Report

OU1 Design Supplement
Lower Fox River Operable Unit 1

Project I.D.: 07G017

GW Partners
Neenah, Wisconsin

November 2007

Foth

CH2MHILL

Foth CH2MHILL

November 16, 2007

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Dear Jim and Greg:

RE: Lower Fox River Operable Unit 1 (OU1) Design Supplement

Please find enclosed the final OU1 Design Supplement. The OU1 Design Supplement incorporates new project data and information collected from the ongoing 2004-2007 remedial action work to develop an OU1 Optimized Remedy.

The proposed OU1 Optimized Remedy will attain the risk based clean-up objectives established by the agencies.

A hard copy is being sent to those listed on the distribution page within the document. An e-mail will also be sent to the addresses and those copied on the distribution list with directions for accessing a project website to download an electronic copy of the document.

Sincerely,

Steve Laszewski
Steve Laszewski, Ph.D.
Foth Infrastructure & Environment, LLC

Michael Jury /BS
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Attachment

OU1 Design Supplement
Lower Fox River Operable Unit 1

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Executive Summary

This OU1 Design Supplement summarizes the remedial design and remedial action work that has been conducted from 2003 through 2007 in Operable Unit 1 (OU1) of the Lower Fox River, and sets forth the framework for an OU1 Optimized Remedy going forward. The Optimized Remedy is based on four years of experience in OU1 implementing the 2002 OU1 Record of Decision (the “ROD” and the “ROD Remedy”), including significant new data gathered to delineate PCB concentrations and sediment characteristics, post-dredging residual data, additional modeling to incorporate the new data, and actual operational and cost experience. During the 2003-2007 time period:

- Pre-design work was performed to collect new PCB data points from throughout OU1;
- The dredging of the high concentration PCB sub-areas in OU1 has been completed;
- Post-dredging data have been collected in the dredged areas and analyzed to verify the effectiveness of the dredging effort; and
- Significant experience has been gained on the practical limitations of implementing a dredging-only remedial strategy to achieve the primary risk reduction goal for OU1.

Based on the new information gathered and experience gained since the 2002 ROD, the OU1 Optimized Remedy would meet the 1.0 ppm PCB Remedial Action Level (the “RAL”) and attain the primary risk reduction goal of the 2002 ROD, which is lowering the Surface Weighted Average Concentration (the “SWAC”) of PCBs in OU1 to 0.25 ppm.

Following issuance of the 2002 ROD for OU1, WTM I Company executed a 2003 Administrative Order on Consent (AOC) with the U.S. Environmental Protection Agency (EPA) and the Wisconsin Department of Natural Resources (WDNR) (collectively the "Agencies") to perform the Remedial Design for OU1. Shortly thereafter, WTM I Company and P.H. Glatfelter Company (the "Performing Companies") executed a 2003 Consent Decree with EPA and WDNR to perform specified Remedial Action in OU1, consistent with the ROD. The two Performing Companies formed GW Partners, LLC to facilitate joint performance of the work required by the Consent Decree.

The AOC and Consent Decree recognized that, while the design and remediation work would be consistent with the ROD, alternative remedial approaches could be evaluated and proposed in a technical submittal. The technical documents supporting such alternative remedial approaches could be submitted after portions of the OU1 work had been commenced, so long as the submittal would not delay any OU1 site work and the remedial work had not commenced in those portions of OU1 addressed by the submittal. This submittal, while comprehensive in addressing all of OU1, describes an alternative remedial approach for those portions of OU1 where remedial work has not yet occurred.

The OU1 Optimized Remedy described in this report uses a mix of remedial technologies (including dredging, residuals management, engineered capping, and sand cover) to achieve the 1.0 ppm RAL and the risk reduction goal set forth in the ROD. Dredging of high concentration PCB areas has occurred in 2004-2006 and portions of 2007. The remaining dredging work proposed as part of the OU1 Optimized Remedy will be completed in 2008. A cap placement test was also performed during the 2007 season to test different cap placement parameters. The Agencies will need to issue an official decision document for GW Partners to complete the remaining portions of the OU1 Optimized Remedy.

As summarized below, the OU1 Optimized Remedy is based on the new data collected since the ROD was issued, as well as the operational experience gained in performing the ROD remedy:

1. More than 5,900 new PCB data points have been collected in OU1 post-ROD. Based on that data and modeling analyses, the current estimate of the PCB mass contained in the 1.0 ppm OU1 dredge footprint prior to any dredging is 1,143 kilograms. The 2002 ROD had estimated the PCB mass as 1,715 kilograms.

2. PCB mass was not uniformly spread throughout OU1, but tended to be concentrated in high concentration areas in the southern portion of OU1. These high concentration areas included sub-areas with relatively high PCB mass, an average PCB concentration within the entire 1.0 ppm dredge prism greater than 1.5 grams/cubic yard, and typically a sub-area SWAC greater than 5 ppm PCBs. The dredging completed in 2004-2006 removed about 2/3rds of the PCB mass in OU1 by focusing on these areas.

3. Dredging alone cannot achieve an OU1 SWAC of 0.25 ppm, which is the risk reduction goal of this remedial action to protect human health and the environment. Assuming all of the OU1 sediment above the 1.0 ppm dredge line could be precisely removed and dredging left behind no residuals, modeling based on the new data projects that the SWAC at the end of dredging (assuming no sand cover of residuals) would be 0.48 ppm.

4. Because of the limitations of even the most advanced dredging equipment in achieving precision dredge cuts, the OU1 experience has shown that the OU1 dredging operation needs to remove an average of 4 inches of additional sediment to assure that the targeted dredge elevations are achieved. This overcut increases the actual volume required to be dredged by the ROD Remedy by about 207,200 cubic yards or 29%. The ROD did not account for this sediment volume when evaluating time or costs to complete the remedy.

5. The new OU1 PCB data for the sediment remaining in OU1 shows that a large sediment volume within the 1.0 ppm dredge prism is not significantly different than the sediment outside that prism. In particular, about 1/3 of the sediment remaining in the 1.0 ppm dredge prism contains low concentrations of PCBs between 1.0 and 2.0 ppm. The average PCB concentration in this 1.0-2.0 ppm area, without overcut, is 1.3 ppm. This 1.0-2.0 ppm PCB area contains only about 2.2% of the total pre-dredge PCB mass in OU1 and less than 0.1% of the total PCB mass in the Lower Fox River.

6. The experience gained during the OU1 operations, together with the new OU1 data, shows that the cost of implementing the all-dredge remedy set forth in the ROD would be more than twice the 2002 ROD's cost estimate of $61.7 million. GW Partners' current cost estimate for the ROD Remedy is between $138 and $150 million, due in large part to overcut volumes and residual sand cover costs (neither of which were accounted for in the ROD), as well as actual costs being higher than were estimated in the ROD. An OU1 Optimized Remedy, with a mix of remedial technologies designed to be as protective of human health and the environment as the ROD Remedy, will be substantially more cost effective.

7. Not only will the risk reduction SWAC target of 0.25 ppm PCBs be achieved with the OU1 Optimized Remedy, it will be achieved more quickly, more efficiently, and more cost effectively than with the ROD Remedy. The OU1 Optimized Remedy described below would take an additional two years to implement in OU1 whereas the 2002 ROD Remedy will take an additional seven years to implement. Achieving a faster reduction in the OU1 SWAC will mean that fish consumption advisories due to PCBs could be lifted sooner with the OU1 Optimized Remedy.

Given this new data and information, various combinations of available methods to achieve the 1.0 ppm RAL and the 0.25 ppm SWAC have been examined. The proposed components of the OU1 Optimized Remedy include components from the 2002 ROD as well as alternative remedies. Dredging remains a very important part of the remedy. The Optimized Remedy will remove 74% of the OU1 PCB mass to be dredged under the ROD Remedy (using the updated mass estimates) and will furthermore address 97% of that mass with a combination of active remedial measures (dredging, engineered armored capping and sand cover). Capping will only be performed in areas where stability and permanence is assured, and the other restrictions of the ROD Contingent Remedy (described in detail in Section 3) would apply unless the Agencies agree that they are unworkable (*e.g.* water depth restriction in the near shore areas).

More specifically, the OU1 Optimized Remedy incorporates the dredging that has been performed to date and other 2002 ROD components that would be performed in the future, as follows:

- Dredging has already been completed of all PCB high concentration areas, meaning those sub-areas with the characteristics of high PCB mass, an average PCB concentration within the entire 1.0 ppm dredge prism greater than 1.5 grams/cubic yard, and typically a sub-area SWAC greater than 5 ppm PCBs. A small portion of one additional sub-area has been dredged where the PCB concentration was greater than 50 ppm. In addition, another area less than one acre with an average PCB surficial concentration greater than 10 ppm (in the top 8-inch interval) has been dredged instead of capped for operational efficiency. Finally, other areas were or will be dredged in lieu of capping to allow for a water depth of no less than 6 feet over all cap surfaces, or for operational efficiency. The year-by-year dredging detail is as follows:

- In 2004-2006, the dredging focused on the southern portion of OU1 where the PCB high concentration areas were located.
- In 2007, dredging removed the remaining portion of one high concentration sub-area in the southern portion of OU1, another small area where the PCB concentration exceeded 50 ppm PCBs in the northern portion of OU1, and another area less than one acre with an average PCB concentration greater than 10 ppm in the top 8-inch interval; additional dredging was performed in lieu of capping in areas where the post-cap water depth would have been less than 6 feet or for operational efficiency.
- In early 2008, additional dredging will be performed in lieu of capping in areas where the post-cap water depth would have been less than 6 feet or for operational efficiency.

- Post-dredge residuals with PCB concentrations greater than 5.0 ppm will be addressed by re-dredging, unless operational efficiencies (such as avoiding remobilization of dredging equipment over long distances for small residual areas) dictate otherwise.
    - Re-dredging to achieve 5.0 ppm was completed in most sub-areas in 2006 and 2007. Additional limited redredging will occur in 2008.
- Residual sand cover will be placed as necessary over already dredged areas to achieve the 0.25 ppm SWAC.
- Long-term monitoring and maintenance will be performed after all active remedial measures have been completed.

The OU1 Optimized Remedy also includes alternative remedies proposed for the remaining undredged areas above the 1.0 ppm RAL, including:

- Placing a 13-inch engineered armored cap (comprised of 6-inches of sand and 7-inches of armor, each layer including a 3-inch overplacement allowance) over remaining undredged sediments with an average PCB concentration between 2 and 10 ppm in the top 8-inch interval.
- Placing 6-inches of sand cover over remaining undredged sediments with an average PCB concentration between 1.4 and 2.0 ppm in any single 8-inch interval, where there is no other 8-inch interval with average PCB concentrations greater than 1.0 ppm.
- Placing 3-inches of sand cover (not including sand overplacement) over remaining undredged sediments with an average PCB concentration between 1.0 and 1.4 ppm in any single 8-inch interval, where there is no other 8-inch interval with average PCB concentrations greater than 1.0 ppm.

All of the components of the Optimized Remedy are described on Table 4-1 and are shown on Figure 4-1.

EPA follows nine criteria to decide how to best remediate a site. Each criterion is examined in more detail in this Design Supplement. The comparison between the ROD Remedy and the

Optimized Remedy shows that the Optimized Remedy is more protective of human health and the environment in that it will achieve the 0.25 ppm SWAC risk-based goal several years before the ROD Remedy. The Optimized Remedy is preferable to the ROD Remedy because it reflects operational reality and real world technical limitations and, in fact, attains the risk-based goal of the ROD through the utilization of a combination of remedial techniques, with an appropriate degree of permanence.

Finally, the Optimized Remedy is much more cost-effective than the ROD Remedy. The ROD Remedy is currently estimated to cost between $138 and $150 million, whereas the Optimized Remedy is estimated to cost between $93 and $111 million. Both options are significantly more expensive than the ROD's $61.5 million estimate, but the Optimized Remedy is much more cost-effective than the ROD Remedy with regard to future expenditures. Through the 2007 dredge season, about $67 million has been spent on dredging in OU1. This means that the future cost of the Optimized Remedy would be between $26 and $44 million, as compared to a future cost of the ROD Remedy of between $71 and $83 million.

OU1 Design Supplement
Lower Fox River Operable Unit 1
List of Abbreviations, Acronyms, and Symbols

AOC	Administrative Order on Consent
A/OT	Agency and Oversight Team
ARAR	Applicable or Relevant and Appropriate Requirements
BODR	Basis of Design Report
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cfs	cubic feet per second
CHE	Coast and Harbor Engineering
cm	Centimeter
COC	chemicals of concern
CQAP	Construction Quality Assurance Plan
cy	cubic yard
DGPS	Differential Global Positioning System
ESD	Explanation of Significant Difference
FS	feasibility study
GIS	Geographic Information System
hp	Horsepower
IDW	inverse-distance-weighted
IGLD	International Great Lakes Datum
lb	Pound
LLBdM	Little Lake Butte des Morts
LWD	Low Water Datum
NCP	National Contingency Plan
OU	Operable Unit
PCB	polychlorinated biphenyl
ppm	part per million
RA	remedial action
RAL	remedial action level
RAO	remedial action objective
RD	remedial design
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
RTK	real time kinematic
SMU	sediment management unit
SWAC	surface-weighted average concentration
TIN	triangulated irregular network
TSCA	Toxic Substances Control Act
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
WDNR	Wisconsin Department of Natural Resources

1. Introduction

1.1 Purpose

This Operable Unit 1 (OU1) Design Supplement document describes and supports the Lower Fox River OU1 Optimized Remedy. The objective of this document is to provide a framework for the evaluation, design and implementation of the Optimized Remedy. By combining the remedial technologies of dredging, capping, dredge residual management, and sand cover, the Optimized Remedy will achieve the Remedial Action Level (RAL) and Surface Weighted Average Concentration (SWAC) objective for OU1.

This document contains a discussion of OU1 physical characteristics, the OU1 Record of Decision (ROD) Remedy and ROD Contingent Remedy, the components of the Optimized Remedy, and a comparative evaluation of the ROD Remedy versus the Optimized Remedy. This document also provides additional information on the project schedule, operational procedures, and project costs associated with the OU1 Optimized Remedy.

The Optimized Remedy was generated using the large OU1 database of chemical and physical data, coupled with the use of a three-dimensional sediment bed model, along with a geographic information system (GIS) interface, as more fully described in Section 4.1.2.

To attain the 0.25 part per million (ppm) PCB SWAC objective and meet the 1.0 ppm RAL, key plan concepts include:

- Dredging of sub-areas with high PCB concentrations or surficial concentrations greater than 10 ppm (*performed in 2004-2007*)
- Dredging of areas in lieu of capping to allow for a water depth of 6 feet over all cap surfaces (*i.e.*, minimum post-cap water depth of 6 feet) and operational efficiencies (*performing in 2006-2008*)
- Re-dredging in specific locations as a residual management tool (*performing in 2006-2008*)
- Applying sand cover in specific post-dredge locations as a residual management tool (*performing in 2007-2008*)
- Applying sand covers in low concentration areas (between 1.0 and 2.0 ppm PCBs) (*performing in 2008*)
- Applying engineered armored caps (*performing in late 2008 and 2009*)
- Implementing a long-term monitoring and maintenance program.

1.2 Site Description

The Lower Fox River is the 39-mile portion of the Fox River beginning at the outlet of Lake Winnebago, the largest inland lake in Wisconsin, and terminating into the Bay of Green Bay (Figure 1-1). The Lower Fox River's most southerly section, from the outlet of Lake Winnebago to the Upper Appleton Dam, is Little Lake Butte des Morts (LLBdM), which has generally been identified by the Agencies as OU1.

The presence of PCBs in the Lower Fox River has long been a concern. PCBs are compounds that were discharged by some area industries in the 1950's, 1960's, and 1970's as part of carbonless copy paper manufacturing, the paper de-inking and recycling process and other industrial processes. Known discharges of PCBs to the Fox River ended in the 1970's.

Historically, soft sediment deposits have been delineated within OU1 and designated as Deposits A through H and POG. However, for the purposes of the OU1 pre-design investigation, OU1 was broken down into sub-areas for the evaluation of both the sampling and analytical requirements. The sub-areas were delineated and defined based on known historical uses of the River (*e.g.*, navigation and facility operations), historical sediment physical transport processes, site physical characteristics (*e.g.*, bathymetry and locations of soft sediment), and historical chemical data. The newly identified sub-areas were established to provide better definition of areas possessing similar physical and chemical characteristics. The sub-areas were used to help determine the quantity and quality of the sampling to be conducted during the pre-design investigation. The sub-area designations and their delineation have continued to be utilized during performance of the RD and RA. The OU1 sub-areas are depicted on Figure 1-2.

1.3 OU1 Record of Decision

The United States Environmental Protection Agency (USEPA) and the Wisconsin Department of Natural Resources (WDNR) (collectively, the Agencies) signed the ROD encompassing OU1 in December 2002.

The ROD establishes a 0.25 ppm PCB SWAC as the risk-based goal for the OU1 remediation. The 0.25 ppm SWAC was identified as a result of the Final Baseline Human Health and Ecological Risk Assessment performed for the Operable Unit, and seeks to abate risks to human health and the environment within an acceptable timeframe. The ROD implements the SWAC through the use of a RAL of 1.0 ppm PCBs for sediment removal, based on the Agencies' calculation that a 1.0 ppm RAL for dredging would result in the attainment of the 0.25 ppm SWAC. The ROD provides that pre-remediation sampling and characterization efforts will define a spatial footprint of sediment containing PCB concentrations greater than 1 ppm. This footprint is targeted for removal by dredging. If sampling shows that the 1 ppm PCB RAL is not achieved after completing sediment removal (dredging) based on the defined spatial footprint, a SWAC of 0.25 ppm PCBs is used to assess the effectiveness of PCB removal at LLBdM. If the SWAC is not achieved, then the ROD provides for either further dredging or the placement of a sand cover over dredged areas. The ROD directs that the dredged sediment be dewatered, and then disposed of in a licensed landfill.

The ROD includes a Contingent Remedy that, if approved, would allow the placement of engineered armored caps in OU1. In order for the Contingent Remedy to be approved, capping would have to be shown to be less expensive and as effective in risk reduction as dredging. The ROD also allows for the Contingent Remedy if it can be predicted, with a high degree of certainty, that dredging alone will not achieve the 0.25 ppm SWAC, after significant dredging of OU1 has been accomplished (*e.g.* Sub-areas A/B, C, and POG), and that capping is less costly than dredging, in accordance with the nine criteria set forth in the National Contingency Plan, 40 C.F.R. Part 300.

Based upon the 1.0 ppm RAL, the ROD estimated that the remedial action would remove 784,200 cubic yards (cy) of sediment containing 3,770 pounds (lbs) or 1,715 kilograms (kg) PCBs. The ROD estimate did not include a dredge overcut allowance. When a 4-inch dredge overcut allowance is included, the revised OU1 removal volume estimate would be 928,400 cy, based on the pre-project sediment bed model.

1.4 OU1 Remedial Actions Completed Through 2007

The Lower Fox River OU1 Remedial Design (RD) Pre-design Basis of Design Report (CH2M HILL, March 2005) delineated the sediment in LLBdM that equals or exceeds 1.0 ppm PCBs. During the 2004-2006 Remedial Action (RA), GW Partners refined the delineation of the targeted sediment, implemented full-scale dredging operations in OU1, dewatered the dredged sediment, loaded and hauled the dewatered sediment to qualified landfills, performed water treatment activities using an on-site water treatment facility, and completed associated activities necessary to accomplish and document these activities.

During 2004-2006, project dredging activities included all or portions of seven Sub-areas (A, C/D2S, POG1, POG2, POG3, POG4, and E1). These areas were targeted because they comprise the high concentration areas in OU1 from the standpoint of higher PCB mass, surficial concentrations and average PCB concentration within the 1.0 ppm footprint, and they were upstream of the remaining sub-areas. This remedial activity substantially changed the OU1 site characteristics from the pre-project condition. Detailed information about OU1 site characteristics is presented in Section 2 of this document.

Dredging during remedial actions in 2004-2006 removed the majority of the PCB mass associated with the 1.0 ppm footprint. By focusing on OU1 high PCB concentration sub-areas in 2004-2006, nearly two-thirds of the PCB mass in the 1.0 ppm footprint areas has been removed.

In 2007, dredging activities focused on completing the remaining portion of one high concentration sub-area not previously completed, as well as a discrete portion of one sub-area with a PCB concentration over 50 ppm and a small area (less than 1 acre) with a surficial concentration greater than 10 ppm. In addition, dredging was performed in lieu of capping to allow for a water depth of no less than 6 feet over all cap surfaces, or for operational efficiencies. Specifically, dredging and/or re-dredging occurred in Sub-areas A, C/D2S, D1, E1, E2, E3S, E3N, E4, E5, E6, POG1, POG2, POG3S, POG3N, and POG4S. The 2004-06 dredging was highly effective in terms of PCB mass removal. Due to the decreased concentration of PCBs remaining in OU1 after the previous dredging, the 2007 dredging was less effective in removing PCB mass for all but a very limited inventory of post-2006 sediment. Redredging in 2007 occurred, where feasible, in areas where post-dredge residual PCB concentrations exceeded 5 ppm PCBs.

In 2007, sand cover was placed for residuals management over several acres that had previously been dredged. This work was performed in 2007 to assist with planning for future residuals management of dredged areas.

Finally, a cap placement test was performed at the end of the 2007 remediation season to test placement rates and operational performance for both sand and armor stone placement. The results of the placement test will be used in designing the details of both the sand cover and the engineered armored caps.

1.5 ROD Amendment for OUs 2-5

The OU2-5 Final Basis of Design Report (BODR) (Shaw/Anchor 2006) developed an OU2-5 Optimized Remedy that includes a combination of dredging, engineered armored capping, and placement of sand covers. The OU2-5 Optimized Remedy is designed to achieve the risk-based SWAC goals and remedial time frame in the ROD. Collection and analysis of new project data were critical in the development of the OU2-5 Optimized Remedy. EPA and WDNR approved the OU2-5 Optimized Remedy via a ROD Amendment issued in June 2007.

Similarly, as a result of the collection and analysis of new project data in OU1, as well as remedial work from 2004-2007, GW Partners gathered a significant amount of new high quality data on PCB delineation and remedial construction operations at OU1. These data are critical in the development of the OU1 Optimized Remedy.

Like the Amended ROD Remedy for OU2-5, the OU1 Optimized Remedy described in this document includes dredging, engineered armored caps, sand cover, and the implementation of institutional controls and monitoring and maintenance protocols. The OU1 Optimized Remedy addresses all sediments above the 1.0 ppm RAL and achieves the 0.25 ppm SWAC through more cost effective and less intrusive remedial methods than the 2002 ROD Remedy.

1.6 Future Remedial Alternatives for OU1

1.6.1 ROD Remedy

Completion of the OU1 ROD remedy would require an additional 522,300 cy of sediment removal beyond what has already been dredged (assuming a 4-inch overcut allowance, but not accounting for high subgrade) and the placement of post-dredge sand cover over 250 acres of dredged areas to attain a 0.25 ppm PCB SWAC. Completion of the ROD Remedy would take another 7 years following the 2007 season and would result in an estimated additional cost of between $71 million and $83 million, post-2007, for a total cost of between $138 and $150 million. The ROD Remedy is discussed in more detail in Section 3.

1.6.2 OU1 Optimized Remedy

As noted above, the OU1 Optimized Remedy will attain the 0.25 ppm SWAC objective in another two years. The substantial reduction in SWAC and PCB mass will result from the dredging of high PCB concentration areas in 2004-2007 and implementation of a mix of remedial options from 2008 through 2009. The Optimized Remedy includes completion of dredging in early 2008, as well as post-dredge sand covers where needed for residual management, engineered armored caps, and sand covers over undredged low PCB concentration areas in 2008/2009.

The remedial action components for the OU1 Optimized Remedy are further discussed in Section 4.

2. Site Characteristics

2.1 Physical Site Characteristics

The framework for the Optimized Remedy is based on a number of considerations regarding site features, including physical site characteristics. The physical characteristics relevant to the OU1 Optimized Remedy are summarized below.

2.1.1 Site Uses and Survey

Current land use in the vicinity of OU1 includes a variety of residential, commercial, and industrial activities. Because of historic issues with water quality in LLBdM, not associated with the presence of PCBs, the surface water resource is not used as a source of potable or domestic use water. Water sources for these uses include Lake Winnebago and groundwater. The main users of the surface water resource include industrial, commercial, and recreational users. The primary recreational uses on LLBdM include fishing, boating, swimming, sailing, personal watercraft, and waterfowl hunting.

A boat use survey was completed by Foth on LLBdM in August and September 2006. The primary purpose of the boat survey was to provide the basis for selection of a design vessel and modeling scenarios to support propeller wash studies. The OU1 boat survey was compared to an OU2-5 boat survey that included Lake Winnebago. The OU2-5 survey consisted of more vessels and a larger size range than the OU1 boat survey. In order to be consistent and protective over time, the OU2-5 boat survey will conservatively be used for the OU1 prop wash cap design work. A summary of the impact of prop wash on cap design is included with the Cap Design Summary (Appendix A).

2.1.2 Infrastructure Restrictions

When considering remedial action work in OU1, logistical considerations must be given to infrastructure within LLBdM. For example, from 2004-2007, the dredging operation addressed pipelines and water intakes in several sub-areas. Many of these features that may provide constraints or limitations to construction operations during remedial action have been identified and field verified.

Infrastructure and obstructions that lie within or cross LLBdM include:

- Road and railway bridges;
- Submerged and overhead cables;
- Submerged pipelines and sewers;
- Intakes and outfalls;
- Dams;
- Active or inactive piers;
- Submerged or exposed pilings;
- A navigational channel; and
- Other submerged structures.

The infrastructure having the potential to impact dredging and capping operations in OU1 are presented in Figure 2-1 (RETEC 2004). As indicated, most of the infrastructure and obstructions in LLBdM is located south of the Highway 441 bridge. These include numerous submerged pipelines and sewers that have been identified through desktop surveys and field verification as part of the ongoing dredging operations in OU1. The rail crossing identified is no longer operational as a rail corridor, but serves as a pedestrian/bike path. Of the infrastructure identified to date in OU1, only the Highway 441 bridge and the submerged pipeline immediately south of the bridge are located in post-2006 areas. Exact infrastructure locations will be more precisely identified during future design and remedial action phases of the project.

2.1.3 Nearshore Areas

Nearshore shallow water areas exist within OU1. It is not always possible to address all areas located in shallow water due to technological limitations. Going forward, these very small areas in OU1 will be evaluated on a case by case basis, as has been done during the 2004-2007 construction work. In 2007, measures have been taken to dredge these near-shore targeted areas during times of highest water levels. If the water depth in 2008 is such that equipment can not access these near-shore target areas and PCB concentrations are sufficiently low, no further action will be proposed and the remaining surface PCB concentrations will be taken into account in the final SWAC evaluation. Overall, the extent of near shore areas where only natural recovery would occur is less than 1 acre, an insignificant amount relative to the overall Optimized Remedy footprint.

Other near shore areas also cannot be dredged due to stability concerns with adjacent shorelines and/or shoreline structures. Shoreline stability issues have been identified on a sub-area by sub-area basis prior to dredging each year. Field surveys have documented the existing slope of the top of sediment and native shoreline in proposed areas where the dredge prism contacts the shoreline. If existing top of sediment slopes are already at or steeper than a 5 horizontal to 1 vertical (5:1) slope, the sediments on those slopes have been excluded from the dredge prism for the relevant sub-area. These excluded areas may then be candidates for sand cover if the water depth is adequate, and other practicality issues do not preclude sand placement operations.

The 5:1 slope was established as a stability “benchmark” for OU1 using classic failure surface analysis in Sub-area A prior to the 2005 dredging season. Only limited areas with slopes at or steeper than 5:1 have been identified in OU1, all in Sub-area A. No additional steep shoreline areas have been identified in the remaining near shore dredging areas in OU1. Specific areas with adjacent shoreline structures and slopes flatter than 5:1 may also be avoided for dredging if the risk of failure warrants a higher factor of safety. To date, no such areas have been encountered in OU1.

2.1.4 Hydraulic Conditions

2.1.4.1 Surface Water Hydrology

The Lower Fox River flows northeast for 39 miles from Lake Winnebago to Green Bay. The Fox River is the largest tributary to Green Bay, draining approximately 6,330 square miles, with a mean annual discharge of 5,000 cfs (USGS 1998). From Lake Winnebago to Green Bay, the River drops 168 feet through a series of locks and dams. The Lower Fox River flows across a relatively low permeability substrate comprised of Quaternary deposits of lacustrine clay, silt, and glacial till, throughout much of its length. Bedrock exposures of the Sinnipee dolomite out-crop in parts of the river outside the OU1 action areas. Groundwater discharge to the River is therefore limited, and is discussed in more detail in Section 2.1.4.4, Hydrogeologic Setting.

The established Low Water Datum (LWD) for LLBdM, based on the National Oceanic and Atmospheric Administration (NOAA) chart between the Menasha Lock and Appleton Lock 1, is 736.1 feet (International Great Lakes Datum (IGLD) 1985). OU1 bathymetric surveys, sediment poling surveys, design work, and dredging have all been based on NAVD 1988 Datum, and equivalent low water elevation expressed in NAVD88 is 736.23 feet.

Information on the historic and maintenance levels of the lake was obtained by personal communication with the US Army Corps of Engineers (USACE).[1] According to the USACE, water levels within LLBdM are regulated in reference to the sill for the Appleton Lock 1. The federal authorized channel depth for navigation within that lock is 6.0 feet in depth. The crest of the dam is 6.1 feet and the upper limit is 7.0 feet. The crest of the dam (6.1 feet) is the same elevation as the LWD (736.1 feet, IGLD 85). Typically, the lock is regulated so that the water level is approximately 6.5 feet, which is equivalent to approximately 0.4 feet above LWD. The USACE operates the Upper Appleton Dam so that the water in the pool created by the dam does not drop below the crest of the dam (Stanick 2006).

The USACE also noted in a separate communication that routine maintenance on the Upper Appleton Dam did not require lowering of the water level below 736.1 feet. According to the USACE, any major work on the dams (*e.g.*, painting of the gates or replacing seals) is accomplished with the use of a coffer dam in front of individual gates.

2.1.4.2 Lower Fox River Flows

The U.S. Geological Survey (USGS) has monitored stream flow in the Lower Fox River at several different gaging stations within the watershed. The longest historical stream gaging record is at the Rapide Croche Dam in Wrightstown in the lower reach of OU 2 (#04084500). Flow rates at Wrightstown have been recorded continuously since 1917 providing a long term data set for determination of flow recurrence intervals (http://waterdata.usgs.gov/wi/nwis/rt; WDNR 2000).

Flow rates during a typical year vary from 30 to 280 cubic meters per second (m^3/s; 1,060 to 9,900 cubic feet per second (cfs)). The late summer months of August and September generally exhibit the lowest flows (Table 2- 4; Retec 2002). The highest discharge typically occurs during the spring months of March through June, when the River is recharged by snowmelt and spring rains. The highest flow rate recorded on the River in the past 80 years occurred in April 1952. This maximum recorded flow was approximately 680 m^3/s (24,000 cfs), which corresponds to a 100-year recurrence interval.

[1] Personal communications (2006) with Bob Stanick/USACE – Fox River Sub-Office, Kaukauna, Wisconsin, and Tim Calappi/USACE - Detroit, Michigan.

The USACE oversees and maintains discharge from Lake Winnebago to the Lower Fox River. The USACE operates the Menasha and Neenah dams so that the discharge from Lake Winnebago is normally split equally between the two dams.

2.1.4.3 Lower Fox River Velocities

River velocity is a key factor in sediment deposition and erosion processes in the Lower Fox River, and is also a critical parameter for evaluation of any proposed cap (Palermo et al. 1998a & 1998b, Johnson Co. 2001). The average stream flow velocity in the LLBdM Reach is 0.15 m/s (0.51 ft/s) and velocities range from 0.08 to 0.35 m/s (0.26 to 1.15 ft/s). However, in LLBdM itself (water column segments 2 through 9), the average steam flow velocity is just under 0.13 m/s (0.42 ft/s) and overall velocities range from 0.08 to 0.20 m/s (0.26 to 0.65 ft/s). This lower average for LLBdM is due to the fact that LLBdM is a wide, generally shallow impoundment in comparison with the rest of the River. This is evident by the increased stream flow velocity in water column segments located at the outlet of LLBdM where the cross-sectional area decreases significantly compared to the other portions of LLBdM.

2.1.4.4 Hydrogeologic Setting

The Lower Fox River occupies a lowland area approximately 10 miles wide, commonly described as the Fox River Valley. The Lower Fox River generally flows across relatively low permeability Quaternary deposits of lacusterine clay and silts and glacial till (Krohelski and Brown, 1986). These low permeability units underlie operable units OU1, OU3 and OU4 and sections of OU2. The clay, silt and till vary in thickness from less than 50 feet to over 100 feet (Need, 1985).

The Upper Aquifer in the area is composed of Silurian dolomites east of the Lower Fox River, and the unconsolidated glacial tills and lake sediments that cover the entire area. Groundwater movement in the Upper Aquifer is part of the local flow system and controlled by local topographic features. Because the Lower Fox River lies in a wide low valley, trending southwest to northeast, regional groundwater movement is toward the River (Krohelski and Brown, 1986; USGS, 1998). There have been no detailed studies of the Upper Aquifer to quantify the amount of ground water discharging to the Lower Fox River. Draw down in the St. Peter aquifer since the development in 1900s has caused an increase in discharge from the Upper Aquifer downward to the St. Peter, reducing the volume of ground water discharging to the Lower Fox River (Conlon, 2002). However, it is likely that groundwater from the Upper Aquifer discharges to the Lower Fox River during periods of low or base flow. Discharge to the River is limited due to the following factors:

- Relatively impermeable tills and lake bed deposits, 50 - 100 feet thick, in which the river bed flows;
- Moderate to low head conditions between the Lower Fox River and the Upper Aquifer;
- High surface run-off after storm events, reducing recharge to the Upper Aquifer; and
- Pumping rates for municipal and industrial use, and consequential drawdown.

The groundwater advection component in Little Lake Butte des Morts (LLBdM) was evaluated using three different methods. First, the literature regarding groundwater use, quality, and quantity in northeastern Wisconsin was analyzed to determine the likelihood of a regional upward or downward hydraulic gradient in the vicinity of LLBdM. This review concluded that it is more likely there is a downward hydraulic gradient through the bed of the Lake. A major factor supporting this conclusion is that the lake elevation is maintained well above its natural level by a set of dams and locks. For the second evaluation, a gross estimate of upward groundwater flow was made with the conservative assumption of a significant upward gradient (0.2) and a moderate permeability for silt ($1x10^{-6}$ cm/s), which yielded groundwater flow of 6.3 cm/yr. through the lake bed. This level of advection is not high enough to significantly influence the chemical isolation layer thickness of the proposed cap. Third, Wisconsin Department of Transportation (DOT) boring logs from the HWY 10 bridge project crossing LLBdM and Wisconsin Department of Natural Resources (WDNR) files were reviewed. The boring logs were used to generate a geologic cross-section that subsequently was modeled to quantify the flux of groundwater through the lake bed. The geologic cross sections identified a thick silt layer and a nearly contiguous clay layer beneath LLBdM. The groundwater modeling results also indicated the groundwater flow into the lake to be negligible. Full results are presented in the Foth OU1 Cap Design Revision No. 2 (Foth, forthcoming December 2007).

The significant users of water in the Little Lake Butte des Morts area primarily use surface water from Lake Winnebago (*e.g.*, cities of Neenah, Menasha, and Appleton). Other users of water, such as towns and smaller cities, do not obtain their water from the upper aquifer, but instead use the Maquoketa Sinnipee confining layer. This relatively impervious layer has depths in the LLBdM area of just under 100 feet. Because the major water users in the area are obtaining their water from surface water or the deep aquifer any future water change would not impact upper aquifer recovery.

2.2 Sampling and Analysis Data

2.2.1 Pre-Design Data

As one of the initial steps in performing the Lower Fox River OU1 Remedial Design (RD), the available data was evaluated for sufficiency as part of the *Lower Fox River OU1 Pre-design Sampling Plan* (CH2M HILL 2003). As anticipated, the available PCB and physical data were of insufficient quantity and quality to perform the RD.

The *Lower Fox River OU1 Pre-design – Basis of Design Report* (CH2M HILL 2005) describes the 2003-2004 data collection effort and presents the data that form the basis of this OU1 Design Supplement. During the pre-design, sediment core sampling was attempted at 996 core locations. At 129 of these 996 locations, either no soft sediments were encountered or a sample could not be recovered for laboratory analysis. More than 5,900 total field samples (not including quality control samples) were collected during the two phases of sediment PCB delineation sampling. All sediment data was collected with a vertical accuracy of +/- 5 centimeters (cm) and a horizontal accuracy of +/- 1 meter. This was accomplished by equipping the sampling vessel(s) with a Real Time Kinematic (RTK) Differential Global Positioning System (DGPS).

With the exception of Sub-area A, the basis for the sediment core collection within the sub-areas was a systematic triangular sampling grid that was used to map out sediment core locations depending on the selected core sample density for the individual sub-areas. The core sampling density used was either a one core per acre density or a one core per 2-acre core density. For all pre-design sediment PCB analyses, the sediment cores were divided into 10 cm (4-inch) vertical intervals. Sub-area A was not sampled using a systematic triangular grid due to the existence of a greater number of historic (pre-2003) sample data, of sufficient quality, which allowed for the use of a different sampling scheme, specific to the larger data density at Sub-area A.

Additional core sampling and poling surveys were conducted as pre-dredge recharacterization efforts. Additional sampling in April 2006 was conducted in Sub-areas C, D2S, POG2, POG3, and POG4. The poling survey added 405 new points to define the sediment thickness, and additional core samples were attempted at 16 locations in southern Sub-area POG3, adding 32 PCB sample points to the GMS-SED dataset (Foth 2007a). Additional core sampling was also conducted in December 2006, January 2007 and February 2007, to support recharacterization for the 2007 Remedial Action. The GMS-SED dataset was expanded by 55 additional PCB samples in the Sub-areas D1, D2N, E3, F, E4, and E6 (Foth 2007b). As of February 2007, the GMS-SED database included roughly 5949 non-duplicate PCB samples at 996 core locations in pre-dredge areas.

2.2.2 Pre-design Sediment PCB Modeling

The primary objective of the OU1 sediment modeling was to accurately delineate the extent of areas that contain PCBs greater than the 1.0 ppm RAL. Data visualization methods and modeling techniques were used to visually present data points (with associated contaminant concentrations) and to model and predict contaminant concentrations three-dimensionally. These methods were used to delineate the horizontal and vertical extent of contaminant concentrations and to output the spatial extent of required remedial activities based on the 1.0 ppm RAL.

The objective of the PCB delineation was to support the RD in such a way that a reasonable level of assurance was developed such that sediment exceeding the RAL was accurately defined. A three-dimensional (3-D) interpolation method was used to delineate the 1.0 ppm PCB extent in OU1. The computer application GMS v. 4.0 (Environmental Modeling Systems, Inc.) was used, along with the GMS implementation of Shepard's inverse-distance weight (IDW) method, to interpolate PCB concentrations from sampling points within the OU1 sediments.

All field investigation data were gathered and combined in an electronic database. The sediment characterization data were evaluated to determine the extent of the sediments containing PCBs at concentrations greater than 1.0 ppm. The lateral and vertical extent of the 1.0 ppm PCB concentration were used to delineate the sediment removal areas and to set the dredge elevations within these sub-areas for the purposes of remedial activities in OU1. The sediment modeling details are further presented in the GMS Modeling Methodologies White Paper (Appendix B). Additional details of pre-dredge recharacterization efforts are also discussed in the *2006 Remedial Action Summary Report* (Foth, 2007a) and the *2007 Remedial Action Work Plan* (Foth, 2007b)

2.2.3 OU1 Pre-dredge Sediment PCB Mass Comparison

Table 2-1 shows that the OU1 pre-dredge sediment PCB mass based on the pre-design data are 33% and 20% less than the OU1 sediment PCB mass estimated in the ROD and RI/FS, respectively. As detailed in the previous section, this refined estimate is based on considerably more data than was available during the preparation of the RI/FS and ROD. In other words, the decreases in the estimated mass of PCBs in OU1 are the result of better data, as discussed below.

Table 2-1
Comparison of OU1 PCB Mass Within 1.0 ppm Prism (kg)

Sub-area	ROD[1]	RI/FS (2002)[2]	Pre-design (2006)[3]	Comparison of Pre-Design to Earlier Estimates
A		237	218.3	-7.9%
B		409	0.0	-100.0%
C		35	33.5	-4.2%
D		78	37.6	-51.7%
E		373	331.4	-11.2%
F		3	2.5	17.1%
G		0	0.0	0.0%
H		0.4	0.0	-100.0%
POG		299	519.5	73.7%
Total	1,715	1,434.4	1,142.9	-20% (RI/FS) -33% (ROD)

Notes:
[1] Source: OU1 ROD, pg. 80
[2] Source: December 2002 RI, Table 5-14; December 2002 FS, Table 5-3
[3] Source: Calculated by Foth using OU1 pre-design data including the Jan./Feb. 2007 re-characterization results and the GMS modeled 1.0 ppm dredge prism with no overcut allowance

The greatly expanded data set and the refined modeling has resulted in a significantly lower estimate of OU1 mass for the following reasons:

Insufficiency and inaccuracy of ROD and RI/FS data

The RI and FS rely on statistical manipulation and data interpolation to fill in large geographic gaps in the data collected. Sample density is critical to mass estimation because there is generally poor spatial correlation of high PCB concentrations in OU1. Typically, when high PCB concentrations are found, nearby samples (both vertically and horizontally) often show a much reduced concentration. Therefore, interpolations with lower sample densities tend to overextend the influence area of core locations with higher PCB concentrations. For this reason, higher data density typically leads to lower mass estimates.

In addition, higher PCB concentrations are often correlated with lower solids contents. PCB mass estimates that are based on coupled estimates of PCB concentration and solids content are often lower (and more accurate) than estimates using an average solids content. Here again, if average percent solids are used in estimating PCB mass, the lower sample densities may result in over-predicting PCB mass in areas near to core locations with high PCB concentrations.

A third factor introducing error is that the model used to compute the RI/FS estimates of PCB mass was a two-dimensional model that was extrapolated into three dimensions using relatively thick vertical sediment layers. The existence of these thick layers of assumed contaminated sediment caused the erroneous appearance of additional mass. By contrast, the GMS-SED model currently in use is a three-dimensional model capable of more refined vertical interpolation.

A few examples of how these principles introduced error into previous PCB mass estimates are described in the following paragraphs.

One of the notable changes between the mass estimates described above is the reduction of PCB mass with concentrations over 1 ppm in Sub-area B from 409 kg in the RI/FS to 0 kg in recent estimates. Earlier estimates for PCB mass in Sub-area B were misleading because no samples in Sub-area B were found to have PCB concentrations at or above 1.0 ppm. It appears that earlier mass estimates were based on interpolation from samples in Sub-area A. Using the additional sampling and modeling methods described below, GW Partners confirmed that Sub-area B sediment concentrations are below 1.0 ppm.

Another sub-area, formerly known as Deposit E, comprises much of the northern half of Little Lake Butte des Morts. The RI/FS Deposit E PCB mass estimate includes the statistical interpretation of data from only two sampling locations in a higher concentration area in Deposit E, collected almost twenty years ago during the 1989/90 Mass Balance Study. In other words, the documentation of a 47 acre area of significant PCB concentration consisted of data interpolation from only two sampling points.

In still other areas, such as the POG deposits, the new data show that areas of higher PCB concentration are smaller and shaped differently than what is predicted by the RI/FS. These differences show that the interpolation of PCB mass from small numbers of samples is statistically problematic. In Sub-area POG, the RI/FS interpolation that shows PCBs extending out from the navigational channel errs because it does not account for the physical discontinuity of the channel.

The limited number of available sediment samples in several sub-areas, of which B, E and POG are examples, created the need for extensive interpolation. As described in the next section, expanded data collection efforts during pre-design and remedial action eliminated the necessity for that interpolation. The resulting new calculations are more directly based on actual data.

Expanded data collection efforts during pre-design and remedial action

During the pre-design and recharacterization efforts, more than 5,900 core samples (not including quality control samples) were collected during several phases of sediment PCB delineation sampling. By contrast, the RI/FS interpolations were based on only 539 samples taken at 293 coring locations. This low sampling density necessitated the use of an "interpolation radius" of 1,312 feet (400 meters). This is a very large interpolation radius considering that the width of much of OU1 is only about twice this radius (3,000 feet) or less for most of its length.

The expanded data set enabled more accurate modeling.

The primary objective of the OU1 sediment modeling was to accurately delineate the extent of areas that contain PCBs greater than the 1.0 ppm RAL based on the expanded data set. The current estimate of OU1 PCB mass has been further refined after dredging has taken place. The post-dredge sediment PCB results from all deposits that have been dredged have been factored into the model to generate the current estimate. Therefore, in addition to the pre-design data, thousands of physical and analytical measurements taken of post-dredge sediments were evaluated. These data have been used to further refine the current model estimate of OU1 PCB mass.

The findings of less PCB mass in OU1, as compared to ROD and Remedial Investigation/Feasibility Study (RI/FS) estimates, is not only a positive for the overall OU1 environment, but also better instructs the development of an Optimized Remedy for OU1.

2.2.4 Dredging to the 1.0 RAL and Overcut

Prior to dredging sediments, target dredge elevations were established based on the modeled extent of sediments exceeding the 1.0 ppm RAL. However, even using the best available dredging technology, the OU1 dredging operation needs to remove an average of 4 inches of additional sediment in order to assure that the targeted dredge elevations are achieved at least 95% of the time. This additional dredge cut beyond the targeted dredge elevation is referred to as dredge overcut. With an average targeted sediment thickness of 1-foot in OU1, an average 4-inch overcut increases the actual dredge volume by 29%. The practical necessity of a dredge overcut was acknowledged in the Lower Fox River Feasibility Study (FS), although the increased volume and cost implications were not addressed in the FS or the ROD.

2.2.5 Data Gathered During Dredging

This Design Supplement incorporates the complete post-dredge data from the 2004, 2005 and 2006 dredging seasons and 2007 recharacterization data. For SWAC estimation, the 2007 post-dredge sediment data through August 8, 2007 are also incorporated. For PCB mass calculations, all post-dredge data through 2006 were used, as well as the 2007 recharacterization data collected through January 2007 (Foth 2007b).

For 2007 locations where the post-dredge PCB data have not yet been obtained (post August 8, 2007), estimates were made for PCB mass removed, residual sediment concentrations, and volumes removed. Residual sediment concentrations were assumed to average 1.01 ppm. Mass and volume removal estimates were obtained from the pre-dredge and post-dredge sediment bed models, with a mass removal efficiency of 92%. These assumptions are based on project experience to date. Project metrics will continue to be adjusted when the actual data are obtained.

Additionally, thousands of physical and analytical measurements taken of surface water, post-dredge sediments, air, dewatered sediments, and treated water during the 2004-2007 dredging seasons have been evaluated during the development of the OU1 Design Supplement. These data have been routinely submitted to the Agencies and are also presented in the year-end project summary reports.

2.2.6 Post-Dredge Sediment Residuals Data

Post-dredge sediment PCB analytical data collected during the 2004-2007 dredging seasons are summarized in Table 2-2. The data are presented as PCB SWAC values, which are summarized for pre-project and post-dredge conditions. Detailed SWAC and PCB mass calculation methodologies are in the OU1 PCB SWAC white paper attached as Appendix C.

The sub-areas in OU1 targeted for dredging in 2004-2006 (including the remainder of Sub-area POG3 for 2007) represented the higher pre-project SWAC values. The post-dredge results for these sub-areas demonstrated a marked reduction in SWAC. The SWAC in these areas is now more characteristic of non-high concentration areas in OU1.

Table 2-2
Sub-areas Dredged 2004-2007
Actual Pre-and Post-Dredge SWAC in Dredged Areas[1]

Sub-area	Pre-Project SWAC (ppm PCBs)	Post-Dredge SWAC (ppm PCBs)
A	12.7	1.6
C	7.9	1.1
D1	2.3	0.4
D2S	3.7	1.0
POG1	16.7	0.4
POG2	2.3	4.0
POG3	20.8	0.6
POG4	1.0	0.5
E1	2.9	0.6
E2	2.1	<0.1
E3S	2.2	0.8

[1] Table includes areas dredged with existing post-dredge data collected through August 8, 2007. SWAC estimates are 4-inch surface estimates in dredge areas only. Pre-Project SWAC estimates include results of additional sampling conducted in 2007.

For all of OU1, the pre-project (prior to 2004 remedial action work) SWAC was 1.9 ppm PCBs. Following the 2007-08 dredging work, the SWAC value will be approximately 0.63 ppm PCBs. This SWAC reduction of 1.3 ppm was achieved via dredging approximately 47% of the 1.0 ppm footprint in OU1. The Optimized Remedy will remove 74% of the PCB mass to be dredged under the ROD Remedy (using the updated estimates) and will address 97% of that mass with a combination of active remedial measures (dredging, engineered armored capping and sand cover). Capping will only be performed in areas where stability and permanence is assured, and the other restrictions of the ROD Contingent Remedy would apply unless the Agencies agree that they are impractical (*e.g.* water depth restriction in the near shore areas).

2.2.7 OU1 Post-2007 Characteristics

Table 2-3 summarizes the sediment quantities addressed by dredging in OU1 from 2004-2007.

- The data show that 74% of the PCB mass will have been removed by the completion of dredging work in OU1. Similarly, 41% of the volume of sediment within the 1 ppm RAL footprint will have been removed. The remaining sediment volume (424,900 cy) contains only 26% of the original OU1 PCB mass.

Table 2-3
Actual and Estimated OU1 Sediment Quantities Addressed by Dredging

Project Year	Area Addressed		Volume Removed (with overdredge)		Volume Removed (without overdredge)		PCB Mass in 1 ppm RAL Footprint	
	(Ac)	(%)	(cy)	(%)	(cy)	(%)	(kg)	(%)
OU1 Total (1 ppm RAL Footprint)[a]	426	100%	928,400[d]	100%	721,200[b]	100%	1,143	100% -
2004-2006[c]	121	28%	210,000	23%	153,100	21%	699	61.2%
2007-2008[d]	95	27%	196,100	21%	143,200	20%	144	12.6%

[a] Quantities reflect pre-design GMS-SED model estimates updated with the 2007 re-characterization results.
[b] The increase in total ROD Remedy dredge volume due to overdredge is approximately one-third.
[c] Quantities reflect actual post-dredge results. PCB mass estimate reflects actual mass removed without overcut.
[d] For 2007-2008 dredge area quantities are estimates reflecting pre-design data and 2007 re-characterization data. PCB mass estimate reflects modeled mass within the 1 ppm footprint with 92% removal efficiency.

The following PCB mass per volume values (without overcut) illustrate the declining PCB concentrations as OU1 remediation work proceeds:

- Removed in 2004-2006: 3.5 g/cy
- Removed in 2007-2008: 1.9 g/cy
- Remaining areas after completion of all dredging: 0.7 g/cy
  - 0.9 g/cy in the proposed cap regions
  - 0.3 g/cy in the proposed sand cover areas (excluding residual sand cover areas)

2.3 Extent of PCBs in OU1 Sediments

2.3.1 OU1 PCB Distribution

The distribution of pre-project surficial PCB contamination in OU1 sediments are presented in Figure 2-2. Surficial concentration refers to the upper 8-inch sediment segment (*i.e.*, contiguous two 4-inch sediment layers). This figure illustrates how the southern section of OU1, prior to 2004, contained high PCB concentration areas. Figure 2-3 presents post-2006 surficial conditions, where the high PCB concentration areas in the southern section of OU1 have been removed.

The post 2006 surficial PCB results (Figure 2-3) clearly indicate the 2004-2006 dredging was successful in addressing the high PCB concentration areas, as shown on the Pre-Project Figure 2-2. For example, prior to 2004, PCB surficial concentrations at certain locations in Sub-areas A and POG3 were greater than 50 ppm (Figure 2-2). Following 2004-2006 dredging, the surficial concentrations dramatically decreased (Figure 2-3). The SWAC estimate for Sub-area A decreased from 13.1 to 2.9 ppm, and for Sub-area POG3 decreased from 21.2 to 0.8 ppm

PCBs. The surficial concentration decreases from these two sub-areas significantly reduced the risk profile of OU1.

Pre-project maximum PCB sediment concentrations at depth (meaning concentrations anywhere throughout the sediment column) are presented in Figure 2-4. Post-2006 PCB sediment maximum concentrations at depth are presented in Figure 2-5. As seen with surficial concentrations, the characteristic high PCB concentration locations are no longer present and these areas are now more characteristic of the low PCB concentration sub-areas present in the mid to northern sections of OU1.

2.3.2 PCB Mass Estimates

Pre-project and post-dredge PCB mass in dredge areas, calculated for OU1 as a whole and also by sub-area, are presented in Table 2-4. Calculations refer to the actual dredge regions within the 1.0 ppm footprint. Mass estimates were calculated including a four-inch overcut, or overcut to clay, whichever is less.

Table 2-4

PCB Mass Removed[1]

OU1 Dredge Areas	Dredge Area (Ac)	Pre-Project PCB Concentration in 1.0 ppm area (g/cy)	Pre-Project PCB Mass (Kg)	Post-2008 PCB Mass (Kg)	Mass Removed (Kg)
OU1 Total	215.7		877	35	842
A	40.6	3.8	214.6	8.6	206
C	13.6	1.6	31.2	1.5	29.7
D1	28.6	0.8	30.7	2.5	28.2
D2N	0.2	0.4	0.1	0.01	0.09
D2S	4.9	1.6	2.5	0.8	1.7
E1	3.7	0.5	19.6	0.2	19.4
E2	2.5	1.0	18.2	1.5	16.7
E3N	0.6	0.3	0.4	0.03	0.37
E3S	42.8	0.6	35.3	2.8	32.5
E4	1.1	0.3	0.7	0.1	0.6
E5	0.7	0.2	0.2	0.01	0.19
E6	5.7	1.0	8.4	0.7	7.7
F	0.1	0.3	0.05	0.002	0.048
POG1	7.8	1.5	37.4	0.1	37.3
POG2	11.3	2.2	141.8	10.3	131.5
POG3	46.1	6.1	328.9	5.3	323.6
POG4	5.4	0.4	7.4	0.2	7.2

[1]Note: Quantities reflect areas within regions dredged or proposed for dredging through 2008. Pre-project estimates include re-characterization data. Post-2006 quantities reflect actual post-dredge results collected through 2006. Quantities for 2007-2008 are estimated assuming 92% mass removal efficiency. Quantities do not include overdredge.

Table 2-4 highlights the significant PCB mass removal from the high concentration sub-areas. Figure 2-6 depicts projected post-2008 PCB maximum concentrations.

2.3.3 SWAC Estimates

Table 2-5 shows PCB surficial concentrations for each sub-area, to illustrate the difference between the high concentration sub-areas and the other OU1 sub-areas. By the end of 2007-08 dredging, the OU1 SWAC will have been reduced from 1.9 to 0.63 ppm. Of note, PCB surficial concentrations in sub-areas not dredged are similar to surficial concentrations in sub-areas that have been dredged. Detailed SWAC and PCB mass calculation methodologies are in the OU1 PCB SWAC white paper attached as Appendix C.

Table 2-5
OU1 SWAC Summary by Sub-area

OU1 Sub-area	SWAC (ppm) in Total Sub-area			SWAC (ppm) in Dredged Areas[a]		
	Acres	Pre-Dredge	Post-Dredge	Acres	Pre-Dredge	Post-Dredge
OU1 (Including Null Areas)	1363	1.9	0.63	149	12.3	1.2
A	72	7.5	1.2	40	12.7	1.6
C	19	6.6	1.0	14	7.9	1.1
D2S	30	1.1	0.5	5	3.7	1.0
D2N	34	0.6	0.6	-	-	-
D1	64	1.4	0.8	15	2.3	0.4
POG1	8	16.7	0.4	8	16.7	0.4
POG2	13	2.1	3.7	11	2.3	4.0
POG3	98	9.7	0.7	45	20.8	0.6
POG4	162	0.4	0.3	5	1.0	0.5
E1	73	1.7	1.6	3	2.9	0.6
E2	89	1.7	1.7	1	2.1	<0.1
E3S	102	2.1	2.0	3	2.2	0.8
E3N	50	0.3	0.3	-	-	-
E4	90	0.4	0.4	-	-	-
E5	60	0.7	0.7	-	-	-
E6	29	0.2	0.2	-	-	-
F	69	0.6	0.6	-	-	-

[a] Reflects areas dredged through August 8, 2007.

3. ROD Remedy and Contingent Remedy

3.1 Overview of December 2002 ROD

The December 2002 ROD sets forth the selected remedy for OU1. The remedy selected in the ROD included the following components:

- Site mobilization and preparation
- Sediment removal
- Sediment dewatering
- Water treatment
- Sediment disposal
- Demobilization and site restoration
- Institutional controls and monitoring

As provided in the ROD, if the post-remedial sediment sampling conducted after dredging is completed shows that the 1 ppm RAL has not been achieved in the area sampled, an OU1-wide SWAC of 0.25 ppm PCBs may be used to determine whether the cleanup objective has been achieved. If the 0.25 ppm SWAC has not been achieved in OU1, the ROD provides several options, including potential additional removal of remaining sediments with PCBs in excess of 1 ppm and potential placement of a sand cover over certain areas to reduce surficial concentrations and achieve the 0.25 ppm SWAC.

The ROD also acknowledged that during the RI/FS comment period, the Agencies received numerous comments relating to the viability of capping as a possible remedy. Based on these public comments, WDNR and EPA developed a Contingent Remedy that may supplement the selected remedy in certain circumstances.

According to the ROD, the Contingent Remedy may only be implemented if it meets the following requirements:

1. The Contingent Remedy, consisting of a combination of dredging and capping, must provide the same level of protection to human health and the environment as the selected remedy,
2. The Contingent Remedy must be less costly than the selected remedy to be implemented,
3. The Contingent Remedy must not take more time to implement than the selected remedy,
4. The Contingent Remedy must comply with all necessary regulatory, administrative and technical requirements discussed below, and
5. Capping will not be permitted in certain areas of OU1:

    a. No capping in areas of navigational channels (with an appropriate buffer zone).
    b. No capping in areas of infrastructure such as pipelines, utility easements, bridge piers, etc (with appropriate buffer zone).
    c. No capping in areas with PCB concentrations exceeding Toxic Substances Control Act (TSCA) levels.

d. No capping in shallow water areas (bottom elevations which would result in a cap surface elevation greater than -3 feet chart datum for OU1 without prior dredging to allow for cap placement).

The Contingent Remedy may also be employed in OU1 to supplement the selected dredging remedy if one or both of the following criteria are demonstrated.

1. Based on sampling results taken after a sufficient amount of OU1 dredging of contaminated sediment deposits (e.g. dredging of deposits A/B, C, and POG), it can be predicted with a high degree of certainty that a PCB SWAC of 0.25 ppm would not be achieved for OU1 by dredging alone, or
2. Capping would be less costly than dredging in accordance with the protectiveness provisions and the nine criteria in the NCP.

The decision as to whether one or both of these criteria have been met will be determined solely by the EPA and WDNR. The selection of the Contingent Remedy would be documented in a formal decision document by the Agencies. The non-dredging components of the Contingent Remedy consist of the following:

- ♦ Cap design
- ♦ Demobilization and site restoration
- ♦ Monitoring
- ♦ Institutional controls

The OU1 Optimized Remedy addresses the Contingent Remedy criteria for capping (as defined in the ROD) in the following respects:

- ♦ The OU1 Optimized Remedy includes dredging in the navigational channel. An engineered armored cap is not proposed in OU1's navigational channel, although a sand cover will be used for residual management.
- ♦ Dredging in the immediate vicinity of certain utilities and infrastructure is neither safe nor logistically possible. The OU1 Optimized Remedy includes capping or sand cover of these areas as a more appropriate remedial option, which differs from the Contingent Remedy criteria for capping. This approach is consistent with the OU2-5 ROD Amendment.
- ♦ The Contingent Remedy does not allow capping of PCB concentrations that exceed TSCA levels. Under the OU1 Optimized Remedy, any PCB concentrations exceeding TSCA levels will be dredged.
- ♦ The OU1 Optimized Remedy includes a provision for dredging areas where capping would result in water depth above the cap surface of less than 6 feet. The Contingent Remedy set forth in the ROD allows for capping unless the water depth above the cap surface is less than three feet. Thus the OU1 Optimized Remedy calls for more dredging than the Contingent Remedy due to this increase in the water depth requirement.

Under the OU1 Optimized Remedy, dredging would still be completed in areas not capped.

3.2 Implementation of the ROD Selected Remedy

The Pre-Design data collection and sediment PCB modeling for OU1 resulted in significant revisions to the estimates of PCB mass within the 1.0 ppm dredge prism. The ROD had estimated the PCB mass in the 1.0 ppm areas at 1,715 kg, whereas the more recent estimate based on the additional data collected during pre-design and subsequent modeling is 1,143 kg, or about 32% less than the ROD estimate.

While the estimate of PCB mass within the 1.0 ppm dredge prisms has decreased significantly due to the additional new data, the estimated quantity of sediment to be dredged has increased due to overdredge requirements. In OU1, the overdredge volume is particularly significant as a percent of the total dredged volume because the average 1.0 ppm dredge prism is only one foot thick, while the overdredge volume averages 4 inches. The ROD had estimated that 784,000 cy of sediment would be dredged. Had the ROD included overdredge volumes, its estimate of the total volume of would have been 928,400 cy. In practice, this required volume may be smaller or larger due to additional overcut, the presence of high subgrade and/or operational efficiences.

4. OU1 Optimized Remedy

4.1 Overview

The OU1 Optimized Remedy utilizes a combination of remedial methods to achieve the 0.25 ppm PCB SWAC endpoint. These technologies were carefully selected for application at OU1 sub-area locations based on specific site characteristics at those locations. Key remedial action components include dredging new areas, residual management dredging, residual management sand cover, engineered armored caps, and sand cover of low concentration areas.

This Section 4 of the Design Supplement document is intended to explain each of these actions in detail and analyze the resulting impacts in OU1. Highlights of this section include:

- Section 4.1.1 presents EPA Sediment Guidance;
- Section 4.1.2 presents the location and extent of the OU1 Optimized Remedy components; and
- Section 4.3 summarizes the OU1 Optimized Remedy capping plan.

4.1.1 EPA Sediment Guidance

The OU1 Optimized Remedy is in accord with USEPA's December 6, 2005 Contaminated Sediment Remediation Guidance for Hazardous Waste Sites (the "Guidance"), which endorses using a combination of approaches depending on site-specific characteristics. "At sites with . . . sections of water bodies with differing characteristics or uses, or differing levels of contamination, project managers have found that alternatives that combine a variety of approaches are frequently the most promising." Guidance pg. 3-2.

<u>Dredging</u>

The Guidance endorses special consideration of dredging when the following site conditions, among others, are present:

- High contaminant concentrations cover discrete areas of sediment
- Water depth is adequate to accommodate dredge but not so great as to be infeasible; or excavation in the dry is feasible
- Contaminated sediment overlies clean or much cleaner sediment (so that over-dredging is feasible)
- Long-term risk reduction of sediment removal outweighs sediment disturbance and habitat disruption
- Suitable disposal site is available and nearby
- Suitable area is available for staging and handling of dredged material
- Existing shoreline areas and infrastructure can accommodate dredging or excavation needs; maneuverability and access not unduly impeded by piers, buried cables, or other structures

(Source: Guidance Highlight 6-2, pg. 6-2).

In OU1, approximately 406,100 cy (216 acres) of sediment have been or will be removed by dredging. As per the Guidance, dredging was targeted to those zones of high contaminant concentrations that constituted 74% of the OU1 PCB mass, but only 51% of the OU1 1.0 ppm RAL area (16% of the total OU1 area) and 41% of the OU1 RAL volume. Section 4.1.2 includes identification and characterization of proposed dredge areas and volumes; dredging equipment selection; dredged materials handling, transport and disposal; and post-dredge residuals management.

Capping

The Guidance advises that "project managers should keep in mind that deeper contaminated sediment that is not currently bioavailable or bioaccessible, and that analyses have shown to be stable to a reasonable degree, do not necessarily contribute to site risks." (pg. 7-3). The Guidance endorses special consideration of capping when the following site conditions, among others, are present:

- Long-term risk reduction outweighs habitat disruption, and/or habitat improvements are provided by the cap
- Water depth is adequate to accommodate cap with anticipated uses (*e.g.* navigation and flood control)
- Hydrodynamic conditions (*e.g.* floods and ice scour) are not likely to compromise cap or can be accommodated in design
- Incidence of cap-disrupting human behavior, such as large boat anchoring, is low or controllable
- Sediment has sufficient strength to support cap (*e.g.* higher density/lower water content, depending on placement method)
- Suitable types and quantities of cap material are readily available
- Anticipated infrastructure needs are compatible with cap
- Contaminants have low rates of flux through cap
- Contamination covers contiguous areas (to simplify capping)

(Source: Guidance Highlight 5-1 pg. 5-2).

The Guidance notes that capping "can quickly reduce exposure to contaminants" and "provides a clean substrate for recolonization by bottom-dwelling organisms." Guidance, pg. 5-2, 5-3. Capping also can "be implemented more quickly and may be less expensive than remedies involving removal and disposal or treatment of sediment." Guidance, pg. 5-3. Cap design methodology was also based on the "Guidance for In-Situ Subaqueous Capping of Contaminated Sediments," EPA 905-B96-004, Great Lakes National Program Office, Chicago, IL (Palermo, M., Miller, J., Maynord, S., and Reible, D. 1998b.)

In OU1, areas have been proposed for capping as part of the Optimized Remedy based on a similar analysis, with the key factors being post-cap water depth and contaminant levels at various locations. Approximately 112 acres have been selected for a 13-inch engineered armored cap. OU1 areas addressed via an engineered armored cap will also be subject to a long term monitoring and maintenance plan to assess the cap effectiveness as well as make repairs to areas of failure, if any.

In addition, a 6-inch thick sand cover will be placed on 46 acres over remaining undredged sediments with an average PCB concentration between 1.4 and 2.0 ppm in a single 8-inch interval, where there is no other 8-inch interval with average PCB concentrations greater than 1.0 ppm. A 3-inch thick sand cover will be placed on 68 acres, over remaining undredged sediments with an average PCB concentration between 1.0 and 1.4 ppm in a single 8-inch interval, where there is no other 8-inch interval with average PCB concentrations greater than 1.0 ppm. Together, these two areas of low PCB contamination (PCB concentrations between 1.0 and 2.0 ppm in a single 8-inch interval) will have 114 acres of sand cover placed. Additionally, sand cover will be placed over certain dredged areas to ensure that the 0.25 ppm SWAC is achieved.

The Optimized Remedy capping plan is summarized in Section 4.3. Appendix A contains additional cap design detail including a detailed, OU1-specific discussion of the cap design, including layer thickness determination, ice scour analysis, overplacement analysis, geotechnical analysis, and post-cap water depth; a detailed explanation of the identification and characterization of areas proposed for capping; capping equipment selection and production rates; and a capping quality assurance plan.

The Optimized Remedy sand cover plan is summarized in Section 4.4. Section 4.4 includes an OU1-specific discussion of the criteria used to select areas for sand cover, sand cover equipment selection and production rates, and a sand cover quality assurance plan.

The long-term monitoring plan is summarized in Section 4.6. Section 4.6 describes the objectives of the long-term monitoring and maintenance plan, including achieving the desired cap thickness; verification of cap materials; verification of the physical integrity of the cap; determination of when response actions are necessary; water quality monitoring; and fish tissue monitoring.

Detailed SWAC and PCB mass calculation methodologies are in the OU1 PCB SWAC white paper attached as Appendix C.

4.1.2 OU1 Sediment Bed Model

The basis of the Optimized Remedy is derived from the three-dimensional sediment bed model developed for the OU1 BODR. In the BODR, this model was used to construct the dredge prism, and to interpret the volumes of sediment that needed to be removed to achieve the OU1 RAL of 1.0 ppm. In developing the Optimized Remedy, the model was run with a more robust dataset, producing a more refined output. Three-dimensional concentration areas were delineated and presented as characteristic areas. Modeled percent solids and sediment thicknesses were combined with the concentration data to provide PCB mass estimates. Concentrations from the top four inches of the model were isolated to provide estimates of surface weighted average concentration. These characteristics were then combined with locational data, water depth data, and ROD objectives and criteria to construct the proposed Optimized Remedy.

Specifically, for Optimized Remedy development, the post-dredge model was utilized in conjunction with a GIS-interface to identify and delineate remedy areas. The post-dredge sediment bed model is a combination of the pre-dredge model for areas not dredged, and newly interpolated post-dredge data for areas that were dredged. Newly interpolated data utilizes the data collected through February 2007 (Foth 2007b), and is interpolated under the same parameter settings as for the BODR.

From the three-dimensional post-dredge model, two-dimensional layouts were constructed and imported to the OU1 GIS project. Many two-dimensional layouts were needed to provide the necessary information for remedy development. Among these were maximum PCB concentration over depth, average PCB concentration over depth, average percent solids over depth and total PCB mass over depth. In calculating these layouts, averages and totals were taken vertically from the surface to the 1.0 ppm cutline, with a four inch overcut or overcut to clay, whichever is less.

Other layouts included isopach thickness, sediment thickness to clay and surface PCB concentration.

Within the OU1 GIS project, the two-dimensional information was connected with additional spatial information such as sub-area and DMU delineations, and dredge regions information. Spatial queries were then developed to support remedy identification. The model is described more fully in the OU1 GMS Modeling Methodologies White Paper (Appendix B).

4.1.3 Components of OU1 Optimized Remedy

The proposed OU1 Optimized Remedy will achieve the primary objectives of the ROD – remediating to the 1.0 ppm RAL and meeting the 0.25 ppm SWAC. This objective will be achieved by a remedy that optimizes the use of dredging, capping, sand cover, and residual management.

The remedial components of the OU1 Optimized Remedy are summarized in Table 4-1.

Table 4-1
OU1 Sediment Characteristics, the ROD Remedy and the Optimized Remedy[1]

Remedial Action	Description	Area (Ac)	Volume to 1.0 ppm with 4" overcut (cy)	Volume to 1.0 ppm (cy)	PCB Mass to 1.0 ppm (kg)
Pre-Project Conditions	Entire OU	1363	---	---	---
ROD Remedy	Addresses sediments greater than or equal to 1.0 ppm by dredging, with residual sand cover to attain 0.25 ppm SWAC	426	**928,400**[2] (updated est.)	784,000 (ROD est.) **721,200** (updated est.)	1,715 (ROD est.) **1,143** (updated est.)
Optimized Remedy Components					
Dredge	Dredge[3]	216	406,100	296,300	843
13-inch Engineered Cap[4]	Sediment with average PCB concentrations between 2.0 and 10 ppm in top 8-inch interval, and less than 50 ppm at depth	112	325,100	265,800	229
6-inch Sand Cover	Sediment with average PCB concentrations between 1.4 and 2.0 ppm over a single 8-inch interval, with no other 8-inch interval averaging more than 1.0 ppm	46	76,800	53,000	19
3-inch Sand Cover	Sediment with average PCB concentrations between 1.0 and 1.4 ppm over a single 8-inch interval, with no other 8-inch interval averaging more than 1.0 ppm	68	102,000	67,800	17
Residual Sand Cover	As necessary to attain 0.25 ppm SWAC (area includes 5.5 ac covered in 2007)	30	21,100	19,100	19

[1] The figures presented in this table are modeled estimates, except for the dredge and residual sand cover components, which are based primarily on actual data. Because of variation between actual conditions and modeled estimates, the total acreage, sediment volume, and PCB mass projected for the Optimized Remedy vary from the acreage, sediment volume, and PCB mass estimated for the ROD Remedy.

[2] The ROD estimate did not account for overcut. The overcut volume of 207,200 cubic yards contains only 26 kg of PCB mass. In addition, the 928.400 cubic yard volume estimate is a modeled estimate and does not account for high subgrade. Based on actual dredging experience, high subgrade is estimated to reduce the total dredge volume by up to 90,000 cubic yards.

[3] Values indicated are based on actual data for the 2004-2006 RA activities and projections for the 2007 and 2008 RA activities. The Optimized Remedy includes dredging in the following areas beyond those areas already identified by the 2007 RA Work Plan: re-dredge of Sub-Area POG2 and areas north of the trestle trail with residual concentrations above 5.0 ppm; 7-8 acres in Sub-Area D1; 40 acres in Sub-Areas D2N, E3 North, E3 South, E4, POG4, and F (due to capping constraints, based on a 6-foot post-cap water depth requirement); and 0.7 acres in Sub-Area E2.

[4] 13-inches includes 3-inch overplacement allowances in both the sand and armor layers.

In summary, the Optimized Remedy includes a combination of remedial components, as shown on Figure 4-1. A summary of these remedial components includes:

- Remedial Action Work Completed
  - Dredged OU1 high PCB concentration sub-areas, areas with surficial PCBs greater than 10 ppm, and additional dredge areas in lieu of capping to allow for a water depth of no less than 6 feet over all cap surfaces, or for operational efficiencies
  - Dredged 216 acres
  - Removed 406,100 cy (includes overcut)
  - Removed 843 kg PCB mass (74% of PCB mass in OU1 RAL volume)

- Future OU1 Remedial Action Work
  - Finish any dredging not completed in 2007
  - Place engineered armored cap at 112 acres
  - Place sand cover at 114 acres
  - Place residual sand cover (over previously dredged areas) at 30 acres (includes 5.5 acres of 2007 sand cover and 3.7 acres of post-dredge sand cover in POG2)

Remedial action work completed during 2004-2007 is shown on Figure 4-2. Post-2007 remedial action work is shown on Figure 4-3.

4.2 OU1 Optimized Remedy – Dredge Plan

4.2.1 Dredge Volumes

The estimated dredge volume for the OU1 Optimized Remedy is approximately 406,100 cy. Any dredging not completed during the 2007 season will be finished at the beginning of 2008. Following the dredging work, the total estimated PCB mass removed from OU1 will be 843 kg. This 843 kg PCBs removed by dredging will represent 74% of the PCB mass present in the OU1 1.0 ppm RAL volume.

4.2.2 Process and Equipment Selection

The remaining dredging of the OU1 Optimized Remedy will be completed in 2008 using the same equipment and processes that were used in 2004-2007 for sediment dredging (two, 8-inch-diameter swinging-ladder cutterhead-type hydraulic dredges), sediment slurry conditioning (ferric sulfate and organic polymer), dewatering (screens/thickeners followed by geotextile tubes), and water treatment (air flotation/sand filtration and granular activated carbon). No sediments subject to TSCA disposal requirements remained to be dredged in OU1 after 2006. The dewatered dredged sediment will be transported by truck to the Veolia Hickory Meadows Landfill.

4.2.3 Post-Dredge Residuals Management

Post-dredge regions with maximum PCB concentrations exceeding 5.0 ppm will be managed by re-dredging, unless operational efficiencies dictate otherwise. Sand cover will be placed over remaining dredged areas as necessary to achieve a post-remedy OU1-wide SWAC of 0.25 ppm PCBs. The sand cover thickness for residuals management will be 6 inches.

4.3 OU1 Optimized Remedy – Capping Plan

The detailed OU1 Cap Design is contained in the OU1 Cap Design Revision No. 2 (Foth, forthcoming December 2007). A summary of the cap design details is attached as Appendix A. Section 4.3.1 contains an overview of the OU1 capping plan.

4.3.1 Cap Design Criteria

Engineered capping of contaminated sediments requires long-term physical, biological, and chemical isolation of contaminated sediments. The design of engineered armored caps must be appropriately conservative, such that there is a reasonable level of assurance that the cap is designed, installed, monitored, and maintained for long-term performance. Caps need to resist natural and human-induced erosive forces that are expected to act on the cap. These erosive forces include 100-yr. flood event flows, high wind-wave conditions, propeller action from boating (prop wash), and ice scour. The OU1 Numerical Model Assessment of Bed Shear Stress for Wind-Waves and Flows is included as Appendix D. A detailed analysis of the effects of ice scour on sediments is included as Appendix E.

Cap design criteria for OU1 include several exclusion conditions. No capping will be proposed for the following areas:

- sediments with a PCB concentration of 50 ppm or greater
- final water depth, using low-water datum, at depths less than 6.0 feet
- federal navigational channels
- areas with sensitive infrastructure (*e.g.*, bridge foundations, inlets, buried utilities)

Figure 4-4 presents the surficial (top 8-inch) PCB concentrations in the proposed cap design which show low level PCB concentrations as a dominant characteristic for this area. For example, approximately 90% of the cap footprint area has PCB concentrations less than 8 ppm. Figure 4-5 presents the maximum PCB concentrations at depth in the proposed cap footprint area.

Water depth is a critical design parameter for two major reasons. First, the post-cap water depth must be at least 3 feet for navigability (OU1 ROD). Second, sufficient armoring is required for cap areas with shallow water depths due to the potential erosive forces from boat propellers (prop wash). In OU1, capping will not occur where the post-cap water depth is less than 6 feet of water. Figure 4-6 shows the post-project water depths for the proposed OU1 cap areas.

Several aspects of the project support the use of caps:

- Sediment areas with high PCB concentration and mass were removed during dredging.
- Additional areas were dredged in 2007 and will be dredged in 2008 in lieu of capping to allow for a water depth of no less than 6 feet over all cap surfaces, or for operational efficiencies.
- The capping plan for OU1 is focused on areas with relatively low PCB concentrations.

- The capping plan is performed in concert with dredging to remove sediment to achieve post-cap water depths necessary to mitigate the impact of prop wash and/or remove higher PCB concentrations. Figure 4-7 shows the post-project surficial PCB concentrations.
- The environmental conditions of the lake sediment in the proposed capping areas are depositional with low water velocities.
- Proposed cap areas are at locations with appreciable sediment thickness and low PCB concentrations, making these areas preferred for engineered armored caps (Figure 4-4) as compared to dredging.

An engineered armored cap is designed to provide long-term, in situ containment of contaminated sediments and long-term stability against physical attack in the LLBdM environment. Engineered cap design is based on a conservative, multi-barrier approach (Palermo, *et al.* 1998b, Palermo, *et al.* 2002). The functions of the conceptual layers of the cap are:

- An operational thickness to address sand-sediment mixing (formation of a filter layer) needed to establish the cap over soft sediment (T_m)
- A chemical isolation layer to contain contaminants in the underlying sediment (T_i)
- A bioturbation layer to provide physical isolation of burrowing benthic organisms (T_b)
- A consolidation layer to correct for any consolidation of the cap media (T_c)
- An erosion layer to provide sufficient thickness and an appropriate gradation of media on the top of the cap that is resistant to erosion (T_e)

Operational considerations, including the mixing layer (T_m), filtering and geotechnical foundation for armored erosion layers, media placement accuracy, and other processes, may also require additional media thickness (T_o).

The multi-barrier approach is generally additive, although some of the conceptual layers can be combined under certain conditions. For the settings of LLBdM (Palermo, *et al.* 2002), the bioturbation and erosion layers (excluding any additional armoring requirements) can be combined into one bioturbation/erosion layer ($T_{b/e}$). For low contaminant concentrations, where very thin layers for chemical isolation are required, the chemical isolation layer can be combined with the underlying mixing layer (T_m). For higher PCB concentrations, a layer of uncompromised sand may be needed for additional chemical isolation.

For granular cap media with a low fines content, no consolidation of the cap media is expected ($T_c = 0$). However, the consolidation of underlying soft sediment may be significant and the sediment pore water expressed from that consolidation should be considered as part of the chemical isolation design.

A summary of proposed OU1 cap media selection and thicknesses for different sediment and erosion conditions is presented in Table 4-2. For all cap conditions, a segment of the operational thickness of 3.0 inches is assigned to deal with sand-sediment mixing. For low PCB concentrations (*e.g.*, average surficial PCB concentration less than 10 ppm), the mixing layer is expected to provide adequate chemical isolation and the combined thickness of the cap is as follows:

$$T = T_{b/e} + T$$

As mentioned above, chemical isolation is incorporated into a mixing layer (part of the operational thickness). Since the minimum thickness of the bioturbation layer is generally considered 4 inches and the minimum operational (mixing) layer is generally considered 3 inches, the minimum thickness of the applied cap could be considered as 7 inches. The cap thickness is 13 inches with overplacement (3 inches overplacement for each media).

Complete cap design details are provided in the OU1 Cap Design Revision No. 2 (Foth, forthcoming December 2007). A summary of the cap design details is attached as Appendix A.

Table 4-2
Cap Layer and Total Thickness for Proposed OU1 Cap Areas

Layer	Category for Thickness	Cap Media	PCB Concentration < 10 ppm in top 8-inches	
			Design Thickness (in.)	**Design Thickness with Operational Overplacement (in.)**
Bioturbation / Erosion Layer	Operational, overplacement	armor stone	0	3
	Bioturbation / Erosion		4	4
Chemical Isolation Layer	Operational, overplacement	sand	0	3
	Chemical Isolation/Mixing Layer		3	3
Total Thickness			7	13

Note: Final operations overplacement allowance will be specified in the work scope and agreements with the selected contractors(s).

4.3.2 Capping Designs and Areas

Proposed OU1 cap regions are presented on Figure 4-4. The cap regions currently consist of 112 acres of a 13-inch engineered armored cap.

4.3.3 Equipment

A hydraulic transport and mechanical broadcast-type spreading system for sand placement was tested during the 2004 RA. The sand placement system was designed to minimize mixing the sand capping material into the sediment. For placing the sand portion of the OU1 Optimized Remedy caps, a transport/placement process similar to the 2004 operation is anticipated. A process similar to that used for sand placement is envisioned for transporting and placing the gravel/stone portion of the engineered armored caps. In addition, methods for cap placement are currently also being evaluated on the basis of a 2007 Cap Placement Test carried out in three areas in Sub-area E2 (Foth, 2007c). The 2007 Cap Placement Test involves a detailed process plan for material specifications, stockpile management, slurry delivery to the placement barge, effective broadcast methods of the capping equipment, accurate positioning and position controls, and site logistics to maintain performance criteria of the project. Details and objectives for the capping demonstration are discussed in the 2007 Cap Placement Test Plan (Foth 2007c).

A variety of controls are in place to assure effective capping and to reduce environmental impacts from the capping. These include metering controls, Dredgepack and Wonderware software, navigational control, media testing to assure clean media is placed, turbidity monitoring of the water column near the capping areas, and a variety of other quality control and monitoring strategies. Best management practices will be used for cap placement operations, such as working in a upstream to downstream manner, using high-grade mufflers to limit engine noise, and clear chain-of-command procedures for emergencies and project communications.

4.3.4 Production Rates and Quality Assurance (CQAP)

The current production rate estimated for placement of both the sand and gravel portions of the OU1 Optimized Remedy caps is expected to be 50 cy/hour for each operation. Both the sand and gravel portions will be placed in single lifts. The armoring gravel will be placed in a separate operation following the sand placement, but within the same season as the sand placement.

Cap placement quality assurance measures will consist of physical measurements to verify the proper placement thickness of each layer. An evaluation of the performance of the 2007 Cap Placement Test will be conducted and reported in the Cap Design Revision No. 2 (Foth, forthcoming December 2007). These results will be discussed with the Agencies and Oversight Team, and the evaluation and review will be used to inform the cap design, future cap placement activities, and related monitoring and verification measures.

4.4 OU1 Optimized Remedy – Sand Cover Plan

4.4.1 Sand Cover Criteria and Areas

The OU1 Optimized Remedy includes sand cover in undredged, low PCB concentration areas, and residual sand cover in areas previously dredged.

Sand Cover in Undredged Areas. The OU1 Optimized Remedy includes a sand cover for undredged but low PCB concentration areas. Sand cover will consist of either a 3-inch or a 6-inch layer of sand, depending on the underlying PCB concentrations. A 6-inch thick sand cover will be placed over remaining undredged sediments with an average PCB concentration between 1.4 and 2.0 ppm in any single 8-inch interval, where there is no other 8-inch interval with average PCB concentrations greater than 1.0 ppm. A 3-inch thick sand cover will be placed over remaining undredged sediments with an average PCB concentration between 1.0 and 1.4 ppm in any single 8-inch interval, where there is no other 8-inch interval with average PCB concentrations greater than 1.0 ppm.

Residual Sand Cover in Areas Previously Dredged. A 6-inch thick sand cover will also be used as a residual management tool to address post-dredge PCB residuals as necessary to meet the 0.25 ppm SWAC.

4.4.2 Production Rates and Quality Assurance (CQAP)

The production rate for placement the sand cover in the OU1 Optimized Remedy caps is expected to be 50 cy/hour. The sand will be placed in a single lift.

Sand cover placement quality assurance will consist of the following measures:

- Testing placement accuracy and precision on dry land
- Physical measurements to verify the proper placement thickness
- Statistically valid measurements to assure a minimum placement thickness in at least 90% of the capped area.

4.4.3 Equipment Selection

The same equipment used to place the engineered armored caps will also be used to place OU1 sand cover (Section 4.3.3).

4.5 Water Depth and Hydrodynamic Considerations

The bathymetry within OU1 will change slightly as a result of the dredging, capping, and cover placement associated with the OU1 Optimized Remedy. To support a further assessment of the long-term effectiveness of this remedy, this section presents an evaluation of the various water depth and hydrodynamic changes expected as a result of implementation of the Optimized Remedy.

4.5.1 Bathymetric Changes Resulting from the Optimized Remedy

The net change in water depth from conditions prior to 2004 to conditions upon completion of the Optimized Remedy are estimated to be 0.8% more water volume in OU1 over the 426 acre entire 1 ppm RAL region. Considering the entire 1,363 acre OU1, the effect will be significantly less than 0.8%. The final water depth above capped areas will be at least 6 feet.

4.5.2 Navigation and Recreational Use Impacts

The federal navigation channel north of the Menasha Lock has already been dredged to the 1 ppm target elevation. Redredging will occur in 2008, followed by placement of 9 inches of sand for residuals management. No capping will take place in the navigation channel.

The OU1 post-cap water depth will be at least 6 feet. This minimum post-cap water depth was partly based on the goal of maintaining existing recreational use of the river. The baseline water elevation used to measure post-remedy water depth was the established LWD for LLBdM as discussed in Section 2.1.4.

4.5.3 Aquatic Habitat Functional Changes

The minimum post-cap water depth discussed above is expected to minimize remedy-induced impacts to fish habitat. Shallow water provides limited habitat for the species considered desirable by anglers. WDNR fish managers prefer that existing depths greater than 8 feet be maintained to avoid these potential adverse impacts. The Optimized Remedy will result in a net water volume gain of approximately 0.8% in the 1.0 ppm RAL area.

4.5.4 Hydrodynamic Modifications

As discussed in the ROD, the remedy for the Lower Fox River must comply with the substantive provisions of WI Statutes Chapter 30 and the federal Rivers and Harbors Act of 1899, 22 CFR Part 403. Under Chapter 116 of the Wisconsin Administrative Code, the remedy must not adversely alter the 100-year flood plain for the river. As described in Section 4.5.1, the net water balance change is insignificant (*i.e.* less than 0.8%) and results in a net increase in the carrying capacity of the waterway.

4.6 Long-Term Monitoring

4.6.1 Objectives

The Optimized Remedy incorporates long-term monitoring to ensure the long term effectiveness of the overall remedial action. The long-term monitoring will include cap integrity, water quality and fish tissue monitoring. The long-term cap performance monitoring plan will consist of physical and chemical monitoring to ensure the long term protectiveness and integrity of the cap. The water and biological fish tissue monitoring will be used to evaluate the risk reduction to humans and wildlife as a result of the implementation of the Optimized Remedy.

A further objective of the water quality and fish tissue monitoring will be to monitor progress toward achieving the Remedial Action Objective (RAO) of reducing risk to humans and the environment. The RAOs were identified in the ROD as follows:

- Achieve, to the extent practicable, surface water quality criteria throughout the Lower Fox River and Green Bay.
- Protect humans who consume fish from exposure to chemicals of concern (COCs) that exceed protective levels.
- Protect ecological receptors from exposure to COCs above protective levels.
- Reduce transport of PCBs from the Lower Fox River into Green Bay and Lake Michigan.
- Minimize the downstream movement of PCBs during implementation of the remedy.

The final details of the Long-Term Monitoring programs will be developed through a collaborative process with the Agencies. The following sections include a preliminary summary of the proposed program. The specific details of the monitoring programs will be included in the Long-Term Monitoring Plan.

4.6.2 Cap Performance and Maintenance

A long-term monitoring, maintenance and contingency response plan, including repair (as necessary) of damaged capped areas, is part of the Optimized Remedy and will be prepared to ensure the integrity and reliability of the *in-situ* cap. The objectives of the cap monitoring program will be to detect and evaluate any physical changes in the cap that would potentially reduce protectiveness over time. The long-term cap monitoring program will include the following components:

- **Bathymetric Surveys –** Bathymetric surveys will be completed to evaluate the physical integrity and thickness of the capped areas. These surveys will be conducted initially post-construction and then at specific time intervals (along the same transects) to identify potential areas of significant erosion, deposition, or consolidation.

- **Coring and Surface Grab Sampling –** Coring (or other approved method of visual analysis) will be conducted to visually inspect the cap and cap thickness. Coring will also be conducted to supplement any elevation data discrepancies obtained from the bathymetric surveys that may indicate significant elevation loss. Follow-up sediment cores will be collected to determine whether the elevation loss is a result of erosion or settlement based on visual evaluation of the cores, considering core compaction. PCB chemical analysis will also be conducted to determine whether contamination is effectively being contained and isolated from biota.

The cap monitoring and maintenance plan will identify the specific details regarding location and type of sampling, and will specify that the bathymetric survey and cores of the cap will be collected, as a minimum, starting two years after the initial post-construction survey and continuing every 5 years thereafter. Based on the results observed in that periodic monitoring, USEPA and WDNR may increase or decrease the frequency of periodic monitoring. USEPA and WDNR may require additional cap monitoring (between periodic monitoring events) after particular events that could cause cap damage, such as major storm events. A contingency response plan will be prepared in conjunction with the Long-Term Monitoring and Maintenance Plan that will identify specific criteria to be monitored and possible outcomes of the monitoring. Evaluation criteria will be identified and a range of responses/actions will be included depending on the results of the evaluation. The Agencies will also evaluate cap performance and the need for and scope of continued cap monitoring and maintenance as part of the five-year CERCLA review process.

4.6.3 Water Quality Monitoring

Water quality will be sampled and analyzed at three stations from Lake Winnebago to the first Appleton Dam. The monitoring locations will be sited near the boundaries of OU1 such that the net PCB contribution and the effectiveness of the Optimized Remedy can be evaluated. The monitoring locations are consistent, to the extent possible, with stations occupied during past sampling events.

The water monitoring plan generally consists of systematic monthly sampling of a station over the course of an entire year (*i.e.*, 12 monitoring events). The baseline water quality monitoring was performed in 2006. Future water quality monitoring for OU1 will occur in conjunction with

OU2-5 monitoring every five years, with monthly sampling over the course of the year. During the subsequent five-year monitoring events, the monitoring frequency may be reduced or eliminated in favor of fish tissue monitoring since fish tissue is the primary medium of exposure to PCBs for humans and wildlife. A detailed description of the conditions under which water quality monitoring may be revised will be provided in the Long-Term Monitoring Plan.

Water quality will be monitored for the following parameters:

- PCB Congeners (209 total) by EPA Method 1668A (high-res GC/MS).
- Total Suspended Solids by EPA Method 160.2.
- Total Organic Carbon by EPA Method 415.1.
- Temperature.
- Turbidity.

The water quality data collected from OU1 monitoring, in combination with data obtained from the water quality monitoring to be collected in conjunction with OU2–5, will be evaluated. The existing pre-remediation data and any data collected for the pre-construction event in conjunction with OU2–5 sampling will be used as a baseline. The combined baseline and long-term monitoring data will be used to provide the Agencies with information to evaluate whether the Optimized Remedy meets risk reduction criteria.

4.6.4 Fish Tissue Monitoring

Fish tissue media will be sampled and analyzed at a number of stations from Lake Winnebago to the Appleton Dam. The fish tissue monitoring plan includes sampling of 5 different species at different stations, including replicates for each species at each station. Fish sampling will be conducted consistent with the Long-Term Monitoring Plan. Fish sampling will be conducted during the same seasonal window for each long-term monitoring event to reduce seasonal differences in fish tissue concentrations between monitoring years. This window will be consistent with the window of sampling being proposed for OU2–5 and will enable collaboration and evaluation of all fish tissue monitoring results.

Similar to OU2–5's program, target fish species will be selected based on a number of criteria:

- Presence of fish consumption advisories;
- Popular recreational fishery;
- Key species evaluated in the Final Baseline Human Health and Ecological Risk Assessment (Retec 2002);
- Common food source for upper-level animals; and,
- Elevated PCB concentrations in recent monitoring data.

Five target fish species were selected to address three different monitoring objectives:

- Protection of human health (walleye, channel catfish);
- Protection of wildlife (carp, drum); and,
- Early indication of river recovery (young gizzard shad).

In addition to the five target fish species, small mouth bass and white suckers also were collected during baseline monitoring to evaluate which species should be carried forward in the long-term monitoring for human health and wildlife protection, respectively. All five selected fish species will be analyzed the first year post-construction. After the first monitoring event, the fish tissue monitoring will be reduced to three species as follows:

- Protection of human health (walleye);
- Protection of wildlife (carp); and,
- Early indication of river recovery (young gizzard shad).

Small mouth bass and drum will be reserved as alternate species if collection of any of the three primary species becomes an issue.

The monitoring program will consist of a total of 200 fish tissue analyses, not including quality control samples.

Fish tissue samples will be analyzed according to the following methods to ensure consistency with past and ongoing monitoring programs, analytical methods will follow procedures used by the Wisconsin State Lab of Hygiene to the extent possible.

- Tissue Extraction by SLOH Method.
- PCB Aroclors by EPA Method 8082.
- Lipid Content by gravimetric method (EPA 2000).

The details on the monitoring locations, frequency and parameters will be included in the Long-Term Monitoring Plan.

4.7 Institutional Controls

Institutional controls are necessary to prevent interference with the remedy and to reduce exposure of contaminants to human or ecological receptors. Institutional controls are defined as non-engineered instruments, such as administrative and legal controls that help minimize potential for exposure to contamination and protect the integrity of the remedy. At OU1, institutional controls are required to protect the cap (an engineered remedy) and to reduce potential exposure to residual contamination. Long-term protectiveness requires compliance with institutional controls. Therefore, effective institutional controls must be implemented, monitored, and maintained.

Institutional controls will be identified as part of the remedial action process in an Institutional Control Implementation and Assurance Plan (ICIAP) for review and approval by USEPA and WDNR. The required institutional controls may include property use controls (such as easements and restrictive covenants), governmental controls (including zoning ordinances and local permits), and informational devices (including maps, signage, and fish consumption advisories). The ICIAP will identify parties responsible (*i.e.*, federal, State or local authorities or private entities) for implementation, enforcement, and monitoring and long-term assurance of each institutional control including costs, both short-term and long-term, and methods to fund the costs and responsibilities for each step. In addition, the ICIAP will identify reporting requirements associated with each institutional control regarding the status and effectiveness of the institutional controls.

For the capped areas, the OU1 ICIAP could include the following institutional controls:

- OU1 Regulated Navigation Areas will be established using governmental and/or property use institutional controls to limit water uses (*e.g.*, limitations on anchoring, dredging, spudding, dragging, or conducting salvage operations) and construction (*e.g.*, restrictions on utilities laying cable and pipelines) that would disturb the engineered cap.

- Maps and shape files in an acceptable GIS format (*i.e.*, NAD 83) will be developed to depict the OU1 Regulated Navigation Areas. The maps and information about the Regulated Navigation Areas will be made easily accessible to the public in several ways, such as a website and posting in the public library. A schedule for updating the maps and shape files will also be provided.

An OU1 fish consumption advisory to the public will be maintained by the state as necessary to assure the protectiveness of the remedy.

The goal will be to create appropriate types of institutional controls as needed to ensure the protectiveness of the remedy.

5. Comparative Evaluation: ROD and OU1 Optimized Remedy

This Section compares the OU1 Optimized Remedy (as described in Section 4) with the ROD Remedy, using the nine evaluation criteria set forth in the National Contingency Plan (NCP), 40 C.F.R. Part 300. The ROD remedy itself, of course, was determined to meet each of the individual NCP criteria as shown on Table 18 of the OU1 - OU2 ROD. The ROD further indicated that if certain additional requirements were met, the ROD Contingent Remedy was a viable and protective alternative to supplement the ROD remedy. Indeed, among other conditions, application of the ROD Contingent Remedy was conditioned upon a "high degree of certainty that a PCB SWAC of 0.25 ppm would not be achieved for OU1 by dredging alone."

The collection of considerable new information, including pre-design data, post-dredging residuals data and further delineation of physical site characteristics (see Section 2 above) were used to develop and refine the Optimized Remedy design, combining elements of both the ROD Remedy and the ROD Contingent Remedy to further improve overall remedy implementation. This Section prevents a comparative analysis focusing on the relative performance of the Optimized Remedy and the ROD Remedy in reference to the evaluation criteria set forth in the NCP.

5.1 Threshold Criteria

5.1.1 Overall Protection of Human Health and the Environment

The ROD Remedy and ROD Contingent Remedy were determined by WDNR and USEPA to provide adequate protection of human health and the environment. WDNR and USEPA selected a PCB concentration of 1 ppm as the appropriate RAL for dredging in the ROD Remedy. This RAL was selected based on its ability to achieve a particular RAO in surface water and for human health and ecological receptors. That particular RAO was a SWAC of 0.25 ppm, which was deemed protective if achieved within a reasonable time frame. Implementation of the ROD Remedy is expected to achieve acceptable fish tissue PCB concentrations within approximately 14 years for human receptors and carnivorous birds. The ROD Contingent Remedy is available when certain criteria are met, one of which is a high degree of certainty that the SWAC of 0.25 ppm would not be achieved in OU1 by dredging alone.

The OU1 Optimized Remedy combines remedial elements from both the ROD Remedy and the ROD Contingent Remedy (*i.e.*, dredging, sand cover if needed after dredging to further reduce surficial concentrations, and engineered armored caps), plus sand cover of certain low concentration surficial areas to provide a similar level of human health and environmental protection, including the achievement of acceptable fish tissue PCB concentrations within a shorter time frame when compared to the ROD Remedy. This comparable level of protection results from both the mass removal and exposure reduction components of the Optimized Remedy. With respect to exposure reduction, experience gathered during OU1 dredging shows that residual sediment contamination can be expected no matter how effective the dredging operation itself. See Section 4.2.3 above. In other words, it is not possible to neatly remove all sediment above the 1.0 ppm RAL. A post-dredging SWAC in OU1, by dredging alone to the 1.0 ppm RAL (*i.e.*, no overcut) and not accounting for the impact of dredged residuals is estimated at 0.48 ppm, almost twice the targeted SWAC of 0.25 ppm.

The Optimized Remedy will achieve a post-construction SWAC of 0.25 ppm. By integrating dredging, engineered armored caps, and sand cover into the overall design, the Optimized Remedy provides lower PCB concentrations in post-dredge residuals, with the result that the post-construction SWAC will be lower than dredging alone would achieve. As discussed in more detail below, to the extent the Optimized Remedy can be completed in less time than the ROD Remedy (see, "Short-Term Effectiveness"), and achieve a similar or lower SWAC at the completion of construction, the Optimized Remedy can be expected to reduce water and fish tissue concentrations sooner than the ROD Remedy.

As discussed in Section 4 above, one of the goals of the Optimized Remedy is to design and apply engineered armored caps and sand cover only to those areas of OU1 where permanent stability and performance can be assured based upon analytical data and detailed engineering evaluations. The Optimized Remedy has been designed to provide long-term chemical isolation and to prevent future exposure to confined subsurface sediments. The technical framework for cap design previously submitted to the agencies, *OU1 Cap Design Revision No. 1 (Foth & Van Dyke October 2006),* and summarized in Section 4.3 and Appendix A, and will be updated as Revision No.2 (Foth, forthcoming December 2007). The cap design is based on agency guidance to ensure protectiveness (Palermo, et al., 1998a) consistent with ROD requirements for the ROD Contingent Remedy. Furthermore, the long-term monitoring, maintenance, and contingent response requirements associated with cap designs are included as integral parts of the OU1 Optimized Remedy to ensure long-term protectiveness. Monitoring and maintenance plans are described in Section 4.6 above.

Based upon these considerations, the Optimized Remedy achieves overall protection of human health and the environment equal to the ROD Remedy.

5.1.2 Compliance with ARARs

As discussed in Sections 11.1.1 and 14.2 of the ROD, the remedy must comply with substantive provisions of various "applicable or relevant and appropriate requirements" (ARARs), which are typically set forth in local, state, and federal statutes and regulations. The ROD identified the specific ARARs for the ROD Remedy in Table 31. The ROD Remedy and the ROD Contingent Remedy were deemed to comply with these ARARs. The Optimized Remedy combines elements from both the ROD Remedy and the ROD Contingent Remedy and will similarly comply with ARARs. During the remedial and detailed design phases of the implementation of the Optimized Remedy, the design and operational alternatives will be tailored so as to assure compliance with ARARs.

5.2 Balancing Criteria

5.2.1 Long-Term Effectiveness and Performance

Both the ROD and the Optimized Remedy provide long-term effectiveness through a combination of dredging and containment of contaminated sediments. Both remedies also require some degree of institutional controls (*e.g.,* fish consumption advisories until remedial action objectives are met). The use of engineered armored capping will require evaluation during design to assure both the appropriate level of institutional controls and plans to maintain the isolation of contaminated sediment.

The ROD stated that the selected remedy would remove approximately 90% of the total PCB mass in OU1, although that figure appears incorrect based on the underlying technical documentation in the FS. See Section 13.1 of the ROD. All dredged sediments are disposed of in off-site upland landfills. Much of the remaining PCB mass in OU1 is widely disbursed at low concentrations just above the 1.0 ppm RAL.

As discussed in Section 4.2, the dredging component of the Optimized Remedy shares many components with the ROD Remedy. In fact, the Optimized Remedy is likewise primarily a dredging remedy, removing 74% of total mass in the OU1 total 1.0 ppm footprint. All dredged sediments (406,100 cy) are disposed of in off-site upland landfills. The PCB mass left in the river under the Optimized Remedy can be found predominantly in the following areas:

- Discrete engineered armored cap areas (112 acres).
- Discrete sand cover areas (114 acres of low concentration areas and 30 acres of post-dredged areas).

As required by the ROD, and as detailed in Section 4.3, engineered armored caps have been designed to ensure the permanent containment of contaminated sediments. Cap designs will provide protective and reliable chemical isolation and, based on modeling and engineering evaluations, will ensure that erosion of underlying sediment will not occur even during major erosion events, such as floods, propeller wash, and ice scour.

To further ensure the adequacy and reliability of controls for an *in-situ* cap, a long-term monitoring, maintenance and contingency response plan, including institutional controls and repair (as needed) is included as part of the Optimized Remedy. A long-term cap monitoring plan will review the cap's physical integrity (*e.g.*, bathymetry surveys and sediment cores) to verify the continued protectiveness of the cap over time. Specific institutional controls necessary to ensure long-term cap integrity will be further assessed during remedial design, detailed design and development of the long term monitoring plan.

Natural recovery modeling, as reported in the RI/FS, suggests that residual sediment contamination remaining on the post-dredge (or post-cap/cover) surface will be expected to decline following implementation of either remedy as a result of control over ongoing sedimentation processes and control over resuspension of formerly contaminated areas.

5.2.2 Reduction of Toxicity, Mobility or Volume Through Treatment

As set forth in the ROD, this criterion evaluates the use of treatment to reduce the harmful effects of contaminants, their ability to move in the environment, and the amount of contamination present. Both the ROD Remedy and the Optimized Remedy remove large sediment volumes and corresponding PCB mass from OU1. Dredged materials are placed in secure upland landfills, which eliminates mobility altogether. Both remedies use in-place containment to eliminate mobility of PCBs that are not removed. Neither the ROD Remedy nor the Optimized Remedy satisfies the statutory preference for treatment. As described in the OU2-5 ROD Amendment, treatment of PCBs by vitrification was found to be not cost-effective.[2]

5.2.3 Short-Term Effectiveness

Short-term effectiveness relates to the length of time needed to implement an alternative and the risks associated with implementation. Completion of the ROD Remedy would require dredging another 522,300 cy in addition to the amount dredged under the Optimized Remedy (assuming a 4-inch overcut allowance, but not accounting for high subgrade), along with post-dredge sand cover as required, and take more than another seven years to complete with post-dredge sand cover. The Optimized Remedy is expected to take approximately two years post-2007 to complete.

Compared to the ROD Remedy, the Optimized Remedy can be achieved in a shorter period of time. Potential impacts on human health or the environment (*e.g.*, to workers and the community) during remedial construction will be less for the Optimized Remedy than the ROD Remedy. A commensurate reduction in noise, air emissions, dust, and interference with river traffic during construction is expected under the Optimized Remedy. With completion in approximately two years versus seven years, the Optimized Remedy will achieve protectiveness more rapidly than the ROD Remedy.

5.2.4 Implementability

Implementability addresses the technical and administrative feasibility of a particular remedy from design through construction and operation. Factors to be considered include the availability of services and materials, administrative feasibility, and coordination with other governmental entities. Sediment dredging, transportation, and disposal are feasible from a technical and administrative standpoint as proven during implementation of the ROD Remedy from 2004-2007. Similarly, as reflected in the ROD, placement of sand cover and capping materials is a readily implementable construction activity. Indeed, based upon successful implementation during other remedial projects, OU1 experience during 2004-2007, and sand cover and capping test installations on the OU1 project, dredging, capping and sand cover are all implementable. The availability of resources necessary for engineered armored caps and sand covers (*e.g.*, sand, gravel, etc.) is well-established within a reasonable distance of OU1.

The Optimized Remedy is comparably implementable as the ROD Remedy. The ROD Remedy, the ROD Contingent Remedy, and the Optimized Remedy all reflect a potential combination of remediation technologies. These technologies vary with water depth, PCB concentrations, and related factors. This complexity, however, can be managed through careful planning and sequencing during implementation.

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[2] See OU2-5 ROD Amendment, page 49.

5.2.5 Cost Effectiveness

The analysis of costs contained in the ROD includes estimated capital and long-term monitoring costs. Cost effectiveness refers to the relative costs of implementing remedies that would be equally protective of human health and the environment.

The original present net worth calculation for the dredging, dewatering, water treatment and disposal portions of the ROD Remedy was $61.7 million to remove 784,000 cy of contaminated sediments containing an estimated 3,770 lbs. (1,715 kg) of PCBs. Based on new data, the current estimate is that the ROD Remedy would require the removal of 928,400 cy (with a 4" overcut) to the 1.0 ppm RAL, with an estimated PCB mass removed of 1,143 kg of PCBs.

While the ROD predicted a post-dredge SWAC of 0.25 ppm, more recent modeling based on the post-ROD data projects that the SWAC at the end of dredging (assuming all of the OU1 sediment above the 1.0 ppm dredge line could be precisely removed and no dredged residuals were created) would be 0.48 ppm. To attain the 0.25 ppm SWAC would in fact require placement of a significant volume of post-dredge sand cover, bringing the actual cost to implement the ROD Remedy to between $138 and $150 million.

By the completion of the dredging work proposed under the Optimized Remedy, GW Partners will have removed approximately 406,100 cy of contaminated sediments containing 843 kg of PCBs. The Optimized Remedy described in Section 4 above will cost between $93 and $111 million, which is between $26 and $44 million in addition to the $67 million incurred through 2007. Taking together the sediment removed from OU1, the engineered armored cap areas, and the sand cover areas proposed in the Optimized Remedy, the Optimized Remedy addresses more than 97% of the PCB mass within the 1.0 ppm footprint.

Under the ROD's comparative evaluation, the ROD Remedy was found to be cost-effective. In hindsight, it turns out that the ROD Remedy does not provide as cost-effective a remedy as had been envisioned. The Optimized Remedy presents a more cost-effective remedy than the ROD Remedy, while providing the same level of protection to human health and the environment as the ROD Remedy.

5.3 Modifying Criteria

5.3.1 State Acceptance

The Optimized Remedy will require administrative approval from EPA through a ROD Amendment. In addition, agency approval of the various design and planning documents and submittals will be required prior to the implementation of the Optimized Remedy.

5.3.2 Community Acceptance

The level of community acceptance of the Optimized Remedy will be gauged through public comments received as part of the administrative process.

5.4 Comparative Evaluation Summary

A detailed summary of the specific elements of the ROD Remedy, the Contingent Remedy, and the Optimized Remedy, highlighting key similarities and differences, is presented in Table 5-1.

Table 5-1
Evaluation Criteria Comparison

CERCLA Criteria	**ROD Remedy**	**Optimized Remedy**
Threshold Criteria		
1. Overall Protection of Human Health	YES – While the ROD predicted the ROD Remedy would achieve a 0.185 ppm SWAC, updated calculations based on data accumulated, since the ROD issuance, indicate that dredging alone would achieve no better than a 0.48 ppm SWAC (assuming no overcut or dredged residuals).	YES - Will achieve a 0.25 ppm SWAC with associated level of protectiveness. Long-term monitoring and contingent response requirements will ensure that cap/cover remains protective.
2. Compliance with ARARs	YES - Expected to meet ARARs.	YES - Expected to meet same ARARs as ROD Remedy plus additional ARARs applicable to capping and sand cover. The Optimized Remedy would meet the same ARARs as the 2007 OU2-5 ROD Amendment.
Balancing Criteria		
3. Long-Term Effectiveness and Permanence	YES - Some degree of institutional controls (*e.g.*, fish consumption advisories) are still required, but the ROD Remedy would remove at least 92% of the PCB mass in the ROD's 1.0 ppm footprint.	YES - Removes about 74% and sequesters or otherwise addresses 97% of the mass within the ROD's 1.0 ppm footprint with a combination of active remedial measures. Capping only where stability and permanence assured. Other restrictions apply (no capping in shallow water/TSCA sediments, etc.) Long-term cap monitoring to assure permanence.

CERCLA Criteria	**ROD Remedy**	**Optimized Remedy**
4. Reduction of Toxicity, Mobility, or Volume through Treatment	YES - Overall mobility reduction is achieved through dredging and placement in secure upland landfills.	YES - Overall mobility reduction is achieved through dredging and placement in secure upland landfills. For PCBs not dredged, mobility will be reduced via cap containment and isolation.
5. Short-Term Effectiveness	YES - Projected duration to complete the ROD Remedy is another 7 years after the completion of the 2007 RA activities, reflecting steady progress in light of dredging/dewatering infrastructure.	YES - Projected duration to complete is another 2 years after the completion of the 2007 RA activities. Dredging, capping and cover should reduce surface concentrations quickly in area of remediation.
6. Implementability	YES - Services, materials, and equipment are available as demonstrated through dredging and pilot projects to date.	YES - Services, materials, and equipment are available as demonstrated through dredging and pilot projects to date.
7. Total Cost	$138 - $150 million	$93 - $111 million
Modifying Criteria		
8. Agency Acceptance	YES - ROD Remedy was previously selected by EPA and WDNR.	Contingent upon approval from EPA and WDNR through an ESD or ROD Amendment.
9. Community Acceptance	YES - See public comments and responsiveness summary for the ROD.	Public comments will be solicited through an ESD or ROD Amendment process.

6. Comparison of Construction Schedule and Sequencing

6.1 ROD Remedy

The ROD remedy is estimated to take seven additional seasons to complete starting in the spring of 2008. The seven additional seasons include five seasons of dredging and two seasons of residual sand cover placement.

6.2 OU1 Optimized Remedy

The Optimized Remedy is estimated to take two additional seasons to complete starting in the spring of 2008. The two additional seasons include the completion of remaining dredging activities, as well as placement of engineered armored cap and sand cover.

7. Cost Estimates: ROD and OU1 Optimized Remedy

7.1 Overview and Framework

The ROD presented cost estimates for the ROD Remedy based on the December 2002 Feasibility Study. This section presents the original cost estimate for the ROD Remedy as presented in the December 2002 Feasibility Study and ROD, and current cost estimates for the ROD Remedy and the Optimized Remedy. The detailed cost estimates for the ROD Remedy and the Optimized Remedy were developed based on the 2004 to 2007 dredging experience and post-2002 site characterization data. The cost estimates for the ROD Remedy (including the work completed to date and the projected post-2007 work), and the Optimized Remedy use the same cost assumptions to provide comparable estimates between the two remedies. The 2002 ROD Remedy cost estimate (based on the 2002 Feasibility Study analysis) is presented for comparative purposes only.

The cost estimates presented in this Section include the following general categories for comparison:

- Dredging (including dewatering, water treatment and off-site disposal costs)
- Capping
- Sand Cover
- Institutional Controls
- Monitoring and Maintenance

Within each of these categories, numerous tasks and subtasks were identified representing the discrete project elements. Detailed costs for each task and subtask were then estimated by combining these tasks and subtasks into the above listed categories, with inclusion of labor, equipment and materials.

7.2 OU1 ROD Remedy Cost Estimates and Assumptions

7.2.1 2002 OU1 ROD Remedy Cost Estimate Based on the Feasibility Study Analysis

The OU1 ROD Remedy was identified as Alternative C2 in the ROD and Feasibility Study. This remedy consisted of the following elements: dredging 784,000 cy (including 16,165 cy of TSCA sediment) to 1 ppm, mechanical sediment dewatering, water treatment, sediment disposal off-site at an existing NR500 Commercial Disposal Facility, institutional controls consisting of deed restrictions, and 40 years of long-term monitoring (with this element valued at net present day worth as of 2002). The Feasibility Study cost summary includes estimates for each of these elements. A cost contingency was not included in the December 2002 ROD cost estimates.

A summary of the 2002 ROD Remedy costs to dredge 784,000 cy (includes 16,165 cy of TSCA sediment) to 1 ppm is as follows:

ROD Remedy Cost Estimate

♦ Dredging (including dewatering, water treatment and off-site disposal)	$61,700,000
♦ Sand Cover	Not Included*
♦ Institutional Controls	$ 5,600
♦ Monitoring and Maintenance	$ 4,500,000
Total Estimated Cost	**$66,200,000**

* The cost estimate did not include the cost for any sand cover to manage residuals in dredged areas.

A copy of the detailed breakdown of the costs, as presented in the 2002 Feasibility Study, is found in Appendix F.

7.2.2 Revised OU1 ROD Remedy Cost Estimate Based on New Information

The ROD Remedy cost estimate has been updated from the 2002 ROD estimate to incorporate the latest developments, including the following significantly revised assumptions:

- **Overdredge Volume –** An average 4-inch overdredge was achieved during the 2004 to 2007 dredging experience. The 2002 ROD cost estimate did not account for an overdredge volume. When the documented overdredge volume is included in the dredge volume estimates, the total volume of sediment to be dredged increases significantly from the ROD estimated volume of 784,000 cy (no overdredge volume included) to a total projected volume of 928,400 cy (with a 4-inch overdredge). This significantly increases all project costs because of having to address additional sediment volume.

- **Unworkable Sediment -** Based on the 2004 to 2007 experience, offsite disposal costs must reflect a high proportion volume of dewatered sediment considered "unworkable" at the landfill, which required increased costs for disposal. The additional costs associated with the "unworkable" dewatered sediment are the result of the dewatered solids characteristics obtained by dewatering with geotextile tubes versus mechanical dewatering, which offsets to some extent the less expensive geotextile tube dewatering costs.

- **High Subgrade -** Because of high subgrade encountered during the 2004-2007 dredging seasons, it is estimated that the model projected volume of 928,400 cy may, in fact, overstate the true volume by up to 90,000 cy. This reduction in sediment volume has been taken into account in the revised ROD Remedy cost estimate.

- **Sand Cover –** Post-dredge characterization data collected from 2004-2007 confirms that post-dredge sand cover would need to be placed over 250 acres to achieve a SWAC of 0.25 ppm.

- **In-situ Sediment Volume versus Disposal Volume –** Based on the 2004 to 2007 dredging experience, one cubic yard of in-situ sediment was approximately equal to one ton of sediment that required off-site disposal after dredging and dewatering. The ROD Remedy cost estimate assumed that the disposal tonnage was one-half of the in-situ sediment volume that would need to be disposed of off-site, significantly underestimating the tonnage of sediment requiring off-site disposal by 50%. This increase in dewatered sediment tonnage is primarily related to higher in-situ sediment solids content than was assumed in the ROD Remedy cost estimate. To a much lesser extent, the increased dewatered sediment tonnage is also caused by the lower percent solids in the dewatered solids obtained by geotextile tube dewatering as compared to the ROD Remedy cost estimate for mechanical dewatering.

- **Project Costs Incurred Through 2007 -** The costs incurred to date for most of the project elements have been the result of obtaining competitive bids. For work performed through the summer of 2007, the costs are actual costs and not estimated costs. The cost estimates developed for future work uses the actual unit costs derived from work incurred to date.

Based on the above, the ROD Remedy cost estimate has been updated from the 2002 ROD estimate presented in Section 7.2.1. Similar assumptions were made in estimating the cost of the Optimized Remedy, with additional assumptions provided in Section 7.3. It should be noted that the 2004-2007 costs include actual costs incurred to date plus estimated costs to complete all project elements for the 2007 season.

UPDATED ROD Remedy Cost Estimate

♦ 2004-2007 Costs	$67,000,000
♦ Post-2007 Dredging[1]	$54,000,000 - $58,500,000
♦ Post-2007 Sand Cover	$14,000,000 - $20,300,000
♦ Post-2007 Site Demobilization	$900,000 - $2,600,000
♦ Post-2007 Monitoring and Maintenance	$2,000,000
Total Estimated Cost	**$138 - $150 million**

[1] Includes dewatering, disposal and water treatment.

The revised ROD Remedy estimate of between $138 and $150 million may escalate based on further analysis of the project's cost data. The revised estimate is based on the following assumptions:

- 426 acres dredged (of which 236 acres assumed dredged post-2007)
- 838,400 cy dredged, including 4-inch-thick overcut and high subgrade allowance (of which 432,300 cy assumed dredged post-2007)

- 250 acres of sand cover placed for residuals management following dredging
- No additional water quality and fish tissue monitoring costs beyond the costs presented in the OU2-5 BODR

7.3 OU1 Optimized Remedy Cost Estimate

The Optimized Remedy cost estimate has been developed to the same level of detail and with the same assumptions as the revised ROD Remedy estimate. Again, it should be noted that the 2004-2007 costs include actual costs incurred to date plus estimated costs to complete all project elements for the 2007 season, including disposal of all sediment dredged during 2007. In addition, it should be noted that over $3 million in interest will have been earned on the OU1 escrow account through 2007, which has increased the overall dollar value available for project costs.

Optimized Remedy Cost Estimate

♦ 2004-2007 Costs	$67,000,000
♦ Post-2007 Dredging[1]	$6,200,000 - $6,700,000
♦ Post-2007 Capping	$7,300,000 - $12,000,000
♦ Post-2007 Sand Cover	$6,200,000 - $11,200,000
♦ Post-2007 Site Demobilization	$900,000 - $2,600,000
♦ Post-2007 Monitoring and Maintenance	$3,400,000 - $5,900,000
♦ Contingency	$2,400,000 - $5,700,000
Total Estimated Cost	**$93 - $111 million**

[1] Includes dewatering, disposal and water treatment.

The Optimized Remedy cost estimate is based on the following assumptions.

- 2004-2007 costs (actual to date plus estimate to complete 2007)
- 25 acres to be dredged post-2007
- 47,400 cy to be dredged (including 4-inch-thick overcut) post-2007
- 30 acres of sand cover placed for residuals management (25 acres post-2007)
- 114 acres of sand cover placed on undredged areas with PCB concentrations between 1.0 and 2.0 ppm
- 112 acres of engineered armored cap
- Cap monitoring to occur in years 2, 7, 12, 17, and 25 and then every 10 years ending at year 95
- Capping O&M cost based on 10% (20% for high-cost estimate), 5% (10% for high-cost estimate), 5%, and 2.5% cap replacement in years 3, 8, 13, and 18, respectively
- Capping O&M present worth factors based on annual compounding at 3% interest
- No additional water quality and fish tissue monitoring costs beyond those presented in the OU 2-5 BODR

In comparison, the OU1 Optimized Remedy is more cost-effective than the ROD Remedy, while achieving the risk-based 0.25 ppm PCB SWAC, and in less time.

8. Conclusion

Based on the new information gathered and experience gained since the 2002 ROD, the OU1 Optimized Remedy will meet the 1.0 ppm PCB RAL and attain the primary risk reduction goal of the ROD (lowering the OU1 PCB SWAC to 0.25 ppm). Four seasons of dredging have already been performed in OU1. Dredging will have removed 74% of the PCB mass in the OU1 RAL volume by the time dredging is completed. Going forward, the OU1 Optimized Remedy uses a mix of remedial technologies, including dredging, residuals management, engineered armored capping, and sand cover.

The Optimized Remedy described in this document is based on significant new information gathered since the issuance of the 2002 ROD, including operational information and new PCB data. Post-ROD sampling included the collection of approximately 6,300 new PCB samples at about 1,000 locations. This new information showed that:

- Dredging to the 1.0 ppm RAL alone cannot achieve an OU1 SWAC of 0.25 ppm. If the existing ROD were followed to project completion, with precise removal of the sediment within the 1.0 ppm dredge prism, the OU1 SWAC at the end of dredging (assuming no sand cover of residuals) would be 0.48 ppm PCBs.

- Because of the technological limitations of even the most advanced dredging equipment in achieving precision dredge cuts, the OU1 experience has shown that a dredging operation needs to remove an average of 4-inches of additional sediment to assure that the targeted dredge elevations are achieved. This necessary overcut increases the actual volume required to be dredged by the ROD Remedy by about 207,200 cubic yards, or 29%. The ROD did not account for this sediment volume when evaluating time or costs to complete the remedy.

- PCB mass was not uniformly spread throughout OU1, but tended to be concentrated in high concentration areas in the southern portion of OU1. The dredging completed in 2004-06 removed about 2/3rds of the PCB mass in OU1 by focusing on these areas.

- The new OU1 PCB data for the sediment remaining in OU1 shows that a large sediment volume within the 1.0 ppm dredge prism is not significantly different than the sediment outside that prism, meaning that it is characterized by average PCB concentrations only marginally above 1.0 ppm.

- Experience gained during OU1 operations, together with the new data, shows that the cost of implementing the all-dredge remedy set forth in the ROD would be more than twice the 2002 ROD's cost estimate of $61.7 million. GW Partners' current cost estimate for the ROD Remedy is between $138 and $150 million due in large part to overcut volumes, residual sand cover costs, and higher unit costs. The OU1 Optimized Remedy will be substantially more cost effective.

- Not only will the risk reduction SWAC target of 0.25 ppm PCBs be achieved with the OU1 Optimized Remedy, it will be achieved more quickly, more efficiently, and more cost effectively than with the ROD Remedy. The OU1 Optimized Remedy described herein will take an addition two years to implement (post-2007) while the ROD Remedy will take an additional seven years (post-2007). Achieving a faster reduction in the OU1 SWAC will mean that fish consumption advisories due to PCBs could be lifted sooner under the Optimized Remedy.

9. References

Ashton, 2006. *Effects of Ice on Sediments in Little Lake Butte des Morts, Fox River above Appleton, Wisconsin*. November 2006.

Baird, 2006. *Numerical Model Assessment of Bed Shear Stress for the 100-Year Return Flow, Little Lake Buttes des Morts, Fox River*. October 2006.

CH2M HILL, 2003. *Lower Fox River Operating Unit 1 Pre-design Sampling Plan*. 2003.

CH2M HILL, 2005. *Lower Fox River Operable Unit 1 Remedial Action-2004 Remedial Summary Report.* February 2005.

Coast and Harbor Engineering, 2006. Technical Memorandum 1. *Comparison of JETWASH Model and EPA Guidance Governing Equations*. October 24, 2006.

Coast and Harbor Engineering, 2006. Technical Memorandum 3. *Fox River Sediment Mobility Analysis*

Conlon, T.D., 2002. *Personal Communication from USGS regarding the hydrogeology of the Lower Fox River*. May 2002.

Foth Infrastructure & Environment, LLC, 2007a. *Lower Fox River Operable Unit 1 – 2006 Remedial Action Summary Report*. September 2007.

Foth Infrastructure & Environment, LLC, 2007b. *Lower Fox River Operable Unit 1 Remedial Action – 2007 Pre-Final Design Report and Remedial Action Work Plan.* October 2007.

Foth Infrastructure & Environment, LLC, 2007c. *Lower Fox River Operable Unit 1 – 2007 Cap Placement Test Plan*. September 2007.

Foth & Van Dyke, 2006. *Lower Fox River Operable Unit 1- OU1 Cap Design Revision No. 1*. October 2006.

Johnson Company Inc., 2001. *Ecosystem-Based Rehabilitation Plan-An Integrated Plan for Habitat Enhancement and Expedited Exposure Reduction in the Lower Fox River and Green Bay*. December 2001.

Krohelski, J.T. and B.A. Brown, 1986. *Hydrogeology and Groundwater Use and Quality, Brown County, Wisconsin*. WGNHS Information Circular Number 57.

Krohelski, J. 2002. *Personal Communication from USGS regarding the hydrogeology of the Lower Fox River*. May 2002.

Montgomery Watson, 1998. *Fox River SMU 56/57 Basis of Design Report for Sediment Remediation Project*.

Need, E.A., 1983. *Pleistocene Geology of Brown County, Wisconsin.* WGNHS Information Circular 48.

Palermo, M.R., J.E. Clausner, M.P. Rollings, G.L. Williams, T.E. Myers, T.J. Fredette, and R.E. Randall, 1998a. *Guidance for Subaqueous Dredged Material Capping. Technical Report DOER-1*. United States Army Corps of Engineers, Waterways Experiment Station, Vicksburg, Mississippi.

Palermo, M.R., J. Miller, S. Maynord, and D. Reible, 1998b. Assessment and Remediation of Contaminated Sediments (ARCS) Program Guidance for In Situ Subaqueous Capping of Contaminated Sediments. EPA 905/B-96/004. Prepared for the Great Lakes National Program Office, United States Environmental Protection Agency, Chicago, Illinois.

Palermo, M.R., Timothy Thompson, and Fred Swed, 2002. White Paper No. 6B- In-Situ Capping as a Remedy Component for the Lower Fox River. Prepared for Wisconsin Department of Natural Resources. December 2002.

Retec Group, Inc., 2002. *Final Feasibility Study, Lower Fox River and Green Bay, Wisconsin. Remedial Investigation and Feasibility Study*. Prepared for the Wisconsin Department of Natural Resources. December 2002.

Retec Group, Inc. 2003. Detailed Evaluation of Alternatives Report, Lower Fox River and Green Bay, Wisconsin. Prepared for the Wisconsin Department of Natural Resources and the United States Environmental Protection Agency, Region 5, Chicago, Illinois. June 2003.

Retec Group, Inc. 2004. Survey Control and Topographic and Bathymetric Mapping on Lower Fox River (WISCN-16740) Task 220 Preliminary Utility Survey.

Shaw and Anchor, 2006. Final Basis of Design Report. Lower Fox River and Green Bay Site. Brown, Outagamie, and Winnebago Counties, Wisconsin. Prepared for Fort James Operating Company, Inc. and NCR Corporation by Shaw Environmental and Infrastructure, Inc. and Anchor Environmental, LLC. June 16, 2006.

Stanick, R. 2006 Personal Communication from USACE regarding Little Lake Butte des Morts Water Levels. September 15, 2006.

USEPA. 2005. Contaminated Sediment Remediation Guidance for Hazardous Waste Sites. December 2005.

USGS, 1998. Water Resources Information, Fox River at Appleton, Wisconsin. http://h20.usgs.gov/swr/WI/?statnum=04084445.

WDNR, 2000. Model Evaluation Workgroup Technical Memorandum 2F, Estimation of Sediment Bed Properties for Green Bay, December 15, 2000.

WDNR and USEPA, 2002. Record of Decision, Operable Unit 1 and Operable Unit 2. Lower Fox River and Green Bay, Wisconsin. December 2002.