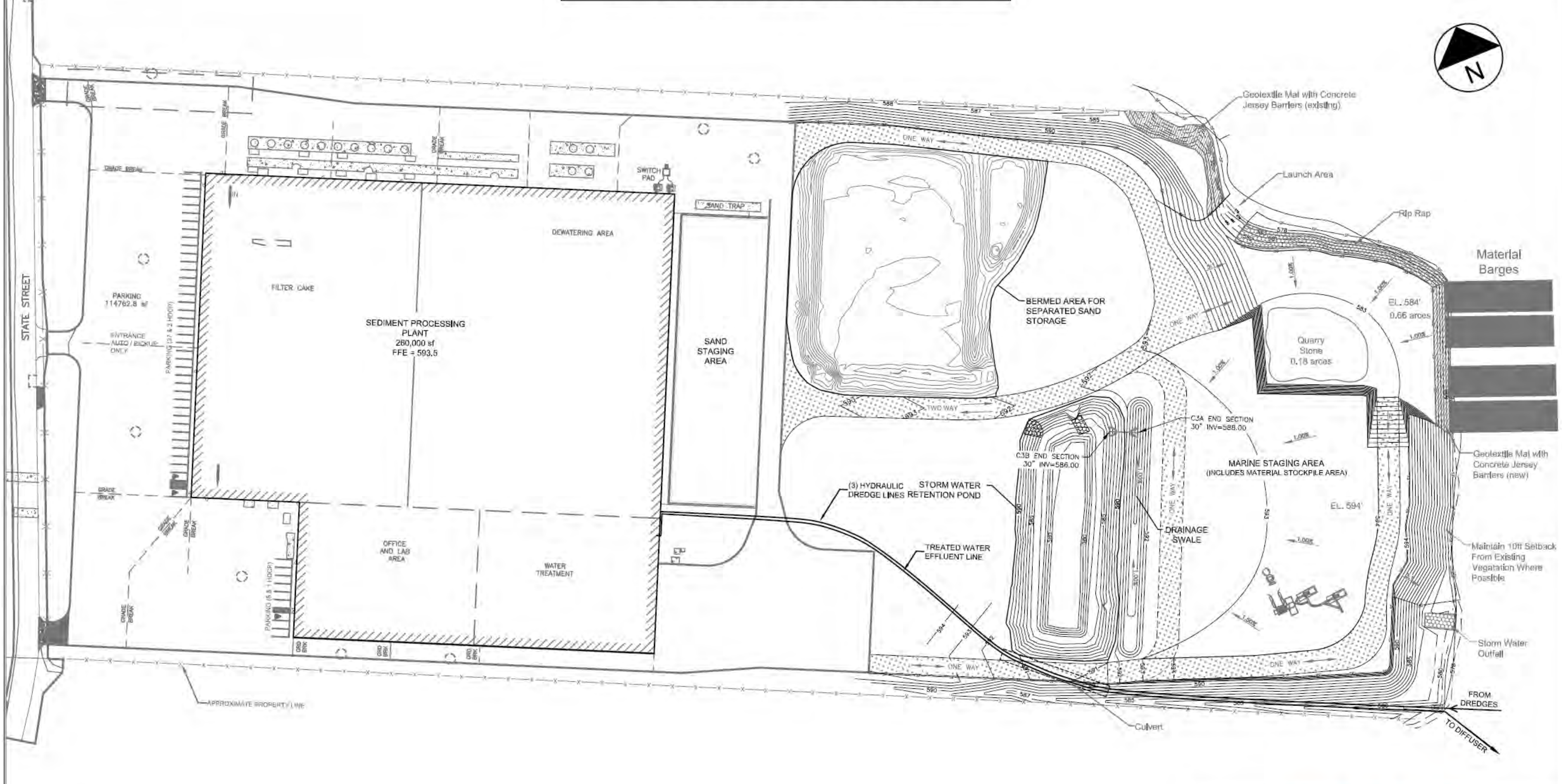
BRENNAN
"Marine Professionals"
La Crosse, WI

Figure 3-1
Preliminary Site Development Plan - OU 2/3 Secondary Staging Area
Fox River 100% Design Volume 2

FOX RIVER
SEDIMENT PROCESSING PLANT - STAGING AREA PLAN



NOTES:

1. THE ELEVATIONS SHOWN ARE PROPOSED AND MAY REQUIRE ADJUSTING IN THE FIELD. FIELD ADJUSTMENTS TO ELEVATIONS SHALL ALLOW DRAINAGE TO THE STORM WATER RETENTION POND, EXCEPT IN THE QUARRY STONE AREA.
2. GRADING IN THE QUARRY STONE AREA SHALL MINIMIZE STORM WATER RUNOFF DIRECTLY TO THE RIVER. APPROPRIATE EROSION CONTROL SHALL BE INSTALLED ALONG THE NON-WORKING FACES TO MINIMIZE DIRECT DISCHARGE TO THE RIVER.
3. THE SLOPES SHOWN ARE PROPOSED AND MAY CHANGE BASED ON FIELD CONDITIONS AND/OR CONSTRUCTION NEEDS.

PROPOSED

—SF— SILT FENCE

60 0 60 120

1" = 60'

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CAD FILE: Shell Site Buildout_REVISED_071312.dwg
REVISED BY: KYLE.ENRIGHT
DRAWN BY: JASON.THAXTON
DATE: July 13, 2012
LAST REVISED: July 12, 2012
CHECKED BY: RICHARD FEENEY

Fox River
Lower Fox River Remediation LLC

TETRA TECH ANCHOR QEA

Figure 3-2
Final Site Development Plan – Former Shell Property Staging Area
Lower Fox River – OU 2 to 5

4 SEDIMENT DREDGING

A detailed discussion of sediment dredging operations is included in Section 4 of the 100 Percent Design Report Volume 1 and is not repeated herein. The sections below present additional information relevant to sediment dredging activities in 2010 and beyond.

4.1 Summary of Sediment Physical Properties and Target Dredge Volumes

Approximately 2.2 million cy of sediments in OUs 3 to 5 are targeted for dredging in 2010 and beyond. The anticipated dredging volumes are summarized by OU in Table 4-1, although these volumes are subject to change based on incorporating the results of the 2012 infill sampling and any additional infill sampling. Any refinements to these dredge volumes will be presented in the annual Phase 2B RAWPs. The physical properties of sediments, dredgeability considerations, seasonal construction windows, and federal navigation channel considerations are discussed in Section 4.1 of the 100 Percent Design Report Volume 1.

Table 4-1
Summary of Dredge Volumes by OU

OU	2009 [c]		2010 [d]		2011		2012 to 2015		Total (2009 to 2016)	
	Cubic Yards [c]	Acres [f]	Cubic Yards [d]	Acres [f]	Cubic Yards [a, e]	Acres [f]	Cubic Yards [a, e]	Acres	Cubic Yards [a, c, d]	Acres
OU 2 [b]	3,009	0.7	0	0	0	0	0	0	3,009	0.7
OU 3	126,351	51.9	45,576	20.2	63,931	33.8	0	0	235,858	105.9
OU 4/5	415,175	65.2	618,284	158.6	171,478	50.6	2703,000	425.9	3,907,900	700.3
Total	544,535	117.8	663,860	178.8	235,409	84.4	2,703,000	425.9	4,146,800	806.9

Notes:

General: All future volumes are rounded. Quantities reported for 2012 and beyond are estimated and all quantities are subject to refinement based on annual Phase 2B RAWPs.

a. All volumes for 2012 and beyond are based on required design including a 6-inch overdredge allowance, appropriate side slopes, and estimated residuals.

b. OU 2 RA was performed in accordance with the refined design presented in the RD Technical Memorandum – OU 2 Remedial Design Refinement, dated June 11, 2009, approved by the A/OT on June 12, 2009.

c. Actual total dredge volumes for 2009 were 544,535 cy, which included additional dredge areas approved in the Phase 2B 2009 RAWP and residual dredging. Approximately 8,555 cy of the total amount removed in 2009 represents residual dredged material.

d. Actual total dredge volume for 2010 was 731,017 cy, which did not include any residual dredging, but did include 67,157 cy dredged from the Phase 1 Area, which is addressed under a separate consent decree.

e. Actual total dredge volume for 2011 was 235,409 cy. Approximately 6,950 cy of the total amount removed in 2011 represents residual dredged material.

f. For 2009 through 2011, this acreage includes only areas for which the 90 percent area criterion was achieved during the indicated year (i.e., it does not include areas that were production dredged and required additional future dredging for removal of sediment to the 90 percent elevation criterion required by the CQAPP). For 2012 and beyond, this acreage represents the approximate sum of all dredge-only areas planned to be dredge to the 90 percent elevation criterion during a particular year.

4.2 Dredge Plan Development

As noted in Section 2.4, a refined geostatistical model incorporating the results of all RD sampling conducted between 2004 and 2011 formed the basis for the dredge plans presented in this 100 Percent Design Report Volume 2. The dredge plan development process for the 2010 and beyond areas was generally consistent with that detailed in Section 4.2 of the 100 Percent Design Report Volume 1, including optimization and sequencing considerations. However, as discussed in Section 2.4.1, the geostatistical models for the stretch of river from the De Pere Dam to the Canadian National Railroad bridge downstream of the Fort Howard turning basin are based on uncorrected core data, whereas the rest of the river was modeled using corrected core data. The use of uncorrected core data in the geostatistical model will continue in the future as infill sampling is completed and data are added to the model. Therefore, the dredge (cap and sand cover) plans developed for future RA areas will also be based on use of uncorrected core data, typically as part of the annual Phase 2B RAWPs.

Dredge areas targeted in this 100 Percent Design Report Volume 2, for years 2010 and beyond, did not have the same risk-based evaluation as performed for dredge areas targeted in OU 3 and discussed in Volume 1 (Attachment A-14 of Appendix A). Rather, the A/OT developed a DRT to identify the appropriate modifications to the Draft 100 Percent Design submitted in April 2011, as described in a memorandum dated June 14, 2012 (USEPA 2012; see Appendix M). Following issuance of the June 14, 2012 memorandum summarizing the DRT, the A/OT and Design Team compared the results of the DRT with the Draft 100 Percent Design plans and reached technical consensus on the most appropriate remedy with consideration of the requirements of the ROD and ROD Amendment. The results of the comparative analysis are presented in Appendix M and reflected on the Final 100 Percent Design Engineered Plan Drawings included in Appendix D.

Following the collaborative workgroup meetings described above, the Design Team developed detailed dredge (and cap and sand cover) plans based on the FIK model, selected dredge-and-cap elevation, engineering considerations such as side slopes, and other constructability considerations. Given the short amount of time available between issuance of the Response Agencies' memorandum dated June 14, 2012, and the Response Agencies' requested submission of this 100 Percent Design Report Volume 2, some of the areas (e.g., the areas downstream of transect 4049) did not undergo the same level of detailed design and constructability review as others. These constructability reviews will be documented in future annual Phase 2B RAWPs, and they may result (along with incorporation of future sampling) in adjustment to remediation area boundaries and, therefore, remediation volumes and areas.

4.3 Equipment Selection and Production Rates

4.3.1 Equipment Selection Process

The equipment selection process and details of hydraulic and mechanical dredge equipment are provided in Section 4.3.1 of the 100 Percent Design Report Volume 1.

4.3.2 Shallow Water and Cleanup Pass Dredging

Most removal of sediments in shallow water portions of OUs 3 to 5 will be performed with the 8-inch dredges. Depending on fuel load, an 8-inch dredge drafts approximately 1.7 feet of water, which is suitable for operating in most shallow water environments. In the event that a shallow water environment does not provide sufficient depth for an 8-inch dredge, either due to low flow or other shallow water conditions, the on-site mechanical plants or excavator will be used to perform removal operations by loading material into a contained material barge for transport to the staging and material processing facility. A derrick or excavator has the ability to be positioned in deeper water depths and excavate material along the shoreline due to the longer reach of the equipment, approximately 20 to 30 feet for the excavator and approximately 50 feet for the derrick. The mechanical plant will either consist of a barge-mounted crane with a clamshell bucket (anticipated to be approximately 3 cy capacity), or a long stick mechanical excavator with a hydraulic clamshell bucket.

Cleanup pass operations will be performed by either the 8-inch dredges or the 12-inch dredge following bulk removal; however, the 8-inch dredges will be primarily utilized for cleanup passes because the 8-inch dredges are better suited for performing this type of dredging. As outlined in the 100 Percent Design Report Volume 1, the thickness of contaminated sediment remaining following bulk removal (production dredging) with the 12-inch dredge will typically be a thinner cut than the bulk removal operations, and will be suitable for cleanup pass operations. The use of a smaller dredge pump is advantageous for the cleanup pass dredging to limit the amount of slurry transport water delivered to the sediment processing facility, and also to improve accuracy and minimize disturbance. However, cleanup passes at the mouth of the Fox River and in Green Bay will be performed by the larger 12-inch dredge due to turbulent water conditions and water depth in some places. Relatively high water content slurry is expected during cleanup work performed by the 12-inch dredge. The expectations for higher water content during 12-inch dredge final pass operations are due to the thin removal layer and larger dredge pump.

Cleanup pass dredging will be undertaken at the mouth of the river following substantial completion of production dredging activities in OU 4. However, cleanup pass dredging must be performed during intervals of good weather, so some cleanup pass dredging at the mouth of the river may be performed concurrently with production dredging. To the extent feasible, cleanup pass dredging will be performed upstream of production dredging. An appropriate offset will be maintained between upstream cleanup pass dredging and downstream production dredging to mitigate the potential for redeposition of dredge residuals. This dredging is anticipated to take place in 2015.

4.3.3 Production Rate Considerations

Dredge production in OUs 3 to 5 is dependent on numerous factors, each of which need to be addressed to maximize the production and efficiency of the dredging operation. The majority of these factors are detailed in Section 4.3.3 of the 100 Percent Design Report Volume 1. The following additional factors were considered in this evaluation for sediment dredging in 2010 and beyond:

- **Green Bay and Fox River Mouth Dredging.** Conditions at the mouth of the Fox River and in Green Bay are expected to be more turbulent than other portions of the river due to exposure to large fetch distances for generation of waves. The Tetra Tech Team plans to utilize the 12-inch dredge in these unprotected, more turbulent waters; however, there may be times during the RA when weather conditions may dictate that production, even with the larger dredge, be temporarily discontinued for safety purposes. Waves with a height in excess of 24 inches will limit or prevent cleanup pass dredge operations with the 12-inch dredge. Waves in excess of approximately 33 inches may require discontinuation of any and all dredging operations. Due to the related weather risk in Green Bay and at the mouth of the Fox River, more downtime is expected during excavation of deposits at the aforementioned locations.

Table 9-1 lists the actual dredging production for 2009 and 2010 and outlines the anticipated yearly dredging production rates for 2010 and beyond.

4.3.4 Survey Methods and Equipment

Survey methods and equipment are provided in Section 4.4.3 of the 100 Percent Design Report Volume 1.

4.3.5 Data Management

Data management is detailed in Section 4.4.4 of the 100 Percent Design Report Volume 1.

4.3.6 Dredge and Survey Software

Dredge and survey software are detailed in Section 4.4.5 of the 100 Percent Design Report Volume 1.

4.4 2010 and Beyond Dredge Plan Design Summary

Dredge plans for 2010 and beyond are presented in the Engineered Plan Drawings in Appendix D. These plans and profiles depict the required dredge areas and depths as well as overdredge allowances based on sampling and geostatistical modeling available at the time of this writing. All of the areas designated as dredge areas have been identified through the design efforts and the collaborative workgroup process discussed in Sections 1.3, 2.4, and 4.2 (incorporating the A/OT's DRT). As described in Sections 1.3.1 and 2.4.1, these areas will be re-evaluated to incorporate the 2012 infill sampling results and may be re-evaluated based on any additional future sampling, AM, or additional geostatistical analyses. Any refinements to the RA plan based on these future re-evaluations will be presented in the annual Phase 2B RAWPs.

Each dredge area depicted on the Engineered Plan Drawings in Appendix D is identified by a unique label (e.g., OU4-D30), where "OU" indicates that the area is in Operable Unit 4, the "D" denotes a dredge area, and the "30" denotes a sequential numbering of dredge areas beginning in OU 2 and generally moving downstream. It should be noted that some dredge area numbering is not sequential due to dredge areas that were either removed or added during the design after the initial labeling at the 60 Percent Design phase. Attachment A-6 of Appendix A presents a summary of the dredge plan design by dredge area and includes a comparison to the 60 and 90 Percent Design phases.

Areas identified on the A/OT's DRT, such as Dredge Low Risk and Confirm, pertain to AM adjustments to the neatline for dredging, and to the option to perform confirmation sampling prior to achieving 90 percent surface area completion criterion for dredging to the neatline, respectively (see Appendix F). These areas are identified in the Appendix M memorandum from the Response Agencies, but they are not identified on the Engineered Plan Drawings in Appendix D because they are post-dredge residuals management measures not design criteria. Production dredge areas are also not identified separately on the Engineered Plan Drawings because these areas are simply a sub-area of dredge-only and dredge-and-cap areas. Other remedy areas, such as engineered caps and remedy sand cover, are also shown on the Engineered Plan Drawings, but residual management areas are not because they are identified based on the results of confirmation sampling after an area is dredged. One additional remedy type, No Action/Confirm, is identified in the DRT polygon comparison tables included in Appendix M and will be shown on Engineered Plan Drawings in the annual Phase 2B RAWPs, as applicable. These areas will be sampled to determine if any dredging is needed because discrete core data in the area indicate that little or no dredging may be needed to remove 1 ppm PCB RAL sediment.

4.5 Management of Potential Impacts from Dredging

Management and best management practices (BMPs) for dredging operations, dredge residuals management (excluding dredge low risk and confirm techniques proposed by the Response Agencies in the DRT presented in the June 14, 2012 memorandum included in Appendix M), slope stability and structural considerations, short-term water quality considerations, and noise and air quality considerations are included in Section 4.7 of the 100 Percent Design Report Volume 1.

5 MATERIALS HANDLING, TRANSPORT, AND DISPOSAL

The design of the materials handling, transport, and disposal operations is described in the 100 Percent Design Report Volume 1. The mass balances used to select and size the dredging, desanding, dewatering, and water treatment equipment can be found in the Process Design Basis Technical Memorandum (Tetra Tech et al. 2009a) in Attachment A-11 of Appendix A of the 100 Percent Design Report Volume 1. At the end of each year of RA operations, the estimated quantities of sediment to be processed the following year may be adjusted based on additional information from any infill sampling and/or from VE-based design revisions described in the AM and VE Plan (Appendix E), and documented in annual Phase 2B RAWPs.

5.1 Transport of Debris and Dredged Material

Section 5.1 of the 100 Percent Design Report Volume 1 presents details of the transport of debris and dredged material for the 2009 RA. Debris and dredged material will be transported in the same manner during RA in 2010 and beyond.

5.2 Dredge Pipeline

The dredge pipeline marking system was designed to allow for high visibility of dangerous areas on the river for the benefit of boaters operating at high speeds. The system consists of a series of different waterway markers, installed as indicated in Technical Memorandum – Pipeline Installation and Maintenance Procedures (J.F. Brennan 2009c). Figure 5-1 outlines the pipeline marking system described in the Technical Memorandum. This system was used by J.F. Brennan at OU 1 and during 2009 in OUs 2, 3, and 4, with additional marking and monitoring of the pipelines added in 2009 after two incidents occurred involving boaters hitting pipelines. Additional information regarding the installation and maintenance of the dredge pipelines is presented in the Technical Memorandum (J.F. Brennan 2009c).

Additional Notes:
-Distances listed are maximum distances, additional buoys may be added as needed
-Illuminated and/or Flashing Construction Signs may be used to guide boaters through construction zones
-Red and Green Buoys may by used to provide safe passage for boaters through construction zones and areas of semi-submerged pipeline.
-Additional Floating Signage or Stick Buoys may be placed in a circle or semi-circle orientation along the shoreline to form a protective barrier around construction zones.

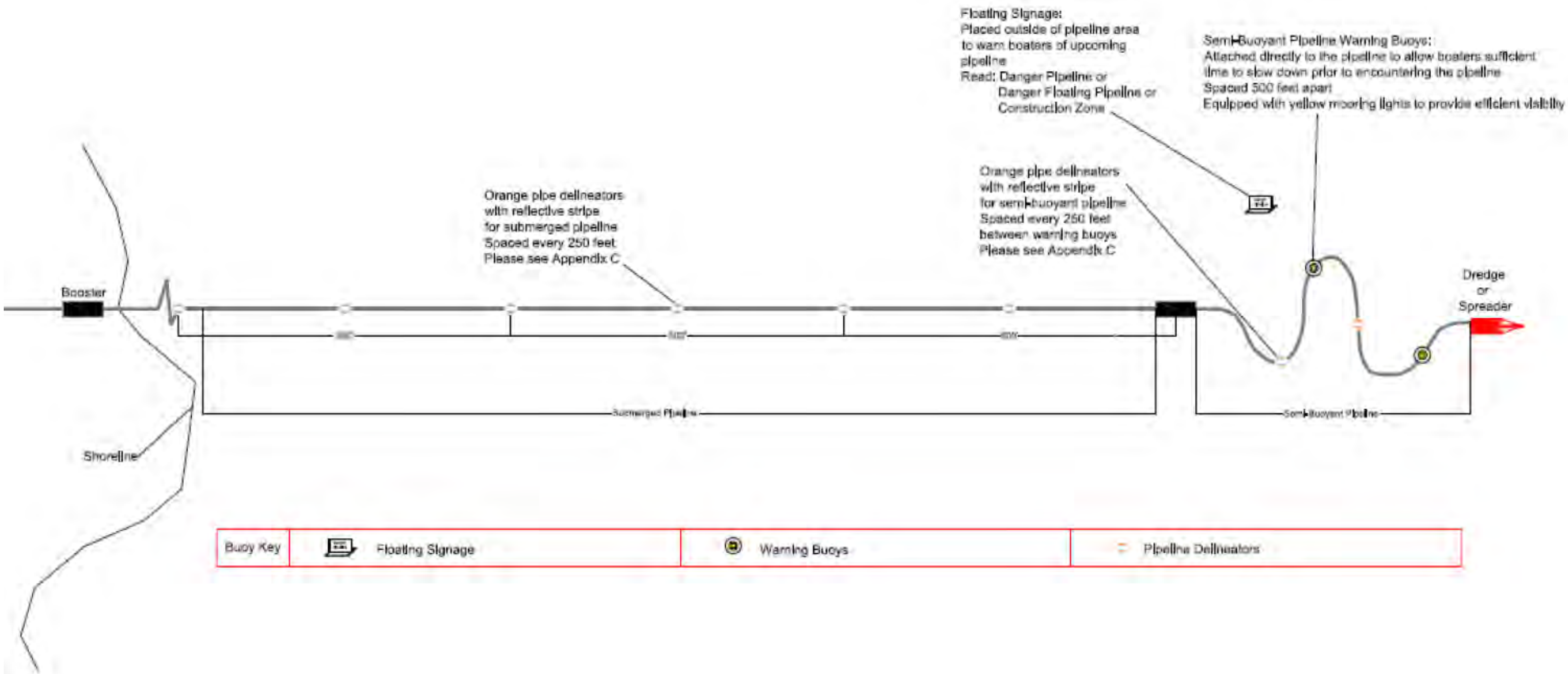

Figure 5-1
Typical Pipeline Marking Procedure for Floating and Submerged Pipeline
Lower Fox River OUs 2 to 5

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5.3 Dredge Sediment Handling

Consistent with the plan of operation for 2009 to 2012 RA discussed in the 100 Percent Design Report Volume 1 and the annual Phase 2B RAWPs to date, typically two 8-inch hydraulic dredges and one 12-inch hydraulic dredge will be used for removal of TSCA and non-TSCA sediments in 2010 and beyond. The dredges will remove the sediment and pump the slurry material through the pipeline and accompanying floating booster stations to the dewatering facility at the LFR Processing Facility. Mechanical dredging will be used as an option only if hydraulic dredging cannot be conducted in certain areas.

5.3.1 Hydraulically Removed Sediment Transport

Beginning in 2010, the following sequence will be performed to transport hydraulically removed non-TSCA sediment:

- The two 8-inch dredges were deployed to OU 3 to continue dredging non-TSCA material following the 2009 RA. When the non-TSCA dredging was completed in OU 3, the 8-inch dredges were moved into OU 4.
- The 12-inch hydraulic dredge will operate in OU 4, generally working from upstream to downstream, removing non-TSCA sediment or TSCA sediment but not coincidentally.
- The 8-inch dredge may also be used to remove TSCA sediment in OU 4.
- There will be no crossover between non-TSCA and TSCA material at the LFR Processing Facility. The dredge conveyance piping and the LFR Processing Facility will be flushed after processing TSCA sediment and prior to processing the non-TSCA material. Detailed procedures for flushing the system following dredging of TSCA material and at the end of each operational season are presented in the Phase 2B 2009 RAWP and also the O&M Plan prepared for Dredging, Sand Covering, and Capping Activities (J.F. Brennan 2009a), the O&M Plan for the sediment desanding and dewatering plant (SDDP) (Tetra Tech et al. 2011a), and the O&M Plan for the water treatment plant (WTP) (Tetra Tech 2011). These plans were submitted to the Agencies under separate cover and were approved; they are also included in Appendix L of this 100 Percent Design Report Volume 2.

5.3.2 Contingency for Mechanically Removed Sediment Transport

Section 5.3.2 of the 100 Percent Design Report Volume 1 presents the procedures for mechanically removed sediment transport.

5.4 Mechanical Dewatering Operations

Section 5.4 of the 100 Percent Design Report Volume 1 presents details of mechanical dewatering operations including SDDP (part of the LFR Processing Facility), processing of hydraulically and mechanically dredged sediment, segregation of sand, monitoring, BMPs, physical characteristics of processed material, and mass balances. Additional detailed information, including detailed design drawings of the SDDP, are included in the Process Design Basis Technical Memorandum (Tetra Tech et al. 2009a).

Based on sand separation data from the 2009 through 2011 dredge seasons, there appears to be less sand than originally estimated—an average of approximately 19 percent versus 30 percent. However, this was determined to be due to the difference in how the sand separation system removes sand, which is based on differences in density, and the way sand is defined using ASTM D422, by particle size. The sand separation system separates the mineral sand, which has a higher density than some of the sand-size particles that would be classified as sand using ASTM D422. Therefore, the sand percentage reported using ASTM D422 will typically include some sand-size particles that are not dense enough to be removed by the sand separation system, but are not mineral sand.

In the Phase 2B 2010 RAWP (Table 3-5), the number of membrane filter presses needed was recalculated using 8.6 percent sand, 35 percent solids, and an in situ density of 76 pcf for the sediment removed in 2009. The number of filter presses was found to be sufficient (5 to 6.7, depending on uptime) for the annual production target of 550,000 in situ cy. In 2010, the tonnage of sand removed increased over the 2009 tonnage, but this did not increase the solids loading to the presses, so eight filter presses are expected to be sufficient for the project needs through the end of the RA.

5.5 Water Treatment Operations

Section 5.5 of the 100 Percent Design Report Volume 1 presents details of the water treatment plant, effluent performance goals, effluent discharge monitoring provisions, and biological oxygen demand (BOD) waste load allocation transfer.

During 2009/2010 winter shutdown activities, Tetra Tech installed a high volume, low pressure air blower and associated piping and valving, for the purpose of enhancing the efficiency of backwashing the WTP multi-media filters. Air lancing or scouring reduces pressure drop across the filters by breaking down mud balls and fluffing up the multi-media bed. These actions reduce flow channeling through the media beds. Air lancing or scouring is also expected to increase effectiveness of the liquid backwash in removing accumulated polymer. Other significant improvements made to the WTP during 2009 or later are summarized as follows:

- Installation of a nephelometric turbidity meter to measure the turbidity of the WTP influent water
- Installation of a streaming current detection meter to measure the amount of positive ions in the WTP influent, to provide an indication of the degree of polymer
- Installation of a chemical injection system to allow for routine addition of hydrogen peroxide (or other suitable chemical agent) to the backwash flow for the multi-media filters and the carbon adsorption units as an aid to dissolving or dispersing and removing accumulated polymer from the media in these vessels
- Discontinuance of the use of cartridge filters, as approved by the A/OT, because these were suspected as being a source of occasional elevated BOD levels in the WTP effluent
- Change in the flow orientation of the granular activated carbon units from dual units in series flow to all units in parallel
- Use of duo flow bag filter elements instead of the previous single flow bags

5.6 Transport and Disposal of Dewatered Sediment and Debris

Sections 5.6.1 through 5.6.5 of the 100 Percent Design Report Volume 1 present a summary of transport and disposal of dewatered sediment and debris, general traffic controls, truck cleanliness and decontamination, and details of outbound materials from the LFR Processing Facility staging area. More detailed information regarding the transportation and disposal of dewatered sediment and debris is provided in the *Final Lower Fox River OU 2 – 5 Remedial Action Final Transportation Plan* (Transportation Plan) in Attachment A-12 of Appendix A of the 100 Percent Design Report Volume 1.

5.6.1 Beneficial Reuse Considerations

Beneficial reuse is defined as the reuse of dredge material (or some portion of it) as a resource instead of disposing of it as a solid waste. This involves using the dredge material in a productive manner, such as habitat creation or restoration, landscaping, soil/material enhancement, construction fill, or land reclamation. The benefits can be derived from the dredge material itself or from the placement of it on a site. By definition, beneficial reuse does not include disposal into a landfill or other permitted facility such that disposal capacity is used by the material. However, beneficial reuse can include use of the material at a landfill or other permitted facility if not for disposal, such as for general construction purposes. In order to meet the definition of beneficial reuse, the material has to have some benefit for construction or operation, or allowing for facility expansion.

Dredge material can have significant value if applied for beneficial reuse. These benefits can be realized through planning and coordination between the regulatory agencies, potential users of sand, and other interested stakeholders. In the case of the OUs 2 to 5 project, the most likely beneficial reuse opportunity pertains to the sand fraction of the non-TSCA dredge material, which can be effectively segregated from the more contaminated silt and organic fraction. Subject to appropriate regulatory approval and testing, separated sand from dredging TSCA sediments may also be suitable as beneficial reuse material. Selecting the most appropriate beneficial reuse alternative for the segregated sand requires an evaluation of the physical and chemical characteristics of the material, defining how the material can be safely used, and understanding how various stakeholders' interests can be integrated into the project.

A primary reference source for information regarding beneficial use is *Testing and Evaluating Dredged Material for Upland Beneficial Uses: A Regional Framework for the Great Lakes* (Great Lakes Commission 2004). Appendix A of this reference summarizes case studies regarding beneficial use. The document also includes contaminant criteria for various beneficial use applications for many of the Great Lakes States; however, specific contaminant levels are not presented for the State of Wisconsin. Most of the regulatory PCB concentrations that would typically apply for a given beneficial reuse application are less than or equal to 1.0 ppm. These concentrations are presented in Table 5-8 in the 100 Percent Design Report Volume 1; however, many of the beneficial use applications allow higher concentrations.

Beneficial reuses of dredge material commonly include shoreline stabilization, island restoration, habitat development, beach nourishment, parks and recreation uses, agriculture uses, construction/industrial uses, and road sanding in winter months. These general alternatives are then tailored to accommodate the particular project needs and logistics, taking into account the following factors:

- Physical characteristics of the material
- Chemical characteristics of the material
- Local project/needs
- Regulatory criteria and approvals
- Site development timelines
- Environmental concerns
- Stakeholder concerns
- Available volumes of suitable materials
- Transportation and material re-handling
- Distances between dewatering/separation plant and the potential beneficial use sites

Approximately 250,000 tons of sand are expected to be generated through the dredging, desanding, and dewatering process. Desanding and beneficial reuse volumes will continue to be refined throughout the project. This sand tonnage is less than the tonnage stated in the 60 Percent Design Report, primarily due to the presence of organics and other non-sand particles that are the same grain size as sand, but were previously mischaracterized as mineral sand. These particles are measured as sand in the standard ASTM D422 grain size test but are not separated as sand by the desanding system due to the difference in specific gravity between mineral sand and these non-sand particles. Therefore, significantly less sand than anticipated was separated during the 2009 dredge season and future estimates for sand separation production have been revised accordingly.

Testing of the separated sand as part of the pilot sand separation/washing process was performed in 2008 and 2009, and provided an indication of the expected chemical characteristics of the sand following desanding and polishing steps similar to those planned for the project. This information was useful in the evaluation of the sand for potential beneficial reuse. The Low Hazard Waste Exemption (LHE) Request presented in Appendix B of the Phase 2B 2009 RAWP describes the substantive requirements for on-site beneficial use of sand separated from non-TSCA sediment. An LHE Request is required for each proposed beneficial reuse of the sand, and sand proposed for off-site beneficial reuse will be subject to the full LHE process. Analysis of full-scale production separated sand will be required and will be used for the final acceptability determination of all proposed off-site beneficial reuse options. Sand separated from non-TSCA sediment during the 2009 and 2010 dredge seasons has been analyzed for the chemical constituents identified in the LHE Request (Appendix B of the Phase 2B 2009 RAWP), and is acceptable for beneficial reuse. Separated fine and coarse sand produced during the 2009 operations season had an average overall PCB concentration of 0.30 ppm. Separated fine and coarse sand produced during the 2010 operations season had an average overall PCB concentration of 0.16 ppm. In combination, separated fine and coarse sand produced during the 2009 and 2010 operations season had an average PCB concentration of 0.20 ppm.

In early July 2010, an LHE Request was submitted to the WDNR concerning potential beneficial reuse opportunities at several specific private and public off-site construction projects. A public meeting was held in early August 2010 as part of the LHE approval process. The WDNR granted a conditional approval of the LHE in October 2010, which allowed sand separated from sediment during 2009 and 2010 RA to be utilized for a Wisconsin Department of Transportation (WIDOT) elevated roadway project in Green Bay. Consequently, all of the separated sand accumulated on Site during 2009 and 2010 operations has since been removed from the Site and used beneficially. A small amount of separated sand was provided to the Veolia Hickory Meadows Landfill at their request in 2009 for construction purposes.

Section 5 of the 100 Percent Design Report Volume 1 provides detailed information on other beneficial reuse alternatives that may be pursued.

As part of the continued VE efforts in years 2011 to 2017, beneficial reuse opportunities for the sand and coarser materials segregated from the dredge material will continue to be evaluated throughout the project. Table 5-1 lists some of the opportunities that will be evaluated. As previously discussed, the bulkhead wall originally planned at the LFR Processing Facility has been eliminated and a plan has been developed for the area that will stage the capping and sand cover materials for future capping and sand covering in OU 4. This plan is presented in the Phase 2B 2012 RAWP (Figure 3-1; Tetra Tech et al. 2011d), and construction of the area is planned for 2012. Therefore, substantially all of the separated sand previously planned for use as bulkhead backfill generated during RA in 2010 and beyond will be available for other beneficial reuse alternatives.

Table 5-1
Beneficial Reuse Opportunities

Beneficial Reuse Opportunity	Description of Opportunity	Estimated PCB Concentration Requirements	Quantity of Material that Could Be Reused as Part of This Opportunity	Opportunity Specific Material Gradation and Other Requirements
Bayport Disposal Facility	Beneficial use for construction material as part of disposal facility operations and/or construction.	≤ 1 ppm	TBD	TBD
Beach Nourishment	Construction materials for beach restoration. No specific sites identified. Could be in Great Lakes states.	≤ 0.05 ppm	TBD	≤ 15% passing the no. 200 sieve Color
Landfill Construction	Construction materials as part local operating landfill(s). Multiple opportunities, including GP landfill.	≤ 5 ppm	TBD	For use in leachate collection system, need permeability of 1×10^{-2} cm/sec or less, for use as daily cover, no permeability requirement
Manufactured Soil	Mix separated sand with other yard waste, agricultural waste, and/or animal waste.	≤ 0.25 ppm	TBD	TBD
Roadway Construction	Construction material for local road construction projects. Highway 41 expansion has been identified as an alternative.	≤ 1 ppm	TBD	TBD
Upland Development	Construction materials for local non-residential development or park enhancement. No specific projects currently identified.	≤ 1 ppm	TBD	TBD

Table 5-1
Beneficial Reuse Opportunities

Beneficial Reuse Opportunity	Description of Opportunity	Estimated PCB Concentration Requirements	Quantity of Material that Could Be Reused as Part of This Opportunity	Opportunity Specific Material Gradation and Other Requirements
Wetland Construction	Construction of wetlands. Possible future USACE projects but no specific projects currently identified.	≤ 0.25 ppm	TBD	TBD
Mine Reclamation	Use material as backfill in local mines for reclamation	≤ 0.25 ppm	TBD	TBD
Raw Material for Concrete or Asphalt Manufacturing	Potential use for Highway usage coordinating with WIDOT for projects in area during project.	≤ 2 ppm	TBD	TBD
Off-site private or public (e.g., WIDOT) construction projects	Granular base fill material on roadway or building construction projects.	<0.49 ppm	220,000 tons for some of the WIDOT projects	As produced

5.6.1.1 Description of Potential Beneficial Use Alternatives

The sections below provide descriptions of beneficial reuse alternatives for the sand fraction from the material dredged during 2010 and beyond, which are being evaluated as part of the ongoing VE efforts.

5.6.1.1.1 Bayport Material Disposal Facility

The Bayport Material Disposal Facility (Bayport) is an upland confined disposal facility (CDF) owned and operated by Brown County. The facility was built to manage non-hazardous (e.g., low leachability) dredge material from the Lower Fox River and shipping channel of Green Bay. The facility is located approximately 1 mile west of the mouth of the Fox River. Construction of the facility was completed in 1999.

The facility is operated as a dredge material re-handling and storage facility. Historically, sediment has been mechanically dredged as part of various maintenance projects on the Lower Fox River and Green Bay, and barged to an off-loading facility at the Fox River Dock slip. From there, dredge material with typical solids content in the range of 30 percent (by weight) is trucked to a dewatering cell at the Bayport facility. After the material is allowed to dewater for 2 to 3 years in a dewatering cell, it is excavated with conventional earth-moving equipment and transported to one of two storage/disposal cells where it is stockpiled and graded. When materials are excavated from the dewatering cell, the drainage system and base of the cell are reconstructed for future placement of new dredge material.

Brown County has an ongoing demonstration project, initiated in 2001, to construct a test fill area to generate data to justify a future request for steeper side slopes and greater depth of fill that could increase the facility design capacity from 2.5 to 7.4 million cy.

The beneficial use concept for Bayport could be to use segregated sand (less than 1.0 ppm PCBs) removed from OUs 3 to 5 to complement current operations such that the capacity of the facility can be increased beyond the proposed 7.4 million cy. This could include placement of internal dewatering layers constructed with the segregated sand to improve sediment dewatering, increase the strength, and allow for steeper/higher final grades. Other changes may be possible to lower operating costs and increase the capacity of the facility. Additional evaluation will be necessary to assess this beneficial reuse alternative.

5.6.1.1.2 Regional Beach Nourishment

Beach nourishment is currently the most common beneficial reuse of dredge material in the Great Lakes. Beach nourishment is a low cost, beneficial option for operation and maintenance of dredging projects in the USACE Detroit District. Many of the District's harbors provide clean, sandy material from the navigation channels that is then transferred to nearby beaches in order to mitigate normal erosion effects of wind, waves, and weather. Beach nourishment also returns sediments trapped between breakwaters into the littoral drift process and aids in the stabilization of beaches.

When developing dredging plans for a particular project, areas of erosion are considered for beach nourishment opportunities. The distance from the dredging areas is also considered because this directly affects the cost of the operations. Other important factors include the locations of parks and public facilities, such as water intakes, and the condition of the shoreline near them. Material not suitable for placement on a beach could be evaluated for other uses such as construction and industrial fill and habitat development. Because of the likelihood of human and wildlife contact with beaches, as well as the potential for leaching into nearshore waters, contamination limits are often strict for this application and will need to be evaluated on a case-by-case basis. In some cases, the background levels measured at the Site are applied as a benchmark.

Beach nourishment operations must comply with state water quality regulations according to Section 401 of the Clean Water Act (CWA). Section 404 of the CWA and the Coastal Zone Management Act also apply. In Wisconsin, beach nourishment is allowed only for Great Lakes locations, not inland waters, per NR 347.07(4). Under the general permit, the acceptable PCB concentration for beach nourishment is less than 0.05 ppm total PCBs. NR 347 lists two additional criteria: grain size and color. Risk to beach users is addressed qualitatively by limits placed on the source material. Grain size is limited by requiring the percent passing the U.S. No. 200 sieve (P200) to be no more than 15 percent (by weight) of the average fines content of the native beach material. Color is qualitatively required to be a close match to existing beach color. Use of segregated sand from OUs 3 to 5 for beach nourishment is under consideration, but no specific projects are identified at this time. Therefore, specific evaluation criteria such as physical or chemical suitability, volume required, and distance to from the Site to the beach location are not known at this time.

5.6.1.1.3 Landfill Construction

This alternative involves beneficial reuse of dredge material in the construction or operation of an upland solid waste landfill. Examples of construction use include external berms either inside or outside the containment liner system, use in the leachate collection system, or use in the final cover system. A potential operational beneficial use is for daily cover at a solid waste landfill.

At some landfill sites, on-site or import soil is used for construction of external berms to achieve additional capacity or due to other site constraints. The segregated sand from dredging non-TSCA sediment in OUs 3 to 5 could be suitable for external berm construction at landfill sites. Granular material is used as part of the leachate collection system at landfills. Final cover is used during closure of municipal solid waste (MSW) landfills to provide a barrier between the landfill wastes and the surface. Physical and contaminant criteria will be dependent on the type of waste and other design considerations such as slope stability and erosion. Most final cover systems include a clay barrier layer, root zone, and topsoil layers. Some landfills also have a gas venting layer placed below the final cover system. The segregated sand from OUs 3 to 5 may be suitable for the root zone layer, or possibly the topsoil layer if mixed with organic materials (see manufactured topsoil alternative). Segregated sand suitable for use in a leachate collection system or for final cover would have to meet permeability and gradation requirements to be used as drainage media.

Landfills use daily cover to prevent odor and litter from escaping the landfill. Daily cover is a thin layer of material, typically 6 inches thick, laid over the waste each day. Materials suitable for daily cover include most grades of soil and sand. Because of the limited direct routes of exposure from a landfill it is likely that daily cover will allow a higher concentration of PCBs than other uses. This option may be dependent upon the final PCB concentrations of segregated sand fraction of the dredge material.

As with the other alternatives, the distance between OUs 3 to 5 and the landfill site is a significant factor in the economic viability of this alternative. The disposal contract negotiated with Veolia Hickory Meadows Landfill includes a provision for possible beneficial reuse of sand segregated from the sediment on the Fox River project, pending WDNR approval. This landfill is located approximately 34 miles from the LFR Processing Facility, where the sediment processing and sand segregation will occur.

Beneficial reuse as a daily cover is defined in NR 538.10(4). According to NR 538.10(1), material used for daily cover, if it can be shown to substantially eliminate leaching or emission of contaminants, will likely require a Category 5 or better industrial by-product as defined in NR 538.08. Additional regulations that could influence the reuse of dredge material for daily cover include NR 506.05, which requires MSW landfills to use a daily cover of 6 inches, NR 506.055, which allows approved alternative materials to be used for this purpose, NR 500.08(5), which allows exemptions from solid waste regulations to allow for beneficial reuse of materials, and the LHE defined under s. 289.43(8) Stats.

5.6.1.1.4 Manufactured Soil

This alternative involves mixing segregated sand from OUs 3 to 5 non-TSCA sediment with composted organic matter to create a saleable topsoil material. The specific application for the material will need to be developed taking into account economics, locally available organic materials, and the chemistry of the resulting by-product. Potential organic materials could include yard waste, WTP biosolids, sewage sludge, manure from large-scale farms, animal organic waste from local meat packers, or other organic wastes. There is also an accumulating body of scientific evidence that shows composting dredge material with organic carbon sources is an effective way to reduce the bioavailability of organic contaminants such as PCBs.

Several examples of this approach have been successfully carried out within Wisconsin and the Great Lakes, as follows:

- Dredge material high in nutrients, removed from Frankfort Harbor, Michigan, has been utilized to reclaim land for farming purposes. The land owner planned to develop an orchard over the reclaimed 20 acres.
- At the Milwaukee CDF, USACE has been involved in a demonstration project to treat dredge material through composting with other organic materials so as to produce a safe topsoil product that can be sold commercially (USACE 2003). (The results of that pilot project are available at: http://el.erdc.usace.army.mil/dots/doer/pdf/doerc33.pdf.) For that project, dredge material was placed in rows of mounds over wood chips and sewage sludge. The biomound rows are periodically turned to provide increased oxygen to facilitate biodegradation. It was shown that total PCB concentrations were reduced to levels not considered a risk by USEPA standards, although a standard was not

provided in the report. Preliminary market studies indicate that the product could sell for approximately $10 per cy, which will offset the cost of treating the dredge material. A similar project has been evaluated by Brown County.

- The Toledo-Lucas County Port Authority has a demonstration project that involves a partnership between the Port Authority, the City of Toledo, and a private topsoil manufacturing company. Under contract to the City, the company recycles the City's sewage sludge for a fee and provides the City with 4 cy of topsoil for every 1 cy of sewage sludge. The company creates the topsoil by mixing the sewage sludge with dredge material and lime sludge, a by-product of the drinking water treatment process. The resulting topsoil has been used extensively as the final vegetative cover for the City of Toledo's landfill. The material also has been used for landscaping at a State Park, at the Toledo shipyard, at a local park, and along roadways. The Port is expanding the acreage available for dredge material composting to create a program for permanent commercial-scale dredge material recycling.

The Fox River Valley is home to food processors, municipal wastewater treatment and solid waste facilities, paper mills, wood manufacturers, and livestock producers. This region also represents one of the fastest growing urbanizing populations in Wisconsin. Increasing competition and restrictions on land spreading, rising landfill costs, and loss of agricultural land to urban development have led farmers and industries to seek alternatives to direct land spreading and/or landfilling of their organic wastes.

A study to evaluate organic waste in the Fox River Valley has been completed by the Fox River Valley Organic Recycling (FRVOR) project (Wells et al. 2001). The FRVOR project was initiated to evaluate the economic, technical, organizational, and regulatory feasibility of centrally processing organic wastes to produce soil amendments. FRVOR has had involvement from local wastewater utilities, industry members, large scale farms, WDNR, and other interested stakeholders. Additional evaluation of this alternative is required to better understand the economic and environmental viability of this alternative in the local market in the Fox River Valley. Wisconsin regulations that address composting of organic wastes are covered in NR 502.12. Composting of other wastes is addressed under NR 502.08. If the dredge material has residual contamination, it might be allowed to be beneficially used under the full LHE process, but it will still be considered a regulated solid waste. NR 538 addresses beneficial use of high volume industrial waste, and contains tables of values for leach test and bulk solids concentrations for several parameters.

5.6.1.1.5 Roadway Construction

Several projects in the Detroit District of the USACE have utilized dredge material in construction, such as general fill for roadway embankments or bridge crossing, dike construction, urban and industrial use parking lots, and road sanding. For example, at the Erie Pier CDF in Duluth, Minnesota, dredge material is washed with on-site water to wash away the fine material, leaving clean sand. The clean sand is then used for various construction and industrial applications, including roadway construction.

This is a general category that shows significant promise for beneficial reuse of segregated sand from OUs 3 to 5. Specific project location(s) have not been identified at this time and need to be pursued in order to make this alternative viable. It is possible that state, county, or town roads could be used for this application. For example, significant road construction is planned in Northeastern Wisconsin over the next decade. Some portions of this work will likely occur in low lying areas where sand fill will be required to bring the roadway embankment to grade. In addition, overpasses will require embankments to be constructed out of suitable material such as clean sand. Important issues that will affect the feasibility of this alternative include distance to the road construction site from OUs 3 to 5, construction schedule for both projects, and the possibility for containment of the imported backfill material. Discussions with the WIDOT and local units of government have occurred and will continue as part of the ongoing VE efforts related to the beneficial reuse of sand.

Wisconsin regulations that address restricted fill are defined in NR 538.10(5-8). These include confined geotechnical fill and encapsulated transportation facility embankments, which require at least Category 4 material. Unconfined geotechnical fill and capped transportation facility embankments will have the more stringent requirements of Category 3 material. The requirements for these material categories are defined in NR 538.08(3-4) and in NR 538 Appendix E, Tables 2-3.

5.6.1.1.6 Upland Development

This is a general category that was identified during preliminary discussions on beneficial use. In general, this application includes placement of clean fill or a soil cover over Brownfield sites that are being redeveloped, or a green field site that requires imported fill as part of site construction. For the Fox River, this concept involves numerous opportunities for developing properties along the navigation channel in the Port of Green Bay. In order to make these properties suitable for commercial use, various site improvement activities may need to occur, such as the following:

- Dredging to allow for large boat access
- Installation of a bulkhead wall(s)
- Backfilling behind a bulkhead wall(s)
- Site preparation such as rail access and specific infrastructure needs

The segregated sand from OUs 3 to 5 would likely be suitable for backfilling behind a bulkhead wall from a geotechnical standpoint. Contaminant limitations will likely vary depending on the intended use of the property and existing or background contaminant levels present at a given site. Only non-residential end uses (industrial or commercial uses) will be considered (see Section 5.6.1.1). Design of a given site could include appropriate engineering controls to minimize environmental concerns associated with this application.

Surface cover or general backfill are not specifically addressed in NR 538; therefore, classification as a Category 1 material according to NR 538.12(3) and an exposure assessment according to NR 720.19(5) will likely need to be conducted prior to this application. The specific requirements for Category 1 materials are defined in NR 538.08(1) and in NR 538 Appendix E, Tables 1A and 1B.

5.6.1.1.7 Wetland Construction

This is a general category that was identified during preliminary discussions within the technical workgroup on beneficial use. Specific project location(s) have not been identified at this time and will need to be pursued in order to make this alternative viable. Wetlands typically occur in fine-grained soils that have a high organic content. Given the material under consideration for beneficial use is sand with low organic content, it is not likely a suitable material for wetland construction.

5.6.1.1.8 Mine Reclamation

This category was brought forward by WDNR in an effort to aid with local non-metallic mine reclamation. Each mine, prior to being permitted, is required to develop a Mine Reclamation Plan. In an effort for the mines not to be left abandoned, the mines are required to present plans that would leave the mines in a usable configuration when they are no longer viable for material mining.

The Tetra Tech Team has contacted some of the local mines to see if, as part of their reclamation plan, they would be in need of additional materials. Initial contacts have been made and conversations with these local mines will continue during the dredging phase of the project. From these initial talks, it is evident that until valid data show the cleanliness of the material, the mines are not willing to commit to the material.

5.6.1.1.9 Raw Material for Concrete or Asphalt Manufacturing

This category was identified during the initial discussions of the beneficial reuse of sand. The sand could be used in the manufacturing of concrete or asphalt in highway, commercial, or industrial projects. No specific manufacturers or projects have yet been identified to beneficially reuse sand in this manner.

5.6.1.1.10 Off-Site Private or Public Construction Projects

This category concerns potential off-site construction projects in the private sector or public works projects (e.g., for WIDOT), on which sand separated from sediment not subject to TSCA regulation may be used. In general, the material is proposed for use as foundation fill, parking lot subgrade fill, site grading, roadway subgrade, or drainage pipe bedding material. During the 2009 and 2010 operations seasons, separated sand was demonstrated to have trace amounts of residual PCBs, making it useful as a construction material. The requirements for the physical properties of the beneficial use material vary according to the construction project and will be evaluated on a case-by-case basis.

In early July 2010, an LHE Request was submitted to WDNR concerning potential beneficial reuse opportunities at several specific private and public off-site construction projects. A public meeting was held in early August 2010 as part of the LHE approval process. Following approval of the LHE, some of the public projects involving WIDOT construction may be able to accept and utilize substantially all of the separated sand produced during the life of the project, including material produced during 2009 and early 2010 that was intended for placement behind the sheetpile bulkhead wall. Altogether, nine off-site public and private construction projects were named in the LHE Request, although some of these are no longer viable. The public works projects, specifically those involving WIDOT, appear most likely to receive the sand as beneficial reuse material, subject to final approval by WDNR. The entire list of nine off-site projects named in the LHE Request and approved by WDNR include the following:

1. Foundation fill and parking lot subgrade fill for construction of the Salvation Army's Ray and Joan Kroc Center at 1315 Lime Kiln Road (north of Verlin Road), Green Bay, Wisconsin
2. Foundation fill, parking lot subgrade fill, site grading, or drainage pipe bedding material for construction of an apartment building at 1900 Morrow Street (near Berger Street), Green Bay, Wisconsin

3. Foundation fill, parking lot subgrade fill, site grading, or drainage pipe bedding material for construction of an apartment building at 2809 University Avenue Street (east of I-43), Green Bay, Wisconsin
4. Site grading, drainage pipe bedding, or backfill material for a construction project at Packerland Drive, between highways 29 and 54
5. Pipe bedding or backfill material for a sewerage pipeline relocation along the west side Highway 41 north of Mason Street; this is a WIDOT lead project on which the Green Bay Metropolitan Sewerage District is also providing funding
6. Foundation fill or site backfill material for deep fill on new elevated roadway construction at an additional WIDOT project at 2059 Shawano Avenue (close to Velp Avenue), Green Bay, Wisconsin
7. Foundation fill, parking lot subgrade fill, site grading, or roadway subgrade material for construction of a new facility expansion for Miller Electric in Appleton, Wisconsin
8. Foundation fill under a commercial building complex and parking lot subgrade fill at the Highline Development construction project located south of the intersection of STH 55 and CTH KK, Calumet County, Wisconsin
9. Subgrade fill and road way subgrade fill located at NW ¼ section 6, T20N, R19E Town of Harrison, Calumet County, Wisconsin

All of the separated sand produced during 2009 and 2010 operations was beneficially reused at location 6 in the list above except for 1,015 tons that were transported in 2009 to Veolia Hickory Meadows Landfill and used for construction in the landfill.

5.6.2 Upland Disposal Facilities

Section 5.6.6 of the 100 Percent Design Report Volume 1 presents details of the upland disposal facilities. The potential exists for changes in TSCA regulations including, for example, changes resulting in closure of disposal facilities, changes in the determination of TSCA and non-TSCA materials (i.e., in situ versus ex situ [i.e., "on the pile"] concentration), and restriction on transportation. These potential changes to regulations by federal, state, and local authorities will be actively monitored and incorporated into annual Phase 2B RAWPs, as appropriate.

In March 2011, Waste Management submitted a Risk-Based Disposal Approval Request and landfill permit information to the USEPA for disposal of dewatered sediment with less than 50 ppm PCBs at the Ridgeview Landfill in Whitelaw, Wisconsin. This request was approved in September 2012, and will allow waste from sediment areas characterized as TSCA in the river to be disposed of at Ridgeview Landfill if analytical results for the wastes show they have less than 50 ppm PCBs during the 2013 season and beyond.

5.6.3 Spill Prevention Measures

Section 5.6.7 of the 100 Percent Design Report Volume 1 presents spill prevention measures during dewatered sediment loading and transportation.

5.7 Handling of Clean Import Materials for Capping

5.7.1 LFR Processing Facility

5.7.1.1 Construction Materials

Section 5.7.1.1 of the 100 Percent Design Report Volume 1 presents a summary of construction materials to be used at the LFR Processing Facility. See also the Site Development Plan for the former Shell property (Tetra Tech et al. 2009b) for additional details.

5.7.1.2 Cap and Sand Cover Materials

The sand cover and capping materials will be delivered to the LFR Processing Facility and stockpiled to support the cover and capping operations on the river in OU 4. Limited stockpile space is available on the Site, requiring trucks to deliver materials periodically as the stockpiles are consumed.

During the capping and sand cover operations to be performed in 2010 and beyond, it is expected that 40 to 50 cy per hour (60 to 75 tons per hour) will be used. Due to the type of work, the capping and cover operations are planned for 24 hours per day, 5 days per week. This will require approximately 1,000 to 2,000 cy (1,500 to 3,000 tons) of these materials per day to support each cap or sand cover placement operation. Depending on the location within the river, J.F. Brennan may operate more than one cap or sand cover placement operation at a time. The planned stockpile areas at the LFR Processing Facility staging area (see Figure 3-2) will provide enough storage such that deliveries of this material to the Site could occur outside the placement times. Cover and capping operations in OU 4 are anticipated to occur during approximately the same times as the dredging starting in 2013 and continuing through the anticipated completion of the project in 2017. However, cold weather in November may limit capping to a greater extent than dredging resulting in an earlier winter shutdown of the capping or cover operations.

Several local suppliers of sand and gravel have been identified and include: Kiel Sand & Gravel, Inc., Daanen & Janssen, Inc., McKeefry & Sons, Fred Radandt and Sons, Inc., and Faulks Bros. The Tetra Tech Team has obtained quotations from these firms and believes each is capable of supplying the quantity and required specifications of capping materials needed for the project; however, it is expected that other potential sources will be identified in the future. Because these materials will likely come from several sources, truck traffic is not expected to be significant until the trucks approach the OU 2/3 secondary staging area or the LFR Processing Facility.

For detailed information on the cap and sand cover material specifications, refer to the Project Plan, included as Attachment C-0 of Appendix C.

5.7.2 OU 2/3 Secondary Staging Facility

Similar to the discussion in Section 5.7.1 for the LFR Processing Facility staging area, the OU 2/3 secondary staging facility will serve as a support area for sand cover and capping operations occurring in OUs 2 and 3 in 2009 and 2011. The material transport system begins at the material staging area, often referred to as the "land plant," which transfers the aggregate material in slurry form from shore to the spreader barge. Once the material has been delivered by trucks to the secondary staging facility, heavy equipment will be used to maintain stockpiles and transfer material into hoppers. The hoppers feed the pipeline that conveys the capping material to the spreader barges performing the capping. Preliminary haul roads, stockpile areas, and the configuration of the material slurry/loading equipment are depicted on Figure 3-1.

6 ENGINEERED CAP DESIGN

As described in the previous RD reports (BODR and 30 and 60 Percent Design Reports), designs for engineered sediment caps in OUs 2 to 5 were developed in accordance with the following detailed guidance for in situ capping developed by USEPA and USACE:

- *Contaminated Sediment Remediation Guidance for Hazardous Waste Sites* (USEPA 2005)
- *Guidance for Subaqueous Dredged Material Capping* (Palermo et al. 1998a)
- *Assessment and Remediation of Contaminated Sediments (ARCS) Program Guidance for In Situ Subaqueous Capping of Contaminated Sediments* (Palermo et al. 1998b)

These documents provide detailed procedures for site and sediment characterization, cap design, cap placement operations, and monitoring for subaqueous capping. Caps designed according to the USEPA and USACE guidance have been demonstrated to be protective of human health and the environment (USEPA 2005).

Consistent with the above-referenced guidance, the BODR, 30 Percent Design, and 60 Percent Design present the design thickness and other specifications for in situ engineered caps in OUs 2 to 5, which are based on consideration of the following five components:

- Chemical isolation of contaminants (Ti)
- Bioturbation (Tb)
- Consolidation (Tc)
- Erosion (Te)
- Operational considerations (i.e., gas generation, placement inaccuracies, and geotechnical filtering) (To)

Given the variability of Site conditions (e.g., PCB concentrations and erosion potential) throughout OUs 2 to 5, three general cap designs were developed for the BODR, primarily based on PCB concentrations, which are described in detail in Appendix D of the BODR (included in Attachment B-10 of Appendix B of this 100 Percent Design Report Volume 2). Subsequent refinements of these cap designs were presented in the 30 and 60 Percent Designs, including considerations of location-specific erosive forces and PCB concentrations; these refinements are briefly summarized in the following sections and details are provided in the 30 and 60 Percent Design Reports.

Numerous technical memoranda and engineering evaluations (related to the cap design) were developed and performed as part of the 30 and 60 Percent Designs. Refer to the BODR, 30 Percent Design Report, and 60 Percent Design Report for a complete description of the engineered cap design. This 100 Percent Design Report presents a summary of the cap design presented in the BODR, 30 Percent Design, and 60 Percent Design. In addition, this 100 Percent Design Report Volume 2 presents the results of a review of cap delineation using the A/OT's DRT (see Section 4.2 and Appendix M). Note that these cap designs may be further refined in the future, as part of the AM or VE processes, or to reflect infill or other sampling results, subject to A/OT concurrence. The Remedial Design Anthology includes a compilation of all technical memoranda and design documents related to the engineered cap design.

6.1 Cap Components

6.1.1 Chemical Isolation Component

The 30 Percent Design presented the design of an appropriate chemical isolation layer thickness based on the PCB concentration in the top 6 inches of sediment immediately underlying the cap, consistent with the criteria specified in the ROD Amendment.

- **Cap Type A – Engineered caps of at least 3 inches of sand for chemical isolation:** PCB concentrations will not exceed 50 ppm within the sediment profile and PCBs in the top 6 inches of sediment immediately beneath the cap will be less than 10 ppm.
- **Cap Type B – Engineered caps of at least 6 inches of sand for chemical isolation:** PCB concentrations will not exceed 50 ppm within the sediment profile and PCBs in the top 6 inches of sediment immediately beneath the cap will be less than 50 ppm.
- **Cap Type C – Engineered caps of at least 6 inches of sand for chemical isolation:** Cap C may be utilized where PCB concentrations exceeding 50 ppm are buried within the sediment profile (i.e., 18 inches or more below the base of the cap) or in shoreline areas where dredging would result in instability. Note: PCB concentrations will not exceed 50 ppm within the top 18 inches of sediment immediately beneath the cap, but can exceed 50 ppm deeper than 18 inches beneath the bottom of the cap. For shoreline caps, if the top 18 inches of sediment is greater than 50 ppm, then, depending upon the concentration, a

thicker layer of chemical isolation sand will be required or the sediment greater than 50 ppm may be dredged before installation of the cap (see Section 6.3).

Field verification of designed cap thicknesses will include the collection of samples for PCB analysis in dredge-and-cap areas following dredging but prior to cap placement, in order to verify RD forecasts and confirm the appropriate cap type and configuration is applied based on the measured concentration of residuals (see the CQAPP in Appendix F for additional details of PCB analysis in dredge-and-cap areas). Sampling densities and frequencies for this purpose may be reduced over time through AM if the RD forecasts are consistently verified and the A/OT concurs.

6.1.2 Bioturbation Component

The BODR stated that the bioturbation depth is expected to be limited to the upper 5 to 10 cm (2 to 4 inches). As mentioned above and as discussed in the BODR, the cap designs developed in the 30 Percent Design and summarized herein provide an erosion protection layer component (Te) of the cap that is sufficient for protection against both anticipated physical forces and bioturbation (Tb).

6.1.3 Consolidation Component

The cap material itself will be granular and is expected to undergo elastic settlement within the period of construction; therefore, no additional cap thickness is included to account for long-term cap consolidation. However, as discussed in the BODR, cap-induced consolidation of existing sediments resulting in porewater expulsion was considered in the chemical isolation thickness design outlined in Section 6.1.1.

6.1.4 Erosion Protection Component

Several potential physical forces of erosion, including hydrodynamic flows, ice scour, wind-induced waves, and vessel-induced propeller wash and vessel wakes, were evaluated for the cap design, as detailed in Appendix D of the BODR. Refinements regarding the erosion component of the cap (e.g., vessel-induced propeller wash, vessel wakes, and hydrodynamic flows) were presented in the 30 Percent Design and 60 Percent Design, as summarized in Sections 6.1.4.1 and 6.1.4.2.

6.1.4.1 Vessel-Induced Propeller Wash Analysis

As part of the BODR, the potential impacts of propeller wash from large ocean-going vessels operating in the OU 4B channel were evaluated consistent with USEPA/USACE guidance documents (Palermo et al. 1998a) and technical literature (Verhey 1983; Blaauw and van de Kaa 1978). The available guidance was used in the BODR to design a protective cap for the OU 4B channel consisting of a 33-inch-thick sand, gravel, and quarry spall (6- to 9-inch-diameter stones) cap, as detailed in Appendix D of the BODR. This propwash and the associated cap armor design analysis specific to the OU 4B channel areas remain unchanged from the BODR, except as noted in Section 6.2.1 relative to the armor design for the navigation channel side slopes. However, the Agencies issued a memorandum on June 14, 2012, summarizing a "minor change to the selected remedy" that permits the use of Cap B2 (see Table 6-6) in the OU 4A navigation channel south of the Fort Howard turning basin except when any core intervals contain greater than 50 ppm PCBs. This is allowed because the OU 4A navigation channel is now designated as "caretaker status," routine navigation dredging is not expected, and large vessels (e.g., cargo) will not subject these areas to significant erosive forces. In addition, the 30 Percent Design presented refinements to the propwash analysis for small, moving recreational vessels, for which the USEPA/USACE guidance may not be fully applicable.

The 30 Percent Design presented the results of a more detailed analyses of the propwash from recreational vessels, conducted to refine and optimize cap designs to further ensure long-term stability and performance by developing recommendations for the size of armor stone that would be necessary to resist the erosive forces from the propeller wash generated by recreational boats operating on the Lower Fox River. As part of these more detailed analyses, available Site-specific vessel information was reviewed to develop a refined propwash modeling framework specifically for evaluating recreational propwash on the Lower Fox River while taking into account modeling results and engineering considerations (e.g., material gradations, implementability, and cost). A series of technical memoranda were developed and submitted summarizing the technical basis for the Fox River propwash modeling framework and illustrating an example computation (see the Remedial Design Anthology for compilation of propwash modeling documentation).

Table 6-1 summarizes the general cap armor recommendations necessary to resist the erosive forces expected to be generated by recreational vessels operating in various water depths of the Lower Fox River. These recommendations were developed through the technical workgroup process with the A/OT based on an engineering evaluation utilizing Monte Carlo model output, engineering considerations, and best professional judgment. A detailed summary of the refined propwash analyses is provided in Attachment B-3 of Appendix B.

Table 6-1
Summary of Cap Armor Recommendations for Recreational Propwash

Post-Cap Water Depth	Median Stone Size, D_{50} (inches) [a]	Maximum Stone Size, D_{100} (inches) [a]	Classification
3 to 4 feet	3	6	Gravel/Cobble
4 to 6 feet	1.5	3	Gravel
>6 feet	0.5 min [b]	2	Gravel

Notes:
This table presents recommended armoring to resist propwash from recreational vessels operating in OUs 2 to 5. Propwash armor designs for the OU 4B channel, where large ocean-going vessels operate, are included in Table 6-6.

a. Armor stone sizes represent minimum design requirements—larger stone sizes may be utilized at the time of construction if available, such that cap designs, thickness, or costs, are not adversely affected.
b. At the request of the A/OT, the Tetra Tech Team has agreed to use armor stone with a median particle diameter (D_{50}) of at least 0.5 inches, which is representative of a specific material gradation approved by the A/OT on August 3, 2011. See Attachment C-0 of Appendix C for specific material gradations approved by the A/OT.

Specifications for material gradations satisfying the armoring criteria presented in Table 6-1 and for the chemical isolation layer are presented in Attachment C-0 of Appendix C. These gradations were reviewed in light of geotechnical filter criteria to assess the potential for migration of smaller underlying particles through the overlying armor (i.e., the sand from the chemical isolation layer through the armor layer) under hydrodynamic mixing. This evaluation was performed utilizing guidance developed by Terzaghi and Peck (1967) and then extended by USACE (1993). The filter layer analysis indicates that the material gradations presented in Attachment C-0 of Appendix C will prevent erosional energies from permeating through the voids of the armor layer and potentially eroding the underlying cap materials. Therefore, a separate filter layer is not required for areas designated as Cap A or Cap B utilizing the armor stone designs presented in Attachment C-0 of Appendix C and summarized in Table 6-1. In these cases, the sand layer will function as both the chemical isolation and geotechnical filter layer.

The general recommendations for cap armor materials were used in conjunction with the results of other hydrodynamic analyses relative to cap design (e.g., wind wave, vessel wake, and river flows) to delineate the extents of various cap armor designs within OUs 2 to 5 (see Section 6.3). In addition to these general recommendations, ground rules were developed in the technical workgroup as part of the 60 Percent Design related to refinements of the general cap armor designs in specific, localized areas of the river based on Site-specific conditions such as shoreline areas, proximity to stormwater or other permitted outfalls, boat launches, and marine facilities. Final designs for these areas based on ongoing Site-specific evaluations will be presented in separate technical memoranda to be submitted as addenda to this 100 Percent Design Report Volume 2, as discussed in Section 6.4.

During 2009 technical workgroup meetings held with the Response Agencies, it was agreed that cap armor stone with the largest size that could be pumped without additional cost would be used, provided the material cost is the same for all gravel, regardless of grain size. Installation of larger armor stone provides an additional factor of safety against erosive forces from propwash, and in the event that water levels decline. According to J.F. Brennan, gravel with a D_{50} of 1 to 1.5 inches (maximum particle size [D_{100}] of 2 to 3 inches) is the largest rock that can be placed without an increase in installation costs. Therefore, the Tetra Tech Team will use gravel armor for caps in areas with more than 6 feet of water depth with a D_{50} of 0.5 inches or larger, as represented by a specific gradation approved by the A/OT (see Attachment C-0 of Appendix C for approved material gradations).

6.1.4.2 Vessel Wake Analysis

As part of the 30 Percent Design phase, engineering analyses were performed to further evaluate the erosive forces in shoreline areas designated for capping (i.e., engineered cap or dredge-and-cap). Specifically, impacts from vessel-generated waves were preliminarily evaluated for representative cap areas in OUs 3 and 4, considering typical design vessels passing through areas targeted for capping, to design cap armor stones to resist the predicted design wave(s). The approach and preliminary results for this evaluation were described in Attachment B-5 of Appendix B of the 30 Percent Design. As part of the 60 Percent Design, additional calculations were performed to refine the general shoreline cap design including wave run-up analyses to determine the appropriate top elevation of armoring and slope stability analyses to support design of appropriate toe of slope support. The results of the vessel wake analyses are summarized herein and presented in Attachment B-2 of Appendix B.

For the vessel-generated wave analysis, classification of design vessels was based on a comprehensive evaluation of data compiled from several resources including ship arrival records from the Port of Green Bay, reported bridge openings on the Lower Fox River within OU 4, and information compiled for the propeller wash analysis discussed in Section 6.1.4.1.

The 30 Percent Design detailed a series of models used to estimate the critical wave height generated by a given design vessel passing through representative sections of the Lower Fox River where dredging and/or shoreline capping are anticipated along the riverbank. Table 6-2 presents a summary of the armor layer design necessary to resist vessel wakes anticipated for representative transects in OUs 3, 4A, and 4B. Future Site-specific RA planning (e.g., annual Phase 2B RAWPs) will include a review of the applicability of these designs to specific shoreline cap areas within OUs 2 to 5 including Site observations and Site-specific conditions. Attachment B-2 of Appendix B provides additional details of the critical wave predictions and armor layer designs.

Table 6-2
Summary of Preliminary Cap Armor Recommendations for Vessel Wakes

Representative Capping Area	Design Water Depth (feet)	Critical Design Wave Height (feet)	Cap Design					
			Armor Layer			Filter Layer		
			D_{50}	D_{100}	Thickness	D_{50}	D_{100}	Thickness
			Cap Armor within Surf Zone [a]					
OU 3/4A (Transect 4044)	0 to 4.1	3.22	8.16 in.	13 in.	16.3 in.	1 in.	1.8 in.	12 in.
OU 4B (Transect 4061)	0 to 4.2	3.27	8.2 in.	13 in.	16.4 in.	01 in.	1.8 in.	12 in.
			Capping Armor below Surf Zone [a] D_{50} (inches)					
OU 3/4A (Transect 4044)	4.1+	3.22	D_{50} = 0.95 inches (Coarse Gravel) as single layer approximately 6 inches thick					
OU 4B (Transect 4061)	4.2+	3.27	D_{50} =0.82 inches (Coarse Gravel) as single layer approximately 6 inches thick					

Notes:

D_{50} = median particle diameter in gradation

D_{100} = maximum particle diameter in gradation

a. Surf zone defined herein as water depth range subject to breaking waves, which may extend from the top of bank to approximately 1 time the wave breaking depth. Therefore, the surf zone can be defined as from the top of bank to approximately 4.2 feet deep. Attachment B-2 of Appendix B provides additional details of the breaking wave depth evaluation.

6.1.4.3 Hydrodynamic Flow Analysis

The BODR presented a hydrodynamic flow analysis of post-cap bathymetric conditions (based on preliminary cap delineation) for the reasonable worst-case hydrodynamic design condition (i.e., simultaneous 100-year flows, historical low water levels, and maximum seiche amplitude). Based on this analysis, a maximum bottom shear stress of 100 dynes/cm^2 was selected for design and was correlated to a stable median grain size (D_{50}) of 1.5 inches, based on the approach described by Shields (1936) and including an additional factor of safety of 2. Therefore, a minimum thickness of 4 inches of armor stone with a median diameter (D_{50}) of 1.5 inches is appropriate for this design and is consistent with USEPA/USACE guidance.

Subsequent to the BODR, additional supplemental model simulations were performed in March 2007 using a range of extreme (greater than 100-year event) flow assumptions, including hindcasting from a record rainfall event that occurred on June 22 and 23, 1990 (Shaw and Anchor 2007). The results of this sensitivity analysis modeling further confirmed that the engineered cap designs presented in the BODR will adequately protect against disturbance from extreme river flows.

To supplement previous modeling of extreme river flows and to further ensure that appropriately conservative cap designs are specified for localized areas of OU 4, the two-dimensional hydrodynamic model was revised in October 2007 as part of the 30 Percent Design to evaluate the localized effects of tributary inflows at their specific geographic location during the peak discharges measured during the June 22 and 23, 1990 event discussed above. For both OUs 3 and 4, resulting shear stresses in the majority of the reaches were predicted to be significantly less than the maximum bottom stress of 100 dynes/cm^2 selected for armor stone design in the BODR. Localized shear stresses in excess of the original design shear stress (100 dynes/cm^2) were observed in only two areas: OU 3 immediately below the Little Rapids Dam, and the federal navigation channel in OU 4 downstream of the East River turning basin. However, these areas have not been targeted for capping as part of the OUs 2 to 5 RA (it should be noted that cap areas are planned adjacent to the East River turning basin and at the mouth of the East River, but these areas are not within the area of localized high shear stress predicted within the navigation channel during the extreme event). Therefore, this supplemental modeling further confirmed that the engineered cap designs presented in the BODR and 30 Percent Design Report will adequately protect against disturbance from extreme (greater than 100-year) river flows. The supplemental hydrodynamic modeling approach and results were presented in detail in Attachment B-4 of Appendix B of the 30 Percent Design.

Localized high shear stress may also occur around bridge pilings and other support structures that constrict flow. These structures are located in bridge corridors with offset areas that were not included in the RA during the previous design stages. However, these areas will be evaluated on a case-by-case basis, following the completion of infill sampling in each area, to determine the most appropriate remedy that can be performed safely. A technical memorandum (or memoranda) will be submitted summarizing the evaluation of each structure, which will include an evaluation of shear stress if capping is proposed in the area. The technical memorandum (or memoranda) will be submitted as an addendum to this 100 Percent Design Report or in the annual Phase 2B RAWPs based on hydrodynamic analyses to be performed later, using the expected post-remedy bathymetry from implementing the approved RD.

6.2 Additional Cap Design Considerations

6.2.1 Federal Navigation Channel

The extent of engineered caps has been delineated to avoid interference with the navigation and maintenance of the federal navigation channel. As such, the horizontal extent of caps was offset beyond the lateral boundaries of the federal navigation channel in both OU 4A and OU 4B, which in many cases is outside of the toe of the slope of the maintained channel. The top of the cap (with target overplacement allowance) was offset at least 2 feet below the vertical boundary of the navigation channel (i.e., 2 feet below the authorized channel depth without consideration of overdredge allowances beyond the minimum required dredge depth). The boundaries of the federal navigation channel in OU 4A were based on the reauthorization language included in the Water Resources Development Act (WRDA) of 2007 (Pub. L. 110-114), provided below:

> **SEC. 3173 GREEN BAY HARBOR, GREEN BAY WISCONSIN**
> The portion of the inner harbor of the Federal navigation channel of the Green Bay Harbor project, authorized by the first section of the Act entitled “An Act making appropriations for the construction, repair, and preservation of certain public works on rivers and harbors, and other purposes”, approved July 5, 1884 (23 Stat. 136), from Station 190+00 to Station 378+00 is authorized to a width of 75 feet and a depth of 6 feet.

Cap design evaluations conducted as part of the BODR, and confirmed during subsequent design phases, indicated that 6- to 9-inch-diameter armor stones (e.g., quarry spalls) would be appropriate for resisting propeller wash generated by large cargo ships operating in the OU 4B federal navigation channel. This armoring was estimated to be necessary primarily along the base of the navigation channel.

Within the turning basins (e.g., immediately downstream of the Canadian National Railroad bridge located at river mile 3.3; often referred to as the “Fort Howard turning basin” and at the confluence of the East River; often referred to as the “East River turning basin”), it is possible that vessel maneuvering operations could result in the main propeller and/or bow thruster propeller being directed perpendicular to the side slopes. Furthermore, given the relatively limited turning radius within this area, the distance between the bow thruster propeller and the side slope could be limited (50 feet or less in extreme cases). An evaluation of possible bow thruster impacts and necessary armoring to resist erosion under a conservative range of possible conditions (e.g., maximum operating power, varying water depth, side slope angle, and vessel offset distance) was conducted as part of this 100 Percent Design and is presented in Attachment B-3 of Appendix B. These results have been utilized to preliminarily design armoring for caps placed on the side slopes of the turning basins that could be subject to significant bow thruster or main propeller propwash. Additional engineering evaluations and possible cap design refinements for these areas may be conducted on a case-by-case basis using Site-specific information. Proposed design refinements for each of these areas will be presented in the annual Phase 2B RAWPs. Attachment B-4 of Appendix B presents slope stability analyses for these capped slopes that were incorporated into the design to ensure cap stability.

The majority of the navigation channel dredge area side slopes (designed at 3 horizontal to 1 vertical [3H:1V] extending outside of the limits of the authorized channel) are not subject to bow thruster impacts. In addition, navigation channel areas that do require dredging have un-designed side slopes resulting from USACE "box cutting" the channel during maintenance dredging operations, where the resulting side slopes are formed at the natural angle of repose underwater. Propwash from the main vessel propellers would be generally directed along the centerline of the channel (i.e., parallel to the side slopes rather than perpendicular to them). Calculations completed as part of the 30 Percent Design and reviewed within the technical workgroup as part of the 60 Percent Design indicated that smaller armoring (typically less than 3-inch diameter) would be appropriate to resist propwash along these side slopes of the navigation channel. In this case, the distance between the propeller and the side slope is typically in excess of several hundred feet, resulting in significant reductions in the erosion potential due to the radial spread and dissipation of energy within the propwash jet. Figure 6-1 presents a conceptual depiction of a vessel's propwash jet in relation to the side slopes. Attachment B-3 of Appendix B presents a summary of the propwash calculations for the cap armor design that is applicable to the majority of the side slopes of the OU 4B navigation channel.

Other limited stretches of the navigation channel side slopes (aside from the Fort Howard and East River turning basins) may be subject to propwash flows at an incident angle to the side slope (i.e., not parallel or perpendicular). This would primarily occur on the outside of a bend in the navigation channel. Within the capping areas delineated as part of this 100 Percent Design, only the eastern side slope of the channel between transects 4050 and 4051 and the western side slope near transect 4056 could be subject to propwash flows at an incident angle. Based on a propwash evaluation for these areas (see Attachment B-3 of Appendix B) the 33-inch-thick cap with quarry spall armoring along the side slopes will be required at transect 4056 due to the proximity of potential propwash flows along the side slopes. However, propwash effects at transects 4050 and 4051 are expected to be less than those on the side slopes of the turning basins and 3-inch-diameter cap armoring will be sufficient. Note that following the collaborative DRT evaluations (see Appendix M), the navigation channel's western side slope at transect 4056 is proposed as dredge only.

Other areas that are subject to significant propwash from the main vessel or bow thruster propellers, such as commercial boat slips or other areas of high vessel activity, have been considered as part of the collaborative workgroup meetings with the A/OT as part of the DRT and have been incorporated into this 100 Percent Design. Areas of apparent propeller wash impacts, as evidenced by scouring visible in bathymetric surveys, were either delineated as dredge only or appropriate cap armoring (e.g., Cap C) was designed. These areas include remedies associated with or adjacent to the following locations:

- Fort Howard turning basin
- LaFarge terminal
- US Oil/Standard Oil
- Fox River Dock
- Highway 172 bridge
- Leicht terminal

The cap designs in these areas are subject to future discussions with property owner and possible Site-specific reviews with any design refinements to be documented in addenda to this 100 Percent Design and/or the annual Phase 2B RAWPs.

In addition to the erosion protection provided by the large armor stone placed within the navigation channel as discussed above, it will serve as a physical marker of the top of the cap if future maintenance dredging inadvertently excavates well below the authorized depth in the OU 4B channel. Appropriate construction techniques will be required to ensure proper cap placement, thereby limiting the potential for slope stability failures from cap construction. This will involve the placement of materials in a "bottom up" fashion on slopes greater than 5 percent (where feasible), whereby materials are first placed at the toe of a slope and construction proceeds towards the top of slope. A toe berm can be used to provide an initial platform for the capped materials to be placed without sloughing. In this way, cap materials will be continually placed against a firm toe support and are not allowed to slump towards the base.

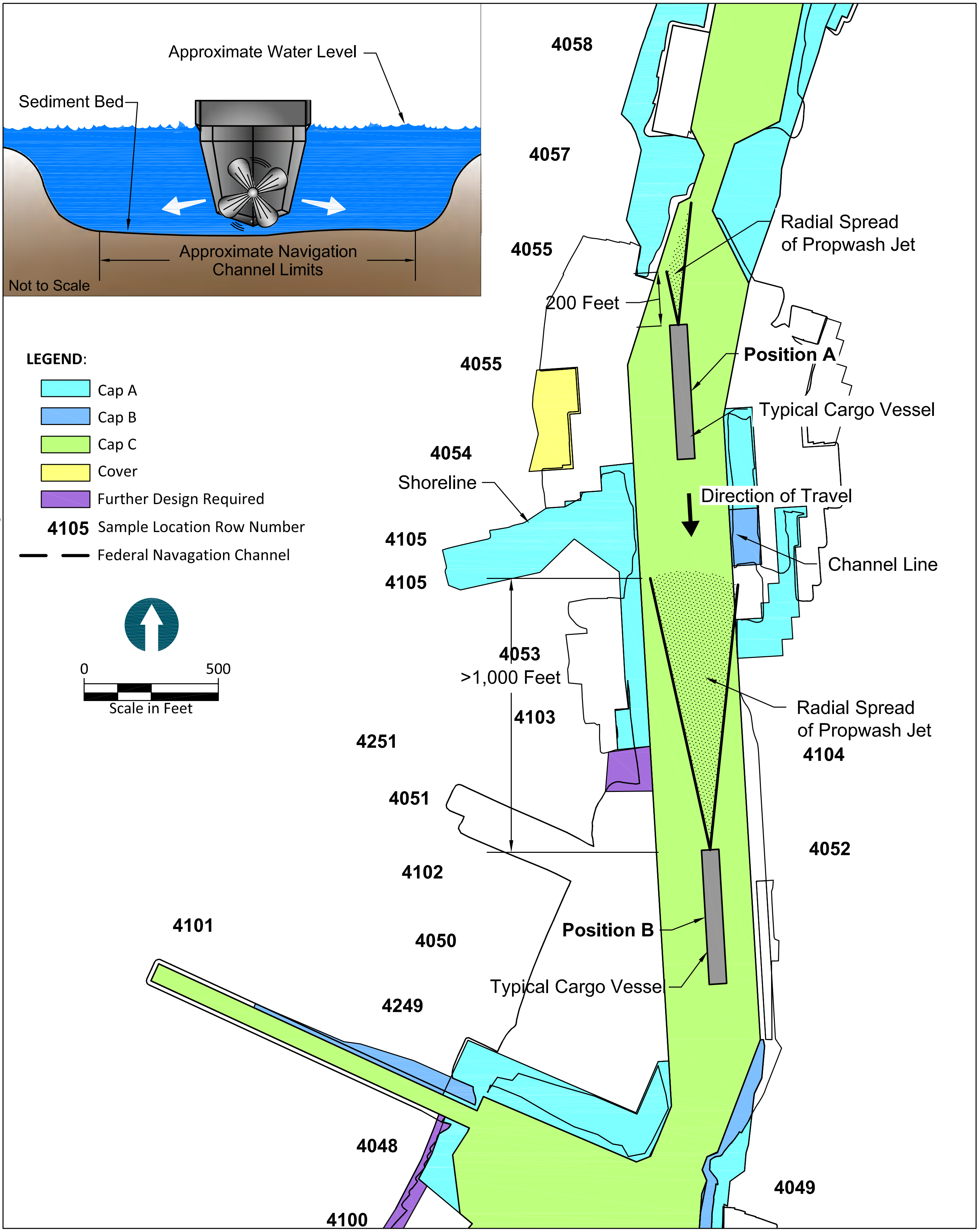

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Figure 6-1
Conceptual Depiction of Propwash in Navigation Channel
Fox River 100% Design Volume 2

6.2.2 Infrastructure and Utilities

The riverbanks along much of the Site have been developed as either commercial (primarily in OU 4B) or residential (primarily in OUs 2, 3, and 4A). Along these banks and crossings of the river, numerous structures (e.g., bulkhead walls and shore protection), docks, piers, bridges, and utility crossings have been identified through surveys and supplemental field reconnaissance. The BODR and 30 Percent Design presented a preliminary set of potential design refinements to address infrastructure, utilities, or shoreline conditions (see Table 6-3).

Table 6-3
Potential Remedial Design Considerations Near Shorelines and Infrastructure

Shoreline Condition	Potential Remedial Design [a,b]
Shoreline deposits	If shoreline DOC < 2 ft, dredge with partial removal of uplands or cap if appropriate; otherwise, cap along shoreline if dredging would impact stability
Sheetpile wall	Review of wall design relative to potential dredge cut; cap along shoreline if dredging would impact stability; caps may not be allowed near sheetpile wall if they impede navigation or the riparian landowner's intended depths.
Riprap or armored slope	Additional sampling in nearshore slope areas to refine extent of sediments > 1.0 ppm RAL; adjust dredging and capping plan accordingly
Pile-supported wharf	Review to address impacts of dredging and/or capping
Floating dock with guide piles	Review to address impacts of dredging and/or capping
Outfall	Review to address potential options including: dredge around outfall, cap above outfall, relocate outfall, and extend outfall through shoreline cap
Shoreline building	Cap or dredge along shoreline depending on stability evaluation
Shoreline or in-river bridge support	Cap along shoreline with review of potential dragdown forces on support
Utility crossings	Dredge and/or cap over utilities and, only when necessary, offset dredge and cap
Boat launch/ramp	Potential options include armored cap and dredge/armored cap

Notes:

a. Preliminary RD for these areas presented herein is based on the ground rules established in Section 6.4. Final RD will be based on the results of detailed shoreline surveys and investigations, including infill sampling, as well as engineering stability analyses. Technical memoranda detailing the final RD will be submitted as addenda to this 100 Percent Design Report, if the final design requires an exception to the ROD or additional A/OT approval.

b. DOC = depth of contamination, as determined through geostatistical modeling or discrete shoreline sampling

As part of the 60 Percent Design, the collaborative workgroup reviewed specific examples to establish ground rules for preliminarily designing remedies surrounding infrastructure, utilities, and shoreline areas (see Section 6.4). The final RA for each area is currently being refined based on further assessment of the extent of contamination (i.e., infill sampling), potential environmental risks posed by the contaminated sediment, practicability and risks of performing the RAs, and discussions with applicable utility owners, as appropriate. The Engineered Plan Drawings associated with this 100 Percent Design Report Volume 2 contain "primary designs" associated with each of these infrastructure, utilities, and shoreline areas. The final RA plans for each area, to be created following Site-specific review, will be presented in a series of technical memoranda, as necessary, to be submitted as addenda to this 100 Percent Design Report. These final RA plans may differ from the primary designs contained in this report.

6.2.3 Geotechnical Stability

Several geotechnical evaluations relative to the stability of engineered caps were evaluated as part of the BODR, 30 Percent Design, and 60 Percent Design, including:

- **Bearing Capacity of Existing Sediments.** A maximum cap layer thickness (i.e., critical height differential of placed sand or armor) of 10 to 12 inches that could be placed in a single application was calculated in general accordance with the USEPA/USACE guidance (Palermo et al. 1998b). However, initial capping as part of the start-up areas will be placed with a maximum 6-inch initial cap lift thickness to assess potential mixing of the cap into underlying sediment. If observations from cap placement verification indicate more than 3 inches of mixing between capping material and existing sediment, cap placement operations will be reviewed and cap may be placed in multiple lifts, potentially providing a consolidation period between lifts to increase bearing strength. The results of initial and ongoing cap placement monitoring, specifically results of the start-up capping, may be used to adjust this maximum lift thickness as construction proceeds. It should be noted that mixing of sand with underlying existing sediments is expected to be negligible based on recent experience at the OU 1 site using the same broadcast spreading equipment that is planned for the OUs 2 to 5 sand placement.
- **Slope Stability.** Analyses indicate that, in general, caps placed on slopes up to 3H:1V are predicted to be stable, with a minimum acceptable factor of safety of 1.5 or higher (see Attachment B-4 of Appendix B). More detailed evaluations of nearshore cap requirements will be performed in the year prior to RA in a particular area based on the ground rules developed in the 60 Percent Design and refined in this 100 Percent Design (see Section 6.4.1) with final designs for each area to be included in the annual Phase 2B RAWPs.

- **Cap Punch-Through Analysis.** Analyses were conducted for the BODR consistent with USEPA/USACE cap design guidance (Palermo et al. 1998b), to ensure that caps would support the weight of an individual walking on the surface, assuming that the top of the caps could be in shallow water (e.g., 3 to 5 feet deep). This analysis concluded that the cap designs have a factor of safety of at least 3.0 under this condition and, thus, will be stable under worst-case bearing loads. It should be noted that human foot traffic on caps is expected to be very limited because the vast majority of capping areas will have a post-cap water depth in excess of 6 feet and that the medium to fine gravel armor layer will spread human foot traffic (incidental point loads) increasing bearing capacity to an acceptable factor of safety.
- **Differential Settlement.** Engineering analyses performed for the BODR and 30 Percent Design indicated that cap-induced settlement of existing sediments will be a slow process, typically occurring over a period of years. In addition, RD geotechnical data indicated that physical properties of the sediment planned for capping have minimal spatial variability. At the edges of the planned capping areas, potential differential settlement resulting from differential loading will be mitigated by the cap design, which includes a "run-out" to gradually transition the cap loading on existing sediments. Bathymetric surveys and sampling efforts following cap placement in OU 1 in 2006 showed effective distribution of the cap load across the footprints and did not reveal significant heaving or disturbances beyond the lateral extent of the caps (Foth Infrastructure and Environment, L.L.C. 2008).
- **Dynamic Pressure.** A literature review of dynamic pressure under varying conditions (e.g., varying hull geometry and vessel speed) concluded that propwash velocities are significantly larger than dynamic pressure-induced bottom velocities measured for barges in the Mississippi River and dynamic pressure effects from recreational vessels have an insignificant forcing relative to propwash forcing (see Attachment B-3 in Appendix B of the 30 Percent Design). Therefore, cap armor designs that are protective of propwash velocities are expected to also be protective of dynamic pressures caused by passing vessels.

6.2.4 Post-Cap Water Depth

Consistent with the ROD Amendment, all engineered caps (including capping with and without prior dredging, but with the exception of shoreline caps) have been designed such that a minimum post-cap water depth of 3 feet will be maintained under historical low water elevations summarized in Table 6-4. These historical low water elevations have been assumed as the baseline water elevation for post-cap water depth evaluations presented herein. Although the ROD allows for capping in waters as shallow as 3 feet, the cap delineation presented herein was aimed at limiting the amount of capping to be performed in areas where the post-cap water depth would be less than 6 feet, as discussed in the Engineered Cap Delineation Tech Memorandum (Attachment B-7 of Appendix B). In addition, detailed armor designs were developed during the 30 Percent Design for ranges of post-cap water depth under historical (baseline) low water conditions to accommodate specific erosion characteristics, including propwash, vessel wakes, and other factors, as detailed above. The AM and VE Plan (Appendix E) discusses the process to be implemented in the event the water levels decline below the baseline water elevation dynamic height summarized in Table 6-4.

Consistent with the general ground rules and evaluation process described in the Engineered Cap Delineation Tech Memorandum (Attachment B-7 of Appendix B), the RD Team reviewed the anticipated post-cap water depth under historical low water condition for each of the planned capping areas in OUs 2 to 5 to select an appropriate armor stone. Any "exceptions" to the design requirements described in Tables 1 or 2 of the Engineered Cap Delineation Tech Memorandum are summarized for Response Agencies' approval as part of the Remedial Design Anthology. It should be noted that armor stone designs for some cap areas may be subject to further refinement based on any additional infill sampling. The Tetra Tech Team may elect to expedite any additional infill sampling in shallow water cap areas to reach resolution on the armor stone design. Any refinements to the delineation of cap areas or armor stone sizing resulting from this additional sampling will be documented in the annual Phase 2B RAWPs.

The delineation of cap areas (including shoreline caps) and specific designs will continue to be evaluated as RA progresses, incorporating the results of the 2012 infill sampling, any additional infill sampling data, and any approved VE revisions. This evaluation will include top of cap elevation relative to the historical low water elevations, alternative cap designs that may be more conducive to these areas, and a dredge-versus-cap cost analysis to determine if dredging these areas would be more cost effective than capping. Potential revisions to shoreline cap areas or design may be pursued through the AM and VE process and incorporated into annual Phase 2B RAWPs for 2010 and beyond.

Table 6-4
Summary Baseline Water Elevations

Operable Unit	Baseline Water Elevation Dynamic Height		Basis for Selection
	(IGLD85)	(NAVD88)	
OU 2	593.5 feet	593.6 feet	NOAA Low Water Datum above Little Kaukauna Dam
OU 3	587.3 feet	587.5 feet	Crest of De Pere Dam (and NOAA Low Water Datum)
OU 4	576.5 feet	576.6 feet	Lower 1% occurrence frequency of hourly summer data from NOAA gage at Green Bay (adjusted for long-term data record through 1953). In comparison, the NOAA Low Water Datum for OU 4 is 577.6 feet.

6.3 General Cap Designs and Areas

As discussed in Section 6.1, the BODR developed three general cap designs based on preliminary engineering analyses. These cap designs were subsequently adopted in the ROD Amendment and subsequent ESD, which specified minimum thickness criteria based on PCB concentration and the preliminary erosion analyses presented in the BODR, as summarized below:

- **Cap A – Sand and gravel cap for PCBs less than 10 ppm** – consisting of a minimum 3 inches of placed sand (equivalent to a targeted average thickness of 6 inches within the placement area considering normal overplacement allowances), overlain by a minimum 4 inches and 6 inches of placed armor material (an average of 7 inches and 12 inches with overplacement allowances) for water depths of 3 feet and 4 feet, respectively. Therefore, Cap A will have a minimum thickness of 7 inches and 9 inches for water depth of 3 and 4 feet, respectively, or 13 inches and 18 inches for water depth of 3 and 4 feet, respectively, with average overplacement allowances. Note, the thickness and size of the armor layer were refined during 30, 60, and 90 Percent Design based on localized conditions, as summarized in Tables 6-1 and 6-2.

- **Cap B – Sand and gravel cap for PCBs greater than 10 ppm and less than 50 ppm and in OU 4A federal navigation channel** – consisting of a minimum 6 inches of placed sand (average of 9 inches with overplacement allowances) overlain by a minimum 4 inches and 6 inches of placed armor material (average of 7 inches and 12 inches with overplacement allowances) for water depth of 3 feet and 4 feet, respectively. Therefore, Cap B will have a minimum thickness of 10 inches and 12 inches (or 16 inches and 21 inches with average overplacement allowances) for water depths of 3 feet and 4 feet, respectively. Note, the thickness and size of the armor layer were refined during 30, 60, and 90 Percent Design based on localized conditions, as detailed in Tables 6-1 and 6-2.
- **Cap C – Sand and quarry spall cap for PCBs greater than 50 ppm and in OU 4B federal navigation channel** – consisting of a minimum 6 inches of placed sand (average of 9 inches with overplacement allowances) overlain by a filter layer of gravel (minimum 3 inches, average of 6 inches with overplacement allowances) or an alternate filter layer design approved by the A/OT (i.e., geotextile) and finally overlain by a minimum 12-inch-thick placed layer of suitably sized armor material (average of 18 inches with overplacement allowances). Therefore, Cap C will have a minimum thickness of 21 inches or 33 inches with average overplacement allowances. Within the OU 4B navigation channel, quarry spall material with a median stone size of 6 to 9 inches will be required for the armor layer. Note that the size and gradation of the filter layer is defined in the Project Plan, located in Attachment C-0 of Appendix C.

In addition to the general cap designs summarized above, the BODR and 30 Percent Design also identified the potential for shoreline capping in limited areas of the river (see Section 6.4.1 for additional details). Site-specific shoreline cap designs will be presented in a series of technical memoranda to be submitted as addenda to this 100 Percent Design Report, but are generally anticipated to include the following:

- **Shoreline Cap** – consisting of 3 or more inches of placed sand (thickness depending on PCB concentrations) overlain by a filter layer of gravel (3 to 6 inches) or an alternate filter layer design approved by the A/OT (i.e., geotextile) and armor stone (size and thickness dependent on erosive forces). See Section 6.4.1 for additional details.

Based on sediment sampling between 2006 and 2011 and the development of ground rules for preliminarily identifying the RD near select in-water structures based on the collaborative workgroup, the areal extents of the engineered caps have been refined since the 60 Percent Design. As discussed above, ongoing investigations and subsequent Site-specific RD refinements in localized areas adjacent will be presented in separate technical memoranda to be submitted as addenda to this 100 Percent Design Report. Table 6-5 presents a summary of the engineered cap areas delineated as part of this 100 Percent Design. Table 6-6 presents a summary of the OUs 2 to 5 engineered cap designs based on the analyses presented in the BODR, 30 Percent Design, 60 Percent Design, and this 100 Percent Design Report Volume 2, which include armor stone sizing and thickness based on location and depth-specific erosional conditions.

Table 6-5
Summary of Cap Delineation

	100 Percent Design			
	OU 2 [b]	OU 3 [c]	OUs 4/5	Total OUs 2 to 5
	Area (acres) [d]	Area (acres) [d]	Area (acres) [d]	Area (acres) [d]
Cap A	6.7	22.9	84.9	114.5
Cap B	0.3	3.9	46.6	50.8
Cap C	0	0	66.9	66.9
Total – Caps A, B, C	7.0	26.8	198.4	232.2
Shoreline Caps [a]	0	0	5.97	5.97

Notes:

a. Shoreline capping will be necessary in those areas where dredging will adversely impact the stability of existing slopes. Areas presented above are preliminary estimates, subject to further RD engineering evaluations, including a location-specific review of these areas during subsequent designs presented in the annual RA Work Plans.
b. Capping in OU 2 was completed in 2009. Therefore the areas presented above represent actual acres capped.
c. Capping in OU 3 was completed in 2011; therefore, the areas presented above represent actual acres capped.
d. All areas are approximate and represent preliminary construction limits aimed at ensuring complete coverage of the minimum required cap area delineated by the geostatistical modeling with a LOS of 0.5 defining the extents of sediment requiring remediation. Actual areas may vary from these limits based on operational considerations and limitations. The areas are also subject to design changes that may occur as a result of incorporating the 2012 infill sampling results into the design, as well as any future sampling. See Section 6.5 for additional details.

Table 6-6
Summary of OUs 2 to 5 Engineered Cap Designs

Cap Type	Post-Cap Water Depth [a]	Median Diameter of Armor, D_{50} [b] (inches)	Minimum Layer Thickness [c] (inches)			Cumulative Layer Thickness [c] (inches)	Average Placed Layer Thickness [d] (inches)			Placed Total Cap Thickness [d] (inches)
			Sand	Gravel Armor	Rock Armor		Sand	Gravel Armor	Rock Armor	
Cap A : PCB in top 6 inches below cap < 10 ppm and < 50 anywhere in depth profile										
Cap A1	3 to 4 feet	3	3	6	0	9	6	12	0	18
Cap A2	4 to 6 feet	1.5	3	4	0	7	6	7	0	13
Cap A3	> 6 feet	0.5	3	4	0	7	6	7	0	13
Cap B: PCB in top 6 inches below cap > 10 ppm and < 50 anywhere in depth profile; Cap B2 also required in OU 4A federal navigation channel										
Cap B1	3 to 4 feet	3	6	6	0	12	9	12	0	21
Cap B2	4 to 6 feet	1.5	6	4	0	10	9	7	0	16
Cap B3	> 6 feet	0.5	6	4	0	10	9	7	0	16
Cap C: PCB concentrations in the top 18 inches < 50 ppm with concentrations allowed to be > 50 ppm in deeply buried sediment.; Cap C also required in OU 4B federal navigation channel										
Cap C1	> 3 feet	6 to 9 [e]	6	3	12	21	9	6	18	33
Shoreline caps [f] (Further engineering of shoreline caps is currently underway)										
OU 3/OU 4A	varies	8 [f]	3 to 6 [g]	3	18	24 to 27	6 to 9 [g]	6	30	42 to 45
OU 4B	varies	7 [f]	3 to 6 [g]	3	16	22 to 22	6 to 9 [g]	6	28	40 to 43

Notes:

a. Caps will not be placed in locations such that the project's low water datum elevation for the particular location (see Table 6-4) is less than 3 feet above the top elevation of the constructed cap, unless otherwise approved by the Agencies as an exception area.

b. Any exceptions to the armor stone size (less than that defined by the design) will require A/OT approval. A/OT-approved gradations are presented in Attachment C-0 of Appendix C.

c. Minimum required thickness based on USEPA/USACE design guidance. Note that for Cap C1, the 3-inch gravel layer is a filter layer, not gravel armor.

d. The Contractor will be required to place enough material (as measured by placement logs) to achieve target thickness that is consistent with the ROD Amendment and the signed Explanation of Significant Differences dated February 2010 (see CQAPP for additional details of thickness verification).

e. Rock armor size based on site-specific erosion analysis. Navigation channel bottom D_{50} = 6 to 9 inches. Navigation channel slopes not subject to bow thruster impact: D_{50} = 3 inches. Navigation channel slopes subject to excessive bow thrusters/propwash will be based on site-specific analysis (see Section 6.2.1). Shoreline areas: D_{50} = 7 to 8 inches.

f. Shoreline cap information presented herein is preliminary. Site-specific shoreline cap design will be presented in technical memoranda submitted as addenda to this 100 Percent Design Report with consideration of additional sampling and local erosion evaluations (propwash, vessel wakes, wind waves, ice, etc.)

g. The thickness of the sand layer in the shoreline cap and exceptional areas will depend on the PCB concentration.

6.4 Localized Cap Design Refinements

The general cap designs presented in Section 6.3 of this 100 Percent Design Report Volume 2 are suitable for the majority of the areas planned for capping within the river. However, cap designs in localized areas, including shorelines, marine terminals, and around in-water structures and utilities may require additional refinement based on Site-specific conditions. This section presents the "ground rules," developed during the 60 Percent Design phase for refining the general cap designs presented in Section 6.3 to accommodate various shoreline conditions and utility/infrastructure types typical of OUs 2 to 5. Ongoing remedial investigations (e.g., infill sampling) to support Site-specific cap design evaluations and refinements will be documented in a series of technical memoranda to be submitted as addenda to this 100 Percent Design Report.

6.4.1 Engineered Shoreline Caps

Shoreline caps will be installed where RD engineering evaluations (to be presented in Site-specific technical memoranda as addenda to this 100 Percent Design Report) conclude that dredging would adversely affect the stability of the existing slopes. Building on the BODR and 30 Percent Design, the 100 Percent cap design plans preliminarily identify a nominal 50-foot-wide zone of potential shoreline capping along the riverbanks or some existing bulkhead walls where greater than 2 feet of sediments exceeding the 1.0 ppm RAL was estimated by the geostatistical model or measured through discrete shoreline sampling at the edge of the shoreline. The "edge of the shoreline," as it pertains to delineating the extent of in-water RA addressed by this RD, is defined as the shoreline identified during the November 2003 photogrammetric aerial survey performed by Jenkins Survey and Design, Inc., as part of the Site survey work contracted by WDNR. During the 60 Percent Design phase, ground rules were established within the technical workgroups for developing the RD of shoreline cap remedies including appropriate transitioning between shoreline dredge or dredge-and-cap remedies and offshore remedies. Site-specific shoreline designs (involving detailed engineering evaluations, where necessary) will be developed and submitted in technical memoranda as addenda to this 100 Percent Design Report, and will include consideration of the results of shoreline investigations, including sampling performed between 2009 and 2012 as well as riparian property owner input.

As part of the collaborative workgroup, three Site-specific design examples ("cases") were reviewed to establish a set of ground rules in the 60 Percent Design that will be used in subsequent design analyses to develop appropriate transitions from offshore remedies into adjacent shoreline areas. Application of these ground rules will be performed following ongoing field investigations such that Site-specific plans can be developed in collaboration with the A/OT, riparian property owners, and owners of submerged utilities, and will be presented in technical memoranda, when necessary, as addenda to this 100 Percent Design Report. Three example cases, representing the general range of conditions throughout OUs 2 to 5, are summarized below and presented in further detail (with example drawings) in Attachment A-3 of Appendix A. The following three cases will be used when developing the Site-specific designs to be included as future addenda:

- Shoreline Transition Case 1: Transitioning from an offshore dredge area where the DOC (represented by the LOS 0.5 surface) or Site-specific shoreline samples (within the bounds of the Site) indicate that sediments exceeding the 1.0 ppm RAL extend to a depth greater than 2 feet below the mudline and preliminary RA delineation included dredging.
- Shoreline Transition Case 2: Transitioning from an offshore dredge area where the DOC (represented by the LOS 0.5 surface) or Site-specific shoreline samples indicate that sediments exceeding the 1.0 ppm RAL extend to a depth less than 2 feet below the mudline and preliminary RA delineation included dredging.
- Shoreline Transition Case 3: Transitioning from an offshore dredge and cap (or offshore cap) area into the shoreline where preliminary RA delineation included capping.

Each of these cases is described in greater detail below.

Shoreline Transition Case 1

This example case represents an area where the DOC (represented by the LOS 0.5 surface) or Site-specific shoreline samples indicate that sediments exceeding the 1.0 ppm RAL extend to a depth greater than 2 feet below the mudline and the nearshore remedy delineated during preliminary RD involved dredging to remove all sediment exceeding the 1.0 ppm RAL. However, initial engineering analyses presented in the 30 Percent

Design (Attachment B-6 of Appendix B) indicate that dredging more than 2 feet immediately adjacent to the shoreline could destabilize the bank. Therefore, the dredge cut will be designed to daylight (i.e., intersect at the top of the slope that extends up from base of cut) at the "edge of the shoreline" (defined by the November 2003 photogrammetric aerial survey performed by Jenkins Survey and Design, Inc.) and slope down towards the river to the required dredge elevation. Slope stability analyses conducted for the 60 Percent Design using available data representative of average Site conditions suggest that shoreline slopes capped with an approximately 4-foot-thick cap (see Table 6-7) will be stable at a 5H:1V slope or shallower (see Attachment B-4 of Appendix B for additional details). Alternate slopes (flatter or steeper) will be considered on a case-by-case basis using Site-specific observations of existing slope conditions and/or physical/geotechnical and chemical information obtained or taken specifically to resolve the shore slope arrangement required to have a minimum factor of safety of 1.5. Additional sampling may be performed along shorelines to collect Site-specific chemical data to confirm the need for a shoreline cap or geotechnical data to evaluate appropriate slope designs. It is anticipated that the collected geotechnical Site information may include index properties and strength parameters. Shoreline cap construction will be generally sequenced to follow shortly after dredging (typically within the same construction season). If Site-specific conditions indicate a high potential for erosion (e.g., from wind waves, vessel wakes, propwash, or ice scour), shoreline cap construction may be sequenced immediately following the dredging (e.g., within 1 to 2 months), to the extent practical. Where shoreline capping is deemed necessary, appropriate armor stone sizes and thicknesses will be applied and refined based on the results of wind wave, ice scour, propwash, vessel wake, and slope stability analyses summarized above. Based on these analyses, vessel wakes are expected to be the dominant erosive force in most shoreline areas. Preliminary wave run-up calculations performed for the maximum predicted vessel wake using the Automated Coastal Engineering System (ACES) software indicate that shoreline caps should conservatively extend approximately 2 feet above the top of shoreline cap elevation to protect against scour during extreme wave events, as described in Attachment A-3 of Appendix A. The appropriate top of shoreline cap elevation will be determined based on Lake Michigan water elevation variation and the results of the hydrodynamic model generated by Sea Engineering for the RD, which incorporated a great than 100-year flow event and a maximum seiche event. As the flood flow and seiche elevation will vary depending on the location within OU 4, this elevation will be Site specific. The top elevation for shoreline caps will be compared to the Renard Island CDF slope armoring top elevation for consistency. The base of the shoreline slope cap will be constructed with a toe berm (as necessary) to facilitate construction of the cap on the slope as well as provide long-term support by preventing undercutting. Attachment A-3 of Appendix A presents an analysis for the design of the toe berm as depicted on Plan Drawing number C-54.

In each year prior to the construction, existing data will be assessed in the areas that are tentatively identified as requiring a shoreline cap in this 100 Percent Design Report Volume 2. Additional data may be necessary to verify the need for this capping. If the need for shoreline capping is verified, the design will be finalized based on a cap configuration that provides a minimum factor of safety of 1.5 and that provides necessary chemical isolation characteristics.

Shoreline Transition Case 2

This design approach will apply to areas where the geostatistical modeling (LOS 0.5 surface) or Site-specific shoreline samples indicate that sediments exceeding the 1.0 ppm RAL extend less than 2 feet below the existing mudline and the nearshore remedy delineated during preliminary RD involves dredging to remove all sediment exceeding the 1.0 ppm RAL. In addition, this case applies to shoreline areas where settlement-sensitive structures (e.g., docks, bulkhead walls, and slope protection) are not positioned within approximately 10 feet of the slope (subject to Site-specific determinations). Based on engineering analyses presented in the 30 Percent Design (Attachment B-6 of Appendix B), it is expected that substantially all of the sediment above the RAL under these conditions could be removed without destabilizing the bank. As in Case 1, the dredge cut will be constructed to daylight at the edge of the shoreline (as defined above) and slope down towards the river to the required dredge elevation at a 5H:1V slope. Alternate slopes (flatter or steeper) will be considered on a case-by-case basis using Site-specific observations of existing slope conditions and/or physical/geotechnical and chemical information obtained or taken specifically to resolve the shore slope arrangement required to have a minimum factor of safety of 1.5. For instance, in the case where the DOC at the edge of the shoreline is very thin (approximately 1 foot or less), a vertical cut will likely be made by the dredge because creating a sloped cut over this distance is impractical with the planned dredge equipment. The bulk of the targeted sediment will be removed; thus, a shoreline cap will not be placed in these areas.

In the year prior to remediation in each of these areas, a Site-specific evaluation will be conducted to determine if dredging can be performed safely. Subject to input from the dredging contractor, it may be necessary to incorporate a dredging offset from these structures as has been done for other in-water structures (e.g., bridge piers). These evaluations will be documented in the annual Phase 2B RAWPs.

Shoreline Transition Case 3

This example case represents an area where the nearshore remedy delineated during preliminary RD involved capping (alone or more typically following initial dredging) to contain sediment exceeding the 1.0 ppm RAL at current depths in excess of 2 feet below the mudline. This design approach provides general design criteria for appropriate transition(s) between the nearshore cap (or dredge-and-cap) remedy and planned offshore remedy (dredge only, dredge and cap, or cap). As with Cases 1 and 2, the dredge cut will be constructed to daylight at the edge of the shoreline (as defined above) and slope down towards the river to the required dredge elevation at a 5H:1V slope. Alternate slopes (flatter or steeper) will be considered on a case-by-case basis using Site-specific observations of existing slope conditions and/or physical/geotechnical and chemical information obtained or taken specifically to resolve the shore slope arrangement required to have a minimum factor of safety of 1.5. Sediments with PCB concentrations above the 1.0 ppm RAL left in place at the shoreline will be capped following dredging.

As with Case 1, shoreline cap construction will be generally sequenced to follow shortly after dredging (typically within the same construction season). If Site-specific conditions indicate a high potential for erosion (e.g., from wind waves, vessel wakes, propwash, or ice scour), shoreline cap construction may be sequenced immediately following the dredging (e.g., within 1 to 2 months), to the extent practical. Where shoreline capping is deemed necessary, appropriate armor stone sizes and thicknesses will be applied based on the results of wind wave, ice scour, propwash, vessel wake, and slope stability analyses summarized above. Based on these analyses, vessel wakes are expected to be the dominant erosive force in most shoreline areas. Preliminary wave run-up calculations performed for the maximum predicted vessel wake using the ACES software indicate that shoreline caps should conservatively extend approximately 2 feet above the top of shoreline cap elevation to protect against scour during extreme wave events, as described in Attachment A-3 of Appendix A. The appropriate top of shoreline cap elevation will be determined based on Lake Michigan water elevation variations and the results of the hydrodynamic model generated by Sea Engineering for the RD, which incorporated a greater than 100-year flow event and a maximum seiche event. As the flood flow and seiche elevation will vary depending on the location within OU 4, this elevation will be Site specific. The top elevation for shoreline caps will be compared to the Renard Island CDF slope armoring top elevation for consistency. The base of the shoreline slope cap will be constructed with a toe berm (as necessary) to facilitate construction of the cap on the slope as well as provide long-term support by preventing undercutting. As discussed above for Case 1, the design of the shoreline cap, including the toe berm if necessary, will be presented in the annual Phase 2B RAWPs based on the Site-specific evaluations.

6.4.2 Cap Design Near Utilities and Infrastructure

As part of the 60 Percent Design, ground rules were established through the collaborative workgroup for the process of transitioning between proposed remedies (dredging and capping), in-water structures (e.g., bridge crossings, marine terminals, and outfalls), and submerged utilities/pipelines. These ground rules were used to preliminarily design RAs near utilities and infrastructure, which are presented on the Engineered Plan Drawings included as Appendix D. However, ongoing Site investigations, discussions with utility and riparian property owners, and subsequent engineering evaluations will be performed to refine the Site-specific remedy for each area with final designs to be presented in addenda to this 100 Percent Design Report. These ground rules are briefly summarized below and described in further detail (including example drawings) in Attachment A-2 of Appendix A and Attachment B-5 of Appendix B.

6.4.2.1 In-Water Structures

Ground rules were developed for dredging and capping remedies near bridge crossings, outfalls, and marine terminals during the 60 Percent Design. Ground rules related to dredge design in these areas are presented in Section 4.4.4 of the 100 Percent Design Report Volume 1.

As part of the 60 Percent Design, the collaborative workgroup reviewed specific examples to establish ground rules for designing remedies surrounding in-water structures. Preliminary primary designs for RA adjacent to all in-water structures were submitted to the Agencies on December 29, 2011, and are included as preliminary designs in the Engineered Plan Drawings (Appendix D). The final RA for these areas will be submitted as part of future technical memoranda, as necessary, which will be submitted as addenda to this 100 Percent Design Report. The final designs will be submitted as part of these memoranda, and will be based on ongoing investigations, including infill sampling, poling, assessment of current RA, discussions with utility or riparian property owners, and its ability to perform safely and with minimal disruptions, extent of contamination, potential environmental risks posed by the contaminated sediment, practicability and risks of performing the RAs, and discussions with property owners in collaboration with the A/OT, as appropriate. The final RA plans for these areas may differ from the primary designs presented in this 100 Percent Design Volume 2.

The ground rules developed for the 60 Percent Design include remedies near the following in-water structures:

- Bridge crossings
- Stormwater and other outfalls
- Marine terminals, marinas, boat launches, and ramps
- Sheetpile walls/riprap or armored slopes/shoreline buildings
- Floating dock with guide piles or fixed pile-supported piers/docks

The Site-specific designs for RA associated with marine terminals will include analyses of propwash and bowthruster effects on engineered caps.

6.4.2.2 Submerged Utilities/Pipelines

The primary concern in dredging or capping near buried utilities/pipelines is that the utility crossing could be damaged during (or following) the implementation of the remedy, potentially resulting in significant worker/public safety issues, environmental damage, or disruption of public service. As part of the 60 Percent Design, ground rules were developed for designing RA near submerged utilities and pipelines.

Preliminary primary designs for RA at all submerged utility crossings were submitted to the Agencies on December 29, 2011, and are included as preliminary designs in the Engineered Plan Drawings (Appendix D). The final RD for these areas will be presented in future technical memoranda, as necessary, which will be submitted as addenda to this 100 Percent Design Report or as described in annual Phase 2B RAWPs. The final designs will be based on ongoing investigations, including infill sampling results, assessment of the extent of contamination, potential environmental risks posed by the contaminated sediment, practicability and risks of performing the RAs, and discussions with utility owners and operators in collaboration with the A/OT, as appropriate. The final RA plans for these areas may differ from the primary designs presented in this 100 Percent Design Volume 2.

Final RA near submerged utilities and pipelines may include an offset from the utility to minimize the chance of damaging the utility during remedial construction. The width of the final offset will be based on several factors, including:

- Nature of the utility (water, electric, sewer, communication, petroleum, natural gas, or other)
- Availability (and reliability) of design drawings or construction (i.e., as-built) data
- PCB concentrations in the sediment surrounding the utility

Site-specific final designs related to submerged utilities and pipelines will be shown in the future technical memoranda, as necessary, or addenda to this 100 Percent Design.

6.5 Delineation of Cap Areas

As noted in Section 4.2 of the 100 Percent Design Report Volume 1, the dredge, cap, cover, and dredge-and-cap boundaries were initially delineated using a core-by-core evaluation process and were subsequently refined based on geostatistical modeling and infill sampling data. Cap and dredge-and-cap areas are generally sited in localized areas with thick, stable deposits of contaminated sediment with limited current bioavailability (i.e., relatively low sediment surface PCB concentrations), that do not contribute measurably to current or future Site risks, and/or that will pose considerable difficulties in a dredge-only remedy. Detailed hydrodynamic analyses were performed to evaluate potential erosion from a wide range of natural and anthropogenic forces at each location. Caps are incorporated into the design within areas where permanent stability and performance is expected. In situ capping of sediments will also be performed along shoreline areas where RD evaluations conclude that dredging will adversely affect the stability of the existing slopes. As described above, shoreline capping will be used in areas where nearshore dredging would create undesirable bank instability. Refinements of these shoreline caps are being evaluated on a case-by-case basis, with final designs to be documented in technical memoranda to be submitted as addenda to this 100 Percent Design Report and/or in the annual Phase 2B RAWPs.

The initial boundaries of capping locations selected from the BODR core-by-core process were delineated using a Thiessen polygon approach. As the design progressed from the conceptual level to the 30, 60, 90, and 100 Percent Design levels, the boundaries were refined using the detailed dredge and sand cover plans and the spatial extent of the DOC at a LOS of 0.5. During the 100 Percent Design phase, the A/OT and Design Team collaboratively reviewed the cap area delineation based on the DRT developed by the A/OT and presented in a June 14, 2012 memorandum (USEPA 2012). Through this collaborative review, a technical consensus was reached on the delineation of capping (and dredging) with consideration of the requirements of the ROD and ROD Amendment. The results of the collaborative review are presented in Appendix M and reflected on the Engineered Plan Drawings included in Appendix D. During the cap delineation process, elevation was tracked to minimize significant elevation changes between adjacent dredge and cap areas, thereby creating a uniform post-dredge surface elevation, to the extent practical.

The spatial extent of the DOC resembles a curvilinear polygon defining the extent of sediments exceeding 1.0 ppm PCBs. The cap plans presented in this 100 Percent Design (see Appendix D) are based on this geostatistical model output with consideration of the construction methods. Because the caps will be constructed primarily using J.F. Brennan's broadcast spreader, which operates most efficiently in a series of overlapping "spreading lanes" (se Section 6.6.2), the actual cap placement footprint will extend beyond the minimum cap limits defined by the geostatistical model. Therefore, in addition to the minimum required cap limits, the Engineered Plan Drawings (Appendix D) also depict the preliminary "construction limits." These preliminary construction limits were developed to fully cover the geostatistical model output based on the 35-foot lane widths for the broadcast spreader. Cap areas presented on Tables 6-6 and 9-2 and in Attachment B-9 of Appendix B reflect these preliminary construction limits. In each year prior to construction, J.F. Brennan will review the minimum required cap footprints (i.e., geostatistical model) and develop a detailed plan of spreading lanes for the upcoming season, which may refine the preliminary construction limits presented in Appendix D. Following J.F. Brennan's review, the LLC and/or its representative (e.g., Foth Infrastructure and Environment, L.L.C.) will review the planned capping lanes and may request further refinements. The refined construction limits based on J.F. Brennan spreading lanes (as approved by the LLC) will be presented to the A/OT in the annual Phase 2B RAWPs, or other appropriate documentation.

After the preliminary cap plan was defined, the cap criteria described in Section 6.3 were evaluated for each general area to determine the required cap type based on the underlying chemistry. For locations where the cap will be placed without prior dredging, the upper 6-inch sample from the nearest core location was evaluated to determine the appropriate chemical isolation layer thickness. For dredge-and-cap areas, the underlying chemistry was based on an estimate of the generated residuals (assuming 5 percent by weight residuals) and predicted post-dredge concentration. Attachment B-6 of Appendix B provides additional details of these calculations. This estimate was used to determine a preliminary cap type (e.g., Cap A, Cap B, etc.) for the area, though final cap type designation will be based on post-dredge confirmation sampling (see the CQAPP in Appendix F for additional information).

Each location within the cap plan was then re-evaluated to determine if the associated core contained concentrations of PCBs greater than or equal to 50 ppm at any depth interval. In the event a location contained a core sample greater than or equal to 50 ppm, a dredge or dredge-and-cap alternative was evaluated consistent with CERCLA guidance (USEPA 1988). If a cap was determined to be more feasible and more cost effective and if the sample interval(s) greater than or equal to exceeding 50 ppm were deeply buried (i.e., more than 18 inches below the surface), a Cap C section was designed in accordance with Section 6.1. Therefore, Cap C areas have been designed such that PCB concentrations greater than or equal to 50 ppm do not exist within the top 18 inches below the base of the cap. However, there may be exceptional areas (such as shoreline areas where dredging would result in instability of a structure, or above cap-only submerged utility crossing areas) in which it may be necessary to have an engineered cap in an area in which PCB concentrations greater than or equal to 50 ppm exist within 18 inches of the cap. These exceptional areas will require A/OT approval. Attachment B-6 of Appendix B contains a comprehensive design spreadsheet used to track these evaluations. After the final delineation of cap type based on chemical criteria was complete, the entire cap plan was reviewed to ensure the appropriate armoring layer was designated based on estimated post-cap water depths as described in Attachment B-7 of Appendix B. Where the preliminary cap plan resulted in water depths less than 3 feet during extreme low water conditions described in Table 6-4 (i.e., above elevation 573.5 feet International Great Lakes Datum (IGLD) [573.6 feet NAVD88]), these caps were converted to either dredge or dredge-and-cap alternatives. Furthermore, the areas of caps planned for placement where the post-cap water depth was projected to be less than 6 feet were minimized to the extent possible. Caps located within the authorized navigation channels and turning basins have been designed with the most protective armor layer allowable for the applicable river stretch (Cap B2 in OU 4A navigation channel south of the Fort Howard turning basin and Cap C in the OU 4B navigation channel including the Fort Howard turning basin).

The areal extents of engineered caps delineated for this 100 Percent Design are shown on Figure 1-5 and on the Engineered Plan Drawings in Appendix D. All of the areas designated as cap areas have been identified through the design efforts and the collaborative workgroup process discussed in Sections 1.3 and 2.4. As described in Sections 1.3.2 and 2.4.1, these areas will be re-evaluated to incorporate the results of the 2012 infill sampling; they may also be re-evaluated based on any future sampling and/or additional geostatistical analyses as well as cost effectiveness (e.g., comparing costs for dredging versus capping). Sediment stability, deeply buried sediment, difficult to dredge sediment, and other concerns will be further considered in an AM setting in order to provide an overall remedy satisfying the ROD. Any refinements to the RA plan based on these future re-evaluations will be presented in the annual Phase 2B RAWPs.

Similar to the unique identification label for each dredge area, as described in Section4.4, each cap area is identified on the Engineered Plan Drawings with a unique identification label taking the form OU3-CA12. In this case, "OU3" refers to Operable Unit 3, "C" identifies the area as a cap, "A" identifies the cap type (A, B, C, or SC for shoreline cap), and "12" represents the sequential numbering beginning in OU 2 and moving generally downstream. It should be noted that some cap area numbering is not sequential due to cap areas that were either removed or added during the design after the initial labeling at the 60 Percent Design phase. Attachment B-9 of Appendix B presents a summary of the cap plan design by cap area and includes a comparison to the 60 Percent Design.

As discussed in Section 6.4.1, shoreline caps are preliminarily delineated for the 100 Percent Design as a nominal 50-foot-wide zone along the riverbanks where greater than 2 feet of sediments exceeding the 1.0 ppm RAL was estimated at the river's edge. The delineation of these shoreline cap areas is currently being refined based on additional investigations and Site-specific evaluations. Preliminary RD plans in the vicinity of utilities, infrastructure, and other sensitive structures are presented on the Engineered Plan Drawings (Appendix D), but may be refined based on ongoing discussions with riparian property owners and presented in separate technical memoranda submitted as addenda to this 100 Percent Design Report and/or in the annual Phase 2B RAWPs. In the event that previously unidentified structures or utilities are identified subsequent to this work (e.g., as construction proceeds), the RD will be completed during the year prior to the planned RA in that vicinity and will be presented in the annual Phase 2B RAWPs.

6.6 Engineered Cap Construction

Armored caps will be placed in select dredged and un-dredged areas within OUs 3 through 5 on the Lower Fox River during the 2011 to 2017 construction seasons. OU 3 capping materials and crews will be staged and loaded from the OU 2/3 secondary staging facility (see Section 3.2). For areas to be capped north of the De Pere Dam, all capping materials will be staged and loaded from the LFR Processing Facility staging area. The crews will typically work two 12-hour shifts per day.

As part of the annual Phase 2B RAWPs, the cap areas to be constructed in the coming construction season will be divided into cap management units (CMUs). CMUs will be used as the primary unit for assessing compliance with the design (e.g., verifying that the specified thickness and extent have been achieved), as discussed in Section 6.7.2. The CMUs will be surveyed and marked prior to initiating capping operations. In addition, the marine sediment capping plants and mechanical plants will be equipped with state-of-the-art technology, which will provide real-time information used to compare actual placement elevations with design elevations. Additional details of the cap placement certification process are provided in the CQAPP (see Appendix F).

The following sections provide additional details on the staging of materials, selection of equipment, and the physical placement of capping materials based on the proposed cap designs. The sequence for capping is also described. The methods and equipment described for installation of the proposed sand and armor caps may be revised if alternative cap designs are proposed as part of the VE process.

6.6.1 Material Staging

Prior to armor cap placement activities, which are anticipated to start in early April of each construction season, cap materials will be stockpiled in designated areas. This occurred at the OU 2/3 secondary staging facility in 2010 and 2011, and at the LFR Processing Facility staging area, likely beginning in 2013, depending on progress. It is also possible that an additional staging area may be identified for storing capping and cover materials in OU 4 beginning in 2013 or later.

The various capping materials will be staged at both of the upland facilities planned for use as part of this project. The LFR Processing Facility will be used for staging of cap material to be placed north of the De Pere Dam, and the OU 2/3 secondary staging facility will be used for staging of cap material to be placed south of the De Pere Dam.

Cap materials will be trucked to these staging areas from several local material suppliers.

There will be designated stockpiles for each type of material (sand, armor stone with minimum D_{50} = 0.5 inch, D_{50} = 1.5 inch, and D_{50} = 3.0 inch [3]) at the OU 2/3 secondary staging facility. In addition to these materials, armor stone with D_{50} of 6 to 9 inches will be stockpiled at the LFR Processing Facility and placed as a part of Cap C or a shoreline cap. Figure 3-2 illustrates the planned stockpile areas at the LFR Processing Facility staging area. The site development plan for the OU 2/3 secondary staging facility presented planned stockpile locations at that facility (J.F. Brennan 2009b).

Sand and armor materials will be delivered to the OU 2/3 secondary staging facility or the LFR Processing Facility staging area by truck. Deliveries are planned during daylight hours; however, if alternate delivery times are required, the A/OT will be notified. Materials will be transported to the broadcast spreading plants by use of a slurry transport system. Any larger capping materials will be transported by barge from the LFR Processing Facility. Cap or cover placement operations on the river will be performed 5 days per week, 24 hours per day; however, the storage areas at both the LFR Processing Facility and OU 2/3 secondary staging facility are sized to accommodate the delivery of capping materials outside of these hours, creating a surplus of capping materials. The storage areas also provide a carryover capacity of 2 days if deliveries from the area suppliers are interrupted for any reason.

Table 6-7 provides potential material sources considered for use on the Lower Fox River Project.

[3] See Appendix C-0 for Agency-approved material gradations.

Table 6-7
Potential Material Suppliers

Material Supplier	Available Materials
Kiel Sand and Gravel	Washed Sand, Gravel, and Quarry Spall
Daanen & Janssen Sand	Washed Sand, Gravel, and Quarry Spall
McKeefry & Sons	Washed Sand, Gravel, and Quarry Spall
Faulks Bros.	Washed Sand, Gravel, and Quarry Spall
F. Radandt & Sons	Washed Sand, Gravel, and Quarry Spall

Note:
The Tetra Tech Team has obtained quotations from these firms and believes each is capable of supplying the quantity and project-specified capping materials needed for the project.

6.6.2 Equipment Selection and Production Rates

The designed capping systems will require the use of various materials and placement technologies, based on the cap system required. Finer portions of the cap (particles less than approximately 3 inches in diameter) will be spread via J.F. Brennan's broadcast spreading methods, which allow for uniform application over large areas with minimal disturbance of underlying contaminated sediment. This application technique has also been shown to minimize mixing of clean cap material with the underlying contaminated sediment. Larger cap material (maximum particle diameter greater than approximately 3 inches) will require placement via more conventional techniques, including the use of excavators and cranes equipped with clamshell buckets or orange-peel grapples. Shoreline caps will be placed mechanically by barge-mounted excavators with hydraulic clamshell attachments.

The broadcast spreading equipment is barge mounted with a "spreading pool," which is an area of open water enclosed by floating barriers measuring approximately 35 feet wide by 30 feet long (direction of spreader movement). The broadcast spreader plant has a draft of approximately 18 inches, making it suitable for shallow water placement. However, in the event that sand cover placement is required in water shallower than 18 inches, the Tetra Tech Team will evaluate alternate means of placement, subject to AM through the technical workgroups. The broadcast spreader uniformly distributes moist granular capping materials as individual particles hitting the water and settling to the bottom at reduced velocity. The low velocity of the particles greatly reduces disturbances to the bottom in shallow water. The enclosed spreading pool and attached partial depth silt curtains serve to control the placement as well as reduce turbidity.

The broadcast spreading barges will be fed by a pipeline conveying a slurry of capping materials, as discussed below. Placement rates for sand and armor placed by the broadcast spreading method are expected to range from 20 to 65 cy per hour with a target of 50 cy per hour (30 to 90 tons per hour with a target of 75 tons per hour). The production assumptions are based on past performance, onshore spreading test runs, and manufacturer specifications. The schedule will be continually reassessed as the project progresses. Capping is expected to be performed 24 hours per day and is based on working 5 days per week.

6.6.2.1 Sediment Re-Suspension and Turbidity Control

Consistent with the approach to addressing sediment re-suspension and turbidity control at OU 1, advanced capping technology and BMPs will be used to minimize sediment re-suspension. In general, turbidity from cap and cover operations is a function of the material and degree of material washing prior to placement. To mitigate turbidity from cap and sand cover operations (see Section 7) the following procedures will be enacted:

- Construction of a 35-foot-wide by 30-foot-long (direction of spreader barge movement) spreading pool, which isolates placement area from ongoing river operations
- Washing of sand and stone prior to delivery to the Site such that the percent passing the U.S. No. 200 sieve is less than 1 percent by weight (see Attachment C-0 of Appendix C for specifications of the cap material gradations); if turbidity becomes a chronic problem, this percent will be reevaluated and potentially reduced
- Use of broadcast technology for sand and smaller gravel to prevent localized dumping of cap material
- Placement of larger gravel and armor stone (maximum particle diameter greater than approximately 3 inches) with a mechanical excavator in close proximity to the riverbed, which will prevent localized dumping of material

The operational practices described above are consistent with BMPs for capping operations and have been successfully implemented on the Fox River OU 1 project.

Water quality monitoring and contingency response actions are described in the CQAPP (Appendix F). If elevated turbidity is sustained, BMPs will be reevaluated. If frequent exceedances are noted, the use of silt curtains or turbidity barriers may be necessary.

6.6.3 Broadcast Spreading Delivery Equipment

J.F. Brennan has developed a broadcast spreading application method for placement of sand and small gravel (maximum particle size less than approximately 3-inch diameter) during in situ capping of contaminated sediments that provides a significant advantage over more conventional cap placement technologies (where large volumes of material are placed via a clamshell bucket in localized areas or where sand slurry is discharged to open water). This broadcast spreading method allows for uniform placement of thin layers of cap material as well as capping in shallow waters.

The material spreader will consist of two barges. One will be the working barge and the other will be the guide barge. The two barges will work in unison walking back and forth parallel to one another. The spreader barge will be 40 feet by 80 feet and the guide barges will be 20 feet by 120 feet. Both barges will be equipped with hydraulic powerpacks, winches, and spuds. One barge will be spudded down at all times. When the spreader barge is stepping back, the guide barge will have both spuds down on the river floor. The spreader barge will move along the guide barge until reaching its stopping point. At this time, the spreader barge will spud down and the guide barge will step back. During these steps, the material will continue to be spread.

Once the sand layer of the cap has been placed over a given area, the spreader barge will reposition and repeat the stepping process to place the overlying armor layer or the filter layer in Cap C areas. This process will involve placing spuds through the previously placed sand layer, but experience gained at the OU 1 project and other sites indicates that this spudding will not cause appreciable disturbance to the placed layer of the cap.

The system for delivering capping materials to the broadcast spreader will depend on the locations within the river. In some cases (e.g., OU 3 and portions of OU 4), it will be most efficient to deliver the capping materials (sand or gravel) from the shoreside stockpile directly to the spreader barge in a hydraulic slurry via a pipeline. In other cases, if may be more feasible and efficient to move the capping materials in bulk form on a barge to an intermediate slurry barge, which will facilitate delivery of the cap material the remainder of the way to the spreader barge through a hydraulic pipeline. It should be noted that there are two primary reasons for use of slurry delivery of capping materials to the spreader barge, as opposed to transport of capping materials via barges directly to the spreader barge. The first is that the additional weight and size of a material barge tied alongside the spreader barge would create difficulties in positioning and moving the spreader barge, thereby reducing the accuracy of placement. Secondly, the heavy materials barges typically have a draft of approximately 6 feet, compared to the 18-inch draft of the spreader barge, which would limit the ability to operate in shallow water. The planned transport methods are discussed further below.

Description of Broadcast System from Shoreline

- An excavator or front-end loader is used to transfer cap/cover material to a conveyor, which loads a metered hopper.
- The metered hopper uses the feed opening and/or variable speed of the belt to meter the transfer of material.
- After material is metered from the hopper it is then fed to the slurry tank.
- Water is injected into the tank, creating a slurry.
- Excess water is discharged from the slurry hopper via an overflow weir. Water quality will be monitored during capping operations in accordance with the CQAPP.
- A booster pump is used to transfer the slurry from the slurry tank through a pipeline (8-inch diameter for sand, 12-inch diameter for gravel) to the broadcast spreading barge.
- For sand, once the slurried material is delivered to the broadcast spreading barge, the material passes through a 30-inch hydrocyclone for primary dewatering.
- For gravel, once the slurried material is delivered to the broadcast spreading barge, the material passes through a velocity box for primary dewatering. The velocity box slows the material slurry from velocities required to move material through the pipeline.

- After passing through a hydrocyclone (for sand) or velocity box (for gravel) material is dropped to a shaker screen for secondary dewatering. It is important to note that all transport water used for conveyance of cap/cover material is collected and discharged within the spreader bay.
- Any fine sand passing through the initial discharge to the shaker is captured in an overflow tank. A pump then re-circulates the fine sand through an 18-inch hydrocyclone, which then discharges on the bed of sand moving across the shaker screen.
- Material passing the shaker screen drops to a collection hopper, which feeds the broadcast spreader.
- The broadcast spreader is located on the bow of the spreader barge and broadcasts the material in a uniform pattern.
- Individual particles will hit the water surface and fall through the water column at a reduced velocity, when compared to direct discharge of material.

Description of Broadcast System from Slurry Barge

When material requires movement to the slurry plant, it will first be placed onto 120-foot by 30-foot material barges loaded at the LFR Processing Facility or OU 2/3 secondary staging facility Material barges used for cap material transport will have flat decks with deck combing on three sides to keep the materials from sliding into the river. Once the barges have been loaded, a small push boat/tug will move the barges to the slurry plant location. Barges shall be docked adjacent to the slurry plant and unloaded with an excavator, which will place material into the slurry tank hopper. Following placement of material into the slurry box, all other steps shall be consistent with the above-described process.

The broadcast spreading units will utilize a Real Time Kinematic (RTK) Global Positioning System (GPS) for real-time position and elevation tracking to within 4 cm accuracy (see description below). The coordinates of the sand spreader will be sent to the DREDGEPACK® survey software system produced by Hypack®.

A belt scale on the sand spreader discharge conveyor will continually monitor the tons per hour of sand being discharged from the sand spreader. A Programmable Logic

Controller (PLC) on the sand spreader will be used to monitor the total tonnage of material being spread. The PLC also monitors the spreader barge location coordinates (as determined by the RTK GPS) and the desired discharged sand setpoint (as entered by the operator). When the desired amount of sand for a specific location has been reached, the PLC sounds an audible alarm to signal the operator it is time to move the spreader barge to a new location. Once the spreader barge has been relocated, the PLC starts tracking spread sand tonnage for the new location.

Wonderware's Intouch software will be used to interface with the PLC to allow an operator to enter the spread setpoint along with other variables such as spreading volume and density. It will also monitor the spreader barge coordinates and display all operating conditions on a graphical screen for the operator.

6.6.4 Mechanical Placement

Mechanical placement will be required for materials with a median particle size larger than (D_{50}) of 1.5 inches (maximum particle size [D_{100}] greater than 3 inches). The delivery system to the transportation crew will begin with a front-end loader, removing materials from the stockpile and placing them on 120-foot by 30-foot material barges. These barges will have combing to keep the materials from sliding into the river. The barge will be pushed by a tugboat to the mechanical placement marine plant.

The plant will consist of an excavator with a clamshell type bucket that utilizes a RTK GPS for position and elevation tracking (see description below). The coordinates of the bucket, as calculated using the RTK GPS system and angle sensors, are sent to the DREDGEPACK® survey software system produced by Hypack®. The system updates the plan view with the real-time bucket position and uses a color gradient to easily show the operator an updated, color-coded view of the lake bottom in real-time.

The mechanical placement operation will work similar to the broadcast spreading operation for movements. Two spud barges will be used for controlled advancement. The two barges will be approximately 40 feet by 100 feet and 30 feet by 80 feet. One will be the working barge with an excavator and the other will be the guide barge working together in unison. The 30-foot by 120-foot barge with capping/cover material will be moored alongside the working barge; the excavator will remove material from the barge. While the material barge is being offloaded it will be moved parallel to the working barge to allow the material to be removed. The rock placement barge, where the excavator will be located, will draw less than 30 inches of water. The loaded material barges will typically draw approximately 6 feet of water; however, in areas of shallow water they can be light loaded to draw as little as 36 inches. Accordingly, this plant will be capable of working in areas of 3 feet of water. To the extent feasible, tugboat operation for positioning the placement and material barges will be oriented to avoid excessive propeller wash towards shallow water.

One type of material will be placed per pass. Each cap area will be divided into a grid, with each cell requiring approximately one, but not more than two, bucket loads to achieve the required thickness. The excavator will load the clamshell from the barge and place the contents over an individual cell displayed in DREDGE PACK®. The operator will position the bucket within 1 or 2 feet of the vertical placement location, and then release the material slowly and evenly over the cell. Based on the equipment configurations, the excavator is expected to be able to extend to a depth of approximately 25 feet; therefore, at water depths greater than 26 to 27 feet, it will be necessary to release capping materials from more than approximately 1 to 2 feet off the bottom. DREDGEPACK® will record the placement of material into each cell, which allows the operator to track the progress of the work.

After completing placement of material into the cells of the grid, a "rake"or other means may be used to level the material, if necessary. Typically, a rake is fabricated from a piece of pipe approximately 18 inches in diameter that extends the width of a barge. The pipe is attached to the barge by use of trunnion beams, which on one end are attached to the pipe, and on the other end are attached to hinge pins on the barge. The rake assembly is rotated over the front of the placement barge and set on top of the material to be leveled and the barge is slowly pushed backwards, allowing the pipe to level the material placed by the bucket of the excavator. The use of a pipe allows the pipe to ride over the top of the potentially mounded-up gravel without digging into the cap. Typically, the pipe is weighted with ballast or sometimes concrete to give it additional mass. In very deep water, an 8-foot-long pipe is attached to the bucket of the excavator and used in the same operation. In this manner, it is possible to extend down to deeper depths than would be possible with the pipe being attached to the barge.

The placement area will be approximately 35 feet by 20 feet, but may be adjusted to optimize material distribution. Once armor stone is placed in this placement area, the barges will step back to allow material to be placed in an adjacent area. A placement rate of 45 cy per hour (67.5 tons per hour) is targeted with the mechanical placement equipment (for materials with larger than a D_{50} of 1.5 inches).

6.7 Position Control and Measurement

Details of the surveying and position control are provided in Section 4.3, relative to dredging activities, and Attachment C-0 of Appendix C of the 100 Percent Design Report Volume 1. The sections below detail information relevant to engineered capping activities in 2011 and beyond that was not addressed in Volume 1.

6.7.1 Geodetic Control

The broadcast spreader utilizes a RTK GPS for position and elevation tracking. The RTK GPS system has the following components and characteristics:

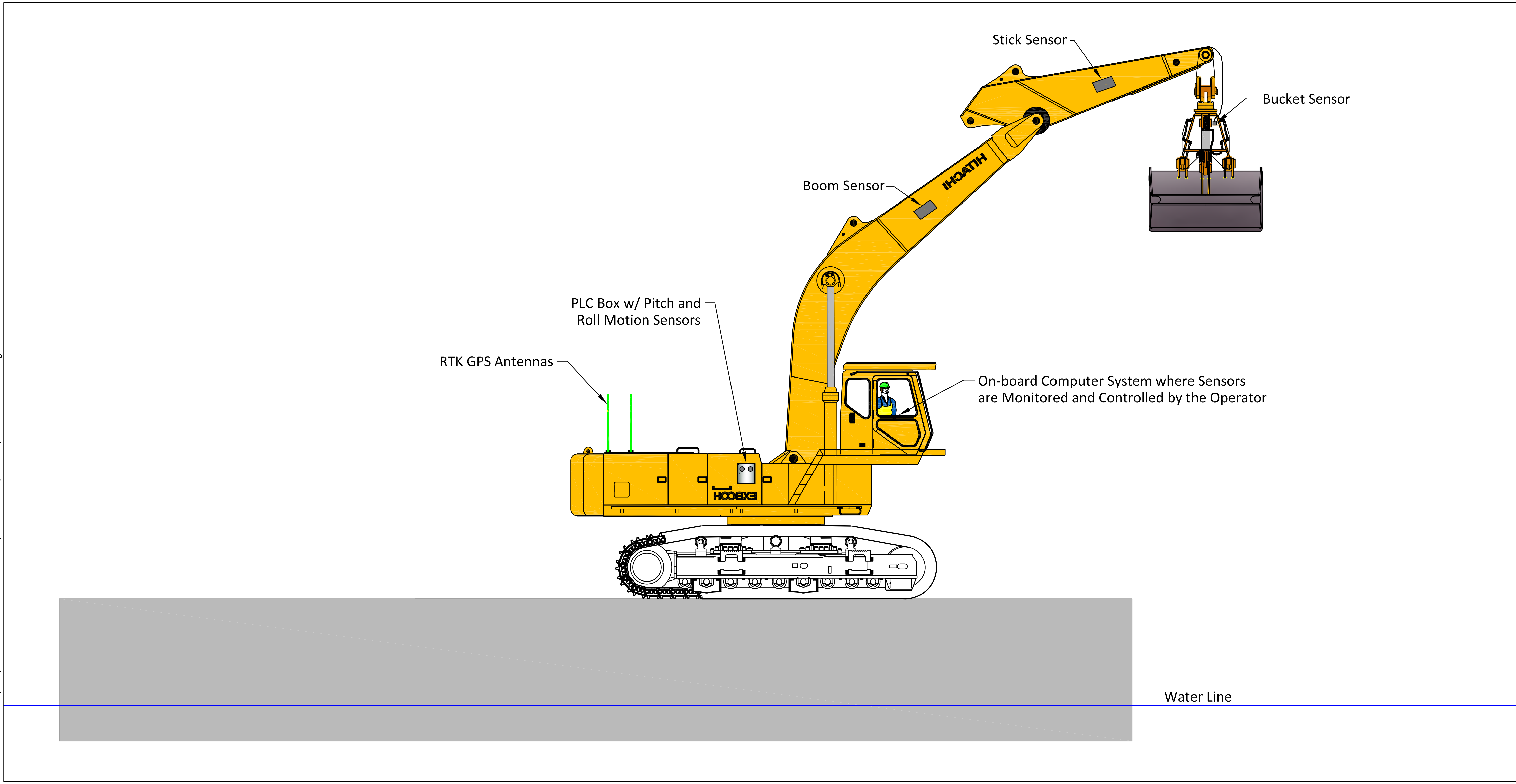
- Uses satellite links to two spreader barge-mounted receivers
- Uses a fixed location receiver with known coordinates
- Uses a geometric method known as trilateration to determine the real-time position and elevation of a point on the sand spreader to within 4 cm accuracy
- Point is configured to be located at the sand discharge location; as the spreader barge travels, turns, rises, and falls on the lake, the system continually updates the northing and easting coordinates, heading, and elevation of the sand discharge position.

The mechanical placement equipment will also utilize RTK GPS for position and elevation tracking. The RTK GPS system uses satellite links to two excavator-mounted receivers, a fixed location receiver with known coordinates, and a geometric method known as trilateration to determine the real-time position and elevation of a point on the excavator to within 4 cm accuracy (see Figure 6-2 for a depiction of equipment sensors). This point is configured to be located at the excavator heel-pin (pivot point between the excavator body and the boom). As the excavator travels, turns, and rises and falls, the system continually updates the northing and easting coordinates, heading, and elevation of the heel-pin position.

Because the point of interest on the excavator is not the heel-pin but the bucket at the end of the excavator arm, additional instrumentation is added to the excavator arm to calculate the real-time, real-world position of the bucket. Inclinometers provide continual measurements of the boom, stick, and bucket angles. Two tilt sensors provide continual measurements of the pitch and roll angles of the excavator. The sensor signals are wired to a dedicated monitoring system sold by Ocala Instruments, Inc. These angle measurements, along with basic dimensions of the excavator arm, are used in a group of geometric and trigonometric calculations within the Ocala Instruments device to determine the real-time position offsets of the bucket location relative to the heel-pin location. By continually applying these three offsets (X, Y, Z) to the RTK GPS heel-pin position, the position and elevation of the bucket is known to within approximately 4 inches, as determined by the root sum square methodology consistent with the accuracy calculations presented for the dredge equipment in Section 4.4 of the 100 Percent Design Report Volume 1.

The coordinates of the sand spreader and/or mechanical bucket are sent to the survey software system DREDGEPACK®. DREDGEPACK® serves the following two purposes:

- It provides a continuous log of coordinates and elevations for the material discharge location (for the broadcast spreader) of the clamshell bucket (for the mechanical placement equipment).
- It provides tools to help the operator accurately locate the spreader barge or clamshell bucket at required coordinates. The system accepts and displays existing survey information in both plan and elevation views.



SOURCE: Prepared from electronic file provided by Brennan dated 10-6-08.

0 8
Scale in Feet

Figure 6-2
Schematic of Positioning System for Cap Placement Equipment
Fox River 100% Design Volume 2

6.7.2 Verification of Placement

As a means of quality assurance (QA)/quality control (QC), bathymetric surveys will be performed and post-placement cores or catch pans will be collected during the broadcast spreading operations, as described below. These surveys and physical measurements will be used to monitor and adjust equipment performance, but will not serve as a means of verifying compliance with the design, which is briefly summarized below and detailed in the CQAPP (Appendix F).

In order to assess compliance and track progress of engineered placement operation, cap areas will be divided into CMUs, as discussed in Section 6.6, for assessing compliance of the placed caps with the design, as described in the CQAPP. If appropriate based on AM, the compliance unit may be expanded to a group of contiguous CMUs forming a cap certification unit (CCU). As discussed in the CQAPP and associated standard operating procedures for sampling, the thickness and extents of placed caps will be verified through a combination of accurate position control, material placement records, physical measurements (where feasible), and comparison of pre- and post-material placement bathymetric surveys. Post-placement surveying and measurement are planned to be conducted within 24 to 48 hours after the spreading barge places material over an area; however, longer periods of time may be necessary based on other survey needs for the ongoing dredging work.

6.7.2.1 Pre-Construction and Post-Construction Surveys

Survey operations will be performed over completed cap (and sand cover; see Section 7) areas. Similar to pre-dredge surveys, a pre-cap single-beam survey will be performed to detail existing conditions prior to the start of a construction season. Multi-beam surveys may also be performed occasionally for internal QC purposes, but these surveys will not be used for assessing compliance. After a capping plant has completed placement in an area and compliance with the design has been verified in accordance with the CQAPP, the single-beam system will return to document the post-placement conditions.

6.7.2.2 Post-Placement Cores and Catch Pans

QC sampling will be conducted by the operators of the placement equipment to ensure that spreading equipment is achieving adequate thicknesses of sand and armor evenly across the spreader bay. Samples can be taken with a range of sampling equipment, but the primary sampling method for placed sand will be the Brennan Push Corer (BPC). The BPC is a sampling apparatus designed to sample sand that has been spread over soft sediment in water depths of approximately 10 feet or less. This device uses a 10-foot-long, 1.5-inch-dimater polyvinyl chloride (PVC) tube with an additional 3-foot-long section of clear, 2-inch-diamter PVC pipe mounted below a one-way valve that is fixed to the bottom of the 10-foot section, as shown on Figure 6-3. Longer sections of PVC tube can be used to allow this sampler to be effective in water depths exceeding 10 feet.

The BPC was designed by J.F. Brennan to ensure that the sampling accomplishes the desired objectives while being easy to use and maintain. This device was used at OU 1 in 2007 and 2008 and in OU 3 in 2009 with favorable results. Core samples will be collected by the equipment operator for immediate thickness verification within the spreader's effective spread area (approximately 35 feet by 6 feet). Typically, five samples are collected across the 35-foot width of the spreader bay. The operator will sample this area, confirming that the minimum thickness requirement is being met prior to advancing to the next spreading step. These sample cores are collected during each step of the placement operation.

QC sampling of the placed armor stone will be conducted to ensure that the proper amount of armor stone is being spread evenly across the spreader bay. Due to the nature of the material, the BPC is not suitable to sample the armor stone. The QC sampling device for armor stone thickness verification will be a "catch pan," which consists of a pail that has a steel ruler riveted to the inside of the pail, perpendicular to its base, as shown on Figure 6-3.

Catch pans will be placed inside the spreader bay immediately after a step has been taken, within the zone that the barge exposes as it steps back. The catch pans can be placed at any position to the right, center, or left of the spreader unit and remain in position until immediately before the next step of the spreader barge. As the barge begins to make this next step, the catch pan will be retrieved and an average thickness of placed material within the catch pan will be recorded. This process is more time consuming than the BPC, so fewer QC samples will be taken. It is important to position the QC sediment traps at different locations in the spreader bay in order to determine if the spreader is placing an even thickness.

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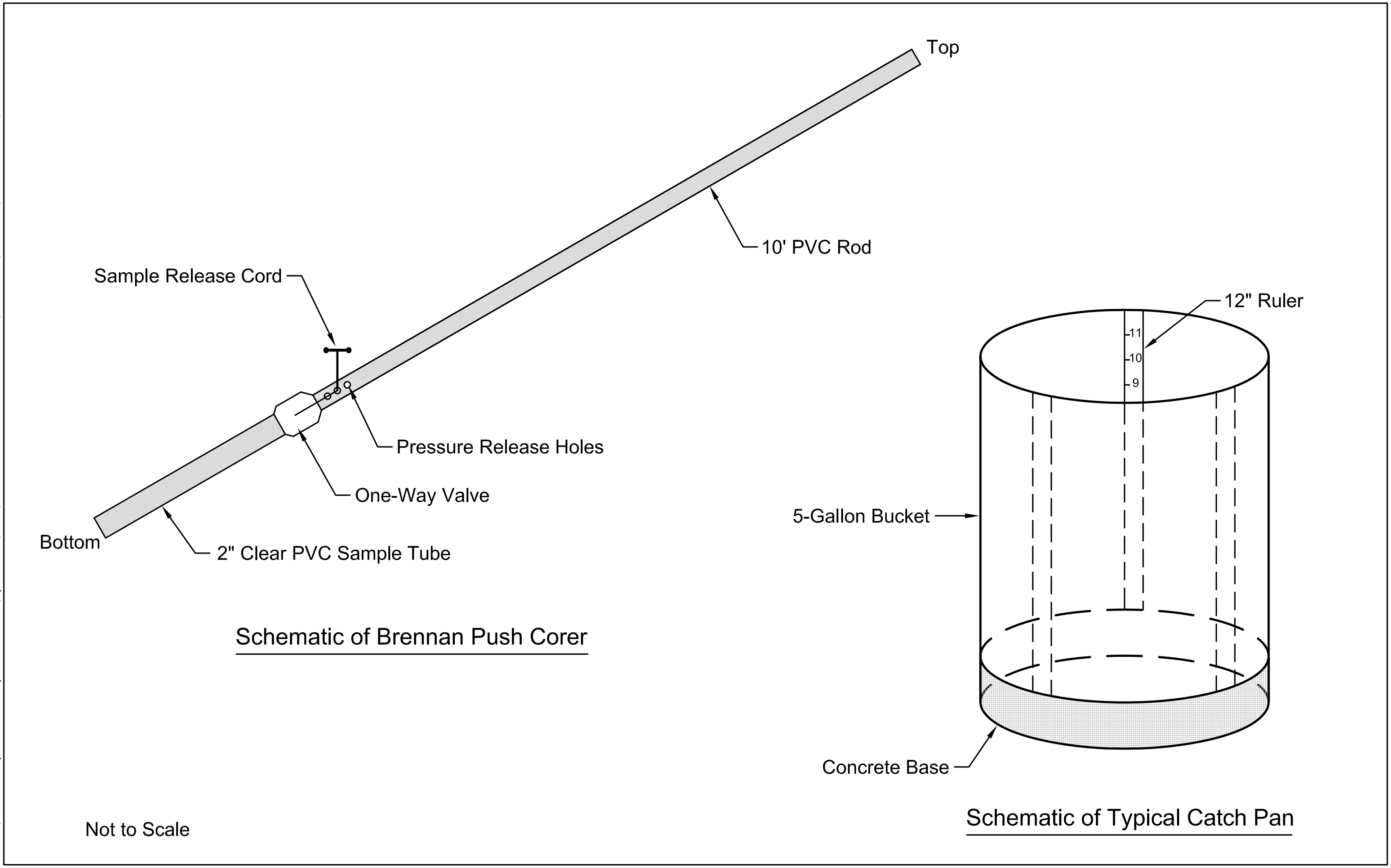

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"Marine Professionals"
La Crosse, WI

Figure 6-3
Schematic of Brennan Push Corer and Typical Catch Pan
Fox River 100% Design Volume 2

6.8 Sequencing of Capping Operations (2011 and beyond)

It is anticipated that most capping and covering of contaminated sediment will be conducted over six work seasons, beginning in 2011, with substantial completion by 2017. No caps or covers are planned for installation during 2012. Some broadcast spreading operations were initiated in 2009 and resumed in 2011, with mechanical placement starting in 2013 or 2014. The anticipated capping seasons will be similar to those noted for dredging, from approximately early April to mid-November of each year, with some fluctuations due to river and weather conditions. If cold weather conditions persist in late fall, it may be necessary to shut down capping operations with the broadcast spreader prior to mechanical placement operations. Within these capping windows, operations will be limited to no more than 5 days per week. This will allow cap construction activities to cease during the peak times for Fox River recreational boaters (i.e., Saturdays and Sundays).

The proposed sequence of capping and covering operations will primarily proceed in an upstream to downstream fashion. In areas where the slope is greater than approximately 5 percent, the caps will be placed starting at the bottom of the slope working to the top of the slope, where feasible. For the majority of the capping seasons, dredging will be conducted simultaneously; however, the simultaneous dredging operations will be downstream of any capped or covered areas. In addition, the sequencing includes broadcast spreading of the smaller granular cap material in the first years of capping (2009 and 2011). Mechanical placement of capping materials (as necessary based on Site conditions) will be initiated following the broadcast spreading operations, in an upstream to downstream fashion.

Table 6-8 outlines the areas currently slated for cap and cover placement as part of the Lower Fox River Project. It should be noted that this sequence is subject to change and a detailed sequence/schedule for each season of RA will be presented in the annual Phase 2B RAWPs.

Table 6-8
Engineered Cap Placement – Yearly Installation 2011 to 2017

Year	Area	Engineered Cap Type	Cap Area
2011	OU 3	Engineered Cap A	In this year of capping, one broadcast spreading marine plant will be operated in OU 3, depending on the progress of dredging operations. It is anticipated that this plant will place all sand and gravel to complete OU 3. One mechanical plant will be operated, as necessary, to place the larger gravel material.
	OU 3	Engineered Cap B	
2013	OU 4A	Engineered Cap A	In 2013, the capping operations will primarily consist of residuals management and placements of remedy sand cover and caps. The broadcast land-based operations will begin capping and sand cover placement in the southern end of OU 4 and work north following the progress of the dredges. Mechanical plants may be used to place the larger stone as the operation moves north.
	OU 4A	Engineered Cap B	
	OU 4A	Cap C	
2014	OU 4A	Engineered Cap A	The capping operations will continue where they left off in 2013. It is anticipated that the one or two broadcast spreading marine plants and one or two mechanical plants will place all sand, gravel, and large armor stone to approximately transect 4038
	OU 4A	Engineered Cap B	
	OU 4A	Engineered Cap C	
2015	OU 4A	Engineered Cap A	Capping placement will continue in OU 4 where operations left off the prior year. One or two broadcast spreading marine plants will place sand and gravel while one or two mechanical plants places the larger armor stone material, as necessary. It is anticipated that capping operations will be completed to the area of the LaFarge Dock. (Approximate river station 4054). The Shoreline Cap along Georgia Pacific's frontage (SHC13) will be completed.
	OU 4B	Engineered Cap A	
	OU 4A	Engineered Cap B	
	OU 4B	Engineered Cap B	
	OU 4A	Engineered Cap C	
	OU 4B	Engineered Cap C	
	OU 4A	Shoreline Cap	
	OU 4B	Shoreline Cap	
2016	OU 4B	Engineered Cap A	During 2016, cap placement will continue in OU 4B. One or two broadcast spreading marine plant will place sand and gravel while one or two mechanical plants will place the larger armor stone material, as necessary. Cap placement will be conducted between the area of LaFarge Dock and the East River Turning Basin. Portions of the Shoreline Caps along the East River Turning Basin (SHC18/19) will be completed.
	OU 4B	Engineered Cap B	
	OU 4B	Engineered Cap C	
	OU 4B	Shoreline Cap	
2017	OU 4B	Engineered Cap A	Capping placement will continue in the area of the East River Turning Basin where operations left off the prior year. The broadcast spreading marine plant will place sand and gravel while the one mechanical plant will place the larger armor stone material, as necessary. Cap and cover operations are expected to be complete this year.
	OU 4B	Engineered Cap B	
	OU 4B	Engineered Cap C	
	OU 4B	Shoreline Cap	

7 REMEDY AND RESIDUAL SAND COVER DESIGN

7.1 Remedy Sand Cover Design

As discussed in the BODR and subsequent Design Reports, a substantial area of OUs 2 to 5 contains a veneer (6 inches) of sediments with PCB concentrations marginally above the 1.0 ppm RAL. These surficial sediments, which contain maximum PCB concentrations of up to 2.0 ppm, overlie cleaner sediments with PCB concentrations below 1.0 ppm. Additional sediment areas within OUs 2 to 5 contain up to two sample intervals with PCB concentrations between 1.0 and 2.0 ppm underlying an existing surface layer of sediment with concentrations below the 1.0 ppm RAL. Consistent with the Response Agencies' June 14, 2012 memorandum summarizing a "minor change to the selected remedy," the RA plans presented in this 100 Percent Design Report include placement of a minimum 6-inch-thick sand covers to address low risk deposits that have the following characteristics:

- Maximum PCB concentration no greater than 2 ppm in any core sample interval
- Maximum of two 6-inch sampled intervals in the core with concentrations exceeding the 1.0 ppm RAL
- All other sediment in the core equal to or less than the 1.0 ppm RAL

In addition, remedy sand cover will be placed in other exceptional areas (no more than two intervals between 1 and 2 ppm, or a maximum concentration greater than 2 ppm may be considered on a case-by-case basis) as approved by the Response Agencies. To date, the technical workgroups have evaluated exceptional areas with PCB concentrations marginally exceeding the RAL where dredging would be difficult or inefficient based on Site-specific conditions. In several of these areas, the Response Agencies have approved alternate RAs (e.g., remedy sand cover or no action). These exceptional areas are summarized in the Remedial Design Anthology and presented in this 100 Percent Design Report Volume 2.

Remedy sand cover areas have been delineated through a collaborative process with the A/OT considering the DRT (presented in USEPA 2012), location in the river, sediment chemistry, and the geostatistical model with a LOS of 0.5, which resembles a curvilinear polygon. Attachment B-8 of Appendix B summarizes special considerations for the delineation of remedy sand covers in OU 3. Similar to the discussion for engineered cap areas (see Section 6.5), the Engineered Plan Drawings presented in Appendix D depict the minimum required remedy sand cover areas based on the geostatistical model as well as the preliminary construction limits based on consideration of the remedy sand cover placement equipment (broadcast spreader with 35-foot lane widths; see Section 7.2.2). These preliminary construction limits may be refined in each year prior to construction, based on J.F. Brennan's detailed plan for spreading lanes. These refinements will be presented to the Agencies in the annual Phase 2B RAWPs, or other appropriate documentation.

The remedy sand cover areas delineated for OUs 2 to 5 for this 100 Percent Design are shown on Figure 1-5. With consideration of anticipated remedy sand cover placement equipment and operations, preliminary remedy sand cover construction limits are expected to cover approximately 134.2 acres, including approximately 36 acres completed in 2009. This number is subject to change once results from the 2012 infill sampling are incorporated into the design.

7.2 Residual Sand Cover Design and Areas

Residual sand covers will be utilized to manage post-dredge residual sediment meeting the following criteria:

- Where no more than one 6-inch, composited interval's PCB concentration in a post-dredge sample within a dredge management unit (DMU; see CQAPP in Appendix F) is between 1.0 and 10.0 ppm and all other composited intervals have less than 1.0 ppm.

On a case-by-case basis, the Response Agencies may approve the use of residual sand cover in DMUs where the composite PCB concentration exceeds 1.0 ppm in more than one composited interval.

7.3 Equipment Selection and Production Rates

7.3.1 Material Staging

The sand cover materials will be staged at both of the upland facilities. The OU 2/3 secondary staging facility will be used for staging of cover material needed for areas south of the De Pere Dam (in OUs 2 and 3), and the LFR Processing Facility staging area will be used for staging of cover material to be placed north of the De Pere Dam (in OU 4), as shown on Figures 3-1 and 3-2, respectively. Cover material will be trucked to these staging areas from local material suppliers. Table 6-8 provides material sources considered for use on the project.

Similar to the material transport discussed in Section 6.6 for capping materials, sand cover materials will be placed primarily by a barge-mounted broadcast spreader unit, but mechanical means (i.e., excavator or clamshell bucket) may be used where broadcast spreading is not feasible or efficient. Section 6.6.3 discusses placement of materials via broadcast spreader, with additional detail specific to sand covers provided in Section 7.2.2. Section 6.6.4 discusses placement of engineered cap materials via mechanical clamshell, which is also applicable to sand covers.

7.3.2 Broadcast Spreading

Sand cover material will be spread over contaminated sediments during in situ placement using a broadcast method. The broadcast spreading method allows for uniform placement of thin layers of cover material as well as cover placement in shallow waters while increasing placement rates and reducing material waste.

Similar to the method discussed in Section 6.6.3 for engineered caps, transport of sand cover material from the staging area to the broadcast spreader barge will be either by direct hydraulic slurry or a combination of barge and hydraulic slurry. There will be two simultaneously operating broadcast spreading marine plants, each consisting of a slurry barge (if direct hydraulic transport is not feasible), a broadcast spreading barge, and a template barge. Material will be transported to the two broadcast spreader barges or to the two slurry barges by 120- by 30-foot deck barges with combing containment. From the slurry barges, sand cover material will be transported via hydraulic slurry to the two broadcast spreader barges for placement. It is anticipated that approximately five deck barges will be required to support these operations, assuming two barges at the slurry plants, two barges being loaded, and one in transport. The barges will be pushed by small tugboats. Typically, the greater the distance from the loading area to the spreader operation, the more barges will have to be put into the program because of the extended transport time. However, based on the pumping distances achieved to date and with the possibility of identifying alternate shoreline staging areas in the future to facilitate land-based slurry operations, it is likely that the number of material transport barges and floating slurry barges may be reduced.

The broadcast spreader plant has a draft of approximately 18 inches, making it suitable for shallow water placement. However, in the event that sand cover placement is required in water shallower than 18 inches, the Tetra Tech Team will assess if alternate means of placement are feasible, subject to AM through the technical workgroups, with approval from the A/OT.

The process of broadcast spreading sand cover will be consistent with that described in Section 6.6.3 for the sand portion of engineered caps. In addition, placement rates for sand cover are also expected to be consistent with engineered cap placement; ranging from 20 to 65 cy per hour (30 to 98 tons per hour). Based on a typical 22 work day month and 65 percent efficiency (i.e., uptime), this target production rate of 50 cy per hour (75 tons per hour) corresponds to approximately 11 acres of sand cover placement (6 inches thick) per month.

7.4 Position Control and Measurement

The measurement and control of the broadcast spreading operation will be similar to that described for engineered caps in Section 6.7

7.4.1 Verification of Placement

As a means of QA/QC, bathymetric surveys will be performed and cores will be collected during the broadcast spreading operations, as described in Section 6.7.2. These surveys and physical measurements will be used to monitor and adjust equipment performance, but will not serve as a means of verifying compliance with the design, which is briefly summarized below and detailed in the CQAPP (Appendix F).

In order to facilitate management and track progress of sand cover placement operation, sand cover areas will be divided into sand cover management units (SCMUs). If appropriate based on AM, the compliance unit may be expanded to a group of several contiguous SCMUs forming a sand cover certification unit (SCCU). As discussed in the CQAPP, the thickness and extents of placed caps will be verified through a combination of accurate position control, material placement records, and physical measurements. Comparison of pre- and post-construction bathymetric surveys are not expected to provide a consistent means of verifying sand cover placement thicknesses due to shallow water conditions and specified thickness of the sand covers relative to the accuracy/precision under these conditions. However, bathymetric surveying is expected to provide valuable information to verify horizontal extent of material placement.

7.5 Sequencing of Sand Cover Operations (2011 and beyond)

Sand covering of contaminated sediment is anticipated to be conducted over six seasons, 2011 through 2017, but excluding 2012. The anticipated cover placement seasons will be similar to those noted for dredging, April 15 to November 15 of each year, with some fluctuations due to river conditions. If cold weather conditions persist in late fall, it may be necessary to shut down capping operations with the broadcast spreader prior to mechanical placement operations. Within these windows, operations will be limited to 5 days per week. This will allow the team to be off the Fox River during the peak times for recreational boaters (i.e., Saturdays and Sundays).

The proposed sequence of sand covering operations will primarily proceed in an upstream to downstream fashion. For the majority of the sand covering seasons, dredging will be conducted simultaneously. However, the simultaneous dredging operations will be downstream of any covered areas. Mechanical placement of sand cover, if necessary based on Site conditions, will be initiated following behind the broadcast spreading operations, in an upstream to downstream fashion.

8 INSTITUTIONAL CONTROLS

As described in the RD Work Plan, the ICIAP (presented as Appendix G of this 100 Percent Design Report Volume 2) is an integral element of RD/RA implementation. The purpose of the ICIAP is to ensure the protectiveness of RAs addressing contaminated sediments in OUs 2 to 5 with the objective of protecting human health and the environment in perpetuity.

Following completion of capping and other associated actions at the Site, contaminated sediments contained beneath engineered caps will be subject to the long-term requirements of the ICIAP (Appendix G). The ROD Amendment anticipated localized impacts to engineered caps such as recreational boat anchoring activities, and noted that such disturbances are not expected to compromise the overall effectiveness of the remedy. Because the OUs 2 to 5 caps will generally be constructed in net depositional environments within the river, new sediment will begin accumulating on the cap surface immediately following construction. The clean sediment layer accumulating on the cap will further reduce the anchor-related impacts and increase the overall effectiveness of the cap over the long term.

Restrictions to ensure cap integrity can be implemented through agencies such as WDNR and the USACE that have permitting authority over construction activities in the aquatic environment, including programs that require permits to be obtained for dredging and filling. Existing regulatory authorities are summarized in the ICIAP (Appendix G). For example, WDNR's Chapter 30 permitting program creates a comprehensive regulatory and permitting framework that governs the types of activities, such as dredging and placement/removal of structures in navigable waters, which could affect the integrity of the engineered caps. Wisconsin law has long recognized the existence of certain common law rights that are incidents of riparian ownership of property adjacent to a body of water. Those riparian rights include the right to reasonable use of the shoreline and reasonable access to water by construction of a pier or other structure to aid in navigation. Likewise, Wisconsin law has long recognized that these riparian rights are qualified, subordinate, and subject to the paramount interest of the State of Wisconsin (the "State") and paramount rights of the public in navigable waters (the so-called public trust). The State administers the public trust through various statutes and rules that regulate activities in navigable waters. Through these statutes and rules, the State has created the regulatory framework to provide the long-term institutional control to protect the integrity of the caps.

The WDNR Chapter 30 regulatory framework, however, exempts certain activities from the permitting requirements, including a riparian owner's ability to place and remove a pier. Though shoreline caps will generally not be placed in less than 3 feet of water and therefore not be impacted by such exempt activity (see Section 6.2.4), additional measures beyond reliance on the Chapter 30 program will be taken in the capping areas that could be affected by riparian activities (e.g., shoreline caps as defined in Section 6.4.1 or other caps close to the shoreline). WDNR has moved away from using deed restrictions as a means of a proprietary control to regulate activities where residual contamination remains after a cleanup. Instead, WDNR requires that the affected area be registered on a WDNR-approved geographic information system (GIS) registry system. WDNR also requires written notification to affected landowners. This revised approach is a result of Wis. Stat. Section 292.12, which the legislature enacted in 2006. Pursuant to this regulatory framework, the location of the caps that could be affected by riparian activities will be registered on the WDNR-approved GIS registry system, and affected riparian landowners will be notified in writing. Additionally, the location of the caps will be indicated on all appropriate local governmental units' mapping systems.

Proprietary institutional control mechanisms to be used in OUs 2 to 5 will include:

- Existing governmental controls arising under local, state, and federal regulatory authority such as permit approval processes, regulation of maintenance activities, removal/placement of contaminated sediments and installation or removal of in-water piles to prevent exposure or migration
- Informational controls such as existing fish consumption advisory programs
- Proprietary controls such as registration on the WDNR-approved GIS registry system and inclusion on appropriate local units of government GIS mapping systems

Following Response Agencies' approval of the 100 Percent Design Report Volume 2 and ICIAP submittals, various memoranda of agreement (MOAs) will be developed as part of the RA among WDNR, USACE, municipalities, and the respondents to the Order or their representatives. These MOAs will be developed for different purposes, as discussed in the ICIAP (Appendix G). For instance, the MOA with USACE will be developed to ensure that future dredging activities within the federal navigation channel do not compromise the integrity of the engineered caps. The MOAs are anticipated to follow the general form of agreements implemented at other similar CERCLA sediment cap sites.

As part of the CERCLA 5-year review, USEPA will require periodic certifications of the status and effectiveness of the institutional controls implemented in OUs 2 to 5. As practical, long-term cap monitoring and maintenance reporting under the COMMP and water/biota sampling and reporting under the LTMP will be coordinated to take place during the same year, conducted approximately 1 year prior to the scheduled CERCLA 5-year reviews, so that the most up-to-date information will be available to inform the review.

9 CONSTRUCTION SCHEDULE

The 100 Percent Design Report Volume 1 presents the construction schedule for RA in 2009. This section describes the sequence of activities from 2010 through project completion. It should be noted that the schedule presented herein is subject to refinement each year prior to construction. An updated schedule will be presented in the annual Phase 2B RAWPs.

9.1 Operations Sequencing

Within the annual Phase 2B RAWPs, a detailed single year schedule will be included. Each schedule will incorporate all final designs and Site-specific remedies designed for that specific annual Phase 2B RAWPs. Such a schedule will be issued every year in each respective Work Plan and will detail the sequence of construction of all remedial activities taking place within that RA year.

Dredging of contaminated sediment is estimated to be conducted over seven seasons: 2009 through 2015 (2009 RA is addressed in the 100 Percent Design Report Volume 1). Most capping and cover work is anticipated to take place beginning in 2011 and substantially finishing by 2017. Some capping and covering was performed during the 2009 dredge season and none is planned for the 2012 season. The work seasons for both capping and dredging are currently anticipated to run from mid-April to mid-November of each year, depending on work plans and conditions. It is anticipated that dredging and capping operations will generally be conducted 24 hours per day and 5 days per week. This provides access to the river by recreational boaters on Saturdays and Sundays. If necessary to maintain or make up schedule, a sixth day of in-water operations may be added.

Consistent with operations in 2009 and 2010, production dredging during 2011 and beyond is planned to take place in advance of final pass dredging focusing on areas where thicker faces can be dredged at a higher production rate.

Dredging of sediments potentially subject to TSCA disposal requirements is expected to be completed by 2014 or 2015, based on where this material is presently known to be located. TSCA dredging will be scheduled to efficiently implement the RD, generally moving upstream to downstream; however, adjustments in that upstream to downstream sequence may be made for efficient scheduling of TSCA dredging. This is important for operational efficiency, as mid-season changeovers from non-TSCA to TSCA and back can add cost and reduce productivity.

In dredge areas where both TSCA and non-TSCA material are present, the overlying non-TSCA material will be dredged first, leaving the underlying material to be removed later. Should TSCA dredging expose sediment greater than or equal to 50 ppm PCBs, that is unable to be removed prior to the end of the dredging season, the sediments will be appropriately covered (e.g., with Reactive Core Mats [RCMs]) in consultation with the A/OT over the winter months (Tetra Tech and Anchor QEA 2009).

During most seasons, dredging and capping will occur simultaneously. However, the simultaneous dredging operations will be downstream of any capped or covered areas. In addition, the sequencing calls for broadcast spreading of the smaller granular cap material in the first 2 years of capping. Mechanical capping will be initiated behind the broadcast spreading operations, in an upstream to downstream fashion.

Tables 9-1, 9-2, and 9-3 summarize the anticipated production for dredging, engineered cap placement, and sand cover placement, respectively, for 2009 through completion.

Table 9-1
Actual and Anticipated Dredging Production Rates, 2009 through Completion

Year	Annual Dredge Production [a, b] (in situ cy)	Total Annual Dredge Production [a] (in situ cy)	Total Annual Dredge Completion Area (acres) [g]	Operating Dredges
2009 [b,c]	537,168 of non-TSCA and 7,367 of TSCA	544,535	60.5	Three Dredges
2010 [b,d]	663,860 of non-TSCA	663,860	41.1	Three Dredges
2011 [b,e]	235,409 of non-TSCA	235,409	50.6	Three Dredges
2012 [f]	638,200 of non-TSCA and 21,800 of TSCA	660,000	120	Three Dredges
2013 [f]	535,000 of non-TSCA and 40,000 of TSCA	575,000	151	Minimum of Three Dredges
2014 [f]	455,400 of non-TSCA and 34,600 of TSCA	490,000	128	Minimum of Three Dredges
2015 [f]	490,000 of non-TSCA	490,000	128	Minimum of Three Dredges
2016 [f]	488,000 of non-TSCA	488,000	127.7	Minimum of Three Dredges
Total	**4,043,037 of non-TSCA and 103,767 of TSCA**	4,146,800	806.9	Minimum of Three Dredges

Notes:

a. Annual estimated production volumes are based on 24 hours per day, 5 days per week operation at 65 percent efficiency.

b. Volumes for 2009, 2010, and 2011 are actual dredge quantities including residual dredging. Details on 2009 dredging quantities were provided in the 2009, 2010 and 2011 RA Summary Reports, respectively.

c. Actual total dredge volumes for 2009 were 544,535 cy, which included additional dredge areas approved in the Phase 2B 2009 RAWP and residual dredging. Approximately 8,555 cy of the total amount removed in 2009 represents residual dredged material.

d. Actual total dredge volume for 2010 was 731,017 cy and included 67,157 cy dredged from the Phase 1 Area, which is addressed under a separate consent decree.

e. Actual total dredge volume for 2011 was 235,409 cy. Approximately 6,950 cy of the total amount removed in 2011 represents residual dredged material

f. Volumes for 2012 and beyond are based on required design including a 6-inch overdredge allowance, appropriate side slopes, and an estimated 172,800 cy of residual dredged material (not including 12,500 cy of residual dredging expected in the Phase 1 Area). All quantities for 2012 and beyond are approximate and subject to refinement in the annual Phase 2B RAWPs based on incorporation of 2012 infill sampling results into the design and on any additional infill sampling or Site-specific analyses done in the future.

g. Dredge acreage is based on the surface area of the dredge area's footprint daylighted to the mudline as mapped during the survey referenced on the applicable design drawing, which includes designed side slopes. This acreage includes only areas dredged during the indicated year for which the 90 percent area criterion was achieved (i.e., it does not include areas that were production dredged and required additional future dredging for removal of sediment to the elevation required by the CQAPP). For 2009 through 2011, this acreage includes only areas for which the 90 percent area criterion was achieved during the indicated year (i.e., it does not include areas that were production dredged and required additional future dredging for removal of sediment to the 90 percent elevation criterion required by the CQAPP). For 2012 and beyond, this acreage represents the approximate sum of all dredge-only areas planned to be dredge to the 90 percent elevation criterion during a particular year.

Table 9-2
Actual and Anticipated Area of Cap Placement by Year, 2009 through Completion

Year	Area of Cap Placement [a] (acres)			
	Cap A (13 inch thick) [b]	Cap B (16 inch thick) [b]	Cap C (33 inch thick) [b]	Shoreline Cap [b]
2009 [c]	7.02	0.27	0	0
2010 [c]	0	0	0	0
2011 [c]	22.54	3.89	0	0
2012	0	0	0	0
2013	5.66	15.15	2.10	0
2014	20	17	23	0
2015	25	10	28	2
2016	22	4.45	10	2
2017	12	0	4	2
Total	**114.50**	**50.80**	**66.91**	**5.97**

Notes:

a. All areas for 2013 and beyond are approximate and subject to refinement in the annual Phase 2B RAWPs based on incorporation of 2012 infill sampling results into the design and on any additional infill sampling or site-specific analyses done in the future. These areas represent preliminary construction limits aimed at ensuring complete coverage of the minimum required cap area as defined by the geostatistical model output. Actual cap areas may vary from these limits based on operational considerations and limitations. See Section 6.5 for additional details. Acreages have been rounded for each year after 2012; therefore, the sum of each column may not exactly match the total at the bottom, but the total should be considered more accurate than the sum of the individual years.

b. See Table 6-6 for a summary of cap designs.

c. Quantities for 2009, 2010, 2011, and 2012 represent actual quantities placed.

Table 9-3
Actual and Anticipated Area of Sand Cover Placement by Year, 2009 through Completion

Year	Area of Sand Cover Placement (acres) [a]	
	Remedy Sand Cover	Post-Dredge Residuals Sand Cover [b]
2009 [c]	37.3	10.95
2010 [c]	0	0
2011 [c]	24.85	41.15
2012	0	0
2013 [d]	11	81
2014	6	117
2015	11.	46
2016	10.	40
2017	34	43
Total	**134.20**	**378.97**

Notes:

a. All remedy sand-cover areas for 2013 and beyond are approximate and subject to refinement in the annual Phase 2B RAWPs based on incorporation of 2012 infill sampling results into the design and on any additional infill sampling or site-specific analyses done in the future. These areas represent preliminary construction limits aimed at ensuring complete coverage of the minimum required sand cover area as defined by the geostatistical model output. Actual sand cover areas may vary from these limits based on operational considerations and limitations.

b. Post-dredge residual sand cover area for 2013 and beyond is an estimate only based on experience during the 2009 through 2011 construction seasons. Actual areas requiring sand cover to be determined during construction based on post-dredge confirmation sampling.

c. Quantities for 2009, 2010, and 2011 represent actual quantities placed. Acreages have been rounded for each year after 2012; therefore, the sum of each column may not exactly match the total at the bottom, but the total should be considered more accurate than the sum of the individual years.

d. Actual total area projected for residual sand cover in 2013 is 95.91 acres, which includes 14.87 acres in the Phase 1 Area (addressed under a separate consent decree).

In addition to the dredging, capping, and sand covering operations, the desanding, dewatering, water treatment, and disposal activities associated with the dredging will progress in time with the dredging operations. The work that supports these activities will occur in conjunction with the major activities, including:

- Bathymetric surveying
- Pre- and post-dredge verification sampling (see CQAPP)
- QA/QC functions
- Community health and safety monitoring
- Environmental monitoring

At the end of each season, a report (Annual Remedial Action Summary Report) will be generated that compiles all the relevant data and information along with a description of the year’s activities. This report will be submitted to the Response Agencies for review and approval at the end of each season. At the end of the project, all reports will be compiled and submitted as the Project Final Report (Remedial Action Certification of Completion Report). Figure 9-1 illustrates the key recurring operational sequence for activities in 2010 to completion. Detailed time phasing of each activity is shown on Figure 9-2.

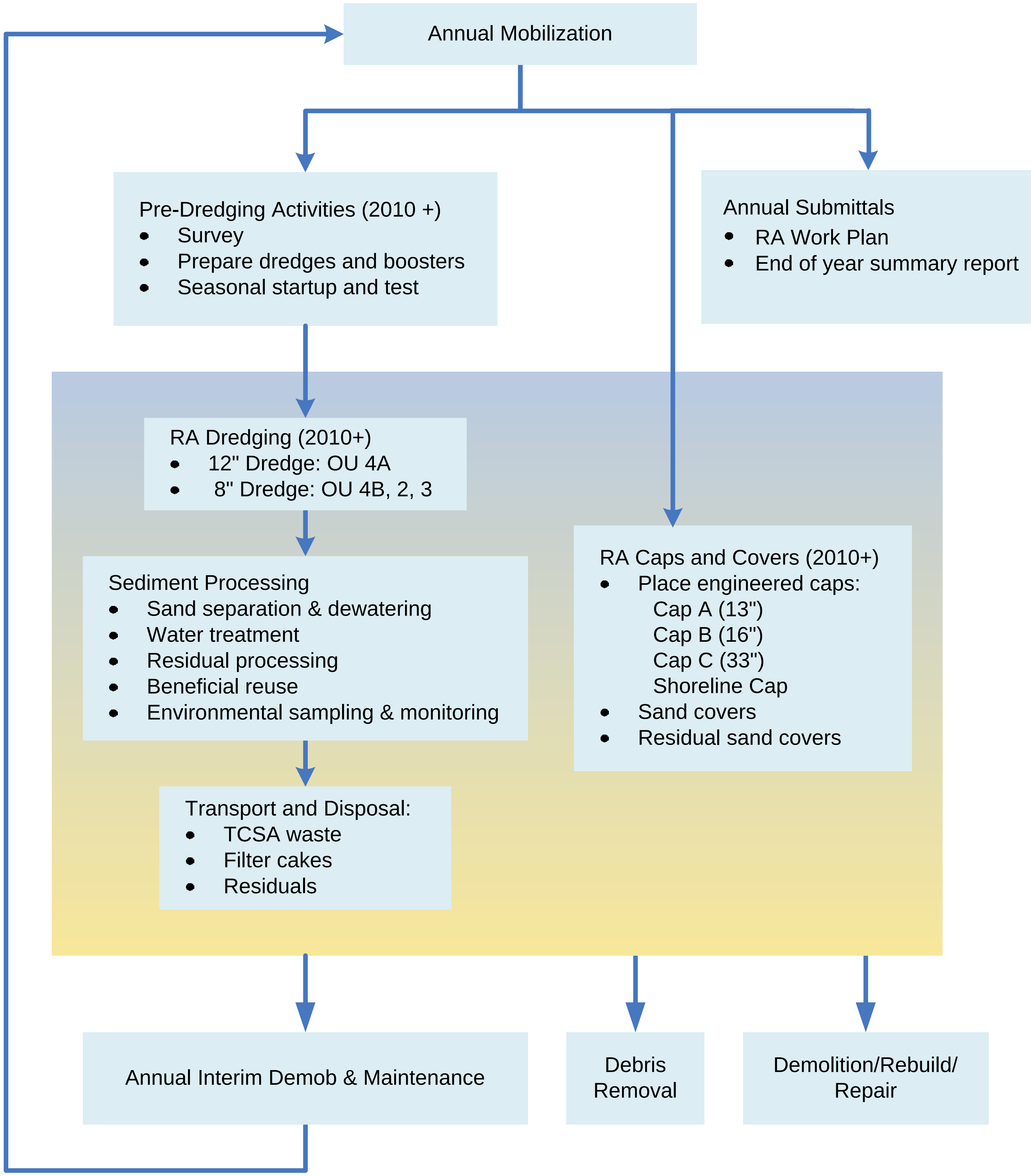

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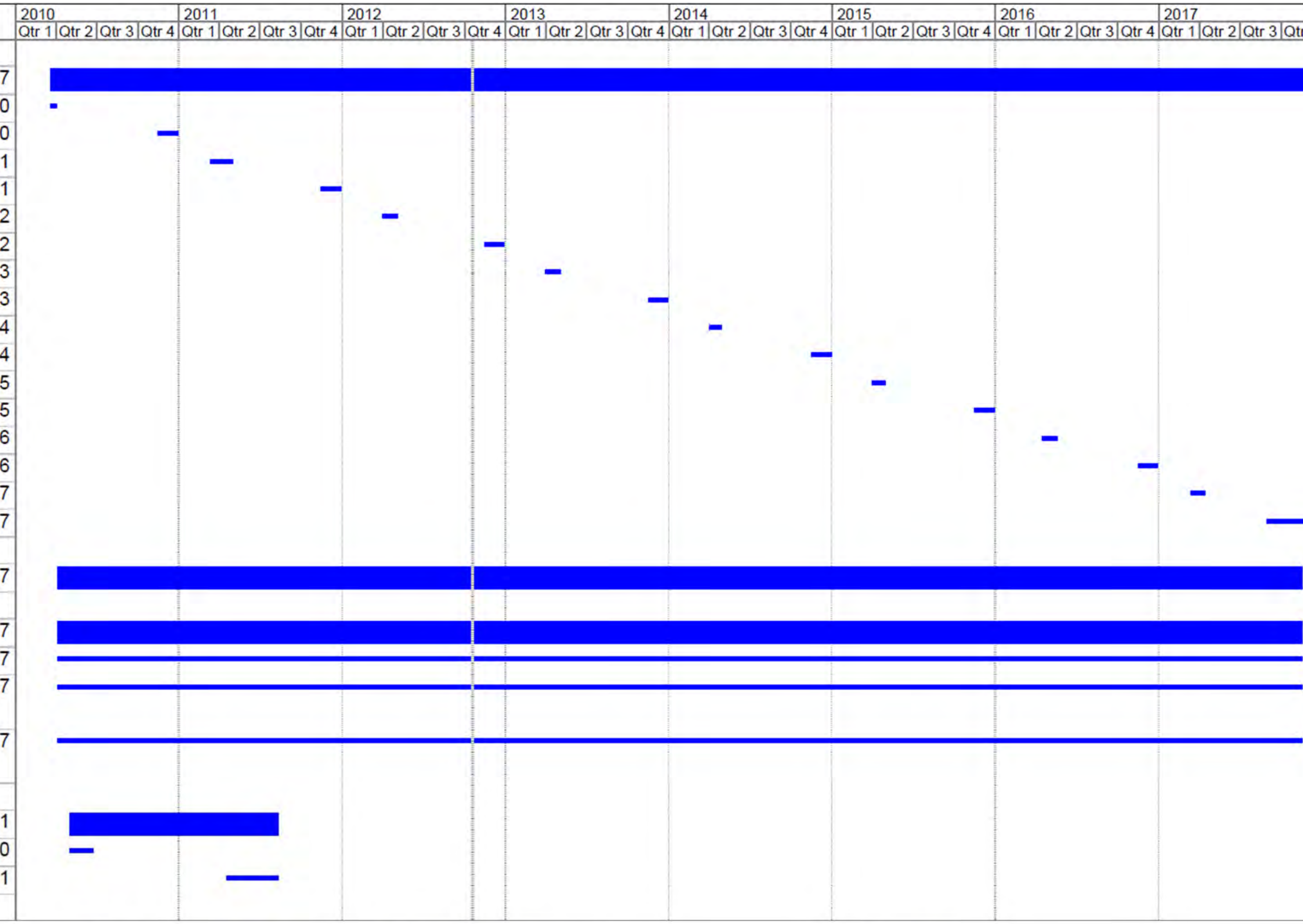
Figure 9-1
Sequence of Recurring Operations
for 2010 through Completion
Lower Fox River – OUs 2 to 5

9.2 Construction Schedule (2010 and Beyond)

The actual construction schedule for 2010 and the currently anticipated construction schedule from 2011 to completion is shown on Figure 9-2.

ID	Task Name	Start	Finish
1			
2	**SOV 8 MOBILIZATION/DEMOBILIZATION**	Mon 3/22/10	Thu 12/28/17
3	2010 Mobilization	Mon 3/22/10	Fri 4/2/10
4	2010 Demobilization & Winter Maintenance	Mon 11/15/10	Thu 12/30/10
5	2011 Mobilization	Mon 3/14/11	Mon 5/2/11
6	2011 Demobilization & Winter Maintenance	Wed 11/16/11	Thu 12/29/11
7	2012 Mobilization	Mon 4/2/12	Fri 5/4/12
8	2012 Demobilization & Winter Maintenance	Fri 11/16/12	Fri 12/28/12
9	2013 Mobilization	Mon 4/1/13	Fri 5/3/13
10	2013 Demobilization & Winter Maintenance	Mon 11/18/13	Mon 12/30/13
11	2014 Mobilization	Tue 4/1/14	Tue 4/29/14
12	2014 Demobilization & Winter Maintenance	Mon 11/17/14	Tue 12/30/14
13	2015 Mobilization	Wed 4/1/15	Thu 4/30/15
14	2015 Demobilization & Winter Maintenance	Mon 11/16/15	Wed 12/30/15
15	2016 Mobilization	Fri 4/15/16	Wed 5/18/16
16	2016 Demobilization & Winter Maintenance	Wed 11/16/16	Thu 12/29/16
17	2017 Mobilization	Wed 3/15/17	Fri 4/14/17
18	2017 Demobilization & Winter Maintenance	Fri 9/1/17	Thu 12/28/17
19			
20	**SOV 11 BATHYMETRIC SURVEYING**	Mon 4/5/10	Fri 11/17/17
21			
22	**SOV 12 REGULATORY COMPLIANCE**	Mon 4/5/10	Fri 11/17/17
23	SOV 12.2 Community Health and Safety	Mon 4/5/10	Fri 11/17/17
24	SOV 12.3 Construction Monitoring (Environmental)	Mon 4/5/10	Fri 11/17/17
25	SOV 12.4 Construction Monitoring (Performance)	Mon 4/5/10	Fri 11/17/17
26			
27	**SOV 15 OU2/3 DREDGING/DEWATERING**	Mon 5/3/10	Wed 8/10/11
28	SOV 15 2010 OU2/3 Dredging/Dewatering	Mon 5/3/10	Wed 6/23/10
29	SOV 25 2011 OU2/3 Dredging/Dewatering	Mon 4/18/11	Wed 8/10/11
30			



Task | Progress | Summary | External Tasks | Deadline

Split | Milestone | Project Summary | External Milestone

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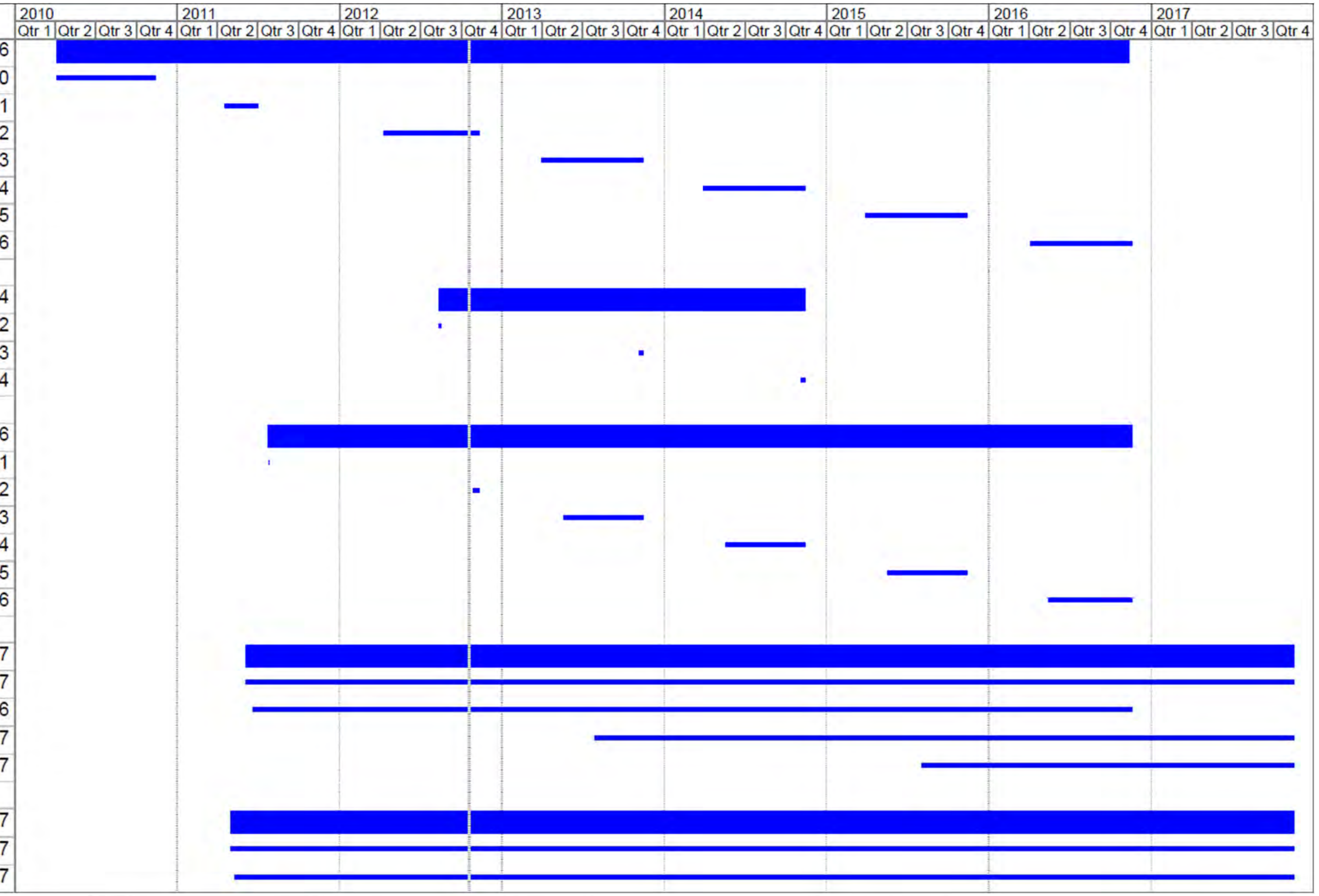
Figure 9-2
Construction Schedule 2010 to Complete
Lower Fox River – OU 2 to 5

ID	Task Name	Start	Finish
31	**SOV 16 OU4 DREDGING/DEWATERING**	Mon 4/5/10	Fri 11/11/16
32	2010 OU4 Dredging/Dewatering	Mon 4/5/10	Sat 11/13/10
33	2011 OU4 Dredging/Dewatering	Mon 4/18/11	Fri 7/1/11
34	2012 OU4 Dredging/Dewatering	Mon 4/9/12	Fri 11/9/12
35	2013 OU4 Dredging/Dewatering	Mon 4/1/13	Fri 11/15/13
36	2014 OU4 Dredging/Dewatering	Mon 3/31/14	Fri 11/14/14
37	2015 OU4 Dredging/Dewatering	Mon 3/30/15	Fri 11/13/15
38	2016 OU4 Dredging/Dewatering	Mon 4/4/16	Fri 11/18/16
39			
40	**SOV 17 OU4 TSCA DREDGING/DEWATERING**	Mon 8/13/12	Fri 11/14/14
41	SOV 17 2012 TSCA Dredging	Mon 8/13/12	Fri 8/17/12
42	SOV 17 2013 TSCA Dredging	Tue 11/5/13	Fri 11/15/13
43	SOV 17 2014 TSCA Dredging	Wed 11/5/14	Fri 11/14/14
44			
45	**RESIDUAL DREDGING/DEWATERING**	Mon 7/25/11	Fri 11/18/16
46	2011 Residual Dredging	Mon 7/25/11	Wed 7/27/11
47	2012 Residual Dredging	Mon 10/29/12	Fri 11/9/12
48	2013 Residual Dredging	Mon 5/20/13	Fri 11/15/13
49	2014 Residual Dredging	Mon 5/19/14	Fri 11/14/14
50	2015 Residual Dredging	Mon 5/18/15	Fri 11/13/15
51	2016 Residual Dredging	Mon 5/16/16	Fri 11/18/16
52			
53	**SOV 20 ENGINEERED CAPS**	Mon 6/6/11	Fri 11/17/17
54	Engineered Cap A	Mon 6/6/11	Fri 11/17/17
55	Engineered Cap B	Tue 6/21/11	Fri 11/18/16
56	Engineered Cap C	Mon 7/29/13	Fri 11/17/17
57	Shoreline Caps	Mon 8/3/15	Fri 11/17/17
58			
59	**SOV 21 SAND COVERS**	Mon 5/2/11	Fri 11/17/17
60	Remedy Sand Covers - 6"	Mon 5/2/11	Fri 11/17/17
61	Residual Sand Covers - 6"	Wed 5/11/11	Fri 11/17/17



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

Figure 9-2
Construction Schedule 2010 to Complete
Lower Fox River – OU 2 to 5

10 MONITORING, MAINTENANCE, AND ADAPTIVE MANAGEMENT

The 2009 CQAPP (Appendix D of the 100 Percent Design Report Volume 1) and the overall project CQAPP (Appendix F of this 100 Percent Design Report Volume 2) outline protection and performance monitoring and associated short-term contingency plans that will be performed during implementation of annual RA activities in 2009 and in 2010 to 2017, respectively. Construction monitoring activities to be performed as described in the CQAPP include water quality monitoring and sediment confirmation sampling. One of the primary CQAPP elements is the design of a post-construction verification plan for assessing compliance with the RD performance objectives (e.g., RAL and SWAC), consistent with the RODs and ROD Amendment. An AM algorithm will likely develop from incorporation of lessons learned as the project proceeds.

Other elements of the RA will require longer term monitoring and/or maintenance. For example, long-term monitoring will be performed on installed caps to ensure their integrity, protectiveness, and effectiveness in perpetuity. Long-term cap monitoring will include, at a minimum, bathymetric surveys. If monitoring or other information indicates that the cap in an area no longer meets its original as-built design criteria and that degradation of the cap in the area may result in an actual or threatened release of PCBs at levels exceeding the RAL, additional response activities will be undertaken in the affected cap area. Long-term cap monitoring plans and contingency measures are presented in the COMMP and LTMP (Appendices H and I of this 100 Percent Design Report Volume 2).

Natural recovery areas in OU 2 (which are downstream of OU 1 and upstream of OU 2 active remediation areas) and in OU 5 (which are offshore of the mouth of the Fox River) will be monitored to verify the anticipated reduction in surface sediment concentrations of PCBs over time to confirm ROD predictions of natural recovery. Long-term sediment natural recovery monitoring plans are presented in the LTMP (Appendix I of this 100 Percent Design Report Volume 2). The LTMP also addresses long-term monitoring of surface water and biota, which will be performed to assess progress in achieving RAOs and to determine remedial success. Addenda to the LTMP (and the COMMP) will be prepared, as necessary, to provide additional detail prior to implementing long-term monitoring activities. Monitoring will continue until acceptable levels of PCBs are reached in surface water and fish.

As practical, natural recovery monitoring, cap monitoring, and water/biota sampling will be coordinated to take place during the same year, conducted approximately 1 year prior to the scheduled CERCLA 5-year reviews, so that the most up-to-date information will be available to inform the process and to better scope future monitoring efforts and strategies. The data collection will include monitoring to assess success criteria as defined in the RODs and ROD Amendment, as well as monitoring to collect data to evaluate design and implementation uncertainties.

The AM and VE Plan for OUs 2 to 5 is presented in Appendix E of this 100 Percent Design Report Volume 2. As described in the RD Work Plan approved by the Response Agencies in June 2004, AM is an integral element of RD, and defines the framework for modification of annual Phase 2B RAWPs as appropriate in response to new information, analysis, and experience during initial RA in OUs 2 to 5. Annual Phase 2B RAWPs incorporating AM and VE elements as appropriate will be reviewed and approved by the Response Agencies pursuant to the Order.

11 COST ESTIMATE

11.1 Summary of Project Estimate

This section presents a summary of the cost estimate for the OUs 2 to 5 RA. This cost estimate was prepared by the Tetra Tech Team in a "bottoms-up" fashion, and was initially based on final construction bids and labor, equipment, and materials information developed since submission of the BODR. The Agency-approved RD Work Plan envisioned development of an updated OUs 2 to 5 cost estimate as part of the 100 Percent Design and this section provides such an update based on current information and actual costs incurred during four years of construction and operations. While the cost estimate presents the estimated costs associated with the dredge, cap, and cover areas presented in this report, it is not the final statement of the cost of the OU 2-5 RA, and the cost estimate is expected to change over time. The most significant expected sources of change to the cost estimate are presented in Section 11.5. For example, 2012 infill sampling results were not incorporated into the designs presented in this report, nor, of course, were the results of future bathymetric surveys. They are expected to be incorporated through annual Remedial Action Work Plans; the results likely will change the quantities of dredging, capping, and covering. This, in turn, will likely change the cost estimate. Any future updates of this cost estimate, if required, will be submitted under separate cover.

The costs presented herein are estimated based on constant 2012 dollars (except that costs already incurred in 2009, 2010, and 2011 have not been updated to 2012 dollars). In addition, RA quantities used for 2009, 2010 and 2011 represent those upon which past costs were incurred. These "payment quantities" may be somewhat different from the "actual or constructed RA quantities" that appear in other sections of this 100 Percent Design Report Volume 2 and the annual RA Summary Reports due to the way the LLC's contract with its general remediation contractor is structured. Payment quantities are used in Section 11, however, because they more accurately relate to remediation costs already incurred or expected.

The OUs 2 to 5 RA cost estimate presented in this section was originally developed using the "Hard Dollar Estimating Software", which allows for integrated development of the critical path project schedule with the cost estimate. The cost estimate has since been updated to reflect the estimates for dredge volume and cap/cover areas included in this report. This link between the project schedule and cost estimate allows for duration-driven activities to be properly estimated. The cost estimate and project schedule were developed by the Tetra Tech Team in consideration of the dredging and capping production rates detailed in Sections 4 and 6, respectively, as well as the sediment processing mass balance calculations presented in Section 5 of the 100 Percent Design Report Volume 1.

The project costs were divided into work elements, as follows:

- Mobilization/demobilization
- Mechanical debris removal
- Non-TSCA dredging, dewatering, transport, and disposal
- TSCA dredging, dewatering, transport, and disposal
- Design and infrastructure
- Engineered capping
- Shoreline capping
- TBD areas
- Remedy sand covers
- Residual sand covers
- Residual dredging (includes T&D)
- Regulatory compliance
- Construction support
- Change orders
- Value engineering
- Escalation
- Long-term monitoring and maintenance
- VE Shared Savings Payout

Individual line items within the work elements are discussed in the sections below, and are referenced to the Table 11-1 cost summary provided below in this section.

11.2 Work Element Descriptions

11.2.1 Mobilization/Demobilization

This task includes mobilization of equipment and personnel to OUs 2 to 5 on an annual basis throughout the duration of RA. In addition, the upfront purchase of equipment required throughout the duration of RA implementation is included in this task, including the sand separation and dewatering equipment and accessories as well as barges, boats, and other marine equipment associated with the dredging process. This task also includes annual winterization/demobilization of equipment and maintenance as required throughout the duration of the RA.

11.2.2 Mechanical Debris Removal

This task includes the removal of debris during dredge operations, including a barge and crew to perform the removal of debris when encountered. Based on available information, there is currently a relatively greater cost uncertainty associated with this line item relative to other tasks.

11.2.3 Non-TSCA Dredging, Dewatering, Transport, and Disposal

This task includes dredging of non-TSCA sediment in OUs 2 to 5, piping the sediment to the SDDP for desanding and dewatering, and transportation of the filter cake to a non-TSCA landfill for disposal. Beneficial re-use of the sand separated from the sediment is included under the Value Engineering cost item rather than being included in the estimate for this item.

The estimate for this work includes labor, equipment, and materials for dredging of the targeted non-TSCA sediments in OUs 2 to 5 as summarized below:

- OU 2/3: 230,293 cy of in situ material
- OU 4/5: 3,709,787 cy of in situ material (including Phase 1)

The cost estimate also includes dewatering of sediments removed from OUs 2 to 5 and includes water treatment and discharge. Costs include labor, materials, and supplies to operate and maintain the sand separation, dewatering process equipment, and water treatment system. The cost estimate includes transport and disposal of dewatered non-TSCA sediment removed from OUs 2 to 5. These volumes vary slightly from the volumes presented in Table 9-1 because the volumes in Table 9-1: (1) include total actual volumes removed in OU2 and OU3; and, (2) exclude the volume removed and remaining in the "Phase 1 area."

In contrast, the OU 2-3 volumes underlying the cost estimate in this section are based on the designs (plus side slope and overdredge volumes) for those areas, rather than on actual material removed. Therefore, where sediment has been removed beyond the overdredge depth, for example, that additional volume is not included in the Section 11 estimate. In addition, the volumes underlying the cost estimate in this section include the volume removed or remaining (e.g., as residual dredging) in the Phase 1 area.

As discussed in Section 2.4 and Appendix E, infill sampling completed to refine dredge plans, is expected to further optimize the required dredging plans by improving the accuracy of the neat line and therefore limiting the amount of sediment removed with PCB concentrations below the RAL, resulting in overall cost savings opportunities.

11.2.4 TSCA Dredging, Dewatering, Transport, and Disposal

This task includes dredging of approximately 106,630 cy of TSCA sediment in OUs 4 to 5, piping the sediment to the SDDP for desanding and dewatering, and transportation of the filter cake to the EQ Wayne Disposal TSCA landfill in Belleville, MI for disposal for TSCA sediment dredged in 2009 and 2012 (32,013 cy) and to Waste Management's (WM's) Ridgeview Landfill in Whitelaw, WI for disposal for the remaining sediment to be dredged (74,617 cy). Sand separated from TSCA sediment dredged in 2013 and beyond is assumed to be transported to the Ridgeview Landfill for disposal.

11.2.5 Design and Infrastructure

This task includes completion of RD, including preparation of drawings, plans, and reports required for the following design phases:

- Intermediate (60 Percent) Design, including A/OT comment resolution
- Pre-Final (90 Percent) Design, including resolution of final comments
- Final (100 Percent) Design preparation

This task also includes the following work:

- Field investigations required to complete the design work
- Agency Coordination: This includes coordination with the A/OT during the RD phase of the work including workgroup meetings

- Public Relations: This task includes efforts to inform the public, conduct plant tours, attend public meetings, and meet with riparian landowners.
- Site preparation and development of infrastructure on the former LFR Processing Facility property
- Bathymetric surveying conducted during the RA, which will include both pre- and post-dredge surveys for the duration of the project; this task also includes pre- and post-cap and sand cover bathymetric surveying.

The field investigation includes pre-construction surveys and investigations associated with work performed in support of the RA activities including the Site Historic Preservation Survey necessary for upland staging areas and in-river RA areas. These activities also include development of work plans for upland and in-water surveys (e.g., geophysical and geotechnical), performing these surveys, and preparing detailed data collection summary reports.

The site preparation and development of infrastructure on the LFR Processing Facility site and the OU 2/3 secondary staging facility includes the following:

- Securing a property lease for the OU 2/3 facilities
- Clearing, grubbing, and other site preparation at the LFR Processing Facility site as well as concrete work and erection of the sediment processing building and offices
- Developing the OU 2/3 secondary staging facility, site preparation, demolition, road and water access, and site restoration

11.2.6 Engineered Caps and Sand Covers

This cost estimate includes installation of Type A, B, and C caps and sand cover in OUs 2 to 5 and procurement of the required cap/cover materials. The installation cost includes equipment crew hours and man hours associated with the marine plants used for the placement of cap materials. Costs are also included for land-based equipment, crews to operate hydraulic pumping equipment for the smaller armor stone, crews to load barges for the large armor stone and quarry spall, and crews to man barges to deliver material to the capping plants and return barges to shore for re-loading. The following engineered cap and sand cover areas were estimated for the 100 Percent Design:

- Engineered Cap A: 114.48 acres
- Engineered Cap B: 50.76 acres
- Engineered Cap C: 66.91 acres
- Shoreline Caps: 5.97 acres
- Remedy Sand Cover: 134.21 acres

11.2.7 RA Assumed for "To Be Determined" Areas

This item was included in the previous cost estimate for remedial action that was assumed required in certain areas that had not been fully investigated or characterized. These areas included primarily commercial riparian boat slips and docks, marinas, assumed shoreline cap locations, utility areas, and areas requiring additional design considerations due to special circumstances (such as the area with sunken vessels).

However, since the prior submittal of the Section 11 cost estimate in May 2011, the list of former TBD areas included in footnote 6 of Table 11-1 in 100 Percent Design Report Volume 2 (Tetra Tech, et al. 2011) have been designed with potential remedies and the associated dredge volumes and/or sand cover/cap areas are now included in the estimates presented in Table 11-1 thus there are no longer any TBD areas. Please see current footnote 3 concerning this issue. In many of these areas, a remedy is shown on the design plans, but further discussions may be held with the riparian landowner or business regarding the proposed remedy; therefore, the remedy is still subject to change. The remedy in most of these areas is also subject to change based on the results of infill sampling performed in 2012 or subsequent design-related investigatory sampling (e.g., possible additional field location efforts at utility crossings). Some TBD area remedies have already been changed at the direction of the A/OT. Any revisions to the design of these areas will be submitted as part of the annual RA Work Plan submittals.

11.2.8 Residual Sand Covers

This item includes costs for placement of residual sand cover in dredge areas in OUs 3, 4 and 5, as well as the cost for procurement of the sand. The installation cost includes equipment crew hours and man hours associated with the marine plants used for the placement of cap materials. Costs are also included for land-based equipment and crews to operate hydraulic pumping equipment to deliver material to the capping plants. Approximately 393.84 acres of residual sand cover are included in the estimate for residual sand cover. This quantity is based on an assumed area of 14.87 acres in Phase 1 and that 60 percent of all dredge-only areas in OUs 4 and 5 will require residual sand cover.

11.2.9 Residual Dredging

This item includes costs for approximately 17,696 cy of residual dredging in OUs 2 and 3 and 175,777 cy of residual dredging estimated for OUs 4 and 5, for a total of 193,473 cy. The residual dredging in OUs 4 and 5 is estimated based on the assumption that 20 percent of dredge-only areas in OUs will require residual dredging. The estimated costs shown in Table 11-1 have been revised based on this assumption and the assumption that 1 foot of additional sediment is removed from each area requiring re-dredging. This cost includes costs for residual dredging, dewatering, transportation and disposal.

11.2.10 Regulatory Compliance

This cost estimate includes the following items:

- Response Agency coordination and reporting that will occur during RA
- Community health and safety provisions including perimeter air monitoring, noise monitoring, light monitoring, and all analytical and data management
- Construction monitoring including collection of post-dredge verification samples
- Construction performance monitoring
- Laboratory subcontractor to perform post-dredge sample testing and preparation of analytical result packages
- Reporting and records retention including preparation and review of annual reports submitted to the Response Agencies and archiving of project records

11.2.11 Construction Support

This estimate includes work related to site support, management, and monitoring of RA. This includes daily project oversight operations performed by the Tetra Tech Team and by the Respondents, including project meetings, management staff, QC, site vehicles, health and safety supplies, temporary project facilities, utilities, site communications, personnel-related direct expenses, etc.

11.2.12 Change Orders

This estimate contains costs for change requests that have been approved as change orders to the LLC's contracts with the general remediation contractor, Tetra Tech, or other direct pay contractors.

11.2.13 Value Engineering

This estimate contains costs for VE changes to the project. The changes are designed to identify new or better methods to implement the remediation. For example, the LLC supported WM's application for risk-based disposal of dewatered TSCA sediment that contains less than 50 ppm PCB at WM's Ridgeview landfill in Whitelaw, Wisconsin. The EPA approved WM's application in September 2012. There are currently 16 VE change orders included in the estimate.

11.2.14 Escalation

As described above, the cost estimate is based on 2012 constant dollars (except that costs already incurred in 2009, 2010, and 2011 have not been updated to 2012 dollars). In addition, the cost of long-term monitoring and maintenance is based on 2012 constant dollars. Many of the costs included in the estimate are set in the LLC's contract with Tetra Tech. These costs are adjusted annually according to an escalation calculation that adjusts each line item according to several indices set out in the contract. This cost estimate reports the result of this escalation calculation for 2009 through 2012 in a separate "escalation" line item, rather than adjusting the prices underlying the other line items. As a result, the individual line items *other* than the escalation line item do not necessarily represent constant 2012 dollars, but once the escalation line item is included, the overall cost estimate does represent constant 2012 dollars.

11.2.15 VE Shared Savings Payout

This cost item includes payments made by the LLC to Tetra Tech for work performed under the value engineering provision of its primary remediation contract.

11.3 Post-Construction Work Elements

11.3.1 Long-Term Monitoring and Maintenance

This task includes costs (net present value in 2012 dollars) for performing long-term monitoring of water, fish and caps and assumed cap maintenance including the following:

- Long-term monitoring of engineered caps is expected to include confirming their physical integrity by bathymetry surveys as described in the COMMP as well as measuring the performance of the chemical isolation layer as described in the LTMP.
- Long-term maintenance of engineered caps is based on experiences at other similar sediment capping sites. Cap maintenance was assumed to be required over 5 percent of the capped area at four events in the future (2, 5, 10, and 30 years after construction). For each cap maintenance event, it was assumed that an armor layer larger than the original design would be placed.
- Long-term monitoring of fish and water in the Lower Fox River and Green Bay following completion of the RA. Costs include long-term monitoring of water quality and fish tissue beginning in 2012, based on the LTMP (Appendix I).
- Long-term monitoring of surface sediments in areas of OU 2 and OU 5 that did not require dredging, capping or covering.

Table 11-1
Summary of Cost Estimates for OUs 2 to 5 Project

Category	October 2012 Totals
Mobilization/Demobilization	
Mob/Demob - SOV 8	45,275,458.70
Mob/Demob Total	45,275,458.70
Mechanical debris removal	
Debris removal	2,975,571.00
T&D TSCA debris	143,440.00
Debris Removal Total	3,119,011.00
Non-TSCA Dredging, Dewatering, Transport & Disposal (DDTD)	
Phase 1	6,258,559.94
OU 2/3 DDTD - SOV 15	31,768,122.07
• OU 4 Non-TSCA DDTD - SOV 16	259,680,486.84
Non-TSCA Dredging, Dewatering, Transport & Disposal Total	297,707,168.85
TSCA Dredging, Dewatering, Transport & Disposal	
TSCA DDTD - SOV 17	11,769,696.20

Table 11-1
Summary of Cost Estimates for OUs 2 to 5 Project

Category	October 2012 Totals
TSCA Dredging, Dewatering, Transport & Disposal Total	11,769,696.20
Design and Infrastructure	
Field investigations - SOV 1	712,000.00
Agency coordination - SOV 2	745,000.00
Public involvement - SOV 3	298,915.00
Staging/access property lease - SOV 5	14,160,748.92
Site historic surveys SOV 6	1,157,000.00
Remedial design - SOV 7	7,078,716.95
Insurance - SOV 8.1	21,448,345.24
Submittals - SOV 9	186,000.00
Infrastructure - SOV 10	45,380,405.99
Bathymetric survey - SOV 11	21,717,500.00
Design and Infrastructure Total	112,884,632.10
Engineered Caps and Sand Covers	
Engineered caps - SOV 20	51,999,612.19
Sand covers - SOV 21	10,451,369.66
Engineered Caps and Sand Covers Total	62,450,981.85
Shoreline Caps	
Shoreline caps - SOV 20.4	3,264,478.86
Shoreline Caps Total	3,264,478.86
TBD Areas	
RA assumed for areas to be investigated further[3]	
TBD Areas Total	0.00[3]
Residual Sand Covers	
Residual sand covers OU 3 and OU 4 - SOV 20.1	30,064,255.85
Residual Sand Covers Total	30,064,255.85
Residual Dredging (includes T&D)	
Residual Dredging – OU 3	2,306,952.31
Residual Dredging – OU 4	12,443,779.38
Residual Dredging Total	14,750,731.69
Regulatory Compliance	
Agency coordination & reporting - SOV 12.1	598,000.00
Community health & safety - SOV 12.2	3,888,000.00
Construction monitoring (environmental) - SOV 12.3	5,406,000.00
Construction monitoring (performance) - SOV 12.4	14,048,325.00
EPA closeout & records retention - SOV 23	1,270,000.00
Regulatory Compliance Total	25,210,325.00
Construction Support	
Site Support - SOV 28	52,924,835.00
Site Support Total	52,924,835.00
Change Orders (COs)	
All COs accounted for in applicable areas	0.00
Change Orders Total	0.00

Table 11-1
Summary of Cost Estimates for OUs 2 to 5 Project

Category	October 2012 Totals
Value Engineering	
Value Engineering	3,039,803.71
Value Engineering Total	3,039,803.71
Escalation	
Escalation	30,041,187.99
Escalation Total	30,041,187.99
Long-term Monitoring and maintenance	
Long-term Monitoring and maintenance	18,000,000.00
Long-term Monitoring and Maintenance Total	18,000,000.00
VE Shared Savings Payout	
VE shared savings payout - VECO2	2,623,171.00
VE shared savings payout - others	1,800,000.00
Shared Savings Payout Total	4,423,171.00
Total Estimated Project Costs	714,925,738

Notes:

a. Current estimate based on Tetra Tech's September 2012, cash flow.

b. The quantities on which the estimated project costs are based are listed below. These quantities are a combination of payment quantities for work performed in 2009 to 2011 and design quantities used elsewhere in this 100 Percent Design Report Volume 2 for work performed in 2012 to completion.

	Current Est.
TSCA (in situ dredged)	106,630 cy
Non-TSCA (in situ dredged)	3,940,080 cy
TSCA for disposal	54,626 tons
Non-TSCA for disposal	2,229,434 tons
Estimated sand volumes	1,530,210 tons
Estimated capping stone volumes	634,009 tons
Residual Dredging	193,473 cy
Cap Areas	232.15 acres
Shoreline Caps	5.97 acres
Remedy Sand Cover Areas	134.21 acres
Residual Sand Cover	393.84 acres

c. Former "to be determined," or "TBD" areas, included: Ashwaubenon Creek, Riverplace Marina; all Shoreline Caps (10.22 acres); Georgia Pacific Boat Slip; area adjacent to the LFR Processing Facility site (with shipwrecks present); OU4-D58 former TSCA dredge area; Allouez Yacht Club; Leicht dock (south); LaFarge dock; C. Reiss Coal dock, K&K Warehouse dock; City Center Boat slips; Western Lime Corp,/St. Mary's Cement dock; Georgia Pacific dock; Fox River dock; Wisconsin Public Service Pulliam Plant slip; Metro Boat Launch; and South Bay Marina. These former TBD areas are now included in the design quantities and estimated costs for each remedy area rather than as TBD areas. No TBD areas remain in the 100 Percent Design.

11.4 Future Factors Impacting this Cost Estimate

This cost estimate is not final and is subject to significant change as OU 2-5 RA continues. The cost estimate is based solely on the designs presented in this report and does not reflect any changes to those designs, and associated dredge, cap, and cover quantities, that will occur as the project continues. As a result, the estimate is subject to change in the future as additional design refinement is completed. Factors that are likely to increase or decrease cost, but are not reflected in this cost estimate, include:

- As described above, the results of 2012 infill sampling could not be incorporated into the designs presented in this report. However, those results will be incorporated, a new, kriged neat line surface will be developed, and the designs may change as a result. Future changes will be incorporated into annual RA work plans and may have a significant effect on the quantities of dredging, capping, and sand cover, and thus, on the cost of the RA.
- Tetra Tech performs a bathymetric survey each year before remediation construction begins in the spring. The actual cost of dredging is based on cubic yards of sediment that are beneath the existing sediment surface, as determined by the then-current bathymetric survey, and are above the neat line, as based on the approved design (as modified, if applicable, by future annual RA work plans). In addition, the cost of dredging includes six inches of allowable overcut below the neat line. To the extent future bathymetric surveys show changes in the sediment surface, that will cause changes to the number of cubic yards to be dredged and, thus, on the cost of the RA.
- Input from commercial riparian and utility landowners regarding the RA proposed for their boat slip, marina, or setback area may cause changes in the design for those areas. More generally, as described in Section 11.2.7, above, areas that had been classified as TBD areas in previous drafts of this report have been assigned a remedy; however, these areas have not been fully investigated or characterized. Any changes arises from landowner input or further investigation will be reflected in future annual RA work plans, and these changes will affect cost.
- The presence of high subgrade may cause a change to the quantity of dredging and, therefore, the cost of dredging.
- Any design changes directed by the Response Agencies, outside of the incorporation of infill sampling, will also cause the actual cost of the project to differ from the cost estimate.

- The cost estimate includes an assumption that residual dredging in OU4 will be required in 20 percent of the dredge-only area. The actual amount of residual dredging is determined by the results of confirmation sampling, which cannot be conducted until dredging occurs. Any increase or decrease in the area requiring residual dredging would cause change to the project cost.
- Likewise, the cost estimate includes an assumption on the percentage of dredge-only areas that will require application of residual sand cover. The actual amount of residual sand cover is determined through confirmation sampling. An increase or decrease in the area requiring residual sand cover would cause a change to the project cost. In addition, the LLC has proposed to apply the summation rule (sum of T's) for OU4; if the Response Agencies allow use of the summation rule, it is likely to reduce cost.
- The Scenario 130 DRT, as described in the Agencies' June 14, 2012 memorandum and attachments, defines the concepts of "dredge/low risk areas" and "confirm-only areas." In the former areas, the Response Agencies have allowed the dredger to target fewer than six inches of overdredge. In the latter areas, which have had production dredging but have not yet met the elevation criteria for final dredging, the Response Agencies have allowed the LLC to proceed directly to post-dredge confirmation sampling, rather than dredge further to meet the elevation criteria. The effect of these decisions on the cost estimate is uncertain at this time and will depend on actual results in the field, as well as on the payment terms of the LLC's contract with Tetra Tech. Because of this uncertainty, the cost estimate does not include any cost savings that these decisions may generate. To the extent that cost savings are, in fact, generated from these decisions, the actual cost will be lower than this cost estimate.
- Revisions to the TSCA polygons that impact the volume of TSCA sediment to be dredged, as well as the potential discovery of additional TSCA sediment, would change the project cost.
- The cost of transportation and disposal is quoted in dollars per ton, not in dollars per in situ cubic yard of sediment removed from the river. The cost estimate uses an estimate of the tons per in situ cubic yard of sediment removed based on the characteristics of the TSCA sediment dredged to date. The actual relationship between mass and volume may be different than estimated.

- The cost estimate uses estimated prices for riprap used for armor stone on shoreline caps.
- The cost estimate also uses estimated prices for insurance in future years. The actual prices of these goods and services may differ from this estimate.
- Contracts for transportation of dewatered sediment and of material for caps and covers generally contain a fuel surcharge that applies if the cost of fuel rises above a particular benchmark. If the fuel surcharges are triggered, the project cost will change.

Because of the number of factors which may change the project cost, and the significance of the cost changes that may occur, this cost estimate should not be viewed as a final statement of the cost of OUs 2-5 RA.

12 LOCATION-SPECIFIC APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

Chemical-specific, action-specific, and location-specific ARARs for project activities and details of the associated regulatory agency/local authority approvals and related submittals are presented on Table 12-1. These ARARs are also presented in the Phase 2B 2011 RAWP (Tetra Tech et al. 2011c) and will continue to be updated as needed in the annual Phase 2B RAWPs. In addition to these ARARs, this section also presents other location-specific notification considerations.

12.1 Notifications to Local Mariners and Adjacent Property Owners

12.1.1 Notification to Local Mariners

OU 4 of the Fox River, from the De Pere Dam north to Green Bay, includes a federally managed and maintained channel. Because of the channel's federal status, compliance with U.S. Coast Guard (USCG) guidelines regarding navigational notices is mandatory. In addition, due to the extensive nature of this project outside the navigation channel, the use of submerged pipelines and anchored equipment, and the limited maneuverability of some of the dredging equipment during operations, notices will be expanded to include work outside the navigational channel. Prior to the start of work each year, the Tetra Tech Team will meet with USCG officials to review upcoming work so that the USCG may issue accurate notices throughout the work year. Also, periodic update meetings with the USCG will occur so that the accuracy of notices is not compromised. USCG navigational notices are typically effective measures for the dissemination of information to commercial vessel traffic moving through the Port of Green Bay.

Recreational vessels, however, may not monitor marine frequencies where notices are conveyed, and remedial work will also occur outside the federal navigation channel (in OU 2, OU 3, and outside the navigation channel in OU 4). Therefore, additional measures to notify the general public of ongoing safety considerations associated with the remedial activities will be taken and will include:

- Posting notices at area boat landings and marinas informing the public of the extent and type of work, and the presence of buoys and dredge pipeline

- Distribution of public safety hand-outs, which can be carried by mariners for continual reference
- Meetings with local WDNR Wardens and the County Sheriffs to discuss safety markers, dredging operations, and previously observed public safety concerns that may have compromised boater safety with law enforcement agencies
- Release of project information to local television and print media for public release
- Public safety informational meetings prior to work each season where citizens will be informed of boater safety issues in the vicinity of project operations
- Staffing boat launches and providing on-water boating staff to inform boating public of boating safety issues associated with the project's RA on an as-needed basis

Finally, prior to each construction season and throughout each season, the project team will meet with officials from the Port of Green Bay to inform them of ongoing work. Information received will be disseminated by the Port to their commercial tenants and will specifically inform commercial mariners of work at berthing locations.

Safety actions to be implemented, information to be provided, and channels for conveyance of information to the general public are consistent with those employed for work on Little Lake Buttes des Morts (OU 1).

12.1.2 Notification to Adjacent Property Owners

Prior to the start of work each year, owners of property adjacent to the work areas for that year will be notified by mail of the upcoming work or by door-to-door visits and will be encouraged to attend the public safety informational meetings for local mariners, as discussed in Section 12.1.1 above. Examples of notification letters sent to riparian land owners and riparian agreements used for 2009 RA are presented in Appendix C of the Phase 2B 2009 RAWP (Tetra Tech et al. 2010a), in the technical memorandum *Evaluation of Available Draft Impact to Riparians and Riparian Notification*. These notifications/agreements with riparian owners may be modified for RA in 2010 and beyond based on experience gained in 2009 and will be included in the annual Phase 2B RAWPs.

Table 12-1
Summary of Fox River ARARs

Act/Regulation	Citation	Description	Applicable Standards
Federal Chemical-Specific ARARs			
TSCA	40 CFR 761.60(a)(5)-761.79 and USEPA Disposal Approval 40 CFR 125(a)(1) 40 CFR 761.65(c)(9)	TSCA disposal regulations including risk-based disposal approval and procedures and testing and decontamination methods for porous and nonporous debris. These are ARARs for the management of filter cake, debris, separated sand, and scalpings generated from sediment areas determined to be equal to or greater than 50 ppm PCBs. Requirements for testing, decontamination, and disposal are addressed in the 100 Percent Design Report Volume 1 and associated documents (CQAPP, Transportation Plan, and Site-Wide O&M Plan). Criteria for on-site storage of bulk remediation PCB waste at a clean-up site.	Waste Disposal Criteria Waste may not be stored longer than 180 days prior to disposal, in a lined area and such that no leachate is generated. Notification of PCB Waste Activity as a commercial PCB waste transporter required to be submitted to USEPA to obtain assigned USEPA ID number. Vehicles must meet specs for hauling PCB wastes and display proper placarding. Notify National Response Center of spills exceeding 1 pound PCBs by weight. Disposal in TSCA-permitted landfill: $\geq$ 50 ppm and < 500 ppm PCBs for in situ sediment based on 2.5-foot interval averaging, plus porous debris and sand from TSCA sediment areas, unless a risk-based exemption is approved by the USEPA for disposal in an NR 500 landfill. In addition, the waste must pass the Paint Filter Test. Uniform Hazardous Waste Manifest must accompany waste. Disposal in non-TSCA permitted landfill: < 50 ppm PCB for in situ sediment based on 2.5-foot interval averaging, plus porous debris from non-TSCA sediment areas. In addition, the waste must pass the Paint Filter Test. Special Waste Manifest must accompany waste. Non-porous metal surfaces must be decontaminated to $\leq$ 10 µg/100 cm^2 For unrestricted use as measured by a standard wipe test. For a spill exceeding 10 pounds PCBs by weight, notify the USEPA regional office within 24 hours of spill and decontaminate the area immediately.
Clean Water Act – Federal Water Quality Standards	40 CFR 131	Federal regulations establish approval standards for state water quality criteria. The Wisconsin water quality standards are ARARs for the WTP point source discharge and are addressed in the design and the WTP O&M Plan.	Water Treatment Plant Discharge Biochemical Oxygen Demand: 1,300 lbs/day and 10 mg/L Total Suspended Solids: 10 mg/L daily max/ 5 mg/L monthly average Ammonia: 8.41 mg/L multiplied by diffuser dilution ratio at pH of 8.0 Mercury: < LOD, with LOD = 0.2 ng/L pH: 6 – 9 Standard Units PCBs: < LOD, with LOD of 0.1 – 0.5 ug/L
Federal Action- and Location-Specific ARARs			
Fish and Wildlife Coordination Act	16 USC 661 et seq	USEPA will consult with USFWS on habitat impacts from dredging, debris removal, and pipeline installation work. Coordination was started in 2008 and will continue over the course of the project. Fish and wildlife considerations for this work are addressed in the Habitat Replacement Plan and in the 100 Percent Design Report Volume 1.	Whenever waters or channels are controlled or modified, adequate provision shall be made for the conservation, maintenance, and management of wildlife resources and habitat.
Endangered Species Act	16 USC 1531 et seq 50 CFR 200 50 CFR 402	Requirements to identify the presence of endangered species and manage any adverse impacts are ARARs for dredging activities. Endangered species considerations are addressed in the Former Shell Property Site Development Plan and in the 100 Percent Design Report Volume 1.	No endangered species have been identified for this project.
Rivers and Harbors Act	33 USC 403 33 CFR 322 – 323	Requirements for remedial activities to prevent obstructing or altering federal navigable waterways are ARARs for dredging work. Navigation considerations are addressed in the 100 Percent Design Report Volume 1 and the Phase 2B RAWPs.	Navigation channel limits and required depth were provided by the U.S. Army Corps and are used as part of the basis for the design.
NHPA	16 USC 470; et seq 30 CFR Part 800	USEPA will consult with the Wisconsin State Historic Preservation Office before affecting any cultural or historic sites. This requirement is an ARAR for upland site development and in-river work. Cultural resource assessments are completed prior to work, results, avoidance and mitigation actions as recommended are documented in the Former Shell Property Site Development Plan, the Underwater Cultural Resources Approach, and the annual Phase 2B RAWPs.	Complete cultural resource assessments and identify any potential impact the work may have to items with historic significance. Applies to both in-river and upland areas. If items are found that may be eligible for listing in accordance with the NHPA, a mitigation plan or other plan to avoid the areas must be developed.
Floodplains and Wetlands Regulations and Executive Orders	40 CFR 264.18(b) and Executive Order 11988 40 CFR Section 401 and 404	Requirements to identify and delineate wetlands, and to manage impacts to wetlands regulated by the U.S. Army Corps of Engineers. These requirements are addressed in the Former Shell Property Site Development Plan, the 100 Percent Design Report, the Wetlands and River Habitat Replacement Work Plan, and the Phase 2B 2010 RAWP.	Conduct wetlands delineation during planning phases for site development and dredging work. Where wetlands are present, avoidance or mitigation actions must be addressed.
National Ambient Air Quality Standards for PM-10		Requirements are ARARs for air monitoring around the site perimeter. The requirements are addressed in the Final Phase 2B Air Monitoring Sampling and Analysis Plan	PM10 $\leq$ 150 µg/m^3 (acute action level)

Table 12-1
Summary of Fox River ARARs

Act/Regulation	Citation	Description	Applicable Standards
OSHA	OSHA 1910.106	Requirements for proper use, handling, and storage of small quantities of petroleum products.	Ensure proper storage of mobile diesel storage tank. Inspect waste storage areas for structural integrity, clean up spills promptly, and dispose of materials properly.
State Chemical-Specific ARARs			
Surface Water Quality Standards	NR 102, 105 (TBC) and 207 NR 722.091-2	Requirements for point source discharges to the river. The Wisconsin water quality standards are ARARs to the OU 4 WTP effluent discharge and are addressed in the WTP design and the WTP O&M Plan.	Water Treatment Plant Discharge Biochemical Oxygen Demand: 1,300 lbs/day and 10 mg/L Total Suspended Solids: 10 mg/L daily max/ 5 mg/L monthly average Ammonia: 8.41 mg/L multiplied by diffuser dilution ratio at pH of 8.0 Mercury: < LOD, with LOD = 0.2 ng/L pH: 6 – 9 Standard Units PCBs: < LOD, with LOD of 0.1 – 0.5 ug/L
Groundwater Quality Standards	NR 140	Requirements are ARARs for remedial activities involving discharges to groundwater.	No planned discharge to groundwater.
Soil Clean-up Standards	NR 720 and NR 722	Requirements include a process for establishing site specific soil clean up levels.	No soil remediation is planned as part of the RA.
Wisconsin Requirements for PCB Transportation and Disposal	NR 157 NR 660 – 665 NR 670	Requirements are ARARs for remedial activities involving the storage, transportation, and off-site disposal of PCB waste. Waste management requirements are addressed in the Site-Wide O&M Plan.	Transporters must be registered as a Hazardous Waste/PCB Waste Transporter. Notify division of emergency government if spillage occurs. Disposal facilities must be approved and permitted by WDNR
Wisconsin Requirements for PCB Transportation and Disposal	NR 157 NR 660 – 665 NR 670	Requirements are ARARs for remedial activities involving the storage, transportation, and off-site disposal of PCB waste. Waste management requirements are addressed in the Site-Wide O&M Plan.	Transporters must be registered as a Hazardous Waste/PCB Waste Transporter. Notify division of emergency government if spillage occurs. Disposal facilities must be approved and permitted by WDNR
State Action- and Location-Specific ARARs			
Wisconsin's Floodplain Management Program	NR 116	Requirements are ARARs for site development work involving the installation of structures/activities within the floodplain. Wisconsin Statues Chapter 30 requirements embody NR 116 and expand the requirement to minimize adverse effects to waterways. Chapter 30 requirements are addressed in the Former Shell Property Site Development Plan and Addendum pertaining to Chapter 30 permit requirements (Sept. 2008), and the 100 Percent Design Report.	
Navigable Waters, Harbors and Navigation	Chapter 30 Stats. NR 329 (Misc. Structures) NR 341 (Grading on Bank) NR 345 (Dredging) NR 343 (Ponds)	Technical guidelines for placement of structures or materials in state waters and below the ordinary high water mark are ARARs for the RA. Substantive requirements include control of erosion and turbidity. Design requirements for site development, dredging, and placement of caps and covers are described in the 100 Percent Design Report (Volumes 1 and 2).	Discharge of fill or dredged material into waters of the United States is prohibited without U.S. Army Corps of Engineers approval. Turbidity action levels during dredging, capping, and covering activities: Trigger Level - 40 mg/L TSS or 40 NTUs above background for four consecutive readings spaced at 1 hour each – exceeding this level triggers evaluation of BMPs by dredge operator and possible modification of operations. Action Level - 80 mg/L TSS or 80 NTUs above background for four consecutive readings spaced at 1 hour each – exceeding this level triggers suspension of RA activities and notification of the A/OT. If a clam shell or bucket is used for precision placement of armor stone it will be lowered to within 1 to 2 feet of the placement location and the material released slowly and evenly over the cell to reduce turbidity.
Solid Waste Management	NR 500-520 Wis. Stats. 289.43	Requirements for remedial activities involving the storage and disposal of solid wastes, specifically filter cake, debris, and desanded material characterized as non-TSCA waste. Waste management requirements are addressed in the 2009 Site-Wide O&M Plan. Beneficial reuse of desanded material is addressed in the 100 Percent Design Report, the Phase 2B 2010 RAWP, and the LHE Request included in the Phase 2B 2009 RAWP. WDNR approval of the beneficial use of separated sand would be done under Wisconsin Statute 289.43 low hazard exemption. All beneficial reuse of sand would require case-by-case approval.	Waste Disposal Disposal in non-TSCA Solid Waste Landfill: < 50 ppm PCBs for in situ sediment, plus porous debris from non-TSCA sediment areas Beneficial Reuse for Sand Relatively unrestricted use: PCB < 0.05 ppm Capping or covering generally not required: PCB < 0.25 ppm Requires capping or covering: PCB > 0.25 ppm Eligible for beneficial reuse: PCB < 1 ppm Need to determine reuse potential: PCB > 1 ppm

Table 12-1
Summary of Fox River ARARs

Act/Regulation	Citation	Description	Applicable Standards
Fish and Wildlife Habitat Structures in Navigable Waterways	NR 323	Requirements are ARARs for construction of habitat structures to replace habitat lost due to in-river installation of sediment transport pipelines, dredging, debris removal, and cap placement. Coordination started in 2008 and will continue over the course of the project. Wildlife considerations for this work are addressed in the Wetlands and River Habitat Replacement Work Plan, and the 100 Percent Design Report.	Construction of habitat replacement required to mitigate impacts – mitigation ratio to be approved by WDNR.
Stormwater Management	NR 216 Subchapter III NR 151 NR 341 WDNR Stormwater Management Technical Standards for Site Erosion and Sediment Control and for Post-Construction Stormwater Management	Requirements for the management of construction and post construction erosion control and stormwater management. Stormwater requirements are addressed in construction designs and plans, the Storm Water and Erosion Control Plan, and the Stormwater Pollution Prevention Plan.	Post-development discharge rates from 2-, 10-, and 100-year 24-hour storm events cannot exceed the pre-development rates. However, the City of Green Bay agreed that the post-developed discharge rate for the 10- and 100-year events could be exceeded and discharged to the Fox River through the detention pond. Removal of 80% of TSS is required. Infiltration of detained stormwater is prohibited. Detention pond design guidelines must be met. Inspect pond, swales, ditches, and erosion control features after all storms exceeding 0.5-inch over 24 hours and daily during prolonged rainfall events. Remove accumulated sediment every 5 years or when depth is reduced to 3 feet or less. Maintain erosion control features in good condition, free of erosion gullies and excess vegetation.

Acronyms and Abbreviations used in this Table:
A/OT – Agencies/Oversight Team
BMP – best management practice
cm^2 –square centimeter
CFR – Code of Federal Regulations
CQAPP – Construction Quality Assurance Project Plan
SHSP – Site Health and Safety Plan
LHE – Low Hazard Waste Exemption
LOD –limit of detection
mg/L –milligrams per liter
NHPA –National Historic Preservation Act
NTU –nephelometric turbidity unit
O&M – Operation & Maintenance
OSHA –Occupational Safety and Health Administration
PCB – polychlorinated biphenyl
ppm – part per million
TSCA – Toxic Substances Control Act
TSS –total suspended solids
µg –microgram
USC – United States Code
USEPA – U.S. Environmental Protection Agency
USFWS –U.S. Fish and Wildlife Service
WDNR – Wisconsin Department of Natural Resources
WTP – water treatment plant

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