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

## VOLUME 2 OF 2

**Prepared for**

Appleton Papers Inc.

Georgia-Pacific Consumer Products LP

NCR Corporation

**For Submittal to**

Wisconsin Department of Natural Resources

U.S. Environmental Protection Agency


**Prepared by**

Anchor Environmental, L.L.C.

Tetra Tech EC, Inc.

J. F. Brennan Co, Inc.

Boskalis Dolman



**June 2008**

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|---|---|
| ACES | Automated Coastal Engineering System |
| Anchor | Anchor Environmental, L.L.C. |
| AOC | Administrative Order on Consent |
| A/OT | Agency/Oversight Team |
| ARAR | Applicable or Relevant and Appropriate Requirement |
| ARCS | Assessment and Remediation of Contaminated Sediments |
| BMP | best management practice |
| BODR | Basis of Design Report |
| CDF | confined disposal facility |
| CERCLA | Comprehensive Environmental Response, Compensation and Liability Act |
| CFR | Code of Federal Regulations |
| cm | centimeter |
| CQAPP | Construction Quality Assurance Project Plan |
| CWA | Clean Water Act |
| cy | cubic yard |
| DCU | dredge certification unit |
| DMU | dredge management unit |
| DOC | depth of contamination |
| FRVOR | Fox River Valley Organic Recycling |
| GIS | geographic information system |
| GP | Georgia-Pacific Consumer Products LP |
| HASP | Health and Safety Plan |
| HDPE | high-density polyethylene |
| h:v | horizontal to vertical |
| ICIAP | Institutional Control Implementation and Assurance Plan |
| IGLD | International Great Lakes Datum |
| J.F. Brennan | J.F. Brennan and Company |
| LOS | level of significance |
| LTMP | Long Term Monitoring Plan |
| MAE | Mean Absolute Error |
| MSW | municipal solid waste |
| NAD | North American Datum |
| NAVD | North American Vertical Datum |

| | |
|---|---|
| NCR | NCR Corporation |
| NOAA | National Oceanic and Atmospheric Administration |
| OMMP | Operations, Maintenance and Monitoring Plan |
| OU | Operable Unit |
| PCB | polychlorinated biphenyl |
| PLC | programmable logic controller |
| ppm | part per million |
| QA | quality assurance |
| QAPP | Quality Assurance Project Plan |
| QC | quality control |
| RA | remedial action |
| RAL | remedial action level |
| RAO | Remedial Action Objective |
| RD | remedial design |
| RD Respondents | Fort James Operating Company, Inc. (Fort James) and NCR Corporation |
| Response Agencies | USEPA and WDNR |
| RM | river mile |
| RMSE | Root Mean Squared Error |
| ROD | Record of Decision |
| RTK | Real Time Kinematic |
| SAP | Sampling and Analysis Plan |
| SEI | Sea Engineering Inc. |
| Shaw | Shaw Environmental and Infrastructure, Inc. |
| SMU | Sediment Management Unit |
| SQT | sediment quality threshold |
| SWAC | surface weighted average concentration |
| Tetra Tech | Tetra Tech EC, Inc. |
| TSCA | Toxic Substances Control Act |
| TSS | total suspended solids |
| µg | microgram (or micron) |
| 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 |
| VFD | variable frequency drive |
| WDOT | Wisconsin Department of Transportation |
| WDNR | Wisconsin Department of Natural Resources |
| WRDA | Water Resources Development Act |
| WTM | Wisconsin Traverse Mercator |
| WTM I | WTM I Company |
| WTP | wastewater treatment plant |

# 1 INTRODUCTION

This document presents Volume 2 of the 60 Percent Design Report 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 Volume 1 submittal 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 upper OU 4, and associated material processing and staging facilities. Volume 1 also describes the background of the OUs 2 to 5 RD/RA project and including a Site description, which are 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. Also included in this Volume 2 document are summaries of sampling, analysis, and engineering evaluations completed to date that form the basis for the overall RD in OUs 2 to 5.

This 60 Percent Design Report Volume 2 builds off of the Basis of Design Report (BODR; Shaw and Anchor 2006), the Record of Decision (ROD) Amendment (USEPA and WDNR 2007), the 30 Percent Design Report (Shaw and Anchor 2007), follow-on collaborative workgroup efforts, and the 60 Percent Design Report Volume 1. As discussed in Volume 1, the Response Agencies and RD Respondents 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 the design deliverable for that Phase of the work (i.e., technical memoranda produced during the 30 Percent Design Phase were included with the 30 Percent Design). At the recommendation of the Response Agencies, each successive RD deliverable has not duplicated technical memoranda, data, etc. that were previously included in, or attached to, an earlier design deliverable. Rather, a "RD Design Anthology" is currently being developed that will include 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, etc.) The intent is to continually update the Design Anthology as the RD progresses to maintain a complete set of RD documents. The Respondents currently plan to submit the Design Anthology, including RD information through the 60 Percent Design phase, in July 2008.

The equipment and methods proposed by the team of Tetra Tech EC, Inc. (Tetra Tech), J.F. Brennan and Company (J.F. Brennan), and Boskalis Dolman (collectively "the Tetra Tech

Team") selected to perform the RA for OUs 2 to 5 have been included in this 60 Percent Design submittal. This Volume 2 submittal 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
- Detailed plans, cross-sections, drawings, sketches, and design calculations
- Selected siting/locations of processes and construction activities
- Draft construction schedule for the implementation of the RA
- Draft Adaptive Management 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
- Addendum to the Volume 1 Construction Quality Assurance Project Plan (CQAPP), including verification plans and contingency plans to be implemented in 2010 and beyond
- Draft Institutional Control Implementation and Assurance Plan (ICIAP)
- Draft Operations, Maintenance and Monitoring Plan (OMMP), including expected long-term monitoring and operation requirements
- Preliminary Draft Long-Term Monitoring Plan (LTMP) for surface water and biota
- Draft Capital and Operation and Maintenance Cost Estimates for the entire RA (including 2009 activities)

## 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 60 Percent Design Report Volume 2 includes the elements listed in Section 1.3 of the 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 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). As discussed in the Volume 1 submittal, further sampling "infill sampling" may be performed annually within specific areas of the Site to refine the neatline dredging plan, subject to review of the benefit of planned sampling in 2008 as part of the adaptive management plan. 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 sediment processing facility at the former Shell property, and mechanically unloaded. For hydraulic dredging, in-water pipelines or other transportation methods 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 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 are provided in Section 1.3 of Volume 1, the CQAPP in Appendix D of Volume 1, Section 5.5 of this Volume 2 submittal, and the CQAPP Addendum in Appendix F of this Volume 2 submittal.
- **Post-removal 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.

- **Engineered Caps**. An engineered cap, consisting of a sand layer and an armor stone layer or equivalent armor component, all from off-site sources, will be installed in portions of the Site where dredging is not feasible, practicable, and/or cost effective, provided the ROD Amendment eligibility criteria are satisfied. These eligibility criteria include:
  - Minimum water depth criteria for capping:
    - 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 low water datum defined in the BODR and 30 Percent Design Report (relative to the North American Vertical Datum of 1988 [NAVD88]; see Table 6-5).
  - Engineered caps at least 33 inches thick, including a surface armor layer comprised of quarry spall or equivalent materials, will be used to contain contaminated sediments in: 1) areas below the federally authorized navigation channel depth (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; and 3) nearshore areas with sediment having PCB concentrations exceeding 50 ppm, if removal of such sediment would impair the stability of shorelines, bridge piers, and utilities.
  - Engineered caps at least 16 inches thick, including a surface armor layer comprised of gravel materials, will be used in areas outside of the federally authorized navigational channel 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 at least 13 inches thick, including a surface armor layer comprised 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 not addressed by the cap designs discussed above.

- **Exceptional Areas**. Modified remedial approaches will be used in exceptional areas in OU s 2 to 5 originally targeted for dredging, where evaluation demonstrated that alternate remedies (primarily sand cover placement) will be sufficiently protective, more feasible, and more cost effective than the dredging-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 will be summarized in the forthcoming RD Design Anthology. The agreed-upon approach to these exceptional areas was incorporated into this 60 Percent Design submittal**.** Further value engineering is being performed through the collaborative workgroup process to continue to identify and evaluate other design approaches that may improve protectiveness and implementation, and reduce the overall project schedule and cost. Such ongoing value engineering is subject to Response Agency review and approval.
- **Sand Covers**. A cover comprised 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 (6 inches or less) of PCB-contaminated sediment with concentrations less than 2.0 ppm. 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 will be presented in Operation and Maintenance Plans to be reviewed and approved by the U.S. Environmental Protection Agency (USEPA) and Wisconsin Department of Natural Resources (WDNR) (collectively the "Response Agencies").
- **Natural Recovery**. Although the 1.0 ppm RAL performance standard or the surface 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, while 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 OMMP provided in Appendix H of this 60 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. A draft LTMP, specifying the types and frequency of monitoring, range of additional response actions, and outcomes triggering those actions, is provided in Appendix I of this 60 Percent Design Report Volume 2, and is subject to further collaborative workgroup review.
- **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 in "sentinel" cap areas (those subject to relatively high peak bottom shear stresses from floods, seiches, wakes, propeller wash, and/or other forces) will include, at a minimum, bathymetric surveys, surface sediment sampling, and core sampling where feasible. 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 or from the area at levels that preclude achieving the RAOs, additional response activities will be undertaken in the affected area. Long-term cap monitoring plans and contingency measures are presented in the OMMP (Appendix H of this 60 Percent Design Report Volume 2).

## 1.2 Summary of 2009 Remedial Actions

The 60 Percent Design Report Volume 1 describes the RD for planned 2009 RA work. The 2009 dredging areas described in the 60 Percent Design Report Volume 1 submittal are depicted in Figure 1-2.

## 1.3 Summary of Remedial Actions in 2010 and Beyond

This 60 Percent Design Report Volume 2 describes the RD for planned activities in 2010 and beyond including dredging, engineering capping, and sand covering. Figure 1-3 depicts planned RA areas during this period.

Dredging, beginning in 2010 upstream of the De Pere Dam in OU 3, will be performed using two of J. F. Brennan's 8-inch dredges (the *Fox River* and the *Palm Beach*), while production dredging will be performed downstream of De Pere Dam in OUs 4 and 5 (river mouth) using J. F. Brennan's 12-inch dredge (the *Mark Anthony)*. Sequencing of 8-inch and 12-inch dredge operations will generally proceed in an upstream to downstream direction. The three dredges will often operate simultaneously to concurrently maximize production, minimize the overall project schedule, and minimize 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 the 60 Percent Design Report Volume 1, including removal of sediment subject to Toxic Substances Control Act (TSCA) requirements as well as non-TSCA sediments, and appropriate segregation and handling of these materials.

Given the length of dredge pipelines, several booster stations will be necessary to convey the dredge slurry to the dewatering plant located at the former Shell property in OU 4. A series of up to six booster stations (two fewer than required in 2009) are planned for the 8-inch dredge pipeline extending upstream of the former Shell property to OU 3. For the 12-inch dredge pipeline, two boosters will be installed to facilitate dredging upstream of the former Shell property to the De Pere Dam. As dredging in OU 4 proceeds downstream, the two booster stations will be shifted downstream of the former Shell property 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 former Shell property. Once removed from in-line use, the booster pumps will serve as backups for the other on-line boosters.

Dredging of sediments is anticipated to be substantially complete by 2015. Engineered capping and sand covering of contaminated sediment will be conducted over eight seasons, beginning in 2010 and substantially complete by 2017. In-water construction work will typically be performed between April 15 and November 15 of each calendar year. However, this is an approximate window that is dependant on actual river conditions and weather, resulting in expanded or reduced schedules for any given year. Within these approximately 6-month construction seasons, in-water dredging operations will generally be conducted 24 hours per day, 5 days per week; with a sixth day planned for regular equipment maintenance and repair. Capping operations are planned to be conducted during daylight hours only (12 hrs per day), 5 days per week.

Sections 1.3.1 through 1.3.3 provide brief summaries of planned annual dredging, cap and cover placement, and long-term monitoring activities beginning in 2010.

### 1.3.1 Dredging

Figure 1-4 depicts planned 2010 to 2015 dredging 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 adaptive management refinements, the dredging slurry transport system and dewatering/disposal operations will be as outlined in the 60 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 RA Work Plans will provide the updated schedule of actions for each year.

The two 8-inch dredges will operate in 2010 within the lower reaches of OU 3, continuing where 2009 dredging left off (see the 60 Percent Design Report Volume 1). These 8-inch dredges will proceed from upstream to downstream and are anticipated to reach the De Pere Dam by the end of the 2010 dredging season. Additionally, the 12-inch dredge will continue production dredging downstream of the De Pere Dam, with target elevations set approximately 1 foot above the 1.0 ppm PCB concentration neatline, as described in Volume 1.

During 2011, all three dredges will operate downstream of the De Pere Dam in OU 4. The two 8-inch dredges will begin the final dredging passes of those areas where the 12-

inch dredge previously completed production passes. The 8-inch dredges will also focus on removal of residual sediment within the Phase 1 Project area and shallow water areas where the 12-inch dredge can not gain access. The two 8-inch dredges will operate in shallow water areas. Meanwhile, the 12-inch production dredge will continue where it left off the prior year.

Dredging in OU 4A will occur from 2010 through 2013, and dredging in OU 4B will occur from 2010 to 2015. Coordination with U.S. Army Corps of Engineers (USACE) maintenance dredging within the OU 4B navigation channel will occur as generally outlined in the Adaptive Management and VE Plan (Appendix E of this 60 Percent Design Volume 2), and as indicated in updated dredging operations provided in annual RA Work Plans. It is anticipated that all sediments subject to TSCA disposal requirements will be removed from the river by the end of the 2013 construction season.

The scheduled dredging for 2015 is currently a short season, allowing additional time for completion of any dredging not accomplished in earlier dredging years and allowing time for completion of capping and cover operations (see Section 1.3.2). The planned dredging schedule for 2010 to 2015 is presented in Section 9, and is subject to adaptive management.

### *1.3.2 Cap and Cover Placement*

Capping and covering of contaminated sediment will be conducted over eight seasons, beginning in 2010 and continuing through 2017. 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 RA Work Plans will provide the updated schedule of actions for each year.

In 2010, two broadcast spreading marine plants will be operated in OU 2 and OU 3. One mechanical plant will be operated, as necessary, to place the larger gravel. From 2011 to 2017, capping and cover placement will continue where operations left off the prior year. Two broadcast spreading marine plants will place sand and gravel while one mechanical plant will place the larger gravel, as necessary. A third broadcast spreading marine plant and a second mechanical plant will be added to the project as necessary.

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

### 1.3.3 Long-term Monitoring

As described in the OMMP (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 will be completed in 2010, and an initial detailed post-construction bathymetric survey of the OU 2 capped areas will be performed towards the end of the 2010 construction season. Similar bathymetric surveys will be completed in subsequent years following completion of cap construction in individual areas.

As discussed in the OMMP, post-construction hydrographic surveys, surface sediment sampling, and limited core sampling (or other suitable subsurface measurement method) will generally be performed during Years 2, 4, and 9 following completion of cap construction in individual areas. Post-construction cap monitoring in OU 2 will thus begin in 2012, and similar monitoring will be completed in subsequent years following completion of cap construction in individual areas. Cap monitoring will be performed in sentinel areas (i.e., cap areas located in the upper 10 percentile of shear stresses) on a routine basis. Additional event-based cap monitoring will be performed 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, follow-on event-based cap monitoring will occur following a 50-year event. Detailed long-term sediment monitoring plans are presented in the OMMP (Appendix H).

Long-term monitoring of surface water and biota will be initiated in 2012, near the completion of RAs in OU 3, consistent with the preliminary draft of the LTMP (Appendix I). The OMMP and LTMP are subject to further collaborative workgroup review. Consistent with the 2007 RD Administrative Order on Consent (AOC), the final LTMP is currently targeted to be submitted to the Response Agencies in February 2009.

## 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 Agency/Oversight Team (A/OT) during design activities was critical in developing and completing this 60 Percent Design. Specific collaborative work elements completed for this 60 Percent Design Report Volume 2 included:

- 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 60 Percent Design, the shoreline and transition area designs are limited to establishing standard design approaches (i.e., "ground rules") and site-specific example designs illustrating these design approaches. Final remedy design around each structure or section of shoreline will be developed in the year prior to remedial construction in that area and will be based on the ground rules developed in this 60 Percent Design. Final design of these site-specific remedies will be documented in annual RA Work Plans.

To document the design effort, this report has been organized to provide the following: 1) a summary of site characteristics from completed RD sampling and analysis events;

2) updated dredge plan designs; 3) beneficial reuse opportunities and landfill disposal requirements for separated sand and dewatered sediments, respectively; 4) design criteria and detailed engineering plans for the staging area, sediment dredging, material handling, transportation and disposal of sediments, engineered capping, and sand covering; 5) institutional controls; 6) scheduling; 7) monitoring, maintenance, and adaptive management strategies; and 8) 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 Engineered Plan Drawings
- Appendix D Specifications/Construction Work Plans for Key Design Elements
- Appendix E Adaptive Management and VE Plan
- Appendix F Addendum to the Volume 1 CQAPP
- Appendix G ICIAP
- Appendix H OMMP, including expected long-term monitoring and operation requirements
- Appendix I LTMP
- Appendix J Health and Safety Plan (HASP)

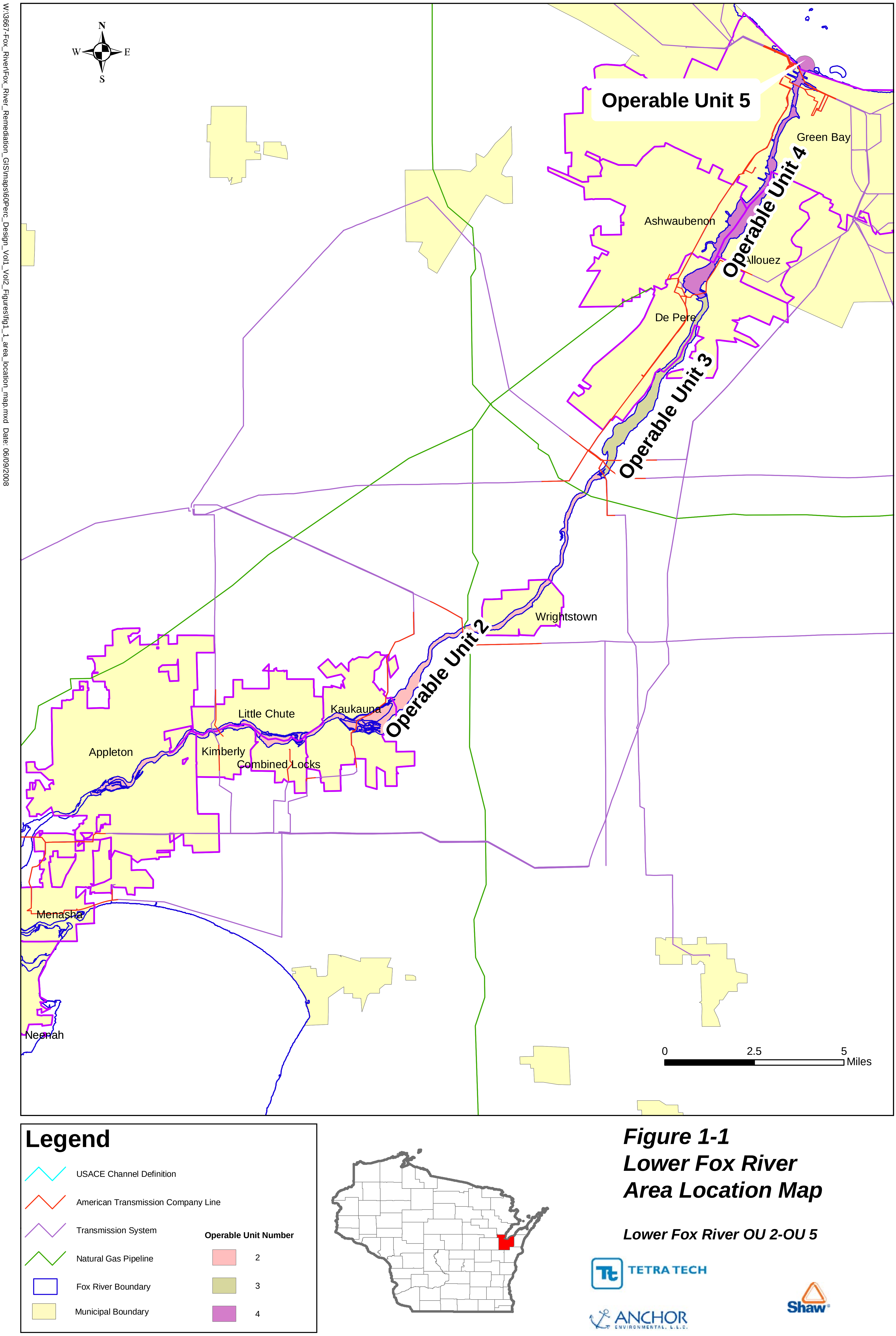


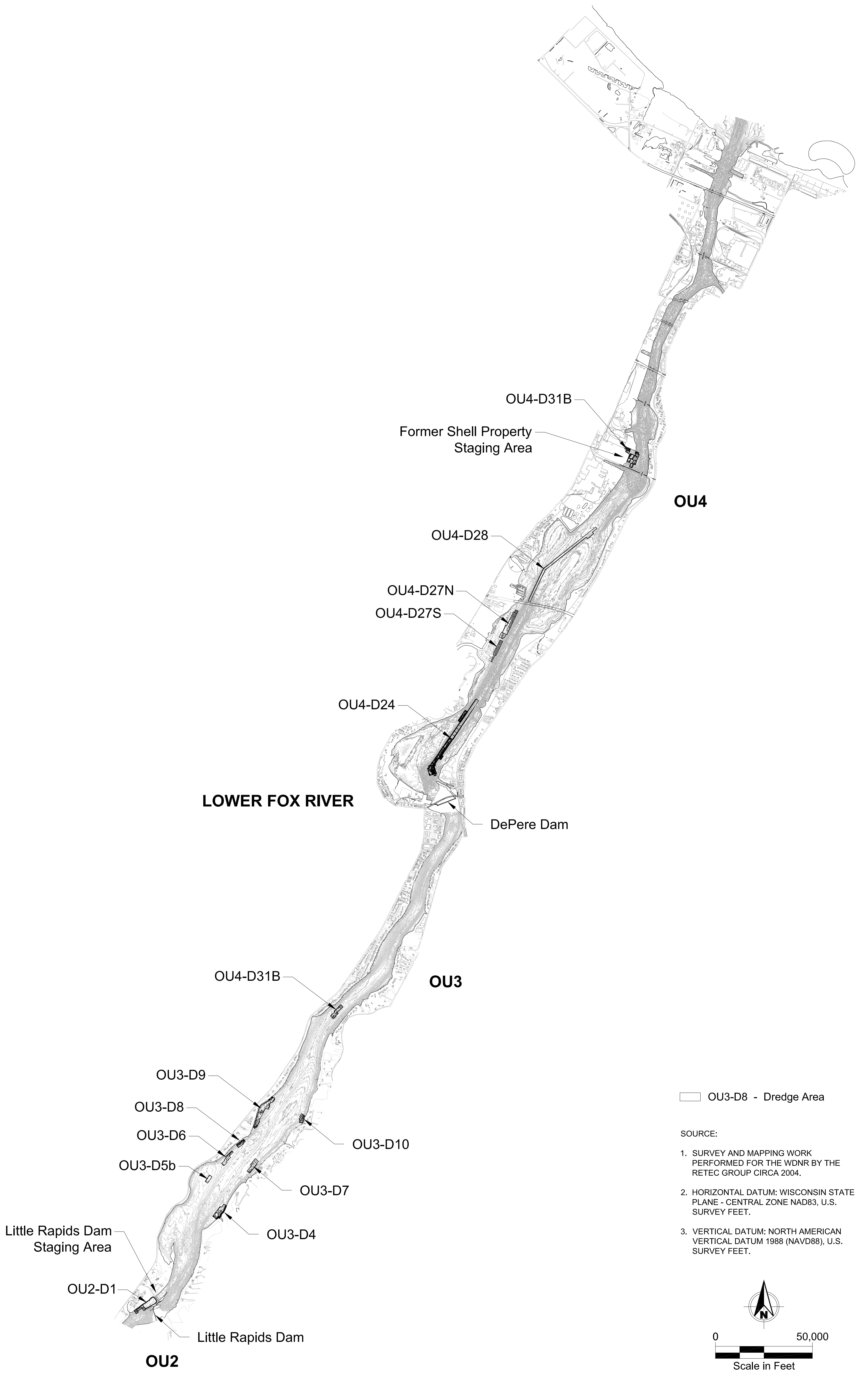

***Figure 1-1***
***Lower Fox River***
***Area Location Map***

***Lower Fox River OU 2-OU 5***

TETRA TECH

ANCHOR ENVIRONMENTAL, L.L.C.

Shaw






ANCHOR ENVIRONMENTAL, L.L.C.    TETRA TECH

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

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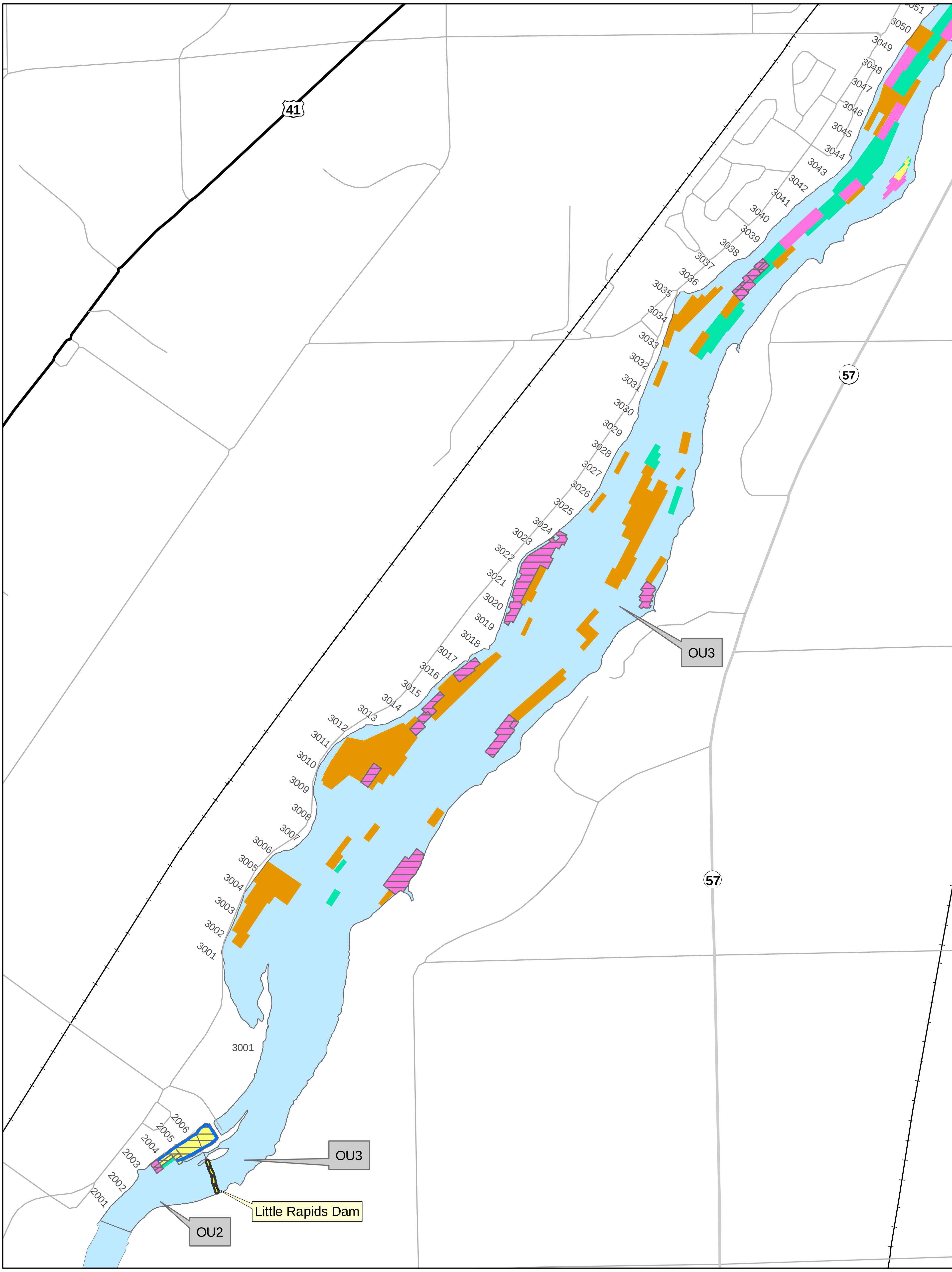
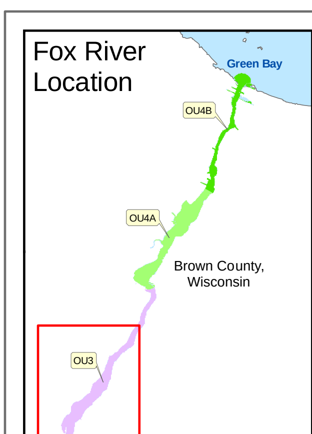



Fox River Location




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

**60% Design**

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

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

OUs 2 to 5 Remedial Action Areas

Brown County, Wisconsin, USA

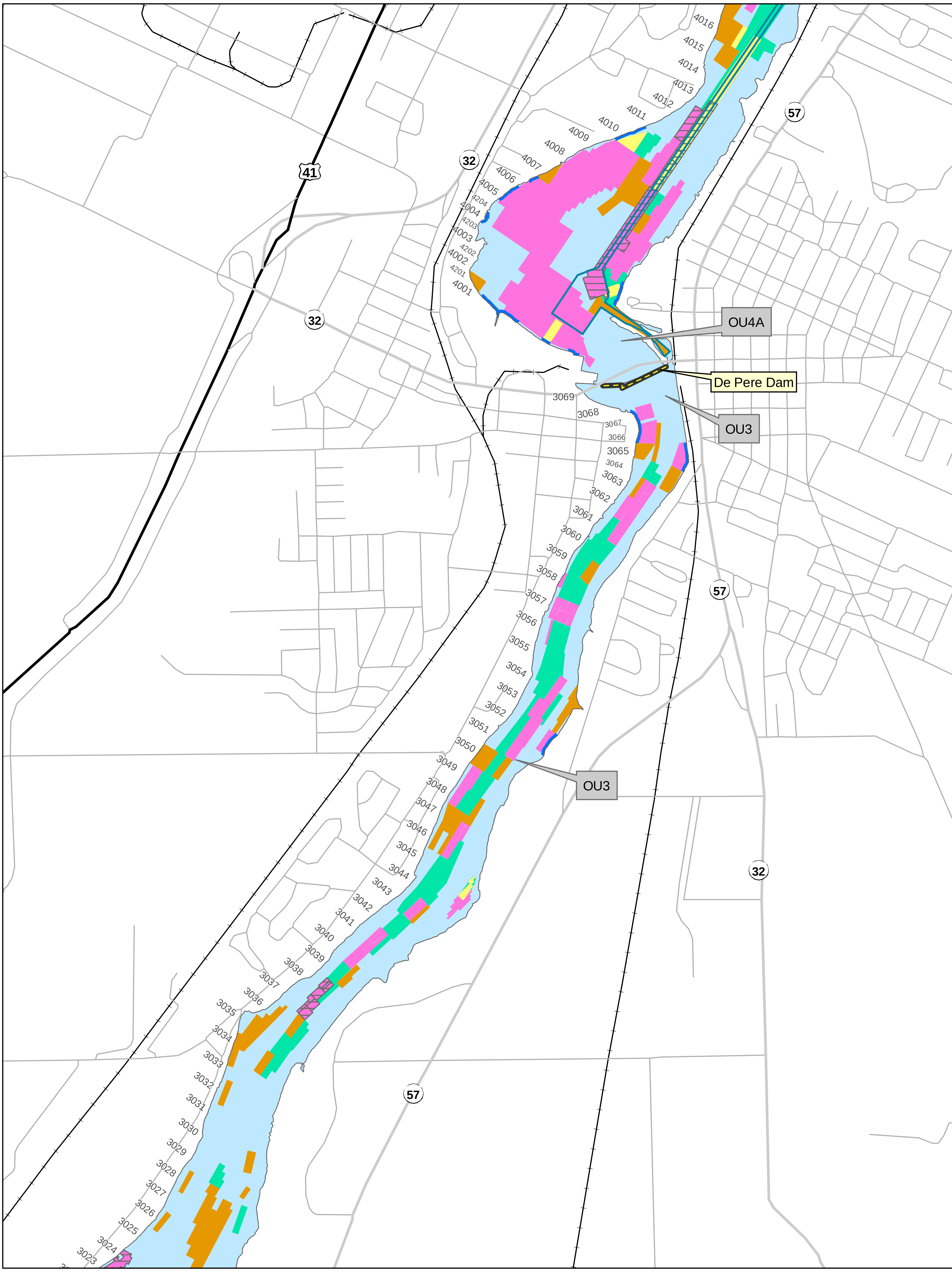
TETRA TECH

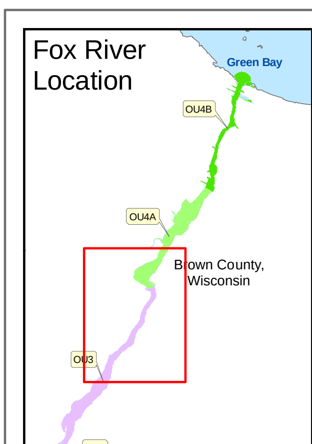
ANCHOR ENVIRONMENTAL, L.L.C.

N W E S

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 | |

**60% Design**

| | |
|---|---|
| Dredge and Cap | Shoreline Cap |
| Engineered Cap A, B or C | Sand Cover |
| Dredge (Volume 1 - 2009) | |
| Dredge to 1 ppm (Volume 2 - 2010 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 ENVIRONMENTAL, L.L.C.

N W E S

Rotation 0°

Feet
0 1,000 2,000

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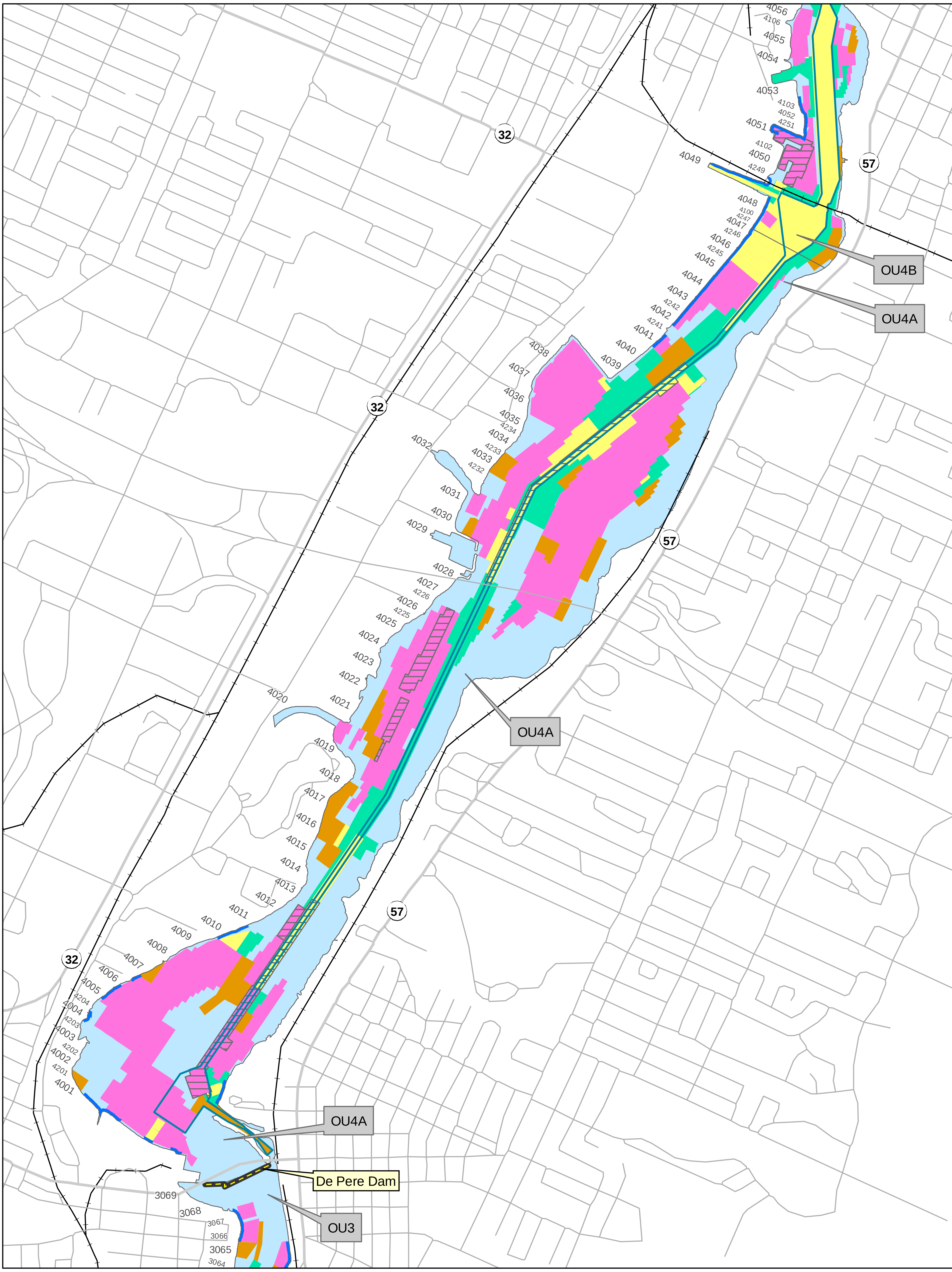
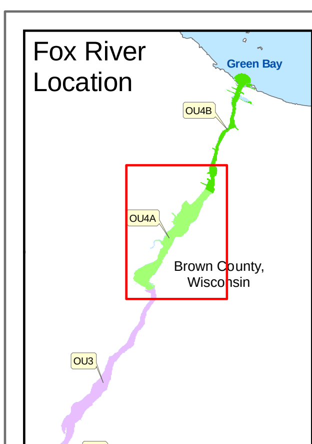



US Highway
State Highway
Road
Railroad
Operable Unit / Fox River Boundary
Dam
3001 Sample Location Row Number
Federal Navigation Channel

**60% Design**

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

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

OUs 2 to 5 Remedial Action Areas

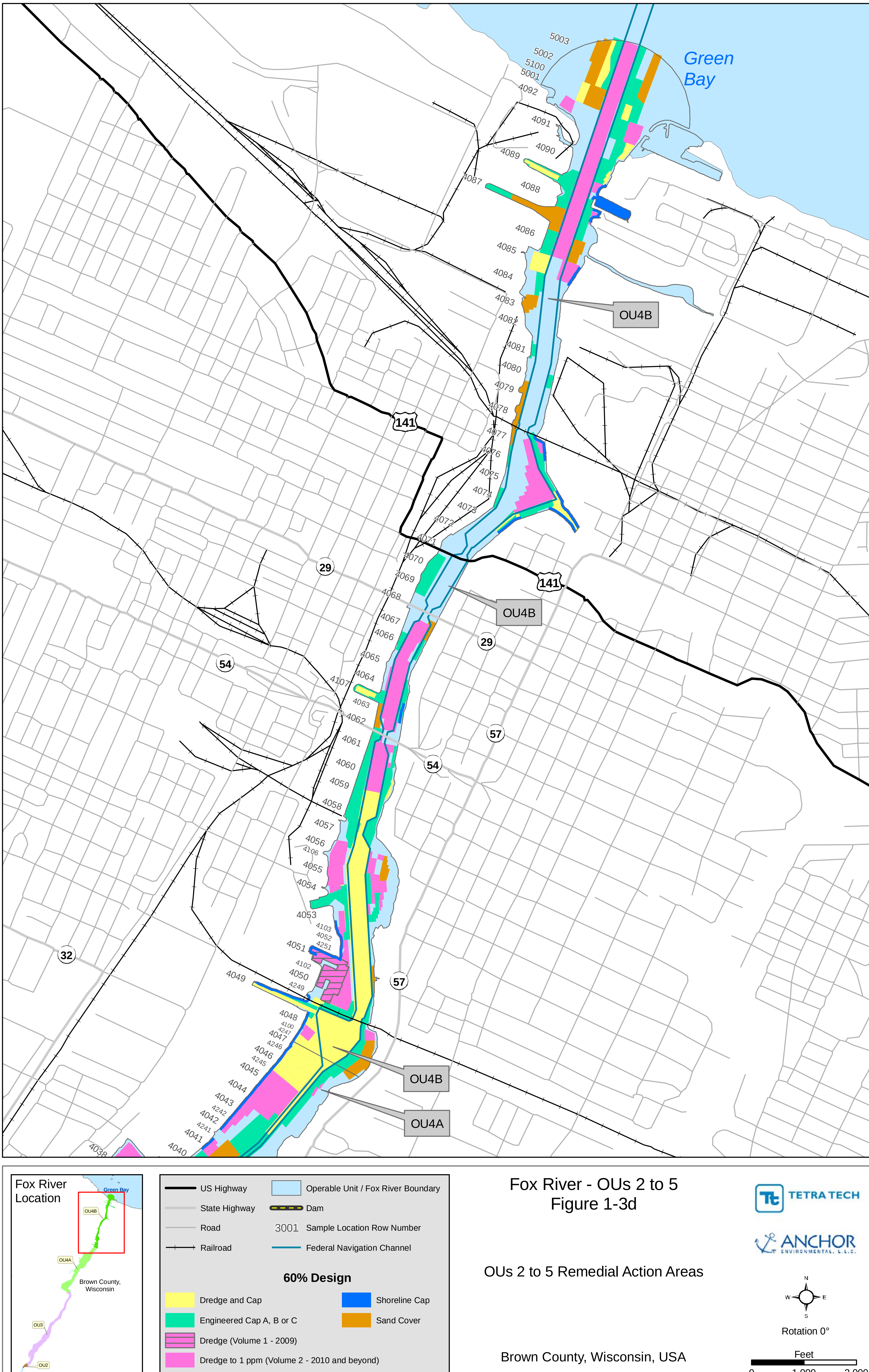
Brown County, Wisconsin, USA

TETRA TECH

ANCHOR ENVIRONMENTAL, L.L.C.

Rotation 0°

Feet
0 1,000 2,000

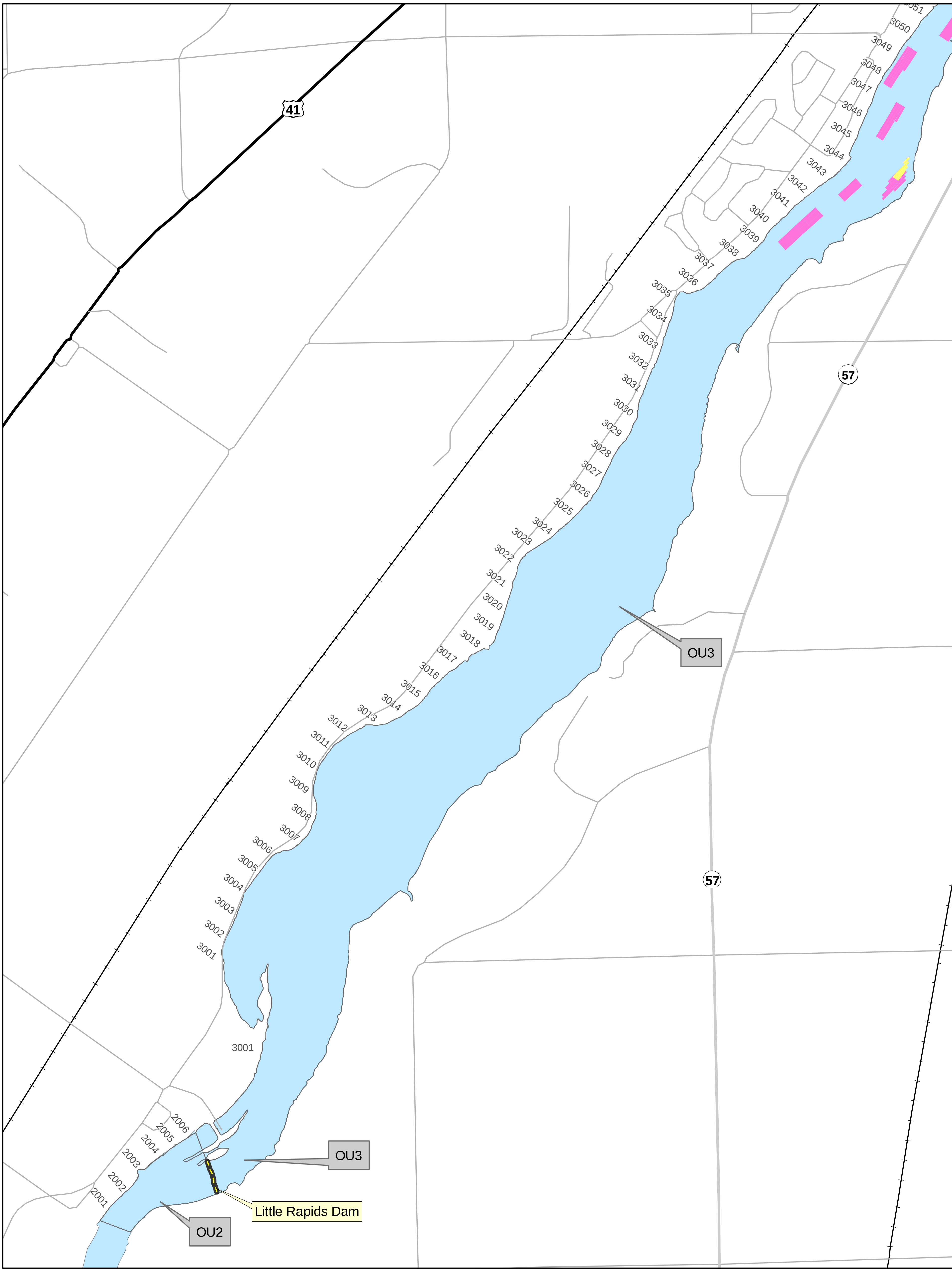


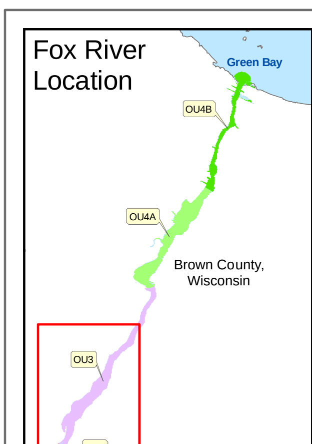

Fox River - OUs 2 to 5
Figure 1-3d

OUs 2 to 5 Remedial Action Areas

Brown County, Wisconsin, USA

W:\3667-Fox_River\Fox_River_Remediation_GIS\maps\60Perc_Design_Vol1_Vol2_Figures\Volume2\fig1_4_2010_to_2015_Dredging_Areas.mxd Date: 06/12/08




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

**60% Design**

- Dredge and Cap - Years 2010 to 2017
- Dredge to 1 ppm - Years 2010 to 2015

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

2010 to 2015 Dredging Areas

Brown County, Wisconsin, USA

TETRA TECH

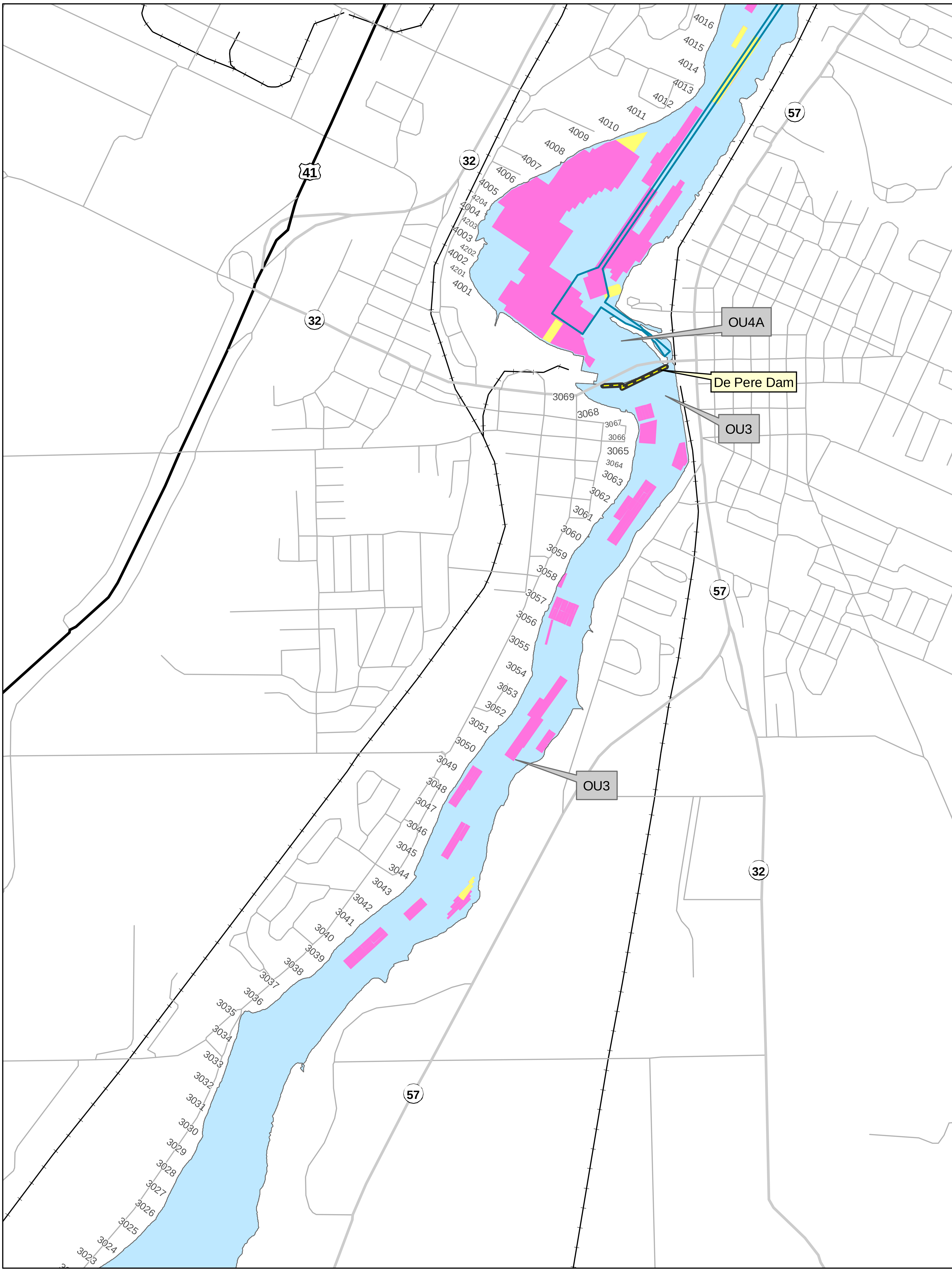
ANCHOR ENVIRONMENTAL, L.L.C.

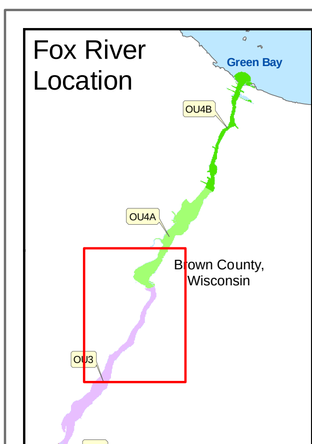
N
W E
S

Rotation 0°

Feet
0 1,000 2,000

W:\3667-Fox_River\Fox_River_Remediation_GIS\maps\60Perc_Design_Vol1_Vol2_Figures\Volume2\fig1_4_2010_to_2015_Dredging_Areas.mxd Date: 06/12/08




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

**60% Design**

- Dredge and Cap - Years 2010 to 2017
- Dredge to 1 ppm - Years 2010 to 2015

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

2010 to 2015 Dredging Areas

Brown County, Wisconsin, USA

TETRA TECH

ANCHOR ENVIRONMENTAL, L.L.C.

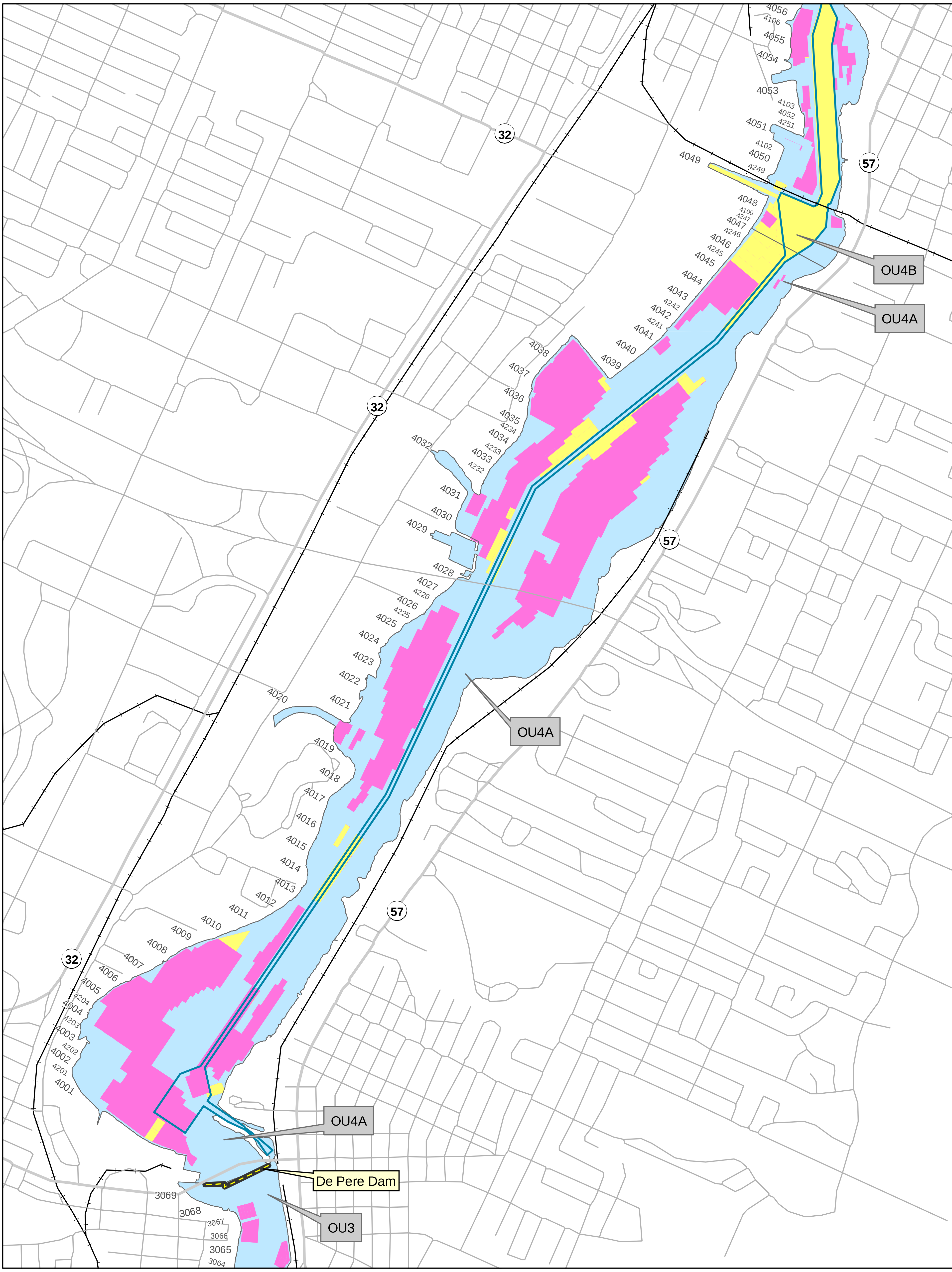
N W E S

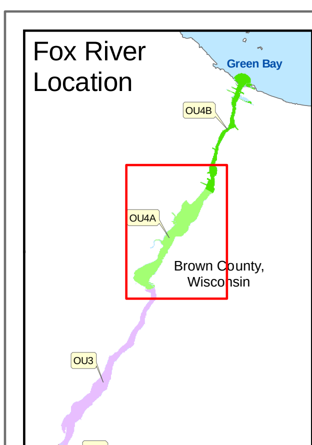
Rotation 0°

Feet

0 1,000 2,000

W:\3667-Fox_River\Fox_River_Remediation_GIS\maps\60Perc_Design_Vol1_Vol2_Figures\Volume2\fig1_4_2010_to_2015_Dredging_Areas.mxd Date: 06/12/08




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

**60% Design**

Dredge and Cap - Years 2010 to 2017
Dredge to 1 ppm - Years 2010 to 2015

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

2010 to 2015 Dredging Areas

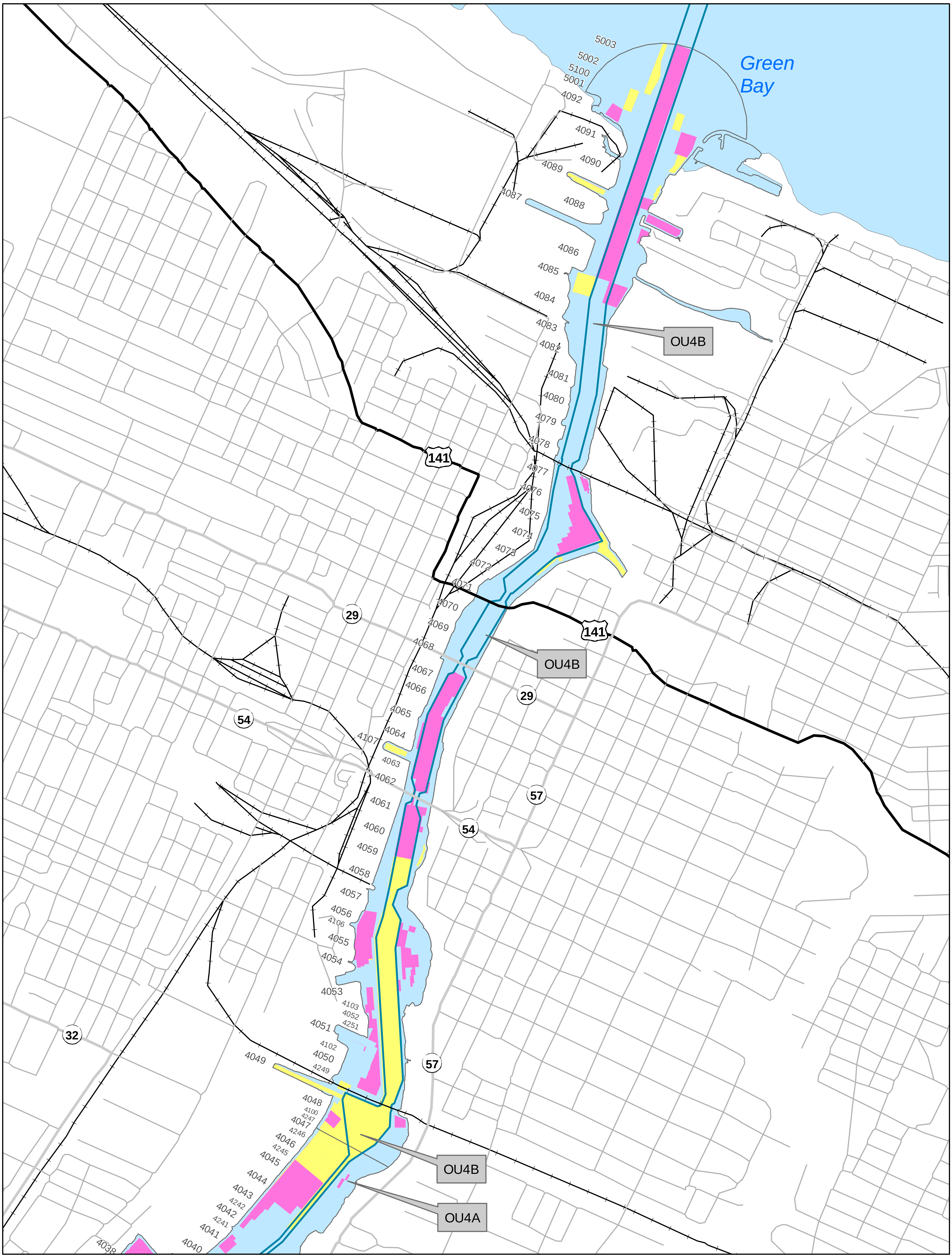
Brown County, Wisconsin, USA

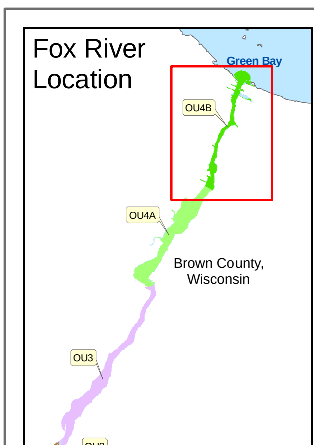
TETRA TECH
ANCHOR ENVIRONMENTAL, L.L.C.

Rotation 0°

Feet
0 1,000 2,000

W:\3667-Fox_River\Fox_River_Remediation_GIS\maps\60Perc_Design_Vol1_Vol2_Figures\Volume2\fig1_4_2010_to_2015_Dredging_Areas.mxd Date: 06/12/08




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

**60% Design**

Dredge and Cap - Years 2010 to 2017
Dredge to 1 ppm - Years 2010 to 2015

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

2010 to 2015 Dredging Areas

Brown County, Wisconsin, USA

TETRA TECH

ANCHOR ENVIRONMENTAL, L.L.C.

N W E S

Rotation 0°

Feet
0 1,000 2,000

# 2 SITE CHARACTERISTICS

## 2.1 Sampling and Analysis Data

### *2.1.1 Pre-2007 Remedial Design Data*

The RD sampling and analysis program conducted to date includes data collection activities from 2004 through 2006, as described in the BODR and 30 Percent Design Report. Figure 2-1 presents the locations of all RD samples collected. In addition, data collected prior to 2004 have been utilized, where appropriate, to support the RD. 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. Detailed descriptions of sampling and analysis data are provided in the 30 Percent Design Report, and are not repeated herein.

### *2.1.2 2007 Sampling and Analysis Program*

The 2007 sampling involved collecting additional sediment core samples using vibracore and piston core methods to further refine the delineation of sediments exceeding the 1.0 ppm RAL in certain areas of OUs 2 to 5, and to obtain additional geotechnical information. A detailed RD Sampling and Analysis Plan (SAP) and Quality Assurance Project Plan (QAPP) addendum was prepared (Shaw and Anchor 2007) with the following objectives:

- Further delineation of sediment PCB concentrations in OUs 2, 3, and 4 to support detailed design of the remedy in areas where cores could previously not be collected and along the edges of the river and adjacent in-water structures
- Supplemental data collection and surveys to support the design of sediment removal (dredging) and capping in the vicinity of shoreline and in-water features such as structures, slopes, and utility crossings

Consistent with previous sampling activities in 2004 to 2006, a co-located surface sediment sample (top 10 centimeter [cm]) was obtained at each vibracore location (see Shaw and Anchor 2004 and 2007 for description of sampling methods). However, surface grab samples were not collected at piston core locations since this sampling device was capable of retrieving a representative surface sample. The 2007 sampling locations are depicted in Figure 2-1, and included the following:

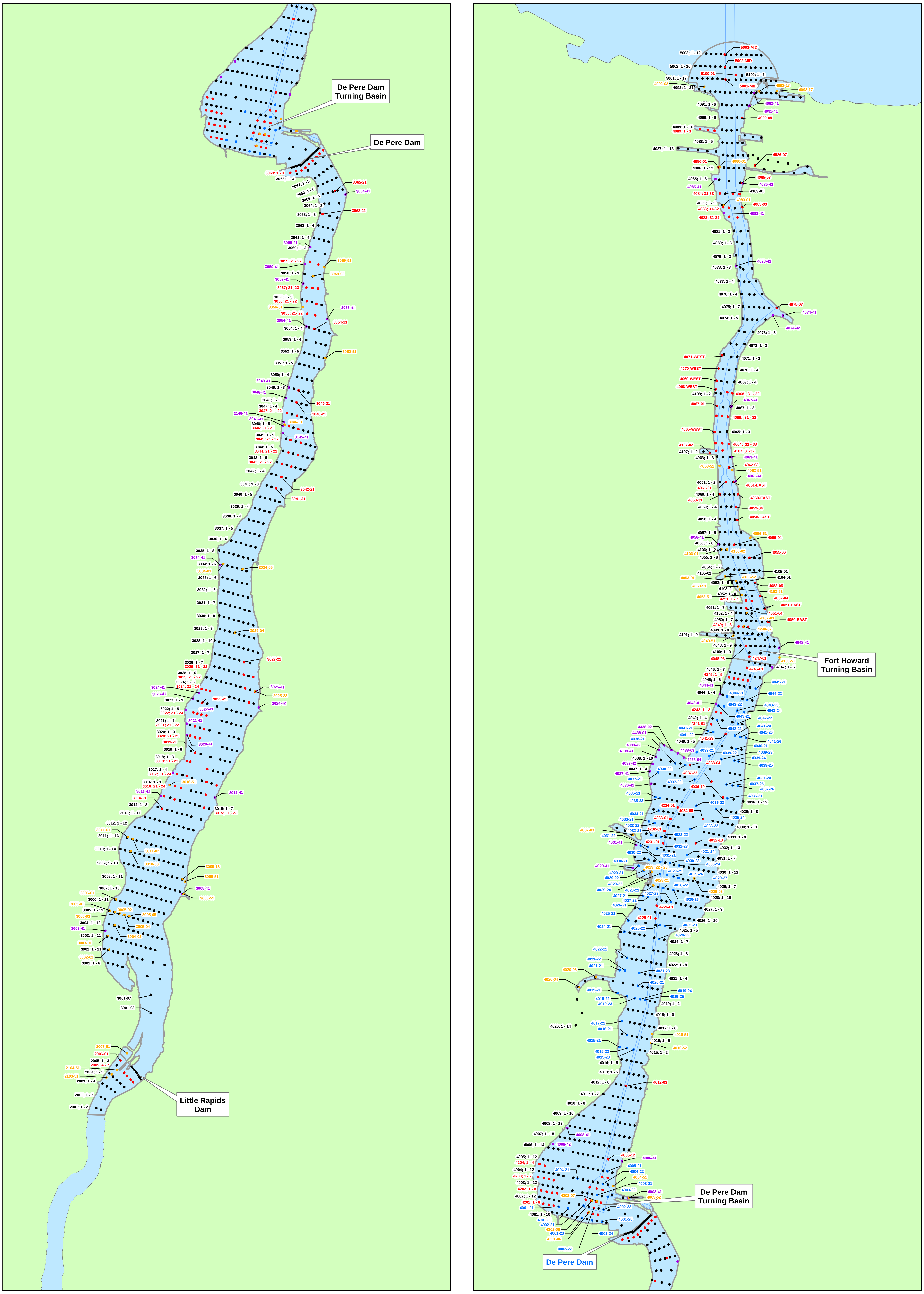
- 33 vibracore and surface sediment (0 to 6 inch) sampling locations
- 73 piston core and surface sediment (0 to 6 inch) samples
- 235 sediment samples were analyzed for selected physical and chemical parameters
- 13 focused geotechnical samples
- Physical observations and surveying of shoreline areas targeted for RA

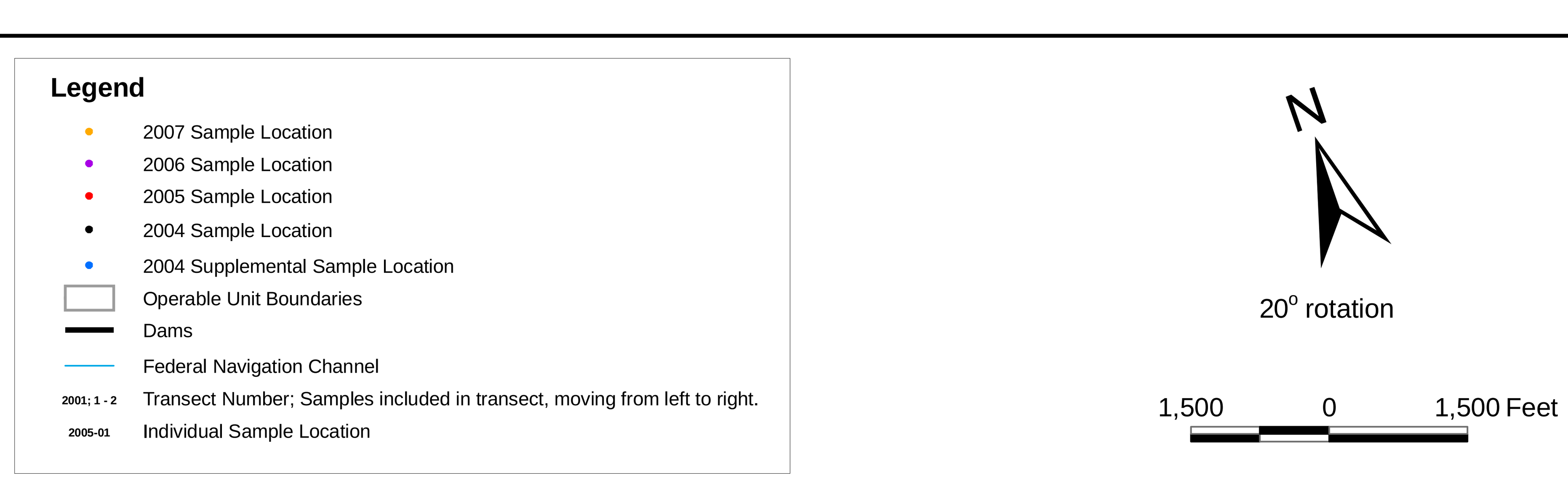
#### *2.1.2.1 Testing Methods (Chemical and Geotechnical)*

Testing methods used in 2007 were identical to those used in 2004 (see BODR Section 2.1.2.2).

#### *2.1.2.2 Data Validation*

A data validation process was performed to assess the reliability and usability of sampling and analysis data collected during the 2007 RD evaluation. The validation process is equivalent to that used for the 2004 program, as summarized in Section 2.1.2.4 of the BODR. The 2007 data validation reports will provided to the Response Agencies in electronic format as part of the forthcoming RD Anthology.




# Figure 2-1

## Sample Location Map Operable Units 2 - 5

TETRA TECH EC, INC.

ANCHOR ENVIRONMENTAL, L.L.C.

Shaw

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### 2.1.3 Ongoing 2008 Sampling and Analysis Program

Section 2.1.2 of Volume 1 presents an overview of the sediment sampling program to be performed in 2008 to further refine the neatline delineation of sediments containing PCB concentrations above the 1.0 ppm RAL in dredge-only areas in upper OU 3 targeted for dredging in 2009. Details of the sediment sampling program that will be performed in 2008 are included in the *Lower Fox River OUs 2 to 5 Phase 2A Sampling and Analysis Plan (SAP) Addendum for 2008 Upper OU 3 "Infill" Sampling* (Tetra Tech 2008).

## 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 60 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.

## 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. Table 2-1 presents a summary of the geotechnical properties for samples collected during the 2004 to 2007 RD investigations 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 silty, clayey sand with an average in situ percent solids content of approximately 35 percent by weight (standard deviation of 14 percent). The sediment within the overall OUs 2 to 5 sediment removal areas averages approximately 36 percent sand (standard deviation 27 percent), 37 percent silt (standard deviation 16 percent), and 26 percent clay (standard deviation 13 percent) by weight, with the remaining trace fraction being gravel-sized particles. The data presented in Table 2-1 has been corrected for coring-induced sample compaction. Appendix A, Attachment A-6 provides a complete summary of geotechnical data collected within the targeted removal areas in OUs 2 to 5.

**Table 2-1**
**Summary of RD Geotechnical Data Representative of 60 Percent Removal Areas Only [a]**

| | Moisture Content [b] (percent) | Percent Solids [b] (percent) | Percent Sand/Gravel (percent) | Percent Silt/Clay (percent) | Liquid Limit (percent) | Plasticity Index (percent) | Organic Content | Specific Gravity | Dry Density [b] (pounds per cubic foot) |
|---|---|---|---|---|---|---|---|---|---|
| **OUs 2 and 3** | | | | | | | | | |
| No. of Samples | 8 | 8 | 4 | 4 | 8 | 8 | NA | 2 | 8 |
| Avg. | 275 | 31 | 18 | 82 | 188 | 141 | NA | 2.37 | 25 |
| St. Dev. | 167 | 14 | 12 | 12 | 21 | 28 | NA | 0.00 | 15 |
| **OUs 4 and 5** | | | | | | | | | |
| No. of Samples | 104 | 104 | 60 | 60 | 76 | 76 | 9 | 14 | 104 |
| Avg. | 224 | 35 | 39 | 61 | 170 | 124 | 11.6 | 2.37 | 30 |
| St. Dev. | 100 | 15 | 24 | 24 | 46 | 39 | 6.5 | 0.09 | 18 |
| **OUs 2 to 5** | | | | | | | | | |
| No. of Samples | 115 | 115 | 65 | 65 | 86 | 86 | 9 | 16 | 115 |
| Avg. | 227 | 35 | 37 | 63 | 171 | 125 | 11.6 | 2.37 | 29 |
| St. Dev. | 105 | 14 | 24 | 24 | 44 | 38 | 6.5 | 0.09 | 18 |

**Notes:**

a. Includes 2004, 2005, and 2006 sample results for all areas targeted for dredging in OUs 2 to 5. Samples collected on 6-inch intervals.

b. Corrected for core compaction

## 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. Section 2.1 of this report discusses the additional sampling conducted in 2006 and 2007 to further delineate the spatial extent of PCBs, particularly within the shoreline areas of OUs 2 to 4. The remainder of this section discusses the refinements (initially described in Geostatistics Technical Memorandum No. 4 [Anchor and LTI 2006d, Attachment A-1]) to the geostatistical model and the resulting updated neatline model surface.

### *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 2006a, 2006b, and 2006c). 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. 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 a second phase of fieldwork in May 2005. These additional cores were targeted towards areas where more precise delineation of depth to the RAL was needed, for example, in areas with steep concentration gradients. Several of the 2005 cores were located in areas where 2004 data indicated contamination extended all the way to refusal, 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. Previous interpolations, which did not segregate

channel from out-of-channel locations, had consistently underestimated DOC in the channel, while 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 indicates some disturbance and sloughing of the sidewalls likely occurred during channel dredging, as might be expected.

- **River Straightening.** In the previous 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 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 supplemental 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 2006d). This verification process was also completed for OU 3 and presented to the Response Agencies in a series of workgroup meetings.

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 are added to the unstraightened model. With the full 2004-2005 dataset included, however, straightening improved most of the metrics for both OU 3 and OU 4. A key advantage of the new model was its 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 Squared 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. The geostatistical metrics are discussed in detail in *Geostatistics Technical Memorandum No. 4* (Anchor and LTI 2006d).

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

| | 2004 | 2004 and 2005 Data | | | | | |
|---|---|---|---|---|---|---|---|
| | 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 | 34 | 38 | 46 | 55 | 58 |
| False Negatives (%) | 21 | 22 | 19 | 15 | 13 | 11 | 11 |
| Sensitivity (%) | 49 | 51 | 58 | 70 | 79 | 87 | 88 |
| Specificity (%) | 83 | 84 | 86 | 80 | 67 | 50 | 43 |
| Percent Correct (%) | 73 | 73 | 77 | 76 | 71 | 62 | 57 |
| RMSE (feet) [c] | 0.5 | 0.6 | 0.5 | 0.5 | 0.6 | 0.7 | 0.8 |
| MAE (feet) [c] | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.5 | 0.6 |
| Bias (feet) [c] | -0.1 | -0.1 | -0.1 | 0.0 | 0.1 | 0.3 | 0.4 |
| **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 |

| | 2004 | 2004 and 2005 Data | | | | | |
|---|---|---|---|---|---|---|---|
| | Unstraightened River | | Straightened River and Segregated Channel [b] | | | | |
| **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.

### *2.4.2 Spatial Extent of PCBs Exceeding 1.0 ppm*

The spatial distributions of PCB mass in OUs 3 and 4 are presented on Figures 2-2 and 2-3, respectively. The DOC in OUs 3 and 4 is presented on Figures 2-4 and 2-5, respectively, using the refined, full indicator kriging model with a significance level of 0.5. The surface represented in DOC maps was subtracted from the mudline elevation to generate an elevation surface of the bottom of contamination, and used to develop the dredge plans (see Section 4.3).

Maps of the spatial extent of PCB concentrations above the RAL in OUs 3 and 4 (i.e., the "footprint" of the remediation boundary) are presented on Figures 2-6 and 2-7, respectively, using the refined full indicator kriging model at significance levels of 0.5, 0.4, and 0.3. Figures 2-2 through 2-5 provide important information on the PCB mass inventory in the sediments, which is not captured in the indicator kriging maps on Figures 2-6 and 2-7, 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.

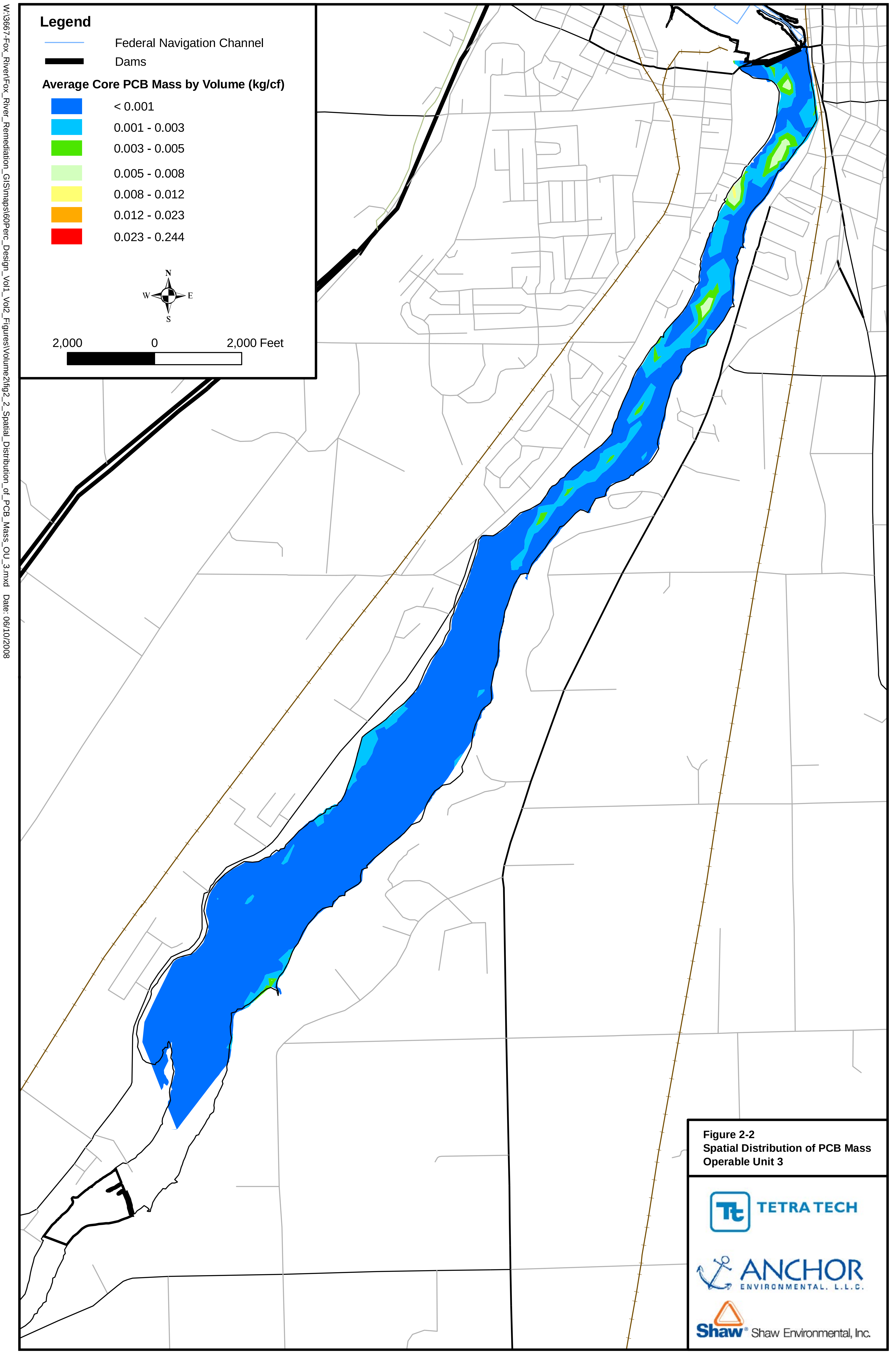


Figure 2-2
Spatial Distribution of PCB Mass
Operable Unit 3

TETRA TECH
ANCHOR ENVIRONMENTAL, L.L.C.
Shaw® Shaw Environmental, Inc.

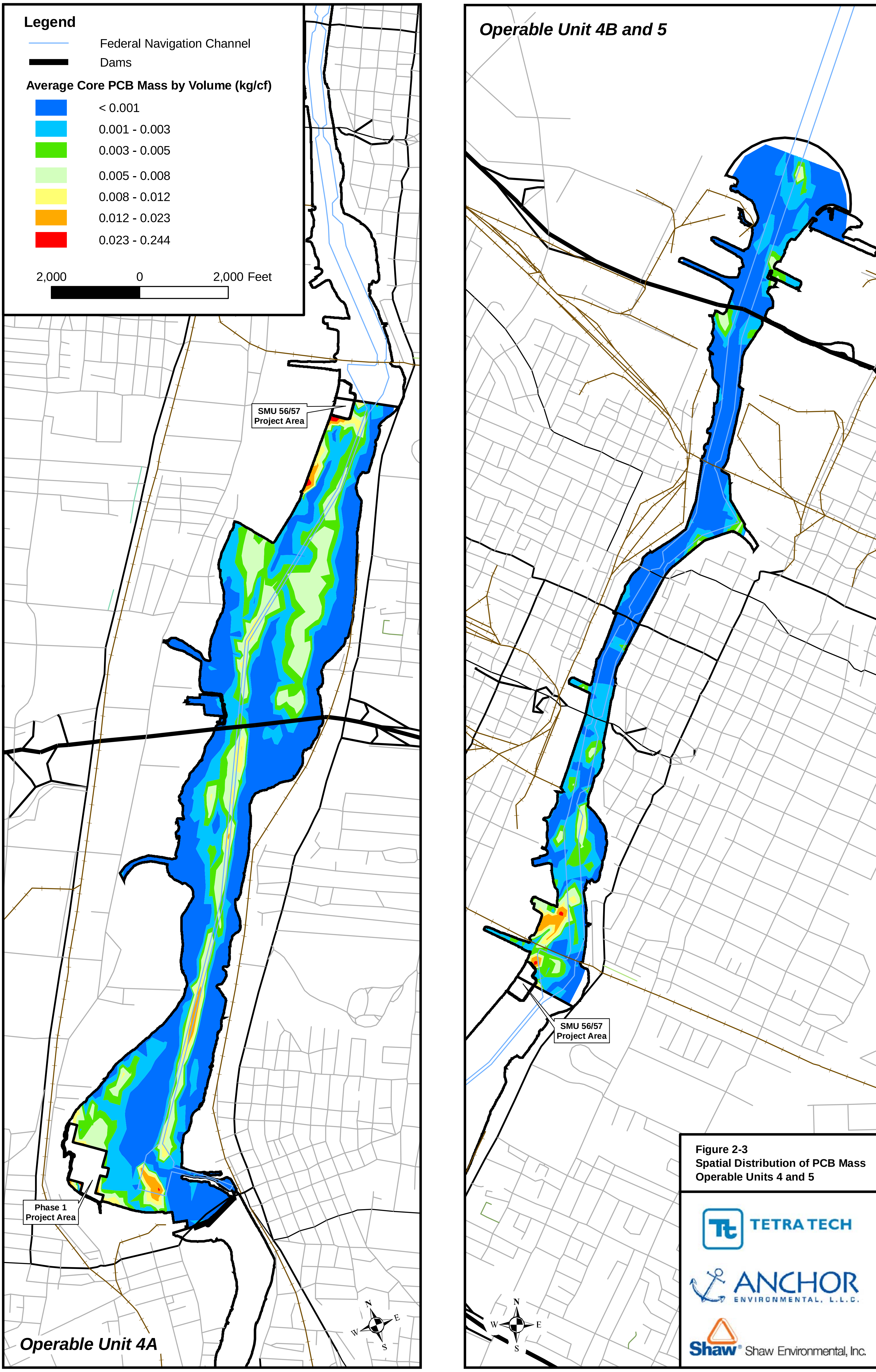


**Figure 2-3**
**Spatial Distribution of PCB Mass**
**Operable Units 4 and 5**

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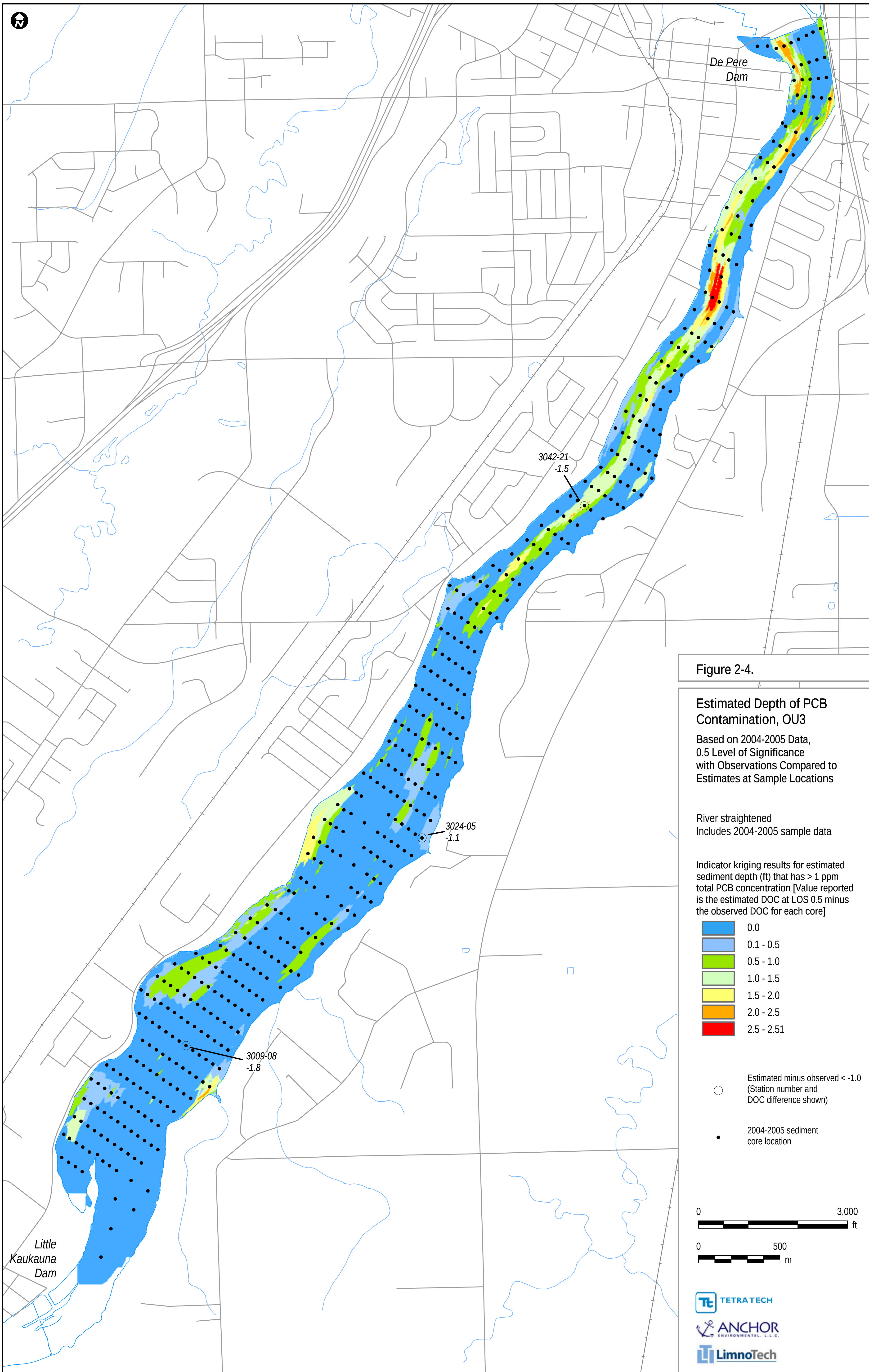
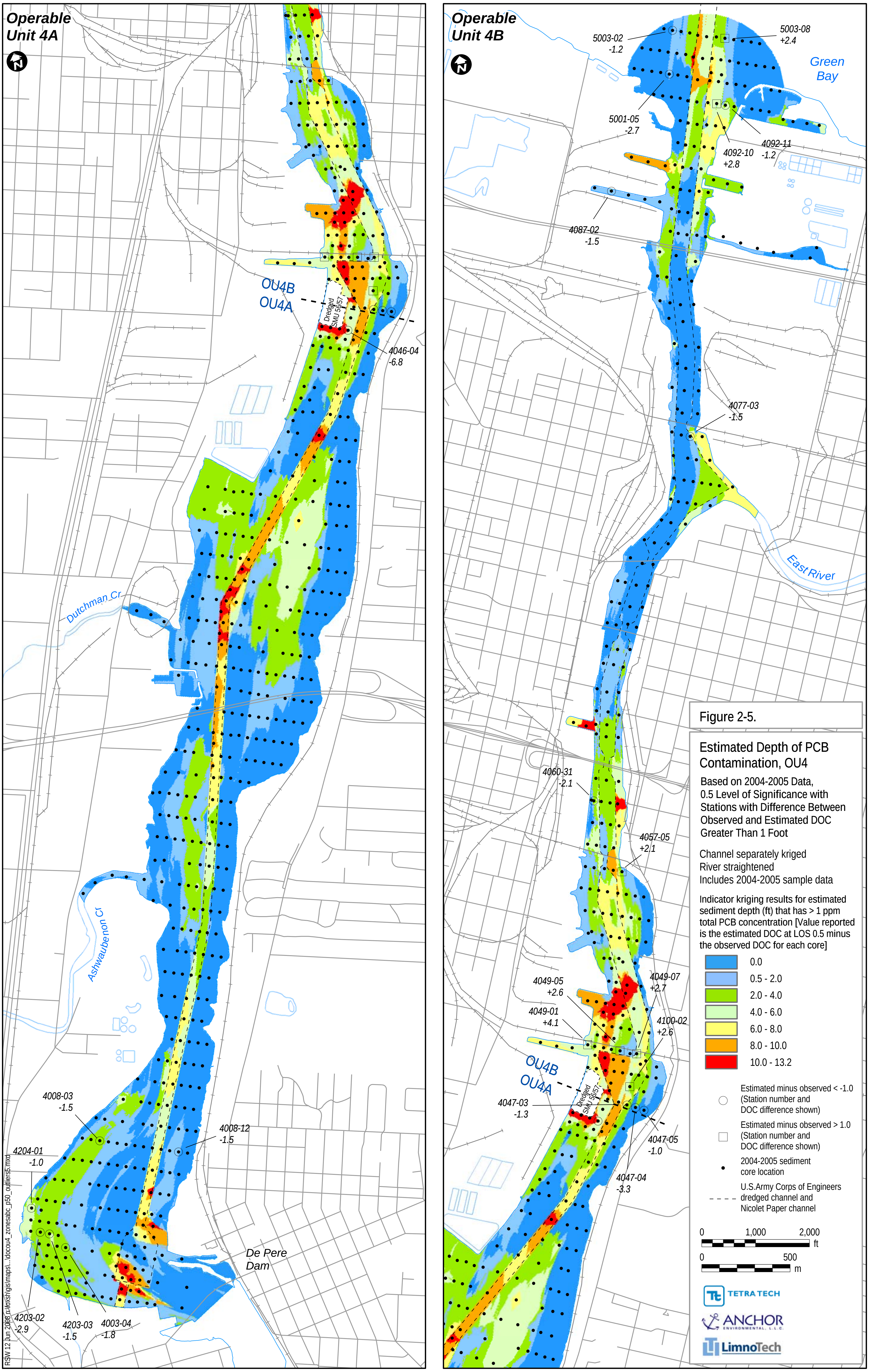

De Pere
Dam
3042-21
-1.5
3024-05
-1.1
3009-08
-1.8
Little
Kaukauna
Dam
Figure 2-4.
Estimated Depth of PCB
Contamination, OU3
Based on 2004-2005 Data,
0.5 Level of Significance
with Observations Compared to
Estimates at Sample Locations
River straightened
Includes 2004-2005 sample data
Indicator kriging results for estimated sediment depth (ft) that has > 1 ppm total PCB concentration [Value reported is the estimated DOC at LOS 0.5 minus the observed DOC for each core]
0.0
0.1 - 0.5
0.5 - 1.0
1.0 - 1.5
1.5 - 2.0
2.0 - 2.5
2.5 - 2.51
Estimated minus observed < -1.0 (Station number and DOC difference shown)
2004-2005 sediment core location
0
3,000
ft
0
500
m
TETRA TECH
ANCHOR ENVIRONMENTAL, L.L.C.
LimnoTech
RSW 12 Jun 2008 n:\foxsh\gis\maps\doc_ou3kriging\...\doc_ou3_straightkriging_jan2006_diffs3.mxd



Operable Unit 4A
OU4B
OU4A
Dredged SMU 56/57
4046-04 -6.8
Dutchman Cr
Ashwaubenon Cr
4008-03 -1.5
4008-12 -1.5
4204-01 -1.0
4203-02 -2.9
4203-03 -1.5
4003-04 -1.8
De Pere Dam
Operable Unit 4B
5003-02 -1.2
5003-08 +2.4
Green Bay
5001-05 -2.7
4092-10 +2.8
4092-11 -1.2
4087-02 -1.5
4077-03 -1.5
East River
4060-31 -2.1
4057-05 +2.1
4049-05 +2.6
4049-07 +2.7
4049-01 +4.1
4100-02 +2.6
4047-03 -1.3
4047-05 -1.0
4047-04 -3.3
Figure 2-5.
Estimated Depth of PCB Contamination, OU4
Based on 2004-2005 Data, 0.5 Level of Significance with Stations with Difference Between Observed and Estimated DOC Greater Than 1 Foot
Channel separately kriged
River straightened
Includes 2004-2005 sample data
Indicator kriging results for estimated sediment depth (ft) that has > 1 ppm total PCB concentration [Value reported is the estimated DOC at LOS 0.5 minus the observed DOC for each core]
0.0
0.5 - 2.0
2.0 - 4.0
4.0 - 6.0
6.0 - 8.0
8.0 - 10.0
10.0 - 13.2
Estimated minus observed < -1.0 (Station number and DOC difference shown)
Estimated minus observed > 1.0 (Station number and DOC difference shown)
2004-2005 sediment core location
U.S.Army Corps of Engineers dredged channel and Nicolet Paper channel
0 1,000 2,000 ft
0 500 m
TETRA TECH
ANCHOR ENVIRONMENTAL, L.L.C.
LimnoTech

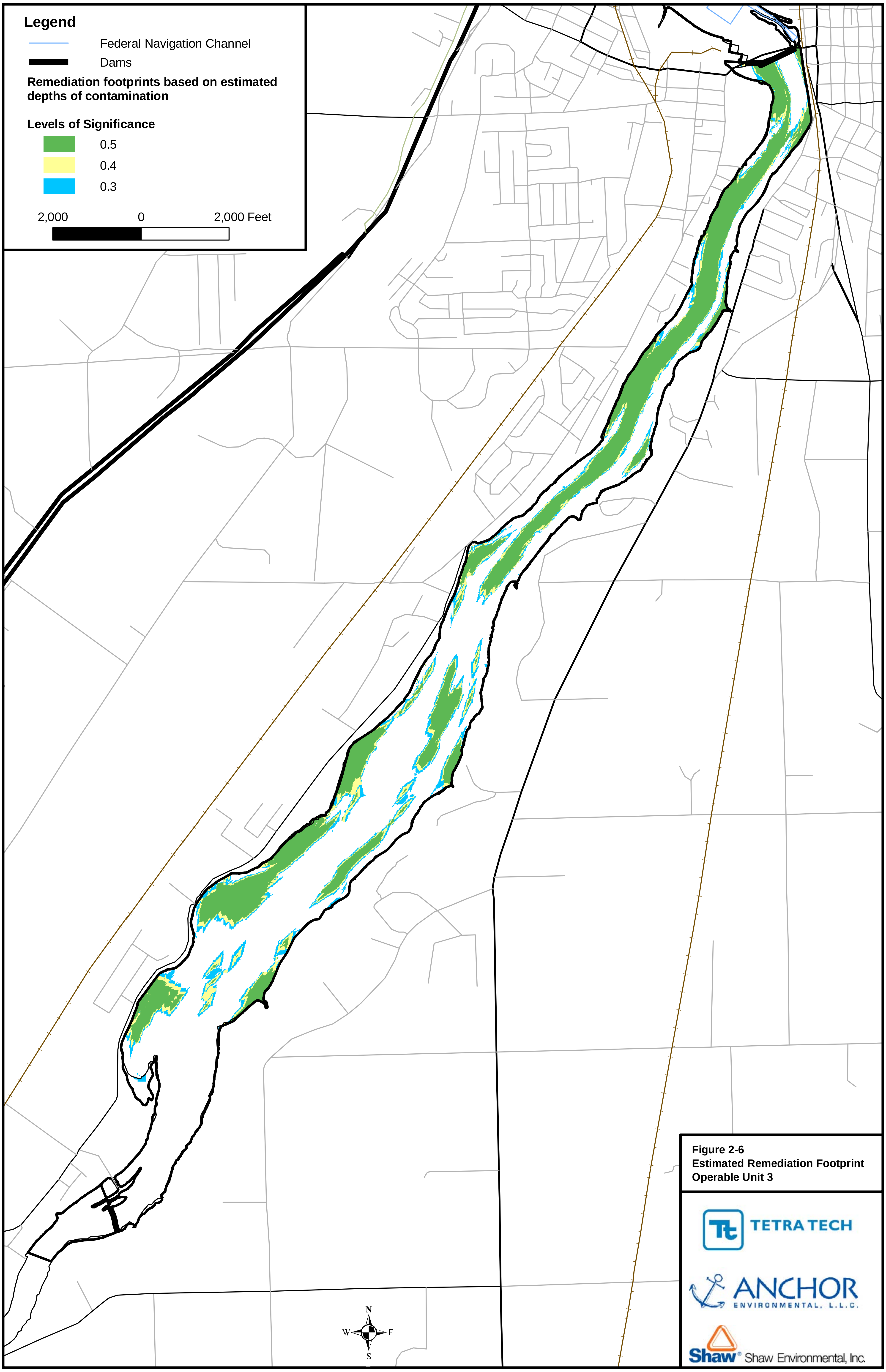



Figure 2-6
Estimated Remediation Footprint
Operable Unit 3

TETRA TECH
ANCHOR ENVIRONMENTAL, L.L.C.
Shaw Environmental, Inc.

W:\3667-Fox_River\Fox_River_Remediation_GIS\maps\60Perc_Design_Vol1_Vol2_Figures\Volume2\fig2_6_Estimated_Remediation_Footprint_OU_3.mxd Date: 06/10/2008

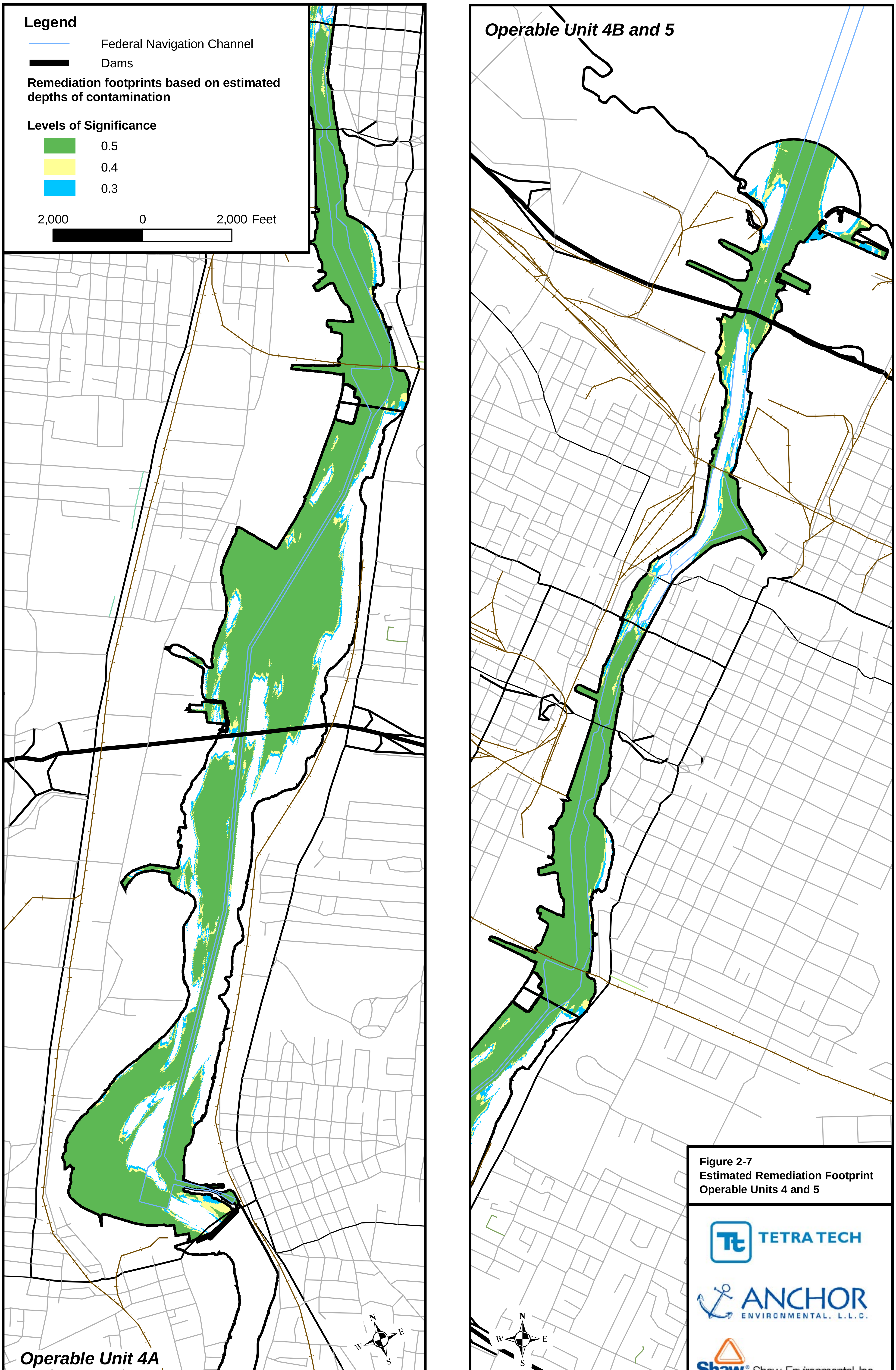



Figure 2-7
Estimated Remediation Footprint
Operable Units 4 and 5

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### 2.4.3 Planned Refinements after Follow-on Sampling

Details of the planned refinements to the dredging neatline are included in the 60 Percent Design Report Volume 1.

## 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 60 Percent Design Report Volume 1.

## 2.6 Project Datum

A discussion of project datums is included in the 60 Percent Design Report Volume 1.

## 2.7 Sequential 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. A brief "Sequential Design Anthology" will be provided to the Response Agencies in late 2008, separate from this 60 Percent Design Report.

# 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 60 Percent Design Report Volume 1.

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

### *3.2.1 OU 2/3 – Little Rapids Dam Area*

The Little Rapids staging facility will be in active use receiving capping materials in the years 2010 through 2012 to support capping and cover activities at OUs 2 and 3. At the end of 2012, the site use will be complete, and the area will be demobilized with the removal of the field trailer office and any other project-related structures. The final site condition will be determined by the leasing agreement with the property owner.

### *3.2.2 OU 4 – Former Shell Property*

The former Shell property staging and material processing facility, including the dock area, will be fully constructed in 2010 and no further layout or development is expected after that. Detailed facility buildout plans are included in Draft Final Site Development Plan, Former Shell Property Material Processing Facility Buildout, and are summarized in the 60 Percent Design Report Volume 1.

Operations will continue to support the dredging, debris disposal, capping, and covering activities on-river and the disposal of TSCA and non-TSCA wastes from the former Shell property through 2017.

Demobilization of the former Shell property will begin when the dredging is completed in 2017. A Demobilization and Lay-up Plan will be prepared as part of the final annual RA Work Plan, to address the actions required to turn over the property, buildings, and facilities to the site owner and according to the lease agreement with the owner.

# 4 SEDIMENT DREDGING

A detailed discussion of sediment dredging operations is included in Section 4 of the 60 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

Approximately 3.4 million cubic yards (cy) of sediments in OUs 3 to 5 are targeted for dredging in 2010 and beyond. The physical properties of sediments, dredgeability considerations, seasonal construction windows, and federal navigation channel considerations are discussed in Section 4.1 of the 60 Percent Design Report Volume 1.

## 4.2 Equipment Selection and Production Rates

### *4.2.1 Equipment Selection Process*

The equipment selection process and details of hydraulic and mechanical dredge equipment are provided in Section 4.2.1 of Volume 1.

### *4.2.2 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 derrick or excavator will 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.

Final pass operations will be performed by the 8-inch dredges following bulk removal by the 12-inch dredge. As outlined in 60 Percent Design Volume 1, the thickness of contaminated sediment remaining following bulk removal with the 12-inch dredge will typically be thin (less than 1 foot), and suitable for cleanup pass operations. The use of a smaller dredge pump is advantageous for the final 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. 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.

#### *4.2.3 Production Rate Considerations*

Dredge production in OUs 3 to 5 is dependent on numerous factor, 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 4.2.3 of 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. 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 outlines the anticipated yearly dredging production rates for 2010 and beyond.

#### *4.2.4 Survey Methods and Equipment*

Survey methods and equipment are provided in Section 4.3.3 of Volume 1.

#### *4.2.5 Data Management*

Data management is detailed in Section 4.3.4 of Volume 1.

#### *4.2.6 Dredge and Survey Software*

Dredge and survey software are detailed in Section 4.3.5 of Volume 1.

### 4.3 Dredge Plan Development

The dredge plan development process, including optimization and sequencing considerations, is detailed in Section 4.4 of Volume 1.

### 4.4 2010 and Beyond Dredge Plan Design Summary

Dredge plans for 2010 and beyond are presented in Appendix C – Engineered Plan Drawings.

### 4.5 Management of Potential Impacts from Dredging

Management and best management practices (BMPs) for dredging operations, dredge residual management, slope and structural considerations, short-term water quality considerations, and noise and air quality considerations are included in Section 4.7 of the 60 Percent Design Report Volume 1.

# 5 MATERIALS HANDLING, TRANSPORT, AND DISPOSAL

The design of the materials handling, transport, and disposal operations are described in Volume 1. The mass balance used to select and size the dredging, desanding, dewatering, and water treatment equipment can be found in Appendix A, Attachment A-5. At the end of each year of RA operations, the estimated quantities of sediment to be processed the following year will be adjusted in accordance with the Adaptive Management and VE Plan (Appendix E), and documented in annual RA Work Plans.

## 5.1 Transport of Debris and Dredged Material

Volume 1 Section 5.1 presents details of the transport of debris and dredged material.

## 5.2 Dredge Pipeline

Volume 1 Section 5.2 presents the dredge pipeline design and marking system, booster station details, and dredge pipeline monitoring procedures.

## 5.3 Dredge Sediment Handling

### *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 will be deployed to OU 3 to begin dredging of non-TSCA material. When the non-TSCA dredging is completed in OU 3, the 8-inch dredges will be moved into OU 4.
- The 12-inch hydraulic dredge will operate from De Pere Dam north into OU 5, removing non-TSCA sediment.
- As the majority of TSCA material is overlain by non-TSCA material in the area between the De Pere Dam and the former Shell property, TSCA dredging will be performed in sequence beginning in 2010, with TSCA materials being removed at the end of the dredge season. TSCA dredging will be completed in 2015.
- There will be no crossover between non-TSCA and TSCA material at the dewatering plant. The dredge, dewatering plant, and water treatment plant will be flushed prior to processing the non-TSCA material.

### *5.3.2 Contingency for Mechanically Removed Sediment Transport*

Volume 1 Section 5.3.2 presents the procedures for mechanically removed sediment transport.

## 5.4 Mechanical Dewatering Operations

Volume 1 Section 5.4 presents details of mechanical dewatering operations including the dewatering plant, processing of hydraulically and mechanically dredged sediment, segregation of sand, monitoring, BMPs, physical characteristics of processed material, and preliminary mass balances.

## 5.5 Water Treatment Operations

Volume 1 Section 5.5 presents details of the water treatment system, effluent performance standards, effluent discharge monitoring requirements, and waste load allocation transfer.

## 5.6 Transport and Disposal of Dewatered Sediment and Debris

Volume 1 Sections 5.6.1 through 5.6.5 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 former Shell property staging and material processing facility and from the Little Rapids staging area.

### *5.6.1 Beneficial Use 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. 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. Selecting the most appropriate beneficial reuse alternative for the 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.

Approximately 1,372,000 tons of sand are expected to be generated through the dredging, desanding, and dewatering process. Desanding and beneficial use volumes will continue to be refined throughout the project.

Testing of the sand as part of the pilot sand separation/washing process, to be performed in 2008, will provide an indication of the expected chemical characteristics and will be useful in the evaluation of beneficial reuse alternatives. However, analysis of full-scale production separated sand will be required and will be used for the final acceptability determination of the various beneficial use options. Volume 1 Section 5 provides detailed information on the currently identified potential beneficial reuse alternatives.

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, September 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 Volume 1 of the 60 Percent Design Report. However, many of the beneficial use applications allow higher concentrations.

Beneficial reuses of dredge material commonly include shoreline stabilization, 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
- Environmental concerns
- Stakeholder concerns

As part of the continued VE efforts in years 2010 to 2017, beneficial reuse opportunities for the sand and coarser materials contained in the dredge material will continue to be evaluated throughout the project. Table 5-1 lists these opportunities. Generally, approximately 572,000 tons of the segregated sand is planned to be used for fill behind the sheetpile wall constructed at the former Shell property. The remaining approximately 800,000 tons of segregated sand is available for other beneficial reuse alternatives.

**Table 5-1**
**Beneficial Reuse Opportunities**

| Beneficial Reuse Opportunity | Description of Opportunity | Quantity of Material that Could Be Reused as Part of This Opportunity | Opportunity Specific Material Gradation and Other Requirements |
|---|---|---|---|
| Staging Area Backfill at Former Shell Property | Sand can be used to fill in behind the sheetpile wall to be constructed at the former Shell property. | Approximately 572,000 tons (total for project) | TBD |
| Bayport Disposal Facility | Beneficial use for construction material as part of disposal facility operations and/or construction. | TBD | TBD |
| Beach Nourishment | Construction materials for beach restoration. No specific sites identified. Could be in Great Lakes States. | TBD | TBD |
| Landfill Construction | Construction materials as part local operating landfill(s). Multiple opportunities, including GP landfill. | TBD | TBD |
| Manufactured Soil | Mix separated sand with other yard waste, agricultural waste, and/or animal waste. | TBD | TBD |
| Renard Island Closure | Construction materials for closure of Renard Island disposal facility, consistent with draft closure plan. | TBD | TBD |
| Roadway Construction | Construction material for local road construction projects. Highway 41 expansion has been identified as an alternative. | TBD | TBD |
| Upland Development | Construction materials for local non-residential development or park enhancement. No specific projects currently identified. | TBD | TBD |

| Beneficial Reuse Opportunity | Description of Opportunity | 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. | TBD | TBD |
| Mine Reclamation | Use material as backfill in local mines for reclamation | TBD | TBD |
| Raw Material for Concrete or Asphalt Manufacturing | Potential use for Highway usage coordinating with WIDOT for projects in area during project | TBD | TBD |

#### *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 Staging Area Backfill at the Former Shell Property

The former Shell property adjacent to the Georgia-Pacific West Mill in OU 4 will be used as the primary upland contractor operations area. The approximately 22 acres of useable upland space will be expanded by way of filling up to the existing bulkhead line, to accommodate the onshore operations. Staging area backfill is described in Volume 1 and in the Phase 2A RA Former Shell Property Site Development Plan.

##### 5.6.1.1.2 Bayport Material Disposal Facility

The Bayport Material Disposal Facility (Bayport) is an upland confined disposal facility 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 and stockpiled in a stockpile cell. 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.

Depending on the schedule for navigational channel dredge projects, the Bayport facility operates in cycles, with dredge material initially deposited in a dewatering cell. The dewatered sediments are then excavated with conventional earth moving equipment and transported to one of two storage/disposal cells where it is stockpiled and graded.

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.

##### 5.6.1.1.3 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, since 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 P200 fraction 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, distance to from the site to the beach location, etc. are not known at this time.

#### 5.6.1.1.4 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 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 dependant 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's Hickory Meadows Landfill includes a provision for possible beneficial re-use of sand segregated from the sediment on the Fox River project, pending WDNR approval. This landfill is located approximately 34 miles from the former Shell site, where the material will be generated.

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 over 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 low hazard exemption defined under s. 289.43(8) Stats.

##### 5.6.1.1.5 Manufactured Soil

This alternative involves mixing segregated sand from OUs 3 to 5 with composted organic matter such as yard waste, wastewater treatment plant (WTP) biosolids, manure, or other organic wastes 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, sewage sludge, manure from large-scale farms, or animal organic waste from local meat packers. 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 confined disposal facility (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. (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 about $10/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 (Preferred Consulting Group 2003). 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 low hazard waste exemption, 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.

###### 5.6.1.1.6 Renard Island Closure

The Renard Island CDF was constructed in 1978 by USACE for storage of dredge material from maintenance dredging of the Green Bay navigational channel. Renard Island is approximately 54 acres in size. Approximately 2,700,000 cy of dredge material was deposited in the Renard Island CDF from 1978 through the early 1990s. Sediment was mechanically dredged and transported to Renard Island by barge. Since the early 1990s, USACE has suspended use of Renard Island and has used the Bayport facility as its primary storage facility for navigational channel dredge materials. WDNR has requested that Renard Island be closed in accordance with rules regulating the closure of a solid waste disposal facility subject to Wisconsin regulation under ch. 289, Wis. Stats. The draft closure plan includes a grading plan, final cover system, and surface water and erosion control plans (Foth & Van Dyke 2005).

The proposed final grades will be placed at a slope of between 3 and 10 percent. These slopes were designed to accommodate settlement of the placed dredge material (grading layer) as the material dewaters while maintaining positive drainage post-settlement. Based on the current site topography, the proposed grading plan could provide Renard Island with an additional 640,000 cy of capacity for general dredge materials, excluding the final cover. All or part of this airspace could potentially be used for beneficial reuse of the segregated sand removed from OUs 3 to 5; however, given ongoing local issues regarding Renard Island closure, this option at Renard Island is uncertain.

###### 5.6.1.1.7 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 WIDOT and local units of government are planned 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 a category 4 material. Unconfined geotechnical fill and capped transportation facility embankments will have the more stringent requirements of a 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.

##### 5.6.1.1.8 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 will need to occur, such as:

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

The segregated sand from OUs 3 to 5 will be suitable for backfilling behind the dock 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 the site. Only non-residential end uses (industrial or commercial uses) will be considered (see Section 5.6.1.1). Design of the site could include appropriate engineering controls to minimize environmental concerns associated with this application.

One identified application of the upland development option is to integrate beneficial use with construction of the staging area. In addition, discussions with the City of Green Bay, Brown County (Port Authority), regulators, potential commercial interests, and other stakeholders will need to occur to perform a more detailed evaluation of this alternative and are planned as part of the ongoing VE efforts.

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.

#### 5.6.1.1.9 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.

#### 5.6.1.1.10 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.

##### 5.6.1.1.11 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.

### 5.6.2 Upland Disposal Facilities

Volume 1 Section 5.6.7 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 TSCA and non-TSCA regulated materials, and restriction on transportation. These potential changes to regulations by federal, state, and local authorities will be actively monitored and incorporated into annual RA Work Plans as appropriate.

### 5.6.3 Spill Prevention Measures

Volume 1 Section 5.6.8 presents spill prevention measures.

## 5.7 Handling of Clean Import Materials for Capping

### 5.7.1 Former Shell Property

#### 5.7.1.1 Construction Materials

Volume 1 Section 5.7.1.1 presents a summary of construction materials to be used at the former Shell property. See also the Phase 2A RA Site Development Plan.

#### 5.7.1.2 Cover Materials

The cover and capping materials will be delivered to the former Shell property and stockpiled to support the cover and capping operations on the river. Limited stockpile space is available on the site, requiring trucks to deliver materials as the stockpiles are consumed.

During the capping and cover operations, it is expected that 40 to 50 cy per hour will be used. Due to the type of work, the capping and cover operations are planned for 12 hours per day, 5 days per week. This would require 2,000 to 3,000 cy (1,000 to 1,500 tons) of these materials per week to support the use. At 20 tons per load, the project would need to receive approximately 50 to 75 loads of material per week. The stockpiles provide enough storage that deliveries of this material to the site could occur outside the placement times. Cover and capping operations are anticipated to occur during approximately the same times as the dredging—April 15 to November 15—starting in 2010 and continuing during the dredging seasons through the completion of the project. However, cold weather in November may limit capping to a greater extent than dredging resulting in an earlier winter shutdown of the capping operations.

Several local suppliers of sand and gravel have been identified. They include: Kiel Sand and Gravel, Daanen & Janssen, McKeefry & Sons, and Faulks Bros. The Tetra Tech Team has obtained quotations from these firms and believes each is capable of supplying the quantity of capping materials needed for the project. It is expected that other potential sources will be identified in the future. Since these materials come from several sources, truck traffic is not expected to be significant until they approach the former Shell property area.

### 5.7.2 OUs 2 and 3 Staging Area

Please refer to Volume 1 Section 5.7.2 for inbound and outbound materials at the Little Rapids staging facility.

# 6 ENGINEERED CAP DESIGN

As described in the BODR and 30 Percent Design Report, 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 2005a)
- *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 2005a).

Consistent with the above-referenced guidance, the BODR and 30 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 other pertinent processes) (To)

Given the variability of site conditions (PCB concentrations, erosion potential, etc.) throughout OUs 2 to 5, three general cap designs were developed for the BODR, primarily based on PCB concentrations, as summarized in Table 6-1 and described in detail in Appendix D of the BODR. Subsequent refinements of these cap designs were presented in the 30 Percent Design, including considerations of location-specific erosive forces and PCB concentrations; these refinements are briefly summarized in the following sections; details are provided in the 30 Percent Design Report.

**Table 6-1**
**Engineered Cap Designs Developed in BODR**

| Cap Description | PCB Concentration Threshold Range (0 to 6-inch interval) | Comments |
|---|---|---|
| Cap A - Minimum 13-inch Sand Cap with Gravel Armor | < 10 ppm | Used in low concentration areas where mixing zone of clean sand provides necessary chemical isolation |
| Cap B - Minimum 16-inch Sand Cap with Gravel Armor | 10 to 50 ppm | Used in areas where 3 inches of uncompromised chemical isolation layer is necessary for protection |
| Cap C - 33-inch Sand/Quarry Spall Cap | 10 to 100 ppm | Used only in OU 4 navigation channel and/or where PCB concentrations exceed 50 ppm at any depth |

Numerous technical memoranda and engineering evaluations (related to the cap design) were developed and performed as part of the 30 Percent Design. The reader is referred to the BODR and the 30 Percent Design Report for a complete description of the engineered cap design. This 60 Percent Design Report presents a summary of the cap design presented in the BODR and 30 Percent Design as well as results of additional cap design analyses conducted since the submittal of the 30 Percent Design. Note that these cap designs may be further refined in the future, as part of the VE process, subject to A/OT concurrence, as presented in Appendix D. The forthcoming RD Anthology will include 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:

- **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 10 ppm
- **Engineered caps of at least 9 inches of sand for chemical isolation:** PCB concentrations will not exceed 50 ppm within the sediment profile
- **Engineered caps of at least 15 inches of sand (and filter material) for chemical isolation:** PCB concentrations exceeding 50 ppm buried within the sediment profile or in shoreline areas where dredging would result in instability

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 thickness is applied based on the measured concentration of residuals (see CQAPP Addendum for additional details of PCB analysis in dredge-and-cap areas). Sampling densities and frequencies for this purpose may be reduced over time if the RD forecasts are consistently verified.

### *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 physical isolation and bioturbation (Tb).

### *6.1.3 Consolidation Component*

The cap material itself will be granular and is expected to undergo minimal elastic settlement within the period of construction. Therefore, no additional cap thickness is included to account for 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 forms 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 in 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, 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 (USACE 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. This propwash and 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 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, cost, etc.). 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 forthcoming "RD Design Anthology" for compilation of propwash modeling documentation).

Table 6-2 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 6-2**
**Summary of Cap Armor Recommendations for Recreational Propwash**

| Post-cap Water Depth | Median Stone Size, $D_{50}$ (inches) | Maximum Stone Size, $D_{100}$ (inches) | Classification |
|---|---|---|---|
| 3 to 4 feet | 3 | 6 | Gravel/Cobble |
| 4 to 6 feet | 1.5 | 3 | Gravel |
| >6 feet | 0.25 | 1 | Sand/Gravel |

Note: 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 6-7.

The general recommendations for cap armor materials were used in conjunction with the results of other hydrodynamic analyses relative to cap design (i.e., wind wave, vessel wake, river flows, etc.) 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, marine facilities, etc. (see Section 6.4). Application of these ground rules will be performed as RA work progresses within the river such that site-specific remedies are designed in the year prior to construction in that area and documented in the annual RA Work Plans.

#### *6.1.4.2 Vessel Wake Analysis*

As part of the 30 Percent Design phase, additional 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. Subsequent to the 30 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 river bank. Table 6-3 presents a summary of the armor layer design necessary to resist vessel wakes anticipated for representative transects in OUs 3, 4A, and 4B. Subsequent phases of design (e.g., annual RA Work Plans) 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. Appendix B, Attachment B-2 provides additional details of the critical wave predictions and armor layer designs.

**Table 6-3**
**Summary of Preliminary Cap Armor Recommendations for Vessel Wakes**

| Representative Capping Area | 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) | 3.22 | 0.68 ft. | 1.08 ft. | 1.36 ft. | 0.08 ft. | 0.15 ft. | 1.0 ft. |
| OU 4B (Transect 4061) | 3.30 | 0.60 ft. | 0.96 ft. | 1.20 ft. | 0.07 ft. | 0.13 ft. | 1.0 ft. |
| | | Capping Armor below Surf Zone[a] $D_{50}$ (inches) | | | | | |
| OU 3/4A (Transect 4044) | 3.22 | 0.95 inches (Coarse Gravel) | | | | | |
| OU 4B (Transect 4061) | 3.30 | 0.81 inches (Coarse Gravel) | | | | | |

**Notes:**

a. Surf zone defined herein as water depth range subject to breaking waves, which may extend from the top of bank to approximately 1 to 2 times the wave breaking depth (4.2 to 8.4 feet)

b. $D_{50}$ = median particle diameter in gradation

c. $D_{100}$ = maximum particle diameter in gradation

#### *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 conservative maximum bottom shear stress of 100 dynes/cm$^2$ was selected for design and was correlated to a minimum thickness of 4 inches of 1.5-inch armor stone, consistent with USEPA/USACE guidance.

Subsequent to the BODR, additional supplemental model simulations were performed in March 2007 using a range of extreme 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

2-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: in OU 3 immediately below the Little Rapids Dam, and in OU 4 just downstream of the East River. However, these areas have not been targeted for capping as part of the OUs 2 to 5 RA. 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 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.

## 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 channel. As such, the horizontal extent of caps was offset at least 10 feet horizontally from the lateral boundaries of the federal channel, which in many cases is outside of the toe of 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). 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:

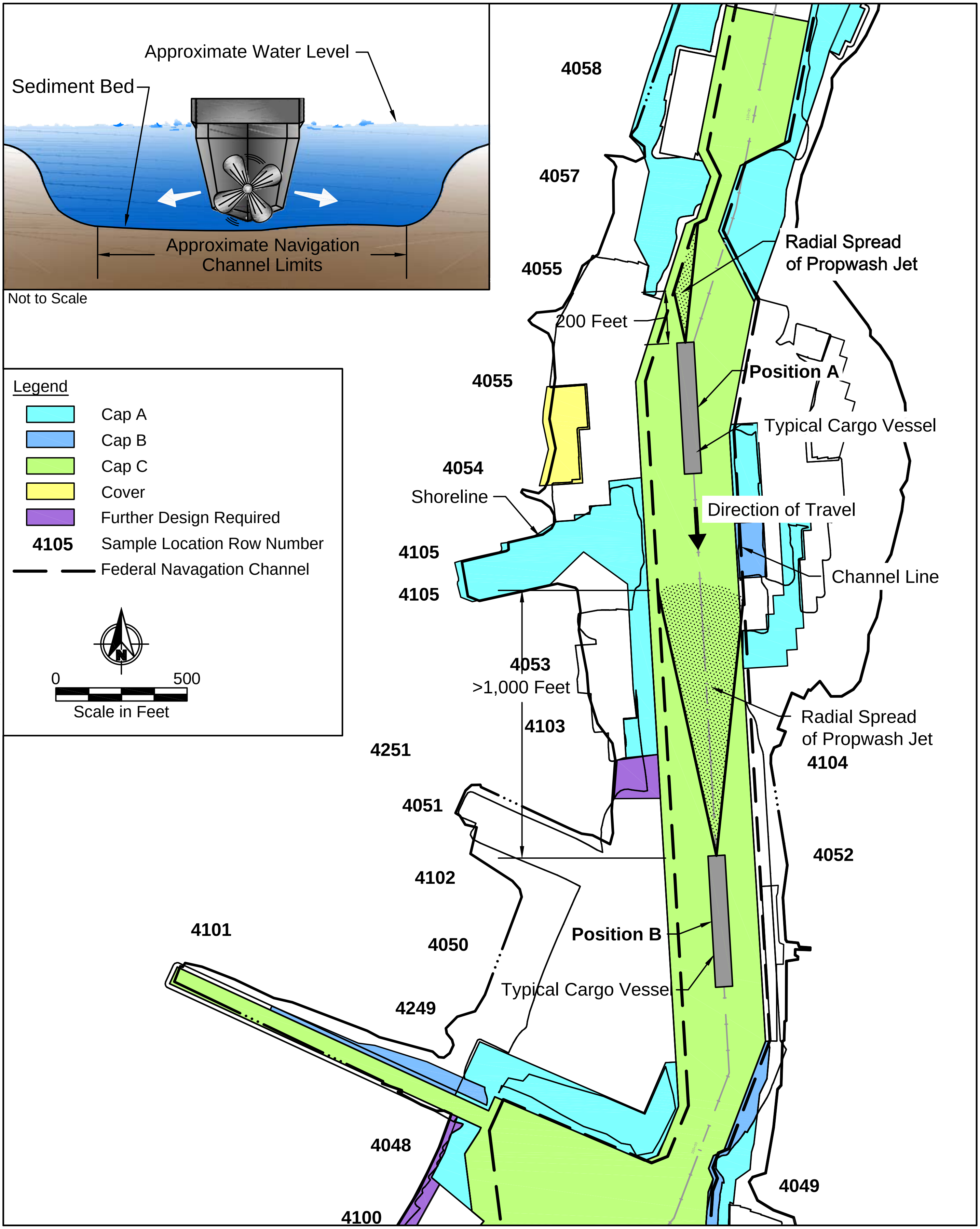
> **SEC. 3173 GREEN BAY HARBOR, GREEN BAY WISCONSIN**
> The portion of the inner harbor of the Federal navigation channel of the Green Bay Harbor project, authorized by the first section of the Act entitled “An Act making appropriations for the construction, repair, and preservation of certain public 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 indicated that 4- 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. 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 most of the side slopes of the navigation channel (designed at 3 horizontal to 1 vertical [3H:1V] extending outside of the limits of the authorized channel) where the propwash would be generally directed along the centerline of the channel (i.e., parallel to the side slopes rather than perpendicular to them). 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 on the slopes of the OU 4B navigation channel.

Within the turning basin at immediately downstream of the Canadian National Railroad bridge (located at River Mile 3.3 opposite the Georgia-Pacific Corp.; often referred to as the "Fort Howard Turning Basin"), it is possible that vessel maneuvering operations could result in the propeller being directed perpendicular to the side slopes. Furthermore, given the relatively limited turning radius within this area, the distance between the propeller and the side slope could be limited (200 feet or less in extreme cases). Therefore, side slopes of the Fort Howard Turning Basin that require capping will be designed for the 33-inch-thick cap with quarry spall armoring. Appendix B, Attachment B-4 presents stability analyses for these capped slopes, which were incorporated into the design to ensure cap stability.

Other limited stretches of the navigation channel side slopes (aside from the Fort Howard Turning Basin) 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 60 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. However, based on a propwash evaluation for these areas (see Appendix B, Attachment B-3), propwash effects are minor and 3-inch-diameter cap armoring will be sufficient.

In addition to the erosion protection provided by the large armor stone placed within the navigation channel as discussed above, it will also 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 4A or 4B channel. Therefore, consistent with the ROD Amendment and subject to future VE analyses, engineered cap designs within the limits of the navigation channel will be a minimum of 33 inches thick with 4- to 9-inch-diameter armor stones.




Jun 16, 2008 1:22pm cdavidson K:\Jobs\080295-03 FOX RIVER OU2-OU4\08029503-002 (Propwash).dwg FIG 6-1

ANCHOR ENVIRONMENTAL, L.L.C.

**Figure 6-1**
Conceptual Depiction of Propwash in Navigation Channel
Lower Fox River - OUs 2 to 5

### 6.2.2 Infrastructure and Utilities

The river banks along much of the Site have been developed as either commercial (primarily in OU 4) or residential (primarily in OUs 2, 3, and 4A). Along these banks and crossings of the river, numerous structures (e.g., bulkhead walls, shore protection, etc.), 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 6-4).

**Table 6-4**
**Potential Shoreline Remedial Design Considerations**

| 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 |
| 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 cap offset from utility location |
| Boat launch/ramp | Potential options include armored cap and dredge/armored cap |

**Notes:**

a. Final RD for these areas to be determined as part of the RA Work Plans based on the “ground rules” established in Section 6.4, the results of detailed shoreline surveys, and associated engineering stability analyses.

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 designing site-specific remedies surrounding infrastructure, utilities, and shoreline areas (see Section 6.4). The final RA for each area will be refined based on further assessment of the extent of contamination, potential environmental risks posed by the contaminated sediment, practicability and risks of performing the RAs, and discussions with property owners, as appropriate. The final RA plans for each area will be prepared in the year prior to planned construction and presented in the annual RA Work Plans.

#### 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 during the start-up of cap placement testing indicate more than 6 inches of mixing between capping material and existing sediment, caps will 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 caps placed on slopes up to 2.75H:1V are predicted to be stable, with a factor of safety of 1.3 or better (see Appendix B, Attachment B-4). 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 this 60 Percent Design (see Section 6.4.1) with final designs for each area to be included in the annual RA Work Plans.
- **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 safety factor of at

least 1.3 under this condition, and thus will be stable under worst-case bearing loads**.**

- **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 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.
- **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 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) have been designed such that a minimum post-cap water depth of 3 feet will be maintained under historic low water elevations summarized in Table 6-5. In addition, detailed armor designs were developed during the 30 Percent Design for ranges of post-cap water depth to accommodate specific erosion characteristics, including propwash, vessel wakes, and other factors, as detailed above. The Adaptive Management 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 6-5.

**Table 6-5**
**Summary Baseline Water Elevations**

| Operable Unit | Baseline Water Elevation Dynamic Height (IGLD85) | Baseline Water Elevation Dynamic Height (NAVD88) | Basis for Selection |
|---|---|---|---|
| OU 2 | 593.5 feet | 593.6 feet | NOAA Low Water Datum above Little Kaukauna Dam |
| OU 3 | 587.3 feet | 587.4 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) |

## 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, 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 < 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 of placed armor material (7 inches with overplacement allowances). Note, the thickness and size of the armor layer were refined during 30 Percent Design based on localized conditions, as summarized in Tables 6-2 and 6-3.
- **Cap B – Sand and gravel cap for PCBs > 10 ppm and < 50 ppm** – consisting of a minimum 6 inches of placed sand (9 inches with overplacement allowances) overlain by a minimum 4 inches of placed armor material (7 inches with overplacement allowances). Note, the thickness and size of the armor layer were refined during 30 Percent Design based on localized conditions, as detailed in Tables 6-2 and 6-3.
- **Cap C – Sand and quarry spall cap for PCBs > 50 ppm and in federal navigation channels** – consisting of a minimum 6 inches of placed sand (9 inches with overplacement allowances) overlain by a filter layer of gravel (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 (18 inches with overplacement allowances). Within the OU 4A and 4B navigation channel, 4- to 9-inch quarry spall material will be required for the armor layer.

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 applied as in-water construction progresses (e.g., site-specific plans will be prepared in the year prior to addressing a particular site and presented in the annual RA Work Plans), but are generally anticipated to include the following:

- **Shoreline Cap** – consisting of 3 to 6 inches of placed sand (thickness depending on PCB concentrations) overlain by a filter layer of gravel 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 in 2006 and 2007 and the development of ground rules for refining the RD near select in-water structures based on the collaborative workgroup, the areal extent of the engineered caps was refined since the BODR and the 30 Percent Design. Table 6-6 presents a summary of the engineered cap areas, as well as volume and mass of PCBs remaining under the cap, delineated as part of the 60 Percent Design in comparison to that from the BODR. Table 6-7 presents a summary of the OUs 2 to 5 engineered cap designs based on the analyses presented in the BODR, 30 Percent Design, and this 60 Percent Design, which include armor stone sizing and thickness based on location and depth-specific erosional conditions.

**Table 6-6**
**Summary of Cap Delineation**

| | 60 Percent Design | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | OU 2 | | OU 3 | | OUs 4/5 | | Total OUs 2 to 5 | |
| | Area (acres) | Mass of PCBs under Cap (kg) | Area (acres) | Mass of PCBs under Cap (kg) | Area (acres) | Mass of PCBs under Cap (kg) | Area (acres) | Mass of PCBs under Cap (kg) |
| Cap A | 3 | -- | 49 | 50 | 147 | 725 | 199 | 775 |
| Cap B | 2 | -- | 15 | 65 | 50 | 219 | 67 | 284 |
| Cap C | 0 | -- | 0 | -- | 102 | 629 | 102 | 629 |
| All Engineered Caps | 5 | -- | 64 | 115 | 299 | 1,574 | 368 | 1,689 |
| Shoreline Caps [a] | 2 | | 3 | | 20 | | 25 | |

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. PCB mass calculations exclude areas targeted for dredge-and-cap

**Table 6-7**
**Summary of OUs 2 to 5 Engineered Cap Designs**

| Cap Type | Post-Cap Water Depth [a] | Median Stone Size of Gravel Armor, $D_{50}$ (inches) | Layer Thickness [b] (inches) | | | Cumulative Layer Thickness [b] (inches) | Placed Layer Thickness [c] | | | Placed Total Cap Thickness [c] (inches) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Sand | Gravel Armor | Quarry Spall Armor ($D_{50}$ = 6 to 9”; $D_{50}$ shoreline = 8 to 10”) | | Sand | Gravel Armor | Quarry Spall Armor ($D_{50}$ = 6 to 9”; $D_{50}$ shoreline = 8 to 10”) | |
| **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 | 0.25 | 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 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 | 0.25 | 6 | 4 | 0 | 10 | 9 | 7 | 0 | 16 |
| **Cap C: PCB > 50 ppm or in federal navigation channel** | | | | | | | | | | |
| Cap C1 | > 3 feet | 1.5 | 6 | 3 | 12 | 21 | 9 | 6 | 18 | 33 |
| **Shoreline caps [d] (Further engineering of shoreline caps is currently underway)** | | | | | | | | | | |
| OU 3/OU 4A | varies | 1.0 | 3 to 6 [e] | 3 | 18 | 24 to 27 | 6 to 9 [e] | 6 | 30 | 42 to 45 |
| OU 4B | varies | 1.0 | 3 to 6 [e] | 3 | 16 | 22 to 22 | 6 to 9 [e] | 6 | 28 | 40 to 43 |

**Notes:**

a. Caps will not be placed in locations such that the minimum low river stage water depth is less than 3 feet above the top elevation of the constructed cap.

b. Minimum required thickness based on USEPA/USACE design guidance.

c. Contractor will be required to place enough material (as measured by placement logs) to achieve target thickness (consistent with ROD Amendment) on average within a certification area (see CQAPP).

d. Shoreline cap information presented herein is preliminary. Site-specific shoreline cap design to be completed as part of the annual RA Work Plans with consideration of local erosion evaluations (propwash, vessel wakes, wind waves, ice, etc.)

e. The thickness of the sand layer in the shoreline cap will depend on the PCB concentration.

## 6.4 Localized Cap Design Refinements

The general cap designs presented in Section 6.3 of this 60 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 and around in-water structures and utilities require additional refinement based on site-specific conditions. This section presents the basis for design (or "ground rules") 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. These site-specific cap design refinements will be applied based on the ground rules developed herein in the year prior to the RA in that area and will be documented in the annual RA Work Plans.

### *6.4.1 Engineered Shoreline Caps*

Shoreline caps will be installed where RD engineering evaluations (to be refined in each year prior to construction and documented as part of the annual RA Work Plans) concluded that dredging would adversely affect the stability of the existing slopes. Building upon the BODR conceptual design, the 60 Percent cap design plans preliminarily identify a nominal 50-foot-wide zone of potential shoreline capping along the river banks 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. For the purposes of this 60 Percent Design, the preliminary 50-foot-wide zone of potential capping extends perpendicular to the river's edge (see Figure 1-5). 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. Final plans within specific shoreline zones will be refined in the year prior to RA construction within that area and documented in the annual RA Work Plans. Site-specific shoreline designs (involving detailed engineering evaluations, where necessary) will be developed in the annual RA Work Plans in consideration of the results of shoreline investigations, including planned sampling in 2008 and beyond used to refine the geostatistical model (see Section 2.1.2).

As part of the collaborative workgroup, three site-specific design examples ("cases") were reviewed to establish a set of ground rules for this 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 as RA work progresses within the river such that site-specific plans will be refined in the year prior to construction in that area and documented in the annual RA Work Plans. These 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.

- Shoreline Transition Case 1: transitioning from an offshore dredge area where the DOC (represented by the level of significance [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 (Appendix B, Attachment B-6) 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 2003 survey, see above) and slope down towards the river to the required dredge elevation at a 5H:1V slope (maximum slope based on shoreline slope stability analysis). Alternate slopes (flatter or steeper) will be considered on a case-by-case basis using site-specific physical/geotechnical and chemical information. Additional sampling, either as part of annual infill sampling or following initial dredging, may be performed along shorelines to confirm the need for a shoreline cap. . 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 the results of the hydrodynamic model generated by Sea Engineering for the RD, which incorporated a 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 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.

**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 involved 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, slope protection, etc.) are not positioned within approximately 10 feet of the slope. Based on engineering analyses presented in the 30 Percent Design (Appendix B, Attachment B-6), 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 physical/geotechnical and chemical information. Since the bulk of the targeted sediment will be removed, a shoreline cap will not be placed in these areas.

**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 physical/geotechnical and chemical information.. 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 the results of the hydrodynamic model generated by Sea Engineering for the RD, which incorporated a 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 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.

### 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, outfalls), and submerged utilities/pipelines and will be subsequently used to refine the site-specific remedy for each condition in the annual RA Work Plans. These ground rules are 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. Ground rules related to dredge design in these areas are presented in Section 4.4 of this Volume 2 and Section 4.4.4 of Volume 1. The remainder of this section presents a summary of the ground rules related to capping in the vicinity of each of these in- water structures.

**Bridge Crossings**

Several logistical and safety concerns are associated with remedial construction in close proximity to in-water or nearshore structures such as bridge piers, including the potential to damage or compromise the integrity of a structure (cap-induced settlement leading to pile down-drag [force exerted on pile by settlement of surrounding soil/sediment] or other structural damage) and ultimately cause damage to the bridge (in short or longer term). Therefore, the following ground rules relative to capping near bridge crossings were established through the collaborative workgroup (see Attachment A-2 in Appendix A for additional details):

1. Engineered capping shall typically be conducted no closer than approximately 25 feet from a bridge pier, dolphin, or fender, except as modified by site-specific conditions (i.e., larger or smaller offset) during preparation of annual RA Work Plans.
2. The placement of a sand cover at locations that are within approximately 25 feet from a bridge pier may be performed if technically feasible and RD sampling results indicate significantly elevated PCB concentrations and environmental risk warranting special consideration.
3. The placement of capping materials around and under the bridge will be evaluated on a case-by-case basis depending on the vertical clearance under the bridge deck as well as horizontal distances between the piers and structures.

In addition, the proposed remedy will be discussed and coordinated with the owner of each structure during the year prior to the planned RA in the vicinity of that bridge structure and the final plan documented in the annual RA Work Plans. For the purposes of this 60 Percent Design, a 25-foot offset from the edge of the bridge piers was shown on the engineering plans within which no capping will be performed.

**Stormwater and Other Outfalls**

The primary design consideration for the placement of capping materials around existing outfalls is the potential for erosion of cap materials due to flow velocities from the outfall pipe. In an effort to minimize the potential for erosion of the capping materials, an outfall "apron" or "splash pad" will be constructed to dissipate the energy of the outfall discharge. The following ground rules relative to capping were established in the collaborative workgroup for cap armor design surrounding outfalls (see Attachment B-5 in Appendix B for additional details):

1. An armor layer apron shall be placed at the base of the outfalls with an outfall pipe diameter of 6 inches or greater.
2. For outfalls between 6- and 12-inch diameter, the width of the outfall apron will be 6 feet and shall be integrated into existing capping materials.
3. For outfalls greater than 12 inches in diameter, the width of the outfall apron will be 6 times the diameter of the outfall pipe and shall be integrated into existing capping materials.
4. The general outfall apron will consist of a 6- to 9-inch-thick layer of sand/filter material placed on the existing sediments overlain by a 12-inch-thick armor layer comprised of quarry spall stone with an average stone diameter between 4 and 8 inches. The thickness of the base sand layer will be based on the PCB concentration within the top 1.5 feet of sediment immediately underlying the prospective cap layer for a given location, consistent with the 30 Percent Design Report. The gradation of the sand layer will be applied with consideration of geotechnical filter criteria to avoid mixing of armor and underlying materials. If required, the filter layer may be soil (i.e., gravel) or geotextile to prevent mixing of the armor with the underlying sand.
5. Limited removal of existing sediments may be performed prior to placement of the outfall apron, if necessary, to avoid placing materials above the invert elevation of the outfall pipe.
6. Alternate site-specific designs for outfall aprons (dimensions, armor stone size, etc.) may be completed based on location-specific considerations including flow conditions, mudline elevations, and water depths.

In addition, the proposed plans will be discussed and coordinated with the owner of each outfall during the year prior to the planned RA in the vicinity of that structure and the final plan will be documented in the annual RA Work Plans.

**Marine Terminals/Marinas/Boat Launches or Ramps**

The primary design considerations for the placement of capping materials within areas of vessel traffic are interference with navigation and the potential for scour of capping materials due to propeller wash. To protect against these potential impacts, the following ground rules relative to capping were established in the collaborative workgroup (see Attachment B-5 in Appendix B for additional details):

1. Discussions will be held with the owners/operators of each marine terminal area, marina, or boat launch to verify the navigation depths required for berths or slips as well as vessel transit locations and authorized navigation depths in adjacent areas.
2. In commercial navigation areas, cap armor designs will be applied based on site-specific erosional characteristics (e.g., propeller wash). For instance, in the case of marine terminals in OU 4B, quarry spall armoring may be appropriate to resist the proposed forces from large commercial vessels. In addition, final plans in commercial marine terminals will incorporate a minimum 2-foot offset between the top of the cap and the required navigation depth, consistent with the 30 Percent Design for caps within the federal navigation channel. For capping areas subject to high frequency recreational traffic (e.g., marinas and boat launches/ramps), larger gravel armoring than designed for the general capping areas based on specific water depths (as summarized in Table 6-2) may be appropriate. For instance, cap armoring in water depths of greater than 6 feet in these areas may be increased to 1.5-inch diameter, as opposed to 0.25-inch diameter, provided that such a change would not adversely affect navigation requirements, placement technique, and/or cost. Based on the bathymetry and the suitable cap thickness, dredging may be required prior to cap placement to achieve the desired final top of cap elevation. Depending on the site-specific conditions (e.g., DOC, existing water depth, and navigation requirements), some areas identified for capping-only in the 30 Percent Design may be converted to dredge-and-cap or dredging-only remedies. This evaluation will be conducted on a site-specific case-by-case basis and documented in annual RA Work Plans.

In addition, the proposed plans will be discussed and coordinated with the owner of the marine terminal area or marina during the year prior to the planned RA in the vicinity of that facility and the final plans documented in the annual RA Work Plans.

**Sheetpile Walls/Riprap or Armored Slopes/Shoreline Buildings**

The primary design consideration for the placement of capping materials near sheetpile walls and riprap or armored slopes is the safety concern associated with remedial construction in close proximity to an in-water structure with the potential to damage or compromise the integrity of a structure (due to cap-induced settlement leading to pile down drag or loss of toe support). To protect against these potential impacts, the following ground rules were established through the collaborative workgroup for proposed remedies near sheetpile walls and riprap or armored slopes:

1. The condition of the existing wall, armored slope, or building foundation will be inspected and documented prior to initiating the site-specific final plans.
2. Discussions will be held with the owners of each sheetpile wall, armored slope, or shoreline building to determine the existence of structure details (e.g., embedment depths, tie backs) and current and future use of the shoreline.
3. A site-specific review of wall design, armored slope, or building foundation will be performed relative to planned cap (and potentially preceding dredge cut) to assess if the remedy would impact stability and, therefore, require an offset or alternate remedy.

The proposed plans will be discussed and coordinated with the owners of the sheetpile walls, armored slopes, or shoreline buildings during the year prior to the planned RA in the vicinity of that facility and the final plans documented in the annual RA Work Plans.

**Floating Dock with Guide Piles**

The primary design consideration for the placement of capping materials near a floating dock with guide piles is interference with navigation (e.g., reduced draft) and the potential to damage or compromise the integrity of a structure (due to settlement or loss of bearing support). To protect against these potential impacts, the following ground rules were established through the collaborative workgroup for proposed remedies near floating docks with guide piles:

1. Capping (and in some cases, the preceding dredging) shall typically not be conducted within 25 feet of a pile, except as modified by site-specific conditions (i.e., larger or smaller offset) during preparation of annual RA Work Plans.
2. Discussions will be held with the owners of each dock to determine the existence of design details (to assist with revising typical offsets) and navigational depth required for vessels.

The proposed plans will be discussed and coordinated with the owner of the floating dock during the year prior to the planned RA in the vicinity of that facility and the final plans documented in the annual RA Work Plans.

#### *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, as well as disruption of public service. An offset from the utility is planned to minimize the chance of damaging the utility during remedial construction. The width of the offset is based on several factors, including:

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

In order to minimize the potential for environmental damage or safety concerns, the following ground rules relative to capping were established through the collaborative workgroup (see Attachment A-2 in Appendix A for additional details):

1. Capping (and in some cases the preceding dredging) shall be conducted to within 50 feet of each known or reported river utility crossing.

2. Capping (and in some cases the preceding dredging) may be conducted using a closer offset distance of 25 feet, if the following conditions are met:
   - If the horizontal and vertical position of the utility or utilities is known with an accuracy of ± 6 inches vertically and ± 5 feet horizontally along the entire utility length as verified by physical surveys (e.g., manual probing)
   - If RD sampling results indicate significantly elevated PCB concentrations and environmental risk warranting special consideration
   - If capping will not pose an adverse stability condition to the submerged utility crossing caused by undue stresses or excessive settlement

The proposed plan and identification of the utility/pipeline prior to construction will be discussed and coordinated with the owner of each structure during the year prior to the planned RA in the vicinity of that utility/pipeline and the final plan documented in the annual RA Work Plans. For the purposes of this 60 Percent Design, a 50-foot offset from the centerline of utility crossings was shown on the engineering plans within which no engineered capping will be performed.

### 6.5 Delineation of Cap Areas

As noted in Section 4.3, the BODR discussed the core-by-core process in which preliminary dredge, cap, cover, and dredge-and-cap boundaries were delineated. Cap and dredge-and-cap areas are generally sited in localized areas with deep, 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 dredging-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 can be assured. 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 will be evaluated on a case-by-case basis during RA, with final designs documented in the annual RA Work Plans.

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 conceptual level to the 30 Percent and then 60 Percent Design level, the boundaries were refined using the detailed dredge plan and the spatial extent of the DOC at a LOS of 0.5. As shown on Figures 2-6 and 2-7, the spatial extent of the DOC resembles a curvilinear polygon. The preliminary cap plan was developed by delineating a series of rectangles that fully capture the DOC, transition to any adjacent dredge or cover areas, and are constructable (i.e., designated at regular 10-foot grid intervals). During this 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.

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 and predicted post-dredge concentration. This estimate was used to determine a preliminary cap type (e.g., Cap A, Cap B, etc.) for the area; although 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 50 ppm at any depth interval. In the event a location contained a core sample greater than 50 ppm, either a Cap C section was designed, or a dredge or dredge-and-cap alternative was evaluated. Appendix B, Attachment B-6 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. Where the preliminary cap plan resulted in water depths less than 3 feet during low water conditions (i.e., above elevation 573.5 feet IGLD [573.6 feet NAVD 88]), these caps were converted to either dredge or dredge-and-cap alternatives. Caps located within the authorized navigation channels and turning basins have been designed with the most protective armor layer (Cap C).

The areal extents of engineered caps delineated for this 60 Percent Design are shown on Figure 1-5. As discussed in Section 6.4.1, shoreline caps are preliminarily delineated for the 60 Percent Design as a nominal 50-foot-wide zone along the river banks 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 caps area will be refined during the year prior to the planned RA in the vicinity of the shoreline area based on the ground rules developed through the collaborative workgroup and presented herein. Similarly, cap plans required to protect utilities, infrastructure, and other sensitive structures will be completed during the year prior to the planned RA in the vicinity of the utilities, infrastructure, and other sensitive structures based on the ground rules presented herein, consistent with workgroup approval.

## 6.6 Engineered Cap Construction

Armored caps will be placed in select dredged and un-dredged areas within OUs 2 through 5 on the Lower Fox River during the 2010 to 2017 construction seasons. From 2010 to 2012, OU 2 and 3 capping materials and crews will be staged and loaded from the Little Rapids staging facility. For areas to be capped north of the De Pere Dam, all capping materials will be staged and loaded from the former Shell property staging and material processing facility. This work will commence in 2012 and continue into the 2017 construction season. The crews will work one 12-hour shift per day.

As part of the annual RA Work Plans, the cap areas to be constructed in the coming construction season will be divided cap management units (CMUs). CMUs will be grouped to form cap certification units (CCUs) for assessing compliance with the design (e.g. verifying that the specified thickness and extent have been achieved). The CMUs and CCUs 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 Addendum (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 mid April of each construction season, cap materials will be stockpiled in designated areas. This will occur at the Little Rapids staging facility in 2010, 2011, and 2012 and at the former Shell property staging and material processing facility in 2012 and beyond.

There will be designated stockpiles for each type of material (sand, armor stone with $D_{50}$ = 0.25 inch, $D_{50}$ = 1.5 inch and $D_{50}$ = 3.0 inch) at the Little Rapids staging facility. In addition to these materials, armor stone with $D_{50}$ = 6 to 9 inches will be stockpiled at the former Shell property and placed as a part of Cap C. Figures 3-3 and 3-5 of Volume 1 illustrate the planned stockpile areas at the Little Rapids staging facility and the former Shell property staging area, respectively.

Granular and armor materials will be delivered to the Little Rapids or former Shell property staging facilities by truck. Capping on the river is based on a 5 days per week, 12 hours per day schedule; however, the storage areas at both the former Shell property staging and material processing facility and the Little Rapids 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. The communication required to achieve this will occur between the quarry manager and the on-site management.

The various capping materials will be staged at both of the upland facilities planned for use as part of this project. The former Shell property will be used for staging of cap material to be placed north of the De Pere Dam while the Little Rapids staging facility in OU 3 will be used for staging of cap material needed to cap areas south of the De Pere

Dam. Cap material will be trucked to these staging areas from several local material suppliers. Table 6-8 provides potential material sources considered for use on the Lower Fox River Project.

**Table 6-8**
**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 |

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

The trucks will dump into designated storage areas (see Figures 3-3 and 3-5 of Volume 1). The barges will be loaded using a loader, conveyor belt, or crane with a clamshell bucket.

### *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 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 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 by mechanical means, such as by excavators with grapple 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 by 12 feet. 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 when compared to slurry or other placement systems. The enclosed spreading pool serves to control the placement as well as reducing turbidity.

The broadcast spreading barges will be serviced by the material barges. 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. The production assumptions are based on past performance, on-shore spreading test runs, and manufacturer specifications. The schedule will be continually reassessed as the project progresses.. Capping is expected to be performed 12 hours per day and is based on working 5 days per week.

**Sediment Re-suspension and Turbidity Control**

Consistent with the approach to addressing sediment resuspension 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 by 12-foot spreading pool, which isolates placement area from ongoing river operations.
- Washing of sand and stone prior to delivery to the site
- Use of broadcast technology for sand and smaller gravel to prevent localized dumping of cap material
- Larger gravel and armor stone will be placed with a mechanical excavator in close proximity to the river bed, which will prevent localized dumping of material

The operational practices described above are consistent with best management practices for capping operations and have been successfully implemented on the Fox River OU1 project.

Water quality monitoring and contingency response actions are described in the CQAPP Addendum (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 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 delivery system to the transportation crew will begin with a front end loader, removing materials from the stockpile and placing it on 120-foot by 30-foot wide material barges. These barges will have deck combing to keep the materials from sliding into the river. The barge will be pushed by a tug boat, to the slurry plant barge. The slurry plant will deliver the armor cap material to the spreader barge.

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. The following sections provide a detailed summary of the broadcast spreader placement operation.

**Description of Broadcast System from Shoreline**

- An excavator or front-end loader is used to transfer 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 feed 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 Addendum.
- 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 hydro cyclone 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 hydro cyclone (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 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 hydro cyclone 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**

Throughout the course of cap and sand cover work in OUs 2 to 5 there will be many areas where it will be more feasible and efficient to move material (sand or gravel) to a slurry barge prior to placement if material into a slurry tank. When material requires movement to the slurry plant it will first be placed onto 120 x 30 foot material barges loaded at the Shell Site or Little Rapids Staging Area. Once the barges have been loaded a small push boat 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 centimeters 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 (TPH) 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, density, etc. It will also monitor the spreader barge coordinates and displays 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 stone size ($D_{50}$) larger than 1.5 inch stone. The delivery system to the transportation crew will begin with a front end loader, removing materials from the stockpile and placing it on 120-foot by 30-foot wide material barges. These barges will have combing to keep the materials from sliding into the river. The barge will be pushed by a tug boat, 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 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 excavator will fill the clamshell from the barge and then place it over a grid displayed in DREDGEPACK®. The operator will position the bucket and then release the material slowly. Once the operator places the material the bucket grid determined from the capacity of the bucket will be filled. This will allow the operator to track the progress of the work. Depending on the thickness of the cap required, more than one bucket may need to be placed in each location. After completing this step the operator may utilize a large rake (typically an I-beam/pipe) to level the material. This will depend on the previous post-placement surveys and sampling.

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 is targeted with the mechanical placement equipment.

## 6.7 Position Control and Measurement

Details of the surveying and position control are provided in Section 4.3, relative to dredging activities, and Appendix C, Attachment C-0 of Volume 1. The sections below detail information relevant to engineered capping activities in 2010 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
- This 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.

As described above, the spreading barge will also have DREDGEPACK® and Wonderware software onboard. This is the same software used by the dredges. Wonderware will integrate the use of four sounding sensors located in each corner of the placement area with RTK GPS for real time measurement of cap material elevation and location. DREDGEPACK® will illustrate pre-placement elevation and targeted elevation in two profile views, along with a top view. As material is added to the river floor, sensors will measure and record the elevation of the material. The operator will see this elevation change visually in both profile views and the top view will display the change as an isopach.

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. 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.

Since 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 a highly accurate degree at all times.

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

#### 6.7.2 Verification of Placement

As a means of QA/QC, bathymetric surveys will be performed and cores will be collected by the contractor during the broadcast spreading operations. 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 Addendum (Appendix F).

In order to facilitate management and track progress of engineered placement operation, cap areas will be divided into cap management units (CMUs). Several contiguous CMUs will be grouped into cap certification units (CCUs) for assessing compliance of the placed caps with the design, as described in the CQAPP Addendum. 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, physical measurements (where feasible) and comparison of pre- and post-material placement bathymetric surveys. Post-placement bathymetric surveys 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 multi-beam survey will be performed to detail existing conditions prior to the start of a construction season. After a capping plant has completed placement in an area and compliance with the design has been verified in accordance with the CQAPP Addendum, the multi-beam system will return to document the post-placement conditions.

### 6.8 Sequencing of Capping Operations (2010 and beyond)

Capping and covering of contaminated sediment will be conducted over eight work seasons from 2010 through 2017. Broadcast spreading operations will be initiated first, with mechanical placement starting in 2012. The anticipated capping seasons will be similar to those noted for dredging, from approximately April 15 to November 15 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 12 hours per day and 5 days per week. This will allow for reduced operations during overnight hours, resulting in less light pollution to the surrounding area. It also allows 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. 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 2 years of capping (2010 and 2011). Mechanical placement of capping (as necessary based on site conditions) will be initiated following the broadcast spreading operations, in an upstream to downstream fashion.

Table 6-9 outlines the areas currently slated for cap and cover placement as part of the Lower Fox River Project.

**Table 6-9**
**Engineered Cap Placement – Yearly Installation 2010 to 2017**

| Year | Area | Engineered Cap Type | Cap Area |
|---|---|---|---|
| 2010 | OU2/3 | Engineered Cap A (Minimum 13 inches) | In this first year of capping, two broadcast spreading marine plants will be operated in OU 2 and OU 3. It is anticipated that these plants will place all sand and gravel through Booster Station 6. One mechanical plant will be operated, as necessary, to place the larger gravel material. |
| | OU2/3 | Engineered Cap B (Minimum 16 inches) | |
| 2011 | OU2/3 | Engineered Cap A (Minimum 13 inches) | Capping placement will continue in OU 3 where operations left over the prior year. Two broadcast spreading marine plants will place sand and gravel while the one mechanical plant will place the larger gravel material, as necessary. |
| | OU2/3 | Engineered Cap B (Minimum 16 inches) | |
| 2012 | OU2/3 | Engineered Cap A (Minimum 13 inches) | In this third year of operation, the capping operations will primarily consist of residuals management and any additional work not completed in the prior two years. At this time, capping operations are anticipated |
| | OU4A | Engineered Cap A (Minimum 13 inches) | |
| | OU2/3 | Engineered Cap B (Minimum 16 inches) | |
| | OU4A | Engineered Cap B (Minimum 16 inches) | |

| Year | Area | Engineered Cap Type | Cap Area |
|---|---|---|---|
| | OU4A | Shoreline Cap | to be minimal during this year. This flexibility in schedule will allow for dredging operations to continue downstream of capping without overlap. |
| | OU4B | Shoreline Cap | |
| 2013 | OU4A | Engineered Cap A (Minimum 13 inches) | Following the residual capping work completed in 2012, the capping operations will continue where it left off in 2011. It is anticipated that the two broadcast spreading marine plants and one mechanical plant will place all sand and gravel through Booster Station 2. |
| | OU4B | Engineered Cap A (Minimum 13 inches) | |
| | OU4A | Engineered Cap B (Minimum 16 inches) | |
| | OU4A | Engineered Cap C (Minimum 33 inches) | |
| | OU4B | Engineered Cap C (Minimum 33 inches) | |
| | OU4A | Brennan Shoreline Cap | |
| | OU4B | Brennan Shoreline Cap | |
| 2014 | OU4A | Engineered Cap A (Minimum 13 inches) | Capping placement will continue in OU 4 where operations left off the prior year. Two broadcast spreading marine plants will place sand and gravel while the one mechanical plant will place the larger gravel material, as necessary. It is anticipated that capping operations will be completed through Booster Station 1. |
| | OU4B | Engineered Cap A (Minimum 13 inches) | |
| | OU4A | Engineered Cap C (Minimum 33 inches) | |
| | OU4B | Engineered Cap C (Minimum 33 inches) | |
| | OU4A | Brennan Shoreline Cap | |
| | OU4B | Brennan Shoreline Cap | |
| 2015 | OU4A | Engineered Cap A (Minimum 13 inches) | During this next year, cap placement will continue in OU 4. Two broadcast spreading marine plants will place sand and gravel while the one mechanical plant will place the larger gravel material, as necessary. Cap placement will be conducted in the vicinity of the former Shell property. |
| | OU4B | Engineered Cap A (Minimum 13 inches) | |
| | OU4A | Engineered Cap B (Minimum 16 inches) | |
| | OU4A | Engineered Cap C (Minimum 33 inches) | |
| | OU4B | Engineered Cap C (Minimum 33 inches) | |
| | OU4A | Brennan Shoreline Cap | |
| | OU4B | Brennan Shoreline Cap | |
| 2016 | OU4A | Engineered Cap A (Minimum 13 inches) | In this seventh year of operation, a third broadcast spreading marine plant and a second mechanical plant will be added to the Lower Fox River Project. Cap placement will continue in the vicinity of the former Shell property. |
| | OU4B | Engineered Cap A (Minimum 13 inches) | |
| | OU4A | Engineered Cap C (Minimum 33 inches) | |
| 2017 | OU4A | Engineered Cap A (Minimum 13 inches) | Capping placement will continue north of the former Shell property where operations left off the prior year. The three broadcast spreading marine plants will place sand and gravel while the two mechanical plants will place the larger gravel material, as necessary. It is anticipated that capping operations will be completed through Booster Station 1 North. |
| | OU4B | Engineered Cap A (Minimum 13 inches) | |
| | OU4A | Engineered Cap B (Minimum 16 inches) | |
| | OU4B | Engineered Cap B (Minimum 16 inches) | |
| | OU4A | Engineered Cap C (Minimum 33 inches) | |
| | OU4B | Engineered Cap C (Minimum 33 inches) | |

The types of armored caps being placed in each year are estimated in Table 6-10.

**Table 6-10**
**Area of Cap Placement by Year**

| 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] |
| 2010 | 35 | 2 | 0 | 0 |
| 2011 | 19 | 10.5 | 1 | 1 |
| 2012 | 25 | 8 | 0 | 10 |
| 2013 | 20 | 11 | 11 | 10 |
| 2014 | 33 | 5 | 18 | 10 |
| 2015 | 18 | 5 | 30 | 10 |
| 2016 | 25 | 2.5 | 0 | 0 |
| 2017 | 40 | 10 | 44 | 0 |

**Notes:**

a. All areas are approximate

b. See Table 6-7 for a summary of cap designs

# 7 SAND COVER DESIGN

## 7.1 Sand Cover Design and Areas

As discussed in the BODR, a substantial area of OUs 2 to 5 contains a veneer (up to 6 inches-thick) 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 well below 1.0 ppm. Additional sediment areas within OUs 2 to 5 contain a similarly thin (6-inch) subsurface layer of sediment with 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 ROD Amendment, the RA plans presented in this 60 Percent Design Report include placement of 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 one sampled interval (6 inch thickness of sediment) 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, sand cover will be placed in other exceptional areas 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., sand cover or no action). These exceptional areas, and others identified based on future infill sampling, will be summarized in the forthcoming RD Design Anthology and final RD presented in the annual RA Work Plans.

The sand cover areas delineated for OUs 2 to 5 for this 60 Percent Design are shown on Figure 1-5, which includes an approximate 210 acres within OUs 2 to 5.

## 7.2 Equipment Selection and Production Rates

### *7.2.1 Material Staging*

The sand cover materials will be staged at both of the upland facilities. The former Shell property staging and material processing facility will be used for staging of cover material to be placed north of the De Pere Dam (in OU 4), while the Little Rapids staging facility will be used for staging of cover material needed for areas south of the De Pere

Dam (in OUs 2 and 3), as shown on Figures 3-3 and 3-5, respectively, of Volume 1. Cover material will be trucked to these staging areas from local material suppliers. Table 7-1 provides material sources considered for use on the project.

**Table 7-1**
**Potential Material Suppliers**

| Material Supplier | Available Materials | Proximity to Staging Areas |
|---|---|---|
| Kiel Sand and Gravel | Sand, Gravel, and Quarry Spall | Local |
| Daanen & Janssen | Sand, Gravel, and Quarry Spall | Local |
| McKeefry & Sons | Sand, Gravel, and Quarry Spall | Local |
| Faulks Bros. | Sand, Gravel and Quarry Spall | Local |

Cover material will be loaded onto barges from the staging areas for placement in the river. Material to be placed via broadcast spreading will be transported to the marine capping plants for placement. Material to be spread via mechanical means will be loaded to a barge equipped with an excavator with clamshell bucket.

### *7.2.2 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. The broadcast method can also be used for the placement of small stone for engineered caps (see Section 6).

A barge will be used to transfer cover material to the slurry barge associated with the marine capping plant. For the slurry barge process, there will be two simultaneously operating broadcast spreading marine plants, consisting of a slurrying barge and a broadcast spreading barge. The two broadcast spreading marine plants will be supported by one material transport barge. 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 are also expected to be consistent with engineered cap placement; ranging from 20 to 65 cy 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 corresponds to approximately 11 acres of sand cover placement (6 inches thick) per month

## 7.3 Postion 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

### *7.3.1 Verification of Placement*

As a means of QA/QC, bathymetric surveys will be performed and cores will be collected by the contractor during the broadcast spreading operations. 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 Addendum (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). Several contiguous SCMUs will be grouped into sand cover certification units (SCCUs) for assessing compliance of the sand cover placement with the design, as described in the CQAPP Addendum. As discussed in the CQAPP Addendum, 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.

## 7.4 Sequencing of Cover Operations (2010 and beyond)

Sand covering of contaminated sediment will be conducted over eight seasons, 2010 through 2017. Broadcast spreading operations will be initiated first, with mechanical placement starting in 2010. 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 12 hours per day and 5 days per week. This will allow for reduced operations during overnight hours, resulting in less impact to the surrounding area from lights. It will also 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. In addition, the sequencing calls for broadcast spreading of the smaller granular cover material in the first 2 years of capping. 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.

Table 7-2 outlines the areas currently slated for 6 inch sand cover and 6 inch residual sand cover placement as part of the project from 2010 to 2017.

**Table 7-2**
**Sand Cover Placement Sequence**

| Year | Area | Sand Cover Type |
|---|---|---|
| 2010 | OU 2/3 | 6” Sand Cover |
| | OU 2/3 | 6” Residual Sand Cover |
| 2011 | OU 2/3 | 6” Sand Cover |
| | OU 2/3 | 6” Residual Sand Cover |
| 2012 | OU 4A | 6” Sand Cover |
| | OU 4A | 6” Residual Sand Cover |
| 2013 | OU 4A | 6” Sand Cover |
| | OU 4B | 6” Sand Cover |
| | OU 4A | 6” Residual Sand Cover |
| | OU 4B | 6” Residual Sand Cover |
| 2014 | OU 4A | 6” Sand Cover |
| | OU 4B | 6” Sand Cover |
| | OU 4A | 6” Residual Sand Cover |
| | OU 4B | 6” Residual Sand Cover |
| 2015 | OU 4B | 6” Sand Cover |
| | OU 4A | 6” Residual Sand Cover |
| | OU 4B | 6” Residual Sand Cover |
| 2016 | OU 4B | 6” Sand Cover |
| 2017 | OU 4A | 6” Sand Cover |
| | OU 4B | 6” Sand Cover |
| | OU 4B | 6” Residual Sand Cover |

**Table 7-3**
**Area of Sand Cover Placement by Year**

| Year | Area of Sand Cover Placement (acres) [a] | |
|---|---|---|
| | Sand Cover as Primary RA | Post-Dredge Residuals Sand Cover [b] |
| 2010 | 50 | 34 |
| 2011 | 77 | 21 |
| 2012 | 23 | 44 |
| 2013 | 25 | 49 |
| 2014 | 11 | 36 |
| 2015 | 0 | 31 |
| 2016 | 3 | 0 |
| 2017 | 18 | 37 |

**Notes:**

a. All area are approximate.

b. Post-dredge residual sand cover area is estimate only based on assumption that approximately 25 percent of dredge areas will require residuals management with sand cover. Actual areas requiring sand cover to be determined during construction based on post-dredge verification sampling.

# 8 INSTITUTIONAL CONTROLS

As described in the RD Work Plan, the Institutional Control Implementation and Assurance Plan (ICIAP), presented as Appendix G of this 60 Percent Remedial Design Volume 2, is an integral element of RD/RA implementation. The purpose of the ICIAP is to ensure the short- and long-term protectiveness of RAs addressing contaminated sediments in OUs 2 to 5 with the objective of protecting human health and the environment.

As discussed in Section 5 of the 60 Percent Design Report Volume 1, the Tetra Tech Team will place crossing channel buoys in OUs 2 to 5 during in-water construction periods to ensure public safety during the RA. The warning buoys will be staggered at a distance of approximately 250 feet on either side of the dredge pipeline, to allow boaters sufficient time to slow down prior to encountering the pipeline. Spacing will be every 500 feet on the same side of the pipeline and every 250 feet when considering buoys on opposing sides. The pipeline delineators will be secured to the pipeline and spaced every 170 feet, providing warning to vessels that may be operating in close proximity to the dredge pipeline. Navigational markers will be placed to designate areas where the dredge pipeline has been securely anchored to the river bottom to provide for safe passage. Both the warning buoys and designated crossing channel buoys will be equipped with mooring lights to better identify the markers during low visibility periods. 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 Butte des Morts (OU 1).

Following completion of dredging, capping, and other associated RAs within each OU, those contaminated sediments that are 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 anchoring activities, and noted that such disturbances are not expected to compromise the overall effectiveness of the remedy. Moreover, should an anchor or other localized disturbance (e.g., metal poles) penetrate through the armor layer of a cap, the "self-healing" behavior of the cap upon withdrawal of the anchor maintains the integrity of the cap (e.g., see Palermo et al. 1998b). Since the OUs 2 to 5 caps will 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). 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, that 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 which 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, the most notable being a riparian owner's ability to place and remove a pier in less than 3 feet of water. While shoreline caps will generally not be placed in less than three feet of water and therefore not be impacted by such exempt activity, additional measures beyond reliance on the Chapter 30 program will be taken in the shoreline capping areas. 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 WDNR's GIS Registry, which is WDNR's public notification system for environmental cleanups that contain in-place, residual contamination. 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 shoreline caps will be registered on the GIS Registry 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 GIS Registry and inclusion on appropriate local units of government GIS mapping systems

Following approval of the 60 Percent Remedial Design Volume 2 submittal, a memorandum of agreement (MOA) will be developed among USACE, USEPA, and the respondents to the Order or their representatives to further ensure that future dredging activities within the federal navigation channel do not compromise the integrity of the engineered caps. The MOA is anticipated to follow the general form of USACE agreements implemented at other similar Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) sediment cap sites located in federally-authorized channels.

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 OMMP and water/biota sampling and reporting under the LTMP will be coordinated to take place during the same year, conducted approximately one 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

Volume 1 of this 60 Percent Design Report presents the construction schedule for RA in 2009. This section describes the sequence of activities that will take place from 2010 through project completion.

## 9.1 Operations Sequencing

In 2010, the upland Little Rapids staging facility will be used to support marine activities south of the De Pere Dam (i.e., OUs 2 and 3). This site will primarily be used to support the capping and cover material placement in OUs 2 and 3. In addition, this site may be used to transfer clean debris from barges to land to be loaded out for disposal. No contaminated material will be moved through this site; all contaminated sediment and debris material will be transported to the former Shell property staging and material processing facility.

Dredging of contaminated sediment will be conducted over seven seasons: 2009 through 2015 (note: 2009 RA is addressed in Volume 1 of this 60 Percent Design Report). Capping and cover work will take place from 2010 through 2017. The work seasons for both capping and dredging are currently anticipated to run from April 15 to November 15 of each year, depending on conditions. Dredging operations will generally be conducted 24 hours per day and 5 days per week. Capping operations will generally be conducted 12 hours per day and 5 days per week. This provides access to the river by recreational boaters on Saturdays and Sundays and, in the case of capping, reduces light pollution caused by overnight operations.

Dredging of sediments potentially subject to TSCA disposal requirements is expected to be completed in 2013. 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. TSCA dredging will generally be scheduled as close-of-season work, allowing proper cleaning of dredges and ancillary equipment to take place during the winter season.

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. Table 9-1 outlines the anticipated dredging production rates for 2010 through completion.

**Table 9-1**
**Anticipated Dredging Production Rates, 2010 Through Completion**

| Year | Annual Dredge Production [a, b] | Operating Dredges |
|---|---|---|
| 2010 | 630,000 of non-TSCA and 30,000 of TSCA | All three dredges |
| 2011 | 480,000 of non-TSCA and 30,000 of TSCA | All three dredges |
| 2012 | 620,000 of non-TSCA and 40,000 of TSCA | All three dredges |
| 2013 | 620,000 of non-TSCA and 40,000 of TSCA | All three dredges |
| 2014 | 610,000 of non-TSCA | All three dredges |
| 2015 | 440,000 of non-TSCA | All three dredges |

a. Based on 24 hour per day, 5 days per week operation at 65 percent efficiency
b. Includes required dredging and 6-inch overdredge allowance, as well as an estimated 230,000 cy of residual dredging

In addition to the dredging and cover 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 Addendum)
- QA/QC functions
- Community health and safety monitoring
- Environmental monitoring

At the end of each season, a 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.

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.

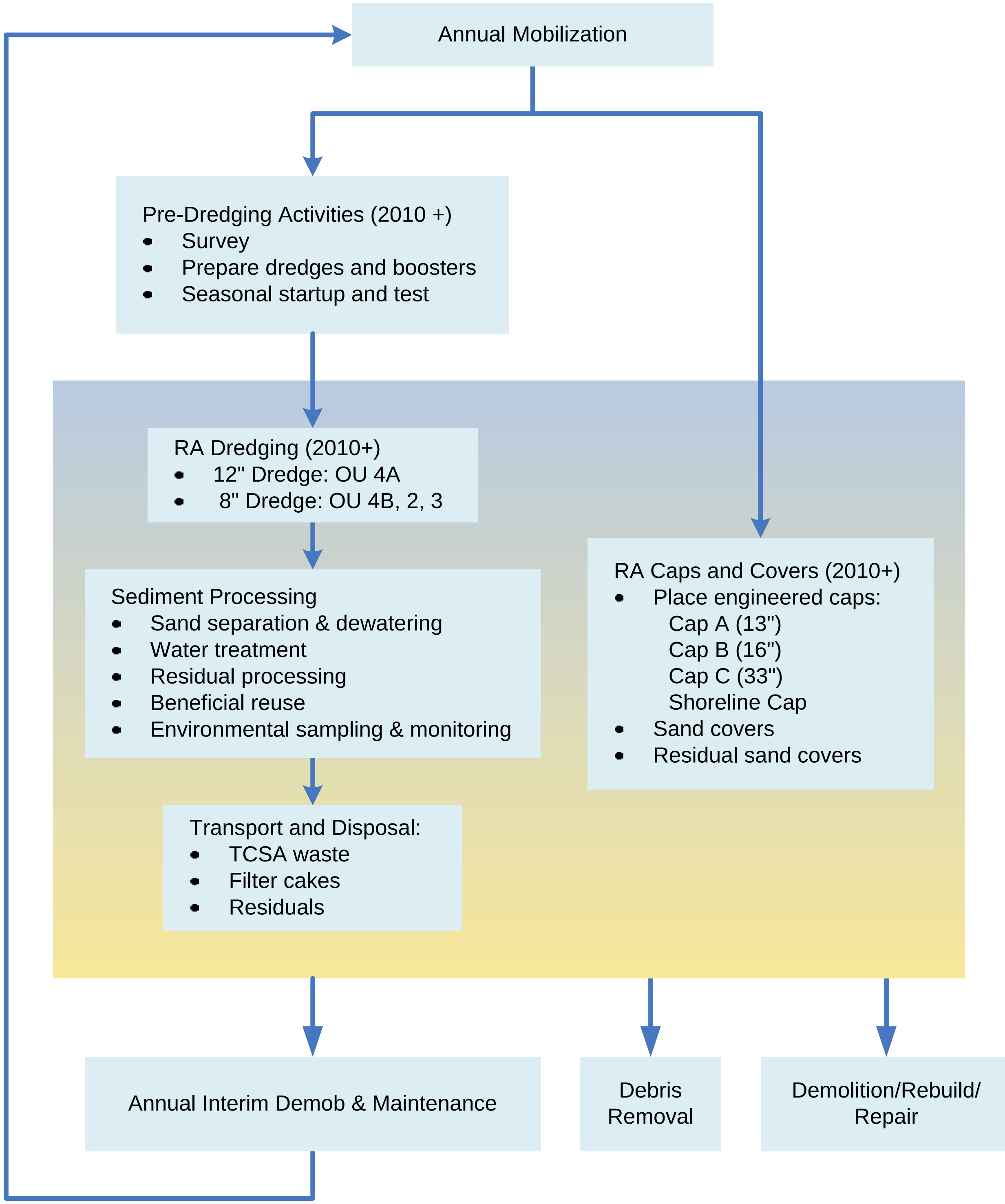


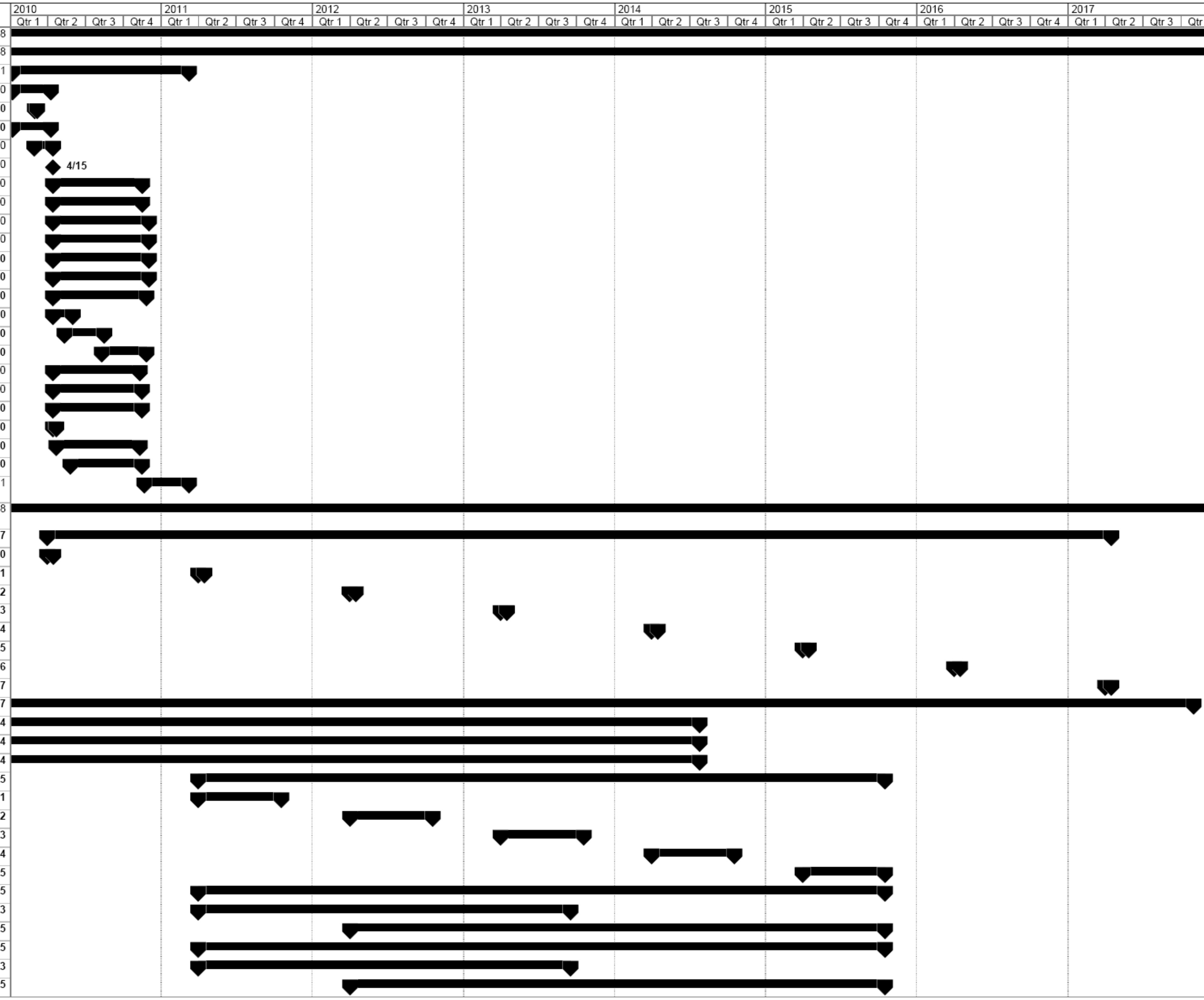

**Figure 9-1**
Sequence of Recurring Operations
for 2010 through Completion
Lower Fox River – OUs 2 to 5

## 9.2 Construction Schedule (2010 and Beyond)

The construction schedule from 2010 to completion is shown in Figure 9-2.

## Fox River Integrated Schedule, 2010 to Completion

| ID | Task Name | Start | Finish |
|---|---|---|---|
| 1 | Fox River Project | 4/28/08 | 6/29/18 |
| 2 | Phase 2A Activities | 4/28/08 | 6/29/18 |
| 3 | 2010 RA | 1/7/10 | 3/10/11 |
| 4 | Mobilization | 1/7/10 | 4/10/10 |
| 5 | **Little Rapids Dam** | **3/2/10** | **3/8/10** |
| 15 | **General** | **1/7/10** | **4/10/10** |
| 30 | Pre-Dredge Activities | 3/1/10 | 4/15/10 |
| 49 | Commence Full-Scale 2010 RA Dredging | 4/15/10 | 4/15/10 |
| 50 | 2010 Dredging | 4/15/10 | 11/16/10 |
| 51 | Dredging in OU4 | 4/15/10 | 11/16/10 |
| 114 | 2010 Sediment Processing | 4/15/10 | 12/2/10 |
| 115 | Dredging in 2010 | 4/15/10 | 12/2/10 |
| 116 | **Dredging OU4A (12" Dredge)** | **4/15/10** | **12/2/10** |
| 117 | **12" Booster Area 3** | **4/15/10** | **12/2/10** |
| 202 | **Dredging OU 3** | **4/15/10** | **11/26/10** |
| 203 | **Booster 5** | **4/15/10** | **6/1/10** |
| 260 | **Booster 4** | **5/13/10** | **8/16/10** |
| 331 | **Booster 3** | **8/11/10** | **11/26/10** |
| 402 | Debris Removal 2010 | 4/15/10 | 11/10/10 |
| 405 | Cap and Cover SystemInstallation 2010 | 4/15/10 | 11/15/10 |
| 406 | **OU 2/3 Cap And Cover System Installation 2010** | **4/15/10** | **11/15/10** |
| 407 | **Engineered Cap B Installation 2010** | **4/15/10** | **4/22/10** |
| 412 | **Engineered Cap A Installation 2010** | **4/23/10** | **11/10/10** |
| 449 | **Sand Cover 6" Installation 2010** | **5/27/10** | **11/15/10** |
| 477 | Annual Interim Demobilization & Equipment Maintenance | 11/22/10 | 3/10/11 |
| 486 | Remaining Phase 2B RA (2011 and Beyond) And Annual Items | 4/28/08 | 6/29/18 |
| 487 | **Mobilization/Demobilization** | **3/31/10** | **4/15/17** |
| 488 | **Mob / Demob 2010** | **3/31/10** | **4/15/10** |
| 491 | **Mob / Demob 2011** | **3/31/11** | **4/15/11** |
| 494 | **Mob / Demob 2012** | **3/31/12** | **4/15/12** |
| 497 | **Mob / Demob 2013** | **3/31/13** | **4/15/13** |
| 500 | **Mob / Demob 2014** | **3/31/14** | **4/15/14** |
| 503 | **Mob / Demob 2015** | **3/31/15** | **4/15/15** |
| 506 | **Mob / Demob 2016** | **3/31/16** | **4/15/16** |
| 509 | **Mob / Demob 2017** | **3/31/17** | **4/15/17** |
| 512 | **Bathymetric Surveying** | **4/28/08** | **10/31/17** |
| 522 | **Community Health and Safety** | **6/2/08** | **7/25/14** |
| 524 | **Construction Monitoring (Environmental)** | **6/2/08** | **7/25/14** |
| 526 | **Construction Monitoring (Performance)** | **6/2/08** | **7/25/14** |
| 528 | **Structures, Utilities, and Outfalls: Demolition/Rebuild/** | **4/1/11** | **10/16/15** |
| 529 | **Demo 2011** | **4/1/11** | **10/18/11** |
| 531 | **Demo 2012** | **4/2/12** | **10/18/12** |
| 533 | **Demo 2013** | **4/1/13** | **10/18/13** |
| 535 | **Demo 2014** | **4/1/14** | **10/17/14** |
| 538 | **Demo 2015** | **4/1/15** | **10/16/15** |
| 541 | **OU 4 Dredging** | **4/1/11** | **10/16/15** |
| 542 | **OU4A Dredging** | **4/1/11** | **9/16/13** |
| 546 | **OU4B Dredging** | **4/2/12** | **10/16/15** |
| 551 | **OU 4 Dewatering** | **4/1/11** | **10/16/15** |
| 552 | **OU 4A Dewatering** | **4/1/11** | **9/16/13** |
| 564 | **OU4B Dewatering** | **4/2/12** | **10/16/15** |




Project: Fox River 4-27-08 CashFlow S
Date: 5/16/08

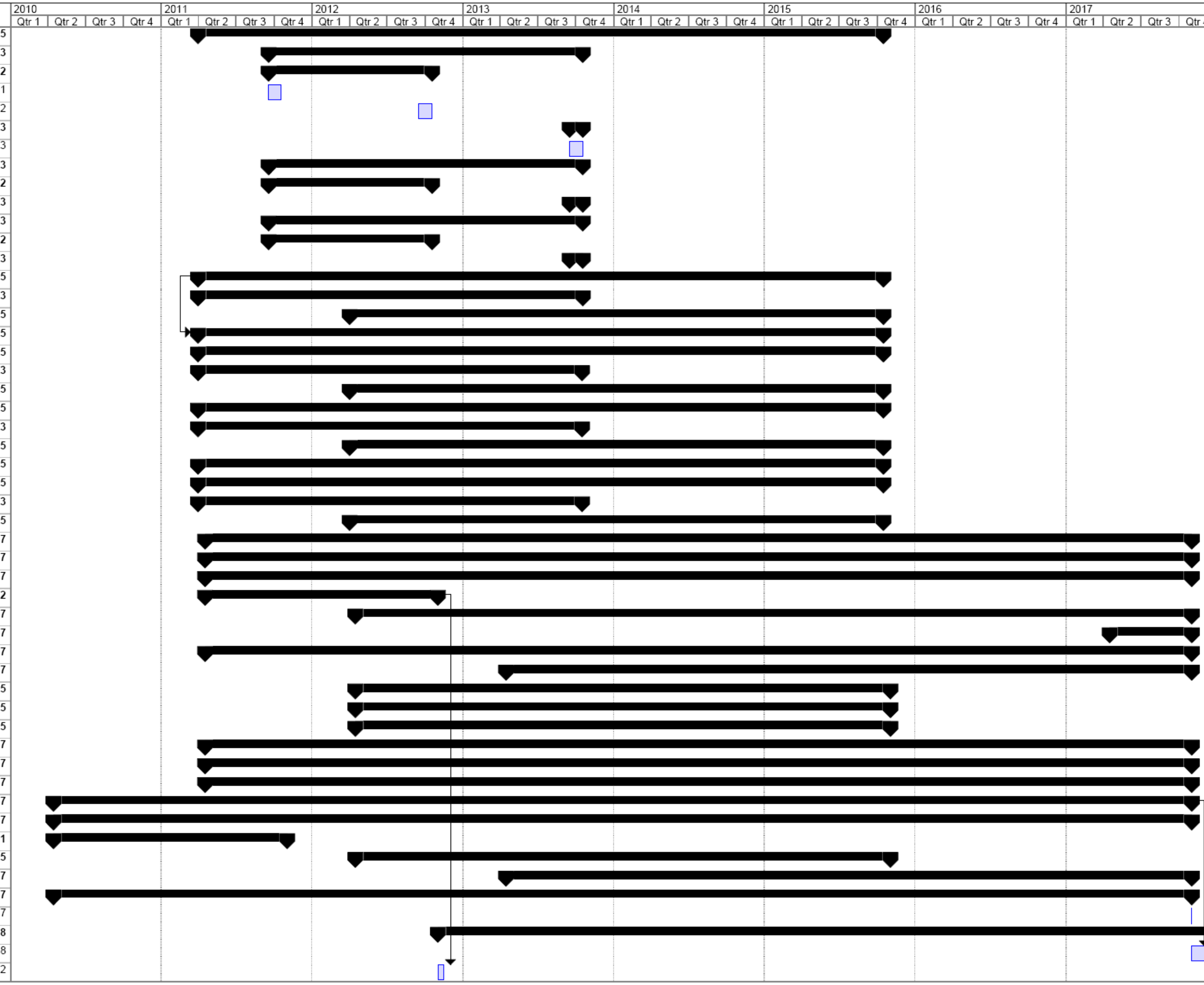
Task | Split | Progress | Milestone | Summary | Project Summary | External Tasks | External Milestone | Deadline

ANCHOR ENVIRONMENTAL, L.L.C. | TETRA TECH

**Figure 9-2**
Construction Schedule 2010 to Complete (part 1 of 2)
Lower Fox River – OUs 2 to 5

## Fox River Integrated Schedule, 2010 to Completion

| ID | Task Name | Start | Finish |
|---|---|---|---|
| 575 | **OU 4 Disposal** | 4/1/11 | 10/16/15 |
| 585 | **OU 4 TSCA Dredging** | 9/19/11 | 10/18/13 |
| 586 | **OU4A TSCA Dredging Brennan** | 9/19/11 | 10/18/12 |
| 587 | OU4A TSCA 2011 | 9/19/11 | 10/18/11 |
| 588 | OU4B TSCA 2012 | 9/17/12 | 10/18/12 |
| 589 | **OU4B TSCA Dredging Brennan** | 9/17/13 | 10/18/13 |
| 590 | OU4B TSCA 2013 | 9/17/13 | 10/18/13 |
| 591 | **OU 4 TSCA Dewatering** | 9/19/11 | 10/18/13 |
| 592 | **OU4A TSCA Dewatering TtEC** | 9/19/11 | 10/18/12 |
| 602 | **OU4B TSCA Dewatering TtEC** | 9/17/13 | 10/18/13 |
| 608 | **OU 4 TSCA Disposal** | 9/19/11 | 10/18/13 |
| 609 | **OU4A TSCA Client Paid T&D** | 9/19/11 | 10/18/12 |
| 612 | **OU4B TSCA Client Paid T&D** | 9/17/13 | 10/18/13 |
| 614 | **Residual Dredging** | 4/1/11 | 10/16/15 |
| 615 | **Residual Dredging OU4A** | 4/1/11 | 10/18/13 |
| 619 | **Residual Dredging OU4B** | 4/2/12 | 10/16/15 |
| 624 | **Residual Dewatering** | 4/1/11 | 10/16/15 |
| 625 | **Residual Water Treatment** | 4/1/11 | 10/16/15 |
| 626 | **Residual Water Treatment OU4A** | 4/1/11 | 10/16/13 |
| 630 | **Residual Water Treatment OU4B** | 4/2/12 | 10/16/15 |
| 635 | **Residual Dewatering** | 4/1/11 | 10/16/15 |
| 636 | **Residual Dewatering OU4A** | 4/1/11 | 10/16/13 |
| 640 | **Residual Dewatering OU4B** | 4/2/12 | 10/16/15 |
| 645 | **Residual Disposal** | 4/1/11 | 10/16/15 |
| 646 | **Residual Disposal Client Paid T&D** | 4/1/11 | 10/16/15 |
| 647 | **Residual Disposal Client Paid T&D OU4A** | 4/1/11 | 10/16/13 |
| 651 | **Residual Disposal Client Paid T&D OU4B** | 4/2/12 | 10/16/15 |
| 656 | **Engineered Cap A (Minimum 13 inches)** | 4/18/11 | 11/1/17 |
| 691 | **Engineered Cap B (Minimum 16 inches)** | 4/18/11 | 11/1/17 |
| 692 | **Engineered Cap B (Minimum 16 inches)** | 4/18/11 | 11/1/17 |
| 693 | **Eng. Cap B (Min. 16 inches) OU2/3** | 4/18/11 | 11/1/12 |
| 696 | **Eng. Cap B (Min. 16 inches) OU4A** | 4/16/12 | 11/1/17 |
| 701 | **Eng. Cap B (Min. 16 inches) OU4B** | 4/17/17 | 11/1/17 |
| 703 | **Eng. Cap B (Min. 16 inches) Client Purchased Mat** | 4/18/11 | 11/1/17 |
| 714 | **Engineered Cap C (Minimum 33 inches)** | 4/16/13 | 11/1/17 |
| 737 | **Shoreline Cap** | 4/16/12 | 11/2/15 |
| 738 | **Shoreline Cap** | 4/16/12 | 11/2/15 |
| 749 | **Shoreline Cap Client Purchased Materials** | 4/16/12 | 11/2/15 |
| 760 | **Sand Cover 6-inch** | 4/18/11 | 11/1/17 |
| 761 | **Sand Cover 6-inch** | 4/18/11 | 11/1/17 |
| 775 | **Sand Cover 6" Client Purchased Materials** | 4/18/11 | 11/1/17 |
| 789 | **Residual Sand Cover 6-inch** | 4/16/10 | 11/1/17 |
| 790 | **Residual Sand Cover 6"** | 4/16/10 | 11/1/17 |
| 791 | **Residual Sand Cover 6" OU2/3** | 4/16/10 | 11/2/11 |
| 794 | **Residual Sand Cover 6" OU4A** | 4/16/12 | 11/2/15 |
| 799 | **Residual Sand Cover 6" OU4B** | 4/16/13 | 11/1/17 |
| 804 | **Residual Sand Cover 6" Client Purchased Materia** | 4/16/10 | 11/1/17 |
| 818 | Construction Completion | 11/1/17 | 11/1/17 |
| 819 | **Staging Area Site Restoration** | 11/2/12 | 6/29/18 |
| 820 | OU 4 Staging Area Site Restoration | 11/1/17 | 6/29/18 |
| 821 | OU 2 Staging Area Site Restoration | 11/2/12 | 11/15/12 |




Project: Fox River 4-27-08 CashFlow S
Date: 5/16/08

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

**Figure 9-2**
Construction Schedule 2010 to Complete (part 2 of 2)
Lower Fox River – OUs 2 to 5

# 10 MONITORING, MAINTENANCE, AND ADAPTIVE MANAGEMENT

The 2009 Construction Quality Assurance Project Plan (CQAPP; Appendix D of the 60 Percent Design Report Volume 1) and CQAPP Addendum (Appendix F of the 60 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 adaptive management 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 any caps that are installed in OUs 2 to 5 to ensure their integrity, protectiveness, and effectiveness in perpetuity. Long-term cap monitoring will include, at a minimum, bathymetric surveys and core sampling where feasible. 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 Operations, Maintenance, and Monitoring Plan (OMMP; Appendix H of the 60 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 over the next decade or more. As practicable, collocation of sampling locations with prior Response Agency remedial investigation/feasibility study (RI/FS) stations will be performed to facilitate assessments of natural recovery over time. Long-term sediment natural recovery monitoring plans are presented in the OMMP (Appendix H of the 60 Percent Design Report Volume 2).

Long-term monitoring of surface water and biota will be performed to assess progress in achieving RAOs and to determine remedial success. Monitoring will continue until acceptable levels of PCBs are reached in surface water and fish. A preliminary draft of the Long-Term Monitoring Plan (LTMP) is presented in Appendix I of the 60 Percent Design Report Volume 2, and is subject to further collaborative workgroup review.

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 Adaptive Management and VE Plan for OUs 2 to 5 is presented in Appendix E. As described in the RD Work Plan approved by the Response Agencies in June 2004, adaptive management is an integral element of RD, and defines the framework for modification of annual RA Work Plans as appropriate in response to new information and experience during initial RA in OUs 2 to 5. Annual RA Work Plans incorporating adaptive management 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 "bottom up" fashion based on initial 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 60 Percent Design, and this section provides such an update based on current information, which is subject to further refinement. For example, this updated cost estimate does not incorporate the results of ongoing and future infill sampling and bathymetric/sub-bottom surveys, which will be used to refine final dredging volumes and costs. Other similar refinements are ongoing, and may increase or decrease the overall cost of the OUs 2 to 5 RA.

In order to estimate the probable final cost range of the OUs 2 to 5 RA project, existing uncertainties associated with individual tasks and work items were estimated based on available information, also incorporating the range of potential cost savings associated with value engineering (VE) concepts. A summary of the VE process developed during the 60 Percent Design phase in collaboration with the technical workgroups, along with plans for integrating VE into future adaptive management of the OUs 2 to 5 RA are presented in Appendix E of the 60 Percent Design Volume 2. Note that there are presently no firm limits to costs or savings for this project. Cost estimates and VE concepts will continue to be developed in subsequent phases of the RD and RA.

The OUs 2 to 5 RA cost estimate presented in this section was developed using the "Hard Dollar Estimating Software", which allows for integrated development of the critical path project schedule with the cost estimate. 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.

The project costs were divided into three general categories of work elements, as follows:

- Pre-construction

- During Construction
- Monitoring and Maintenance

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

## 11.2 Pre-Construction Work Elements

### *11.2.1 Pre-Construction Investigations (Line Item 1)*

The field investigation task includes pre-construction surveys and investigations associated with work to be 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.

### *11.2.2 Remedial Design and Support (Line Item 2)*

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:

- Agency Coordination: This includes coordination with the A/OT during the RD phase of the work including workgroup meetings
- Public Relations: This task includes retaining an outside public relations firm to develop a website to keep the public informed of the OUs 2 to 5 RA; the website will be developed and updated quarterly

## 11.3 During Construction Work Elements

### *11.3.1 Mobilization/Demobilization (Line Item 3)*

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 dredge process. This task also includes annual winterization/demobilization of equipment and maintenance as required throughout the duration of the RA.

### *11.3.2 Staging Area Site Preparation (Line Item 4)*

This task includes site preparation and development of the former Shell property staging and material processing facility and the Little Rapids staging facility including the following:

- Securing property leases for the former Shell property and Little Rapids facilities
- Clearing, grubbing, and other site preparation at the former Shell property as well as concrete work and erection of the sediment processing building and offices
- Design and installation of the sheetpile wall at the former Shell property staging area
- Development the Little Rapids staging facility, site preparation, demolition, road and water access, and site restoration

### *11.3.3 Site Support, Construction Management and Monitoring (Line Item 5)*

This task includes work related to site support, management, and monitoring of RA including the following:

- Respondents and Tetra Tech Team daily oversight operations of the project, including project meetings, management staff, quality control, site vehicles, health and safety supplies, temporary project facilities, utilities, site communications, personnel-related direct expenses, etc.
- Bathymetric surveying conducted during the RA, which will include both pre- and post-dredge surveys and third-party QA for the duration of the project. This task will also include pre- and post-cap and sand cover bathymetric surveying.
- 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.
- Development of an on-site lab for performing environmental monitoring during RA such as post-dredge verification sample analysis, including subcontractor management, 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.

### 11.3.4 Debris Removal (Line Item 6)

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.

### 11.3.5 Dredging (Line Item 7)

This task includes labor, equipment, and materials for dredging of the targeted sediments in OUs 2 to 5 as summarized below:

- OU 2/3: 230,000 cy of in situ material.
- OU 4 (Non-TSCA): 3,400,000 cy of in situ material
- OU 4 (TSCA): 170,000 cubic yards of in situ material
- Residual Dredging in OUs 2 to 5: 230,000 in situ cubic yards (estimated)

As discussed in Section 2.4 and Appendix E, infill sampling to refine dredge plans, along with other related VE concepts, will likely further optimize the required dredging plans by limiting the amount of sediment removed with PCB concentrations below the RAL, resulting in overall cost savings opportunities.

### 11.3.6 Sediment Dewatering and Water Treatment (Line Item 8)

The task includes dewatering of sediments removed from OUs 2 to 5 including sediments removed as part of residuals management, 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.

#### *11.3.7 Transport, Disposal and Beneficial Reuse (Line Item 9)*

This task includes transport and disposal of dewatered non-TSCA and TSCA sediment removed from OUs 2 to 5, as well as transport and disposal of segregated sand for on-site and/or off-site beneficial reuse. The VE concepts related to transport and disposal that are being considered by the technical workgroup include alternate TSCA landfill sites and transportation methods, along with regional beneficial reuse of segregated sand.

#### *11.3.8 Engineered Capping and Sand Cover (Line Item 10)*

This task includes placement of engineered caps and sand covers in OUs 2 to 5, and include procurement of cap and sand cover materials, 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 load barges and for crews to man barges to deliver material to the capping plants and return barges to shore for reloading. The following engineered cap and sand cover areas were estimated for the 60 Percent Design:

- Engineered Cap A: 215 acres
- Engineered Cap B: 54 acres
- Engineered Cap C: 103 acres
- Shoreline Caps: 41 acres
- Sand Cover: 207 acres
- Residuals Sand Cover: (estimated range: 100 to 500 acres)

The VE concepts related to engineered capping that are being considered by the technical workgroup include alternate sources of import materials for capping and the use of geotextile fabrics to optimize cap designs and construction.

### 11.4 Post-Construction Work Elements

#### *11.4.1 Long-Term Monitoring and Maintenance (Line Item 11)*

This task includes costs (net present value in 2008 dollars) for performing long-term monitoring and maintenance associated with the OUs 2 to 5 RA, including the following:

- Long-term monitoring of engineered caps. Long-term monitoring requirements are currently being developed through the collaborative workgroup process.

However, for the purposes of this 60 Percent Design cost estimate, long-term cap monitoring was assumed to include both physical integrity monitoring (bathymetry surveys and coring) as well as chemical analyses of surface sediment samples and core intervals, as outlined in the draft OMMP (Appendix H).

- Long-term maintenance of engineered caps based on the results of long-term cap monitoring. Based on experiences at other similar sediment cap sites, cap maintenance was assumed to be required over 5 percent of the 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 baseline monitoring of water quality and fish tissue beginning in 2012, based on the preliminary LTMP (Appendix I), which is subject to workgroup review.
- Long-term monitoring of surface sediments. Post-dredge surface sediment confirmation sampling and analysis was assumed to be required as generally described in the draft OMMP (Appendix H).

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

| | Item | 60 Percent Design Cost Estimate [(a)] |
|---|---|---|
| 1 | Pre-Construction Investigations [(b)] | $2,100,000 |
| 2 | Remedial Design and Support [(c)] | $7,000,000 |
| 3 | Mobilization/Demobilization [(d)] | $63,200,000 |
| 4 | Staging Area Site Preparation [(e)] | $32,800,000 |
| 5 | Construction Management and Monitoring [(f)] | $55,200,000 |
| 6 | Debris Removal [(g)] | $4,200,000 |
| 7 | Dredging [(h)] | $144,600,000 |
| 8 | Sediment Dewatering and Water Treatment and Transport, Disposal and Beneficial Reuse [(i)] | $164,600,000 |
| 9 | Engineered Capping and Sand Cover [(j)] | $100,000,000 |
| 10 | Long-Term Monitoring and Maintenance (Net Present Value)[(k)] | $6,400,000 |
| | **Total Project Costs** | **$600,000,000** |

**Notes:**

a. Costs based on Tetra Tech estimates in 2008 dollars except for long-term monitoring, which is based on escalation of the BODR Optimized Remedy line item in 2005 dollars and adding 15 percent for escalation to 2008 dollars. Note: The updated costs for the OUs 2 to 5 remedy ($600,000,000) are approximately 36 percent higher than the ROD Amendment cost estimate, scaled to 2008 dollars ($440,000,000).

b. Cost based on initial pre-construction investigations for 2009 RAs; additional pre-construction investigations may be required for each year of remedial activity

c. Includes completion of RD and associated support

d. Includes mobilization/demobilization, and major equipment purchases

e. Includes preparation of Little Rapids Dam and former Shell property staging areas, including sheetpile wall installation; potential variability in steel costs for sheetpile wall may cause costs to increase

f. Includes site support, bathymetric monitoring, construction monitoring and community health and safety programs; potential variability of construction duration could cause cost to change

g. Includes the removal of debris encountered during dredging potential for cost increase due to additional crew and equipment costs to remove debris and uncertainty in level of debris to be encountered

h. Includes all dredging including residual dredging (estimated quantity); potential variability of dredging residuals may cause cost to change

i. Includes costs for sand separation and dewatering and water treatment of process water; also includes costs for disposal at TSCA and non-TSCA facilities and beneficial reuse as practicable of segregated sand and gravel, including backfill of sheetpile wall at former Shell property; based on line item 7 and the potential for a portion of sand may require landfill disposal, which would cause cost to change

j. Includes materials and placement of engineered caps (Caps A, B, C, and shoreline caps) and sand covers (as stand-alone RA or post-dredge residuals management [estimated quantity]); potential variability of dredging residuals, shoreline cap requirements, and associated materials unit prices may cause cost to change

k. Based on draft OMMP and LTMP programs presented in Appendices H and I, which are subject to workgroup review.

# 12 LOCATION-SPECIFIC APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

Volume 1 Section 7 presents location-specific ARARs for project activities and details of the associated regulatory agency/local authority approvals and related submittals. In addition to 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, north 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 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

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 .

# 13 REFERENCES

Shaw et al. 2008. Lower Fox River Phase 1 Remedial Action Draft Summary Report 2007. Prepared for NCR Corporation and U.S. Paper Mills Corporation by Shaw Environmental and Infrastructure, Inc., Anchor Environmental, L.L.C., and Foth Infrastructure and Environment, L.L.C. February 21, 2008.

Tetra Tech EC, Inc. and Dolman Research Inc. 2008. Lower Fox River Operable Units 2 through 5 Phase 2A Work Plan Addendum: 2008 Hydrographic & Geophysical Surveys and Submerged Cultural Resources Investigation. Prepared Appleton Papers Inc., Georgia-Pacific Consumer Products LP, NCR Corporation, and U.S. Paper Mills Corporation by Tetra Tech EC, Inc. and Dolman Research Inc. April 28, 2008.