Detailed Evaluation of Alternatives Report

Lower Fox River and Green Bay Wisconsin

Prepared by:

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RETEC Project Number: WISCI-15933-121

Prepared for:

Wisconsin Department of Natural Resources
101 S. Webster Street
Madison, Wisconsin 53702

and

United States Environmental Protection Agency
Region 5
Chicago, Illinois 60604

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Executive Summary

This report represents a Detailed Evaluation of Alternatives (DEA) of the remedial alternatives presented in the Feasibility Study for the Lower Fox River. This DEA reviews the range of remedial technologies used to develop the alternatives in the FS and confirms that they are feasible. The DEA is intended to develop a higher level of engineering detail for the individual technologies and representative process options (capping, dredging, dewatering, and disposal), and establishes a design basis for the technologies and representative process options upon which final engineering and detailed design can later be performed.

The DEA does not pre-suppose or design the remedy, but rather provides additional engineering content for those technologies and process options that might eventually be incorporated into the remedy. The DEA is presented as a transition effort; providing additional engineering detail subsequent to the FS, but prior to detailed remedial design.

Technical Review Team

The DEA process began with the convocation of a Technical Review Team (TRT). The TRT included local, national and internationally recognized engineers, scientists, and sediment remedial contractors. The TRT also included the co-chair of the National Research Council's Committee on Remediation of PCB-contaminated Sediments, and the Wisconsin Department of Natural Resources and the U.S. Environmental Protection Agency.

The TRT evaluated the remedial alternatives presented in the Feasibility Study, along with the available data for the Lower Fox River and reached the following general conclusions:

- The range of alternatives in the FS that in combination, or individually, have a high degree of probability of being able to be successfully implemented.

- The capping, removal, dewatering and disposal technologies are implementable using currently available equipment and methods. However, certain remedial technologies may not be implementable, practicable, or face considerable social constraints in some reaches of the River.

- A well-defined remedial footprint (horizontal and vertical) is needed to set the remedial boundaries, and to better refine the remedial cost. The sensitivity of the costs, and feasibility, of all alternatives is highly dependent on the remedial footprint.

- The TRT recommended that effort be put into resolving variability prior to construction, including (1) adequate and carefully-controlled vertical and horizontal PCB distributions, (2) setting landfill space for dredged sediments, and (3) physical sediment data upon which to base removal or capping components.

The TRT developed combinations of the representative process options, and recommended that each of the technologies be developed within the DEA report. Specifically, these included capping, dredging, material transport, dewatering and wastewater treatment, solids treatment and disposal. In addition, the TRT recommended that the permitting requirements, riverside land and access requirements, specifications, and finally costs for each of the process options be developed in more detail. The findings of the TRT then formed the basis for the DEA report. Members of the TRT then also were part of the DEA report team.

Summary of Existing Conditions

Based upon the recommendation of the TRT, the DEA report examined the existing conditions along the Fox River from the perspective of adequacy of information upon which to develop a remedial design. These included upland conditions (land-side support sites), operational considerations (mudline elevations, water depth operational constraints), presence of in-water obstructions to remedial activities (e.g., bridges, railroads, navigational channels, pipelines, cables, piers, sunken vessels), hydraulic conditions (e.g., flood scour, flood capacity, scour, ice), as well as the adequacy of the existing sediment physical and PCB data upon which to base a design.

Based on that review, data gaps were identified that would need to be addressed for the remedial design. Of the information needed, the greatest uncertainty in developing final engineering concepts and cost estimates is in the quantity of sediment solids that would be dredged. This quantity, in turn, hinges on the delineation of the 1 ppm contour and the solids content of the in-place sediment. Additional sampling is recommended to better delineate the horizontal and vertical PCB footprint, and to provide better physical data upon which to build removal and capping alternatives.

A representative dredge plan was created based upon the PCB bed maps. The dredge plan is presented as a series of plan drawings of dredged management units (DMU). These engineering plan sheets show the removal elevation to the bottom of the 1 ppm PCB footprint, and were used to develop dredged volume estimates. Drawings similar to these would be required for any bid specification package, and would need to be refined upon acquisition of additional PCB data.

Capping

The TRT concluded that capping is a viable component of a remedy for the River, and that a detailed capping design, construction, permitting and cost evaluation be developed for each of the three OUs. The DEA capping evaluation also addressed long-term protection from contaminants, long-term liability, and operations and maintenance. For all OUs, capping did not eliminate the need for removal actions in order to meet the defined goals within the Proposed Plan.

Advective and diffusive flux calculations were conducted to determine the design basis for the isolation cap. The cap design basis included allowance for mixing with underlying soft sediments, PCB isolation for 1000 years, operational placement limitations, and included a factor of safety. Hydraulic calculations for the 100 year flood were also conducted to determine that appropriate armoring requirements for each OU.

For OU1, over 200 acres of sediment bed, representing 235,000 cubic yards (cy) out of the 784,000 total cy of impacted sediment met the recommended technical criteria for placement of a cap. Within OU3, 79 acres within the 1 ppm RAL met the technical criteria for placement of a cap. This cap footprint represents approximately 11% of the remedial volume (64,000 cy of the 586,788 cy). For OU4, a maximum area of 262 acres, or 45% of the potential remedial volume (1.5 million cy out of 5.9 million cy). For all three reaches, the design basis for the isolation cap was determined to be 18 inches of sand, with 6 inches of armor. However, the armor specification required different grains sizes for the various reaches.

Removal Actions

Three types of dredges were recommended for further development by the TRT; (1) hydraulic pipeline dredge with cutterhead, (2) mechanical dredge with a haul barge, and (3) mechanical dredge with hydraulic discharge ("hybrid dredging"). The DEA developed evaluated each of these process options for each of the three OUs.

At OU1, a project consisting of hydraulic dredging and mechanical dewatering (as described in the Proposed Plan and Record of Decision) remains practicable. Using smaller-sized dredging equipment (to minimize sediment resuspension) and typical production rates, the project could be completed over a duration of 3 years. The Bergstrom fill site at the southern end of the OU has potential as the central processing site, pending a geotechnical evaluation of soil conditions.

The proposed remedy for OU3 and OU4, consisting of hydraulic dredging and passive dewatering, is practicable. A timeframe of 8 to 11 years for a combined project is anticipated. The most significant detail to be resolved will be the acquisition of a very large parcel(s) of land, on the order of 500 acres, for the construction of the necessary land-based facilities. Assuming that this land would be located in southern or eastern Brown County, the siting and design of the overland slurry forcemain would then be necessary. While implementable using current technologies, both the construction of large land-based facilities and an overland slurry forcemain are expected to generate significant interest from the local community.

For OU3 and OU4, the use of a mechanical dewatering process at a riverside location (compared to the use of an upland, land-based system) would greatly reduce the land requirement and would avoid the need for an overland forcemain. Mechanical dewatering would also significantly reduce the tonnage (and volume) of sediment that would be landfilled.

For OU3 and OU4, a hybrid dredging system (compared to a conventional hydraulic dredge) provides the advantage of pumping solids at a higher concentration. All other things equal, this attribute, when coupled with the use of a riverside dewatering plant, could reduce the dredging duration.

Material Transport

Four means of transporting dredged material to a final disposal site were evaluated within the DEA; barge, hydraulic transport via pipeline, truck, and rail transport. The use of haul barges to transport mechanically dredged solids is considered a feasible means of transport in OUs 3 and 4, but is operationally limited in OU1 due to depth constraints. Hydraulic transport using a series of pumps and forcemains (pipes)to move dredged sediment as an aqueous slurry was described in the Proposed Plan, and is still considered practicable and implementable for OUs 3 and 4. For OU1 a forcemain was determined to be less practicable. Pipeline routes, design basis, pumping requirements, and inwater vs. overland routes were evaluated and presented. Truck transport of dredged solids had been previously conducted at the Deposit N and the SMU 56/57 Demonstration Projects, and is practical and feasible for either a post-press filter cake or for mechanically dredged sediments that have been drained of free water. Rail transport could be implemented for either wet or dewatered sediment, and is being used at several sites around the country for material transport. Existing rail service lines within the Fox Valley were evaluated for potential for use in transport.

Dewatering and Wastewater Treatment

Dewatering elements included course material separation, mechanical presses, and gravity dewatering cells. Course material separation included screens or hydrocyclones to separate sand from the finer fractions in the dredged sediments before dredging, as was done in the previous demonstration projects. Based on those projects, a minimum design requirement of 15 percent separation was considered reasonable. Mechanical dewatering via plate-and-frame filter presses or belt press were conducted as part of the demonstration projects and are developed within the DEA. Filter presses have an established performance record with the demonstration projects, whereas belt presses would require additional development in order to demonstrate effectiveness for Fox sediments. However, both remain viable alternatives.

A settling basin design was included in the DEA for either hybrid or hydraulic dredging. A four-cell system was designed so that a single cell would hold all the dredge sediments from one dredging season. The dewatering facility included appropriate clay liners consistent with Wisconsin regulations, a granular drainage layer, and a vacuum-enhanced under-drain system. The gravity-settled solids would be rehandled after three to four years to a newly constructed NR500 landfill, or to a vitrification facility.

Carriage water from dredging operations requires treatment prior to discharging back into the River. A wastewater treatment facility was detailed based on granular media filtration and granular activated carbon polishing, consistent with what was successfully accomplished at the demonstration projects.

Solids Treatment and Disposal

Vitrification, the process of melting sediments into a glass-like material, as a treatment option was further developed in the DEA, and found to be implementable for the treatment of dewatered sediment from OU3 and OU4. Vitrification provides the advantage of providing a permanent disposition of the material. The DEA found that the most practicable application of vitrification is when coupled with a mechanical dewatering process. Based on current projections and plant design assumptions, the per-ton cost may not yet be sufficiently low to compete favorably with a land disposal option. This issue should be revisited periodically, as engineering improvements or project financing options may eventually reduce the cost.

Disposal options considered both a combined dewatering basin/landfill, as well as construction of a new monofill that could receive dewatered sediment solids. The use of a combined “dewatering landfill” for management and disposal of OU3 and OU4 dredge slurry is practicable and the facility could be designed and constructed under existing state rules. Because of the very large land area required, however, it does not appear to offer cost savings in comparison with the other options described above. Liner plans and typical sections for both the dewatering landfill and a monofill were developed and presented.

Costs

The detailed engineering evaluation for each of the process options was used as a basis for updating the costs presented in the FS. Within the DEA, costs were developed only on the basis of individual technologies or process options, and not for comprehensive remedial alternatives. For any of the technologies or composite remedial alternatives, the costs consist of a combination of fixed capital costs (such as for purchased equipment, buildings, equipment, etc.) and quantity-proportional costs (such as for operating the equipment, consumable items, etc. As a result, there are very few true “unit costs” (i.e., a cost per ton or cubic yard that is valid over any range of quantities). Because of this, costs derived in the FS or DEA cannot always be applied to larger or smaller quantities of sediment that might later be estimated. Similarly, if the project is broken up in to smaller component projects (such as by deposit), aggregate costs are likely to increase because of a loss of efficiency. In either event, both the FS and DEA use a set of assumed quantities that will change after an expected, major pre-design sampling effort is completed. Costs will change accordingly.

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List of Acronyms

RETEC	The RETEC Group, Inc.
RI/FS	Remedial Investigation/Feasibility Study
WDNR	Wisconsin Department of Natural Resources
EPA	United States Environmental Protection Agency
FS	Feasibility Study
RI	Remedial Investigation
TRT	Technical Review Team
DEA	Detailed Evaluation of Alternatives
USACE	United States Army Corps of Engineers
OU	Operable Unit
ROD	Record of Decision
Proposed Plan	Proposed Remedial Action Plan/
CDF	confined disposal facility
HDPE	high-density polyethylene
PCB	polychlorinated biphenyl
CN	Canadian National
lf	linear foot
ppm	parts per million
cm	centimeter
TSCA	Toxic Substances Control Act
RI	Remedial Investigation
gpm	gallons per minute
psf	pounds per square foot
tsf	tons per square foot
SMU	Sediment Management Unit
cy	cubic yard
cy/day	cubic yard per day
PFD	process flow diagram
GAC	granular activated carbon
BDAT	best demonstrated available technology
WPDES	Wisconsin Pollutant Discharge Elimination System
mg/L	milligrams per liter
µg/L	micrograms per liter
s.u.	standard unit
RP	responsible party
°F	degrees Fahrenheit
WAC	Wisconsin Administrative Code
TSS	total suspended solids
COD	chemical oxygen demand
POTW	publicly owned treatment works
tpd	tons per day
cy/yr	cubic yards per year
tons/cy	tons per cubic yard
ASY	access and storage yard
STP	sediment transfer point

List of Acronyms

DWTP	dewatering and wastewater treatment plant
OSI	Ocean Surveys Incorporated
FERC	Federal Energy Regulation Commission
FEMA	Federal Flood Emergency Management Act
FRDB	Fox River Database
DMU	Dredge management unit
WQS	Water Quality Segments
ISC	In situ capping
GPS	Global Positioning System
EA	Environmental Assessment
EIS	Environmental Impact Statement
NEPA	National Environmental Policy Act
PFD	Process flow diagram

1 Introduction

1.1 Background

The RETEC Group, Inc. (RETEC) has been performing Remedial Investigation/Feasibility Study (RI/FS) work for the Wisconsin Department of Natural Resources (WDNR) and United States Environmental Protection Agency (EPA) Superfund program on the Lower Fox River and Green Bay site since 1998.

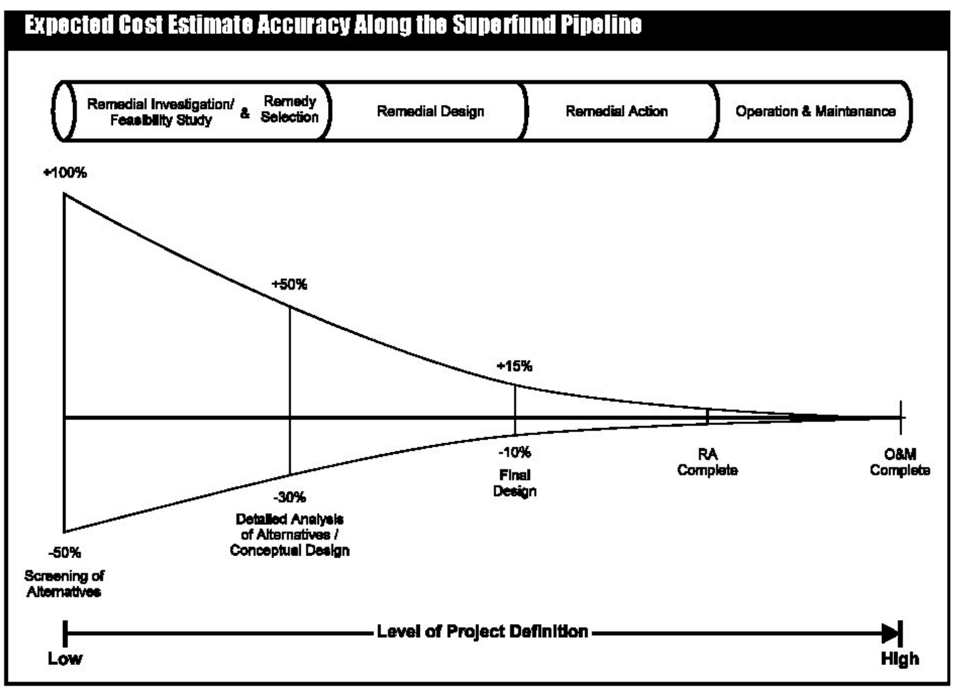
In 2001, as the WDNR was proceeding with its remedy selection process, they decided to perform some additional refinement of some of the remedial technologies and process options identified in the Draft Feasibility Study (FS). Towards this end, in early 2002, RETEC was awarded a contract to convene a Technical Review Team (TRT) and conduct a detailed evaluation of remedial alternatives. A summary of the findings of the TRT is contained in Appendix A. This report and its supplements comprise the output for the detailed evaluation of alternatives.

1.2 Discussion of The FS and Superfund Process

The level of engineering performed at the FS stage is generally considered to be "conceptual" (USACE, 2000). Based on contaminant concentrations and exposure pathways, the FS identifies general response actions (e.g., containment, removal, institutional controls, etc.) that are necessary to protect human health and the environment. To implement these general response actions, a range of remedial technologies were identified and screened (e.g., capping, dredging, etc.). Then, individual technologies were assembled into integrated remedial alternatives (e.g., dredging followed by disposal with long-term monitoring of the residuals). The detailed analysis of these remedial alternatives ultimately establishes the basis for remedy selection (EPA, 1989). The extent of engineering detail is limited and concepts are subject to change or refinement later in the Superfund process.

Within the FS, the individual remedial technologies and the integrated remedial alternatives were developed to a level of detail sufficient to select a preferred remedy from among a variety of possibly disparate approaches. For example, for each technology that comprises a remedial alternative within the FS, a representative process option is selected from what might be a lengthy list of candidates. In situations like the Lower Fox River where a remedy can be comprised of several remedial technologies each with several process options, the number of combinations can be substantial. The FS assembled a finite number of remedial alternatives which cover a wide spectrum of ways to achieve the necessary risk reduction. This is necessary so that the comparison of alternatives and remedy selection can proceed. The representative process option provides a basis for developing a preliminary design, but the actual process may not be selected until detailed design is undertaken (EPA, 1988). Another process option may be selected during remedial design if it is found to be more advantageous (EPA, 1989). Thus, even at the point of remedy selection and the development of a Proposed Remedial Action Plan (Proposed Plan), significant engineering detail, cost estimating, and decision-making is pending.

Within the Superfund process, the design of a remedy and the estimate of the cost to complete a remedial action are influenced by the completeness and accuracy of the conceptual site model. The model reflects the nature and extent of contamination, the expected exposure pathways, and the overall scale of the problem. It is first developed during the scoping of the RI/FS and modified as additional information becomes available (EPA, 1996). As the model is refined and engineering work on the selected remedy progresses, uncertainty is reduced and estimates narrow. The Superfund process anticipates that new information and additional detail will be developed throughout the process and that these may result in modifications to earlier work. This inherent progression is reflected in the following graphic (USACE, 2000).



1.3 Purpose and Scope of the DEA

This report and accompanying drawings constitute the Detailed Evaluation of Alternatives (DEA). The purpose of the work is to:

- Review the range of remedial technologies used to develop the remedial alternatives in the FS, and confirm that they are feasible

- Where possible, develop a higher level of engineering detail for the individual technologies and representative process options (capping, dredging, dewatering, and disposal) first developed within the FS

- Establish a design basis for the technologies and representative process options upon which final engineering and detailed design can later be performed

This DEA should be considered to be a transition effort, providing additional engineering detail subsequent to the FS, but prior to detailed remedial design. The intent of the DEA is not to pre-suppose or design the remedy, but rather to provide additional engineering content for those technologies and process options that might eventually be incorporated into the remedy.

The scope of the DEA does not displace the FS, but extends the engineering work started in the FS by providing a greater level of detail and site specificity. The DEA establishes the design basis from which subsequent final engineering and detailed design can quickly proceed.

To provide additional engineering detail for potential technologies and process options, the DEA has developed the following:

- Additional engineering detail for such dredging process options as hydraulic dredging, mechanical dredging, and "hybrid" dredging

- Engineering details for hydraulic conveyance of dredge slurry

- Engineering details for a sediment cap

- Identification of potential land availability and siting considerations for the construction of land-based remediation facilities

- Additional process detail for such remedial technologies as dewatering, wastewater treatment, materials handling and materials transport, including general arrangement drawings for these kinds of facilities

- Design basis and preliminary sizing for potential disposal facilities

- Additional detail on permits and approvals for each remedial technology

- Suggested scope and content for final construction specifications for the range of remedial technologies and facilities that may be required to implement a final remedy

- An analysis of the effect of substituting other representative process options for those originally included in the FS remedial alternatives

The DEA is not a formal part of the Superfund process. It is intended as a supporting document. Compared to the graph in Section 1.2, the work represents a point just to the right of the "conceptual design" milestone (i.e., the FS), but still well short of what will eventually be developed at final design. Both the DEA and a significant pre-design sampling program (scheduled for 2003) will expand the level of project definition so that future work can progress in the manner anticipated by the Superfund process.

1.4 Sensitivity Analysis of Process Options and Contingent Remedy Selection

As described above, the original FS screened and retained a number of representative process options. Some of these were then incorporated into specific remedial alternatives. The DEA provides additional engineering and cost detail to some of these process options, and their possible inclusion as part of an integrated remedial alternative is further evaluated.

This evaluation is similar to a "sensitivity analysis". The combination of process options reflected in the remedial alternatives in the Proposed Plan and/or Record of Decision (ROD) represents the "baseline." For Operable Unit 3 (OU3) and Operable Unit 4 (OU4), the DEA then evaluates the technical and cost effect of substituting one or more process options for those in the baseline. For Operable Unit 1 (OU1), the ROD identified a contingent remedy that modifies one technology and adds another. The DEA evaluates this combination further. The evaluations are contained in Section 10, and summarized, as follows in the following table.

	Operable Units Where Applicable	
	OU1	**OU3 and OU4**
Baseline Alternatives		
• Hydraulic dredging, mechanical dewatering, disposal at a monofill (From the ROD)	X	
• Hydraulic dredging, transport via a slurry forcemain, passive dewatering in basins, disposal at a monofill (From the Proposed Plan)		X
Analysis of Process Option Substitutes and Contingent Remedies		
• **Scenario A:** "Contingent Remedy" for OU1 – in-situ capping in combination with removal	X	
• **Scenario B:** Substitute hybrid dredging and mechanical dewatering at a riverside location (as the dredging and dewatering technologies, respectively)		X
• **Scenario C:** Substitute disposal in an upland dewatering landfill		X
• **Scenario D:** Substitute mechanical dredging and vitrification		X

2 Summary of Existing Conditions

This section summarizes the upland and in-water conditions that are pertinent to the alternatives analysis. The relevant existing conditions within the Lower Fox River are documented in the Remedial Investigation (RETEC 2002) (RI), and in subsequent White Papers to the Record of Decision for OU1 and OU2 (WDNR, 2003b). New information developed since the RI/FS is noted below.

2.1 OU1

2.1.1 Upland Conditions

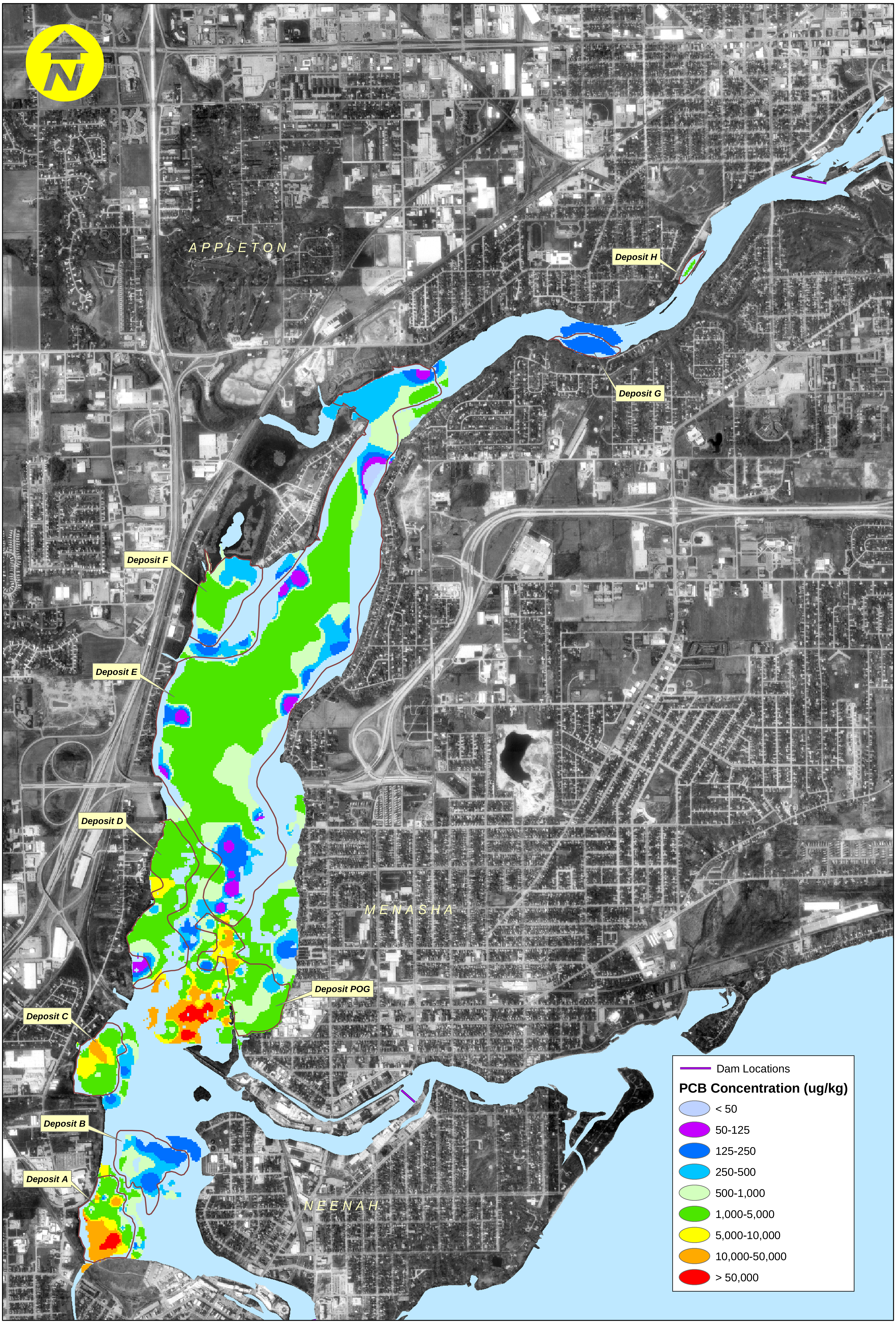
OU1 includes all of Little Lake Buttes des Morts (LLBdM), and extends from the Neenah and Menasha channel outlets from Lake Winnebago, to Appleton Lock Number 1. Covering a total of 1,426 acres, OU1 is approximately 6 miles from north to south, and approximately 3,500 feet wide. This reach includes sediment deposits A through H and POG. The total area of PCBs exceeding the 1 ppm action level is approximately 441 acres (Figure 2-1).

The towns of Neenah, Menasha, and Appleton (Figure 2-2) are configured around LLBdM. The regional land use along the Lower Fox River was compiled by planning commissions in both the Fox Cities and Brown County, and reported in the RI. The Fox Cities Area Existing Land Use Map (East Central Wisconsin Regional Planning Commission [ECWRPC], 1996) extends from the outlet of Lake Winnebago to a point about 5 km (3 mi) downstream of Kaukauna. The Fox River Corridor Land Use Map (Brown County Planning Commission, 1990) covers the entire length of the Lower Fox River within Brown County. There is a stretch of river about 1.5 km (1 mile) not covered by these two maps; however, land-use details on these maps provide a general description of development in the river vicinity. The approximated land use percentages for areas within about 0.4 km (0.25 mi) of the bank of the Lower Fox River are in Table 2-1.

Table 2-1 Land Use Summary - Lower Fox River Valley

Land Use	Fox Cities (1996)	Brown County (1990)	Entire River
Residential	32.9%	25.5%	29.2%
Industrial/Commercial	26.2%	25.3%	25.8%
Woodlands	14.6%	17.9%	16.2%
Parks	11.6%	6.8%	9.3%
Agricultural	0.5%	11.4%	5.8%
Public	7.2%	1.3%	4.3%
Wetlands	5.1%	1.6%	3.4%
Vacant	2.0%	10.2%	6.0%

Notes: Percentages are approximate and are intended to provide a general indication of land use along the Lower Fox River. The Fox Cities includes all communities between Neenah/Menasha and Kaukauna. Public land includes school properties.



0 1000 2000 4000

1" = 1000 Feet

RETEC

OPERABLE UNIT 1 Lower Fox River, Wisconsin (WISCN-15933-121)		**DISTRIBUTION OF INTERPOLATED PCB CONCENTRATIONS IN SEDIMENTS (0-10 cm)** **LITTLE LAKE BUTTE DES MORTS**	
DATE: 12/20/02	DRWN: SCJ / SEA	MAP: PCB Layer1.mxd	FIGURE: 2-1

0 2,000 4,000

1" = 2,000 Feet

RETEC

OPERABLE UNIT 1 Lower Fox River, Wisconsin (WISCN-15933-122)	LOWER FOX RIVER BATHYMETRIC CONTOURS: LITTLE LAKE BUTTE DES MORTS

DATE: 01/30/03		FILE: OU1 Bathymetry.mxd	FIGURE: 2-2

The largest category of land use along the Lower Fox River is residential, and this is especially evident in Figure 2-1 provided in Section 2 for OU1, where the residential/industrial comprises 60 percent of the land use around LLBdM.

2.1.2 Operational Considerations

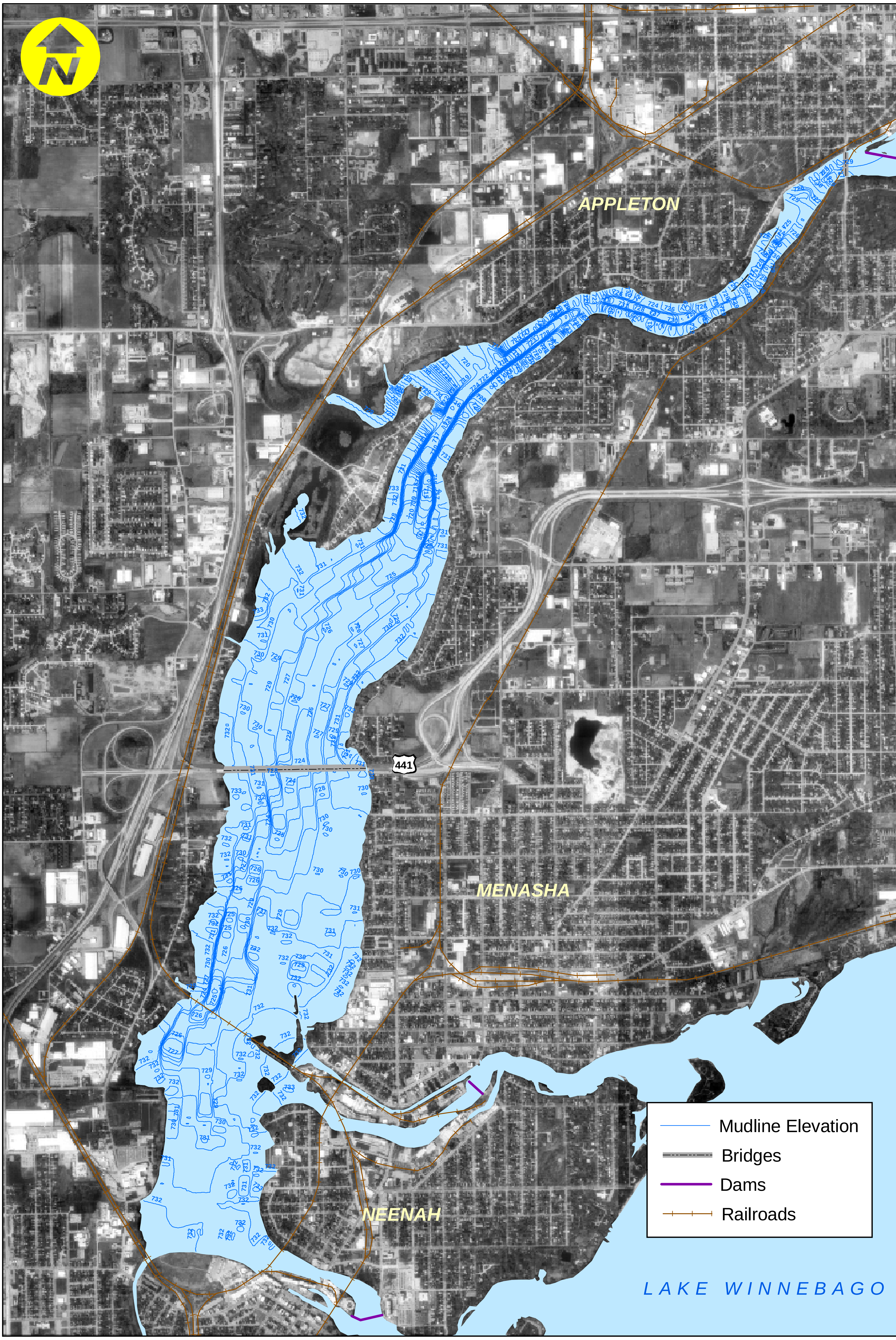
Mudline Elevations and Water Depth Constraints

Bathymetric contours, and corresponding mudline (bed) elevations are presented in Figures 2-2 and 2-3. Bathymetric transects were conducted by Ocean Surveys Incorporate (OSI) in 1999; metadata were provided as X and Y coordinates for each recorded depth datapoint and were reported in meters as Wisconsin Tranverse Mercator (WTM) NAD 1927. The OSI transect data were converted to WTM NAD 1983, and depth contours were generated using ArcView 8.0. To set mudline elevations, lake level was set at 736.1 feet above mean sea level (MSL) (lower water datum), based upon the published NOAA lake elevations between the Menasha Lock and Appleton Lock Number 1 (NOAA, 1992). Water depth contours were subtracted from the base lake elevation, to yield mudline elevations on 1-foot contour intervals.

Water depths may present operational constraints for in-water work. Most of the OU water depths are less than 5 feet, and less than 2 to 3 feet in areas around deposits A/B, C, and POG. Within the central part of the river along the thalweg, depths are greater than 5 feet; being 10 feet deep throughout the central part of the River, to a maximum depth of 18 feet at the north end of the OU.

Depth to mudline is shown in Figure 2-2. The mudline elevation in OU1 is generally greater than 730 ft. msl; corresponding water depths are less than 6 ft (NOAA, 1992). Within the center of the lake, elevations extend down as low as 725 ft. Bed elevations near deposits A, C, and POG are 732 feet msl or greater.

Mudline elevations in OU1 are estimates; they have specific uncertainties associated with the type of survey conducted, and lack of specific QA/QC information. Detailed project information was not forwarded with the OSI survey data. Based upon a review of what was provided, the existing bathymetric surveys do not appear to meet the USACE specifications for conducting construction surveys (USACE, 2002). The transects were run parallel to the shore, an average of 300 feet apart, with no apparent overlap. In addition, near-shore transects were no closer than 100 feet from the shoreline, leaving a data gap in terms of depths and changes in contours near shore. It is not clear whether a single, or multi-beam survey was conducted, and what the water elevation was in each OU at the time of the survey.



0 2000 4000

1" = 2000 Feet

RETEC

OPERABLE UNIT 1 Lower Fox River, Wisconsin (WISCN-15933-121)	**MUDLINE ELEVATION CONTOURS: LITTLE LAKE BUTTE DES MORTS**
DATE: 04/04/03	FILE: Mud1 ElvCtrs.mxd / FIGURE: 2-3

Pre-design surveys conducted according to USACE specifications are required for final design. At a minimum, transect lines conducted perpendicular to the flow of the river no more than 100 feet apart will be required. An additional bathymetric and a sidescan sonar survey, tied to fixed locations in WTM 1983 and measured lake elevation levels, are required.

Dams

OU1 is bounded on the southern end by the dams impounding Lake Winnebago at Neenah and Menasha, and on the northern end by the Upper Appleton dam. These three dams are indicated on Figure 2-1. There are no indications of dam removal requirements or plans for any of the three dams bounding OU1.

The Neenah and Menasha Power Company own the Neenah dam, while ownership and maintenance of the other two are the responsibility of the USACE. Based upon structural reports conducted in 1989 and 1994 for the Menasha Dam, the dam is in good structural condition overall and no structural deficiencies were found that would effect the operation of the dam. However, in 1989 1,200 tons of armor stone were placed to fill scour holes. For the upper Appleton dam, the USACE reported in 1995 that the dam was in satisfactory condition, but that it could be expected to degrade over time. No significant structural deficiencies were found that would immediately affect the safety or operation of the dam. There were no safety inspection reports available for the Neenah dam.

All three dams impounding waters into and out of OU1 are classified as "large" dams[1], and are classified as High Hazard when their failure would put lives at risk. The "hazard" rating is not based on the physical attributes, quality, or strength of the dam itself, but rather the possibility of loss of life and property should the dam fail.

Any consideration for leaving sediments in place (natural attenuation or an *in situ* cap) will need to consider the maintenance of the dam/lock system as an institutional control with requirements for maintenance of the system in perpetuity. All three dams have Federal Energy Regulation Commission (FERC) re-licensing requirements, which would need to be considered in any long-term planning and/or permitting. For this engineering analysis, only the containment of sub-aqueous contaminants was considered (i.e., the long-term maintenance of the dams is assured). In a final design, a component of safety for safe isolation under conditions of dam failure, and/or the creation of remnant on-land deposits, should be considered.

[1] A dam with a structural height of over 6 feet and impounding 50 acre-feet or more, or having a structural height of 25 feet or more and impounding more than 15 acre-feet is classified as a large dam.

A detailed description of the dams in all operable units (OU) is given in *White Paper No. 4 – Dams in Wisconsin and on the Lower Fox River, to the December 2002 Responsiveness Summary* (WDNR, 2002b).

Federal Navigation Channels

Navigation channels are indicated on the U.S. Army Corps of Engineers plan sheets (USACE Detroit District) in OU1 at the Menasha Lock on the southern end, and the upper Appleton Lock on the northern end, and are shown in Figure 2-6.

The Menasha channel is authorized to a project depth of 6 feet, a width of 100 feet, and extends approximately 3,400 feet into LLBdM. The Menasha Channel passes through Deposit POG. The Upper Appleton Channel is authorized to a project depth of 7 feet, a width of 100 feet, and extends approximately 6,000 ft. southward into LLBdM. The Upper Appleton Channel does not extend into any identified PCB-containing deposits in LLBdM. The navigation channels do not extend further into LLBdM; there is currently sufficient water depth in Little Lake Butte des Mortes (> 6 feet) to accommodate navigation needs.

Infrastructure and Obstructions to In-water Operations

Infrastructure that have the potential to impact remedial operations are shown in Figure 2-4. These include the railroad crossing at Menasha, the Highway 441 bridge, water intakes and discharge outfalls, submarine pipelines, overhead cables, and cribs placed by WDNR for fish breeding. These sources of information come from both the NOAA chart for LLBdM, as well as from a GIS listing of structures obtained from WDNR and Winnebago County.

Transportation corridors across the River represent potential barriers to in-water work. While not operational, the rail crossing sits on pilings with insufficient overhead clearance to pass a vessel under the rail trestle. The Highway 441 bridge does not represent a barrier to in-water removal activities, but could impact potential capping locations. Discussions are occurring within the Wisconsin Department of Transportation about adding a second bridge south of the current one, which may need to be considered in final design.

Aerial cable crossings are indicated near deposits A and B, and at the northern end of Stroebe Island. The only indicated submarine cable is indicated at the upper Appleton Dam.

RETEC

OPERABLE UNIT 1

Lower Fox River, Wisconsin (WISCN-15933-122)

LOWER FOX RIVER INFRASTRUCTURE: LITTLE LAKE BUTTE DES MORTS

DATE: 04/21/03 | FILE: OU1 Infrastructure.mxd | FIGURE: 2-4

Outfalls and submarine pipelines occur through or in the vicinity of deposits A/B, C, POG, and E. The pipelines that run from Neenah are indicated as gas pipelines. The municipal sewer outfall runs from Menasha through Deposit POG. A pipeline runs through the southern edge of Deposit E, but the contents are unknown. Underwater structures that must be considered include existing water intake lines for Eggers Industries and Kimberly-Clark, located in Deposit A. Additionally The Eggers Industries line is abandoned, but the Kimberly-Clark line is still active.

Natural obstructions or in-water structures indicated on the NOAA charts include submerged pile, rocks, and other unknown obstructions. Neenah Slough discharges adjacent to the Bergstrom Fill, and must be considered with any action involving deposits A, B, or C.

Prior to completing remedial design, the nature and extent of these in-water structures and obstructions must be understood and well demarcated. This is best achievable through the use of detailed side-scan sonar surveys, as well as checking with the local utilities for the presence of in-water cables and pipelines.

Recreational Use

Principal known recreational uses on LLBdM include fishing, boating, sailing and personal watercraft (e.g., jet ski). Recreational use was not covered in the RI, and hard data on the actual area use was not available for the DEA. For the purposes of design, the DEA does make an assumption that all recreational boats within OU1 will have a draft of less than 3 feet. At a minimum, it will be necessary to prepare and release post-construction navigation charts to the public to reflect changes in depth conditions

2.1.3 River Characteristics

Hydrodynamic Conditions

Water flow and velocity rates in OU1 are typically low, owing to the fact that LLBdM is a wide, generally shallow lake in comparison with the rest of the river. Water is controlled into the lake by releases from Lake Winnebago. As the lake narrows in the upper region, velocities increase. As reported in the RI, discharge records by the Appleton water department show that the flow into OU1 generally exceeds 96 m^3/s (3,400 cfs). A flood frequency evaluation completed by USGS (Krug, et al., 1992) showed that the expected 10-year flood discharge is 544 m^3/s (19,200 cfs) while the 100-year flood flow is over 685 m^3/s (24,200 cfs), which is 5 to 6 times greater than the average discharge of 122 m^3/s (4,300 cfs). There are no projections for 500 or 1000-year floods.

Maximum bottom velocities that could be expected in OU1 were estimated from the modeled projections developed in the *Evaluation of the Hydrodynamics of the Lower Fox River between Lake Winnebago and*

De Pere, WI. (HydroQual, 2000) (Figure 2-5). The projections developed in that document were for the period of January 1, 1989 to May 31, 1990, and had a maximum measured flow of 408 m^3/s. The 100-year flow conditions were not estimated for OU1.

To estimate the 100-year flood velocities, the linear regressions developed by HydroQual (HydroQual, 2000) relating flow and velocity were used. Applying these velocity-flow relationships to the 100-year flood flow of 680 m^3/s results in an increase of between 1.2 and 1.9 times the velocities developed for 408 m^3/s.

There is a lack of direct-measured bottom velocities within all operable units of the Lower Fox River. As such modeling estimates are used in the basis of design. Limits to the interpretation lie within the estimate of velocities within OU1, and changes that would occur with loss of hydraulic control. Additional hydrodynamic conditions data would improve the estimates.

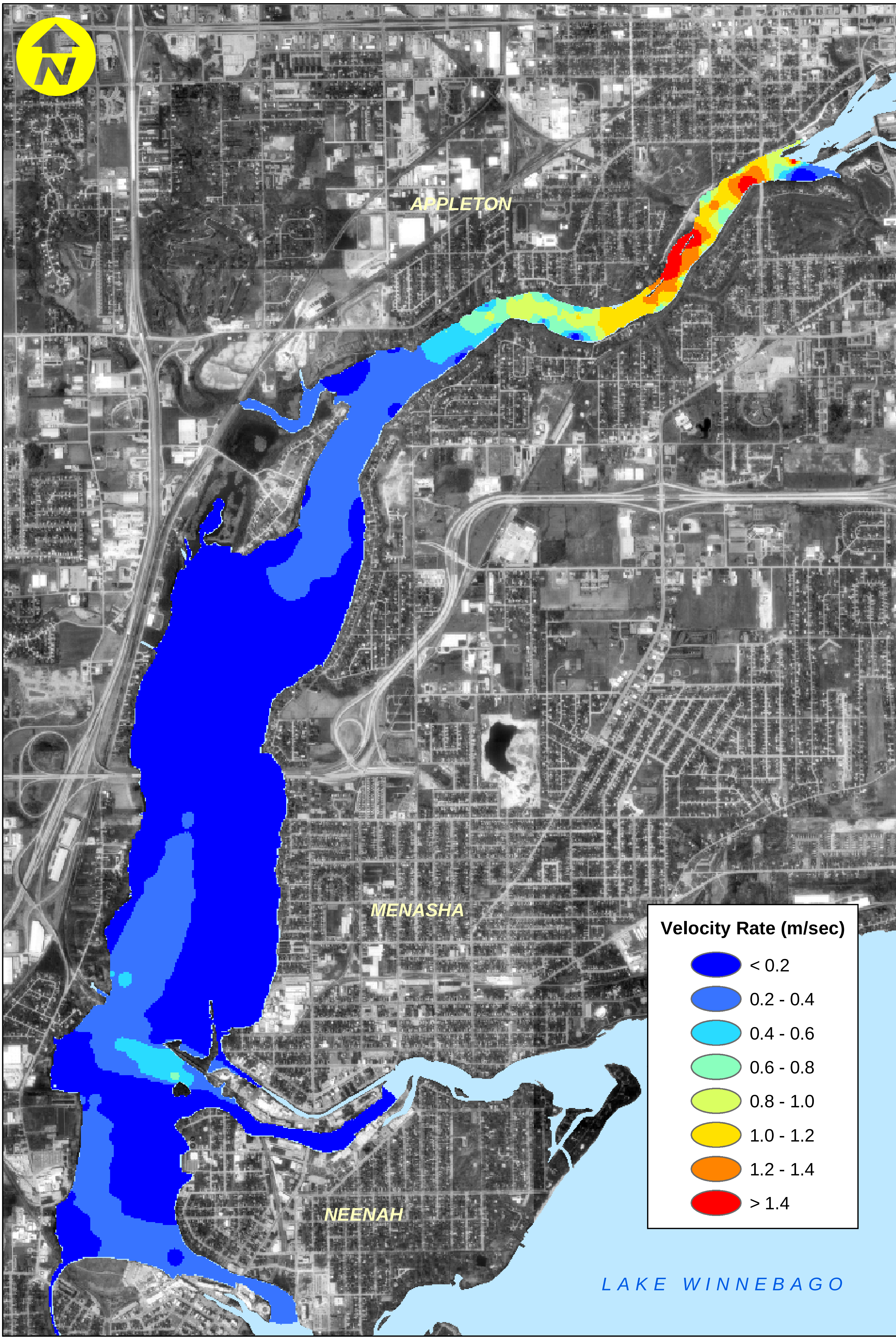
Geological and Hydrogeological Conditions

The current understanding of the regional geological and hydrogeological conditions is documented in Section 3 of the RI. The Lower Fox River is fairly well documented to have either relatively nonporous clay or bedrock underlying most of the River. Based on the fine-grained glacial deposits which underlie the Lower Fox River and the absence of regional groundwater extraction, there is little groundwater recharge from the Lower Fox River into the upper aquifer. Available information also indicates little potential seepage (advection) due to groundwater flow.

The regional geology of the Fox Valley does include sand stringers or fractured bedrock. These features would need to be considered during sampling for final design purposes. This information should be derived based upon drilling and logging of cores in the uplands, parallel to the capping area. If a shallow aquifer is identified to occur within the elevations from the mudline to the bottom of the contaminated sediment, the overall gradient, flow rate, and emergence points will need to be identified. In addition, the presence of sand stringers may be identified by complete logging of sediment cores collected through, and into, the underlying native materials.

Flood Flow Capacity

Federal Flood Emergency Management Act (FEMA) floodplain map for Outagamie County along the shores of LLBdM are shown in Figure 2-6.



0 2,000 4,000

1" = 2,000 Feet

RETEC

OPERABLE UNIT 1 Lower Fox River, Wisconsin (WISCN-15933-122)	MAXIMUM VELOCITY RATE ESTIMATED FOR FLOW CONDITION OF 408 CMS AT RAPID CROCHE DAM : LITTLE LAKE BUTTE DES MORTS
DATE: 01/30/03	FILE: OU1 Velocity.mxd

FIGURE: 2-5

0 2000 4000

1" = 2000 Feet

RETEC

OPERABLE UNIT 1 Lower Fox River, Wisconsin (WISCN-15933-121)	**FEMA FLOOD ZONE COVERAGE: LITTLE LAKE BUTTE DES MORTS**

DATE: 04/04/03 | FILE: OU1 Flood Zones.mxd | FIGURE: 2-6

Remedial alternatives for OU1 have the potential to influence flood flow capacity. Chapter 116 of the Wisconsin Administrative Code (WAC), Wisconsin's Floodplain Management Program, details the regulations for construction and development in floodways and floodplains. NR 116 requires that an in-water construction (including a cap) would be required to undertake a determination of the potential effects on the regional flood heights. This would require a substantive study on the hydrologic and hydraulic conditions pre- and post-construction to determine if there would be an increase in flood height due to any potential cap placement. NR 116.03(28) defines an "increase in regional flood height" as being equal to or greater than 0.01 foot if a cap would result in an increase in regional flood height.

FEMA Flood Zone maps were obtained and plotted for the 100-year and 500-year floods. Within OU1, the 100-year FEMA flood zone is indicated throughout most of the length of OU1 and may be specifically affected by remedial actions within deposits A/B, C, POG, E and F. The 500-year flood zones are indicated at the southernmost point at Neenah, and along Strobe Island. Remedial actions at deposits A/B, C, POG, E and F may affect 500-year flood zones.

Ice Conditions

There are no data available concerning ice conditions on LLBdM. Ice does form on the lake, but available data are anecdotal relating to the actual thickness. In 1999, ice in excess of 18 inches had to be broken up in order to conduct the post-removal confirmation sampling at Deposit N. Also, winter outflow through the Neenah and Menasha gates can create problems with frazil ice. Frazil ice is formed when fast moving water comes in contact with air below 25 ºF and develops into a slushy ball which rolls along the river bottom. The USACE recognizes frazil ice formation as a management issue in the regulation of pool elevation for Lake Winnebago especially during mild winters when extensive gate changes may be required (USACE Facts Book, 2003) in addition to the obvious consequences to the integrity of a cap. Confirmation of actual ice thickness must be incorporated into final design of a cap.

Gas Formation

The Lower Fox River has high methane sediment content (GAS/SAIC, 1996). Sub-bottom profiles of sediments revealed large subsurface accumulations of methane in OU1, OU2, and OU3. Methane releases are frequently observed during sediment sampling and were observed during the demonstration project at SMU 56/57.

Habitat Considerations

Major habitat areas identified within the RI included the Stroebe Island Marsh and backwater areas (see RI, Figure 4-1). In LLBdM, the marshland around Stroebe Island has been identified by the WDNR as a valuable spawning habitat for bluegill, sunfish, and bass, and the last remnant of northern pike spawning ground. Studies of LLBdM included descriptions of various species of pondweeds, waterweed, eel-grass or water celery, and the water lilies. These species are located on the shallow edges and backwater coves. Large cattail stands are also identified near Stroebe Island where Mud Creek enters the Lower Fox River. The last remnant of northern pike spawning marsh is located along the west side of Stroebe Island. Northern pike is an important predator species and WDNR has indicated that this spawning marsh should be protected from future dredging or fill (WDNR, 2002c). A detailed discussion of the habitat within OU1, and the potential impacts associated with remedial actions, may be found in *White Paper No. 8 – Habitat And Ecological Considerations As A Remedy Component For The Lower Fox River*.

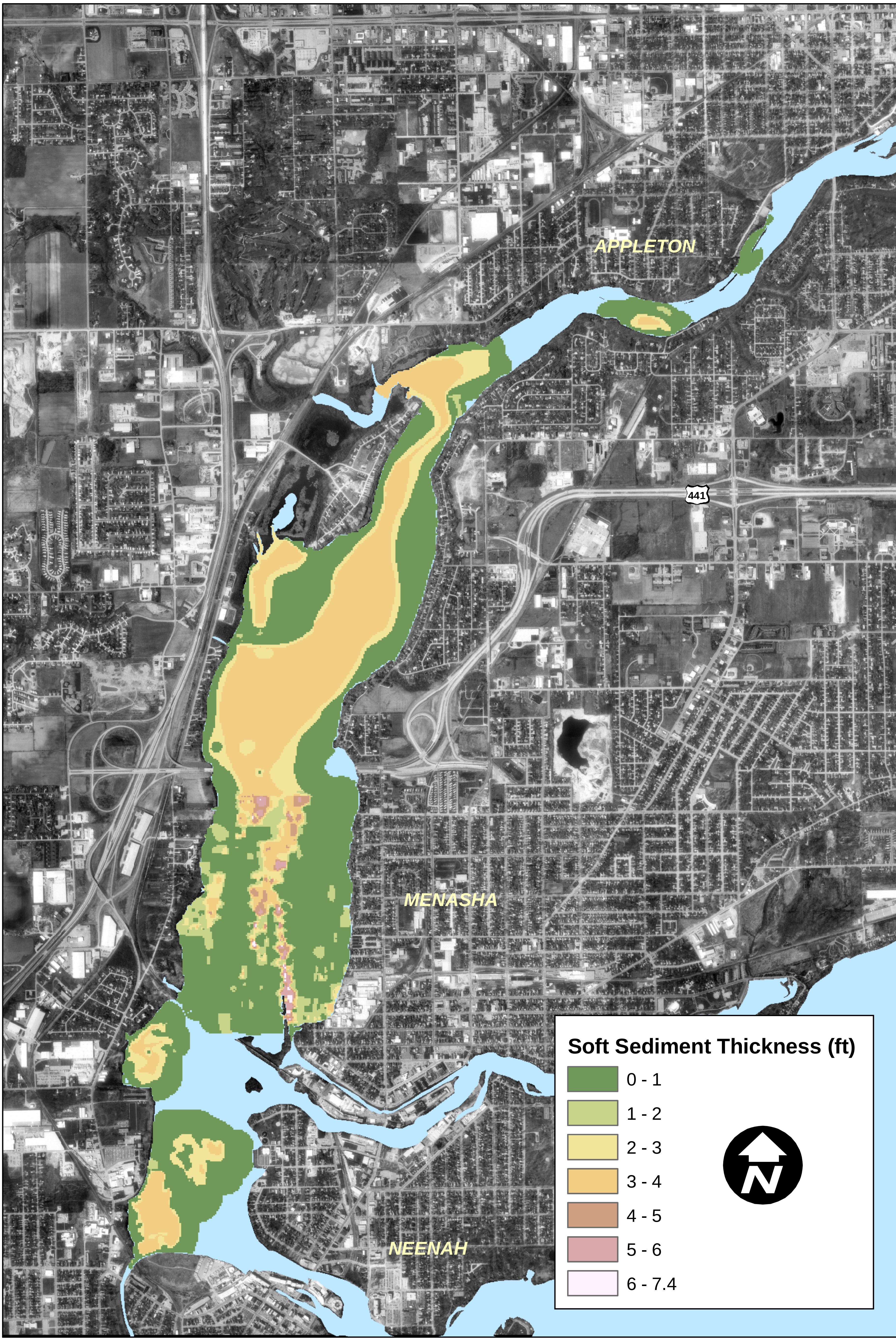
2.1.4 Sediment Characteristics

Sediment Thickness and Deposition Rates

LLBdM is considered to be a net depositional environment, but the rates at which sediments accumulate are not well understood. Sediment-thickness maps (Figure 2-7) used in the design are based principally on the relatively sparse poling data collected as part of the Green Bay Mass Balance study, as well as some supplemental information from sediment cores collected in the individual deposits. All of the poling data are based upon depth-to-refusal during poling, and are not tied to specific elevations.

The aerial extent and depth of the soft sediment in OU1 is not sufficiently documented for final engineering design of either a removal or capping alternative. Specific information needed includes bathymetric and side scan sonar surveys tied to NAD 1983 waypoints and specific lake elevations to document the mudline elevation and the aerial extent of soft sediment thickness. In addition, core samples collected through the soft sediments and into underlying native materials, tied to specific elevations are needed. Finally, well-documented core logs are needed to identify the physical conditions and potentially different substrata in the sub-surface layers.

There is a paucity of information on net deposition rates in OU1. Furthermore, whether the net deposition represents sediment solids transported into the system, or the accumulation of decayed organic matter in the highly eutrophic system is unknown. Finally, how the deposition rate may change upon completion of removal and/or capping actions is unknown.



0 2000 4000

1" = 2000 Feet

RETEC

OPERABLE UNIT 1 Lower Fox River, Wisconsin (WISCN-15933-121)	SOFT SEDIMENT THICKNESS: LITTLE LAKE BUTTE DES MORTS
DATE: 04/10/03 FILE: OU1 XSection.mxd	FIGURE: 2-7

Sediment Physical Properties

The sediment physical properties in OU1 are discussed in the RI, and specifically are listed for all operable units in Appendix G of the RI. The data in Appendix G of the RI includes grain size, Atterberg Limits, the maximum depth of sampling (i.e., soft sediment), total solids, total organic carbon, and bulk densities by deposit. Additional data collected since the RI includes samples in deposits A, C, POG, and southern portions of Deposit E.

At the present time, there are too few physical sediment data points for final engineering and design of a remedy. These include data to support the design of a removal project, as well as potential capping activities. To fill these gaps, a major pre-design sampling program is anticipated for 2003-2004.

PCB Distribution

The vertical and horizontal extent of PCB distribution in the Lower Fox River was developed in the RI, and discussed specifically for the purposes of remedial planning in Section 2.4.2 of the FS. The basis for determining the spatial distribution, volumes and mass are PCB chemical isopachs generated using the Spatial Analyst Tool in ArcView 8.0. Table 2-1 of the FS provides the aerial and depth extent of PCB contamination, as well as total volume, in the individual deposits for OU1. As shown in Table 2-1 of the FS, the nine sediment deposits in this reach (deposits A through H and POG) contain about 1,540 kg (3,395 pounds) of PCBs in about 1.35 million m^3 (1.77 million yd^3) of sediment with concentrations greater than 50 µg/kg PCB. These deposits cover about 314 hectares (775 acres) and occur in thicknesses that range up to approximately 1.9 meters (6.2 feet) thick. The highest detected total PCB concentration in sediment was 222,722 µg/kg (average 15,043 µg/kg).

The ROD for OU1 sets 1 mg/kg (ppm) as the Remedial Action Level (RAL) for PCBs within LLBdM. At that RAL, the FS defined the total potential volume for removal as 784,192 yd^3 over 526 surface acres. Within that volume, an estimated 16,165 yd^3 exceed the Toxic Substance Control Act (TSCA) limit of 50 mg/kg.

Since release of the RI/FS, additional data were provided to WDNR; these are in part documented in the white paper prepared as part of the *Responsiveness Summary for Operable Units 1 and 2; Evaluation of new LLBdM PCB Sediment Samples*. These data were used to re-interpolate the PCB mudline maps following the same procedures described in *Technical Memo 2e Estimation of Lower Fox River Sediment Bed Properties* (WDNR 1999). Specific data handling procedures are given in Appendix B.

Within the RI, the area falling within the 1 ppm action level totaled 527 acres (2,133,979 m^2), whereas in the re-interpolated mudline maps the area is approximately 493 acres (1,993,087 m^2). Thus, there is a reduction of roughly 6 percent in the overall surface area. While the overall surface area of PCB-contaminated sediments did not change appreciably with the 2003 bed maps, the volume of sediment increased from the 784,192 yd^3 reported in the Feasibility Study, to 883,848 yd^3. This difference of almost 100,000 yd^3 represents an increase of 13 percent from the FS.

For purposes of this DEA, only the original volumes documented through the RI/FS process have been used. The discussion above indicates the potential variability in the volume estimates. Once the upcoming pre-design sampling program is implemented (as described above), the mudline mapping will again be updated, and revised estimates suitable for final engineering of the remedy will be prepared.

Development of DMUs

It is important to note that the theoretical mudline volume described above is not necessarily the volume of material that would be removed during the dredging project. The actual dredge volume will reflect constructability factors, and the discretization of the PCB footprint into a series of individual "cut" volumes, the aerial size of which depends on the dredge equipment used. Each area, known as a dredge management unit (DMU), has a pre-determined dredge elevation. For the DEA, the dredge elevation cut is defined as that elevation that must be excavated to in order to remove all PCBs greater than 1 ppm in a specified area. The direct recommendation of the TRT was to provide contractors with a performance standard of a specific aerial distribution and an absolute dredge elevation to ensure that all of the PCBs greater than 1 ppm are removed. Plan sheets showing the dredge elevations were created to develop an estimate of the volume that would actually be removed during a dredging operation.

A dredge plan was created based upon the 2003 mudline maps showing PCB distribution, and input from Greg Hartman, Bean Dredging, and RETEC. The dredge plan is presented as a series of drawings of DMUs, bound separately as supplemental documents to the DEA Report. Drawings of DMUs are presented in Supplement I Plan Level Drawings, Dredge Management Units, OU1 (Supplement I) for OU1, Supplement II Plan Level Drawings, Dredge Management Units, OU3, (Supplement II) and Supplement III Plan Level Drawings, Dredge Management Units, OU4 (Supplement III). Due to the magnitude of OU1, the volume calculations and DMU representations were presented within the Water Quality Segments (WQS) developed as part of the Lower Fox River modeling efforts. The ten WQS are shown in drawing OU1-1.

The procedure for developing the DMU and estimating volumes are defined in detail in Appendix B, *Developing Dredge Management Units and Estimating Sediment Dredge Volume* (RETEC, December 3, 2002). Briefly summarized here, the DMUs were based first upon the PCB mudline maps (Drawing OU1-2). The 1 ppm aerial contour was defined (Drawing OU1-3), and assigned to a WQS. Where the segments were too big to show on a single drawing, they were further divided and delineated by letters (e.g., WQS 8a and 8b). DMUs were developed by first projecting mudline elevations from existing bathymetric data. Dredge elevation contours showing the depth of PCBs at 1 ppm were then developed from the PCB mudline maps.

Mudline elevations for each OU were determined from the bathymetric profiles discussed above. For each of the data points generated in the bathymetric survey, the reported depth was subtracted from the NOAA-reported pool elevations, and contouring the resultant data[2]. For example, in OU1, each of the measured depth intervals was subtracted from the pool elevation of 736.1 feet msl to create the bottom profile shown in Drawing OU1-4.

A dredge-depth elevation contour map showing the lowest elevation below the mudline elevation where PCB concentrations exceed 1 ppm was then created. A script was written in ArcView GIS to create a depth-of-dredge cut grid. The depth of dredge cut script took into account all the 9 model sediment thickness layers (e.g., 0 cm to 10 cm, 10 to 30, 300 cm to 350 cm). The depth-of-dredge contour was subtracted from the mudline elevation to result in the dredge elevation. The dredge elevation contours were generated at 1-foot intervals.

DMUs were determined by fitting 60 feet long by 20 feet wide dredge lanes (equal to two 1 m^3 clam-shell bucket lengths) over the dredged depth elevation contours and the 1 ppm RAL aerial footprint. Dredge lanes were set parallel to the River. The width, length, and direction of construction of the individual DMU for mechanical dredging was confirmed in a discussion with an experienced contractor. The resultant drawings for DMUs in OU1 are represented in Drawings OU1-5 through OU1-14. While those drawings are set for mechanical dredges, DMUs for a hydraulic removal would be a series of 120 foot dredge lanes, with 20 foot depths (i.e., combining two dredge lanes).

The mechanical dredging DMU plan drawings (OU1-5 through OU1-14) are grouped by DMUs with similar dredge elevations along the dredge lanes that traverse in the north-south direction. For example, Drawing OU1-5 represents the DMUs for Deposit A/B, where the depth-of-cut for the individual DMUs range from 728 feet msl to 732 feet msl, with most the dredge lanes between 729 feet msl to 731 feet msl elevation. Final design plan drawings would group all of the individual 60 foot by 20 foot units in a single lane with similar depth into a single DMU. For the purposes of this DEA, the individual DMUs shown in the drawings were left as discrete units. Individual dredge cross sections were also generated from these drawings. These are presented in sheets 04 through 07 of the plan set of a fourth supplemental document to the DEA Report, *Supplement IV, Engineering Concept Drawings (*Supplement IV).

[2] No pool elevations were provided with the OSI survey data. As such, the NOAA navigation chart values were used as a default for each operable unit.

Each DMU is assigned a unique identification number starting from the northwest corner of the WQS in OU1, with sequential numbering traversing west to east. For example, the DMUs for Deposit A/B shown in Drawing OU1-16 are numbered as OU1 WQS2-1 through WQS2-1479 from the north to the south. DMU IDs are shown in Drawings OU1-16 through OU1-25.

To determine the volume in each DMU, the corrected mean dredge depth elevation[3] was subtracted from the highest mudline elevation to obtain mean dredge cut depth. The mean dredge depth for each DMU was multiplied by the corresponding area of the DMU to obtain the mean volume of sediments to be dredged within the DMU. These volumes were then summed for all DMUs within the water quality segment, and within the OU, as shown in Table 2-2. There is a total of 968,220 yd^3 in 18,544 DMUs in OU1. The volume of material estimated in the DMUs is 23 percent greater than that estimated in the 2002 FS. Of that, 13 percent is due to the reinterpolated PCB distributions, and 10 percent due to additional volume that will be dredged in the management units, as summarized in Table 2-3.

Table 2-2 Number of DMUs and Estimated Mean Volume from Each Water Quality Segment

Water Quality Segment Number	Number DMUs	Mean Volume (cy)
2	1479	72177
4	2353	70021
5	1254	74356
6A	2414	123930
6B	1757	80314
7A	2541	103482
7B	2767	148455
8A	486	7699
8B	3366	280663
9	127	7123
TOTAL	**18,544**	**968,220**

[3] In some cases a single DMU was traversed by two or more mudline and/or PCB depth-of-cut contours. In those cases, the highest mudline elevation was always used, but the volumes were calculated based upon the lowest, mean, and highest PCB depth-of-cut contour.

Table 2-3 Comparison of Estimated Mean DMU Volume with the Volume Estimated in the Feasibility Study, and in the 2003 Interpolated Bed Maps

Reach	DMU Mean Volume[1] (cy)	FS Volume[2] (cy)	New Interpolated Dredge Volume[3] (cy)
OU 1	968,220	784,192	883,848
Percent Increase	23%	-	13%

(1) Does not include 6 inches of overdredge factored to the mean dredge elevation
(2) From Table 7-2 of the Draft 2001 FS document. Includes overburden volume
(3) Based on 2002 re-interpolation utilizing new data. Includes overburden volume

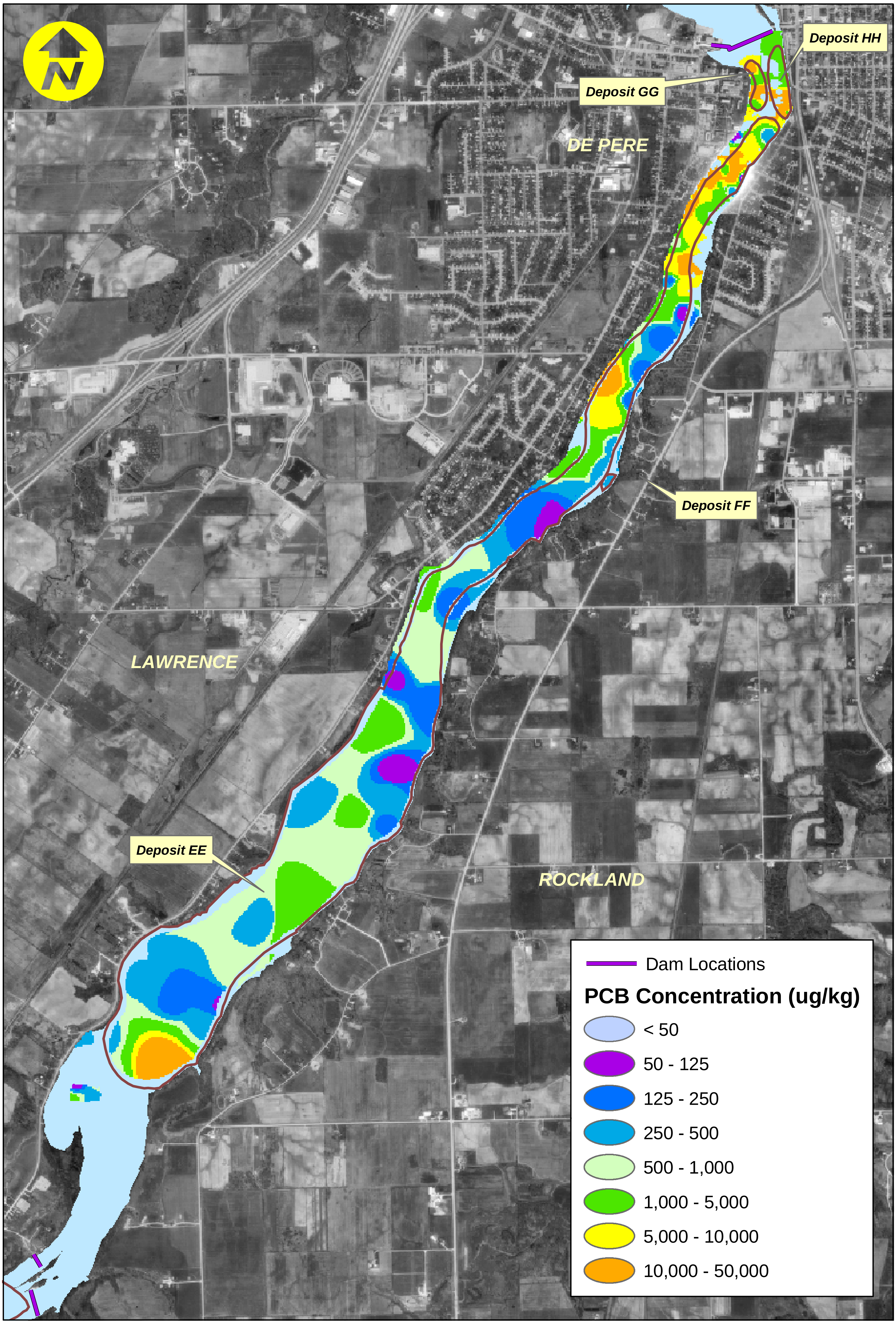
The mean dredge volume for a mechanical dredging option and maximum dredge volume for a hydraulic dredge option would be appropriate representative volumes for design purposes. The mean dredge volume was recommended for a mechanical dredge option as clamshell buckets with the small bite size (20 ft x 10 ft) have the capability of removing sediments with greater precision, thereby eliminating sediment removal within a DMU to flat-bottom based on maximum dredge depth. For hydraulic dredging, use of the maximum dredge volume was recommended as cutterhead dredges have a larger horizontal span (120 ft x 10 ft), which reduces precision and precludes sediment removal at varied depths within a DMU.

2.2 OU3

2.2.1 Upland Conditions

OU3 includes Little Rapids to De Pere and extends from the Little Rapids (Kaukauna) dam to De Pere dam. OU3 is approximately 7 miles from north to south, and varies in width from over 2000 ft. at the southern end, to approximately 1000 ft. at the narrows before the De Pere Dam. This reach includes sediment deposits EE through HH. Most of the contaminated sediments exist in a single contiguous depositional zone (Deposit EE). The total area of PCBs exceeding the 1 ppm action level is approximately 328 acres (Figure 2-8).

OU3 lies entirely within Brown County and is largely agricultural for much of the upper segment. In the area of De Pere dam, property use is principally residential, with the community of De Pere on both sides of the river and St. Norbert’s College on the west bank. The approximated land use percentages for areas within about 0.4 km (0.25 mi) of the bank of the Lower Fox River are summarized in Section 2.1.1.



0 1,000 2,000 4,000

1" = 2,000 Feet

RETEC

OPERABLE UNIT 3 Lower Fox River, WI (WISCN-15933-131)		**DISTRIBUTION OF INTERPOLATED PCB CONCENTRATIONS IN SEDIMENTS (0-10 cm): LITTLE RAPIDS TO DE PERE**
DATE: 05/21/03	FILE: Y:/15933/Maps/OU3/OU3 Layer1 PCB.mxd	FIGURE: 2-8

2.2.2 Operational Considerations

Mudline Elevations and Water Depth Constraints

Bathymetric contours, and corresponding mudline elevations, are presented in Figures 2-9 and 2-10, respectively. Bathymetric transects were conducted by OSI in 1999; metadata were provided as X and Y coordinates for each recorded depth datapoint were reported in meters as Wisconsin Tranverse Mercator NAD 1927. The OSI transect data were converted to WTM NAD 1983, and depth contours were generated using ArcView 8.0. To set mudline elevations, lake level was set at 587.4 feet above MSL (lower water datum), based upon the published NOAA lake elevations between Little Kaukauna Lock and De Pere Lock. (NOAA, 1992). Water depth contours were subtracted from the base lake elevation, to yield mudline elevations on 1 foot contour intervals.

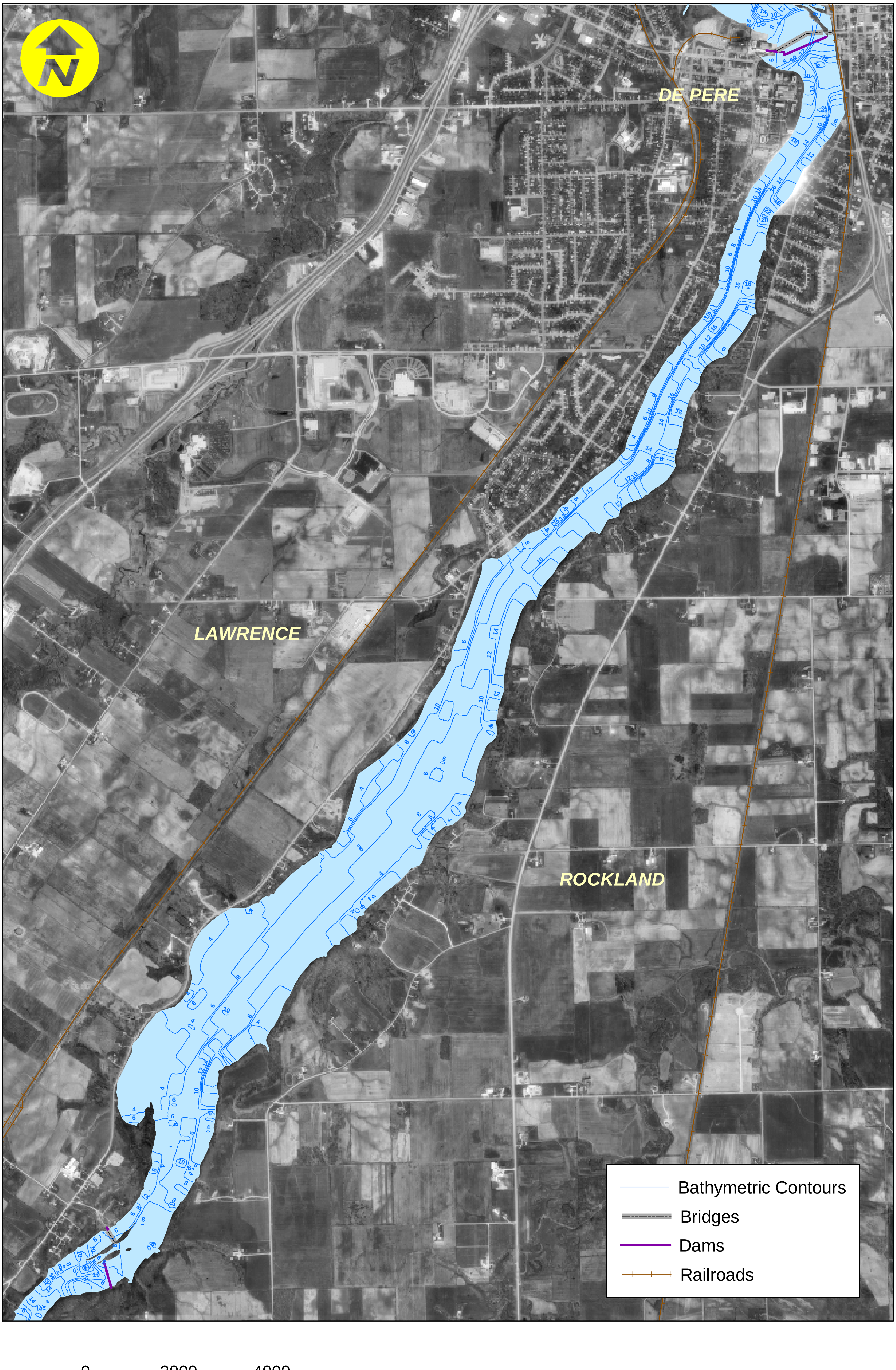
The main channel depth is generally greater than 6 feet throughout most of OU3, and as deep as 18 feet at the De Pere dam. The water depth is less than 4 feet close to the shore and drops off abruptly.

Depth to mudline is shown in Figure 2-9. The mudline elevation in OU3 is generally greater than 578 feet. msl; corresponding water depths are less than 10 feet (NOAA, 1992). Toward downstream portion of OU3, elevations extend down as low as 571 feet. Mudline elevations near Deposit EE are 578 feet msl or greater.

The mudline elevations in OU3 are estimates, and have the same uncertainties associated with the type of survey conducted, and lack of construction-specific QA/QC information, as were described for OU1. As described previously, pre-design surveys conducted according to USACE construction specifications are required for final design. At a minimum, transect lanes conducted perpendicular to the flow of the river no more than 100 ft. apart will be required. QA/QC according to Corps specifications will final engineering considerations, both an additional bathymetric and a sidescan sonar surveys, tied to fixed locations in NAD 1983 and measured river elevation levels in OU3, are required.

Dams

OU3 is bounded on the southern end by Little Rapids (Kaukana) dam, and on the northern end by the De Pere dam. These two dams are indicated on Figure 2-11. There are no indications of dam removal requirements or plans for either of the two dams bounding OU3.



RETEC

OPERABLE UNIT 3
Lower Fox River, Wisconsin (WISCN-15933-121)

LOWER FOX RIVER BATHYMETRIC CONTOURS:
LITTLE RAPIDS TO DE PERE

DATE: 02/03/03 | FILE: OU3 Bathymetry.mxd | FIGURE: 2-9

0 2000 4000

1" = 2000 Feet

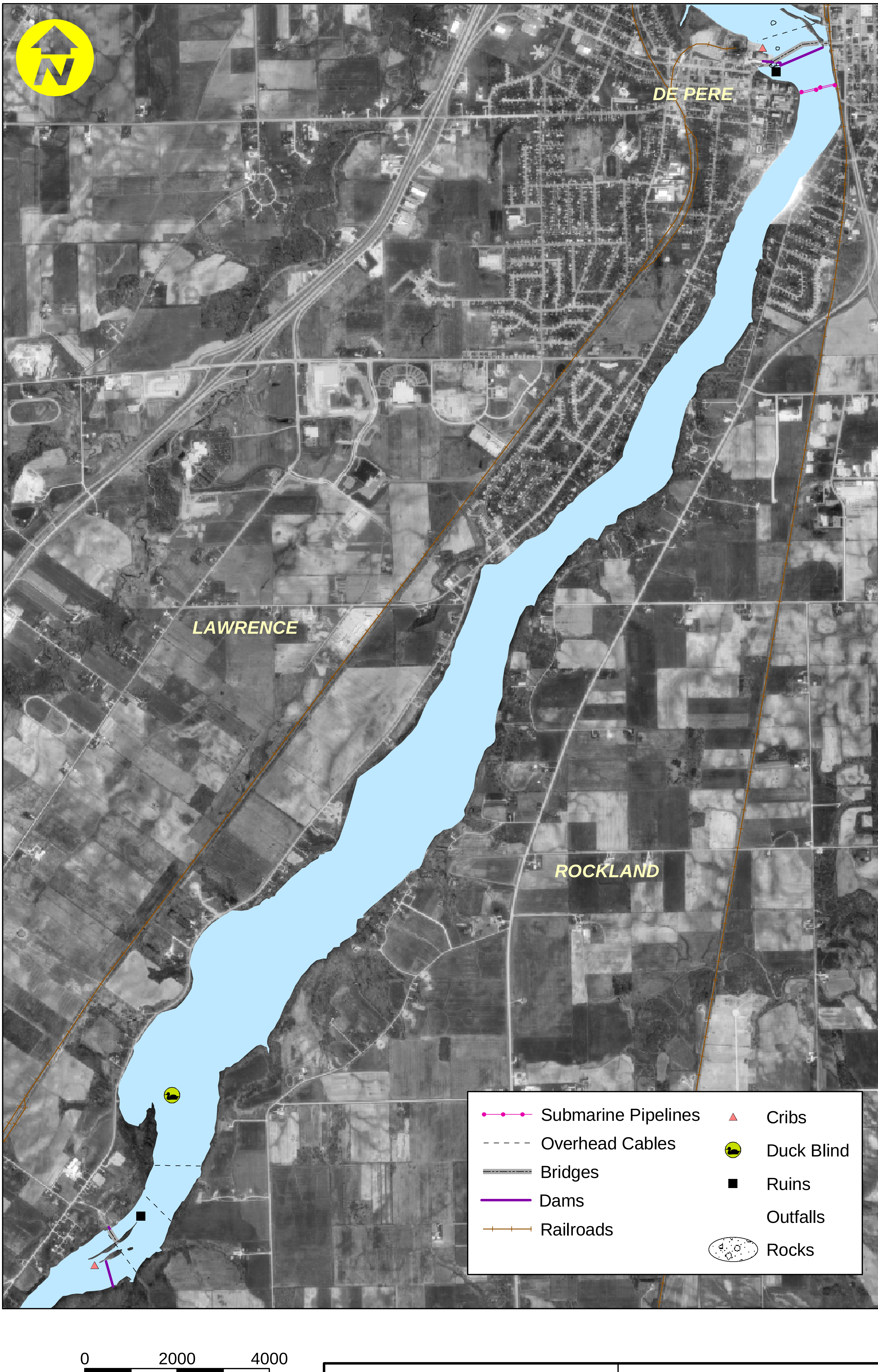
RETEC

OPERABLE UNIT 3

Lower Fox River, Wisconsin (WISCN-15933-121)

MUDLINE ELEVATION CONTOURS:
LITTLE RAPIDS TO DE PERE

DATE: 02/03/03		FILE: Mud3 ElvCtrs.mxd	FIGURE: 2-10



RETEC

OPERABLE UNIT 3
Lower Fox River, Wisconsin (WISCN-15933-121)

LOWER FOX RIVER INFRASTRUCTURE: LITTLE RAPIDS TO DE PERE

DATE: 04/28/03 | FILE: OU3 Infrastructure.mxd | FIGURE: 2-11

Both the dams impounding waters into and out of OU3 are classified as "large" dams[4], and are classified as High Hazard when their failure would put lives at risk. The "hazard" rating is not based on the physical attributes, quality, or strength of the dam itself, but rather the possibility of loss of life and property should the dam fail.

Any consideration for leaving sediments in place (natural attenuation of an *in situ* cap) will need to consider the maintenance of the dam/lock system as an institutional control with requirements for maintenance of the system in perpetuity. While the most recent safety surveys conducted by the USACE do not indicate any structural issues, a failure of the De Pere dam would have catastrophic implications for any *in situ* or natural recovery alternatives in both OU3 and OU4. A detailed description of the dams in all operable units is given in *White Paper No. 4 – Dams in Wisconsin and on the Lower Fox River, to the December 2002 Responsiveness Summary* (WDNR, 2002a).

Federal Navigation Channels

Navigation channels are indicated on the USACE Detroit District in OU3 at the Little Kaukauna Lock on the southern end, and the De Pere Lock on the northern end, and are shown in Figure 2-11.

Infrastructure and Obstructions to In-water Operations

Infrastructure that have the potential to impact remedial operations are shown in Figure 2- 11. These include submarine pipelines, overhead cables, and ruins at the southern and northern ends of the OU. These sources of information come from both the NOAA chart for Little Rapids to De Pere, as well as from a GIS-listing of structures obtained from DNR and Brown County.

Aerial cable crossings are indicated south of Deposit EE. Submarine cables traverse through deposits GG and HH south of De Pere dam.

Prior to completing remedial design, the nature and extent of these in-water structures and obstructions must be understood and well demarcated. This is best achievable through the use of detailed side-scan sonar surveys, as well as checking with the local utility firms for the nature and activity of in-water cables and pipelines.

Recreational Use

Principal known recreational uses on OU3 include fishing, boating, sailing and personal watercraft. Recreational use was not covered in the RI, and hard data on the actual area use was not available to the DEA. For the purposes of design, the DEA does make an assumption that all recreational boats within OU3 will have a draft of less than 3 ft. At a minimum, it will be necessary to

[4] A dam with a structural height of over 6 feet and impounding 50 acre-feet or more, or having a structural height of 25 feet or more and impounding more than 15 acre-feet is classified as a large dam.

prepare and release post-construction navigation charts to the public to reflect changes in depth conditions.

2.2.3 River Characteristics

Hydrodynamic Conditions

The average stream velocity in OU3 is 0.12 m/s (0.39 f/s). Flow velocities in this OU range from 0.11 m/s (0.37 f/s) to 0.13 m/s (0.42 f/s), the smallest variation in flow velocities in comparison with the rest of the OUs. The maximum flood flow velocity noted in this OU is 0.68 m/s (2.23 f/s).

Maximum bottom velocities that could be expected in OU3 were estimated from the modeled projections developed in the *Evaluation of the Hydrodynamics of the Lower Fox River between Lake Winnebago and De Pere, WI.* (HydroQual, 2000) (Figure 2-12). The 100-year flow conditions were not estimated for OU3.

There is a lack of direct-measured bottom velocities within all operable units of the Lower Fox River. As such, modeling estimates are used in the basis of design. Limits to the interpretation lie within the estimate of velocities within OU3, and changes that would occur with loss of hydraulic control. Additional hydrodynamic conditions data would improve the estimates.

Geological and Hydrogeological Conditions

The geological and hydrogeological conditions are similar to those described in Section 2.1.3.

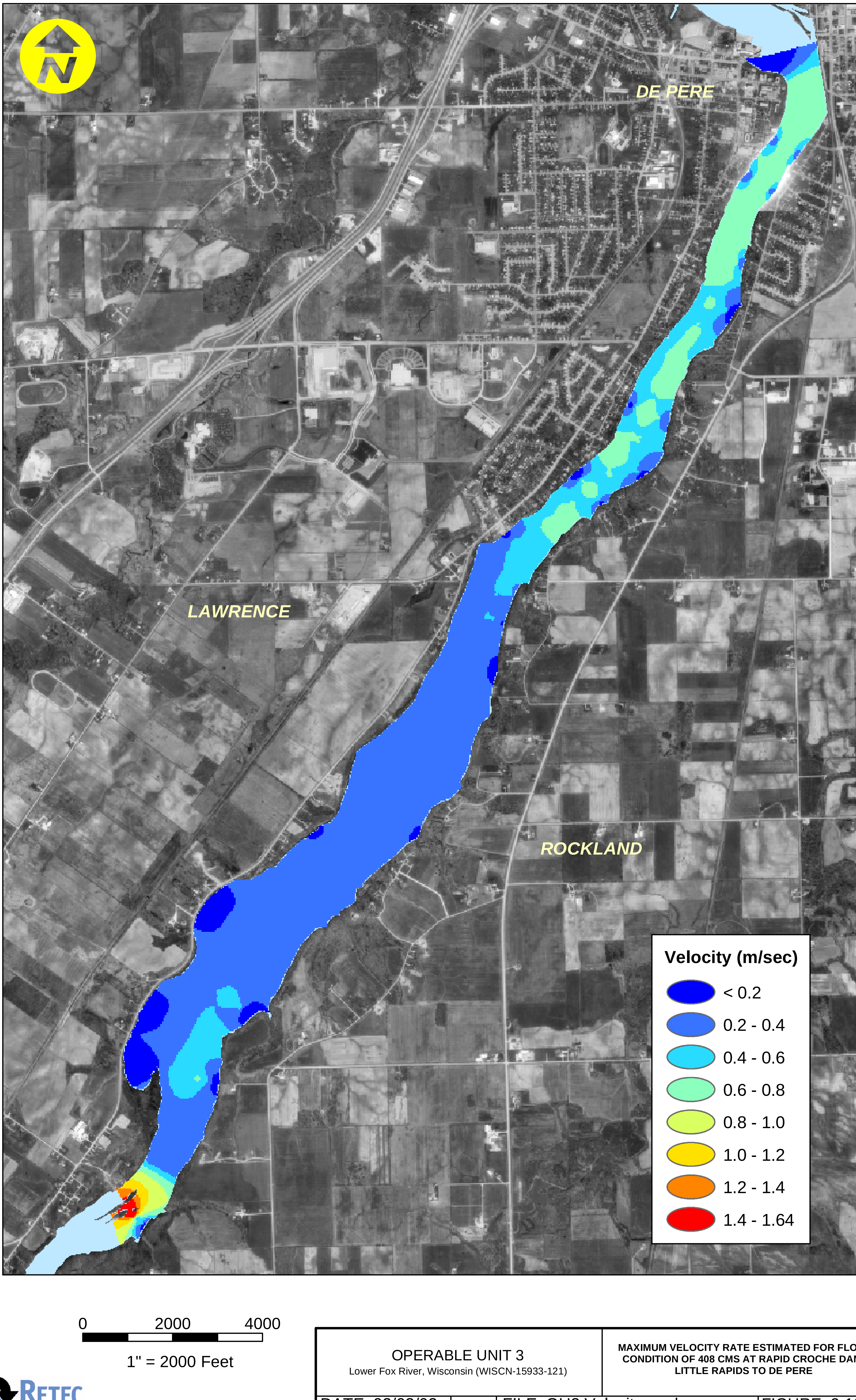
Flood Flow Capacity

FEMA floodplain map for Brown County along the shores of OU3 are shown in Figure 2-13. Remedial alternatives that may impact flood flow capacity for OU3 must meet the same substantive requirements of NR 116, described previously.

FEMA Flood Zone maps were obtained and plotted for the 100-year and 500-year floods. Within OU3, the 100-year FEMA flood zone is indicated throughout most of the length of OU, and may be specifically affected by remedial actions within all the deposits. Remedial actions at deposit EE may affect 500-year flood zones.

Ice Conditions

Ice conditions, as discussed for OU1, are also applicable to OU3.

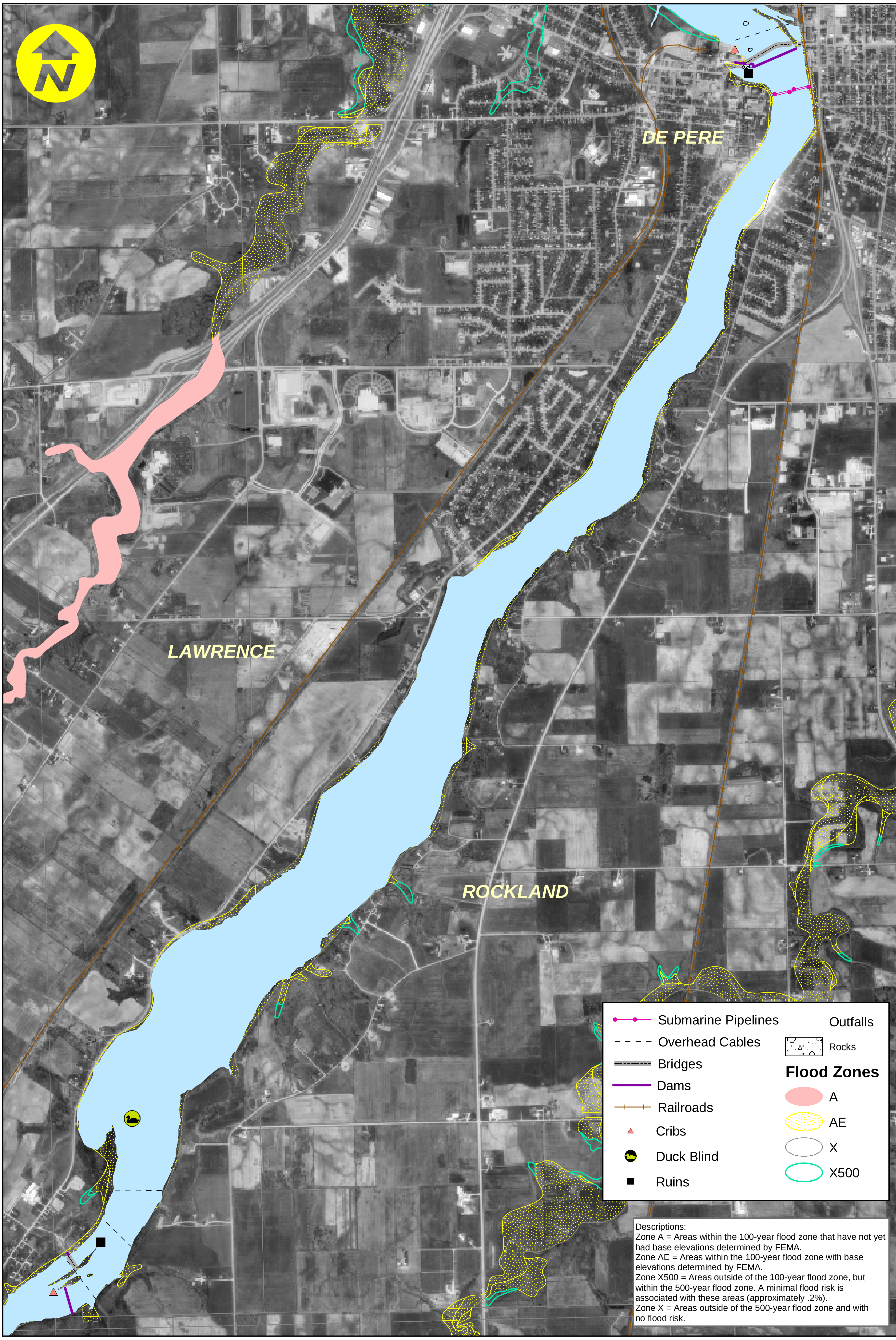


RETEC

OPERABLE UNIT 3
Lower Fox River, Wisconsin (WISCN-15933-121)

MAXIMUM VELOCITY RATE ESTIMATED FOR FLOW CONDITION OF 408 CMS AT RAPID CROCHE DAM: LITTLE RAPIDS TO DE PERE

DATE: 02/03/03 | FILE: OU3 Velocity.mxd | FIGURE: 2-12



0 2000 4000

1" = 2000 Feet

RETEC

OPERABLE UNIT 3 Lower Fox River, Wisconsin (WISCN-15933-121)	FEMA FLOOD ZONE COVERAGE: APPLETON TO LITTLE RAPIDS
DATE: 04/03/03	FILE: OU3 Flood Zone.mxd — FIGURE: 2-13

Gas Formation

OU3 is subject to the same methanogenesis issues described for OU1, and observed in all OUs. The Lower Fox River has high methane sediment content (GAS/SAIC, 1996). Sub-bottom profiles of sediments revealed large subsurface accumulations of methane in OUs 1, 2, and 3. Methane releases are frequently observed during sediment sampling, and were seen during the demonstration project at SMU 56/57.

Habitat Considerations

There is little wetland, nearshore or in-water habitat, identified within OU3. The RI identifies very little SAV in this reach. This is likely due to the fact that the river is narrower with faster stream flow velocities: conditions that are not favorable for the establishment of SAV. No specific fish spawning areas have been identified for OU3.

2.2.4 Sediment Characteristics

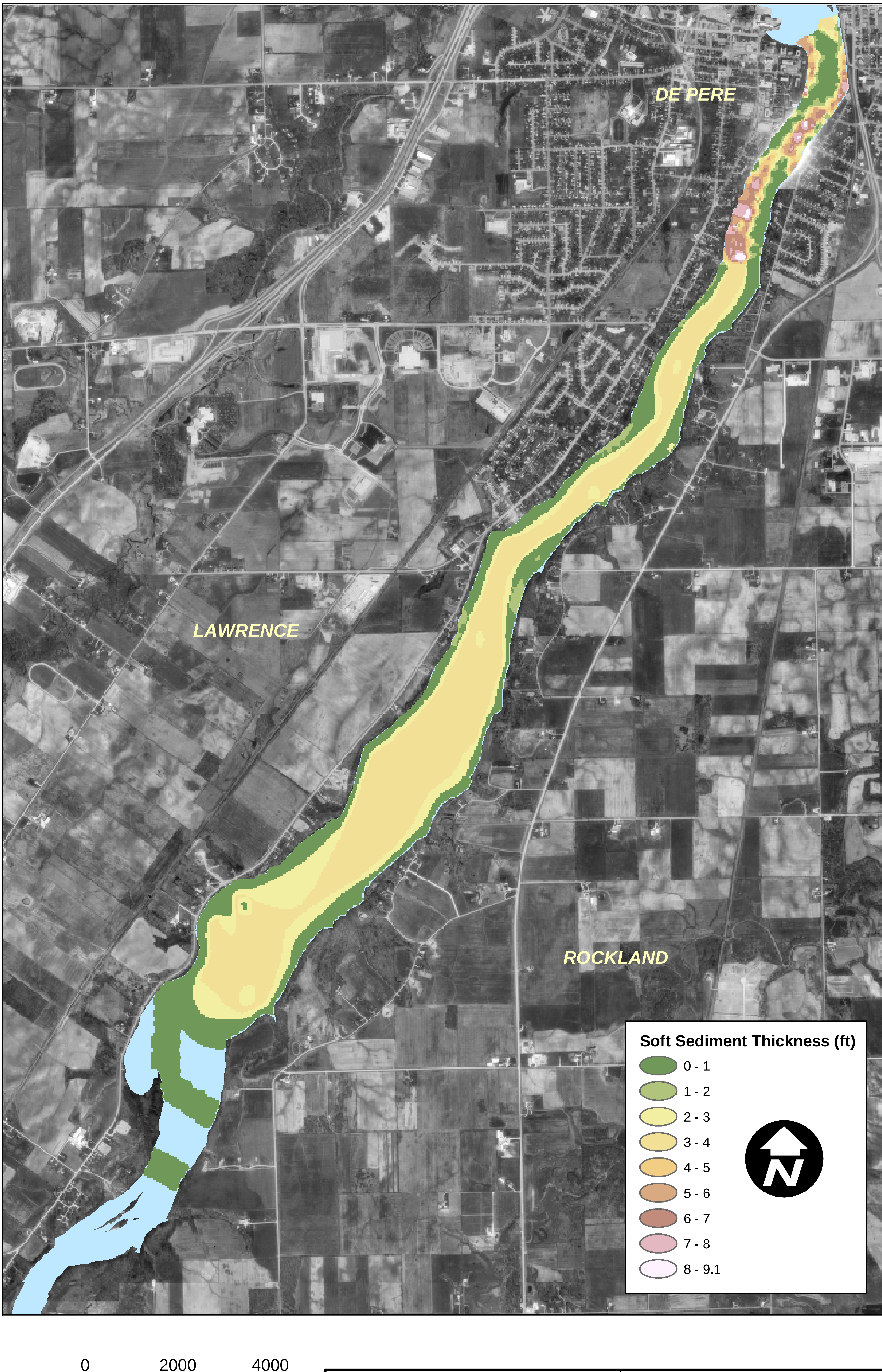
Sediment Thickness and Deposition Rates

Soft-sediment-thickness maps for OU3 are presented in Figure 2-14. These deposits cover about 266 hectares (655 acres) with soft sediment thickness range up to approximately 2.3 meters (7.5 feet) thick. For much of Deposit EE, the soft-sediment accumulation is between 3 to 4 feet. The deposits immediately behind the De Pere dam have greater accumulations, between 4 to 7.5 feet. As described previously, soft sediment thickness data are based upon depth-to-refusal during poling, and are not tied to specific elevations.

The aerial extent and depth of the soft sediments in OU3 are not sufficiently documented for final engineering design. There is no information on net deposition rates in OU3. Specific information needed includes bathymetric and side scan sonar surveys tied to NAD 1983 waypoints and specific lake elevations to document the mudline elevations and the aerial extent of soft sediment thickness. In addition, core samples collected through the soft sediments and into underlying native materials, tied to specific elevations are needed. Finally, well-documented core logs are needed to identify the physical conditions and potentially different substrata in the sub-surface layers.

Sediment Physical Properties

The sediment physical properties in OU3 are discussed in the RI, and specifically are listed for all operable units in Appendix G of the RI. The data in Appendix G includes grain size, Atterberg Limits, the maximum depth of sampling (i.e., soft sediment), total solids, total organic carbon, and bulk densities by deposit.



RETEC

OPERABLE UNIT 3
Lower Fox River, Wisconsin (WISCN-15933-121)

SOFT SEDIMENT THICKNESS: APPLETON TO LITTLE RAPIDS

DATE: 04/28/03 | FILE: OU3 SoftSed Thickness.mxd | FIGURE: 2-14

At the present time there are too few physical sediment data points for final engineering and design of a remedy. These include data to support the design of a removal project, as well as potential capping activities. To fill these gaps, a major pre-design sampling program is anticipated for 2003-2004.

PCB Distribution

The vertical and horizontal extent of PCB distribution in the Lower Fox River was developed in the RI, and discussed specifically for the purposes of remedial planning in Section 2.4.2 of the FS. Table 2-1 of the FS provides the aerial and depth extent of PCB contamination, as well as total volume, in the individual deposits for OU3. As shown in Table 2-1 of the FS, the four sediment deposits in this reach (deposits EE through HH) contain about 980 kg (2,156 pounds) of PCBs in about 1.70 million m^3 (2.22 million yd^3) of sediment with concentrations greater than 50 µg/kg PCB. As reported in the RI, the average concentration in sediment throughout the reach is 5,980 µg/kg, with the highest detected total PCB concentration is 54,000 µg/kg.

For the purposes of the DEA, the Remedial Action Level for the OU1/OU2 ROD of 1 mg/kg (ppm) was applied to OU3. At that RAL, the FS defined the total potential volume for removal as 586,788 yd^3 over 328 surface acres.

Development of DMUs

DMUs were set for OU3 as described previously for OU1. A dredge plan for OU3 was created based upon the 2003 bed maps showing PCB distribution, and input from Greg Hartman, Bean Dredging, and RETEC. The dredge plan is presented as a series of drawings of DMUs in supplement II. Due to the magnitude of OU3, the volume calculations and DMU representations were presented by dividing the deposits into sub units (e.g., EE1, EE2). The sub-divided deposits are shown in Drawing OU3-1.

The procedure for developing the DMU and estimating volumes are defined in detail in Appendix B, *Developing Dredge Management Units and Estimating Sediment Dredge Volume* (RETEC, December 3, 2002). The discussions for developing DMUs and sediment volumes for OU3 are similar to the procedures described under Section 2.1.3. The resultant plan drawings for DMUs in OU3 are represented in Drawings OU3-2 through OU3-14. Information pertaining to the individual DMUs that include area, minimum dry bulk density, mean dredge depth, shallow mudline elevation, mean dredge elevation and mean volume of dredged sediments are provided in Appendix C. Volumes were summed for all DMUs within OU3 as shown in Table 2-4. There is a total of 793,761 yd^3 in 9,944 DMUs in OU3 as shown in Table 2-4. The volume of material estimated in the DMUs is 35 percent greater than that estimated in the 2002 FS, as summarized in Table 2-5.

Table 2-4 Number of DMUs and Estimated Mean Volume from Each Deposit

Deposit	Number DMUs	Mean Volume (cy)
EE1	1,400	97,418
EE2	1,260	56,922
EE3	1,375	61,186
EE4	2,667	155,960
EE5	2,258	310,025
GG-HH	984	112,250
TOTAL	**9,944**	**793,761**

Table 2-5 Comparison of Estimated Mean DMU Volume with the Volume Estimated in the Feasibility Study

Reach	DMU Mean Volume(1) (cy)	FS Volume(2) (cy)
OU 3	793,761	586,788
Percent Increase	35%	-

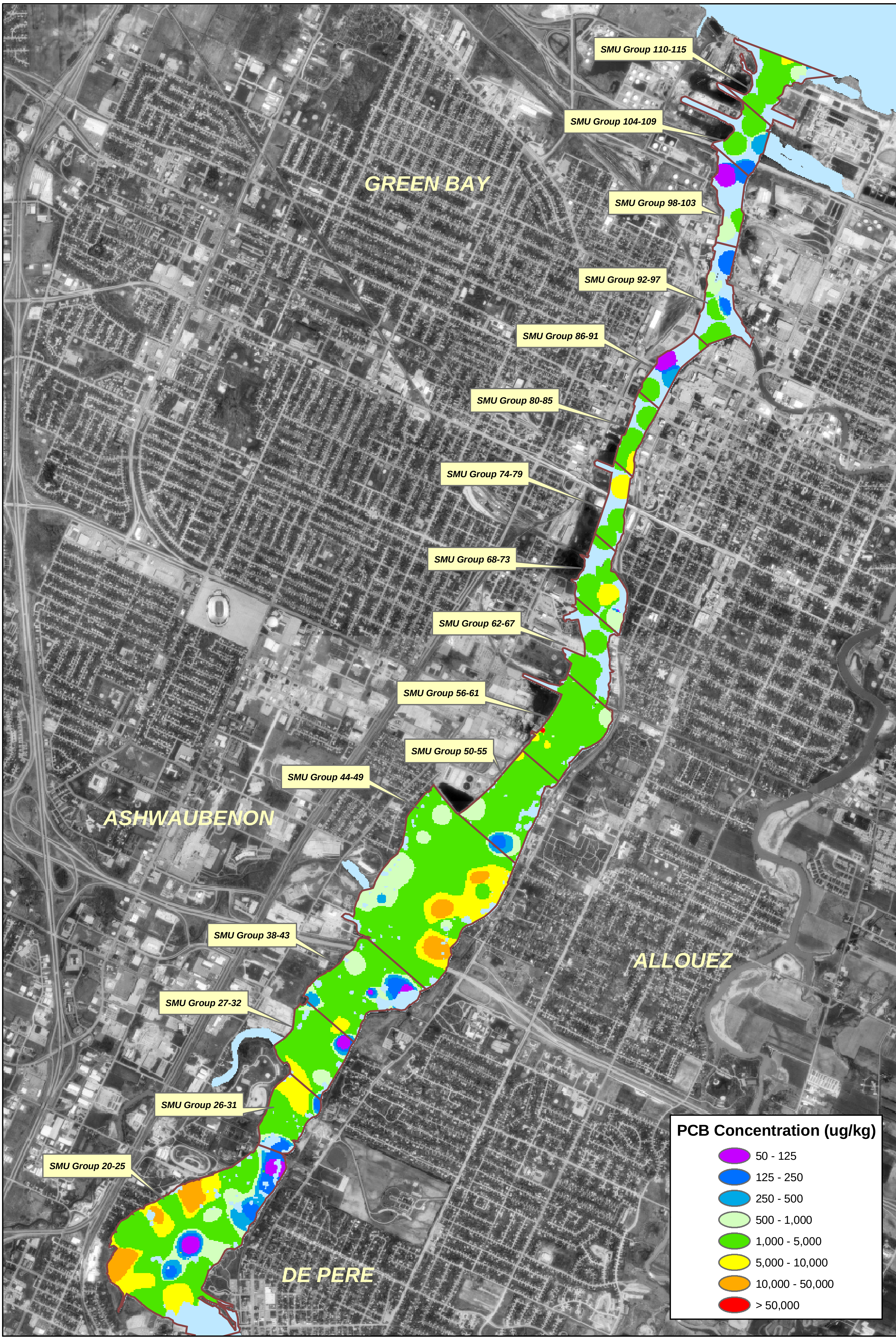
(1) Does not include 6 inches of overdredge factored to the mean dredge elevation.
(2) From Table 7-2 of the Draft 2001 FS document. Includes overburden volume.

The engineering design team determined that using mean dredge volume for a mechanical dredging option and maximum dredge volume for a hydraulic dredge option would be the appropriate representative volume for design purposes. The mean dredge volume was recommended for a mechanical dredge option as clamshell buckets with the small bite size (20 ft x 10 ft) have the capability of removing sediments with greater precision, thereby eliminating sediment removal within a DMU to flat-bottom based on maximum dredge depth. For hydraulic dredging, use the maximum dredge volume was recommended as cutterhead dredges have a larger horizontal span (120 ft x 10 ft), which reduces precision and precludes sediment removal at varied depths within a DMU.

2.3 OU4

2.3.1 Upland Conditions

OU4 includes De Pere to Green Bay and extends from the De Pere dam to the mouth of the river at Green Bay. OU4 is approximately 7 miles from north to south. This reach includes 96 Sediment Management Units (SMU), numbered 20 through 115 and 16 water column segments (6 SMUs to a segment). The SMUs and water column segments were initially established for computer modeling studies. The total area of PCBs exceeding the 1 ppm RAL is approximately 1,034 acres (Figure 2-15).



0 1,250 2,500 5,000

1" = 2,500 Feet

RETEC

OPERABLE UNIT 4 Lower Fox River, WI (WISCN-15933-131)	**DISTRIBUTION OF INTERPOLATED PCB CONCENTRATION IN SEDIMENTS (0-10 cm): DE PERE TO GREEN BAY**
DATE: 05/21/03	FILE: OU4 Layer1 PCB.mxd — FIGURE: 2-15

OU4 is within the city of Green Bay. The shoreline is heavily developed, principally with industrial uses, but with some mixed residential and parklands. The approximated land use percentages for areas within about 0.4 km (0.25 mi) of the bank of the Lower Fox River are summarized in Section 2.1.1.

2.3.2 Operational Considerations

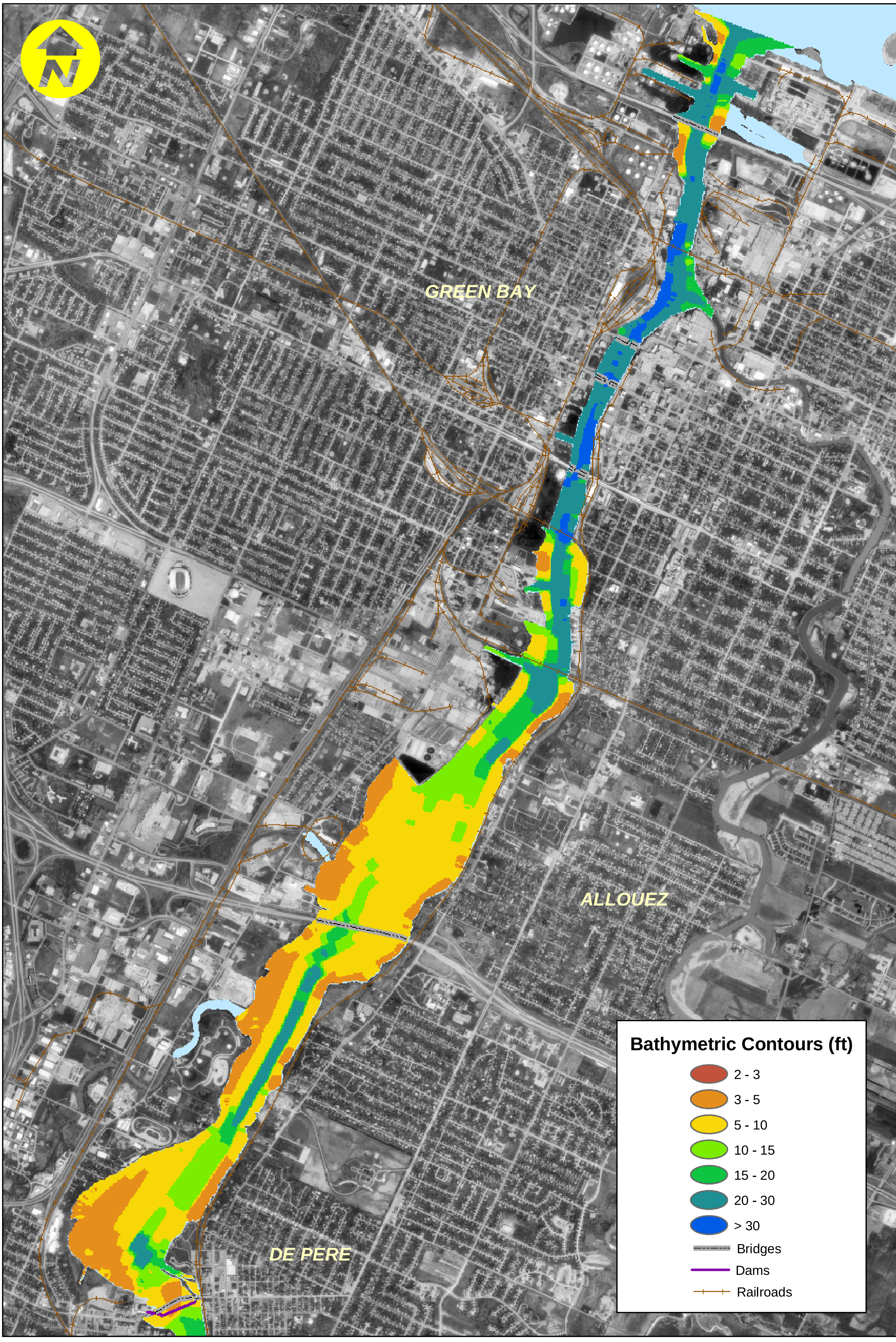
Mudline Elevations and Water Depth Constraints

Bathymetric contours and corresponding mudline elevations, are presented in Figures 2-16 and 2-17, respectively. Bathymetric survey data were those previously described for OU1 and OU3. Data were converted to WTM NAD 1983, and depth contours were generated using ArcView 8.0. To set mudline elevations, lake level was set at 577.5 feet above MSL (lower water datum), based upon the published NOAA (1992) lake elevations between De Pere Lock and Green Bay (NOAA, 1992). Water depth contours were subtracted from the base lake elevation, to yield mudline elevations on 1 foot contour intervals.

The river is broad and shallow at the upper end, becoming narrow and deep as it approaches the mouth of the river. In the downstream portion, the federal channel has been routinely dredged to maintain a navigation depth of 24 feet. River depths outside of the federal channel range from 4 to 12 feet from De Pere to the Fort James-West facility and up to 20-foot depths between the Fort James-West facility and the mouth of the river.

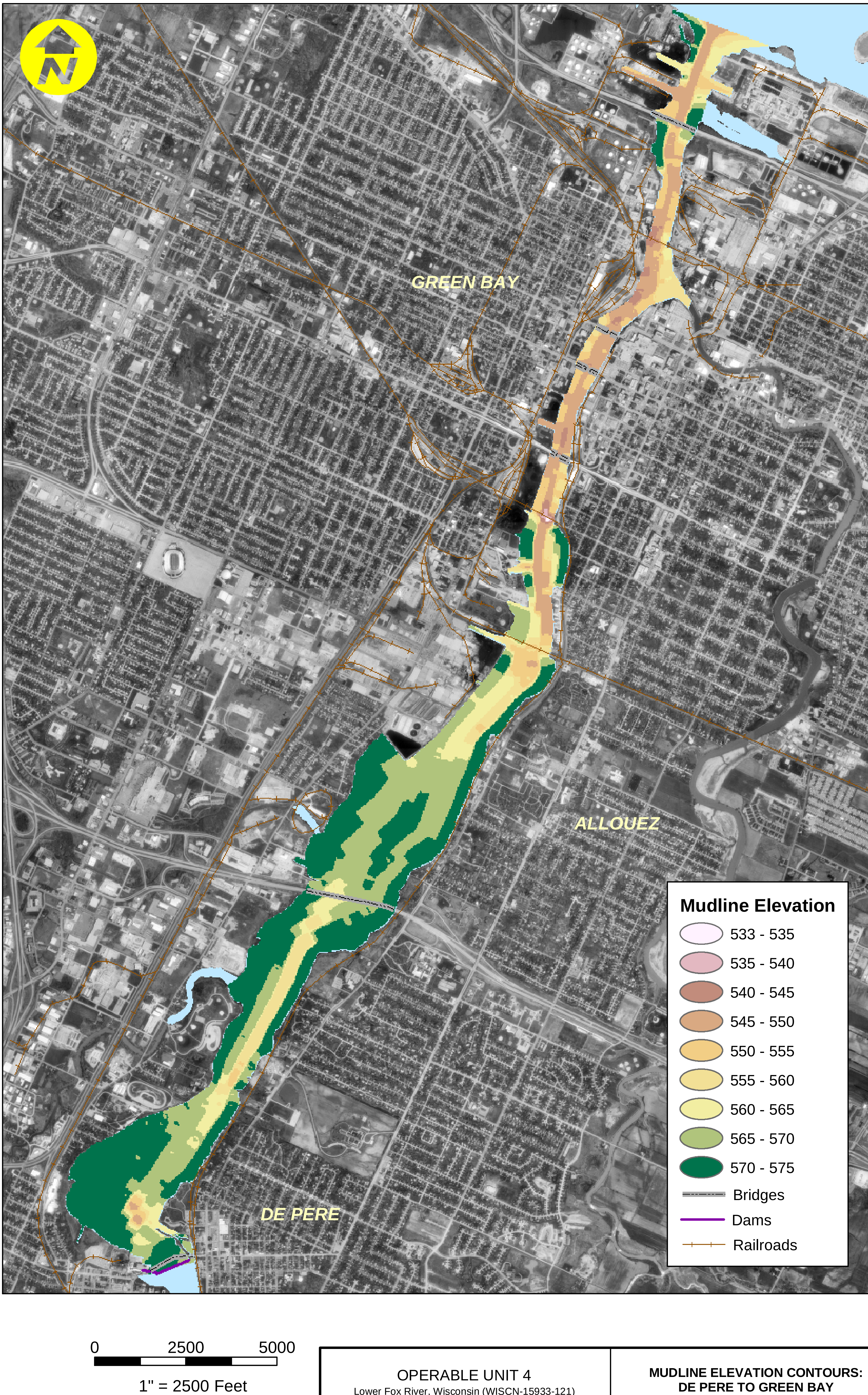
Depth to mudline is shown in Figure 2-17. The mudline elevation in OU4 is generally greater than 570 ft. msl; corresponding water depths are less than 8 feet (NOAA, 1992). Toward downstream portion of OU3, elevations extend down as low as 550 feet. The same uncertainties described for OU1 and OU3 are also applicable to OU4.

Pre-design surveys conducted according to USACE construction specifications are required for final design. At a minimum, transect lines conducted perpendicular to the flow of the river no more than 100 feet apart will be required. QA/QC according to USACE specifications will final engineering considerations, both an additional bathymetric and a sidescan sonar surveys, tied to fixed locations in WTM 1983 and measured lake elevation levels, are required.



RETEC

OPERABLE UNIT 4 Lower Fox River, Wisconsin (WISCN-15933-121)	LOWER FOX RIVER BATHYMETRIC CONTOURS: DE PERE TO GREEN BAY
DATE: 04/07/03 FILE: OU4 Bathymetry.mxd	FIGURE: 2-16



RETEC

OPERABLE UNIT 4
Lower Fox River, Wisconsin (WISCN-15933-121)

MUDLINE ELEVATION CONTOURS: DE PERE TO GREEN BAY

DATE: 04/07/03	FILE: OU4 Mudline.mxd	FIGURE: 2-17

Dams

OU4 is bounded on the southern end by the De Pere dam, and open to the bay of Green Bay to the north. The dam is indicated on Figure 2-18. There are no indications of removal requirements for this dam. Dam conditions for the De Pere dam were discussed for OU3.

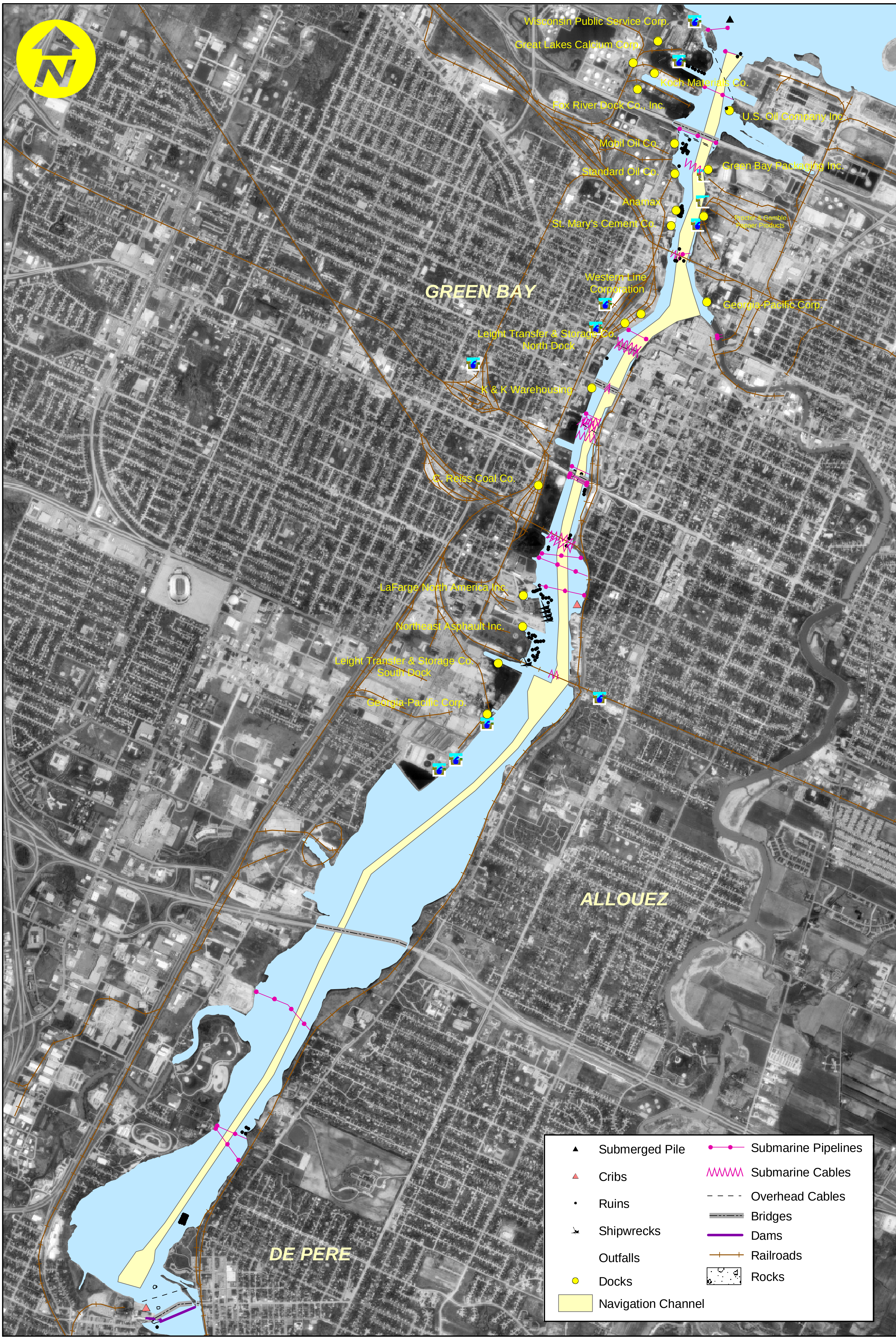
Federal Navigation Channels

Navigation channels are indicated on the USACE Detroit District Drawings in OU4 between the De Pere dam and mouth of the river as shown in Figure 2-18. This section of the Lower Fox River receives active dredging in order to maintain the federal channel. The USACE currently only dredges and maintains the navigation channel.

The navigational channel in Green Bay extends as far upstream as the Fort Howard turning basin, located approximately 5.5 km (3.4 miles) upstream of the mouth of the river. The channel between De Pere dam and Fort James Corp is not maintained. The remaining portions of the navigation channel, along with the lock and dam system, have been placed in “caretaker” status. Data available on the USACE Detroit District web site indicates that since 1958, an average of 63,000 yd^3 is dredged from OU4, with a range of 5,300 to 377,000 yd^3. Currently, all dredged material is handled at the Bay Port Confined Disposal Facility (CDF). As documented in the RI, to date almost 9.4 million yd^3 have been placed in the Bay Port CDF, with the capacity for another 2 million yd^3 of sediment.

Infrastructure and Obstructions to In-Water Operations

Infrastructure that have the potential to impact remedial operations are shown in Figure 2-18. As would be expected in a heavy industrial use area, infrastructure includes numerous road and railroad crossings, submerged pipelines and cables, intake/discharge pipes, pilings, dolphins, and overhead cables. Most of the infrastructure occurs north of the Fort Howard facility, in SMU groups 50 through 115. In addition, there are several active docks in OU4 that have boat dockings that would need to be considered in any remedial design.



0 2500 5000

1" = 2500 Feet

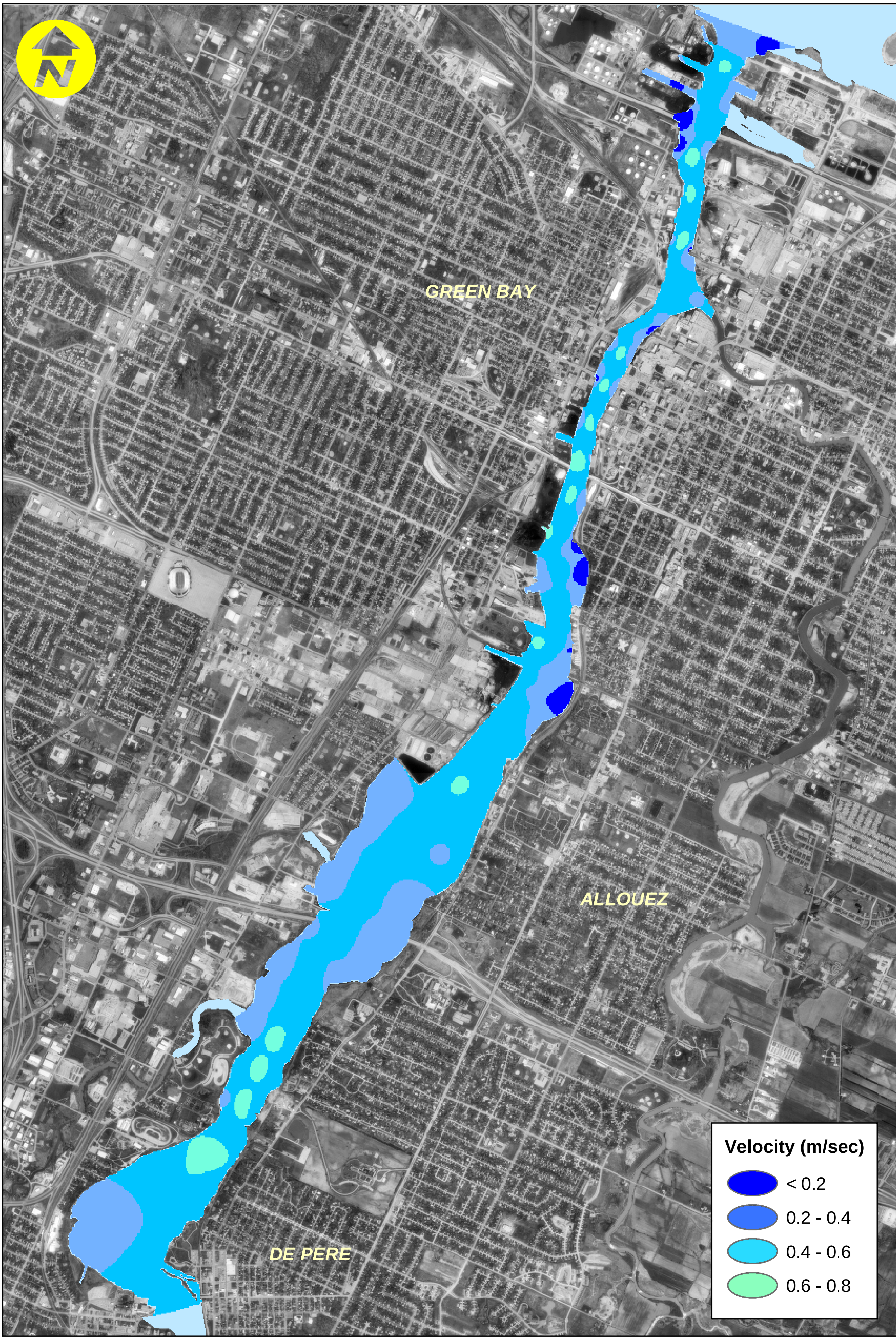
RETEC

OPERABLE UNIT 4

Lower Fox River, Wisconsin (WISCN-15933-121)

LOWER FOX RIVER INFRASTRUCTURE: DE PERE TO GREEN BAY

DATE: 05/01/03 | FILE: OU4 Infrastructure.mxd | FIGURE: 2-18

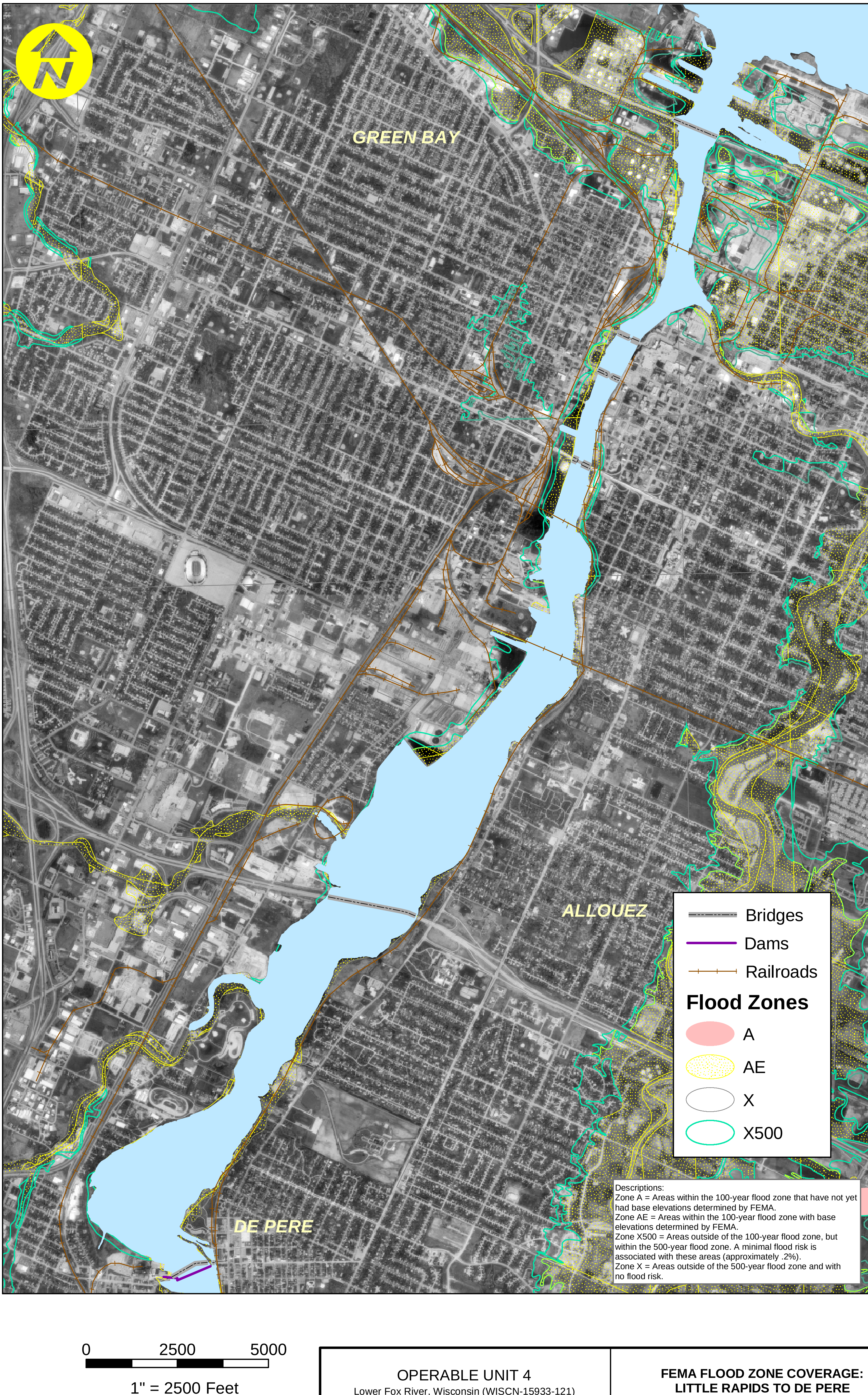


0 2500 5000

1" = 2500 Feet

RETEC

OPERABLE UNIT 4 Lower Fox River, Wisconsin (WISCN-15933-121)		MAXIMUM VELOCITY RATE ESTIMATED FOR FLOW CONDITION OF 408 CMS AT RAPID CROCHE DAM: DE PERE TO GREEN BAY	
DATE: 02/12/03		FILE: OU4 Velocity.mxd	FIGURE: 2-19



RETEC

OPERABLE UNIT 4
Lower Fox River, Wisconsin (WISCN-15933-121)

FEMA FLOOD ZONE COVERAGE: LITTLE RAPIDS TO DE PERE

DATE: 04/03/03		FILE: OU4 Flood Zone.mxd	FIGURE: 2-20

There are four bridges, and three railroad crossings over the river (Port of Green Bay web site). The roads are principally fixed structures, while the railroad crossings are swing bridges. Both physical support structures and operations would need to be considered in any remedial design. These include:

- Tower Drive - At mile 0.41 from River mouth. Fixed span 4-lane 1-43 Interstate Highway Bridge. Vertical clearance can vary depending upon fluctuations of lake level, but was built at 120 feet above high water datum. Full channel width is available through the bridge

- Wisconsin Central RR - At mile 1.02. Left opening 85 feet. Right opening 85.6 feet. Vertical clearance 7.5 feet. Normal position open. The crossing is unattended, and is closed by train personnel only as required for train crossings. Audio and visual warnings when moving

- Main Street - At mile 1.57. Horizontal clearance 95 feet; vertical clearance 14.9 feet

- Walnut Street - At mile 1.8. Horizontal Clearance 95 feet with a vertical clearance 11.8 feet

- Don A. Tilleman (Mason Street) - At mile 2.25. Horizontal clearance of 95 feet, with vertical clearance of 32.6 feet

- Wisconsin Central RR - At mile 2.6. The left and right openings each 75 feet with a vertical clearance 8.3 feet. Unattended with normal position open

- Wisconsin Central RR - At mile 3.3. The left and right openings each 75 feet with a vertical clearance of 31.1 feet. Unattended with normal position open

Aerial cable crossings are indicated at the southern and northern ends of the OU4. Submarine pipelines are indicated to traverse through SMU 26-31 and 32-37 at the southern end of OU4. Submarine pipelines and submarine cables traverse through a significant portion of OU4 at the northern end.

WDNR records indicate that there are 15 outfalls located along the River in OU4. One outfall is at the sewage treatment facility into SMU 26, and the remainder are located north of the Fort Howard facility, beginning in SMU 50 and the northward to the mouth of Green Bay (Figure 2-18).

The NOAA navigation chart (NOAA Chart 14918) shows that there are potential barges or ships submerged in the river, as well as sites of potential archeological interest. These are shown on Figure 2-18, and include sites just north of the railroad bridge at mile 3.3 (next to the Northeast Asphalt and LaFarge North America facilities), at the Mason Street Bridge, and then at and north of the railroad bridge at mile 1.02. There are no immediate records concerning what those sites are.

Shipping traffic includes approximately 200 ship-calls annually, handling principally cement, coal, limestone, salt, and asphalt (Port of Green Bay web site). Active docking facilities, as indicated by the Port of Green Bay, are shown in Figure 2-18. Turning basins include the confluence of the Fox and East Rivers, and a second turning basin above the Wisconsin Central RR bridge at the south limits of the city of Green Bay.

Prior to completing remedial design, the nature and extent of these in-water structures and obstructions must be understood and well demarcated. This is best achievable through the use of detailed side-scan sonar surveys, as well as checking with the local utility firms for the nature and activity of in-water cables and pipelines.

Recreational Use

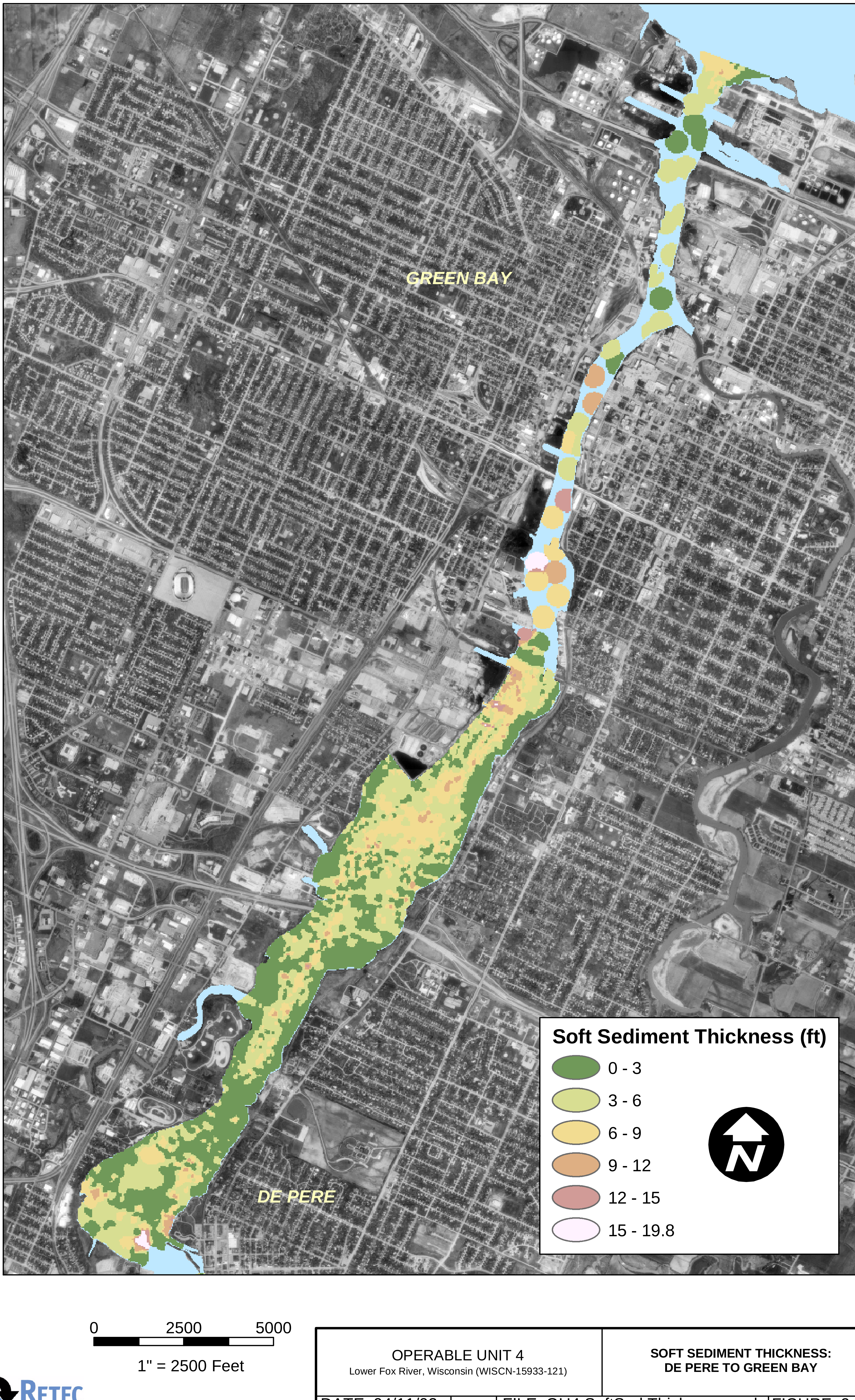
Principal known recreational uses on OU4 include fishing, boating, sailing and personal watercraft. Recreational use was not covered in the RI, and hard data on the actual area use was not available for the DEA. For the purposes of design, the DEA does make an assumption that all recreational boats within OU4 will have a draft of less than 3 feet. At a minimum, it will be necessary to prepare and release post-construction navigation charts to the public to reflect changes in depth conditions.

2.3.3 River Characteristics

Hydrodynamic Conditions

The stream velocity in OU4 is the lowest compared to other OUs with an average stream velocity of 0.08 m/s (0.26 f/s). Due to the overall low stream flow velocities, the largest volume of deposited sediment occurs in OU4.

Bottom velocities that could be expected in OU4 were obtained from the output of the whole Lower Fox River Model (wLFRM) (WDNR 2001). Figure 2-19 shows the velocity obtained for averaged model units in the wLFRM over the 1989 – 1995 calibration period, and not the maximum estimated velocities. While those data were generated for WDNR in Technical Memo 5b (Baird and Associates, 2000) to the Model Documentation Report, the output data were not available, directly for evaluation by the DEA. As such, the generalized conditions used in the wLFRM were used.



RETEC

OPERABLE UNIT 4
Lower Fox River, Wisconsin (WISCN-15933-121)

SOFT SEDIMENT THICKNESS: DE PERE TO GREEN BAY

DATE: 04/11/03 | FILE: OU4 SoftSed Thickness.mxd | FIGURE: 2-21

There is a lack of direct-measured bottom velocities within all operable units of the Lower Fox River; as such modeling estimates are used in this design. Limits to the interpretation lie within the estimate of velocities within OU4, and changes that would occur with loss of hydraulic control. Additional hydrodynamic conditions data would improve the estimates.

Geological and Hydrogeological Conditions

The geological and hydrogeological conditions are similar to those described in Section 2.1.3.

Flood Flow Capacity

The FEMA floodplain map for Brown County along the shores of OU4 is shown in Figure 2-20. Remedial alternatives for OU4 have the potential to influence flood flow capacity. Wisconsin state regulations, and specifically Chapter 116 of the WAC, Wisconsin's Floodplain Management Program, details the regulations for construction and development in floodways and floodplains. These were discussed previously for OU1 and OU3, and are applicable for OU4.

FEMA Flood Zone maps were obtained and plotted for the 100-year and 500-year floods. Within OU4, the 100-year FEMA flood zone is indicated throughout most of the length of OU. Both the 100 and 500 year zones are especially indicated where the River narrows, beginning at SMU 50, and northward into Green Bay. Those SMUs in particular may be specifically affected by remedial actions.

Ice Conditions

Ice conditions, as discussed for OU1, are also applicable to OU3.

Gas Formation

The Lower Fox River has high methane sediment content (GAS/SAIC, 1996). Sub-bottom profiles of sediments revealed large subsurface accumulations of methane in OU1, OU2, and OU3. Methane releases are frequently observed during sediment sampling and were observed during the demonstration project at SMU 56/57.

Habitat Considerations

The RI and the Ecological Risk Assessment indicate that there is very little nearshore habitat within OU4. There are some smaller wetlands and/or submerged aquatic vegetation at the southern end of the reach near the Brown County Fairgrounds below the De Pere dam, but otherwise the River is heavily channelized with riprap or industrial use along the water edge. Notwithstanding this, there is a considerable influx of fish into the reach from

Green Bay. These especially include walleye, perch, sturgeon, carp and several species of forage fish. WDNR has installed spawning cribs for walleye in the southern end of the reach.

2.3.4 Sediment Characteristics

Sediment Thickness and Deposition Rates

As reported in the RI, OU4 is almost a continuous deposit of sediment extends from the De Pere dam to the Fort James-West turning basin (Figure 2-21). These deposits cover about 524 hectares (1,284 acres) and thicknesses range up to approximately 3.96 meters (13 feet) thick. Downstream of the turning basin, most of the sediment is routinely removed by dredging operations conducted to maintain the navigation channel, and only isolated areas of sediment are present. Sediment thickness is typically up to 3 feet between the dam and SMU group 38-43. Downstream of SMU group 38-43, large areas of the river bottom are covered by sediment thicker than 6 feet. This is especially true in SMU group 44 – 49, where sediments have been measured exceeding 12 feet.

Sediment Physical Properties

The sediment physical properties in OU4 are discussed in the RI, and specifically are listed for all operable units in Appendix G of that document. The data in Appendix G of the RI includes grain size, Atterberg Limits, the maximum depth of sampling (i.e., soft sediment), total solids, total organic carbon, and bulk densities by deposit.

As noted previously for OU1 and OU3, at the present time there are too few physical sediment data points for the purpose of planning and evaluating remedial activities. These include data to support the design of a removal project, as well as potential capping activities. To fill these gaps, a major pre-design sampling program is anticipated for 2003-2004.

PCB Distribution

The vertical and horizontal extent of PCB distribution in the Lower Fox River was developed in the RI, and discussed specifically for the purposes of remedial planning in Section 2.4.2 of the FS. The basis for determining the spatial distribution, volumes and mass are PCB chemical isopachs generated using the Spatial Analyst Tool in ArcView 8.0. Table 2-1 of the FS provides the aerial and depth extent of PCB contamination, as well as total volume, in the individual SMUs for OU4. As shown in Table 2-1 of the FS, the sixteen SMU groups in this reach contain about 25,984 kg (57,165 pounds) of PCBs in about 5.50 million m^3 (7.19 million yd^3) of sediment with concentrations greater than 50 µg/kg PCB.

For the purposes of the DEA, the RAL of 1 ppm total PCBs set for the OU1 ROD was applied to OU4. At that RAL, the FS defined the total potential volume for removal as 5,879,529 yd^3 over 1,034 surface acres. Within that volume, an estimated 240,778 yd^3 exceed the TSCA limit of 50 mg/kg.

Development of DMUs

An important element directly influencing the final volume to be excavated is the depth-of-cut. For the DEA, the depth-of-cut is defined as that elevation that must be excavated to in order to remove all PCBs greater than 1 ppm in a specified area. The direct recommendation of the TRT was to provide contractors with a performance standard of a specific aerial distribution and an absolute removal elevation to ensure that all of the PCBs greater than 1 ppm are removed. Standard engineering plan sheets showing the depth of cut were created to develop an estimation of the volume that would actually be removed during a removal operation.

A dredge plan was created based upon the 2003 bed maps showing PCB distribution, and input from Greg Hartman, Bean Dredging, and RETEC. The dredge plan is presented as a series of drawings of DMUs in Supplement III. Due to the magnitude of OU4, the volume calculations and DMU representations were presented by SMU group. The SMU groups for OU4 are shown in Plan Drawing OU4-1.

The procedure for developing the DMU and estimating volumes are defined in detail in Appendix B, *Developing Dredge Management Units and Estimating Sediment Dredge Volume* (RETEC, December 3, 2002). The discussions for developing DMUs and sediment volumes for OU4 are similar to the procedures described under Section 2.1.3. The resultant plan drawings for DMUs in OU4 are represented in Drawings OU4-2 through OU4-36 and are provided in Appendix C. Information pertaining to the individual DMUs that include area, minimum dry bulk density, mean dredge depth, shallow mudline elevation, mean dredge elevation and mean volume of dredged sediments. Volumes were then summed for all DMUs within OU4, as shown in Table 2-6. There is a total of 6,866,021 yd^3 in 39,029 DMUs in OU3. The volume of material estimated in the DMUs is 17 percent greater than that estimated in the 2002 FS, as summarized in Table 2-7.

Table 2-6 Number of DMUs and Estimated Mean Volume from Each SMU

SMU	Number DMUs	Mean Volume (cy)
20-25	7,724	1,184,605
26-31	1,657	248,918
32-37	2,339	349,424
38-43	3,074	487,271
44-49	10,531	1,753,342
50-55	2,930	460,746
56-61	2,778	753,783
62-67	1,149	262,365
68-73	1,196	436,212
74-79	763	181,430
80-85	799	139,198
86-91	582	92,908
92-97	917	125,516
98-103	319	20,705
104-109	992	98,429
110-115	1,279	271,169
TOTAL	**39,029**	**6,866,021**

Table 2-7 Comparison of Estimated Mean DMU Volume with the Volume Estimated in the Feasibility Study

Reach	DMU Mean Volume(1) (cy)	FS Volume(2) (cy)
OU 4	6,866,021	5,879,529
Percent Increase	17%	-

(1) Includes 6 inches of overdredge factored to the mean dredge elevation.

(2) From Table 7-2 of the Draft 2001 FS document. Includes overburden volume.

The engineering design team determined that using mean dredge volume for a mechanical dredging option and maximum dredge volume for a hydraulic dredge option would be the appropriate representative volume for design purposes. The mean dredge volume was recommended for a mechanical dredge option as clamshell buckets with the small bite size (20 feet x 10 feet) have the capability of removing sediments with greater precision, thereby eliminating sediment removal within a DMU to flat-bottom based on maximum dredge depth. For hydraulic dredging, use of the maximum dredge volume was recommended as cutterhead dredges have a larger horizontal span (120 feet x 10 feet), which reduces precision and precludes sediment removal at varied depths within a DMU.

3 Capping

This section provides a description of the conceptual design of *in situ* capping (ISC) for isolating and containing the contaminated sediments. ISC is defined as the placement of an engineered subaqueous cover, or cap, of clean isolating material over an *in situ* deposit of contaminated sediment.

The placement technique proposed in this section has evolved out of past dredging and filling methods that have been used for decades in creating nearshore or open water fills. Projects that have been successfully accomplished using the spreader barge technique are described and included as Table 3-1. Detailed backup materials are contained in Appendix C.

Table 3-1 Examples of Capping Projects Using Spreader Barge Configuration

Site Name	Description
Port of Portland, Oregon - Terminal 2	In 1965, the Port of Portland designed a fill project on the Willamette River using this method to fill 20 acres of shallow water area. The area was filled from an approximate elevation of –20 to +30 using sand applied in one to two foot lifts. The soft underlying soil was compressed slowly and no soft sediment failures where noted during placement.
Port of Los Angeles, California	Over the past 25 years the Port of Los Angeles has used this method of subaqueous material placement. While this method was not used to cap contaminated sediments, the method of material placement was the same proposed for the Lower Fox River applying the material from a radial controlled spreader barge in multiple passes. This method has been used to create added real estate to the Port facilities. In all, over 20 successful projects have been completed placing over 100 million tons of materials.

Site Name	Description
Port of Oakland, California	Over the past 5 years the Port of Oakland has used this method of subaqueous material placement. While this method was not used to cap contaminated sediments, the method of material placement was the same proposed for the Lower Fox River applying the material from a radial controlled spreader barge in multiple passes. This method has been used to create added real estate to the Port facilities. To date, three successful projects have been completed placing over 4 million tons of materials in one to two foot lifts.
Milwaukee Waterway, Port of Tacoma, Washington	In the early 1990's, the Port of Tacoma filled the 50 acre Milwaukee waterway using this method of subaqueous material placement. One to two foot lifts of cap material where placed in over 10-25 foot thick soft sediments in water depths reaching 30 feet. The area was successfully filled with no apparent failure of soft sediments.

This section contains the details of a containment option involving the construction of a subaqueous ISC. An ISC is used to isolate contaminated sediments in-place. This option could be designed and implemented at OU1, OU3 or OU4.

A few key assumptions form the basis for designing the ISC for the different OUs. The assumptions are listed below:

- No capping in areas of navigation channels (with an appropriate buffer zone)

- No capping in areas of infrastructure such as pipelines, utility easements, bridge piers, etc (with appropriate buffer zone)

- No capping in areas with PCB concentrations exceeding TSCA levels

- No capping in shallow water areas (bottom elevations which would result in a cap surface at elevation greater than -3 feet chart datum for OU 1 or OU3, but -4 feet. chart datum in OU4 to account for potential lake level changes, without prior dredging to allow for cap placement)

The above-mentioned criteria were considered to design the ISC for different OUs for physical and chemical isolation of contaminated sediments. The ISC areas have been estimated to be 221 acres, 102 acres and 634 acres for OU1, OU3 and OU4 respectively. Cross-sections for each of the OUs are provided in Appendix C.

3.1 Process Description

Considering the magnitude of capping area and requirement for precise cap placement, a spreader barge with a diffuser plate and pipeline assembly is recommended for the cap installation. A process schematic and list of required equipment has been included in Appendix C. The spreader barge will be fitted with a diffuser plate, drum winches, fairleads, a GPS and plotter, and a generator. Cap material will be stockpiled and developed into a slurry at an on-shore staging area. The slurry is then hydraulically pumped from the staging area to the mobile spreader barge operating in the capping area and systematically discharged using a diffuser plate. The diffuser plate will be positioned at or near the surface of the river water. A reduction in slurry velocity occurs as the slurry is distributed onto the diffuser plate minimizing the potential for erosion of in-place material. The spreader barge will have a draft of approximately 1.5 to 3 feet. Movement of the barge will be controlled using winches and anchor wires that will follow an “arc” pattern across the capping area. The anchor wires will be attached to submerged anchors.

For each of the OUs, the ISC will consist of 18-inches of sand cap overlain by 6-inches of armor. The cross-section of the ISC in each OU is depicted in Appendix C. Each cap layer (lift) will be applied in 1.5-inch lifts, half of which is immediately covered with a second 1.5-inch lift creating a 3-inch lift as shown in Sheet 31. This method is specified to minimize disturbance of the contaminated sediment, specifically; mixing, lateral redistribution, mud waves and shear failure. Additional sand layers will be applied in similar 3-inch lifts, although pilot testing may show that thicker lifts may be acceptable. The 6-inch armor layer will be placed using the same method as the cap.

The barge will be anchored using a submerged anchoring system and moved using the drum winch and anchor wires discussed. Accurate cap placement is dependant on barge speed and slurry (sand) flow rate. Therefore, the barge operator and slurry operator will be in constant communication and maintain detailed records to show that the cap has been installed properly. To assist in placement verification, the spreader barge movement will be constantly monitored and regulated to control the rate of application of capping material. The barge location will be tracked with a Global Positioning System (GPS) and will be coordinated with the pre-construction survey reference points established for the river. These data will be plotted and reviewed to ensure that planned coverage of the ISC has been achieved.

Operation and maintenance monitoring will be required to ensure adequate and accurate cap placement, maintenance of cap integrity, compliance with water quality standards and isolation and containment of contaminants. Both physical and chemical monitoring will be conducted during ISC placement. Construction monitoring will include collection of bathymetric survey data at 50 feet intervals along the ISC placement area and surface water sample collection (1 sample upstream and 3 samples downstream) for Total Suspended Solids analysis.

Upon completion of cap placement, long-term monitoring will be conducted after 5, 10, 20, 30 and 40 years to verify maintenance of cap integrity for physical and chemical isolation of contaminated sediments. Long-term monitoring will include bathymetric or side-scan sonar profiling, sediment and cap sampling, and capture and analysis of pore water that may migrate through the cap, as well as diver inspections to ensure that the cap is intact and containing contaminants.

Several of the main assumptions made for ISC placement include:

- On-river work can occur during 8 months of the year
- Time for mobilization and demobilization, wintering over, and start-ups will occur during the 4 months when river work cannot be performed
- Average slurry rates are 3,000 cy per day
- Work will be performed 22 days per month

Based on these assumptions it would require two years to install the cap in OU1 if the entire acceptable area were remediated in this manner. Similarly, one construction season would be needed to complete the cap installation at OU3 and five construction seasons would be needed to complete OU4.

3.2 Design Basis

The design of the ISC is based on hydrodynamic conditions that vary by reach and operable unit. Sets of preliminary calculations and analyses have been performed to arrive at the suggested cap and armor thickness and material gradations. The design basis and calculations are described in detail in Appendix C.

3.3 Follow-Up Information and Needs

The design concepts for ISC have been developed based on the available information. To further refine the capping design calculations, the following information required is presented in Table 3-2, below.

Table 3-2 Information Needs for Design of ISC

Tasks and Needs	Means for Completing
Capping site selection	WDNR input required to determine the basis for selection of capping areas considering that only less than twenty five percent of the total sediment volume within any OU can be capped.
Geotechnical testing	This work could be completed during "pre-design" sampling efforts. A number of samples should be collected and tested, representing the full range of grain size distributions that are likely to be encountered during this project. The results will then be used to make a final determination on the cap material and thickness.
Water depth and bathymetry	This work could be completed during "pre-design" sampling efforts.

3.4 Permits and Approvals

The permits and approvals necessary for construction of an ISC is not a straightforward matter. The use of the technology is still somewhat innovative in Wisconsin, and a number of legal and jurisdictional issues that do not yet have well-developed precedents will eventually impact the project. These are described in detail in Appendix C.

4 Removal

This section describes the type of dredges and the methods of dredging that are considered to be feasible for the removal of sediment from OU1, OU3 and OU4.

Three types of dredging operations are described below

- Hydraulic pipeline dredge with cutterhead
- Mechanical dredge with haul barge
- Mechanical dredge with hydraulic discharge (hybrid dredging)

The selection of a specific method depends on cost, location of the dewatering or disposal options, the availability and development potential of waterfront support property, and the variability of the sediment. These factors are described below and in subsequent sections of this report.

4.1 Hydraulic Pipeline Dredge with Cutterhead

The hydraulic pipeline cutterhead dredge is the most widely used dredge type in the United States. This type of dredge operates on the design principles of a centrifugal pump with a suction line (ladder pipe) and a discharge line (discharge pipe).

As described in the Proposed Plan, the standard pipeline dredge with cutterhead is considered a preferred dredge type for the Lower Fox River remediation. Specifically, a 10 to 14 inch pipeline dredge was identified because of concerns that larger equipment may result in unacceptable amounts of resuspension. Additional details of the hydraulic dredging option are described below.

4.1.1 Process Description

Using a hydraulic pipeline dredge with cutterhead, sediment is removed to a design elevation by the suction pipeline that is vertically controlled by the dredge operator. An active cutterhead is positioned at the end of the suction pipe that excavates and disturbs the bed sediment up into the water column near the suction mouth. The solid sediment and water slurry is entrained into the pipeline, through the pump and discharged to the dewatering or disposal site without re-handling. The design of the dewatering or disposal site must accommodate this slurry delivery. Additional discussion of this integral hydraulic transport component is contained in Section 5.2.

The cutterhead on a pipeline dredge can be the standard basket cutterhead, an auger cutter, a dustpan head, or a bucket cutterhead. The diameter of a cutterhead is determined by pipeline dredge size (measured by the inside diameter of the discharge pipe). A small to medium dredge is 12 to 14 inches in diameter and typically supports a cutterhead with a 3.5 to 4.5 foot diameter.

For this project, the proposed dredge size is in the range of 10 to 14 inches. The distance the dredge slurry must be pumped and the overall project schedule will determine the final size. For example, in OU3 and OU4, the dredging operation must achieve a typical production rate of approximately 3000 cubic yards per day to meet a proposed eight to ten year remediation schedule.

Maintenance dredging, or navigation dredging as it is often labeled, is subtly different than environmental dredging. Understanding these differences is extremely important in the successful completion of an environmental dredging project. Maintenance dredging is performed in areas that have been dredged before. Environmental dredging is most often performed in areas that have never been dredged. First-time dredging is called “new work” dredging. Maintenance dredging is in soft, recently deposited sediment with little or no debris. “New work” dredging is typically in a geological deposit with dense sediment and a lot of debris, trash and other man-made materials. Maintenance dredging minimizes the dredge time and maximizes the dredge volume. Environmental dredging minimizes the dredge volume and maximizes the x, y and z precision of dredging.

The hydraulic pipeline dredge was developed to provide high production rates of maintenance dredging for navigable waterways. The removal rate of a large pipeline dredge, 24 to 32 inch discharge diameter, performing maintenance work (as opposed to new work dredging) can be as high as 70,000 cubic yards per day. The pipeline dredge operator must maneuver the dredge in a more precise and deliberate manner to realize environmental project success. However, recent designs of pipeline dredges for environmental dredging have improved the suction capture of the sediment excavated by the cutterhead. This assures that the majority of the disturbed and resuspended sediment is within the energy field of the suction mouth, which reduces resuspension at the point of dredging.

Residual contamination is a potential artifact of hydraulic dredging. Residual contamination is defined as an elevated concentration in surface sediments that remain after remedial dredging has occurred. All proven dredging methods available today leave some post dredge residuals on the bed of the waterway. This occurs for several reasons; however, the predominant reason for excessive residual contamination is the design engineer’s and operator’s lack of knowledge regarding environmental dredging.

The following items describe the typical dredging practices that result in residual contamination and how they can be overcome:

- **Cutterhead excavation beyond the suction limit.** The cutterhead dredge excavates and disturbs sediment beyond the suction limit of the dredge. This results in a layer of "spillage" that makes up a portion of the residual deposit after dredging. Use of a smaller pipeline dredge with a smaller diameter cutterhead and extension of the suction pipe, to reduce angle of attack of the cutterhead, reduces the depth of spillage, and residual.

- **Cut slope failure causing adjacent contaminated bed sediment to flow back into the dredge cut.** Control of the dredging operation will require precise horizontal and vertical positioning. This will be accomplished by use of GPS and acoustical sounding, as well as real time monitoring of the dredge head and the bed elevation. The dredging must be accomplished limiting the thickness of cut to a value that is less than 0.8 times the cutterhead diameter. Two cuts will be made for all dredging areas except those areas that are less than two feet thick to avoid over spill onto the rotating cutterhead due to cut slope failure. Completion of the work in a two cut approach also limits the residual concentration. The two cut approach limits the height of the cut slope, and further reduces the impact of cut slope sloughing back into the completed dredge cut.

- **Localized scour by auxiliary work boats on the contaminated non-dredged bed.** This can create resuspension, and residual after the disturbed sediment settles. Control of vessel draft and vessel movement to deeper water areas or dredged areas will reduce and avoid this source of residual contamination.

The standard pipeline dredge is not a powered vessel like typical boats or other work vessels. A standard pipeline dredge with a basket cutterhead moves and positions itself in the waterway using swing wires on winches at the front of the barge, and spuds, or anchors, at the rear of the barge. To perform sediment excavation, the barge operator positions the ladder and cutterhead at the required depth of excavation. This depth is identified as a specific elevation, or a depth at a low water datum. The operator swings the fixed ladder/cutterhead in an arc across the dredging area to remove sediment to specific elevation. The rate of advance is determined by the swing wire winch speed and the width of the cut.

4.1.2 Design Basis

The hydraulic pipeline dredge is one continuous operating unit from the suction mouth through the pump and out the discharge pipeline to the dewatering or disposal site. The dredge depth, cut thickness, sediment grain size and specific gravity, debris and the length of discharge pipeline, impacts the production of the dredge. This report evaluates the dredging of sediment in OU1, OU3, and OU4, each of which represents a different set of characteristics in this regard.

The 4-1 presents the design basis for a hydraulic dredging operation. (Note that Section 2 described how the estimate of the quantity of sediment can change once the dredge prism is discretized into actual dredge management units. However, until the expected pre-design characterizations are complete, this DEA will use the sediment quantity estimates from the FS).

Table 4-1 Design Basis for Hydraulic Dredging

Parameter	Value	Basis or Assumption
Volume of in-place sediment dredged, cy	OU1: 784,000 cy OU3: 587,000 cy OU4: 5,880,000 cy	These values are presented in the RI/FS and are rounded off. They are subject to change after the pre-design sampling program is implemented.
Solids content of in-place sediment, percent by weight	OU1: 24.2% OU3: 37.1% OU4: 33.8%	These values are from the overall RI/FS data set, but adjusted as needed to reflect the characteristics of the interval that is expected to be dredged. They are subject to change after the pre-design sampling program is implemented.
Specific gravity of sediment solids (dimensionless)	OU1: 2.51 OU3: 2.47 OU4: 2.36	These values are from the RI/FS data set. They are subject to change after the pre-design sampling program is implemented.
Years to accomplish removal (preferred)	OU1: 2 - 3 years OU3 and OU4 (if performed sequentially): 8 - 11 years	These values are based on schedules suggested in the FS and Proposed Plan, and discussions with the WDNR.
Duration of dredging season	35 weeks (8 months, April to November)	This is based on typical weather conditions in the Fox Valley.
Maximum allowable hours/days per week during the dredging season	OU1: 12/5 (175 days/yr) OU3 and OU4: 24/7 (245 days/yr)	These values are presented in the FS. It is expected that work on OU1 will be limited to a maximum 12-hr day for 5 days per week because of the residential nature of the surrounding area. After considering routine maintenance and downtime (as described below), a maximum 12-hr day will likely result in less than 11 hours of useful production. Work in OU3 and OU4 would not be constrained, and a full 24/7 schedule would be allowed.
Long-term daily production required to meet schedule preference	OU1: 2010 cy/day OU3: 2280 cy/day OU4: 2560 cy/day	These are the minimum values needed to meet the upper end of the preferred schedule. Higher daily rates would be desirable to provide a contingency against downtime and seasonal conditions.

The design of a hydraulic dredging project will be based largely on the desired rate of sediment removal. Dredge production rates for a standard hydraulic pipeline dredge with a basket cutterhead are typically expressed as cubic yards removed per hour. The cubic yard measurement is by the *in situ* cubic yard volume in the waterway. When calculating the ability of a particular dredge and pipeline to meet a desired daily rate, however, it is important to consider two components: the dredge/pipeline average hourly rate and the effective time in each day. Effective time is when the dredge is actually dredging and sediment slurry is in the pipeline. Non-effective time typically includes the following:

- Clean out of the cutterhead,
- Dredge repositioning into another cut,
- Shutdown due to vessel passage,
- Debris removal from the pump,
- Adding or taking out pipe,
- Minor repairs, and
- Other non-effective time.

Maintenance dredging in navigable waterways typically has an effective time of 18 hours per 24-hour working day (75 percent). This type of dredging handles the loose, unconsolidated sediment deposited since the last dredging event, and does not encounter significant debris. The majority of dredging in OU1, OU3, and OU4 is in new work areas that have denser sediment and significant debris to contend with. Therefore, it is assumed that OU3 and OU4 will have a maximum effective time of 16 hours per 24-hour working day (67 percent). In OU1, the allowable hours of work time per day is 12, and it is assumed that routine downtime and maintenance would occur outside this 12-hour window.

Since the dredge is one continuous operating unit from the suction mouth through the pump and out the discharge pipeline, the length of discharge pipeline also impacts the production of the dredge. Dredging and disposal at all three OUs will require the use of at least one booster pump from the most distant dredging locations to reach the anticipated processing sites.

As described in further detail in Section 5.2.1, the addition of a booster pump into the discharge line will decrease the amount of effective time for the pipeline dredge. When one pump stops (either the on-dredge pump or the booster pump), the entire dredging operation stops. For purpose of production estimates for the entire project, a value of 10 percent reduced effective time will occur with the addition of each booster pump in the discharge pipeline. This is consistent with the USACE's cost estimating guidelines for dredging operations (USACE, 1985).

Production rates in cubic yards per hour for 10, 12 and 14-inch pipeline dredges were determined using the program DRDGRATE (Hartman, 1984).

As described above, each OU sediment to be dredged has a distinct grain size and *in situ* specific gravity. Each OU also has a specific assumed pumping distance to reach the possible dewatering and/or disposal sites. These factors were taken into account in the calculation of the hourly production rate. This hourly rate was then converted to an average daily rate, using the effective time based upon the number of booster pumps. The results of these calculations are described for a range of alternative scenarios in Section 10.

The DRDGRATE program also computes the corresponding dredge slurry rate (in gallons of slurry per minute) and dredge slurry solids (as a percent solids by weight) that would be generated when a dredge of specified size is operating at a particular production rate and pumping through a pipeline of specified length. These values are also important because they determine the sizing of downstream dewatering and wastewater treatment facilities. This is discussed further in Sections 6, 7 and 10.

4.1.3 Follow-Up Information Needs and Tasks

The most significant information need for the dredging component of the project is a final determination on sediment volume and physical parameters. This information is expected to be derived from a major pre-design sampling effort that is scheduled to begin in 2003. It will form the basis for the preparation of "performance-based" construction specifications, as described further in Section 9 of this report.

4.1.4 Permits and Approvals

Section 30.20, Wis. Stats, regulates the removal of materials from the beds of waterways (WDNR, 2003a). A permit is required for the dredging of streams where the bed is not owned by the State. A contract is required for the dredging of lakes where the bed material is owned by the state.

The substantive requirements for contracts and permits are contained in WAC NR 346 and NR 347, respectively. WDNR's dredging project guidance specifies that the application for a permit or contract must include the information required in WAC NR 347.07 through 347.11 (WDNR, 2003a).

Because the dredging component of the Lower Fox River remedy would be an "on-site" activity under the Superfund process, the need to actually obtain the relevant permit is waived. Nonetheless, any substantive requirements in the corresponding regulations would apply.

The most significant component of WAC NR 347 is the sediment sampling and analysis requirements contained in NR 347.06. However, for the Lower Fox River project, these requirements have already been met through the extensive RI/FS process. Other requirements within NR 347 cover the management of dredge carriage water and the disposal of dredge solids in accordance with other state laws and regulations, but these requirements are described elsewhere in this DEA for the particular remedial technologies affected, and do not bear upon the dredging activity itself. Thus, it does not appear that implementation of the dredging component of a remedial action will be subject to any new permit or substantive requirements.

4.2 Mechanical Dredge with Haul Barge

The mechanical dredge with haul barge is a widely used dredging process in the United States. It is designed to excavate loose to dense sediment, for sand and gravel harvesting, and for work in open water where the wave climate can disrupt a floating pipeline or damage a ladder structure on a hydraulic pipeline dredge. The use of a mechanical dredge at OU3 and OU4 is considered to be feasible, subject to further review during final engineering.

4.2.1 Process Description

A major difference in operation between the standard mechanical dredge and the hydraulic pipeline dredge is that the sediment dredged by a mechanical dredge is at or near its *in situ* water content. No additional water needs to be added to the dredged sediment for transport. The sediment is transported by haul barge, and requires re-handling from the barge to a processing or disposal site, or to truck or rail for transport to a treatment or disposal site.

The mechanical dredge operates on the design principle of a digging bucket, or a re-handling bucket, to remove sediment and place it into a haul barge. The standard mechanical dredge can have a wire-connected dredge bucket (clamshell) or a fixed arm dredge bucket (backhoe or dipper). A third type of mechanical dredge, the bucket ladder dredge, is not considered a feasible alternative for the Lower Fox River remediation effort.

Recent design and modification of the dredge bucket has focused on minimizing the resuspension of sediment at the point of dredging. This has resulted in the development of the environmental bucket, or closed-bucket, and the hydraulic bucket. These environmental buckets reduce the loss of sediment during the bucket closure and retrieval through the water column.

The size of a mechanical dredge is identified by the capacity of the bucket. An 8 to 10 cubic yard bucket would be effective for the remediation dredging at OU3 and OU4.

The mechanical dredge requires a haul barge and tugboat for transport of contaminated sediment from the dredging site to the processing site. As a result, the use of a mechanical dredge will require at least one re-handling of the dredged sediment from the barge before final disposal. The material can be dewatered at the offloading site, transferred to overland transport such as rail or truck, or placed in a mixing hopper where slurry water is added to allow hydraulic pumping to the disposal site. Scenarios for mechanical dredging and disposal would require the use of multiple barges with re-handling and upland transport to the disposal site. Additional details of these potential remedy components are described in Section 5.

Environmental dredging is accomplished by minimizing the dredge volume and maximizing the x, y and z precision of dredging. The wire-connected bucket of a standard mechanical dredge is not a precision dredging unit. Even with a good operator, the inherent operation capability of a cable connected bucket will mean the dredging accuracy on the vertical will be in a range of one to two foot overdepth dredging. Use of a fixed arm mechanical dredge, equipped with precision real time monitoring, can control dredging depth with a vertical accuracy of four inches overdepth (FWENC, 2001b).

The standard mechanical dredge is not a powered vessel that can move as a typical boat or other work vessel. The dredge is a barge mounted clamshell or backhoe excavator that is equipped with working spuds or an anchor system to hold the barge in position while dredging. The depth of dredging is identified as a specific elevation, or a depth at a low water datum. The dredge removes sediment to that specific elevation.

The barge is anchored in one position, and the dredge arm or boom is set at a specific distance out from the barge. The boom rotates and removes an arc of sediment with several bucket grabs. The dredge boom is rotated so that each grab is slightly overlapped to assure removal of all sediment. One barge position can have two or three boom sets. The barge is then moved forward, and a new two or three set dredging action is completed.

The width of the dredge cut for a mechanical dredge can be limited to one bucket footprint, or to one set of bucket grabs on the radius of the boom swing. The mechanical dredge does not need to have a minimum swing to advance as would a standard pipeline dredge. This is an important difference between the mechanical and cutterhead dredges; the cutterhead dredge’s volume is determined by the constant cut elevation times the swing. The mechanical dredge’s volume is determined by each bucket grab area times the cut elevation. A standard hydraulic pipeline dredge will cut a 60-foot wide swath at a constant elevation. The mechanical dredge cuts a 15-foot wide bucket footprint at a constant elevation.

For purpose of preliminary engineering and analysis of the mechanical dredge in this report, the swing width of the fixed arm dredge is at 60 feet, with the bucket grabs equivalent to an 8-10 cubic yard bucket footprint, and 10 percent overlap.

The issue of residual contamination was first described in Section 4.1.1. Residual contamination by a mechanical dredge, equipped with an environmental hydraulic bucket on a fixed arm dredge, has demonstrated better control of residual than the standard pipeline dredge (FWENC, 2001 a,b). However, the primary cause of excessive residual has historically been the design engineer's and operator's lack of knowledge and understanding on how residuals are created from dredging. The improved operational factors of the environmental hydraulic bucket cannot override the lack of operator skill, or bank sloughing caused by excessive dredge cut thickness.

Control of the dredging operation will require precise horizontal and vertical positioning. This control has been implemented and proven successful using the fixed arm mechanical dredge with standard and environmental buckets (Taylor, 2003). This mechanical dredge system (fixed arm) has demonstrated the capability to control vertical dredging to within 4 inches of target depth. This allows the contractor to remove a smaller cut of material, which limits the amount of slope failure and recontamination during the dredging.

Sensors placed on the bucket, and on the dredge arm, provide real time monitoring and control of the dredge bucket. The development of the hydraulically closed bucket allows the operator to slowly lower the open bucket and set it on the surface of the fine, soft grain sediment, thereby reducing resuspension. The bucket is articulated so that as the hydraulic motors close the bucket, it removes a constant and level layer of sediment from the bed. The closed bucket prevents escape of any captured sediment during retrieval to the surface.

Localized scour by auxiliary work boats on the contaminated non-dredged bed are independent actions from the dredging. The requirement is to limit vessel draft and to keep vessel movement only in deeper water areas or dredged areas. Failure to do this will override any reduction in residuals the dredge operation may provide.

4.2.2 Design Basis

The quantitative design basis and production expectations for a hydraulic dredging operation as described in Section 4.1.2 are the same for a mechanical dredging operation.

The Lower Fox River project characteristics (sediment grain size, disposal options, dredging season) will have different impacts on the mechanical dredge production and residual than they will on the hydraulic dredge. Production rates for the mechanical dredge are based on the bucket size, the fill capacity, the bucket retrieval and return to the bed, and the number of boom sets per barge move. The Lower Fox River sediment is fine grain silts and clays with some granular sediment. This will require use of an environmental bucket to reduce or eliminate sediment resuspension during dredging. To meet the overall schedule requirements identified in the design basis, a production rate for dredging with a hydraulic environmental bucket must be on the order of 150 to 200 cubic yards per hour. This is based on an average cut thickness of 3 feet, an average cycle time of 80 seconds, using an 8 to 10 cubic yard bucket, and factoring the impact of dredge effective time.

Effective time for a mechanical dredge is that time when the dredge is actually removing material from the bed, lifting and swinging to the barge, and depositing sediment into the haul barge. Non- effective time occurs when the dredge is waiting for an empty haul barge, minor repairs, crew change, bucket repair or debris removal, vessel passage, and other non-dredge activities. Effective time for maintenance dredging in navigable waterways with a mechanical dredge is typically 18 hours per 24-hour working day (75 percent). The remaining 6 hours of each working day is non-effective time.

As described in Section 4.1.1, the majority of dredging in OU3 and OU4 is not in the navigation channel area. It is in new work areas that have never been dredged before. These new work areas will have significant debris to contend with. For OU3 and OU4 effective time per day for the mechanical dredge, based on use of a fixed arm dredge equipped with a hydraulic environmental bucket, is estimated at 17 hours per 24-hour working day (70 percent).

Dewatering and/or disposal will require secondary transport of sediment, or slurry transport from an off loading site. The haul barges should be offloaded at a rate that allows the empty barge return to the dredge for continuous dredge operations. The details of such a barge transfer operation are described further in Section 5.1.

4.2.3 Follow-Up Information Needs and Tasks

The follow-up information needs for a mechanical dredging process option will be the same as for the use of a hydraulic dredge. These are described in Section 4.1.3.

4.2.4 Permits and Approvals

The permitting considerations for a project using a mechanical dredge will be the same as those for a hydraulic dredge. These are described in Section 4.1.4.

4.3 Performance of Hydraulic and Mechanical Dredges on Recent Projects

RETEC reviewed the performance of hydraulic and mechanical dredges used for three separate PCB sediment dredging events in New Bedford Harbor, Massachusetts. Several key parameters of these events were analyzed for applicability to the Lower Fox River project.

The New Bedford Harbor Pilot Dredging Study was completed in 1989, the Hot Spot Dredging Event was completed in 1995, and the Pre-Design Field Test (PDFT) was completed in 2000 (FWENC, 2001a, b). The first two dredging events were completed prior to understanding the differences between environmental and navigational dredging. Foster Wheeler concluded that remedial dredging technology changed substantially after the completion of the first two projects (FWENC, 1999).

The dredging technology that demonstrated the best performance on the first two events was an Ellicott 370 HP Dragon Series 10 inch hydraulic pipeline dredge. The third event was a field test of a Caterpillar 375 LC Hydraulic Excavator with a 4.5 cubic yard Horizontal Profiling Grab Bucket. This is a fixed arm mechanical dredge with an environmental bucket that is hydraulically opened and closed. A comparison of the performance of these dredges is shown in Table 4-2.

Table 4-2 Comparison of Hydraulic Pipeline and Mechanical Dredge Performance

	New Bedford, 1989. 10 inch pipeline dredge	New Bedford, 1995. 10 inch pipeline dredge	New Bedford, 2001. 4.5 cy bucket
Average workday, hr	4.1	7.7	11
Effective time	78%	52%	47%
Average production rate	37 cy/hr	13.4 cy/hr	72.5 cy/hr
Accuracy	Avg. 9.5 in*	N/A	+/- 4 in.
Required dredging	1574 cy	8428 cy	1985 cy
Over dredging	0	5568 cy	323 cy
Total volume dredged	951 cy	14000 cy	2308 cy

The table summarizes a number of important project metrics that can be compared to work on the Lower Fox River.

- The effective time for a long-term operation like the Lower Fox River project will be significantly higher than that experienced during a limited-time testing project like New Bedford.
- The accuracy of vertical dredging depth is affected primarily by dredge type, not dredge size and sediment characteristics. Therefore, the New Bedford values for vertical dredge accuracy are directly representative of the dredge types proposed for the Lower Fox River.
- Production rates depend on the dredge size and the sediment characteristics. While the New Bedford production rates indicate the relative rates that each type of dredge can achieve, they are not indicative of those that can be achieved on the Lower Fox River.

The production rate for the Lower Fox River project will be significantly higher because the project will employ a larger pipeline dredge (12 to 14 inch) or a larger mechanical dredge (8 to 10 cy), and the sediment will be less dense. The New Bedford Harbor sediment was typically denser than Lower Fox River sediment, as indicated by the sediment *in situ* specific gravity data in Table 4-3.

Table 4-3 Comparisons of New Bedford and Lower Fox River Sediment Characteristics

	New Bedford	Lower Fox River		
		OU1	OU3	OU4
Sediment *in situ* specific gravity	1.26 – 1.41	1.18	1.28	1.24
Sediment D50 grain size	0.01 to 0.25 mm	Not Available		
Solids specific gravity	2.4	2.51	2.47	2.36

Although not specifically indicated in Table 4-2 and Table 4-3, the data for dredge solids from the New Bedford project can also be compared to future work on the Lower Fox River. In general, the dredge solids concentration of the pipeline dredge (10 inch) at New Bedford Harbor was on the low side of average, reflecting a method of operation where the suction was also used to capture surface sheen by lifting the ladder off the bed (US Corps of Engineers, 2000). For purpose of analysis in this report, an average value of 8 percent solids in the dredge slurry over the long term is expected for the 12 to 14 inch dredge. This is based on the 2000 performance at the SMU 56/57 demonstration project on the Lower Fox River (Hart Crowser, 2001).

4.4 Mechanical Dredge with Hydraulic Discharge (Hybrid Dredging)

Hybrid dredging uses mechanical excavation with a hydraulic material transport system. This dredging technology was developed specifically for environmental dredging. It provides material excavation with high vertical accuracy and limited water entrainment, and materials transportation by pipeline with controlled slurry water input.

For a hybrid dredging operation, the mechanical dredge would operate as described in section 4.2.1. The dredge is a fixed arm hydraulic excavator mounted on a barge. The bucket is a horizontal profiling grab bucket that is hydraulically powered, and a crane monitoring system that provides the operator precise control of the bucket in the horizontal and vertical plane. The equipment is designed to achieve a vertical dredging accuracy exceeding +/- 0.5 feet, and horizontal accuracy exceeding +/- 2 feet.

The dredged material is transported by hydraulic slurry rather than haul barge. The excavated material is placed into a hopper and mixed with make-up water to create the transport slurry. To minimize the water delivered to the dewatering or disposal location, a patented Slurry Processing Unit (SPU) (C. F. Bean Environmental LLC) delivers slurry with high percent solids concentration. The recirculation system reduces the volume of water generated during dredging by pumping the decant water from the processing facility back to the dredge for use as make-up water for the dredge slurry.

The hybrid dredge system was used on a remediation project in Bayou Bon Fouca**,** Louisiana, and on the test dredge in New Bedford. The Bayou Bon Fouca was a large dredging project, with removal controlled to within +/- 3 inches vertical accuracy. New work dredging was completed in the Bayou at a production rate of 1,000 cubic yards per day, working a 9-hour workday with 72 percent effective time. The material dredged was a dense silt and plastic clay (Taylor, 2003).

A modified version of the hybrid dredge was used for the New Bedford Pre-Design Field Test. This field test was designed to determine the ability of the dredge bucket (sediment profiling grab) to remove contaminated sediment without causing adverse ecological impacts (FWENC, 2001b). The removal efficiency was evaluated by determining the sediment PCB concentrations before and after dredging and calculating overall PCB removal. Results indicated that approximately 97 percent of the PCB mass within the dredging boundaries was removed. The data also indicated that the average post dredging sediment PCB concentration was 29 ppm, which was above the upper harbor clean up level of 10 ppm. The average post dredging PCB concentration was attributed to re-contamination from adjacent areas by sloughing, tidal action, work vessel prop wash, not inefficient or inaccurate dredging (FWENC, 2001b). After further analysis of the Pre-Design Field Test data set, it was concluded that residual contamination caused by sloughing or vessel disturbance could be controlled by using alternative dredging and vessel movement procedures.

The solids concentration of the dredge slurry (by weight) in New Bedford ranged from 13 to 16 percent (FWENC, 2001a). This solids concentration is similar to what we expect to achieve on the Lower Fox River project.

5 Material Transport

This section describes options for transporting dredged sediment, either in bulk or as slurry, and options for transporting dewatered sediment. Throughout this and subsequent sections the reader is referred to supporting drawings in Supplement IV to this report.

5.1 Barge Transport

This section describes the options for using barges to transport dredged sediment. Barges can transport large volumes of contaminated sediment to a transfer facility, in an efficient and effective manner, within specified operational and environmental restrictions.

5.1.1 Process Description

Transport barges, also referred to as scows or haul barges, are cargo-carrying craft towed or pushed by powered vessels (i.e., tugboats) on inland or ocean waters. Tugboats operate to move both sediment-laden and empty barges between the dredge site and transfer facility. Haul barges are designed to provide effective transportation of materials on waterways and are commonly used to transport dredged sediment from a dredging operation to the transfer facility.

The use of haul barges as a means of sediment transport in OU3 and OU4 is considered a feasible method for transfer of mechanically dredged sediment. As described in Section 4.2, mechanical dredging has a lower production capacity than hydraulic dredging operations; however, mechanical dredging is more feasible in restricted areas and areas confined by piers and docks. Mechanical dredging is advantageous because the removed sediment has nearly the same water content as the *in situ* sediment. For this reason, less dewatering is necessary and the use of haul barges for transporting sediment becomes a viable option.

During dredging, continuous tugboat and haul barge movement would be required to complete the implementation of the dredging operations within a reasonable timeframe. With this continuous movement, the tugboats and haul barges would be equipped with the necessary and mandatory accessories to facilitate surveillance and compliance with all navigation and channel requirements.

The primary features to consider in the selection of an appropriate tugboat are maneuverability and draft. Dredging operations will be conducted along shoreline areas and shallow shelves where the draft of the tugboat may be limited by water depth. There are also specific draft allowances within the locks of Lower Fox River that restrict vessel size. The selected tugboats must be sized based on water depths at all locations where the tugboats would be operating and based on the size of the locks. To provide effective and efficient tugboat operation, a tugboat that is reliable under varied conditions should be selected and an experienced and skilled tugboat operator should be employed. The speed of the tugboat is a less relevant feature because The Lower Fox River is a "no wake" zone. Tugboat speed with or without tow cannot exceed a maximum rate of 5 miles per hour.

The primary features to consider in the selection of an appropriate haul barge are work area restrictions such as channel dimensions, site obstructions, lock size, piers, jetties, and height restrictions such as bridges and power lines. Barge draft is also a consideration when dredging along shallow shorelines or shallow shelves. Haul barges can be single or double hulled, and drafts of the barges are typically 6 to 8 feet when full, and 4.5 to 5 feet when half full. Tank barges, flat deck barges, and hopper barges are three types of barges typically used for transferring dredged sediment over waterways.

- Tank barges have cargo compartments that are either continuous or divided into sections, and can be loaded and unloaded using a mechanical or hydraulic dredge. Tank barge capacities typically range from 100 to 6,000 cubic yards (75 to 4,600 cubic meters). Tank barges can be used to transport fluids of bulk materials and have been used to transport dredged materials.

- Hopper barges have funnel shaped hull interiors that can be opened longitudinally, or have bottom mounted discharge doors for unloading. The design principle of hopper barges is for delivery of bulk materials to open water sites, but is also used in mechanical dredging operations as a method of transfer. Hopper barges have the same capacity range as tank barges, and can be unloaded from the top using a mechanical or hydraulic dredge, or from the bottom using the discharge doors. Hopper barges can be used for mechanical or hydraulic dredging operations, but are generally avoided in environmental dredging operations. According to USACE Buffalo District studies, hopper barges have been shown to leak from hull seams, and should be stabilized with plastic liners, sandbags, or hay bales. Thus, use of a hopper barge would cause loss of contaminants to surrounding waters, and would offset efforts to minimize the re-suspension of contaminants. Typical hopper barges capacities range from 100 to 6,000 cy (75 to 4,600 m^3).

- The deck barge is a typical design chosen for transferring dredged sediment. Deck barges have an open and flat work surface and can be modified to provide leak proof cargo containment. This type of barge is most suitable for hauling equipment, as well as bulk materials. Modifications can be made to the deck barges that will facilitate material transfer on the deck of the barge, or sediment can be hauled on unmodified deck barges by placing sediment bins or dumpsters on the barges. Modified deck barges would be a useful method for transporting dredge equipment and mechanically dredged sediment in the Lower Fox River. The capacity of the deck barge is dependant upon the size of the modification or sediment containment dumpster implemented. Deck barges also have more offloading options than the other barge types, and are available and frequently used on the Lower Fox River. It may be paramount that modifications be made to flat deck barges used during environmental dredging operations in the Lower Fox River. Sealed, reinforced steel sides can easily be added to provide dredged sediment containment. Modifications can also be made to deck barges that will provide for residual water removal at the transfer facility. Deck barge capacity is dependant upon modification design applied or upon capacity of containers implemented.

Transport of the sediment between the dredge site and the processing facility or disposal facility will require at least one re-handling of the material at the transfer facility. Processing and/or short-term storage of the contaminated dredged sediment may also be necessary at the transfer facility, and may also require construction of a lined containment area or large holding tank.

Re-handling of the sediment will require positioning the barges against a dock or bulkhead in such a manner as to minimize sediment loss. The following options are feasible for transfer of materials from haul barges to a land based facility:

- Pumping of the slurry via hydraulic or modified hydraulic dredge. This method could be used for removing dredged sediment from tank barges without compartment divisions, or deck barges with or without modification. Water may be added to the slurry, if necessary, to employ hydraulic pumping.

- Use of a submerged dredge pump re-handling is an option for removing dredged sediment from any barge type selected.

- Clamshell bucket used in combination with crane equipment is an option for removing dredged sediment from any barge type selected.

- Backhoes, dozers, belt conveyers, and re-handling buckets are options that may be used for removing dredged sediment from deck barges only.

- Bucket line dredge used in combination with crane equipment is an option that could be used for removing dredged sediment from deck barges only.

Three significant sediment re-handling considerations are offloading time, spill prevention, and management of residual contaminated water. With respect to offloading time, offloading operations are expected to take longer than loading operations. The transfer facility and re-handling methods should be designed to minimize offloading time and not limit the rate of dredging. With respect to spill prevention, the transfer facility should be equipped with a drip apron to minimize the potential for loss of material and re-suspension of contaminants in the waterway. Preventative measures can also be implemented by ensuring that equipment operators are trained and skilled. With respect to residual contaminated water, following the transfer of sediment from the haul barges, an estimated 20 percent of each haul barge load will be residual wastewater. The wastewater must be removed at a rate that is somewhat equivalent to the material offloading time.

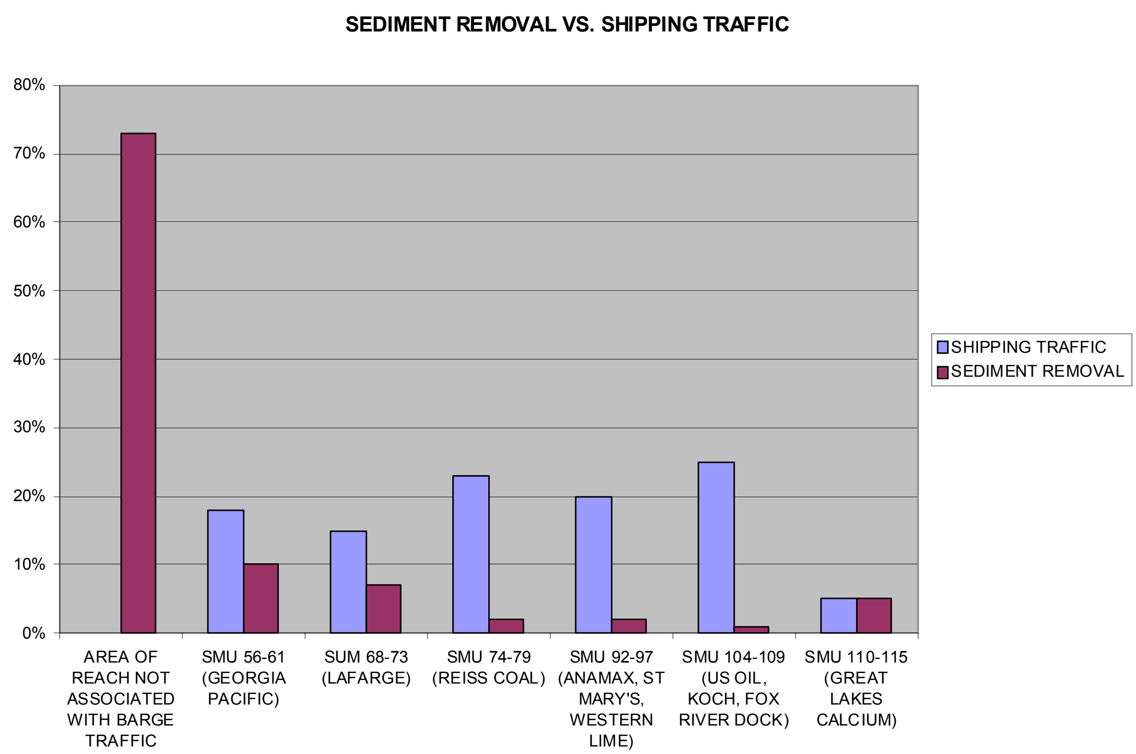
Management of residual wastewater could be addressed by several different methods. The wastewater could be removed from the haul barge and transported to a treatment facility or treated on modified haul barges fitted with a treatment unit for immediate discharge of treated wastewater to the river. To facilitate removal of the wastewater from the haul barges, sump pumps could be used and the haul barges could be modified to allow for wastewater to collect at a certain location prior to treatment. Another option is to mix the wastewater with sediment to form a slurry with a flocculating polymer for transport to a dewatering facility prior to treatment. The most feasible method for removing residual wastewater is to provide pumps that will transfer the wastewater to a collection point prior to transfer to treatment.

Water depth, channel dimensions, lock and bridge access way dimensions, in-water traffic, and the presence of obstructions influence the effective use of tugboats and haul barges. The following items describe specific features of the Lower Fox River that pose limitations to the use of haul barges for transport of dredged sediment:

- One lock exists between OU3 and OU4 that is 35 feet wide by 144 feet long, and permits a 6-foot draft. Typical tugboats and loaded barges either draft more water, or are larger than the lock will accommodate. Smaller tugboats and deck barges are available; however, load capacity is reduced with these options.

- The Lower Fox River has areas outside the shipping channel that are shallow, and in many areas will not draft full barge loads or tugboats.

- Several drawbridges exist in OU4 that may result in delays in transfer of materials from dredge site to the re-handling site.
- Shipping traffic in OU4 may also result in delays. Based on analysis of traffic on the Lower Fox River, most shipping traffic occurs close to the mouth of the river. However, the percentage of sediment removal within these high traffic areas is minimal, as indicated in the following graph:



5.1.2 Design Basis

As indicated in section 5.1.1, barge type, barge modification, type of dredging being performed, and nature of the dredged sediment are all factors in the efficient and effective transport of dredged sediment from the remedial site to the transfer facility. The dredging contractor, under a performance-based contract, would ultimately make final selection from the options available. Table 5-1 indicates minimum performance requirements.

Table 5-1 Design Basis for Barge Transport

Parameter	Value	Basis or Assumption
Volume of in-place sediment dredged, cy	OU3: 587,000 cy OU4: 5,880,000 cy	These values are represented in the RI/FS and are rounded off. They are subject to change after the pre-design sampling program is implemented.
Duration of barging season	35 weeks/year (8 months; April-November)	This is based on typical weather conditions in the Fox Valley.
Long term daily production required to meet schedule preference	2550 cy	This is the minimum value needed to meet the upper end of the preferred schedule. It corresponds to a dredging rate of 150 cy/hr and an effective time of 17 hr/day. Higher daily rates would be desirable to provide a contingency against downtime and seasonal conditions.
Years to accomplish removal (preferred)	8-11 years	These values are based on performing OU3 and OU4 dredging sequentially, and on schedules suggested in the FS and Proposed Plan, and discussions with the WDNR.
Maximum allowable hours/days per week during the dredging season	24/7 (245 days/yr)	Work in OU3 and OU4 would not be constrained, and a full 24/7 schedule would be allowed.
Expected rate of wastewater generation	127,500 gallons/day	Based on a barge load containing 20% residual wastewater offloaded at a rate of 7,500 gallons/hour, and assuming 17-hour effective time per day.

5.1.3 Follow-Up Information Needs and Tasks

There is no further information that is needed to further the design of barge transfer. Once the dredging contractor has been selected, decisions such as barge size, barge capacity, and off-loading crane size will be determined.

5.1.4 Permits and Approvals

There are no specific environmental permits or approvals associated with this particular project element.

5.2 Hydraulic Transport

Hydraulic transfer is the process of pumping dredge slurry from a point of generation to a point of processing or disposal. Several options and possible configurations for hydraulic transfer of dredge slurry are discussed in Section 4.2.1.

5.2.1 Process Description

Hydraulic transport uses a series of pumps and forcemains (pipes) to move dredged sediment as aqueous slurry. While hydraulic transport is not typically utilized in conjunction with dredging projects, it is analogous to other common applications. For example, municipalities throughout the country pump wastewater from a point of generation to a point of processing or disposal. Also, the mining industry routinely transports solids-bearing slurries over long distances.

This process is compatible with several remedial scenarios. Certain logical combinations include the following:

- To convey slurry directly from a hydraulic dredge or hybrid processing unit via an in-water route, to a riverside mechanical dewatering plant

- To convey slurry from a hydraulic dredge or hybrid processing unit via a combination of in water and overland routes, to an upland confined disposal facility (CDF)

From an engineering standpoint, the primary difference in pumping slurry from a hydraulic or hybrid dredge source would be the solids content. The long-term average solids content from a hydraulic dredge is expected to be approximately 7 or 8 percent (by weight) compared to approximately 15 percent from a hybrid dredging operation. The hydraulic dredge solids content will vary in accordance with the action of the cutterhead. The solids content from a hybrid dredging operation will have less variability since the goal of the process is to maintain more consistent slurry. Higher solids content results in denser slurry, which in turn requires additional pump horsepower and/or shorter distances between pumps.

The in-water run of a slurry forcemain could consist of floating or submerged pipe, depending on local navigational needs. Booster pump stations would be situated on barges. The barges would likely be anchored near a riverside access point or materials staging yard. It is assumed that booster pump stations require electrical service and potable water (for maintaining seals).

The booster pump stations would be located at intervals along the run of slurry forcemain.

The overland length of forcemain could follow any accessible route where rights-of-way can be secured. Wherever possible, the forcemain would be exposed at-grade for inspection and maintenance purposes. Road crossings would be constructed by conventional jacking or open-cut methods, depending on the volume of traffic in the area. As with the in-water forcemain, booster pump stations would be located at intervals along the run of slurry forcemain, and would be housed in small, pre-engineered buildings such as those used for telephone and other utility operations.

The length over which dredge slurry can be pumped does not have an inherent hydraulic limit. However, each booster pump serves to reduce the amount of time that a dredge can productively operate due to startup, maintenance, and operational coordination between the dredge and conveyance system. An industry rule of thumb is that each pump reduces the available dredge time by 10 percent. With a dredge in production for 16 hours (i.e., at best), the number of booster pumps soon becomes limiting. For example, the corresponding available dredge time in a maximum workday of 24 hours would be as follows:

- No booster pumps – 16 hours
- One pump – 14.4 hours
- Two pumps – 13.0 hours
- Three pumps – 11.7 hours
- Four pumps – 10.5 hours
- Five pumps – 9.4 hours

For a given pumping scenario, the required pipe diameter can be calculated based on the following major variables:

- Dredge slurry rate (varies by size and type of dredging equipment)
- Solids concentration of the slurry
- Distance between pumps

When the distance between pumps and the maximum slurry solids concentration are fixed, a range of dredge slurry rates and the corresponding required pipe diameters could be calculated through iteration. Since the number of pumps will be limited, the total forcemain distance will also have a practical maximum limit (i.e., “x” times the spacing between the pumps, where “x” is the number of pumps) for a particular combination of pipe diameter, slurry rate, and slurry solids concentration. The results of these relationships and the corresponding calculations are discussed in Section 5.2.2.

5.2.2 Design Basis

As indicated in Section 5.2.1, the design of a slurry forcemain and intermediate booster pumps is closely linked to the output of the dredge, in terms of slurry flow rate and slurry solids concentration. Sizing of the pipe and pumps cannot be completed until the dredge output is known. However, certain minimum parameters (presented in the Table 5-2) are likely to be relevant for any configuration of facilities.

Table 5-2 Design Basis for Hydraulic Transport

Parameter	Value	Basis or Assumption
Slurry Solids Concentration, Percent by Weight	7 to 15 percent, long-term average (short-term exceedances likely)	The low end of this range of values represents the expected long-term average output of a hydraulic dredge and the upper end represents a hybrid dredging operation. For a hydraulic dredge, exceedances outside of this range are likely due to the normal action of the cutterhead.
Pipe Materials of Construction	In-water: HDPE Overland: Steel	These are recommended based on common dredging applications and the need to provide a protective, secure system.
Pipe Diameter	In OU3 and OU4, likely to be in the range of 12 inches to 16 inches For OU1, could be as small as 8 inches	This is based on the sizes of dredge equipment that are likely to be needed to meet the overall production and schedule requirements.
Secondary Containment	Not required	The use of double-walled piping system is not believed to provide benefits that are commensurate with the cost and complexity. A single-walled piping system can be instrumented to provide good control and process safety. Routine, preventative maintenance and replacement of long runs of pipe is also greatly facilitated by the use of single-wall piping system.
Booster Pumps, Power Supply	Onland: electric-driven motors Floating: diesel or electric-driven	These are recommended configurations. Electric service, wherever possible, is probably more cost effective, and avoids the need to provide fuel storage or handling operations.
Typical System Appurtenances	Cleanout points along pipe route, air relief points at pipe transitions, possible backup pumps at booster stations	These are standard features that would be part of a final system.

The routing of the forcemain and the siting of intermediate booster pump stations cannot yet be established because the type and location of slurry processing facilities has not been determined. However, the following scenarios are described for illustrative purposes:

- For OU1, construction of an overland slurry forcemain would be limited by the density of development and current land uses around LLBdM. On the other hand, if a central dewatering facility could be located at the Bergstrom fill site, then an in-water route would be straightforward and implementable, and any overland facilities could be avoided. For a maximum pumping distance of 5 miles (from the most distant end of the OU, back to Bergstrom) only a single booster pump may be needed. This is illustrated on Sheet 02 on the plan set in Supplement IV.

- For OU3 and OU4, if a central dewatering plant could be sited at the river's edge, in-water piping from each end of the OU could be constructed and overland piping could be avoided. The total length of OU3 and OU4 is approximately 12 miles, as indicated on Sheet 03 of the plan set in Supplement IV. Pumping from either end to a location near the center would equate to a maximum transport distance of 5 to 7 miles. A distance of 5 to 7 miles could be accommodated with one booster pump.

- For OU3 and OU4, if an upland dewatering or disposal facility were located in rural Brown County, an overland route could be established. A route could follow existing roads or other corridors. For example, the existing Fox River Bike Trail provides a convenient corridor from the river's edge to the southeast, with the exception of the northern end of the bike trail that traverses heavily developed areas of Green Bay and De Pere. South of De Pere, the trail is routed through rural lands. The Bomier Boat Launch in De Pere, where the trail turns inland from the river, could serve as a location for transitioning the pipe route from an in-water segment to an overland segment. The overland route along the bike trail is indicated on Sheet 03 of the plan set in Supplement IV, although no commitment has been made to siting a sediment dewatering plant or disposal location in this vicinity.

- For OU3 and OU4, the in-water segment could be extended further south where the near-river land use is more rural. This option would avoid possible interferences with residential neighborhoods and city street crossings near the Bomier Boat Launch. An overland route could then be established from a take-out point south of De Pere along rural county roads and perhaps connect to the Bike Trail for part of its length depending on the ultimate location of the slurry dewatering or disposal facility. An example of this configuration is also illustrated on Sheet 03 in Supplement IV.

5.2.3 Follow-Up Information Needs and Tasks

At this time, there are no immediate information needs for the hydraulic transfer element of this project. Final design details would be determined based on the design and location of dewatering facilities and the type of dredge employed.

5.2.4 Permits and Approvals

There are no specific permits or approvals that would be required prior to final engineering and design. However, any overland route would be subject to routine construction approvals from the local jurisdictions through which it traverses. While such construction approvals are routine in nature, the unique aspects of the Lower Fox River project and public sensitivity to any handling of the polychlorinated biphenyl (PCB) sediment means that additional effort and transactional time will be required to obtain these approvals.

Securing access agreements needed to cross private lands may be a greater challenge than obtaining local approvals. This work would commence once the siting of facilities is established. The project schedule must provide time for negotiating and drafting necessary easements and possible owner indemnifications.

5.3 Truck Transport

This section provides a description of options and procedures for loading dredged material into trucks for transportation to a disposal facility.

5.3.1 Process Description

Trucks could be used to transport sediment to a treatment or disposal facility. This process could be applied in at least two ways:

- Dewatered dredge solids, in the form of sand and filter cake, could be transported from the dewatering plant to an off-site treatment or disposal facility (such as a vitrification plant or landfill)

- A mechanically dredged sediment, after free water is allowed to drain, could be transported from a barge or riverside processing site to an off-site treatment or disposal facility

The transport of either kind of material would be performed using standard over-the-road vehicles. The material would be loaded from the dewatering or processing site into trucks using conventional earthmoving equipment or conveyors. The loadout facility would be equipped with paved access roads and a weigh scale. A typical arrangement of such a facility is shown on Sheet 13 of the plan set.

For this project, quad-axle dump trucks or dump trailers would be used. Gross vehicle weight limits restrict the payload that a truck can haul. For planning purposes, a maximum truckload of 20 tons will be assumed, which is common for conventional quad-axle dump trucks with steel boxes.

5.3.2 Design Basis

Commercial hauling of bulk quantities of material like this is a commodity service that could be accomplished using local resources. For planning purposes, the assumptions and calculations in Table 5-3 indicate the scale of the trucking operation that would be required.

Table 5-3 Design Basis for Truck Transport

Parameter	Value	Basis or Assumption
Quantities, as Generated	OU1: 840 ton per day (4,200 ton per week) OU3 and OU4: 2,330 ton per day (16,300 ton per week)	These values represent the quantity of separated sand and dewatered filter cake produced from desanding and mechanical dewatering processes. Values are based on operating assumptions described in Section 10.
Truck Load	20 tons	Based on typical truck capacities after allowing for gross vehicle weight limit (i.e., 80,000 pounds).
Available Loading and Hauling Time	12 hours per day 5.5 days per week	For OU3 and OU4 work, these values assume that the filter cake would be hauled to a landfill whose operating schedule will limit the hauling operation. If another treatment or disposal option were used where the times of operation were not limited (such as at a vitrification plant), the hauling time could perhaps be extended to 24 hours per day.
Required Loadout Rate	OU1: 840 ton per day OU3 and OU4: 3,000 ton per day	These are calculated values based on operating parameters assumed above (i.e., for OU3 and OU4 the loadout rate exceeds the generation rate because of the limit of 5.5 days per week).
Frequency of Truck Traffic Under These Operating Conditions	OU1: Up to 3 to 4 trucks per hour (1 every 15 to 20 minutes) OU3 and OU4: Up to 12 to 13 trucks per hour (1 every 5 minutes)	These values are calculated based on the operating assumptions described above.

Parameter	Value	Basis or Assumption
Typical Time for Round Trip	Maximum 2 hours	This value does not affect the calculations described above, but it would eventually be used to determine the size of the fleet needed to accomplish the required throughput of material. It is also used below as the basis for establishing a unit cost for hauling.
Transporter Requirements	Described in NR 502.06	This assumption is based on the classification of the dewatered sediment as a solid waste.

The trucking operation would have the following implications on the upstream and downstream elements of this project:

- **Dewatering Plant Capacity.** At OU3 and OU4, the dewatering operation would be an 18 to 24-hour per day operation. (OU1 would be shorter due to a reduced dredging day). However, landfills may only operate on a limited schedule to reduce the impact on the neighboring community. Thus, if landfilling is the selected disposal option, the landfill schedule will dictate the times at which dewatered material can be hauled. Since a fleet of trucks is used in continuous service, they cannot remain idle at the end of their haul, waiting until the landfill opens in the morning. As a practical matter, a few trucks out of the entire fleet may do this since they will not be needed back at the loading point first thing in the morning. As a result, the dewatering plant must provide holding capacity of almost 48 hours of production (i.e., one-half day Saturday, through Monday morning) when hauling is suspended. This will require additional acreage and equipment at the dewatering facility.

- **Loading Equipment.** For OU1, the estimated quantity per day does not result in a particularly aggressive loading schedule. The loading of a quad-axle dump truck using a single end-loader or excavator typically takes only about 5 minutes. This is less than the frequency of loads required (1 every 15 or 20 minutes), so the throughput can be met with a single piece of equipment. For OU3 and OU4, however, the frequency is much greater (on average, 1 truck every 5 minutes). It is more likely that multiple machines and loadout stations will be required.

- **Unloading Station.** To improve cycle time and eliminate the need for over-the-road trucks to enter the disposal cell (in the case of landfill disposal), an unloading station could be constructed to convey the dewatered material to the working face of the landfill (or into a treatment process).

5.3.3 Follow-Up Information Needs and Tasks

At this time, there are no immediate information needs for this particular project element. Details such as the size of the truck fleet needed and the routing of traffic to minimize neighborhood impacts can be developed once decisions on facility siting are made and final engineering begins.

5.3.4 Permits and Approvals

Because the Lower Fox River sediment, when and if removed, would be regulated as a solid waste, the requirements of NR 502.06 will apply. Under these rules, trucking firms must obtain an operating license from the WDNR. The following operational requirements would apply:

- Trucks must be labeled with their license number
- Trucks must be durable, easy to clean, and leak-proof (considering the nature of the material and its water content)
- Trucks must be loaded and operated in a manner so that the contents do not spill or leak (covers shall be provided)

For a project of this size, local jurisdictions may require traffic control plans and specified haul routes. Nonetheless, these requirements are straightforward, and it is expected that sufficient capacity can be obtained through local firms.

5.4 Rail Transport

This section provides a description of possible scenarios for utilizing rail lines to transport dredged material to a disposal facility.

5.4.1 Process Description

Wet or dewatered sediment can be transported via rail. To employ this option, both the riverside processing site (where the sediment is transferred from the river or is dewatered) and the treatment or disposal site must have rail access. The preferred arrangement at the loadout location would be to have two, parallel sidings—one for the staging of empty cars, and one for the staging of loaded cars. Sediment would be transported using 70- or 100-ton open-topped gondola cars. They could be tarped, if necessary.

Within the Fox River Valley, Canadian National (CN), formerly Wisconsin Central, is the primary and largest rail carrier. In railroad terms, CN would be the "serving carrier at origin". If the destination is not served directly by CN, cars would be transferred to another carrier at interchange points such as Chicago, Illinois; St. Louis, Missouri; or St. Paul, Minnesota.

Within the city of Green Bay, CN serves a number of large industrial customers along the Lower Fox River. For work in OU3 and OU4, it would be possible to add service from a number of sites along Broadway or State Street using existing or extended spurs. The Broadway/State Street area is an industrial and commercial corridor, and rail operations are common.

A new service to a large-scale dewatering plant may consist of the following:

- The rail operations would be designed to have minimum impact on the community and would integrate with CN's existing operations. A possible scenario would establish a 3-hour "window of operation" in the early morning hours (e.g., 1:00 to 4:00 a.m.). This would minimize road traffic disruptions.

- During the window of operation, a CN engine would deliver enough empty cars to accommodate the next 24 hours of production.

- The engine would pick up the loaded cars from a second siding and move them to a nearby yard where they would be staged until a complete train (100 cars) could be formed.

- These operations could be provided on a 6-day per week schedule (Monday through Saturday) for the 8-month dredging/dewatering operation.

CN also serves the Neenah area, and service arrangements could likely be established at a location in OU1. For example, the existing spur that enters the P.H. Glatfelter plant could be extended to the neighboring city-owned Arrowhead property.

5.4.2 Design Basis

The feasibility of rail transport is contingent on three factors:

- First, does a potentially economical, rail-accessible disposal option exist (i.e., after factoring in the added "per ton" cost of rail transport)?

- Second, is the disposal option compatible with the removal component of this project? That is, can a processing or dewatering plant be placed in close proximity to CN's existing service along the west side of the Lower Fox River?

- Third, within CN's service territory, can a specific property be secured which provides sufficient acreage for the staging of the requisite number of railcars (along with the processing and dewatering plant), without requiring major new bridges, road crossings, etc.?

Once it is determined that these conditions are met, the actual design of track and loading facilities would be a straightforward matter. The basis of design is described in Table 5-4.

Table 5-4 Design Basis for Rail Transport

Parameter	Value	Basis or Assumption
Quantities, as Generated	OU1: 840 tons per day (4,200 tons per week) OU3 and OU4: 2,330 tons per day (16,300 tons per week)	These values represent, for example, the nominal quantity of separated sand and dewatered filter cake produced from a mechanical dewatering process.
Required Loadout Rate	OU1: 840 tons per day OU3 and OU4: 2,700 tons per day	These values assume that a week's production must be loaded out in no more than 6 days, to accommodate the railroad's pickup capabilities. (A corresponding amount of on-site product storage must also be provided.)
Rail Cars Loaded per Day, Average	OU1: 9 per day (for 5 days per week) OU3 and OU4: 27 per day (for 6 days per week)	Based on use of 100-ton gondola cars and maximum daily loadout capacity listed above.
Length of Siding, Minimum Provided	OU1: total of 1,800 linear feet OU3 and OU4: total of 4,000 linear feet	For OU1: Need to accommodate 18 cars (9 empty and 9 full) at 60 linear feet each, plus length of switches and setbacks. The length of the entrance track to the site would be in addition to the length of the siding, and would depend on geometry of property and proximity of existing service. For OU3 and OU4: Need to accommodate 54 cars (27 empty and 27 full) at 60 linear feet each, plus length of switches and setbacks. The length of the entrance track to the site would be in addition to the length of the siding and would depend on geometry of property and proximity of existing service.

Within OU4, a number of properties have been identified that are proximate to CN's existing service. These are identified on Sheet 03 of the plan set in Supplement IV. In general, the properties within the city of Green Bay have characteristics that are the most amenable to the use of rail, requiring the least amount of new infrastructure. Within OU1, only the Bergstrom fill site has been identified for possible construction of dewatering facilities and the property is also accessible to rail. It is identified on Sheet 02 of the plan set.

5.4.3 Follow-Up Information Needs and Tasks

There is no specific information that is needed to further the design of rail or loading facilities. Once a processing site is selected, a final rail availability determination can be made. If rail is found to be a viable means of transport, design of the required facilities can begin.

5.4.4 Permits and Approvals

There are no specific environmental permits or approvals associated with this particular project element. Building permits would be required for any infrastructure additions to private land. If it is necessary to construct a rail spur across a public right-of-way, additional local approvals will be required, but at this early stage of planning, these are not considered to be limiting.

6 Dewatering and Wastewater Treatment

This section describes processes for separating dredge solids from interstitial or carriage water and the subsequent operations for treating that water. It includes both the initial physical separation of coarser materials, and the passive or mechanical dewatering of the remaining finer-grained solids.

6.1 Coarse Material Separation

The process of coarse material separation will vary according to the type of dredging that is used, and the manner in which the dredge slurry will be dewatered. In all cases, the objective is to remove objectionable material or solids that will interfere with the downstream processing of the sediment.

6.1.1 Process Description

If hybrid dredging is used, solids pre-processing is performed prior to the hydraulic transport of the dredge slurry. Bulk debris and coarse material (typically greater than 5 cm in size) is separated from the mechanically-dredged sediment as part of the operations at the dredge. These materials are then separately conveyed to the shore for treatment and/or disposal.

The slurry from a hydraulic dredge or hybrid operation can be subject to additional separation steps consisting of screens and hydrocyclones. Desanding units can provide several operations in an integrated manner. For example, a unit that has been used at the Fox River demonstration project and specified for use at New Bedford Harbor includes the following operations:

- The dredge slurry is discharged onto a “scalper” screen that separates coarse material greater than 3/8 inches
- The slurry that passes through the screen is collected in a “v-bottom” tank
- Heavy material settles to the bottom of the tank and is pumped to one or more hydrocyclones
- Material separated by the hydrocyclone drops on to a linear motion screen, which in turn separates the material greater than 200 mesh
- The slurry which passes the hydrocyclone and the linear motion screen, is returned to the v-bottom tank

- The overflow from the v-bottom tank, containing only the finest solids, is pumped to the dewatering operation

It is desirable to separate as much sand as possible from the soft sediment. This has the beneficial result of reducing the mass of solids that must be dewatered, and also improves the dewatering process. As a separate fraction, the sand may be approximately 70 percent solids (by weight). For example, the 2000 work on SMU 56/57 produced coarse fraction solids (i.e., sand size and larger) at an average of 76 percent solids (Foth and Van Dyke, 2001). Sand at 70 percent solids (by weights) is a comparatively dry product in terms of materials handling and disposal.

Historically, for some kinds of projects, the sand fraction that is separated from dredge slurry has been beneficially reused. The sand fraction of the solids in the soft sediment averages from 20 percent to over 40 percent and represents a significant fraction of the total mass of solids that would be dredged. If the solids were managed as a separate waste stream, the dewatering and filter cake disposal effort would be reduced dramatically. Therefore, beneficial reuse would certainly be a possibility for Lower Fox River materials based solely on the physical properties of the dredge slurry.

However, the chemical properties of the dredge slurry pose a roadblock to beneficial reuse of the sand fraction due to the PCB content of the material. Generally, PCBs will be inclined to adsorb to the organic finer soil fraction, but a certain residual amount will be found in the sand. At the Deposit N demonstration project in 1998–1999, the mean PCB concentration in coarse material (i.e., material with a diameter greater than 0.95 centimeters [cm] [0.375 inch]) was 1.2 parts per million (ppm) (WRI, 2000). The mean PCB content in the sand fraction was 5.0 ppm. At these concentrations, the material from the full-scale project would not be regulated as a TSCA waste (greater than 50 ppm). However, due to the sensitive nature of the Lower Fox River project, any detection of PCBs would likely require the disposal of coarse material and sand as a solid waste.

Thus, while the dewatering process will still be enhanced by the removal of the sand fraction, there may not be a significant savings in disposal cost because the solids would ultimately be landfilled. Nonetheless, separation of the sand fraction may prove beneficial in some scenarios. First, the sand fraction would typically be at a higher solids content (lower water content) than the filter cake (e.g., nominally 70 percent solids vs. 55 percent solids). For a given dry mass of sand, the total wet tonnage is less when it is separated as a side stream than if the same dry mass was turned into a filter cake. This could result in a small savings in disposal. Second, if the filter cake was being disposed of on a higher "per ton" rate than other solid waste, there would be a small savings by separating the sand fraction of the total solids and disposing of it at the lower unit cost.

6.1.2 Design Basis

The design basis for coarse material separation is somewhat limited. The contractor will have the flexibility to use specific equipment and methods that will vary according to the dredging technique chosen. The design of coarse material separation equipment and methods will be subject to contractor experience and preference, based on the parameters presented in Table 6-1.

Table 6-1 Design Basis for Coarse Material Separation

Parameter	Value	Basis or Assumption
Percent Solids of In-Place River Sediment (by weight)	OU1: 24.2% OU3: 37.1% OU4: 33.8%	These are average values, presented in the FS. There is likely to be considerable variability across each OU.
Percent Sand	OU1: 46% OU3: 23% OU4: 42%	These values are presented in the RI Appendix G, Table 1. As stated above, there is likely to be significant variability across each OU.
Specific Gravity of Solids	OU1: 2.51% OU3: 2.47% OU4: 2.36%	These values are presented in the RI, Appendix G, Table 7. However, they represent the specific gravity of the bulk solids, not necessarily the sand or coarse fraction that may be separated. This item is further identified as an information need below.
Percent Sand Removed (by weight)	15%	This is a possible performance specification for the separation of sand prior to mechanical dewatering, as discussed below.
Post-Separation Materials Handling	—	The design of materials handling facilities (lay down pads, bermed areas, truck loading operations, etc.) would require that all sand and bulk materials be contained, staged, and handled separately from filter cake and other project residues.

The value indicated above for "percent sand removed" represents a possible performance-based specification for the fraction of dry solids that must be removed, by contract, in the separation steps before a mechanical dewatering operation. The "percent sand removed" would represent the sand and gravel fraction, as opposed to bulk debris, which are certain to be separated before any further sediment processing could occur.

The value selected for "percent sand removed" is based on past performance on Lower Fox River demonstration projects, as follows:

- During the 1998–1999 project at Deposit N, the reported removal of sand and bulk material combined (via a series of screens and cyclones) was approximately 30 percent of the total solids in the dredge slurry (WRI, 2000).

- During the 2000 project at SMU 56/57, the reported removal of sand was approximately 12 percent (Crystal, 2002).

Results from previous demonstration projects suggest that a reasonable minimum design requirement would be 15 percent removal. The contractor would have substantial flexibility as to what equipment to use to achieve that specification, subject only to the materials handling requirements. Contractual incentives could be developed to encourage a higher degree of removal if such removal were to yield downstream savings. For purposes of completing mass balance calculations at this stage of this project, it will be assumed that 15 percent (by weight) of the dry sediment solids will be separated as a side stream, at a typical solids content of 70 percent (30 percent moisture) (by weight). This does not include the weight of bulk materials, whose mass is not otherwise included in the current estimate of total sediment mass.

6.1.3 Follow-Up Information Needs and Tasks

The most significant information need for the final design and selection of separation equipment is a more definitive characterization of sediment physical properties. This work is expected to be a part of a major pre-design sampling program that is currently in the planning stage. Specific data should include grain size analyses and sand fraction specific gravity.

6.1.4 Permits and Approvals

There are no specific permits and approvals associated with this particular process. The separation equipment will be constructed as part of the larger dewatering and wastewater treatment plants whose permit requirements are described in Section 6.4.4. Characterization of the sand and bulk material fractions will be required for disposal approval.

6.2 Mechanical Thickening/Dewatering

This section describes concepts for the mechanical thickening and dewatering of dredge slurry. The processes of thickening and dewatering are standard wastewater operations, although experience with handling dredge slurry is not as widespread as for other high-solids, inorganic waste streams.

6.2.1 Process Description

Dredge slurry can be thickened and dewatered using a series of mechanical devices. A typical configuration of unit operations as they might be used for the Lower Fox River project at any of the OUs is illustrated on Sheet 09 of the plan set in Supplement IV.

As described in Section 6.1, a precursor to slurry thickening would be one or more separation steps where bulk debris and coarse materials are removed from the slurry. This operation will have the net effect of removing a fraction of the total mass of dry solids from the slurry. The debris or coarse solids would be at sufficiently high solids content that no further dewatering would be needed.

After one or more separation steps, the slurry would be pumped to a thickener. The purpose of this operation would be to concentrate the solids to a greater degree, and provide a more consistent flow to the downstream presses. For example, it is expected that the incoming slurry from a hydraulic dredge may average 7 or 8 percent solids over time, with wide swings in concentration from normal dredge movement and operations. A thickener would serve to dampen this variability and to consolidate the solids to 15 percent or greater.

The thickening operation may be aided by the addition of a polymer (i.e., chemical conditioning). Some contractors have provided flow equalization prior to thickening by using an agitated tank, which could serve as a mixing tank, if polymers were needed. Providing a higher and more consistent solids loading to the downstream presses will improve dewatering performance. Low solids loading was cited as a cause of poor performance of the recessed plate presses during the first year of work at SMU 56/57 (Montgomery Watson, 2001).

The supernatant (i.e., overflow) from the thickener would be a low-solids aqueous stream that could be pumped directly to a wastewater treatment process, as described in Section 6.4. The thickener underflow would be pumped to an agitated feed tank. Chemical conditioning could be provided at this stage. This agitated feed tank, or a series of tanks, would supply multiple downstream presses.

Sheet 09 also shows an alternative flow pattern where dilute dredge slurry is diverted directly to wastewater treatment, bypassing the thickener. This may occur when flushing lines, performing maintenance, or when other dredge operations result in the pumping of comparatively clear river water with little to no sediment solids.

Two styles of press may be appropriate to the Lower Fox River project: a plate-and-frame filter press and a belt press. The filter press is a batch process, and is widely used for fixed-base and mobile applications. The belt press is a continuous process and is highly specialized and customized for particular applications. With either style of press, multiple units would be operated in parallel to provide sufficient daily throughput.

The downside of filter presses compared to belt presses is that they operate in a batch mode and require comparatively higher operator effort. A belt press is generally more sensitive, but when optimized for a particular operation can provide good long-term service.

Filter presses are generally thought to produce a filter cake with higher percent solids than belt presses. The percent solids achieved is a critical parameter because the cost of disposal is on a weight basis and every percentage point of water that can be removed from the cake results in a direct savings in disposal. The demonstration projects at Deposit N and SMU 56/57 used mobile plate-and-frame filter presses. By the second year of the SMU 56/57 project, the mobile plate-and-frame filter presses were producing a cake with relatively high percent solids—up to 66 percent solids (Foth and Van Dyke, 2001). The average over the entire second year of this project was 59 percent solids, which was achieved as a result of ongoing refinements.

Unfortunately, there is not a comparable body of experience with belt presses. For the Lower Fox River, the best available data comes from some initial bench-scale testing completed by Andritz-Ruthner, Inc. This work was done on actual sediment samples provided to Andritz by Minergy, Inc., as part of Minergy’s process engineering work on a potential vitrification plant. Minergy’s interest in dewatering methods was based on the possible use of a press to reduce the water content of a sediment feed material prior to drying.

Andritz tested a number of belt press configurations, using typical sizes and types of equipment. They were able to achieve percent solids from the high-40s to low 60s. While this initial testing was limited in scope, and additional work on a wider range of sediment samples will ultimately be needed, it indicates that the performance of belt presses may compare favorably with filter presses for Lower Fox River sediment. On this basis, the performance specification for this project should allow for the use of either style of press.

6.2.2 Design Basis

The final design of the dewatering process and selection of specific process equipment would be based on the parameters presented in the Table 6-2.

Table 6-2 Design Basis for Mechanical Thickening/Dewatering

Parameter	Value	Basis or Assumption
Unit Operations Required	Dredge slurry flow thickening, dewatering, and supernatant collection and pumping	Although the dewatering specification will be performance-based, these minimum operations should be identified and planned for.
Capacity	Capable of thickening and dewatering up to several thousand gallons per minute (gpm) of dredge slurry (or the slurry rate generated from contractor's specific dredging operations)	Several flow rates are described in Section 10 for different process combinations in each of the OUs. These could be higher if alternative dredging equipment or multiple dredges are used.
Filter Cake Solids, Percent by Weight	Minimum 55%	This is based on the SMU 56/57 project performance and should be achievable using typical equipment and methods.
Filter Cake Unconfined Compressive Strength, pounds per square foot (psf)	To be determined (could be 0.4 ton per square foot [tsf])	This is a specification that is based on the need for filter cake disposed in a landfill to have sufficient strength for stability purposes. (If the filter cake were disposed via vitrification, for example, no such specification would be needed.) The SMU 56/57 project used a value of 0.4 tsf, and this was readily achievable. Additional geotechnical work is needed to confirm that this would be an appropriate value for the full-scale project.
Filter Cake, Other Characteristics	Pass paint filter test	This test may be redundant. A specification for 55% solids will most likely accomplish the degree of dewatering necessary for the filter cake to pass the paint filter test. WDNR has indicated that free liquids would not necessarily be excluded from an NR 500 landfill, since a CDF taking dredge slurry is a permittable facility under existing regulations. This is discussed further in a subsequent section.

6.2.3 Information Needs and Follow-Up Tasks

Several information needs are described in Table 6-3.

Table 6-3 Information Needs for Design of Mechanical Thickness/Dewatering

Tasks and Needs	Means for Completing
Volume Determination	The estimate of the volume of sediment that will be managed as part of this project is subject to ongoing change as additional information is collected. At least one major "pre-design" sampling effort is anticipated, and this will allow better volume estimates to be completed. The sediment volume estimate will be used to estimate the quantity (tonnage) of dewatered filter cake that will be generated.
Geotechnical Confirmation of Strength Specification	The specification on the filter cake for unconfined compressive strength is subject to confirmation. This can be completed once a final landfill design is completed, and critical slopes and failure mode can be determined.
Filter Press Treatability Work	Equipment suppliers and independent testing firms can perform tests to assist in the selection of dewatering equipment, operating conditions, and filter fabrics. (Initial work has been performed by one supplier, as described in Section 6.2.1.) Further, detailed testing could be done independently prior to a construction bid process, or could be performed by a selected contractor, prior to actual equipment selection and fabrication.

The filter press treatability work is the most significant information need. Available information demonstrates that the plate-and-frame filter presses would be effective for this project. On the other hand, while the effectiveness of belt presses for this type of application has not been fully evaluated, they could prove to be effective and may result in a significant labor cost savings.

In addition to the results of the treatability work, the options for proceeding with the implementation of the work will influence the design and cost. For example, there are certain advantages and disadvantages to consider in choosing to conduct the treatability work prior to or following the construction bid process. If an owner (Responsible Party or WDNR) conducts the treatability work prior to the construction bid process, the following possible scenarios may develop:

- Owner-supplied treatability work may benefit bidders by confirming an existing preference in equipment they may have, or by adding validity to an alternative approach they might suggest.
- If this project is bid as an integrated dredging and dewatering project, bidders with an existing preference in equipment may end up tailoring their approach to the equipment that they have the

most experience with and believe will deliver a competitive advantage, independent of the treatability work. In this scenario, the upfront treatability work may be superfluous.

Notwithstanding the second scenario presented above, results from treatability work performed prior to the construction bid process would still serve as a basis for evaluating bids by demonstrating the general range of reasonable possibilities that bidders may propose. Upfront knowledge obtained through the treatability work (i.e., parameters associated with specific dewatering approaches) would place the WDNR in a position to gain a higher degree of confidence that the work will proceed as expected even though the contractor will ultimately be responsible for meeting the project specifications using means and methods of their choosing under a performance-based, unit-price contract. Independent of the treatability work, given the scale of this project, a contractor is likely to perform a certain amount of in-house testing for their own confirmation purposes. Therefore, at a minimum, a methodology for providing representative samples of sediment should be provided by the WDNR.

6.2.4 Permits and Approvals

There are no permits or approvals specific to a mechanical dewatering process. In general, though, the equipment will be subject to the larger, overall review and permitting procedure for the wastewater treatment plant as a whole. This is described in more detail in a subsequent section of the report.

6.3 Settling Basins

Settling basins are structures used for dewatering solids from the dredged sediments and allow effective handling and disposal of sediments. Settling basins could be used in conjunction with either hybrid or hydraulic dredging.

6.3.1 Process Description

Dredged sediments are pumped to the basins and allowed to settle to promote gravity settling of solids prior to removal and re-handling for transport to a landfill. Concepts for a typical facility are indicated on Sheets 16 and 17 of the plan set in Supplement IV.

The proposed facility would consist of four cells. Each cell will have capacity to hold dredged sediments from one dredge season (35 weeks). Following placement of sediment in the first cell after the first dredge season, active placement of sediment proceeds in the second cell. The third cell and fourth cell will be used during rotation or as needed to assist with uninterrupted work activities. While sediment is placed in the fourth cell during the fourth dredge season, dewatered sediments from the first cell are managed for placement in a landfill.

A vacuum enhanced under drainage system will be constructed to assist with the gravity dewatering of sediment slurry. A network of drainage pipes covered with filter fabric will traverse along the bottom of the settling basin. Vacuum pumps located outside the settling basin will apply vacuum to the drainage pipes to expedite the dewatering process. Recovered water will be transferred to the wastewater treatment unit prior to discharge to the Lower Fox River.

Conventional equipment will be used within the settling basin to construct perimeter trenches and interior trenches to optimize the dewatering process. Sediment slurry will be subject to a residence time of approximately 24 months to 36 months in each cell. The dewatered sediments will be loaded into dump trucks equipped with sealed tailgates and tarps over the loads, and transported to a landfill for permanent storage. Access and perimeter roads will be constructed for equipment and personnel to work around the settling basin.

6.3.2 Design Basis

The procedures described in the United States Army Corps of Engineers (USACE) Engineer Manual 1110-2-5027 (USACE, 1987) provided a basis for sizing the settling basins. Data, presented in Table 6-4, from the 2001 FS (RETEC, 2001) and SMU 56/57 Basis of Design Report (Montgomery Watson, 1998) were used for settling basin design calculations.

Table 6-4 Design Basis for Settling Basins

Parameter	Value	Basis or Assumption
Average Sand Content	OU3 and OU4: 32.5%	From RI/FS
Average Specific Gravity	OU3 and OU4: 2.4	From RI/FS
Dredge Slurry Flow Rate	Up to 4100 gpm with 8% solids (by weight)	From FS and this DEA
Minimum Dredge Duration	OU3 and OU4: 11 years	From FS and this DEA
Total *in situ* Dredge Volume	OU3 and OU4: 6,500,000 cubic yards (cy)	From RI/FS
Total Dredge Volume per Dredge Season	Up to 812,500 cy	Calculated based on above parameters
Solids Content after 24 to 36 Months of Dewatering and Drying Sediment	Approximately 40%	Assumed based on Bayport operations data
Configuration and Loading Cycle	Alternating, 4-cell design	Cells will be alternately filled in 34-week cycles
Settling Time for Sediments per Cell	24 to 36 months	Assumed based on SMU 56/57 Demonstration project data
Liner Slope	0.5%	Typical
Liner Design	4-inch asphalt layer over 3 feet clay	Subject to leachate analysis and WDNR review
Effective Weir Length	10 feet	Typical practice

The dredge volume per season was used to determine the surface area of the settling basin with a limiting fill height of 6 feet. The fill height was limited to allow efficient handling and removal of dewatered sediments. An effective surface area of 83 acres per dredge season is required to accommodate dredged sediments for dewatering. The settling basin was configured to four cells with each cell measuring 83 acres. The settling basins were configured to allow each cell to be managed separately (i.e., some cells can be filled while the dredged sediments in other cells are dewatered to allow multiple tasks to be accomplished simultaneously and to facilitate efficient flow of work activities). The main advantage with the four-cell approach is increased effective settling time over the three-cell configuration. However, the four-cell settling basin would require 25 percent more land area. The final cell configuration will be determined based on evaluating and balancing required land area and effective settling time.

A rectangular weir structure was selected in the design as it is commonly used for dewatering operations. The effective weir length was calculated to be a minimum of 10 feet for each cell. Additional weirs may be constructed in each cell for effective removal of effluent without causing higher local velocities around the weir structure and possible resuspension of solids. The number of weir structures and locations will be determined based on the final cell configuration.

A clay liner was selected for the settling basin to meet the intent of the design and construction criteria specified in Chapters NR 213 and 504. It is indicated on Sheet 25 of the plan set. The liner will consist of a 3-foot minimum compacted clay layer and an asphalt layer. A granular drainage layer will be included.

A vacuum enhanced under drainage system was selected to assist with the gravity dewatering process. The under drain will consist of a series of corrugated perforated HDPE pipes wrapped in filter fabric, spaced at 50-foot intervals along the slope of the settling basin. A 4-inch corrugated perforated HDPE header pipe wrapped in filter fabric will be connected to the pipes at the toe end of the berm on the low end of the settling basin for collecting water. Vacuum pumps housed outside the settling basin will be used to apply vacuum for enhancing the drainage of sediments. Drainage water accumulated in the header pipe will be pumped out and transferred to the wastewater treatment unit prior to discharge to the Lower Fox River. The number of vacuum pumps and amount of vacuum to be applied will be determined based on final cell configuration and finalized in the subsequent detailed design.

6.3.3 Follow-Up Information Needs and Tasks

To further refine the settling basin design calculations, the following information is required:

- Accurate dredge volume of sediments under consideration
- Sediment characterization data
- Column settling tests conducted on representative samples of sediments to be dredged
- Site selection in the vicinity of the OU under consideration

It is anticipated that most of these data needs will be fulfilled as part of the pre-design sampling work anticipated for 2003.

6.3.4 Permits and Approvals

WAC NR 213 (Lining of Industrial Lagoons and Design of Storage Structures) contains the regulatory requirements applicable to the settling basins. These include design and construction standards, as well as subsurface investigative requirements for the site on which the basins would be constructed.

The owner of the basins will be required to submit to the WDNR an engineering report and construction plans and specifications. These documents shall describe the following:

- Subsurface site conditions
- Waste source, analysis and volume
- Materials of construction for the liner
- Waste compatibility with the liner
- Liner installation methods
- Construction quality control

The WDNR will approve the engineering report and construction plans and specifications prior to the start of construction.

6.4 Wastewater Treatment

Carriage water from a hydraulic or hybrid dredging operation will require treatment prior to discharge back to the Lower Fox River. The kind of system necessary for this purpose would be comparable to an industrial wastewater treatment plant that is designed for removal of suspended solids and dissolved organics. The concepts and design basis for such a facility are discussed in this section.

6.4.1 Process Description

For the purposes of this evaluation, wastewater is defined as the water that is released from the dredge slurry during the initial processes of thickening and/or dewatering. The source could be a mechanical process (Section 6.2) or a passive, gravity process (Section 6.3). In either case, the characteristics of the wastewater that dictate the treatment process will be the suspended solids and PCB concentrations. Other sources of wastewater include yard runoff and equipment wash water, but these are expected to be minor contributions of intermittent duration. The parameters of concern in these minor streams would be sufficiently similar to the primary sources that they do not require special consideration.

Sheet 10 of the plan set in Supplement IV illustrates a typical process flow diagram (PFD) for wastewater treatment. The basic operations include clarification, granular media filtration, and granular activated carbon (GAC) polishing. The use of granular media filtration and GAC polishing is based on an initial determination by the WDNR that these processes constitute "best demonstrated available technology (BDAT)" for a dilute aqueous stream containing dissolved or suspended PCBs. As a result, it is expected that these will be specified as part of a Wisconsin Pollutant Discharge Elimination System (WPDES) permit for the project.

The sequence and combination of operations on Sheet 10 is for illustrative purposes. If mechanical dewatering is used, the wastewater treatment process will be closely linked with the dewatering operations shown on Sheet 09. Other combinations are possible and an alternative may, during final engineering, be found to be preferable. Examples of other arrangements include the following:

- The illustrative PFD shows parallel subsystems for the clarification of the two major streams of wastewater coming from the thickening/dewatering operations: thickener supernatant and press filtrate. (These sources are indicated on Sheet 09). The benefit of separating of these streams was identified during the SMU 56/57 demonstration project (Montgomery Watson, 2001) and would represent reasonable engineering practice. However, an alternative would be to return the press filtrate to the thickener, which in turn would be sized to accommodate a higher combined flow and solids loading. The thickener overflow would then discharge to a single clarifier.

- Similarly, the solids underflow from the clarifier(s) is shown as being returned to the thickener. An alternative, depending on the solids loading, could be to pump this directly to the presses.

- Although it is not shown on the PFD, a large slurry holding tank (e.g. 1,000,000 gallons or greater) could be added to the process ahead of the coarse material separation operation or the thickener. The purpose would be to provide equalization of the incoming solids load from the dredge, to dampen some of the variability in the loading to the thickener. It would be continuously agitated, and could, if desired, be configured as a "pre-thickener," with separate draw-offs for an underflow and overflow.

- A comparatively small filter press feed tank is shown after the thickener. Alternatively, a much larger holding tank could be used as a way of providing a certain amount of solids storage. This could provide a contingency for times when the press operation is erratic, or when multiple units are unexpectedly down for maintenance.

Decisions on such process options can be made at the point of final engineering, and do not change the overall concepts for the system. The basic operations of clarification, filtration, and GAC polishing are fairly straightforward.

Clarifiers would provide the means for removing 50 to 70 percent of the suspended solids. A solids contact clarifier could be a feasible style. Clarifiers placed upstream of the granular media filters will reduce suspended solids to within a range that is compatible with the design of the granular media filters and could reduce suspended solids to levels that meet the discharge limit (i.e., 10 milligrams per liter [mg/L]). Granular media filters are most effective where loading to the filters is in the range of 30 to 50 mg/L suspended solids. If the suspended solids loading is too high, improved clarification through chemical addition is a common method used to reduce concentrations prior to filtration.

A number of styles of filters exist. Process options include pressure and gravity feed systems, upflow and downflow filtration, single or multi-media packed filter cells, and automatic or continuous backwash methods. A significant reduction in cost may be achieved with the installation and use of gravity filters. However, gravity filters usually require more space for construction where pressure filters could be more easily configured to accommodate available space. Depending on head losses through the filter, higher effluent pressures are expected from pressure filters and may be advantageous for further processing in subsequent steps of the treatment process, such as final GAC polishing.

Generally, upflow systems are considered for applications with higher suspended solids loading. Certain disadvantages associated with upflow filters include potential bed expansion and fluidization channeling. With downflow feed, higher filtration rates may be achieved and there is greater utilization of the bed depth.

The filter bed may be comprised of a single media or multiple media. Single media usually consist of sand with an option to increase bed utilization by layering with finer grades of sand. Multiple media filters commonly consist of a combination of two or more types of material such as sand, anthracite, or coal and offer more flexibility for customizing the bed based on the composition of the waste stream.

Continuous backwash generally involves the separation of solids in an internal system using an airlift. Particular advantages associated with the use of continuous backwash systems include decreased plugging or fouling due to continuous movement of the filter bed. The continuous nature of operation is advantageous in that no shutdown is required for backwash cycles and pressure drops remain low and equal among the filters. On the other hand, air scouring in the airlift is a high-energy system that may increase overall operating costs.

In contrast, automatic backwashing methods operate by shutting down flow to one filter cell in a system while continuing to filter through other cells in the system. Fluctuations in effluent flow rates and pressure drops are inherent in automatic backwashing systems. Where filtered water is required for subsequent industrial purposes, the continuous backwash system is ideal for sustaining constant production rates. For this project, the main objective is treatment of the carriage water. In this case, the advantages of a continuous backwash system are less significant. For the purpose of this analysis, it is assumed that an automatic, dual-media downflow pressure filter would be installed.

The GAC polishing process will remove any dissolved-phase organic compounds prior to discharge. The size of GAC vessels are based on hydraulic loading (gpm of flow per square foot of cross-sectional area) and providing a sufficient contact time. A number of individual vessels will be used in parallel, and periodic backwashing may be required.

The concentration of dissolved PCBs in the carriage water is expected to be very low (at the ppb level only), and thus the organic loading to the carbon will be minimal. Changeouts of carbon will therefore be infrequent, and probably somewhat less than once per year per vessel.

After GAC treatment, effluent will be collected in an aboveground steel tank, prior to gravity or pressure discharge to the river. An allowance will also be made for adjusting the pH of the effluent to within the range of 6 to 9 S.U. which is the typical range specified in a WPDES permit.

In the case of OU3 and OU4, the size and duration of this project is such that it is anticipated that the wastewater treatment system would be constructed as a fixed-base facility at a central location. The level of quality would be that of a semi-permanent installation with purchased, dedicated equipment, as opposed to a short-term, mobile facility that might make use of temporary, leased equipment.

For OU1, the project is somewhat smaller, and would be completed in 2 to 3 years. It is anticipated that the wastewater treatment plant would still be constructed at a central location using purchased, dedicated equipment designed specifically for this application.

While there may be salvage value at the end of the life of each project, it is assumed that any such benefit would accrue to the operating contractor, and no allowance is made in the current planning process or estimating of costs for the reuse or resale of process equipment from either the OU1 or OU3 and OU4 plants.

At OU3 and OU4, it is assumed that the wastewater treatment plant will operate continuously, 7 days per week, throughout the dredging season. OU1 may only operate for 5 days per week. In either case the system would be largely automated, and the controls system would be interlocked with the upstream dredging and dewatering operations so that any alarm conditions could be monitored and appropriate responses put into place. This fact notwithstanding, the plant would still require operations and maintenance staffing on a full-time basis.

6.4.2 Design Basis

As described above, the combination of unit operations on Sheet 09 is for illustrative purposes. Other arrangements are possible, and it is likely that the final system will vary from the one that is shown. It is expected that the dredging, dewatering, and wastewater treatment elements of this project will eventually be bid as a single scope of supply, using a series of performance-based specifications. As such, the final design of the wastewater treatment facilities would thus be based on the upstream components selected by the successful bidder.

As described in an earlier section on dewatering, a performance-based form of contracting means that even a design parameter as basic as flow rate cannot be established with certainty at this time. The final system will be sized to match the output of the dredge and dewatering system, and will thus ultimately be determined by the contractor.

The minimum design basis that is expected to be applicable to any combination of contractor-selected processes and equipment is provided in Table 6-5.

Table 6-5 Design Basis for Wastewater Treatment

Parameter	Value	Basis or Assumption
Flow Rate, gpm	To match the rate of wastewater generation from upstream dredging and dewatering processes Expected to be in the range of 1,500 to 3,500 gpm, depending on size and number of dredges	This range is based on the expected sizing of the dredge (Section 4) and the resulting dredge slurry rate. The range also takes into account the fact that a fraction of the dredge carriage water will be removed from the system as part of the dewatered solids (i.e., the forward flow to the wastewater treatment system will ordinarily be less than the volumetric dredge slurry rate.)
Operations	Could be continuous, 7 days per week, over an 8-month dredging season, for OU3 and OU4. 5 day per week operations at OU1.	This is intended to match the dredge schedule. However, considering downtime, the dredge will usually not be producing slurry for a full 24-hour day. A contractor may choose to provide storage capacity (tanks) for flow equalization capability so that the rate of wastewater treatment is reduced, while extending across a 24-hour/7-day schedule.
Minimum Processes Required	Granular media filtration and GAC	These are based on the expected WPDES permit conditions.
Effluent Limits	PCB – 1 µg/L pH – 6 to 9 standard units (s.u.) Suspended solids, BOD, mercury, ammonia – not yet determined	In addition to the use of BDAT, the effluent limits for PCB and pH are expected to drive the selection and sizing of wastewater treatment process equipment. The WPDES permit may also have limits for the other parameters listed, but these would be based on the "pass through" of contaminants. They are not expected to result in the need for additional treatment processes.

6.4.3 Follow-Up Information Needs and Tasks

The most significant information need for the final design of a wastewater treatment system will be the determination of the hydraulic loading for the plant. As described above, this parameter depends on the specific dredging method and equipment that is chosen and therefore cannot be known until a contractor is selected. Bench-scale settling tests will also be required as a pre-design task.

6.4.4 Permits and Approvals

This project element will be subject to the following permits and approvals:

- The discharge of treated wastewater will be subject to the conditions of a WPDES permit issued by the State of Wisconsin (Wisconsin Statutes Chapter 283)
- The final design and construction plans and specifications for the plant are subject to review and approval by the WDNR (NR 108)
- The operation of the plant must be under the direction of a state-certified operator (NR 114)

These requirements are routinely applied to industrial wastewater treatment plants of similar and greater size and complexity across the state, and none of them are believed to be a limiting factor for this project. The permit requirements would be achieved as described in Table 6-6.

Table 6-6 Permits and Approvals for Wastewater Treatment

Requirement	Fulfilled By	When
WPDES Permit	WDNR or responsible party (RP), depending on who is implementing the remedy	Draft permit limits (at a minimum) should be established prior to the bid process for dredging/dewatering services, so that they can be incorporated into the final performance specification for wastewater treatment.
Submittal of Construction Plans and Specifications	Contractor or construction manager, depending on form of construction contract	After award of contract, and prior to construction of the system
Certified Operator	Contractor or construction manager	Certified operator needs to be retained prior to operation commencement, and remain assigned for the duration of the operations.

6.5 Solids Handling and Plant Infrastructure

For many projects, the handling of solid residuals from a dewatering operation would be only a minor, incidental activity. For the Lower Fox River project, however, the quantities of material involved are sufficiently large that the solids handling process will be a more significant feature of the work. This section describes concepts and facility needs for two specific operations: the staging and loadout of coarse materials separated from the dredge slurry, and the staging and loadout of filter cake generated by the dewatering operation.

6.5.1 Process Description

The solids handling operations include the facilities and methods for conveying, staging (stockpiling), reclaiming, and loading the solid residuals generated from the separation and mechanical dewatering operations. The facility for performing these operations would be integrated with the overall dewatering/wastewater treatment plant infrastructure in terms of road access, utilities, and stormwater management.

A typical facility plan is shown on Sheet 12 of the plan set in Supplement IV. A schematic cross-section is shown on Sheet 15. In both cases, these drawings represent a possible configuration and general sizing of the equipment and facilities needed. The final system is likely to be different, particularly when site selection and final quantities are established.

In general, the facility is expected to have the following characteristics and components:

- The coarse material (sand) and filter cake may have differing PCB concentrations and disposal requirements, and will be handled separately

- Each staging area should be lined with a durable, reinforced concrete surface designed to accommodate the operations of heavy, wheeled equipment. For migration control, a geomembrane liner and liquid collection layer can be placed under the concrete

- Concrete sidewalls should be provided to retain stormwater and reduce the incidental spreading or tracking of contaminated solids on to the access road and other parts of the plant

- The process equipment for the initial coarse material separation process should be located inside the corresponding staging footprint to retain stormwater and reduce the incidental spreading or tracking of contaminated solids

- The staging areas would drain to catch basins, and stormwater would be pumped into the dewatering/wastewater treatment plant

- Where possible, fixed-based (or pivoting, stacker-type) conveyors should be used to speed the movement of material and reduce the labor and equipment needs for stockpiling

- Loadout stations would be constructed adjacent to the staging areas in sufficient number to meet the truck loading frequencies required

It is expected that the daily production of coarse solids and filter cake would be segregated pending sampling and release for disposal. Since solids destined for landfilling probably would only be loaded out on a maximum 6 day-per-week basis (as described in Section 5.3.2), space for at least three day-piles must be provided (i.e., Saturday, Sunday, and then Monday while the Saturday day-pile is being loaded out).

The facility plan shown on Sheet 12 of Supplement IV provides this minimum configuration for both the coarse material staging area and the filter cake staging area. For the filter cake area, however, it is suggested that at this early stage of engineering, an allowance be included to expand this area, and allow for additional on-site holding.

The facility plan and schematic cross-section anticipate that conveyors would be used to move solids from the point of generation (i.e., the screens and belt presses) to the day piles. Diverter plates on the conveyor would be opened and closed, as required, to create the individual piles. It is expected that the reclaiming of material from the piles would be performed by end-loaders. A mechanical conveyor and loading system was also considered for the actual truck loading, but it was felt that it would not provide for sufficient cycle-time improvement compared to manual loading by the end-loaders reclaiming from the piles.

As described earlier in the section on truck transport (Section 5.3), the necessary frequency of truck loadouts is such that concurrent loading of trucks may be needed. It may be possible to stage multiple trucks along a single side of the staging area as shown on Sheet 12; if not, then a parallel arrangement could be designed for the opposite site of the day piles to allow for efficient handling.

In either event, it would be preferable to provide a separate truck gate(s) and access road(s) so that pedestrian and routine traffic at the plant would not interfere with the loadout operations. The final geometry of the access road would be such that loaded trucks would exit the facility with a minimum of turns. An allowance for a truck scale is included, although it may be sufficient to weigh the trucks at the point of disposal, which is customary. (There may also be occasions when incoming trucks need to be weighed, for some particular reason.) A truck wheel-wash unit is not included at this point, since the facility design would be intended to eliminate the incidental spread of contaminated solids to the trucks and access road, but it could be added if later thought to be necessary.

6.5.2 Design Basis

The design of the solids handling facilities and other plant infrastructure will be based on the final process sizing, loadout schedule, and property constraints. The minimum requirements described above that would comprise the design basis are summarized in Table 6-7.

Table 6-7 Design Basis for Solids Handling and Plant Infrastructure

Parameter	Value or Criteria	Basis or Assumption
Solids staging capacity	3 days	This assumes the following: 1. A several day holding time may be needed to allow for the sampling and analysis of the dewatered material, and/or, 2. It may not be possible to load out the material generated on a Saturday or Sunday until Monday, if there are limits on the operating schedule of a landfill.
Segregation	Coarse solids and dewatered filter cake would be staged separately in contained areas	This would allow for the separate management of these two waste streams, if necessary.
Loadout	Via separate gates and paved access road	This is intended to isolate the heavy volume of truck traffic from other aspects of plant operation.
Other access	Gates, paved access road and yard sufficient for pedestrians and commercial vehicles, and occasional semi-truck deliveries	The dewatering and wastewater treatment buildings will need to be accessible to semi-trucks for the occasional delivery of equipment, chemicals and GAC replacement.
Stormwater control – solids staging areas	Paved staging areas drained to catch basins; stormwater pumped to wastewater treatment	This criteria would apply to those areas that are likely to contain PCB-impacted solids which may otherwise be transported via runoff
Stormwater control- other yard locations	No specific requirement	Drainage would be based on property characteristics and surrounding land uses.
Yard lighting	Sufficient to allow 24-hour per day operations, if needed	Overhead pole lighting would be provided across areas where routing operations or maintenance work may extend into the evening or nighttime hours.
Utilities	Electricity, sanitary sewer and potable water	All required to support long-term operations at the facility.
Offices	Separate, all-weather office space for contractors, WDNR (USEPA) personnel and WDNR's engineering oversight personnel	Required to support long-term operations at the facility.

Parameter	Value or Criteria	Basis or Assumption
Security	Perimeter fencing and locking gates	Required to support long-term operations at the facility.

6.5.3 Follow-Up Information Needs and Tasks

Specific information needs and/or tasks for the materials handling process have not been identified. The final engineering and detailed design of the needed equipment and facilities will be a straightforward matter, once a site is selected and the final process materials balance is established.

6.5.4 Permits and Approvals

Similarly, there are no specific permits and approvals relevant to this process alone. The overall dewatering/wastewater treatment plant infrastructure will be subject to local zoning requirements, building codes, and building permits, but these are straightforward and do not pose any unique constraints on the work.

7 Solids Treatment and Disposal

This section describes several alternatives for treatment or disposal of dredged sediment that were first identified in the FS.

7.1 Vitrification

Vitrification is the process of converting a solid, semisolid, or liquid material into a glass-like compound. Over the last several years, the WDNR has participated in a demonstration project with Minergy, Inc. of Neenah, Wisconsin to study the feasibility of using a glass furnace to convert Lower Fox River sediment into a glass aggregate suitable for commercial use. While formal approval of the work from EPA is pending, the Minergy process is considered to be representative of vitrification technology and is used as the basis for this evaluation.

7.1.1 Process Description

The proposed Minergy glass furnace is a refractory-lined, rectangular melter. The furnace uses oxy-fuel burners that combine natural gas and oxygen to raise the internal temperature of the melter to 2,900 degrees Fahrenheit (°F). At this temperature and with the lengthy gas residence time in this style of device, the destruction efficiency for PCB contaminants is expected to exceed 99.9999 percent.

The treated sediment would flow out of the melter as molten glass. When quenched in water, the molten glass produces an inert aggregate that can be marketed to the construction industry.

Based on Minergy's demonstration project and subsequent engineering studies, Minergy has concluded that a full-scale vitrification plant might consist of the unit operations illustrated on Sheet 11 of Supplement IV. For purposes of this evaluation, it is assumed that the incoming sediment would be in the form of either a mechanically dredged, bulk sediment or a filter cake from a mechanical dewatering plant (although a plant could be designed to handle material with a moisture content as high as a pumpable slurry). The process is only under consideration for use at OU3 and OU4.

This incoming sediment would be dried to approximately 10 percent moisture (by weight.) If necessary, lime would be added and the mixture fed to the melter. Off-gas control would consist of a mechanical collector, followed by a venturi scrubber/packed tower. Subsystems for wastewater treatment and heat recovery would also be provided.

Minergy currently operates a full-scale melting plant for the processing of wet paper mill sludge. The technology is proven to be implementable for this particular waste stream, and the plant is operated safely and within state air permit requirements. Although river sediments have not yet been processed at a full-scale level of throughput, the process engineering and testing work has not identified any limiting factors to applying this technology to river sediments.

7.1.2 Design Basis

Minergy has made a number of process assumptions as part of their engineering work. These assumptions are subject to modification once the production rates and volumes from the dredging element of the full-scale project are established. However, a design basis can be generalized based on the dredging and dewatering scenarios indicated in earlier sections of this report. This would include the data presented in Table 7-1.

Table 7-1 Design Basis for Vitrification

Parameter	Value	Basis or Assumption
Total Filter Cake Supplied to Vitrification Plant for Processing	Minimum of 3,600,000 tons	Assumes 6,500,000 cy of in-place sediment from OU3 and OU4, dewatered to 55% solids. Mass would be greater as a mechanically dredged material
Solids Content (moisture content) of Feed Material, by weight	30% (70%) or 55% (45%)	The first solids content value represents mechanically dredged, bulk sediment. The second value is based on what is expected to be the performance specification for filter cake from a mechanical dewatering process
Duration of Remediation Operations	Up to 10.3 years (a year consists of 8 months of operation)	8 years corresponds to the length of dredging assumed in the FS and reflects WDNR preference on total project duration. 10.3 years is calculated in this DEA based on slightly different assumptions (see Section 10). The actual plant may have a longer effective life, if Minergy can market the technology to industrial customers with similar waste streams
Daily Feed Rate	Up to 2,300 tpd (when working in OU4)	This assumes that the plant is sized to match the dewatering rate
Preprocessing	Remove bulk material greater than 0.25 inch	This would be achievable when sediment is processed and dewatered to a filter cake condition

Parameter	Value	Basis or Assumption
BACT for Air Permitting Purposes	For NOx control: use of oxy-fuel For SO_2 control: wet scrubber at 95% control	These are assumptions used in the basic Minergy process design and economic analysis, but are not limiting. Other requirements could be incorporated

7.1.3 Follow-Up Information Needs and Tasks

Minergy has performed a demonstration project using a pilot-scale plant and has completed preliminary engineering for a full-scale plant. They continue to perform studies of Lower Fox River sediment properties and engineering evaluations to refine their estimates of process parameters.

Before detailed engineering can begin, the project would require final definition of some of the feed parameters described above. A conceptual range of plant capacities has been explored. When a specific capacity is selected, detailed work on that option can begin. Further, because the WDNR or a responsible party has not committed to using this type of facility, Minergy's economic analysis has not included certain items such as financing costs and working capital requirements. These can be factored in when a specific project solicitation is issued.

7.1.4 Permits and Approvals

Air

Air emissions from a vitrification plant would be subject to state permitting requirements, according to the WAC NR 400 series of regulations. Minergy has evaluated the emissions from a pro-forma 250-glass ton per day facility and concluded that it would meet all current emissions regulations and that the expected annual emissions would not trigger the major source threshold.

The 250-glass ton per day facility is smaller than the facility that would be necessary to handle the full quantity of sediment generated from a dredging effort in OU3 and OU4. The input to the 250-glass ton per day facility is approximately 600 tons per day of dewatered filter cake. This may be an appropriate plant capacity if only a fraction of the dewatered sediment was diverted to treatment. However, the full-scale rate of generation of filter cake could be as high as 2300 tons per day. As such, when a final throughput requirement is established, Minergy would have to re-compute the plant emissions and evaluate them against state requirements.

Wastewater

Wastewater discharges will also be subject to state permitting and/or local discharge approval. The full-scale plant would generate wastewater from at least three sources: Dryer exhausts condensate, packed tower blowdown, and cooling tower blowdown. Options for managing these streams are as follows:

- **Dryer Exhaust Condensate.** Since this wastewater may contain sediment fines containing PCBs, treatment would most likely be needed. If the suspended solids concentration is comparatively low (e.g., 50 mg/L or less), the wastewater could be treated by sand filtration and GAC. (These treatment processes will most likely be designated as BDAT for the treatment of PCB-containing dredge carriage water.) If the vitrification plant were co-located with the treatment plant for dredge carriage water, the wastewater stream could be pumped and treated at that plant. Alternatively, a small standalone treatment facility could be constructed at the vitrification plant. In either case, the treated water could be discharged to the Lower Fox River under a WPDES permit.

- **Packed Tower Blowdown.** Minergy anticipates that this wastewater will be high in both total suspended solids (TSS) and chemical oxygen demand (COD). It may also require treatment, either prior to surface water discharge or as pretreatment before discharging to a local publicly owned treatment works (POTW).

- **Cooling Tower Blowdown**. It is expected that this wastewater stream would be classified as non-contact cooling water. As a result, it could be discharged to surface water without treatment, subject to the WPDES general permit.

Thus, although the quantity and characterization of the air and wastewater emissions have not yet been definitively established, it is believed that permitting of these streams will not be limited by the implementability of vitrification technology. Treatment, as required to attain permit levels, can be accomplished using conventional, readily available processes.

7.2 NR 500 Dewatering Landfill

This disposal option consists of the construction of a single land-based facility that serves as both a dewatering basin and an NR 500 landfill. For sediment projects, this kind of facility has also been described as a CDF.

7.2.1 Process Description

CDFs are engineered structures designed to retain dredged material solids and provide adequate storage capacity of those solids. Hydraulic dredging (or the hydraulic "re-slurry" of mechanically dredged material) generally adds several volumes of water for each volume of sediment removed. When the sediment solids are pumped into the CDF as slurry, they will initially occupy several times their original in-river volume. Over time, the solids will undergo settling and consolidation. If the surface of the sediment can eventually be allowed to drain (after years of dredging and input are complete), such consolidation would be enhanced and the sediment may return to its original "in-river" volume or less.

CDFs are neither conventional wastewater treatment facilities nor conventional solid waste disposal facilities. An effective CDF consists of features from both a wastewater treatment facility and the solid waste facility. They are distinct facilities because of the physical and chemical properties of the dredged materials placed into them. For example, solid waste facilities are designed to receive solids with very little water. On the other hand, sediments subject to dredging typically contain 30 to 90 percent water (by weight).

In Wisconsin, a CDF would be regulated as a solid waste disposal facility under the WAC NR 500 regulations. The most significant implication of this determination is that the liner of the facility for Lower Fox River sediment would be far more substantial than might be the case for comparable facilities in other jurisdictions.

For purposes of this evaluation, it is assumed that the use of a CDF would only be applicable to the disposal of sediment generated from the dredging of OU3 and OU4. OU1 material would be managed in some other manner. It is assumed that dredge slurry would be transported via a forcemain to an upland site located within Brown County. Decant water from the facility would be treated and returned to the Lower Fox River under a WPDES permit.

7.2.2 Design Basis

The design for a CDF typically follows the procedures contained in USACE Engineer Manual 1110-2-5027 (USACE, 1987). These procedures allow for the calculation of minimum required surface area and required retention times to retain fine-grained dredged solids in the CDF. The procedures in the manual have been incorporated into a computer program named SETTLE for ease of calculations (Hayes and Schroeder, 1992). SETTLE was used to size a "pro-forma" facility for this project.

The calculations for sizing the CDF require data on the anticipated project or operational characteristics (e.g., volumes to be dredged, dredge sizes or slurry rate, and dredging times) and sediment characteristics (e.g., *in situ* densities, grain size distributions, and settling characteristics). Settling characteristics, in particular, are critical to the sizing calculations and typically should be based on laboratory Long Tube Settling Tests as described in the USACE Engineer Manual (USACE, 1987).

To date, only limited settling data is available for Lower Fox River sediments and this comes from the original design work on the SMU 56/57 demonstration project (Montgomery Watson, 1998.) These tests include compression and zone settling conducted in accordance with the USACE Engineer Manual (USACE, 1987). The sediment from SMU 56/57 generally contained a higher percentage of silt/clay, a higher *in situ* water content, and a higher organic content than is believed to be the case elsewhere in OU4. Higher silt/clay content and higher organic content generally result in slower settling rates and require more conservative CDF size estimates (i.e., larger).

The SMU 56/57 data were also compared to a range of settling test results for a number of fine-grained sediments tested by the USACE for purposes of field verification of the test procedures (Averett, Palermo, and Wade, 1988). This comparison indicates that the SMU 56/57 settling properties fall within the lower range of other fine-grained sediments tested, and therefore exhibit comparatively slow settling rates. Based on these considerations, the SMU 56/57 settling data are considered appropriately conservative, but not overly conservative, for purposes of establishing a design basis at this stage of this project.

Other assumptions, including regulatory requirements, are provided in Table 7-2.

Table 7-2 Design Basis for NR 500 Dewatering Landfill

Parameter	Value	Basis or Assumption
Total in-place sediment volume to be dredged	6,500,000 cy (4,400,000 tons)	This assumes 6,500,000 cy of in-place sediment from OU3 and OU4, at an average of 35% solids (by weight)
Bulk density of *in situ* sediment	OU3: 1.08 t/cy OU4: 1.05 t/cy	From RI/FS
Solids content of *in situ* sediment	OU3: 37.1% OU4: 33.8%	From RI/FS
Duration of filling	8 years to 10+ years	8 years corresponds to the length of dredging on OU3 and OU4 assumed in the FS and it reflects WDNR preference on total project duration. This DEA calculates a slightly longer duration based on revised dredging assumptions
Flow rate to the CDF	Up to 4,100 gpm	This is a representative dredge slurry rate, typically carrying 5% to 10% solids (by weight). (The sizing of the facility is not affected by the solids concentration alone). The basis for this dredge slurry rate is described in Section 10

Parameter	Value	Basis or Assumption
Air space provided	11,300,000 cy	This value includes 20% excess space above and beyond the minimum volume calculated for the settled solids, and allows for the potential addition of intermediate drainage layers between successive years of waste placement
Liner required?	Yes	Because the CDF will ultimately serve as a landfill, the WDNR would require that the CDF be lined in accordance with NR 500 requirements
Liner design	60-mil geomembrane overlaying 4 ft. of recompacted clay	Per NR 504 minimum requirements
Leachate collection	12-inch granular drainage layer and related piping components	Per NR 504.06 minimum requirements
Cover design	Grading/stabilization layer, 12" granular venting layer, geosynthetic clay liner, 40-mil geomembrane, 12-inch sand drainage layer, 18-inch rooting zone, 6-inch topsoil	Alternative NR 500 composite cover design suitable for low strength wastes
Final grades at closure	To be determined	An alternative to the NR 500 minimum of 5% will be needed due to the low strength of the waste in the fill
Infrastructure required	• Surface water controls • Paved access road • Leachate storage and loadout station • Maintenance building • Weight scale	These are standard features of land disposal facilities and would be incorporated into a final design

The design process results in the calculation of two parameters: the surface area required for zone settling (for a given incoming flow rate) and the storage volume required for the quantity of solids placed. The first calculation determines the surface area that must be ponded during filling operations so that dredge slurry can be clarified by zone settling processes prior to the "overflow" of the supernatant for further treatment and discharge. At the assumed dredge slurry rate of 4,100 gpm a minimum area of 4.3 acres is required.

The storage volume calculation considers the constraint of waste thickness (40 feet). It further assumes that actual placement occurs over an 8-month dredging season, and that settling will continue for a total of up to 12 months (i.e., until the next dredging season begins). To be conservative, two additional factors were not included in this preliminary analysis: compression settling of prior lifts and long-term consolidation. The SETTLE program calculated the annual storage requirement to be approximately 1.2 million cy. The total storage requirement for an 8-year project with 20 percent airspace added for possible drainage layers is 11.3 million cy. With a maximum fill thickness of 40 feet, this results in a "wetted" area of 176 acres.

Thus, of these two parameters, the area required for storage will determine the size of the facility. An overall facility plan and typical section is shown on Sheets 23 and 24 respectively of Supplement IV.

7.2.3 Follow-Up Information Needs and Tasks

The design concepts for the CDF have been developed based on available information. The information needed to complete a final design is described in Table 7-3.

Table 7-3 Information Needs for Design of NR 500 Dewatering Landfill

Tasks and Needs	Means for Completing
Site Selection	This will eventually be undertaken by the WDNR, its developer/contractor, or one of the RPs. The site will then dictate the landfill geometry, soils balance, etc.
Volume Determination	The estimate of the volume of sediment that will be managed as part of this project is subject to ongoing change as additional information is collected. At least one major "pre-design" sampling effort is anticipated, and this will allow better volume estimates to be completed. However, the final site design should allow for the addition and deletion of cells as needed.
Settling Data for Dredge Slurry	As described above, the sizing is based on settling data generated during the demonstration project at SMU 56/57. The corresponding samples for that project would only be representative of a very small portion of the river. Therefore, comparable testing on representative samples from other parts of the river should also be performed. This could be completed at any time.

7.2.4 Permits and Approvals

As described above, a CDF for treatment and disposal of dredge slurry would be regulated under the WAC NR 500 series of regulations. At the state level, the landfill siting and permitting process consists of a series of well-defined steps. An important milestone in this process is obtaining the WDNR's "feasibility determination" for a proposed facility. The feasibility determination gives an applicant the assurance that its "Feasibility Report" is acceptable and that the proposed landfill can be developed. The feasibility determination is followed by a "plan of operations" approval, landfill construction and documentation, and the issuance of a license to operate.

At the local level (i.e., county, city, township, or village), there is a parallel "local approvals" process. Prior to submittal of the Feasibility Report to the state, an applicant must apply for all local approvals. Affected local units of government may choose to enter into negotiations. If a local unit of government chooses not to negotiate, it waives its right to enforce local approvals. Otherwise, negotiations would usually cover such items as operational restrictions, nuisance and traffic control, site improvements and aesthetics, and financial matters, including host community compensation. If negotiations are unsuccessful, an arbitration process would be administered.

The combination of state licensing and local approvals results in a process that can take a minimum of 3 to 5 years to complete. Applicants should plan for a timeframe of at least 5 years.

7.3 NR 500 Monofill

This section describes the concepts for an NR 500 monofill or landfill that is dedicated to the disposal of dewatered sediment.

7.3.1 Process Description

This disposal option consists of the construction of a landfill dedicated to the disposal of dewatered sediment. As required by the WDNR, the location and design of the facility would be in accordance with WAC NR 504. NR 504 includes both siting criteria, and the minimum design requirements for a composite liner and a composite cover.

Disposal at a new monofill could be coupled with any number of dewatering options. Dewatering could take place in gravity settling basins (Section 6.3) or by a mechanical, fixed-base system (Section 6.2). These facilities could be located at a riverside location, at the monofill site, or at some other upland location.

7.3.2 Design Basis

The design of the monofill would be based on the quantitative and qualitative criteria provided in Table 7-4.

Table 7-4 Design Basis for NR 500 Monofill

Parameter	Value	Basis or Assumption
Total Waste Volume	If mechanically dewatered: Up to 3,400,000 cy (4,300,000 tons) (assuming no sand separation) If passively dewatered: 5,300,000 cy (5,800,000 tons)	The quantity for mechanical dewatering is based on a filter cake at 55% solids. The quantity for passive dewatering is based on sludge at 40% solids. In both cases, the quantity of in-place sediment is 6,500,000 cy (per the FS)
Total Airspace Provided	If mechanically dewatered: 4,100,000 cy If passively dewatered: 6,800,000 cy	These values represent a 20% to 30% increase over the estimated waste volumes, to allow for one or more of the following: 1. The addition of intermediate drainage layers, 2. Intermediate cover 3. Small increase in waste volume
Liner Design	60-mil geomembrane overlaying 4 feet compacted clay	Per NR 504.06 minimum requirements
Leachate Collection	12-inch granular drainage layer and related piping components	Per NR 504.06 minimum requirements
Cover Design	Grading/stabilization, 12" granular venting layer, geosynthetic clay liner, 40-mil geomembrane, 12-inch sand drainage layer, 18-inch rooting zone, 6-inch topsoil	Per NR 504.07 minimum requirements

Parameter	Value	Basis or Assumption
Final Grades	Not to exceed 6:1	This is the maximum grade specified in NR 504.09 for sludges Geotechnical testing and slope stability calculations have not yet been performed. For the disposal of mechanically-dewatered sediment, final waste grades of approximately 11:1 will be assumed. Passively-dewatered sediment, will have low strength, and an alternative to the NR 500 minimum of 5% will be required
Infrastructure Required	• Surface water controls • Paved access road • Leachate storage and loadout station • Maintenance building • Weight scale	These are standard features of land disposal facilities and would be incorporated into a final design.

These design concepts have been used to develop a representative monofill facility for each of the dewatering scenarios. Concepts are shown on Sheets 18 through 22, and described further in Section 10. These drawings are for illustrative purposes only. A detailed design can be developed once a site is selected and other project assumptions are refined.

7.3.3 Follow-Up Information Needs and Tasks

The design concepts for the monofill have been developed based on available information. The information needed to complete a final design is described in Table 7-5.

Table 7-5 Information Needs for Design of NR 500 Monofill

Tasks and Needs	Means for Completing
Site Selection	This will eventually be undertaken by the WDNR, its developer/contractor, or one of the RPs. The site will then dictate the final monofill geometry, soils balance, etc.
Volume Determination	The estimate of the volume of sediment that will be managed as part of this project is subject to ongoing change as additional information is collected. At least one major "pre-design" sampling effort is anticipated, and this will allow better volume estimates to be completed. However, the final site design should allow for the addition and deletion of cells as needed.
Geotechnical	This work could be performed at any time. It would be

Tasks and Needs	Means for Completing
Testing of Dewatered Sediment (Filter Cake)	reasonable to combine this work with sediment dewatering tests, so that a representative filter cake is generated and then tested for its strength properties. A number of samples should be collected and tested, representing the full range of grain size distributions that are likely to be encountered during this project. The results will then be used to make a final determination on the maximum waste grades that can be used.

7.3.4 Permits and Approvals

A landfill for the disposal of dewatered sediment would be regulated under the WAC NR 500 series of regulations. At the state level, the landfill siting and permitting process consists of a series of well-defined steps. An important milestone in this process is obtaining the WDNR's "feasibility determination" for a proposed facility. The feasibility determination gives an applicant the assurance that its "Feasibility Report" is acceptable and that the proposed landfill can be developed. The feasibility determination is followed by a "plan of operations" approval, landfill construction and documentation, and the issuance of a license to operate.

At the local level (i.e., county, city, township or village), there is a parallel "local approvals" process. Prior to submittal of the Feasibility Report to the state, an applicant must apply for all local approvals. Affected local units of government may choose to enter into negotiations. If a local unit of government chooses not to negotiate, it waives its right to enforce local approvals. Otherwise, negotiations would usually cover such items as operational restrictions, nuisance and traffic control, site improvements and aesthetics, and financial matters, including host community compensation. If negotiations are unsuccessful, an arbitration process would be administered.

The combination of state licensing and local approvals results in a process that can take a minimum of 3 to 5 years to complete. Applicants should plan for a timeframe of at least 5 years.

8 Riverside Land and Access Requirements

8.1 Expected Needs

At the TRT meeting in July 2002, logistical considerations for a range of potential remedies were discussed. Some of these logistics were originally identified in the FS; others have been identified based on further detailed evaluation of the remedial technologies and process options described in this report. For an economical implementation of any future remedial action, riverside land will be necessary. Depending on the remedy at each operable unit, one or more specific types of facilities will be needed, each with a corresponding land requirement. This range of uses is expected to include those described in Table 8-1.

Table 8-1 Summary of Riverside Land Requirements

Land Use	Description	Size and Attributes
Access and Storage Yard (ASY)	This is the minimum facility required, and would be needed as part of any number of possible remedies. For a long-term project involving significant amounts of heavy equipment and materials, it will not be practicable to rely on public access points to the river. A dedicated site (or sites) will be needed to provide a secure access point for launching dredges, barges, supply boats, etc. It will also be needed for staging/storing/fabricating equipment and materials such as dredge piping, aggregate for cap construction, etc. For OU1, depending on whether the abandoned Fox Valley & Western railroad bridge across LLBdM can be breached, two separate ASYs may be needed (one on each side of the bridge). Along the length of OU3 and OU4, multiple ASYs would be desirable to minimize travel time.	Minimum of 2 acres with at least 300 feet. of bulkhead frontage; up to 5 acres desirable; 10 feet draft desirable
Sediment Transfer Point (STP)	If mechanical dredging were implemented as part of a removal remedy, one option would be to offload sediment from barges into trucks (or railcars) for transport to an upland dewatering and/or disposal facility. This would require one or more transfer points on the river. If a sufficiently large parcel could be secured, such a transfer point could also serve as an ASY point. At OU3 and OU4, multiple STPs may be needed during the life of this project to reduce travel time.	Minimum of 5 acres, with at least 600 feet of bulkhead frontage; 10 feet draft desirable

Land Use	Description	Size and Attributes
Dewatering and Wastewater Treatment Plant (DWTP)	The selected remedy for OU1 includes the construction of a large mechanical dewatering and wastewater treatment plant. The operations at this location would also include a loadout facility for dewatered solids (to truck or rail). If an upland location is used, sediments would be transported through a slurry forcemain. Alternatively, the plant could be built on the river's edge to achieve cost and operating efficiency. Mechanical dewatering is also a process option for OU3 and OU4, but separate facilities serving OU1 and OU3 and OU4 would be required, due to the distances between these locations.	Minimum 10 acres; 15 to 20 acres desirable

8.2 Review of Possible Sites

As part of the DEA, RETEC has made limited review of possible sites along the Lower Fox River. Some of these sites have been verbally mentioned by stakeholders during the Lower Fox River work. Other sites have been newly identified.

The current effort only identified parcels of land that appear to be inactive or largely undeveloped. A limited review of plat maps and municipal records was made to establish a general understanding of the shape and limits of the parcels, but no attempt has yet been made to fully confirm the size or ownership of each property. Owners have not been contacted to determine if acquisition or leasing would even be possible. In addition, RETEC did not research zoning or other restrictions that would preclude the properties from being used or developed. This review is summarized in Table 8.2. The most promising properties are also identified on Sheets 02 and 03 of the plan set.

For work at OU1, this initial survey indicates that the Bergstrom fill site is the preferred candidate. Although there will be geotechnical considerations associated with construction of large facilities (slurry thickeners, clarifiers, a treatment building, etc.) on the site, its attributes, and the lack of other options, appear to outweigh this drawback. If the abandoned Fox Valley & Western railroad bridge can be breached (by removing one or more sections of the trestle), then additional access points to the north would not be needed, and all work could be conveniently centered at the Bergstrom fill site. However, if the Bergstrom fill site cannot be used, additional effort will be needed to identify private, industrial locations where sufficient, unused acreage might be available via a lease or purchase arrangement.

For OU3 and OU4, there appear to be several viable properties on the west side of the river, on the south side of the city of Green Bay, or in the Village of Ashwaubenon (i.e., the former Shell property, the former WPSC lot, and the former Lakeside Marina facility, respectively). Each of these has strong attributes and could serve multiple needs. Other industrial properties within the city of Green Bay, on the west side of the river and closer to downtown (such as the Leicht property or parcels in the vicinity of the Mason Street bridge), might be useful for short-term access or limited staging of materials or equipment. Properties on the east side of the river (Heritage Hill and the Brogan property) are only viable for short-term access or storage because of their locations and current land use.

8.3 Follow-Up Information Needs and Tasks

Final decisions on implementation of the remedies at each OU have not yet been made. To facilitate the continuing planning work, several additional tasks could be undertaken at this time or in the near future. These include the following:

- Confirm ownership on parcels of highest interest
- Confirm status of Fox Valley & Western bridge at LLBdM, and whether partial (or temporary) removal could be possible
- Determine local zoning or facilities siting requirements within the city of Green Bay, city of Neenah, and the Village of Ashwaubenon (at a minimum)
- Perform a limited geotechnical investigation at the Bergstrom fill site for the purpose of further evaluation of foundation requirements. At a minimum this would consist of standard hollow-stem borings, but could include shallow backhoe pits to assess the presence of large, bulk debris which would not otherwise be identified through borings alone

Table 8-2 Review of Riverside Properties for Possible Use as Part of Lower Fox River Remedial Actions

Property/Location	Description	Size	River Frontage and Attributes	Possible Uses	Observations
At OU1:					
Bergstrom fill site (Arrowhead) South side LLBdM City of Neenah	Open, undeveloped, fill site west of Minergy Plant. Bounded by Wisconsin Central railroad tracks and industrial/commercial properties. Existing rail spurs on south side.	Approx. 20 acres	1,000 feet of riprap bank	All	Excellent potential to serve any or all requirements for access and facilities needed at OU1. Because it is a fill site, structures would require more substantial foundations, but this is not limiting. Good location and access for truck or rail, while providing a degree of isolation from nearby community.
Frontage west of Corps locks, and north of the abandoned Fox Valley & Western railroad bridge East side of LLBdM City of Menasha	Low-lying area proposed by CH2M HILL, on behalf of Wisconsin Tissue Mills, as an in-water CDF.	Not determined	At least several hundred yards of unimproved bank or wetland	None	While adjacent to the water, this location has little available land. It is “locked in” by an active rail spur, residential lots and industry. Access is poor.
Commercial lots N. Lake Road City of Neenah	Inactive commercial property and parking lot, bounded on the east by Wisconsin Central tracks, which also bound Arrowhead Park. The neighborhood is largely industrial/commercial.	Approx. 2 to 3 acres	No direct access; can reach water by a nearby sluiceway	Storage yard only	Because there is no direct frontage, the use of this land would be limited to material or equipment storage. A sluiceway to LLBdM is located to the south, but would require crossing several residential lots.

Table 8-2 Review of Riverside Properties for Possible Use as Part of Lower Fox River Remedial Actions

Property/Location	Description	Size	River Frontage and Attributes	Possible Uses	Observations
Vacant lot Lock St. City of Menasha	Riverfront lot immediately east of Corps locks. Residences on two sides.	Approx. 2 to 3 acres	Several hundred feet	Access or storage	The local property owner has offered to lease this lot to support remedial work. It is accessible only by water or by passing through the side yards of adjacent residences.
Former agricultural land south of Highway 441 bridge West side of LLBdM Butte des Morts Beach Road Town of Menasha	Former farm, with an occupied house. The southern end of the site is being offered for sale as a series of 2-acre riverfront residential lots. It is at the fringe of residential development that extends north of Neenah.	Approx. 15 acres	Several hundred yards of low-lying, unimproved bank	Access or storage	The frontage is low-lying, and appears to be subject to occasional flooding. This location has also been identified as within or near the footprint of a future bridge. Because of this, as well as the advancing residential development to the south, this property may not be suitable for construction of longer-term facilities. For use as an access point, dredging and construction of a bulkhead would be needed.

Table 8-2 Review of Riverside Properties for Possible Use as Part of Lower Fox River Remedial Actions

Property/Location	Description	Size	River Frontage and Attributes	Possible Uses	Observations
At OU4:					
WDNR land at Heritage Hill State Park (each side of Highway 172 bridge) East side of river Village of Allouez	Green space, much of it with mature trees, situated between Riverside Drive (Highway 57) and the river. It is transected by the Lower Fox River State Recreational Trail. Part of the property north of the Highway 172 bridge is connected by a tunnel to Heritage Hill State Park. A small part of the property south of the bridge is used for storage.	Approx. 15 acres (combined, both sides of Highway 172 bridge)	At least 2,500 feet of unimproved bank	Access or storage	Facilities construction probably not implementable at this location due to sensitive nearby land use (Heritage Hill State Park, residential, etc.). It may be possible to use the land south of the Highway 172 bridge for materials staging. Dredging and bulkhead construction would be necessary.

Table 8-2 Review of Riverside Properties for Possible Use as Part of Lower Fox River Remedial Actions

Property/Location	Description	Size	River Frontage and Attributes	Possible Uses	Observations
Brogan property East side of river City of Green Bay	Narrow strip of green space (grass and brush cover), between Adams Street and the river. It is over 2 city blocks long, and is transected by the bike trail. It is bounded on the south by the former Wisconsin Central bridge (now abandoned). Local land use is residential.	Approx. 3 to 4 acres	At least 1,000 feet of unimproved bank	Access or storage	Because of its location and size, this property is probably only suitable for access or storage. Since it is currently used essentially as parkland, a short-term use only may be appropriate. For example, since it is a long, narrow parcel, it may be suitable for the initial laydown and fabrication of in-water dredge piping at the time of project startup.
Leicht Material Handling – North Dock West side of river, north of Main Street bridge City of Green Bay	Commercial property, now partly used for warehousing. Bounded on west by Fox Valley & Western tracks, on the north by St. Mary's Cement Co., and on the south by a small parcel of green space now owned by the city.	Approx. 10 to 12 acres	Approx. 1,200 feet of bulkhead	Access or storage	This property has very good attributes for development, but is at a somewhat sensitive location at the gateway to downtown Green Bay. For this reason, potential uses may be limited to access and storage. It may have potential for use as a limited-term sediment transfer point (STP), but this would require the routing of truck traffic to a busy downtown street unless an arrangement could be made with St. Mary's Cement Co. to route truck traffic through their property to the north.

Table 8-2 Review of Riverside Properties for Possible Use as Part of Lower Fox River Remedial Actions

Property/Location	Description	Size	River Frontage and Attributes	Possible Uses	Observations
Former industrial land North side of Mason Street bridge West side of river City of Green Bay	Open, former industrial space, bounded on the west by Fox Valley & Western tracks. Contains a boat slip in good condition. One of the owners may be the coal company located immediately to the south, but the acreage may actually be comprised of several individual, contiguous properties/owners.	Approx. 10 acres (not including the boat slip)	Approx. 800 feet of bulkhead on the river (plus the boat slip)	All, except for vitrification plant	The boat slip is an excellent attribute. Good access to Broadway, which is a major commercial route. Potential for rail access. Community garden is adjacent to the west. Additional note: There has been a suggestion that the city of Green Bay is trying to eliminate bulk freight operations on the waterfront between the Mason Street and Main Street bridges to facilitate redevelopment. This property is located just within this zone. However, since the remediation project would be of limited duration, the issue may not be a limiting one. Further discussion with the city would be warranted.
Former Shell property (Georgia Pacific)	Former industrial land used during the SMU 56/57 demonstration project.	Approx. 20 to 25 acres	Approx. 600 feet	All	This property is sufficiently large that it could accommodate all required uses. Local land use is industrial, and accessible to truck traffic. Rail connections are possible.

Table 8-2 Review of Riverside Properties for Possible Use as Part of Lower Fox River Remedial Actions

Property/Location	Description	Size	River Frontage and Attributes	Possible Uses	Observations
Former Wisconsin Public Service property Highway H (Broadway), south of Brown County solid waste facility West side of river Village of Ashwaubenon	Former industrial land, now owned by the Village of Ashwaubenon.	Approx. 20 acres	At least 700 or 800 feet (unable to observe directly)	All	This property is sufficiently large enough to accommodate all required uses. Local land use is industrial, and accessible to truck traffic. Does not appear to have direct proximity to rail spur.
Former Lakeside Marina and adjacent parcels Highway H, North of Highway 172 bridge West side of river Village of Ashwaubenon	Former marina, now owned by the Village of Ashwaubenon. Large commercial structure on site, with improved slip and docks. Additional unused land (partly wooded) immediately to the north.	Approx. 11 acres, with at least 10 additional acres to the north	At least several hundred feet, not including slip	All (if combined with adjacent parcel)	Because of the existing improvements at this former marina, the property would be well suited as an access and staging point. Surrounding land use is industrial, with good access for trucks. Rail is not in immediate vicinity. If combined with the adjacent property, the marina would be sufficiently large enough to accommodate all potential facilities.
Ashwaubomay Park Highway H (Broadway) Village of Ashwaubenon	Local community park, with ball fields and a swimming center	Approx. 75 acres	Over 1,000 feet, plus inlet	Access or limited storage only	This is a large, well-situated property, but because it is a park, it probably could be used only for non-intrusive, short-term access or staging/storage of materials.
Brown County Fairgrounds Fort Howard Avenue (Broadway) City of De Pere	Country fairgrounds and recreation area	Over 40 acres	Over 1,000 feet	Access or limited storage only	Because of current land use, this location probably could be used only for non-intrusive, short-term access or staging/storage of materials.

9 Specifications

It is expected that the construction scope of work for the Lower Fox River project will consist of a combination of descriptive and performance-based specifications. These will be produced at the completion of the detailed design process, in coordination with a set of construction-level drawings.

Construction specifications and drawings would be issued as part of a comprehensive set of construction bidding documents. This set of documents would also include contractual terms and conditions, a contractual form of agreement, bonding requirements, and a standardized bid form. For each of these components, the State of Wisconsin has standard templates that would be adapted to this project, if the state proceeds as the Owner of the project

The specifications, on the other hand, are generally prepared in an industry-standard format, from the consulting engineer's in-house library of standards and masters. The sequence and numbering of specifications generally follows the recommended practices of the Construction Specifications Institute.

The TRT and the state have indicated a preference for the use of performance-based specifications where appropriate. They have also indicated the desirability of integrating the dredging, dewatering, and wastewater treatment elements of the work into a single scope of supply. This approach is intended to encourage bidding contractors to bring ingenuity and potential cost-saving approaches forward. The approach would also be consistent with a design-build project delivery system, if the state decides to move in that direction.

Designing an integrated, performance-based project, however, does not mean that significant details will be absent from the specifications. For environmental reasons and to indicate the overall level of quality expected, even a performance-based specification will contain a number of specific requirements, and may have components that are highly descriptive.

A list of the specifications that are likely to be needed on the Lower Fox River project is contained in Table 9-1. This list includes all of the specification sections relevant to any of the individual technologies, processes or facilities that are likely to comprise the final remedy. As a placeholder, the so-called Division 0 documents (that are not actually specifications) are also listed so that their relationship to the specifications themselves is clear.

Of the sections on this global list, many are sufficiently generic that the engineer's existing standards and masters will not require significant adaptation. On the other hand, some sections will require a substantial amount of customization.

Two sections that will be highly customized to this project include those for measurement and payment (Section 01025) and dredging (Section 02482). Notwithstanding the fact that final specifications will require the resolution of a number of regulatory, contracting and technical issues, an attempt has been made to draft language that would be typical of these two sections. Typical specification are contained in Appendix D. These typical sections indicate the level of detail that should be expected in the final documents.

For other major components of the work, the expected scope of the sections (but not an actual mockup of the specification) are contained in Tables 9-2 through 9-4. Again while, while many details have yet to be established, these tables indicate the type of information that should be provided in the final specifications to convey the required scope and quality of the project.

Table 9-1 Master List of Specifications

Division and Section Number	Title	General Scope and Applicability
Division 0 – Bidding Requirements, Contract Forms and Conditions of Contract		
These documents would ordinarily follow the standard CSI numbering sequence. EJCDC contract documents could be used. However, because this work is assumed to be proceeding as a state project, Wisconsin Department of Administration documents would most likely be used. Discussion is needed with WDNR to determine which documents and supporting materials will be required.		
Division 1 – General Requirements		
01010	Summary of Work	Short description of each of the major elements of the work, for each construction contract. The descriptions could also parallel the listing of pay items, depending on the specific contract and the State's preference (for unit price versus lump work, for example.)
01025	Measurement & Payment	Description of bid items and requirements for measurement and payment.
01060	Regulatory Requirements	Regulatory requirements and permit needs (by Contractor or by others). A description of health & safety requirements would also be included.
01200	Project Meetings	List of meetings required, parties attending and frequency (where progress meetings are on-going.)
01300	Submittals	Procedures for submittal and approval of contractor- or vendor-supplied drawings or other technical information. Includes schedules and Contractor Health & Safety Plan. For a design-build project, would include scope of required Contractor design, and Owner's procedures for review. (Note: This Section primarily discusses procedural items. A detailed list of specific technical items required is generally contained within each Specification Section of Divisions 2 through 16.
01500	Construction Facilities and Temporary Controls	Requirements for site controls (fencing, security, etc.), offices, support facilities, etc.
01650	Starting of Systems	Procedures for the starting, testing and proving of mechanical systems and related instrumentation, prior to full-scale operation. Could include the dredge slurry conveyance system, wastewater treatment system, etc.
01700	Contract Closeout	Substantial completion, final inspections and closeout procedures for each construction contract.
Division 2 – Site Work		

Table 9-1 Master List of Specifications

Division and Section Number	Title	General Scope and Applicability
02100	Site Preparation	Preparatory work that might be needed at each site or location where construction will be occurring. Could include clearing of vegetation, removal of old structures, construction of access roads, bringing in utility services, etc.
02220	Excavating, Trenching, Backfilling & Compacting	Earthwork requirements applicable to excavation of liners or other land-based facilities. Trenching of utilities or wastewater discharge piping. Backfilling of utility trenches. Compacting of fill soils.
02230	Fill	Material specifications for general fill, structural fill, aggregate base course material, sand drainage layer material and clay.
02270	Silt Fence	Requirements for silt fencing around temporary construction and disturbed areas.
02280	Materials Handling	Broad-based, performance-based specification to cover miscellaneous handling operations for dredge solids, dewatered filter cake, etc. Include conveyance, stockpile and loading operations.
02482	Dredging	This would be a detailed performance-based specification covering the extent of dredging, materials handling requirements, progress testing and post-dredge confirmation testing.
02500	Asphaltic Pavement	For yard at treatment plant, access road to monofill, etc.
02701	HDPE Geomembrane	Materials, placement, and testing of the geomembrane liner at a monofill or CDF.
02702	LLDPE Geomembrane	Materials, placement, and testing of the geomembrane cover at a monofill or CDF.
02703	Geotextile	Materials, placement, and testing of geotextiles used in liners or covers at a monofill or CDF.
02704	Geosynthetic Clay Liner (GCL)	Materials, placement, and testing of a GCL, if used as part of a composite cover at a monofill or CDF.
02705	Geosynthetic Drainage Layer (GDL)	Materials, placement, and testing of a GDL, if used as part of a gradient control layer or intermediate drainage layer at a monofill.
02970	Topsoil	Materials and placement requirements for topsoil on landfill or CDF cover.
02975	Seed, Fertilize, Mulch	Materials for vegetative cover on landfill or CDF.
Division 3 – Concrete		
03300	Concrete Work	For materials, formwork, reinforcing steel, placement and finishing of floor slabs and tank foundations.
Division 10 – Specialties		

Table 9-1 Master List of Specifications

Division and Section Number	Title	General Scope and Applicability
10880	Truck Scale	For installation at a materials handling facility or monofill. Will be required to monitor production and disposal rates.
Division 11 – Equipment		
11210	Leachate Pumps	Pump specification for long-term leachate recovery at a monofill or CDF. Include pump, motor and controls
112xx	Leachate Collection & Handling	Include leachate accumulation tank, transfer facilities, instrumentation and controls.
11330	Solids Separation System	Performance-based requirements for separation of the sand fraction from a dredge slurry. Include expected flowrate, instrumentation, materials handling and measurement provisions.
11332	Thickening System	Performance-based requirements for the mechanical thickening of a dredge slurry prior to dewatering. This part of the overall system would be viewed as an equipment package, including pumps, collection tanks and instrumentation. Specify the range of flowrates required and underflow solids concentration required.
11360	Dewatering System	Performance-based requirements for dewatering equipment. May allow for either filter presses or belt presses (or other device), depending on whether future testing determines a preferred method. Include ancillary tanks and pumps.
11364	Wastewater Treatment System	Combination of descriptive and performance requirements. Per expected WPDES permit, the system must consist of, at a minimum, sand filtration and GAC. Beyond that, the specification can be largely performance based, including flowrate and solids removal requirements.
Division 13 – Special Construction		
13121	Pre-Engineered Building	To house parts of the dewatering and wastewater treatment systems. Pre-engineered, metal buildings with utilities.
Division 15 – Mechanical		
15450	Process Piping	Materials, installation and testing of slurry piping and interior wastewater piping.
15470	Process Instrumentation	Minimum instrumentation required (flow, pressure, temperature) to effectively monitor the dewatering and wastewater treatment processes.

Table 9-1 Master List of Specifications

Division and Section Number	Title	General Scope and Applicability
15999	Process Control	Minimum automation and controls requirements, including local and remote PC-based interfaces, as required.
Division 16 – Electrical		
16050	Basic Electrical Materials and Methods	Basic standards applicable to wiring and electrical systems. Would apply to such facilities as the wastewater treatment plant, landfill maintenance building, etc.
16400	Service and Distribution	Covers power supply to buildings and other facilities.
16500	Lighting	Lighting requirements for the wastewater treatment plant and other facilities.
16850	Electric Resistance Heating	Heaters sufficient to maintain nominal 40 deg in buildings during winter idle months.

Table 9-2 Scope and Typical Content for Hydraulic Transport (Slurry Forcemain) Specification

Category	Item
Piping Materials	• Carbon steel piping system (pipe, joints, fittings) • High-density polyethylene (HDPE) piping system (pipe, joints, fittings) • Testing requirements
Valves	• Type and materials
Pumps	• Pump/motor materials and general requirements • Startup and testing requirements • Requirements for pump stations
Instrumentation and Controls Requirements	• Minimum points at which flow, pressure and temperature shall be measured • For each instrument, whether indicator is local or remote • Points at which continuous logging of data shall be provided • Requirements for remote monitoring of the process (telemetry) (such as at Resident Engineers on-site office, at WDNR's Green Bay or Madison offices, etc.)
Forcemain Route	• Installation requirements • Boring and jacking requirements • Inspection and inspection reporting requirements • Restoration requirements
Submittals Required (for example)	• Sizing calculations for piping system and pumps • Piping and instrumentation diagram • Route plan and sections • Piping details • Catalog cut sheets for pumps and instrumentation

Table 9-3 Scope and Typical Content for Mechanical Dewatering Specification

Category	Item
Dewatering Production	• Required filter cake characteristics (% solids and unconfined compressive strength; possibly paint filter testing) • Frequency of contractor-performed filter cake testing (for purposes of confirming contract compliance)
Dewatering Performance	• Location of intermediate sampling points and frequency of other sampling and analysis at points other than the final dewatered cake. These would be contractor-performed, but would not necessarily be for confirmation of filter cake properties. Instead they would be for Owner's evaluation of ongoing system performance, the early identification of problems, and confirmation of overall solids balance. At a minimum, these could include the thickener supernatant and press filtrate solids concentration and flow rates, for example.
Process Requirements	• Minimum operations required (i.e., coarse fraction separation, equalization/thickening, dewatering, supernatant and filtrate handling) • Capacity of equipment required (e.g., any minimum tank volumes, overflow rates, or other parameters believed to be necessary to provide a reasonable level of performance) • Redundancy of equipment required, if any (e.g. excess filter press capacity of, say, x% to allow for ongoing operations during routine maintenance or downtime of individual units) • Coarse solids and filter cake conveyance requirements (to staging and loadout area, for example) • List of spare parts and backup equipment required (e.g., spare pumps, motors, flow elements, pH meters, etc.), tank materials, and general requirements • Pump/motor materials and general requirements • Piping materials and standards • Startup and testing requirements
Instrumentation and Controls Requirements	• Local or remote • Points at which continuous logging of data shall be provided • Control panel materials and general requirements (e.g., NEMA enclosures, indicator lights, or panel-vue displays, etc.) • Requirements for remote monitoring of the process (telemetry) (such as at Resident Engineer's on-site office, at WDNR's Green Bay or Madison offices, etc.)
Submittals Required (for example)	• Contractor's final Process Flow Diagram • Sizing calculations for major process equipment • Piping and instrumentation diagram • General arrangement drawing • Mechanical/piping plan and sections • Catalog cut sheets for major equipment, pumps, mixers, and instrumentation • Controls narrative (sequence of operations) • Controls logic (ladder diagram)

Table 9-4 Scope and Typical Content for Wastewater Treatment Specification

Category	Item
Process Requirements	• Minimum processes required (i.e., granular media filtration and GAC) • Redundancy of equipment required (e.g., parallel GAC filters to allow for uninterrupted operation during carbon change outs, lead-lag service, etc.) • List of spare parts and backup equipment required (e.g., spare pumps, motors, flow elements, pH meters, etc.) • Tank materials and general requirements • Pump/motor materials and general requirements • Piping materials and standards • Startup and testing requirements
Instrumentation and Controls Requirements	• Minimum points at which flow, pressure, and temperature shall be measured • For each instrument, whether indicator is local or remote • Points at which continuous logging of data shall be provided • Control panel materials and general requirements (e.g., NEMA enclosures, indicator lights or panel-vue displays, etc. • Requirements for remote monitoring of the process (telemetry) (such as at Resident Engineer's on-site office, at WDNR's Green Bay or Madison offices, etc.)
Submittals Required (for example)	• Contractor's final Process Flow Diagram • Sizing calculations for major process equipment • Piping and instrumentation diagram • General arrangement drawing • Piping plan and sections • Catalog cut sheets for major equipment, pumps and instrumentation • Controls narrative (sequence of operations) • Controls logic (ladder diagram)

10 Evaluation of Process Option Substitutions

In the FS, a series of remedial alternatives were assembled and evaluated. In this DEA, remedial technologies and representative processes were developed in greater engineering detail for the options that comprised one or more alternatives in the FS. This section describes the effects of substituting one or more specific process options for the representative ones described in the FS and Proposed Plan. Estimates of sediment quantities are from the FS.

10.1 Baseline Alternative for OU1 – Hydraulic Dredging, Mechanical Dewatering and Disposal at an NR500 Monofill

This section describes the concepts for implementing the Proposed Plan/ROD remedy for OU1. The details of the individual technologies for removal, material transport, dewatering, and wastewater treatment and disposal that were described in Sections 4, 5, 6 and 7, respectively.

10.1.1 Removal and Hydraulic Transport

As described in Sections 4 and 5, the design of the removal and hydraulic transport processes are inseparable. The design will depend on the distance of the slurry processing facility from the dredging operation. For work in OU1, it is assumed that the facility would be constructed at the Bergstrom fill. This results in a maximum 5-mile conveyance distance from the downstream extent of dredging. The area around OU1 is highly developed and an overland forcemain route is believed to be impractical. A floating pipe is assumed. The lift from the river stage to the discharge point in the dewatering plant is assumed to be 30 ft. Based on these conditions and assumptions, the calculation of dredge production and sizing is summarized in Table 10-1.

Table 10-1 Process Assumptions for Baseline Alternative OU1

Parameter	Value for OU1
In-place volume removed	784,000 cy
Solids specific gravity	2.51
In-place solids content, by weight	24.2%
Dredge size	10 inches
Conveyance distance, maximum	5 miles

Parameter	Value for OU1
Number of booster pumps	Maximum of 1
Slurry flowrate, per dredge	2100 gpm
Number of dredges	1
Total slurry flowrate	2100 gpm
% solids at this flowrate	8%
Average hourly production (i.e., volume sediment removed)	186 cy/hr
Effective dredge time	10.8 hr/day (90% of allowable 12 hr/day)
Total average daily production	1922 cy/day
Dredging season	175 days (5 days/wk for 8 months)
Time to complete	2.3 years

Calculations indicate that a 10-inch dredge and accompanying forcemain, with a maximum of 1 booster pump, could deliver 2100 gpm of an 8 percent slurry over the required 5 miles. The 8 percent slurry represents a typical, long-term average solids concentration for a hydraulic dredging operation, and it is used for calculating the average flux of solids, and hence the actual production rate that can be accomplished over the long-term. This is different than the capacity of the system, which is higher. For example, the instantaneous solids concentration in the slurry will routinely vary with the movement of the cutterhead through the sediment. While the average value of 8 percent is used for production calculations, the dredge will produce higher and lower slurry densities during its normal operation. The transport system described above would accommodate such peaks of slurry solids without exceeding pressure limitations.

Assuming a dredging season of 8 months (35 weeks), this work could be competed in less time than was first estimated in the FS (2.3 yrs versus 5.7 yrs). The work could be completed in less than 2 years if a longer workday and/or longer workweek schedule was allowable. However, with the current criteria, a duration of 2 to 3 full dredging seasons should be anticipated.

The greatest uncertainty associated with the dredging scenario, however, is the accuracy of the assumptions for the percent solids of the in-place sediment. The best estimate developed in the RI/FS is 24.8 percent. In comparison to other projects this value is quite low. The percent solids has substantial implications not only for final sizing of the dredging and hydraulic transport equipment, but also for the cost of disposing the filter cake solids. Confirming the percent solids estimate will be a primary goal of the pre-design sampling effort anticipated for 2003.

10.1.2 Dewatering and Wastewater Treatment

The concepts for a pro-forma dewatering and wastewater treatment plant were discussed in Section 6.2 and 6.4, respectively. The size of the facilities needed to accommodate the OU1 dredging will depend on the dredge slurry rate and the range of solids concentrations (weight basis) in that slurry.

The calculations described above suggest that a dredge slurry rate of 2100 gpm would provide acceptable performance. The FS estimated a rate of 2464 gpm which was based on slightly different hydraulic and operating assumptions. The flowrate from the actual system, which is likely to fall within this range, represents the influent flowrate for the dewatering and wastewater treatment plant.

Similarly, for purposes of calculating a mass balance and solids loading, a long-term average dredge slurry solids concentration of 8 percent is assumed. Using this value, the 2100 gpm flowrate, and various other assumptions for sediment physical parameters derived from the RI, a summary of filter cake production and other process metrics was developed (Appendix E).

It is assumed that the dewatering and wastewater treatment plant would be constructed on the Bergstrom fill site in Neenah (although this has not been confirmed). Because filling of the lake created this property, the bearing capacity of the existing ground surface is limited. To compensate for comparatively poor subsurface conditions, the adjacent Minergy facility, for example, is constructed on piles that extend 60 ft. or deeper. Even so, settlement has been an issue, requiring periodic repairs. The OU1 project is only expected to last for a period of several years, but stability will still be an important consideration. It may be necessary to design a foundation system similar to the one used at Minergy for some of the larger tanks, equipment and storage pads for the OU1 plant. The use of deep piles will increase the cost of the foundation work for the facility, but the positive attributes of the Bergstrom site still outweigh this drawback.

10.1.3 Transportation and Disposal

Filter cake would be loaded out using a facility comparable to that indicated on Sheet 12 of the plan set in Supplement IV. Concepts for the loading and truck transport of material were described in Sections 6.5 and 5.3, respectively. Although a disposal location has not yet been identified, it is assumed that it would be located somewhere in Winnebago County within a reasonable, one-way haul distance of a ½ hour or less. Based on the expected rate of filter cake generation, and a 5-1/2 day/week loadout schedule, a truck would depart the dewatering plant every 15 or 20 minutes. With the plant located at the Bergstrom fill site, trucks could use existing commercial routes out of the Neenah/Menasha area without causing disruption.

10.2 Baseline Alternative for OU3 and OU4 – Hydraulic Dredging, Passive Dewatering at an Upland Facility and Disposal at an NR500 Monofill

This section describes the concepts for implementing the Proposed Plan remedy for OU3 and OU4. The Proposed Plan remedy for OU3 and OU4 is summarized in Section 1.4. The details of the individual technologies for removal, transport, dewatering and disposal were described in Sections 4, 5, 6 and 7, respectively. The baseline alternative serves as the point of departure for considering the substitution of process options, which are described later in this report.

10.2.1 Removal and Hydraulic Transport

As with OU1, the design of the dredging and hydraulic transport processes depends on the siting of the dewatering facility. This section assumes that a facility would be sited in southern Brown County, with a maximum conveyance distance of 18 miles, when the dredge is located at the mouth of the river at Green Bay. The ground elevation at that property is assumed to be 680 ft., and the berm height elevation for a dewatering landfill would be approximately 710 ft. This would result in a maximum lift from the river stage (elevation 577 ft.) in OU4 of at least 133 ft.

As described in Section 5.2.2 and indicated on Sheet 03 of the plan set in Supplement IV, a possible route for the slurry forcemain would make use of a section of the Fox River Bike Trail. The pipe would remain in-water to a point south of the De Pere Dam before transitioning to an overland route. An accessible take-out point may be at a ravine west of Old Martin Road, or at a similarly undeveloped location on the east side of the river.

The concepts developed during the FS included the use of multiple dredges for the OU4 portion of the dredging. The dredges would pump to an intermediate receiving basin, located between the dredge and the upland dewatering/disposal location. A separate dredge would then forward the material to the dewatering/disposal location using a single overland forcemain. The remedy outlined in the Proposed Plan did not include the use of such a facility, however, and it now appears that it may be just as appropriate to pump directly to the upland location using parallel lines. If the upland dewatering facility was located in southern Brown County, and considering potential takeout points from the River along OU3, an intermediate basin would be positioned less than 10 miles from the ultimate discharge point. The capital cost of constructing the basin and the operating cost of maintaining another dredge at this location would likely not offset the cost of simply constructing a parallel forcemain for this distance.

Alternatively, a large holding tank with several million gallons capacity could be constructed. It is likely that the tank and forwarding pump would have lower capital and operating costs than a land-based system. The comparison of this option, versus parallel forcemains for the entire distance to the dewatering facility, can be made at the point of final engineering.

Because of the concerns over resuspension, this scenario limits the dredge size to 12 inches. The total dredge slurry flowrate would be maintained at approximately 4100 gpm, which is comparable to the rate used in the FS for initial evaluation purposes. To accommodate the longest conveyance distance in OU4, up to 5 booster pumps would be used along the forcemain. Potential locations include the following:

- In-water, near the former Shell property
- In-water or on the bank, at the De Pere dam
- In-water or on the bank on the east side of the River, at an undeveloped ravine west of Old Martin Road
- Along bike trail, near Eiler Road
- Along bike trail, near Duester Road

These locations are tentative and are subject to change as the engineering and design work proceeds. They have not been optimized from a hydraulic standpoint, and only represent an attempt to maintain a roughly equivalent spacing between pumps. Specific locations would be subject to land use considerations, access and availability of electrical service along the route.

Pumping of dredge slurry from the mouth of the river in OU4 would require that all 5 booster pumps be used. When the dredging in OU4 moves upriver of Mile 3 or 4, the total conveyance distance would be sufficiently reduced that the system could operate with 4 pumps. This would increase the dredge effective time and the corresponding daily production rate.

To accommodate the longest conveyance distance in OU3, up to 3 booster pumps would be needed. If the work in OU3 was done after the work in OU4, the system should be designed so that the pumps and overland route constructed for the OU4 work could be used for the OU3 work. This would avoid the capital cost of new or re-located pump stations.

A summary of this removal and transport scenario for OU3 and OU4, and the resulting typical dredge production, is presented in Table 10-2.

Table 10-2 Process Assumptions for Baseline Alternative at OU3 and OU4 (12" Dredge)

Parameter	Value for OU3	Value for OU4
In-place volume removed	587,000 cy	5,880,000 cy
Solids specific gravity	2.47	2.36
In-place solids content, by weight	37.1%	33.8%
Dredge size	12"	12"
Conveyance distance, maximum	10.5 miles	18 miles
Number of booster pumps	3	4 or 5, depending on location of dredge
Slurry flowrate, per dredge	3100	2050 gpm
Number of dredges	1	2
Total slurry flowrate	3100	4100 gpm
Percent solids at this flowrate	8.3%	8.3%
Average hourly production (i.e., volume sediment removed)	195 cy/hr	254 cy/hr
Effective dredge time	11.7 hr/d	10.5 hr/day when 4 pumps used; 9.4 hr/day when 5 pumps used (for 7 days/week)
Total average daily production	2280 cy/day	2380 cy/day when 5 pumps used; 2680 cy/day when 4 pumps used
Dredging season	245 days (8 months / 35 weeks)	245 days (8 months / 35 weeks)
Time to complete	1.0 yr	9.3 yr

As the summary table indicates, two 12-inch dredges and accompanying forcemains, each equipped with 5 booster pumps, would have the combined hydraulic capacity to deliver 4100 gpm of an 8 percent slurry over a distance of 18 miles. The 8 percent solids concentration represents a long-tem average, and is the value used for computing production rates only. The system will have the capacity to convey a denser slurry as needed.

The schedule for completing OU3 and OU4 in series is slightly longer than the original estimate in the FS (10.3 years versus 7.5 years). This is primarily due to the updated assumptions concerning dredge effective time. As described in Section 4.1, a recommended dredge effective time for a hydraulic dredge on an environmental project of this type would be no higher than 16 hr/day (67 percent) when no booster pumps are on-line. Adding pumps, the current estimates of 9.4 to 11.7 hr/day (depending on pumping configuration) represent an on-line factor on the order of 40 to 50 percent. For planning purposes at this stage of the project, this is believed to be an appropriate and not overly conservative assumption.

Alternatively, the dredge and forcemain size could be increased to 14 inches without compromising the resuspension concerns. This alternative would use a single dredge and forcemain, resulting in reduced capital and operation costs. With a 14-inch dredge and forcemain, the following performance, as presented in Table 10-3, could be achieved:

Table 10-3 Process Assumptions for Baseline Alternative at OU3 and OU4 (14" Dredge)

Parameter	Value for OU3	Value for OU4
In-place volume removed	587,000 cy	5,880,000 cy
Solids specific gravity	2.47	2.36
In-place solids content, by weight	37.1%	33.8%
Dredge size	14"	14"
Conveyance distance, maximum	10.5 miles	18 miles
Number of booster pumps	3	3 or 4, depending on location of dredge
Slurry flowrate, per dredge	4040 gpm	4190 gpm
Number of dredges, required	1	1
Total slurry flowrate	4040	4190 gpm
Percent solids at this flowrate	8.5%	8.5%
Average hourly production (i.e. volume sediment removed)	258 cy/hr	267 cy/hr
Effective dredge time	11.7 hr/d	10.5 hr/d when 4 pumps used; 11.7 hr/d when 3 pumps used (for 7 days/week)
Total average daily production (i.e., volume of in-place sediment removed, at total slurry flowrate and average %	3020 cy/d	2800 cy/d when 4 pumps used; 3125 cy/d when 3 pumps used

Parameter	Value for OU3	Value for OU4
solids)		
Dredging season	245 days (8 months / 35 weeks)	245 days (8 months / 35 weeks)
Time to complete	0.8	8 yr

Under this scenario, the total time to complete the dredging at OU3 and OU4 would be approximately 8 years, which is consistent with the timeframe present in the FS and Proposed Plan.

10.2.2 Dewatering and Wastewater Treatment

The slurry generated from the removal operation would be dewatered in a series of basins. The removal and hydraulic transport scenarios described above, using dual 12-inch dredges or a single 14-inch dredge indicate that the dewatering and wastewater treatment design should accommodate a slurry flowrate of approximately 3100 to 4100 gpm.

A process description and design basis for a typical settling basin arrangement was described in Section 6.3. The prototype facility indicated on Sheets 16 and 17 of the plan set illustrates the concepts for this baseline alternative. An evaluation of the siting of this facility, in combination with the monofill that is needed for disposal of the dewatered sediment, is discussed in Section 10.2.3.

The decant water removed from the basins would be treated in a co-located wastewater treatment plant. A typical plant configuration was described in Section 6.4, and this kind of facility would be appropriate for this alternative.

The overflow rate from the basins that requires treatment will be lower than the dredge slurry influent, because some water will be retained with the solids in the basin. Mass balance calculations indicate that at a slurry influent rate of 4100 gpm (for work in OU4), the overflow rate from the basins would be approximately 3100 gpm. When the influent rate is lower, the overflow rate will be lower. However, at this stage, the 3100 gpm value is used to calculate the size of the downstream wastewater equipment. A mass balance summary is contained in Appendix E.

A PFD for wastewater treatment is presented on Sheet 10 of the plan set. This PFD assumes that the influent would be comprised of supernatant and filtrate from a mechanical dewatering plant, which may be clarified in one or two separate units (depending on subsequent process decisions). For the baseline alternative for OU3 and OU4, the only influent stream is from the overflow of the basins and this would be treated in a single clarifier. The underflow solids from the clarifier would be returned to the settling basin.

If this facility were located on a rural Brown County site, an effluent discharge line would be constructed back to the Lower Fox River. Because of the distances and elevation changes, this would be a pressure line, rather than a gravity line, possibly requiring one or more lift stations along the route. The facilities would involve conventional technology, resembling other wastewater discharge systems.

To date, it has been assumed that the treated effluent would be discharged back to the Lower Fox River, and discussions concerning possible WPDES limits have been based on using the Lower Fox River s the receiving stream. However, the Holland property is located adjacent to the East River and its tributaries, which could provide a more convenient discharge point. Several miles of below-grade piping could be avoided if the East River were found to be an acceptable receiving stream. This would result in a capital cost savings of up to several hundred thousand dollars, as well as fewer logistical and access issues associated with negotiating easements for construction of a line back to the Lower Fox River.

10.2.3 Transport and Disposal

The baseline alternative assumes that dewatered sediment is removed from the basins and disposed of in an adjacent or nearby monofill. The dewatered sediment could be transported using a conveying system if the two facilities were sufficiently close, or by trucks if needed.

The monofill suitable for this alternative was described in Section 7.3 and is indicated on Sheets 18 and 19 of Supplement IV. The design basis for this facility indicates that the waste limits would be approximately 112 acres, and the total land requirement would be approximately 200 acres.

The Brown County land holdings in the Town of Holland have been identified as a potential site for the construction of the settling basins, wastewater treatment plant and monofill. The properties straddle Lamers & Clancey Road. The northernmost property, known as the Stock site, has been permitted under state rules for the construction of a municipal solid waste landfill. A footprint within the property limits was identified by the County for a possible “wet process residuals monofill”. It was anticipated that this facility might receive such material as paper mill sludge or river sediment. In terms of permitting, this footprint has received a feasibility determination, but the plan of operation has not been submitted.

The monofill originally anticipated by the County for the Stock site has a designated waste limit of approximately 38 acres, with a corresponding available airspace of approximately 3,700,000 cy. Thus, even if it were made available wholly for the Lower Fox River project, it would be insufficient to accommodate the full volume of sediment expected to be generated under the baseline alternative for OU3 and OU4.

The individual dewatering and monofill facilities indicated on Sheets 16 and 18 of the plan set require a combined total acreage of over 700 acres. If the arrangement of the facilities is optimized on a single parcel (e.g., by minimizing the land dedicated to setbacks and infrastructure), the land requirement would still be in excess of 500 acres. This acreage does not include an allowance for the lateral expansion of the monofill, should sediment volumes increase above the current estimation.

At a minimum, the settling basins and wastewater treatment facility should be co-located so that the basin supernatant can be pumped directly into the plant. However, it would also be practical for the wastewater treatment plant to be co-located with the monofill so that it can serve as the long-term leachate management facility. This would be particularly advantageous since the comparatively higher water content of the passively dewatered sludge may yield higher leachate volumes over time, and it would be economical to use the plant for on-site treatment prior to discharge. Constructing the settling basins, monofill, and wastewater treatment plant on a single parcel would allow the facilities to share the infrastructure (access roads, utilities, etc.), and the haul distance between the basins and monofill would be minimized.

10.3 Scenario A – *In Situ* Capping in Combination with Removal at OU1

Section 13.4 of the ROD for OU1 contained a Contingent Remedy which allows for partial or supplemental capping, to augment the dredging remedy, under specific site conditions. Section 7 of the FS included an alternative (Alternative F) similar to the Contingent Remedy which would implement the capping remedy, to the extent practicable given site conditions, combined with the dredging remedy for the remaining portion of site. Initial cap placement location criteria were also identified in Section 6 of the FS. As the ROD for OU3 and OU4 has not been released, this partial cap and dredge alternative will only be applied to OU1 although Section 3 previously discussed capping for all three OUs.

The capping alternative defined in the FS evaluated, based on a set of physical criteria (i.e., bathymetry, TSCA material, currents, navigation channel), the entire OU1 area bounded by the 1 ppm remedial footprint. If a given area met these conditions, prior to any removal, this alternative implemented a capping remedy over that area. The areas that did not meet all the criteria were included in the dredging portion of the remedy. During the TRT review, there was considerable discussion regarding recent projects that implemented a partial removal followed by capping. The DEA was not constrained to the approach contained in the FS.

Potential capping areas for OU1 were first determined based upon the areas where the PCBs exceeded the 1 ppm RAL, and a clear, post-construction water depth of at least 3 ft. could be achieved. The DEA was also not constrained by the 25 percent volume limitation articulated in the ROD; rather the DEA identified the maximum areas where capping could be considered. Additional considerations included the presence of PCBs > 50 ppm, and presence of the federal navigation channel.

In applying the various site criteria for application of a cap, it was determined that deposits A/B, C, POG, D and F would require partial dredging in order to meet the final clear water criteria of at least three feet. To evaluate a partial dredge/cap at Deposit A, POG, and C, the DEA examined the current mudline, and then determined that to achieve appropriate water depths, the partial dredging would need to remove all sediments in those deposits to an elevation of 731 feet, followed by placement of a sand cap over the residuals. Table 10-4 shows the residual area and volume for those deposits after removal to 731 feet. After removal, there is a relatively limited volume left at those deposits. For the DEA report, it was determined that given the cost of capping, and the ROD requirement for <25 percent of the total mass, that these small residuals would be more effectively dealt with by removal alone rather than applying an additional capping alternative.

Table 10-4 Post-Removal Residual Area and Volume

Deposit	Area (sq m)	Volume (cu m)
A	62,200	10,960
C	19,800	3,890
POG	60,900	10,520

When considering all the site specific location criteria presented in the FS and ROD as well as the Lower Fox River specific issues presented in White Paper 6b to the OU1 and 2 Record of Decision, the total surface acres, volumes and mass exceeding the 1 ppm RAL are listed in Tables 10-5 and 10-6. Of the total 1 ppm PCB footprint presented in the FS, approximately 40 percent of the total acres, 30 percent of the volume, and 20 percent of the total mass are within the areas eligible for capping.

Table 10-5 Capping Area, Volume and Mass Based on RI/FS OU1 Bedmap

OU1	Surface Acres	Volume (cy)	Mass (kg)
1 ppm PCB Footprint	526	784,192	1,715
Final DEA Cap Foot Print	221	235,143	380
Residual Dredge Area	305	522,381	1,324

Alternatively, these same capping areas represent nearly 60 percent of the total acres, 57 percent of the volume, and 29 percent of the total mass within the 1 ppm PCB footprint of the OU 1 bedmap presented in White Paper No. 2 – Evaluation of New LLBdM PCB Sediment Samples (WDNR, 2002a).

Table 10-6 Capping Area, Volume and Mass Based on WP No. 2 OU1 Bedmap

	Surface Acres	Volume (cy)	Mass (kg)
1 ppm PCB footprint	**441**	**831,334**	**1,394**
Final DEA Cap Footprint	**221**	**371,693**	**345**
Residual Dredge Areas	**228**	**449,569**	**1036**

Thus, continuing on with use of the FS volume estimates, this partial capping scenario could consist of capping 221 acres and removal of approximately 450,000 cy of contaminated sediment.

10.4 Scenario B – Substitute Hybrid Dredging and Riverside Mechanical Dewatering at OU3 and OU4

As described in Section 10.1, the baseline alternative for OU3 and OU4 uses hydraulic dredging as the representative process option for removal, and a series of upland settling basins as the process option for dewatering of the dredge slurry. The TRT and DEA have confirmed that other process options identified in the FS are also feasible and implementable. This section describes the impact of substituting certain process options on the overall project.

10.4.1 Hybrid Dredging

Scenario B substitutes hybrid dredging for the hydraulic dredging process option identified in the Proposed Plan. These process options were described and contrasted in Section 4. The analysis indicated that a hybrid dredge can achieve the same amount of production (cubic yards of river sediment removed) at a lower dredge slurry flowrate (i.e., smaller volume of water). For work in OU4, calculations suggest that this results in a reduction from 4100 gpm (from two hydraulic dredges) to perhaps 2100 gpm (for a single hybrid dredge). If upland settling basins are used for dewatering, such a reduction would not result in a significant savings because most of the cost is in the construction of the liner, and the facility size is driven by storage volume, not influent rate. On the other hand, for a mechanical dewatering plant, the rate reduction would result in a capital cost savings, as well as a small savings in operational costs because the equipment for the downstream processes of sand separation, dewatering and wastewater treatment can be reduced proportionally.

In addition, a hybrid dredging operation can typically achieve a slightly higher dredge effective time than a comparable hydraulic dredging operation. If no booster pumps are used, then this is estimated to be a maximum of 17 hr/day versus 16 hr/day. While this is less than a 10 percent improvement, any potential incremental savings is important.

10.4.2 Mechanical Dewatering at a Riverside Location

This scenario also substitutes mechanical dewatering for the passive dewatering in the baseline alternative for OU3 and OU4. Both mechanical and passive dewatering have advantages. The advantages of passive dewatering through the use of gravity settling basins is that it is a simple process and less subject to operational upsets and possible downtime compared to a mechanical system. With large-capacity settling basins, the dewatering process is unlikely to constrain the dredging operation. Further, when the dewatering facility is co-located with the disposal facility (e.g., the monofill), the hauling of dewatered material over local and county roads can be avoided.

However, since the preparation of the FS and Proposed Plan, at least three factors that favor the consideration of mechanical dewatering have gained significance.

- **Facility Siting –** The analysis in Section 10.2 of this report indicates that a large parcel of land would be required for the construction of necessary facilities. Brown County land in the Town of Holland has been suggested as a candidate location but its availability for use has not been confirmed. Because of expanding residential construction along the east side of the Lower Fox River, it is unlikely that a larger, viable parcel could be located any closer to the river than the County land. Constructing the project on two parcels, using County land to satisfy part of the land requirement, could also be possible, but the advantage of co-locating all facilities would be lost.

- **Construction Time -** The WDNR would prefer a shorter project duration so that restoration of the river system may begin. For remedial alternatives that involve the land disposal of sediment, the siting, permitting, and construction of landfill space are "critical path tasks" (i.e., tasks that ultimately control the overall project schedule). If land-based settling basins are used, the construction of the basins would be a critical path task. A landfill liner can be constructed in phases over multiple years so that airspace is provided on a "just-in-time" basis, and sufficient liner could be constructed in a single year to start filling operations. Even one of the settling basins, on the other hand, will have a much larger footprint than a single landfill cell, and would need to be completed before filling could begin. This would add years of preparatory construction before dredging could begin.

- **Dredge effective time when using booster pumps –** The use of upland facilities requires the hydraulic transport of slurry, which would require a number of booster pumps along the route. While hydraulic transport remains feasible and implementable, Sections 4 and 5.2 identified that booster pumps reduce the effective dredge operating time that in turn extends the overall project schedule.

As described in Section 6, a mechanical dewatering plant and associated wastewater treatment and solids load out facility would require approximately 10 to 15 acres and a number of candidate parcels for such a facility were identified in Section 8. The results of the demonstration projects, and subsequent evaluations by equipment suppliers, suggest that both filter presses and belt presses can achieve reasonable solids concentrations in the filter cake.

Once the design and procurement work is complete, the ordering and fabrication of equipment, and the construction of necessary buildings and infrastructure could be completed within 9 to 12 months. Most or all of the construction work could be performed year-round thereby helping to reduce the overall project duration. Conversely, the construction of settling basins is weather dependant, and could be delayed if the timing of the design and procurement was such that a contractor was not selected until December, for example.

Substituting a mechanical dewatering plant for a series of settling basins would dramatically reduce the volume and mass of dewatered sediment that requires disposal. The expected difference in the solids content between a passively dewatered material and a mechanically dewatered material is approximately 15 percentage points (40 percent solids versus 55 percent). The mass of mechanically dewatered material is only about 60 percent of the mass of passively dewatered material.

Since disposal costs are linear with respect to tonnage, the costs would be reduced accordingly. The difference in total mass is on the order of several million tons, and when disposal costs are equivalent to something on the order of $20 or $30 per ton, the cost savings is substantial. Also, the filter cake is likely to have better strength properties than a passively dewatered material, and would support somewhat steeper final grades in a landfill. This means that, on a per-acre of liner basis, more material can be disposed.

The combination of these two factors - smaller mass of dewatered material, and greater disposal capacity per acre – means that the monofill footprint at the County's Stock site may be a viable option. However, the site may not have the capacity to receive the total amount of OU3 and OU4 filter cake. Using this site would also yield significant timesavings because it already has a feasibility determination. The permitting and construction lead-time would potentially be shorter compared to the option of developing a new site. Even if additional disposal capacity were needed, that space could be permitted and constructed later in the project, without delaying the start of actual dredging operations and the filling of available space.

The siting of a mechanical dewatering plant at a riverside location, compared to an upland location, would eliminate the overland segment of slurry forcemain. A segment of in-water forcemain would still be needed. However, the reduced length of pipe and static head requirements would result in fewer booster pumps and increased dredge effective time.

For example, in OU4, using a riverside dewatering plant instead of the upland settling basins would eliminate the use of booster pumps. This would increase the estimated dredge effective time from 9.4 or 10.5 hrs/day, to 16 hrs/day (which is considered the maximum available time for a hydraulic dredge in a 24-hour day). All other things equal (sediment volume, size of dredge and forcemain, etc.), the schedule could be reduced from 9 to 10 years to approximately 6 years.

10.4.3 Disposal of Filter Cake

As described above, it has been assumed that mechanically dewatered filter cake would be disposed in a newly-constructed NR500 monofill located somewhere in Brown County. However, other disposal options are possible. Vitrification technology, for example, could be used as a substitute for land disposal, if found to be cost effective. The costs of this option have been evaluated in Section 11.4.

10.5 Scenario C – Substitute a Single, Dewatering Landfill for the Separate Facilities at OU3 and OU4

Under this scenario, a single “dewatering” landfill would be substituted for the separate dewatering and disposal facilities specified in the baseline alternative. The dewatering landfill would receive dredge slurry from OU3 and OU4, and supernatant would be treated in an adjacent wastewater treatment facility. The design concepts were described in Section 7.2 and are shown on Sheets 23 and 24 of the plan set.

Other components of this scenario, such as the dredging process and the wastewater treatment facility, would be comparable to those of the baseline alternative. A dewatering landfill could be coupled with either a hydraulic or hybrid dredging operation. As described earlier, the volume of solids and not necessarily the incoming dredge slurry rate drives the sizing of the dewatering landfill. As a result, a dewatering landfill for OU3 and OU4 would have a low potential of constraining the dredging operations.

The primary advantage of a single dewatering landfill is that it requires less land than the separate dewatering and disposal facilities. The limits of waste for each facility have been estimated, as presented in Table 10-7.

Table 10-7 Acreage Requirements for Scenario C

Facility Arrangement	Limits of Waste
NR213 settling basins NR500 monofill **Total**	332 acres 112 acres **444 acres**
Combined NR500 dewatering landfill	237 acres

The "limits of waste" is the footprint on which sediment would actually be managed. It is the acreage that would be lined and closed in accordance with the corresponding WDNR regulations. The total land requirement for construction of the necessary facilities is actually greater, however, because of required setbacks from property lines, berm construction, support facilities, etc. Nonetheless, even after taking into account these additional land requirements, a combined facility would require on the order of 200 fewer acres than separate, co-located facilities.

The dewatering landfill itself occupies a greater area than the monofill that would receive passively dewatered sediment. This is because the bulking of sediment within the dewatering landfill has to be considered, and volume reduction will occur only over an extended period of time. The cost implications of this sizing consideration are described in Section 11.

10.6 Scenario D – Substitute Mechanical Dredging and Vitrification Process Options for OU3 and OU4

This scenario assumes that vitrification would be substituted as the treatment process option for dredged sediment in place of a land disposal technology. It is assumed that the vitrification process would be developed by a private business and sufficient capacity would be provided for the treatment of dredged material. The treatment process is described more fully in Section 7.1. Costs are described in Section 11.

Vitrification technology is not necessarily a commodity item, and to date only a single provider of this technology, Minergy, Inc., has a demonstrated capability in processing Lower Fox River sediment. This means that the implementability of this scenario is contingent upon the WDNR or the implementing RPs successfully reaching a business agreement with Minergy for the development and operation of the necessary facility. Such issues as facility siting, final engineering details and project financing have yet to be developed, and yet are significant milestones.

If a vitrification plant could be sited adjacent to the river somewhere within OU3 or OU4, then the effort and cost of transport of sediment, either as a hydraulic slurry or a bulk material, could be reduced. For comparison purposes, this scenario assumes that mechanical dredging would be substituted for hydraulic dredging, and that bulk sediment would be off-loaded directly at a handling facility at the rivers edge. Material would then be fed to the vitrification process without further processing or dewatering.

While such a combination of processes would reduce the handling and intermediate transport of sediment, the mass of wet sediment would be greatly increased. Recent experience with navigational dredging in OU4 indicates that the solids content of the bulk material removed from the haul barge after mechanical dredging is on the order of 30% (Larsheid, 2003). The current FS estimate of the mass of dry solids from OU3 and OU4 is approximately 2,325,000 tons. At 30% solids, the total mass destined for treatment or disposal would be 7,750,000 tons.

This value can be compared to the tonnage that would be expected if the sediment were dewatered to 40% solids (via a passive process) or to 55% solids (via a mechanical process). These values are presented in Table 10-8.

Table 10-8 Waste Mass at Varying Solids Content

Solids Content of Bulk Material	Equivalent Tonnage Generated for Treatment/Disposal
30% (direct from mechanical dredging operation)	7,750,000
40% (if passively dewatered)	5,807,000
55% (if mechanically dewatered)	3,560,000

This comparison indicates that the mass of material from a mechanical dredging operation, without further processing, would be more than twice the mass generated from the most aggressive processing option, that of mechanical dewatering (following a hydraulic dredging operation). This means that the savings from eliminating the handling, dewatering and intermediate transport of sediment must be sufficient to offset what would be a substantial increase in treatment or disposal costs. These cost tradeoffs are described further in Section 11.

11 Costs

The FS developed comprehensive cost estimates for each of the remedial alternatives that were evaluated therein. These estimates were based on initial concepts and representative process options. They included direct costs (construction, disposal, etc.), as well as indirect costs (engineering, construction management, long-term monitoring, etc.)

The DEA has expanded upon the initial concepts in the FS and made some additional assumptions concerning specific processes and throughputs. Where the cost estimates in the FS were based necessarily on many broad, simplifying assumptions, it is now possible to provide additional detail and to make more focused assumptions.

This section includes a discussion of the updated cost estimates for several individual technologies and process options that were developed earlier in the DEA. Estimates have not been updated for certain remedy components where no significantly new assumptions have been made.

Similarly, costs have been developed only on the basis of individual technologies or process options, not necessarily for comprehensive remedial alternatives. This is to allow a comparison among technologies and process option substitutions only, rather than redevelop the full costs of implementation. For this purpose, the reader is referred back to the FS to gain a sense of the full scope of the alternatives and all of their cost components.

The level of accuracy of costs within an FS is generally expected to be within the range of +50 percent to –30 percent. While the DEA makes use of new information and provides additional analysis, there is still a significant level of uncertainty in what will be the final scope of the remediation, at least in terms of the sizing of facilities and the volume and mass of sediment removed or otherwise managed. To partly compensate for this, many of the individual line items in the cost calculations incorporate an allowance to reflect the range of uncertainty associated with the specific assumptions for that line item. This is believed to be a preferable approach than using a blanket "across the board" contingency of, say, 25 percent or 30 percent.

The series of cost estimate spreadsheets are contained in Appendix F, along with a summary memo describing how the individual estimates were applied to specific alternatives or scenarios within the DEA. These are described below.

11.1 Baseline Alternative – OU1

For the baseline alternative at OU1, costs were developed in further detail for the following technologies and possible remedy components:

- Mechanical dewatering
- Wastewater treatment
- Plant infrastructure and material loadout
- Truck transport

The manner in which the estimates were developed is described more fully in the summary memo in Appendix F. The roll-up of costs is as follows:

- **The capital cost** for constructing the dewatering, wastewater treatment and other plant infrastructure is estimated to be on the order of **$18,600,000**. Given uncertainties over the siting of these facilities, the exact size and throughput of the necessary equipment (which is a function of the selected dredge rate), and such issues as the possible need for a deep foundation system if the Bergstrom fill site is used, the actual capital cost could be higher

- The **annual operating cost** for these facilities is estimated to be on the order of **$2,800,000**. Given the current assumptions for removal, the project duration would be on the order of 2.3 years, for a total of **$6,400,000**.

- The **truck transport** (for the dewatered filter cake) is estimated at approximately **$1,800,000**

The evaluation of these costs results in the following findings and conclusions:

- The sum of the costs for these remedy components is approximately $26,800,000. This current estimate is well within the expected range of accuracy of the estimates for components developed in the final FS (e.g. +50 percent/-30 percent.)

- Expressed on a "sediment removed" basis, the sum of the costs for mechanical dewatering, wastewater treatment and material loading would be approximately $33 per cubic yard of in-place river sediment. The cost of truck transport for the dewatered sediment to a local monofill would be equivalent to $2.25 per cubic yard of sediment removed.

- The costs of dewatering and wastewater treatment are not true unit costs, however. This is because the capital cost of constructing the necessary facilities is large compared to their operating costs. The capital cost is more sensitive to the rate of production that is desired (i.e. how big to make things), and it is rather insensitive to the final quantity of material that must be treated. Thus, if the quantity of sediment increases, the cubic yard cost will actually decrease because the high capital cost is distributed over a larger quantity.

For this baseline alternative, a specific estimate for the construction of an NR500 monofill suitable for the disposal of mechanically-dewatered filter cake has not been made. The agencies expect that space at an existing or newly-constructed, dedicated facility will be procured. However, several points can be made:

- For comparison, the estimate for constructing and operating such a facility for the OU3 and OU4 sediment is on the order of $12 to $13 per cubic yard of sediment removed, or $22 to $23 per ton of filter cake disposed

- Since a facility sized to accommodate the smaller quantity of sediment from OU1 may not have the same economies of scale as the OU3 and OU4 project, the cost could be higher

- On the other hand, the tipping fees at large, commercial landfills in the Fox Valley in recent years has been as low as $12 to $13/ton for contaminated soil and debris. Disposal of PCB sediment may carry with it a premium, and a tipping fee in the high-$10's to mid-$20's would not seem to be out of the ordinary

In either case, these values are below the disposal estimate of $43 per ton contained in the FS. The FS estimate is appropriately conservative for planning purposes; it appears that the actual cost at the time of implementation could be lower.

11.2 Baseline Alternative for OU3 and OU4

For the baseline alternative at OU3 and OU4, costs were developed in further detail for the following technologies and possible remedy components:

- Hydraulic dredging and transport
- Passive dewatering using NR213 settling basins
- Wastewater treatment
- Disposal of dewatered sediment in an NR500 monofill

The concepts and costs for the NR213 settling basins have changed somewhat since the original FS. The basins are now intended to provide an extended period of ambient drying of the sediment, resembling the performance of the Brown County facilities at Bayport. The net effect of this change is that the basins are somewhat larger, and a 4th basin has been added. The cost of sediment stabilization using an additive has been deleted.

The roll-up of costs for this baseline alternative is as follows:

- The sum of **capital and operating costs** for hydraulic dredging is estimated to be on the order of **$67,900,000**. The duration of dredging is estimated to be on the order of 10.3 years.

- The **capital cost** for hydraulic transport is estimated to be on the order of **$7,700,000**. The annual operating cost for the system is estimated to be on the order of **$2,000,000**, over the dredging duration of 10.3 years.

- The **capital cost** for constructing the NR213 dewatering facility is estimated to be on the order of **$60,800,000**. The annual operating cost for this facility is estimated to be on the order of up to **$2,900,000**. Given the current assumptions for the rate of sediment removal, the total duration of dewatering operations would be on the order of 14 years.

- The **capital cost** for constructing the NR500 monofill is estimated to be on the order of **$32,400,000**. The **annual operating cost** for this facility is estimated to be on the order of **$6,500,000**. Given the current assumptions for removal, the project duration would be on the order of 10.3 years. Long-term care costs would then accrue.

- The capital cost for constructing the wastewater treatment facility is estimated to be on the order of **$6,400,000**. The **annual operating cost** for this facility is estimated to be approximately **$1,000,000**.

The cost evaluation results in the following findings and conclusions:

- The estimated combined capital and operating costs for the removal component of the remedy is equivalent to $10.45 per cubic yard of sediment removed. The transport component is equivalent to $4.26 per cubic yard of sediment removed.

- The estimated combined capital and operating cost for the dewatering component of the remedy is now $96,600,000, or approximately $14.86 per cubic yard of in-place river sediment.

- The cost of wastewater treatment is estimated at approximately $2.60 per cubic yard of sediment removed. The estimated combined cost to process the sediment prior to the point of disposal (e.g. passive dewatering and wastewater treatment) is therefore approximately $16.14.

- The cost of constructing, operating and maintaining over the long-term an NR500 monofill is estimated to be on the order of $110,400,000. (On a present worth basis, this is $80,900,000.) This is equivalent to $16.98 per cubic yard of river sediment removed, or $18.99 per ton of the passively-dewatered material transferred out of the NR213 settling basins.

- The estimated combined cost of processing and disposal is therefore on the order of $33.12 per cubic yard of sediment removed.

- One of the most significant components of the total cost of this alternative is the fee that would be paid to the community within which the NR500 monofill would be built. This fee is negotiated under the state solid waste licensing rules. It is typically computed on a "per ton of waste disposed" basis. A recent precedent within Brown County is for the Holland municipal waste landfill. At this landfill, the host community fee was set at $10 per ton. This value has been used for representative purposes within the current estimates.

- It has been assumed that the quantity to which this fee would attach is the mass of passively dewatered material that is removed from the NR213 basins and then transferred to the NR500 monofill. This is estimated to be on the order of 5,810,000 tons, assuming that the sediment can be dewatered and dried to a solids content of 40 percent. The tonnage (and costs) will be higher if this solids content cannot be achieved.

The degree of dewatering can therefore be viewed as a critical issue, since the more water that can be removed from the sediment prior to disposal, the lower the total mass of waste, and hence the amount paid in host community fees. This will be illustrated further below when comparing the costs of disposing of mechanically-dewatered sediment with this baseline alternative.

11.3 Scenario A – *In Situ* Capping in Combination with Removal at OU1

The discussion in Section 10 indicated that capping could be substituted for removal in certain locations and subject to certain technical qualifications. In doing so, the cost of the capping component of the work replaces some of what would otherwise be the cost of removal.

Section 10 suggests that up to 221 acres of sediment bed in OU1 may be capped. This would leave approximately 450,000 cubic yards of sediment to be removed. It is assumed that such a dredging project would proceed as generally described in the Final FS and as further detailed in the discussion of the Baseline Alternative in this DEA report.

A cost estimate for capping has been developed. Detailed backup information is contained in Appendix F, and is labeled as Cost Estimate #19. The roll-up of costs indicates the following:

- The **capital cost** for constructing an 18" cap, with a 6" armor layer, over 221 acres in OU1 is estimated to be on the order of **$17,300,000**. When long-term monitoring is included, the total cost is on the order of **$17,800,000**.
- This cost is equivalent to approximately **$81,000 per acre**.
- Unlike many of the other remedy components, the cost of capping is close to being a true unit cost because most of the capping cost is for items that are directly proportional to the size of the area capped (volume of sand, labor, etc.), and there are no significant facilities that must first be constructed at a large fixed initial cost. For evaluation purposes, the value of $81,000 per acre will be used as a unit cost for any acreage that is selected for capping, recognizing that this is still an approximation.

In order to compare the cost of capping with the cost of removal, an estimate of the removal component is needed. The FS developed a comprehensive estimate for complete removal and this was carried over in to the Proposed Plan. In this DEA, some of the components of the Baseline Alternative for OU1 (e.g. the Proposed Plan remedy) were further also developed and updated estimates were prepared, as described in Section 11.1. This included the costs of dewatering, wastewater treatment and plant infrastructure, where additional assumptions and details have been developed since the FS. The cost of the dredging component of the remedy for OU1 was not further evaluated within this DEA, since no significant changes in the scope or methods of the dredging operation have been assumed. As a result, the FS numbers for dredging have been extracted and combined with those developed through the DEA for the remaining downstream operations (dewatering, etc.)

These calculations are summarized in Cost Estimate #20 in Appendix F. The following findings have been reached:

- The removal and downstream processing can not be reduced to a simple unit cost that is applicable to all possible quantities of sediment removed, because there is potentially a large cost component in fixed capital equipment and facilities. (Note that this is based on the assumption that equipment is purchased and dedicated to the project, and comparatively little short-term leased equipment is used. This is a reasonable assumption for a long-duration project like the work to be performed at OU3 and OU4. OU1 is expected to be of intermediate length, on the order of 3 years, and one could argue that the assumption of dedicated equipment is not necessary. However, given the large size and specialized nature of the equipment (particularly the dewatering presses), and for consistency of the estimating approach, the assumption of dedicated equipment will carry through OU1, as well.

- For this reason, Cost Estimate #20 attempts to separate out the fraction of the cost of each major remedy component that is tied to a fixed direct capital item (e.g. equipment and buildings), from the costs that are proportional to the volume of dredged material (e.g. annual labor, chemical usage.) This results in an estimate of fixed direct capital costs on the order of **$20,400,000** and an estimate of quantity-proportional capital costs on the order of **$34,000,000**.

- For the total quantity of 784,000 cubic yards of sediment removal (upon which the original component estimates were based), the quantity-proportional capital costs are equivalent to approximately $44 per cubic yard.

- Using the separate values for fixed direct capital and quantity-proportional capital costs, a graph can be generated that shows the combined cost for a given quantity of removal. This is contained at the end of Cost Estimate #20. For the 450,000 cubic yards of removal identified within this scenario, the cost would be on the order **$40,000,000**.

Thus, the combined cost of the capping and partial removal remedy described herein is as follows:

Capping component (221 acres)	$17,000,000
Removal component (450,000 cy)	$40,000,000
Combined cost	**$57,000,000**

This analysis is very approximate and the calculation of dredging and dewatering costs for the partial removal scenario in Cost Estimate #20 is subject to many simplifying assumptions. In particular, the separation of fixed capital and quantity-proportional capital costs is subject to considerable judgement. In addition, not all project costs, such as indirect capital costs and minor remedy components, are presently included. Nonetheless, several conclusions can be reached:

- The combined cost of capping and partial removal calculated above ($57,000,000) is very similar to the simplified extrapolation of costs for total removal that is calculated in Cost Estimate #20 ($54,000,000.)

- The combined cost ($57,000,000), which does not include indirect capital and minor component costs, is approaching the total project cost for complete removal that was developed in the FS and expressed in the Proposed Plan ($66,000,000), which does include indirect and minor costs.

- This suggests that using capping as a substitute for some amount of removal, at least at the proportions evaluated herein, does not substantially reduce the total project cost.

Again, this analysis is based on several simplifying assumptions and the final costs of an actual remedy will be different. There is still a large window of uncertainty around each value described above. But the individual values are still comparatively close, and the difference between them probably falls well within the current uncertainty of any one of them alone. As a result, at this level of analysis there does not currently appear to be a dramatic cost impact of substituting capping for removal.

11.4 Scenario B for OU3 and OU4 – Substitute Hybrid Dredging and Mechanical Dewatering at a Riverside Location

For this scenario, costs were developed in further detail for the following technologies and possible remedy components:

- Mechanical dewatering
- Wastewater treatment
- Plant infrastructure and material loadout
- Truck transport
- Disposal of dewatered sediment in an NR500 monofill

The roll-up of costs indicates the following:

- The **capital cost** for constructing a mechanical dewatering plant is estimated to be on the order of **$15,300,000**. The **annual operating cost** for this facility is estimated to be on the order of **$4,000,000**. Given the current assumptions for removal, the project duration would be on the order of 6.4 years.

- The **capital cost** for constructing the wastewater treatment facility is estimated to be on the order of **$4,900,000**. The **annual operating cost** for this facility is estimated to be on the order of **$1,000,000**.

- The **capital cost** for other plant infrastructure and loadout facilities is estimated to be on the order of **$4,900,000**, with an **annual operating cost** of **$800,000**.

- The **annual cost** for truck transport is estimated to be on the order of **$3,400,000**.

- The **capital cost** for constructing the NR500 monofill is estimated to be on the order of **$29,300,000**. The sum of **annual operating costs and long-term care costs** for this facility over the post-closure care period is estimated to be on the order of **$51,900,000**.

The following findings and conclusions have been reached:

- The sum of the estimated capital costs for the dewatering plant, wastewater treatment plant and related infrastructure is $25,100,000. The sum of estimated annual operating costs is $5,800,000. When these costs are summed over the life of the project, the combined capital and operating costs are equivalent to approximately $9.62 per cubic yard of sediment removed.

- When truck transport of the filter cake to an upland disposal location is added (at approximately $3.34 per cubic yard of sediment removed), the total cost is approximately $13 per cubic yard of sediment removed.

- The estimated cost in the original FS for this set of remedy components was on the order of $253,000,000, or $39 per cubic yard of sediment removed. This figure includes various minor cost components not specifically estimated in this DEA, such as the construction cost for the discharge line for treated wastewater, indirect capital costs, etc. As a result, the $39 figure is only loosely comparable to the $13 figure.

- In the FS, the largest component of this estimate was the cost assumption for dewatering, expressed as a $ per dry ton of solids figure. Based on a more detailed, “bottom-up” evaluation, using purchased equipment and operating labor assumptions, it appears that mechanical dewatering could be accomplished at a lower cost than was conservatively estimated in the FS.

- The estimated cost for landfill disposal of the dewatered sediment is $81,200,000, or approximately $12.50 per cubic yard of sediment removed. The estimated combined cost of processing, transport and disposal is therefore on the order of $26 per cubic yard of sediment removed.

The cost for this set of possible remedy components can also be compared to the analogous components in the baseline alternative. This leads to the following findings and conclusions:

- As described in Section 11.2, the combined cost of the passive dewatering and wastewater treatment processes has been estimated in this DEA at $16.14 per cubic yard. This compares to the estimate for the substitute process option of mechanical dewatering (and related wastewater treatment and truck transport of filter cake) at approximately $13 per cubic yard of sediment removed. There is still considerable uncertainty in both estimates and the individual numbers may actually fall within the uncertainty range of one another. Nonetheless, the analysis suggests that mechanical dewatering could be implemented at lower cost.

- There is a more substantial and definitive difference in cost for the disposal of the dewatered sediment in an NR500 monofill. The combined cost of constructing, operating and maintaining over the long-term an NR500 monofill is estimated to be on the order of $81,200,000. This is equivalent to approximately $12.50 per cubic yard of sediment removed. The analogous disposal cost estimate if the sediment is passively dewatered is approximately $17 per cubic yard of sediment removed.

- The decrease in disposal costs when mechanical dewatering is used is the result of two primary factors. First, the size of the monofill can be reduced because the volume of mechanically-dewatered sediment will be less than the volume of passively-dewatered sediment. Second, the mass of material that is subject to the host community fee is reduced. Thus, if landfill disposal of the dewatered sediment is to be the selected disposal technology, these considerations illustrate the desirability of removing as much water as possible from the sediment.

The use of vitrification technology as a substitute for disposal of mechanically-dewatered filter cake in an NR500 monofill has also been considered. Minergy, Corp. of Neenah, Wisconsin has performed a unit cost study for a range of plant capacities and project durations. Details are provided in Appendix F. The following findings have been reached:

- When the Minergy data for capital and operating costs are converted to a common basis as the monofill option, the cost range (using different assumptions for the value of the glass aggregate produced) is on the order of $21 to $28 per cubic yard of sediment removed.

- This value compares with the NR500 monofill disposal option at approximately $12.50 per cubic yard of sediment removed.

Thus at the present time, the vitrification process would be higher in cost than the monofill disposal option by approximately a factor of 2. However, this process option may continue to receive consideration if changing economic or social factors mitigate against the monofill disposal option. It remains a flexible technology and one where the marginal costs will decrease if volumes increase.

11.5 Scenario C – Substitute Disposal in an Upland Dewatering Landfill

For this scenario, costs were developed in further detail for the following technologies and possible remedy components:

- Disposal of dredge slurry in a dewatering landfill
- Wastewater treatment

The roll-up of this cost estimate is as follows:

- The **capital cost** for constructing the dewatering landfill is estimated to be on the order of **$61,800,000**. The sum of **annual operating costs** for this facility over the post-closure care period is estimated to be on the order of **$82,800,000**. Given the current assumptions for removal, the project duration would be on the order of 10.3 years.

- The **capital cost** for constructing the wastewater treatment plant is estimated to be on the order of **$6,400,000**. The **annual operating cost** for this facility is estimated to be on the order of **$1,000,000**.

An evaluation of these costs indicates the following:

- The combined cost of constructing, operating and maintaining over the long-term the dewatering landfill is estimated to be on the order of $144,600,000. This is equivalent to $22.25 per cubic yard of sediment removed.

- The combined cost of constructing and operating the wastewater treatment plant is estimated at $16,900,000, or the equivalent of $2.60 per cubic yard of sediment removed. The sum of these disposal and wastewater treatment costs is therefore approximately $25 per cubic yard of sediment removed.

- This compares with the analogous figure of $33 per cubic yard for the baseline alternative of separate passive dewatering, followed by disposal. These two values are within 35 percent of each, and they may very well fall within the uncertainty range of each other.

The difference in disposal cost between the baseline alternative and this scenario is primarily due to the increased landfill acreage that is required to accommodate the dewatering of the dilute dredge slurry (237 acres versus 112 acres). The sizing assumptions for the dewatering landfill are somewhat conservative at this point. A significant degree of sediment bulking has been assumed, and the potential volume-reducing effects of long-term consolidation have not been included. In comparison, using the NR213 settling basins is anticipated to provide a significant amount of volume reduction (prior to landfill disposal) because the sediment is allowed to air dry in comparatively thin lifts for a number of years.

Geotechnical engineering work may conclude that the current assumptions for the dewatering landfill can be relaxed, and that the size of the landfill can be reduced. If so, costs would decrease accordingly.

11.6 Scenario D – Substitute Mechanical Dredging and Vitrification

For this scenario, costs were developed in further detail for the following technologies and possible remedy components:

- Barge transport
- Plant infrastructure and offloading
- Vitrification

Based on the additional analysis of the DEA, the costs for the remaining components of this scenario are contained in Appendix F. The roll-up of these costs includes the following:

- The **capital cost** of barge transport for OU3 and OU4 material, in total, is estimated to be on the order of **$48,000,000**.

- The **capital cost** of constructing a central offloading facility and other infrastructure is estimated to be on the order of **$2,100,000**. **Annual costs** for offloading and transfer operations are estimated to be on the order of **$1,800,000** per year. The **sum of capital and operating costs is** estimated to be on the order of **$20,500,000**.

- The **capital cost** of constructing the vitrification plant, using Minergy's raw cost analysis data, is on the order of **$79,400,000**. Including the annual operating costs, the **total cost of vitrification** is estimated to be on the order of **$225,000,000 to $280,000,000**. (The cost range is due to the possible range of value of the finished glass product.)

In addition, such a scenario would include the processes of mechanical dredging and wastewater treatment. For these remedy components, the costs are represented as follows:

- **Mechanical dredging –** The DEA has not developed new information that would significantly change the concepts and estimate of costs originally contained in the FS for the mechanical dredging component of the work. For OU4, the FS estimate of the direct capital cost for mechanical dredging alone (including monitoring, but exclusive of barge transport, indirect engineering costs, etc.) was approximately $52,000,000. This is equivalent to approximately $8.90 per cubic yard of sediment removed. If this is assumed to be a reasonable equivalent cost for work in OU3, as well, the total dredging costs for both OUs would be on the order of $58,000,000.

- **Wastewater treatment –** Elsewhere in this DEA, the cost of wastewater treatment was estimated for the larger quantities of water generated from a mechanical dewatering system, a passive dewatering system or a dewatering landfill. The total costs for the construction and operation of these facilities were in the range of $11,000,000 to 17,000,000. A much smaller volume of wastewater would be generated from the decanting of free liquids off of a mechanically-dredged material. A placeholder of $8,000,000 is assumed to cover such costs.

Thus, the following findings and conclusions have been reached:

- The capital cost of mechanical dredging alone (i.e. exclusive of barge transport) is lower than the cost of hydraulic dredging alone (i.e. exclusive of slurry transport), as described in the baseline alternative ($58,000,000 versus $67,900,000). However, when the cost of barge transport is added (particularly from OU3 where the presence of the lock significantly increases the cycle time and costs), hydraulic dredging to a riverside location would end up being the lower cost process option.

- The sum of dredging, barge transport, handling and wastewater treatment is on the order of $135,000,000. This gets the sediment to the point of treatment in the vitrification plant. An equivalent set of activities described in the Baseline Alternative (i.e. hydraulic dredging, slurry transport and passive dewatering, all prior to monofill disposal) is on the order of $195,000,000.

- However, the disposal costs (in a monofill) for the Baseline Alternative is estimated at $110,000,000. The vitrification costs are more than double this amount, and greatly offset the savings that might otherwise be realized in dredging, handling and transport.

A comparison of this scenario with Scenario B (hybrid dredging and mechanical dewatering) would yield a similar conclusion. The high cost of treating by vitrification the large mass of high-water content material generated by a mechanical dredge more than offsets the potential savings in handling, dewatering and transport. Even a low cost monofill disposal option coupled with mechanical dredging is unlikely to generate a lower total project cost because the cost of transporting the large mass of material (at a fairly significant per ton cost) to an upland location must be added.

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Appendix A

Summary of TRT Meeting

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MEMORANDUM

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TO:	Greg Hill	**CLIENT:**	Wisconsin DNR
FROM:	RETEC	**TASK:**	WISC 15933
DATE:	August 13, 2002	**RE:**	Summary of TRT Meeting

Purpose

This memorandum documents the major areas of discussion during the Fox River Technical Review Team (TRT) meeting. The TRT was convened to provide technical, economic and socio-environmental review of the remedial technologies and alternatives first developed by RETEC for the Department in its Draft Feasibility Study (FS.) The conclusions of the TRT are being used to guide development of remedial design, and will be incorporated into the *Detailed Evaluation of Alternatives* document being prepared for the Wisconsin Department of Natural Resources.

The TRT met in Green Bay, Wisconsin from July 15 – 19, 2002. Prior to the meeting, the individual TRT members were supplied with supporting information from the Remedial Investigation, the Feasibility Study, and the Proposed Plan, However, a key operating principal for the TRT was that there is no Record of Decision at the time of the meeting, therefore, all options are still open to consideration. The TRT task was to develop input for a conceptual (referred to in this memo as a 30%) design for selected alternatives. The TRT reviewed the existing alternatives within the FS, carried some forward and/or proposed new alternatives that are a combination of processes already identified in the FS.

The weeklong meeting was generally organized around individual remedial technologies or project elements (capping, removal, etc.) Conclusions, recommendations and specific findings are contained in subsequent sections of this memo.

Members of the Technical Review Team

The TRT included local, national, and internationally recognized engineers, scientists, and sediment remedial contractors. The TRT was composed of members who have actual design, construction, and implementation experience in sediment removal or capping actions.

The principal review and design members of the TRT included:

- **Dr. Raymond Loehr,** *University of Texas at Austin*. Dr. Loehr served as the Vice-Chairperson for the National Research Council's Committee on Remediation of PCB-Contaminated Sediments. Dr. Loehr served as the chair for the TRT, and brought the NRC's perspective into the remedial design and selection process.

- **Dr. Michael Palermo**, P.E. *USACE Waterways Experiment Station, Vicksburg, MS.* Dr. Palermo is the Director of the Center for Contaminated Sediments at the Corps' Waterways Experiment Station, and is an internationally-recognized expert in sediment capping. As a senior scientist within the Corps specializing in contaminated sediment management, Dr. Palermo represented all facets of sediment management, including capping, removal, and confined disposal facility design and management.

- **Greg Hartman**, P.E., *Dalton, Olmstead and Fugelvand, Ltd., Seattle, WA* Mr. Hartman has over 31 years of direct experience in waterway engineering, including projects for the Corps, the Navy, EPA, and the Port of New York and New Jersey. Mr. Hartman also developed and taught dredging curriculum for the Corps of Engineers and the U.S. Navy. He is past President of the Western Dredging Association, and a member of the Technical Committee for the World Dredging Conference. Mr. Hartman's design and implementation experience includes contaminated and navigation dredging, design of nearshore fills, confined aquatic disposal (CAD) sites, and capping.

- **Dave Werren, P.E.,** *Baird and Associates, LTD, Madison, WI.* Mr. Werren is a coastal engineer with considerable local Wisconsin marine construction experience (including sediment removal) through Baird's projects throughout Wisconsin and the Great Lakes. Baird has been a member of the Fox River RI/FS team since 1998. This has included remedial analysis, as well as modeling work done in association with DNR and the Fox River Group. Mr. Werren's represented coastal engineering design, as well as construction management and contracting perspectives through his experience in several large (>10 million c.y.) international dredge and construction projects.

- **Ancil Taylor,** *Bean Environmental LLC, New Orleans, LA.* Mr. Taylor is the President of Bean Environmental, and has been the manager and production engineer for multiple large contaminated sediment management projects. This includes the successful Superfund removal at the Bayou Bonfouca site in Louisiana, and the New Bedford Harbor Pilot Dredging Project in Massachusetts for the Corps. Bean Environmental is also associated with the Dutch dredging firm of Boskalis, and represented contaminated sediment management technologies and experience in Europe. Mr. Taylor also consults with the Marine Board of the National Academy of Science and is the First Vice President of the Western Dredging Association.

- **Mike Crystal,** *Sevenson Environmental Services, Inc, Buffalo, N.Y.* Mike Crystal is well known to Wisconsin through Sevenson's successful work at the SMU 56/57 dredging demonstration project in the second season of operation. Sevenson was solely responsivle for the hydraulic dredging and mechanical dewatering of 50,000 cy of PCB contaminated river sediments. As the Manager of Dewatering Operations for Sevenson, Mr. Crystal brought additional contractor's design and implementation perspective to the TRT.

- **Minergy Corporation**. Minergy is the developer of the Glass Furnace Technology. In 2001, Minergy teamed with the Department of Natural Resources, the U.S. EPA SITE program, and the Great Lakes National Program Office, to fund the construction and demonstration of the technology. Minergy's vitrification process was represented by it's two principal engineers, Terry Carroll and Tom Baudhuin.

- **Sonya Newenhouse**, *Madison Environmental Group, Madison, WI* Dr. Newenhouse is a leading expert for waste issues and policy in Wisconsin, and is an external invited expert for DNR's on the Future of Solid Waste Management in Wisconsin (Target 3 Committee). She is also working for DNR to analyze and assist recycling policy Dr. Newenhouse was present at the TRT representing potential stakeholder issues.

- **Tim Thompson,** *RETEC, Seattle, WA.* Mr. Thompson is the program manager for the DNR on the Fox River RI/FS, and has been working on the Fox River since 1993. He served as the assistant chairperson to Dr. Loehr. In addition to his Fox River experience, Mr. Thompson represented practical design, construction and monitoring for sediment capping programs including the design of placement and monitoring programs for the Corps/EPA (East Eagle Harbor Superfund Site, WA), as well as design and construction of capping projects in New York, Indiana and Wyoming.

- **Steve Dischler, P.E.**, *RETEC, Green Bay, WI.* Mr. Dischler is a Wisconsin native with 20 years experience in landfill design engineering. This includes several landfills within Wisconsin. This experience includes siting, permitting, design and construction of facilities to handle paper sludge, coal ash, and municipal wastes.

- **Bob Paulson,** *RETEC, Madison, WI.* Mr. Paulson has been working on the overall Fox River program since 1989, first for the DNR, and now in his role at RETEC. Mr. Paulson provided the programmatic institutional knowledge for the entire Fox River program, including a complete understanding of the data for the site, ongoing characterization programs.

The primary design team interacted with key staff from the DNR and EPA that will ultimately have responsibility for permitting, overseeing the implementation, and reviewing final remedial design documents and construction. These were lead by Mr. Greg Hill of the WDNR, and Mr. Jim Hahnenberg of the EPA. The Oneida Nation, as a trustee and host for the TRT meeting, attended the TRT meeting as an observer. Finally, the TRT was supported by engineering staff and scientists from the respective firms. Members of the Technical Review Team, representatives of the DNR and the U.S. Environmental Protection Agency (EPA), and the supporting personnel to the TRT are listed in Table 1.

Table 1. Technical Review Team Meeting Attendees and Affiliations.

ATTENDEES	***AFFILIATION***
Facilitators	
Dr. Raymond Loehr	University of Texas at Austin
Timothy Thompson	The RETEC Group, Inc.
Participants	
Dr. Michael Palermo	USACE
Greg Hartman, P.E.	Dalton, Olmsted & Fugelvand, Ltd.
Dave Werren, P.E.	Baird & Associates, Ltd
Ancil Taylor, P.E.	Bean Environmental, LLC
Terry Carroll, P.E.	Minergy Corporation
Mike Crystal	Sevenson Environmental Services
Dr. Sonya Newenhouse	Madison Environmental Group, Inc.
Robert Paulson	The RETEC Group, Inc.
Steve Dischler, P.E.	The RETEC Group, Inc.
Resource/Public Agencies	
Greg Hill	WDNR
Jim Hahnenberg	EPA
Bob Grefe	WDNR
Ed Lynch	WDNR
Gary Kincaid	WDNR
Len Polczinski	WDNR
Tom Nelson	Oneida Environmental Office
Additional Technical Resources	
Tim Kenny	Baird & Associates, Ltd
Harry Van Dam	Bean Environmental, LLC
John Lally	Bean Environmental, LLC
Nuria Hernandez-Mora	Madison Environmental Group, Inc.
Kelly Thibadeaux	Sevenson Environmental Services

RETEC

General Conclusions

The following conclusions represented the consensus opinion of the group:

1. The TRT found the feasibility study presented a range of alternatives that in combination, or individually, have a high degree of probability of being able to be successfully implemented. The TRT identified certain information gaps that could impact the final cost of the remediation. It is anticipated that these data needs can be accomplished in the pre-design phase, based on the input of the TRT with some additional analyses.

2. The capping, removal, dewatering and disposal technologies are implementable using currently available equipment and methods. However, certain remedial technologies may not be implementable, practicable, or face considerable social constraints in some reaches of the River. The TRT recommended a select group of alternatives for pre-design, as shown in Figure 1.

3. The agencies need a well-defined remedial footprint (horizontal and vertical) to set the remedial boundaries, and to better refine the remedial cost. The sensitivity of the costs, and feasibility, of all alternatives is highly dependent on remedial footprint. It is the recommendation of the TRT that effort be put into resolving variability prior to construction, and should be a prerequisite for successful implementation of any alternative. The TRT determined that a more precise definition of the footprint would allow the agencies to address now the issues of over-dredging, and post-remedial confirmation sampling in the future.

4. Information needs for the final design include (1) adequate and carefully-controlled vertical and horizontal PCB distributions, (2) setting landfill space for dredged sediments, and (3) physical sediment data upon which to base removal or capping components.

Recommendations Concerning Operational Performance Standards

The TRT discussed, and developed proposed operational performance standards for the project. An important consideration stressed by all members was that any of the FS-identified processes could be used to implement the action, but that remedial contractors would need to understand the performance specifications to which they would be held. For the purposes of moving forward, the TRT adapted the standards listed below. It should be understood that these are only proposed standards; DNR and EPA may set different specifications as part of the ROD.

Sediment Cleanup Standards

Vertical and Area-wide Considerations:

The TRT discussed spatial considerations, both vertical in the sediment column, and horizontal for areas under consideration,. These must be addressed in the evaluation of action levels and cleanup levels. Rules regarding vertical averaging over a sediment thickness must be determined to apply at discrete sampling stations. Rules regarding averaging the results for multiple stations must be determined to evaluate reaches, areas, or polygons. Concepts such as the Surface Area Weighted Average (SWAC) address this need.

Sediment Concentration Limits

Remedial Action Level is defined as the in-place sediment concentration that defines the perimeter and depth of the remedial action. For the purposes of the Fox River, the RAL was set at 1 ppm total PCBs by the WDNR and the EPA.

Surface Weighted Average Concentration is the average concentration of total PCBs represented in the top 10 cm of sediment over the entire operable unit. The SWAC is calculated by interpolating the measured sediment concentrations, and then averaging those concentrations by the total area in the OU. Upon completion of the remedial action, the resultant SWAC for an operable unit will be less than 0.5 ppm.

Sediment Quality Threshold is a point-sediment concentration of total PCBs below which risks to human and ecological health are determined to be acceptable. The SQT for the Lower Fox River is set at 0.250 ppm. For a removal action, achievment of the SQT is a goal, but not a requirement. For capping, the SQT is the compliance level.

The State/EPA made the determination of a 1 ppm action level for the Proposed Plan in part to achieve a SWAC in the 0.25 – 0.35 ppm range for each individual reach. The TRT discussed the issue of the sediment horizon over which the action level will be applicable. Concentrations can be determined in cores to a fine level of vertical resolution (e.g., 1-2 cm), but neither nature nor engineering act at that resolution.

For the purposes of removal, the TRT recommended an elevational removal; that the dredge footprint would be on achieving a pre-specified depth horizon. The 1 ppm footprint is based upon the assumption that if PCBs exceeded the RAL at any horizontal/vertical profile, then those sediments were removed to the lowest profile where PCBs were effectively below the RAL. For example, in the table below, at Point's A and B, even though the surface concentration is less than the RAL, within the stratum there are levels that exceed the Action Level. For Point A, the elevation limit is 120 cm; the depth to bedrock. In Point B, the vertical limit is 90 cm; the point at which PCBs are no longer exceeding the Action Level. The removal occurs here even though the top 30 cm are below the RAL. At Point C, only the top 10 cm require removal.

Depth Profile (cm)	PCBs Point A (ppb)	PCBs Point B (ppb)	PCBs Point C (ppb)
0 – 10	900	400	1000
10 – 30	1500	400	900
30 – 90	500	1000	400
90 – 120	1000	900	400
>120	Bedrock	400	400
Determination	Remove to 120 cm	Remove to 90 cm	Remove to 10 cm

Clean up Level for Dredging

If the action level is 1 ppm, then 1 ppm logically becomes the goal for dredging. But dredging will leave a residual, and that residual may reflect an average of the sediment column removed. If 1ppm is the goal, the State should define over what sediment horizon the concentration will be measured. Logically, this should correspond to the mixed layer thickness, or biolgicaly active thickness, say (0 – 10) cm.

For dredging, the conditions regarding residual are worst immediately after construction. Past experience has indicated that achieving a target is not easy. Multiple passes have been used with mixed success to improve the surficial concentration. The State should define some limit on the number of additional passes which may be required. Say a maximum of 3 passes. This provides some level of certainty for purposes of cost estimating and bidding.

As an option to multiple passes, placement of a thin cap could be considered in lieu of additional dredging passes. Or as the last step if the cleanup goal is not met following the maximum of 3 passes. The purpose of a thin cap is to provide sediment dilution to bring the residual layer below the target.

For the demonstration projects, DNR/EPA set two distinct performance standards. At Deposit N, it was strictly an elevational limit with no performance criteria; Deposit N was located over bedrock. For 56/57, while an elevational limit was specified, samples were collected over the dredged material to manage residual risks. The goal was to achieve the < 1 ppm RAL, but where the concentrations remained greater than 10 ppm, a thin-cap was placed to manage residuals. DNR/EPA need to articulate if this still remains the expectation.

Long Term Cleanup Level with Capping

Areas exceeding the action level of 1 ppm may be considered for capping. The compliance level is set at the SQT of 0.25 ppm in the top 10 cm.

Water Quality Standards

A change in the present constraints on river assimilative capacity seems a necessity for any remedy involving a significant dredging and dewatering/treatment component. Assuming this will be the case, the team should request clear guidance from the State for various scenarios on WQ standards. There is a clear need to determine the allowable numerical standards (concentrations) and points of compliance:

- applicable water quality standards for COC
- basis of those standards (e.g. dissolved vs. total; acute vs. chronic)
- point of compliance for various types of discharges (i.e. mixing zones, etc.)

The assumption going in is that the water quality standards will be equivalent, or less stringent, than those used in the two demonstration projects. The TRT left to the State/EPA to clearly define those standards.

For dredging, the TRT assumed that

- Standards would be applicable to the water column at a point of compliance downstream of the point of dredging. Acute standards would be applicable for this case since the source is moving around in a time scale of hours and days.

- The dredging options now call for dewatering the sediment at a treatment facility and discharge of the excess water back to the river, so standards would be applicable at some point of compliance downstream of the inflow point to the river. Chronic standards would apply in this case.

- Background standards for a number of the sediment constituents are already elevated above WQ standards. Need to have the state and EPA define whether background or WQS will apply

For capping, the TRT assumed that:

- Standards would be applicable in the water column at a point of compliance downstream of the capping activity, and would be an issue for sediment resuspension during capping. Acute standards would be applicable for this case since the source is moving around in a time scale of hours and days.

- WQ standards may also be applicable in the water column above a capped area, i.e. the flux of contaminants through the cap should not cause an exceedance of the WQ standard in the water column. Chronic standards would apply for this case.

- The issue of application of WQ standards applied to the pore water within the biologically active zone of the cap was discussed, but remain unresolved.

A draft Dredging Specification Document was developed by the TRT, and is given in Appendix A.

Recommendations concerning information needs

In addition to providing detailed information on specific technologies or project elements, the TRT offered several broad recommendations. These are particularly important because they cut across multiple possible remedies, and represent the minimum additional information that is needed to move the project as a whole towards detailed engineering and design. They include the following:

- The estimate of the in-place volume and acreage of sediment that exceeds the 1 ppm action level should be refined through additional sampling. This sampling program could be based on a geostatistical evaluation of PCB spatial variability (vertical and horizontal) across the project area, or more simply by defining sediment management units (SMU) within each operable unit, and sampling within those units..

- For purposes of defining the limits of any dredging that may occur, the vertical extent of PCBs in excess of the 1 ppm action level should be expressed as a "cut elevation." This means that PCB sample points need to be converted to a common and reproducible survey datum. Sampling points should also be accurately located in the x, y, and z dimension so that post-remediation samples can be taken at the same points. (It is generally felt that current technology allows for lateral reproducibility to within 1 meter.)

- To further determine the mass of dry solids that will result from removing in-place deposits and for designing handling and dewatering systems, additional sediment physical data is needed for some reaches of the river. The tests should include total solids, bulk density, grain size distribution (sieve and hydrometer) and specific gravity (of the solids.)

- To improve the confidence level in sizing of possible disposal facilities (as well as certain dewatering equipment), additional geotechnical testing is needed. The basic engineering properties of the sediment have not yet been adequately established. This should include routine Atterberg limits, column settling tests, consolidation tests and shear strength tests. (These basic tests are described in the COE design manuals.)

Discussion items and findings

This section includes many of the specific details discussed during one or more group sessions. It is organized by remedial technology or project element, recognizing that each individual item may have been discussed at multiple times during the week. The order in which the technologies/elements are presented generally follows the flowchart in Figure 1. A set of "general" items is listed first; the technology of in-place capping and the issue of contracting strategy are contained at the end.

General:

- The USEPA and WDNR provided some introductory comments on the goal of the remediation. The goal is to provide for long-term risk reduction, using a numeric action level, now set at 1 ppm, with a surface-weighted average concentration (SWAC) of between 0.25 – 0.35 ppm. There will be some flexibility in how the action level is attained, but it remains as the measure of success for the project. The agencies want to clearly define within the ROD how success is defined, so that the public's expectations can be satisfied.

- A program of pre-design sampling will be implemented. The scope of the program is being developed. The density of sample cores has not yet been determined; opinions varied from between 1 and 4 per acre, based on past experience.

- The amount of pre-design sampling (to support a dredging or capping option, for example) should be determined based on the Department's interest in securing firm bids for construction. Inadequate characterization will lead to significantly higher construction costs, because a higher-than-necessary volume could be removed.

Removal using either hydraulic or mechanical (hybrid) dredging (see Project Elements B and C on attached flowchart):

- Conventional hydraulic dredging, mechanical dredging and a hybrid form of mechanical dredging (where the solids can be processed back in to slurry form for transport), are considered feasible and implementable using current technology.

- A dredging contractor (using any of the methods identified above) would want to see the full horizontal and vertical variability in sediment physical characteristics. For this reason, samples from multiple stations should not be composited. A contractor may choose to do a certain amount of additional sampling to satisfy their own interests on the project.

- A dredging contract can make use of a "performance specification." The most straightforward means of establishing performance is to specify a "cut elevation" along with the tolerance (+/- elevation) for acceptance. This approach takes some of the risk out of the contractor's bid, allowing for competitive pricing. It requires that the state have a corresponding higher level of certainty that the goal of 1 ppm can be met by removal to a fixed elevation. This, in turn, impacts the degree of pre-design sampling that is desired, as discussed above.

- Using a "cut elevation" as part of a performance specification could form the basis for a "lump sum" method of payment. Any "cleanup passes" that are required could (although not necessarily) be a separate pay item. In either case, the normal re-deposition of disturbed and suspended sediment needs to be considered because it may mask the determination (for documentation and pay purposes) of whether a target elevation or concentration has been reached.

- Confirmation/documentation samples should be collected from the same locations as the pre-design samples from which the cut elevation was calculated. They should be collected as soon as possible after dredging so that the results are not biased by subsequent deposition or disturbance.

- To accomodate the "spillage" described above, a dredge operator would otherwise "overdredge." In an environmental project, however, this does not necessarily provide any further benefit, and would increase costs. This needs to be factored in to the calculation of the cut elevation and the writing of the dredging specification.

- For environmental projects using a hydraulic dredge, the average slurry solids concentration will probably fall within the range of 5 to 10%. It will vary depending on the in-place solids concentration, operator skill, the speed of the dredging and the presence of bulk debris.

- For either method, the presence of bulk debris will be an issue. It is likely to be a larger concern within OU3 and OU4, compared to OU1. Pre-dredge characterization and removal are recommended, wherever possible.

- The assumption within the FS of a dredging duration of 7 or 8 years (for OU3 and OU4) is reasonable, although some contractors may wish to expedite this schedule. This will have an effect of the sizing of downstream facilities (dewatering, water treatment, vitrification, etc.) The Department will have to decide if there are any limiting factors (such as availability or rate of disposal) that would otherwise constrain a bidder's ability to compress the schedule.

- Various passes and final capping should consider turbidity, ecological effects (on fish spawning and habitat, plants, etc.). Time of year in relation to fish spawning periods may be relevant.

"Hybrid" dredging followed by slurry processing (see Project Element D on attached flowchart):

- With this method, the mechanically dredged material (that might come out of the river at 80% sediment, or in the range of 30% to 40% solids) is pre-processed and then returned to a slurry condition for hydraulic conveyance to shore. Debris and coarse material are separated. The slurry itself may end up at 14 to 20% solids, which is often double the solids concentration in the slurry from a conventional hydraulic dredge.

- The supernatant (carriage water) can be returned to the dredge for use as slurry "makeup" water, thus reducing the amount of water that is treated for discharge.

Barge transfer of mechanically dredged solids (Project Element E):

- This process option could be implementable and cost-effective if a riverfront staging area (of sufficient size) could be secured.

- If 10 ft. or more of draft were available, river hopper barges could be used for transfer to the shore. Deck barges could operate in 5 or 6 ft. of water, but offer less containment without modifications.

- Considering this, barge transfer would only be feasible for OU3 and OU4. At OU1 there is insufficient draft, no navigational channel, impediments posed by railroad bridge crossings, and the potential for significant resuspension of material under heavy traffic.

- Typical production might be 150 c.y./hr/dredge. Could readily operate multiple dredges. May go with 18 hrs of production time per day.

- Dredged material would be allowed to drain within the landside containment area. This would result in a more limited quantity of decant water requiring treatment (compared to any method that puts the sediment solids in to a slurry.)

- Using mechanical dredging and landside decanting of free water, a facility (like the existing Bayport site) adjacent to the river could be a reasonable and cost-effective disposal option.

Slurry transport via a force main (Project Element F):

- With either a hydraulic dredge or a hybrid dredge there will be a certain length of floating pipe immediately behind the dredge to accomodate the dredge's operational movement. (This might be on the order of 1500 l.f.) This project element, however, covers the longer run of pipe that would convey the slurry to an upland processing or disposal location.

- For OU3 and OU4, the Department wishes to see concepts for both an overland route and in-water route. Both are considered to be feasible and practicable for this project.

- For any in-water piping, it is generally preferable to place it on the bottom as soon as possible (i.e. after allowing for a length of floating pipe immediately behind the dredge, as described above.) In-water placement of piping is almost always easier than overland piping. If anchored to the bottom in at least 3 ft. of water, ice impact should not be an issue. A requirement to take in-water piping out of the water at the end of each dredging season would greatly increase the cost.

- For an overland route, it is reasonable to lay the forcemain directly on the ground. This will facilitate inspection and maintenance. A shallow soil cover would not significantly add to the cost, but this impedes maintenance and inspection. The tradeoff in the reduction for vandalism potential would need to be considered. Road crossings would require burial, but this is a simple matter.

- There is little or no incremental benefit for providing a double-walled piping arrangement. Leaks are exceedingly rare, and the double-walled configuration is an impediment to routine maintenance and pipe rotation. Most contractors will inspect the forcemain at the beginning and end of each shift, and as soon as any unusual pressure changes are observed. For these reasons, a single-wall pipe design is recommended. (Note that road crossings may be double-cased, for physical protection, but this would not be a “double-walled” pipe, per se.)

- Steel pipe is generally easier to work with than HDPE pipe. It allows for higher working pressures, and would be preferred for this project. Salvaged natural gas piping, when available, is often an economical option.

- A representative forcemain length of 11 or 12 miles was discussed. Such lengths are not unreasonable. (Examples of 13-mile and 37-mile forcemains were cited.) At this length and using 15” pipe, a total of 5 booster pumps along the route would probably be needed. For a longer route, additional pumps would be needed.

- The booster pumps would be in-line pumps, housed in a building for security and sound-control. A continuous flow of seal water is needed at each pump, meaning that a water supply would have to be provided at each pump, either from local municipal services, from the river, or from a new dedicated well (for rural pump stations.)

Settling basins (passive) (Project Element G):

- There was general agreement that settling basins are feasible, but that the sizing assumptions in the FS should be re-visited. An arrangement of 2, 3 or more basins, configured to allow seasonal cycles of drainage and removal, is reasonable.

- If a drying additive is used (such as lime) the tonnage needs to be considered in the calculation of the total mass that goes to disposal.

- It had previously been assumed that Arrowhead Park was a feasible location for siting of a settling basin option for OU1. However, it is now apparent that this location is inappropriate from a geotechnical standpoint (the area is an historic fill location, with low-strength soil/fill material.) It may also lack sufficient acreage. The use of Arrowhead Park may also be received negatively by the public.

- An alternative to a set of land-based settling basins may be an in-water (near-shore) unit. Such a configuration may require a lake-bed grant from the state legislature. This could potentially create stakeholder concerns and may be difficult to achieve.

- Upland settling basins remain a feasible option for OU3 and OU4, and could be sited adjacent to a permanent disposal location (i.e. an NR500 landfill.) Even though the basins would be for a limited duration, there is nothing in state rules that distinguishes a "temporary" facility from a "permanent" facility. The performance requirements will be the same, and any such facility will have to be lined.

- For a land-based unit, the state's NR213 rules may apply. However, the Department is probably more inclined to regulate both a settling basin and its subsequent disposal facility under the NR500 rules, so that there is not a split in authority between the water program and the solid waste program.

- There does not appear to be an economic advantage to a separate dewatering arrangement, compared to a combined dewatering/disposal facility. (This kind of facility is permittable under state rules, and is discussed further below.)

- Use of a separate passive dewatering facility as a temporary facility for dewatering only would be regulated as a NR 213 facility. This type of facility would not necessarily require a liner, so would be less expensive and siting would not be as problematic.

- The comparative costs should be determined for a larger footprint NR 500 for passive dewatering and final disposal versus a NR 213 for passive dewatering with a smaller NR 500 footprint for final disposal.

Mechanical dewatering (Project Element H):

- The experience at the Deposit N and Area 56/57 demonstration projects confirms that mechanical dewatering is feasible and cost effective. It would be compatible with either hydraulic or hybrid dredging. (It would probably not be used with mechanical dredging, where the dredged material is already at a comparatively higher solids content, and would not otherwise be put back in to a slurry form.)

- Separation of coarse material (i.e. the sand fraction) from the dredge slurry prior to mechanical dewatering is recommended. For hydraulic dredging, this will be an additional processing step. With hybrid mechanical dredging and slurry processing, it is already an integral part of the process. Depending on its chemical characteristics and grain size distribution, the separated material could have beneficial re-use potential elsewhere on or off the project, such as for drainage layer material in a CDF (although there is some opinion that the sand is likely to be too fine for this to be implementable.)

- Using conventional filter presses, an average of 59% solids was achieved in the filter cake at the 56/57 demonstration project. The range of results was from 49% to over 60%. Belt presses may typically achieve results in the range of 40 or 44%. Establishing a performance-based specification of something at or above 50% would be reasonable.

- When calculating costs, need to include the cost of polymer.

- Downstream disposal costs will be highly sensitive to the percent solids achieved in the filter cake because as the water content decreases, so too does the total tonnage (and volume) destined for disposal.

- For a downstream process like vitrification, it is possible to handle wet (i.e. lower solids content) material. However, the rule-of-thumb is that it is cheaper to "press out" the water than to evaporate it via a thermal process, up to something on the order of 50% to 60% solids. (See additional discussion on vitrification below.)

Water treatment (referenced on flowchart as a sidestream from several project elements):

- The treatment facility for carriage water, decant water, etc. will be permitted under the states WPDES program.

- The Department expects that the discharge permit will require using "Best Demonstrated Available Technology" for PCB removal.

- The consensus of the group was that BDAT for this kind of project would be coagulation/flocculation, followed by sand filtration and granular activated carbon (GAC.)

- Other possible parameters, such as ammonia, BOD and mercury, are not expected to be limiting.

- A discharge limit will also be established for TSS, but it will not be based on the BDAT used for PCB removal (i.e. the TSS limit will be one that is achievable without going to the extent of GAC filtration.)

- The point of discharge is assumed to be the Fox River. A specific route for the discharge line has not yet been evaluated or proposed, since there is not yet a proposal for upland siting of the disposal facility. It would most likely be different than any overland slurry forcemain route, using a more direct path back to the river.

Transport to an upland disposal facility (Project Element I):

- If a dewatering facility can not be sited adjacent to a final disposal facility, either rail or truck transport will be required (unless a slurry forcemain is used.) It was generally agreed that rail transport would not be feasible for OU1 due to logistical considerations and the size of that particular project.

- If mechanical dredging was used, the process sequence would be: dredge in to a barge, transfer from barge to a landside stockpile, then move from stockpile in to a railcar. (Water-tight containers on flat cars, with a 34-capacity, may be used.)

- There was an opinion that for hauls of 100 miles or less, truck transport is cheaper. (An example was cited where wet, mechanically-dredged material was transported 250 miles by rail for something on the order of $20 to $30/ton.)

- On the other hand, it was generally agreed that building rail spurs to disposal or processing sites was not a significant technical or cost issue.

NR500 "wet" landfill (Project Element J):

(Note: The term "wet landfill" has been sometimes been used interchangeably with the term "confined disposal facility" or "CDF.")

- A wet landfill is feasible and implementable. From a regulatory standpoint, there is nothing that precludes the placement of a flowable, high-water content material (like a dredge slurry) to an NR500 landfill. (The closest analogy would probably be wet paper mill sludges or a mine tailings facility.)

- From a purely technical standpoint, it was felt that even conventional composite liners may not be needed. However, it became clear that regulatory and perception considerations would predominate, and that NR500 liner requirements would apply to any such facility (i.e. single composite liner - minimum 4 ft. of compacted clay overlain by a geomembrane.) (Deviating from this might invalidate USEPA's prior acceptance of Wisconsin's NR500 rules for PCB material less than 50 ppm.)

- General design considerations for CDFs include the following:

    a. To improve drainage of free water, using thinner annual lift heights is preferable (something on the order of a few feet per year is common.)
    b. Before long-term consolidation is considered, the "bulking" factor for fine-grained sediment is as high as 1.4
    c. After the last year of filling is complete, would ordinarily allow the unit to consolidate for a couple of years before placing the final cover.
    d. The design is insensitive to the incoming slurry solids concentration.
    e. As stated above, could remove coarse fraction (sand) first.
    f. Operation usually includes continuous removal of decant water.

- To illustrate these concepts, a series of calculations were performed to size a hypothetical CDF for the volume of sediment assumed to exceed the 1 ppm action level in OU4 (5,879,529 in-place cubic yards.) The settling test results from Montgomery Watson's 56/57 treatability work were used. (These values are reasonable, although probably on the conservative side.) For a 7 year fill period, and ignoring long-term consolidation but adding 20% volume for the construction of drainage layers, the total airspace required would be approximately 10,000,000 c.y.

- If a total fill height of 40 ft. were assumed, and before allowing for freeboard, the corresponding area for this hypothetical facility would be on the order of 155 acres. Such a facility would be sufficiently large that it would require a construction duration of several years. An important consideration will be the size of the landfill cells to be constructed, due to the limited construction season in Wisconsin. Limitations exist with respect to compacting clay and placing geomembrane during the winter months. Normally, the maximum amount of liner or cover that could be constructed in one season is 50 acres.

Disposal at a commercial landfill (Project Element K):

- Existing facilities within a 40-mile radius of the project site had previously been evaluated. Within this area, Superior's "Hickory Meadows" site is the closest site that can currently accept PCB sediments.

- Facilities that have previously been proposed by Brown County (the "Stock" site and the "Vandehey" sites) were also evaluated as potential destinations for OU3 and OU4 material.

- Brown County has signed a local agreement with the Town of Holland for the construction of an industrial/municipal landfill at the Stock site and the state has approved the Feasibility Report for the site. These are very significant milestones in the overall siting and permitting process. It is not clear, though, whether either of these properties would be available for use by the project. In addition, while the local agreement with the Town of Holland allows for the acceptance of PCB-contaminated sediments, a host fee of $10/ton (as received at the landfill) would be imposed.

- For this reason, the Department has indicated that other county-owned properties or commercial proposals should be considered. Several existing facilities within the state could obtain the necessary permit modifications and local agreement modifications within a relatively short period of time. However, negotiations at Holland took 6 years. The community may now on be board because of the dollars. But this may be a bigger step because of the publicity associated to the Fox River clean up if re-permitting were necessary for CDF.

- Town of Holland mostly rural, not a bedroom community yet. Wrightstown, has lots of expensive homes from young newcomers. Although they knew about it, he gets about 3 or 4 calls a week about the proposed Vandehey landfill site, and about 50% of people decide not to build there as a result. Residents in Wrightstown may be unwilling to allow permitting of a PCB facility.
- Brown County has access to over 700 acres south of the property, which makes it possible to use a site outside of the permitted area.

- The air-space requirements for the volumes of waste assumed in the FS should be re-visited and confirmed to the extent possible. The criteria for final sizing of a commercial landfill should be clearly developed, so that the state has this information available when entertaining possible proposals by counties or private developers.

NR500 "Monofill" (Project Element L):

- Brown County had planned for an "industrial process residue monofill" in its early permit documents for both the Stock and Vandehey properties. Such a monofill could be compatible with the disposal of PCB sediments. It would be designed in accordance with NR500 requirements. Each footprint was approximately 38 acres, with an anticipated design capacity of 3.7 million cubic yards (each.)

- If the county properties were to be made available, various combinations of dewatering and disposal facilities could be configured at one or both of the sites. The Stock site is conveniently located in proximity to an abandoned rail line, now used as a bike path, which could serve as an overland route for a slurry forcemain (see discussion above.) The Vandehey site is closer to the river, suggesting it could be used in conjunction with a predominantly in-water forcemain route. Depending on the as-received solids content, it appears that neither footprint alone would likely be able to accomodate the total amount of sediment that is anticipated to be removed from OU 3 and OU4.

Vitrification (Project Element M):

- Minergy, Inc. has developed a conceptual process design and cost information for vitrification of PCB sediments.

- The conceptual process (similar in some ways to their existing full-scale facility) would consist of the following operations:

  a. Material receiving (with or without stockpiling for year-round operation)
  b. Backmixing (if needed)
  c. Drying
  d. Lime addition (if needed)
  e. Melting (in a glass melter, compared to a boiler which they currently use)
  f. Air emissions control
  g. Product staging, prior to sale and removal off-site

- Design parameters for a single, “pro forma” facility include the following:

  a. Production – nominal 250 tons of glass per day
  b. Feedrate – nominal 600 tons per day of wet sediment
  c. Feed characteristics – assumed to be a filter cake material at 50% solids
  d. Gas residence time in melter – 16 sec.
  e. Emissions control – includes wet scrubber, electrostatic precipitator, GAC filter

- The process can be designed at the outset to accomodate any feed solids content required. This should be determined based on the upstream processing that will be performed. Once operating, an occasional swing of 10 or 20 percentage points in solids content could be accommodated. A range of, say, 40% to 60% solids in the as-delivered material would be reasonable. However, it would not be reasonable to all of a sudden change from, say, a 15% slurry to a 60% filter cake.

- Typical capital and operating costs have been calculated, and converted to a cost per ton, based on the estimates of material from OU3 and OU4. The cost is sensitive to the incoming solids content and to the length of time over which the facility would be operated. (The pro-forma is based on a nominal 15-year operational life.) As the solids content changes, the number of dryers becomes the critical factor. For general planning purposes, the following numbers are representative:

Feed solids, %	# dryers needed	$ / wet ton
15	16	$17
35	5	$28
50	3	$36
59	2	not calculated

- Depending on the solids content in the as-delivered material, Minergy could also design and construct a dewatering facility as a pre-process to drying.

- There was an opinion that the Minergy unit costs were low, especially compared to costs developed for thermal processes in Europe. Part of the difference may be in higher fuel costs in Europe. Another difference is that the proposed melter is a simpler and less energy-intensive unit than other options.

- The size of the system would depend not only on the dredge/dewatering production rate, but on the length of operation desired each year. If holding capacity for filter cake is constructed (such as a warehouse), the daily processing rate could be reduced and the season extended to year-round. These are decisions the customer would make (along with the feed solids content) and Minergy would design the final plant around them.

- Final design, equipment procurement and construction would require at least 18 months for a plant of this size. The time to secure an air permit will add to this.

- If large volumes of sediment are vitrified, there will have a very large volume of glass sand. We need to insure they present a definite plan for beneficial use of such a large volume of product.

In-place capping:

- Capping is considered as a remedy component, but not a full remedy alternative; i.e. capping is considered as an element for some areas within an OU, with a full dredging remedy in the other areas.

- Two approaches to capping are possible:
    1. *In-situ Capping (ISC).* In deeper water areas, capping sediments in-situ without prior dredging. These would be limited to areas outside federal navigation channels and areas not involving TSCA materials (see below).

2. *Residual Capping.* In shallow areas, initial dredging can be used to make sufficient room for the cap. The top of a cap could not extend about the –4 ft chart datum elevation. Once again, limited to areas not involving TSCA materials. In shallow areas with limited depth of contamination, necessary dredging may remove most of the contamination, and it makes little sense to cap a very thin residual thickness. Some depth of contamination filter on this should be developed to define potential shallow water areas.

- An example of where a combination approach may not make sense is for OU1 and OU3. In these areas, over 90% of the PCB mass is in the top meter (3 ft.) of sediment. It would not make sense to remove, say, 2 ft. and then cap.

- Criteria for selection of possible capping areas should include:

  a. Must maintain a post-cap water depth of at least 3 ft. (out of consideration for habitat and ice scour.)
  b. No construction within a federally-authorized navigation channel
  c. Areas involving TSCA materials will not be capped.

- The issue of post-cap water depth must consider the long-term natural fluctuation of water levels, and using the correct Lake Michigan chart datum. The natural fluctuation in Lake Michigan is +5 ft. to –1 ft. When sediment bed elevations are properly converted to this datum, the resulting top-of-cap elevation could be no higher than –4 ft.

- The federally-authorized navigation channel extends from the Menasha Channel in Little Lake Butte des Morts to the mouth of the Fox River at Green Bay. Federal law prohibits construction of long-term deed-restrictions within the federal channels. Unless specifically authorized by Congress, capping would not be allowed.

- Caps must be designed for the specific site they are beingproposed for; i.e., no single cap design can be applied to all areas of the River. The FS provided for an 18 inches armored sand cap, on the basis that it is a commonly employed depth for sand. The API Panel report suggests a 6 inch sand/armored cap based upon a computer model exercise, although they did not provide supporting details. Neither of these approaches is suitable for a 30% design, much less a final design.

- Cap design must consider the specific depth of sediments, the site bathymetry and hydrology, concentration of PCBs in the bulk sediments and porewater, potential for groundwater influx, consolidation of foundation and underlying sediments, advective flux during application, long term diffusive flux, and the need for armoring.

- Armoring design should be very conservative. The addition of an armoring layer to a cap usually makes sense. It is not possible to generalize a single design, since shear stresses (i.e. the stress induced on the sediment by the overlying water current) can vary by several orders or magnitude depending on local conditions. These local conditions must be examined, and incorporated into the site design.

- Conventional methods of placing cap material include jetting off of a barge, mechanical placement, or by a diffuser. The selection usually depends on water depth and other factors.

- Long-term performance criteria should be developed. Similarly, there may be future institutional issues that could affect the life (and hence acceptability) of a cap, such as dam removal or failure.

- There are a number of institution issues must be fully considered during capping design. These include:
  1. Dam maintenance – Safety issue for capping, and pressure to remove dams in general. But there are needs to keep the dams on the Fox (lamprey barrier, hydropower, intakes, rec use).
  2. Lake bed grants – These may present limits on cap thickness.
  3. Riparian owner issues – There will be limits on subsequent construction of piers, marinas, etc. in capped areas.
  4. Deed restrictions – Same as for riparian issues.
  5. Montoring and Maintenance – Must insure that cap performance is maintained at a minimum for 40 years (similar to landfills). But there would be some requirement for a longer period because of the nature of a capping remedy.
  6. Fiduciary responsibility – Same responsibility applies to cap as to an upland soil cover for site remediation.

- Long Term Liability – PRPs must be informed that a capping remedy would require a long-term commitment, and the question of release from liability will be an important issue.

Procurement strategy (not illustrated on attached flowchart):

(Note that this topic was a recurring one throughout the week. The summary below is based on comments made during various sessions, when contracting issues were raised while discussing a range of technologies.)

- In general, there is no single contracting method or form of construction specifications that will be applicable to the entire job. For example, the design and contracting for construction of an NR500 monofill or a vitrification plant could be completely independent from procurement of dredging services.

- Similarly, the state could secure an arrangement or agreement for disposal of, say, filter cake at a fixed unit price ($ per ton delivered.) Construction bidders could be allowed to either accept this option, or propose one that is lower in cost. This would provide for a minimum "implementable" project, while still allowing for innovation and possible savings.
- Possible to set the specifications in a way that the State secures contract with landfill at a fixed price and you just bid out that price and let the contractors tell you how they are going to do that or something else at that same price.
- Advantages: You may obtain lower prices because the contractors have the flexibility to choose the cheapest option.
- Disadvantages: State loses control over design, public impacts, and legal responsibilities. People of Wisconsin whose interests should be represented by the State Agency would lose any influence over the process. From a public perspective not acceptable. On the other hand,
- Set basic guidelines (elevation, baseline concentrations, etc.) but let contractors obtain whatever extra data they need, and come back with the technical specs of how they would do it.

- The contractors favor an arrangement where the dredging, conveyance and dewatering elements are bundled together. These elements could be combined, for example, in to a design-build project. The project could be put out for bid in such a way as to leave a certain degree of flexibility to accomodate a range of technical approaches (such as both hydraulic dredging and hybrid mechanical dredging.)

- A design-build contracting format may include certain performance-based specifications, but a design-build contract is not merely a performance specification. In a design-build project, the owner (in this case, the state) is an active participant in the design-construction continuum, making important decisions and providing approvals along the way. In fact, the owner may independently "design" the project in parallel, as a continuing check on the contractor's proposals.

- Further, if a design-build contracting format is selected for a part of the total project, a certain amount of upfront engineering and design work may still be performed prior to bidding. A representative process option may be selected, for example, and a design developed in sufficient detail so that there is confidence that the project can be done, and to establish a set of criteria against which a bidder's proposals can be judged.

- The form of bidding for a design-build project may separate the bidder's cost proposal from their technical proposal. Technical proposals could be reviewed against a set of evaluation criteria that are specified in the bidding documents. A complete design would not be required, but sufficient detail would be required to distinguish among a range of possible technical approaches. Non-responsive technical proposals could be rejected, before consideration of the cost proposals.

- If a performance-based specification is used to define the dredging element of the work, then it should contain the following minimum items:

  a. The "cut" elevation
  b. The tolerance for the cut elevation
  c. The manner in which performance will be measured
  d. How clean-up passes will be handled (i.e. either as integral to the work, or as a separate pay item.)

Attachments

1. Flowchart (8 x 11 drawing) – Active Remediation Technologies and Process Sequences Determined To Be Feasible for OU3/4 (by TRT)

Appendix B

Backup for PCB Interpolation and Dredge Management Unit (DMU) Calculations

- Memorandum, "PCB Interpolation Procedures with New and Existing Data For OU1," April 28, 2003
- Memorandum, "Developing Dredge Management Units And Estimating Sediment Dredge Volume," December 3, 2002 (With Accompanying CD Containing Data Tables)

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MEMORANDUM

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TO: Project File
FROM: Shashi Muttige
DATE: April 25, 2003

CLIENT: WDNR
TASK: WISCN1-15933
RE: PCB Interpolation Procedures with New and Existing Data for OU1

Purpose

The purpose of this memorandum is to summarize the procedures adopted to re-interpolate existing bed maps (2001 RI/FS) for Little Lake Butte des Morts utilizing additional sediment sampling data. Additional PCB data were the result of sampling events undertaken by Blasland, Bouck and Lee (BBL) and Foth and Van Dyke on behalf of the P.H. Glatfelter Company and CH2M HILL for WTMI.

Data Validation

Additional sediment sampling data were provided to WDNR in three formats: hard copy data reports (Form 1 and/or the reports included with the respective company comments), electronic data files from the individual companies, and the FoxView database assembled for the Fox River Group.

For the WTMI data, only Form 1s were submitted to WDNR for review. Pertinent information that is necessary to validate data, including an approved Sampling and Analysis Plan, core logs, methods and verification procedures for horizontal and vertical control during sampling, and a full data package were not part of any submittal given to WDNR. A separate data validation exercise for the Form 1 data was undertaken for the WTMI-collected soil/sediment (and one set of woodchip) samples in 2000 and 2001. While requested by WDNR, data validation reports were not provided. The information reviewed consisted of data validation worksheets and annotated sample result summary forms. The results of the review are given in the *Addendum to the Data Management Summary Report* (EcoChem, 2002), which is a separate paper in the *Responsiveness Summary*. Based upon the Form 1 review only, the overall data appear to be of acceptable quality. However, given the lack of a complete submittal, these data are considered not fully validated, but may be used to qualitatively support the evaluation of Little Lake Butte des Morts sediments.

BBL collected sediment samples in Little Lake Butte des Morts in 2001. Samples were analyzed for PCB congeners (one data set), PCB Aroclors, total organic carbon (TOC), and grain size. The data set consisted of 158 samples. A complete set of validation worksheets and a report were submitted with this data package. These data were also independently reviewed and are discussed in the *Addendum to the Data Management Summary Report* (EcoChem, 2002). Overall, the data were found to be of acceptable quality and are usable for the intended purpose.

BBL also collected samples in August 2002. Those data have not been provided, and thus are not included in this analysis.

Foth and Van Dyke collected sediment samples in Little Lake Butte de Morts in 2002. Samples were analyzed for PCB Aroclors and TOC. The data set consisted of 47 samples. The electronic data files submitted included core logs. However, the data validation reports were not provided with the data package. Therefore RETEC took the PCB data for face value to be used for interpolation.

Procedures

To begin the process, it was necessary to create an electronic set of data that included the coordinates, sample interval, and resultant total PCB concentrations for each new sample date. WDNR had received a working copy of the FoxView database, and it was initially thought that querying that database would provide the information to complete the evaluation. However, FoxView did not contain the CH2M HILL data for Little Lake Butte des Morts. As such, the electronic data files that were provided to WDNR as part of the WTMI response was placed into a new spreadsheet with the files generated from FoxView. The spreadsheet created was reviewed to ensure data were not duplicated. Upon further review, it was determined that additional data was not in either electronic format provided. Therefore, a 100 percent check was undertaken against the hard copy data provided. The resultant graphics generated were subsequently checked against graphics provided by the respective companies.

The following steps summarize the procedure for developing the figures with the new PCB sampling data.

1) The Access database file and Excel file were converted to a dbf format file.
2) The latitude/longitude data provided in the Access database file and Excel file were in degrees, minutes, and seconds format. The data was converted to decimal degrees coordinates.
3) The data was filtered to show records by station ID and PCB sampling results for primary sediment samples in the Little Lake Butte des Morts Reach. The resulting dbf file was converted to a shape file and projected in Wisconsin Transverse Mercator (WTM) projection. Separate shape files were created for each depth interval (0 to 10 cm, 10 to 30 cm, 30 to 50 cm, 50 to 100 cm, and 100 to 150 cm).
4) The PCB data in the data set were not presented in a consistent format (CH2MHill and BBL only). Certain PCB samples were provided solely as individual Aroclors, while other samples were reported as total PCBs. To present data in a manner consistent with the Remedial Investigation, all data were expressed as total PCBs. A script was written in ArcView GIS that calculated total PCB values for a particular sample ID by summing the individual Aroclors for that particular location. Consistent with the RI, non-detected Aroclors were calculated as 50 percent of the method detection limit (MDL) for samples with non-detect values. For sample locations where total PCB values were provided, the script selected either the given

total PCB value for a particular sampling location or 50 percent of the MDL for samples with non-detect values.

5) Scripts on all shape files created in Step 3 (CH2MHill and BBL only) were run to sum up the PCB values for each sampling location. Running the script creates a new table with the total PCB values. Separate shape files were created for the script output tables based on depth interval and the shape files were projected in WTM projection to represent the new PCB sampling locations.
6) A script was not required for data from Foth and Van Dyke as the PCB values were expressed consistently as total PCBs and the data set was relatively small. The total PCB data from Foth and Van Dyke was added to the PCB data created from the script as explained in Step 5 to create a master dbf file of new data.
7) The new PCB sampling locations were overlaid on the interpolated PCB distribution map from the Draft 2001 RI/FS for each depth interval for comparison purposes. Five maps, corresponding to the five depth intervals, were generated for Little Lake Butte des Morts with the new sampling data.
8) The output table from the script with total PCB values was randomly checked and manual calculations completed by summing individual PCB Aroclors to verify the results obtained from the script. During the process of quality assurance (QA), certain sampling locations (BBL) were identified to have two total PCB values for the same sample ID and depth interval. The higher of the two PCB values was selected for presenting the data on the map. Also certain sampling data (approximately six sampling locations by BBL) were identified with the sampling depth range specified as 10 to 100 cm. The PCB samples were assumed to be collected from the 50- to 100-cm depth range for presentation purposes.
9) WTMI has a provided a map with the new PCB sampling points presented in the report Appendix to WTM Comments I dated January 2002. The map generated by WDNR with the new sediment sampling data was checked against the map provided by WTMI as part of QA.
10) Prior to re-interpolating new PCB data, RETEC wanted to ensure that the interpolation procedure specified by WDNR in Technical Memorandum 2e can be followed to recreate the PCB grids produced by WDNR for 2001 RI/FS. The first attempt at recreating bed maps revealed a difference of less than 1% between our PCB grids and the grids created by WDNR. It was discovered that the reason for the difference was a slightly different implementation of the data. WDNR interpolated the PCB data separately within the boundaries of each of the 4 reaches in the lower Fox River, and then merged the resulting 4 grids into a single grid. During our initial attempt, we simply set the PCB data to interpolate within the boundary of the Fox River as a whole. During our second attempt we implemented the WDNR approach and the grid was a 100% match with their original interpolation. The PCB bed map created by RETEC were overlaid on top of the bed maps created for 2001 RI/FS for comparison and determined that the bed maps were similar.

11) Upon verifying that our process of interpolation was correct, PCB bed maps were created incorporating new PCB data. To be consistent with the procedure specified by WDNR in Technical Memorandum 2e, RETEC utilized all the new data created in Step 6 and the existing PCB data supplied by WDNR to initiate a filtering process. This procedure involved using all the new PCB data and filtering existing PCB data so that only data points that fall beyond 133-meter radius of the new PCB data points are retained.
12) The newly created bed maps were clipped to previously masked grids, which represented the presence of soft sediment within the lower Fox River. This resulted in the creation of new PCB bed maps for six depth intervals (0 to 10 cm, 10 cm to 30 cm, 30 cm to 50 cm, 50 cm to 100 cm, 100 cm to 150 cm and 150 cm to 200 cm).
13) The newly created PCB grid data was used to run the ArcView GIS script to calculate sediment dredge volume.
14) The newly created PCB grid data was used to run the ArcView GIS script to create a depth of dredge cut grid for OU 1 to assist with Dredge Management Unit sediment volume calculations.
15) Upon checking the PCB volume breakdown by depth interval and comparing those depth intervals for the old and new PCB interpolated grids, we noticed that sediment volumes reduced significantly for new PCB grids at lower depth intervals (> 30 cm), particularly for Deposits A and B. Upon further examining the data, it was determined that the filtering process described in Step 11 was the potential reason for eliminating PCB data in the new grids that were apparent in the old grids. The filtering process caused some of the PCB data greater than 1 ppm to be eliminated because they were within the 133 m radius (as specified in Technical Memorandum 2e) of the newly collected data that showed possibly non-detects at the same strata. We discussed the issue with WDNR on December 20,2002 and received authorization from WDNR to proceed with the PCB interpolation by utilizing the new PCB data and historical data excluding 1989/1990 Mass Balance Sediment Data. Upon checking the PCB bed maps with the PCB sample data points, we noticed that several 1989/1990 Mass Balance Sediment Data points were collected in locations (i.e., Deposit G and H) where no other sampling data existed. Therefore the filtering process was adopted to retain all the 1989/1990 Mass Balance Sediment Data that were outside 133 m radius of the retained PCB data (i.e., PCB data from 1992 to 2002). Table 1 lists all the PCB data points that were utilized for PCB interpolation while Table 2 lists PCB data points that were discarded. The final PCB interpolation was completed in ArcView GIS utilizing data from Table 1.

Table 1 PCB Data Retained for 2002 Interpolation

Station ID	Total PCB (ug/kg)	Start Depth (cm)	End Depth (cm)	Easting	Northing	Source
11001	2955	0.00000	10.00000	643039.68956	418084.06494	2000-01 CH2M Hill
11002	2732	0.00000	10.00000	643136.15972	418052.54146	2000-01 CH2M Hill
11003	2135	0.00000	10.00000	643041.56468	417984.09893	2000-01 CH2M Hill
11004	406	0.00000	10.00000	642951.41559	418104.63219	2000-01 CH2M Hill
11005	2890	0.00000	10.00000	643201.51678	417975.98992	2000-01 CH2M Hill
11006	3150	0.00000	10.00000	643150.46560	418141.70003	2000-01 CH2M Hill
11007	2598	0.00000	10.00000	643263.32702	418088.26368	2000-01 CH2M Hill
11008	4342	0.00000	10.00000	643197.13577	418209.24396	2000-01 CH2M Hill
11009	236	0.00000	10.00000	643021.42390	418205.94602	2000-01 CH2M Hill
11010	2248	0.00000	10.00000	642889.80837	417981.25414	2000-01 CH2M Hill
11011	1905	0.00000	10.00000	642955.37132	417893.59286	2000-01 CH2M Hill
11012	2698	0.00000	10.00000	643115.11696	417896.58903	2000-01 CH2M Hill
11013	295	0.00000	10.00000	642658.41149	416254.68715	2000-01 CH2M Hill
11014	2900	0.00000	10.00000	642896.42568	416348.02928	2000-01 CH2M Hill
11015	3523	0.00000	10.00000	642898.08960	416259.17083	2000-01 CH2M Hill
11016	226	0.00000	10.00000	642947.89783	416160.10288	2000-01 CH2M Hill
11017	10080	0.00000	10.00000	642925.59385	416070.79553	2000-01 CH2M Hill
11018	605	0.00000	10.00000	642927.88207	415948.61522	2000-01 CH2M Hill
11019	5180	0.00000	10.00000	642863.96489	415947.41849	2000-01 CH2M Hill
11020	8880	0.00000	10.00000	642665.88422	415854.82430	2000-01 CH2M Hill
11021	365	0.00000	10.00000	642906.20086	415825.98608	2000-01 CH2M Hill
11022	385000	0.00000	10.00000	642708.11699	415733.39071	2000-01 CH2M Hill
11023	142	0.00000	10.00000	642675.01285	416221.66388	2000-01 CH2M Hill
11024	142	0.00000	10.00000	642673.35197	416310.52231	2000-01 CH2M Hill
11025	525	0.00000	10.00000	642944.36066	416348.92706	2000-01 CH2M Hill
11026	2192	0.00000	10.00000	643056.20893	416351.02327	2000-01 CH2M Hill
11027	375	0.00000	10.00000	642969.99304	416260.51765	2000-01 CH2M Hill
11028	1280	0.00000	10.00000	643057.87502	416262.16483	2000-01 CH2M Hill
11029	614	0.00000	10.00000	642971.86602	416160.55191	2000-01 CH2M Hill
11030	1338	0.00000	10.00000	643115.46673	416174.35521	2000-01 CH2M Hill
11031	263	0.00000	10.00000	642990.13424	416038.67098	2000-01 CH2M Hill
11032	1333	0.00000	10.00000	643124.70628	416107.86126	2000-01 CH2M Hill
11034	1673	0.00000	10.00000	642862.30159	416036.27688	2000-01 CH2M Hill
11035	38980	0.00000	10.00000	642866.25187	415825.23820	2000-01 CH2M Hill
11036	2105	0.00000	10.00000	642883.47907	415758.89353	2000-01 CH2M Hill
11037	10615	0.00000	10.00000	642908.48855	415703.80581	2000-01 CH2M Hill
11038	655	0.00000	10.00000	643043.69306	415739.67233	2000-01 CH2M Hill
11039	22780	0.00000	10.00000	642669.41284	415666.00026	2000-01 CH2M Hill
11040	78000	0.00000	10.00000	642780.64940	415701.41344	2000-01 CH2M Hill
11041	16700	0.00000	10.00000	642708.73989	415700.06882	2000-01 CH2M Hill
11042	42800	0.00000	10.00000	642780.02614	415734.73533	2000-01 CH2M Hill
11043	70300	0.00000	10.00000	642675.32705	415777.22254	2000-01 CH2M Hill
11044	12180	0.00000	10.00000	642618.56813	415820.60673	2000-01 CH2M Hill
11045	57850	0.00000	10.00000	642778.98736	415790.27181	2000-01 CH2M Hill
11046	5980	0.00000	10.00000	642730.42531	415822.69720	2000-01 CH2M Hill
11047	2408	0.00000	10.00000	642617.53069	415876.14321	2000-01 CH2M Hill
11048	33000	0.00000	10.00000	642705.41773	415877.78558	2000-01 CH2M Hill
11049	4160	0.00000	10.00000	642640.25471	415943.23481	2000-01 CH2M Hill
11050	2888	0.00000	10.00000	642752.10979	415945.32570	2000-01 CH2M Hill
11051	4070	0.00000	10.00000	642111.35344	415588.92869	2000-01 CH2M Hill
11052	8680	0.00000	10.00000	641938.87297	415407.94456	2000-01 CH2M Hill
11053	8640	0.00000	10.00000	641939.49190	415374.62269	2000-01 CH2M Hill
11054	5450	0.00000	10.00000	642027.38547	415376.25584	2000-01 CH2M Hill
11055	14000	0.00000	10.00000	642024.49502	415531.75790	2000-01 CH2M Hill
11056	1575	0.00000	10.00000	642157.43358	415689.78627	2000-01 CH2M Hill
11058	367	0.00000	10.00000	642224.86880	415502.15210	2000-01 CH2M Hill
11059	5150	0.00000	10.00000	642138.01012	415444.97982	2000-01 CH2M Hill
11060	323	0.00000	10.00000	642225.90280	415446.61564	2000-01 CH2M Hill
11061	217	0.00000	10.00000	642227.14359	415379.97190	2000-01 CH2M Hill
11062	3280	0.00000	10.00000	642140.48989	415311.69235	2000-01 CH2M Hill
11063	4760	0.00000	10.00000	642052.59543	415310.05771	2000-01 CH2M Hill
11064	9660	0.00000	10.00000	642102.25554	414788.75824	2000-01 CH2M Hill
11065	9540	0.00000	10.00000	642103.28826	414733.22184	2000-01 CH2M Hill
11066	4680	0.00000	10.00000	642101.63589	414822.08008	2000-01 CH2M Hill
11067	2882	0.00000	10.00000	642123.95618	414911.38416	2000-01 CH2M Hill
11068	774	0.00000	10.00000	642197.52791	414823.86395	2000-01 CH2M Hill
11069	2870	0.00000	10.00000	642174.17491	414790.09601	2000-01 CH2M Hill
11070	4570	0.00000	10.00000	642183.19935	414734.70831	2000-01 CH2M Hill
11071	2060	0.00000	10.00000	642266.00582	414580.69386	2000-01 CH2M Hill
11072	11150	0.00000	10.00000	642179.34149	414512.41407	2000-01 CH2M Hill
11073	844	0.00000	10.00000	642291.22081	414514.49662	2000-01 CH2M Hill
11074	251	0.00000	10.00000	642220.33202	414457.62125	2000-01 CH2M Hill
11075	932	0.00000	10.00000	642308.23794	414459.25790	2000-01 CH2M Hill
11076	502	0.00000	10.00000	642245.54694	414391.42385	2000-01 CH2M Hill
11077	674	0.00000	8.00000	642333.45375	414393.06083	2000-01 CH2M Hill
11078	2520	0.00000	10.00000	642246.58075	414335.88749	2000-01 CH2M Hill
11079	1578	0.00000	10.00000	642247.82130	414269.24385	2000-01 CH2M Hill
11080	2500	0.00000	10.00000	642383.67982	414271.77423	2000-01 CH2M Hill
12000	1675	0.00000	10.00000	643372.84766	418212.54661	2000-01 CH2M Hill
12001	2530	0.00000	10.00000	643118.03541	417741.08640	2000-01 CH2M Hill
12002	1435	0.00000	10.00000	642958.28598	417738.09024	2000-01 CH2M Hill
12003	3340	0.00000	10.00000	642758.59920	417734.35049	2000-01 CH2M Hill

12004	192	0.00000	10.00000	642495.01265	417729.42335	2000-01 CH2M Hill
12005	2440	0.00000	10.00000	642579.96908	417886.56717	2000-01 CH2M Hill
12006	3220	0.00000	10.00000	642755.68928	417889.85311	2000-01 CH2M Hill
12007	1158	0.00000	10.00000	642642.20600	417976.62017	2000-01 CH2M Hill
12090	852	0.00000	10.00000	642970.53541	415804.96861	2000-01 CH2M Hill
12092	1550	0.00000	10.00000	642844.77684	415691.50202	2000-01 CH2M Hill
12093	70650	0.00000	10.00000	642662.25305	415621.42178	2000-01 CH2M Hill
12094	8625	0.00000	10.00000	642774.11363	415623.51293	2000-01 CH2M Hill
12095	1133	0.00000	10.00000	642901.74634	415637.01245	2000-01 CH2M Hill
12097	1138	0.00000	10.00000	642854.63766	415591.68590	2000-01 CH2M Hill
12098	1778	0.00000	10.00000	642687.67628	415544.11867	2000-01 CH2M Hill
12099	1578	0.00000	10.00000	642783.97341	415523.69673	2000-01 CH2M Hill
12100	1090	0.00000	10.00000	642895.62776	415536.89722	2000-01 CH2M Hill
12101	8740	0.00000	10.00000	642840.73592	415480.31392	2000-01 CH2M Hill
12102	23475	0.00000	10.00000	642742.98419	415578.48609	2000-01 CH2M Hill
12103	326	0.00000	10.00000	642962.66959	415371.48480	2000-01 CH2M Hill
12104	455	0.00000	10.00000	643147.28111	415330.50037	2000-01 CH2M Hill
12112	77	0.00000	10.00000	643827.06394	414887.72608	2000-01 CH2M Hill
12117	216	0.00000	10.00000	642142.55632	415200.61948	2000-01 CH2M Hill
12118	226	0.00000	10.00000	642128.84797	415078.14204	2000-01 CH2M Hill
12119	560	0.00000	10.00000	642114.51924	414988.98652	2000-01 CH2M Hill
12132	745	0.00000	10.00000	642980.18999	415716.25992	2000-01 CH2M Hill
12133	850	0.00000	10.00000	642989.84475	415627.55124	2000-01 CH2M Hill
12134	873	0.00000	10.00000	642799.95374	415523.99564	2000-01 CH2M Hill
12135	16400	0.00000	10.00000	642841.35943	415446.99204	2000-01 CH2M Hill
DA01S-02	1050	0.00000	10.00000	642108.80065	414866.65780	2001 Blasland, Bouck, and Lee
DA01S-03	406	0.00000	10.00000	642220.46716	414879.84655	2001 Blasland, Bouck, and Lee
DA01S-04	178	0.00000	9.00000	642363.88996	414904.74008	2001 Blasland, Bouck, and Lee
DA01S-06	542	0.00000	10.00000	642286.67007	414758.85672	2001 Blasland, Bouck, and Lee
DA01S-08	418	0.00000	10.00000	642018.89473	414542.76414	2001 Blasland, Bouck, and Lee
DA01S-09	1663	0.00000	10.00000	642200.21510	414679.46933	2001 Blasland, Bouck, and Lee
DA01S-11	314	0.00000	10.00000	642305.13480	414625.86705	2001 Blasland, Bouck, and Lee
DA01S-12	152	0.00000	10.00000	642384.84023	414638.46322	2001 Blasland, Bouck, and Lee
DA01S-13	2630	0.00000	10.00000	642121.74931	414600.23173	2001 Blasland, Bouck, and Lee
DA01S-14	1554	0.00000	10.00000	642193.87745	414590.46240	2001 Blasland, Bouck, and Lee
DA01S-17	2490	0.00000	10.00000	642148.61559	414445.17576	2001 Blasland, Bouck, and Lee
DA01S-18	99	0.00000	10.00000	642380.36796	414449.49059	2001 Blasland, Bouck, and Lee
DA01S-19	110700	0.00000	10.00000	641941.86887	414385.77788	2001 Blasland, Bouck, and Lee
DA01S-20	5800	0.00000	10.00000	642142.27683	414356.16894	2001 Blasland, Bouck, and Lee
DA01S-21	25550	0.00000	10.00000	642024.05435	414265.08231	2001 Blasland, Bouck, and Lee
DA01S-22	77000	0.00000	10.00000	642168.11116	414256.64944	2001 Blasland, Bouck, and Lee
DA01S-23	137	0.00000	10.00000	642304.38361	414236.96362	2001 Blasland, Bouck, and Lee
DA01S-24	305	0.00000	10.00000	642368.31735	414238.15458	2001 Blasland, Bouck, and Lee
DE01S-01	89	0.00000	10.00000	643123.80446	417007.85315	2001 Blasland, Bouck, and Lee
DE01S-02	1200	0.00000	10.00000	642955.00812	417060.24408	2001 Blasland, Bouck, and Lee
DE01S-03	2600	0.00000	10.00000	642786.83819	417079.31736	2001 Blasland, Bouck, and Lee
DE01S-03	2700	0.00000	10.00000	642786.83819	417079.31736	2001 Blasland, Bouck, and Lee
DE01S-04	760	0.00000	10.00000	642602.69290	417098.09639	2001 Blasland, Bouck, and Lee
DE01S-05	1800	0.00000	10.00000	642808.10033	417224.16102	2001 Blasland, Bouck, and Lee
DE01S-06	960	0.00000	10.00000	643031.97523	417217.24395	2001 Blasland, Bouck, and Lee
DE01S-06	1100	0.00000	10.00000	643031.97523	417217.24395	2001 Blasland, Bouck, and Lee
DE01S-07	2400	0.00000	10.00000	642631.94707	417243.08866	2001 Blasland, Bouck, and Lee
DE01S-08	83	0.00000	10.00000	642462.53912	417328.81404	2001 Blasland, Bouck, and Lee
DE01S-08	0	0.00000	10.00000	642462.53912	417328.81404	2001 Blasland, Bouck, and Lee
DE01S-09	810	0.00000	10.00000	642885.90090	417336.72988	2001 Blasland, Bouck, and Lee
DE01S-10	2050	0.00000	10.00000	642748.65094	417411.93912	2001 Blasland, Bouck, and Lee
DE01S-10	2360	0.00000	10.00000	642748.65094	417411.93912	2001 Blasland, Bouck, and Lee
DE01S-11	870	0.00000	10.00000	642963.07420	417482.62170	2001 Blasland, Bouck, and Lee
DE01S-12	1450	0.00000	10.00000	642746.36499	417534.11969	2001 Blasland, Bouck, and Lee
DE01S-12	890	0.00000	10.00000	642746.36499	417534.11969	2001 Blasland, Bouck, and Lee
DE01S-13	2340	0.00000	10.00000	642577.79286	417575.41272	2001 Blasland, Bouck, and Lee
DE01S-14	1690	0.00000	10.00000	643057.26084	417573.27755	2001 Blasland, Bouck, and Lee
DE01S-15	660	0.00000	10.00000	643216.59710	417598.49070	2001 Blasland, Bouck, and Lee
DE01S-15	630	0.00000	10.00000	643216.59710	417598.49070	2001 Blasland, Bouck, and Lee
DE01S-16	95	0.00000	10.00000	642615.23993	417709.44699	2001 Blasland, Bouck, and Lee
DE01S-16	2570	0.00000	10.00000	642615.23993	417709.44699	2001 Blasland, Bouck, and Lee
DE01S-17	83	0.00000	10.00000	643332.65303	417800.67406	2001 Blasland, Bouck, and Lee
DE01S-18	1000	0.00000	10.00000	643196.24137	417831.44459	2001 Blasland, Bouck, and Lee
DE01S-19	1060	0.00000	10.00000	643329.93826	417945.06937	2001 Blasland, Bouck, and Lee
DE01S-19	910	0.00000	10.00000	643329.93826	417945.06937	2001 Blasland, Bouck, and Lee
DE01S-20	180	0.00000	10.00000	643457.31583	417969.68799	2001 Blasland, Bouck, and Lee
DE01S-20	260	0.00000	10.00000	643457.31583	417969.68799	2001 Blasland, Bouck, and Lee
DE01S-21	640	0.00000	10.00000	643375.35467	418079.25858	2001 Blasland, Bouck, and Lee
DE01S-21	790	0.00000	10.00000	643375.35467	418079.25858	2001 Blasland, Bouck, and Lee
DE01S-22	330	0.00000	10.00000	643574.40356	418116.33930	2001 Blasland, Bouck, and Lee
DE01S-23	640	0.00000	10.00000	643477.93197	418147.85636	2001 Blasland, Bouck, and Lee
DE01S-23	780	0.00000	10.00000	643477.93197	418147.85636	2001 Blasland, Bouck, and Lee
DE01S-24	440	0.00000	10.00000	643603.63062	418261.33665	2001 Blasland, Bouck, and Lee
DE01S-25	2100	0.00000	10.00000	643268.18293	418255.02382	2001 Blasland, Bouck, and Lee
DE01S-25	2400	0.00000	10.00000	643268.18293	418255.02382	2001 Blasland, Bouck, and Lee
DE01S-26	1100	0.00000	10.00000	643483.82786	418259.08010	2001 Blasland, Bouck, and Lee
DE01S-27	1300	0.00000	10.00000	643147.54601	418297.20276	2001 Blasland, Bouck, and Lee
DE01S-28	2000	0.00000	10.00000	642905.28694	417581.53991	2001 Blasland, Bouck, and Lee
DE01S-28	1900	0.00000	10.00000	642905.28694	417581.53991	2001 Blasland, Bouck, and Lee
DE01S-29	2200	0.00000	10.00000	643345.75370	418378.70606	2001 Blasland, Bouck, and Lee

DE01S-29	3200	0.00000	10.00000	643345.75370	418378.70606	2001 Blasland, Bouck, and Lee
DE01S-30	670	0.00000	10.00000	643657.44445	418373.46385	2001 Blasland, Bouck, and Lee
DE01S-30	730	0.00000	10.00000	643657.44445	418373.46385	2001 Blasland, Bouck, and Lee
DE01S-31	1500	0.00000	10.00000	643513.26525	418392.96971	2001 Blasland, Bouck, and Lee
DE01S-31	1300	0.00000	10.00000	643513.26525	418392.96971	2001 Blasland, Bouck, and Lee
DE01S-32	210	0.00000	10.00000	643185.39385	418409.02605	2001 Blasland, Bouck, and Lee
DE01S-33	86	0.00000	10.00000	643286.71489	418544.26502	2001 Blasland, Bouck, and Lee
DE01S-33	96	0.00000	10.00000	643286.71489	418544.26502	2001 Blasland, Bouck, and Lee
DE01S-34	1400	0.00000	10.00000	643798.68941	418509.46394	2001 Blasland, Bouck, and Lee
DE01S-34	130	0.00000	10.00000	643798.68941	418509.46394	2001 Blasland, Bouck, and Lee
DE01S-35	2100	0.00000	10.00000	643479.01821	418514.54893	2001 Blasland, Bouck, and Lee
DE01S-36	1700	0.00000	10.00000	643605.96547	418561.38539	2001 Blasland, Bouck, and Lee
DE01S-36	1400	0.00000	10.00000	643605.96547	418561.38539	2001 Blasland, Bouck, and Lee
DE01S-37	63	0.00000	10.00000	643397.27194	418613.01188	2001 Blasland, Bouck, and Lee
DE01S-38	1000	0.00000	10.00000	643748.04552	418652.95507	2001 Blasland, Bouck, and Lee
DE01S-38	960	0.00000	10.00000	643748.04552	418652.95507	2001 Blasland, Bouck, and Lee
DE01S-39	1300	0.00000	10.00000	643516.23142	418659.69635	2001 Blasland, Bouck, and Lee
PD-A/B-01	4400	0.00000	10.00000	642141.22141	414728.82286	2001 Blasland, Bouck, and Lee
PD-A/B-02	600	0.00000	10.00000	642244.82822	414728.85077	2001 Blasland, Bouck, and Lee
PD-A/B-03	13000	0.00000	10.00000	642057.47161	414543.52700	2001 Blasland, Bouck, and Lee
PD-A/B-06	1000	0.00000	10.00000	642218.39705	414431.43103	2001 Blasland, Bouck, and Lee
PD-A/B-07	15000	0.00000	10.00000	641970.34345	414342.35405	2001 Blasland, Bouck, and Lee
PD-A/B-08	12000	0.00000	10.00000	642054.17438	414339.35971	2001 Blasland, Bouck, and Lee
PD-A/B-09	340	0.00000	10.00000	642231.82970	414339.40733	2001 Blasland, Bouck, and Lee
PD-A/B-11	280000	0.00000	10.00000	642133.73163	414250.70571	2001 Blasland, Bouck, and Lee
PD-A/B-12B	800	0.00000	10.00000	642322.35718	414250.75626	2001 Blasland, Bouck, and Lee
PD-A/B-13	22000	0.00000	10.00000	641992.96960	414170.52509	2001 Blasland, Bouck, and Lee
PD-A/B-14	23000	0.00000	10.00000	642133.14363	414170.56257	2001 Blasland, Bouck, and Lee
PD-A/B-15	90	0.00000	10.00000	642418.36748	414170.63895	2001 Blasland, Bouck, and Lee
14	183	0.00000	10.00000	642496.94858	414880.52998	1989/90 Mass Balance Sediment Data
29	435	0.00000	10.00000	643135.30380	416661.60901	1989/90 Mass Balance Sediment Data
42	940	0.00000	10.00000	644051.08755	419679.07450	1989/90 Mass Balance Sediment Data
43	1715	0.00000	10.00000	644295.01789	419790.82538	1989/90 Mass Balance Sediment Data
44	1300	0.00000	10.00000	644254.51903	419837.82585	1989/90 Mass Balance Sediment Data
47	2250	0.00000	10.00000	643197.98899	417339.95912	1989/90 Mass Balance Sediment Data
109	1955	0.00000	10.00000	642859.99792	418539.78326	1989/90 Mass Balance Sediment Data
110	1395	0.00000	10.00000	642976.18205	418542.40820	1989/90 Mass Balance Sediment Data
151	130	0.00000	10.00000	645230.80297	420156.07815	1989/90 Mass Balance Sediment Data
163	1400	0.00000	10.00000	643155.49084	416478.32594	1989/90 Mass Balance Sediment Data
262	1300	0.00000	10.00000	643682.78605	419234.91426	1989/90 Mass Balance Sediment Data
263	118	0.00000	10.00000	643141.67726	418534.81431	1989/90 Mass Balance Sediment Data
264	120	0.00000	10.00000	644210.02023	419966.51460	1989/90 Mass Balance Sediment Data
289	320	0.00000	10.00000	643016.24329	418675.44074	1989/90 Mass Balance Sediment Data
290	430	0.00000	10.00000	642901.93416	418602.47133	1989/90 Mass Balance Sediment Data
292	230	0.00000	10.00000	645313.48810	420120.20275	1989/90 Mass Balance Sediment Data
295	2040	0.00000	10.00000	645963.15634	420671.17618	1989/90 Mass Balance Sediment Data
11001	5030	10.00000	30.00000	643039.68956	418084.06494	2000-01 CH2M Hill
11002	15675	10.00000	30.00000	643136.15972	418052.54146	2000-01 CH2M Hill
11003	2815	10.00000	30.00000	643041.56468	417984.09893	2000-01 CH2M Hill
11004	138	10.00000	20.00000	642951.41559	418104.63219	2000-01 CH2M Hill
11005	3075	10.00000	30.00000	643201.51678	417975.98992	2000-01 CH2M Hill
11006	4245	10.00000	30.00000	643150.46560	418141.70003	2000-01 CH2M Hill
11007	4600	10.00000	30.00000	643263.32702	418088.26368	2000-01 CH2M Hill
11008	10920	10.00000	30.00000	643197.13577	418209.24396	2000-01 CH2M Hill
11010	456	10.00000	30.00000	642889.80837	417981.25414	2000-01 CH2M Hill
11011	2760	10.00000	30.00000	642955.37132	417893.59286	2000-01 CH2M Hill
11012	2778	10.00000	30.00000	643115.11696	417896.58903	2000-01 CH2M Hill
11013	77	10.00000	30.00000	642658.41149	416254.68715	2000-01 CH2M Hill
11014	14300	10.00000	30.00000	642896.42568	416348.02928	2000-01 CH2M Hill
11015	27750	10.00000	30.00000	642898.08960	416259.17083	2000-01 CH2M Hill
11017	43100	10.00000	30.00000	642925.59385	416070.79553	2000-01 CH2M Hill
11018	22550	10.00000	30.00000	642927.88207	415948.61522	2000-01 CH2M Hill
11019	98	10.00000	30.00000	642863.96489	415947.41849	2000-01 CH2M Hill
11020	361	10.00000	30.00000	642665.88422	415854.82430	2000-01 CH2M Hill
11021	122	10.00000	30.00000	642906.20086	415825.98608	2000-01 CH2M Hill
11022	17340	10.00000	30.00000	642708.11699	415733.39071	2000-01 CH2M Hill
11023	77	10.00000	30.00000	642675.01285	416221.66388	2000-01 CH2M Hill
11024	77	10.00000	30.00000	642673.35197	416310.52231	2000-01 CH2M Hill
11025	110	10.00000	30.00000	642944.36066	416348.92706	2000-01 CH2M Hill
11026	430	10.00000	30.00000	643056.20893	416351.02327	2000-01 CH2M Hill
11027	123	10.00000	17.00000	642969.99304	416260.51765	2000-01 CH2M Hill
11028	338	10.00000	20.00000	643057.87502	416262.16483	2000-01 CH2M Hill
11029	109	10.00000	20.00000	642971.86602	416160.55191	2000-01 CH2M Hill
11030	376	10.00000	30.00000	643115.46673	416174.35521	2000-01 CH2M Hill
11031	77	10.00000	26.00000	642990.13424	416038.67098	2000-01 CH2M Hill
11032	605	10.00000	30.00000	643124.70628	416107.86126	2000-01 CH2M Hill
11033	1024	10.00000	30.00000	642991.79927	415949.81258	2000-01 CH2M Hill
11034	1185	10.00000	17.00000	642862.30159	416036.27688	2000-01 CH2M Hill
11035	284	10.00000	30.00000	642866.25187	415825.23820	2000-01 CH2M Hill
11036	110	10.00000	30.00000	642883.47907	415758.89353	2000-01 CH2M Hill
11037	2318	10.00000	30.00000	642908.48855	415703.80581	2000-01 CH2M Hill
11038	338	10.00000	30.00000	643043.69306	415739.67233	2000-01 CH2M Hill
11039	9860	10.00000	30.00000	642669.41284	415666.00026	2000-01 CH2M Hill
11040	395	10.00000	21.00000	642780.64940	415701.41344	2000-01 CH2M Hill
11041	10025	10.00000	30.00000	642708.73989	415700.06882	2000-01 CH2M Hill

11042	9400	10.00000	27.00000	642780.02614	415734.73533	2000-01 CH2M Hill
11043	14620	10.00000	30.00000	642675.32705	415777.22254	2000-01 CH2M Hill
11044	375	10.00000	30.00000	642618.56813	415820.60673	2000-01 CH2M Hill
11045	1445	10.00000	23.00000	642778.98736	415790.27181	2000-01 CH2M Hill
11046	811	10.00000	30.00000	642730.42531	415822.69720	2000-01 CH2M Hill
11047	139	10.00000	20.00000	642617.53069	415876.14321	2000-01 CH2M Hill
11048	381	10.00000	30.00000	642705.41773	415877.78558	2000-01 CH2M Hill
11049	77	10.00000	20.00000	642640.25471	415943.23481	2000-01 CH2M Hill
11050	251	10.00000	30.00000	642752.10979	415945.32570	2000-01 CH2M Hill
11051	1356	10.00000	30.00000	642111.35344	415588.92869	2000-01 CH2M Hill
11052	9330	10.00000	30.00000	641938.87297	415407.94456	2000-01 CH2M Hill
11053	19300	10.00000	30.00000	641939.49190	415374.62269	2000-01 CH2M Hill
11054	1238	10.00000	30.00000	642027.38547	415376.25584	2000-01 CH2M Hill
11055	39700	10.00000	30.00000	642024.49502	415531.75790	2000-01 CH2M Hill
11056	196	10.00000	30.00000	642157.43358	415689.78627	2000-01 CH2M Hill
11058	331	10.00000	30.00000	642224.86880	415502.15210	2000-01 CH2M Hill
11059	168	10.00000	30.00000	642138.01012	415444.97982	2000-01 CH2M Hill
11060	2060	10.00000	30.00000	642225.90280	415446.61564	2000-01 CH2M Hill
11061	149	10.00000	30.00000	642227.14359	415379.97190	2000-01 CH2M Hill
11062	321	10.00000	30.00000	642140.48989	415311.69235	2000-01 CH2M Hill
11063	1865	10.00000	30.00000	642052.59543	415310.05771	2000-01 CH2M Hill
11064	335	10.00000	30.00000	642102.25554	414788.75824	2000-01 CH2M Hill
11065	6810	10.00000	30.00000	642103.28826	414733.22184	2000-01 CH2M Hill
11066	235	10.00000	25.00000	642101.63589	414822.08008	2000-01 CH2M Hill
11067	146	10.00000	16.00000	642123.95618	414911.38416	2000-01 CH2M Hill
11069	156	10.00000	30.00000	642174.17491	414790.09601	2000-01 CH2M Hill
11070	77	10.00000	30.00000	642183.19935	414734.70831	2000-01 CH2M Hill
11071	123	10.00000	15.00000	642266.00582	414580.69386	2000-01 CH2M Hill
11072	77	10.00000	23.00000	642179.34149	414512.41407	2000-01 CH2M Hill
11073	173	10.00000	16.00000	642291.22081	414514.49662	2000-01 CH2M Hill
11074	77	10.00000	20.00000	642220.33202	414457.62125	2000-01 CH2M Hill
11075	152	10.00000	18.00000	642308.23794	414459.25790	2000-01 CH2M Hill
11076	77	10.00000	30.00000	642245.54694	414391.42385	2000-01 CH2M Hill
11078	197	10.00000	30.00000	642246.58075	414335.88749	2000-01 CH2M Hill
11079	106	10.00000	30.00000	642247.82130	414269.24385	2000-01 CH2M Hill
11080	144	10.00000	30.00000	642383.67982	414271.77423	2000-01 CH2M Hill
12000	1430	10.00000	30.00000	643372.84766	418212.54661	2000-01 CH2M Hill
12001	2940	10.00000	30.00000	643118.03541	417741.08640	2000-01 CH2M Hill
12002	1744	10.00000	30.00000	642958.28598	417738.09024	2000-01 CH2M Hill
12003	3230	10.00000	30.00000	642758.59920	417734.35049	2000-01 CH2M Hill
12005	918	10.00000	30.00000	642579.96908	417886.56717	2000-01 CH2M Hill
12006	1625	10.00000	30.00000	642755.68928	417889.85311	2000-01 CH2M Hill
12007	97	10.00000	30.00000	642642.20600	417976.62017	2000-01 CH2M Hill
12090	1290	10.00000	30.00000	642970.53541	415804.96861	2000-01 CH2M Hill
12092	127	10.00000	28.00000	642844.77684	415691.50202	2000-01 CH2M Hill
12093	1675	10.00000	30.00000	642662.25305	415621.42178	2000-01 CH2M Hill
12095	164	10.00000	30.00000	642901.74634	415637.01245	2000-01 CH2M Hill
12097	856	10.00000	30.00000	642854.63766	415591.68590	2000-01 CH2M Hill
12098	135	10.00000	20.00000	642687.67628	415544.11867	2000-01 CH2M Hill
12099	21550	10.00000	28.00000	642783.97341	415523.69673	2000-01 CH2M Hill
12101	8560	10.00000	30.00000	642840.73592	415480.31392	2000-01 CH2M Hill
12102	26900	10.00000	30.00000	642742.98419	415578.48609	2000-01 CH2M Hill
12119	77	10.00000	30.00000	642114.51924	414988.98652	2000-01 CH2M Hill
12132	906	10.00000	30.00000	642980.18999	415716.25992	2000-01 CH2M Hill
12133	521	10.00000	30.00000	642989.84475	415627.55124	2000-01 CH2M Hill
12134	3075	10.00000	30.00000	642799.95374	415523.99564	2000-01 CH2M Hill
DA01S-02	77	10.00000	30.00000	642108.80065	414866.65780	2001 Blasland, Bouck, and Lee
DA01S-03	154	10.00000	30.00000	642220.46716	414879.84655	2001 Blasland, Bouck, and Lee
DA01S-06	124	10.00000	30.00000	642286.67007	414758.85672	2001 Blasland, Bouck, and Lee
DA01S-08	81	10.00000	30.00000	642018.89473	414542.76414	2001 Blasland, Bouck, and Lee
DA01S-09	290	10.00000	30.00000	642200.21510	414679.46933	2001 Blasland, Bouck, and Lee
DA01S-11	77	10.00000	30.00000	642305.13480	414625.86705	2001 Blasland, Bouck, and Lee
DA01S-12	154	10.00000	30.00000	642384.84023	414638.46322	2001 Blasland, Bouck, and Lee
DA01S-13	244	10.00000	30.00000	642121.74931	414600.23173	2001 Blasland, Bouck, and Lee
DA01S-14	130	10.00000	30.00000	642193.87745	414590.46240	2001 Blasland, Bouck, and Lee
DA01S-17	92	10.00000	30.00000	642148.61559	414445.17576	2001 Blasland, Bouck, and Lee
DA01S-18	154	10.00000	30.00000	642380.36796	414449.49059	2001 Blasland, Bouck, and Lee
DA01S-19	13375	10.00000	30.00000	641941.86887	414385.77788	2001 Blasland, Bouck, and Lee
DA01S-20	380	10.00000	30.00000	642142.27683	414356.16894	2001 Blasland, Bouck, and Lee
DA01S-21	3080	10.00000	30.00000	642024.05435	414265.08231	2001 Blasland, Bouck, and Lee
DA01S-22	10775	10.00000	30.00000	642168.11116	414256.64944	2001 Blasland, Bouck, and Lee
DA01S-24	318	10.00000	30.00000	642368.31735	414238.15458	2001 Blasland, Bouck, and Lee
DE01S-01	0	10.00000	20.00000	643123.80446	417007.85315	2001 Blasland, Bouck, and Lee
DE01S-02	570	10.00000	30.00000	642955.00812	417060.24408	2001 Blasland, Bouck, and Lee
DE01S-03	2100	10.00000	30.00000	642786.83819	417079.31736	2001 Blasland, Bouck, and Lee
DE01S-04	41	10.00000	30.00000	642602.69290	417098.09639	2001 Blasland, Bouck, and Lee
DE01S-05	2800	10.00000	30.00000	642808.10033	417224.16102	2001 Blasland, Bouck, and Lee
DE01S-06	1400	10.00000	30.00000	643031.97523	417217.24395	2001 Blasland, Bouck, and Lee
DE01S-07	760	10.00000	30.00000	642631.94707	417243.08866	2001 Blasland, Bouck, and Lee
DE01S-09	960	10.00000	30.00000	642885.90090	417336.72988	2001 Blasland, Bouck, and Lee
DE01S-10	1190	10.00000	30.00000	642748.65094	417411.93912	2001 Blasland, Bouck, and Lee
DE01S-11	1320	10.00000	30.00000	642963.07420	417482.62170	2001 Blasland, Bouck, and Lee
DE01S-12	1530	10.00000	30.00000	642746.36499	417534.11969	2001 Blasland, Bouck, and Lee
DE01S-13	1800	10.00000	30.00000	642577.79286	417575.41272	2001 Blasland, Bouck, and Lee
DE01S-14	2740	10.00000	30.00000	643057.26084	417573.27755	2001 Blasland, Bouck, and Lee

DE01S-15	151	10.00000	30.00000	643216.59710	417598.49070	2001 Blasland, Bouck, and Lee
DE01S-16	700	10.00000	30.00000	642615.23993	417709.44699	2001 Blasland, Bouck, and Lee
DE01S-17	0	10.00000	30.00000	643332.65303	417800.67406	2001 Blasland, Bouck, and Lee
DE01S-18	940	10.00000	30.00000	643196.24137	417831.44459	2001 Blasland, Bouck, and Lee
DE01S-19	378	10.00000	30.00000	643329.93826	417945.06937	2001 Blasland, Bouck, and Lee
DE01S-20	27	10.00000	30.00000	643457.31583	417969.68799	2001 Blasland, Bouck, and Lee
DE01S-21	870	10.00000	30.00000	643375.35467	418079.25858	2001 Blasland, Bouck, and Lee
DE01S-22	47	10.00000	30.00000	643574.40356	418116.33930	2001 Blasland, Bouck, and Lee
DE01S-23	920	10.00000	30.00000	643477.93197	418147.85636	2001 Blasland, Bouck, and Lee
DE01S-24	140	10.00000	30.00000	643603.63062	418261.33665	2001 Blasland, Bouck, and Lee
DE01S-25	3000	10.00000	30.00000	643268.18293	418255.02382	2001 Blasland, Bouck, and Lee
DE01S-26	510	10.00000	30.00000	643483.82786	418259.08010	2001 Blasland, Bouck, and Lee
DE01S-27	600	10.00000	30.00000	643147.54601	418297.20276	2001 Blasland, Bouck, and Lee
DE01S-28	1900	10.00000	30.00000	642905.28694	417581.53991	2001 Blasland, Bouck, and Lee
DE01S-29	4900	10.00000	30.00000	643345.75370	418378.70606	2001 Blasland, Bouck, and Lee
DE01S-30	220	10.00000	30.00000	643657.44445	418373.46385	2001 Blasland, Bouck, and Lee
DE01S-31	3100	10.00000	30.00000	643513.26525	418392.96971	2001 Blasland, Bouck, and Lee
DE01S-32	0	10.00000	23.00000	643185.39385	418409.02605	2001 Blasland, Bouck, and Lee
DE01S-33	0	10.00000	30.00000	643286.71489	418544.26502	2001 Blasland, Bouck, and Lee
DE01S-34	0	10.00000	27.00000	643798.68941	418509.46394	2001 Blasland, Bouck, and Lee
DE01S-35	2400	10.00000	30.00000	643479.01821	418514.54893	2001 Blasland, Bouck, and Lee
DE01S-36	2000	10.00000	30.00000	643605.96547	418561.38539	2001 Blasland, Bouck, and Lee
DE01S-37	0	10.00000	17.00000	643397.27194	418613.01188	2001 Blasland, Bouck, and Lee
DE01S-38	1100	10.00000	30.00000	643748.04552	418652.95507	2001 Blasland, Bouck, and Lee
DE01S-39	1500	10.00000	30.00000	643516.23142	418659.69635	2001 Blasland, Bouck, and Lee
PD-A/B-01	44	10.00000	30.00000	642141.22141	414728.82286	2001 Blasland, Bouck, and Lee
PD-A/B-03	2200	10.00000	30.00000	642057.47161	414543.52700	2001 Blasland, Bouck, and Lee
PD-A/B-07	1700	10.00000	30.00000	641970.34345	414342.35405	2001 Blasland, Bouck, and Lee
PD-A/B-08	2000	10.00000	30.00000	642054.17438	414339.35971	2001 Blasland, Bouck, and Lee
PD-A/B-09	40	10.00000	18.00000	642231.82970	414339.40733	2001 Blasland, Bouck, and Lee
PD-A/B-09	22	18.00000	23.00000	642231.82970	414339.40733	2001 Blasland, Bouck, and Lee
PD-A/B-11	330000	10.00000	30.00000	642133.73163	414250.70571	2001 Blasland, Bouck, and Lee
PD-A/B-12B	25	10.00000	30.00000	642322.35718	414250.75626	2001 Blasland, Bouck, and Lee
PD-A/B-13	2400	10.00000	30.00000	641992.96960	414170.52509	2001 Blasland, Bouck, and Lee
PD-A/B-14	6500	10.00000	30.00000	642133.14363	414170.56257	2001 Blasland, Bouck, and Lee
324	15130	10.00000	30.00000	641985.21394	414146.08582	LLBDM RI/FS Deposit A - 1992,1993 BBL
325	2070	10.00000	30.00000	641975.83920	414167.77353	LLBDM RI/FS Deposit A - 1992,1993 BBL
326	2280	10.00000	30.00000	641978.71408	414211.08645	LLBDM RI/FS Deposit A - 1992,1993 BBL
327	4613	10.00000	30.00000	641962.27704	414241.30545	LLBDM RI/FS Deposit A - 1992,1993 BBL
332	1723	10.00000	30.00000	642216.89469	414201.92989	LLBDM RI/FS Deposit A - 1992,1993 BBL
342	24250	10.00000	30.00000	641949.40238	414286.39969	LLBDM RI/FS Deposit A - 1992,1993 BBL
346	3975	10.00000	30.00000	642043.83726	414129.64812	LLBDM RI/FS Deposit A - 1992,1993 BBL
356	1187	10.00000	30.00000	642172.77100	414149.49192	LLBDM RI/FS Deposit A - 1992,1993 BBL
357	1300	10.00000	30.00000	642023.83761	414448.90119	Woody Clyde Deposit A Sediment Samples - 1994
358	290	10.00000	30.00000	642016.52531	414456.52627	Woody Clyde Deposit A Sediment Samples - 1994
359	960	10.00000	30.00000	642015.90034	414441.58862	Woody Clyde Deposit A Sediment Samples - 1994
360	1900	10.00000	30.00000	642008.58805	414448.58870	Woody Clyde Deposit A Sediment Samples - 1994
381	240	10.00000	30.00000	642098.14788	414545.21456	Woody Clyde Deposit A Sediment Samples - 1994
382	245	10.00000	30.00000	642090.21061	414552.52713	Woody Clyde Deposit A Sediment Samples - 1994
383	93	10.00000	30.00000	642091.14809	414537.90199	Woody Clyde Deposit A Sediment Samples - 1994
384	2800	10.00000	30.00000	642083.52331	414545.21457	Woody Clyde Deposit A Sediment Samples - 1994
409	1300	10.00000	30.00000	642087.77318	414555.27716	Woody Clyde Deposit A Sediment Samples - 1994
410	2400	10.00000	30.00000	642080.46088	414562.87094	Woody Clyde Deposit A Sediment Samples - 1994
411	2200	10.00000	30.00000	642080.77339	414547.33959	Woody Clyde Deposit A Sediment Samples - 1994
412	6600	10.00000	30.00000	642072.83611	414554.65216	Woody Clyde Deposit A Sediment Samples - 1994
413	1778	10.00000	30.00000	642530.19618	416881.86154	1994 Sediment Data - SAIC and GAS
414	448	10.00000	30.00000	642439.88662	416436.45106	1994 Sediment Data - SAIC and GAS
415	1021	10.00000	30.00000	642509.38461	416432.76348	1994 Sediment Data - SAIC and GAS
416	2017	10.00000	30.00000	642465.94840	416388.48189	1994 Sediment Data - SAIC and GAS
418	2840	10.00000	30.00000	642472.38575	416339.07511	1994 Sediment Data - SAIC and GAS
423	1863	10.00000	30.00000	642640.56797	416899.73663	1994 Sediment Data - SAIC and GAS
431	9133	10.00000	30.00000	642475.88547	416579.26490	1994 Sediment Data - SAIC and GAS
432	3195	10.00000	30.00000	642536.88375	416523.51432	1994 Sediment Data - SAIC and GAS
462	1510	10.00000	30.00000	642663.37977	416951.79961	1994 Sediment Data - SAIC and GAS
463	990	10.00000	30.00000	642808.56332	416595.73361	1994 Sediment Data - SAIC and GAS
464	55	10.00000	30.00000	642939.37203	416583.54590	1994 Sediment Data - SAIC and GAS
465	506	10.00000	30.00000	642832.31267	416533.63921	1994 Sediment Data - SAIC and GAS
466	356	10.00000	30.00000	642768.56459	416443.23219	1994 Sediment Data - SAIC and GAS
467	59	10.00000	30.00000	642872.37408	416445.23213	1994 Sediment Data - SAIC and GAS
468	440	10.00000	30.00000	642809.50097	416343.85621	1994 Sediment Data - SAIC and GAS
469	12430	10.00000	30.00000	642903.68574	416351.57492	1994 Sediment Data - SAIC and GAS
470	45850	10.00000	30.00000	642917.49790	416254.98029	1994 Sediment Data - SAIC and GAS
471	635	10.00000	30.00000	642801.50075	416971.54970	1994 Sediment Data - SAIC and GAS
472	157	10.00000	30.00000	642964.43354	416951.76809	1994 Sediment Data - SAIC and GAS
473	1828	10.00000	30.00000	643061.24322	416972.33072	1994 Sediment Data - SAIC and GAS
474	116	10.00000	30.00000	642934.18448	416859.57974	1994 Sediment Data - SAIC and GAS
475	228	10.00000	30.00000	642998.87011	416863.54853	1994 Sediment Data - SAIC and GAS
476	145	10.00000	30.00000	642936.74698	416761.29760	1994 Sediment Data - SAIC and GAS
477	1389	10.00000	30.00000	642872.49891	416667.57795	1994 Sediment Data - SAIC and GAS
478	113	10.00000	30.00000	642929.74725	416670.26544	1994 Sediment Data - SAIC and GAS
514	755	10.00000	30.00000	642810.06352	416257.69909	1994 Sediment Data - SAIC and GAS
517	311	10.00000	30.00000	643218.30191	415941.35208	1994 Sediment Data - SAIC and GAS
519	663	10.00000	30.00000	643149.99146	415845.03871	1994 Sediment Data - SAIC and GAS
521	4630	10.00000	30.00000	643282.30014	415827.97595	1994 Sediment Data - SAIC and GAS
524	970	10.00000	30.00000	642551.88394	415648.84977	1994 Sediment Data - SAIC and GAS

525	1030	10.00000	30.00000	642742.56554	416164.79206	1994 Sediment Data - SAIC and GAS
527	1269	10.00000	30.00000	643149.86660	415662.25567	1994 Sediment Data - SAIC and GAS
529	7472	10.00000	30.00000	642843.31262	416162.63566	1994 Sediment Data - SAIC and GAS
530	11760	10.00000	30.00000	642947.24711	416161.22937	1994 Sediment Data - SAIC and GAS
532	154	10.00000	30.00000	642782.50195	416068.50981	1994 Sediment Data - SAIC and GAS
533	24750	10.00000	30.00000	642942.30982	416071.72852	1994 Sediment Data - SAIC and GAS
718	39940	10.00000	30.00000	642106.08533	414294.96216	1998 BBL Sediment/Tissue Data
743	17200	10.00000	30.00000	642100.27302	414266.55559	1998 BBL Sediment/Tissue Data
744	720	10.00000	30.00000	642056.27352	415350.87848	1998 BBL Sediment/Tissue Data
745	220	10.00000	30.00000	642823.31363	415561.56744	1998 BBL Sediment/Tissue Data
746	75	10.00000	30.00000	642856.62495	415867.78914	1998 BBL Sediment/Tissue Data
747	76	10.00000	30.00000	642327.64011	416108.97932	1998 BBL Sediment/Tissue Data
748	2150	10.00000	30.00000	642296.32839	416288.79356	1998 BBL Sediment/Tissue Data
749	180	10.00000	30.00000	642799.56243	418189.21748	1998 BBL Sediment/Tissue Data
750	140	10.00000	30.00000	643635.03823	418142.09142	1998 BBL Sediment/Tissue Data
751	410	10.00000	30.00000	642461.76024	417481.08599	1998 BBL Sediment/Tissue Data
851	5	10.00000	30.00000	642123.77161	415285.28411	1998 RI/FS Supplemental Data Collection
852	197	10.00000	30.00000	642055.46105	415347.34725	1998 RI/FS Supplemental Data Collection
853	169	10.00000	30.00000	642106.45953	415407.16029	1998 RI/FS Supplemental Data Collection
854	2109	10.00000	30.00000	641978.96314	415513.25509	1998 RI/FS Supplemental Data Collection
855	7344	10.00000	30.00000	642109.95939	415448.22317	1998 RI/FS Supplemental Data Collection
861	58	10.00000	30.00000	643001.74463	417403.33486	1998 RI/FS Supplemental Data Collection
862	29	10.00000	30.00000	642641.13005	417455.42942	1998 RI/FS Supplemental Data Collection
863	9	10.00000	30.00000	643718.16069	418322.34308	1998 RI/FS Supplemental Data Collection
864	527	10.00000	30.00000	643347.60881	418500.53254	1998 RI/FS Supplemental Data Collection
865	17	10.00000	30.00000	643873.28051	419266.32072	1998 RI/FS Supplemental Data Collection
866	81	10.00000	30.00000	643920.59124	419804.32578	1998 RI/FS Supplemental Data Collection
14	70	10.00000	30.00000	642496.94858	414880.52998	1989/90 Mass Balance Sediment Data
29	50	10.00000	30.00000	643135.30380	416661.60901	1989/90 Mass Balance Sediment Data
42	50	10.00000	30.00000	644051.08755	419679.07450	1989/90 Mass Balance Sediment Data
43	999	10.00000	30.00000	644295.01789	419790.82538	1989/90 Mass Balance Sediment Data
47	560	10.00000	30.00000	643197.98899	417339.95912	1989/90 Mass Balance Sediment Data
109	723	10.00000	30.00000	642859.99792	418539.78326	1989/90 Mass Balance Sediment Data
110	340	10.00000	30.00000	642976.18205	418542.40820	1989/90 Mass Balance Sediment Data
262	238	10.00000	30.00000	643682.78605	419234.91426	1989/90 Mass Balance Sediment Data
263	56	10.00000	30.00000	643141.67726	418534.81431	1989/90 Mass Balance Sediment Data
289	320	10.00000	30.00000	643016.24329	418675.44074	1989/90 Mass Balance Sediment Data
290	288	10.00000	30.00000	642901.93416	418602.47133	1989/90 Mass Balance Sediment Data
292	113	10.00000	30.00000	645313.48810	420120.20275	1989/90 Mass Balance Sediment Data
295	663	10.00000	30.00000	645963.15634	420671.17618	1989/90 Mass Balance Sediment Data
11001	1190	30.00000	50.00000	643039.68956	418084.06494	2000-01 CH2M Hill
11002	3500	30.00000	50.00000	643136.15972	418052.54146	2000-01 CH2M Hill
11003	5220	30.00000	50.00000	643041.56468	417984.09893	2000-01 CH2M Hill
11005	736	30.00000	50.00000	643201.51678	417975.98992	2000-01 CH2M Hill
11006	26250	30.00000	50.00000	643150.46560	418141.70003	2000-01 CH2M Hill
11007	406	30.00000	50.00000	643263.32702	418088.26368	2000-01 CH2M Hill
11008	31150	30.00000	50.00000	643197.13577	418209.24396	2000-01 CH2M Hill
11010	102	30.00000	50.00000	642889.80837	417981.25414	2000-01 CH2M Hill
11011	329	30.00000	50.00000	642955.37132	417893.59286	2000-01 CH2M Hill
11012	7310	30.00000	50.00000	643115.11696	417896.58903	2000-01 CH2M Hill
11014	26300	30.00000	50.00000	642896.42568	416348.02928	2000-01 CH2M Hill
11015	36350	30.00000	50.00000	642898.08960	416259.17083	2000-01 CH2M Hill
11017	117400	30.00000	50.00000	642925.59385	416070.79553	2000-01 CH2M Hill
11018	34750	30.00000	50.00000	642927.88207	415948.61522	2000-01 CH2M Hill
11020	77	30.00000	50.00000	642665.88422	415854.82430	2000-01 CH2M Hill
11021	77	30.00000	50.00000	642906.20086	415825.98608	2000-01 CH2M Hill
11022	315	30.00000	50.00000	642708.11699	415733.39071	2000-01 CH2M Hill
11023	77	30.00000	50.00000	642675.01285	416221.66388	2000-01 CH2M Hill
11024	77	30.00000	50.00000	642673.35197	416310.52231	2000-01 CH2M Hill
11032	77	30.00000	50.00000	643124.70628	416107.86126	2000-01 CH2M Hill
11033	1024	30.00000	50.00000	642991.79927	415949.81258	2000-01 CH2M Hill
11036	77	30.00000	50.00000	642883.47907	415758.89353	2000-01 CH2M Hill
11037	109	30.00000	50.00000	642908.48855	415703.80581	2000-01 CH2M Hill
11038	81	30.00000	50.00000	643043.69306	415739.67233	2000-01 CH2M Hill
11039	149	30.00000	45.00000	642669.41284	415666.00026	2000-01 CH2M Hill
11041	127	30.00000	50.00000	642708.73989	415700.06882	2000-01 CH2M Hill
11043	77	30.00000	50.00000	642675.32705	415777.22254	2000-01 CH2M Hill
11046	77	30.00000	50.00000	642730.42531	415822.69720	2000-01 CH2M Hill
11048	77	30.00000	50.00000	642705.41773	415877.78558	2000-01 CH2M Hill
11050	77	30.00000	50.00000	642752.10979	415945.32570	2000-01 CH2M Hill
11051	77	30.00000	50.00000	642111.35344	415588.92869	2000-01 CH2M Hill
11052	333	30.00000	50.00000	641938.87297	415407.94456	2000-01 CH2M Hill
11053	366	30.00000	50.00000	641939.49190	415374.62269	2000-01 CH2M Hill
11054	266	30.00000	50.00000	642027.38547	415376.25584	2000-01 CH2M Hill
11055	399	30.00000	50.00000	642024.49502	415531.75790	2000-01 CH2M Hill
11058	77	30.00000	50.00000	642224.86880	415502.15210	2000-01 CH2M Hill
11059	77	30.00000	50.00000	642138.01012	415444.97982	2000-01 CH2M Hill
11060	77	30.00000	50.00000	642225.90280	415446.61564	2000-01 CH2M Hill
11061	77	30.00000	50.00000	642227.14359	415379.97190	2000-01 CH2M Hill
11062	77	30.00000	50.00000	642140.48989	415311.69235	2000-01 CH2M Hill
11063	159	30.00000	50.00000	642052.59543	415310.05771	2000-01 CH2M Hill
11069	77	30.00000	50.00000	642174.17491	414790.09601	2000-01 CH2M Hill
11070	77	30.00000	40.00000	642183.19935	414734.70831	2000-01 CH2M Hill
12000	151	30.00000	50.00000	643372.84766	418212.54661	2000-01 CH2M Hill
12001	1940	30.00000	50.00000	643118.03541	417741.08640	2000-01 CH2M Hill

12002	756	30.00000	50.00000	642958.28598	417738.09024	2000-01 CH2M Hill
12003	283	30.00000	50.00000	642758.59920	417734.35049	2000-01 CH2M Hill
12005	77	30.00000	50.00000	642579.96908	417886.56717	2000-01 CH2M Hill
12006	107	30.00000	50.00000	642755.68928	417889.85311	2000-01 CH2M Hill
12007	77	30.00000	50.00000	642642.20600	417976.62017	2000-01 CH2M Hill
12090	2330	30.00000	50.00000	642970.53541	415804.96861	2000-01 CH2M Hill
12097	171	30.00000	50.00000	642854.63766	415591.68590	2000-01 CH2M Hill
12101	310	30.00000	50.00000	642840.73592	415480.31392	2000-01 CH2M Hill
12132	6375	30.00000	50.00000	642980.18999	415716.25992	2000-01 CH2M Hill
12133	536	30.00000	50.00000	642989.84475	415627.55124	2000-01 CH2M Hill
DA01S-02	77	30.00000	36.00000	642108.80065	414866.65780	2001 Blasland, Bouck, and Lee
DA01S-06	77	30.00000	50.00000	642286.67007	414758.85672	2001 Blasland, Bouck, and Lee
DA01S-08	77	30.00000	50.00000	642018.89473	414542.76414	2001 Blasland, Bouck, and Lee
DA01S-09	77	30.00000	50.00000	642200.21510	414679.46933	2001 Blasland, Bouck, and Lee
DA01S-11	77	30.00000	50.00000	642305.13480	414625.86705	2001 Blasland, Bouck, and Lee
DA01S-12	77	30.00000	50.00000	642384.84023	414638.46322	2001 Blasland, Bouck, and Lee
DA01S-13	77	30.00000	50.00000	642121.74931	414600.23173	2001 Blasland, Bouck, and Lee
DA01S-14	77	30.00000	50.00000	642193.87745	414590.46240	2001 Blasland, Bouck, and Lee
DA01S-17	77	30.00000	50.00000	642148.61559	414445.17576	2001 Blasland, Bouck, and Lee
DA01S-18	81	30.00000	50.00000	642380.36796	414449.49059	2001 Blasland, Bouck, and Lee
DA01S-19	81	30.00000	50.00000	641941.86887	414385.77788	2001 Blasland, Bouck, and Lee
DA01S-20	77	30.00000	50.00000	642142.27683	414356.16894	2001 Blasland, Bouck, and Lee
DA01S-21	434	30.00000	50.00000	642024.05435	414265.08231	2001 Blasland, Bouck, and Lee
DA01S-22	1535	30.00000	50.00000	642168.11116	414256.64944	2001 Blasland, Bouck, and Lee
DA01S-24	81	30.00000	50.00000	642368.31735	414238.15458	2001 Blasland, Bouck, and Lee
DE01S-02	0	30.00000	50.00000	642955.00812	417060.24408	2001 Blasland, Bouck, and Lee
DE01S-03	45	30.00000	50.00000	642786.83819	417079.31736	2001 Blasland, Bouck, and Lee
DE01S-05	3100	30.00000	50.00000	642808.10033	417224.16102	2001 Blasland, Bouck, and Lee
DE01S-06	50	30.00000	50.00000	643031.97523	417217.24395	2001 Blasland, Bouck, and Lee
DE01S-07	0	30.00000	50.00000	642631.94707	417243.08866	2001 Blasland, Bouck, and Lee
DE01S-09	37	30.00000	50.00000	642885.90090	417336.72988	2001 Blasland, Bouck, and Lee
DE01S-10	0	30.00000	50.00000	642748.65094	417411.93912	2001 Blasland, Bouck, and Lee
DE01S-11	980	30.00000	50.00000	642963.07420	417482.62170	2001 Blasland, Bouck, and Lee
DE01S-12	790	30.00000	50.00000	642746.36499	417534.11969	2001 Blasland, Bouck, and Lee
DE01S-13	45	30.00000	50.00000	642577.79286	417575.41272	2001 Blasland, Bouck, and Lee
DE01S-14	2110	30.00000	50.00000	643057.26084	417573.27755	2001 Blasland, Bouck, and Lee
DE01S-15	0	30.00000	46.00000	643216.59710	417598.49070	2001 Blasland, Bouck, and Lee
DE01S-16	0	30.00000	50.00000	642615.23993	417709.44699	2001 Blasland, Bouck, and Lee
DE01S-17	0	30.00000	50.00000	643332.65303	417800.67406	2001 Blasland, Bouck, and Lee
DE01S-18	27	30.00000	50.00000	643196.24137	417831.44459	2001 Blasland, Bouck, and Lee
DE01S-19	0	30.00000	50.00000	643329.93826	417945.06937	2001 Blasland, Bouck, and Lee
DE01S-20	0	30.00000	50.00000	643457.31583	417969.68799	2001 Blasland, Bouck, and Lee
DE01S-21	260	30.00000	50.00000	643375.35467	418079.25858	2001 Blasland, Bouck, and Lee
DE01S-22	0	30.00000	50.00000	643574.40356	418116.33930	2001 Blasland, Bouck, and Lee
DE01S-23	420	30.00000	50.00000	643477.93197	418147.85636	2001 Blasland, Bouck, and Lee
DE01S-24	0	30.00000	50.00000	643603.63062	418261.33665	2001 Blasland, Bouck, and Lee
DE01S-25	15000	30.00000	50.00000	643268.18293	418255.02382	2001 Blasland, Bouck, and Lee
DE01S-26	30	30.00000	50.00000	643483.82786	418259.08010	2001 Blasland, Bouck, and Lee
DE01S-27	0	30.00000	50.00000	643147.54601	418297.20276	2001 Blasland, Bouck, and Lee
DE01S-28	110	30.00000	50.00000	642905.28694	417581.53991	2001 Blasland, Bouck, and Lee
DE01S-29	15000	30.00000	50.00000	643345.75370	418378.70606	2001 Blasland, Bouck, and Lee
DE01S-30	0	30.00000	50.00000	643657.44445	418373.46385	2001 Blasland, Bouck, and Lee
DE01S-31	350	30.00000	50.00000	643513.26525	418392.96971	2001 Blasland, Bouck, and Lee
DE01S-33	0	30.00000	42.00000	643286.71489	418544.26502	2001 Blasland, Bouck, and Lee
DE01S-35	23000	30.00000	50.00000	643479.01821	418514.54893	2001 Blasland, Bouck, and Lee
DE01S-36	2200	30.00000	50.00000	643605.96547	418561.38539	2001 Blasland, Bouck, and Lee
DE01S-38	0	30.00000	50.00000	643748.04552	418652.95507	2001 Blasland, Bouck, and Lee
DE01S-39	290	30.00000	50.00000	643516.23142	418659.69635	2001 Blasland, Bouck, and Lee
PD-A/B-01	22	30.00000	58.00000	642141.22141	414728.82286	2001 Blasland, Bouck, and Lee
PD-A/B-03	50	30.00000	60.00000	642057.47161	414543.52700	2001 Blasland, Bouck, and Lee
PD-A/B-07	120	30.00000	60.00000	641970.34345	414342.35405	2001 Blasland, Bouck, and Lee
PD-A/B-08	95	30.00000	60.00000	642054.17438	414339.35971	2001 Blasland, Bouck, and Lee
PD-A/B-11	1400	30.00000	60.00000	642133.73163	414250.70571	2001 Blasland, Bouck, and Lee
PD-A/B-12B	22	30.00000	60.00000	642322.35718	414250.75626	2001 Blasland, Bouck, and Lee
PD-A/B-13	310	30.00000	60.00000	641992.96960	414170.52509	2001 Blasland, Bouck, and Lee
PD-A/B-14	130	30.00000	50.00000	642133.14363	414170.56257	2001 Blasland, Bouck, and Lee
324	3831	30.00000	50.00000	641985.46393	414146.36702	LLBDM RI/FS Deposit A - 1992,1993 BBL
325	170	30.00000	50.00000	641975.46421	414167.36723	LLBDM RI/FS Deposit A - 1992,1993 BBL
327	1240	30.00000	50.00000	641962.46453	414241.36795	LLBDM RI/FS Deposit A - 1992,1993 BBL
356	62	30.00000	50.00000	642172.45851	414149.36692	LLBDM RI/FS Deposit A - 1992,1993 BBL
357	1300	30.00000	50.00000	642023.46262	414449.36989	Woody Clyde Deposit A Sediment Samples - 1994
359	960	30.00000	50.00000	642015.46285	414441.36982	Woody Clyde Deposit A Sediment Samples - 1994
360	1900	30.00000	50.00000	642008.46305	414448.36989	Woody Clyde Deposit A Sediment Samples - 1994
381	240	30.00000	50.00000	642098.46037	414545.37076	Woody Clyde Deposit A Sediment Samples - 1994
382	245	30.00000	50.00000	642090.46060	414552.37083	Woody Clyde Deposit A Sediment Samples - 1994
384	2800	30.00000	50.00000	642083.46081	414545.37077	Woody Clyde Deposit A Sediment Samples - 1994
409	1300	30.00000	50.00000	642087.46069	414555.37086	Woody Clyde Deposit A Sediment Samples - 1994
410	2400	30.00000	50.00000	642080.46088	414563.37094	Woody Clyde Deposit A Sediment Samples - 1994
411	2200	30.00000	50.00000	642080.46089	414547.37079	Woody Clyde Deposit A Sediment Samples - 1994
412	6600	30.00000	50.00000	642072.46112	414554.37086	Woody Clyde Deposit A Sediment Samples - 1994
414	448	30.00000	50.00000	642439.44913	416436.38856	1994 Sediment Data - SAIC and GAS
415	1021	30.00000	50.00000	642509.44711	416432.38847	1994 Sediment Data - SAIC and GAS
416	2017	30.00000	50.00000	642466.44838	416388.38809	1994 Sediment Data - SAIC and GAS
418	2840	30.00000	50.00000	642472.44825	416339.38761	1994 Sediment Data - SAIC and GAS
431	9133	30.00000	50.00000	642475.44799	416579.38990	1994 Sediment Data - SAIC and GAS

432	3195	30.00000	50.00000	642536.44626	416523.38932	1994 Sediment Data - SAIC and GAS
463	990	30.00000	50.00000	642808.43832	416595.38981	1994 Sediment Data - SAIC and GAS
464	55	30.00000	50.00000	642939.43453	416583.38960	1994 Sediment Data - SAIC and GAS
465	506	30.00000	50.00000	642832.43767	416533.38920	1994 Sediment Data - SAIC and GAS
466	356	30.00000	50.00000	642768.43959	416443.38839	1994 Sediment Data - SAIC and GAS
467	59	30.00000	50.00000	642872.43657	416445.38834	1994 Sediment Data - SAIC and GAS
468	440	30.00000	50.00000	642809.43847	416343.38741	1994 Sediment Data - SAIC and GAS
469	12430	30.00000	50.00000	642903.43574	416351.38742	1994 Sediment Data - SAIC and GAS
470	45850	30.00000	50.00000	642917.43541	416255.38649	1994 Sediment Data - SAIC and GAS
471	635	30.00000	50.00000	642801.43825	416971.39340	1994 Sediment Data - SAIC and GAS
472	157	30.00000	50.00000	642964.43354	416951.39309	1994 Sediment Data - SAIC and GAS
473	1828	30.00000	50.00000	643061.43071	416972.39322	1994 Sediment Data - SAIC and GAS
474	116	30.00000	50.00000	642934.43448	416859.39223	1994 Sediment Data - SAIC and GAS
475	228	30.00000	50.00000	642998.43262	416863.39223	1994 Sediment Data - SAIC and GAS
476	145	30.00000	50.00000	642936.43449	416761.39130	1994 Sediment Data - SAIC and GAS
477	1389	30.00000	50.00000	642872.43641	416667.39045	1994 Sediment Data - SAIC and GAS
478	113	30.00000	50.00000	642929.43476	416670.39044	1994 Sediment Data - SAIC and GAS
514	755	30.00000	50.00000	642810.43851	416257.38659	1994 Sediment Data - SAIC and GAS
517	311	30.00000	50.00000	643218.42691	415941.38328	1994 Sediment Data - SAIC and GAS
519	663	30.00000	50.00000	643150.42895	415845.38241	1994 Sediment Data - SAIC and GAS
521	4630	30.00000	50.00000	643282.42513	415828.38216	1994 Sediment Data - SAIC and GAS
527	1269	30.00000	50.00000	643149.42911	415662.38067	1994 Sediment Data - SAIC and GAS
530	11760	30.00000	50.00000	642947.43460	416161.38557	1994 Sediment Data - SAIC and GAS
532	154	30.00000	50.00000	642782.43945	416068.38481	1994 Sediment Data - SAIC and GAS
533	24750	30.00000	50.00000	642942.43481	416071.38472	1994 Sediment Data - SAIC and GAS
718	86	30.00000	50.00000	642106.46032	414295.36836	1998 BBL Sediment/Tissue Data
743	17200	30.00000	50.00000	642100.46052	414266.36809	1998 BBL Sediment/Tissue Data
744	720	30.00000	50.00000	642056.46101	415351.37849	1998 BBL Sediment/Tissue Data
745	220	30.00000	50.00000	642823.43863	415561.37994	1998 BBL Sediment/Tissue Data
746	75	30.00000	50.00000	642856.43745	415867.38284	1998 BBL Sediment/Tissue Data
748	2150	30.00000	50.00000	642296.45339	416288.38725	1998 BBL Sediment/Tissue Data
749	180	30.00000	50.00000	642799.43743	418189.40498	1998 BBL Sediment/Tissue Data
750	140	30.00000	50.00000	643635.41322	418142.40393	1998 BBL Sediment/Tissue Data
851	15	30.00000	50.00000	642123.45912	415285.37781	1998 RI/FS Supplemental Data Collection
852	40	30.00000	50.00000	642055.46105	415347.37845	1998 RI/FS Supplemental Data Collection
854	39	30.00000	50.00000	641979.46313	415513.38009	1998 RI/FS Supplemental Data Collection
861	20	30.00000	50.00000	643001.43214	417403.39736	1998 RI/FS Supplemental Data Collection
862	36	30.00000	50.00000	642641.44254	417455.39812	1998 RI/FS Supplemental Data Collection
864	24	30.00000	50.00000	643347.42131	418500.40753	1998 RI/FS Supplemental Data Collection
866	48	30.00000	50.00000	643920.40375	419804.41948	1998 RI/FS Supplemental Data Collection
42	50	30.00000	50.00000	644051.40004	419679.41820	1989/90 Mass Balance Sediment Data
43	68	30.00000	50.00000	644295.39288	419790.41907	1989/90 Mass Balance Sediment Data
109	50	30.00000	50.00000	642860.43541	418539.40826	1989/90 Mass Balance Sediment Data
249	190	30.00000	50.00000	642196.45720	415012.37515	1989/90 Mass Balance Sediment Data
262	50	30.00000	50.00000	643682.41107	419235.41426	1989/90 Mass Balance Sediment Data
289	320	30.00000	50.00000	643016.43079	418675.40943	1989/90 Mass Balance Sediment Data
290	430	30.00000	50.00000	642902.43415	418602.40882	1989/90 Mass Balance Sediment Data
295	50	30.00000	50.00000	645963.34384	420671.42618	1989/90 Mass Balance Sediment Data
11001	128	50.00000	100.00000	643039.68956	418084.06494	2000-01 CH2M Hill
11002	353	50.00000	100.00000	643136.15972	418052.54146	2000-01 CH2M Hill
11003	248	50.00000	100.00000	643041.56468	417984.09893	2000-01 CH2M Hill
11005	105	50.00000	100.00000	643201.51678	417975.98992	2000-01 CH2M Hill
11006	6550	50.00000	100.00000	643150.46560	418141.70003	2000-01 CH2M Hill
11007	97	50.00000	100.00000	643263.32702	418088.26368	2000-01 CH2M Hill
11008	1366	50.00000	100.00000	643197.13577	418209.24396	2000-01 CH2M Hill
11010	77	50.00000	100.00000	642889.80837	417981.25414	2000-01 CH2M Hill
11011	99	50.00000	100.00000	642955.37132	417893.59286	2000-01 CH2M Hill
11012	726	50.00000	100.00000	643115.11696	417896.58903	2000-01 CH2M Hill
11014	36350	50.00000	100.00000	642896.42568	416348.02928	2000-01 CH2M Hill
11015	63750	50.00000	100.00000	642898.08960	416259.17083	2000-01 CH2M Hill
11017	124400	50.00000	100.00000	642925.59385	416070.79553	2000-01 CH2M Hill
11018	1510	50.00000	100.00000	642927.88207	415948.61522	2000-01 CH2M Hill
11020	77	50.00000	100.00000	642665.88422	415854.82430	2000-01 CH2M Hill
11022	178	50.00000	100.00000	642708.11699	415733.39071	2000-01 CH2M Hill
11023	77	50.00000	90.00000	642675.01285	416221.66388	2000-01 CH2M Hill
11032	77	50.00000	100.00000	643124.70628	416107.86126	2000-01 CH2M Hill
11033	152	50.00000	63.00000	642991.79927	415949.81258	2000-01 CH2M Hill
11038	77	50.00000	60.00000	643043.69306	415739.67233	2000-01 CH2M Hill
11041	77	50.00000	100.00000	642708.73989	415700.06882	2000-01 CH2M Hill
11043	77	50.00000	100.00000	642675.32705	415777.22254	2000-01 CH2M Hill
11046	77	50.00000	100.00000	642730.42531	415822.69720	2000-01 CH2M Hill
11048	77	50.00000	100.00000	642705.41773	415877.78558	2000-01 CH2M Hill
11050	77	50.00000	100.00000	642752.10979	415945.32570	2000-01 CH2M Hill
11052	101	50.00000	100.00000	641938.87297	415407.94456	2000-01 CH2M Hill
11053	81	50.00000	75.00000	641939.49190	415374.62269	2000-01 CH2M Hill
11054	77	50.00000	100.00000	642027.38547	415376.25584	2000-01 CH2M Hill
11055	122	50.00000	90.00000	642024.49502	415531.75790	2000-01 CH2M Hill
11058	77	50.00000	100.00000	642224.86880	415502.15210	2000-01 CH2M Hill
11059	158	50.00000	83.00000	642138.01012	415444.97982	2000-01 CH2M Hill
11060	77	50.00000	100.00000	642225.90280	415446.61564	2000-01 CH2M Hill
11061	77	50.00000	100.00000	642227.14359	415379.97190	2000-01 CH2M Hill
11062	77	50.00000	100.00000	642140.48989	415311.69235	2000-01 CH2M Hill
11069	77	50.00000	90.00000	642174.17491	414790.09601	2000-01 CH2M Hill
12000	119	50.00000	100.00000	643372.84766	418212.54661	2000-01 CH2M Hill
12001	175	50.00000	100.00000	643118.03541	417741.08640	2000-01 CH2M Hill

12002	158	50.00000	100.00000	642958.28598	417738.09024	2000-01 CH2M Hill
12003	77	50.00000	100.00000	642758.59920	417734.35049	2000-01 CH2M Hill
12005	77	50.00000	100.00000	642579.96908	417886.56717	2000-01 CH2M Hill
12006	77	50.00000	100.00000	642755.68928	417889.85311	2000-01 CH2M Hill
12090	5475	50.00000	100.00000	642970.53541	415804.96861	2000-01 CH2M Hill
12097	77	50.00000	66.00000	642854.63766	415591.68590	2000-01 CH2M Hill
12101	149	50.00000	72.00000	642840.73592	415480.31392	2000-01 CH2M Hill
12133	523	50.00000	70.00000	642989.84475	415627.55124	2000-01 CH2M Hill
DA01S-06	77	50.00000	100.00000	642286.67007	414758.85672	2001 Blasland, Bouck, and Lee
DA01S-08	77	50.00000	90.00000	642018.89473	414542.76414	2001 Blasland, Bouck, and Lee
DA01S-09	77	50.00000	100.00000	642200.21510	414679.46933	2001 Blasland, Bouck, and Lee
DA01S-11	77	50.00000	100.00000	642305.13480	414625.86705	2001 Blasland, Bouck, and Lee
DA01S-13	81	50.00000	100.00000	642121.74931	414600.23173	2001 Blasland, Bouck, and Lee
DA01S-14	81	50.00000	100.00000	642193.87745	414590.46240	2001 Blasland, Bouck, and Lee
DA01S-17	81	50.00000	100.00000	642148.61559	414445.17576	2001 Blasland, Bouck, and Lee
DA01S-18	81	50.00000	76.00000	642380.36796	414449.49059	2001 Blasland, Bouck, and Lee
DA01S-19	84	50.00000	87.00000	641941.86887	414385.77788	2001 Blasland, Bouck, and Lee
DA01S-20	77	50.00000	100.00000	642142.27683	414356.16894	2001 Blasland, Bouck, and Lee
DA01S-21	102	50.00000	100.00000	642024.05435	414265.08231	2001 Blasland, Bouck, and Lee
DA01S-22	109	50.00000	100.00000	642168.11116	414256.64944	2001 Blasland, Bouck, and Lee
DA01S-24	77	50.00000	66.00000	642368.31735	414238.15458	2001 Blasland, Bouck, and Lee
DE01S-02	0	50.00000	100.00000	642955.00812	417060.24408	2001 Blasland, Bouck, and Lee
DE01S-03	0	50.00000	100.00000	642786.83819	417079.31736	2001 Blasland, Bouck, and Lee
DE01S-05	0	50.00000	100.00000	642808.10033	417224.16102	2001 Blasland, Bouck, and Lee
DE01S-06	0	50.00000	95.00000	643031.97523	417217.24395	2001 Blasland, Bouck, and Lee
DE01S-07	0	50.00000	100.00000	642631.94707	417243.08866	2001 Blasland, Bouck, and Lee
DE01S-09	0	50.00000	100.00000	642885.90090	417336.72988	2001 Blasland, Bouck, and Lee
DE01S-10	268	50.00000	84.00000	642748.65094	417411.93912	2001 Blasland, Bouck, and Lee
DE01S-11	0	50.00000	100.00000	642963.07420	417482.62170	2001 Blasland, Bouck, and Lee
DE01S-12	0	50.00000	100.00000	642746.36499	417534.11969	2001 Blasland, Bouck, and Lee
DE01S-13	0	50.00000	100.00000	642577.79286	417575.41272	2001 Blasland, Bouck, and Lee
DE01S-14	184	50.00000	100.00000	643057.26084	417573.27755	2001 Blasland, Bouck, and Lee
DE01S-16	0	50.00000	100.00000	642615.23993	417709.44699	2001 Blasland, Bouck, and Lee
DE01S-17	0	50.00000	53.00000	643332.65303	417800.67406	2001 Blasland, Bouck, and Lee
DE01S-18	0	50.00000	100.00000	643196.24137	417831.44459	2001 Blasland, Bouck, and Lee
DE01S-19	0	50.00000	100.00000	643329.93826	417945.06937	2001 Blasland, Bouck, and Lee
DE01S-20	0	50.00000	78.00000	643457.31583	417969.68799	2001 Blasland, Bouck, and Lee
DE01S-21	0	50.00000	100.00000	643375.35467	418079.25858	2001 Blasland, Bouck, and Lee
DE01S-22	0	50.00000	100.00000	643574.40356	418116.33930	2001 Blasland, Bouck, and Lee
DE01S-23	0	50.00000	100.00000	643477.93197	418147.85636	2001 Blasland, Bouck, and Lee
DE01S-24	0	50.00000	100.00000	643603.63062	418261.33665	2001 Blasland, Bouck, and Lee
DE01S-25	7300	50.00000	100.00000	643268.18293	418255.02382	2001 Blasland, Bouck, and Lee
DE01S-26	0	50.00000	100.00000	643483.82786	418259.08010	2001 Blasland, Bouck, and Lee
DE01S-27	0	50.00000	76.00000	643147.54601	418297.20276	2001 Blasland, Bouck, and Lee
DE01S-28	23	50.00000	100.00000	642905.28694	417581.53991	2001 Blasland, Bouck, and Lee
DE01S-29	3100	50.00000	100.00000	643345.75370	418378.70606	2001 Blasland, Bouck, and Lee
DE01S-30	0	50.00000	100.00000	643657.44445	418373.46385	2001 Blasland, Bouck, and Lee
DE01S-31	36	50.00000	100.00000	643513.26525	418392.96971	2001 Blasland, Bouck, and Lee
DE01S-35	8600	50.00000	100.00000	643479.01821	418514.54893	2001 Blasland, Bouck, and Lee
DE01S-36	250	50.00000	100.00000	643605.96547	418561.38539	2001 Blasland, Bouck, and Lee
DE01S-38	0	50.00000	97.00000	643748.04552	418652.95507	2001 Blasland, Bouck, and Lee
DE01S-39	0	50.00000	100.00000	643516.23142	418659.69635	2001 Blasland, Bouck, and Lee
PD-A/B-01	22	58.00000	63.00000	642141.22141	414728.82286	2001 Blasland, Bouck, and Lee
PD-A/B-03	78	60.00000	71.00000	642057.47161	414543.52700	2001 Blasland, Bouck, and Lee
PD-A/B-03	28	71.00000	76.00000	642057.47161	414543.52700	2001 Blasland, Bouck, and Lee
PD-A/B-08	29	60.00000	66.00000	642054.17438	414339.35971	2001 Blasland, Bouck, and Lee
PD-A/B-11	73	60.00000	91.00000	642133.73163	414250.70571	2001 Blasland, Bouck, and Lee
PD-A/B-14	32	50.00000	55.00000	642133.14363	414170.56257	2001 Blasland, Bouck, and Lee
324	3815	50.00000	100.00000	641985.21394	414146.08582	LLBDM RI/FS Deposit A - 1992,1993 BBL
382	245	50.00000	100.00000	642090.21061	414552.52713	Woody Clyde Deposit A Sediment Samples - 1994
409	1300	50.00000	100.00000	642087.77318	414555.27716	Woody Clyde Deposit A Sediment Samples - 1994
410	2400	50.00000	100.00000	642080.46088	414562.87094	Woody Clyde Deposit A Sediment Samples - 1994
411	2200	50.00000	100.00000	642080.77339	414547.33959	Woody Clyde Deposit A Sediment Samples - 1994
412	6600	50.00000	100.00000	642072.83611	414554.65216	Woody Clyde Deposit A Sediment Samples - 1994
415	249	50.00000	100.00000	642509.38461	416432.76348	1994 Sediment Data - SAIC and GAS
416	459	50.00000	100.00000	642465.94840	416388.48189	1994 Sediment Data - SAIC and GAS
418	654	50.00000	100.00000	642472.38575	416339.07511	1994 Sediment Data - SAIC and GAS
431	9133	50.00000	100.00000	642475.88547	416579.26490	1994 Sediment Data - SAIC and GAS
432	1018	50.00000	100.00000	642536.88375	416523.51432	1994 Sediment Data - SAIC and GAS
464	28	50.00000	100.00000	642939.37203	416583.54590	1994 Sediment Data - SAIC and GAS
465	127	50.00000	100.00000	642832.31267	416533.63921	1994 Sediment Data - SAIC and GAS
466	136	50.00000	100.00000	642768.56459	416443.23219	1994 Sediment Data - SAIC and GAS
467	59	50.00000	100.00000	642872.37408	416445.23213	1994 Sediment Data - SAIC and GAS
468	440	50.00000	100.00000	642809.50097	416343.85621	1994 Sediment Data - SAIC and GAS
469	3401	50.00000	100.00000	642903.68574	416351.57492	1994 Sediment Data - SAIC and GAS
470	15760	50.00000	100.00000	642917.49790	416254.98029	1994 Sediment Data - SAIC and GAS
471	155	50.00000	100.00000	642801.50075	416971.54970	1994 Sediment Data - SAIC and GAS
472	63	50.00000	100.00000	642964.43354	416951.76809	1994 Sediment Data - SAIC and GAS
473	763	50.00000	100.00000	643061.24322	416972.33072	1994 Sediment Data - SAIC and GAS
474	116	50.00000	100.00000	642934.18448	416859.57974	1994 Sediment Data - SAIC and GAS
475	66	50.00000	100.00000	642998.87011	416863.54853	1994 Sediment Data - SAIC and GAS
476	59	50.00000	100.00000	642936.74698	416761.29760	1994 Sediment Data - SAIC and GAS
477	396	50.00000	100.00000	642872.49891	416667.57795	1994 Sediment Data - SAIC and GAS
478	41	50.00000	100.00000	642929.74725	416670.26544	1994 Sediment Data - SAIC and GAS
514	755	50.00000	100.00000	642810.06352	416257.69909	1994 Sediment Data - SAIC and GAS

527	1269	50.00000	100.00000	643149.86660	415662.25567	1994 Sediment Data - SAIC and GAS
530	13410	50.00000	100.00000	642947.24711	416161.22937	1994 Sediment Data - SAIC and GAS
532	154	50.00000	100.00000	642782.50195	416068.50981	1994 Sediment Data - SAIC and GAS
533	83080	50.00000	100.00000	642942.30982	416071.72852	1994 Sediment Data - SAIC and GAS
743	4026	50.00000	100.00000	642100.27302	414266.55559	1998 BBL Sediment/Tissue Data
744	318	50.00000	100.00000	642056.27352	415350.87848	1998 BBL Sediment/Tissue Data
746	75	50.00000	100.00000	642856.62495	415867.78914	1998 BBL Sediment/Tissue Data
748	2150	50.00000	100.00000	642296.32839	416288.79356	1998 BBL Sediment/Tissue Data
749	164	50.00000	100.00000	642799.56243	418189.21748	1998 BBL Sediment/Tissue Data
750	124	50.00000	100.00000	643635.03823	418142.09142	1998 BBL Sediment/Tissue Data
290	430	50.00000	100.00000	642901.93416	418602.47133	1989/90 Mass Balance Sediment Data
11001	80.50000	100.00000	150.00000	643039.68956	418084.06494	2000-01 CH2M Hill
11002	120.00000	100.00000	124.00000	643136.15972	418052.54146	2000-01 CH2M Hill
11003	175.50000	100.00000	150.00000	643041.56468	417984.09893	2000-01 CH2M Hill
11005	80.50000	100.00000	124.00000	643201.51678	417975.98992	2000-01 CH2M Hill
11007	80.50000	100.00000	133.00000	643263.32702	418088.26368	2000-01 CH2M Hill
11011	77.00000	100.00000	125.00000	642955.37132	417893.59286	2000-01 CH2M Hill
11012	147.50000	100.00000	150.00000	643115.11696	417896.58903	2000-01 CH2M Hill
11014	4890.00000	100.00000	150.00000	642896.42568	416348.02928	2000-01 CH2M Hill
11015	14120.00000	100.00000	150.00000	642898.08960	416259.17083	2000-01 CH2M Hill
11017	57800.00000	100.00000	150.00000	642925.59385	416070.79553	2000-01 CH2M Hill
11018	430.00000	100.00000	115.00000	642927.88207	415948.61522	2000-01 CH2M Hill
11020	77.00000	100.00000	114.00000	642665.88422	415854.82430	2000-01 CH2M Hill
11022	77.00000	100.00000	150.00000	642708.11699	415733.39071	2000-01 CH2M Hill
11041	77.00000	100.00000	150.00000	642708.73989	415700.06882	2000-01 CH2M Hill
11046	77.00000	100.00000	150.00000	642730.42531	415822.69720	2000-01 CH2M Hill
11048	77.00000	100.00000	116.00000	642705.41773	415877.78558	2000-01 CH2M Hill
11050	77.00000	100.00000	114.00000	642752.10979	415945.32570	2000-01 CH2M Hill
11060	77.00000	100.00000	150.00000	642225.90280	415446.61564	2000-01 CH2M Hill
11061	77.00000	100.00000	150.00000	642227.14359	415379.97190	2000-01 CH2M Hill
12000	80.50000	100.00000	150.00000	643372.84766	418212.54661	2000-01 CH2M Hill
12001	80.50000	100.00000	150.00000	643118.03541	417741.08640	2000-01 CH2M Hill
12002	84.00000	100.00000	150.00000	642958.28598	417738.09024	2000-01 CH2M Hill
12003	77.00000	100.00000	150.00000	642758.59920	417734.35049	2000-01 CH2M Hill
12005	80.50000	100.00000	150.00000	642579.96908	417886.56717	2000-01 CH2M Hill
12006	77.00000	100.00000	150.00000	642755.68928	417889.85311	2000-01 CH2M Hill
DA01S-06	77.00000	100.00000	150.00000	642286.67007	414758.85672	2001 Blasland, Bouck, and Lee
DA01S-11	77.00000	100.00000	124.00000	642305.13480	414625.86705	2001 Blasland, Bouck, and Lee
DA01S-13	77.00000	100.00000	142.00000	642121.74931	414600.23173	2001 Blasland, Bouck, and Lee
DA01S-14	77.00000	100.00000	110.00000	642193.87745	414590.46240	2001 Blasland, Bouck, and Lee
DA01S-21	111.00000	100.00000	129.00000	642024.05435	414265.08231	2001 Blasland, Bouck, and Lee
DA01S-22	80.50000	100.00000	131.00000	642168.11116	414256.64944	2001 Blasland, Bouck, and Lee
DE01S-02	0.00000	100.00000	106.00000	642955.00812	417060.24408	2001 Blasland, Bouck, and Lee
DE01S-03	0.00000	100.00000	148.00000	642786.83819	417079.31736	2001 Blasland, Bouck, and Lee
DE01S-05	0.00000	100.00000	150.00000	642808.10033	417224.16102	2001 Blasland, Bouck, and Lee
DE01S-07	0.00000	100.00000	139.00000	642631.94707	417243.08866	2001 Blasland, Bouck, and Lee
DE01S-09	0.00000	100.00000	112.00000	642885.90090	417336.72988	2001 Blasland, Bouck, and Lee
DE01S-11	0.00000	100.00000	150.00000	642963.07420	417482.62170	2001 Blasland, Bouck, and Lee
DE01S-12	0.00000	100.00000	111.00000	642746.36499	417534.11969	2001 Blasland, Bouck, and Lee
DE01S-13	32.00000	100.00000	110.00000	642577.79286	417575.41272	2001 Blasland, Bouck, and Lee
DE01S-14	0.00000	100.00000	150.00000	643057.26084	417573.27755	2001 Blasland, Bouck, and Lee
DE01S-16	0.00000	100.00000	150.00000	642615.23993	417709.44699	2001 Blasland, Bouck, and Lee
DE01S-18	0.00000	100.00000	142.00000	643196.24137	417831.44459	2001 Blasland, Bouck, and Lee
DE01S-19	0.00000	100.00000	150.00000	643329.93826	417945.06937	2001 Blasland, Bouck, and Lee
DE01S-21	0.00000	100.00000	150.00000	643375.35467	418079.25858	2001 Blasland, Bouck, and Lee
DE01S-22	0.00000	100.00000	112.00000	643574.40356	418116.33930	2001 Blasland, Bouck, and Lee
DE01S-23	0.00000	100.00000	150.00000	643477.93197	418147.85636	2001 Blasland, Bouck, and Lee
DE01S-24	0.00000	100.00000	150.00000	643603.63062	418261.33665	2001 Blasland, Bouck, and Lee
DE01S-25	290.00000	100.00000	150.00000	643268.18293	418255.02382	2001 Blasland, Bouck, and Lee
DE01S-26	0.00000	100.00000	150.00000	643483.82786	418259.08010	2001 Blasland, Bouck, and Lee
DE01S-28	0.00000	100.00000	150.00000	642905.28694	417581.53991	2001 Blasland, Bouck, and Lee
DE01S-29	380.00000	100.00000	150.00000	643345.75370	418378.70606	2001 Blasland, Bouck, and Lee
DE01S-30	0.00000	100.00000	150.00000	643657.44445	418373.46385	2001 Blasland, Bouck, and Lee
DE01S-31	0.00000	100.00000	150.00000	643513.26525	418392.96971	2001 Blasland, Bouck, and Lee
DE01S-35	680.00000	100.00000	150.00000	643479.01821	418514.54893	2001 Blasland, Bouck, and Lee
DE01S-36	28.00000	100.00000	150.00000	643605.96547	418561.38539	2001 Blasland, Bouck, and Lee
DE01S-39	0.00000	100.00000	150.00000	643516.23142	418659.69635	2001 Blasland, Bouck, and Lee
PD-A/B-11	170.00000	91.00000	122.00000	642133.73163	414250.70571	2001 Blasland, Bouck, and Lee
PD-A/B-11	32.00000	122.00000	132.00000	642133.73163	414250.70571	2001 Blasland, Bouck, and Lee
11003	81	150.00000	200.00000	643041.56468	417984.09893	2000-01 CH2M Hill
11012	81	150.00000	200.00000	643115.11696	417896.58903	2000-01 CH2M Hill
11014	2180	150.00000	200.00000	642896.42568	416348.02928	2000-01 CH2M Hill
11015	405	150.00000	190.00000	642898.08960	416259.17083	2000-01 CH2M Hill
11017	1795	150.00000	175.00000	642925.59385	416070.79553	2000-01 CH2M Hill
11060	77	150.00000	175.00000	642225.90280	415446.61564	2000-01 CH2M Hill
12000	81	150.00000	200.00000	643372.84766	418212.54661	2000-01 CH2M Hill
12001	77	150.00000	190.00000	643118.03541	417741.08640	2000-01 CH2M Hill
12006	81	150.00000	200.00000	642755.68928	417889.85311	2000-01 CH2M Hill
DE01S-05	0	150.00000	174.00000	642808.10033	417224.16102	2001 Blasland, Bouck, and Lee
DE01S-11	0	150.00000	200.00000	642963.07420	417482.62170	2001 Blasland, Bouck, and Lee
DE01S-14	0	150.00000	182.00000	643057.26084	417573.27755	2001 Blasland, Bouck, and Lee
DE01S-16	0	150.00000	152.00000	642615.23993	417709.44699	2001 Blasland, Bouck, and Lee
DE01S-19	0	150.00000	200.00000	643329.93826	417945.06937	2001 Blasland, Bouck, and Lee
DE01S-21	0	150.00000	200.00000	643375.35467	418079.25858	2001 Blasland, Bouck, and Lee
DE01S-23	0	150.00000	180.00000	643477.93197	418147.85636	2001 Blasland, Bouck, and Lee

DE01S-24	0	150.00000	193.00000	643603.63062	418261.33665	2001 Blasland, Bouck, and Lee
DE01S-25	0	150.00000	200.00000	643268.18293	418255.02382	2001 Blasland, Bouck, and Lee
DE01S-26	0	150.00000	200.00000	643483.82786	418259.08010	2001 Blasland, Bouck, and Lee
DE01S-28	0	150.00000	200.00000	642905.28694	417581.53991	2001 Blasland, Bouck, and Lee
DE01S-29	0	150.00000	200.00000	643345.75370	418378.70606	2001 Blasland, Bouck, and Lee
DE01S-31	0	150.00000	200.00000	643513.26525	418392.96971	2001 Blasland, Bouck, and Lee
DE01S-35	0	150.00000	200.00000	643479.01821	418514.54893	2001 Blasland, Bouck, and Lee
DE01S-36	0	150.00000	200.00000	643605.96547	418561.38539	2001 Blasland, Bouck, and Lee
DE01S-39	0	150.00000	167.00000	643516.23142	418659.69635	2001 Blasland, Bouck, and Lee
478	20	150.00000	200.00000	642929.74725	416670.26544	1994 Sediment Data - SAIC and GAS
749	150	150.00000	200.00000	642799.56243	418189.21748	1998 BBL Sediment/Tissue Data
750	180	150.00000	200.00000	643635.03823	418142.09142	1998 BBL Sediment/Tissue Data

Table 2 PCB Data Not included in 2002 Interpolation

Station ID	Total PCB (ug/kg)	Start Depth (cm)	End Depth (cm)	Easting	Northing	Source
8	22680	0.00000	10.00000	642106.27249	414759.56030	1989/90 Mass Balance Sediment Data
17	8755	0.00000	10.00000	642115.83411	415601.75584	1989/90 Mass Balance Sediment Data
30	14650	0.00000	10.00000	643142.42760	418035.21577	1989/90 Mass Balance Sediment Data
31	2900	0.00000	10.00000	643352.17156	417975.46505	1989/90 Mass Balance Sediment Data
32	190	0.00000	10.00000	643449.98125	417932.12086	1989/90 Mass Balance Sediment Data
37	2520	0.00000	10.00000	643612.35096	418740.09712	1989/90 Mass Balance Sediment Data
38	1400	0.00000	10.00000	643764.84654	418729.19070	1989/90 Mass Balance Sediment Data
49	4925	0.00000	10.00000	642862.99863	417432.83524	1989/90 Mass Balance Sediment Data
52	21100	0.00000	10.00000	643041.24300	418082.34129	1989/90 Mass Balance Sediment Data
187	18500	0.00000	10.00000	642355.89064	414231.68007	1989/90 Mass Balance Sediment Data
195	2500	0.00000	10.00000	642862.99858	417507.49225	1989/90 Mass Balance Sediment Data
196	2713	0.00000	10.00000	642623.38074	417218.70838	1989/90 Mass Balance Sediment Data
231	40000	0.00000	10.00000	641962.52700	414279.52461	1989/90 Mass Balance Sediment Data
249	190	0.00000	10.00000	642196.14471	415012.37515	1989/90 Mass Balance Sediment Data
250	100	0.00000	10.00000	642326.07852	414910.21788	1989/90 Mass Balance Sediment Data
304	490	0.00000	10.00000	642350.20296	414714.18469	1989/90 Mass Balance Sediment Data
306	750	0.00000	10.00000	642445.26304	414240.46139	1989/90 Mass Balance Sediment Data
8	49060	10.00000	30.00000	642106.27249	414759.56030	1989/90 Mass Balance Sediment Data
17	1659	10.00000	30.00000	642115.83411	415601.75584	1989/90 Mass Balance Sediment Data
30	9022	10.00000	30.00000	643142.42760	418035.21577	1989/90 Mass Balance Sediment Data
31	1640	10.00000	30.00000	643352.17156	417975.46505	1989/90 Mass Balance Sediment Data
32	50	10.00000	30.00000	643449.98125	417932.12086	1989/90 Mass Balance Sediment Data
37	416	10.00000	30.00000	643612.35096	418740.09712	1989/90 Mass Balance Sediment Data
38	2500	10.00000	30.00000	643764.84654	418729.19070	1989/90 Mass Balance Sediment Data
49	2459	10.00000	30.00000	642862.99863	417432.83524	1989/90 Mass Balance Sediment Data
52	18380	10.00000	30.00000	643041.24300	418082.34129	1989/90 Mass Balance Sediment Data
187	6257	10.00000	30.00000	642355.89064	414231.68007	1989/90 Mass Balance Sediment Data
195	288	10.00000	30.00000	642862.99858	417507.49225	1989/90 Mass Balance Sediment Data
196	2152	10.00000	30.00000	642623.38074	417218.70838	1989/90 Mass Balance Sediment Data
231	20750	10.00000	30.00000	641962.52700	414279.52461	1989/90 Mass Balance Sediment Data
249	190	10.00000	30.00000	642196.14471	415012.37515	1989/90 Mass Balance Sediment Data
250	100	10.00000	30.00000	642326.07852	414910.21788	1989/90 Mass Balance Sediment Data
8	55900	30.00000	50.00000	642106.45999	414759.37280	1989/90 Mass Balance Sediment Data
31	50	30.00000	50.00000	643352.42155	417975.40255	1989/90 Mass Balance Sediment Data
52	530	30.00000	50.00000	643041.43049	418082.40379	1989/90 Mass Balance Sediment Data
187	1900	30.00000	50.00000	642355.45315	414231.36757	1989/90 Mass Balance Sediment Data
195	2	30.00000	50.00000	642863.43607	417507.39845	1989/90 Mass Balance Sediment Data
231	3032	30.00000	50.00000	641962.46451	414279.36831	1989/90 Mass Balance Sediment Data

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MEMORANDUM

TO: Project File
FROM: Shashi Muttige
DATE: December 3, 2002

CLIENT: WDNR
TASK: WISC1-15933
RE: Developing Dredge Management Units and Estimating Sediment Dredge Volume

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The purpose of this memorandum is to summarize the procedures adopted to develop Dredge Management Units (DMU) and estimate sediment dredge volumes utilizing mechanical dredging alternative (clamshell bucket). The DMUs and sediment dredge volumes have been completed for Operable Unit (OU) 4. Due to the magnitude of OU 4, the volume calculations and DMU representation was completed by SMU groupings. OU 4 was divided into fifteen SMU groups. Procedures for DMU representation and dredge volume calculations for one SMU group (SMU 20-25) are described in this memorandum. The procedures mentioned in this memorandum will be followed to complete dredge volume estimations for the remaining Lower Fox River Operable Units requiring mechanical dredging. Table and figures referenced in this memorandum are provided as an attachment.

The following steps summarize step-by-step procedures for developing DMUs and generating sediment dredge volumes for SMU 20-25.

1. The first step involved developing dredge elevation contours (Figure 1). The genesis of the dredge elevation contours was a three-part process.
    - A bathymetric grid (water depth) was created from more than 16,000 known data points in the lower Fox River. The mudline elevation was developed by subtracting the newly created bathymetric grid from the average surface water elevation for OU 4 which is 577.50 feet.
    - A script was written in ArcView GIS to create a depth of dredge cut grid. The depth of dredge cut script took into account all the 9 model sediment thickness layers (0 cm – 10 cm,....300 cm to 350 cm). The resulting grid represented the depth at which an action level of 1,000 parts per billion (PCB concentration) was exceeded. The depth of dredge cut was subtracted from the mudline elevation to result in the dredge depth elevation.
    - The dredge depth elevation contours were generated at 1-foot intervals to produce the contour lines as represented on Figure 1.
2. The next step (Figure 2) involved setting a series of 60-feet dredge lanes with 20-feet width (equal to two clam-shell bucket lengths) resulting in the formation several 60 feet by 20 feet DMUs. This is a reasonable representation based on discussion with John Lally of Bean Environmental. The DMUs were created in AutoCAD and trimmed to fit the 1,000 ppb action level dredge footprint. As a result some of the DMUs created along the perimeter of the SMU do not conform to the model DMU area of 1,200 sq. feet. The

DMUs were overlaid on top of the dredge elevation contours created in Step 1 as depicted on Figure 2.

3. As depicted on Figure 3, mudline elevation contours were generated for SMU 20-25.
4. As shown on Figure 4, the lowest elevation contour was set as the bottom dredge depth cut for each individual DMU. The values were obtained by overlaying the DMU layout with the interpolated dredge elevation grid and subsequently running a "Zonal Statistics" function which reports the minimum, maximum, and mean cell values of dredge elevation per DMU.
5. The next step involved grouping DMUs with similar dredge elevations along the dredge lanes that traverse in the north-south direction. The combined DMUs are depicted on Figure 5.
6. Each DMU was assigned a unique identification number starting from the northwest corner of the SMU with sequential numbering traversing west to east. The DMU IDs are shown on Figure 6.
7. Within each DMU, the corrected mean dredge depth elevation was subtracted from the highest mudline elevation to obtain mean dredge cut depth. The mean dredge for each DMU was multiplied by the corresponding area of the DMU to obtain the mean volume of sediments to be dredged within the DMU. Table 1 presents information pertaining to the individual DMUs that include area, minimum dry bulk density, mean dredge depth, shallow mudline elevation, mean dredge elevation and mean volume of dredge sediments. Comparison of sediment dredge volumes for SMU 20-25 with the Draft 2001 RI/FS dredge volume is presented in Table 2.

RETEC held discussions with Mr. Greg Hartman on October 30, 2002, to determine the logical process for combining the DMUs with similar dredge elevations and discuss the validity of the process for calculating sediment volumes. Mr. Greg Hartman recommended combining individual DMUs with similar dredge elevations that are located adjacent to each other in the north-south direction. This results in the formation of several large DMUs and facilitates enhanced representation of the dredge areas for future activities. Figure 5 depicts representative combined DMUs for mechanical dredging technique. Mr. Greg Hartman also recommended using mean dredge volume for mechanical dredging option and maximum dredge volume for hydraulic dredge option to be used as the representative volume for design purposes. The mean dredge volume was recommended for mechanical dredge option as clamshell buckets with the small bite size (20 ft x 10 ft) have the capability of removing sediments with greater precision, thereby eliminating sediment removal within a DMU to flat-bottom based on maximum dredge depth. For hydraulic dredging, maximum dredge volume was recommended as cutterhead dredges have bigger horizontal control (120 ft x 10 ft) which reduces precision and precludes sediment removal at varied depths within a DMU.

During a weekly conference call held on November 6, 2002, Mr. Greg Hartman suggested applying 6 inches to the dredge elevation across the dredge footprint to account for overdredge factor. Therefore 6-inch correction factor was applied to the mean and minimum dredge elevations across the SMU. The corrected mean dredge elevation was used to calculate dredge volume for mechanical dredge option.

Based on the discussions with Mr. Greg Hartman, it was determined that the above-mentioned process for calculating sediment volumes and developing DMUs is valid and will be used for completing the sediment volumes for the remaining Lower Fox River OUs.

Appendix C

Supporting Material for *In Situ* Capping

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C1 Introduction

C1.1 Background

This appendix to the Detailed Evaluation of Alternatives (DEA) report represents a detailed analysis for capping alternatives for the Lower Fox River in Operable Units (OUs) 1, 3, and 4. *In-situ* capping (ISC) was identified within the *Final Feasibility Study for the Lower Fox River and Green Bay, Wisconsin* (FS) (RETEC, 2002a) as an appropriate and applicable remedy for consideration within the Lower Fox River and Green Bay. Subsequently, *White Paper No. 6B – In-Situ Capping as a Remedy Component for the Lower Fox River* (White Paper No. 6B) (Palermo et al., 2002) to the OU 1 and OU 2 Responsiveness Summary, defined the conditions and design considerations for capping to be included as a remedy component. This appendix, follows the elements defined in White Paper No. 6B, and presents a preliminary basis for design, costs, implementation, and permitting requirements.

This appendix provides the detailed analysis for the design basis presented in Section 3 of the DEA. However, it is important to note that this document does not constitute design. There are too few data upon which to build a design document. Rather, it is a preliminary document that would serve as guidance for final design. The elements defined in this document would need to be reevaluated based upon additional data that are identified as part of this report.

The Wisconsin Department of Natural Resources (WDNR) and the United States Environmental Protection Agency (EPA) did not include ISCs as part of the *Proposed Remedial Action Plan, Lower Fox River and Green Bay* (Proposed Plan) (WDNR and EPA, 2001), but did allow for potential consideration of ISCs in the Record of Decision (ROD). The ROD noted that while capping could be considered a component of the final remedial alternative for the Lower Fox River, it could not be the sole remedial action. The ROD limited restricted capping to 25 percent of the estimated volume within the 1 part per million (ppm) Remedial Action Level (RAL) contour for each OU.

C1.2 Purpose and Scope

This appendix provides specific detailed analyses to support Section 3 of the DEA report. It follows specific guidance on how a capping alternative should be designed, evaluated, and managed to include long-term requirements for monitoring and institutional controls for the Lower Fox River. It is intended to address concerns raised regarding long-term protection from contaminants, long-term liability, and operations and maintenance.

The DEA report was not constrained by the 25 percent volume limitation articulated in the Record of Decision. Rather, this document identifies the maximum areas where capping could be considered, and leaves the details of determining which areas of each OU that would be capped in the final design to the proponents and the WDNR and EPA (Agencies). An explicit understanding in this document is that capping does not eliminate the need for removal actions in order to meet the defined goals within the Proposed Plan.

This paper describes the technical, regulatory, and institutional considerations for selecting and designing subaqueous ISC as a remedy component for the Lower Fox River. General technical considerations for ISC design are summarized and specifics on application of existing cap design guidance for the Lower Fox River are described. This appendix follows the ISC chapter in EPA's recent release *Contaminated Sediment Remediation Guidance for Hazardous Waste Sites* (EPA, 2002). This appendix also considers Wisconsin and federal laws as they may impact final selection and design of an ISC alternative.

Finally, this document also covers specific construction, placement techniques, and performance criteria, as well as detailed costs for capping. Specific costs for dredging residual areas outside the capping areas are not included.

C1.3 Capping As a Remedial Alternative

C1.3.1 Definitions

This appendix focuses primarily on considerations for isolation capping as a remedy component. As defined in White Paper No. 6B, the following definitions are applicable design considerations for the Lower Fox River:

***In-Situ* Capping** is defined as the placement of an engineered subaqueous cover, or cap, of clean isolating material over an *in-situ* deposit of contaminated sediment (EPA, 1994, 2002; NRC, 1997, 2001; Palermo et al., 1998a, 1998b). *In-situ* caps are generally constructed using granular material, such as clean sediment, sand, or gravel, but cap designs can include geotextiles, liners, and multiple layers. Such engineered caps are also called isolation caps. *In-situ* capping may be considered as a sole remedial alternative or may be used in combination with other remedial alternatives (e.g., removal and monitored natural recovery). Within this document, *in-situ* capping is considered to be used in conjunction with removal alternatives for each OU.

***In-Situ* Capping with Partial Removal** is an option involving placement of an ISC over contaminated sediments which remain in place upon completion of a partial dredging action. In this case, ISC involves the removal of contaminated sediment to some depth followed by ISC of the remaining sediment. This can be suitable where capping alone is not feasible due to habitat, hydraulic, navigation, or other restrictions on minimum water depth. *In-situ* capping with partial dredging can also be used when leaving deeper contaminated sediment capped in place is desirable for preserving bank or shoreline stability. When ISC is used with partial dredging, the cap is designed as an engineered isolation cap, since a portion of the contaminated sediment deposit is not dredged and remains in place. *In-situ* capping with partial removal is considered in this appendix.

Residual Capping is defined as placement of a thin cap layer over a thin layer of residual sediment left behind following dredging. In this case, the dredging operation is designed to remove all the contaminated sediments, but the dredging process resuspends contaminated sediment that resettles onto the dredged surface, forming the residual layer. Such residual layers are typically a few centimeters (cm) thick. Residual capping may be employed in OUs of the Lower Fox River as a means to manage residual sediments following completion of removal, but is not considered as part of this evaluation.

C1.3.2 Capping Guidance Documents

The capping evaluation process follows the detailed guidance for subaqueous dredged material capping and ISC for sediment remediation that has been developed by the United States Army Corps of Engineers (USACE) and EPA. The documents *Contaminated Sediment Remediation Guidance for Hazardous Waste Sites* (EPA, 2002), *Guidance for Subaqueous Dredged Material Capping* (Palermo et al., 1998a), and *Guidance for In-Situ Subaqueous Capping of Contaminated Sediments* (Palermo et al., 1998b), provide detailed procedures for site and sediment characterization, cap design, cap placement operations, and monitoring for subaqueous capping.

In addition to these documents, there are multiple references that discuss physical considerations, design, and monitoring requirements for capping. These include the following:

- *Review of Removal, Containment and Treatment Technologies for Remediation of Contaminated Sediment in the Great Lakes* (Averett et al., 1990)

- *Design Requirements for Capping* (Palermo, 1991a)

- *Site Selection Considerations for Capping* (Palermo, 1991b)

- *Washington State Department of Ecology 1990 Standards for Confined Disposal of Contaminated Sediments Development Document* (Ecology, 1990)

- *Equipment and Placement Techniques for Capping* (Palermo, 1991c)

- *Monitoring Considerations for Capping* (Palermo et al., 1992)

- *Subaqueous Capping of Contaminated Sediments: Annotated Bibliography* (Zeman, et al., 1992)

- *Design Considerations for Capping/Armoring of Contaminated Sediments In-Place* (Maynord and Oswalt, 1993)

The salient elements of site selection, design, construction, monitoring, and liability management from these references will be discussed in this appendix.

C1.4 Appendix Organization

Section 2 first presents the design criteria established for an ISC. The physical, chemical, and biological components with each Operable Unit are then compared to the design criteria to reach a determination of suitable capping areas. Section 2 also presents the area to by capped, the volume and mass of PCB-contaminated sediments under the cap(s), and the residual volumes exceeding the 1 ppm RAL that would require dredging and disposal.

Section 3 develops the specific physical structure for the isolation cap. First, the process of designing an isolation cap is presented. Iterative advective and diffusive flux modeling was conducted to ensure that PCB concentrations would not exceed risk reduction goals in the biologically active surface sediments. The input and output data for these models is included. Section 3 concludes with the structure and thickness of the ISC for each OU and identifies additional information requirements needed for final design.

Section 4 describes the evaluation of hydrodynamic conditions in the Lower Fox River, relative to the long-term physical stability of the ISC. One-hundred-year flood velocities are derived from previous modeling work done by WDNR to project a conservative maximum near-bed velocity. This design velocity is used to identify suitable armoring materials from local sources. Section 4 concludes with the recommended armor thickness, stone size, and recommendations for application.

Section 5 takes the information developed in the previous three sections and develops the application design basis used in the DEA report. A specific method of application, required equipment, long-term monitoring and project schedule are presented. In addition, Section 5 presents the institutional and regulatory issues that must be addressed for an ISC.

Section 6 presents the detailed cost estimates for the ISC for each Operable Unit.

Section 7 lists references used in this document.

C2 Identification of ISC Areas

C2.1 Design and Performance Criteria and Potential Areas to Be Capped

The design criteria for capping are based on the conclusions of White Paper No. 6B as follows:

- Capping may be a component of a remedy, but could not be the sole remedy for any OU. A combination of some capping and removal is likely the most efficient remedy.

- Technical, regulatory, and institutional issues would need to be appropriately considered in identifying potential areas for capping. Potential areas for capping should be selected based on the following:

  - The overall remedy must manage all sediments within the 1 ppm contour, and should achieve a sediment-weighted average concentration of 250 (parts per billion) ppb.

  - No capping within authorized navigation channels (with an appropriate buffer).

  - No capping would occur in areas of infrastructure such as pipelines, utility easements, bridge piers, etc. (with appropriate buffer).

  - No capping would occur in areas with [polychlorinated biphenyl] PCB concentrations exceeding [Toxic Substances Control Act] TSCA levels.

  - No capping would occur in shallow-water areas (bottom elevations which would result in a cap surface at elevation greater than -3 feet chart datum for OUs 1 and 3 and -4 feet chart datum for OU 4) because of habitat and ice scour considerations without prior deepening to allow for cap placement.

- The composition and thickness of the cap components comprise the cap design. A detailed design effort for any selected capping remedy should address all pertinent design considerations.

- The cap will be designed to provide physical isolation of the PCB-contaminated sediments from benthic organisms.

- The cap will be physically stable from scour by currents, flood flow, and ice scour. The 100-year flood event will be considered in these evaluations.
- The cap will provide isolation of the PCB-contaminated sediments in perpetuity from flux or resuspension into the overlying surface waters.
- The performance criteria for chemical isolation will be a limit of 250 ppb of PCBs in the cap sediment (dry-weight basis) in the biologically active zone, defined as the upper 10 cm of the isolation layer of the cap. This standard would apply as a construction standard to ensure the cap is initially placed as a clean layer, and would also apply as a long-term limit with respect to chemical isolation.
- The cap design will consider operational factors such as the potential for cap and sediment mixing during cap placement and variability in the placed cap thickness.
- The cap design will incorporate an appropriate factor of safety to account for uncertainty in Site conditions, sediment properties, and migration processes.
- Institutional/regulatory constraints associated with capping, such as capping TSCA materials, lake bed grants, riparian owner issues, deed restrictions, fiduciary responsibility, and long-term liability should be fully considered in selecting potential areas for capping and in design of the caps for specific areas.

The design criteria described above were applied to each OU to determine specific identified areas within OUs 1, 3, and 4 that would potentially be capped. The physical conditions and potential obstructions for capping are defined in Section 2 of the DEA report. Application of the design criteria to site limitations for each of the OUs is defined, below.

C2.2 Operable Unit 1

C2.2.1 Physical Environment

OU 1 includes all of Little Lake Buttes des Morts, and extends from the Neenah and Menasha channel outlets from Lake Winnebago to Appleton Lock Number 1. Covering a total of 1,426 acres, OU 1 is approximately 6 miles from north to south, and approximately 3,500 feet wide. This reach includes sediment deposits A through H and POG. The total area of PCBs exceeding the 1 ppm action level is approximately 441 acres (Figure 2-1)

C2.2.2 Potential Capping Areas in OU 1

Potential capping areas for OU 1 were first determined based upon the areas where the PCBs exceeded the 1 ppm RAL, and a clear, post-construction water depth of at least 3 feet could be achieved. Additional considerations included the presence of PCBs greater than 50 ppm (i.e., TSCA materials), presence of the federal navigation channel, in-water obstructions, and potential to affect 100-year floodplains. All of the potential capping area is shown on Figure 2-2. Based on evaluations discussed below, the final areas are shown on Figure 2-3. The total surface acres, volumes, and mass exceeding 1 ppm, the maximum potential capping area, the final DEA capping area, and the residual areas that will require removal and disposal are listed in the table below. Based on other considerations described later in this appendix, the final DEA cap footprint was reduced to 221 acres. This represents 50 percent of the total 1 ppm footprint, 45 percent of the total volume, and 25 percent of the total mass in OU 1.

	Surface Acres	Volume (cy)	Mass (kg)
1 ppm PCB Footprint	441	831,334	1,394
Potential Capping Areas	266	471,987	400
Final DEA Cap Footprint	221	371,693	345
Residual Dredge Areas	228	449,569	1,036

For OU 1, an elevation (depth) of 731 feet mean sea level (msl), or lower, is required to support the cap and still leave sufficient depth post-construction to meet the -3 feet clear water requirement. Mudline elevations were determined using existing bathymetric profiles, and tying those depth intervals to a fixed lake elevation. Within OU 1, most of Deposit E falls in the less than or equal to 731 feet msl contour (i.e., 771, 770, etc.). For OU 1, this was the principal consideration in setting the potential cap boundaries. Deposits A/B, C, most of POG, D, and F are too shallow to support a capping alternative without at least partial dredging. There is some uncertainty associated with the bathymetric contours. The accurate bathymetry planned in the pre-design sampling will help better delineate the capping areas.

To evaluate a partial dredge/cap at deposits A, POG, and C, the DEA examined the current mudline, and then determined that to achieve appropriate water depths, the partial dredging would need to remove all sediments in those deposits to an elevation of 731 feet msl, followed by placement of a sand cap over the residuals. The table below shows the residual area and volume for those volumes at a removal to 731 feet msl. After removal, there is a relatively limited volume left at those deposits. It was determined that given the cost of capping, and the ROD requirement for less than 25 percent of the total mass, that this small residual would be more effectively dealt with by removal.

Deposit	Area (sq. m)	Volume (cu. m)
A	62,200	10.960
C	19,800	3,890
POG	60,900	10,520

The constraints on the recommended cap site include the accurate assessment of bottom elevations. These will be resolved by the additional bathymetric and side-scan work currently included in the pre-design work plan.

C2.2.3 Operational Water Depth Constraints

An additional consideration for capping is the operational water depths. For OU 1 over the identified capping area, depths exceed 5 feet; being 10 feet deep throughout the central part of the River, to a maximum depth of 18 feet at the north end of the capping area. The areas adjacent to the identified capping area, water depths in OU 1 are generally shallow (less than 6 feet), which may present some constraints for equipment access for cap placement. Shallow draft barges for movement of cap material or hydraulic placement methods using pipeline could be considered.

C2.2.4 Hydrodynamic Conditions

Hydrodynamic conditions were evaluated to determine whether the cap would be hydraulically stable in OU 1 and whether armoring would be required. Cap stability is contingent upon understanding hydrodynamic conditions in the planned capping area. Velocity rates in OU 1 are typically low, owing to the fact that Little Lake Butte des Morts is a wide, generally shallow lake in comparison with the rest of the River. Water is controlled into the lake by releases from Lake Winnebago. As the lake narrows in the upper region, velocities increase.

Cap stability and potential armoring requirements were evaluated by first estimating the maximum bottom velocities that could be expected in OU 1. The modeled projections developed in the *Evaluation of the Hydrodynamics of the Lower Fox River between Lake Winnebago and De Pere, Wisconsin* (HydroQual, 2000), were plotted (Figure 2-4). The projections developed in that document were for the period of January 1, 1989 to May 31, 1990, and had a maximum measured flow of 408 cubic meters per second (m^3/s).

All modeled conditions are at best estimates, and as such an application of an uncertainty factor is appropriate. The velocities shown on Figure 2-4 are for a flow rate of 408 m^3/s, and not the 100-year flood condition of 680 m^3/s. As part of the modeling effort, linear regressions between flow and velocity were developed. Applying these velocity-flow relationships to the 100-year flood flow of 680 m^3/s results in an increase of between 1.2 and 1.9 times the velocities developed for 408 m^3/s. As such, an uncertainty term of 2 times the estimated velocity is appropriate. Thus, the potential maximum design velocity applied for OU 1 is 1.2 meters per second (m/s).

The proposed cap for OU 1 would have to meet the substantive requirements of Section 116.16(1), of the Wisconsin Administrative Code (WAC). That chapter defines Wisconsin's Floodplain Management Program, which requires that structures built within floodways and floodplains must be built to withstand flood depths, pressures, velocities, impact, uplift forces, and other factors associated with the regional (100-year) flood. An analysis of stability and armoring requirements for capping in all reaches of the River is presented in Section 4.

An assumption of this analysis is that the dams located at the head and toe of the OU will remain in perpetuity (see below). Changes in velocities that would occur related to removal of the dams at Lake Winnebago, or at Appleton, are not considered.

C2.2.5 Ice Conditions

The institutional restriction that post-construction water depth over a cap will be at least 3 feet should accommodate most ice conditions found on Little Lake Butte des Morts. There are no data available concerning ice conditions on Little Lake Butte des Morts. Ice does form on the lake, but available data are anecdotal relating to the actual thickness. In 1999, ice in excess of 18 inches, had to be broken up in order to conduct the post-removal confirmation sampling at Deposit N. Also, winter outflow through the Neenah and Menasha gates can create problems with frazil ice. The USACE recognizes frazil ice formation as a management issue in the regulation of pool elevation for Lake Winnebago especially during mild winters when extensive gate changes may be required (USACE Facts Book, 2003) in addition to the obvious consequences to the integrity of a cap. Confirmation of actual ice thickness must be incorporated into final design of a cap.

C2.2.6 Sediment Thickness and Deposition Rates

Little Lake Butte des Morts is considered to be a net depositional environment, but the rate at which sediments accumulate is not well understood, particularly over the area of Deposit E where capping would occur. Sediment thickness and rates of accumulation are discussed below.

Sediment thickness maps used in the design are those generated and discussed in the *Final Remedial Investigation for the Lower Fox River and Green Bay, Wisconsin* (RI) (RETEC, 2002b) and FS. Within the identified capping area, sediment thickness approached or exceeded 3 feet (Figure 2-5). These depths of accumulation were used to generate the capping design. However, these depths are based upon relatively sparse poling data, and were not tied to specific elevations. Additional data are needed to supplement existing soft sediment thickness data.

There is a paucity of information on net deposition rates in OU 1. Furthermore, whether the net deposition represents sediment solids transported into the system, or the accumulation of decayed organic matter in the highly eutrophic system is unknown. In addition, how the deposition rate may change upon completion of removal and capping actions is unknown. As such, the engineering design is for a self-contained cap that does not consider accumulation of additional sediments. Any net increase in sediment accumulation in voids within an armor layer can increase the isolation effectiveness of the cap over the long term, which should be considered only in the design of the long-term monitoring program. No additional data gathering activities are recommended for net deposition.

C2.2.7 Dam Stability

OU 1 is bounded on the southern end by the dams impounding Lake Winnebago at Neenah and Menasha, and on the northern end by the Upper Appleton dam (Figure 2-6). There are no indications of dam removal requirements or plans for any of the three dams bounding OU 1. All three dams have Federal Energy Regulation Commission (FERC) re-licensing requirements, which would need to be considered in any long-term planning and/or permitting.

Long-term dam stability is assumed here. Only the containment of subaqueous contaminants was considered; i.e., the long-term maintenance of the dams is assured. In a final design, safe isolation under conditions of dam failure/removal, and/or the creation of remnant on-land deposits, should be considered. A recommendation for final design is that any ISC must consider the maintenance of the dam/lock system as an institutional control in perpetuity.

C2.2.8 Geological and Hydrogeological Conditions

The design basis in this document did not consider potential for groundwater flow through a placed cap. The current understanding of the regional geological and hydrogeological conditions is documented in Section 3 of the RI. The Lower Fox River is fairly well documented to have either relatively nonporous clay or bedrock underlying most of the River. Based on the fine-grained glacial deposits which underlie the Lower Fox River and the absence of regional groundwater extraction, there is little groundwater recharge from the Lower Fox River into the upper aquifer. Available information also indicates little potential seepage (advection) due to groundwater flow, so continuous advective flow processes are not considered in this cap design.

The regional geology of the Fox River Valley does include sand stringers or fractured bedrock; these would need to be considered during sampling for final design purposes. This information should be derived based upon drilling and logging of cores in the uplands, parallel to the capping area. If a shallow aquifer is identified to occur within the elevations from the mudline to the bottom of the contaminated sediments, the overall gradient, flow rate, and emergence points will need to be identified. In addition, the presence of sand stringers may be identified by complete logging of sediment cores collected through, and into, the underlying native materials.

C2.2.9 Sediment Characteristics

Sediment Physical Properties

The sediment physical properties used for determining cap thickness are discussed in the RI (Appendix G). Where specific information was needed, it was taken from the Fox River Database. A complete set of physical data are necessary to determine the potential for shear stress/failure during cap placement, the extent of consolidation that will occur under placed materials, and the extent to which those placed material will cause advective flux in the underlying materials. These data are needed to determine cap design and constructability. To compensate for the lack of data, the design basis made conservative assumptions about consolidation and placement rates. The planned pre-design sampling and analyses should address the data gaps.

Extent of Contamination

The horizontal and vertical extent of PCBs exceeding the 1 ppm RAL are discussed in Section 2 of the DEA report. For the cap design basis, mean and maximum PCB concentrations were determined by depth interval and Water Quality Segment (WQS) from the interpolated PCB bed maps (Table 2-1). These data were used in the advective and diffusive flux modeling, described in Section 3, below.

Gas Formation

The potential for gas formation and breaching of the cap by PCBs advected with gas generation and release was not specifically considered in the DEA, but will need to be addressed in the final design. The potential for methane generation and cap breach was discussed in White Paper No. 6B to the RS for OU 1 and OU 2. The Lower Fox River has a high methane sediment content (GAS/SAIC, 1996). Sub-bottom profiles of sediments revealed large subsurface accumulations of methane in OUs 1, 2, and 3. Methane releases are frequently observed during sediment sampling and were seen during the demonstration project at Sediment Management Unit (SMU) 56/57. Gas generation and subsequent buildup may cause disruption of a membrane or low-permeability cap layer. This was illustrated by the displacement of a temporary membrane cap placed by EPA at the Manistique site. A 100-foot by 240-foot high-density polyethylene (HDPE) plastic membrane (40-mil) mat was placed over a hot spot at this site as a temporary control. The mat was weighted on the bottom with Jersey barrier concrete sections attached to the mat with cable and was fitted with 10 gas control valves to relieve gas buildup. An inspection of the mat 12 months after installation found that a number of bubbles had formed under the mat, causing upward displacement of the mat off the bottom as high as 8 feet (Lopata, 1994). Ultimately, this cap was removed and sediments were dredged from this site. In Wisconsin, a capping project at Oxbox Lake in Wausau capped lead-contaminated sediments in the late 1990s. The cap consisted of 2 feet of sand over a geotextile. Results of a recent inspection report found that methane buildup under the geotextile caused part of the cap to surface, appearing as large bubbles at the water surface. This raising, in turn, pulled the geotextile and cap material off of the underlying contaminated sediments (WDNR, 2002c).

Methane generation in sediments appears to be highly temperature dependent (Matsumoto et al., 1992) and there is some suggestion that capping will provide thermal insulation and prevent gas generation (Appendix GT-3, Service Engineering Group, 2002). At a minimum, the types of tests conducted for the Duluth Tar Site should be conducted prior to final cap design.

C2.2.10 Waterway Uses

Flood Flow Capacity

The capping area was restricted based on the potential to adversely impact flood zones on Strobe Island, as indicated on Figure 2-7. The line was placed based upon consideration of: (1) Stroebe Island, (2) where existing bathymetry indicates the thalweg of the River constricts (Figure 2-7), and where the velocity rates (Figure 2-4) increase. The resultant cap area for OU 1 considered in the DEA report is 221 acres, with a corresponding volume of approximately 371,700 cubic yards (cy) and mass of 1,036 kilograms (kg). It should be clear that the 45 surface acres at Strobe Island could potentially be capped in the final design. However to place a cap in those areas would require adequate data and reliable FEMA-based modeling to demonstrate that there would be no impacts to the flood height.

Placement of a cap in OU 1 will reduce water depths and may influence the flow-carrying capacity of the River. As noted previously, Chapter 116 of the WAC, Wisconsin's Floodplain Management Program, details the regulations for construction and development in floodways and floodplains. NR 116 requires that an in-water construction (including a cap) would be required to undertake a determination on the potential effects on the regional flood heights. This would require a substantive study on the hydrologic and hydraulic conditions pre- and post-construction to determine if there would be an increase in flood height due to cap placement. NR 116.03(28) defines an "increase in regional flood height" as being equal to or greater than 0.01 foot if a cap would result in an increase in regional flood height.

Specific modeling for increased flood height conditions was not considered in this analysis. Rather, the FEMA Flood Zone maps for the 100-year and 500-year floods were plotted, relative to the proposed capping areas (Figure 2-7), and evaluated for the potential to impact flood zones. The 100-year FEMA flood zone is indicated for the entire length of the proposed capping area. This is especially true in the area proposed offshore from Strobe Island, where both a 100-year and 500-year flood zones are indicated. As such, the area considered for capping was reduced by 45 surface acres, to a total of 221 surface acres.

	Surface Acres	Volume (cy)	Mass (kg)
1 ppm PCB Footprint	441	831,334	1,394
Strobe Island Area	45	100,294	55
Final DEA Cap Footprint	221	371,693	345

Federal Navigation Channels

Federal navigation channels restrict the area considered for capping. Navigation channels are indicated on the USACE plan sheets (USACE Detroit District) in OU 1 at the Menasha Lock on the southern end, and the upper Appleton lock on the northern end.

The Menasha channel is authorized to a project depth of 6 feet, 100 feet in width, and extends approximately 4,000 feet into Little Lake Butte des Morts. The Menasha channel passes through Deposit POG. The upper Appleton channel is authorized to a project depth of 7 feet depth, 100 feet width, and extends approximately 6,000 feet southward into Little Lake Butte des Morts. The upper Appleton channel does not extend into any identified PCB-containing deposits in Little Lake Butte des Morts. The navigation channels do not extend further into Little Lake Butte des Morts; there is currently sufficient water depth (greater than 6 feet) to accommodate navigation needs.

Cap areas were set to be outside of the navigation channels, consistent with the design criteria set in Section 2.1.

Recreational Use

Within the area considered for capping, the DEA report assumed that recreational use should not be impeded by changes in water depth. Principal known recreational uses on Little Lake Butte des Morts include fishing, boating, sailing, and personal watercraft (jet ski). Recreational use was not covered in the RI, and hard data on the actual area use was not available for the DEA report. For the purposes of design, the DEA report does make an assumption that all recreational boats within OU 1 will have a draft of less than 3 feet. As noted above, post-construction navigation charts will need to be made available to the public to reflect changes in water depth.

Infrastructure

The presence of in-water structures in OU 1 effects cap design. Infrastructure that could interfere with cap placement and long-term stability are shown on Figure 2-6. This includes the Highway 441 bridge, and a transmission cable crossing at Stroebe Island. For the DEA report, the presence of the Highway 441 bridge does not represent a barrier to construction. However, discussions are occurring within the Wisconsin Department of Transportation about adding a second bridge south of the current one. If this were to occur, it may be necessary to further restrict the areal extent of capping. The cable crossing at Stroebe Island does not affect the capping area for the DEA report, as it was reduced based on FEMA considerations in the same area. Final design would need to better define any other current or planned use of the area.

Habitat Considerations

The capping area is not anticipated to affect critical habitat areas within OU 1. Major habitat areas identified within the RI included the Stroebe Island Marsh and backwater areas. The considered cap area will not impact those areas. Additional habitat concerns raised by WDNR fisheries biologists were that additional carp habitat should not be created; these areas were identified as being less than 2 to 3 feet of water. This is addressed through the post-construction depth restriction (3 feet). Additional discussions on the potential affects on habitat in OU 1 are found in *White Paper No. 8 – Habitat and Ecological Considerations as a Remedy Component for the Lower Fox River* (White Paper No. 8) (WDNR, 2002b) to the ROD for OU 1 and OU 2, and are not considered further here.

C2.3 Operable Unit 3

C2.3.1 Physical Environment

OU 3 includes Little Rapids to De Pere and extends from the Little Rapids (Kaukauna) dam to De Pere dam. OU 3 is approximately 7 miles from north to south, and varies in width from over 2,000 feet at the southern end, to approximately 1,000 feet at the narrows before the De Pere dam. This reach includes sediment deposits EE through HH. Most of the contaminated sediments exist in a single contiguous depositional zone (Deposit EE). The total area of PCBs exceeding the 1 ppm action level is approximately 328 acres, as identified on Figure 2-8 of the DEA report.

C2.3.2 Potential Capping Areas

Potential capping areas for OU 3 were first determined based upon the areas where the PCBs exceeded the 1 ppm RAL, and a clear, post-construction water depth of at least 3 feet could be achieved (Figure 2-9). There are no areas identified with TSCA levels of PCBs. Additional considerations included the federal navigation channel, in-water obstructions, flow velocity through the northern portions of the reach, and the potential to affect 100-year floodplains.

The identified capping areas for OU 3 are shown on Figure 2-10. These are all within the 1 ppm RAL in Deposit EE that fall within Water Column Segment (WCS) 22 to 25. The total surface acres, volumes, and mass exceeding 1 ppm, the maximum potential capping area, the final DEA capping area, and the residual areas that will require removal and disposal are listed in the table below. This represents approximately 25 percent of the total 1 ppm footprint, 11 percent of the total volume, and 8 percent of the total mass in OU 3.

	Surface Acres	Volume (cy)	Mass (kg)
1 ppm PCB Footprint	328	586,788	1,111
Final DEA Cap Footprint	79	63,684	89
Residual Dredge Areas	249	523,104	1,022

For OU 3, an elevation of 583.4 feet msl, or lower, is required to support the cap and still leave sufficient water depth post-construction to meet the –3 feet clear water requirement (Figure 2-9). Elevations meeting that criterion lie principally within the thalweg of the River. Within WCS 22 to 24, the River is relatively broad, and narrows down to steep-walled channels from WCS 26 to the De Pere dam. Additional considerations included the velocity of the River through WCS 26 and 27, FEMA flood insurance issues, as well as the long-term consideration for maintenance of the De Pere dam. As discussed for OU 1, these decisions were made for the purposes of the DEA report. Additional areas could be proposed for capping within OU 3, but would require additional work to satisfy the concerns, identified below.

C2.3.3 Operational Water Depth Constraints

Bathymetric contours, and corresponding mudline elevations, are presented in Section 2 of the DEA report. The main channel depth is generally greater than 6 feet throughout most of OU 3, and as deep as 18 feet at the De Pere dam. The water depth is less than 4 feet close to the shore and drops off abruptly. In the areas adjacent to the identified capping area, water depths in OU 3 are generally shallow, which may present some constraints for equipment access for cap placement. Shallow-draft barges for movement of cap material or hydraulic placement methods using pipeline should be considered.

C2.3.4 Hydrodynamic Conditions

An evaluation of the hydrodynamic conditions in OU 3 was conducted to determine if materials would be stable and whether armoring would be required. Cap stability is contingent upon understanding hydrodynamic conditions in the planned capping area. Velocity rates in OU 3 are higher than those observed in OU 1, generally due to the more narrow width of the channel, particularly from WCS 26 to the De Pere dam.

The evaluation of cap stability and potential armoring requirements followed that described for OU 1. Maximum bottom velocities that could be expected in OU 3 were developed based upon the modeled projections developed in the *Evaluation of the Hydrodynamics of the Lower Fox River between Lake Winnebago and De Pere, Wisconsin* (HydroQual, 2000) (Figure 2-11). The projections developed in that document were for the period of January 1, 1989 to May 31, 1990, and had a maximum measured flow of 408 m^3/s.

C2.3.5 Ice Conditions

The institutional restriction that post-construction water depth over a cap will be at least 3 feet should accommodate most ice conditions found in OU 3. Ice conditions in OU 3 are the same as those described for OU 1 in Section 2.2.5. Confirmation of actual ice thickness must be incorporated into final design of a cap.

C2.3.6 Sediment Thickness and Deposition Rates

Depth of soft sediments within the area identified for capping is generally 3 to 4 feet thick, as shown on Figure 2-12. As discussed in Section 2 of the DEA report, the deposits in OU 3 cover about 266 hectares (655 acres) with soft sediment thickness range up to approximately 2.3 meters (7.5 feet) thick. For much of Deposit EE, the soft sediment accumulation is between 3 and 4 feet. The deposits immediately behind the De Pere dam have greater accumulations, between 4 and 7.5 feet. As described previously, soft sediment thickness data are based upon depth-to-refusal during poling and are not tied to specific elevations. Final cap design will require better definition of sediment thickness.

C2.3.7 Dam Stability

OU 3 is bounded on the southern end by Little Rapids (Kaukauna) dam, and on the northern end by the De Pere dam. These two dams are indicated on Figure 2-13. There are no indications of dam removal requirements or plans for either of the two dams bounding OU 3. A detailed description of the dams in all OUs is given in *White Paper No. 4 – Dams in Wisconsin and on the Lower Fox River* (WDNR, 2002a), to the RS for OU 1 and OU 2.

While the most recent safety surveys conducted by the USACE do not indicate any structural issues, a failure of the De Pere dam would have catastrophic implications for an *in-situ* cap that would be located anywhere from WCS 26 to the De Pere dam. Armoring and safety modeling and design requirements to account for a dam failure at that site were deemed to be beyond the scope of the DEA report. As such, a decision was made to not include those areas in the DEA report, but acknowledge that capping is still a potential option in those areas, if the physical issues can be adequately addressed by a future applicant.

For the areas identified for capping, long-term dam stability is assumed. Only the containment of subaqueous contaminants was considered; i.e., the long-term maintenance of the dams is assured. In a final design, safe isolation under conditions of dam failure/removal, and/or the creation of remnant on-land deposits, should be considered. A recommendation for final design is that any ISC must consider the maintenance of the dam/lock system, as an institutional control in perpetuity.

C2.3.8 Geological and Hydrogeological Conditions

As previously described for OU 1, the design basis in this document did not consider potential for groundwater flow through a placed cap. The current understanding of the regional geological and hydrogeological conditions is documented in Section 3 of the RI. The Lower Fox River is fairly well documented to have either relatively nonporous clay or bedrock underlying most of the River. Based on the fine-grained glacial deposits which underlie the Lower Fox River and the absence of regional groundwater extraction, there is little groundwater recharge from the Lower Fox River into the upper aquifer. Available information also indicates little potential seepage (advection) due to groundwater flow, so continuous advective flow processes are not considered in this cap design.

The regional geology of the Fox River Valley does include sand stringers or fractured bedrock; these would need to be considered during sampling for final design purposes. This information should be derived based upon drilling and logging of cores in the uplands, parallel to the capping area. If a shallow aquifer is identified to occur within the elevations from the mudline to the bottom of the contaminated sediments, the overall gradient, flow rate, and emergence points will need to be identified. In addition, the presence of sand stringers may be identified by complete logging of sediment cores collected through, and into, the underlying native materials.

C2.3.9 Sediment Characteristics

Sediment Physical Properties

The sediment physical properties in OU 3 are discussed in the RI, and specifically are listed for all OUs in Appendix G of that document. The data in that appendix include grain size, Atterberg Limits, the maximum depth of sampling (i.e., soft sediment), total solids, total organic carbon (TOC), and bulk densities by deposit. Where specific data for cap design were required, they were extracted from the Fox River Database.

Extent of Contamination

The aerial extent of PCBs exceeding the 1 ppm RAL in OU 3 is documented in the RI and FS, as well as in Section 2 of the DEA report. Within OU 3, the large bulk of the mass is in WCS 26, and within deposits GG and HH immediately behind the De Pere dam. For reasons described above, those areas are recommended for removal in the DEA report. The five segments identified for capping within OU 3 are relatively small areas totaling 79 acres.

For the cap design basis, mean and maximum PCB concentrations were determined by depth interval from the interpolated PCB bed maps for the five capping segments in Deposit EE (Table 2-2). For the purposes of identifying PCB concentrations in those areas, they were numbered from south to north as EE1 through EE5. As can be seen in the attached table, those five segments represent relatively thin deposits of PCBs that exceed the RAL, and are probably better candidates for capping than removal. These data were used in the advective and diffusive flux modeling, described in Section 3, below.

Gas Formation

As described for OU 1, the potential for gas formation and breaching of the cap by PCBs advected with gas generation and release was not specifically considered in the DEA report, but is expected and will need to be addressed in the final design.

C2.3.10 Waterway Uses

Flood Flow Capacity

The 100-year flood zone is indicated on FEMA maps throughout all of OU 3 (Figure 2-14). Placement of a cap in OU 3 will reduce water depths and may influence the flow-carrying capacity of the River. Prior to final construction, it will be necessary to evaluate the hydrologic and hydraulic conditions pre- and post-construction to determine if there would be an increase in flood height due to cap placement per 116.03(28) WAC.

As described previously, the proposed cap for OU 3 would have to meet the substantive requirements of Section 116.16(1), of the WAC. That chapter defines Wisconsin's Floodplain Management Program, which requires that structures built within floodways and floodplains must be built to withstand flood depths, pressures, velocities, impact, uplift forces, and other factors associated with the regional (100-year) flood.

Federal Navigation Channels

Navigation channels are indicated on the USACE plan sheets (USACE Detroit District) in OU 3 at the Little Kaukauna lock on the southern end, and the De Pere lock on the northern end. Navigation channels are not impacted by the proposed capping in OU 3.

Recreational Use

Principal known recreational uses on OU 3 include fishing, boating, sailing and personal watercraft (jet ski). Recreational use was not covered in the RI, and hard data on the actual area use was not available for the DEA report. For the purposes of design, the DEA report does make an assumption that all recreational boats within OU 3 will have a draft of less than 3 feet. At a minimum, it will be necessary to prepare and release post-construction navigation charts to the public to reflect changes in depth conditions.

Infrastructure

There do not appear to be any infrastructure that will impact the proposed capping locations (Figure 2-13). Aerial cable crossings are indicated south of

Deposits EE, while submarine cables traverse through deposits GG and HH south of the De Pere dam. However, those areas are not proposed for capping.

Prior to completing remedial design, the nature and extent of these in-water structures and obstructions must be understood and well demarcated. This is best achieved through the use of detailed side-scan sonar surveys, as well as checking with the local utility firms for the nature and activity of in-water cables and pipelines.

Habitat Considerations

As discussed in Section 2 of the DEA report, there is little wetland, nearshore, or in-water habitat identified within OU 3. The proposed capping areas would not be expected to impact more than temporarily benthic infauna. Recolonization is expected to occur shortly after sand cap placement, as was documented for SMU 56/57 in White Paper No. 8.

C2.4 Operable Unit 4

C2.4.1 Physical Environment

OU 4 includes De Pere to Green Bay and extends from the De Pere dam to the mouth of the River at Green Bay. OU 4 is approximately 7 miles from north to south. This reach includes 96 SMUs, numbered 20 through 115 and 16 water column segments (six SMUs to a segment). The SMUs and water column segments were initially established for computer modeling studies. The total area of PCBs exceeding the 1 ppm RAL is approximately 1,034 acres (Figure 2-15).

C2.4.2 Potential Capping Areas

Potential capping areas for OU 4 followed the same process described for OUs 1 and 3, beginning with the areas where the PCBs exceeded the 1 ppm RAL, and a clear, post-construction water depth of at least 4 feet could be achieved (Figure 2-16). TSCA-level PCBs in sediments are indicated in portions of SMU groups 20 to 25, and in 68 to 73; applying the design criteria those areas were not considered. Additional considerations included the federal navigation channel, in-water obstructions, flow velocity through the northern portions of the reach, and the potential to affect 100-year floodplains.

The potential capping areas for OU 4 are shown on Figure 2-17. These are all within the 1 ppm RAL at an elevation of 577.5 feet msl or lower, and do not include any area within the authorized federal navigation channel. The total surface acres, volumes, and mass exceeding 1 ppm, the DEA-identified capping area, and the residual areas that will require removal and disposal are listed in the table below. The capping in OU 4 represents 25 percent of the total 1 ppm aerial footprint, 25.5 percent of the total estimated volume, and 23 percent of the total PCB mass.

	Surface Acres	Volume (cy)	Mass (kg)
1 ppm PCB Footprint	1,034	5,879,529	26,433
Final DEA Cap Footprint	262	1,501,331	6,064
Residual Dredge Areas	772	4,378,198	20,369

To allow for the potential for elevation changes in OU 4 due to continued Lake Michigan surface elevation loss, the total water depth was increased to 6 feet. For OU 4, an elevation of 571.5 msl, or lower, is required to support the cap and still leave sufficient water depth post-construction to meet the –4 feet clear water requirement. Consistent with the design criteria, OU 4 has an additional requirement of -4 feet chart datum for OU 4 because of potential changes to Great Lakes water levels over the long term.

The identification of capping areas in OU 4 were also influenced by the federal navigation channel, in-water infrastructure, location of Wisconsin Pollutant Discharge Elimination System (WPDES)-outfalls, and active shipping and piers identified by the Port of Green Bay.

C2.4.3 Operational Water Depth Constraints

Bathymetric contours, and corresponding mudline elevations, are presented in Section 2 of the DEA report. Within OU 4, the areas identified for capping have water depths equal to our exceeding 7 feet. Under these conditions, cap placement can be hydraulically placed or mechanically placed using a mechanical bucket from a barge deck. Mechanical placement of sand was successfully employed at SMU 56/57 for application of the residual cap.

C2.4.4 Hydrodynamic Conditions

Bottom velocities that could be expected in OU 4 were obtained from the output of the whole Lower Fox River Model (wLFRM) (WDNR, 2001). Figure 2-18 shows the velocity obtained for averaged model units in the wLFRM over the 1989 to 1995 calibration period, and not the maximum estimated velocities. While those data were generated for WDNR in Technical Memorandum 5b (Baird and Associates, 2000) included in the *Final Model Documentation Report for the Lower Fox River and Green Bay, Wisconsin* (MDR) (WDNR and RETEC, 2002), the output data were not available directly for evaluation for the DEA report. As such, the generalized conditions used in the wLFRM were used.

C2.4.5 Ice Conditions

The institutional restriction that post-construction water depth over a cap will be at least 4 feet should accommodate most ice conditions found in OU 4. Confirmation of actual ice thickness must be incorporated into final design of a cap.

C2.4.6 Sediment Thickness and Deposition Rates

OU 4 is almost a continuous deposit of sediment that extends from the De Pere dam to the Fort James West turning basin (Figure 2-19). These deposits cover about 524 hectares (1,284 acres) and thicknesses range up to approximately 3.96 meters (13 feet) thick. Downstream of the turning basin, most of the sediment is routinely removed by dredging operations conducted to maintain the navigation channel, and only isolated areas of sediment are present. Sediment thickness is typically up to 3 feet between the dam and SMU Group 38 to 43. Downstream of SMU Group 38 to 43, large areas of the River bottom are covered by sediment thicker than 6 feet. This is especially true in SMU Group 44 to 49, where sediments have been measured exceeding 12 feet.

C2.4.7 Dam Stability

OU 4 is bounded on the southern end by the De Pere dam, and open to the Bay of Green Bay to the north. The dam is indicated on Figure 2-20. There are no indications of removal requirements for this dam. Dam conditions for the De Pere dam were discussed for OU 3 and are relevant here.

For the areas identified for capping, long-term dam stability is assumed. Only the containment of subaqueous contaminants was considered; i.e., the long-term maintenance of the dams is assured. In a final design, safe isolation under conditions of dam failure/removal, and/or the creation of remnant on-land deposits, should be considered. A recommendation for final design is that any ISC must consider the maintenance of the dam/lock system as an institutional control in perpetuity.

C2.4.8 Geological and Hydrogeological Conditions

As previously described for OU 1, the design basis in this document recognized the importance of, but did not specifically consider potential for groundwater flow through a placed cap. The current understanding of the regional geological and hydrogeological conditions is documented in Section 3 of the RI. The previous discussions presented for OU 1 and OU 3 are relevant here.

C2.4.9 Sediment Characteristics

Sediment Physical Properties

The sediment physical properties in OU 4 are discussed in the RI and specifically are listed for all OUs in Appendix G of that document. The data in that appendix include grain size, Atterberg Limits, the maximum depth of sampling (i.e., soft sediment), total solids, TOC, and bulk densities by deposit. For the purposes of cap design, where specific information was required it was extracted from the Fox River Database for the specific SMU under consideration.

Extent of Contamination

The aerial extent of PCBs exceeding the 1 ppm RAL in the proposed capping areas is listed in Table 2-3. These data were extracted from the PCB bed maps developed as part of the RI and FS for the specifically identified capping areas. These data were used in the advective and diffusive flux modeling, described in Section 3, below.

Gas Formation

The Lower Fox River has a high methane sediment content (GAS/SAIC, 1996). Methane releases are frequently observed during sediment sampling, and were seen during the demonstration project at SMU 56/57. The potential for ebullition (i.e., gas transport) of contaminants through the cap was not specifically modeled or considered here. Final design must consider this potential transport pathway.

C2.4.10 Waterway Uses

Flood Flow Capacity

The FEMA floodplain map for Brown County, relative to the proposed capping areas for OU 4, is shown on Figure 2-21. Within OU 4, the 100-year FEMA flood zone is indicated throughout most of the length of OU 4, including the identified capping areas. Both the 100- and 500-year zones are especially indicated where the River narrows, beginning at SMU 50, and northward into Green Bay. Those SMUs in particular may be specifically affected by remedial actions.

Prior to final construction, it will be necessary to evaluate the hydrologic and hydraulic conditions pre- and post-construction to determine if there would be an increase in flood height due to cap placement per 116.03(28) WAC.

Federal Navigation Channels

The presence of the federal navigation throughout the entire reach presents a technical limitation to cap placement in OU 4 (Figure 2-20). Navigation channels are indicated on the USACE plan sheets (USACE Detroit District) in OU 4 between the De Pere dam and mouth of the River as shown on Figure 2-19. This section of the Lower Fox River receives active dredging in order to maintain the federal channel. The USACE currently only dredges and maintains the navigation channel in Green Bay and as far upstream as the Fort Howard turning basin, located approximately 5.5 km (3.4 miles) upstream of the mouth of the River. The channel between the De Pere dam and Fort James is not maintained by the USACE. The identified capping areas are south of the actively maintained channel and are designated “east” and “west” based upon the area being split by the navigation channel.

Recreational Use

Principal known recreational uses on OU 4 include fishing, boating, sailing and personal watercraft (jet ski). Recreational use was not covered in the RI and hard data on the actual area use was not available for the DEA report. For the purposes of design, the DEA report does make an assumption that all recreational boats within OU 4 will have a draft of less than 4 feet. At a minimum, it will be necessary to prepare and release post-construction navigation charts to the public to reflect changes in depth conditions.

Infrastructure

Areas identified for capping, relative to known infrastructure on/in OU 4, are shown on Figure 2-20. Presence of infrastructure and active River use in the last 4 miles was an important consideration in determining areas for cap placement. As discussed in Section 2 of the DEA report, consistent with the industrial nature of the River, the known infrastructure includes numerous road and railroad crossings, submerged pipelines and cables, intake/discharge pipes, pilings, dolphins, and overhead and submerged cables. This corresponds to SMU Groups 50 to 115. Consistent with the design criteria, capping was not considered in those areas.

The National Oceanic and Atmospheric Administration (NOAA) navigation chart (NOAA Chart 14918) shows that there are potential barges or ships submerged in the River, as well as sites of potential archeological interest. There are no institutional restrictions to placing cap material over historic barges, isolating contaminants under a cap that has to be constructed around in-place structures has yet to be demonstrated. For the DEA report, capping was not considered for those areas.

Unique to OU 4 is that the last 4 River miles is an active port-of-call for approximately 200 ship-calls annually. Active docking facilities are shown on Figure 2-20. Turning basins include the confluence of the Lower Fox and East rivers, and a second turning basin above the Wisconsin Central Railroad bridge at the south limits of the city of Green Bay. From a design basis, ship traffic does not necessarily represent a barrier to capping, but propeller wash would need to be considered as part of armoring considerations. Part of the DEA cap area determination was based upon not having to do specific armoring calculations.

For the DEA report, the selected capping areas represent the largest contiguous acreage that did not have infrastructure of other use (e.g., active shipping) restrictions. This report acknowledges that other areas potentially could be capped, but would need to be designed for the area intended, and determine the appropriate covenants and use restrictions that would need to accompany multi-use River bottom.

Finally, it is a finding of this report that there is scattered and inconsistent information on what infrastructure is in fact present upon the River bottom in all reaches of the River. For example, there are multiple outfalls indicated in WDNR's WPDES program for this reach, but the actual physical location is not indicated on the NOAA charts. At the time of completing this document, additional information was provided by a local company that showed multiple communication cables stretching across the River bottom. Prior to completing remedial design, the nature and extent of these in-water structures and obstructions must be understood and well demarcated. This is best achievable through the use of detailed side-scan sonar surveys, as well as checking with the local utility firms for the nature and activity of in-water cables and pipelines.

Habitat Considerations

The areas indicated for capping in OU 4 will only principally affect benthic habitat on the River floor. This effect is expected to be temporary as recolonization will occur shortly after sand cap placement, as was documented for SMU 56/57 in White Paper No. 8.

As noted in Section 2 of the DEA report, there is a considerable influx of fish into the reach from Green Bay. These species include walleye, perch, sturgeon, carp, and several species of forage fish. Consideration was given to armoring the cap surface with gravel that would be conducive to spawning walleye, as was suggested in the API Panel Report (The Johnson Company, 2002). An evaluation by WDNR fisheries biologists concluded that given the demonstrated depositional nature of this reach of the River, there is insufficient scour to keep the gravel bed in a condition that would favor walleye spawning. In essence, the gravel will rapidly become filled with sediments again. The preferred method for spawning enhancement is the walleye spawning cribs, which WDNR has installed in the southern end of the reach. These are not expected to be impacted by capping operations, but could be potentially impacted by removal operations. This affect would be temporary, and consideration could be given to placing additional cribs onto the cap surface post implementation.

Table 2-1 Operable Unit 1 Water Quality Segment

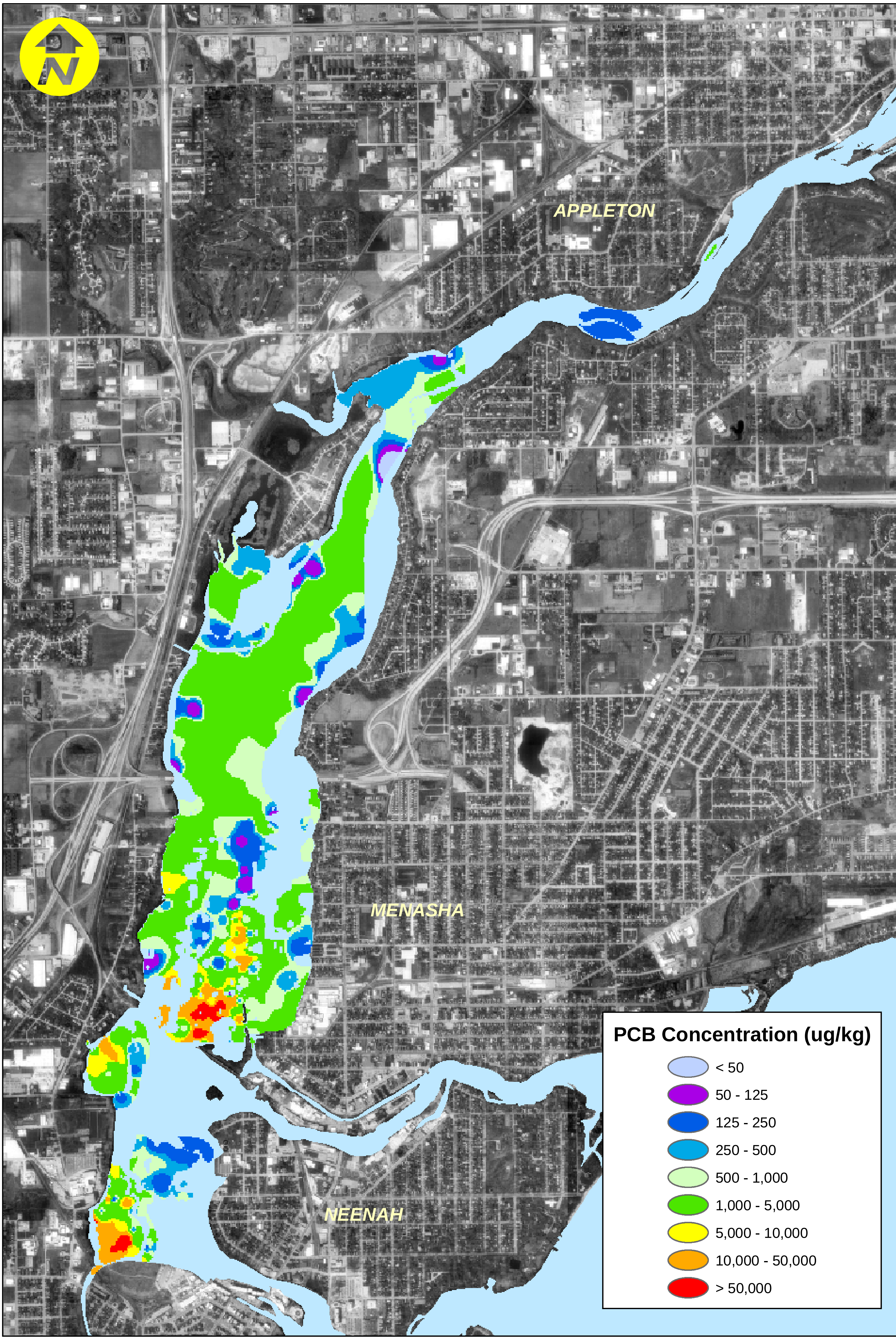
PCB Layer		PCB Concentration (µg/kg)							
		WCS 4	WCS 6A	WCS 6B	WCS 7A	WCS 7B	WCS 8A	WCS 8B	WCS 9
0–10 cm	Maximum	16,604	9,906	1,762	3,340	3,113	2,680	4,342	1,300
	Mean	9,406	1,847	878	2,127	1,645	1,772	1,606	1,192
10–30 cm	Maximum	1,318	7,642	1,754	3,230	12,989	1,229	15,675	1,309
	Mean	727	1,679	888	1,482	1,843	614	2,607	433
30–50 cm	Maximum	598	6,673	1,786	3,100	7,310	301	31,150	1,664
	Mean	598	1,873	876	376	1,214	177	5,707	146
50–100 cm	Maximum	—	5,754	724	268	1,006	147	8,600	514
	Mean	—	810	262	57	152	98	1,900	55
100–150 cm	Maximum	—	—	6,935	—	—	—	—	—
	Mean	—	—	5,695	—	—	—	—	—

Table 2-2 Operable Unit 3 Deposit EE Cap Area

PCB Layer		PCB Concentration (µg/kg)				
		EE1	EE2	EE3	EE4	EE5
0–10 cm	Maximum	17,240	2,460	1,300	2,300	1,646
	Mean	10,190	1,714	1,206	1,876	1,394
10–30 cm	Maximum	4,097	173	86	519	519
	Mean	2,593	147	54	164	164
30–50 cm	Maximum	147	26	50	59	59
	Mean	106	21	48	49	49
50–100 cm	Maximum	118	66	77	165	165
	Mean	104	63	62	87	87

Table 2-3 Operable Unit 4 Sediment Management Unit

PCB Layer		PCB Concentration (µg/kg)							
		SMU 20–25	SMU 26–31	SMU 32–37	SMU 38–43	SMU 44–49 (West)	SMU 44–49 (East)	SMU 50–55 (West)	SMU 50–55 (East)
0–10 cm	Maximum	25,000	8,750	8,735	3,985	4,200	14,998	3,892	3,226
	Mean	5,561	5,065	4,016	2,702	1,758	4,765	2,082	1,266
10–30 cm	Maximum	25,000	19,000	18,993	11,783	14,979	18,000	3,100	8,809
	Mean	7,069	11,786	10,276	6,953	4,311	9,337	1,266	4,025
30–50 cm	Maximum	29,927	18,875	12,000	17,152	24,961	32,000	31,000	30,883
	Mean	8,405	5,323	7,929	8,497	7,345	12,559	8,234	22,261
50–100 cm	Maximum	14,149	15,595	12,863	14,345	21,018	27,320	27,940	27,836
	Mean	2,159	4,417	9,747	9,379	12,270	12,293	8,431	21,143
100–150 cm	Maximum	2,993	641	63,000	62,657	22,998	22,957	14,000	13,968
	Mean	1,614	162	9,787	6,569	10,835	7,180	8,829	11,266
150–200 cm	Maximum	4,940	173	9,912	1,036	27,797	27,149	14,000	13,972
	Mean	452	118	2,473	564	7,252	1,570	11,618	12,032
200–250 cm	Maximum	30,000	154	6,960	7,776	7,725	26,086	7,501	—
	Mean	28,777	151	2,740	4,531	507	8,192	1,544	—
250–300 cm	Maximum	—	—	6,700	—	540	23,973	23,422	—
	Mean	—	—	3,911	—	515	5,669	22,405	—
300–350 cm	Maximum	—	—	—	—	—	12,576	18,755	—
	Mean	—	—	—	—	—	8,875	18,508	—



0 2,000 4,000

1" = 2,000 Feet

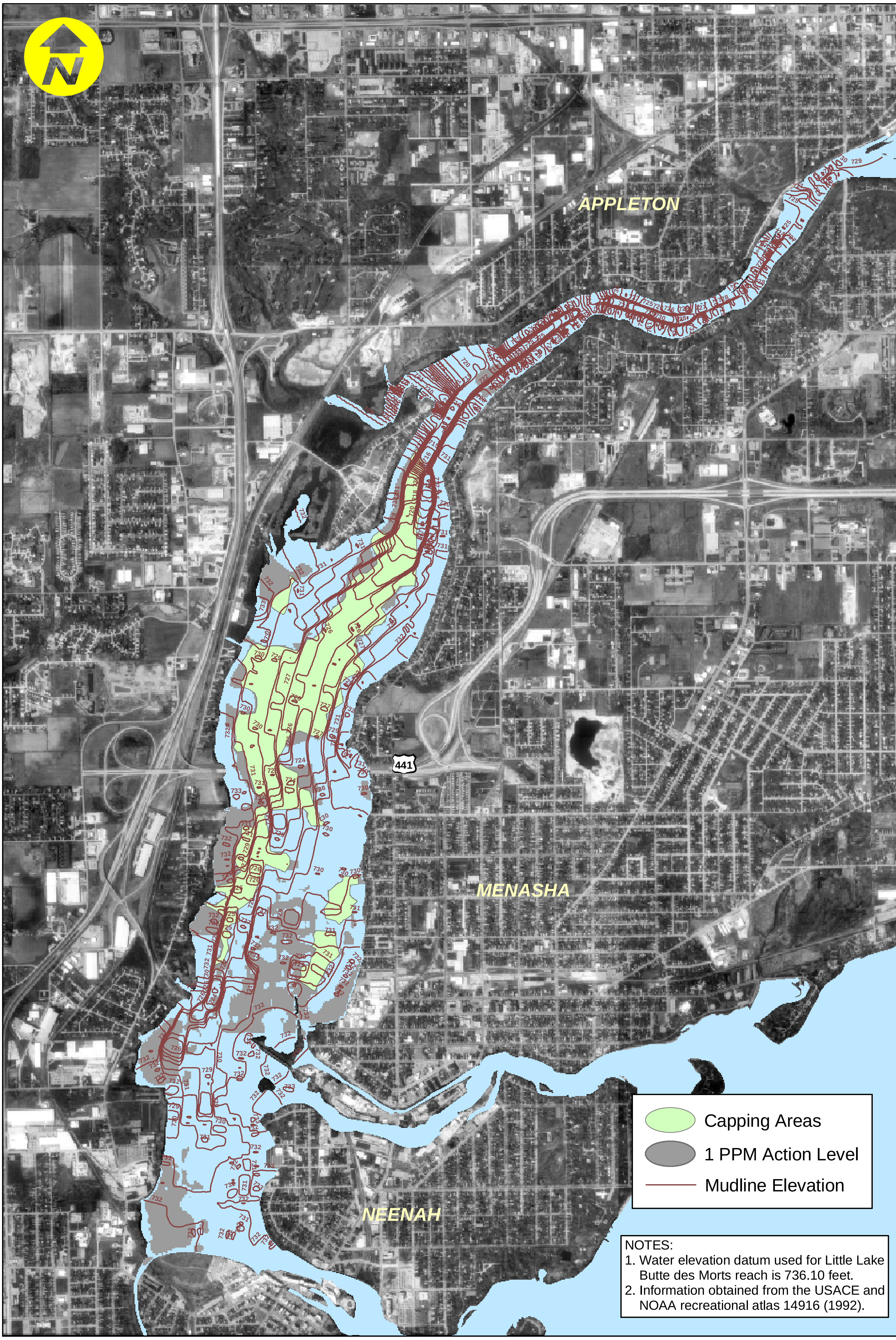
RETEC

OPERABLE UNIT 1

Lower Fox River, Wisconsin (WISCN-15933-122)

DISTRIBUTION OF INTERPOLATED PCB CONCENTRATIONS IN SEDIMENTS (0-10 cm):: LITTLE LAKE BUTTE DES MORTS

DATE: 01/30/03		FILE: PCB Layer1B.mxd	FIGURE: 2-1



0 2000 4000

1" = 2000 Feet

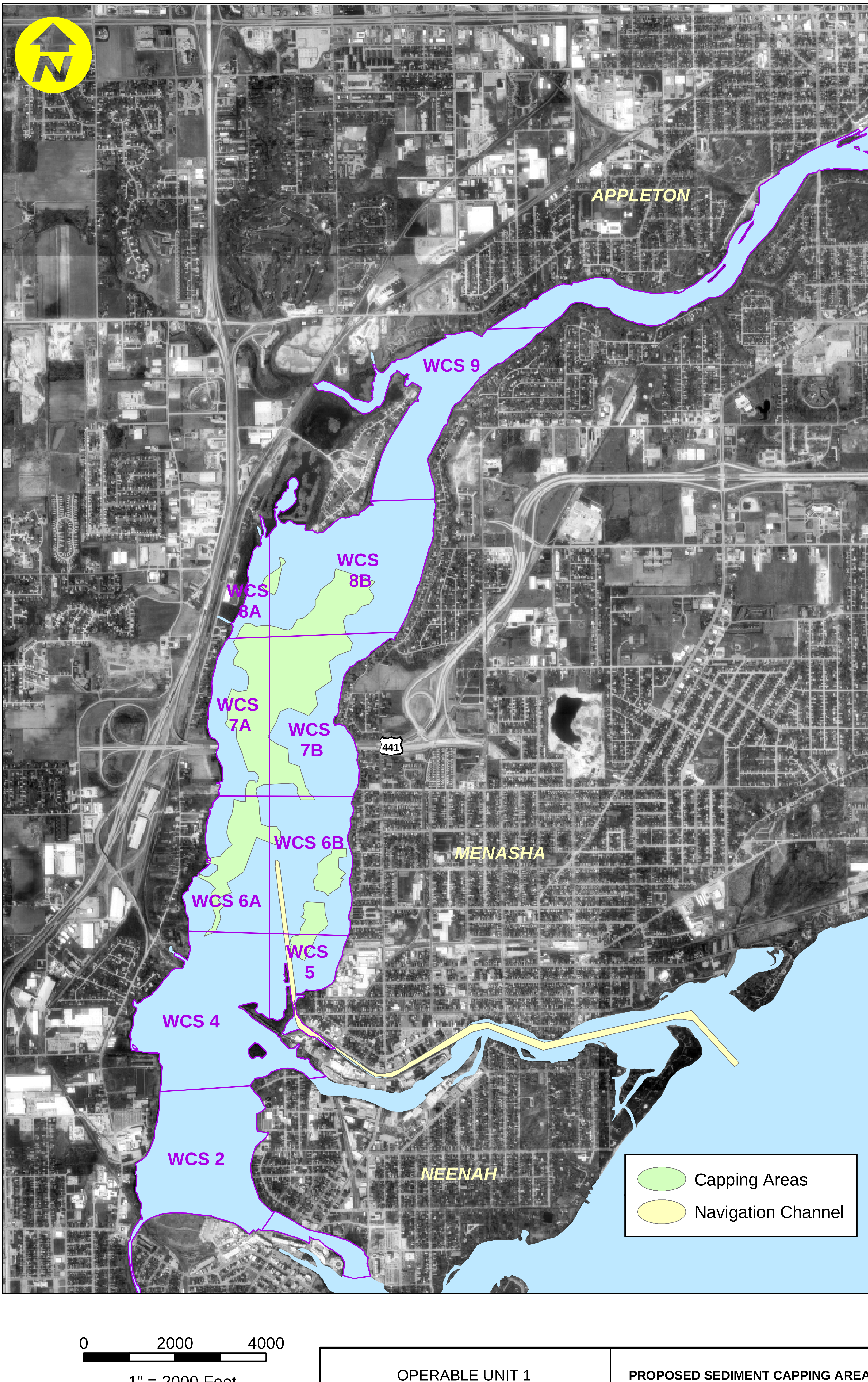
RETEC

OPERABLE UNIT 1

Lower Fox River, Wisconsin (WISCN-15933-121)

MUDLINE ELEVATION CONTOURS AND SEDIMENT CAPPING AREAS OVER 1 PPM ACTION LEVEL AT ELEVATION 736.10: LITTLE LAKE BUTTE DES MORTS

DATE: 04/04/03		FILE: Mud1 ElvCtrs.mxd	FIGURE: 2-2

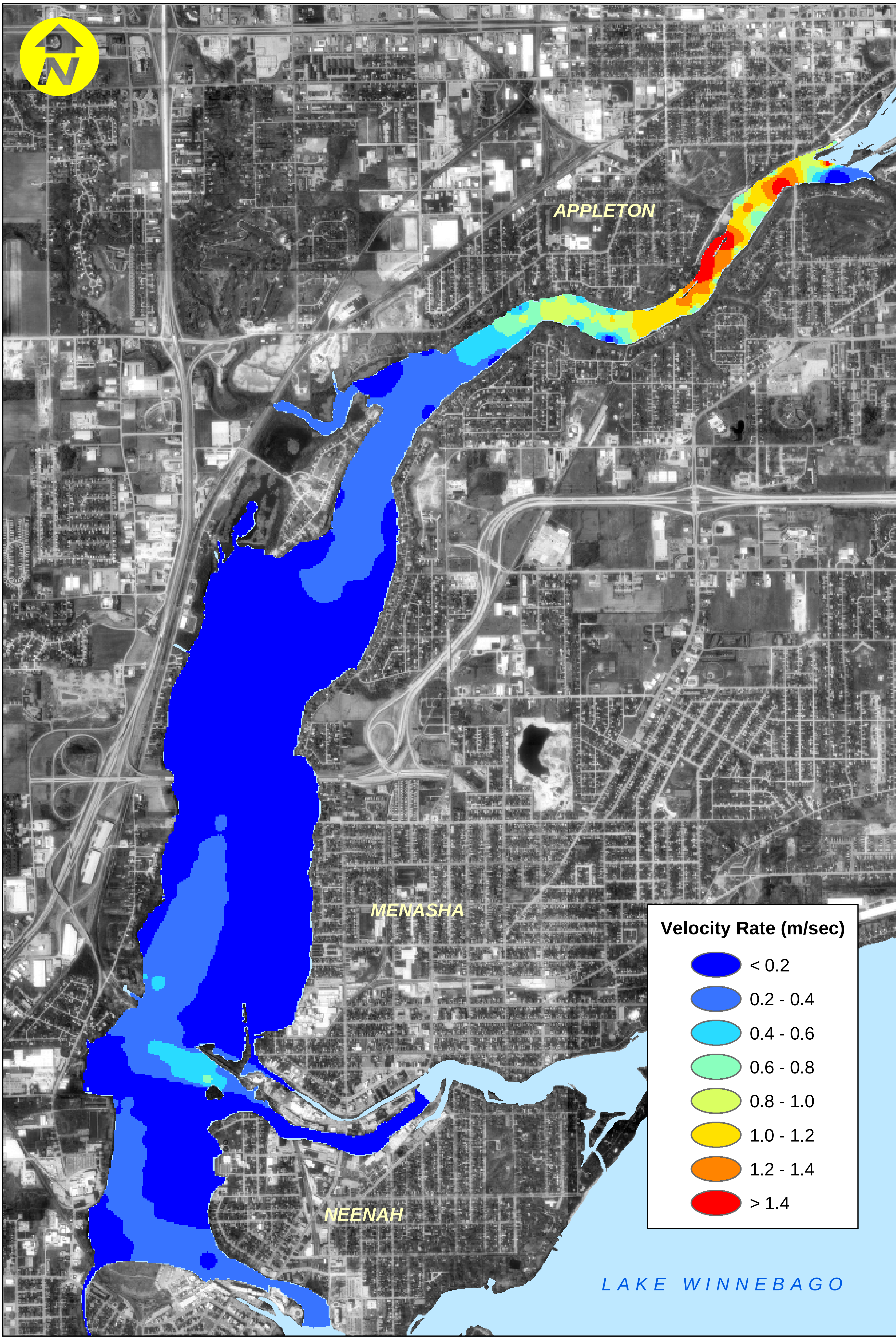


RETEC

OPERABLE UNIT 1
Lower Fox River, Wisconsin (WISCN-15933-121)

PROPOSED SEDIMENT CAPPING AREAS: LITTLE LAKE BUTTE DES MORTS

DATE: 02/03/03 | FILE: OU1 Capping.mxd | FIGURE: 2-3



0 2,000 4,000

1" = 2,000 Feet

RETEC

OPERABLE UNIT 1 Lower Fox River, Wisconsin (WISCN-15933-122)		MAXIMUM VELOCITY RATE ESTIMATED FOR FLOW CONDITION OF 408 CMS AT RAPID CROCHE DAM : LITTLE LAKE BUTTE DES MORTS	
DATE: 01/30/03		FILE: OU1 Velocity.mxd	FIGURE: 2-4

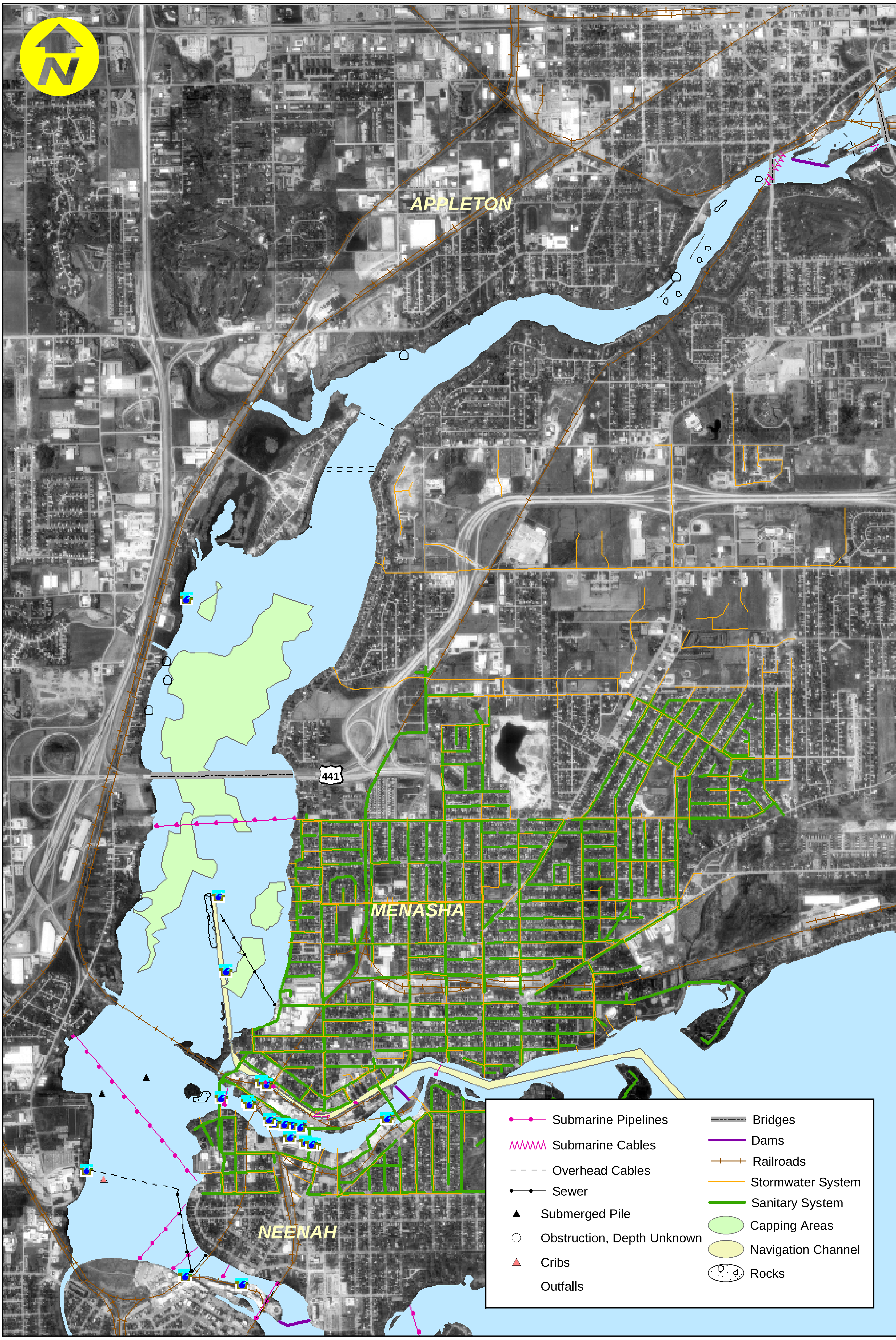
0 2000 4000

1" = 2000 Feet

RETEC

OPERABLE UNIT 1 Lower Fox River, Wisconsin (WISCN-15933-121)	SEDIMENT CAPPING AREAS AND SOFT SEDIMENT PROFILE: LITTLE LAKE BUTTE DES MORTS

DATE: 04/10/03 | FILE: OU1 SoftSed Thickness.mxd | FIGURE: 2-5



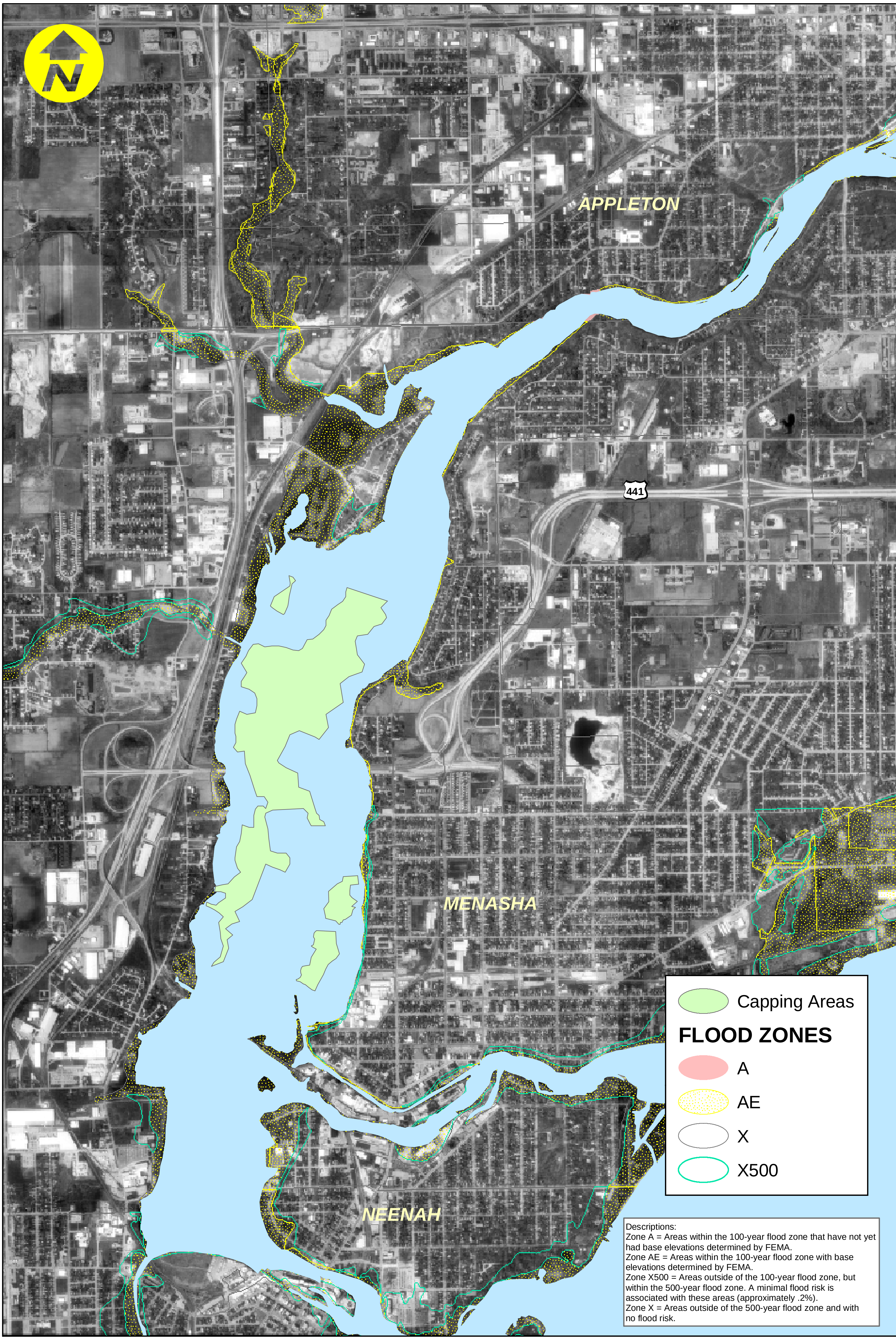
RETEC

OPERABLE UNIT 1

Lower Fox River, Wisconsin (WISCN-15933-122)

LOWER FOX RIVER INFRASTRUCTURE AND SEDIMENT CAPPING AREAS: LITTLE LAKE BUTTE DES MORTS

DATE: 04/21/03 | FILE: OU1 Infrastructure.mxd | FIGURE: 2-6

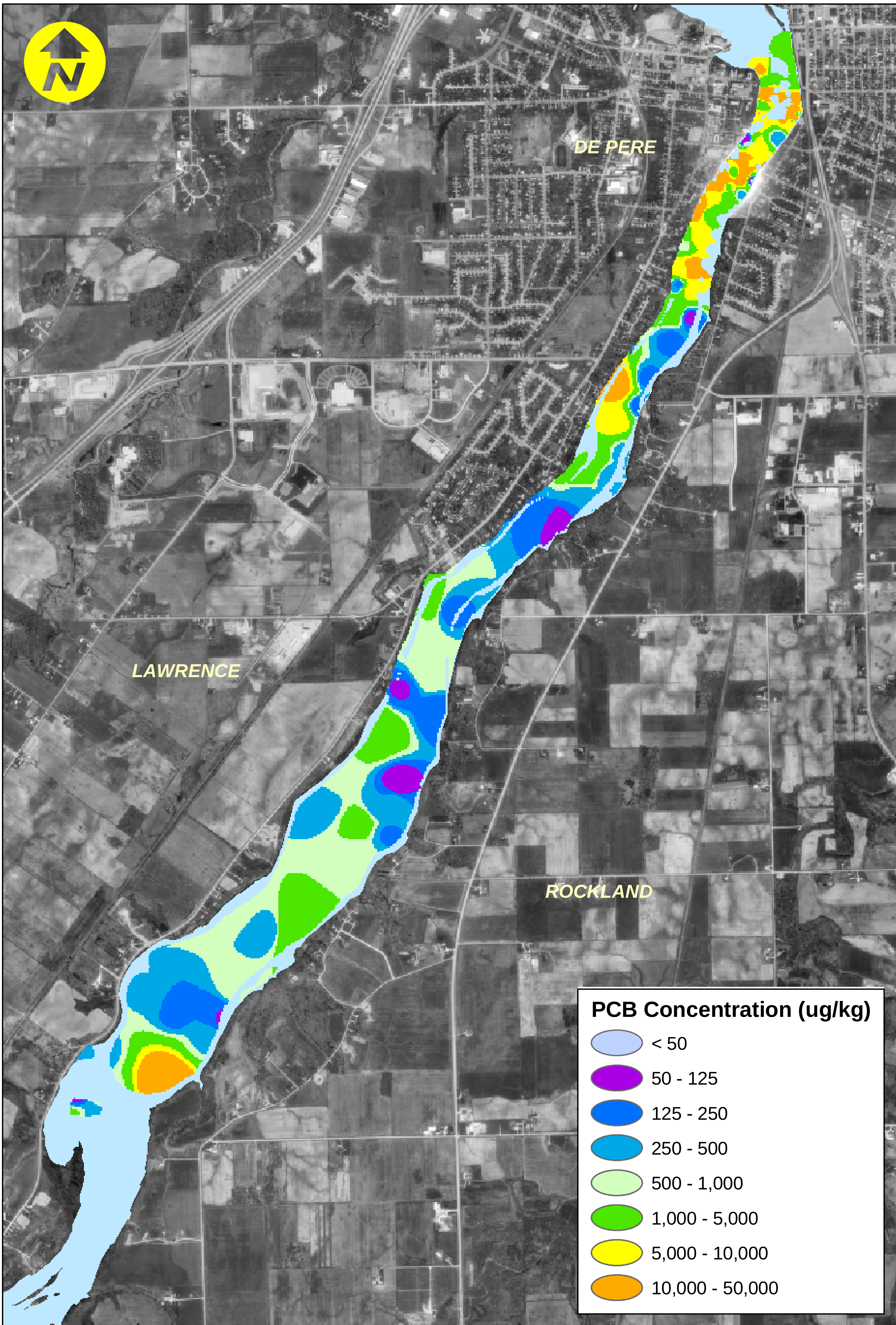


0 2000 4000

1" = 2000 Feet

RETEC

OPERABLE UNIT 1 Lower Fox River, Wisconsin (WISCN-15933-121)	FEMA FLOOD ZONE COVERAGE AND SEDIMENT CAPPING AREAS: LITTLE LAKE BUTTE DES MORTS
DATE: 04/04/03	FILE: OU1 Flood Zones.mxd — FIGURE: 2-7



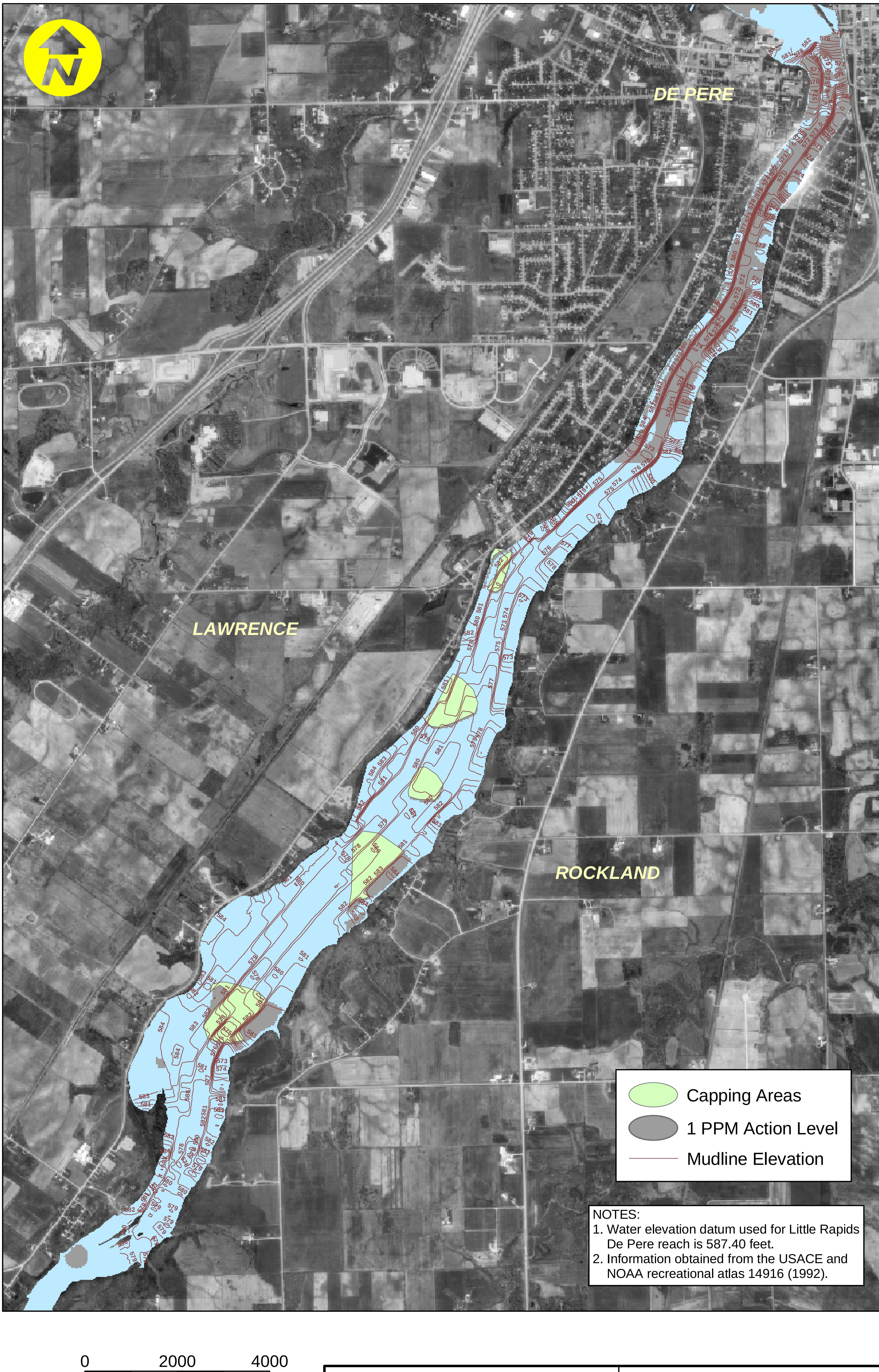
0 1,000 2,000 4,000

1" = 2,000 Feet

RETEC

OPERABLE UNIT 3 Lower Fox River, WI (WISCN-15933-131)	**DISTRIBUTION OF INTERPOLATED PCB CONCENTRATIONS IN SEDIMENTS (0-10 cm): LITTLE RAPIDS TO DE PERE**

DATE: 05/21/03	FILE: Y:/15933/Maps/OU3/OU3 Layer1 PCB.mxd	FIGURE: 2-8

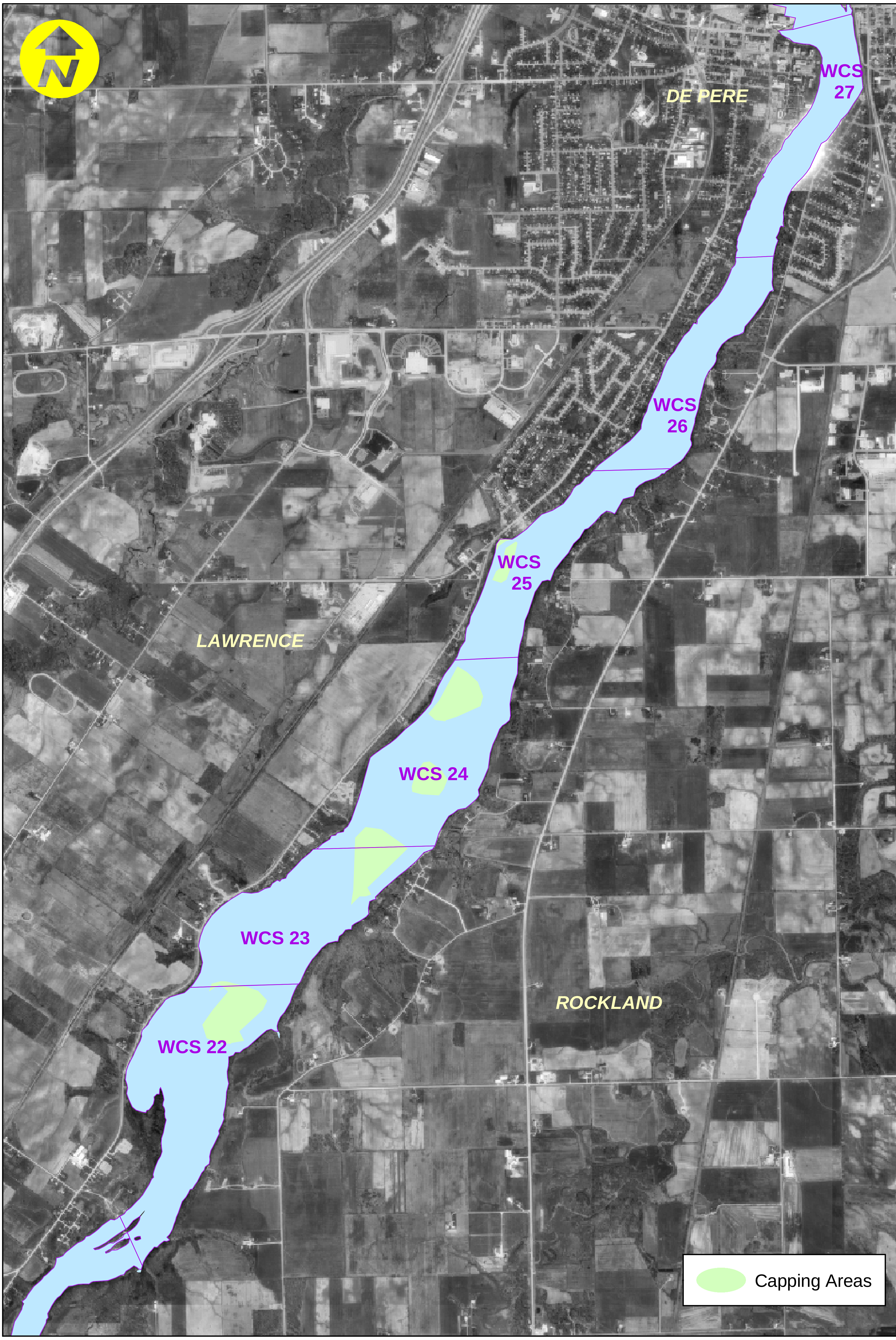


RETEC

OPERABLE UNIT 3
Lower Fox River, Wisconsin (WISCN-15933-121)

MUDLINE ELEVATION CONTOURS AND SEDIMENT CAPPING AREAS OVER 1 PPM ACTION LEVEL AT ELEVATION 587.40: LITTLE RAPIDS TO DE PERE

DATE: 02/03/03 | FILE: Mud3 ElvCtrs.mxd | FIGURE: 2-9

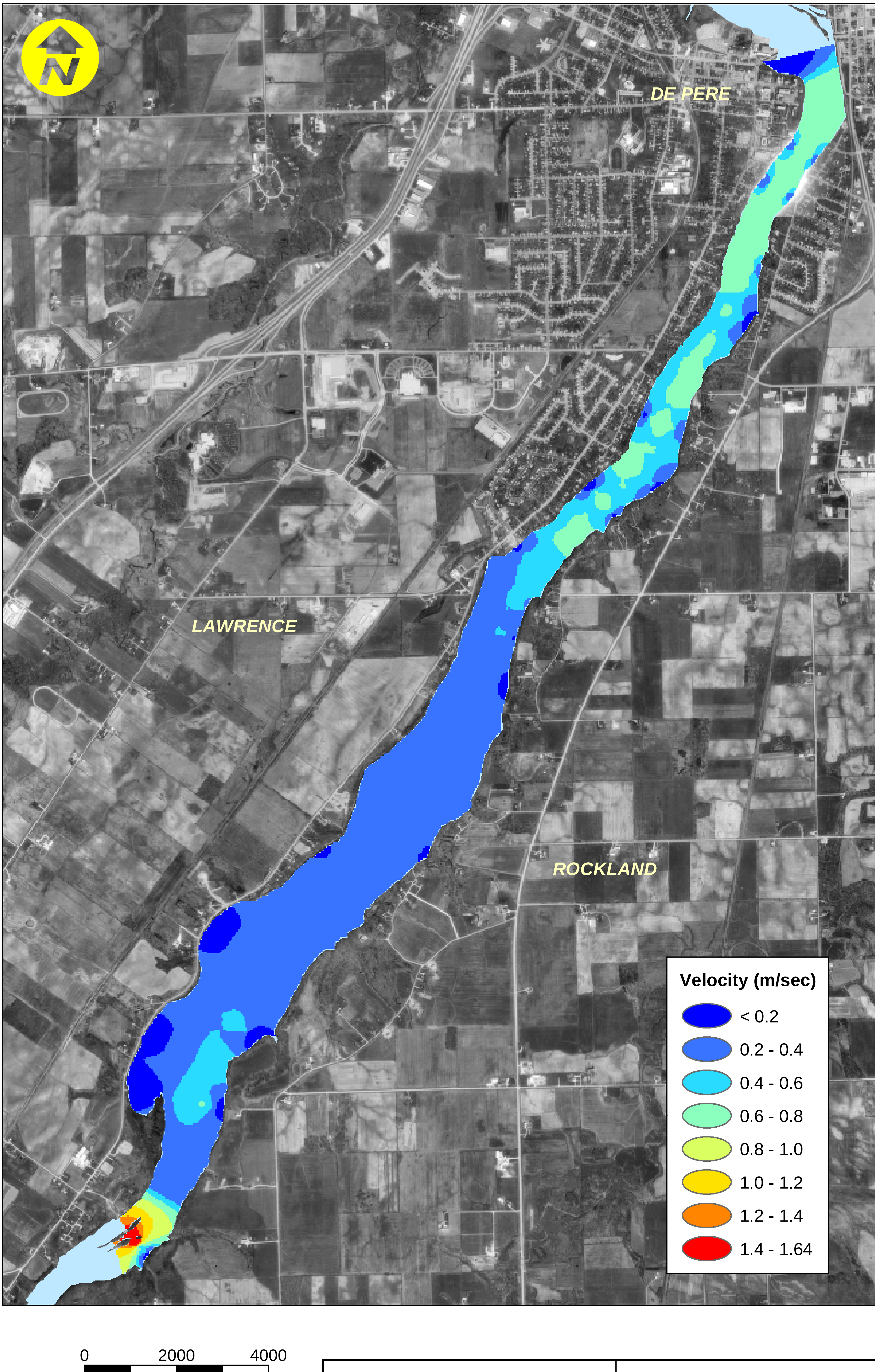


RETEC

OPERABLE UNIT 3
Lower Fox River, Wisconsin (WISCN-15933-121)

PROPOSED SEDIMENT CAPPING AREAS: LITTLE RAPIDS TO DE PERE

DATE: 02/03/03 | FILE: OU3 Capping.mxd | FIGURE: 2-10

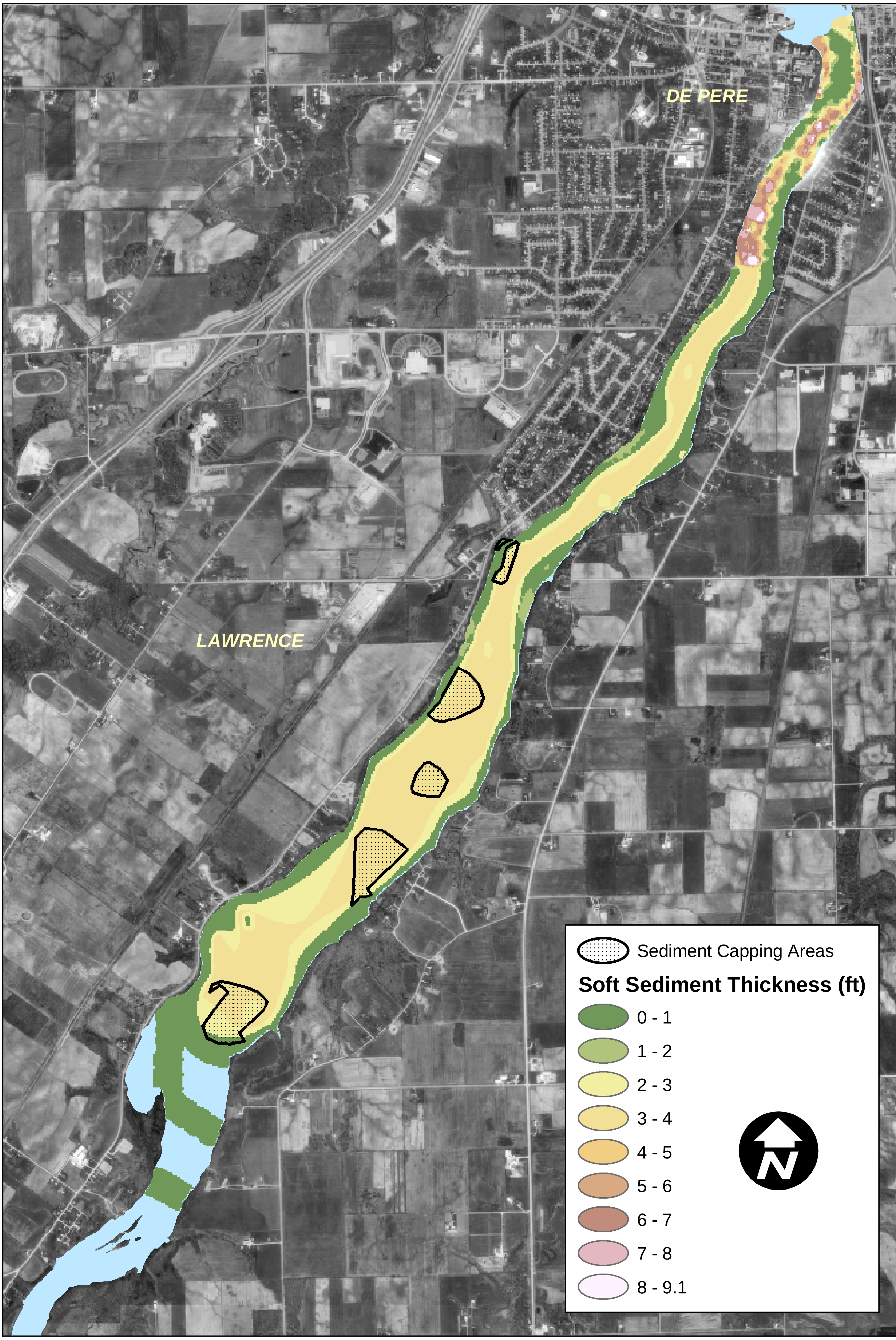


RETEC

OPERABLE UNIT 3
Lower Fox River, Wisconsin (WISCN-15933-121)

MAXIMUM VELOCITY RATE ESTIMATED FOR FLOW CONDITION OF 408 CMS AT RAPID CROCHE DAM: LITTLE RAPIDS TO DE PERE

DATE: 02/03/03	FILE: OU3 Velocity.mxd	FIGURE: 2-11



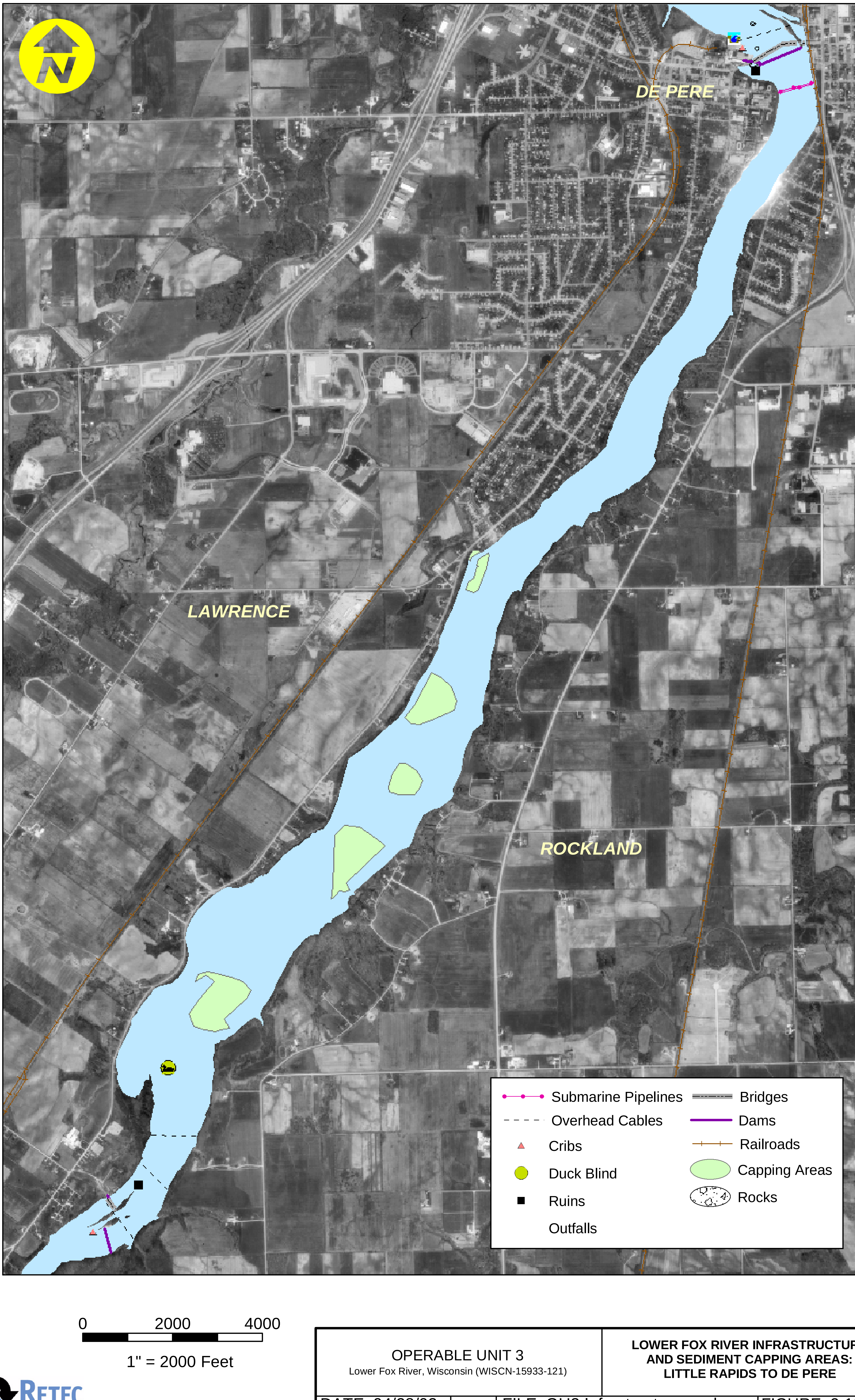
0 2000 4000

1" = 2000 Feet

RETEC

OPERABLE UNIT 3 Lower Fox River, Wisconsin (WISCN-15933-121)	SEDIMENT CAPPING AREAS AND SOFT SEDIMENT PROFILE: LITTLE RAPIDS TO DE PERE

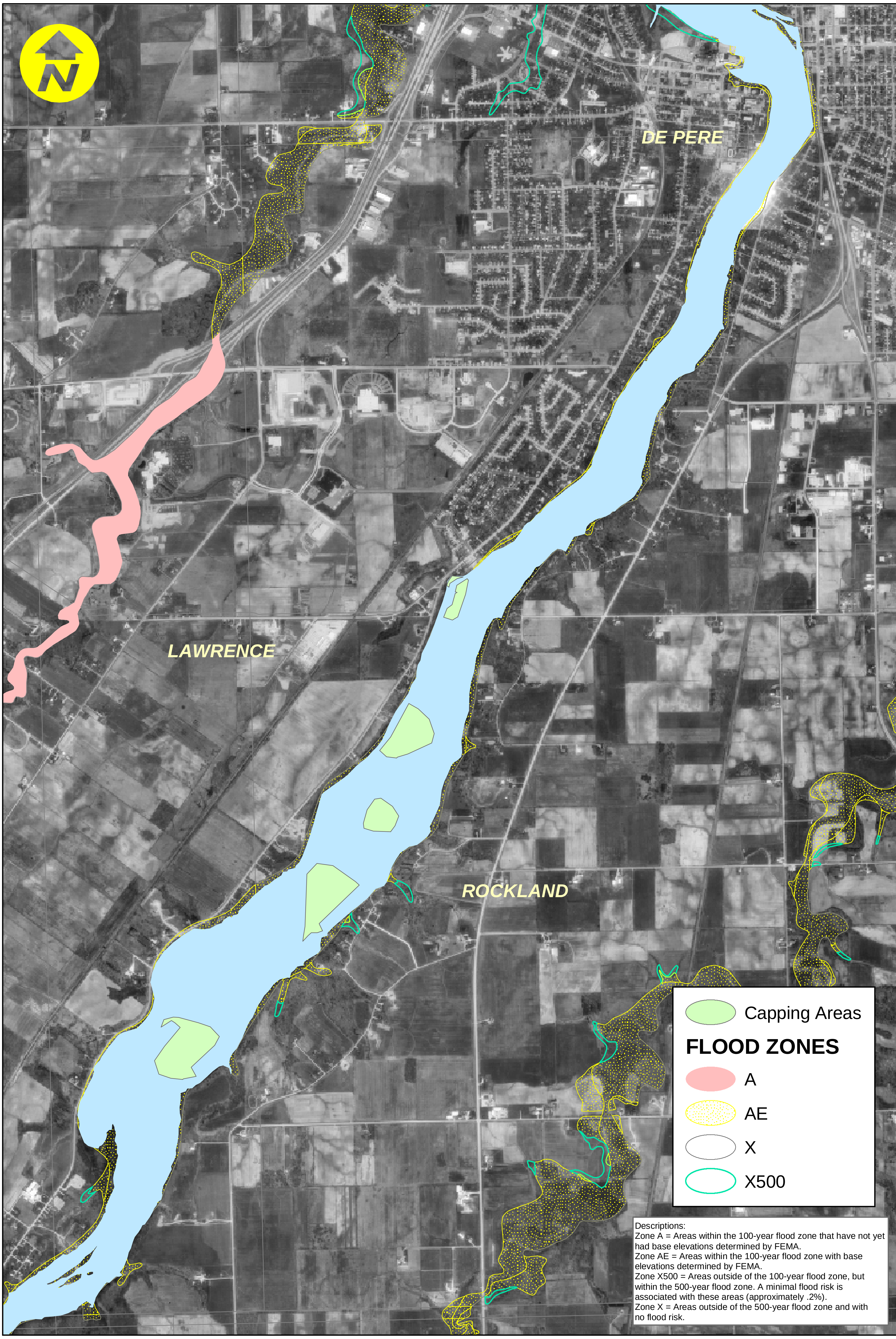
DATE: 04/28/03 | FILE: OU3 SoftSed Thickness.mxd | FIGURE: 2-12



RETEC

OPERABLE UNIT 3 Lower Fox River, Wisconsin (WISCN-15933-121)	**LOWER FOX RIVER INFRASTRUCTURE AND SEDIMENT CAPPING AREAS: LITTLE RAPIDS TO DE PERE**

DATE: 04/28/03 | FILE: OU3 Infrastructure.mxd | FIGURE: 2-13



0 2000 4000

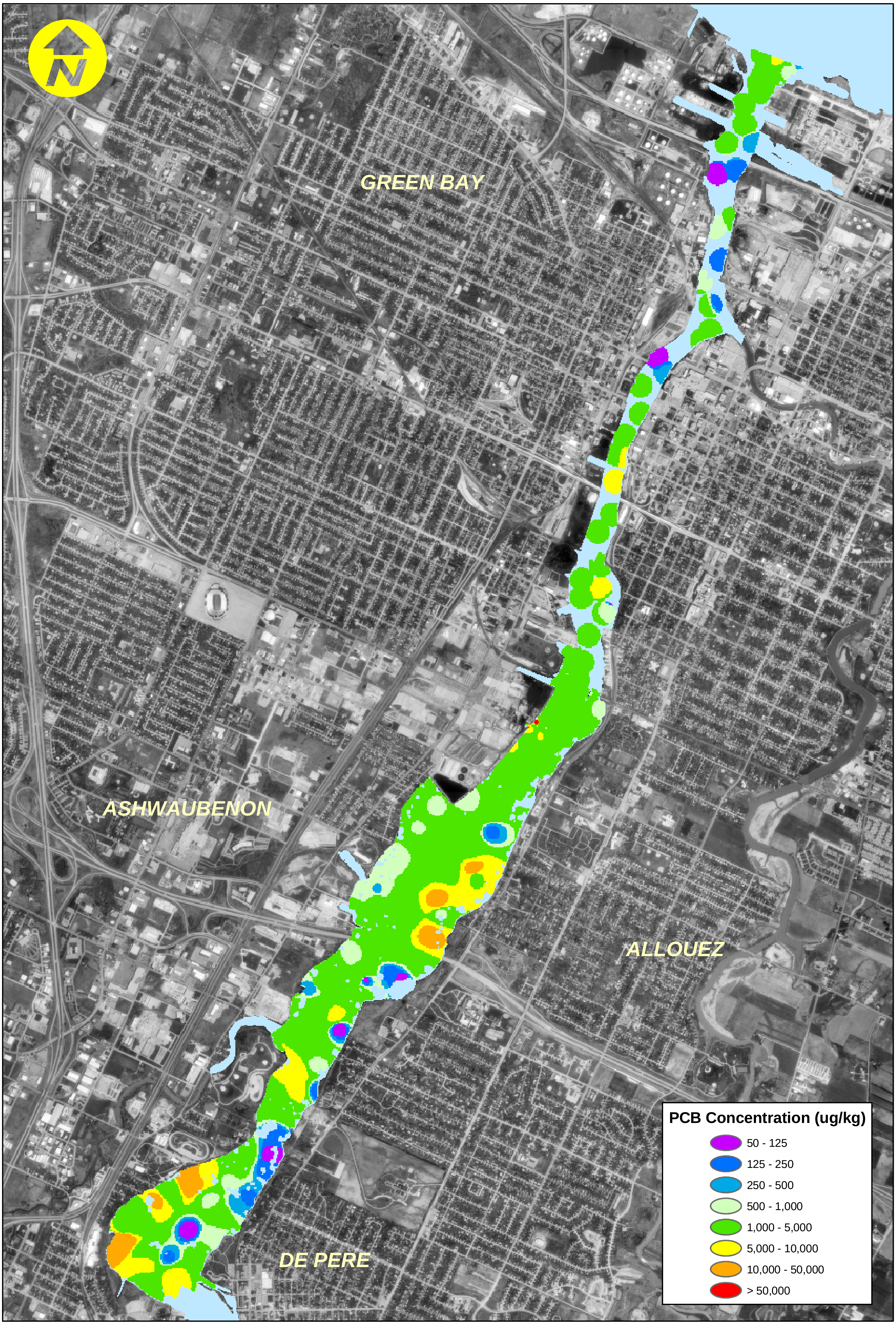
1" = 2000 Feet

RETEC

OPERABLE UNIT 3
Lower Fox River, Wisconsin (WISCN-15933-121)

FEMA FLOOD ZONE COVERAGE AND SEDIMENT CAPPING AREAS: LITTLE RAPIDS TO DE PERE

DATE: 04/03/03		FILE: OU3 Flood Zone.mxd	FIGURE: 2-14



0 1,250 2,500 5,000

1" = 2,500 Feet

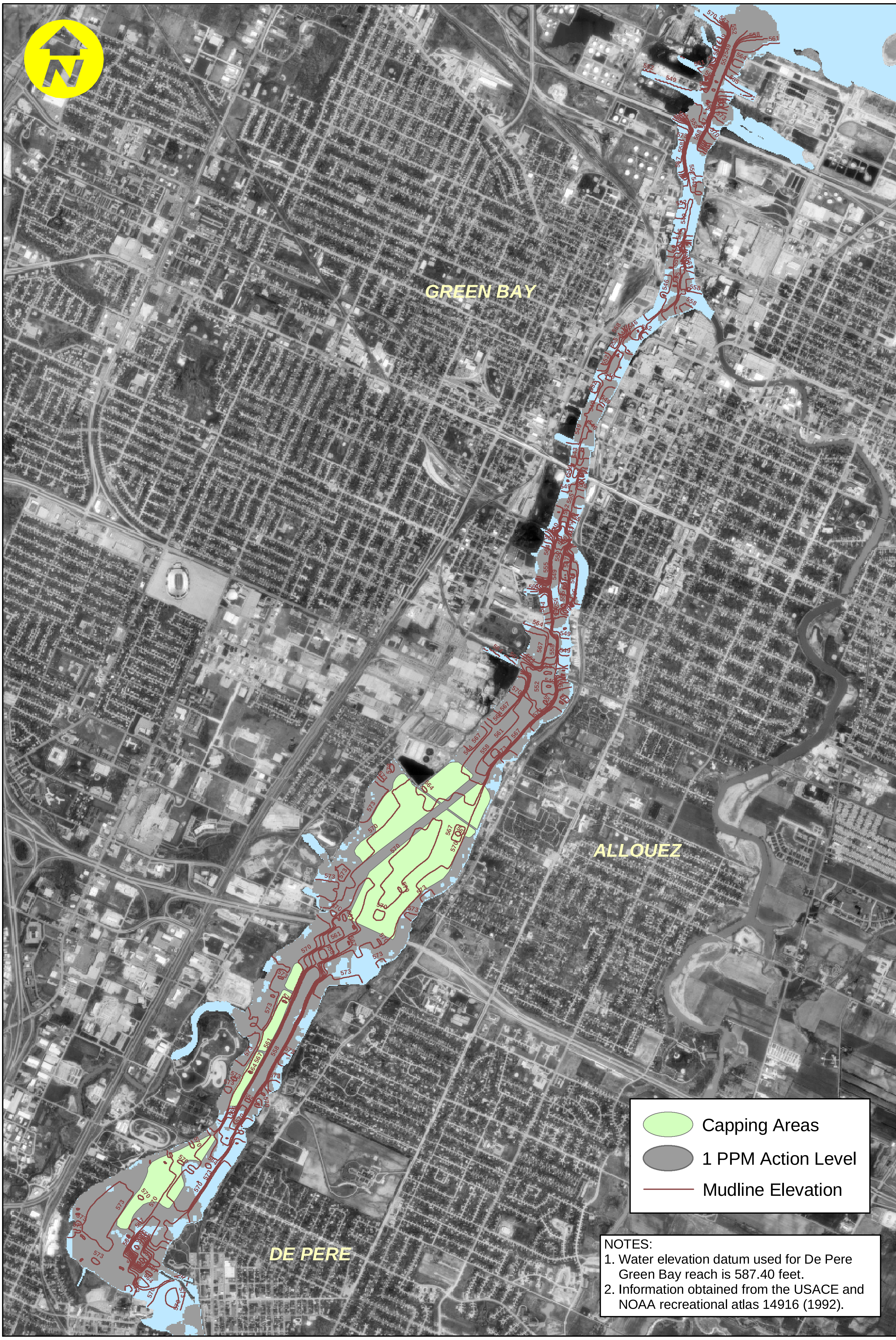
RETEC

OPERABLE UNIT 4

Lower Fox River, WI (WISCN-15933-131)

DISTRIBUTION OF INTERPOLATED PCB CONCENTRATION IN SEDIMENTS (0-10 cm): DE PERE TO GREEN BAY

DATE: 05/21/03 | FILE: OU4 Layer1 PCB.mxd | FIGURE: 2-15



0 2500 5000

1" = 2500 Feet

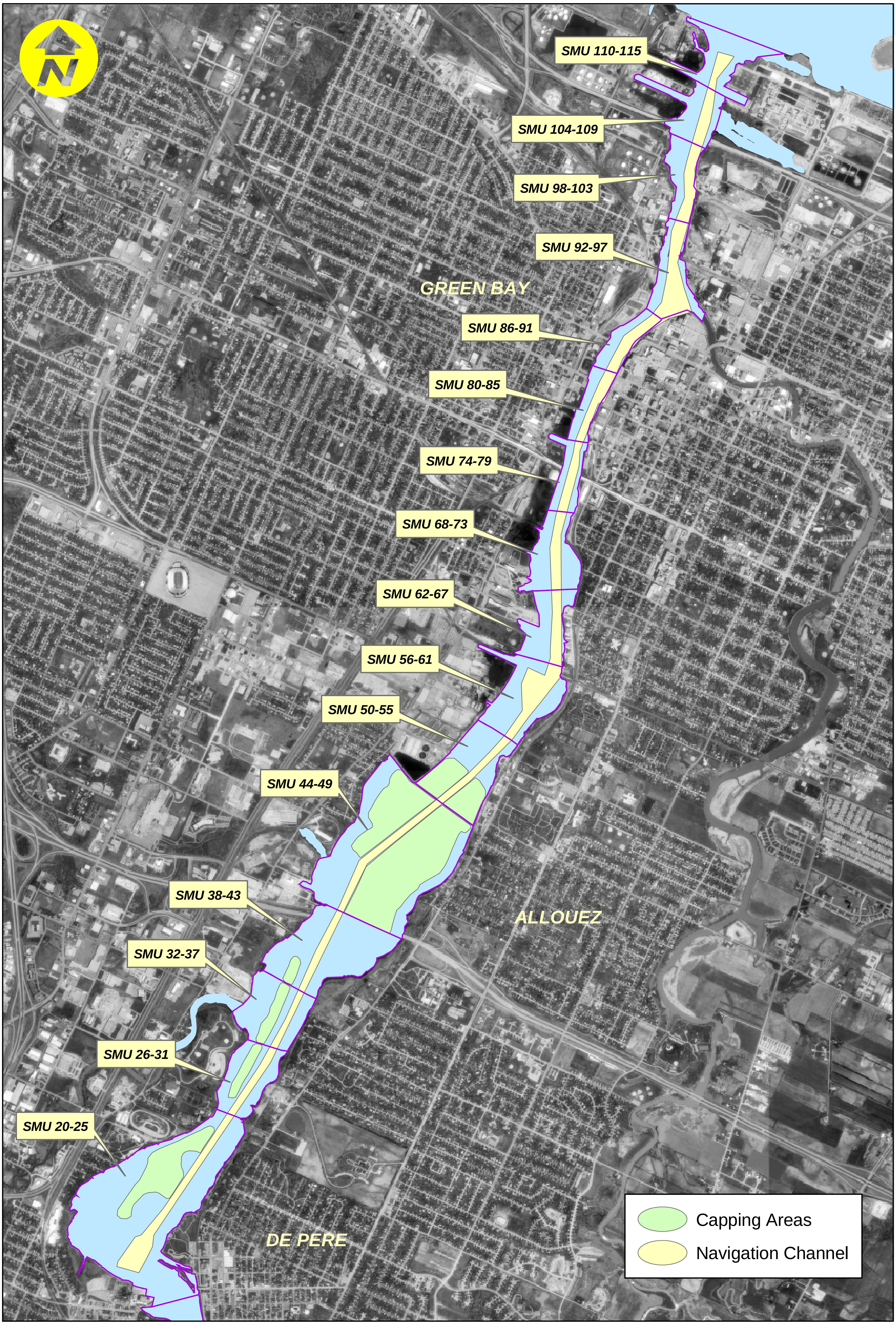
RETEC

OPERABLE UNIT 4

Lower Fox River, Wisconsin (WISCN-15933-121)

MUDLINE ELEVATION CONTOURS AND SEDIMENT CAPPING AREAS OVER 1 PPM ACTION LEVEL AT ELEVATION 577.50: DE PERE TO GREEN BAY

DATE: 04/07/03		FILE: OU4 Mudline.mxd	FIGURE: 2-16

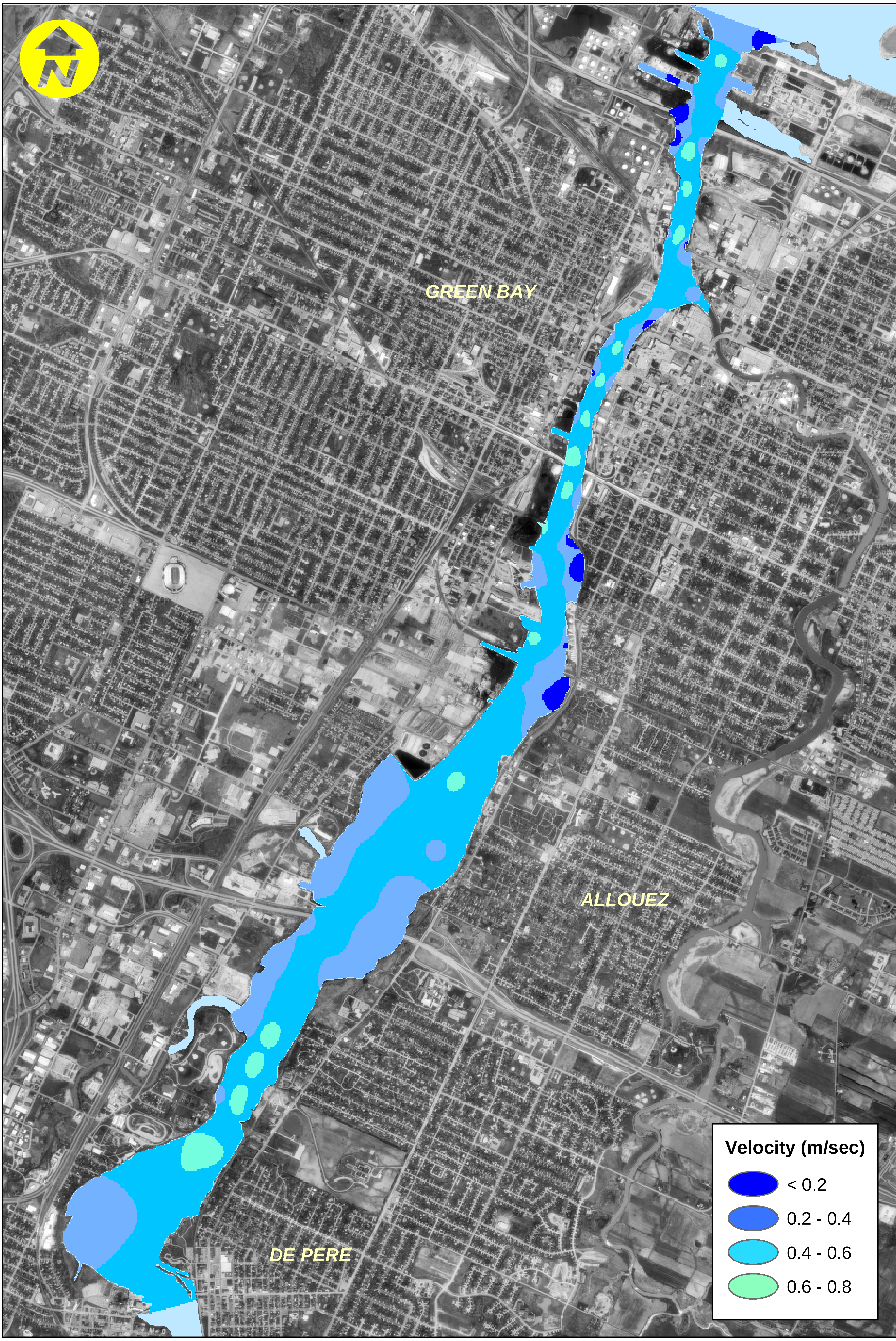


0 2500 5000

1" = 2500 Feet

RETEC

OPERABLE UNIT 4 Lower Fox River, Wisconsin (WISCN-15933-121)		**PROPOSED SEDIMENT CAPPING AREAS: DE PERE TO GREEN BAY**
DATE: 05/01/03	FILE: OU4 Capping.mxd	FIGURE: 2-17



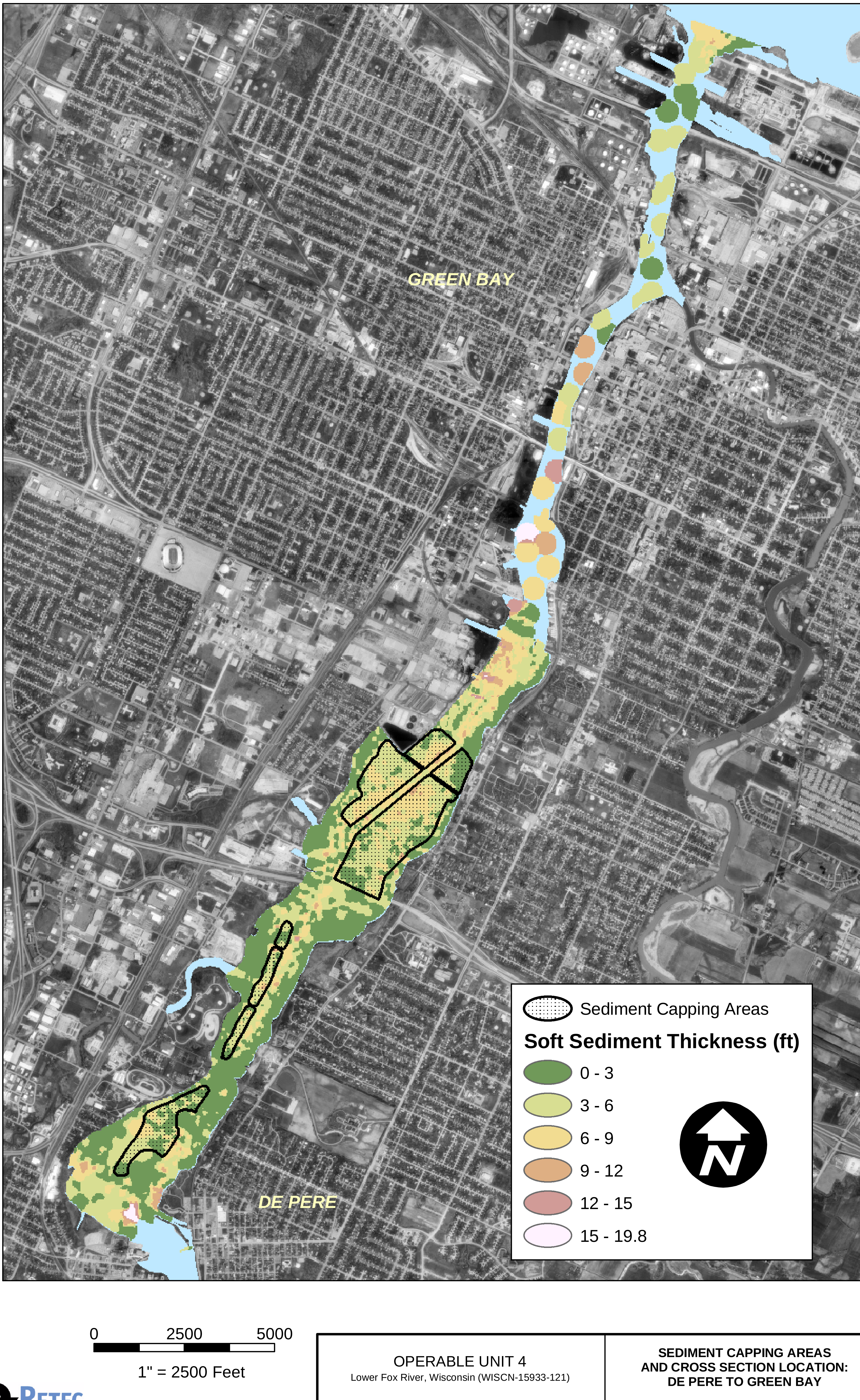
0 2500 5000

1" = 2500 Feet

RETEC

OPERABLE UNIT 4 Lower Fox River, Wisconsin (WISCN-15933-121)	MAXIMUM VELOCITY RATE ESTIMATED FOR FLOW CONDITION OF 408 CMS AT RAPID CROCHE DAM: DE PERE TO GREEN BAY

DATE: 02/12/03 | FILE: OU4 Velocity.mxd | FIGURE: 2-18

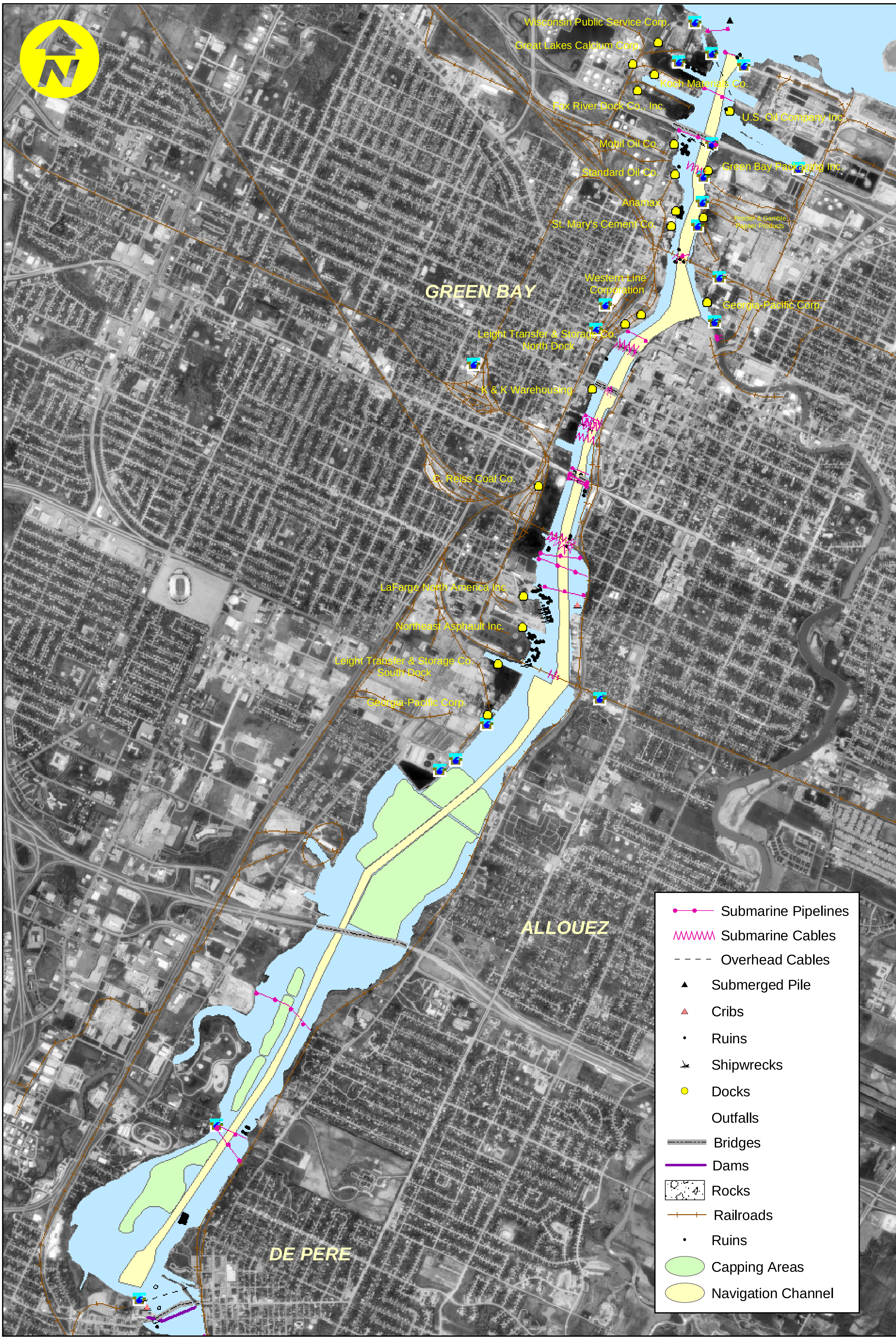


RETEC

OPERABLE UNIT 4
Lower Fox River, Wisconsin (WISCN-15933-121)

SEDIMENT CAPPING AREAS AND CROSS SECTION LOCATION: DE PERE TO GREEN BAY

DATE: 04/11/03 | FILE: OU4 SoftSed Thickness.mxd | FIGURE: 2-19

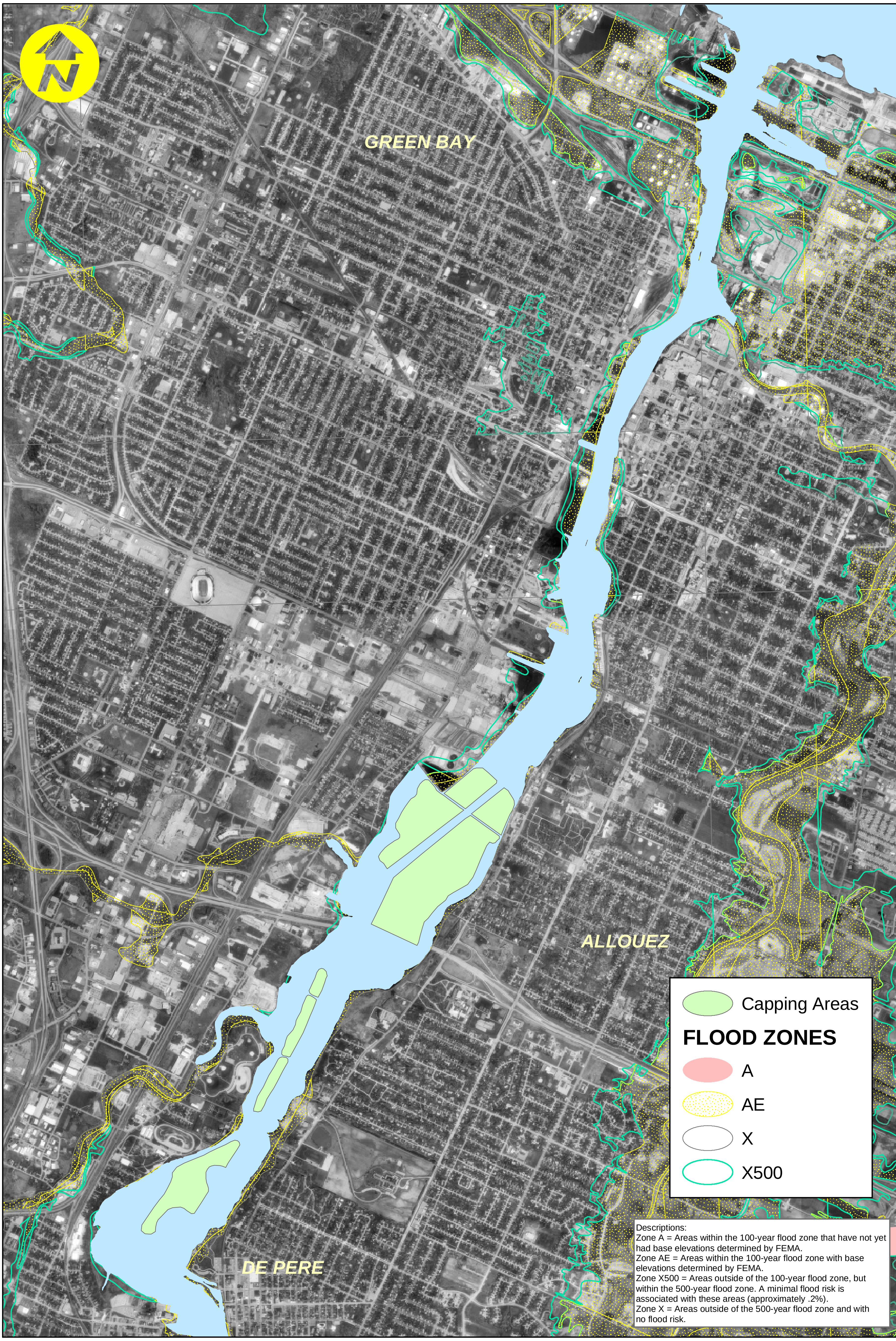


0 2500 5000

1" = 2500 Feet

RETEC

OPERABLE UNIT 4 Lower Fox River, Wisconsin (WISCN-15933-121)		LOWER FOX RIVER INFRASTRUCTURE AND SEDIMENT CAPPING AREAS: DE PERE TO GREEN BAY	
DATE: 05/01/03		FILE: OU4 Infrastructure.mxd	FIGURE: 2-20



0 2500 5000

1" = 2500 Feet

RETEC

OPERABLE UNIT 4 Lower Fox River, Wisconsin (WISCN-15933-121)	FEMA FLOOD ZONE COVERAGE AND SEDIMENT CAPPING AREAS: DE PERE TO GREEN BAY

DATE: 04/03/03 | FILE: OU4 Flood Zone.mxd | FIGURE: 2-21

C3 Capping Design Basis

The overall basis of design for subaqueous capping as a remedy component for the Lower Fox River, as described in Section 1, includes process descriptions, overall basis of design, selection of potential areas to be capped, institutional considerations, cap placement operations, and long-term operations maintenance and monitoring requirements. Identification of the areas that are considered for capping, based upon application of the design criteria, are discussed previously in Section 2.

Section 3 presents the process for deriving, and the conclusions of the design basis for the cap itself in each of the three Operable Units. For this basis of design, the cap would be composed of two distinct layers, an armor layer for physical stability and resistance to erosion and a sand cap layer for long-term isolation of the contaminants (the subject of this appendix). This section provides a description of the design basis for the isolation cap layer to include the specific data and procedures used.

C3.1 Design and Performance Criteria and Potential Areas to Be Capped

The design criteria for capping used for this basis of design are described in Section 2.1. The criterion most directly related to the isolation cap design was that for chemical isolation, specifically, a limit of 250 ppb of PCBs in the cap sediment (dry-weight basis), in the biologically active zone, defined as the upper 10 cm of the isolation layer of the cap. This standard would apply as a construction standard to ensure the cap is initially placed as a clean layer, and would also apply as a long-term limit with respect to chemical isolation. To meet the requirement for chemical isolation and reduction in flux, the isolation cap was designed as a sand layer with a required minimum TOC content.

C3.2 Capping Areas Evaluated for Design

The isolation cap design described in this section was conducted separately for the specific identified areas within OUs 1, 3, and 4. The areas meeting the criteria and subsequently selected as potential capping areas for the DEA report are shown on Figures 2-3, 2-10, and 2-17. The capping areas corresponded to either a total or partial Water Column Segment (WCS), SMU or named Deposit within each OU.

C3.3 Capping Materials

For this basis of design, the isolation sand cap material is composed of a sand or sandy soil material. The specific source of material for the isolation cap has not yet been determined, but several potential sources have been identified. The sand cap properties used in this basis of design were a deposited void ratio of 1.09, a specific gravity of 2.68, and a TOC concentration of 0.2 percent by weight. A higher TOC for the isolation cap material would be desirable, and sources for such material should be evaluated for the design. Addition of TOC in the form of granulated carbon can also be considered for the final design.

The armor layer materials would differ in gradation by deposit capped in accordance with the analysis of flow velocity/shear stress for the corresponding reach of the River. The armoring analysis is presented in Section 4, below. For cap design basis, for all capped areas the armor layer is composed of 6 inches of gravelly sand or sandy gravel with a porosity of 40 percent and a specific gravity of 2.68.

C3.4 Isolation Cap Design

The design of the isolation cap was based on an evaluation of the bioturbation potential of local bottom-dwelling organisms; the potential interactions and compatibility among cap components, including mixing and consolidation of compressible materials; the operational considerations for cap placement; and the need to control the potential flux of sediment contaminants such that the cap remains clean. A "layer" approach was used for the design basis, in which each process was separately evaluated to determine a sand cap thickness component, and the total sand cap thickness was determined as the sum of the component thicknesses. Many of the processes addressed by cap design are iterative in nature, but an efficient sequence for the design calculations was used. For this basis of design, the calculation sequence was as follows:

1) The armor layer thickness and composition was determined for the capping area (based in the results described in Section 4).

2) A trial thickness of the sand isolation cap was determined. For this basis of design, the minimum thickness for the sand cap layer was selected as 25 cm (about 10 inches), and this minimum thickness was used as the trial thickness for subsequent calculations (see discussion below).

3) A post-cap placement sediment profile of physical and chemical properties was then developed for each the capping area. This profile was based on the core data for *in-situ* contaminated sediments within that area, with the addition of armor and trial sand cap thickness, with a mixed layer in the lower portion of the sand cap.

4) The consolidation of the underlying contaminated sediments due to cap placement was calculated.

5) The mass of contaminants advected due to consolidation was calculated, and an initial contaminant concentration in the sand cap following consolidation-induced advection was determined.

6) A post-consolidation sediment profile was developed accounting for the initial contaminant concentrations in the sand cap and the changes in sediment porosities throughout the profile resulting from consolidation due to cap placement.

7) The post-consolidation sediment profile was used to assess the long-term effectiveness of the cap in maintaining clean conditions in the upper 10 cm of the sand cap. This evaluation involved modeling the long-term diffusion of contaminants using the USACE RECOVERY model.

8) If the long-term effectiveness evaluation indicated a contaminant concentration in the upper sand cap exceeding the 250 ppb PCB standard, the trial isolation sand cap thickness was increased and the calculation sequence was repeated.

9) Once the required sand cap thickness meeting the standard was determined, a factor of safety of 1.5 was applied and the total thickness was then rounded to the next highest 6-inch thickness increment to determine the design isolation sand cap thickness.

Separate evaluations following the above sequence were conducted for each of the capping areas within OUs 1, 3, and 4. The following subsections describe these steps in detail and summarize the results of the design calculations for each capping area.

C3.4.1 Physical Stability and Erosion

The overall cap design required the evaluation of an armor layer for purposes of physical cap stability and resistance to erosion. However, the thickness and composition of the armor layer directly influenced the design of the sand cap layer because the armor contributed to the consolidation of the underlying contaminated sediments, with resulting advective flux due to consolidation, and resulting changes in sediment porosity within the contaminated sediment layers. Details of the basis of design for the cap armor design to include a tabulation of armor size and thickness by capping area is provided in Section 4. In all cases, the armor layer thickness was determined to be 6 inches (about 15 cm).

C3.4.2 Bioturbation and Physical Isolation

The performance criterion for chemical isolation of 250 ppb of PCBs in the biologically active zone, defined as the upper 10 cm of the isolation layer of the cap was a major driver for the isolation cap design. Based on this definition of the biologically active zone, a thickness of 10 cm was selected for this basis of design as the physical isolation/bioturbation component of the cap thickness.

Benthic organisms recolonizing the capped areas are likely to be limited to the fine-grained, organic-rich sediments, which may deposit on top of the cap or settle in the interstices of armor stone. Depending on its thickness and grain size, the armor layer may also provide resistance to bioturbation. The armor layer component of the cap was therefore considered to act in a dual function as the component for both physical isolation of benthos from the underlying layers and bioturbation.

In either case, the upper 10 cm of the sand isolation cap was, by definition, considered the biologically active zone, and the cap design was conducted assuming a requirement that this upper sand cap layer would meet the standard of 0.25 ppm of PCBs in the long term.

C3.4.3 Operational Considerations

For this basis of design, an operational thickness component of 10 cm (about 4 inches) was selected to account for mixing of cap sand with underlying contaminated sediments upon placement. Data on the measured thicknesses of mixed capping and contaminated sediments resulting from capped placement is limited. For example, at the Palos Verdes Superfund Pilot Cap, this mixed thickness was limited to a few centimeters (Fredette et al., 2002). However, the Lower Fox River sediments are known to exhibit a very soft "fluff" layer at the sediment surface. The sediment cores taken to date are characterized by core segments to define the physical and chemical properties within the sediment profile at any given location but, in many cases, the fluff layer was not retained for characterization as a distinct core segment.

For the operational cap thickness component in this basis of design, the fluff layer is assumed to be present when the cap is placed and mixed uniformly into the operational cap thickness component, corresponding to the lower 10 cm (about 4 inches) of the cap material. The contaminant concentration of this lower portion of the sand cap was assumed to be one-half that of the upper sediment layer as defined by the cores.

C3.4.4 Trial Sand Cap Thickness

Once the thickness of the armor layer and operational component of the sand cap for cap/contaminated sediment mixing due to placement were selected, a trial thickness of the sand isolation cap was determined. For this basis of design, the minimum trial thickness for the sand cap layer of 25 cm (about 10 inches) was selected. This minimum thickness was determined as the sum of the upper 10 cm of the cap (that corresponding to the biologically active zone which must meet the standard of 0.25 ppm PCBs), plus a trial 5-cm thickness for chemical isolation, plus the 10-cm operational thickness component assumed to be affected by mixing with the contaminated sediment upon placement.

A post-cap placement sediment profile of physical and chemical properties was then developed for each capping area. This profile consisted of the armor layer, underlain by the trial sand cap thickness (15 cm of surficial clean sand cap underlain by 10 cm of mixed cap and contaminated sediment fluff material), underlain by the contaminated sediment sublayers. Concentration profiles for PCBs for the *in-situ* sediments were presented in Section 2 for each Operable Unit. Both mean and maximum PCB concentration profiles were developed for each area. For the basis of design, the highest PCB concentrations at each depth interval was applied over the entire area, providing an additional factor of conservatism in the design. The sediment profiles for each capping layer, to including both physical properties and PCB concentrations, are also shown in the Microsoft Excel files on the Compact Disk provided with this section.

C3.4.5 Consolidation

Since the cap layer will be sandy material, internal consolidation of the cap will not occur. Therefore no cap thickness component for consolidation was assumed for this basis of design. However, the contaminated sediment is highly compressible, and will undergo consolidation due to the added weight of sand capping material and armor stone. The consolidation will result in the expression of porewater from the contaminated sediments, and this porewater will carry some contaminants as the water is advected upward into and, in some cases, through the cap. This consolidation will occur rapidly in the early stages following cap placement and more slowly over time. Most of the consolidation will occur within the first weeks to months following cap placement, so consolidation-induced advection is a short-term process.

The consolidation of the underlying contaminated sediments due to cap placement is an important consideration in the effectiveness of the cap for two reasons. First, the advection of contaminants will result in an accumulation of contaminants in the sand cap (although anticipated to be very slight). Second, the consolidation of the contaminated sediments results in a decrease in the porosity of these sediments, and consequently a change in the conditions for long-term diffusion rates through these sediments.

No consolidation data is currently available for Lower Fox River sediments, and only a limited number of Atterberg Limit data were available (such data are well correlated with basic consolidation properties of soils). This basis of design therefore used a value of 4.0 for the coefficient of consolidation, a conservative value for organic silts and clays, for estimating settlements due to cap placement (Carter and Bently, 1991; Holtz and Kovacs, 1981). The consolidation calculations were performed using a Microsoft Excel spreadsheet (the Excel files are on the Compact Disk provided with this section).

C3.4.6 Consolidation-Induced Advection

The degree of consolidation of the underlying contaminated sediment (see discussion above) was used to estimate the movement of a front of porewater upward into the cap and the total volume of water advected into or through the cap due to consolidation. The magnitude of consolidation is equivalent to the volume of porewater advected through a unit surface area due to consolidation. Although some of the porewater may move downward into the foundation sediments, for this basis of design, all advected porewater was assumed to move upward into and through the cap (a conservative assumption).

The advected porewater will carry some contaminants with it; therefore, the mass of contaminants was calculated so than an initial contaminant concentration within the sand cap could be estimated prior to evaluating the long-term effectiveness of the cap. Equilibrium partitioning principles were used to estimate the porewater concentrations in the contaminated sediment profile before cap placement.

The following relationships were used in calculating the porewater concentrations advected due to consolidation (Ruiz and Gerald, 2001):

$$C_w = \frac{Cs}{K_d}$$

where

- Cs = the equilibrium contaminant concentration in the sediment solids (mg/kg)
- C_w = the equilibrium contaminant concentration in the porewater (milligrams per liter [mg/L])
- K_d = the distribution coefficient (liters per kilogram [L/kg]), calculated as:

$$K_d = 0.617 f_{oc} K_{ow}$$

where

- K_d = the partition coefficient for organic contaminants (Karickoff, 1979)
- f_{oc} = the weight fraction of organic carbon in the solid matter (grams of organic carbon per gram [g-orgC/g])
- K_{ow}= octanol-water partition coefficient (milligrams per cubic meter [mg/m^3]-octanol)/(mg/m^3-water)])

The values for f_{oc} were based on available data for each OU. A value of log K_{ow} of 6.0 was used for PCB 1242 (USACE, 1998).

The total contaminant mass advected was assumed to be uniformly distributed within the sand cap as a post-consolidation concentration due to advection. This is a conservative approach, since a larger portion of the advected mass would likely be distributed in the lower portions of the sand cap.

The calculations for advected contaminant mass were performed using a Microsoft Excel spreadsheet. In all cases, the initial concentration of contaminants due to advection into the sand cap was low. A post-consolidation sediment profile was then developed accounting for the initial contaminant concentration in the sand cap due to consolidation advection. The results of the consolidation analysis were also used to adjust the sediment porosities throughout the sediment profile to account for reductions due to consolidation. This revised profile was used as the initial condition for the evaluation of long-term contaminant diffusion. The calculations for advected contaminant mass and the resulting post-consolidation sediment profiles for each capping area are on the Excel files on the Compact Disk provided with this section.

C3.4.7 Chemical Isolation Component

The design for chemical isolation considered both advection due to consolidation (as described above) and long-term diffusion. This evaluation was done using an iterative approach, first using the minimum sand cap thickness to determine consolidation-advection, which included a 5-cm chemical isolation thickness. As discussed above, the advection due to consolidation established the initial movement of contaminants into the cap, and this was used as the starting condition for the long-term diffusion evaluations. The post-consolidation sediment profile was then used to assess the long-term effectiveness of the cap in maintaining clean conditions in the upper 10 cm of the sand cap.

C3.4.8 Long-Term Diffusive Flux

The long-term diffusion of contaminants was evaluated using the USACE model RECOVERY (Ruiz and Gerald, 2001). This model simulates contaminant flux due to diffusion for a cap/sediment vertical profile in which the sediment contaminant concentrations, fractions of organic carbon, porosities, and specific gravities can be varied for specified sublayers in the profile. RECOVERY output includes the concentration of contaminants in a mixed surficial layer, concentrations within the entire cap and sediment profile, and contaminant flux into the water column.

The model can estimate long-term diffusive fluxes and sediment and porewater concentrations in a system composed of a completely mixed water column, a completely mixed sediment surface layer, and any number of clean and contaminated layers of material of varying properties and contaminant concentrations. The contaminant is assumed to follow linear, reversible, equilibrium sorption, and first-order decay kinetics. The physical representation of a system by RECOVERY consists of a well-mixed water column (i.e., zero-dimensional) underlain by a vertically stratified sediment column (i.e., one-dimensional). The analysis is based on the assumption that the overlying water column is well mixed. The sediment is well mixed horizontally but segmented vertically into a well-mixed surface (active) layer and underlying layers of sediment for which a varying profile may be defined. Since the mixed surface layer and underlying layers may be defined as clean or contaminated, the model is applicable to capping evaluations.

Processes incorporated in the RECOVERY model, in addition to sorption and decay, are volatilization, burial, resuspension, settling, advection, porewater diffusion, and enhanced biodiffusion. For this analysis, porewater diffusion was assumed to be active, but burial, resuspension, and decay were not assumed to occur.

RECOVERY is based on the principles of equilibrium partitioning and considers diffusive flux from porewater to overlying water. The same equilibrium principles and partitioning coefficients as used for the advective flux analysis were applied in the RECOVERY diffusive flux.

The mass transfer coefficient used in RECOVERY for diffusive exchange between mixed sediment layer porewater and the water column is related to fundamental parameters by:

$$v_d = \frac{\varphi D_s}{z'}$$

where

- v_d = diffusion mass-transfer coefficient at the sediment-water interface (meters per year [m/yr])
- φ = porosity
- D_s = diffusion coefficient in the sediment porewater (square meters per year [m^2/yr])
- z' = characteristic length over which the gradient exists at the sediment-water interface (meters)

A value of 1 cm is assumed for z' based on Thomann and Mueller (1987). Also, D_s is related to molecular diffusivity D_m by the relation (Bernier, 1980; Manheim and Waterman, 1974).

$$D_s = D_m \varphi^2$$

Although the armor layer was considered in calculating consolidation and determining the conditions within the sediment profiles, no contribution of the armor layer for resistance to flux was assumed for the long-term diffusion calculations using RECOVERY (a conservative assumption).

RECOVERY results included the sediment concentrations in the upper sand cap layer as a function of time. The model simulation period selected for this basis of design was 1,000 years (considered a conservative time period). Views of the RECOVERY model runs for each capping area, showing input data and calculated values along with a plot of the PCB concentrations versus time for the upper sand layer, are included on the Excel files on the Compact Disk provided with this document. The CDs also contain the input and output files for each of the model runs conducted.

Table 3-1 summarizes the model results for each capping area, showing the PCB concentrations in the 10 cm upper sand cap layer at simulation times of both 100 years and 1,000 years. In all cases, the trial sand cap thickness of 25 cm was adequate in maintaining the surficial cap concentrations below the design criterion of 0.25 ppm at 100 years. The surficial cap concentrations using the 25-cm sand cap thickness were also below the design criterion of 0.25 ppm at 1,000 years with the exception of one capping area in OU 3 and two areas within OU 4. Results for these areas were below the criterion of 0.25 ppm at 1,000 years when the sand cap thickness was increased from 25 to 30 cm.

C3.4.9 Total Isolation Cap Thickness

The total cap thickness for the basis of design is the sum of the required thickness components as described above, with an additional 50 percent thickness (a factor of safety of 1.5) to account for processes for unevenness of cap placement, uncertainty in site conditions, sediment properties, and migration processes. Once the safety factor was applied, the resulting thickness was rounded up to the nearest 15-cm (6-inch) increment, since the minimum sand cap thickness which can be operationally managed is about 6 inches.

Table 3-1 Summary of Cap Modeling Results Using Recovery

OU 1 - Lower Fox River

Cap ID	WCS	Cap Thickness (m)	Armor Thickness (m)	PCB Concentration in Cap Surface(mg/kg)	
				100 years	1,000 years
1	6a	0.25	0.15	0.001	0.107
2	7a	0.25	0.15	0.0002	0.036
3	7b	0.25	0.15	0.001	0.107
4	8a	0.25	0.15	0.0001	0.029
5	8b	0.25	0.15	0.0004	0.047
6	9	0.25	0.15	0.0001	0.014

OU 3 - Lower Fox River

Cap ID	Deposit	Cap Thickness (m)	Armor Thickness (m)	PCB Concentration in Cap Surface(mg/kg)	
				100 years	1,000 years
1	EE	0.25	0.15	0.002	0.468
1	EE	0.3	0.15	0.001	0.072
1	EE	0.4	0.15	0.001	0.001
2	EE	0.25	0.15	0.0002	0.067
3	EE	0.25	0.15	0.0001	0.035
4	EE	0.25	0.15	0.0002	0.062
5	EE	0.25	0.15	0.0001	0.045
6	EE	0.25	0.15	0.0002	0.043

OU 4 - Lower Fox River

Cap ID	SMU Group	Cap Thickness (m)	Armor Thickness (m)	PCB Concentration in Cap Surface(mg/kg)	
				100 years	1,000 years
1	20 - 25	0.25	0.15	0.002	0.580
1	20 - 25	0.3	0.15	0.001	0.087
1	20 - 25	0.4	0.15	0.002	0.001
2	26 - 31	0.25	0.15	0.001	0.196
3	32 - 37	0.25	0.15	0.001	0.200
4	38 - 43	0.25	0.15	0.001	0.109
5	44 - 49 (West)	0.25	0.15	0.001	0.083
6	44 - 49 (East)	0.25	0.15	0.002	0.297
6	44 - 49 (East)	0.3	0.15	0.001	0.044
6	44 - 49 (East)	0.4	0.15	0.001	0.001
7	50 - 55 (West)	0.25	0.15	0.001	0.127
8	50 - 55 (East)	0.25	0.15	0.001	0.105

Notes:
1. Target level PCB concentration is 0.250 mg/kg. Shaded areas indicate exceedance of target level concentration.

C4 Evaluation of Fox River Capping Material

C4.1 Introduction

In order to provide confinement and isolation of contamination, the *in-situ* cap design must provide for a stable, non-erodible cap material. Cap erosion can be caused by wave impact, water, or tidal flow velocity, and human interaction such as vessel propeller wash. Prevention of cap erosion is accomplished by selection and placement of a stable grain size mixture that will create a natural protective armor layer for the cap. The stable grain size is selected based on the shear stress caused by near bed velocities. In general, the larger grain (particle) sizes are stable at higher velocities than smaller particles. This section discusses the evaluation of hydrodynamic conditions within the River, relative to the cap materials that are available locally within the Fox River Valley. The recommendations for armoring material used in the design basis in Section 3, are developed here.

C4.2 General Considerations

C4.2.1 Single- and Multi-Layer Caps

Both single-layer and multi-layer caps were evaluated. A single-layer cap uses a single application of material with a well-sorted grain size. The grain size will be specified based on the near-bed velocities determined for design. The cap can also be constructed as a multi-layer cap with a subsurface isolation layer (finer grain size) placed first, and a surficial armoring layer, where the grain size exceeds the incipient motion, placed over the isolation layer.

For single layer caps, the material must have a gradation specification that assures the material will self-armor at the surface when the cap is exposed to high wave, current, or propeller wash velocities. Self-armoring occurs when the surface fine-grained material is winnowed out, leaving a cap surface comprised of lag material. This lag material is of sufficient grain size to resist the near-bed shear force, and armors against further cap erosion.

A single-layer cap design may require limited sacrificial sediment (fine grain) that will be eroded from the bed surface. This consideration for sacrificial sediment requires adequate cap thickness placement to assure the required final cap thickness after self-armoring is realized. Single-layer caps are, in general, easier to construct than multiple-layer caps, and are most appropriate in waters with lower wave and current (low-energy) conditions.

A multiple-layer cap consists of an armor layer with large-grained material placed on top of the confinement cap, which is a finer-grained material. The armor layer includes only the grain size large enough to be stable for the design velocities. The armor layer design thickness is typically a function of the armor grain size. The confinement layer design thickness must have a thickness and a grain size mixture that assures isolation of the contaminated material, and will not erode due to groundwater movement.

C4.2.2 Cap Stability

Cap stability requires that incipient motion of the higher grain sizes in the cap mix are not realized for the design flow maximum velocity. Erosion-deposition criteria for varying grain sizes is provided graphically by Hjulstrum (1935). Helley (1969) has found agreement with the Hjulstrum's diagram in field studies concerning large particle diameters up to 1 foot. A version of the Hjulstrum diagram is provided (Davis, 1985).

This figure identifies the limiting zone at which incipient motion starts and the line of demarcation between the sediment transport and sedimentation. The upper area of the chart above the shaded area is the erosion zone. The upper edge of the shaded area represents the velocity required to initiate movement (incipient motion) of a sediment grain that is at rest on the bed of the waterway. The lower edge of the shaded area represents cessation of movement of a sediment grain that has been eroded. The area below the shaded area is called the sedimentation zone. The table below indicates stable grain sizes for sediment at rest on the bottom for various velocities, as interpreted from the diagram.

Grain Size (mm)	Approximate Velocity (cm/sec) at Which Grain Size Will Not Be Eroded, after Hjulstrum
1	75
5	180
10	250
15	300
20	350
25	400
50	500

The natural armoring process of the bed is complicated. The values on Figure C4-1 are based on the average flow velocity and uniform grain size in the bed, but there is considerable local and temporal variation on flow velocity and grain size in any natural setting. Natural armoring occurs when the drag force caused by the flow that acts on the particles are greater than the resisting forces of only a portion of the bed grain size mixture. An exact mathematical approach is complicated because of the variability of the bed material grain size. The initiation of motion of a specific bed material is different when the bed material is non-uniform instead of being uniform. This is due to a sheltering effect created by the larger (non-erodible) grain sizes.

In an attempt to evaluate the range of sediment grain sizes that could accommodate natural armoring for a specific waterway at a specific flood stage, the relationship of critical shear value to grain size is applied by the following formula:

$$\tau_c = \frac{0.1}{\left(\log\left(19 * \frac{D_{50}}{D_m}\right)\right)^2} \quad \text{(Egiazaroff, 1965)}$$

where

- τ_c = the critical shear value at which particle motion begins
- D_{50} = diameter of the median grain (50 percent passing by weight)
- D_m = diameter of the average grain representing the mixture

The preliminary analysis for this report considers a representative channel width and flow for the entire cap area in the waterway. This analysis for armoring does not include impacts of localized scouring caused by structures or converging flows from multiple channels. Those conditions would require additional evaluation and selection of cap armoring for the limited impact area on the riverbed.

C4.3 Operable Unit Specific Considerations

Conditions within the Operable Units were described previously in Section 2. The range of River flow velocity in the OUs is based on hydrodynamic modeling, and maximum flow conditions are presented on Figures 2-4, 2-11, and 2-18. These velocities results were modeled using an input flow of 408 m^3/s. A 100-year flood flow is identified at 680 m^3/s.

A simple relationship of flow velocity (m/s) to total flow (m^3/s) is provided by the Manning Equation:

$$V = \frac{1.486 * (R_h)^{2/3} * (s)^{1/2}}{n}$$

where

- V = velocity
- R_h = hydraulic radius (area/wetted perimeter of channel)
- s = slope
- n = Manning coefficient for waterway

and

$$Q = V * A$$

where

- Q = discharge of flow
- A = cross-section area of flow

The Lower Fox River is a wide river (width typically greater than 50 times the depth). The slope value is very small for the Lower Fox River, as is often the case for open channel flow in lowlands near the mouth of the River. A wide river with very small slope does mean the relative change in discharge, Q, is approximately proportional to the relative change in velocity. For the Lower Fox River this would mean that a maximum velocity of 0.6 m/s for a 408 m^3/s discharge would equate to an approximate 67 percent increase (680 m^3/s/408 m^3/s), or a 1.0 m/s flow for 680 m^3/s discharge.

The relationship of discharge to river flow velocity is not exact, but does represent a technically correct rationale to derive a conservative discharge velocity based on the data available. For purpose of conservative design and analysis, the design velocities for the 408 m^3/s flow are increased 100 percent for preliminary design evaluation.

The Lower Fox River water surface and flow velocities are also impacted by the presence of several low head dams. The conditions in the river for flow velocities without the dams present have not been provided in this report.

C4.3.1 Operable Unit 1

Velocities in the proposed capping area of the Lower Fox River OU 1 are estimated to range from less than 0.2 up to 0.6 m/s based on modeling done by others (HydroQual, 2000). These velocities were developed using modeling results with an input flow of 408 m^3/s at Rapid Croche dam. For purpose of conservative design and analysis, the design velocities for the 408 m^3/s flow are increased 100 percent for preliminary design evaluation. The potential maximum design velocity applied for OU 1 is 1.2 m/s.

This design velocity is identified as a maximum velocity within OU 1. A cap armor design for this velocity will assure that no capped area within OU 1 will erode. Other areas proposed for capping have lower velocities. It is an obviously conservative design for these other areas in OU 1 that have a velocity less than 0.6 m/s (see Figure 2-4).

For a design velocity of 1.2 m/s (4 fps), a uniform sediment mixture with a grain size greater than 3.0 mm (approximately 0.12 inch) would provide an effective armor cap (see Figure 4-1). Based on the formula that describes the critical shear value to the characteristics of a self-armoring bed, the cap design for the site will require the average grain size to be equal to or greater than 3.2 mm. An acceptable mixture of sediment grain sizes for an armor cap layer is provided on Figure 4-2.

If the grain size range was within zone 1 of Figure 4-2, there would be little or no erosion of any of the armor cap grain sizes. If these grain sizes were representative of the cap, there would be no need to place an additional armor layer, or sacrificial layer, on the confinement cap. That cap would already be self-armoring with only a minimal loss of surface fine-grained sediment.

C4.3.2 Operable Unit 3

Velocities in the proposed capping area of the Lower Fox River OU 3 are estimated to range from less than 0.2 up to 1.0 m/s based on modeling done by others (HydroQual, 2000). These velocities were developed using modeling results with an input flow of 408 m^3/s. For purposes of conservative design and analysis, the design velocities for the 408 m^3/s flow are increased 100 percent for preliminary design evaluation. The preliminary design velocity applied for this OU is 2.0 m/s.

This design velocity is identified as a preliminary design velocity within OU 3. A cap armor design for this velocity will assure that no area proposed for capping within OU 3 will erode. Other areas proposed for capping have lower velocities. It is an obviously conservative design for these other areas in OU 3 that have a velocity less than 1.0 m/s as determined by modeling for 408 m^3/s (see Figure 2-11).

For a design velocity of 2.0 m/s (6.6 fps), a uniform grain size at 7 mm (approximately 0.27 inch) would provide an effective armor cap. Based on the formula that describes the critical shear value to the characteristics of a self-armoring bed, an acceptable range of sediment grain size for an armor cap is provided on Figure 4-3.

C4.3.3 Operable Unit 4

Velocities in the proposed capping area of the Lower Fox River OU 4 are estimated to range from less than 0.2 up to 0.8 m/s. For purposes of conservative design and analysis, the design velocities for the 408 m^3/s flow are increased 100 percent for preliminary design evaluation. The preliminary design velocity applied for this OU 4 is 1.6 m/s.

This design velocity is identified as a maximum preliminary design velocity within OU 4. A cap armor design for this velocity will assure that no proposed cap area within OU 4 will erode. Other areas proposed for capping have lower velocities. It is an obviously conservative design for these other areas in OU 4 that have a velocity less than 1.6 m/s, which is twice the velocity as determined by modeling for 408 m^3/s (see Figure 2-18).

For a design velocity of 1.6 m/s (5.3 fps), a uniform grain size greater than 5 mm (approximately 0.2 inch) would provide an effective armor layer (see Figure 4-1). Based on the formula that describes the critical shear value to the characteristics of a self-armoring bed, a range of acceptable sediment grain size is provided on Figure 4-4.

C4.4 Cap Placement

The placement of the self-armoring cap layer must be adequately planned to assure armor success. The-self armoring cap design is comprised of a range of grain sizes, and those grain sizes can include gravel through silt. Placement methods must be incorporated into the decisions for cap mixture design.

The problem of placing an armor mix cap into the water column is the segregation of the grain sizes as they settle on the bed surface. The most coarse material reaches the bed first, and the finest material last. The fine material is on the surface covering the coarser material. The intention of a self-armoring cap is to release only the finer grain sediment from the surface veneer, and allow the coarser sand sizes to create a natural armor layer. If all the fine-grained sediment is on the surface, all of the fine-grained sediment will be lost until the armoring size is uncovered.

The solution to this placement segregation of grain sizes is to release the sediment under water, near the bed, to reduce or avoid settling time in the water column. Another approach is to place the self-armoring layer in thin lifts. Both of these methods would assure a more random mixture of fine to coarse grain sizes through the full layer of the armor cap.

The thickness of a thin layer of cap material, both for confinement and for armor, is a function of the sediment grain size and the equipment capability to control sediment volume over area during placement. Based on actual use of a mechanical dredge to place silty sand cap material on a soft bed in Wards Cove, Ketchikan, Alaska, a realistic limit of the thin layer placement is approximately 0.5 foot. With hydraulic placement, 1.5- to 3-inch layers have been successfully achieved.

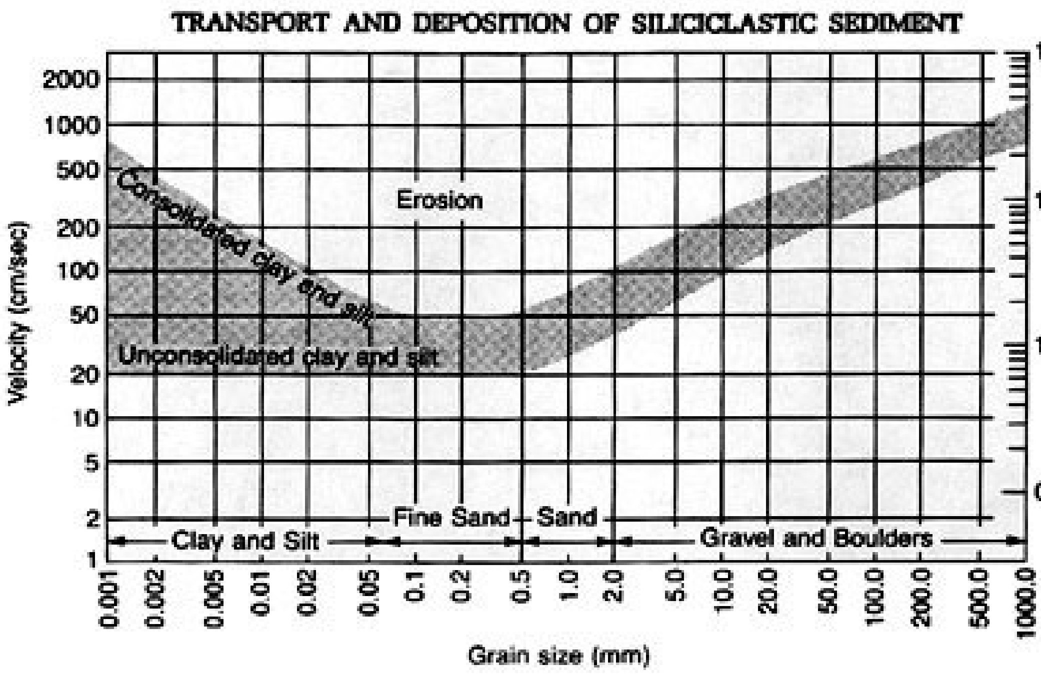
The grain size of the armor cap material required in the Lower Fox River ranges from a small gravel to a coarse/medium sand. The minimum thickness for the armor layer to be an effective erosion protection layer could be as thin as 0.25 foot. The capability to control placement of the armor cap would approach 0.5 foot. For assurance of constructability, and 100 percent armor cap cover, a thickness of 0.5 foot is identified for the cap design.

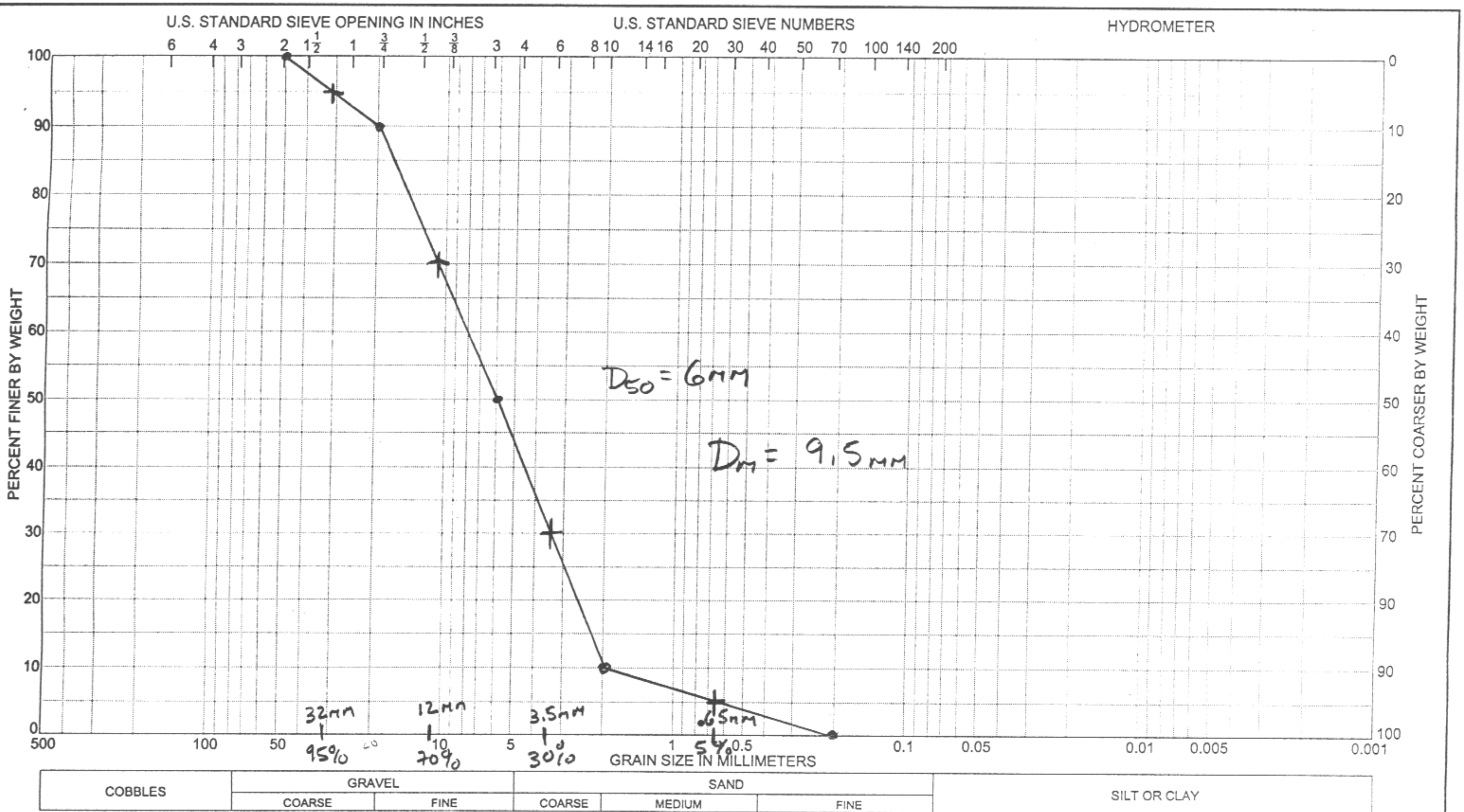
Sampling must be conducted during armor cap placement to evaluate and assure a general mixture of cap sediment. If the sampling indicates significant segregation the consideration for the final cap thickness and sacrificial volume placement must be evaluated.

C4.5 Geotechnical Characteristics of the Armor Cap

The geotechnical properties of the armor cap material used in the design basis were determined based upon a review of geotechnical properties of locally available materials that had met Wisconsin Department of Transportation specifications. Five different sources were evaluated, and the average was used as the design basis. For OU 1, the armor cap material is a poorly graded gravelly sand with no fines. Porosity of this material is 40 percent, void ratio of 0.67, and a d50 of 5 to 6 mm. For OUs 3 and 4, the armor cap is a poorly graded sandy gravel with no fines. Porosity and void ratio is the same as for OU 1; the d50 is 20 mm.

Figure 4-1 Erosion-Deposition Relationship for Bed Sediment with Uniform Grain Size (after Hjulstrum)





Sample No.	Elev or Depth	Classification	Nat w%	LL	PL	PI

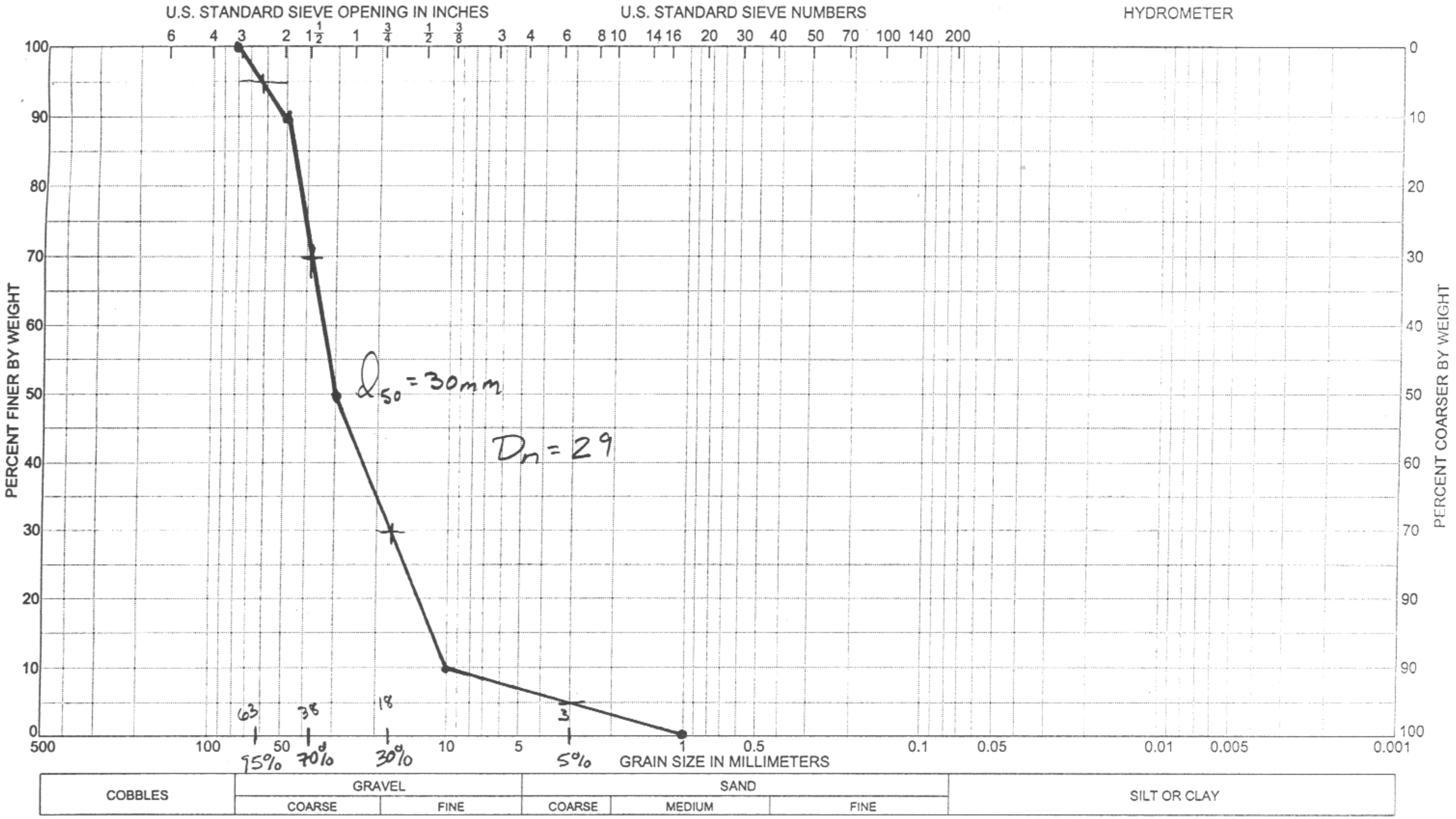
Project

Area **FIGURE 4-2 CAPPING OU 1**

Boring No. $\tau_c = .174$

Date

GRADATION CURVES



Sample No.	Elev or Depth	Classification	Nat w%	LL	PL	PI

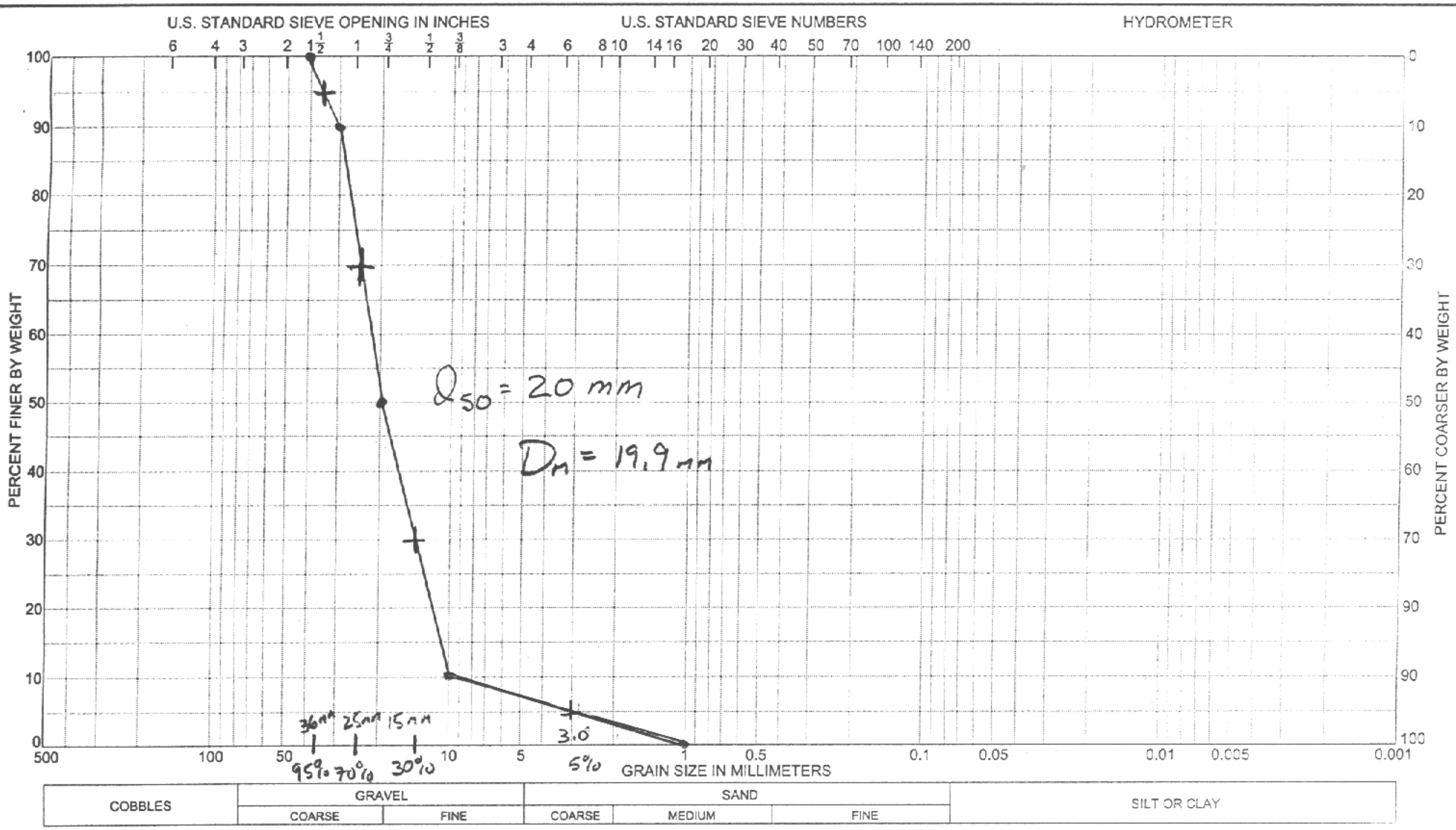
Project

Area **FIGURE 4-3 CAPPING OU 3**

Boring No. τ_c = .606

Date

GRADATION CURVES



Sample No.	Elev or Depth	Classification	Nat w%	LL	PL	PI

Project

Area **FIGURE 4-4 CAPPING OU 4**

Boring No. τ_c = .41

Date

GRADATION CURVES

OU1

Width =	1200	Feet	Scaled from velocity map
Velocity =	4	FPS	1.2m/s * 2 = 2.4m/sec design vel. 2.4m/s * 3.28 FT/M= 3.94 F/S. USE 4 F/Sec
Flow Rate=	24000	CFS	
Area=	6000	Ft2	Area=Q/V
Depth=	5	ft	Depth = area/width
Mannings r	0.025		
Slope =	0.000527		Calculated using mannings eqn
Hyd Radius	4.959		Same as depth for wide river or A/Wp

Critical Shear Stress for River=g*Hyd Rad*Slope*ρ

0.163	Crit shear of material must be greater than this for stability

Using Hjulstrom Diagram, ~3mm stable at 4 FPS, up to ~15mm transported

Selected Capping Material

MATERIAL CURVE #3

Calculate Dm (based on theoretical sieve Curve)

Material Curve #3 d50=6mm

y % Passing range	median %	% of Total	Grain Size (from Curve)	Cumulative grain Size
0 - 10	5%	10%	0.65	0.065
10 to 50	30%	40%	3.5	1.4
50 - 90	70%	40%	12	4.8
90 - 100	95%	10%	32	3.2
			Dm=	9.5

Critical Shear Stress for Material

Material Curve #3

	mm	ft
D50	6	0.0197
Dm	9.5	0.0312
Crit Shear Stress=		0.174

OU3

Width =	1100	Feet	Scaled from velocity map
Velocity =	6.6	FPS	2.0m/s * 2 = 4m/sec design vel. 4m/s * 3.28 FT/M= 6.6 F/S. USE 6.6 F/Sec
Flow Rate=	24000	CFS	
Area=	3636	Ft2	Area=Q/V
Depth=	3	ft	Depth = area/width
Mannings r	0.025		
Slope =	0.002490		Calculated using mannings eqn
Hyd Radius	3.286		Same as depth for wide river or A/Wp

Critical Shear Stress for River=g*Hyd Rad*Slope*ρ

0.511 Crit shear of material must be greater than this for stability

Using Hjulstrom Diagram, ~7.5mm stable at 6.6 FPS, up to ~50mm transported

Selected Capping Material

MATERIAL CURVE #4

Calculate Dm (based on theoretical sieve Curve)

Material Curve #4 — d50=30mm

y % Passing range	median %	% of Total	Grain Size (from Curve)	Cumulative grain Size
0 - 10	5%	10%	3	0.3
10 to 50	30%	40%	18	7.2
50 - 90	70%	40%	38	15.2
90 - 100	95%	10%	63	6.3
			Dm=	29

Critical Shear Stress for Material

Material Curve #4

	mm	ft
D50	30	0.0984
Dm	29	0.0951
Crit Shear Stress=		0.606

OU4

Width =	2000	Feet	Scaled from velocity map
Velocity =	5.3	FPS	0.8m/s * 2 = 1.6m/sec design vel. 1.6m/s * 3.28 FT/M= 5.25 F/S. USE 5.3 FT/Sec
Flow Rate=	24000	CFS	
Area=	4528	Ft2	Area=Q/V
Depth=	2	ft	Depth = area/width
Mannings r	0.025		
Slope =	0.002660		Calculated using mannings eqn
Hyd Radius	2.259		Same as depth for wide river or A/Wp

Critical Shear Stress for River=g*Hyd Rad*Slope*ρ

0.375 Crit shear of material must be greater than this for stability

Using Hjulstrom Diagram, ~5mm stable at 5.3 FPS, up to ~25mm transported

Selected Capping Material

MATERIAL CURVE #6

Calculate Dm (based on theoretical sieve Curve)

Material Curve #6 d50=20mm

y % Passing range	median %	% of Total	Grain Size (from Curve)	Cumulative grain Size
0 - 10	5%	10%	3	0.3
10 to 50	30%	40%	15	6
50 - 90	70%	40%	25	10
90 - 100	95%	10%	36	3.6
			Dm=	19.9

Critical Shear Stress for Material

Material Curve #6

	mm	ft
D50	20	0.0656
Dm	19.9	0.0653
Crit Shear Stress=		0.412

C5 Cap Placement

This section provides a description of the application design basis for the *in-situ* capping based upon the areas identified in Section 2 for each of the Operable Units, and the engineered caps from Sections 3 and 4. The ISC areas have been estimated to be 221 acres, 102 acres, and 634 acres for OU 1, OU 3, and OU 4, respectively. Cross sections for each of the OUs are provided on Figures 5-1 through 5-3.

The placement technique proposed in this section has evolved out of past dredging and filling methods that have been used for decades in creating nearshore or open-water fills. Projects that have been successfully accomplished using this technique are described below.

C5.1 Process Description

Considering the magnitude of capping area, shallow-water conditions in OUs 1 and 3, and the requirement for precise cap placement, a spreader barge with a diffuser plate and pipeline assembly is recommended for the cap installation. As noted previously, mechanically placed sand using a barge and spreader bucket is possible for OU 4, but for purposes of the DEA report the hydraulic-spreading method was used, in part because of the potential to use the existing planned hydraulic dredging infrastructure – in reverse.

A process schematic is shown on Figure 5-4. The spreader barge will be fitted with a diffuser plate, drum winches, fairleads, a Global Positioning System (GPS) and plotter, and a generator (Figure 5-5). Cap material will be stockpiled and developed into a slurry at an on-shore staging area. River water will be withdrawn using a floating water supply pump and mixed with the sand to form the slurry. The slurry is then hydraulically pumped from the staging area to the mobile spreader barge operating in the capping area and systematically discharged using a diffuser plate. The diffuser plate will be positioned at or near the surface of the river water. A reduction in slurry velocity occurs as the slurry is distributed onto the diffuser plate minimizing the potential for erosion of in-place material. The spreader barge will have a draft of approximately 1.5 to 3 feet. Movement of the barge will be controlled using winches and anchor wires that will follow an “arc” pattern across the capping area (Figure 5-6). The anchor wires will be attached to submerged anchors.

For each of the OUs, the ISC will consist of 18 inches of sand cap overlain by 6 inches of armor. The cross section of the ISC in each OU is depicted on Figures 5-1 through 5-3. Each cap layer (lift) will be applied in 1.5-inch lifts, half of which is immediately covered with a second 1.5-inch lift creating a 3-inch lift as shown on Figure 5-6. This method is specified to minimize disturbance of the contaminated sediment, specifically, mixing, lateral redistribution, mud waves, and shear failure. Additional sand layers will be applied in similar 3-inch lifts, although pilot testing may show that thicker lifts may be acceptable. The 6-inch armor layer will be placed using the same method as the cap.

The barge will be anchored using a submerged anchoring system and moved using the drum winch and anchor wires discussed. Accurate cap placement is dependant on barge speed and slurry (sand) flow rate. Therefore, the barge operator and slurry operator will be in constant communication and maintain detailed records to show that the cap has been installed properly. To assist in placement verification, the spreader barge movement will be constantly monitored and regulated to control the rate of application of capping material. The barge location will be tracked with a GPS and will be coordinated with the pre-construction survey reference points established for the River. These data will be plotted and reviewed to ensure that planned coverage of the ISC has been achieved.

C5.2 Required Equipment

The primary method used to apply the cap has been discussed above. The major pieces of equipment that would be required to perform this work is listed herein:

- Spreader barge fitted with a multiple drum winch and a diffuser plate (draft of 1.5 to 3 feet)
- A 36- to 48-inch belt conveyor with scale and soil screen
- 500-horsepower (hp) water supply pump to feed slurry tank
- 16-inch HDPE water supply line (1,500 feet)
- Two 1,000-hp centrifugal slurry pumps
- 16-inch HDPE slurry supply line (1,500 feet)
- 16-inch HDPE slurry line (with floats) positioned and connected to the spreader barge (1,000 feet)
- Two front-end loaders (3- to 4-cubic yard capacity)
- Steel blending tank (20,000-gallon capacity)
- Trimble 4000Rsi GPS Receiver and Racal Landstar Differential Receiver
- Two support boats
- Two job trailers at the staging area

C5.3 Construction Monitoring

Operation and maintenance monitoring will be required to ensure adequate and accurate cap placement, maintenance of cap integrity, compliance with water quality standards, and isolation and containment of contaminants. Both physical and chemical monitoring will be conducted during ISC placement. Construction monitoring will include collection of bathymetric survey data at 50-foot intervals along the ISC placement area and surface water sample collection (one sample upstream and three samples downstream) for total suspended solids analysis.

C5.4 Long-Term Monitoring

Upon completion of cap placement, long-term monitoring will be conducted after 5, 10, 20, 30, and 40 years to verify maintenance of cap integrity for physical and chemical isolation of contaminated sediments. Long-term monitoring will include bathymetric or side-scan sonar profiling, sediment and cap sampling, and capture and analysis of porewater that may migrate through the cap, as well as diver inspections to ensure that the cap is intact and containing contaminants.

C5.5 Project Schedule

Several of the main assumptions made for ISC placement include:

- On-River work can occur during 8 months of the year.
- Time for mobilization and demobilization, wintering over, and startups will occur during the 4 months when River work cannot be performed.
- Average slurry rates are 3,000 cy per day.
- Work will be performed 22 days per month.

Based on these assumptions, it would require 2 years to install the cap in OU 1 if the entire acceptable area were remediated in this manner. Similarly, one construction season would be needed to complete the cap installation at OU 3 and five construction seasons would be needed to complete OU 4.

C5.6 Design Basis

The procedures and data described in Sections 2 through 4 above provided the basis for estimating cap area, volumes, and construction time. Isolation cap thickness is based upon the modeling of advective and diffusive flux of PCBs through the isolation cap; final thickness was based upon ensuring that PCBs never exceeded 250 ppb in the top 10 cm of the isolation cap after a 1,000-year model run. Armoring was based upon an evaluation of the incipient motion of specific grain sizes in the cap mix based upon the design flow maximum velocity. For both the isolation cap and armor thickness, appropriate safety factors were included, as well as constructability of the final cap layers. Volumes were determined based upon cap thickness and the overall contaminated area to be capped. An increase of approximately 11 percent in foundation area was included to allow for side slope stability at the cap edges. Given area and height, volume of sand required for both isolation and armor layers was readily calculated. Duration of cap construction was estimated from the physical design basis, and time estimates for spreading based upon application rates, available timeframes, and upon man-hours derived from similar construction sites conducted elsewhere.

Parameter	Value OU 1	 OU 3	 OU 4	Basis or Assumption
Isolation cap thickness, inches	18	18	18	From flux modeling this DEA
Armor thickness, inches	6	6	6	From armor modeling this DEA
Contaminated area	221	79	262	From RI/FS
Cap foundation area	246	88	290	From FS and this DEA
Area for cap volume estimates	234	84	276	Calculated base on above parameters
Volume of cap material, cy	566,280	203,280	667,920	Calculated base on above parameters
Volume of armor material, cy	188,760	67,760	222,640	Calculated base on above parameters
Duration of cap construction, months	8.6	3.1	10.1	Calculated in this DEA
Duration of armor construction, months	4.3	1.5	5.1	Calculated in this DEA

C5.7 Follow-Up Information and Needs

The design concepts for ISC have been developed based on the available information. To further refine the capping design calculations, the following information is required:

Tasks and Needs	Means for Completing
Capping Site Selection	WDNR input required to determine the basis for selection of capping areas considering that only less than 25 percent of the total sediment volume within any OU can be capped.
Geotechnical Testing	This work could be completed during “pre-design” sampling efforts. A number of samples should be collected and tested, representing the full range of grain size distributions that are likely to be encountered during this project. The results will then be used to make a final determination on the cap material and thickness.
Water Depth and Bathymetry	This work could be completed during “pre-design” sampling efforts. Bathymetric surveys would be completed according to USACE construction design specifications.

C5.8 Permits and Approvals

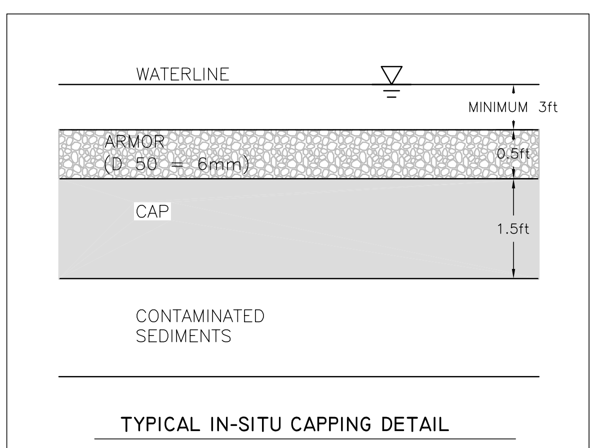
Institutional and regulatory requirements are discussed in detail in Section 5 of White Paper No. 6B, which is provided as Attachment C1 to this appendix.

Federal permits would include Section 10 of the Rivers and Harbors Act of 1899 (22 CFR 403) and Section 404(b)(1) of the Clean Water Act would be required for any construction that would impact the course, capacity, or condition of navigable waters of the United States. Wisconsin Statutes Chapter 30 prohibits the deposition of materials except into structures that are permitted or authorized under statute or other legislative means (WDNR, 1998). It also requires the issuance of permits for the construction of any structure on the bed of navigable water of the state. In order to permit under Chapter 30, a determination of whether the riverbed represents state interest as a lakebed, riparian bed, or lies within a specifically authorized bulkhead line. White Paper No. 6B also describes a range of other possible state regulations that may affect the planning, design, construction, or maintenance of an ISC remedy. These would be equivalent to the "To Be Considered" (TBC) requirements under CERCLA.

Wisconsin's Floodplain Management Program (Chapter 116, WAC) details the regulations for construction and development in floodways and floodplains. Any proposed cap would have to meet the substantive requirements of Section 116.16(1), which requires that structures built within floodways and floodplains must be built to withstand flood depths, pressures, velocities, impact, uplift forces, and other factors associated with the regional (100-year) flood. In addition, any cap proposed would be required to undertake a determination on the potential effects on the regional flood heights. This would require a substantive study on the hydrologic and hydraulic conditions pre- and post-construction to determine if there would be an increase in flood height due to cap placement. 116.03(28) WAC defines an "increase in regional flood height" as being equal to or greater than 0.01 foot if a cap would result in an increase in regional flood.

In addition to the affects of specific state and federal laws and regulations, a series of institutional considerations will also be needed for an ISC project. These are likely to include restrictions on the bed where the project is constructed (analogous to traditional "deed restrictions" for a land-based project), as well as possible "water use" restrictions that would affect the resource overlying the bed. Whether a cap is constructed over a leased bed from a riparian owner, or as part of a lakebed grant by the legislature, it will be necessary to set permanent restrictions on future development.

Finally, fiduciary responsibilities for an ISC would need to be established. Fiduciary limits would be equivalent to those associated with any upland landfill or soil cap; the Responsible Party, or other designated entity, retains the long-term liability for the cap. An additional fiduciary responsibility that will need to be considered for an ISC at the Lower Fox River includes the long-term maintenance of dams on the River, and/or the potential for management of remnant deposits in the event of dam failure or removal.



NOTES:

1. BED ELEVATION IS THE SAME AS MUD LINE ELEVATION WHICH IS THE ELEVATION AT THE INTERFACE OF SURFACE WATER AND NATIVE SEDIMENTS.
2. CONTAMINANT ELEVATION REFERS TO THE BOTTOM OF 1,000 PPB ELEVATION IN THE SEDIMENT LAYER.

LEGEND

- RIVER ELEVATION
- SUBAQUEOUS CAP WITH ARMOR
- BED ELEVATION
- CONTAMINANT ELEVATION (1PPM)
- BOTTOM OF SOFT SEDIMENTS

DRAFT

RETEC

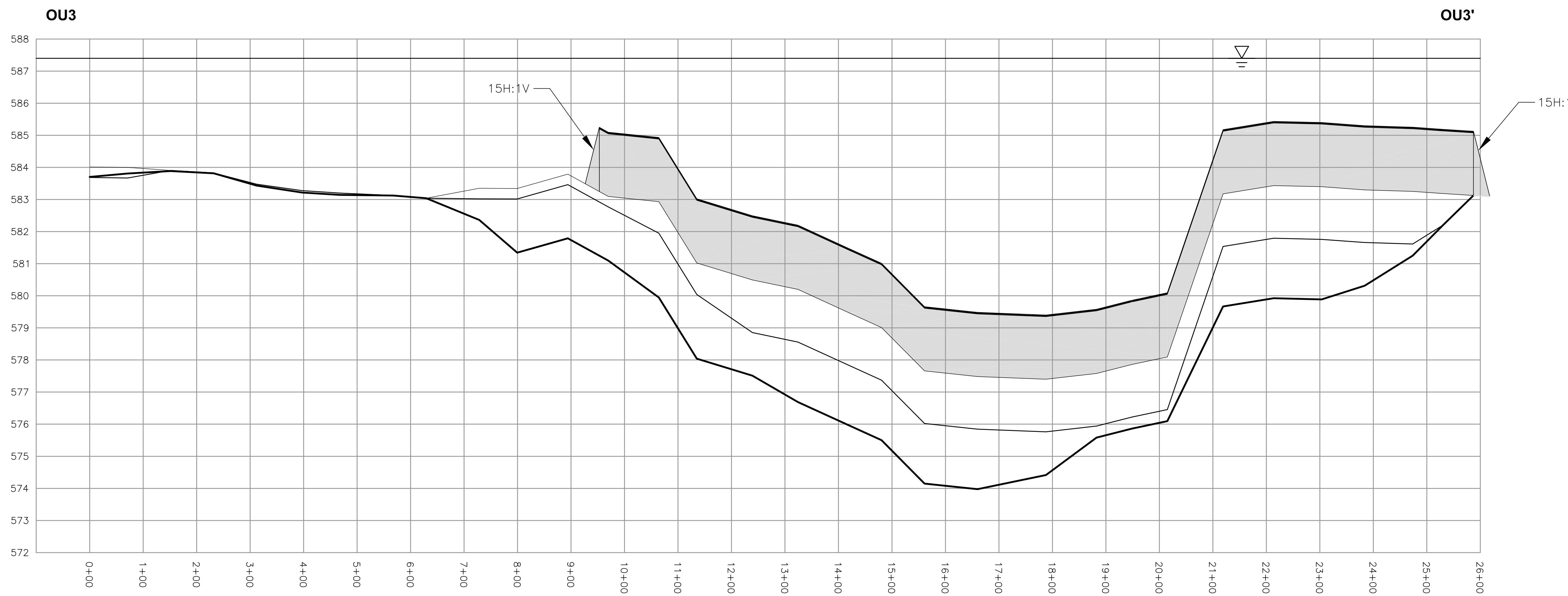
NO	DRWN	DATE	REVISION	CHKD	DATE	APPVD	DATE
5							
4							
3							
2							
1							
0	A.S.	4/22/03	DRAFT	C.H.	4/22/03	C.H.	4/22/03

WDNR - FOX RIVER
DETAILED EVALUATION OF ALTERNATIVES
WISC1-15933-121

CURRENT DATE 04/22/03

CAPPING SECTIONS
OPERABLE UNIT 1

SHEET 27 FIGURE 5-1 REVISION

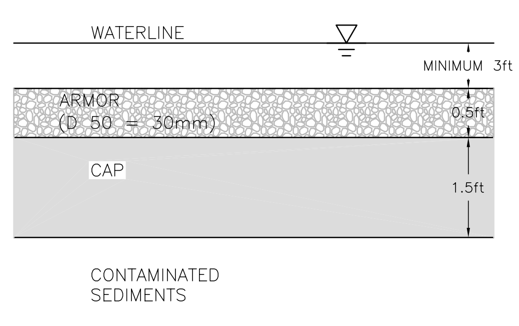


WATER ELEVATION – 587.4'

SECTION LOOKING NORTH (OU3 / 25)

VERTICAL SCALE IN FEET (30 0 60)

HORIZONTAL SCALE IN FEET (60 0 120)



TYPICAL IN-SITU CAPPING DETAIL

NOTES:

1. BED ELEVATION IS THE SAME AS MUD LINE ELEVATION WHICH IS THE ELEVATION AT THE INTERFACE OF SURFACE WATER AND NATIVE SEDIMENTS.
2. CONTAMINANT ELEVATION REFERS TO THE BOTTOM OF 1,000 PPB ELEVATION IN THE SEDIMENT LAYER.

LEGEND

- RIVER ELEVATION
- SUBAQUEOUS CAP WITH ARMOR
- BED ELEVATION
- CONTAMINANT ELEVATION (1PPB)
- BOTTOM OF SOFT SEDIMENTS

DRAFT

RETEC

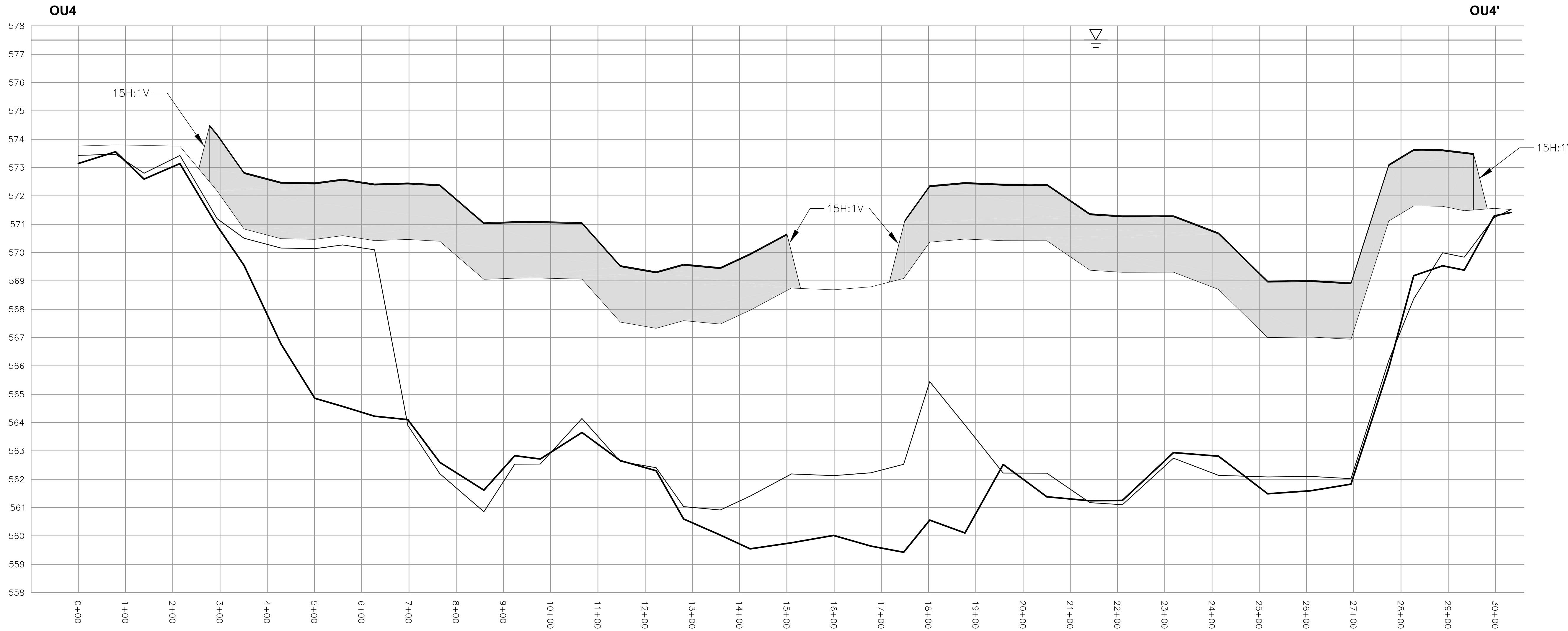
NO	DRWN	DATE	REVISION	CHKD	DATE	APPVD	DATE
5							
4							
3							
2							
1							
0	A.S.	4/22/03	DRAFT	C.H.	4/22/03	C.H.	4/22/03

WDNR - FOX RIVER
DETAILED EVALUATION OF ALTERNATIVES
WISC1-15933-121

CURRENT DATE 04/22/03

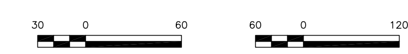
CAPPING SECTIONS
OPERABLE UNIT 3

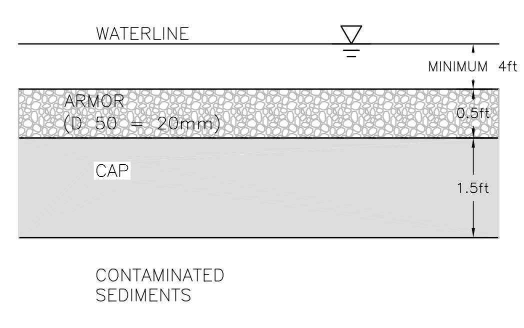
SHEET 28 FIGURE 5-2 REVISION



WATER ELEVATION – 577.5'

SECTION LOOKING NORTH (OU4 / 26)





TYPICAL IN-SITU CAPPING DETAIL

NOTES:

1. BED ELEVATION IS THE SAME AS MUD LINE ELEVATION WHICH IS THE ELEVATION AT THE INTERFACE OF SURFACE WATER AND NATIVE SEDIMENTS.
2. CONTAMINANT ELEVATION REFERS TO THE BOTTOM OF 1,000 PPB ELEVATION IN THE SEDIMENT LAYER.

LEGEND

- RIVER ELEVATION
- SUBAQUEOUS CAP WITH ARMOR
- BED ELEVATION
- CONTAMINANT ELEVATION (1PPB)
- BOTTOM OF SOFT SEDIMENTS

DRAFT

RETEC

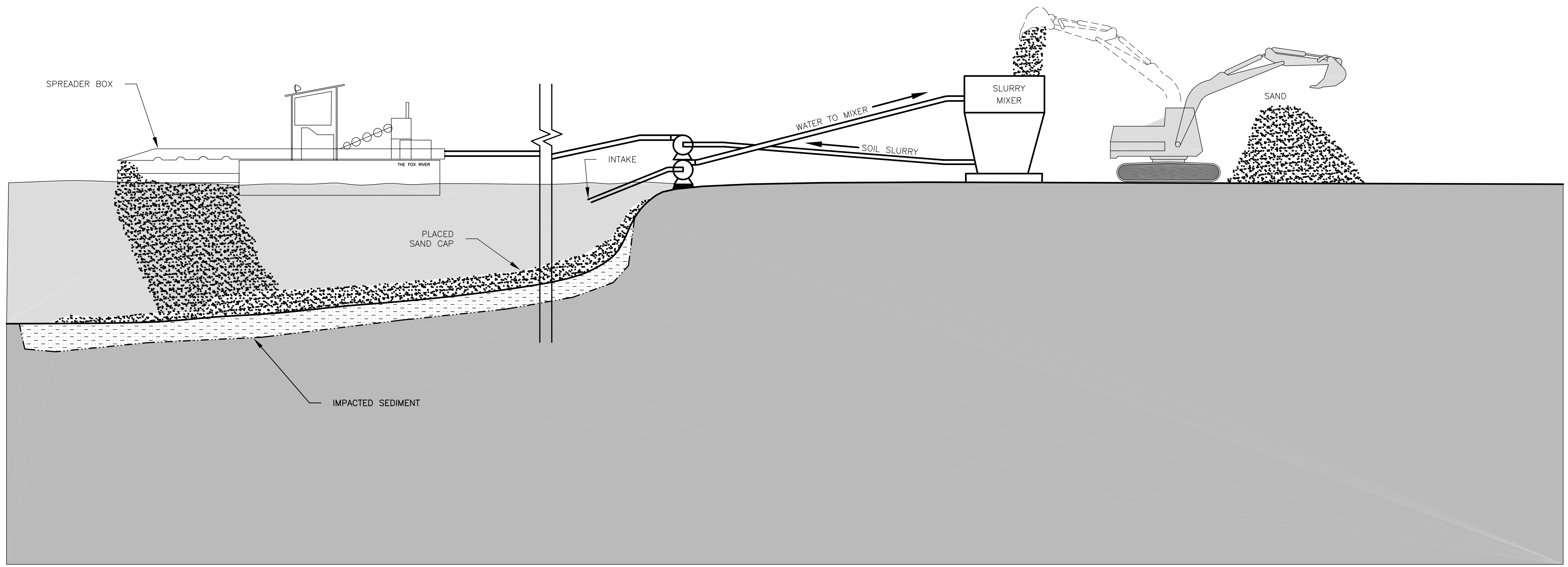
NO	DRWN	DATE	REVISION	CHKD	DATE	APPVD	DATE
5							
4							
3							
2							
1							
0	A.S.	4/22/03	DRAFT	C.H.	4/22/03	C.H.	4/22/03

WDNR - FOX RIVER
DETAILED EVALUATION OF ALTERNATIVES
WISC1-15933-121

CURRENT DATE 04/22/03

CAPPING SECTIONS
OPERABLE UNIT 4

SHEET 29 FIGURE 5-3 REVISION



DRAFT

RETEC

NO	DRWN	DATE	REVISION	CHKD	DATE	APPVD	DATE
5							
4							
3							
2							
1							
0	A.S.	4/22/03	DRAFT	C.H.	4/22/03	C.H.	4/22/03

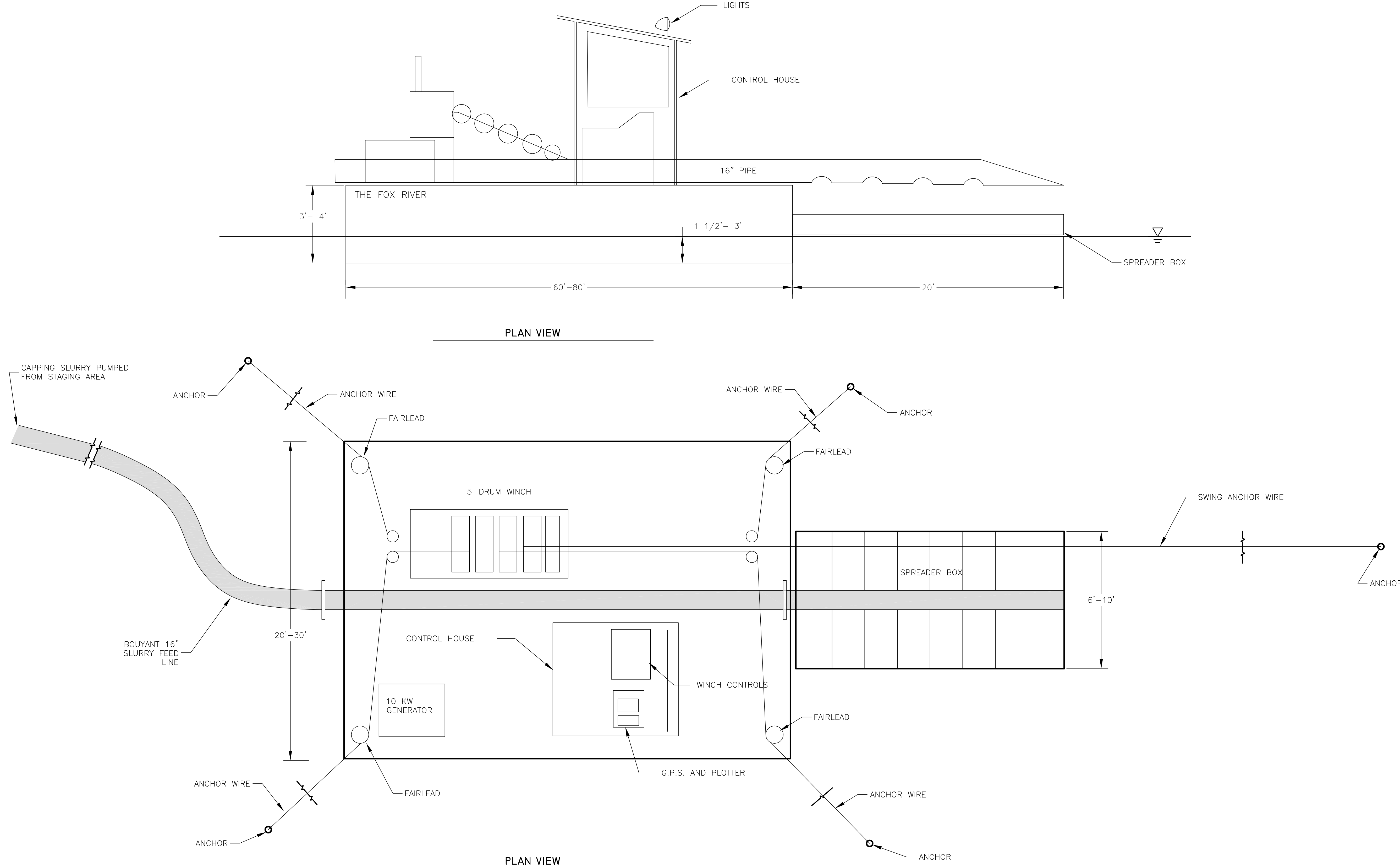
WDNR - FOX RIVER
DETAILED EVALUATION OF ALTERNATIVES
WISC1-15933-121

CURRENT DATE 04/22/03

PROCESS SCHEMATIC
CAP PLACEMENT

SHEET 30 FIGURE 5-4 REVISION

File: H:\15933\15933003.dwg Layout: ANSI_B1-CP User: ostenberg Plotted: Jun 27, 2003 - 11:24am Xref's:



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5							
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3							
2							
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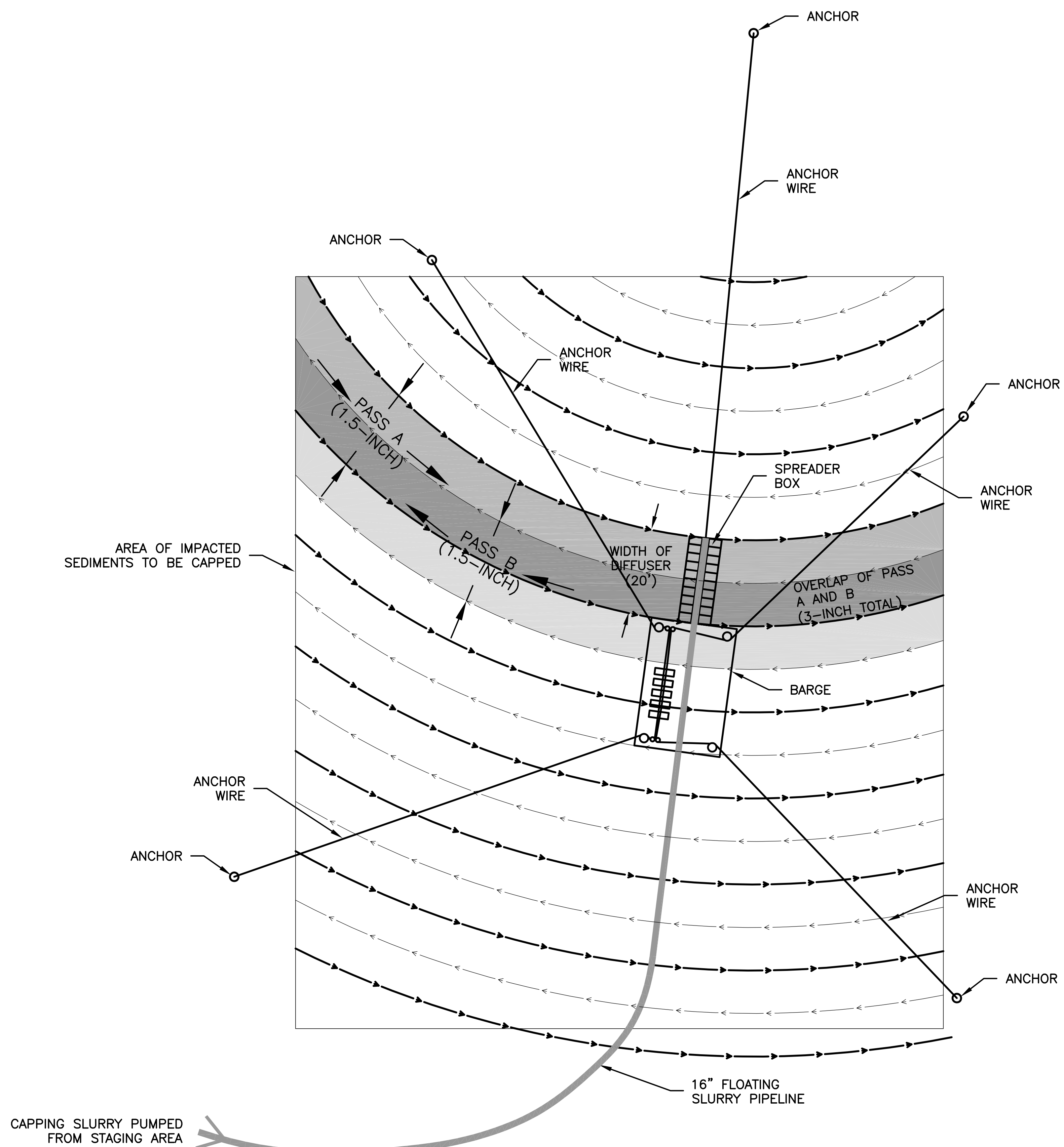
0	A.S.	4/22/03	DRAFT	C.H.	4/22/03	C.H.	4/22/03

WDNR - FOX RIVER
DETAILED EVALUATION OF ALTERNATIVES
WISC1-15933-121

CURRENT DATE 04/22/03

TYPICAL DETAIL
SPREADER BARGE WITH SPREADER BOX

SHEET 32 FIGURE 5-5 REVISION



DRAWING NOT TO SCALE

DRAFT

RETEC

NO	DRWN	DATE	REVISION	CHKD	DATE	APPVD	DATE
5							
4							
3							
2							
1							
0	A.S.	4/22/03	DRAFT	C.H.	4/22/03	C.H.	4/22/03

WDNR - FOX RIVER
DETAILED EVALUATION OF ALTERNATIVES
WISC1-15933-121

CURRENT DATE 4/22/03

PLAN VIEW - SPREADER BARGE APPLICATION TECHNIQUE

SHEET 31 | FIGURE 5-6 | REVISION

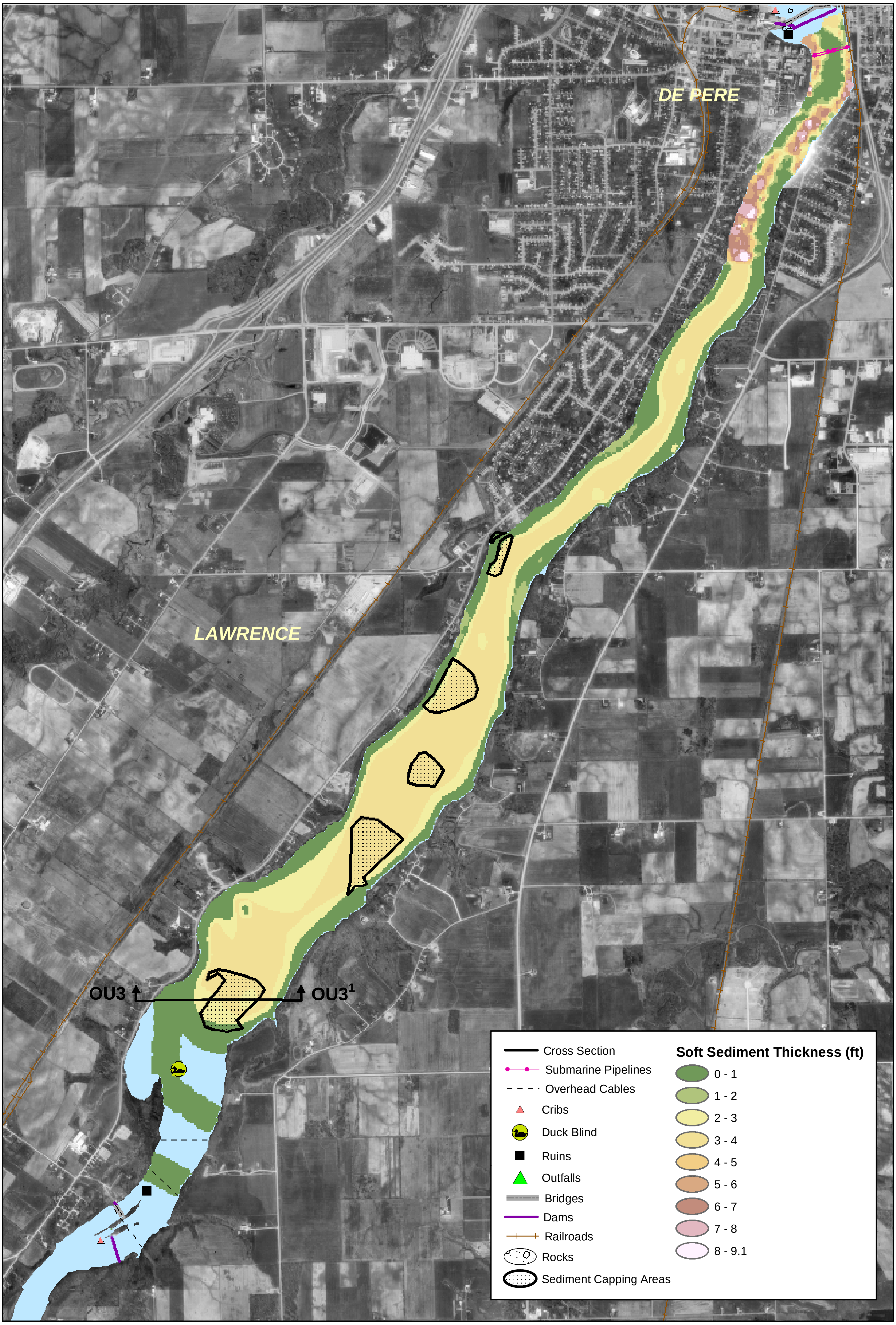
0 2000 4000

1" = 2000 Feet

RETEC

OPERABLE UNIT 1 Lower Fox River, Wisconsin (WISCN-15933-121)	**SEDIMENT CAPPING AREAS AND CROSS SECTION LOCATION: LITTLE LAKE BUTTE DES MORTS**

DATE: 04/10/03		FILE: OU1 XSection.mxd	FIGURE: 5-1

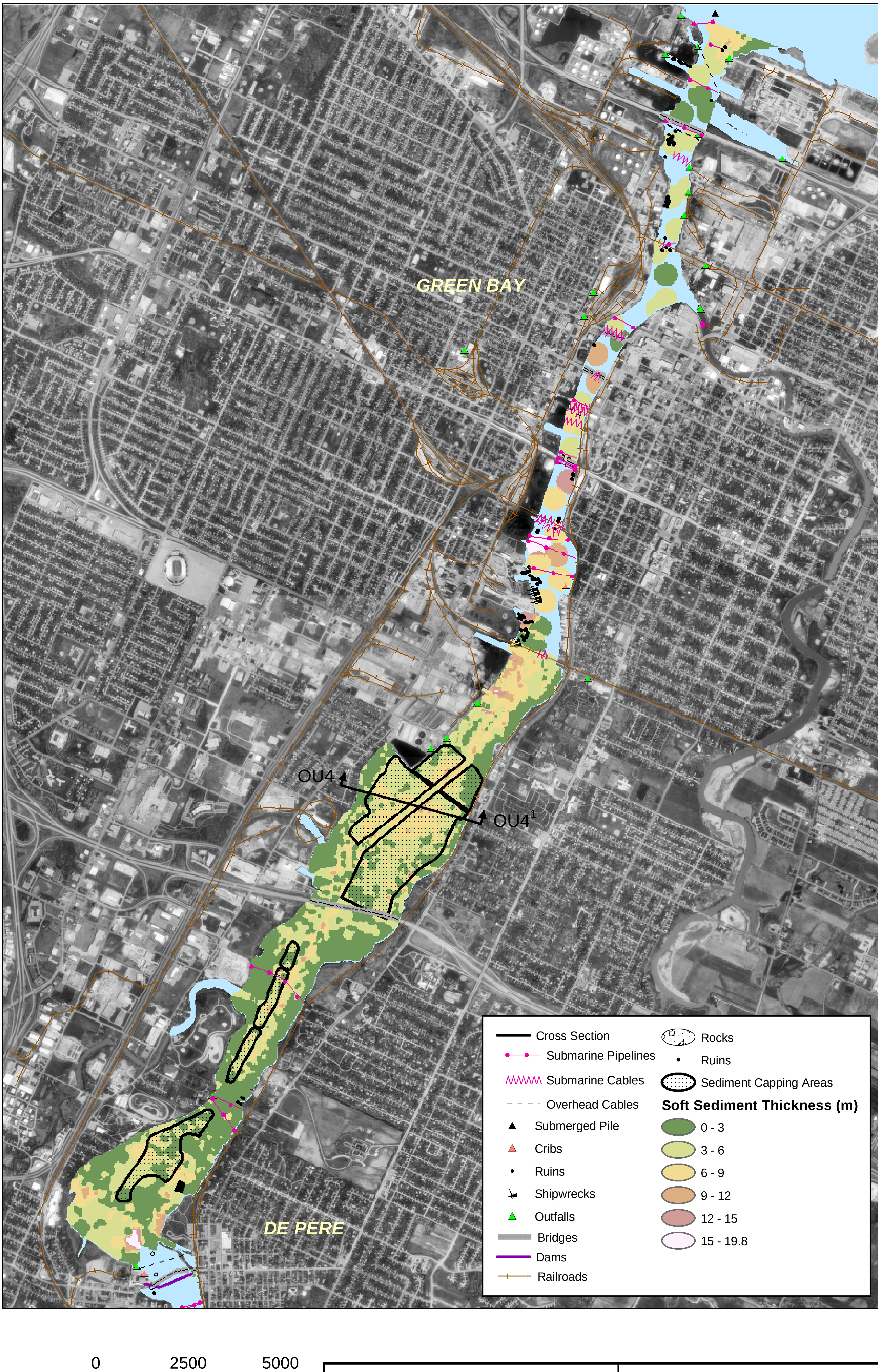


RETEC

OPERABLE UNIT 3
Lower Fox River, Wisconsin (WISCN-15933-121)

SEDIMENT CAPPING AREAS AND CROSS SECTION LOCATION: LITTLE RAPIDS TO DE PERE

DATE: 04/28/03 | FILE: OU3 XSection.mxd | FIGURE: 5-2



RETEC

OPERABLE UNIT 4 Lower Fox River, Wisconsin (WISCN-15933-121)	SEDIMENT CAPPING AREAS AND CROSS SECTION LOCATION: DE PERE TO GREEN BAY
DATE: 04/11/03 FILE: OU4 XSection.mxd	FIGURE: 5-3

C6 Detailed Cost Estimates

COST ESTIMATE #19 — **Rev: 5.13.03**
DETAILED EVALUATION OF ALTERNATIVES — **draft - in progress**
WDNR - FOX RIVER

PROJECT ELEMENT:
Capping
Scenario A - OU 1, OU 3 and OU 4

PROCESS METRICS

	OU1	OU3	OU4
Cap thickness, inches	18	18	18
Armor thickness, inches	6	6	6
Contaminated area	221	79	262
Cap foundation area	246	88	290
Area for cap volume estimates	234	84	276
Volume of cap material, cy	566,280	203,280	667,920
Volume of armor material, cy	188,760	67,760	222,640
Duration of cap construction, months	8.6	3.1	10.1
Duration of armor construction, months	4.3	1.5	5.1

COST SUMMARY

OU 1	Total Cost (1)	Total as Present Worth (2)
Subtotal, capital costs	$17,300,000	$17,300,000
Total, capital plus long-term costs	$17,800,000	$17,400,000
Cost per acre of capping (3)	$81,000	$79,000
OU 3		
Subtotal, capital costs	$6,500,000	$6,500,000
Total, capital plus long-term costs	$6,800,000	$6,600,000
Cost per acre of capping (3)	$86,000	$84,000
OU 4		
Subtotal, capital costs	$20,200,000	$20,200,000
Total, capital plus long-term costs	$20,700,000	$20,400,000
Cost per acre of capping (3)	$79,000	$78,000

Notes

1. The "total cost" does not discount the long-term monitoring costs.
2. The "present worth" discounts long-term monitoring costs costs. The discount rate is 7% (USEPA, "Guide to Developing and Documenting Cost Estimates During the Feasibility Study", July 2000).
3. "Cost per acre cap" values are for informational purposes only. Values are not true unit costs because they represent a combination of fixed capital and quantity-proportional components.

CAPITAL COSTS - OU1

	Item	Units	Quantity	Unit Cost	Extension
Direct Capital					
Purchased Items					
D.2	Sand	ton	792,792	$8.40	$6,659,453
D.3	Armor	ton	264,264	$8.40	$2,219,818
	Subtotal, purchased items				$8,879,270
Civil Work					
C.1	Mobilization	ls	1	$250,000	$250,000
C.2	Move and startup	season	1	$150,000	$150,000
C.3	Slurry unit	day	189	$5,400	$1,020,600
C.4	Additional slurry unit cost for armor	day	94	$8,300	$780,200
C.5	Spreader unit	day	283	$4,500	$1,273,500
C.6	Field supervision	day	283	$2,800	$792,400
C.7	Winterization	season	1	$100,000	$100,000
C.8	Demobilization	ls	1	$150,000	$150,000
C.9	Routine maintenance	season	2	$25,000	$50,000
C.10	Bathymetric survey	ea	3	$5,200	$15,600
C.11	Surface water monitoring	day	283	$750	$212,250
C.12	Construction monitoring report	season	2	$50,000	$100,000
C.13	Staging arrea	season	2	$20,000	$40,000
C.14	Electricity	season	2	$6,000	$12,000
C.15	Telephone	season	2	$2,400	$4,800
	Subtotal, purchased equipment and trades				$13,830,620
	Prime contractor administration, overhead & profit (% of above)		25%		$3,457,655
	TOTAL DIRECT CAPITAL				$17,288,276

Notes

1 Unit cost backup provided on subsequent sheets

CAPITAL COSTS - OU3

Item		Units	Quantity	Unit Cost	Extension
Direct Capital					
Purchased Items					
D.2	Sand	ton	284,592	$8.40	$2,390,573
D.3	Armor	ton	94,864	$8.40	$796,858
	Subtotal, purchased items				$3,187,430
Civil Work					
C.1	Mobilization	ls	1	$250,000	$250,000
C.2	Move and startup	season	0	$150,000	$0
C.3	Slurry unit	day	68	$5,400	$367,200
C.4	Additional slurry unit cost for armor	day	34	$8,300	$282,200
C.5	Spreader unit	day	102	$4,500	$459,000
C.6	Field supervision	day	102	$2,800	$285,600
C.7	Winterization	season	0	$100,000	$0
C.8	Demobilization	ls	1	$150,000	$150,000
C.9	Routine maintenance	season	1	$25,000	$25,000
C.10	Bathymetric survey	ea	3	$1,800	$5,400
C.11	Surface water monitoring	day	102	$750	$76,500
C.12	Construction monitoring report	season	1	$50,000	$50,000
C.13	Staging arrea	season	1	$20,000	$20,000
C.14	Electricity	season	1	$6,000	$6,000
C.15	Telephone	season	1	$2,400	$2,400
	Subtotal, purchased equipment and trades				$5,166,730
	Prime contractor administration, overhead & profit (% of above)		25%		$1,291,683
	TOTAL DIRECT CAPITAL				$6,458,413

Notes

1 Unit cost backup provided on subsequent sheets

CAPITAL COSTS - OU4

Item		Units	Quantity	Unit Cost	Extension
Direct Capital					
Purchased Items					
D.2	Sand	ton	935,088	$8.40	$7,854,739
D.3	Armor	ton	311,696	$8.40	$2,618,246
	Subtotal, purchased items				$10,472,986
Civil Work					
C.1	Mobilization	ls	1	$250,000	$250,000
C.2	Move and startup	season	1	$150,000	$150,000
C.3	Slurry unit	day	223	$5,400	$1,204,200
C.4	Additional slurry unit cost for armor	day	111	$8,300	$921,300
C.5	Spreader unit	day	334	$4,500	$1,503,000
C.6	Field supervision	day	334	$2,800	$935,200
C.7	Winterization	season	1	$100,000	$100,000
C.8	Demobilization	ls	1	$150,000	$150,000
C.9	Routine maintenance	season	2	$25,000	$50,000
C.10	Bathymetric survey	ea	3	$6,100	$18,300
C.11	Surface water monitoring	day	334	$750	$250,500
C.12	Construction monitoring report	season	2	$50,000	$100,000
C.13	Staging arrea	season	2	$20,000	$40,000
C.14	Electricity	season	2	$6,000	$12,000
C.15	Telephone	season	2	$2,400	$4,800
	Subtotal, purchased equipment and trades				$16,162,286
	Prime contractor administration, overhead & profit (% of above)		25%		$4,040,571
	TOTAL DIRECT CAPITAL				$20,202,857

Notes

1 Unit cost backup provided on subsequent sheets

LONG TERM OPERATING COSTS - OU1

	Item	Units	Quantity	Unit Cost	Extension
	Long Term Monitoring				
O.1	Bathymetric survey	ls	1	$5,200	$5,200
O.2	Core sampling	ea	12	$3,000	$36,000
O.3	Construction monitoring report	ls	1	$50,000	$50,000
		Subtotal			$91,200
		Prime contractor OH & P		10%	$9,120
		Total, long term costs			$100,320

LONG TERM OPERATING COSTS - OU3

	Item	Units	Quantity	Unit Cost	Extension
	Long Term Monitoring				
O.1	Bathymetric survey	ls	1	$1,800	$1,800
O.2	Core sampling	ea	5	$3,000	$15,000
O.3	Construction monitoring report	ls	1	$50,000	$50,000
		Subtotal			$66,800
		Prime contractor OH & P		10%	$6,680
		Total, long term costs			$73,480

LONG TERM OPERATING COSTS - OU4

	Item	Units	Quantity	Unit Cost	Extension
	Long Term Monitoring				
O.1	Bathymetric survey	ls	1	$6,100	$6,100
O.2	Core sampling	ea	14	$3,000	$42,000
O.3	Construction monitoring report	ls	1	$50,000	$50,000
		Subtotal			$98,100
		Prime contractor OH & P		10%	$9,810
		Total, long term costs			$107,910

PRESENT WORTH CALCULATION - OU1

i = 7%

Year, n	Capital Costs (construction)	Annual Long-Term Care Costs (post closure)	Sum of Year "n" Costs	Cumulative Costs, Year 1 through n	Present Worth Factor, i	Present Worth of Year "n" Capital Costs Only	Present Worth of All Year "n" Costs	Cumulative Present Worth of All Costs, Year 1 through n
0	$17,288,276		$17,288,276	$17,288,276	1	$17,288,276	$17,288,276	$17,288,276
1			$0	$17,288,276	0.9346	$0	$0	$17,288,276
2			$0	$17,288,276	0.8734	$0	$0	$17,288,276
3			$0	$17,288,276	0.8163		$0	$17,288,276
4			$0	$17,288,276	0.7629		$0	$17,288,276
5			$0	$17,288,276	0.7130		$0	$17,288,276
6			$0	$17,288,276	0.6663		$0	$17,288,276
7		$100,320	$100,320	$17,388,596	0.6227		$62,474	$17,350,750
8			$0	$17,388,596	0.5820		$0	$17,350,750
9			$0	$17,388,596	0.5439		$0	$17,350,750
10			$0	$17,388,596	0.5083		$0	$17,350,750
11			$0	$17,388,596	0.4751		$0	$17,350,750
12		$100,320	$100,320	$17,488,916	0.4440		$44,543	$17,395,293
13			$0	$17,488,916	0.4150		$0	$17,395,293
14			$0	$17,488,916	0.3878		$0	$17,395,293
15			$0	$17,488,916	0.3624		$0	$17,395,293
16			$0	$17,488,916	0.3387		$0	$17,395,293
17			$0	$17,488,916	0.3166		$0	$17,395,293
18			$0	$17,488,916	0.2959		$0	$17,395,293
19			$0	$17,488,916	0.2765		$0	$17,395,293
20			$0	$17,488,916	0.2584		$0	$17,395,293
21			$0	$17,488,916	0.2415		$0	$17,395,293
22		$100,320	$100,320	$17,589,236	0.2257		$22,644	$17,417,937
23			$0	$17,589,236	0.2109		$0	$17,417,937
24			$0	$17,589,236	0.1971		$0	$17,417,937
25			$0	$17,589,236	0.1842		$0	$17,417,937
26			$0	$17,589,236	0.1722		$0	$17,417,937
27			$0	$17,589,236	0.1609		$0	$17,417,937
28			$0	$17,589,236	0.1504		$0	$17,417,937
29			$0	$17,589,236	0.1406		$0	$17,417,937
30			$0	$17,589,236	0.1314		$0	$17,417,937
31			$0	$17,589,236	0.1228		$0	$17,417,937
32		$100,320	$100,320	$17,689,556	0.1147		$11,511	$17,429,447
33			$0	$17,689,556	0.1072		$0	$17,429,447
34			$0	$17,689,556	0.1002		$0	$17,429,447
35			$0	$17,689,556	0.0937		$0	$17,429,447
36			$0	$17,689,556	0.0875		$0	$17,429,447
37			$0	$17,689,556	0.0818		$0	$17,429,447
38			$0	$17,689,556	0.0765		$0	$17,429,447
39			$0	$17,689,556	0.0715		$0	$17,429,447
40			$0	$17,689,556	0.0668		$0	$17,429,447
41			$0	$17,689,556	0.0624		$0	$17,429,447
42		$100,320	$100,320	$17,789,876	0.0583		$5,852	$17,435,299
43			$0	$17,789,876	0.0545		$0	$17,435,299
44			$0	$17,789,876	0.0509		$0	$17,435,299
45			$0	$17,789,876	0.0476		$0	$17,435,299
46			$0	$17,789,876	0.0445		$0	$17,435,299
47			$0	$17,789,876	0.0416		$0	$17,435,299
48			$0	$17,789,876	0.0389		$0	$17,435,299
49			$0	$17,789,876	0.0363		$0	$17,435,299
50			$0	$17,789,876	0.0339		$0	$17,435,299
51			$0	$17,789,876	0.0317		$0	$17,435,299
52			$0	$17,789,876	0.0297		$0	$17,435,299
53			$0	$17,789,876	0.0277		$0	$17,435,299
54								
55								
56								
57								
58								
59								
60								
Totals	$17,288,276	$501,600	$17,789,876			$17,288,276	$17,435,299	

PRESENT WORTH CALCULATION - OU3

i = 7%

Year, n	Capital Costs (construction)	Annual Long-Term Care Costs (post closure)	Sum of Year "n" Costs	Cumulative Costs, Year 1 through n	Present Worth Factor, i	Present Worth of Year "n" Capital Costs Only	Present Worth of All Year "n" Costs	Cumulative Present Worth of All Costs, Year 1 through n
0	$6,458,413		$6,458,413	$6,458,413	1	$6,458,413	$6,458,413	$6,458,413
1			$0	$6,458,413	0.9346	$0	$0	$6,458,413
2			$0	$6,458,413	0.8734	$0	$0	$6,458,413
3			$0	$6,458,413	0.8163		$0	$6,458,413
4			$0	$6,458,413	0.7629		$0	$6,458,413
5			$0	$6,458,413	0.7130		$0	$6,458,413
6		$73,480	$73,480	$6,531,893	0.6663		$48,963	$6,507,376
7			$0	$6,531,893	0.6227		$0	$6,507,376
8			$0	$6,531,893	0.5820		$0	$6,507,376
9			$0	$6,531,893	0.5439		$0	$6,507,376
10			$0	$6,531,893	0.5083		$0	$6,507,376
11		$73,480	$73,480	$6,605,373	0.4751		$34,910	$6,542,286
12			$0	$6,605,373	0.4440		$0	$6,542,286
13			$0	$6,605,373	0.4150		$0	$6,542,286
14			$0	$6,605,373	0.3878		$0	$6,542,286
15			$0	$6,605,373	0.3624		$0	$6,542,286
16			$0	$6,605,373	0.3387		$0	$6,542,286
17			$0	$6,605,373	0.3166		$0	$6,542,286
18			$0	$6,605,373	0.2959		$0	$6,542,286
19			$0	$6,605,373	0.2765		$0	$6,542,286
20			$0	$6,605,373	0.2584		$0	$6,542,286
21		$73,480	$73,480	$6,678,853	0.2415		$17,746	$6,560,032
22			$0	$6,678,853	0.2257		$0	$6,560,032
23			$0	$6,678,853	0.2109		$0	$6,560,032
24			$0	$6,678,853	0.1971		$0	$6,560,032
25			$0	$6,678,853	0.1842		$0	$6,560,032
26			$0	$6,678,853	0.1722		$0	$6,560,032
27			$0	$6,678,853	0.1609		$0	$6,560,032
28			$0	$6,678,853	0.1504		$0	$6,560,032
29			$0	$6,678,853	0.1406		$0	$6,560,032
30			$0	$6,678,853	0.1314		$0	$6,560,032
31		$73,480	$73,480	$6,752,333	0.1228		$9,021	$6,569,053
32			$0	$6,752,333	0.1147		$0	$6,569,053
33			$0	$6,752,333	0.1072		$0	$6,569,053
34			$0	$6,752,333	0.1002		$0	$6,569,053
35			$0	$6,752,333	0.0937		$0	$6,569,053
36			$0	$6,752,333	0.0875		$0	$6,569,053
37			$0	$6,752,333	0.0818		$0	$6,569,053
38			$0	$6,752,333	0.0765		$0	$6,569,053
39			$0	$6,752,333	0.0715		$0	$6,569,053
40			$0	$6,752,333	0.0668		$0	$6,569,053
41		$73,480	$73,480	$6,825,813	0.0624		$4,586	$6,573,639
42			$0	$6,825,813	0.0583		$0	$6,573,639
43			$0	$6,825,813	0.0545		$0	$6,573,639
44			$0	$6,825,813	0.0509		$0	$6,573,639
45			$0	$6,825,813	0.0476		$0	$6,573,639
46			$0	$6,825,813	0.0445		$0	$6,573,639
47			$0	$6,825,813	0.0416		$0	$6,573,639
48			$0	$6,825,813	0.0389		$0	$6,573,639
49			$0	$6,825,813	0.0363		$0	$6,573,639
50			$0	$6,825,813	0.0339		$0	$6,573,639
51			$0	$6,825,813	0.0317		$0	$6,573,639
52			$0	$6,825,813	0.0297		$0	$6,573,639
53			$0	$6,825,813	0.0277		$0	$6,573,639
54								
55								
56								
57								
58								
59								
60								
Totals	$6,458,413	$367,400	$6,825,813			$6,458,413	$6,573,639	

PRESENT WORTH CALCULATION - OU4

i = 7%

Year, n	Capital Costs (construction)	Annual Long-Term Care Costs (post closure)	Sum of Year "n" Costs	Cumulative Costs, Year 1 through n	Present Worth Factor, i	Present Worth of Year "n" Capital Costs Only	Present Worth of All Year "n" Costs	Cumulative Present Worth of All Costs, Year 1 through n
0	$20,202,857		$20,202,857	$20,202,857	1	$20,202,857	$20,202,857	$20,202,857
1			$0	$20,202,857	0.9346	$0	$0	$20,202,857
2			$0	$20,202,857	0.8734	$0	$0	$20,202,857
3			$0	$20,202,857	0.8163		$0	$20,202,857
4			$0	$20,202,857	0.7629		$0	$20,202,857
5			$0	$20,202,857	0.7130		$0	$20,202,857
6			$0	$20,202,857	0.6663		$0	$20,202,857
7		$107,910	$107,910	$20,310,767	0.6227		$67,201	$20,270,058
8			$0	$20,310,767	0.5820		$0	$20,270,058
9			$0	$20,310,767	0.5439		$0	$20,270,058
10			$0	$20,310,767	0.5083		$0	$20,270,058
11			$0	$20,310,767	0.4751		$0	$20,270,058
12		$107,910	$107,910	$20,418,677	0.4440		$47,913	$20,317,971
13			$0	$20,418,677	0.4150		$0	$20,317,971
14			$0	$20,418,677	0.3878		$0	$20,317,971
15			$0	$20,418,677	0.3624		$0	$20,317,971
16			$0	$20,418,677	0.3387		$0	$20,317,971
17			$0	$20,418,677	0.3166		$0	$20,317,971
18			$0	$20,418,677	0.2959		$0	$20,317,971
19			$0	$20,418,677	0.2765		$0	$20,317,971
20			$0	$20,418,677	0.2584		$0	$20,317,971
21			$0	$20,418,677	0.2415		$0	$20,317,971
22		$107,910	$107,910	$20,526,587	0.2257		$24,357	$20,342,328
23			$0	$20,526,587	0.2109		$0	$20,342,328
24			$0	$20,526,587	0.1971		$0	$20,342,328
25			$0	$20,526,587	0.1842		$0	$20,342,328
26			$0	$20,526,587	0.1722		$0	$20,342,328
27			$0	$20,526,587	0.1609		$0	$20,342,328
28			$0	$20,526,587	0.1504		$0	$20,342,328
29			$0	$20,526,587	0.1406		$0	$20,342,328
30			$0	$20,526,587	0.1314		$0	$20,342,328
31			$0	$20,526,587	0.1228		$0	$20,342,328
32		$107,910	$107,910	$20,634,497	0.1147		$12,382	$20,354,710
33			$0	$20,634,497	0.1072		$0	$20,354,710
34			$0	$20,634,497	0.1002		$0	$20,354,710
35			$0	$20,634,497	0.0937		$0	$20,354,710
36			$0	$20,634,497	0.0875		$0	$20,354,710
37			$0	$20,634,497	0.0818		$0	$20,354,710
38			$0	$20,634,497	0.0765		$0	$20,354,710
39			$0	$20,634,497	0.0715		$0	$20,354,710
40			$0	$20,634,497	0.0668		$0	$20,354,710
41			$0	$20,634,497	0.0624		$0	$20,354,710
42		$107,910	$107,910	$20,742,407	0.0583		$6,294	$20,361,004
43			$0	$20,742,407	0.0545		$0	$20,361,004
44			$0	$20,742,407	0.0509		$0	$20,361,004
45			$0	$20,742,407	0.0476		$0	$20,361,004
46			$0	$20,742,407	0.0445		$0	$20,361,004
47			$0	$20,742,407	0.0416		$0	$20,361,004
48			$0	$20,742,407	0.0389		$0	$20,361,004
49			$0	$20,742,407	0.0363		$0	$20,361,004
50			$0	$20,742,407	0.0339		$0	$20,361,004
51			$0	$20,742,407	0.0317		$0	$20,361,004
52			$0	$20,742,407	0.0297		$0	$20,361,004
53			$0	$20,742,407	0.0277		$0	$20,361,004
54								
55								
56								
57								
58								
59								
60								
Totals	$20,202,857	$539,550	$20,742,407			$20,202,857	$20,361,004	

BASIS OF UNIT COSTS

I.D.	Item	Source	Description	Value or Range Provided (rounded)	Value Used for Estimate (rounded)	Basis
D.1	Sand	In-house estimate based on typical availability and price of sand in Fox valley	Cost for purchasing sand for capping and transportation to Site	$8.40	$8.40	Typical cost for similar work. Based on $65 per hour truck and driver, 1.5 hour round trip and 20 ton truck, per ton rate = $4.90. Total sand procurement and transportation = $8.40
D.2	Armor	In-house estimate based on typical availability and price of sand in Fox valley	Cost for purchasing armor to be placed over the cap and transportation to Site	$8.40	$8.40	Typical cost for similar work. Based on $65 per hour truck and driver, 1.5 hour round trip and 20 ton truck, per ton rate = $4.90. Total armor procurement and transportation = $8.40
C.1	Mobilization	Contractor estimate for similar work and typical experience (Bob Lofgren, Lofgren Imagineering and Const. Co., Vancouver, WA)	Mobilize labor and equipment to the Site at the beginning of the project	$250,000	$250,000	Typical cost for similar work
C.2	Move and startup	Contractor estimate for similar work and typical experience (Bob Lofgren, Lofgren Imagineering and Const. Co., Vancouver, WA)	Move equipment from one reach of the river to another reach of the river during the course of the project	$150,000	$150,000	Typical cost for similar work
C.3	Slurry unit	Contractor estimate for similar work and typical experience (Bob Lofgren, Lofgren Imagineering and Const. Co., Vancouver, WA)	Includes labor and equipment to prepare sand slurry for transportation to cap area	$5,350	$5,400	Typical cost for similar work per day basis. Cost breakup for labor and equipment includes, Frontend loader - $1,000, Hopper and Conveyer - $650, Tank - $30, Water supply pump - $420, half booster pump and barge - $1,500 and Slurry pump, 14", 1000 H.P - $1,750. Total - $5,350. Use $5,400.
C.4	Additional slurry unit cost for armor	Contractor estimate for similar work and typical experience (Bob Lofgren, Lofgren Imagineering and Const. Co., Vancouver, WA)	Includes additional labor and equipment required to prepare armor slurry for transportation to placement area	$8,300	$8,300	Includes booster pump and barge - $2,200, slurry pump add/wear - $300 and added pipe/wear - $400. Total - $2,900. Add $5,400 slurry unit cost from C.3. Total - $8,300
C.5	Spreader unit	Contractor estimate for similar work and typical experience (Bob Lofgren, Lofgren Imagineering and Const. Co., Vancouver, WA)	Includes labor and equipment to place sand cap and armor	$4,445	$4,500	Typical cost for similar work per day basis. Cost breakup for labor and equipment includes, Barge, 8 units - $1,450, Winch - $1,050, Fairleads - $60, Building with GPS - $660, Generator - $50, Small tugboat - $950 and Pipeline, 4,000 ft avg - $225. Total - $4,445. Use $4,500.
C.7	Winterization	Contractor estimate for similar work and typical experience (Bob Lofgren, Lofgren Imagineering and Const. Co., Vancouver, WA)	Includes equipment lockdown, servicing and site security	100,000	100,000	Typical cost for similar work.
C.8	Demobilization	Contractor estimate for similar work and typical experience (Bob Lofgren, Lofgren Imagineering and Const. Co., Vancouver, WA)	Dis-assemble equipment, load and haul equipment, materials and site facilities at the termination of the project	$150,000	$150,000	Typical cost for similar work

C.9	Routine maintenance	In-house opinion	Purchased materials and labor to install miscellaneous small and expendible items associated with operations and maintenance. Possible non-routine maintenance requirements included.		$25,000	Typical experience, similar projects.
C.6	Field supervision	Contractor estimate for similar work and typical experience (Bob Lofgren, Lofgren Imagineering and Const. Co., Vancouver, WA)	Includes labor for supervision, on-site office, vehicles and legal and accounting charges	$2,790	$2,800	Typical cost for similar work per day basis. Cost breakup includes, Site Superintendent - $700, Site Engg - $600, Office - $550, Vehicles - $140, Survey boat - $300 and Legal and Acct - $500. Total - $2,790. Use $2,800.
C.10	Bathymetric survey	Contractor estimate for similar work and typical experience (Trent Nedens, Onyx Special Services, WI)	Perform bathymetric survey at 100 ft center to center using single beam sonar. Collect sounding lines every 100 ft. Frequency during year 5, 10, 20, 30 and 40 during Long-term Monitoring. Three events per river reach during cap and armor placement - middle of capping, end of capping	$6,072 $1,738 $5,148	$6,100 $1,800 $5,200	Vendor quote per acre = $ 22. Includes labor, equipment, fuel, mob/demob and deliverable (map of bathymetric contours). Total for OU 4 = 276 ac * $22/acre = $6,072 For OU 3 = 79 ac * $22/ac = $1738 For OU 1 = 234 ac * $22/ac = $5148.
C.11	Surface water monitoring	In-house opinion based on prior project experience	Collect 4 surface water samples (1 upstream and 3 downstream) for TSS analysis (Method 160.2). Frequency 1 per day.	$710	$750	Typical cost for similar work. TSS sample - $25*4 = $100, GPS unit = $110, and Env Tech = $500. Total per day = $710. Use $750 to include data validation
C.12	Construction monitoring report	In-house opinion based on prior project experience	Report documenting construction monitoring data		$50,000	Typical cost for similar work.
C.13	Staging arrea	In-house experience in the vicinity	Staging area for office trailer, equipment and materials assuming 10 acres of land is leased. $2,000 per acre per year.		$20,000	Placeholder - Typical cost for leasing rural land in Brown County
C.14	Electricity	Prior project experience	Annual power requirements for equipment, lighting, office trailer etc.		$6,000	This is a placeholder to cover minor electrical usage at the facility.
C.15	Telephone	Prior project experience	Cost of phone service to main operating facility.		$2,400	Placeholder, annual estimated cost.

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Attachment C1

Section 5 from White Paper No. 6B

5 INSTITUTIONAL AND REGULATORY CONSIDERATIONS

There are very few federal or state laws that pertain specifically to ISCs. While various chapters of the Wisconsin Administrative Code contain technical or administrative requirements for the management of waste material and contaminated media, there are no regulations that are specifically directed to the planning, permitting, design, construction, or maintenance of ISCs.

On the other hand, there are certain compelling interests in managing contaminated sediment that are parallel to those that arise when managing wastes and contaminated media. In a certain sense, a sediment cap, as a means of protecting human health and the environment, is analogous to a landfill cover at a Subtitle D facility or a soil performance standard at a spill site. Like these other control mechanisms, a cap over contaminated sediment can reduce the likelihood of migration, the opportunity for contact and biological uptake, or a combination of both. As with some land-based containment systems, the sediment cap uses earthen materials to provide control and physical separation. When correctly designed, properly constructed and well maintained, it can be an alternative method for achieving risk-based goals for reducing human and aquatic exposures.

A soil, aggregate, or multimedia cap that is used to contain contaminated sediment might therefore be subject to the same kinds of objectives as for other regulated materials. These include the following:

- The selection of the type of cap should be based on providing an appropriate physical barrier to limit contact with or migration of contaminants (or both).

- The design of the cap should provide for resistance to erosion, decay, or incidental penetration.

- The cap should be subject to periodic inspections and maintenance to insure that it accomplishes its design objectives over its intended life.

- Financial assurance should be established to provide for this post-construction, long-term monitoring, and maintenance.

- The cap must meet the substantive requirements of both state and federal law.

- The planning, design, construction, and monitoring phase of the project should be subject to state review at certain key milestones.

The fulfillment of objectives like these is the basis for various state regulations. Certain rules provide specific technical requirements for environmental facilities (e.g. solid waste landfills, hazardous waste incinerators, wastewater treatment plants). Other rules require the use of general evaluation methods and broad mandates for accomplishing protection (e.g., the NR 700 series of rules for remedial actions).

In addition, since the use of an ISC involves construction within navigable waters, there are additional considerations beyond those that affect land-based remediation. These are discussed specifically in the following subsection. Federal rules, other state rules, institutional considerations, and recent practices are discussed in subsequent subsections.

5.1 CONSTRUCTION WITHIN NAVIGABLE WATERS OF WISCONSIN

Wisconsin Statutes Chapter 30 prohibits the deposition of materials except into structures that are permitted or authorized under statute or other legislative means (WDNR, 1998). It also requires the issuance of permits for the construction of any structure on the bed of navigable water. The authorization and permitting of a project is, in turn, affected by the ownership of the bed. In Wisconsin, this varies according to the type of water body, as follows:

- For natural, navigable lakes the state owns the bed.
- For rivers, upland owners have riparian rights that extend to the center of the stream. (This includes "man-made" lakes or reservoirs created by the damming of a river. Riparian ownership is determined as though the previous stream still remains.)

As a result of these differences, deposits on the bed of navigable waters have historically been authorized under by one of four means (WDNR, 1998):

1. **Legislative Authorization:** For a river, the legislature can authorize a project with riparian owners as applicants or co-applicants. (In this context, it is important to note that riparian owners may separate the ownership or the riverbed from the ownership of the adjacent land, and riparian rights may be sold or leased.) In doing so, however, the project must be shown to be consistent with the public trust doctrine.

2. **Lakebed Grants:** For lakes, a "lakebed grant" from the legislature can remove the prohibition on deposits of material. The structure itself would still be subject to all approvals and permits required to protect the water quality of the surrounding water body.

3. **Bulkhead Lines:** Bulkhead lines can be used, but are required to conform as nearly as practicable to existing shores. Therefore, they would probably not be applicable to a broad area of ISC placement.

4. **Leases:** The Commission of Public Lands may lease the rights to the beds of lakes to a municipality for the purpose of improving navigation or harbors. The WDNR must establish that such a lease would be in the public interest, and they may include conditions of use and operation.

These considerations indicate that an RP who wishes to construct a sediment cap is not free to do so without consideration of riparian rights and without a means of authorization from the State. From the outset, there would be a commercial aspect to this process, in that the RP may need to negotiate with and provide compensation to private riparian owners. Equally important, however, would be the demonstration that the proposed ISC is an improvement allowable and envisioned under state law and that if authorization is provided, the state would continue to maintain its obligation to the public trust. Further, once the appropriate means of authorizing the project is established and implemented, the regulatory permitting process will add requirements that are necessary for the protection of the aquatic resource.

The applicability of Chapter 30 requirements and the use of lakebed grants for sediment caps is just beginning to be explored. While the WDNR has started to make determinations on which authorities (e.g., legislative authorization, lakebed grants, etc.) might be used on certain water bodies, it does not appear that a sediment capping project has yet moved fully through the process. Final determinations are likely to require considerable additional work and subsequent interpretations. In addition, obtaining a lease or lakebed grant is likely to result in additional financial encumbrances not otherwise accounted for.

5.2 OTHER WISCONSIN REGULATIONS

Beyond the laws that specifically affect the ability to construct a project within navigable waters, there are a range of other possible state regulations that may affect the planning, design, construction, or maintenance of an ISC remedy. Table 4 contains information on state regulatory requirements. These regulations, which cover such things as capping of upland disposal sites and other aspects of remedial activities, are not directly applicable to an ISC. They do, however, provide some general direction and they suggest how relevant state regulations may be considered for an ISC project.

Each of these items is characterized (for informational purposes) as being either “procedural” or “technical.” A procedural item, for example, could be the submittal of a work plan or other document. A “technical” requirement might specify a design feature, material of construction, or construction method.

The “procedural” aspects of the NR 700 series would probably be relevant to most ISC projects because they are, by definition, intended to be generic to a wide range of remedies. Technical items developed under other regulatory programs may have less relevance because they are usually facility-specific (such as the thickness of the vegetative layer for a landfill cover).

5.3 FEDERAL REQUIREMENTS

Section 10 of the Rivers and Harbors Act of 1899 (22 CFR 403) permitting is required for any construction that would impact the course, capacity, or condition of navigable waters of the United States (Palermo et al., 1998b). Any cap would be considered as an obstruction to navigation. For the Lower Fox River, the federal navigation channel runs the length of the River up to the Menasha Locks to Lake Winnebago. If a cap footprint were proposed within an authorized federal navigation channel, congressional action would be required to de-authorize the project or modify the authority.

TABLE 4 WISCONSIN "ACTION-SPECIFIC" REGULATIONS THAT MAY BE RELEVANT TO SEDIMENT CAPPING PROJECTS

Citation from Wisconsin Administrative Code	Is the Regulation Procedural or Technical?	Specific Item	Is There a Parallel Procedural or Technical Element in a Sediment Capping Project?	Comment
Chapter NR 504 – Landfill Location, Performance, Design, and Construction Criteria				
504.07	Technical	This paragraph establishes minimum design requirements for a solid waste landfill cover system. Includes design objectives, materials specifications, and thickness of layers.	Yes. The sediment cap is analogous to a landfill cover. It is subject to some of the same kinds of stability and long-term maintenance concerns which have been addressed for landfill covers via this paragraph.	The NR 500 series of regulations are not applicable to sediment capping. Further, the specific design elements contained in this paragraph are not relevant to a sediment cap. However, some of the underlying design objectives for landfill covers that are stated in 504.07(1)(a) would be relevant and appropriate. These include: • "Reduce…maintenance by stabilizing the final surface…" and • "Account for differential settlement and other stresses on the capping layer…" Just like in a landfill cover project, these objectives would form the basis for design of the sediment cap (i.e., the selection of materials and thickness that would resist erosive forces in the River and which could be adequately supported by the sediment bed).
Chapter NR 506 – Landfill Operational Criteria				
506.08	Procedural and Technical	Establishes general closure requirements for solid waste landfills, as well as specific requirements for facilities that accepted municipal solid waste up to certain cutoff dates.	Yes. The sediment cap could be viewed as the closure mechanism for a historic disposal location.	Not applicable. Because they are focused on a particular kind of solid waste facility, the specific content of this paragraph is not as relevant to a sediment cap as other parts of the NR 500 code might be.

TABLE 4 WISCONSIN "ACTION-SPECIFIC" REGULATIONS THAT MAY BE RELEVANT TO SEDIMENT CAPPING PROJECTS

Citation from Wisconsin Administrative Code	Is the Regulation Procedural or Technical?	Specific Item	Is There a Parallel Procedural or Technical Element in a Sediment Capping Project?	Comment
Chapter NR 514 – Plan of Operation and Closure Plan for Landfills				
514.08	Procedural	Requires the submittal of a closure plan for solid waste disposal facilities that do not have an approved plan of operation, or which are required to develop a closure plan as remediation for surface water contamination.	Yes. The sediment cap is, in part, a response action to an instance of surface water contamination.	Appears relevant. Because it is only a procedural requirement, though, it may not be appropriate if another relevant regulation is invoked (such as NR 724.09, 724.11, or 724.13) that requires equivalent information in a more focused document.
Chapter NR 516 – Landfill Construction Documentation				
516.04	Procedural	Describes the procedures for construction quality assurance and documentation reporting for construction at solid waste landfills.	Yes. The construction of the sediment cap is analogous to the construction of a landfill cover and would be subject to the same kinds of construction quality assurance and documentation.	Appears relevant. This paragraph merely sets forth a procedural task that is already largely consistent with conventional engineering practice. It would only be viewed as not appropriate if some other relevant regulation is invoked (such as NR 724.15) which is more targeted to remediation work.
516.06	Procedural and Technical	This paragraph describes more of the substantive requirements for closure documentation and reporting, such as the grid interval for determining final grades and the content of documentation drawings.	Yes. The types of documentation activities anticipated by this paragraph would also occur in a sediment capping project.	Some of the general requirements would be relevant. It would only be viewed as not appropriate if some other relevant regulation is invoked (such as NR 724.15) which is more targeted to remediation work.

TABLE 4 WISCONSIN "ACTION-SPECIFIC" REGULATIONS THAT MAY BE RELEVANT TO SEDIMENT CAPPING PROJECTS

Citation from Wisconsin Administrative Code	Is the Regulation Procedural or Technical?	Specific Item	Is There a Parallel Procedural or Technical Element in a Sediment Capping Project?	Comment
516.07	Technical	Contains the required frequency for materials testing during construction.	Yes. Some of the earthen materials used in a landfill cover may also be used in a sediment cap.	Some of the requirements for testing of specific materials (such as sand or small aggregate) may be relevant and appropriate. (Note that as a practical matter and so that the total number of samples is not unreasonable, the actual frequency of testing may be modified if very large volumes of cap material are required.)
Chapter NR 520 – Solid Waste Management Fees and Financial Responsibility Requirements				
520.05	Procedural	This paragraph identifies three types of site activity for which owners of solid waste facilities must establish financial responsibility: • Closure; • Long-term care; and • Remedial action.	Yes. Construction of a sediment cap constitutes a closure action, and long-term care (maintenance) is necessary.	Although a sediment cap is not one of the specific facilities identified in NR 520, the objective of establishing responsibility for future costs is relevant.
520.06	Procedural	This paragraph identifies seven different financial instruments by which owners can establish financial responsibility.		
520.07 and 520.08	Technical	Identifies the types of costs and methods of estimating which must be included within the categories of closure, long-term care and remedial action.		

TABLE 4 WISCONSIN "ACTION-SPECIFIC" REGULATIONS THAT MAY BE RELEVANT TO SEDIMENT CAPPING PROJECTS

Citation from Wisconsin Administrative Code	Is the Regulation Procedural or Technical?	Specific Item	Is There a Parallel Procedural or Technical Element in a Sediment Capping Project?	Comment
Chapter NR720 – Soil Cleanup Standards				
Note: The elements within this chapter that describe the process for calculating soil cleanup standards are not included in this analysis. For the Lower Fox River and Green Bay, the action level for contaminated sediments would be based on site-specific risk calculations and risk management decision.				
720.19(2)	Technical	Allows for the use of a soil performance standard when contaminants are left in place (in excess of what would otherwise be a residual contaminant level). If used, the soil performance standard must then be operated and maintained in accordance with NR 722 and NR 724 (see below).	Yes. A "soil performance standard" may consist of an engineering control, such as a physical barrier, to limit exposure or contact with residual contaminants. In this sense, a sediment cap is analogous to a cover system, pavement or other containment structure.	May be relevant. The rule anticipates that a soil performance standard would achieve one of more of the following: 1. Isolate residual contaminants from direct contact (by a physical barrier); 2. Limit infiltration and subsequent migration via groundwater (via a low-permeability barrier); or 3. Otherwise stabilize the soil while natural degradation reduces the contaminant concentration to within acceptable levels. Goals Nos. 1 and 3, for example, could be similar to those sought when selecting a sediment cap as a remedy.
Chapter NR 722 – Standards for Selecting Remedial Action				
722.09(2)(c)(3)	Procedural	This paragraph requires that, for sites "in surface water bodies or wetlands," active remedial actions be taken to preclude any exceedance of water quality criteria in Chapters NR 102 to NR 106.	Yes. In some cases, the goal of the sediment cap may be to prevent resuspension or dissolution of contaminants that might lead to an exceedance of water quality criteria in the overlying water column.	Could be relevant to the evaluation and selection of a sediment cap.

TABLE 4 WISCONSIN "ACTION-SPECIFIC" REGULATIONS THAT MAY BE RELEVANT TO SEDIMENT CAPPING PROJECTS

Citation from Wisconsin Administrative Code	Is the Regulation Procedural or Technical?	Specific Item	Is There a Parallel Procedural or Technical Element in a Sediment Capping Project?	Comment
722.09(3)	Procedural	This paragraph introduces the concept of a performance-based standard in lieu of a numeric cleanup standard.	Yes. A sediment cap is a "performance-based" remedial action (as compared to, say, an action that removes contaminants down to a risk-based, numeric standard).	Appears relevant.
722.13	Procedural	This paragraph contains the requirements for the submittal of a Remedial Action Options Report (RAOR).	Yes. Presumably, the selection of a sediment cap would generally be made after a review of remedial options and that process would generally be documented in a report of this type.	Appears relevant, unless the project is organized under some other regulatory authority (such as CERCLA) with its own document submittal requirements. The analog to a ROAR would probably be an FS.
Chapter NR 724 – Remedial and Interim Action, Design, Implementation, Operation, Maintenance and Monitoring Requirements				
724.09	Procedural	Describes the required contents for a "design report" for the selected remedial action at sites regulated under Section 292.11 or 292.31. (This also applies to sites referenced in 724.02, which in turn specifically includes "on-site engineering controls or barriers…")	Yes. Such a report would most likely be produced for any capping project once the concept for the remedy was established and approved.	NR 724 appears relevant because of the broad definition of regulated sites and the latitude that WDNR has in selecting a regulatory authority (NR 724.02(2)). The regulation sets forth a procedural task that is already largely consistent with good and conventional engineering practice. On the other hand, the regulation may not be appropriate if the site is being managed under the NCP where the administrative requirements for document submittal are generally more comprehensive.

TABLE 4 WISCONSIN "ACTION-SPECIFIC" REGULATIONS THAT MAY BE RELEVANT TO SEDIMENT CAPPING PROJECTS

Citation from Wisconsin Administrative Code	Is the Regulation Procedural or Technical?	Specific Item	Is There a Parallel Procedural or Technical Element in a Sediment Capping Project?	Comment
724.11	Procedural	Includes the substantive requirements for the production and submittal of construction-level plans (drawings) and specifications.	Yes. These documents would routinely be produced prior to construction of the project.	Appears relevant. The regulation sets forth a procedural task that is already largely consistent with conventional engineering practice. May also be appropriate if more comprehensive NCP protocols are not being followed.
724.13, especially (2)	Procedural	Includes the substantive requirements for the production and submittal of an "operation and maintenance plan." It includes the consideration of long-term monitoring, required under 724.17 (see below).	Yes. Such a plan could also be produced to describe the post-construction inspection, testing, and maintenance of the cap.	
724.15	Procedural	Includes the substantive requirements for the production and submittal of a "construction documentation report."	Yes. This kind of report would routinely be produced to document the construction of the cap.	
724.17	Procedural	Includes the substantive requirements for the parameters, frequency, and reporting of a long-term monitoring program. This paragraph also allows for a 5-year review by WDNR.	Perhaps. Such a program would be an element of the operation and maintenance plan. In addition to monitoring of the physical nature of the cap, it might also incorporate ongoing sediment chemical monitoring if long-term natural degradation of contaminants is an expectation of the remedy.	Parts of the paragraph appear relevant. Certain elements which anticipate chemical monitoring and data reporting may not be relevant. May also be appropriate if more comprehensive NCP protocols are not being followed.

While daunting, such relief from federal requirements is not unachievable. For example, capping was conducted on a portion of the federal navigation channel at the Manistique Harbor Superfund site in Michigan. That action was approved in Congress. For the Lower Fox River, Congress has approved the transfer of authority for the existing system of locks from the USACE to the state. In this case, the federal government will also relinquish control of the channel. In turn, the state has indicated that it will maintain a navigational depth of at least 4 feet. (Note that, while authorized, this transfer has not yet occurred.) If this is accomplished, a grant or release will then be required from the State Legislature. Until that time, however, the state's current interpretation is that "you can't fill in a federal channel."

5.4 INSTITUTIONAL CONTROLS

In addition to the affects of specific state and federal laws and regulations, a series of institutional considerations will also affect an ISC project. These may include restrictions on the bed where the project is constructed (analogous to traditional "deed restrictions" for a land-based project), as well as possible "water use" restrictions that would affect the resource overlying the bed.

Whether a cap is constructed over a leased bed from a riparian owner, or as part of a lakebed grant by the legislature, it will be necessary to set permanent restrictions on future development. This may include restrictions on setting utility or cable corridors, construction of fixed-post docks, or any other construction activity that would otherwise disturb the integrity of the cap. Water use restrictions might include limits on anchoring or propeller and keel impacts.

An assessment of the need for and reliability of such institutional controls should be part of an evaluation of the long-term effectiveness and permanence of a capping remedy. The ability to devise appropriate controls, educate the public regarding the need for controls, and enforce the controls should also be considered.

An inherent assumption in the cap designs discussed herein is that the location of the ISC will remain permanently submerged. On the Lower Fox River, this in turn, requires a commitment to the maintenance of the system of dams and locks on the River. There are already a number of compelling reasons for doing so (such as providing a lamprey barrier, hydropower capability, water supplies, and recreational use), but the use of ISC as a long-term remedial action will add to this list.

This range of institutional controls should be identified and memorialized as part of a detailed, long-term maintenance plan (LTMP). More broadly, the LTMP would include such elements as the following:

- Identification of failure modes that could result from the loss of institutional controls (degradation from propeller wash, etc.);
- Identification of failure modes the could result from natural causes (excessive ice scour, extreme flood events, etc.);

- Description of maintenance procedures or restoration activities needed for each type of failure;

- A schedule of routine inspections and sampling; and

- A means of identifying if the ISC has been affected by contaminants reloading the River system.

When routine inspections and sampling indicate a potential problem, actions will be required to physically repair the cap. A more complete assessment will be required to fully evaluate the type and severity of the failure and potential corrective measures. There are several ways a cap may fail. The more benign would be contaminant flux is greater than estimated and the design concentration has been exceeded. Catastrophic failure could occur during placement (due to shear failure) or scouring due to flood, ice, or propeller wash. Once this is determined, the type of maintenance can be specified. Maintenance could range from full cap replacement to placing additional cap materials or armor over the failed area.

5.5 FIDUCIARY RESPONSIBILITY

Fiduciary responsibilities for an ISC are equivalent to those associated with any upland landfill or soil cap; the RP retains the long-term liability for the cap in perpetuity. This is also consistent with soil caps at brownfield sites, where there is no transfer of liability for the site. An additional fiduciary responsibility that will need to be considered for an ISC at the Lower Fox River includes the long-term maintenance of dams on the River, and/or the potential for management of remnant deposits in the event of dam failure or removal.

5.6 RECENT PROJECTS WITHIN WISCONSIN

This section describes how ISC projects have been approved, designed, and/or implemented in Wisconsin. Where appropriate, references are made to some of the regulations described above.

While there have been a large number of capping projects addressing soils and waste materials within the state, only a very limited number of ISCs have been built. Two examples include the Sheboygan River and Harbor, a National Priorities List (NPL) site in eastern Wisconsin, and the Wausau Steel site, in north central Wisconsin.

At Sheboygan, PCBs were (and are) the constituent of concern. Sediment "armoring" was proposed as a pilot study in approximately 1989 and constructed in 1990, as part of the Alternative-Specific Remedial Investigation (ASRI) for the site. The objectives of the pilot study were as follows (Blasland, 1989):

- Demonstrate the constructability of the technology;
- Evaluate the effectiveness of reducing water column PCBs;
- Evaluate the effectiveness of reducing the bioaccumulation potential of PCBs;
- Develop engineering data for future projects; and
- Assess the impact on in-situ biodegradation of PCBs.

From an engineering perspective, the Sheboygan cap was designed for structural integrity. It is not clear how the above-stated goals impacted the specific design chosen. In total, it consisted of the following layers and materials:

- Geotextile fabric (placed directly on the soft sediments);
- 6-inch minimum run-of-bank aggregate material;
- Geotextile fabric;
- 6 inches of cobble; and
- The perimeter of the geotextiles was anchored with 3-foot by 3-foot stone-filled gabions.

The Sheboygan River project has followed federal National Contingency Plan (NCP) protocols. Both EPA and WDNR provided review of and comments on the technical aspects of the work. The project pre-dated the Wisconsin NR 700 series of rules and there were no specific technical regulations available or cited that covered the planning, design, construction, or operations of the sediment cap. WDNR commented at the time that, in general, the technology should be used sparingly and only for sediments at point bar locations with "low" PCB concentrations (WDNR, 1989). Specific contaminant levels were not stated.

Since it was constructed as a pilot project, the burden of performance monitoring would have fallen on the RP. Apparently, an agreement with the RP on a suitable monitoring program was never reached (Janisch, 2002). As a result, there appears to have been only limited monitoring or studies targeted towards determining the success with which the above-stated goals have been met. In a general sense, the performance has not been viewed favorably. Deficiencies observed by WDNR personnel over time have included the following (Weitland, 2002):

- From a biological standpoint, the technology was felt to be inappropriate.
- PCB concentrations in downstream sediment traps increased (although it is not certain that these PCBs emanate from the armored locations).
- There has been visible damage to the gabions resulting from subsequent storm events and/or ice action.

As early as 1997, after a technical review of the original FS for the permanent site remedy, the Lake Michigan Federation recommended that the removal of the armoring be included as a component of some of the long-term alternatives for the site (BT2, 1997). In fact, EPA's Record of Decision for the final site remedy now calls for it to be removed.

A second sediment capping project of interest has been the Wausau Steel project in Wausau (also referred to as the "Oxbow Lake" site on the Big Rib River). The contaminants of concern were zinc and lead, and a cap was proposed in the late 1990s as a means of addressing both in-place sediments and on-site soils. The Remediation and Redevelopment Bureau and the department's sediment team jointly reviewed the project. Chapter 30 permitting (referenced above) was administered through the department's Water Regulation and Zoning group, as for any construction in a navigable waterway.

The cap consisted of 2 feet of sand over a geotextile. The technical innovation on the project was that the cap materials were placed in the winter on the frozen lake surface and then allowed to settle into place upon ice melt.

The RP, through a consent order, is required to perform monitoring and maintenance for a 5-year period and to submit annual reports. To date, much of the cap has survived. However, within the first few years following construction, WDNR personnel observed that, in places, tears and holes had occurred, and some of it was pulling away from the shoreline. Erosion has occurred from storm events, and in at least two areas, gas generation from beneath the geotextile has caused it to "bubble." It had pushed through the sand layer and was exposed above the water's surface.

Maintenance has included the placement of additional sand, as needed. Nonetheless, these conditions have led the WDNR to raise questions that affect not only this project, but that will most likely be relevant in evaluating the design or implementability of future ISCs. These issues include the following (Janisch, 2002):

- In light of these initial observations (which to date affect only relatively small areas), what are the implications for long-term stability and effectiveness?
- Will water levels or ice action cause additional damage or worsen the existing defects?
- What is an appropriate degree of monitoring and maintenance over the long term?

While the RP has met the state's requirements to date, the WDNR does not currently have a mechanism in place for maintenance over the longer term. With this experience, department staff now recognize that some kind of extended monitoring or financial assurance may be needed as conditions of future orders.

For caps over contaminated soil and waste material, the WDNR has used both the NR 700 and NR 500 series of regulations as appropriate. Some specific examples include the following:

- When direct contact is the exposure pathway, the remedy selection process within NR 726 has resulted in the use of soil caps consisting of 1 to 2 feet of clean soil. (Note that a direct contact pathway for unsaturated soil would be analogous to an aquatic uptake pathway for sediment. The remedial objective of isolating the material is met by providing a layer of material of designated thickness.)

- When waste material has been excavated and relocated or consolidated, a cover designed according to the NR 500 rules has been required. Depending on the nature of the material, it may also be underlain by a liner designed according to NR 500 requirements. (In at least one innovative application, the NR 500 liner design was modified to add a layer or chemically reactive material suitable for neutralizing an acidic leachate.)

- When deed restrictions are needed on the capped property, NR 726 is used.

When long-term maintenance or monitoring is necessary, NR 700 has been invoked. The cases noted have generally involved larger, financially stable RPs, and financial responsibility has not been questioned. The issue of using NR 500 financial assurance requirements as a relevant and appropriate requirement for an NR 700 maintenance activity has apparently not yet been explored. In this regard, it is interesting to note that as early as 1999, a review of the Sheboygan remedy completed on behalf of the Lake Michigan Federation pointed to the need for an escrow account to cover the costs of long-term impacts when impacted sediments are left in place (BT2, 1999).

Appendix D

Typical Specifications

SECTION 01025
MEASUREMENT & PAYMENT

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. This section includes requirements for the measurement and payment of items contained on the bid form, and related incentives and damages.

1.02 DESCRIPTION OF BID ITEMS

A. Mobilization & demobilization

Measure and pay for the mobilization & demobilization at the start and completion of the Project, respectively. Includes all labor, materials and non-fixed base equipment on a lump sum basis. Seventy-five percent of the lump sum amount will be paid at the start of the Project, and twenty-five percent at Substantial Completion.

B. Maintenance & winterization

Measure and pay for the maintenance & winterization of equipment at the beginning and end of each dredge season on a lump sum basis. Fifty percent of the lump sum amount will be paid at the beginning of each dredge season, and fifty percent will be paid at the end of each dredge season.

C. Site preparation, construction of dredge support and slurry transport facilities and restoration

Measure and pay for the preparation of riverside access sites, and the construction of all fixed-based, semi-permanent facilities related to the dredge and slurry transport operations, on a lump sum basis. This pay item includes, but is not limited to, the dredge slurry piping and booster pumps. Ninety-five percent of the lump sum amount will be paid at the completion of initial construction. Five percent of the lump sum amount will be paid for deconstruction of facilities and restoration upon Substantial Completion.

D. Debris sweep

Measure and pay for the removal of debris from within the dredge limits, prior to the commencement of production dredging, on a per acre basis. Measurement will be made by survey. Hauling and disposal of debris will be paid as a separate bid item.

E. Production dredging

Measure and pay for the dredging of sediment to the dredge elevation, per cubic yard of in-place sediment. This pay item also includes the dredging of sediment below the dredge elevation and above the maximum pay elevation. The removal of debris encountered after the initial debris sweep is incidental to this pay item. Measurement will be by the post-dredge survey, as defined in Section 02482, Dredging.

F. Site preparation, construction of dewatering and wastewater treatment facilities, and restoration

Measure and pay for the preparation of the sediment processing site; the construction of all fixed-based, semi-permanent facilities and equipment used for sediment dewatering, wastewater treatment, solids rehandling and related infrastructure; and the deconstruction of facilities and restoration; on a lump sum basis. Ninety-five percent of the lump sum amount will be paid at the completion of initial construction. Five percent of the lump sum amount will be paid for deconstruction of facilities and restoration upon Substantial Completion.

G. Dewatering/wastewater treatment

Measure and pay for all labor, materials and utilities necessary to dewater the dredge slurry and to treat the resulting wastewater. The handling and loading of dewatered sediment, prior to hauling and final disposal, is incidental to this pay item.

[*For OU1:*

Measurement will be by the ton of dry solids. The mass of dry solids will be determined by taking the wet weight of filter cake, as measured at the landfill, and multiplying by the corresponding % solids value. Owner has estimated that (x cubic yards of river sediment) will result in a total of (y tons of filter cake) when dewatered to the % solids specified in Section 11360, Dewatering. Payment will be made on the basis of actual tons dry solids dredged and dewatered to the required % solids.]

[*For OU3 and OU4:*

Measurement will be per month of the dredging season, subject to the completion of all work activities identified in the Specifications. This item includes, but is not limited to, the decanting of water from the settling basins to wastewater treatment, scarifying and working the sediment crust to enhance drying, and the removal of sediment in lifts and transfer to the

monofill. Minor work done in the months prior to and after the dredge season will be compensated as part of the bid item, Maintenance and Winterization.]

H. Hauling – debris

Measure and pay for the hauling of debris, excavated during the initial debris sweep and during dredging, from the riverside staging location to the landfill. Any necessary rehandling of debris and the loading of debris in to trucks is incidental to this pay item. Measurement will be by the ton, as weighed at the landfill.

I. Disposal – debris

Measure and pay for the disposal of debris by the ton, as weighed at the landfill.

[*For OU1 only:*

J. Hauling – filter cake

Measure and pay for the hauling of filter cake by the ton, as weighed at the landfill.

K. Disposal – filter cake

Measure and pay for the disposal of filter cake by the ton, as weighed at the landfill.]

1.03 DESCRIPTION OF ALTERNATE BID ITEMS

A. Supplemental dredging

Measure and pay for supplemental dredging, below the maximum pay elevation, per cubic yard of in-place sediment. This work may be implemented at the request of WDNR, based on sampling performed after production dredging has been completed. Measurement will be by the pre-dredge and post-dredge survey, as defined in Section 02482, Dredging.

B. Residual Capping – Mobilization & demobilization

Measure and pay for the mobilization of all labor, materials and equipment necessary for the placement of a residual cap. This work may be implemented at the request of WDNR, based on sampling performed after production dredging has been completed. Seventy-five percent of the lump sum amount will be paid for mobilization. Twenty-five percent of this item will be paid for demobilization at Substantial Completion.

C. Residual Capping – Site preparation

Measure and pay for the preparation of materials staging areas and related facilities for the placement of a residual cap. This work may be implemented at the request of WDNR, based on sampling performed after production dredging has been completed. Ninety percent of the lump sum amount will be paid after initial construction of facilities. Ten percent of this item will be paid for deconstruction and restoration at Substantial Completion.

D. Residual Capping – Cap placement

Measure and pay for the placement of the cap layer, per square yard of area placed. Measurement will be by real-time monitoring using an x,y,z system, as specified in the corresponding Section for capping, and at areas where capping is completed in accordance with the Specifications and Drawings.

E. Residual Capping – Armor placement

Measure and pay for the placement of the armor layer, per square yard of area placed. Measurement will be by real-time monitoring using an x,y,z system, as specified in the corresponding Section for armor placement, and at areas where capping is completed in accordance with the Specifications and Drawings.

1.04 INCENTIVES AND DAMAGES

A. Damages for untimely performance

Contractor shall develop a multi-year Project Schedule that allows for completion of the Project within **[x]** years duration. The Project Schedule shall include Contractor's annual targets for production dredging, expressed as cubic yards of sediment removed per year, and cumulative cubic yards removed, that are necessary to achieve the Project duration.

Failure to comply with an annual target shall result in damages of $**[x]** per cubic yard at the end of that dredging season. Owner shall retain such damages, and release them at such a time as Contractor's production returns to the cumulative target in a subsequent dredging season. These damages will be in anticipation of Owner's future expenses for construction management, environmental monitoring and regulatory oversight should the project duration be exceeded **[in accordance with Paragraph 2(F) of the General Conditions of Contract.]** ***[Note to User:***

Substitute other clause, or delete, if Wisconsin DFD contract documents are not used.]

B. Damages for WPDES exceedance

Failure to meet WPDES permit limits for treated wastewater discharge shall result in damages of $**[x]** per **[exceedance] [day of exceedance.]** These damages shall cover Owner's expenses for environmental monitoring, administrative reporting and agency penalties.

C. Damages for overdredge

Owner estimates that each additional cubic yard of sediment removed below the maximum pay elevation results in a dewatering and disposal expense of $**[x]**, which will be assessed on Contractor as liquidated damages.

[For OU 1:]

D. Incentive for marginal improvement in dewatering

Owner estimates that each percentage point increase in the solids content (by weight) of the filter cake results in a hauling and disposal savings of **[$ x per ton of filter cake.]** Contractor will be paid **[x %]** of this amount for each full percentage point increase in the solids content above the specification contained in Section 02482, Dewatering.

PART 2 – PRODUCTS

Not Used

PART 3 – EXECUTION

Not Used

END OF SECTION

SECTION 02482
DREDGING

PART 1 - GENERAL

1.01 SECTION INCLUDES

This section includes requirements for the dredging of contaminated river sediment indicated on the Drawings.

1.02 RELATED WORK

The provisions and intent of the contract, including the General Conditions, apply to this work as if specified in this section. Work related to this section is described in

SECTION 01230 – CONSTRUCTION PROGRESS DOCUMENTATION
SECTION 01300 – SUBMITTALS
SECTION 11360 - DEWATERING
SECTION 01025 – MEASUREMENT AND PAYMENT

1.03 SUBMITTALS

A. Dredging Work Plan

B. Contractor's Project Schedule

C. Contractor Quality Control Plan

D. Daily Quality Control Reports

E. Dredging Cut and Data Sheets

F. Survey Equipment List

G. Plan for Establishment and Maintenance of Horizontal Survey Control

H. Progress Survey Cross Sections

1.03 DEFINITIONS

A. Dredge Elevation: The elevation to which sediment shall be removed. The WDNR has calculated the dredge elevation as the elevation necessary to achieve a remediation action level of 1 ppm PCB. The dredge elevation, including associated sideslopes, is also referred to as the required dredging prism.

B. Dredge Management Unit (DMU): A DMU is the subdivision of the dredging limits, for which a dredge elevation is established. Each DMU has an assigned dredge elevation. The x,y dimensions of the DMU are based on ENGINEER's estimate of the typical reach of the dredge equipment. As a Value Engineering function, alternative sizes and arrangements of DMUs may be proposed by Contractor to Owner and Engineer for consideration after award of contract.

C. Dredging limits: In the x,y dimensions, the sum of the DMUs.

D. Allowable Overdepth: The allowable overdepth is 0.5 ft. It is the dredging tolerance and it is established to ensure removal of all the sediment within the required dredging prism. Sediment actually removed within the 0.5-foot allowable overdepth zone will be measured and paid for as specified in Section 01025 MEASUREMENT AND PAYMENT.

E. Maximum Pay Elevation: The dredge elevation minus the allowable overdepth.

F. Sideslope: The slope outside the dredge cut that is created by sediment sloughing due to the excavation at the design depth (toe).

F. Slough Material: For the purpose of this contract, this is sediment that loses toe support and sloughs into the dredge prism from the slope above as a result of making the vertical cut to grade along the toe of dredging or face of the pier.

G. Excessive Dredging: Any material that is dredged outside the maximum pay elevation and associated side slopes (i.e. the dredge prism), as indicated on the Drawings.

H. Supplemental Dredge Elevation: This is a second dredge prism at a depth greater than the contract dredge elevation. It will be determined by post-dredge sampling and testing to have contaminated sediment in the range of 1 ppm or greater, and is below the original dredge prism following post dredging sampling and testing. This work will be completed at the option of the Owner.

1.04 SUMMARY OF WORK

A. Objective

This is an environmental dredging project. The WDNR has established dredging limits within which all sediment must be removed, to a defined dredge elevation.

B. Quantity Estimate

The volume of in-place sediment above the dredge elevation and subject to production dredging is estimated at **[784,000 cy for OU1] [6,500,000 for OU3 and OU4.]**

C. Construction Period

The dredging work described in this Section shall be performed on an annual basis during the period April 1 through November 30. This 8 month period comprises a dredge season. Work at upland facilities (e.g. sediment dewatering and transfer/disposal, wastewater treatment, etc.) may be performed at any time.

D. Dredging Duration

To meet environmental requirements, the dredging work shall be completed within a maximum period of **[3 years for OU1] [11 years for OU3 and OU4.]** Notwithstanding the limitations described in Part 1.04(F), the WDNR will prefer a shorter duration, as possible. Delay of completion beyond this schedule will be subject to penalty, as described in the Contract Documents.

E. Dredging

1. Production Dredging

Production dredging will be performed in the Fox River between channel mile **[XX]** and channel mile **[XX]** as indicated on the drawings. This dredging work will be entirely new work dredging. Significant amounts of debris and trash will be found and shall be removed along with sediment from the dredge prism.

2. Supplemental Dredging

After completion of the production dredging, the WDNR will collect confirmation samples for PCB analysis. If WDNR determines that additional sediment is contaminated and must be removed, a supplemental dredge elevation (and corresponding dredge prism) will be identified. This work comprises a separate pay item for supplemental dredging and will be paid at the corresponding unit rate as bid.

3. Debris Removal and Disposal

The Contractor shall remove logs and debris from the surface of the dredge areas prior to production dredging. The logs and debris shall be separated and shall be placed on separate barges, transported to and placed in separate upland storage areas to be identified by the Contractor, and approved by the WDNR and the Owner. The handling and transport system must provide containment of debris, attached sediment and water, so that release of sediment or debris back to waters of the Fox River or to land areas outside the designated storage sites is minimized. All debris shall be **[disposed as a solid waste at a licensed Subtitle D landfill.]**

4. Sediment Dewatering/Disposal and Wastewater Treatment

The Contractor shall convey the dredge slurry to the dewatering facility indicated on the Drawings. Dewatered sediment shall be disposed in a licensed Subtitle D landfill. Wastewater generated from the dewatering process shall be treated in an onsite facility. The requirements for slurry dewatering and wastewater treatment are described Sections **[XX]** and **[YY]**, and as indicated on the Drawings

F. Acceptable Dredge Equipment

The following types of dredge equipment will be acceptable:

1. Hydraulic pipeline dredge with cutterhead. Includes hydraulic transport system, with booster pumps as needed to convey the dredge slurry to the dewatering facility. Because of WDNR concerns over sediment resuspension, the size of the hydraulic pipeline dredge shall be limited to **[10" for OU1] [12" to 14" for OU3 and OU4.]**

2. Mechanical dredge with hydraulic slurry transport by discharge pipeline (hybrid dredge.) Includes booster pumps as needed to convey the dredge slurry to the dewatering facility.

1.04 EXISTING CONDITIONS

A. Character of Materials

The sediment to be dredged is generally characterized as very soft, fine grain material, with some sand and organics, and high water contents. Exploration and sampling to determine geotechnical character of sediments and their physical properties has been conducted. This data is summarized in the core logs and sieve analyses, as contained in the following documents:

1. [xxx]
2. [xxx]

The explorations are representative of the subsurface conditions at their respective locations. These conditions are generally described above; however, the Contractor shall evaluate the soil classifications to his own satisfaction prior to bidding. Variations in the type of materials encountered may occur which do not differ materially from those indicated in this contract, and if encountered, will not be considered as basis for claims.

B. Debris

Debris will be encountered during the dredging work. Debris is defined as any material other than sediment, such as logs, wood, metal, wire rope, cable, chain, steel bands, anchors, lockers, desks, push carts, brick, ballast stone, etc. The Contractor shall separate the debris from the dredged material and transport it to the on-site storage area that will be identified by the Contractor as part of his Dredging Work Plan, and approved by the Owner. The Contractor shall take possession and dispose of all debris **[as a solid waste at a licensed Subtitle D landfill.]**

C. Vessel Movement and Berthing

The Fox River is currently used for commercial and recreational boat and barge movement. Contractor shall schedule and perform its work around commercial vessel movement schedules. The Contractor’s standby costs due to commercial vessel movement will be included in the unit cost for dredging.

D. Protection of Existing Facilities

Dredging will be conducted adjacent to piers and mooring structures and revetment as shown on the contract drawings. The Contractor shall exercise care when conducting its dredging operation so as not to damage, undermine or otherwise disturb these structures. Care shall be taken when dredging next to the structures not to hit the fender piles or concrete bearing piles with the dredge, or to excavate deeper than the depth shown on the drawings. Any damage to the structures caused by the Contractor's operations, as determined by the Owner’s Representative, shall immediately be repaired to the pre-project condition at the Contractor's expense.

E. Spill Contingency Plan

The Contractor shall prepare a spill contingency plan as part of the Dredging Work Plan. In the event of a spill, the Contractor shall conform to established reporting systems as dictated by the Spill Contingency Plan.

F. Underground Utilities

Underground utilities that have been identified to the Owner are indicated on the Drawings. It is the Contractor’s responsibility to determine the locations and depths of any other utilities or pipelines that may be buried within the dredge limits. Contractor shall repair to pre-construction conditions, at Contractor’s expense, any damage to buried utilities or pipelines.

1.05 MISPLACED MATERIAL

A. Should the Contractor, during the execution of the work, lose, dump, throw overboard, sink or misplace anything whether it is material or equipment, the dredge, barge, machinery, or an appliance, the Contractor shall promptly recover and remove the same. The Contractor shall give immediate verbal notice, followed by written confirmation, of the description and location of such material or equipment to the Owner's Representative and shall mark and buoy same until they are removed. Should the Contractor refuse, neglect, or delay compliance with this requirement, such material or equipment may be removed by the Owner's Representative, and the cost of such operations may be deducted from any money due to the Contractor, or may be recovered from his bond. The liability of the Contractor for the removal of a vessel wrecked or sunk without his fault or negligence shall be limited to that provided in Sections 15, 19, and 20 of the River and Harbor Act of 3 March 1899 (33 U.S.C. 410 et seq.).

1.06 DREDGING AND DISPOSAL PERMITS

A. Permits and Compliance

[To be written]

PART 2 - PRODUCTS

Not Used

PART 3 – EXECUTION

3.01 DREDGING WORK PLAN

A. Within 21 calendar days after award, the Contractor shall submit to the Owner's Representative, for approval, a detailed, written project Dredging Work Plan. As a minimum, the plan shall contain the following:

1. Order in which the work is to be performed indicating the work sequence; number, types and capacity of equipment to be used; hours of operation; methods of operation and the time required to complete each activity.

2. Project schedule indicating the total duration of dredging. The schedule shall identify the annual production targets (in cubic yards of sediment removed) that Contractor shall accomplish in order to remove the total estimated quantity of sediment in the duration proposed.

3. Any proposed changes to the dredge limits and designation of Dredge

Management Units indicated on the Drawings.

4. A list of key personnel and supervisory chain.

5. Layout of the work and positioning of dredge equipment and environmental monitoring, including a Spill Contingency Plan with procedures for emergency spill containment and removal operations.

6. Notification and procedures to be used for moving dredging equipment to accommodate inbound and outbound vessel traffic using the waterways. Operations will be scheduled so as not to conflict with these vessel movements.

3.02 QUALITY CONTROL

A. Quality Control Plan

The Contractor shall furnish for review by Owner's Representative, within 21 calendar days of award, its Contractor Quality Control (CQC) plan. This plan will be used to document the inspections, monitoring, surveys and other actions to be taken by the Contractor to ensure that the work complies with all contract requirements. The Contractor shall assure that all required gauges, targets, ranges and other survey markers are in place and properly maintained. The Contractor shall install sufficient river surface elevation gauge(s) or staff(s) at the dredging location so that the dredge operator, dredging inspectors and hydrographic surveyors can observe on a real-time basis the water surface elevation.

B. Reporting Requirements

The Contractor shall prepare and maintain a daily report of operations and furnish a copy to the Owner's Representative on the day after the date of the report. Information to be included as a minimum in the report will be the date, period covered by the report, equipment used, description of activity as identified by dredge area, dredge depths, quantity of sediments dredged that day and to date, results of continuous slurry flowrate and % solids monitoring, downtime and delays to the operation, safety, and other relevant comments concerning the conduct of the operation. The report shall include the results of all inspections, surveys and monitoring activities and shall be signed by the Contractor's dredging superintendent or quality control manager. An example of a suitable Daily Dredging Report is included as Attachment No. 1 to this Section.

3.03 SURVEYS

A. Progress Surveys

The Contractor shall provide daily sounding cross-sections of the previous day's work, at no greater than 50-foot trackline intervals using a survey-grade fathometer. Sounding and survey lines will be perpendicular and parallel to the cut alignment of the previous days dredging. Perpendicular sections (cross lines) will extend beyond the catch points for excavation of side slopes, and cover the adjacent dredging alignment channel by 50% of total width. Intervals between soundings on each trackline generally will not exceed 5 feet. The survey data will be made available to the Owner's Representative as soon as the survey plots are completed. Survey results may be used to adjust dredging procedures to assure that the configuration of the dredging site conforms with the drawings. The Owner's Representative may direct the Contractor to adjust its dredging procedure to assure compliance with the drawings at no additional expense to Owner's Representative.

For the progress payment dredge surveys, quantities will be computed by the Contractor to the nearest cubic yard for each dredge area based on the progress sounding lines surveyed, the pre-dredge survey, and the dredging sections indicated on the Drawings. Tabular summaries of the dredge areas and dredged material quantities for each bid item for which the Contractor desires payment shall be submitted to Owner's Representative to support the Contractor's monthly payment request.

B. Pre- and Post-Dredge Surveys

The survey used to create this document were obtained on **[Date]** and represent conditions at that time. Pre-dredge surveys will be performed by the Owner's Representative a maximum of 4 weeks prior to scheduled dredging based on the Contractors dredge schedule. Post-dredge surveys for confirmation and pay purposes will be performed a maximum of 2 weeks following notification by Contractor on completion of dredging.

When the Contractor determines that dredging in any acceptance area or areas is completed, the Contractor will notify the Owner's Representative and request that a post-dredge survey for the completed area(s) be conducted. The post-dredge survey will be completed by Owner's Representative.

These post-dredge surveys will be used as the basis for determination of final pay quantities and acceptance of the work. Final pay quantities will be calculated by Owner's Representative, computing dredged volumes to the nearest cubic yard. Upon request, the Contractor will be provided a copy of the bathymetric soundings and the quantity calculations.

C. Bathymetric Equipment and Methods

Pre- and post-dredge surveys shall be conducted using a survey-grade, **[dual frequency]** fathometer and electronic horizontal positioning device (DGPS.)

Bed surface and dredge elevations will be determined using depth soundings and tide gauge reading for each trackline. Water level and other corrections will be applied and corrected depth shown on the survey sounding sheets. Required precision for vertical measurements shall be +/- 0.1 ft and +/- 3 feet for horizontal position. All elevations shall be expressed as **[datum.]**

D. River Water Surface Gauges

The Contractor shall furnish, set and maintain in good order, all ranges, buoys and other markers necessary to define the work and to facilitate inspection. The Contractor shall establish and maintain a water surface elevation gauge or board in a location where it may be clearly seen during dredging operations, hydrographic surveys and inspections. The Contractor shall also install an automatic recording tide gage with water level sensor. The tide gage shall provide a continuous recording of river surface change for every 15-minute interval or each 0.1 foot change, whichever occurs first. River surface changes shall be recorded in the **[datum]**, with these changes visually provided in the dredge operator’s cab of the dredge at all times during the dredging process to allow proper adjustment of dredge depth. All costs for providing the water surface gauges and other survey control shall be included in the bid price for dredging and disposal.

3.04 CONDUCT OF DREDGING

A. Layout of Work

An accurate method of horizontal control shall be established by the Contractor before dredging begins. The proposed method and maintenance of the horizontal control system shall be subject to the approval of the Owner’s Representative and if, at any time, the method fails to provide accurate location for the dredging operation, the Contractor will be required to suspend its dredging operations. The Contractor shall lay out the work from horizontal and vertical control points indicated on the drawings and shall be responsible for all measurements taken from these points. The Contractor shall furnish at its own expense all stakes, templates, platforms, equipment, range markers, transponder stations and labor as may be required to lay out the work from the control points shown on the drawings. It shall be the responsibility of the Contractor to maintain all points established for the work until authorized to remove them. If such points are destroyed by the Contractor or disturbed through contractor negligence prior to authorized removal, they shall be replaced by the Contractor at its own expense. Setting of control points on piers and other structures shall be approved by the Owner’s Representative.

B. Positioning Equipment and Methods

The Contractor shall employ Differential Global Positioning System (DGPS) to locate and control horizontal dredging position. Observation data will be recorded in standard surveying field book format. Automated position determinations will be accomplished by standard trilateration procedures whereby lengths to two or more shore-based control points are electronically measured by either time delay or phase comparison techniques. Observed ranges are corrected for scale, calibration, and/or automatic variations when present. Accuracy of dredge position shall be within +/- 3 feet. The Contractor shall submit for approval a list of survey equipment to be used for the work.

C. Dredging

1. The Contractor shall excavate the dredge areas to the lines and dredge elevations shown on the drawings.

2. For hydraulic dredging, dredging shall be accomplished by limiting the thickness of each cut to a value that is less than 0.8 times the cutterhead diameter. A minimum of two cuts will be made for all areas, except those areas that are less than two feet thick, to avoid overspill onto the rotating cutterhead due to cut slope failure.

3. If slope material sloughs into the cut area, the Contractor shall remove this material by making a final pass along the toe of slope or pier/fender line, prior to requesting a post-dredge survey.

4. During the dredging the Contractor may experience sediment of physical characteristics that differ form those anticipated and identified in this Specification. The Contractor should continue to dredge to depth required, and should notify the Owner’s Representative immediately if the material is different. If the material causes refusal, the Contractor must report within 24 hours in writing of the Changed Condition as required by the General Conditions.

3.06 PROCESS MONITORING

A. Slurry flowrate: Contractor shall provide continuous monitoring of the slurry flowrate, in gallons per minute, at a point in the slurry pipeline prior to the first dewatering operation, using a Doppler flow meter or equivalent instrumentation.

B. Solids content: Contractor shall provide continuous monitoring of the % solids (by weight) in the dredge slurry at a point in the slurry pipeline prior to the first dewatering operation, using a nuclear density gauge or equivalent instrumentation.

C. Contractor shall provide process monitoring results to Owner on a daily basis, as part of the Contractor’s Daily Quality Control Report.

D. Contractor shall provide on-site an operational backup for all instruments used in the measurement of slurry flowrate and solids content in the dredge slurry. Failure to provide daily data shall be subject to penalty, as described in Section 01025, Measurement & Payment.

3.07 SALVAGED MATERIAL

A. Anchors, chains, straps, wire rope, shopping baskets, and other debris or material brought to the surface during the course of the dredging operations shall be separated out from the dredge material and delivered to an onsite location to be identified by the Contractor, and approved by the WDNR and the Owner's Representative. Contractor shall then dispose of this salvaged material. Removal and delivery of the salvaged material during the dredging activity to the designated onsite location will be considered incidental to the dredging work and included in the unit price. The initial debris sweep prior to start of dredging is included as a separate bid item.

3.08 PROJECT PROGRESS

A. As described in Section 01025, Measurement & Payment, Contractor shall submit a Project Schedule with annual targets for production target.

B. Owner, WDNR and Contractor shall meet at monthly intervals during the first dredging season, and at bi-monthly intervals during subsequent dredging seasons, to review Contractor's progress towards annual targets. Prior to each meeting, Contractor will notify Owner in writing of its progress in relation to that year's annual target. If Owner concludes that progress is deficient, Contractor shall notify Owner in writing of its proposed cure within 5 business days of the meeting.

3.09 FINAL EXAMINATION AND ACCEPTANCE

A. Dredging shall be performed on an approval area basis as indicated on the Contract plans **[and as agreed by Owner and WDNR prior to commencement of the Work.]** Contractor shall complete the dredging of each approval area before final surveys are performed, and surveys will be completed within two weeks after notice of completion in writing by the Contractor to the Owner's Representative. If the post-dredge survey confirms that dredge elevations have been achieved in that area , the work within that area will be considered complete. Should the work be determined to be incomplete, the Contractor shall immediately perform such additional work as may be necessary to satisfactorily complete the project to the satisfaction of the Owner's Representative.

END OF SECTION

Appendix E

Mass Balance Summary

TECHNICAL MEMORANDUM

TO:	File #15933	**CLIENT:**	WDNR – Fox River
FROM:	FMS, SRT	**TASK:**	Change Order 13 - DEA
DATE:	October 30, 2003 (Rev. 1)	**RE:**	Mass balance summaries

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This memo documents the mass balance calculations for a number of remedial alternatives and process option scenarios described in the DEA report. It includes the mass and solids flux from a dredge slurry, through coarse solids separation, dewatering and wastewater treatment.

At this stage of the project, specific dredging and process equipment have not been selected. Treatability work and final in-place sediment characterizations are pending. Therefore, a number of simplifying assumptions have been made:

- Sediment quantities and physical properties are from the final RI/FS. (Note that all % solids values are on a weight basis, unless otherwise indicated.)
- Dredge slurry rates and dredge effective times were calculated by RETEC based on typical operating conditions in each OU and certain objectives described in the FS (such as using smaller dredges vs. larger ones.) For calculating average rates of sediment removal and solids flux to the dewatering/treatment system, the long-term % solids in the dredge slurry is used. The instantaneous rate of removal and solids flux will fluctuate above and below this value.
- Typical Process Flow Diagrams (PFDs) for dewatering and wastewater treatment are contained in the DEA report. The letter codes used herein correspond to those indicated on the PFDs.
- A coarse solids separation step, when used, will remove at least 15% of the dry solids from the dredge slurry. This material will come off at 70% solids.
- A mechanical thickener will generate an underflow of 15% solids.
- A dewatering press will generate a cake at 55% solids (increased from FS assumption of 50% based on additional evaluation). The press will capture 95% of the influent solids as cake.
- A gravity settling basin will initially generate a material at 30% solids (assumption from FS), which will then be allowed to air dry for an extended period of time to 40% solids (revised assumption per WDNR comments.)
- Flowrates within the dewatering and wastewater treatment processes are stated on the basis of forward flow through the system only. The contributions of chemical addition, recycle and return flows are not included at this time, since a specific process arrangement and equipment have not yet been determined. The final sizing of pumps and certain process equipment will take into account these contributions, so that adequate capacity is provided. Also, for general planning purposes herein, calculated flowrates are rounded off to the nearest 100 gpm.

Calcution sheets are attached and summary sheets are contained at the end of this memo.

Operable Unit 1: Baseline Alternative - Hydraulic dredging, mechanical dewatering, monofill disposal

A. Calculate mass of in-place dry solids

Volume	=	784,000 cy sediment @ 0.99 t/cy and 24.1% solids
Mass dry solids	=	(784,000 cy)(0.99 t/cy)(0.242%)
	=	**188,000 tons (t)**

B. Calculate solids flux in dredge slurry. Slurry flowrate is estimated at 2100 gpm at a long-term average concentration of 8% solids (specific gravity of slurry = 1.05)

Total mass flux	=	(2100 gpm)(8.34 #/gal) (1.05)(60 min/hr)(t/2000 #)
	=	**552 tons per hour (tph)**
Dry solids flux	=	(552 tph)(0.08)
	=	**44.2 tph**

Therefore, 44.2 tons of dry solids per hour of dredging are entering the dewatering/treatment process.

C. Calculate solids removed from the dredge slurry by the coarse material (sand) separation process. Process is estimated to remove 15% of incoming solids, which will be separated as a 70% solids material.

Rate of dry solids separated	=	(44.2 tph)(0.15)
	=	**6.6 tph**
Rate of total mass separated	=	(6.6 tph)/(0.7)
	=	**9.5 tph**

For the total project, the mass of coarse solids separated would be:

Total mass separated	=	(188,000 tons dry solids)(0.15)/(0.7)
	=	**40,000 tons**

Therefore, the total mass separated for disposal during the project is 40,000 tons.

D. Calculate thickener performance. Dredge slurry is thickened and underflow is pumped to dewatering. At equilibrium (and after downstream solids are return), assume underflow is at 15% solids.

Dry solids to dewatering	=	(Dry solids in dredge slurry) – (Dry solids removed as sand)
	=	44.2 tph – 6.6 tph
	=	**37.6 tph**

37.6 tph of solids are thickened and forwarded to dewatering. At 15% solids, the total mass flux of the underflow is:

Total mass

underflow	=	(37.6 tph)/(0.15)
	=	**250 tph**

The specific gravity of a 15% slurry is about 1.1

Underflow rate	=	(250 tph)(2000 #/t)(g/8.34 #)(1/1.1)(h/60 m)
	=	**900 gpm**

E. Calculate overflow rate (supernatent) by balancing on total mass.

Supernatent out	=	(Mass of slurry in) – (Mass of sand out) – (Mass of underflow)
	=	552 tph – 9.5 tph – 250 tph
	=	**292 tph**

For a dilute aqueous stream like this, assume specific gravity is essentially 1.0.

Supernatent flow	=	(292 tph)(2000 #/t)(h/60 m)(gal/ 8.34#)
	=	**1200 gpm**

F. Calculate rate of generation of filter cake. Assume solids from thickener are removed as a filter cake at 55% solids.

Mass filter cake	=	(37.6 tph)/(0.55)
	=	**68.4 tph**

The rate of generation of filter cake is 68.4 tph for every hour that the dredge is running. For an effective day of 10.8 hours:

Filter cake per day	=	(68.4 tph)(10.8)
	=	**738 tpd**

G. Calculate rate of filtrate generated. Use a balance on total mass.

Mass filtrate	=	(Mass of thickener underflow in) – (Mass of filter cake out)
	=	250 tph – 68.4 tph
	=	**182 tph**

Assume specific gravity of 1.0 for a dilute stream.

Filtrate flowrate	=	(182 tph)(g/8.34 #)(2000 #/t)(h/ 60 m)
	=	**700 gpm**

H. Calculate rate of effluent discharge to the river after treatment (i.e. this does not include the return/recycling of various aqueous streams within the system.) Use a balance on total mass.

Mass effluent	=	(Mass of dredge slurry in) – (Mass of sand out) – (Mass of filter cake out)
	=	552 tph – 9.5 tph – 68.4 tph

	=	**474 tph**

Assume specific gravity of 1.0 for a dilute stream.

Effluent flowrate	=	(474 tph)(g/8.34 #)(2000 #/t)(h/ 60 m)
	=	**1900 gpm**

Operable Unit 3: Baseline alternative – Hydraulic dredging and transport to dewatering basin, monofill disposal

A. Calculate mass of in-place dry solids

Volume	=	587,000 cy sediment @ 1.08 t/cy and 37.1% solids
Mass dry solids	=	(587,000 cy)(1.08 t/cy)(.371)
	=	**235,000 t**

B. Calculate solids flux in dredge slurry. Slurry flowrate is estimated at 3100 gpm at a long-term average concentration of 8.3% solids (specific gravity of slurry = 1.05)

Total mass flux	=	(3100 gpm)(8.34 #/g)(1.05)(60 m/h)(t/2000 #)
	=	**814 tph**
Dry solids flux	=	(814 tph)(0.083)
	=	**68 tph**

Therefore, 68 tons of dry solids per hour of dredging are entering the dewatering/treatment process.

F. Calculate solids removed from the dredge slurry and retained in settling basin. Assume all dry solids from in-place sediment are eventually captured in the basin (i.e. after return of solids from downstream wastewater treatment.) Material initially settles and thickens to 30% solids, with excess water removed as supernatent. After extended drying, material in basin ends up at 40% solids.

Rate of mass retained at 30% solids	=	(68 tph)/(0.30)
	=	**227 tph**
Total mass after drying to 40% solids	=	(235,000 t)/(0.40)
	=	**587,000 t**

This is the total mass of material that will be removed and disposed in a monofill. Density is estimated at 1.10 t/cy. The airspace requirement is:

Volume	=	(587,000 t)/(1.10 t/cy)
	=	**534,000 cy**

E. Calculate long-term average rate of supernatent withdrawal to wastewater treatment.

Total mass supernatent	=	(Mass of dredge slurry in) – (mass retained at 30% solids)
	=	814 tph – 227 tph
	=	**587 tph**

Assume a specific gravity of 1.0 for a dilute stream like this.

Supernatent flowrate = (587 tph)(g/8.34 #)(2000 #/t)(h/ 60 m)

= **2300 gpm**

G. Calculate rate of effluent discharge to the river. Because the solids in the supernatent are low, the effluent flowrate will essentially be the same as the influent supernatent.

Effluent flowrate = **2300 gpm**

Operable Unit 4: **Baseline alternative – Hydraulic dredging and transport to dewatering basin, monofill disposal**

A. Calculate mass of in-place dry solids.

Volume	=	5,880,000 cy sediment @ 1.05 t/cy and 33.8% solids
Mass dry solids	=	(5,880,000 cy)(1.05 t/cy)(.338)
	=	**2,090,000 t**

B. Calculate solids flux in dredge slurry. Slurry flowrate is estimated at 4100 gpm (from 2 dredges) at a long-term average concentration of 8.3% solids (specific gravity of dredge slurry = 1.05)

Total mass flux	=	(4100 gpm)(8.34 #/g)(1.05)(60 m/h)(t/2000 #)
	=	**1077 tph**
Dry solids flux	=	(1077 tph)(0.083)
	=	**89.4 tph**

Therefore, 89.4 tons of dry solids per hour of dredging are entering the dewater/treatment process.

F. Calculate solids removed from the dredge slurry and retained in settling basin. Assume all dry solids from in-place sediment are eventually captured in the basin (i.e. after return of solids from downstream wastewater treatment.) .) Material initially settles and thickens to 30% solids, with excess water removed as supernatent. After extended drying, material in basin ends up at 40% solids.

Rate of mass retained at 30% solids	=	(89.4 tph)/(0.30)
	=	**298 tph**
Total mass after drying to 40% solids	=	(2,090,000 t)/(0.40)
	=	**5,220,000 t**

This is the total mass of material that will be removed and disposed in a monofill. Density is estimated at 1.10 t/cy. The airspace requirement is:

Volume	=	(5,220,000 t)/(1.10 t/cy)
	=	**4,750,000 cy**

E. Calculate long-term average rate of supernatent withdrawal to wastewater treatment.

Total mass Supernatent	=	(Mass of dredge slurry in) – (mass retained in basin at 30% solids)
	=	1077 tph – 298 tph
	=	**779 tph**

Assume a specific gravity of 1.0 for a dilute stream like this.

Supernatent flowrate = (779 tph)(g/8.34 #)(2000 #/t)(h/ 60 m)

= **3100 gpm**

G. Calculate rate of effluent discharge to the river. Because the solids in the supernatent are low, the effluent flowrate will essentially be the same as the influent supernatent.

Effluent flowrate = **3100 gpm**

Operable Unit 3: Scenario B – Hybrid dredging to riverside mechanical dewatering plant

A. Calculate mass of in-place dry solids. Same as for baseline alternative.

Mass dry solids	=	**235,000 t**

B. Calculate solids flux in dredge slurry. Slurry flowrate is assumed to be 2100 gpm at a long-term average concentration of 15% solids (specific gravity of slurry = 1.1.)

Total mass flux	=	(2100 gpm)(8.34 #/gal)(1.1)(60 m/h)(t/2000 #)
	=	**578 tph**
Dry solids flux	=	(578 tph)(.15)
	=	**86.7 tph**

Therefore, 86.7 tons of dry solids per hour of dredging are entering the dewatering/treatment process.

C. Calculate solids removed from the dredge slurry by the coarse material (sand) separation process. Process is estimated to remove 15% of incoming solids, which will be separated as a 70% solids material.

Rate of dry solids separated	=	(86.7 tph)(0.15)
	=	**13 tph**
Rate of total mass separated	=	(13 tph)/(0.7)
	=	**18.6 tph**

For the total project, the mass of coarse material separated would be:

Total mass generated	=	(235,000 tons dry solids in river)(.15)/(0.7)
	=	**50,000 t**

D. Calculate thickener performance. Dredge slurry is thickened and underflow is pumped to dewatering. At equilibrium (and after downstream solids are returned), assume underflow is at 20% solids.

Dry solids to dewatering	=	(Dry solids in dredge slurry) – (Dry solids removed as sand)
	=	86.7 tph – 13 tph
	=	**73.7 tph**

73.7 tph of solids are thickened and forwarded to dewatering. At 20% solids, the total mass flux of the underflow is:

Total mass underflow	=	(73.7 tph)/(0.2)
	=	**368 tph**

The specific gravity of a 20% slurry is about 1.13.

Underflow rate	=	(368 tph)(2000 #/t)(g/8.34 #)(1/1.13)(h/60 m)

= **1300 gpm**

E. Calculate overflow rate (supernatent) by balancing on total mass

Supernatent out = (Mass of slurry in) – (Mass of sand out) – (Mass of underflow)

= 578 tph – 18.6 tph – 368 tph

= **191 tph**

For a dilute aqueous stream like this, assume specific gravity is essentially 1.0.

Supernatent flow = (191 tph)(2000 #/t)(h/ 60 m)(gal/ 8.34#)

= **800 gpm**

F. Calculate rate of generation of filter cake. Assume solids from thickener are removed as filter cake at 55% solids.

Mass filter cake = (73.7 tph)/(0.55)

= **134 tph**

The rate of generation of filter cake is 134 tons for every hour that the dredge is running. For an effective day of 15.3 hours:

Filter cake per day = (134 tph)(15.3 h)

= **2050 tpd**

G. Calculate rate of filtrate generated. Use a balance on total mass.

Mass filtrate = (Mass of thickener underflow in) – (Mass of filter cake out)

= 368 tph – 134 tph

= **234 tph**

Assume specific gravity of 1.0 for a dilute stream.

Filtrate flowrate = (234 tph)(g/8.34 #)(2000 #/t)(h/ 60 m)

= **900 gpm**

H. Calculate rate of effluent discharge to the river after treatment (i.e. this does not include the return/recycling of various aqueous streams within the system.) Use a balance on total mass.

Mass effluent = (Mass of dredge slurry) – (Mass of sand out) – (Mass of filter cake out)

= 578 tph – 18.6 tph – 134 tph

= **425 tph**

Assume specific gravity of 1.0 for a dilute stream.

Effluent flowrate = (425 tph)(g/8.34 #)(2000 #/t)(h/ 60 m)

= **1700 gpm**

Operable Unit 4: Scenario B – Hybrid dredging to riverside mechanical dewatering plant

A. Calculate mass of in-place dry solids. Same as for baseline alternative.

Mass dry solids = **2,090,000 t**

B. Calculate solids flux in dredge slurry. Slurry flowrate is assumed to be 2100 gpm at a long-term average concentration of 15% solids (specific gravity of slurry = 1.1.)

Total mass flux = (2100 gpm)(8.34 #/g)(1.1)(60 m/h)(t/2000 #)

= **578 tph**

Dry solids flux = (578 tph)(.15)

= **86.7 tph**

Therefore, 86.7 tons of dry solids per hour of dredging are entering the dewatering/treatment process.

C. Calculate solids removed from the dredge slurry by the coarse material (sand) separation process. Process is estimated to remove 15% of incoming solids, which will be separated as a 70% solids material.

Rate of dry solids separated = (86.7 tph)(0.15)

= **13 tph**

Rate of total mass separated = (13 tph)/(0.7)

= **18.6 tph**

For the total project, the mass of coarse material separated would be:

Total mass separated = (2,090,000 tons dry solids in river)(.15)/(0.7)

= **450,000 t**

D. Calculate thickener performance. Dredge slurry is thickened and underflow is pumped to dewatering. At equilibrium (and after downstream solids are returned), assume underflow is at 20% solids.

Dry solids out = (Dry solids in dredge slurry) – (Dry solids removed as sand)

= 86.7 tph – 13 tph

= **73.7 tph**

73.7 tph of solids are thickened and forwarded to dewatering. At 20% solids, the total mass of the underflow is:

Total mass underflow = (73.7 tph)/(0.2)

= **368 tph**

The specific gravity of a 20% slurry is about 1.13.

Underflow rate = (368 tph)(2000 #/t)(g/8.34 #)(1/1.13)(h/60 m)

= **1300 gpm**

E. Calculate overflow rate (supernatent) by balancing on total mass

Supernatent out = (Mass of slurry in) – (Mass of sand out) – (Mass of underflow)

= 578 tph – 18.6 tph – 368 tph

= **191 tph**

For a dilute aqueous stream like this, assume specific gravity is essentially 1.0.

Supernatent flow = (191 tph)(2000 #/t)(h/ 60 m)(gal/ 8.34#)

= **800 gpm**

F. Calculate rate of generation of filter cake. Assume all solids from thickener are removed as filter cake at 55% solids.

Mass filter cake = (73.7 tph)/(0.55)

= **134 tph**

The rate of generation of filter cake is 134 tons for every hour that the dredge is running. For an effective day of 17 hours:

Filter cake per day = (134 tph)(17 h)

= **2300 tpd**

G. Calculate rate of filtrate generated. Use a balance on total mass.

Mass filtrate = (Mass of thickener underflow in) – (Mass of filter cake out)

= 368 tph – 134 tph

= **234 tph**

Assume specific gravity of 1.0 for a dilute stream.

Filtrate flowrate = (234 tph)(g/8.34 #)(2000 #/t)(h/ 60 m)

= **900 gpm**

H. Calculate rate of effluent discharge to the river after treatment (i.e. this does not include the return/recycling of various aqueous streams within the system.) Use a balance on total mass.

Mass effluent = (Mass of dredge slurry) – (Mass of sand out) – (Mass of filter cake out)

= 578 tph – 18.6 tph – 134 tph

= **425 tph**

Assume specific gravity of 1.0 for a dilute stream.

Effluent flowrate = (425 tph)(g/8.34 #)(2000 #/t)(h/ 60 m)

= **1700 gpm**

MASS BALANCE **Update: 10.30.03**
DREDGING, DEWATERING, WASTEWATER TREATMENT

Operable Unit 1
Baseline Alternative - Hydraulic dredging to Arrowhead fill, mechanical dewatering, monofill disposal (1)

	A (2) Existing conditions (3)	B Dredge slurry	C Coarse solids to disposal	D Thickener underflow to dewatering	E Thickener supernatant to clarification (4)	F Filter cake to disposal	G Filtrate to clarification	H Treated effluent to discharge
In-place sediment volume, cy	784,000							
Density, ton/cy	0.99		1.5			1.26		
In-place solids, %	24.2							
In-place wet mass, tons	776,000							
In-place dry solids, tons	188,000							
Solids specific gravity	2.51							
Sediment removal rate, cy/hr		186						
Dredge effective time, hr/d		10.8						
Flowrate,gpm		2,100		900	1,200		700	1,900
Solids, %		8%	70%	15%		55%		
Solids, mg/L					2,000		10,600	10
Dry solids, ton/hr		44.2	6.6	37.6		37.6		
Dry solids, ton/d		477	71			406		
Wet solids, tons/d			102			738		
Wet solids, cy/d			68			586		
Wet solids, total project, tons			40,000			290,000		
Volume, total project, cy			27,000			230,000		

Notes:
1. Mass balance is based on a simplifying assumption that the duration of dewatering and water treatment is equal to the effective time of dredging. This results is a conservative sizing of downstream processes. Actual duration may extend over a 24 hour schedule if solids holding capacity is provided.
2. See Process Flow Diagrams (PFDs) for location of letter codes in system.
3. Volumes and sediment physical parameters from Feasibility Study and subject to pre-design confirmation.

4. Aqueous flowrates include forward flow through system. Return flows from downstream processes, as indicated on the PFD, not included.

MASS BALANCE **Update: 10.30.03**
DREDGING, DEWATERING, WASTEWATER TREATMENT

Operable Unit 3
Baseline Alternative - Hydraulic dredging to dewatering basin, monofill disposal

	A (1)	B	C	D	E	F	G
	Existing conditions (2)	Dredge slurry to basin			Basin supernatant to clarification	Dewatered solids to disposal (after drying)	Treated effluent to discharge
In-place sediment volume, cy	587,000						
Density, ton/cy	1.08		N.A.			1.1	
In-place solids, %	37.1						
In-place wet mass, tons	634,000						
In-place dry solids, tons	235,000						
Solids specific gravity	2.47						
Sediment removal rate, cy/hr		195					
Dredge effective time, hr/d		11.7					
Flowrate, gpm		3,100		N.A.	2,300		2,300
Solids, %		8.3%	N.A.	N.A.		40%	
Solids, mg/L					2,100		10
Dry solids, ton/hr		68	N.A.			N.A.	
Dry solids, ton/d		796					
Wet solids, tons/d			N.A.			N.A.	
Wet solids, cy/d			N.A.			N.A.	
Wet solids, total project, tons			N.A.			587,000	
Volume, total project, cy			N.A.			534,000	

Notes:
1. See Block Diagrams (BDs) or Process Flow Diagrams (PFDs) for location of letter codes in system.
2. Volumes and sediment physical parameters are from Feasibility Study and subject to pre-design confirmation.

MASS BALANCE **Update: 10.30.03**
DREDGING, DEWATERING, WASTEWATER TREATMENT

Operable Unit 4
Baseline Alternative - Hydraulic dredging to dewatering basin, monofill disposal

	A (1) Existing conditions (2)	B Dredge slurry to basin	C	D	E Basin supernatant to clarification	F Dewatered solids to disposal (after drying)	G Treated effluent to discharge
In-place sediment volume, cy	5,880,000						
Density, ton/cy	1.05		N.A.			1.1	
In-place solids, %	33.8						
In-place wet mass, tons	6,174,000						
In-place dry solids, tons	2,090,000						
Solids specific gravity	2.36						
Sediment removal rate, cy/hr		254					
Dredge effective time, hr/d		10.1					
Flowrate, gpm		4,100		N.A.	3,100		3,100
Solids, %		8.3%	N.A.	N.A.		40%	
Solids, mg/L					2,100		10
Dry solids, ton/hr		89.4	N.A.			N.A.	
Dry solids, ton/d		902					
Wet solids, tons/d			N.A.			N.A.	
Wet solids, cy/d			N.A.			N.A.	
Wet solids, total project, tons			N.A.			5,220,000	
Volume, total project, cy			N.A.			4,750,000	

Notes:

1. See Block Diagrams (BDs) or Process Flow Diagrams (PFDs) for location of letter codes in system.
2. Volumes and sediment physical parameters are from Feasibility Study and subject to pre-design confirmation.

MASS BALANCE **Update: 10.30.03**
DREDGING, DEWATERING, WASTEWATER TREATMENT

Operable Unit 3
Scenario B - Hybrid dredging to riverside mechanical dewatering (1)

	A (2)	B	C	D	E	F	G	H
	Existing conditions (3)	Dredge slurry	Coarse solids to disposal	Thickener underflow to dewatering	Thickener supernatant to clarification (4)	Filter cake to disposal	Filtrate to clarification	Treated effluent to discharge
In-place sediment volume, cy	587,000							
Density, ton/cy	1.08		1.5			1.26		
In-place solids, %	37.1							
In-place wet mass, tons	634,000							
In-place dry solids, tons	235,000							
Solids specific gravity	2.47							
Sediment removal rate, cy/hr		216						
Dredge effective time, hr/d		15.3						
Flowrate,gpm		2,100		1,300	800		900	1,700
Solids, %		15%	70%	15%		55%		
Solids, mg/L					2,000		16,300	10
Dry solids, ton/hr		86.7	13	73.7		73.7		
Dry solids, ton/d		1322	199			1,128		
Wet solids, tons/d			284			2,050		
Wet solids, cy/d			189			1,627		
Wet solids, total project, tons			50,000			360,000		
Volume, total project, cy			33,000			290,000		

Notes:

1. Mass balance is based on a simplifying assumption that the duration of dewatering and water treatment is equal to the effective time of dredging. This results is a conservative sizing of downstream processes. Actual duration may extend over a 24 hour schedule if solids holding capacity is provided.
2. See Process Flow Diagrams (PFDs) for location of letter codes in system.
3. Volumes and sediment physical parameters from Feasibility Study and subject to pre-design confirmation.

4. Aqueous flowrates include forward flow through system. Return flows from downstream processes, as indicated on the PFD, not included.

MASS BALANCE **Update: 10.30.03**
DREDGING, DEWATERING, WASTEWATER TREATMENT

Operable Unit 4
Scenario B - Hybrid dredging to riverside mechanical dewatering (1)

	A (2)	B	C	D	E	F	G	H
	Existing conditions (3)	**Dredge slurry**	**Coarse solids to disposal**	**Thickener underflow to dewatering**	**Thickener supernatant to clarification (4)**	**Filter cake to disposal**	**Filtrate to clarification**	**Treated effluent to discharge**
In-place sediment volume, cy	5,880,000							
Density, ton/cy	1.05		1.5			1.26		
In-place solids, %	33.8							
In-place wet mass, tons	6,174,000							
In-place dry solids, tons	2,090,000							
Solids specific gravity	2.36							
Sediment removal rate, cy/hr		244						
Dredge effective time, hr/d		17						
Flowrate,gpm		2,100		1,300	800		900	1,700
Solids, %		15%	70%	15%		55%		
Solids, mg/L					2,000		16,300	10
Dry solids, ton/hr		86.7	13	73.7		73.7		
Dry solids, ton/d		1,469	221			1,240		
Wet solids, tons/d			315			2,300		
Wet solids, cy/d			210			1,790		
Wet solids, total project, tons			450,000			3,200,000		
Volume, total project, cy			290,000			2,500,000		

Notes:

1. Mass balance is based on a simplifying assumption that the duration of dewatering and water treatment is equal to the effective time of dredging. This results is a conservative sizing of downstream processes. Actual duration may extend over a 24 hour schedule if solids holding capacity is provided.
2. See Process Flow Diagrams (PFDs) for location of letter codes in system.
3. Volumes and sediment physical parameters from Feasibility Study and subject to pre-design confirmation.

4. Aqueous flowrates include forward flow through system. Return flows from downstream processes, as indicated on the PFD, not included.

Appendix F

Cost Estimate Backup

TECHNICAL MEMORANDUM

TO:	File #15933	**CLIENT:**	WDNR – Fox River
FROM:	FMS	**TASK:**	Change Order 13 - DEA
DATE:	October 30, 2003 (rev. 2)	**RE:**	Cost estimate summaries

Background

This memo documents a series of cost estimates developed to support the DEA. Detailed cost estimate spreadsheets accompany this summary. They are written around specific project elements (technologies or process options). Some estimates are developed more than one time, where there are slight differences in the size of a facility or process for a specific operable unit or remedial scenario.

The series of estimates is as follows:

No.	Project Element	OU	Remedial Alternative Or Scenario For Which This Estimate Is Used	Major Process Assumptions For This Estimate
1.	Hydraulic dredging	OU3 and OU4	Baseline – This estimate includes the capital and operating costs for hydraulic dredging, as anticipated by the Proposed Plan for these OUs Scenario C – This estimate is also used in combination with an upland dewatering landfill (CDF.)	• 6,500,000 cy sediment dredged • 12” dredge • Project duration of up to 10.3 years
2.	Hydraulic transport system	OU3 and OU4	Baseline – This estimate includes the capital and operating costs for a hydraulic transport sytem to an upland dewatering facility, as anticipated by the Proposed Plan for these OUs. Scenario C – The same estimate is used in combination with an upland dewatering landfill (CDF.)	• Total of 18 miles • Up to 11 miles of in-water piping • 7 miles of overland piping
3.	*Reserved*			
4.	Mechanical dewatering system, Type I	OU1	Baseline – This estimate includes the capital and operating costs for a fixed-based mechanical dewatering plant, as anticipated by the Proposed Plan for this OU.	• 784,000 cy sediment dredged • Influent dredge slurry rate of 2100 gpm • Nominal press capacity of 38 tons dry solids per hour • Project duration of 2.3 years
5.	Wastewater treatment system, Type I	OU1	Baseline – This estimate includes the capital and operating costs for a fixed base wastewater treatment plant, as anticipated by the Proposed Plan for this OU.	• Nominal capacity of 2100 gpm • Processes include clarification, granular media filtration, granular activated carbon polishing
6.	NR213 settling basins	OU3 and OU4	Baseline – This estimate includes the capital and operating costs for settling basins used to dewater and dry a hydraulic dredge slurry, as anticipated by the Proposed Plan for this OU.	• 6,500,000 cy sediment dredged • 4 cells at 83 lined acres each • Liner includes 3 ft. of recompacted clay

				• Project duration of 14 years
7.	Wastewater treatment system, Type II	OU3 and OU4	Baseline – This estimate includes the capital and operating costs for treating the wastewater that is generated from the NR213 settling basins, as anticipated by the Proposed Plan for this OU. Scenario B – This estimate is also used to represent the wastewater treatment costs if an upland NR500 dewatering landfill (CDF) were used in place of an NR213 basin and NR500 monofill.	• Nominal capacity of 4100 gpm • Processes include clarification, granular media filtration, granular activated carbon polishing
8.	NR500 monofill, Type A	OU3 and OU4	Baseline – This estimate includes the capital, operating and long-term care costs for developing a new NR500 monofill. The capacity of the monofill is sufficient to receive the dewatered sediments from the NR213 basins.	• Nominal capacity of 5,800,000 tons (5,300,000 cy) of passively dewatered sediment, received @ 40% solids. • Limits of waste = 112 acres • Composite liner, including 4 ft. of recompacted clay and a 60 mil geomembrane. • Composite cover, including a GCL and 40 mil geomembrane
9.	Mechanical dewatering system, Type II	OU3 and OU4	Scenario B – This estimate includes the capital and operating costs for a fixed-base mechanical dewatering plant as a substitute to passive dewatering.	• 6,500,000 cy of sediment removed • Influent dredge slurry rate of 2100 gpm • Nominal press capacity of 74 tons dry solids per hour • 3,560,000 tons filter cake generated at 55% solids • Project duration of 6.4 years
10.	Wastewater treatment system, Type I	OU3 and OU4	Scenario B – This estimate includes the capital and operating costs for treating the wastewater that would be generated from a mechanical dewatering plant for these OUs.	• Nominal capacity of 2000 gpm • Processes include clarification, granular media filtration, granular activated carbon polishing
11.	Plant infra-structure and loadout facility	OU3 and OU4	Scenario B – This estimate includes the capital and operating costs for the infrastructure, conveyance systems, staging areas and loadout facilties for handling solids from a mechanical dewatering operation.	• Onsite staging of up to 3 days of separated sand and filter cake • Use of conveyor systems where possible • Includes project-wide costs of bringing in utilities, on-site office space, etc.
12.	NR500 monofill, Type B	OU3 and OU4	Baseline – This estimate includes the capital, operating and long-term care costs for developing a new NR500 monofill. The capacity of the monofill is sufficient to receive the filter cake from the mechanical dewatering process.	• Nominal capacity of 3,560,000 tons (2,900,000 cy) of mechanically dewatered sediment, received @ 55% solids. • Limits of waste = 49 acres • Composite liner, including 4 ft. of recompacted clay and a 60 mil geomembrane. • Composite cover, including a GCL and 40 mil geomembrane

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13.	NR500 dewatering landfill (CDF)	OU3 and OU4	Scenario C – This estimate includes the capital, operating and long-term care costs for developing a new NR500 dewatering landfill. This disposal option would be a substitute for separate NR213 settling basins and NR500 monofill.	• 6,500,000 cy of sediment removed and conveyed to the facility as a slurry. • Limits of waste = 237 acres. • Composite liner, including 4 ft. of recompacted clay and a 60 mil geomembrane. • Composite cover, including a GCL and 40 mil geomembrane
14.	Barge transport	OU3 and OU4	Scenario D – This estimate includes the operating cost for the barge transport of mechanically dredged sediment.	• 6,500,000 cy of sediment removed. • Offloading facility located near midpoint of OU4.
15.	Barge offloading facility	OU3 and OU4	Scenario D – This estimate includes the capital and operating cost for a riverside facility for the offloading of mechanically dredged sediment.	• Offloading rate sized to match dredging rate (nominal 150 cy/hr.)
19.	Capping	OU1, OU3, OU4	Scenario A – This estimate includes the construction cost and long-term monitoring costs for an in-situ cap.	• Cap thickness of 18 inches. • Armor layer thickness of 6 inches.
20.	Partial removal in conjunction with capping	OU1	Scenario A – This estimate computes an approximate reduction in removal costs if the quantity of sediment is reduced from what was assumed in the baseline alternative. Results are expressed graphically.	• Simplifying assumptions are made to distinquish between fixed capital costs and quantity-proportional costs.

In addition to these detailed cost spreadsheets, other project elements have been estimated as if they were purchased services. These include the following:

No.	Project Element	OU	Remedial Alternative Or Scenario For Which This Estimate Is Used	Major Process Assumptions For This Estimate
16.	Truck transport	OU1, OU3 or OU4	This cost would be applied wherever wet or dewatered sediment was transported by truck, such as from a mechanical dewatering plant to a monofill.	• 20 tons per truck • Roundtrip of 1.5 hours (including loading, travel and unloading)
17.	Vitrification	OU3 and OU4	Scenario B – This estimate includes the capital and operating costs for a fixed base vitrification plant, as estimated by Minergy, Inc. Neenah, WI. It serves as a substitute to disposal in an NR500 monofill for mechanically-dewatered sediment.	• Input to the plant assumed to be 3,560,000 tons of mechanically-dewatered filter cake, @ 55% solids, processed over 7 years • Value of glass produced from the process could be \$2 to \$25 per ton.
18.	Vitrification	OU3 and OU4	Scenario D – This estimate includes the capital and operating costs for a fixed base vitrification plant, as estimated by Minergy, Inc. Neenah, WI. It serves as a substitute to disposal in an NR500 monofill.	• Input to the plant assumed to be7,700,000 tons of mechanically-dredged sediment, @ 30% solids, processed over 10+ years. • Value of glass produced from the process could be \$2 to \$25 per ton.

Assumptions

These estimates take in to account certain process assumptions described in the DEA. Specific assumptions are also documented within the "unit cost backup" of each estimate. Generic assumptions that are common to most or all of the estimates include the following:

- The estimates reflect design concepts only. Final engineering has not yet been performed. The costs will change as the project proceeds.
- Because additional work has been completed, and new data is available, the costs are not strictly comparable to those first developed in the earlier FS. Wherever possible, the costs have been developed "from the ground up" using specific equipment, material and labor estimates.
- Estimates and opinions from contractors and vendors are documented as such. These are "budgetary values" only, and subject to change as the engineering work proceeds. In some cases, the outside opinions have been modified to reflect in-house experience or a particular level of uncertainty.
- Not all of the project elements have been estimated as part of this DEA. For those that have been estimated, the intent is to provide sufficient detail to see the effect of substituting one or more process options.
- For this reason, indirect costs (such as engineering, permitting, construction management, etc.) are generally not included. (The exception to this is for the cost of monofill development. In this case, indirect costs are included so that a total "per ton" cost can be developed and compared to what might be charged on a commercial basis by existing, permitted facilities.)
- Similarly, costs that are common to the remedial project as a whole (such as in-river monitoring, institutional controls, etc.) are not included. The user is referred to the original FS for estimates of these costs.
- In most cases, the estimates are prepared using costs for purchased equipment dedicated specifically to this project, rather than leased equipment out of a contractor's inventory. This includes dredges, barges, wastewater tanks and filters, dewatering presses, etc. To be conservative, no salvage value is included.

Summary of Costs By Alternative or Scenario

Baseline Alternative for OU1 – Hydraulic dredging, mechanical dewatering, NR500 disposal

This alternative was contained in the Proposed Plan, and is evaluated in the DEA as a baseline. The costs for dredging, slurry conveyance and filter cake disposal have not been updated since the original FS. Certain other project elements have been evaluated in further detail and the roll-up of these costs is as follows:

No.	Project Element	Years of Operation	Capital Cost	Annual Operating Cost	Capital Plus Operating Cost (rounded off) (Unit cost based on 784,000 cy sediment removed)
4.	Mechanical dewatering system, Type I	2.3	• From the spreadsheet, capital cost estimated to be on the order of $10.7 M.	• Costs to operate the facility estimated at $1.4M per year (for 2.3 years)	• $14.4 M. • $18/cy of sediment removed
5.	Wastewater treatment system, Type I	2.3	• From the spreadsheet, capital cost estimated to be on the order of $4.9M	• Costs to operate the facility estimated at $0.8M per year (for 2.3 years)	• $6.7 M. • $9/cy of sediment removed
	Plant infrastruc-ture and material loadout	2.3	• An estimate specific to this scenario was not prepared. Assume facility would be slightly smaller than the one developed in Estimate #11. • Assume $3.0 M.	• An estimate specific to this scenario was not prepared. Assume annual costs would be slightly less than those developed in Estimate #11. • Assume $0.6 M per year (for 2.3 years)	• $4.4 M. • $6/cy of sediment removed
16.	Truck transport	2.3	• None	• Annual costs to haul 126,000 tons of filter cake at $6.09/ton = $0.8 M	• $1.8 M • $2.25/cy of sediment removed

Baseline Alternative for OU3 and OU4 – Hydraulic dredging, passive dewatering, NR500 disposal

Certain elements of the remedy contained in the Proposed Plan have been estimated as a baseline. The combination of project elements and roll-up of these costs for this particular remedial alternative is as follows:

No.	Project Element	Years of Operation	Capital Cost	Annual Operating Cost	Capital Plus Operating Cost (rounded off) (Unit cost based on 6,500,000 cy sediment removed)
1.	Hydraulic dredging	10.3	• Capital cost was estimated assuming that all equipment was purchased and dedicated to the project. • Estimated to be on the order of $67.9 M.	• Costs estimated to be on the order of $5.8 M per year (for 10.3 years)	• $67.9 M • $10.45/cy of sediment removed
2.	Hydraulic transport	10.3	• From the spreadsheet, capital cost estimated to be on the order of $7.7 M.	• Costs to operate the system estimated to be on the order of $2.0 M (for 10.3 years)	• $27.7 M • $4.26/cy of sediment removed
6.	NR213 dewatering facility	14	• From the spreadsheet, capital cost estimated to be on the order of $60.8 M.	• Costs to operate the facility estimated at up to $2.9 per year (for 14 years)	• $96.6 M. • $14.86/cy of sediment removed
7.	Wastewater treatment system, Type II	10.3	• From the spreadsheet, capital cost estimated to be on the order of $6.4 M	• Costs to operate the facility estimated at $1.0 M per year (for 10.3 years)	• $16.9 M. • $2.60/cy of sediment removed
8.	NR500 monofill, Type A	10.3	• From the spreadsheet, capital cost estimated to be on the order of $32.4 M.	• The sum of annual operating costs estimated at $67.3 M • The sum of long-term care costs estimated at $10.7 M per year (for 40 years)	• $110.4 M. • $16.98/cy of sediment removed

Scenario A – Adding a residual cap to OU1

This scenario assumes that an in-situ cap would be applied to a portion of OU1, either as a sole remedial action or in combination with a certain amount of sediment removal. The roll-up of cost is as follows:

No.	Project Element	Years of Operation	Capital Cost	Annual Operating Cost	Capital Plus Long-term Monitoring Cost (rounded)
19.	Capping	variable	• A capital cost was estimated on the basis of capping a total of 221 acres. The estimate is $17,300,000.	• Not applicable	• $17,800,000 M • $81,000/acre of sediment capped

Unlike many of the other remedial technologies, the cost for capping is very nearly a true unit cost. This is because the large majority of the cost components are directly proportional to the area capped. For the purposes of the DEA analysis, it is assumed that the per acre cost will apply regardless of the final acreage that might be selected for capping.

Scenario A may also include some amount of sediment removal. It is assumed that this component of the project would be comparable to that described under the baseline alternative (i.e. hydraulic dredging, mechanical dewatering and disposal at an existing monofill.) The extent of dredging that might be combined with capping is variable, however.

The cost of the dredging component of this scenario is not a true unit cost because it consists of a combination of fixed capital costs (to build the dewatering infrastructure, for example) and quantity-proportional operating costs (the dredging and disposal.) The estimates for the individual technologies that comprise the removal alternative are based on an in-place quantity of approximately 784,000 c.y. of sediment. If the quantity of sediment to be dredged is reduced, however, the fixed capital costs would stay the same, and only the operating and disposal costs would decline. This is illustrated in Cost Estimate #20.

Scenario B for OU3 and OU4 – Hybrid dredging, mechanical dewatering, NR500 disposal

This scenario substitutes a hybrid dredging process and riverside mechanical dewatering, in place of the hydraulic dredging and passive dewatering described in the Proposed Plan. The dredging and slurry conveyance costs have not been updated from those in the FS. Other project elements and associated costs would include the following:

No.	Project Element	Years of Operation	Capital Cost	Annual Operating Cost	Capital Plus Operating Cost (rounded) (Unit cost based on 6,500,000 cy sediment removed)
9.	Mechanical dewatering system, Type II	6.4	• From the spreadsheet, capital cost estimated to be on the order of $15.3 M.	• Costs to operate the facility estimated at $4.0 per year (for 6.4 years)	• $41.2 M. • $6.34/cy of sediment removed
10.	Wastewater treatment system, Type I	6.4	• From the spreadsheet, capital cost estimated to be on the order of $4.9M	• Costs to operate the facility estimated at $1.0 M per year (for 6.4 years)	• $11.2 M. • $1.73/cy of sediment removed
11.	Plant infrastruc-ture and material loadout	6.4	• From the spreadsheet, capital cost estimated to be on the order of $4.9 M.	• Annual cost estimated at $0.8 M per year (for 6.4 years) • Long-term care costs estimated at $xx M per year (for 40 years)	• $10.1 M. • $1.55/cy of sediment removed
15.	Truck transport	6.4	• None	• Annual cost to haul 556,000 tons of filter cake = $3.4 M	• $21.7 M. • $3.34/cy of sediment removed
12.	NR500 monofill, Type B	6.4	• From the spreadsheet, capital cost estimated to be on the order of $29.2 M.	• Annual costs, long-term care costs and host community fees are estimated at $51.9 M.	• $81.1 M • $12.48/cy of sediment removed
			or		
17.	Vitrificatio n	6.8	• From Minergy's calculations, capital cost estimated at $79.4 M.	• Annual plant operating cost estimated at $15.6 M per year (for an operating duration of 6.8 years)	• Total cost is offset by value of glass product sold. • Range is estimated at $141 to $182 M. • $21.67 to $27.99/cy of sediment removed.

Scenario C for OU3 and OU4 – Substitute disposal in an upland dewatering landfill

This scenario substitutes the disposal of dredge slurry in an upland dewatering landfill, in place of the separate dewatering and landfill facilities described in the Proposed Plan. The costs of dredging and conveyance have not been updated from those in the FS. Other project elements and associated costs would include the following:

No.	Project Element	Years of Operation	Capital Cost	Annual Operating Cost	Capital Plus Operating Cost (rounded) (Unit cost based on 6,500,000 cy sediment removed)
1.	Hydraulic dredging	10.3	• Capital cost was estimated assuming that all equipment was purchased and dedicated to the project. • Estimated to be on the order of $67.9 M.	• Costs estimated to be on the order of $5.8 M per year (for 10.3 years)	• $67.9 M • $10.45/cy of sediment removed
2.	Hydraulic transport	10.3	• From the spreadsheet, capital cost estimated to be on the order of $7.7 M.	• Costs to operate the system estimated to be on the order of $2.0 M (for 10.3 years)	• $27.7 M • $4.26/cy of sediment removed
7.	Wastewater treatment system, Type II	10.3	• It is assumed that the wastewater treatment facility would be of the same type and capacity as for the OU3 and OU4 baseline alternative, where separate dewatering and landfill facilities were used. • Capital cost estimated on the order of $6.4 M.	• Costs to operate the facility estimated at $1.0 M per year (for 10.3 years)	• $16.9 M. • $2.60/cy of sediment removed
13.	NR500 dewatering landfill	10.3	• From the spreadsheet, capital cost estimated to be on the order of $61.8 M.	• The sum of annual costs, long-term care costs and host community fees are estimated at $82.8 M.	• $144.6 M • $22.25/cy of sediment removed

Scenario D for OU3 and OU4 – Substitute mechanical dredging and disposal/treatment via vitrification

This scenario substitutes mechanical dredging and the treatment of the dredged solids via vitrification. The costs of dredging have not been updated from those in the FS. Other project elements and associated costs would include the following:

No.	Project Element	Years of Operation	Capital Cost	Annual Operating Cost	Capital Plus Operating Cost (rounded) (Unit cost based on 6,500,000 cy sediment removed)
14.	Barge transport	10.3	• From the spreadsheet, capital cost estimated on the order of $6.3 M (for the purchase of deck barges only.)	• All other costs are operating costs, at a total of $41.7 M (both OUs)	• $48 M. • $12.66/cy of sediment removed in OU3 • $6.90/cy of sediment removed in OU4
15.	Barge offloading facility	10.3	• From the spreadsheet, capital cost estimated on the order of $2.1 M.	• Annual costs for offloading and transfer operations estimated on the order of $1.8 M per year.	• $20.5 M • $3.15/cy of sediment removed
16.	Truck transport	10.3	• None	• Annual costs to haul 733,000 tons of sediment at $6.09/ton = $4.5 M	• $46.9 M • $7.22/cy of sediment removed
18.	Vitrificatio n	10.3	• From Minergy's calculations, capital cost estimated at $79.4 M.	• Annual plant operating cost estimated at $19.6 M per year (for an operating duration of 10.5 years)	• Total cost is offset by value of glass product sold. • Range is estimated at $225 to $280 M. • $34.57 to $43.06/cy of sediment removed.

PROJECT ELEMENT:
Hydraulic dredging
Baseline Alternative - OU3 and OU4

PROCESS METRICS

Total volume sediment removed from river	6,500,000 cy
Duration of dredging operations	10.3 years

COST SUMMARY

	Total Cost (1)	Total as Present Worth (2)
Subtotal, capital costs	$8,300,000	$8,300,000
Annual operating cost	$5,800,000	
Total, capital plus annual operating costs	$67,900,000	$49,800,000
Cost per cy sediment removed	$10.45	$7.66

Notes

1. The "total cost" does not discount the multi-year operating costs.
2. The "present worth" discounts all construction and operating costs. The discount rate is 7% (USEPA, "Guide to Developing and Documenting Cost Estimates During the Feasibility Study," July 2000).
3. "Cost per cy sediment removed" values are for informational purposes only. Values are not true unit costs because they represent a combination of fixed capital and quantity-proportional components.

CAPITAL COSTS

	Item	Units	Quantity	Unit Cost	Extension
Purchased Equipment					
K.1	Dredge	ea	2	$650,000	$1,300,000
K.2	Booster pumps	ea	3	$200,000	$600,000
K.3	In-water slurry pipe	ft	125,400	$12	$1,504,800
K.4	Work boat	ea	3	$225,000	$675,000
K.5	Flat deck barge	ea	2	$350,000	$700,000
K.6	Landing barge	ea	1	$100,000	$100,000
K.7	Ancillary equipment (cutterhead, swing anchors, discharge hose, cranes, HVAC, meters)	ls	1	$100,000	$100,000
K.8	Shore equipment	ls	1	$500,000	$500,000
	Subtotal, purchased equipment				$5,479,800
Civil Work					
C.1	Shoreline improvements	ls	1	$250,000	$250,000
C.2	Floating dock with piling	ls	1	$75,000	$75,000
C.3	Field office	ls	1	$25,000	$25,000
Electrical					
E.1	Yard lighting	ls	1	$50,000	$50,000
	Subtotal, purchased equipment and trades				$5,879,800
	Mobilization, demobilization, general conditions (% of above)		8%		$470,384
	Freight (% of purchased equipment)		5%		$273,990
	Prime contractor administration, overhead & profit (% of above)		25%		$1,656,044
	TOTAL DIRECT CAPITAL				$8,280,218

Notes

1. Unit cost backup provided on subsequent sheets

ANNUAL OPERATING COSTS

	Item	Units	Quantity	Unit Cost	Extension
	Purchased materials & services				
O.1	Fuel	day	245	$3,600	$882,000
O.2	Debris sweep	ac	40	$16,000	$640,000
	Operations labor				
O.10	Dredge crew (operator, engineer, boat operator, 2-person deck crew, boat operator, deck hand)	day	245	$6,008	$1,471,960
O.11	Shore crew (equipment operator, oiler, laborer)	day	245	$1,752	$429,240
O.12	Supervision (superintendent, field engineer)	day	245	$2,140	$524,300
O.13	Surveyor (QC)	day	245	$1,200	$294,000
	Leased land				
O.20	Staging area	ls	1	$20,000	$20,000
	Utilities				
O.30	Electricity	mo	8	$3,000	$24,000
O.31	Telephone	mo	8	$500	$4,000
	Subtotal				$4,289,500
	Mobilization, demobilization, general conditions (% of above)			8%	$343,160
	Prime contractor administration, overhead & profit (% of above)			25%	$1,158,165
	TOTAL ANNUAL OPERATIONS				$5,790,825

Notes

1. Unit cost backup provided on subsequent sheets

PRESENT WORTH CALCULATION

i = 7%

Year, n	Capital Costs (Construction and Equipment)	Annual Operations	Sum of Year "n" Costs	Cumulative Costs, Year 1 through n	Present Worth Factor, i	Present Worth of Capital Costs Only	Present Worth of Year "n" Costs	Cumulative Present Worth, Year 1 through n
0	$8,280,218		$8,280,218	$8,280,218	1	$8,280,218	$8,280,218	$8,280,218
1		$5,790,825	$5,790,825	$14,071,043	0.9346	$0	$5,411,986	$13,692,203
2		$5,790,825	$5,790,825	$19,861,868	0.8734	$0	$5,057,931	$18,750,134
3		$5,790,825	$5,790,825	$25,652,693	0.8163	$0	$4,727,038	$23,477,172
4		$5,790,825	$5,790,825	$31,443,518	0.7629	$0	$4,417,793	$27,894,965
5		$5,790,825	$5,790,825	$37,234,343	0.7130	$0	$4,128,778	$32,023,743
6		$5,790,825	$5,790,825	$43,025,168	0.6663	$0	$3,858,671	$35,882,415
7		$5,790,825	$5,790,825	$48,815,993	0.6227	$0	$3,606,235	$39,488,649
8		$5,790,825	$5,790,825	$54,606,818	0.5820	$0	$3,370,313	$42,858,962
9		$5,790,825	$5,790,825	$60,397,643	0.5439	$0	$3,149,825	$46,008,787
10		$5,790,825	$5,790,825	$66,188,468	0.5083	$0	$2,943,762	$48,952,549
11		$1,737,248	$1,737,248	$67,925,715	0.4751	$0	$825,354	$49,777,903
Totals	$8,280,218		$67,925,715			$8,280,218	$49,777,903	

BASIS OF UNIT COSTS

I.D.	Item	Source	Description	Value or Range Provided (rounded)	Value Used for Estimate (rounded)	Basis
K.1	Dredge	Vendor budgetary estimate (Ellicott Division of Baltimore Dredges LLC, Baltimore, MD)	Sediment removal equipment consisting of 12 inch hydraulic pipeline cutterhead dredge, 670 Dragon Series, 750 HP total	$650,000	$650,000	Vendor quote
K.2	Booster pumps	Vendor budgetary estimate (Ellicott Division of Baltimore Dredges LLC, Baltimore, MD)	Pump to transport dredge slurry from dredge location in the river to shoreline. 12-inch 650 HP booster pump	$200,000	$200,000	Vendor quote
K.3	In-water slurry pipe	Contractor estimate based on typical work and similar experience	19 miles of 12 inch HDPE pipe for transporting sediment slurry in-water. Assume 25% of pipe to be replaced over duration of the project.	$12	$12	Typical cost for similar work. Length is based on 2 dredges, located at maximum distance in OU4 from riverside take-out point, plus replacement. Length is conservatively high. Length of overland pipe (to an upland facility) not included in this element.
K.4	Work boat	Vendor budgetary estimate (Ellicott Division of Baltimore Dredges LLC, Baltimore, MD)	Three work boats. 22' aluminum work boat with outboard 200HP gas engine, 25' x 8' steel work boat or dredge tender with 200HP diesel, 30' x 10 steel dredge tender or push boat with 200HP diesel	$205,570	$225,000	Vendor quote: 22 ft Aluminum work boat - $34,160. 25 ft by 8 ft steel work boat - $73,810. 30 ft by 10 ft steel dredge tender - $97,600. Total work boats = $205,570. Use $225,000
K.5	Flat deck barge	Vendor budgetary estimate (Ellicott Division of Baltimore Dredges LLC, Baltimore, MD)	Flat deck work barges, one for removal of debris and other for hauling equipment. Barge size 120 ft by 40 ft by 6 ft steel hull deck barge	$341,000	$350,000	Vendor quote. $341,000 per barge.
K.6	Landing barge	Vendor budgetary estimate (Ellicott Division of Baltimore Dredges LLC, Baltimore, MD)	Landing barge to support shoreline activities. Barge size 60 ft by 20 ft by 6 ft steel hull landing barge	$97,600	$100,000	Vendor quote. $97,600 per barge.
K.7	Ancillary equipment (cutterhead, swing anchors, discharge hose, cranes, HVAC, meters)	Vendor budgetary estimate (Ellicott Division of Baltimore Dredges LLC, Baltimore, MD)	Miscellaneous equipment required for dredging not included in the dredge capital cost	$100,000	$100,000	Vendor quote
K.8	Shore equipment	Typical cost for similar work	Front end loader (CAT 950), 2 pickups, rubber tire hydraulic excavator (CAT 320), welder, truck (flatbed)	$500,000	$500,000	Typical equipment cost. Front end loader - $175,000, pickup at $30,000, excavator at $175,000, welder at $20,000 and truck at $100,000. Use $500,000
C.1	Shoreline improvements	Contractor opinion for similar work and typical experience	Shoreline improvements to facilitate equipment to be staged and personnel to work around the site. Include gravel access road, material laydown area, fencing, etc.		$250,000	Typical cost for similar work
C.2	Floating dock with piling	Contractor opinion for similar work and typical experience	Floating dock with piling to facilitate entry of personnel and equipment		$75,000	Typical cost for similar work
C.3	Field office	Means Sitework (2000)	Pre-fabricated office, trailer style, 50 ft by 12 ft, purchased	$18,900	$25,000	Means, # 01520_0550. Add allowance for site prep, installation and weatherization
E.1	Yard lighting	Contractor opinion (Boudry Control Panels, LLC, Fond du Lac, Wi)	Overhead industrial lighting in staging areas, acess road, lighting for office trailer		$50,000	Past experience is approximately 7 pole lights per acre, which seems high for this project. At least 2 acres require coverage. Assume 10 poles at $2,500 each, plus incidental costs. Assume cost of bringing in service to site is included with wastewater treatment element. Use $50,000.

BASIS OF UNIT COSTS

I.D.	Item	Source	Description	Value or Range Provided (rounded)	Value Used for Estimate (rounded)	Basis
O.1	Fuel	In-house estimate based on vendor estimate	Total fuel consumption for dredge and in-water booster pumps assuming 30 gal/hr consumption. Cost is delivered.		$3,600	Fuel consumption per dredge and per booster pump - 30 gal/hr. Average dredge effective time (over a 24 hr workday) = 12 hours per day. Total fuel consumption per 2 dredges = (30 gal/hr)(12 hr/day)(2) = 720 gal/d. Total fuel consumption per 3 booster pumps = (30 gal/hr)(12 hr/d)(3) = 1080 gal. Combined usage = 1800 gal/day. Assume $2 per gallon of diesel fuel delivered. Use $3600/day.
O.2	Debris sweep	Consultant estimate (Ogden Beeman, Portland, OR)	This item involves picking up debris from the river using conventional equipment. Assume debris sweeping applicable for 30% of the total work area	$16,000	$16,000	Total area in OU 3 and 4 = 1362 acres. 30% of the total area = 408.6 acres. Use 410 acres. Dredge duration = 10.3 years. Therefore 40 acres per year.
O.10	Dredge crew (operator, engineer, boat operator, 2-person deck crew, boat operator, deck hand)	Contractor opinion (Union rates provided by Pitz McMullen, WI)	Cost of crew to operate dredge, on a per day basis. A work day is assumed to be 24 hrs for this scenario. Shifts are nominally 8 hr each. Marine pay scale.			
		Labor - $30 per hr	Operator - 8 hrs * 3 shifts: (24 hrs)($30/hr) = $720	$720		
		Labor - $30 per hr	Engineer - 8 hrs * 3 shifts: (24 hrs)($30/hr) = $720	$720		
		Labor - $23 per hr	Boat operator - 8 hrs * 3 shifts: (24 hrs)($23/hr) = $552	$552		
		Labor - $23 per hr	Deck crew (2 person) - 10 hrs * 1 shifts: (2)(10 hr)($23/hr) = $460	$460		
		Labor - $23 per hr	Deck hand - 8 hrs * 3 shifts: (24 hrs)($23/hr) = $552	$552		
			Subtotal, dredge crew daily cost		**$6,008**	Cost is doubled to reflect 2 dredges operating in paralell.
O.11	Shore crew (equipment operator, oiler, laborer)	Contractor opinion (Union rates provided by Pitz McMullen, WI)	Cost of shore crew supporting dredge operations, on a per day basis. A work day is assumed to be 24 hrs for this scenario. Shifts are nominally 8 hr each. Marine pay scale.			
		Labor - $27 per hour	Equipment operator - 8 hrs * 3 shifts: (24 hrs)($27/hr) = $648	$648		
		Labor - $23 per hr	Oiler - 8 hrs * 3 shifts: (24 hrs)($23/hr) = $552	$552		
		Labor - $23 per hr	Laborer - 8 hrs * 3 shifts: (24 hrs)($23/hr) = $552	$552		
		Use avg labor of $ 25 per hour	**Subtotal, shore crew**		**$1,752**	
O.12	Supervision (superintendent, field engineer)	Contractor opinion.	Cost of dredging operations supervision, on a per day basis. Union rates not applicable.			
		Labor - $ 70 per hr	Site supervisor - 10 hrs * 1 shifts: (10 hrs)($70/hr) = $700	$700		
		Labor - $ 60 per hr	Field engineer - 8 hrs * 3 shifts: (24 hrs)($60/hr) = $1440	$1,440		
		Use avg labor of $ 65 per hr	**Subtotal, supervision**		**$2,140**	

BASIS OF UNIT COSTS

I.D.	Item	Source	Description	Value or Range Provided (rounded)	Value Used for Estimate (rounded)	Basis
O.13	Surveyor (QC)	Contractor opinion. Union rates not applicable.	Survey support for pre- and post-dredge progress surveys, on a per day basis. 10 hrs*1 shift*2 persons: (20 hrs)($60/hr) = $1200		$1,200	
O.20	Staging area	In-house experience in the vicinity	Staging area for office trailer, equipment and materials. Assume 4 acres of land is leased, at $5,000 per acre per year.		$20,000	Placeholder only, until site is selected.
O.30	Electricity	Typical experience	Monthly power requirements for office trailer and industrial lighting in staging area		$3,000	Placeholder, monthly estimated cost.
O.31	Telephone	General experience	Cost of phone connection and monthly usage charges		$500	Placeholder, monthly estimated cost.

COST ESTIMATE #02 **Rev: 10.30.03**
DETAILED EVALUATION OF ALTERNATIVES **Final**
WDNR - FOX RIVER

PROJECT ELEMENT:
Hydraulic transport system
Baseline Alternative - OU3 and OU4

PROCESS METRICS

Total volume sediment removed from river	6,500,000	cy
Length of operations	10.3	yr

COST SUMMARY

	Total Cost (1)	Total as Present Worth (2)
Subtotal, capital costs	$7,700,000	$7,700,000
Annual operating cost	$2,000,000	
Total, capital plus annual operating costs	$27,700,000	$21,700,000
Cost per cy sediment removed	$4.26	$3.34

Notes

1. The "total cost" does not discount the multi-year operating costs.
2. The "present worth" discounts all construction and operations costs. The discount rate is 7% (USEPA, "Guide to Developing and Documenting Cost Estimates During the Feasibility Study," July 2000).
3. "Cost per cy sediment removed" values are for informational purposes only. Values are not true unit costs because they represent a combination of fixed capital and quantity-proportional components.

CAPITAL COSTS

Item		Units	Quantity	Unit Cost	Extension
Purchased Equipment					
K.1	Slurry pipe	lf	92,400	$12	$1,108,800
K.2	Booster pump	ea	6	$200,000	$1,200,000
K.3	Pre-engineered pump house	ea	6	$15,000	$90,000
	Subtotal, purchased equipment				$2,398,800
Civil Work					
C.1	Site preparation	ac	20	$75,000	$1,527,273
C.2	Lay slurry pipe	lf	73,920	$6	$443,520
C.3	Road crossing	ea	12	$50,000	$600,000
C.4	Pump house site work & foundation	ea	6	$10,000	$60,000
C.5	Remove slurry pipe	lf	73,920	$3	$221,760
C.6	Land surface restoration	ls	1	$300,000	$300,000
Electrical					
E.1	Power supply to pump house	ea	3	$10,000	$30,000
E.2	Wiring and controls	ea	3	$25,000	$75,000
	Subtotal, purchased equipment and trades				$5,581,353
	Mobilization, demobilization, general conditions (% of above)			8%	$446,508
	Freight (% of purchased equipment)			5%	$119,940
	Prime contractor administration, overhead & profit (% of above)			25%	$1,536,950
	TOTAL DIRECT CAPITAL				$7,684,751

Notes

1. Unit cost backup provided on subsequent sheets

ANNUAL OPERATING COSTS

	Item	Units	Quantity	Unit Cost	Extension
	Operations				
O.1	Routine operations and maintenance	day	245	$2,000	$490,000
O.2	Winterization	ls	1	$300,000	$300,000
	Leased Land				
O.10	Pipeline route	ls	1	$50,000	$50,000
	Utilities				
O.20	Electricity	mo	8	$80,000	$640,000
	Subtotal				$1,480,000
	Mobilization, demobilization, general conditions (% of above)			8%	$118,400
	Prime contractor administration, overhead & profit (% of above)			25%	$399,600
	TOTAL ANNUAL OPERATIONS				$1,998,000

Notes

1. Unit cost backup provided on subsequent sheets

PRESENT WORTH CALCULATION

i = 7%

Year, n	Capital Costs (Construction and Equipment)	Annual Operations	Sum of Year "n" Costs	Cumulative Costs, Year 1 through n	Present Worth Factor, i	Present Worth of Capital Costs Only	Present Worth of Year "n" Costs	Cumulative Present Worth, Year 1 through n
0	$7,684,751		$7,684,751	$7,684,751	1	$7,684,751	$7,684,751	$7,684,751
1		$1,998,000	$1,998,000	$9,682,751	0.9346	$0	$1,867,290	$9,552,041
2		$1,998,000	$1,998,000	$11,680,751	0.8734	$0	$1,745,131	$11,297,171
3		$1,998,000	$1,998,000	$13,678,751	0.8163	$0	$1,630,963	$12,928,135
4		$1,998,000	$1,998,000	$15,676,751	0.7629	$0	$1,524,265	$14,452,399
5		$1,998,000	$1,998,000	$17,674,751	0.7130	$0	$1,424,546	$15,876,946
6		$1,998,000	$1,998,000	$19,672,751	0.6663	$0	$1,331,352	$17,208,297
7		$1,998,000	$1,998,000	$21,670,751	0.6227	$0	$1,244,254	$18,452,551
8		$1,998,000	$1,998,000	$23,668,751	0.5820	$0	$1,162,854	$19,615,406
9		$1,998,000	$1,998,000	$25,666,751	0.5439	$0	$1,086,780	$20,702,185
10		$1,998,000	$1,998,000	$27,664,751	0.5083	$0	$1,015,682	$21,717,867
11		$599,400	$599,400	$28,264,151	0.4751	$0	$284,771	$22,002,638
Totals	$7,684,751		$27,664,751			$7,684,751	$21,717,867	

BASIS OF UNIT COSTS

I.D.	Item	Source	Description	Value or Range Provided (rounded)	Value Used for Estimate (rounded)	Basis
K.1	Slurry pipe	Vendor budgetary estimate (Ellicott Division of Baltimore Dredges LLC, Baltimore, MD)	14 miles (2 parallel runs of 7 miles) of 12-inch steel pipe for transporting sediment slurry from shoreline to upland dewatering facility. Assume 25% of pipe to be replaced over duration of the project, for a total of 92,400 lf of pipe purchased.	$12	$12	Vendor quote.
K.2	Booster pump	Vendor budgetary estimate (Ellicott Division of Baltimore Dredges LLC, Baltimore, MD)	Pump to transport dredge slurry from shoreline to dewatering facility. 12-inch 650 HP booster pump. Estimate of 3 upland pumps required.	$200,000	$200,000	
K.3	Pre-engineered pump house	In house opinion based on similar projects	Pre-fabricated building, 25 ft by 25 ft by 10 ft for housing upland booster pumps.		$15,000	Typical cost for small, pre-engineered metal buildings on similar projects.
C.1	Site preparation	Typical experience	Prepare access to route and clear and grub vegetation prior to laying pipeline		$75,000	Typical clear and grub cost of $2100/acre. Minimum 20 acres required along route. Include allowance for temporary access roads, other local earthwork, etc. Use $75,000.
C.2	Lay slurry pipe	Contractor opinion and typical experience	Cost to lay overland slurry pipe. Assume at-grade placement, except at road crossings.		$6	Labor: ($20/hr)(10 hrs/d)(3) = $600 per day plus supervision. Use $1000/day. Equipment: $5000/day. Production = 1500 ft/day. 50 days required for laying 73,920 ft of pipe. Total labor & equipment = ($6000/day)(50 day) = $300,000, or $4/lf. Add bedding material and allowance for miscellaneous items not yet determined. Use $6 per foot
C.3	Road crossing	Typical experience	Open cut or jack and bore 12-inch sediment slurry steel pipe at road crossings		$50,000	Typical cost for similar work.
C.4	Pump house site work & foundation	Builder opinion (Howard Immel, Inc., Green Bay, WI)	Assume min of 4-inch slab for the pump house and 25 ft by 25 ft.		$10,000	4 inch slab for $2.50/sf. Assume 25 ft by 25 ft slab = 625 sf. Include site prep, gravel entrance and allowance for minor items not yet defined. Use $10,000.
C.5	Remove slurry pipe	Contractor opinion and typical experience	Cost to remove slurry pipe.		$3	Labor: ($20/hr)(10 hr/d)(3) = $600/d plus supervision. Use $1000/day. Equipment: $5000/day. Production = 2500 ft./day. 30 days for laying 73,920 ft of pipe. Total labor & equipment = ($6000/d)(30 d) = $180,000, or $2.43/lf. Add allowance for miscellaneous items. Use $3/lf.
C.6	Land surface restoration	Typical experience	Demolition of pump house slabs and pump houses, site regrading, restore road crossings and material disposal		$300,000	Placeholder, typical cost for similar work.
E.1	Power supply to pump house	Typical cost for similar work	Electrical service to pump houses		$10,000	Placeholder, pending site selection and final engineering.
E.2	Wiring and controls	Typical cost for similar work	Local panels, wiring, instrumentation and lighting at pump house		$25,000	Typical cost for similar work.
O.1	Routine operations and maintenance	Contractor opinion and typical experience	Daily cost for maintenance labor and materials on pipeline.		$2,000	Typical experience, similar projects. Assume 1 field engineer, 1 technician. Engineer: (10 hr/day)($ 60/hr) = $600/day. Technician: (18 hr/day)($25/hr) = $450/day. Include pickup truck, materials, etc. Use $2000/day.

BASIS OF UNIT COSTS

I.D.	Item	Source	Description	Value or Range Provided (rounded)	Value Used for Estimate (rounded)	Basis
O.2	Winterization	Typical experience	Includes equipment lockdown, draining of pipeline. Include an allowance of $10,000 per month for security during 4 months of winter downtime.		$300,000	Placeholder, typical cost for similar work.
O.10	Pipeline route	Typical experience	Cost to lease land or payments for right-of-way access for overland dredge slurry pipeline (from river to dewatering facility.) Assume up to 25 land owners or affected parties, with an average annual payment of $2,000. Use a placeholder of $50,000 per year.		$50,000	Placeholder only, pending route selection.
O.20	Electricity	Typical experience	Monthly electricity costs for operating booster pumps	$73,300	$80,000	Total motor HP for 6 booster pumps = (650 HP)(6) = 3900 HP = 2910 Kw. Average dredge effective time per day = 12 hours. Therefore total Kw*hr per day = (2910 Kw)(12 hr/day) = 34,920 Kw*hr/d = 1,047,000 Kw*hr/mo. Assume $0.07 per Kw*hr. Monthly cost = $73,300. Use $80,000.

COST ESTIMATE #04 **Rev: 10.30.03**
DETAILED EVALUATION OF ALTERNATIVES **Final**
WDNR - FOX RIVER

PROJECT ELEMENT:
Mechanical dewatering plant, Type I
Baseline Alternative - OU1

PROCESS METRICS

Total volume sediment removed from river	784,000	cy
Total wet tons filter cake (at 55% solids) generated from this volume of sediment	290,000	ton
Length of operations	2.3	yr

COST SUMMARY

	Total Cost	**Total as Present Worth**	
Subtotal, construction costs	$11,000,000	$11,000,000	
Total, construction plus operating costs	$14,400,000	$14,000,000	
Cost per cy sediment removed	$18.37	$17.86	/cy
Cost per ton filter cake disposed	$49.66	$48.28	/ton

Notes

1. This estimate is based on the major processes/equipment identified in the accompanying drawing, "Process Flow Diagram for Solids Dewatering." It is based on preliminary concepts, and is suitable only as a general indicator of eventual project costs. It will change as final engineering and detailed design work proceed.
2. The Type I facility is sized to accommodate a dredge slurry flowrate of up to 2,100 gpm and dewatering with a press capacity of 38 tons dry solids per hour.
3. It assumes that the plant is constructed as a fixed-base, semi-permanent facility. Equipment is purchased, with no salvage value at end of project. Site infrastructure (roads, offices, etc.) common to the larger project are not included, and will be estimated elsewhere. Indirect capital costs (engineering, construction management, etc.) are not included.
4. The "total cost" does not discount the multi-year operating costs.
5. The "present worth" discounts all construction and operations costs over the active life of the facility. The discount rate is 7% (USEPA, "Guide to Developing and Documenting Cost Estimates During the Feasibility Study", July 2000).
6. "Cost per ton" and "cost per cy" values are for informational purposes only. Values are not true unit costs because they represent a combination of fixed capital and flow-proportional components.

CAPITAL COSTS

	Item	Units	Quantity	Unit Cost (1)	Extension
Purchased Equipment					
K.1	Coarse material separation equipment	ls	1	$500,000	$500,000
K.2	Thickener	ea	1	$300,000	$300,000
K.3	Thickener solids pump (plus spare)	ea	3	$20,000	$60,000
K.4	Press feed tank and agitator	ea	2	$135,000	$270,000
K.5	Press feed pump (plus two spare)	ea	8	$15,000	$120,000
K.6	Press	lot	1	$2,100,000	$2,100,000
K.7	Filtrate forwarding pump (plus two spare)	ea	8	$6,200	$49,600
K.8	Chemical feed system	ea	2	$20,000	$40,000
	Subtotal, major equipment				$3,439,600
K.9	Minor equipment & support facilities	% of major equipment		25%	$859,900
	Subtotal, purchased equipment				$4,299,500
Mechanical Work					
M.1	Equipment erection	% of equipment	1	15%	$644,925
M.2	Process piping	% of equipment	1	30%	$1,289,850
M.3	Building HVAC	ls	1	$150,000	$150,000
M.4	Site restoration	ls	1	$150,000	$150,000
Electrical Work					
E.1	Service entrance	ls	1	$0	$0
E.2	Main panels	ls	1	$0	$0
E.3	Process electrical & instrumentation	% of equipment	1	20%	$859,900
E.4	Primary control panel/package	ls	1	$0	$0
E.5	Building lighting	ls	1	$8,000	$8,000
Structural					
S.1	Building	sf	7,800	$50	$390,000
S.2	Building foundation	ls	1	$115,000	$115,000
S.3	Outside tank foundations	ls	1	$38,000	$38,000
	Subtotal, purchased equipment and trades				$7,945,175
	Mobilization, demobilization, general conditions (% of above)			8%	$635,614
	Freight (% of purchased equipment)			5%	$214,975
	Prime contractor administration, overhead & profit (% of above)			25%	$2,198,941
	TOTAL DIRECT CAPITAL				$10,994,705

Notes

1. Unit cost backup provided on subsequent sheets

ANNUAL OPERATING COSTS

	Item	Units	Quantity	Unit Cost (1)	Extension
	Purchased materials				
O.1	Polymer	ls	1	$415,000	$415,000
	Operations labor				
O.10	Wastewater technician	hrs	9,500	$35	$332,500
O.11	Certified operator	hrs	0	$50	$0
O.12	Project manager	hrs	350	$75	$26,250
	Maintenance labor & materials				
O.20	Maintenance & replacement parts	% of equipment	5%	$4,299,500	$214,975
	Utilities				
O.30	Electricity				$108,133
	Subtotal				$1,096,858
	Mobilization, demobilization, general conditions (% of above)			8%	$87,749
	Prime contractor administration, overhead & profit (% of above)			25%	$296,152
	TOTAL ANNUAL OPERATIONS				$1,480,758

Notes

1. Unit cost backup provided on subsequent sheets

ANNUAL ELECTRICAL COSTS

	Item	Total Motor HP	Kw	Operating Time Per Day (1)	Kw*hr per day
E.1	Coarse material separation equipment (sum of HP for individual components of system)	99	73.9	12	886
E.2	Thickener	5	3.7	12	45
E.3	Thickener solids pump (assume 2 at 20 HP)	40	29.8	12	358
E.4	Press feed tank and agitator (assume 2 agitators at 40 HP)	80	59.7	24	1432
E.5	Press feed pump (assume 6 at 5 HP)	30	22.4	12	269
E.6	Press (6 machines w/ 2 - 10 HP & 1 - 2 HP)	132	98.5	12	1,182
E.7	Filtrate forwarding pump (assume 6 at 5 HP)	30	22.4	12	269
E.8	Chemical feed system (assume 2 at 1 HP)	2	1.5	12	18
	Subtotal, major equipment				4,458
E.9	Minor equipment & support facilities not yet defined	50	37.3	12	448
	Subtotal, all equipment (kw*hr/day)				4,906
	Number of operating days per year				245
	Cost of electricity ($/kw*hr)				$0.07
	Subtotal, electricity for equipment				$84,133
			Months	$/month	Extension
O.30	Lighting, ventilation & occasional minor heating of press building	month	8	3,000	$24,000
	TOTAL ANNUAL ELECTRICAL				$108,133

Notes

1. To be conservative, the daily operating time for system is assumed to be slightly longer than the typical daily dredge effective time.

PRESENT WORTH CALCULATION

i = 7%

Year, n	Capital Costs (Construction)	Annual Operations	Sum of Year "n" Costs	Cumulative Costs, Year 1 through n	Present Worth Factor, i	Present Worth of Year "n" Construction Costs Only	Present Worth of All Year "n" Costs
0	$10,994,705		$10,994,705	$10,994,705	1	$10,994,705	$10,994,705
1		$1,480,758	$1,480,758	$12,475,463	0.9346	$0	$1,383,886
2		$1,480,758	$1,480,758	$13,956,221	0.8734	$0	$1,293,351
3		$444,227	$444,227	$14,400,448	0.8163	$0	$362,622
4			$0	$14,400,448	0.7629	$0	$0
5			$0	$14,400,448	0.7130	$0	$0
6			$0	$14,400,448	0.6663	$0	$0
7			$0	$14,400,448	0.6227	$0	$0
8			$0	$14,400,448	0.5820	$0	$0
9			$0	$14,400,448	0.5439		$0
10			$0	$14,400,448	0.5083		$0
11			$0	$14,400,448	0.4751		$0
12			$0	$14,400,448	0.4440		$0
13			$0	$14,400,448	0.4150		$0
14			$0	$14,400,448	0.3878		$0
15			$0	$14,400,448	0.3624		$0
16			$0	$14,400,448	0.3387		$0
17			$0	$14,400,448	0.3166		$0
18			$0	$14,400,448	0.2959		$0
19			$0	$14,400,448	0.2765		$0
20			$0	$14,400,448	0.2584		$0
21			$0	$14,400,448	0.2415		$0
22			$0	$14,400,448	0.2257		$0
23			$0	$14,400,448	0.2109		$0
24			$0	$14,400,448	0.1971		$0
25			$0	$14,400,448	0.1842		$0
26			$0	$14,400,448	0.1722		$0
27			$0	$14,400,448	0.1609		$0
28			$0	$14,400,448	0.1504		$0
29			$0	$14,400,448	0.1406		$0
30			$0	$14,400,448	0.1314		$0
31			$0	$14,400,448	0.1228		$0
32			$0	$14,400,448	0.1147		$0
33			$0	$14,400,448	0.1072		$0
34			$0	$14,400,448	0.1002		$0
35			$0	$14,400,448	0.0937		$0
36			$0	$14,400,448	0.0875		$0
37			$0	$14,400,448	0.0818		$0
38			$0	$14,400,448	0.0765		$0
39			$0	$14,400,448	0.0715		$0
40			$0	$14,400,448	0.0668		$0
Totals	$10,994,705	$3,405,743	$14,400,448			$10,994,705	$14,034,564

BASIS OF UNIT COSTS

I.D.	Item	Source	Description	Value or Range Provided (rounded)	Value Used for Estimate (rounded)	Basis
K.1	Coarse material separation equipment	Vendor budgetary estimate (Del Tank&Filtration Systems, Lafayette, LA)	Separation equipment consisting of tank, shakers desanding manifolds, and hydrocylone feed pumps. Quote based on flow of 2,000 gpm with recommendation for two units for 3,000 gpm.	$500,000	$500,000	Use quote provided by Del for 2,000 gpm, assuming 1 unit required to accommodate a dredge slurry flowrate of up to 2,100 gpm (Type I system).
K.2	Thickener	Vendor budgetary estimate (WesTech, Rockton, IL)	HiFlo thickener mechanism and steel tank. 50' dia. Total depth of 25'. Sized for nominal 4,000 gpm slurry influent.	$300,000 - $400,000		Interpolated from quote provided by WesTech for dewatering and wastewater treatment package.
		Vendor opinion (EIMCO, Pittsburgh)	Thickener mechanism and steel tank. 80' dia. Total depth 15'. Sized for overflow of 2,500 gpm at a rate of 0.5 gpm per sf. Expected underflow solids 20% to 25%.	$350,000		
		Summary:			$300,000	For Type I system (2,000 gpm), use lower end of estimate.
K.3	Thickener solids pump (plus spare)	Vendor budgetary estimate (A.A. Anderson Company, Waukesha, WI)	Pump to feed thickener underflow to press feed tank. 6" rotary lobe pump with motor and fittings. An additional backup pump will be purchased.	$15,000 - $20,000	$20,000	Vendor opinion that rotary lobe pump may be appropriate for this type of application and suggested 2 pumps required for flow of 1,000 gpm. Use upper end of range.
K.4	Press feed tank and agitator	Vendor budgetary estimate (Enprotec, Hebron, Ky and Tident Process, Inc., MN)	100,000 gal bolted steel tank, 32'8" dia x 16'1" h or 47'6" dia x 8'1/2" h. 40 HP, TEFC severe duty/high efficiency Lightnin mixer, Model 508Q40.	$134,420	$135,000	Assume 1 solids holding tank per 5 presses.
K.5	Press feed pump (plus two spare)	Vendor budgetary estimate (A.A. Anderson Company)	Pumps to feed thickener underflow to individual presses. 6" rotary lobe pump with motor and fittings. Two additional backup pumps will be purchased.	$15,000 - $20,000	$15,000	Vendor opinion that rotary lobe pump may be appropriate for this type of application. 1 pump required to accommodate each press. Use low end of range for flows ranging from 200-300 gpm.
K.6	Press	Vendor budgetary estimate (WesTech, Rockton, IL)	Belt press, 3-meter, 30 ton dry solids per hr (TPH). Includes control panel, sludge feed pump, polymer system and wash water booster pump.	$385,000		Estimate is $187,500 per machine. 2 machines would be required to achieve 38 tons/hr throughput. However, the capacity appears to overestimated.
		Vendor opinion (JWI/US Filter)	Plate and frame filter press. 600 cf. Total of 6 required based on approx. 2,000 gpm flow to presses.	$3,000,000		Interpolated estimate of 3 presses required for Type I system at $1,000,000 each based on JWI quote. This opinion by JWI based on types of presses proposed for New Bedford Harbor project, after comparing vacuum filter and centrifuge options.
		Vendor opinion (JWI/US Filter)	Belt press, 3-meter, 120 gpm per unit. Total of 16 required based on approx. 2,000 gpm flow to presses.	$2,400,000		Interpolated estimate of 8 presses required for Type I system at $300,000 each based on JWI quote.
		Vendor opinion (Andritz-Ruthner, Inc., Houston)	Belt press, 3-meter, Minimum 8 TPH per machine (10 TPH possible). Dual chemical addition at total input of 2.3 lb/dry ton solids.	$1,750,000		This opinion based on initial dewatering tests performed by Andritz on Fox River sediment. 5 machines required to achieve 38 TPH throughput, at $350,000 each.
		Summary:			$2,100,000	Of the three opinions, the Andritz opinion is based on the most thorough analysis and actual bench-scale work. For planning purposes, assume 6 machines required. At low end of performance (8 TPH per machine), this would provide approx. 25% excess capacity. At high end of performance (10 TPH per machine), this would provide over 50% excess capacity.

BASIS OF UNIT COSTS

I.D.	Item	Source	Description	Value or Range Provided (rounded)	Value Used for Estimate (rounded)	Basis
K.7	Filtrate forwarding pump (plus two spare)	Means/ECHOS (2001)	Pumps to forward filtrate from individual presses to wasterwater treatment. 150 gpm, 5HP centrifugal transfer pump with motor and fittings. Two additional backup pumps will be purchased.	$5,600	$6,200	Means, #33_29_0124 plus 10% to account for inflation. Pump sized for approx. 150 gpm includes allowance for fluctuations in flow.
K.8	Chemical feed system		System to add a chemical for conditioning prior to downstream presses		$20,000	Placeholder, pending final engineering.
K.9	Minor equipment & support facilities	Prior project experience	Minor items such as controls, materials handling equipment, storage units, laboratory instrumentation, that are not currently defined for the project.		25%	Placeholder, pending final engineering.
M.1	Equipment erection	Prior project experience	Labor and materials to erect large tanks and other process equipment.	11%	15%	Increase percentage to account for several unknown factors at this stage in the project.
M.2	Process piping	Prior project experience	Interconnecting piping between and not supplied with process equipment.	7 - 50%	30%	Range from past mid-size treatment systems, as a percentage of purchased equipment. Use mid-point of range to account for current unknowns.
M.3	Building HVAC	Prior project experience	Heating and ventilation equipment for treatment building.		$150,000	Past projects at $9 to $33/sf, or 50% to 100% of building cost. For Type I building, sized at approximately 7,800 sf, assume $150,000.
M.4	Site restoration	Prior project experience	Remove system and building at end of project		$150,000	Based on recent experience with process equipment removal and building demolition in the Fox Valley.
E.1	Service entrance				$0	Cost is included with estimate for wastewater treatment system.
E.2	Main panels				$0	Cost is included with estimate for wastewater treatment system.
E.3	Process electrical and instrumentation	Prior project experience	Includes process wiring, loose process instrumentation and controls, as a percentage of the purchased equipment.	15 - 27%		Range from past, smaller projects.
		Contractor opinion (Boudry Control Panels, LLC, Fond du Lac, WI)		Min. $750,000		Contractor opinion is for total site (dewatering, water treatment, infrastructure, etc.). $750,000 would be less than 10% of purchased equipment. This assumes that all starters and local panels are provided with individual equipment packages.
		Summary:			20%	Increase contractor's opinion to allow for some starters not provided with equipment, other items not yet defined, etc. Use 20% of purchased equipment, which is at mid-point of past experience on smaller projects.
E.4	Primary control panel/package	Contractor opinion (Boudry Control Panels, LLC, Fond du Lac, WI)	Central controls package and process monitoring, that integrates all loose controllers provided with individual equipment packages. Include 5 or 6 remote PCs at various points in plant/offices, with process monitoring software, local network, etc.		$0	Cost is included with estimate for wastewater treatment system.

BASIS OF UNIT COSTS

I.D.	Item	Source	Description	Value or Range Provided (rounded)	Value Used for Estimate (rounded)	Basis
E.5	Building lighting	Contractor opinion (Boudry Control Panels, LLC, Fond du Lac, WI)	Overhead, industrial lighting in press building.		$8,000	Assumes 1 fixture for every 400 sf Total = 7,800 sf/400 = 20 fixtures. Fixtures at $200 each plus $100 to install/wire. Use $8,000.
S.1	Building	Builder opinion (Butler Buildings/Howard Immel, Inc., Green Bay, WI)	Pre-engineered metal building, industrial quality, w/ OH doors, etc.		$50	Estimate represents typical square foot cost. Based on contractor experience in Fox Valley. Original opinion includes 4" concrete slab.
S.2	Building foundation	Builder opinion (Howard Immel, Inc., Green Bay, WI)	Assume minimum of 8" slab plus 4 ft. frost wall and strip footing.		$115,000	Estimate has been developed for the larger Type II building. Assume Type I building is 75% of Type II.
S.3	Outside tank & equipment foundations	Builder opinion, typical projects and Means Site Work, 2000.	Along perimeter of circular tanks, assume minimum of 4 ft. foundation wall, 8" thick, with continuous strip footing, 16" d x 48" w.		$38,000	From Means assemblies, p. 387: Footing = $35/lf. 8' x 8" wall = $57/lf. For shorter wall, use $75/lf total. Assume at least 1 tank at 50' dia, 1 at 32' dia, for total of 258 lf, or $19,300. Include allowance for small tanks and equipment pads. Use $38,000.
O.1	Polymer	Vendors general experience (Andritz-Ruthner, Inc., Houston, TX)	Chemical conditioner added to slurry prior to press.	$319,000		Andritz has done limited initial testing on Fox River sediment. Estimate for total of cationic and anionic addition is 2.3 lb polymer/ton dry solids, but this is very approximate. For annual generation of 126,000 tons filter cake per year: (126,000 tons)(55% solids)(2.3 lb polymer/ton dry solids)($2/lb polymer) = $318,997
		Area 56/57 demonstration project design basis (MWH, 1998)	Chemical conditioner added to slurry prior to press.	$425,000		MWH tested a cationic polymer (Betz/Dearborn #CP-210) and found it to be effective at 250mg/L, in an 8% simulated "thickened" slurry, prior to a belt press. Based on current mass balance, slurry from thickener would be on order of 900 gpm. Usage: (900 gal/min)(10.8 hr/d)(60min/hr)(175 day/yr)(250 mg/L)(3.78 L/gal)(lb/454,000mg)($2/lb) = $425,000.
		Summary:			$415,000	The calculation using MWH data may be low considering their testing was done at a lower solids concentration than what is anticipated for this project. The Andritz opinion is probably reasonable, because it applies to a specific machine and actual Fox River sediment. Due to the very early stage of the work include 30% allowance on the Andritz value in consideration of MWH findings.
O.10	Wastewater technician	Prior project experience	3 FTE, 18/5 - Two 9-hour shifts 5 days per week to conduct continuous operations and maintenance-related tasks. LOE is based on 1 FTE operating separation equipment, 1 FTE operating presses and 1 FTE as general operations. 9,450 hrs/yr.		$35	Assume typical hourly rate for contract environmental labor. Rate includes basic per diem expenses.
O.11	Certified operator	Prior project experience	Plant operator with state certification. LOE and cost is allocated to wastewater treatment element.		$50	Cost is included with estimate for wastewater treatment system.

BASIS OF UNIT COSTS

I.D.	Item	Source	Description	Value or Range Provided (rounded)	Value Used for Estimate (rounded)	Basis
O.12	Project manager	Prior project experience	On-site project controls and personnel supervision. Assume LOE is 0.2 FTE (based on a 50 hr week), or 10 hrs/wk for 8 months, with the remainder of time allocated to other project elements. 350 hrs/yr.		$75	Assume typical hourly rate for onsite supervisor. Rate includes basic per diem expenses.
O.20	Maintenance & replacement parts	Prior project experience	Purchased materials and labor to install miscellaneous small and expendible items associated with process equipment.		5%	Professional judgement from similar project experience.
O.30	Electricity	Various vendors used for development of process equipment.	Power requirements for proccess equipment, lighting, etc.		$108,133	Refer to cost sheet, "Annual Electrical Costs"

PROJECT ELEMENT:

Wastewater treatment system, Type I
Baseline Alternative - OU1

PROCESS METRICS

Total volume of sediment removed from river	784,000	cy
Nominal capacity of system (expressed as the dredge slurry rate)	2,100	gpm
Length of operations	2.3	yr
Total gallons treated & discharged	496,000,000	gal

COST SUMMARY

	Total Cost	Total as Present Worth	
Subtotal, construction costs	$4,900,000	$4,900,000	
Total, construction plus operating costs	$6,700,000	$6,500,000	
Cost per cy sediment removed	$8.55	$8.29	/cy
Cost per gallon water discharged	$0.0135	$0.0131	/gal

Notes

1. This estimate is based on the major processes/equipment identified in the accompanying drawing, "Process Flow Diagram for Wastewater Treatment." It is based on preliminary concepts, and is suitable only as a general indicator of eventual project costs. It will change as final engineering and detailed design work proceed.
2. The Type I facility is sized to treat the carriage water that would be released from a dredge slurry flowrate of up to 2,100 gpm.
3. The estimate assumes that the plant is constructed as a fixed-base, semi-permanent facility. Equipment is purchased, with no salvage value at end of project. Site infrastructure (roads, offices, etc.) common to the larger project not included, and will be estimated elsewhere. Indirect capital costs (engineering, construction management, etc.) not included.
4. The "total cost" does not discount the multi-year operating costs.
5. The "present worth" discounts all construction and operations costs over the active life of the facility. The discount rate is 7% (USEPA, "Guide to Developing and Documenting Cost Estimates During the Feasibility Study", July 2000).
6. "Cost per gallon" and "cost per cy" values are for informational purposes only. Values are not true unit costs because they represent a combination of fixed capital and flow-proportional components.
7. "Cost per gallon treated" is based on the total volume of water treated and discharged, after taking in to account the online factor of the dredging operation (i.e. the maximum capacity of the system over a 24-hour period would be greater).

CAPITAL COSTS

	Item	Units	Quantity	Unit Cost (1)	Extension
Purchased Equipment					
K.1	Polymer feed/flocculation unit	ea	1	$62,000	$62,000
K.2	Clarifier #1	ea	1	$300,000	$300,000
K.3	Clarifier #2	ea	0	$0	$0
K.4	Filter feed tank	ea	1	$89,000	$89,000
K.5	Clarifier solids pump (plus spare)	ea	2	$4,800	$9,600
K.6	Filter feed pump (plus spare)	ea	3	$14,000	$42,000
K.7	Granular media filter	lot	1	$300,000	$300,000
K.8	GAC filters	lot	1	$200,000	$200,000
K.9	Backwash supply pump (plus spare)	ea	2	$2,600	$5,200
K.10	Effluent collection tank	ea	1	$38,000	$38,000
K.11	Effluent discharge pump (plus spare)	ea	2	$15,000	$30,000
K.12	pH control (chemical feed) system	ea	1	$20,000	$20,000
	Subtotal, major equipment				$1,095,800
K.13	Minor equipment & support facilities	% of major equipment		25%	$273,950
	Subtotal, purchased equipment				$1,369,750
Mechanical Work					
M.1	Equipment erection	% of equipment	1	15%	$205,463
M.2	Process piping	% of equipment	1	30%	$410,925
M.3	Treatment building HVAC	ls	1	$150,000	$150,000
M.4	Site restoration	ls	1	$200,000	$200,000
Electrical Work					
E.1	Service entrance	ls	1	$150,000	$150,000
E.2	Main panels	ls	1	$30,000	$30,000
E.3	Process electrical & instrumentation	% of equipment	1	20%	$273,950
E.4	Primary control panel/package	ls	1	$200,000	$200,000
E.5	Building lighting	ls	1	$8,000	$8,000
Structural					
S.1	Treatment building	sf	7,800	$50	$390,000
S.2	Building foundation	ls	1	$115,000	$115,000
S.3	Outside tank and equipment foundations	ls	1	$43,000	$43,000
	Subtotal, purchased equipment and trades				$3,546,088
	Mobilization, demobilization, general conditions (% of above)			8%	$283,687
	Freight (% of purchased equipment)			5%	$68,488
	Prime contractor administration, overhead & profit (% of above)			25%	$974,566
	TOTAL DIRECT CAPITAL				$4,872,828

Notes

1. Unit cost backup provided on subsequent sheets

ANNUAL OPERATING COSTS

	Item	Units	Quantity	Unit Cost (1)	Extension
Purchased materials					
O.1	Granular activated carbon	lbs	2,800	$1.30	$3,640
O.2	Filter media	ls	1	$20,000	$20,000
O.3	Coagulant	ls	1	$50,000	$50,000
O.4	Caustic	ls	1	$10,000	$10,000
Operations labor					
O.10	Wastewater technician	hrs	6,300	$35	$220,500
O.11	Certified operator	hrs	1,750	$50	$87,500
O.12	Project manager	hrs	350	$75	$26,250
O.13	Analytical work	day	175	$200	$35,000
Maintenance labor & materials					
O.20	Maintenance and replacement parts	% of equipment	$1,369,750	5%	$68,488
Utilities					
O.30	Electricity	per detail			$50,703
O.31	Telephone	mo	8	$200	$1,600
	Subtotal				$573,680
	Mobilization, demobilization, general conditions (% of above)			8%	$45,894
	Prime contractor administration, overhead & profit (% of above)			25%	$154,894
	TOTAL ANNUAL OPERATIONS				$774,468

Notes

1. Unit cost backup provided on subsequent sheets

SUMMARY OF CARBON USAGE

Volume treated at breakthrough (1,2)	265,000,000	gal
Operating days per year	175	days
Daily volume treated, total	1,230,000	gal
Number of vessels	6	
Daily volume treated, per vessel	205,000	gal
Volume treated per year, per vessel	35,910,000	gal
Number of changeouts per year	0.14	
Mass of carbon per changeout, per vessel	20,000	lbs
Mass carbon per year, if averaged (3)	2,800	lbs

Notes

1. To be conservative, define breakthrough as 1/2 the expected discharge limit of 1.0 ug/L.
2. Breakthrough calculations provided by Carbonair, Inc., Minneapolis, MN, based on typical operating and loading conditions estimated by The RETEC Group, Inc.
3. Carbon changeout would actually occur roughly simultaneously in all GAC units, not evenly spaced over time.

ANNUAL ELECTRICAL COSTS

	Item	Total Motor HP	Kw	Operating Time Per Day (1)	Kw*hr per day
E.1	Polymer feed/flocculation unit	10	7.46	12	90
E.2	Clarifier #1	5	3.73	24	90
E.3	Clarifier #2	0	0	12	0
E.4	Filter feed tank	0	0	0	0
E.5	Clarifier solids pump	20	14.92	12	179
E.6	Filter feed pump (assume 2 at 40 HP)	80	59.68	12	716
E.7	Granular media filter	0	0	0	0
E.8	GAC filters	0	0	0	0
E.9	Backwash supply pump	15	11.19	2	22
E.10	Effluent collection tank	0	0	0	0
E.11	Effluent discharge pump	100	74.6	12	895
E.12	pH control (chemical feed) system	1	0.746	12	9
	Subtotal, major equipment				2,001
E.13	Minor equipment & support facilities	20	14.92	12	179
	Subtotal, all equipment (kw*hr/day)				2,180
	Number of days per operating year				175
	Cost of electricity ($/kw*hr)				$0.07
	Subtotal, electricity for equipment				$26,703
			Months	$/month	Extension
O.30	Lighting, ventilation & occasional minor heating of treatment building	month	8	3,000	$24,000
	TOTAL ANNUAL ELECTRICAL				$50,703

Notes

1. To be conservative, the daily operating time for system is assumed to be slightly longer than the typical daily dredge effective time.

PRESENT WORTH CALCULATION

i = 7%

Year, n	Capital Costs (Construction)	Annual Operations	Sum of Year "n" Costs	Cumulative Costs, Year 1 through n	Present Worth Factor, i	Present Worth of Year "n" Construction Costs Only	Present Worth of All Year "n" Costs	Cumulative Present Worth of All Costs, Year 1 through n
0	$4,872,828		$4,872,828	$4,872,828	1	$4,872,828	$4,872,828	$4,872,828
1		$774,468	$774,468	$5,647,296	0.9346	$0	$723,802	$5,596,630
2		$774,468	$774,468	$6,421,764	0.8734	$0	$676,451	$6,273,080
3		$232,340	$232,340	$6,654,105	0.8163	$0	$189,659	$6,462,739
4			$0	$6,654,105	0.7629	$0	$0	$6,462,739
5			$0	$6,654,105	0.7130	$0	$0	$6,462,739
6			$0	$6,654,105	0.6663	$0	$0	$6,462,739
7			$0	$6,654,105	0.6227	$0	$0	$6,462,739
8			$0	$6,654,105	0.5820	$0	$0	$6,462,739
9			$0	$6,654,105	0.5439		$0	$6,462,739
10			$0	$6,654,105	0.5083		$0	$6,462,739
11			$0	$6,654,105	0.4751		$0	$6,462,739
12			$0	$6,654,105	0.4440		$0	$6,462,739
13			$0	$6,654,105	0.4150		$0	$6,462,739
14			$0	$6,654,105	0.3878		$0	$6,462,739
15			$0	$6,654,105	0.3624		$0	$6,462,739
16			$0	$6,654,105	0.3387		$0	$6,462,739
17			$0	$6,654,105	0.3166		$0	$6,462,739
18			$0	$6,654,105	0.2959		$0	$6,462,739
19			$0	$6,654,105	0.2765		$0	$6,462,739
20			$0	$6,654,105	0.2584		$0	$6,462,739
21			$0	$6,654,105	0.2415		$0	$6,462,739
22			$0	$6,654,105	0.2257		$0	$6,462,739
23			$0	$6,654,105	0.2109		$0	$6,462,739
24			$0	$6,654,105	0.1971		$0	$6,462,739
25			$0	$6,654,105	0.1842		$0	$6,462,739
26			$0	$6,654,105	0.1722		$0	$6,462,739
27			$0	$6,654,105	0.1609		$0	$6,462,739
28			$0	$6,654,105	0.1504		$0	$6,462,739
29			$0	$6,654,105	0.1406		$0	$6,462,739
30			$0	$6,654,105	0.1314		$0	$6,462,739
31			$0	$6,654,105	0.1228		$0	$6,462,739
32			$0	$6,654,105	0.1147		$0	$6,462,739
33			$0	$6,654,105	0.1072		$0	$6,462,739
34			$0	$6,654,105	0.1002		$0	$6,462,739
35			$0	$6,654,105	0.0937		$0	$6,462,739
36			$0	$6,654,105	0.0875		$0	$6,462,739
37			$0	$6,654,105	0.0818		$0	$6,462,739
38			$0	$6,654,105	0.0765		$0	$6,462,739
39			$0	$6,654,105	0.0715		$0	$6,462,739
40			$0	$6,654,105	0.0668		$0	$6,462,739
Totals	$4,872,828	$1,781,277	$6,654,105			$4,872,828	$6,462,739	

BASIS OF UNIT COSTS

I.D.	Item	Source	Description	Value or Range Provided (rounded)	Value Used (rounded)	Basis
K.1	Polymer feed/flocculation unit	Vendor budgetary estimate (Enprotec, Hebron, KY)	Flash, floc tanks with mixers and polymer blending feed system. Sizing: 1,600 to 2,500 gpm influent. Flash mix tank at 30 sec, flocculation tank at 5-7 min.	$52,000 - $62,000	$62,000	Size varies to accomodate different influent flowrates to individual subsystems. Use upper end of range for treatment of carriage water released from a dredge slurry of up to 2,100 gpm (Type I system), which corresponds to a wastewater flow on order of 2,000 gpm.
K.2	Clarifier #1	Vendor budgetary estimate (Enprotec, Hebron, KY)	Model J6220, rectangular clarifier, 500 gpd/sf, 10'w x 12'h x length as needed. Sized for nominal 2,500 gpm influent at 2000 mg/L solids.	$415,000		
		Vendor budgetary estimate (WesTech, Rockton, IL)	Clarifier mechanism (SCS71) and tank (TKC11.) Solids contact style, sized for 4000 gpm thickener overflow. 85' dia x 16' side wall depth. 25' total side depth.	$400,000 - $500,000		Interpolated from quote provided by WesTech for dewatering and wastewater treatment package.
		Summary:			$300,000	For Type I system at 2,000 gpm, use scale-down factor of 75% on low end of range for the larger clarifier. Assume combined system for handling supernatent and filtrate streams with allowance for excess capacity (for an overflow rate of 1000 gpd/sf, tank dia. = 60 ft)
K.3	Clarifier #2	Vendor budgetary estimate (Enprotec, Hebron, KY)	Model J6220, rectangular clarifier, overflow rate of 500 gpd/sf, 10'w x 12'h x length as needed. Sized for nominal 1,600 gpm influent at 500 mg/L solids.	$264,000		Not used.
K.4	Filter feed tank	Vendor budgetary estimate (Enprotec, Hebron, KY)	100,000 gal bolted steel tank, 32'8" dia x 16'1" h or 47'6" dia x 8'1/2" h.	$85,000	$89,000	Assume 1 tank required to provide approx. 50 minute holding capacity for flow on order of 2,000 gpm. Add allowance for pipes and fittings.
K.5	Clarifier solids pump (plus spare)	Means/Echos (2001)	Pump to return up to several hundred gpm underflow solids from clarifier to thickener. 500 gpm, 100' TDH, 20 HP centrifugal transfer pump with motor and fittings. An additional backup pump will be purchased.	$4,800	$4,800	Means, #33_29_0130. Pump sized for combined system for handling supernatent and filtrate streams including allowance for fluctuations in flow.
K.6	Filter feed pump (plus spare)	Means/Echos (2001)	Pump to feed supernatant from clarifier to filters. 1,000 gpm at 100' TDH, 40 HP centrifugal transfer pump with motor and fittings. An additional backup pump will be purchased.	$12,800	$14,000	Means, #33_29_0134 plus 10% to account for inflation.
K.7	Granular media filter	Vendor budgetary estimate (WesTech, Rockton, IL)	Dual-media (anthracite, silica sand), automatic backwash, pressure filters. Two vessels with 3-cell design required to treat 4,000 gpm. Model: SA516 GR70; Vessel: 10' dia. X 34' L horizontal	$150,000 - $200,000		Interpolated from quote provided by WesTech for dewatering and wastewater treatment package. Assume 2 vessels required at $75,000 - $100,000 each for approx. 2,000 gpm. Design rate = 5.9 gpm/sf; maximum during backwash = 8.9 gpm/sf; backwash = 17.7 gpm/sf.
		Vendor budgetary estimate (Enprotec, Hebron, KY)	Multi-media, automatic backwash, pressure filters. Two vessels with 3-cell design required to treat 1800 gpm. Model: J3396-150; Cell: 96" dia, 50 sf area	$390,000		Assume cost of 1 unit (2 vessels) at approx. $260,000 scaled up by 50% to provide excess capacity. Units sized for 90% removal of +20 micron solids, at an assumed influent loading of up to 100 mg/L.
		Vendor budgetary estimate (Zimpro/US Filter, Rothschild, WI)	Single-media (sand), continuous backwash, gravity flow filters. Hydro-Clear 4-cell design required to treat 2,500 gpm. Model KK-12X25(4); Cell: 250 sf area	$295,000		Assume 1 unit required at $295,000.

I.D.	Item	Source	Description	Value or Range Provided (rounded)	Value Used (rounded)	Basis
		Vendor opinion (Parkson Corp.)	Single-media sand (DynaSand) filter, continuous backwash, gravity flow filters required to treat 1,725 gpm. Details not specified.	> $750,000		Assume cost of 1 unit at approx. $500,000 scaled up by factor of 150% to provide excess capacity
		Vendor budgetary estimate (Applied Process Technology, Conroe, TX)	Multi-grade sand media, continuous backwash, gravity flow filters. 24-filter 6-cell and 32-filter 8-cell Centra-flo filter design required to treat 1,725 and 2,258 gpm, respectively. Model: CF-50C; Filter: 8 sf area	$615,000 $815,000		Assume 32-filter, 8-cell design required at approx. $815,000. Cells would be contained in a concrete, rectangular tank, by others.
		Summary:			$300,000	A number of process options and configurations are available. Assume pressure filter style. Use mid-point of range for pressure-style filters.
K.8	GAC filters	Vendor budgetary estimate (Carbonair, Inc., Minneapolis)	Model PC78. 10' dia. x 18'h, vertical steel tanks, each containing 20,000 lb of liquid-phase carbon. Hydraulic loading = 5.9 gpm/sf. Purchase price includes first load of carbon.	$163,000		Quote provided by Carbonair of 5 vessels at $32,600 each required for 2,300 gpm (initial proposal included 9 vessels for 4,000 gpm).
		Vendor budgetary estimate (WesTech, Rockton, IL)	Model SA516 GR70. 8' dia x 32'L, horizontal steel tanks. Hydraulic loading = 3.7 gpm/sf.	$100,000		Interpolated from quote provided by WesTech for dewatering and wastewater treatment package. Assume 2 units required at $50,000 each.
		Summary:			$200,000	Proposed loading for both options is within or better than typical range (4-8 gpm/sf, Cheremisinoff, 1993). Use Carbonair cost estimate as representative, due to their prior experience on original demonstration projects. Approx. 6 vessels required for flow on order of 2,000 gpm. Include allowance for interconnecting pipe racks and valving.
K.9	Backwash supply pump (plus spare)	Vendor budgetary estimate (Carbonair, Inc., Minneapolis)	Pump to return water from effluent collection tank to filters for periodic backwashing. 800 gpm at 25 psi, 15 HP, 3 phase, 1,750 rpm, TEFC motor. An additional backup pump will be purchased.	$2,560	$2,600	Quote provided by Carbonair.
K.10	Effluent collection tank	Vendor budgetary estimate (Enprotec, Hebron, KY)	44,000 gal bolted steel tank, 21' dia x 16'h	$36,300	$38,000	Assume 1 tank required to provide approx. 20 minute holding capacity for flow on order of 2,000 gpm. Add allowance for pipes and fittings.
K.11	Effluent discharge pump (plus spare)	Means/Echos (2001)	Pump for discharging treated water to river. 3,000 gpm at 100' TDH, 100 HP centrifugal transfer pump with motor and fittings. An additional backup pump will be purchased.	$13,200	$15,000	Means, #33_29_0135 plus 10% to account for inflation. Pump sized for flow on order of 2,000 gpm with allowance for fluctuations in flow. Cost includes the purchase of spare pump.
K.12	pH control (chemical feed) system		Chemical feed system to re-adjust effluent pH to within 6 to 9 per WPDES permit.		$20,000	Placeholder, pending final engineering.
K.13	Minor equipment & support facilities	Prior project experience	Minor items such as compressed/instrument air system, materials handling equipment, storage units, laboratory instrumentation, that are not currently defined for the project.		25%	Placeholder, pending final engineering.
M.1	Equipment erection	Prior project experience	Labor and materials to erect large tanks and other process equipment.	11%	15%	Increase percentage to account for several unknown factors at this stage in the project.

BASIS OF UNIT COSTS

I.D.	Item	Source	Description	Value or Range Provided (rounded)	Value Used (rounded)	Basis
M.2	Process piping	Prior project experience	Interconnecting piping between and not supplied with process equipment.	7 - 50%	30%	Range from past mid-size treatment systems, as a percentage of purchased equipment. Use mid-point of range to account for unknown factors at this stage in the project.
M.3	Treatment building HVAC	Prior project experience	Heating and ventilation equipment for treatment building.		$150,000	Past projects at $9 to $33/sf, or 50% to 100% of building cost. For Type I building, sized at approximately 7800 sf, assume $150,000.
M.4	Site restoration	Prior project experience	Remove system and building at end of project.		$200,000	Based on recent experience with process equipment removal and building demolition, Fox Valley.
E.1	Service entrance	Contractor opinion (Boudry Control Panels, LLC, Fond du Lac, WI) (formerly Boudry Electric, Inc.)	New overhead primary line from nearby street. Assume 500 to 1000 feet required.		$150,000	Could range from $0 to $300,000, depending on whether utility would subisidize (or pay) based on projected revenue, whether transformer is purchased or leased, if power factor correction is needed, etc. Use midpoint of $150,000 as a placeholder.
E.2	Main panels	Contractor opinion (Boudry Control Panels, LLC, Fond du Lac, WI)	Main panel and disconnect at plant building.		$30,000	Assumes $20,000 for 2,000 amp panel, plus installation.
E.3	Process electrical and instrumentation	Prior project experience	Includes process wiring, loose process instrumentation and controls, as a percentage of the purchased equipment.	15 - 27%		Range from past, smaller projects.
		Contractor opinion (Boudry Control Panels, LLC, Fond du Lac, WI)		Min. $750,000		Contractor opinion is for OU3/4 total facility (dewatering, water treatment, infrastructure, etc.). $750,000 would be a little less than 10% of purchased equipment for OU3/4. This assumes that all starters and local panels are provided with individual equipment packages.
		Summary:			20%	Increase contractor's opinion to allow for some starters not provided with equipment, other items not yet defined, etc. Use 20% of purchased equipment, which is at mid-point of past experience on smaller projects.
E.4	Primary control panel/package	Contractor opinion (Boudry Control Panels, LLC, Fond du Lac, WI)	Central controls package and process monitoring, that integrates all loose controllers provided with individual equipment packages. Include 5 or 6 remote PCs at various points in plant/offices, with process monitoring software, local network, etc.		$200,000	Cost breakdown is: PCs - $12,000, networking - $10,000, software - $35,000, programming and installation - $120,000. Add contingency for items not yet defined. Use $200,000.
E.5	Building lighting	Contractor opinion (Boudry Control Panels, LLC, Fond du Lac, WI)	Overhead, industrial lighting in press building.		$8,000	Assumes 1 fixture for every 400 sf Total = 7,800 sf/400 = 20 fixtures. Fixtures at $200 each plus $100 to install/wire. Use $8,000.
S.1	Treatment building	Builder opinion, typical projects (Butler Buildings/Howard Immel, Inc., Green Bay, WI)	Pre-engineered metal building, industrial quality, w/ OH doors, etc. On a square foot of floorspace basis.		$50	Estimate represents typical square foot cost, based on contractor experience in Fox Valley. Size has been developed for the larger Type II building. Assume Type I building is 75% of Type II.
S.2	Building foundation	Builder's opinion (Howard Immel, Inc., Green Bay, WI)	Assume minimum of 8" slab plus 4 ft. frost wall and strip footing.		$115,000	Estimate has been developed for the larger Type II building. Assume Type I building is 75% of Type II.

BASIS OF UNIT COSTS

I.D.	Item	Source	Description	Value or Range Provided (rounded)	Value Used (rounded)	Basis
S.3	Outside tank & equipment foundations	Builder opinion, typical projects and Means Site Work, 2000.	Along perimeter of circular tanks, assume minimum of 4 ft. foundation wall, 8" thick, with continuous strip footing, 16" d x 48" w.		$43,000	From Means assemblies, p. 387: Footing = $35/lf. 8' x 8" wall = $57/lf. For shorter wall, use $75/lf total. Assume at least 1 tank at 60' dia, 1 at 32' dia, for total of 289 lf, or $21,700. Include allowance for small tanks and equipment pads. Use $43,000.
S.4	Interior buildout	In-house opinion	Includes construction of interior walls for office space, lab benches, storage, lavatory, etc.		$75,000	Placeholder pending detailed design of the facility.
O.1	Granular activated carbon	Vendor model calculations and recommendations (Carbonair, Inc., Minneapolis)	Media used for polishing step in filtration process. Annual cost.		$3,640	Refer to cost sheet, "Summary of Carbon Usage"
O.2	Filter media	In-house opinion	Typically a type of sand, either graded or combined with other media (i.e., anthracite, coal) used in the granular media filters. Annual cost.		$20,000	Placeholder, pending final engineering of the system. Replacement not expected to be needed, but could be several % by weight per year; therefore, a small allowance is included.
O.3	Coagulant	In-house opinion	Chemical addition to improve clarification. Annual cost.		$50,000	Placeholder pending final treatability testing. Type and dose of chemical not known.
O.4	Caustic	In-house opinion	For pH control. Annual cost.		$10,000	Placeholder, pending final treatability testing.
O.10	Wastewater technician	In-house opinion	2 FTE, 18/5 - Two 9-hour shifts 5 days per week to conduct continuous operations and maintenance-related tasks. 6,300 hrs/yr.		$35	Assume typical hourly rate for contract environmental labor. Rate includes basic per diem expenses.
O.11	Certified operator	In-house opinion	Plant operator with state certification. 1 FTE (based on 50 hr week). LOE and cost is allocated to wastewater treatment element. 1750 hrs/yr.		$50	Assume typical hourly rate for senior contract environmental personnel.
O.12	Project manager	In-house opinion	On-site project controls and personnel supervision. Assume LOE is 0.2 FTE (based on a 50 hr week), or 10 hrs/wk for 8 months, with the remainder of time allocated to other project elements. 350 hrs/yr.		$75	Assume typical hourly rate for onsite supervisor. Rate includes basic per diem expenses.
O.13	Analytical work	Estimate from FS	Daily effluent samples or samples from other intermediate points in the process to confirm discharge compliance and process control.		$200	Assumes analysis of BOD, TSS, PCBs, and other minor parameters per WPDES permit.
O.20	Maintenance and replacement parts	In-house opinion	Purchased materials and labor to install miscellaneous small and expendible items associated with process equipment.		5%	Professional judgement from similar projects experience.
O.30	Electricity		Power requirements for process equipment, lighting, etc.		$50,703	Refer to cost sheet, "Annual Electrical Costs"
O.31	Telephone	Prior project experience	Cost of phone service from treatment plant.		$200	Monthly estimated cost.

COST ESTIMATE #06 **Rev: 10.30.03**
DETAILED EVALUATION OF ALTERNATIVES **Final**
WDNR - FOX RIVER

PROJECT ELEMENT:
NR213 settling basins
Baseline Alternative - OU3 and OU4

PROCESS METRICS

Total volume sediment removed from river	6,500,000	cy
Total wet tons generated for disposal	5,813,000	tons
Duration of dredging operations	10.3	yr
Duration of drying operations in basins	14	yr

COST SUMMARY

	Total Cost (1)	Total as Present Worth (2)
Subtotal, construction costs	$60,800,000	$60,800,000
Annual operations (3)	$2,900,000	
Total, construction plus operating costs	$96,600,000	$82,100,000
Cost per cy sediment removed (4)	$14.86	$12.63

Notes

1. The "total cost" does not discount the multi-year operations costs. As a simplifying assumption, all construction costs assumed to occur in Year 0. Actual construction would occur over several years, prior to the beginning of dredging operations.
2. The "present worth" discounts the operations costs over the active life of the facility. The discount rate is 7% (USEPA, "Guide to Developing and Documenting Cost Estimates During the Feasibility Study", July 2000).
3. Excavation of dried sediment from the basins is assumed to being in Year 4. Prior to that, the operations labor will be lower. 1/2 of the typical annual operating cost is assigned to Years 1 - 3.
4. "Cost per cy sediment removed" values are for informational purposes only. Values are not true unit costs because they represent a combination of fixed capital and quantity-proportional components.

CAPITAL COSTS

	Item	Units	Quantity	Unit Cost	Extension
Development					
D.1	Land acquisition	ac	505	$2,000	$1,010,000
Civil Work					
C.2	Clear & grub	ac	430	$2,100	$903,000
C.3	Strip & stockpile topsoil (6")	cy	325,000	$1	$325,000
C.4	Excavation to subgrade	cy	1,200,000	$1.50	$1,800,000
C.5	Berm construction	cy	760,000	$2.50	$1,900,000
C.6	Liner system	ac	332	$110,000	$36,520,000
C.7	Weir structure construction	ls	4	$50,000	$200,000
C.8	Effluent collection trench	lf	8,500	$28	$238,000
C.9	Perimeter drainage ditches	lf	11,600	$4	$46,400
C.11	Access road, paved	sf	156,780	$4	$627,120
C.12	Perimeter fence	lf	23,200	$35	$812,000
C.13	Demolition/disposal/regrading of basins	ea	4	$100,000	$400,000
Mechanical Work					
M.1	Piping, valves and dredge hookup	ls	1	$200,000	$200,000
Electrical Work					
E.1	Power supply	ls	1	$30,000	$30,000
E.2	Wiring and controls	ls	1	$25,000	$25,000
		Subtotal			$45,036,520
		Mobilization, demobilization, general conditions (% of above)	8%		$3,602,922
		Prime contractor administration, overhead & profit (% of above)	25%		$12,159,860
		TOTAL DIRECT CAPITAL			$60,799,302

Notes

1. Unit cost backup provided on subsequent sheets

ANNUAL OPERATING COSTS

	Item	Units	Quantity	Unit Cost	Extension
	Operations Labor and Equipment				
O.10	Environmental technician	hrs	2,500	$30	$75,000
O.11	Project manager	hrs	500	$70	$35,000
O.12	Sediment Surface Management	ls	1	$100,000	$100,000
O.13	Sediment Loading	ton	573,241	$1.03	$590,438
O.14	Sediment Hauling	ton	573,241	$1.63	$934,383
	Maintenance Labor & Materials				
O.20	Replace coarse sand layer for vacuum enhanced drainage system	ls	1	$225,000	$225,000
O.21	Routine maintenance	ls	1	$75,000	$75,000
	Utilities				
O.30	Electricity	mo	12	$10,000	$120,000
	Subtotal				$2,154,821
	Mobilization, demobilization, general conditions (% of above)			8%	$172,386
	Prime contractor administration, overhead & profit (% of above)			25%	$538,705
	Total, annual costs				$2,865,912

PRESENT WORTH CALCULATION

i = 7%

Year, n	Capital Costs (construction)	Annual Operations (1)	Sum of Year "n" Costs	Cumulative Costs, Year 1 through n	Present Worth Factor, i	Present Worth of Capital Costs Only	Present Worth of Year "n" Costs	Cumulative Present Worth, Year 1 through n
0	$60,799,302		$60,799,302	$60,799,302	1	$60,799,302	$60,799,302	$60,799,302
1		$1,432,956	$1,432,956	$62,232,258	0.9346	$0	$1,339,211	$62,138,513
2		$1,432,956	$1,432,956	$63,665,214	0.8734	$0	$1,251,599	$63,390,112
3		$1,432,956	$1,432,956	$65,098,170	0.8163	$0	$1,169,719	$64,559,831
4		$2,865,912	$2,865,912	$67,964,082	0.7629	$0	$2,186,391	$66,746,222
5		$2,865,912	$2,865,912	$70,829,994	0.7130	$0	$2,043,356	$68,789,578
6		$2,865,912	$2,865,912	$73,695,906	0.6663	$0	$1,909,678	$70,699,256
7		$2,865,912	$2,865,912	$76,561,818	0.6227	$0	$1,784,746	$72,484,002
8		$2,865,912	$2,865,912	$79,427,730	0.5820	$0	$1,667,987	$74,151,989
9		$2,865,912	$2,865,912	$82,293,642	0.5439	$0	$1,558,866	$75,710,855
10		$2,865,912	$2,865,912	$85,159,554	0.5083	$0	$1,456,884	$77,167,739
11		$2,865,912	$2,865,912	$88,025,466	0.4751	$0	$1,361,574	$78,529,313
12		$2,865,912	$2,865,912	$90,891,378	0.4440	$0	$1,272,499	$79,801,813
13		$2,865,912	$2,865,912	$93,757,290	0.4150	$0	$1,189,252	$80,991,064
14		$2,865,912	$2,865,912	$96,623,202	0.3878	$0	$1,111,450	$82,102,514
15			$0	$96,623,202	0.3624	$0	$0	$82,102,514
Totals	$60,799,302		$96,623,202			$60,799,302	$82,102,514	

BASIS OF UNIT COSTS

I.D.	Item	Source	Description	Value or Range Provided (rounded)	Value Used for Estimate (rounded)	Basis
D.1	Land acquisition	In-house experience in the vicinity	Cost for acquiring property.	$2,000	$2,000	Typical cost for rural land in Brown County.
C.1	Mobilization/demobilization	Contractor estimate/bid for similar work (local Fox Valley contractor)	Mobilize labor and equipment for each year's liner or cover construction work.	$37,000	$0	Included in annual costs.
C.2	Clear & grub	Contractor estimate/bid for similar work (local Fox Valley contractor)	Clear and grub vegetation prior to excavation to subbase grades and other on-site construction.	$2,100	$2,100	Typical per acre cost for similar work.
C.3	Strip & stockpile topsoil (6")	Contractor estimate/bid for similar work (local Fox Valley contractor)	Strip existing topsoil and stockpile onsite for future cover construction.	$0.70	$1	Contractor estimate is $0.70/cy. Increase to $1.00/cy to be conservative.
C.4	Excavation to subgrade	Contractor estimate/bid for similar work (local Fox Valley contractor)	Excavated material will be stockpiled on-site for re-use as berm, liner and cover soil.	$1.15	$1.50	Contractor estimate is on low side of typical range. Increase to account for bidding uncertainty at time of work. Assumes cut soils are suitable clay for liner construction.
C.5	Berm construction	Contractor estimate/bid for similar work (local Fox Valley contractor)	Construct perimeter berm from cut soils/stockpile. Also includes internal berms where needed.	$1.80	$2.50	Contractor estimate is on low side of typical range. Increase to account for bidding uncertainty at time of work.
C.6	Liner system	Contractor estimate/bid for similar work (local Fox Valley contractor) and typical experience	Construct composite liner, using 3 ft. recompacted clay from onsite borrow, 4-inch crushed rock base, 4-inch asphalt layer and under drain system embedded in 1 ft coarse sand layer. Express cost as "per acre of liner constructed", with an allowance for miscellaneous other material. The cost components for this assembly are as follows:			
			Place & compact clay = (3 ft)(43560 sf/acre)($3.00/cy)(cy/27 cy) = $14,520	$14,520		Local estimate is $1.50/cy to place and recompact clay from onsite stockpile. Typical range is as high as $3.00/cy. Use
			Purchase and place non-woven filter fabric = ($0.20/sf)(43560 sf/acre) = $8,712	Not used		Typical unit cost for similar work.
			Place and compact coarse crushed rock base = (0.33 ft)(43560 sf/acre)($15.00/cy)(cy/27 cf) = $7,997	$7,997		Typical unit cost for similar work.
			Asphalt paving =($10.20/sy)(4840 sy/acre) = 49,368	$49,368		Typical unit cost for similar work.
			Place drainage rock = (1 ft)(43560 sf/acre)($18/cy)(cy/27 cy) = $29,040	$29,040		RS Means 2002, 04060-750-0200.
			Drainage system piping, sumps and pumps = (72,000 ft) ($4/ft)+ (2,300 ft) ($3.85/ft)+ $200,000 (for vac pumps) / (83 acres) = $5,987	$6,000		Bid from Hugh Supply, Seattle for drainage pipe.
			Subtotal, liner and leachate collection assembly	$106,925	**$110,000**	Include an allowance for other related work. Use $110,000 per acre of waste limits.
C.7	Weir structure construction	Typical experience	Overflow weir structure, 10 ft wide with adjustable boards		$50,000	Typical cost for similar work
C.8	Effluent collection trench	Typical experience	Trench 6 ft wide and 6 ft deep for collection of effluent lined with 40-mil HDPE		$28.00	RS Means 2002, G1030-805-4030. Add allowance for HDPE liner. Use $28 per linear feet

BASIS OF UNIT COSTS

I.D.	Item	Source	Description	Value or Range Provided (rounded)	Value Used for Estimate (rounded)	Basis
C.9	Perimeter drainage ditches	Contractor estimate/bid for similar work (local Fox Valley contractor) and typical experience	Drainage ditches constructed around the perimeter to collect stormwater run-off. Quote of 3.25/lf.	$3.25	$4.00	Typical unit cost for similar work.
C.11	Access road, paved	Contractor estimate/bid for similar work (local Fox Valley contractor), Means Sitework (2000) and typical experience	Main access road for personnel vehicle entrance, expressed on a "per square foot" basis.	$3.00 - 4.00	$4	Typical unit cost for similar work.
C.12	Perimeter fence	Means Sitework (2000)	Perimeter fence, chain link, 8' h w/ 3-strand barb wire	$30	$35	Means #02820_528_0920. $30/lf. With price inflation, allowance for gates, etc., use $35/lf.
C.13	Demolition/disposal/regrading of basins	In-house opinion	Demolition of basins upon project completion, site regrading and material disposal		$100,000	Typical cost per basin.
M.1	Piping, valves and dredge hookup	Typical experience	Piping and associated valves from different cells connecting to the dredge slurry forcemain.	$200,000	$200,000	Typical experience, similar projects.
E.2	Power supply	Typical experience	Provide new 3-phase power supply to site to run blowers, lighting, etc.		$30,000	This is a placeholder, based on typical projects.
E.1	Wiring and controls	Typical experience	Local wiring of leachate pump stations, yard lights, etc.		$25,000	This is a placeholder, based on typical projects.
O.10	Environmental technician	In-house opinion	1 FTE to conduct continuous operations and maintenance-related tasks. 2,500 hrs/yr.		$30	Typical labor cost for local technician.
O.11	Project manager	In-house opinion	On-site project controls and personnel supervision. Assume LOE is 0.20 FTE. 500 hrs/yr.		$70	Local project oversight and administration.
O.12	Sediment surface management	Typical experience	Perimeter and interior trench construction, scarifying the crust, etc. inside the dewatering cells, using heavy equipment		$100,000	Cost of labor and equipment to till and aerate the surface of sediments in cell
O.13	Sediment loading	Typical experience	5-cy loader and laborer		$1.03	Typical cost for loading
O.14	Sediment hauling	Typical experience	20 tons per truck, 30 min cycle, $65/ hr		$1.63	Typical cost for hauling
O.20	Replace coarse sand layer for vacuum enhanced drainage system	In-house opinion	Replace 4 inches of drainage layer sand per cell assuming loss of sand during removal of dewatered sediments from the cell		$225,000	RS Means 2002, 04060-750-0200.
O.21	Routine maintenance	In-house opinion	Purchased materials and labor to install miscellaneous small and expendible items associated with operations and maintenance. Possible non-routine maintenance requirements included.		$75,000	Typical experience, similar projects.

BASIS OF UNIT COSTS

I.D.	Item	Source	Description	Value or Range Provided (rounded)	Value Used for Estimate (rounded)	Basis
O.30	Electricity	In-house opinion	Monthly power requirements for blowers, lighting, etc.		$10,000	Average H.P for mid-size vacuum blower (300 scfm) is 25 H.P per Rogers Machinery Company Inc., Seattle. Assume 5 blowers per cell. Total HP per cell = (5)(25 HP) = 125 HP, or 94 Kw. Monthly usage = (24 hours)(94Kw)(30 d/mo) = 68,000 Kw*hr/mo. Monthly cost = ($0.07/Kw*hr)(68,000 Kw*hr/yr) = $4,800. Based on the 4 cell configuration and rotation cycle, 2 cells will be drying during any given time during the project cycle. Therefore, total monthly usage = (2)($4800) = $9,600. Include allowance for other minor loads. Use $10,000 per month.

COST ESTIMATE #07 **Rev: 10.30.03**
DETAILED EVALUATION OF ALTERNATIVES **Final**
WDNR - FOX RIVER

PROJECT ELEMENT:
Wastewater treatment system, Type II
Baseline Alternative - OU3 and OU4

PROCESS METRICS

Total volume of sediment removed from river	6,500,000	cy
Nominal capacity of system (expressed as the dredge slurry rate)	4,100	gpm
Length of operations	10.3	yr
Total gallons treated & discharged	4,680,000,000	gal

COST SUMMARY

	Total Cost	**Total as Present Worth**	
Subtotal, construction costs	$6,300,000	$6,300,000	
Total, construction plus operating costs	$16,900,000	$13,700,000	
Cost per cy sediment removed	$2.60	$2.11	/cy
Cost per gallon water discharged	$0.0036	$0.0029	/gal

Notes

1. This estimate is based on the major processes/equipment identified in the accompanying drawing, "Process Flow Diagram for Wastewater Treatment." It is based on preliminary concepts, and is suitable only as a general indicator of eventual project costs. It will change as final engineering and detailed design work proceed.
2. The Type II facility is sized to treat the carriage water that would be released from a dredge slurry flowrate of up to 4,100 gpm.
3. The estimate assumes that the plant is constructed as a fixed-base, semi-permanent facility. Equipment is purchased, with no salvage value at end of project. Site infrastructure (roads, offices, etc.) common to the larger project not included, and will be estimated elsewhere. Indirect capital costs (engineering, construction management, etc.) not included.
4. The "total cost" does not discount the multi-year operating costs.
5. The "present worth" discounts all construction and operations costs over the active life of the facility. The discount rate is 7% (USEPA, "Guide to Developing and Documenting Cost Estimates During the Feasibility Study", July 2000).
6. "Cost per gallon" and "cost per cy" values are for informational purposes only. Values are not true unit costs because they represent a combination of fixed capital and flow-proportional components.
7. "Cost per gallon treated" is based on the total volume of water treated and discharged, after taking in to account the online factor of the dredging operation (i.e. the maximum capacity of the system over a 24-hour period would be greater).

CAPITAL COSTS

	Item	Units	Quantity	Unit Cost (1)	Extension
Purchased Equipment					
K.1	Polymer feed/flocculation unit	ea	1	$78,000	$78,000
K.2	Clarifier #1	ea	1	$450,000	$450,000
K.3	Clarifier #2	ea	0	$0	$0
K.4	Filter feed tank	ea	1	$89,000	$89,000
K.5	Clarifier solids pump (plus spare)	ea	2	$4,800	$9,600
K.6	Filter feed pump (plus spare)	ea	4	$14,000	$56,000
K.7	Granular media filter	lot	1	$450,000	$450,000
K.8	GAC filters	lot	1	$270,000	$270,000
K.9	Backwash supply pump (plus spare)	ea	2	$2,600	$5,200
K.10	Effluent collection tank	ea	1	$38,000	$38,000
K.11	Effluent discharge pump (plus spare)	ea	2	$16,300	$32,600
K.12	pH control (chemical feed) system	ea	1	$20,000	$20,000
	Subtotal, major equipment				$1,498,400
K.13	Minor equipment & support facilities	% of major equipment		25%	$374,600
	Subtotal, purchased equipment				$1,873,000
Mechanical Work					
M.1	Equipment erection	% of equipment	1	15%	$280,950
M.2	Process piping	% of equipment	1	30%	$561,900
M.3	Treatment building HVAC	ls	1	$200,000	$200,000
M.4	Site restoration	ls	1	$200,000	$200,000
Electrical Work					
E.1	Service entrance	ls	1	$150,000	$150,000
E.2	Main panels	ls	1	$30,000	$30,000
E.3	Process electrical & instrumentation	% of equipment	1	20%	$374,600
E.4	Primary control panel/package	ls	1	$200,000	$200,000
E.5	Building lighting	ls	1	$10,000	$10,000
Structural					
S.1	Treatment building	sf	10,400	$50	$520,000
S.2	Building foundation	ls	1	$150,000	$150,000
S.3	Outside tank and equipment foundations	ls	1	$58,000	$58,000
	Subtotal, purchased equipment and trades				$4,608,450
	Mobilization, demobilization, general conditions (% of above)			8%	$368,676
	Freight (% of purchased equipment)			5%	$93,650
	Prime contractor administration, overhead & profit (% of above)			25%	$1,267,694
	TOTAL DIRECT CAPITAL				$6,338,470

Notes

1. Unit cost backup provided on subsequent sheets

ANNUAL OPERATING COSTS

	Item	Units	Quantity	Unit Cost (1)	Extension
Purchased materials					
O.1	Granular activated carbon	lbs	9,245	$1.30	$12,019
O.2	Filter media	ls	1	$20,000	$20,000
O.3	Coagulant	ls	1	$50,000	$50,000
O.4	Caustic	ls	1	$10,000	$10,000
Operations labor					
O.10	Wastewater technician	hrs	9,800	$35	$343,000
O.11	Certified operator	hrs	1,750	$50	$87,500
O.12	Project manager	hrs	350	$75	$26,214
O.13	Analytical work	day	245	$200	$49,000
Maintenance labor & materials					
O.20	Maintenance and replacement parts	% of equipment	$1,873,000	5%	$93,650
Utilities					
O.30	Electricity	per detail			$66,439
O.31	Telephone	mo	8	$200	$1,600
		Subtotal			$759,422
	Mobilization, demobilization, general conditions (% of above)			8%	$60,754
	Prime contractor administration, overhead & profit (% of above)			25%	$205,044
	TOTAL ANNUAL OPERATIONS				$1,025,219

Notes

1. Unit cost backup provided on subsequent sheets

SUMMARY OF CARBON USAGE

Volume treated at breakthrough (1,2)	265,000,000	gal
Operating days per year	245	days
Daily volume treated, total	3,500,000	gal
Number of vessels	7	
Daily volume treated, per vessel	500,000	gal
Volume treated per year, per vessel	122,500,000	gal
Number of changeouts per year	0.46	
Mass of carbon per changeout, per vessel	20,000	lbs
Mass carbon per year, if averaged (3)	9,245	lbs

Notes

1. To be conservative, define breakthrough as 1/2 the expected discharge limit of 1.0 ug/L.
2. Breakthrough calculations provided by Carbonair, Inc., Minneapolis, MN, based on typical operating and loading conditions estimated by RETEC, Inc.
3. Carbon changeout would actually occur roughly simultaneously in all GAC units, not evenly spaced over time.

ANNUAL ELECTRICAL COSTS

	Item	Total Motor HP	Kw	Operating Time Per Day (1)	Kw*hr per day
E.1	Polymer feed/flocculation unit	10	7.46	14	104
E.2	Clarifier #1	5	3.73	24	90
E.3	Clarifier #2	0	0	14	0
E.4	Filter feed tank	0	0	0	0
E.5	Clarifier solids pump	20	14.92	14	209
E.6	Filter feed pump (assume 3 at 40 HP)	120	89.52	14	1,253
E.7	Granular media filter	0	0	0	0
E.8	GAC filters	0	0	0	0
E.9	Backwash supply pump	15	11.19	2	22
E.10	Effluent collection tank	0	0	0	0
E.11	Effluent discharge pump	150	111.9	14	1,567
E.12	pH control (chemical feed) system	1	0.746	14	10
	Subtotal, major equipment				3,256
E.13	Minor equipment & support facilities	20	14.92	14	209
	Subtotal, all equipment (kw*hr/day)				3,464
	Number of days per operating year				175
	Cost of electricity ($/kw*hr)				$0.07
	Subtotal, electricity for equipment				$42,439
			Months	$/month	Extension
O.30	Lighting, ventilation & occasional minor heating of treatment building	month	8	3,000	$24,000
	TOTAL ANNUAL ELECTRICAL				$66,439

Notes

1. To be conservative daily operating time for system is assumed to be slightly longer than the typical daily dredge effective time.

PRESENT WORTH CALCULATION

i = 7%

Year, n	Capital Costs (Construction)	Annual Operations	Sum of Year "n" Costs	Cumulative Costs, Year 1 through n	Present Worth Factor, i	Present Worth of Year "n" Construction Costs Only	Present Worth of All Year "n" Costs	Cumulative Present Worth of All Costs, Year 1 through n
0	$6,338,470		$6,338,470	$6,338,470	1	$6,338,470	$6,338,470	$6,338,470
1		$1,025,219	$1,025,219	$7,363,689	0.9346	$0	$958,149	$7,296,619
2		$1,025,219	$1,025,219	$8,388,908	0.8734	$0	$895,466	$8,192,085
3		$1,025,219	$1,025,219	$9,414,128	0.8163	$0	$836,884	$9,028,969
4		$1,025,219	$1,025,219	$10,439,347	0.7629	$0	$782,135	$9,811,104
5		$1,025,219	$1,025,219	$11,464,566	0.7130	$0	$730,967	$10,542,071
6		$1,025,219	$1,025,219	$12,489,785	0.6663	$0	$683,147	$11,225,218
7		$1,025,219	$1,025,219	$13,515,005	0.6227	$0	$638,455	$11,863,673
8		$1,025,219	$1,025,219	$14,540,224	0.5820	$0	$596,687	$12,460,360
9		$1,025,219	$1,025,219	$15,565,443	0.5439		$557,651	$13,018,011
10		$1,025,219	$1,025,219	$16,590,662	0.5083		$521,169	$13,539,181
11		$307,566	$307,566	$16,898,228	0.4751		$146,122	$13,685,303
12			$0	$16,898,228	0.4440		$0	$13,685,303
13			$0	$16,898,228	0.4150		$0	$13,685,303
14			$0	$16,898,228	0.3878		$0	$13,685,303
15			$0	$16,898,228	0.3624		$0	$13,685,303
16			$0	$16,898,228	0.3387		$0	$13,685,303
17			$0	$16,898,228	0.3166		$0	$13,685,303
18			$0	$16,898,228	0.2959		$0	$13,685,303
19			$0	$16,898,228	0.2765		$0	$13,685,303
20			$0	$16,898,228	0.2584		$0	$13,685,303
21			$0	$16,898,228	0.2415		$0	$13,685,303
22			$0	$16,898,228	0.2257		$0	$13,685,303
23			$0	$16,898,228	0.2109		$0	$13,685,303
24			$0	$16,898,228	0.1971		$0	$13,685,303
25			$0	$16,898,228	0.1842		$0	$13,685,303
26			$0	$16,898,228	0.1722		$0	$13,685,303
27			$0	$16,898,228	0.1609		$0	$13,685,303
28			$0	$16,898,228	0.1504		$0	$13,685,303
29			$0	$16,898,228	0.1406		$0	$13,685,303
30			$0	$16,898,228	0.1314		$0	$13,685,303
31			$0	$16,898,228	0.1228		$0	$13,685,303
32			$0	$16,898,228	0.1147		$0	$13,685,303
33			$0	$16,898,228	0.1072		$0	$13,685,303
34			$0	$16,898,228	0.1002		$0	$13,685,303
35			$0	$16,898,228	0.0937		$0	$13,685,303
36			$0	$16,898,228	0.0875		$0	$13,685,303
37			$0	$16,898,228	0.0818		$0	$13,685,303
38			$0	$16,898,228	0.0765		$0	$13,685,303
39			$0	$16,898,228	0.0715		$0	$13,685,303
40			$0	$16,898,228	0.0668		$0	$13,685,303
Totals	$6,338,470	$10,559,758	$16,898,228			$6,338,470	$13,685,303	

BASIS OF UNIT COSTS

I.D.	Item	Source	Description	Value or Range Provided (rounded)	Value Used (rounded)	Basis
K.1	Polymer feed/flocculation unit	Vendor budgetary estimate (Enprotec, Hebron, KY)	Flash, floc tanks with mixers and polymer blending feed system. Sizing: 1,600 to 2,500 gpm influent. Flash mix tank at 30 sec, flocculation tank at 5-7 min.	$52,000 - $62,000	$78,000	Size varies to accomodate different influent flowrates to individual subsystems. Use upper end of range scaled up by factor of 125% for treatment of carriage water released from a dredge slurry of up to 4,100 gpm (Type II system), which corresponds to a wastewater flow on order of 3,000 gpm.
K.2	Clarifier #1	Vendor budgetary estimate (Enprotec, Hebron, KY)	Model J6220, rectangular clarifier, 500 gpd/sf, 10'w x 12'h x length as needed. Sized for nominal 2,500 gpm influent at 2000 mg/L solids.	$415,000		
		Vendor budgetary estimate (WesTech, Rockton, IL)	Clarifier mechanism (SCS71) and tank (TKC11). Solids contact style, sized for 4000 gpm thickener overflow. 85' dia x 16' side wall depth. 25' total side depth.	$400,000 - $500,000		Interpolated from quote provided by WesTech for dewatering and wastewater treatment package.
		Summary:			$450,000	For Type II system, use mid-point of range. Assume combined system for handling supernatent and filtrate streams with allowance for excess capacity.
K.3	Clarifier #2	Vendor budgetary estimate (Enprotec, Hebron, KY)	Model J6220, rectangular clarifier, overflow rate of 500 gpd/sf, 10'w x 12'h x length as needed. Sized for nominal 1600 gpm influent at 500 mg/L solids.	$264,000		Not used.
K.4	Filter feed tank	Vendor budgetary estimate (Enprotec, Hebron, KY)	100,000 gal bolted steel tank, 32'8" dia x 16'1" h or 47'6" dia x 8'1/2" h.	$85,000	$89,000	Assume 1 tank required to provide approx. 30 minute holding capacity for flow on order of 3,000 gpm. Add allowance for pipes and fittings.
K.5	Clarifier solids pump (plus spare)	Means/Echos (2001)	Pump to return up to several hundred gpm underflow solids from clarifier to thickener. 500 gpm, 100' TDH, 20 HP centrifugal transfer pump with motor and fittings. An additional backup pump will be purchased.	$4,800	$4,800	Means, #33_29_0130. Pump sized for combined system for handling supernatent and filtrate streams including allowance for fluctuations in flow.
K.6	Filter feed pump (plus spare)	Means/Echos (2001)	Pump to feed supernatant from clarifier to filters. 1,000 gpm at 100' TDH, 40 HP centrifugal transfer pump with motor and fittings. An additional backup pump will be purchased.	$12,800	$14,000	Means, #33_29_0134 plus 10% to account for inflation.
K.7	Granular media filter	Vendor budgetary estimate (WesTech, Rockton, IL)	Dual-media (anthracite, silica sand), automatic backwash, pressure filters. Two vessels with 3-cell design required to treat 4,000 gpm. Model: SA516 GR70; Vessel: 10' dia. X 34' L horizontal	$225,000 - $300,000		Interpolated from quote provided by WesTech for dewatering and wastewater treatment package. Assume 3 vessels required at $75,000 - $100,000 each for approx. 3,000 gpm. Design rate = 5.9 gpm/sf; maximum during backwash = 8.9 gpm/sf; backwash = 17.7 gpm/sf.
		Vendor budgetary estimate (Enprotec, Hebron, KY)	Multi-media, automatic backwash, pressure filters. Two vessels with 3-cell design required to treat 1800 gpm. Model: J3396-150; Cell: 96" dia, 50 sf area	$520,000		Assume cost of 2 units (4 vessels) at approx. $260,000. Units sized for 90% removal of +20 micron solids, at an assumed influent loading of up to 100 mg/L.
		Vendor budgetary estimate (Zimpro/US Filter, Rothschild, WI)	Single-media (sand), continuous backwash, gravity flow filters. Hydro-Clear 4-cell design required to treat 2,500 gpm. Model KK-12X25(4); Cell: 250 sf area	$590,000		Assume 2 units required at $295,000.
		Vendor opinion (Parkson Corp.)	Single-media sand (DynaSand) filter, continuous backwash, gravity flow filters required to treat 1,725 gpm. Details not specified.	> $1,000,000		Assume cost of 2 units at approx. $500,000.

BASIS OF UNIT COSTS

I.D.	Item	Source	Description	Value or Range Provided (rounded)	Value Used (rounded)	Basis
		Vendor budgetary estimate (Applied Process Technology, Conroe, TX)	Multi-grade sand media, continuous backwash, gravity flow filters. 24-filter 6-cell and 32-filter 8-cell Centra-flo filter design required to treat 1,725 and 2,258 gpm, respectively. Model: CF-50C; Filter: 8 sf area	$770,000 $1,020,000		Assume 32-filter, 8-cell design required at approx. $815,000 scaled up by factor of 125% for Type II system. Cells would be contained in a concrete, rectangular tank, by others.
		Summary:			$450,000	A number of process options and configurations are available. Assume pressure filter style. Use mid-point of range for pressure-style filters.
K.8	GAC filters	Vendor budgetary estimate (Carbonair, Inc., Minneapolis)	Model PC78. 10' dia. x 18'h, vertical steel tanks, each containing 20,000 lb of liquid-phase carbon. Hydraulic loading = 5.9 gpm/sf. Purchase price includes first load of carbon.	$228,000		Quote provided by Carbonair of 7 vessels at $32,600 each required for 2,300 gpm (initial proposal included 9 vessels for 4,000 gpm).
		Vendor budgetary estimate (WesTech, Rockton, IL)	Model SA516 GR70. 8' dia x 32'L, horizontal steel tanks. Hydraulic loading = 3.7 gpm/sf.	$200,000		Interpolated from quote provided by WesTech for dewatering and wastewater treatment package. Assume 4 units required at $50,000 each.
		Summary:			$270,000	Proposed loading for both options is within or better than typical range (4-8 gpm/sf, Cheremisinoff, 1993). Use Carbonair cost estimate as representative, due to their prior experience on original demonstration projects. Approx. 7 vessels required for flow on order of 3,000 gpm. Include allowance for interconnecting pipe racks and valving.
K.9	Backwash supply pump (plus spare)	Means/Echos (2000)	Pump to return water from effluent collection tank to filters for periodic backwashing. 800 gpm at 25 psi, 15 HP, 3 phase, 1,750 rpm, TEFC motor. An additional backup pump will be purchased.	$2,560	$2,600	Quote provided by Carbonair.
K.10	Effluent collection tank	Vendor budgetary estimate (Enprotec, Hebron, KY)	44,000 gal bolted steel tank, 21' dia x 16'h	$36,300	$38,000	Assume 1 tank required to provide approx. 15 minute holding capacity for flow on order of 3,000 gpm. Add allowance for pipes and fittings.
K.11	Effluent discharge pump (plus spare)	Means/Echos (2001)	Pump for discharging treated water to river. 3,500 gpm at 125' TDH, 150 HP centrifugal transfer pump with motor and fittings. An additional backup pump will be purchased.	$14,800	$16,300	Means, #33_29_0136 plus 10% to account for inflation. Pump sized for flow on order of 3,000 gpm with allowance for fluctuations in flow. Cost includes the purchase of spare pump.
K.12	pH control (chemical feed) system		Chemical feed system to re-adjust effluent pH to within 6 to 9 per WPDES permit.		$20,000	Placeholder, pending final engineering.
K.13	Minor equipment & support facilities	Prior project experience	Minor items such as compressed/instrument air system, materials handling equipment, storage units, laboratory instrumentation, that are not currently defined for the project.		25%	Placeholder, pending final engineering.
M.1	Equipment erection	Prior project experience	Labor and materials to erect large tanks and other process equipment.	11%	15%	Increase percentage to account for several unknown factors at this stage in the project.
M.2	Process piping	Prior project experience	Interconnecting piping between and not supplied with process equipment.	7 - 50%	30%	Range from past mid-size treatment systems, as a percentage of purchased equipment. Use mid-point of range to account for unknown factors at this stage in the project.
M.3	Treatment building HVAC	Prior project experience	Heating and ventilation equipment for treatment building.		$200,000	Past projects at $9 to $33/sf, or 50% to 100% of building cost. For Type II building, sized at approximately 10,400 sf, assume $200,000.

BASIS OF UNIT COSTS

I.D.	Item	Source	Description	Value or Range Provided (rounded)	Value Used (rounded)	Basis
M.4	Site restoration	Prior project experience	Remove system and building at end of project.		$200,000	Based on recent experience with process equipment removal and building demolition, Fox Valley.
E.1	Service entrance	Contractor opinion (Boudry Control Panels, LLC, Fond du Lac, WI) (formerly Boudry Electric, Inc.)	New overhead primary line from nearby street. Assume 500 to 1000 feet required.		$150,000	Could range from $0 to $300,000, depending on whether utility would subisidize (or pay) based on projected revenue, whether transformer is purchased or leased, if power factor correction is needed, etc. Use midpoint of $150,000 as a placeholder.
E.2	Main panels	Contractor opinion (Boudry Control Panels, LLC, Fond du Lac, WI)	Main panel and disconnect at plant building.		$30,000	Assumes $20,000 for 2000 amp panel, plus installation.
E.3	Process electrical and instrumentation	Prior project experience	Includes process wiring, loose process instrumentation and controls, as a percentage of the purchased equipment.	15 - 27%		Range from past, smaller projects.
		Contractor opinion (Boudry Control Panels, LLC, Fond du Lac, WI)		Min. $750,000		Contractor opinion is for OU3/4 total facility (dewatering, water treatment, infrastructure, etc.). $750,000 would be a little less than 10% of purchased equipment for OU3/4. This assumes that all starters and local panels are provided with individual equipment packages.
		Summary:			20%	Increase contractor's opinion to allow for some starters not provided with equipment, other items not yet defined, etc. Use 20% of purchased equipment, which is at mid-point of past experience on smaller projects.
E.4	Primary control panel/package	Contractor opinion (Boudry Control Panels, LLC, Fond du Lac, WI)	Central controls package and process monitoring, that integrates all loose controllers provided with individual equipment packages. Include 5 or 6 remote PCs at various points in plant/offices, with process monitoring software, local network, etc.		$200,000	Cost breakdown is: PCs - $12,000, networking - $10,000, software - $35,000, programming and installation - $120,000. Add contingency for items not yet defined. Use $200,000.
E.5	Building lighting	Contractor opinion (Boudry Control Panels, LLC, Fond du Lac, WI)	Overhead, industrial lighting in press building.		$10,000	Assumes 1 fixture for every 400 sf Total = 10,400 sf/400 = 26 fixtures. Fixtures at $200 each plus $100 to install/wire. Use $10,000.
S.1	Treatment building	Builder opinion, typical projects (Butler Buildings/Howard Immel, Inc., Green Bay, WI)	Pre-engineered metal building, industrial quality, w/ OH doors, etc. On a square foot of floorspace basis.		$50	Estimate represents typical square foot cost, based on contractor experience in Fox Valley. Building footprint of 80' x 130' has been developed for the larger Type II building.
S.2	Building foundation	Builder's opinion (Howard Immel, Inc., Green Bay, WI)	Assume minimum of 8" slab plus 4 ft. frost wall and strip footing.		$150,000	Floor slab: 4" at $2.50/sf. Double thickness and assume minimum of $5.00/sf. For 10400 sf, slab = $52,000. Frost wall/footing. At least $55/lf. for 80' x 130' building, wall = $23,100. include earthwork and allowance for housekeeping pads, curbs, thickened slab at heavy loads. Use total foundation system = $150,000 for the larger Type II building.

BASIS OF UNIT COSTS

I.D.	Item	Source	Description	Value or Range Provided (rounded)	Value Used (rounded)	Basis
S.3	Outside tank & equipment foundations	Builder opinion, typical projects and Means Site Work, 2000.	Along perimeter of circular tanks, assume minimum of 4 ft. foundation wall, 8" thick, with continuous strip footing, 16" d x 48" w.		$58,000	From Means assemblies, p. 387: Footing = $35/lf. 8' x 8" wall = $57/lf. For shorter wall, use $75/lf total. Assume at least 1 tank at 85' dia, 1 at 40' dia, for total of 392 lf, or $29,500. Include allowance for small tanks and equipment pads. Use $58,000.
S.4	Interior buildout	In-house opinion	Includes construction of interior walls for office space, lab benches, storage, lavatory, etc.		$75,000	Placeholder pending detailed design of the facility.
O.1	Granular activated carbon	Vendor model calculations and recommendations (Carbonair, Inc., Minneapolis)	Media used for polishing step in filtration process. Annual cost.		$12,019	Refer to cost sheet, "Summary of Carbon Usage"
O.2	Filter media	In-house opinion	Typically a type of sand, either graded or combined with other media (i.e., anthracite, coal) used in the granular media filters. Annual cost.		$20,000	Placeholder, pending final engineering of the system. Replacement not expected to be needed, but could be several % by weight per year; therefore, a small allowance is included.
O.3	Coagulant	In-house opinion	Chemical addition to improve clarification. Annual cost.		$50,000	Placeholder pending final treatability testing. Type and dose of chemical not known.
O.4	Caustic	In-house opinion	For pH control. Annual cost.		$10,000	Placeholder, pending final treatability testing.
O.10	Wastewater technician	In-house opinion	2 FTE, 20/7 - Two 10-hour shifts 7 days per week to conduct continuous operations and maintenance-related tasks. 9800 hrs/yr.		$35	Assume typical hourly rate for contract environmental labor. Rate includes basic per diem expenses.
O.11	Certified operator	In-house opinion	Plant operator with state certification. 1 FTE (based on 50 hr week). LOE and cost is allocated to wastewater treatment element. 1,750 hrs/yr.		$50	Assume typical hourly rate for senior contract environmental personnel.
O.12	Project manager	In-house opinion	On-site project controls and personnel supervision. Assume LOE is 0.2 FTE (based on a 50 hr week), or 10 hrs/wk for 8 months, with the remainder of time allocated to other project elements. 350 hrs/yr.		$75	Assume typical hourly rate for onsite supervisor. Rate includes basis per diem expenses.
O.13	Analytical work	Estimate from FS	Daily effluent samples or samples from other intermediate points in the process to confirm discharge compliance and process control.		$200	Assumes analysis of BOD, TSS, PCBs, and other minor parameters per WPDES permit.
O.20	Maintenance and replacement parts	In-house opinion	Purchased materials and labor to install miscellaneous small and expendible items associated with process equipment.		5%	Professional judgement from similar projects experience.
O.30	Electricity		Power requirements for process equipment, lighting, etc.		$66,439	Refer to cost sheet, "Annual Electrical Costs"
O.31	Telephone	Prior project experience	Cost of phone service from treatment plant.		$200	Monthly estimated cost.

COST ESTIMATE #08 **Rev: 10.30.03**
DETAILED EVALUATION OF ALTERNATIVES **Final**
WDNR - FOX RIVER

PROJECT ELEMENT:
NR500 Monofill, Type A
Baseline Alternative - OU3 and OU4

PROCESS METRICS

Total volume of sediment removed from river	6,500,000	cy
Total wet tons generated for disposal	5,813,000	tons
Length of operations	10.3	yr
Mass disposed per year	564,369	tons

COST SUMMARY

	Total Cost (1)	Total as Present Worth (2)	
Subtotal, capital costs	$32,400,000	$32,400,000	
Subtotal, operating costs (including host community fee)	$67,300,000		
Subtotal, long-term care costs	$10,700,000		
Total, capital, operating and long-term care costs	$110,400,000	$80,919,031	
Cost per cy sediment removed (4)	$16.98	$12.45	/cy
Cost per ton filter cake disposed (4)	$18.99	$13.92	/ton

Notes

1. The "total cost" does not discount the multi-year construction costs, annual operating costs or long-term care costs.
2. The "present worth" discounts all construction and operations costs over the active life of the facility, as well as the post-closure annual costs. The discount rate is 7% (USEPA, "Guide to Developing and Documenting Cost Estimates During the Feasibility Study", July 2000). For this alternative, all site preparation and liner construction is assumed to occur in "Year 0." Construction will actually require several years to complete.
3. "Direct capital costs" include construction costs during the active life of the facility, up until final closure. Leachate management and groundwater monitoring, both prior to and after final closure, are included as "annual costs."
4. "Cost per cy sediment removed" and "cost per ton disposed" values are for informational purposes only. Values are not true unit costs because they represent a combination of fixed capital and quantity-proportional components.

CAPITAL COSTS

	Item	Units	Unit Cost	Year 0 Quantity	Year 0 Extension	Year 1 Quantity	Year 1 Extension	Year 2 Quantity	Year 2 Extension	Year 3 Quantity	Year 3 Extension	Year 4 Quantity	Year 4 Extension	Year 5 Quantity	Year 5 Extension
Direct Capital															
Facility Development															
D.1	Land acquisition	ac	$2,000	205	$410,000										
Civil Work															
C.1	Mobilization/demobilization	ls	$40,000	1	$40,000										
C.2	Clear & grub	ac	$2,100	126	$264,600										
C.3	Strip & stockpile topsoil (6")	cy	$1.00	101,640	$101,640										
C.4	Excavation to subgrade	cy	$1.50	2,743,382	$4,115,073										
C.5	Berm construction	cy	$2.50	1,223,950	$3,059,875										
C.6	Gradient control layer	ac	$35,000	112	$3,920,000										
C.7	Liner & leachate collection system	ac	$120,000	112	$13,440,000										
C.8	Place intermediate drainage layers [1]	ac	$20,000					56	$1,120,000	56	$1,120,000	56	$1,120,000	56	$1,120,000
C.9	Place grading layer [2]	cy	$2.50												
C.10	Cover system [2]	ac	$100,000												
C.11	Seed, fertilize, mulch	ac	$2,500	6.04	$15,100										
C.12	Perimeter drainage ditches	lf	$4	10,100	$40,400										
C.13	Perimeter road	lf	$10	10,100	$101,000										
C.14	Access road, paved	sf	$4	64,645	$258,580										
C.15	Perimeter fence	lf	$35	11,970	$418,950										
Mechanical															
M.1	Leachate collection tank	ls	$120,000	1	$120,000										
M.2	Leachate loadout station	ls	$50,000	1	$50,000										
Electrical															
E.1	New service to site	ls	$30,000	1	$30,000										
E.2	Wiring and controls	ls	$20,000	1	$20,000										
Structural															
S.1	Maintenance building	ls	$500,000	1	$500,000										
	Subtotal, direct capital, by year				$26,905,218										
Indirect Capital															
I.1	Siting studies, permitting, engineering and final design, through first phase of construction [1]	ls	$1,500,000	1	$1,500,000										
I.2	Engineering/ final design of subsequent phases (% of construction direct capital spent in year n +1)	%	7%		$0										
I.3	Construction documentation (% of construction direct capital spent in year n)	%	15%		$4,035,783										
	Subtotal, indirect capital, by year				$5,535,783										
	Total capital, by year				$32,441,001		$0		$0		$0		$0		$0

CAPITAL COSTS

	Item	Units	Unit Cost	Year 6 Quantity	Year 6 Extension	Year 7 Quantity	Year 7 Extension	Year 8 Quantity	Year 8 Extension	Year 9 Quantity	Year 9 Extension	Year 10 Quantity	Year 10 Extension	Year 11 Quantity	Year 11 Extension
Direct Capital															
Facility Development															
D.1	Land acquisition	ac	$2,000												
Civil Work															
C.1	Mobilization/demobilization	ls	$40,000												
C.2	Clear & grub	ac	$2,100												
C.3	Strip & stockpile topsoil (6")	cy	$1.00												
C.4	Excavation to subgrade	cy	$1.50												
C.5	Berm construction	cy	$2.50												
C.6	Gradient control layer	ac	$35,000												
C.7	Liner & leachate collection system	ac	$120,000												
C.8	Place intermediate drainage layers (1)	ac	$20,000	56	$1,120,000	56	$1,120,000	56	$1,120,000	56	$1,120,000	56	$1,120,000	56	$1,120,000
C.9	Place grading layer (2)	cy	$2.50												
C.10	Cover system (2)	ac	$100,000												
C.11	Seed, fertilize, mulch	ac	$2,500												
C.12	Perimeter drainage ditches	lf	$4												
C.13	Perimeter road	lf	$10												
C.14	Access road, paved	sf	$4												
C.15	Perimeter fence	lf	$35												
Mechanical															
M.1	Leachate collection tank	ls	$120,000												
M.2	Leachate loadout station	ls	$50,000												
Electrical															
E.1	New service to site	ls	$30,000												
E.2	Wiring and controls	ls	$20,000												
Structural															
S.1	Maintenance building	ls	$500,000												
	Subtotal, direct capital, by year														
Indirect Capital															
I.1	Siting studies, permitting, engineering and final design, through first phase of construction (1)	ls	$1,500,000												
I.2	Engineering/ final design of subsequent phases (% of construction direct capital spent in year n +1)	%	7%												
I.3	Construction documentation (% of construction direct capital spent in year n)	%	15%												
	Subtotal, indirect capital, by year														
	Total capital, by year				$0		$0		$0		$0		$0		$0

CAPITAL COSTS

	Item	Units	Unit Cost	Year 12 Quantity	Year 12 Extension	Year 13 Quantity	Year 13 Extension
Direct Capital							
Facility Development							
D.1	Land acquisition	ac	$2,000				
Civil Work							
C.1	Mobilization/demobilization	ls	$40,000				
C.2	Clear & grub	ac	$2,100				
C.3	Strip & stockpile topsoil (6")	cy	$1.00				
C.4	Excavation to subgrade	cy	$1.50				
C.5	Berm construction	cy	$2.50				
C.6	Gradient control layer	ac	$35,000				
C.7	Liner & leachate collection system	ac	$120,000				
C.8	Place intermediate drainage layers (1)	ac	$20,000	56	$1,120,000		
C.9	Place grading layer (2)	cy	$2.50	56	$140	56	$140
C.10	Cover system (2)	ac	$100,000	56	$5,600,000	56	$5,600,000
C.11	Seed, fertilize, mulch	ac	$2,500				
C.12	Perimeter drainage ditches	lf	$4				
C.13	Perimeter road	lf	$10				
C.14	Access road, paved	sf	$4				
C.15	Perimeter fence	lf	$35				
Mechanical							
M.1	Leachate collection tank	ls	$120,000				
M.2	Leachate loadout station	ls	$50,000				
Electrical							
E.1	New service to site	ls	$30,000				
E.2	Wiring and controls	ls	$20,000				
Structural							
S.1	Maintenance building	ls	$500,000				
	Subtotal, direct capital, by year						
Indirect Capital							
I.1	Siting studies, permitting, engineering and final design, through first phase of construction (1)	ls	$1,500,000				
I.2	Engineering/ final design of subsequent phases (% of construction direct capital spent in year n +1)	%	7%				
I.3	Construction documentation (% of construction direct capital spent in year n)	%	15%				
	Subtotal, indirect capital, by year						
	Total capital, by year				$0		$0

Notes

1. Construction of the intermediate drainage layers will begin in Year 3 and continue through Year 12 as material is transferred from the settling basins following a drying period.
2. Grading layer placement and cover construction will begin in Year 12 and will be phased over 2 years to allow for additional settling and drying of the material in sequentially filled cells.
3. Siting studies, permitting, and engineering would be performed over several years. As a simplifying assumption, all costs assigned to "Year 0."

ANNUAL OPERATING COSTS

	Item	Units	Quantity	Unit Cost	Extension
	Purchased services				
O.1	Environmental monitoring	ls	1	$85,000	$85,000
O.2	Leachate hauling	gal	1,600,000	$0.04	$64,000
O.3	Leachate disposal	gal	1,600,000	$0.01	$16,000
	Operations				
O.10	Landfill technician	hrs	2,000	$20	$40,000
O.11	Project manager	hrs	500	$50	$25,000
O.12	Waste placement	ton	564,369	$1	$564,369
	Maintenance				
O.20	Land surface care	ls	1	$10,000	$10,000
	Utilities				
O.30	Electricity	mo	12	$300	$3,600
O.31	Telephone	mo	12	$50	$600
		Subtotal			$808,569
		Prime contractor OH & P		10%	$80,857
O.40	Host community fee	ton	564,000	$10	$5,640,000
		Total, annual costs			$6,529,426

ANNUAL LONG-TERM CARE COSTS

	Item	Units	Quantity	Unit Cost	Extension
	Purchased services				
O.1	Environmental monitoring	ls	1	$85,000	$85,000
O.2	Leachate hauling	gal	1,300,000	$0.04	$52,000
O.3	Leachate disposal	gal	1,300,000	$0.01	$13,000
	Operations				
O.10	Landfill technician	hrs	2,000	$20	$40,000
O.11	Project manager	hrs	500	$50	$25,000
	Maintenance				
O.20	Land surface care	ls	1	$10,000	$10,000
O.21	Leachate pump replacement	ea	2	$4,000	$8,000
O.22	Leachate pipe cleaning	ls	1	$5,000	$5,000
	Utilities				
O.30	Electricity	mo	12	$300	$3,600
O.31	Telephone	mo	12	$50	$600
		Subtotal			$242,200
		Prime contractor OH & P		10%	$24,220
		Total, annual costs			$266,420

PRESENT WORTH CALCULATION

i = 7%

Year, n	Capital Costs (construction)	Annual Operating Costs (prior to final closure)	Annual Long-Term Care Costs (post closure)	Sum of Year "n" Costs	Cumulative Costs, Year 1 through n	Present Worth Factor, i	Present Worth of Year "n" Capital Costs Only	Present Worth of All Year "n" Costs	Cumulative Present Worth of All Costs, Year 1 through n
0	$32,441,001			$32,441,001	$32,441,001	1	$32,441,001	$32,441,001	$32,441,001
1	$0	$6,529,426		$6,529,426	$38,970,427	0.9346	$0	$6,102,267	$38,543,268
2		$6,529,426		$6,529,426	$45,499,852	0.8734	$0	$5,703,053	$44,246,321
3		$6,529,426		$6,529,426	$52,029,278	0.8163		$5,329,956	$49,576,278
4		$6,529,426		$6,529,426	$58,558,704	0.7629		$4,981,268	$54,557,545
5		$6,529,426		$6,529,426	$65,088,130	0.7130		$4,655,390	$59,212,936
6		$6,529,426		$6,529,426	$71,617,556	0.6663		$4,350,832	$63,563,768
7		$6,529,426		$6,529,426	$78,146,981	0.6227		$4,066,198	$67,629,966
8		$6,529,426		$6,529,426	$84,676,407	0.5820		$3,800,185	$71,430,151
9		$6,529,426		$6,529,426	$91,205,833	0.5439		$3,551,575	$74,981,726
10		$6,529,426		$6,529,426	$97,735,259	0.5083		$3,319,229	$78,300,955
11		$1,958,828		$1,958,828	$99,694,087	0.4751		$930,625	$79,231,580
12			$266,420	$266,420	$99,960,507	0.4440		$118,294	$79,349,874
13			$266,420	$266,420	$100,226,927	0.4150		$110,555	$79,460,429
14			$266,420	$266,420	$100,493,347	0.3878		$103,322	$79,563,751
15			$266,420	$266,420	$100,759,767	0.3624		$96,563	$79,660,314
16			$266,420	$266,420	$101,026,187	0.3387		$90,246	$79,750,560
17			$266,420	$266,420	$101,292,607	0.3166		$84,342	$79,834,901
18			$266,420	$266,420	$101,559,027	0.2959		$78,824	$79,913,725
19			$266,420	$266,420	$101,825,447	0.2765		$73,667	$79,987,393
20			$266,420	$266,420	$102,091,867	0.2584		$68,848	$80,056,241
21			$266,420	$266,420	$102,358,287	0.2415		$64,344	$80,120,585
22			$266,420	$266,420	$102,624,707	0.2257		$60,135	$80,180,719
23			$266,420	$266,420	$102,891,127	0.2109		$56,200	$80,236,920
24			$266,420	$266,420	$103,157,547	0.1971		$52,524	$80,289,443
25			$266,420	$266,420	$103,423,967	0.1842		$49,088	$80,338,531
26			$266,420	$266,420	$103,690,387	0.1722		$45,876	$80,384,407
27			$266,420	$266,420	$103,956,807	0.1609		$42,875	$80,427,283
28			$266,420	$266,420	$104,223,227	0.1504		$40,070	$80,467,353
29			$266,420	$266,420	$104,489,647	0.1406		$37,449	$80,504,801
30			$266,420	$266,420	$104,756,067	0.1314		$34,999	$80,539,800
31			$266,420	$266,420	$105,022,487	0.1228		$32,709	$80,572,509
32			$266,420	$266,420	$105,288,907	0.1147		$30,569	$80,603,079
33			$266,420	$266,420	$105,555,327	0.1072		$28,569	$80,631,648
34			$266,420	$266,420	$105,821,747	0.1002		$26,700	$80,658,349
35			$266,420	$266,420	$106,088,167	0.0937		$24,954	$80,683,302
36			$266,420	$266,420	$106,354,587	0.0875		$23,321	$80,706,624
37			$266,420	$266,420	$106,621,007	0.0818		$21,796	$80,728,419
38			$266,420	$266,420	$106,887,427	0.0765		$20,370	$80,748,789
39			$266,420	$266,420	$107,153,847	0.0715		$19,037	$80,767,826
40			$266,420	$266,420	$107,420,267	0.0668		$17,792	$80,785,617
41			$266,420	$266,420	$107,686,687	0.0624		$16,628	$80,802,245
42			$266,420	$266,420	$107,953,107	0.0583		$15,540	$80,817,785
43			$266,420	$266,420	$108,219,527	0.0545		$14,523	$80,832,308
44			$266,420	$266,420	$108,485,947	0.0509		$13,573	$80,845,881
45			$266,420	$266,420	$108,752,367	0.0476		$12,685	$80,858,567
46			$266,420	$266,420	$109,018,787	0.0445		$11,855	$80,870,422
47			$266,420	$266,420	$109,285,207	0.0416		$11,080	$80,881,502
48			$266,420	$266,420	$109,551,627	0.0389		$10,355	$80,891,857
49			$266,420	$266,420	$109,818,047	0.0363		$9,677	$80,901,534
50			$266,420	$266,420	$110,084,467	0.0339		$9,044	$80,910,578
51			$266,420	$266,420	$110,350,887	0.0317		$8,453	$80,919,031
52				$0	$110,350,887	0.0297		$0	$80,919,031
53				$0	$110,350,887	0.0277		$0	$80,919,031
54									
55									
56									
57									
58									
59									
60									
Totals	$32,441,001	$67,253,086	$10,656,800	$110,350,887			$32,441,001	$80,919,031	

BASIS OF UNIT COSTS

I.D.	Item	Source	Description	Value or Range Provided (rounded)	Value Used for Estimate (rounded)	Basis
D.1	Land acquisition	In-house experience in the vicinity	Cost for acquiring property.	$2,000	$2,000	Typical cost for rural land in Brown County.
C.1	Mobilization/demobilization	Contractor estimate/bid for similar work (local Fox Valley contractor)	Mobilize labor and equipment for each year's liner or cover construction work.	$37,000	$40,000	Add allowance for as yet undefined conditions and round off to $40,000 per year.
C.2	Clear & grub	Contractor estimate/bid for similar work (local Fox Valley contractor)	Clear and grub vegetation prior to excavation to subbase grades and other on-site construction. Year 0 includes area for cells 1-2 of monofill plus the area for construction of the sedimentation basin, stockpile area, building, and road.	$2,100	$2,100	Typical per acre cost for similar work.
C.3	Strip & stockpile topsoil (6")	Contractor estimate/bid for similar work (local Fox Valley contractor)	Strip existing topsoil and stockpile onsite for future cover construction. Year 0 includes area for cells 1-2 of monofill plus the area for construction of the sedimentation basin, stockpile area, building, and road.	$0.70	$1	Contractor estimate is $0.70/cy. Increase to $1.00/cy to be conservative.
C.4	Excavation to subgrade	Contractor estimate/bid for similar work (local Fox Valley contractor)	Year 0 includes soil from monofill and sedimentation basin excavation. Excavated material will be stockpiled on-site for re-use as berm, liner and cover soil.	$1.15	$1.50	Contractor estimate is on low side of typical range. Increase to account for bidding uncertainty at time of work. Assumes cut soils are suitable clay for liner construction.
C.5	Berm construction	Contractor estimate/bid for similar work (local Fox Valley contractor)	Construct perimeter berm from cut soils/stockpile.	$1.80	$2.50	Contractor estimate is on low side of typical range. Increase to account for bidding uncertainty at time of work.
C.6	Gradient control layer	Contractor estimate/bid for similar work (local Fox Valley contractor) and typical experience	Construct drainage layer and collection sumps below clay liner. Express cost as "per acre of liner constructed", with an allowance for miscellaneous other material. The cost components for this assembly are as follows:			
			Granular layer = (1 ft.)(43560 sf/acre)(1 cy/27 cf)($15/cy) = $24,200/acre	$24,200		Assumes use of a granular drainage layer as representative for budgeting. Could use a geocomposite material, if appropriate and more cost effective at time of final engineering. (At $0.40/sf, per acre cost = $17,400).
			Purchase and place geotextile, 12 oz = ($0.20/sf)(43560 sf/acre) = $8700/acre	$8,700		Typical unit cost for similar work.
			Coarse aggregate for collection sump, collection piping and sideslope risers = $1000/acre	$1,000		Estimate is back-calculated from typical project.
			Subtotal, gradient control layer assembly	$33,900	**$35,000**	Include allowance for other minor components. Use $35,000 per acre of waste limits.
C.7	Liner and leachate collection system	Contractor estimate/bid for similar work (local Fox Valley contractor) and typical experience	Construct composite liner, using 4 ft. recompacted clay from onsite borrow and a 60 mil HPDE geomembrane. Express cost as "per acre of liner constructed", with an allowance for miscellaneous other material. The cost components for this assembly are as follows:			

BASIS OF UNIT COSTS

I.D.	Item	Source	Description	Value or Range Provided (rounded)	Value Used for Estimate (rounded)	Basis
			Place & compact clay = (4 ft.)(43560 sf/acre)($3.00/cy)(cy/27 cy) = $19,400	$19,400		Local estimate is $1.50/cy to place and recompact clay from onsite stockpile. Typical range is as high as $3.00/cy. Use $3.00/cy.
			Purchase and place 60 mil geomembrane = ($0.60/sf)(43560 sf/acre) = $26,100	$26,100		Local estimate is $0.46/sf. Other projects as high as $0.01 per mil of thickness. Use $0.60/sf.
			Place 12" granular drainage layer = (1 ft.)(43560 sf/acre)($15.00/cy)(cy/27 cf) = $24,200	$24,200		Typical unit cost for similar work.
			Allowance for interior berms, if needed	$6,000		Estimate is back-calculated from typical project.
			Leachate piping (solid wall and perforated), cleanout risers, aggregate sumps, manholes, header pipe, pump and controller	$10,000		Estimate is back-calculated on a "per acre" basis from typical project. All piping HDPE.
			Subtotal, liner and leachate collection assembly	$85,700	**$120,000**	Include an allowance for other related earthwork; extra quantities for side slopes, anchor trenches; liner splices; etc. Use $120,000 per acre of waste limits.
C.8	Place intermediate drainage layers	Typical experience	This is a placeholder for possible use of intermediate lateral drainage layers during filling. Assume placement of either 1' granular material or a geocomposite after each year's fill cycle.		$20,000	As indicated below, the cost per acre for granular material or geocomposite range from $17,400 to $24,000 per acre. Assume $20,000 per acre.
C.9	Place grading layer	Contractor estimate/bid for similar work (local Fox Valley contractor) and typical experience	This item includes the placement of general soils to establish subgrades for final cover. It is assumed that the material comes from an on-site stockpile of previously cut soil.	$1.80	$2.50	Same basis as for general berm construction.
C.10	Cover system	Contractor estimate/bid for similar work (local Fox Valley contractor) and typical experience	Construct a composite liner consisting of (from top to bottom): 6" topsoil (from onsite stockpile), 18" general soil rooting zone (from onsite borrow); 12" granular drainage layer (purchased); 40 mil LLDPE; geosynthetic clay liner (GCL); 12" granular vent layer (purchased). Express cost as "per acre of cover constructed", with an allowance for miscellaneous other material that is not strictly proportional to area. The cost components for this assembly are as follows:			
			Purchase and place 12" granular vent layer = (1 ft.)(43560 sf/acre)($15/cy)(cy/27 cf) = $24,200	$24,000		Typical unit cost for similar work.
		Vendor budgetary estimate (CETCO, Inc.)	Purchase and place GCL = ($0.40/sf)(43560 sf/acre) = $17400/acre	$17,400		Assume Bentomat ST.
			Purchase and place 40 mil geomembrane = ($0.40/sf)(43560 sf/acre) = $17,400	$17,400		Other projects as high as $0.01 per mil of thickness. Use $0.40/sf.
			Purchase and place 12" granular drainage layer = (1 ft.)(43560 sf/acre)($15/cy)(cy/27 cf) = $24,200	$24,000		Could substitute a geocomposite drainage product for granular material. Budget estimate is $0.40/sf installed, which would be slightly lower cost on a per acre basis ($17,400). Use cost for granular material to be conversative at this early stage of project.
			Place general soils from on-site stockpile = (1.5 ft.)(43560 sf/acre)($1.25/cy)(cy/27 cf) = $3000	$3,000		Typical unit cost for similar work.

BASIS OF UNIT COSTS

I.D.	Item	Source	Description	Value or Range Provided (rounded)	Value Used for Estimate (rounded)	Basis
			Place topsoil from on-site stockpile = (0.5 ft.)(43560 sf/acre)($1.00/cy)(cy/27 cf) = $800	$800		Typical unit cost for similar work.
			Seed, fertilize, mulch = $2500/acre	$2,500		Typical unit cost for similar work.
			Subtotal, cover system assembly, per acre of waste limits	$89,100	**$100,000**	Include allowance for other minor construction, extra quantities for anchor trenches, possible gas vents, perimeter toe drain pipes, drainage structures, etc. Use $100,000/acre.
C.11	Seed, fertilize, mulch	Typical experience	Restore grounds to original conditions		$2,500	?
C.12	Perimeter drainage ditches	Contractor estimate/bid for similar work (local Fox Valley contractor) and typical experience	Drainage ditches constructed around the perimeter of the monofill to collect stormwater run-off.	$3.25	$4	Contractor estimate is on low side of typical. Use $4.00/lf.
C.13	Perimeter road	Contractor estimate/bid for similar work (local Fox Valley contractor) and typical experience	Gravel road constructed around the perimeter of the monofill for access during monitoring and maintenance activities.	$10	$10	Typical unit cost for similar work.
C.14	Access road, paved	Contractor estimate/bid for similar work (local Fox Valley contractor), Means Sitework (2000) and typical experience	Main access road for personnel vehicle entrance, expressed on a "per square foot" basis.	$3.00 - 4.00	$4	Typical unit cost for similar work.
C.15	Perimeter fence	Means Sitework (2000)	Perimeter fence, chain link, 8' h w/ 3-strand barb wire	$35	$35	Means #02820_528_0920. $30/lf. With price inflation, allowance for gates, etc., use $35/lf.
M.1	Leachate collection tank	Contractor estimate/bid for similar work (local Fox Valley contractor) and typical experience	Leachate tank, 30,000 gal FRP, underground, with concrete tie-down pad and appurtenences.	$120,000	$120,000	Typical experience, similar projects.
M.2	Leachate loadout station	Contractor estimate/bid for similar work (local Fox Valley contractor) and typical experience	Equipment for leachout pumpout and truck loading	$50,000	$50,000	Typical experience, similar projects.
M.3	Scale	Contractor estimate/bid for similar work (local Fox Valley contractor) and typical experience	Truck scale for weighing incoming loads.	$100,000	$100,000	Typical experience, similar projects.
E.1	New service to site	Typical experience	Establish new electrical service to the facility	$30,000	$30,000	This is a placeholder, based on typical projects.
E.2	Wiring and controls	Typical experience	Local wiring of leachate pump stations, yard lights, etc.	$20,000	$20,000	This is a placeholder, based on typical projects.
S.1	Maintenance building	Contractor estimate/bid for similar work (local Fox Valley contractor) and typical experience	Maintenance building, pre-engineered, metal building, 100' x 100', w/ 4" slab and frost wall.	$500,000	$500,000	This a placeholder, based on typical projects.

BASIS OF UNIT COSTS

I.D.	Item	Source	Description	Value or Range Provided (rounded)	Value Used for Estimate (rounded)	Basis
I.1	Siting studies, permitting, engineering and final design, through first phase of construction	Typical experience	Siting and hydrogeologic studies and preparation of permit documents.		$1,500,000	This is a placeholder for all initial permitting and engineering work, based on prior experience.
I.2	Engineering/ final design of subsequent phases (% of construction direct capital spent in year n +1)		Final engineering and preparation of construction plans and specifications for phased construction and closure work. Cost expressed as a % of the constructed value of the work.		7%	Typical cost for engineering/design services on large civil projects.
I.3	Construction documentation (% of construction direct capital spent in year n)		Soils and geomembrane testing, construction observation, and preparation of construction documentation reports and drawings. Cost expressed as a % of the constructed value of the work.		15%	Typical cost for construction-phase services on large civil projects.
O.1	Environmental monitoring	Typical project experience and laboratory analytical estimate (EnChem, Minneapolis, MN)	Annual monitoring and reporting activities for collection and laboratory analysis of groundwater, leachate, GCL, and sedimentation pond samples.	$85,000	$85,000	A separate cost spreadsheet was developed to incorporate all expenses related to monitoring - well installation, labor (field technician and reporting), laboratory analysis, and equipment costs. Scope is based on typical work at NR500 landfills in Wisconsin.
O.2	Leachate hauling	Typical experience	Haul leachate to a local POTW (location not yet defined.) During filling, quantity estimated as 6" collected over a maximum open area of 10 acres: (6"/year)(ft/12")(7.48 gal/cf)(43560 sf/acre)(10 acre) = 1.6 MG per year. After final closure, quantity estimated as 1" infiltration per year over 49 acres after closure: (1"/year)(ft/12")(7.48 gal/cf)(43560 sf/acre)(49 acre) = 1.3 MG per year.		$0.04	Typical cost could be up to $200 per 4000 or 5000 gal load. Use $0.04/gal. Quantity estimates are placeholders only, pending final engineering.
O.3	Leachate disposal	Typical experience	Disposal of leachate at local POTW (location not yet defined.)		$0.01	Typical POTW charge for disposal plus BOD and TSS surcharges could be on the order of $0.01/gal. Leachate from this project may be low in BOD, but use this value to account for possible concern over organics content.
O.10	Landfill technician	Typical experience	1 FTE to conduct landfill operations and maintenance-related tasks. 2,000 hrs/yr.		$20	Typical labor cost for local technician.
O.11	Project manager	Typical experience	On-site project controls and personnel supervision. Assume LOE is 0.25 FTE. 500 hrs/yr.		$50	Local project oversight and administration.
O.12	Waste placement	Typical experience	Filling and compacting waste within the monofill.		$1	Estimate is on a "per ton" basis, for sediment delivered to the facility from the NR213 settling basins.
O.20	Land surface care	Typical experience	Re-seeding, minor erosion control and restoration of cover		$10,000	This is a placeholder for typical cost of cover maintenance.
O.21	Leachate pump replacement	Typical experience	Replace leachate pump and motor. Assume 25% replacement rate of 2 per year.		$4,000	Typical cost for submersible pump and motor.
O.22	Leachate pipe cleaning	Typical experience	Annual cost for cleaning of leachate lines.		$5,000	Typical cost, similar project

BASIS OF UNIT COSTS

I.D.	Item	Source	Description	Value or Range Provided (rounded)	Value Used for Estimate (rounded)	Basis
O.30	Electricity		Monthly power requirements for collection system equipment, lighting, etc.		$300	This is a placeholder to cover intermittent pumping of leachate and other minor electrical usage at the facility.
O.31	Telephone	Prior project experience	Monthly cost of phone service to main operating facility.		$50	Placeholder, monthly estimated cost.
O.40	Host community fee (per ton disposed)		Fee paid to local community, as negotiated through the state's local approvals process.		$10	Typical fee for other Brown County disposal facilities. Cost is expressed on a "per ton of waste disposed" basis.

PROJECT ELEMENT:
Mechanical dewatering plant, Type II
Scenario B - OU3 and OU4

PROCESS METRICS

Total volume sediment removed from river	6,500,000	cy
Total wet tons filter cake (at 55% solids) generated from this volume of sediment	3,560,000	ton
Length of operations	6.4	yr

COST SUMMARY

	Total Cost	Total as Present Worth	
Subtotal, construction costs	$15,600,000	$15,600,000	
Total, construction plus operating costs	$41,700,000	$36,100,000	
Cost per cy sediment removed	$6.42	$5.55	/cy
Cost per ton filter cake disposed	$11.71	$10.14	/ton

Notes

1. This estimate is based on the major processes/equipment identified in the accompanying drawing, "Process Flow Diagram for Solids Dewatering." It is based on preliminary concepts, and is suitable only as a general indicator of eventual project costs. It will change as final engineering and detailed design work proceed.
2. The Type II facility is sized to accommodate a dredge slurry flowrate of up to 2,100 gpm and dewatering with a press capacity of 74 tons dry solids per hour.
3. It assumes that the plant is constructed as a fixed-base, semi-permanent facility. Equipment is purchased, with no salvage value at end of project. Site infrastructure (roads, offices, etc.) common to the larger project are not included, and will be estimated elsewhere. Indirect capital costs (engineering, construction management, etc.) are not included.
4. The "total cost" does not discount the multi-year operating costs.
5. The "present worth" discounts all construction and operations costs over the active life of the facility. The discount rate is 7% (USEPA, "Guide to Developing and Documenting Cost Estimates During the Feasibility Study", July 2000).
6. "Cost per ton" and "cost per cy" values are for informational purposes only. Values are not true unit costs because they represent a combination of fixed capital and flow-proportional components.

CAPITAL COSTS

	Item	Units	Quantity	Unit Cost (1)	Extension
Purchased Equipment					
K.1	Coarse material separation equipment	ls	1	$500,000	$500,000
K.2	Thickener	ea	1	$300,000	$300,000
K.3	Thickener solids pump (plus spare)	ea	3	$20,000	$60,000
K.4	Press feed tank and agitator	ea	2	$135,000	$270,000
K.5	Press feed pump (plus two spare)	ea	12	$15,000	$180,000
K.6	Press	lot	1	$3,500,000	$3,500,000
K.7	Filtrate forwarding pump (plus two spare)	ea	12	$6,200	$74,400
K.8	Chemical feed system	ea	2	$20,000	$40,000
		Subtotal, major equipment			$4,924,400
K.9	Minor equipment & support facilities	% of major equipment		25%	$1,231,100
		Subtotal, purchased equipment			$6,155,500
Mechanical Work					
M.1	Equipment erection	% of equipment	1	15%	$923,325
M.2	Process piping	% of equipment	1	30%	$1,846,650
M.3	Building HVAC	ls	1	$200,000	$200,000
M.4	Site restoration	ls	1	$150,000	$150,000
Electrical Work					
E.1	Service entrance	ls	1	$0	$0
E.2	Main panels	ls	1	$0	$0
E.3	Process electrical & instrumentation	% of equipment	1	20%	$1,231,100
E.4	Primary control panel/package	ls	1	$0	$0
E.5	Building lighting	ls	1	$10,000	$10,000
Structural					
S.1	Building	sf	10,400	$50	$520,000
S.2	Building foundation	ls	1	$150,000	$150,000
S.3	Outside tank foundations	ls	1	$53,000	$53,000
	Subtotal, purchased equipment and trades				$11,239,575
	Mobilization, demobilization, general conditions (% of above)			8%	$899,166
	Freight (% of purchased equipment)			5%	$307,775
	Prime contractor administration, overhead & profit (% of above)			25%	$3,111,629
	TOTAL DIRECT CAPITAL				$15,558,145

Notes

1. Unit cost backup provided on subsequent sheets

ANNUAL OPERATING COSTS

	Item	Units	Quantity	Unit Cost (1)	Extension
	Purchased materials				
O.1	Polymer	ls	1	$1,830,000	$1,830,000
	Operations labor				
O.10	Wastewater technician	hrs	19,600	$35	$686,000
O.11	Certified operator	hrs	0	$50	$0
O.12	Project manager	hrs	350	$75	$26,250
	Maintenance labor & materials				
O.20	Maintenance & replacement parts	% of equipment	5%	$6,155,500	$307,775
	Utilities				
O.30	Electricity				$180,597
		Subtotal			$3,030,622
	Mobilization, demobilization, general conditions (% of above)			8%	$242,450
	Prime contractor administration, overhead & profit (% of above)			25%	$818,268
	TOTAL ANNUAL OPERATIONS				$4,091,340

Notes

1. Unit cost backup provided on subsequent sheets

ANNUAL ELECTRICAL COSTS

	Item	Total Motor HP	Kw	Operating Time Per Day (1)	Kw*hr per day
E.1	Coarse material separation equipment (sum of HP for individual components of system)	99	73.9	20	1,477
E.2	Thickener	5	3.7	20	75
E.3	Thickener solids pump (assume 2 at 20 HP)	40	29.8	20	597
E.4	Press feed tank and agitator (assume 2 agitators at 40 HP)	80	59.7	24	1432
E.5	Press feed pump (assume 10 at 5 HP)	50	37.3	20	746
E.6	Press (10 machines w/ 2 - 10 HP & 1 - 2 HP)	220	164.1	20	3,282
E.7	Filtrate forwarding pump (assume 10 at 5 HP)	50	37.3	20	746
E.8	Chemical feed system (assume 2 at 1 HP)	2	1.5	20	30
	Subtotal, major equipment				8,385
E.9	Minor equipment & support facilities not yet defined	50	37.3	20	746
	Subtotal, all equipment (kw*hr/day)				9,131
	Number of operating days per year				245
	Cost of electricity ($/kw*hr)				$0.07
	Subtotal, electricity for equipment				$156,597
			Months	$/month	Extension
M.3	Lighting, ventilation & occasional minor heating of press building	month	8	3,000	$24,000
	TOTAL ANNUAL ELECTRICAL				$180,597

Notes

1. To be conservative, the daily operating time for system is assumed to be slightly longer than the typical daily dredge effective time.

PRESENT WORTH CALCULATION

i = 7%

Year, n	Capital Costs (Construction)	Annual Operations	Sum of Year "n" Costs	Cumulative Costs, Year 1 through n	Present Worth Factor, i	Present Worth of Year "n" Construction Costs Only	Present Worth of All Year "n" Costs	Cumulative Present Worth of All Costs, Year 1 through n
0	$15,558,145		$15,558,145	$15,558,145	1	$15,558,145	$15,558,145	$15,558,145
1		$4,091,340	$4,091,340	$19,649,485	0.9346	$0	$3,823,682	$19,381,827
2		$4,091,340	$4,091,340	$23,740,825	0.8734	$0	$3,573,535	$22,955,362
3		$4,091,340	$4,091,340	$27,832,165	0.8163	$0	$3,339,752	$26,295,115
4		$4,091,340	$4,091,340	$31,923,506	0.7629	$0	$3,121,264	$29,416,378
5		$4,091,340	$4,091,340	$36,014,846	0.7130	$0	$2,917,069	$32,333,447
6		$4,091,340	$4,091,340	$40,106,186	0.6663	$0	$2,726,233	$35,059,680
7		$1,636,536	$1,636,536	$41,742,722	0.6227	$0	$1,019,152	$36,078,833
8			$0	$41,742,722	0.5820	$0	$0	$36,078,833
9			$0	$41,742,722	0.5439		$0	$36,078,833
10			$0	$41,742,722	0.5083		$0	$36,078,833
11			$0	$41,742,722	0.4751		$0	$36,078,833
12			$0	$41,742,722	0.4440		$0	$36,078,833
13			$0	$41,742,722	0.4150		$0	$36,078,833
14			$0	$41,742,722	0.3878		$0	$36,078,833
15			$0	$41,742,722	0.3624		$0	$36,078,833
16			$0	$41,742,722	0.3387		$0	$36,078,833
17			$0	$41,742,722	0.3166		$0	$36,078,833
18			$0	$41,742,722	0.2959		$0	$36,078,833
19			$0	$41,742,722	0.2765		$0	$36,078,833
20			$0	$41,742,722	0.2584		$0	$36,078,833
21			$0	$41,742,722	0.2415		$0	$36,078,833
22			$0	$41,742,722	0.2257		$0	$36,078,833
23			$0	$41,742,722	0.2109		$0	$36,078,833
24			$0	$41,742,722	0.1971		$0	$36,078,833
25			$0	$41,742,722	0.1842		$0	$36,078,833
26			$0	$41,742,722	0.1722		$0	$36,078,833
27			$0	$41,742,722	0.1609		$0	$36,078,833
28			$0	$41,742,722	0.1504		$0	$36,078,833
29			$0	$41,742,722	0.1406		$0	$36,078,833
30			$0	$41,742,722	0.1314		$0	$36,078,833
31			$0	$41,742,722	0.1228		$0	$36,078,833
32			$0	$41,742,722	0.1147		$0	$36,078,833
33			$0	$41,742,722	0.1072		$0	$36,078,833
34			$0	$41,742,722	0.1002		$0	$36,078,833
35			$0	$41,742,722	0.0937		$0	$36,078,833
36			$0	$41,742,722	0.0875		$0	$36,078,833
37			$0	$41,742,722	0.0818		$0	$36,078,833
38			$0	$41,742,722	0.0765		$0	$36,078,833
39			$0	$41,742,722	0.0715		$0	$36,078,833
40			$0	$41,742,722	0.0668		$0	$36,078,833
Totals	$15,558,145	$26,184,577	$41,742,722			$15,558,145	$36,078,833	

BASIS OF UNIT COSTS

I.D.	Item	Source	Description	Value or Range Provided (rounded)	Value Used for Estimate (rounded)	Basis
K.1	Coarse material separation equipment	Vendor budgetary estimate (Del Tank&Filtration Systems, Lafayette, LA)	Separation equipment consisting of tank, shakers desanding manifolds, and hydrocylone feed pumps. Quote based on flow of 2,000 gpm with recommendation for two units for 3,000 gpm.	$500,000	$500,000	Use quote provided by Del for 2,000 gpm, assuming 1 unit required to accommodate a dredge slurry flowrate of up to 2,100 gpm (Type II system).
K.2	Thickener	Vendor budgetary estimate (WesTech, Rockton, IL)	HiFlo thickener mechanism and steel tank. 50' dia. Total depth of 25'. Sized for nominal 4000 gpm slurry influent.	$300,000 - $400,000		Interpolated from quote provided by WesTech for dewatering and wastewater treatment package.
		Vendor opinion (EIMCO, Pittsburgh)	Thickener mechanism and steel tank. 80' dia. Total depth 15'. Sized for overflow of 2,500 gpm at a rate of 0.5 gpm per sf. Expected underflow solids 20% to 25%	$350,000		
		Summary:			$300,000	For Type I system (2,000 gpm), use lower end of estimate.
K.3	Thickener solids pump (plus spare)	Vendor budgetary estimate (A.A. Anderson Company, Waukesha, WI)	Pump to feed thickener underflow to press feed tank. 6" rotary lobe pump with motor and fittings. An additional backup pump will be purchased.	$15,000 - $20,000	$20,000	Vendor opinion that rotary lobe pump may be appropriate for this type of application and suggested 2 pumps required for flow of 1,000 gpm. Use upper end of range.
K.4	Press feed tank and agitator	Vendor budgetary estimate (Enprotec, Hebron, Ky and Tident Process, Inc., MN)	100,000 gal bolted steel tank, 32'8" dia x 16'1" h or 47'6" dia x 8'1/2" h. 40 HP, TEFC severe duty/high efficiency Lightnin mixer, Model 508Q40.	$134,420	$135,000	Assume 1 solids holding tank per 5 presses.
K.5	Press feed pump (plus two spare)	Vendor budgetary estimate (A.A. Anderson Company)	Pumps to feed thickener underflow to individual presses. 6" rotary lobe pump with motor and fittings. Two additional backup pumps will be purchased.	$15,000 - $20,000	$15,000	Vendor opinion that rotary lobe pump may be appropriate for this type of application. 1 pump required to accommodate each press. Use low end of range for flows ranging from 200-300 gpm.
K.6	Press	Vendor budgetary estimate (WesTech, Rockton, IL)	Belt press, 3-meter, 30 ton dry solids per hr (TPH). Includes control panel, sludge feed pump, polymer system and wash water booster pump.	$562,000		Estimate is $187,500 per machine. 3 machines would be required to achieve 74 TPH throughput. However, the capacity appears to overestimated.
		Vendor opinion (JWI/US Filter)	Plate and frame filter press. 600 cf. Total of 6 required based on approx. 2,000 gpm.	$6,000,000		For Type II system, assume 6 presses at $1,000,000 each based on JWI quote. This opinion by JWI based on types of presses proposed for New Bedford Harbor project, after comparing vacuum filter and centrifuge options.
		Vendor opinion (JWI/US Filter)	Belt press, 3-meter, 120 gpm per unit. Total of 16 required based on approx. 2,000 gpm.	$4,800,000		For Type II system, assume 16 presses at $300,000 each based on JWI quote.
		Vendor opinion (Andritz-Ruthner, Inc., Houston)	Belt press, 3-meter, Minimum 8 TPH per machine (10 TPH possible). Dual chemical addition at total input of 2.3 lb/dry ton solids.	$3,500,000		This opinion based on initial dewatering tests performed by Andritz on Fox River sediment. 10 machines required to achieve 74 TPH throughput, at $350,000 each.
		Summary:			$3,500,000	Of the three opinions, the Andritz opinion is based on the most thorough analysis and actual bench-scale work. For planning purposes, assume 10 machines. At low end of performance (8 TPH per machine), this would provide approx. 25% excess capacity. At high end of performance (10 TPH per machine), this would provide over 50% excess capacity.

BASIS OF UNIT COSTS

I.D.	Item	Source	Description	Value or Range Provided (rounded)	Value Used for Estimate (rounded)	Basis
K.7	Filtrate forwarding pump (plus two spare)	Means/ECHOS (2001)	Pumps to forward filtrate from individual presses to wasterwater treatment. 150 gpm, 5HP centrifugal transfer pump with motor and fittings. Two additional backup pumps will be purchased.	$5,600	$6,200	Means, #33_29_0124 plus 10% to account for inflation. Pump sized for approx. 150 gpm includes allowance for fluctuations in flow.
K.8	Chemical feed system		System to add a chemical for conditioning prior to downstream presses		$20,000	Placeholder, pending final engineering.
K.9	Minor equipment & support facilities not yet defined	Prior project experience	Minor items such as controls, materials handling equipment, storage units, laboratory instrumentation, that are not currently defined for the project.		25%	Placeholder, pending final engineering.
M.1	Equipment erection	Prior project experience	Labor and materials to erect large tanks and other process equipment.	11%	15%	Increase percentage to account for several unknown factors at this stage in the project.
M.2	Process piping	Prior project experience	Interconnecting piping between and not supplied with process equipment.	7 - 12%	30%	Range from past mid-size treatment systems, as a percentage of purchased equipment. Use mid-point of range to account for current unknowns.
M.3	Building HVAC	Prior project experience	Heating and ventilation equipment for treatment building.		$200,000	Past projects at $9 to $33/sf, or 50% to 100% of building cost. For Type II building, sized at approximately 10400 sf, assume $200,000.
M.4	Site restoration	Prior project experience	Remove system and building at end of project		$150,000	Based on recent experience with process equipment removal and building demolition in the Fox Valley.
E.1	Service entrance				$0	Cost is included with estimate for wastewater treatment system.
E.2	Main panels				$0	Cost is included with estimate for wastewater treatment system.
E.3	Process electrical and instrumentation	Prior project experience	Includes process wiring, loose process instrumentation and controls, as a percentage of the purchased equipment.	15 - 27%		Range from past, smaller projects.
		Contractor opinion (Boudry Control Panels, LLC, Fond du Lac, WI)		Min. $750,000		Contractor opinion is for total site (dewatering, water treatment, infrastructure, etc.). $750,000 would be less than 10% of purchased equipment. This assumes that all starters and local panels are provided with individual equipment packages.
		Summary:			20%	Increase contractor's opinion to allow for some starters not provided with equipment, other items not yet defined, etc. Use 20% of purchased equipment, which is at mid-point of past experience on smaller projects.
E.4	Primary control panel/package	Contractor opinion (Boudry Control Panels, LLC, Fond du Lac, WI)	Central controls package and process monitoring, that integrates all loose controllers provided with individual equipment packages. Include 5 or 6 remote PCs at various points in plant/offices, with process monitoring software, local network, etc.		$0	Cost is included with estimate for wastewater treatment system.
E.5	Building lighting	Contractor opinion (Boudry Control Panels, LLC, Fond du Lac, WI)	Overhead, industrial lighting in press building.		$10,000	Assumes 1 fixture for every 400 sf Total = 10,400 sf/400 = 26 fixtures. Fixtures at $200 each plus $100 to install/wire. Use $10,000.

BASIS OF UNIT COSTS

I.D.	Item	Source	Description	Value or Range Provided (rounded)	Value Used for Estimate (rounded)	Basis
S.1	Building	Builder opinion (Butler Buildings/Howard Immel, Inc., Green Bay, WI)	Pre-engineered metal building, industrial quality, w/ OH doors, etc.		$50	Estimate represents typical square foot cost. Based on contractor experience in Fox Valley. Original opinion includes 4" concrete slab.
S.2	Building foundation	Builder opinion (Howard Immel, Inc., Green Bay, WI)	Assume minimum of 8" slab plus 4 ft. frost wall and strip footing.		$150,000	Floor slab: 4" at $2.50/sf. Double thickness and assume minimum of $5.00/sf. For 10400 sf, slab = $52,000. Frost wall/footing. At least $55/lf. for 80' x 130' building, wall = $23,100. include earthwork and allowance for housekeeping pads, curbs, thickened slab at heavy loads. Use total foundation system = $150,000 for the larger Type II building.
S.3	Outside tank & equipment foundations	Builder opinion, typical projects and Means Site Work, 2000.	Along perimeter of circular tanks, assume minimum of 4 ft. foundation wall, 8" thick, with continuous strip footing, 16" d x 48" w.		$53,000	From Means assemblies, p. 387: Footing = $35/lf. 8' x 8" wall = $57/lf. For shorter wall, use $75/lf total. Assume at least 1 tank at 50' dia, 2 at 32' dia, for total of 358 lf, or $26,860. Include allowance for small tanks and equipment pads. Use $53,000.
O.1	Polymer	Vendors general experience (Andritz-Ruthner, Inc., Houston, TX)	Chemical conditioner added to slurry prior to press	$1,407,000		Andritz has done limited initial testing on Fox River sediment. Estimate for total of cationic and anionic addition is 2.3 lb polymer/ton dry solids, but this is very approximate. For annual generation of 556,250 tons filter cake per year: (556,250 tons)(55% solids)(2.3 lb polymer/ton dry solids)($2/lb polymer) = $1,407,312
		Area 56/57 demonstration project design basis (MWH, 1998)	Chemical conditioner added to slurry prior to press	$1,350,000		MWH tested a cationic polymer (Betz/Dearborn #CP-210) and found it to be effective at 250mg/L, in an 8% simulated "thickened" slurry, prior to a belt press. Based on current mass balance, slurry from thickener would be on order of 900 gpm. Usage: (1300 gal/min)(17 hr/d)(60 min/hr)(245 day/yr)(250 mg/L)(3.78 L/gal)(lb/454,000 mg)($2/lb) = $1,352,432.
		Summary:			$1,830,000	The calculation using MWH data may be low considering their testing was done at a lower solids concentration than what is anticipated for this project. The Andritz opinion is probably reasonable, because it applies to a specific machine and actual Fox River sediment. Due to the very early stage of the work include 30% allowance on the Andritz value in consideration of MWH findings.
O.10	Wastewater technician	Prior project experience	4 FTE, 20/7 - Two 10-hour shifts 7 days per week to conduct continuous operations and maintenance-related tasks. LOE is based on 1 FTE operating separation equipment, 2 FTE operating presses and 1 FTE as general operations. 19,600 hrs/yr.		$35	Assume typical hourly rate for contract environmental labor. Rate includes basic per diem expenses.
O.11	Certified operator	Prior project experience	Plant operator with state certification. LOE and cost is allocated to wastewater treatment element.		$50	Cost is included with estimate for wastewater treatment system.
O.12	Project manager	Prior project experience	On-site project controls and personnel supervision. Assume LOE is 0.2 FTE (based on a 50 hr week), or 10 hrs/wk for 8 months, with the remainder of time allocated to other project elements. 350 hrs/yr.		$75	Assume typical hourly rate for onsite supervisor. Rate includes basic per diem expenses.

BASIS OF UNIT COSTS

I.D.	Item	Source	Description	Value or Range Provided (rounded)	Value Used for Estimate (rounded)	Basis
O.20	Maintenance & replacement parts	Prior project experience	Purchased materials and labor to install miscellaneous small and expendible items associated with process equipment.		5%	Professional judgement from similar project experience.
O.30	Electricity	Various vendors used for development of process equipment.	Power requirements for proccess equipment, lighting, etc.		$180,597	Refer to cost sheet, "Annual Electrical Costs"

COST ESTIMATE #10 | **Rev: 10.30.03**
DETAILED EVALUATION OF ALTERNATIVES | **Final**
WDNR - FOX RIVER

PROJECT ELEMENT:
Wastewater treatment system, Type I
Scenario B - OU3 and OU4

PROCESS METRICS

Total volume of sediment removed from river	6,500,000	cy
Nominal capacity of system (expressed as the dredge slurry rate)	2,100	gpm
Length of operations	6.4	yr
Total gallons treated & discharged	2,690,000,000	gal

COST SUMMARY

	Total Cost	**Total as Present Worth**	
Subtotal, construction costs	$4,900,000	$4,900,000	
Total, construction plus operating costs	$11,200,000	$9,900,000	
Cost per cy sediment removed	$1.72	$1.52	/cy
Cost per gallon water discharged	$0.0042	$0.0037	/gal

Notes

1. This estimate is based on the major processes/equipment identified in the accompanying drawing, "Process Flow Diagram for Wastewater Treatment." It is based on preliminary concepts, and is suitable only as a general indicator of eventual project costs. It will change as final engineering and detailed design work proceed.
2. The Type I facility is sized to treat the carriage water that would be released from a dredge slurry flowrate of up to 2,100 gpm.
3. The estimate assumes that the plant is constructed as a fixed-base, semi-permanent facility. Equipment is purchased, with no salvage value at end of project. Site infrastructure (roads, offices, etc.) common to the larger project not included, and will be estimated elsewhere. Indirect capital costs (engineering, construction management, etc.) not included.
4. The "total cost" does not discount the multi-year operating costs.
5. The "present worth" discounts all construction and operations costs over the active life of the facility. The discount rate is 7% (USEPA, "Guide to Developing and Documenting Cost Estimates During the Feasibility Study", July 2000).
6. "Cost per gallon" and "cost per cy" values are for informational purposes only. Values are not true unit costs because they represent a combination of fixed capital and flow-proportional components.
7. "Cost per gallon treated" is based on the total volume of water treated and discharged, after taking in to account the online factor of the dredging operation (i.e. the maximum capacity of the system over a 24-hour period would be greater).

CAPITAL COSTS

	Item	Units	Quantity	Unit Cost (1)	Extension
Purchased Equipment					
K.1	Polymer feed/flocculation unit	ea	1	$62,000	$62,000
K.2	Clarifier #1	ea	1	$300,000	$300,000
K.3	Clarifier #2	ea	0	$0	$0
K.4	Filter feed tank	ea	1	$89,000	$89,000
K.5	Clarifier solids pump (plus spare)	ea	2	$4,800	$9,600
K.6	Filter feed pump (plus spare)	ea	3	$14,000	$42,000
K.7	Granular media filter	lot	1	$300,000	$300,000
K.8	GAC filters	lot	1	$200,000	$200,000
K.9	Backwash supply pump (plus spare)	ea	2	$2,600	$5,200
K.10	Effluent collection tank	ea	1	$38,000	$38,000
K.11	Effluent discharge pump (plus spare)	ea	2	$15,000	$30,000
K.12	pH control (chemical feed) system	ea	1	$20,000	$20,000
	Subtotal, major equipment				$1,095,800
K.13	Minor equipment & support facilities	% of major equipment		25%	$273,950
	Subtotal, purchased equipment				$1,369,750
Mechanical Work					
M.1	Equipment erection	% of equipment	1	15%	$205,463
M.2	Process piping	% of equipment	1	30%	$410,925
M.3	Treatment building HVAC	ls	1	$150,000	$150,000
M.4	Site restoration	ls	1	$200,000	$200,000
Electrical Work					
E.1	Service entrance	ls	1	$150,000	$150,000
E.2	Main panels	ls	1	$30,000	$30,000
E.3	Process electrical & instrumentation	% of equipment	1	20%	$273,950
E.4	Primary control panel/package	ls	1	$200,000	$200,000
E.5	Building lighting	ls	1	$8,000	$8,000
Structural					
S.1	Treatment building	sf	7,800	$50	$390,000
S.2	Building foundation	ls	1	$115,000	$115,000
S.3	Outside tank and equipment foundations	ls	1	$43,000	$43,000
	Subtotal, purchased equipment and trades				$3,546,088
	Mobilization, demobilization, general conditions (% of above)			8%	$283,687
	Freight (% of purchased equipment)			5%	$68,488
	Prime contractor administration, overhead & profit (% of above)			25%	$974,566
	TOTAL DIRECT CAPITAL				$4,872,828

Notes

1. Unit cost backup provided on subsequent sheets

ANNUAL OPERATING COSTS

	Item	Units	Quantity	Unit Cost (1)	Extension
Purchased materials					
O.1	Granular activated carbon	lbs	10,170	$1.30	$13,221
O.2	Filter media	ls	1	$20,000	$20,000
O.3	Coagulant	ls	1	$50,000	$50,000
O.4	Caustic	ls	1	$10,000	$10,000
Operations labor					
O.10	Wastewater technician	hrs	9,800	$35	$343,000
O.11	Certified operator	hrs	1,750	$50	$87,500
O.12	Project manager	hrs	350	$75	$26,250
O.13	Analytical work	day	245	$200	$49,000
Maintenance labor & materials					
O.20	Maintenance and replacement parts	% of equipment	$1,369,750	5%	$68,488
Utilities					
O.30	Electricity	per detail			$67,591
O.31	Telephone	mo	8	$200	$1,600
		Subtotal			$736,649
	Mobilization, demobilization, general conditions (% of above)			8%	$58,932
	Prime contractor administration, overhead & profit (% of above)			25%	$198,895
		TOTAL ANNUAL OPERATIONS			$994,476

Notes

1. Unit cost backup provided on subsequent sheets

SUMMARY OF CARBON USAGE

Volume treated at breakthrough (1,2)	265,000,000	gal
Operating days per year	245	days
Daily volume treated, total	3,300,000	gal
Number of vessels	6	
Daily volume treated, per vessel	550,000	gal
Volume treated per year, per vessel	134,750,000	gal
Number of changeouts per year	0.51	
Mass of carbon per changeout, per vessel	20,000	lbs
Mass carbon per year, if averaged (3)	10,170	lbs

Notes

1. To be conservative, define breakthrough as 1/2 the expected discharge limit of 1.0 ug/L.
2. Breakthrough calculations provided by Carbonair, Inc., Minneapolis, MN, based on typical operating and loading conditions estimated by The RETEC Group, Inc.
3. Carbon changeout would actually occur roughly simultaneously in all GAC units, not evenly spaced over time.

ANNUAL ELECTRICAL COSTS

	Item	Total Motor HP	Kw	Operating Time Per Day (1)	Kw*hr per day
E.1	Polymer feed/flocculation unit	10	7.46	20	149
E.2	Clarifier #1	5	3.73	24	90
E.3	Clarifier #2	0	0	20	0
E.4	Filter feed tank	0	0	0	0
E.5	Clarifier solids pump	20	14.92	20	298
E.6	Filter feed pump (assume 2 at 40 HP)	80	59.68	20	1194
E.7	Granular media filter	0	0	0	0
E.8	GAC filters	0	0	0	0
E.9	Backwash supply pump	15	11.19	2	22
E.10	Effluent collection tank	0	0	0	0
E.11	Effluent discharge pump	100	74.6	20	1,492
E.12	pH control (chemical feed) system	1	0.746	20	15
	Subtotal, major equipment				3,260
E.13	Minor equipment & support facilities not yet defined	20	14.92	20	298
	Subtotal, all equipment (kw*hr/day)				3,558
	Number of days per operating year				175
	Cost of electricity ($/kw*hr)				$0.07
	Subtotal, electricity for equipment				$43,591
			Months	$/month	Extension
O.30	Lighting, ventilation & occasional minor heating of treatment building	month	8	3,000	$24,000
	TOTAL ANNUAL ELECTRICAL				$67,591

Notes

1. To be conservative, the daily operating time for system is assumed to be slightly longer than the typical daily dredge effective time.

PRESENT WORTH CALCULATION

i = 7%

Year, n	Capital Costs (Construction)	Annual Operations	Sum of Year "n" Costs	Cumulative Costs, Year 1 through n	Present Worth Factor, i	Present Worth of Year "n" Construction Costs Only	Present Worth of All Year "n" Costs	Cumulative Present Worth of All Costs, Year 1 through n
0	$4,872,828		$4,872,828	$4,872,828	1	$4,872,828	$4,872,828	$4,872,828
1		$994,476	$994,476	$5,867,304	0.9346	$0	$929,417	$5,802,244
2		$994,476	$994,476	$6,861,780	0.8734	$0	$868,614	$6,670,858
3		$994,476	$994,476	$7,856,256	0.8163	$0	$811,789	$7,482,647
4		$994,476	$994,476	$8,850,732	0.7629	$0	$758,681	$8,241,328
5		$994,476	$994,476	$9,845,208	0.7130	$0	$709,048	$8,950,376
6		$994,476	$994,476	$10,839,684	0.6663	$0	$662,661	$9,613,037
7		$397,790	$397,790	$11,237,474	0.6227	$0	$247,724	$9,860,761
8			$0	$11,237,474	0.5820	$0	$0	$9,860,761
9			$0	$11,237,474	0.5439		$0	$9,860,761
10			$0	$11,237,474	0.5083		$0	$9,860,761
11			$0	$11,237,474	0.4751		$0	$9,860,761
12			$0	$11,237,474	0.4440		$0	$9,860,761
13			$0	$11,237,474	0.4150		$0	$9,860,761
14			$0	$11,237,474	0.3878		$0	$9,860,761
15			$0	$11,237,474	0.3624		$0	$9,860,761
16			$0	$11,237,474	0.3387		$0	$9,860,761
17			$0	$11,237,474	0.3166		$0	$9,860,761
18			$0	$11,237,474	0.2959		$0	$9,860,761
19			$0	$11,237,474	0.2765		$0	$9,860,761
20			$0	$11,237,474	0.2584		$0	$9,860,761
21			$0	$11,237,474	0.2415		$0	$9,860,761
22			$0	$11,237,474	0.2257		$0	$9,860,761
23			$0	$11,237,474	0.2109		$0	$9,860,761
24			$0	$11,237,474	0.1971		$0	$9,860,761
25			$0	$11,237,474	0.1842		$0	$9,860,761
26			$0	$11,237,474	0.1722		$0	$9,860,761
27			$0	$11,237,474	0.1609		$0	$9,860,761
28			$0	$11,237,474	0.1504		$0	$9,860,761
29			$0	$11,237,474	0.1406		$0	$9,860,761
30			$0	$11,237,474	0.1314		$0	$9,860,761
31			$0	$11,237,474	0.1228		$0	$9,860,761
32			$0	$11,237,474	0.1147		$0	$9,860,761
33			$0	$11,237,474	0.1072		$0	$9,860,761
34			$0	$11,237,474	0.1002		$0	$9,860,761
35			$0	$11,237,474	0.0937		$0	$9,860,761
36			$0	$11,237,474	0.0875		$0	$9,860,761
37			$0	$11,237,474	0.0818		$0	$9,860,761
38			$0	$11,237,474	0.0765		$0	$9,860,761
39			$0	$11,237,474	0.0715		$0	$9,860,761
40			$0	$11,237,474	0.0668		$0	$9,860,761
Totals	$4,872,828	$6,364,646	$11,237,474			$4,872,828	$9,860,761	

BASIS OF UNIT COSTS

I.D.	Item	Source	Description	Value or Range Provided (rounded)	Value Used (rounded)	Basis
K.1	Polymer feed/flocculation unit	Vendor budgetary estimate (Enprotec, Hebron, KY)	Flash, floc tanks with mixers and polymer blending feed system. Sizing: 1,600 to 2,500 gpm influent. Flash mix tank at 30 sec, flocculation tank at 5-7 min.	$52,000 - $62,000	$62,000	Size varies to accomodate different influent flowrates to individual subsystems. Use upper end of range for treatment of carriage water released from a dredge slurry of up to 2,100 gpm (Type I system), which corresponds to a wastewater flow on order of 2,000 gpm.
K.2	Clarifier #1	Vendor budgetary estimate (Enprotec, Hebron, KY)	Model J6220, rectangular clarifier, 500 gpd/sf, 10'w x 12'h x length as needed. Sized for nominal 2,500 gpm influent at 2000 mg/L solids.	$415,000		
		Vendor budgetary estimate (WesTech, Rockton, IL)	Clarifier mechanism (SCS71) and tank (TKC11.) Solids contact style, sized for 4,000 gpm thickener overflow. 85' dia x 16' side wall depth. 25' total side depth.	$400,000 - $500,000		Interpolated from quote provided by WesTech for dewatering and wastewater treatment package.
		Summary:			$300,000	For Type I system at 2,000 gpm, use scale-down factor of 75% on low end of range for the larger clarifier. Assume combined system for handling supernatent and filtrate streams with allowance for excess capacity (for an overflow rate of 1000 gpd/sf, tank dia. = 60 ft)
K.3	Clarifier #2	Vendor budgetary estimate (Enprotec, Hebron, KY)	Model J6220, rectangular clarifier, overflow rate of 500 gpd/sf, 10'w x 12'h x length as needed. Sized for nominal 1600 gpm influent at 500 mg/L solids.	$264,000		Not used.
K.4	Filter feed tank	Vendor budgetary estimate (Enprotec, Hebron, KY)	100,000 gal bolted steel tank, 32'8" dia x 16'1" h or 47'6" dia x 8'1/2" h.	$85,000	$89,000	Assume 1 tank required to provide approx. 50 minute holding capacity for flow on order of 2,000 gpm. Add allowance for pipes and fittings.
K.5	Clarifier solids pump (plus spare)	Means/Echos (2001)	Pump to return up to several hundred gpm underflow solids from clarifier to thickener. 500 gpm, 100' TDH, 20 HP centrifugal transfer pump with motor and fittings. An additional backup pump will be purchased.	$4,800	$4,800	Means, #33_29_0130. Pump sized for combined system for handling supernatent and filtrate streams including allowance for fluctuations in flow.
K.6	Filter feed pump (plus spare)	Means/Echos (2001)	Pump to feed supernatant from clarifier to filters. 1,000 gpm at 100' TDH, 40 HP centrifugal transfer pump with motor and fittings. An additional backup pump will be purchased.	$12,800	$14,000	Means, #33_29_0134 plus 10% to account for inflation.
K.7	Granular media filter	Vendor budgetary estimate (WesTech, Rockton, IL)	Dual-media (anthracite, silica sand), automatic backwash, pressure filters. Two vessels with 3-cell design required to treat 4,000 gpm. Model: SA516 GR70; Vessel: 10' dia. X 34' L horizontal	$150,000 - $200,000		Interpolated from quote provided by WesTech for dewatering and wastewater treatment package. Assume 2 vessels required at $75,000 - $100,000 each for approx. 2,000 gpm. Design rate = 5.9 gpm/sf; maximum during backwash = 8.9 gpm/sf; backwash = 17.7 gpm/sf.
		Vendor budgetary estimate (Enprotec, Hebron, KY)	Multi-media, automatic backwash, pressure filters. Two vessels with 3-cell design required to treat 1,800 gpm. Model: J3396-150; Cell: 96" dia, 50 sf area	$390,000		Assume cost of 1 unit (2 vessels) at approx. $260,000 scaled up by 50% to provide excess capacity. Units sized for 90% removal of +20 micron solids, at an assumed influent loading of up to 100 mg/L.
		Vendor budgetary estimate (Zimpro/US Filter, Rothschild, WI)	Single-media (sand), continuous backwash, gravity flow filters. Hydro-Clear 4-cell design required to treat 2,500 gpm. Model KK-12X25(4); Cell: 250 sf area	$295,000		Assume 1 unit required at $295,000.

BASIS OF UNIT COSTS

I.D.	Item	Source	Description	Value or Range Provided (rounded)	Value Used (rounded)	Basis
		Vendor opinion (Parkson Corp.)	Single-media sand (DynaSand) filter, continuous backwash, gravity flow filters required to treat 1,725 gpm. Details not specified.	> $750,000		Assume cost of 1 unit at approx. $500,000 scaled up by factor of 150% to provide excess capacity
		Vendor budgetary estimate (Applied Process Technology, Conroe, TX)	Multi-grade sand media, continuous backwash, gravity flow filters. 24-filter 6-cell and 32-filter 8-cell Centra-flo filter design required to treat 1,725 and 2,258 gpm, respectively. Model: CF-50C; Filter: 8 sf area	$615,000 $815,000		Assume 32-filter, 8-cell design required at approx. $815,000. Cells would be contained in a concrete, rectangular tank, by others.
		Summary:			$300,000	A number of process options and configurations are available. Assume pressure filter style. Use mid-point of range for pressure-style filters.
K.8	GAC filters	Vendor budgetary estimate (Carbonair, Inc., Minneapolis)	Model PC78. 10' dia. x 18'h, vertical steel tanks, each containing 20,000 # of liquid-phase carbon. Hydraulic loading = 5.9 gpm/sf. Purchase price includes first load of carbon.	$163,000		Quote provided by Carbonair of 5 vessels at $32,600 each required for 2,300 gpm (initial proposal included 9 vessels for 4,000 gpm).
		Vendor budgetary estimate (WesTech, Rockton, IL)	Model SA516 GR70. 8' dia x 32'L, horizontal steel tanks. Hydraulic loading = 3.7 gpm/sf.	$100,000		Interpolated from quote provided by WesTech for dewatering and wastewater treatment package. Assume 2 units required at $50,000 each.
		Summary:			$200,000	Proposed loading for both options is within or better than typical range (4-8 gpm/sf, Cheremisinoff, 1993). Use Carbonair cost estimate as representative, due to their prior experience on original demonstration projects. Approx. 6 vessels required for flow on order of 2,000 gpm. Include allowance for interconnecting pipe racks and valving.
K.9	Backwash supply pump (plus spare)	Vendor budgetary estimate (Carbonair, Inc., Minneapolis)	Pump to return water from effluent collection tank to filters for periodic backwashing. 800 gpm at 25 psi, 15 HP, 3 phase, 1750 rpm, TEFC motor. An additional backup pump will be purchased.	$2,560	$2,600	Quote provided by Carbonair.
K.10	Effluent collection tank	Vendor budgetary estimate (Enprotec, Hebron, KY)	44,000 gal bolted steel tank, 21' dia x 16'h	$36,300	$38,000	Assume 1 tank required to provide approx. 20 minute holding capacity for flow on order of 2,000 gpm. Add allowance for pipes and fittings.
K.11	Effluent discharge pump (plus spare)	Means/Echos (2001)	Pump for discharging treated water to river. 3,000 gpm at 100' TDH, 100 HP centrifugal transfer pump with motor and fittings. An additional backup pump will be purchased.	$13,200	$15,000	Means, #33_29_0135 plus 10% to account for inflation. Pump sized for flow on order of 2,000 gpm with allowance for fluctuations in flow. Cost includes the purchase of spare pump.
K.12	pH control (chemical feed) system		Chemical feed system to re-adjust effluent pH to within 6 to 9 per WPDES permit.		$20,000	Placeholder, pending final engineering.
K.13	Minor equipment & support facilities	Prior project experience	Minor items such as compressed/instrument air system, materials handling equipment, storage units, laboratory instrumentation, that are not currently defined for the project.		25%	Placeholder, pending final engineering.
M.1	Equipment erection	Prior project experience	Labor and materials to erect large tanks and other process equipment.	11%	15%	Increase percentage to account for several unknown factors at this stage in the project.

BASIS OF UNIT COSTS

I.D.	Item	Source	Description	Value or Range Provided (rounded)	Value Used (rounded)	Basis
M.2	Process piping	Prior project experience	Interconnecting piping between and not supplied with process equipment.	7 - 50%	30%	Range from past mid-size treatment systems, as a percentage of purchased equipment. Use mid-point of range to account for unknown factors at this stage in the project.
M.3	Treatment building HVAC	Prior project experience	Heating and ventilation equipment for treatment building.		$150,000	Past projects at $9 to $33/sf, or 50% to 100% of building cost. For Type I building, sized at approximately 7,800 sf, assume $150,000.
M.4	Site restoration	Prior project experience	Remove system and building at end of project.		$200,000	Based on recent experience with process equipment removal and building demolition, Fox Valley.
E.1	Service entrance	Contractor opinion (Boudry Control Panels, LLC, Fond du Lac, WI) (formerly Boudry Electric, Inc.)	New overhead primary line from nearby street. Assume 500 to 1,00 feet required.		$150,000	Could range from $0 to $300,000, depending on whether utility would subisidize (or pay) based on projected revenue, whether transformer is purchased or leased, if power factor correction is needed, etc. Use midpoint of $150,000 as a placeholder.
E.2	Main panels	Contractor opinion (Boudry Control Panels, LLC, Fond du Lac, WI)	Main panel and disconnect at plant building.		$30,000	Assumes $20,000 for 2,000 amp panel, plus installation.
E.3	Process electrical and instrumentation	Prior project experience	Includes process wiring, loose process instrumentation and controls, as a percentage of the purchased equipment.	15 - 27%		Range from past, smaller projects.
		Contractor opinion (Boudry Control Panels, LLC, Fond du Lac, WI)		Min. $750,000		Contractor opinion is for OU3/4 total facility (dewatering, water treatment, infrastructure, etc.). $750,000 would be a little less than 10% of purchased equipment for OU3/4. This assumes that all starters and local panels are provided with individual equipment packages.
		Summary:			20%	Increase contractor's opinion to allow for some starters not provided with equipment, other items not yet defined, etc. Use 20% of purchased equipment, which is at mid-point of past experience on smaller projects.
E.4	Primary control panel/package	Contractor opinion (Boudry Control Panels, LLC, Fond du Lac, WI)	Central controls package and process monitoring, that integrates all loose controllers provided with individual equipment packages. Include 5 or 6 remote PCs at various points in plant/offices, with process monitoring software, local network, etc.		$200,000	Cost breakdown is: PCs - $12,000, networking - $10,000, software - $35,000, programming and installation - $120,000. Add contingency for items not yet defined. Use $200,000.
E.5	Building lighting	Contractor opinion (Boudry Control Panels, LLC, Fond du Lac, WI)	Overhead, industrial lighting in press building.		$8,000	Assumes 1 fixture for every 400 sf Total = 7800 sf/400 = 20 fixtures. Fixtures at $200 each plus $100 to install/wire. Use $8,000.
S.1	Treatment building	Builder opinion, typical projects (Butler Buildings/Howard Immel, Inc., Green Bay, WI)	Pre-engineered metal building, industrial quality, w/ OH doors, etc. On a square foot of floorspace basis.		$50	Estimate represents typical square foot cost, based on contractor experience in Fox Valley. Size has been developed for the larger Type II building. Assume Type I building is 75% of Type II.
S.2	Building foundation	Builder's opinion (Howard Immel, Inc., Green Bay, WI)	Assume minimum of 8" slab plus 4 ft. frost wall and strip footing.		$115,000	Estimate has been developed for the larger Type II building. Assume Type I building is 75% of Type II.

BASIS OF UNIT COSTS

I.D.	Item	Source	Description	Value or Range Provided (rounded)	Value Used (rounded)	Basis
S.3	Outside tank & equipment foundations	Builder opinion, typical projects and Means Site Work, 2000.	Along perimeter of circular tanks, assume minimum of 4 ft. foundation wall, 8" thick, with continuous strip footing, 16" d x 48" w.		$43,000	From Means assemblies, p. 387: Footing = $35/lf. 8' x 8" wall = $57/lf. For shorter wall, use $75/lf total. Assume at least 1 tank at 60' dia, 1 at 32' dia, for total of 289 lf, or $21,700. Include allowance for small tanks and equipment pads. Use $43,000.
S.4	Interior buildout	In-house opinion	Includes construction of interior walls for office space, lab benches, storage, lavatory, etc.		$75,000	Placeholder pending detailed design of the facility.
O.1	Granular activated carbon	Vendor model calculations and recommendations (Carbonair, Inc., Minneapolis)	Media used for polishing step in filtration process. Annual cost.		$13,221	Refer to cost sheet, "Summary of Carbon Usage"
O.2	Filter media	In-house opinion	Typically a type of sand, either graded or combined with other media (i.e., anthracite, coal) used in the granular media filters. Annual cost.		$20,000	Placeholder, pending final engineering of the system. Replacement not expected to be needed, but could be several % by weight per year; therefore, a small allowance is included.
O.3	Coagulant	In-house opinion	Chemical addition to improve clarification. Annual cost.		$50,000	Placeholder pending final treatability testing. Type and dose of chemical not known.
O.4	Caustic	In-house opinion	For pH control. Annual cost.		$10,000	Placeholder, pending final treatability testing.
O.10	Wastewater technician	In-house opinion	2 FTE, 20/7 - Two 10-hour shifts 7 days per week to conduct continuous operations and maintenance-related tasks. 9,800 hrs/yr.		$35	Assume typical hourly rate for contract environmental labor. Rate includes basic per diem expenses.
O.11	Certified operator	In-house opinion	Plant operator with state certification. 1 FTE (based on 50 hr week). LOE and cost is allocated to wastewater treatment element. 1,750 hrs/yr.		$50	Assume typical hourly rate for senior contract environmental personnel.
O.12	Project manager	In-house opinion	On-site project controls and personnel supervision. Assume LOE is 0.2 FTE (based on a 50 hr week), or 10 hrs/wk for 8 months, with the remainder of time allocated to other project elements. 350 hrs/yr.		$75	Assume typical hourly rate for onsite supervisor. Rate includes basic per diem expenses.
O.13	Analytical work	Estimate from FS	Daily effluent samples or samples from other intermediate points in the process to confirm discharge compliance and process control.		$200	Assumes analysis of BOD, TSS, PCBs, and other minor parameters per WPDES permit.
O.20	Maintenance and replacement parts	In-house opinion	Purchased materials and labor to install miscellaneous small and expendible items associated with process equipment.		5%	Professional judgement from similar projects experience.
O.30	Electricity		Power requirements for process equipment, lighting, etc.		$67,591	Refer to cost sheet, "Annual Electrical Costs"
O.31	Telephone	Prior project experience	Cost of phone service from treatment plant.		$200	Monthly estimated cost.

COST ESTIMATE #11 **Rev: 10.30.03**
DETAILED EVALUATION OF ALTERNATIVES **Final**
WDNR - FOX RIVER

PROJECT ELEMENT:
Plant infrastructure, material staging & loadout facility, Type II
Scenario B - OU3 and OU4

PROCESS METRICS

Total volume sediment removed from river	6,500,000	cy
Total wet tons filter cake (at 55% solids) generated from this volume of sediment	3,560,000	ton
Length of operations	6.4	yr

COST SUMMARY

	Total Cost (3)	**Total as Present Worth (4)**	
Subtotal, construction costs	$4,900,000	$4,900,000	
Total, construction plus operating costs	$10,100,000	$9,000,000	
Cost per cy sediment removed (5)	$1.55	$1.38	/cy
Cost per ton filter cake disposed (5)	$2.84	$2.53	/ton

Notes

1. This estimate includes the facilities, equipment, and labor needed to stage and loadout the separated sand and filter cake from a mechanical dewatering plant. It is based on preliminary concepts, and is suitable only as a general indicator of eventual project costs. It will change as final engineering and detailed design work proceed.
2. The Type II facility is sized to accommodate the quantity of filter cake generated from the dewatering of a dredge slurry flowrate of up to 2,100 gpm and 74 tons dry solids per hour.
3. The estimate assumes that the plant is constructed as a fixed-base, semi-permanent facility. Indirect capital costs (engineering, construction management, etc.) not included.
4. The "total cost" does not discount the multi-year operating costs.
5. The "present worth" discounts all construction and operations costs over the active life of the facility. The discount rate is 7% (USEPA, "Guide to Developing and Documenting Cost Estimates During the Feasibility Study", July 2000).
6. "Cost per ton" and "cost per cy" values are for informational purposes only. Values are not true unit costs because they represent a combination of fixed capital and quantity proportional components.

DIRECT CAPITAL COSTS

	Item	Units	Quantity	Unit Cost (1)	Extension
Purchased Equipment					
K.1	Conveyor system - dewatering building to filter cake staging	ls	1	$450,000	$450,000
K.2	Conveyor system - coarse material staging	ls	1	$250,000	$250,000
K.3	Loadout stations	ea	2	$10,000	$20,000
K.4	Truck scale	ea	1	$75,000	$75,000
K.5	Stormwater transfer pump	ea	3	$4,800	$14,400
K.6	Office trailers	ea	5	$25,000	$125,000
	Subtotal, major equipment				$934,400
K.7	Minor equipment not yet defined	% of major equipment	1	25%	$233,600
	Subtotal, purchased equipment				$1,168,000
Civil work					
C.1	Structural concrete slab and liner at filter cake staging area	sf	80,700	$10	$807,000
C.2	Structural concrete slab and liner at coarse material staging area	sf	32,500	$10	$325,000
C.3	Concrete sidewalls at staging areas	lf	2,000	$90	$180,000
C.4	Storm sewer (main yard and staging areas)	lf	1,000	$20	$20,000
C.5	Stormwater catch basins and wet wells	ea	6	$2,500	$15,000
C.6	Stormwater transfer piping (to thickener)	ls	1	$10,000	$10,000
C.7	Truck driveway, asphalt	sf	41,300	$3	$123,900
C.8	Plant driveway, asphalt	sf	21,600	$3	$64,800
C.9	Main yard, asphalt	sf	19,800	$3	$59,400
C.10	Effluent discharge piping (to river)	lf	500	$45	$22,500
C.11	Plant fencing	lf	2,800	$35	$98,000
C.12	Vehicle gates	ls	1	$32,000	$32,000
C.13	Personnel gates	ea	4	$400	$1,600
C.14	Sewer line	ls	900	$20	$18,000
C.15	Potable water line	ls	900	$45	$40,500
C.16	Telephone service	ls	1	$10,000	$10,000
C.17	Site restoration	ls	1	$100,000	$100,000
Mechanical Work					
M.1	Equipment erection	% of equipment	1	15%	$175,200
Electrical Work					
E.1	Process electrical and instrumentation	% of equipment	1	20%	$233,600
E.2	Yard lighting	ls	1	$50,000	$50,000
Structural					
S.1	Conveyor foundations	ls	1	$50,000	$50,000
	Subtotal, purchased equipment and trades				$3,604,500
	Mobilization, demobilization, general conditions (% of above)			8%	$288,360
	Freight (% of purchased equipment)			5%	$58,400
	Prime contractor administration, overhead & profit (% of above)			25%	$987,815
	TOTAL DIRECT CAPITAL				$4,939,075

Notes

1. Unit cost backup provided on subsequent sheets

ANNUAL OPERATING COSTS

	Item	Units	Quantity	Unit Cost (1)	Extension
	Leased equipment				
O.1	Front end loader - coarse material staging	month	8	$6,000	$48,000
O.2	Front end loader - filter cake staging	month	8	$12,000	$96,000
	Operations labor				
O.10	Loader operators	hrs	6,930	$35	$242,550
O.11	General labor	hrs	4,900	$25	$122,500
	Maintenance labor & materials				
O.20	Maintenance & replacement parts	% of equipment	5%	$1,168,000	$58,400
	Utilities				
O.30	Electricity	per detail			$31,353
	Subtotal, all annual operations				$598,803
	Mobilization, demobilization, general conditions (% of above)			8%	$47,904
	Prime contractor administration, overhead & profit (% of above)			25%	$161,677
	TOTAL ANNUAL OPERATIONS				$808,384

Notes

1. Unit cost backup provided on subsequent sheets

ANNUAL ELECTRICAL COSTS

	Item	Total Motor HP	Kw	Operating Time Per Day (1)	Kw*hr per day
E.1	Conveyor system - dewatering building to filter cake staging	20	14.9	20	298
E.2	Conveyor system - coarse material staging	20	14.9	20	298
E.3	Loadout stations	0	0.0	20	0
E.4	Truck scale	0	0.0	20	0
E.5	Stormwater transfer pump	0	0.0	20	0
E.6	Office trailers	0	0.0	20	0
	Subtotal, major equipment				597
E.7	Minor equipment not yet defined	20	14.9	20	298
	Subtotal, all equipment (kw*hr/day)				895
	Number of operating days per year				245
	Cost of electricity ($/kw*hr)				$0.07
	Subtotal, electricity for equipment				$15,353
			Months	$/month	Extension
E.8	Lighting, ventilation & heating of office trailers	month	8	$2,000	$16,000
	TOTAL ANNUAL ELECTRICAL				$31,353

Notes

1. Daily operating time for system is assumed to be somewhat longer than daily dredge effective time.

PRESENT WORTH CALCULATION

i = 7%

Year, n	Capital Costs (Construction)	Annual Operations	Sum of Year "n" Costs	Cumulative Costs, Year 1 through n	Present Worth Factor, i	Present Worth of Year "n" Construction Costs Only	Present Worth of All Year "n" Costs	Cumulative Present Worth of All Costs, Year 1 through n
0	$4,939,075		$4,939,075	$4,939,075	1	$4,939,075	$4,939,075	$4,939,075
1		$808,384	$808,384	$5,747,459	0.9346	$0	$755,499	$5,694,574
2		$808,384	$808,384	$6,555,842	0.8734	$0	$706,074	$6,400,647
3		$808,384	$808,384	$7,364,226	0.8163	$0	$659,882	$7,060,529
4		$808,384	$808,384	$8,172,609	0.7629	$0	$616,712	$7,677,241
5		$808,384	$808,384	$8,980,993	0.7130	$0	$576,366	$8,253,607
6		$808,384	$808,384	$9,789,377	0.6663	$0	$538,660	$8,792,268
7		$323,353	$323,353	$10,112,730	0.6227	$0	$201,368	$8,993,636
8			$0	$10,112,730	0.5820	$0	$0	$8,993,636
9			$0	$10,112,730	0.5439		$0	$8,993,636
10			$0	$10,112,730	0.5083		$0	$8,993,636
11			$0	$10,112,730	0.4751		$0	$8,993,636
12			$0	$10,112,730	0.4440		$0	$8,993,636
13			$0	$10,112,730	0.4150		$0	$8,993,636
14			$0	$10,112,730	0.3878		$0	$8,993,636
15			$0	$10,112,730	0.3624		$0	$8,993,636
16			$0	$10,112,730	0.3387		$0	$8,993,636
17			$0	$10,112,730	0.3166		$0	$8,993,636
18			$0	$10,112,730	0.2959		$0	$8,993,636
19			$0	$10,112,730	0.2765		$0	$8,993,636
20			$0	$10,112,730	0.2584		$0	$8,993,636
21			$0	$10,112,730	0.2415		$0	$8,993,636
22			$0	$10,112,730	0.2257		$0	$8,993,636
23			$0	$10,112,730	0.2109		$0	$8,993,636
24			$0	$10,112,730	0.1971		$0	$8,993,636
25			$0	$10,112,730	0.1842		$0	$8,993,636
26			$0	$10,112,730	0.1722		$0	$8,993,636
27			$0	$10,112,730	0.1609		$0	$8,993,636
28			$0	$10,112,730	0.1504		$0	$8,993,636
29			$0	$10,112,730	0.1406		$0	$8,993,636
30			$0	$10,112,730	0.1314		$0	$8,993,636
31			$0	$10,112,730	0.1228		$0	$8,993,636
32			$0	$10,112,730	0.1147		$0	$8,993,636
33			$0	$10,112,730	0.1072		$0	$8,993,636
34			$0	$10,112,730	0.1002		$0	$8,993,636
35			$0	$10,112,730	0.0937		$0	$8,993,636
36			$0	$10,112,730	0.0875		$0	$8,993,636
37			$0	$10,112,730	0.0818		$0	$8,993,636
38			$0	$10,112,730	0.0765		$0	$8,993,636
39			$0	$10,112,730	0.0715		$0	$8,993,636
40			$0	$10,112,730	0.0668		$0	$8,993,636
Totals	$4,939,075	$5,173,655	$10,112,730			$4,939,075	$8,993,636	

BASIS OF UNIT COSTS

I.D.	Item	Source	Description	Value or Range Provided (rounded)	Value Used for Estimate (rounded)	Basis
K.1	Conveyor system - dewatering building to filter cake staging	Vendor budgetary estimate (Feeco, Green Bay, WI)	Conveyor belt system for transfering material from the presses to a series of stockpiles.	$450,000	$450,000	Assuming conventional conveyance system is feasible for transfer of materials generated, use Feeco quote as reasonable estimate.
K.2	Conveyor system - coarse material staging	Vendor budgetary estimate (Feeco, Green Bay, WI)	Conveyor belt system for transfering material from the presses to a series of stockpiles.	$250,000	$250,000	Assuming conventional conveyance system is feasible for transfer of materials generated, use Feeco quote as reasonable estimate.
K.3	Loadout stations		Equipment to facilitate loading operations.		$10,000	Placeholder, pending final engineering.
K.4	Truck scale	Means Sitework (2000)	Installed scale at truck entrance to weigh loaded and/or incoming trucks.		$75,000	Means, #10880_100_1680. Truck scale, 70' x 10', digital, electronic = $39,900. Add remote readout system, foundation, site prep. Assume $75,000.
K.5	Stormwater transfer pump (plus spare)	Means/Echos (2001)	500 gpm at 100' TDH, 20 HP centrifugal transfer pump with motor and fittings for management of stormwater. An additional backup pump will be purchased.	$4,800	$4,800	Means, #33_29_0130. Conservative estimate of approx. 1,000 gpm based on 25-year, 24-hour storm event assuming no infiltration. Assume 2-500 gpm pumps installed.
K.6	Office trailers	Means Sitework (2000)	Pre-fabricated office, trailer-style, 50' x 12', purchased.	$18,900	$25,000	Means, #01520_0550. $18,900 to buy. Add allowance for site prep, installation and weatherization.
K.7	Minor equipment not yet defined	Prior project experience	Minor equipment not yet defined.		25%	Placeholder, pending final engineering.
C.1	Slab and liner at filter cake staging area	Means/Echos (2000) and contractor opinion	12" reinforced concrete slab, with 60 mil geomembrane liner and sand collection layer. Include grading, surface prep.		$10	Slab: Means, #18_02_0324 = $7.35/sf. Geomembrane = $0.60/sf. With sand layer and possibly embedded steel for wear suface, assume $10/sf.
C.2	Structural concrete slab and liner at coarse material staging area	Means/Echos (2000) and contractor opinion	12" reinforced concrete slab, with 60 mil geomembrane liner and sand collection layer. Include grading, surface prep.		$10	Slab: Means, #18_02_0324 = $7.35/sf. Geomembrane = $0.60/sf. With sand layer and possibly embedded steel for wear suface, assume $10/sf.
C.3	Concrete sidewalls at staging areas	Means/Echos (2000) and contractor opinion	10" concrete reinforced retaining wall, on a 26" wide footing surrounding the staging areas.		$90	Means Assemblies, #A12.7_310_1000. Concrete reinforced retaining wall = $83/lf. Add water stop, contingency. Assume $90/lf.
C.4	Storm sewer (main yard and staging areas)	Project experience	4" PVC, gravity drains to common wet well. Length of runs not yet known. Assume coverage for each staging area, at a minimum.		$20	Recent project, central Wisconsin, 4" gravity PVC, max. 4' excavation, including backfill, etc.
C.5	Stormwater catch basins and wet wells	Means Sitework (2000)	Concrete, pre-cast concrete manhole to serve as collection point for staging area and yard runoff.	$2,090	$2,500	Means Assemblies, #12.3_170_5820. Assume 4' dia and 6' d, on base, with frame and lid.
C.6	Stormwater transfer piping (to thickener)	General experience	Aboveground or underground piping to connect stormwater sump pumps to thickener.		$10,000	Routing not yet determined. Include a placeholder of $10,000 for up to several hundred feet of 2" or 3" pipe, fittings, connections, etc.
C.7	Truck driveway, asphalt	Means Sitework (2000)	Main truck access area for loading, weighing, and hauling operations.		$3	Means Assemblies, #12.5_111_3400. For 5" asphalt, 14" base, 32' wide = $96/lf. This equals $3/sf.
C.8	Plant driveway, asphalt	Means Sitework (2000)	Main access road for personnel vehicle entrance.		$3	Means Assemblies, #12.5_111_3400. For 5" asphalt, 14" base, 32' wide = $96/lf. This equals $3/sf.
C.9	Main yard, asphalt	Means Sitework (2000)	Area used for parking of personnel vehicles and access to dewatering and wastewater treatment buildings and offices.		$3	Means Assemblies, #12.5_111_3400. For 5" asphalt, 14" base, 32' wide = $96/lf. This equals $3/sf.
C.10	Effluent discharge piping (to river)	Means Sitework (2000) Project Experience	Piping from wastewater treatment plant to Fox River. Assume 500 lf straight run of pipe.		$45	Means, #02510_820_2060. For 8" ductile iron, mechanical joints = $26.50/lf. With excavation, backfill, fittings, assume $45/lf.

BASIS OF UNIT COSTS

I.D.	Item	Source	Description	Value or Range Provided (rounded)	Value Used for Estimate (rounded)	Basis
C.11	Plant fencing	Means Sitework (2000)	Chain-link fencing for perimeter of facility. 8' h, w/ 3 strand barb wire.		$35	Means, #02820_528_0920. $30.50/lf. With contingency, use $35.00/lf
C.12	Vehicle gates		Sliding, chain-link gates at the truck entrances and the plant entrance.		$32,000	Means, #02820_528_3100. $152/lf for up to 18'. Assume $200/lf for longer span. $32,000 total.
C.13	Personnel gates	Means Sitework (2000)	Gates at front of facility and at back (towards river.) 4 total needed.		$400	Means, #02820_528_1400. $280 for a 6' high, 3' wide gate. Assume $400 each for a taller, 8' gate.
C.14	Sewer line	General experience	Sanitary sewer connection to lavatory in Wastewater Treatment Building.		$20	Assume $5 - 10/lf for 4" PVC pipe, gravity, installed. Excavation, bedding and backfill at $5-8/lf. Add allowance for fittings, connections, etc. Use $20/lf total.
C.15	Potable water line	General experience	Potable water service to buildings for equipment cleaning, general washdown, etc.		$45	Assume 1" to 1-1/2" line is needed. Copper pipe at $26 to $34/lf. Trenching, bedding and backfill at $5-8 lf. Add allowance for service connection, backflow preventer, etc. Use $45/lf.
C.16	Telephone service	General experience	Cost of phone service from treatment plant.		$10,000	This is an assumed placeholder for bringing in new service to the plant, and making local connections to trailers and buildings.
C.17	Site restoration	Prior project experience	Remove slabs, driveways and facilities at end of project		$100,000	Based on recent experience with process equipment removal and building demolition, Fox Valley.
M.1	Equipment erection	Prior project experience	Labor and materials to erect equipment and structures.	11%	15%	Prior project, increased to reflect current unknowns.
E.1	Process electrical and instrumentation	Prior project experience	Includes process wiring, loose process instrumentation and controls, as a percentage of the purchased equipment.	15 - 27%	20%	Use mid-point of range from past, smaller projects.
E.2	Yard lighting	Contractor opinion (Boudry Control Panels, LLC, Fond du Lac, WI)	Overhead, industrial lighting in staging areas and along roads		$50,000	Past experience is approximately 7 pole lights per acre, which seems high for this project. At least 5 acres require coverage. Assume 20 poles at $2,500 each.
S.1	Conveyor foundations		Labor and materials to erect buildings and other structures.		$50,000	Placeholder, pending final engineering.
O.1	Front end loader - coarse material staging	Means Sitework (2001)	Tractor loader with 3 to 4.5 cy capacity for tranfer of coarse material from stockpiles to trucks.	$6,000	$6,000	Means, #01590_200_4730. Assume monthly rental of 1 loader operating in coarse material staging area.
O.2	Front end loader - filter cake staging	Means Sitework (2001)	Tractor loader with 3 to 4.5 cy capacity for tranfer of coarse material from stockpiles to trucks.	$6,000	$12,000	Means, #01590_200_4730. Assume monthly rental of 2 loaders operating in filter cake staging area.

COST ESTIMATE #12 **Rev: 10.30.03**
DETAILED EVALUATION OF ALTERNATIVES **Final**
WDNR - FOX RIVER

PROJECT ELEMENT:
NR500 Monofill, Type B
Scenario B - OU3 and OU4

PROCESS METRICS

Total volume of sediment removed from river	6,500,000	cy
Total mass of filter cake generated for disposal	3,560,000	tons
Length of operations	6.4	yr
Mass disposed per year	556,250	tons

COST SUMMARY

	Total Cost (1)	Total as Present Worth (2)	
Subtotal, capital costs	$29,300,000	$24,900,000	
Subtotal, operating costs (including host community fee)	$41,200,000		
Subtotal, long-term care costs	$10,700,000		
Total, capital, operating and long-term care costs	$81,200,000	$59,435,989	
Cost per cy sediment removed (4)	$12.49	$9.14	/cy
Cost per ton filter cake disposed (4)	$22.81	$16.70	/ton

Notes

1. The "total cost" does not discount the multi-year construction costs, annual operating costs, or long-term care costs.
2. The "present worth" discounts all construction and operations costs over the active life of the facility, as well as the post-closure annual costs. The discount rate is 7% (USEPA, "Guide to Developing and Documenting Cost Estimates During the Feasibility Study", July 2000).
3. "Direct capital costs" include construction costs during the active life of the facility, up until final closure. Leachate management and groundwater monitoring, both prior to and after final closure, are included as "annual costs."
4. "Cost per cy sediment removed" and "cost per ton disposed" values are for informational purposes only. Values are not true unit costs because they represent a combination of fixed capital and quantity-proportional components.

CAPITAL COSTS

	Item	Units	Unit Cost	Year 0 Quantity	Year 0 Extension	Year 1 Quantity	Year 1 Extension	Year 2 Quantity	Year 2 Extension	Year 3 Quantity	Year 3 Extension	Year 4 Quantity	Year 4 Extension	Year 5 Quantity	Year 5 Extension
Direct Capital															
Facility Development															
D.1	Land acquisition	ac	$2,000	130	$260,000										
Civil Work															
C.1	Mobilization/demobilization	ls	$40,000	1	$40,000	1	$40,000	1	$40,000	1	$40,000	1	$40,000	1	$40,000
C.2	Clear & grub	ac	$2,100	21.4	$45,003	5.5	$11,550	5.5	$11,550	5.5	$11,550	11.0	$23,100	8.0	$16,800
C.3	Strip & stockpile topsoil (6")	cy	$1.00	17,287	$17,287	4,437	$4,437	4,437	$4,437	4,437	$4,437	8,873	$8,873	6,453	$6,453
C.4	Excavation to subgrade	cy	$1.50	353,620	$530,431	126,765	$190,147	126,765	$190,147	126,765	$190,147	265,053	$397,580	184,385	$276,577
C.5	Berm construction	cy	$2.50	193,929	$484,823	34,068	$85,170	34,068	$85,170	34,068	$85,170	68,137	$170,343	159,861	$399,653
C.6	Gradient control layer	ac	$35,000	13.5	$472,500	5.5	$192,500	5.5	$192,500	5.5	$192,500	11.0	$385,000	8.0	$280,000
C.7	Liner & leachate collection system	ac	$120,000	13.5	$1,620,000	5.5	$660,000	5.5	$660,000	5.5	$660,000	11.0	$1,320,000	8.0	$960,000
C.8	Place intermediate drainage layers	ac	$110,000	13.5	$1,485,000	5.5	$605,000	5.5	$605,000	5.5	$605,000	11.0	$1,210,000	8.0	$880,000
C.9	Place grading layer	cy	$2.50					6,453	$16,133	8,873	$22,183	4,437	$11,092	4,437	$11,092
C.10	Cover system	ac	$100,000					8.0	$800,000	11.0	$1,100,000	5.5	$550,000	5.5	$550,000
C.11	Seed, fertilize, mulch	ac	$2,500	3	$7,500										
C.12	Perimeter drainage ditches	lf	$4	2,605	$10,419	458	$1,830	458	$1,830	458	$1,830	915	$3,661	2,147	$8,589
C.13	Perimeter road	lf	$10	2,605	$26,048	458	$4,576	458	$4,576	458	$4,576	915	$9,152	2,147	$21,472
C.14	Access road, paved	sf	$4	50,875	$203,500										
C.15	Perimeter fence	lf	$35	9,640	$337,400										
Mechanical															
M.1	Leachate collection tank	ls	$120,000	1	$120,000										
M.2	Leachate loadout station	ls	$50,000	1	$50,000										
Electrical															
E.1	New service to site	ls	$30,000	1	$30,000										
E.2	Wiring and controls	ls	$20,000	1	$20,000										
Structural															
S.1	Maintenance building	ls	$500,000	1	$500,000										
	Subtotal, direct capital, by year				$6,259,910		$1,795,210		$2,611,343		$2,917,393		$4,128,800		$3,450,636
Indirect Capital															
I.1	Siting studies, permitting, engineering and final design, through first phase of construction[3]	ls	$1,500,000	1	$1,500,000										
I.2	Engineering/ final design of subsequent phases (% of construction direct capital spent in year n +1)	%	7%		$125,665		$182,794		$204,218		$289,016		$241,544		$42,076
I.3	Construction documentation (% of construction direct capital spent in year n)	%	15%		$938,987		$269,281		$391,701		$437,609		$619,320		$517,595
	Subtotal, indirect capital, by year				$2,564,651		$452,076		$595,919		$726,625		$860,864		$559,672
	Total capital, by year				$8,824,561		$2,247,285		$3,207,262		$3,644,018		$4,989,665		$4,010,307

CAPITAL COSTS

	Item	Units	Unit Cost	Year 6 Quantity	Year 6 Extension	Year 7 Quantity	Year 7 Extension
Direct Capital							
Facility Development							
D.1	Land acquisition	ac	$2,000				
Civil Work							
C.1	Mobilization/demobilization	ls	$40,000	1	$40,000	1	$40,000
C.2	Clear & grub	ac	$2,100				
C.3	Strip & stockpile topsoil (6")	cy	$1.00				
C.4	Excavation to subgrade	cy	$1.50				
C.5	Berm construction	cy	$2.50				
C.6	Gradient control layer	ac	$35,000				
C.7	Liner & leachate collection system	ac	$120,000				
C.8	Place intermediate drainage layers	ac	$110,000				
C.9	Place grading layer	cy	$2.50	4,437	$11,092	10,890	$27,225
C.10	Cover system	ac	$100,000	5.5	$550,000	13.5	$1,350,000
C.11	Seed, fertilize, mulch	ac	$2,500				
C.12	Perimeter drainage ditches	lf	$4				
C.13	Perimeter road	lf	$10				
C.14	Access road, paved	sf	$4				
C.15	Perimeter fence	lf	$35				
Mechanical							
M.1	Leachate collection tank	ls	$120,000				
M.2	Leachate loadout station	ls	$50,000				
Electrical							
E.1	New service to site	ls	$30,000				
E.2	Wiring and controls	ls	$20,000				
Structural							
S.1	Maintenance building	ls	$500,000				
	Subtotal, direct capital, by year				$601,092		$1,417,225
Indirect Capital							
I.1	Siting studies, permitting, engineering and final design, through first phase of construction[3]	ls	$1,500,000				
I.2	Engineering/ final design of subsequent phases (% of construction direct capital spent in year n +1)	%	7%		$99,206		$0
I.3	Construction documentation (% of construction direct capital spent in year n)	%	15%		$90,164		$212,584
	Subtotal, indirect capital, by year				$189,370		$212,584
	Total capital, by year				$790,461		$1,629,809

Notes

1. Construction of 8 cells of the monofill will occur in the following sequence: Year 0 - cells 1 and 2, Year 1 - cell 3, Year 2 - cell 4, Year 3 - cell 5, Year 4 - cells 6 and 7, Year 5 - cell 8. Costs for all items that are constructed prior to placement of waste in the cells are distributed in phases according to this sequence and account for the number of cells and location of the cell(s) being constructed during each phase.
2. Cover construction will occur in the following sequence: Year 2 - cell 1, Year 3 - cells 2 and 3, Year 4 - cell 4, Year 5 - cell 5, Year 6 - cell 6, Year 7 - cells 7 and 8. Costs for the grading layer placement and cover are distributed in phases according to this sequence and account for the number of cells and location of the cell(s) being constructed during each phase.
3. Siting studies, permitting, and engineering would be performed over several years. As a simplifying assumption, all costs assigned to "Year

ANNUAL OPERATING COSTS

	Item	Units	Quantity	Unit Cost	Extension
	Purchased services				
O.1	Environmental monitoring	ls	1	$85,000	$85,000
O.2	Leachate hauling	gal	1,600,000	$0.04	$64,000
O.3	Leachate disposal	gal	1,600,000	$0.01	$16,000
	Operations				
O.10	Landfill technician	hrs	2,000	$20	$40,000
O.11	Project manager	hrs	500	$50	$25,000
O.12	Waste placement	ton	556,250	$1	$556,250
	Maintenance				
O.20	Land surface care	ls	1	$10,000	$10,000
	Utilities				
O.30	Electricity	mo	12	$300	$3,600
O.31	Telephone	mo	12	$50	$600
		Subtotal			$800,450
	Prime contractor OH & P			10%	$80,045
O.40	Host community fee	ton	556,250	$10	$5,562,500
	Total, annual costs				$6,442,995

ANNUAL LONG-TERM CARE COSTS

	Item	Units	Quantity	Unit Cost	Extension
	Purchased services				
O.1	Environmental monitoring	ls	1	$85,000	$85,000
O.2	Leachate hauling	gal	1,300,000	$0.04	$52,000
O.3	Leachate disposal	gal	1,300,000	$0.01	$13,000
	Operations				
O.10	Landfill technician	hrs	2,000	$20	$40,000
O.11	Project manager	hrs	500	$50	$25,000
	Maintenance				
O.20	Land surface care	ls	1	$10,000	$10,000
O.21	Leachate pump replacement	ea	2	$4,000	$8,000
O.22	Leachate pipe cleaning	ls	1	$5,000	$5,000
	Utilities				
O.30	Electricity	mo	12	$300	$3,600
O.31	Telephone	mo	12	$50	$600
		Subtotal			$242,200
		Prime contractor OH & P		10%	$24,220
		Total, annual costs			$266,420

PRESENT WORTH CALCULATION

i = 7%

Year, n	Capital Costs (construction)	Annual Operating Costs (prior to final closure)	Annual Long-Term Care Costs (post closure)	Sum of Year "n" Costs	Cumulative Costs, Year 1 through n	Present Worth Factor, i	Present Worth of Year "n" Capital Costs Only	Present Worth of All Year "n" Costs	Cumulative Present Worth of All Costs, Year 1 through n
0	$8,824,561			$8,824,561	$8,824,561	1	$8,824,561	$8,824,561	$8,824,561
1	$2,247,285	$6,442,995		$8,690,280	$17,514,842	0.9346	$2,100,267	$8,121,757	$16,946,319
2	$3,207,262	$6,442,995		$9,650,257	$27,165,099	0.8734	$2,801,347	$8,428,908	$25,375,227
3	$3,644,018	$6,442,995		$10,087,013	$37,252,112	0.8163	$2,974,604	$8,234,007	$33,609,235
4	$4,989,665	$6,442,995		$11,432,660	$48,684,772	0.7629	$3,806,591	$8,721,921	$42,331,156
5	$4,010,307	$6,442,995		$10,453,302	$59,138,074	0.7130	$2,859,294	$7,453,060	$49,784,216
6	$790,461	$6,442,995		$7,233,456	$66,371,530	0.6663	$526,718	$4,819,957	$54,604,173
7	$1,629,809	$2,577,198		$4,207,007	$70,578,537	0.6227	$1,014,963	$2,619,912	$57,224,086
8			$266,420	$266,420	$70,844,957	0.5820	$0	$155,059	$57,379,144
9			$266,420	$266,420	$71,111,377	0.5439	$0	$144,915	$57,524,059
10			$266,420	$266,420	$71,377,797	0.5083		$135,434	$57,659,494
11			$266,420	$266,420	$71,644,217	0.4751		$126,574	$57,786,068
12			$266,420	$266,420	$71,910,637	0.4440		$118,294	$57,904,362
13			$266,420	$266,420	$72,177,057	0.4150		$110,555	$58,014,916
14			$266,420	$266,420	$72,443,477	0.3878		$103,322	$58,118,239
15			$266,420	$266,420	$72,709,897	0.3624		$96,563	$58,214,801
16			$266,420	$266,420	$72,976,317	0.3387		$90,246	$58,305,047
17			$266,420	$266,420	$73,242,737	0.3166		$84,342	$58,389,389
18			$266,420	$266,420	$73,509,157	0.2959		$78,824	$58,468,213
19			$266,420	$266,420	$73,775,577	0.2765		$73,667	$58,541,880
20			$266,420	$266,420	$74,041,997	0.2584		$68,848	$58,610,728
21			$266,420	$266,420	$74,308,417	0.2415		$64,344	$58,675,072
22			$266,420	$266,420	$74,574,837	0.2257		$60,135	$58,735,207
23			$266,420	$266,420	$74,841,257	0.2109		$56,200	$58,791,407
24			$266,420	$266,420	$75,107,677	0.1971		$52,524	$58,843,931
25			$266,420	$266,420	$75,374,097	0.1842		$49,088	$58,893,019
26			$266,420	$266,420	$75,640,517	0.1722		$45,876	$58,938,895
27			$266,420	$266,420	$75,906,937	0.1609		$42,875	$58,981,770
28			$266,420	$266,420	$76,173,357	0.1504		$40,070	$59,021,840
29			$266,420	$266,420	$76,439,777	0.1406		$37,449	$59,059,289
30			$266,420	$266,420	$76,706,197	0.1314		$34,999	$59,094,288
31			$266,420	$266,420	$76,972,617	0.1228		$32,709	$59,126,997
32			$266,420	$266,420	$77,239,037	0.1147		$30,569	$59,157,566
33			$266,420	$266,420	$77,505,457	0.1072		$28,569	$59,186,136
34			$266,420	$266,420	$77,771,877	0.1002		$26,700	$59,212,836
35			$266,420	$266,420	$78,038,297	0.0937		$24,954	$59,237,790
36			$266,420	$266,420	$78,304,717	0.0875		$23,321	$59,261,111
37			$266,420	$266,420	$78,571,137	0.0818		$21,796	$59,282,907
38			$266,420	$266,420	$78,837,557	0.0765		$20,370	$59,303,276
39			$266,420	$266,420	$79,103,977	0.0715		$19,037	$59,322,313
40			$266,420	$266,420	$79,370,397	0.0668		$17,792	$59,340,105
41			$266,420	$266,420	$79,636,817	0.0624		$16,628	$59,356,733
42			$266,420	$266,420	$79,903,237	0.0583		$15,540	$59,372,272
43			$266,420	$266,420	$80,169,657	0.0545		$14,523	$59,386,796
44			$266,420	$266,420	$80,436,077	0.0509		$13,573	$59,400,369
45			$266,420	$266,420	$80,702,497	0.0476		$12,685	$59,413,054
46			$266,420	$266,420	$80,968,917	0.0445		$11,855	$59,424,909
47			$266,420	$266,420	$81,235,337	0.0416		$11,080	$59,435,989
48				$0	$81,235,337	0.0389		$0	$59,435,989
49									
50									
51									
52									
53									
54									
55									
56									
57									
58									
59									
60									
Totals	$29,343,369	$41,235,168	$10,656,800	$81,235,337			$24,908,345	$59,435,989	

BASIS OF UNIT COSTS

I.D.	Item	Source	Description	Value or Range Provided (rounded)	Value Used for Estimate (rounded)	Basis
D.1	Land acquisition	In-house experience in the vicinity	Cost for acquiring property.	$2,000	$2,000	Typical cost for rural land in Brown County.
C.1	Mobilization/demobilization	Contractor estimate/bid for similar work (local Fox Valley contractor)	Mobilize labor and equipment for each year's liner or cover construction work.	$37,000	$40,000	Add allowance for as yet undefined conditions and round off to $40,000 per year.
C.2	Clear & grub	Contractor estimate/bid for similar work (local Fox Valley contractor)	Clear and grub vegetation prior to excavation to subbase grades and other on-site construction. Year 0 includes area for cells 1-2 of monofill plus the area for construction of the sedimentation basin, stockpile area, building, and road.	$2,100	$2,100	Typical per acre cost for similar work.
C.3	Strip & stockpile topsoil (6")	Contractor estimate/bid for similar work (local Fox Valley contractor)	Strip existing topsoil and stockpile onsite for future cover construction. Year 0 includes area for cells 1-2 of monofill plus the area for construction of the sedimentation basin, stockpile area, building, and road.	$0.70	$1	Contractor estimate is $0.70/cy. Increase to $1.00/cy to be conservative.
C.4	Excavation to subgrade	Contractor estimate/bid for similar work (local Fox Valley contractor)	Year 0 includes soil from monofill and sedimentation basin excavation. Excavated material will be stockpiled on-site for re-use as berm, liner and cover soil.	$1.15	$1.50	Contractor estimate is on low side of typical range. Increase to account for bidding uncertainty at time of work. Assumes cut soils are suitable clay for liner construction.
C.5	Berm construction	Contractor estimate/bid for similar work (local Fox Valley contractor)	Construct perimeter berm from cut soils/stockpile.	$1.80	$2.50	Contractor estimate is on low side of typical range. Increase to account for bidding uncertainty at time of work.
C.6	Gradient control layer	Contractor estimate/bid for similar work (local Fox Valley contractor) and typical experience	Construct drainage layer and collection sumps below clay liner. Express cost as "per acre of liner constructed", with an allowance for miscellaneous other material. The cost components for this assembly are as follows:			
			Granular layer = (1 ft.)(43560 sf/acre)(1 cy/27 cf)($15/cy) = $24,200/acre	$24,200		Assumes use of a granular drainage layer as representative for budgeting. Could use a geocomposite material, if appropriate and more cost effective at time of final engineering. (At $0.40/sf, per acre cost = $17,400).
			Purchase and place geotextile, 12 oz = ($0.20/sf)(43560 sf/acre) = $8700/acre	$8,700		Typical unit cost for similar work.
			Coarse aggregate for collection sump, collection piping and sideslope risers = $1000/acre	$1,000		Estimate is back-calculated from typical project.
			Subtotal, gradient control layer assembly	$33,900	**$35,000**	Include allowance for other minor components. Use $35,000 per acre of waste limits.
C.7	Liner and leachate collection system	Contractor estimate/bid for similar work (local Fox Valley contractor) and typical experience	Construct composite liner, using 4 ft. recompacted clay from onsite borrow and a 60 mil HPDE geomembrane. Express cost as "per acre of liner constructed", with an allowance for miscellaneous other material. The cost components for this assembly are as follows:			

BASIS OF UNIT COSTS

I.D.	Item	Source	Description	Value or Range Provided (rounded)	Value Used for Estimate (rounded)	Basis
			Place & compact clay = (4 ft.)(43560 sf/acre)($3.00/cy)(cy/27 cy) = $19,400	$19,400		Local estimate is $1.50/cy to place and recompact clay from onsite stockpile. Typical range is as high as $3.00/cy. Use $3.00/cy.
			Purchase and place 60 mil geomembrane = ($0.60/sf)(43560 sf/acre) = $26,100	$26,100		Local estimate is $0.46/sf. Other projects as high as $0.01 per mil of thickness. Use $0.60/sf.
			Place 12" granular drainage layer = (1 ft.)(43560 sf/acre)($15.00/cy)(cy/27 cf) = $24,200	$24,200		Typical unit cost for similar work.
			Allowance for interior berms, if needed	$6,000		Estimate is back-calculated from typical project.
			Leachate piping (solid wall and perforated), cleanout risers, aggregate sumps, manholes, header pipe, pump and controller	$10,000		Estimate is back-calculated on a "per acre" basis from typical project. All piping HDPE.
			Subtotal, liner and leachate collection assembly	$85,700	**$120,000**	Include an allowance for other related earthwork; extra quantities for side slopes, anchor trenches; liner splices; etc. Use $120,000 per acre of waste limits.
C.8	Place intermediate drainage layers	Typical experience	This is a placeholder for possible use of intermediate lateral drainage layers during filling. Assume placement of either 1' granular material or a geocomposite after each year's fill cycle.		$110,000	As indicated below, the cost per acre for granular material or geocomposite range from $17,400 to $24,000 per acre. Assume $20,000 per acre. Based on liner and cover geometry, the total acreage of 7 intermediate layers (for an 80 ft. thick fill) is about 5.5 times the maximum limits of waste. Therefore, on a "per acre of waste limits" basis, use 5.5 x $20,000 or $110,000/acre
C.9	Place grading layer	Contractor estimate/bid for similar work (local Fox Valley contractor) and typical experience	This item includes the placement of general soils to establish subgrades for final cover. It is assumed that the material comes from an on-site stockpile of previously cut soil.	$1.80	$2.50	Same basis as for general berm construction.
C.10	Cover system	Contractor estimate/bid for similar work (local Fox Valley contractor) and typical experience	Construct a composite liner consisting of (from top to bottom): 6" topsoil (from onsite stockpile), 18" general soil rooting zone (from onsite borrow); 12" granular drainage layer (purchased); 40 mil LLDPE; geosynthetic clay liner (GCL); 12" granular vent layer (purchased). Express cost as "per acre of cover constructed", with an allowance for miscellaneous other material that is not strictly proportional to area. The cost components for this assembly are as follows:			
			Purchase and place 12" granular vent layer = (1 ft.)(43560 sf/acre)($15/cy)(cy/27 cf) = $24,200	$24,000		Typical unit cost for similar work.
		Vendor budgetary estimate (CETCO, Inc.)	Purchase and place GCL = ($0.40/sf)(43560 sf/acre) = $17400/acre	$17,400		Assume Bentomat ST.
			Purchase and place 40 mil geomembrane = ($0.40/sf)(43560 sf/acre) = $17,400	$17,400		Other projects as high as $0.01 per mil of thickness. Use $0.40/sf.
			Purchase and place 12" granular drainage layer = (1 ft.)(43560 sf/acre)($15/cy)(cy/27 cf) = $24,200	$24,000		Could substitute a geocomposite drainage product for granular material. Budget estimate is $0.40/sf installed, which would be slightly lower cost on a per acre basis ($17,400). Use cost for granular material to be conversative at this early stage of project.

BASIS OF UNIT COSTS

I.D.	Item	Source	Description	Value or Range Provided (rounded)	Value Used for Estimate (rounded)	Basis
			Place general soils from on-site stockpile = (1.5 ft.)(43560 sf/acre)($1.25/cy)(cy/27 cf) = $3000	$3,000		Typical unit cost for similar work.
			Place topsoil from on-site stockpile = (0.5 ft.)(43560 sf/acre)($1.00/cy)(cy/27 cf) = $800	$800		Typical unit cost for similar work.
			Seed, fertilize, mulch = $2500/acre	$2,500		Typical unit cost for similar work.
			Subtotal, cover system assembly, per acre of waste limits	$89,100	**$100,000**	Include allowance for other minor construction, extra quantities for anchor trenches, possible gas vents, perimeter toe drain pipes, drainage structures, etc. Use $100,000/acre.
C.11	Seed, fertilize, mulch	Typical experience	Restore grounds to original conditions		$2,500	?
C.12	Perimeter drainage ditches	Contractor estimate/bid for similar work (local Fox Valley contractor) and typical experience	Drainage ditches constructed around the perimeter of the monofill to collect stormwater run-off.	$3.25	$4	Contractor estimate is on low side of typical. Use $4.00/lf.
C.13	Perimeter road	Contractor estimate/bid for similar work (local Fox Valley contractor) and typical experience	Gravel road constructed around the perimeter of the monofill for access during monitoring and maintenance activities.	$10	$10	Typical unit cost for similar work.
C.14	Access road, paved	Contractor estimate/bid for similar work (local Fox Valley contractor), Means Sitework (2000) and typical experience	Main access road for personnel vehicle entrance, expressed on a "per square foot" basis.	$3.00 - 4.00	$4	Typical unit cost for similar work.
C15	Perimeter fence	Means Sitework (2000)	Perimeter fence, chain link, 8' h w/ 3-strand barb wire	$35	$35	Means #02820_528_0920. $30/lf. With price inflation, allowance for gates, etc., use $35/lf.
M.1	Leachate collection tank	Contractor estimate/bid for similar work (local Fox Valley contractor) and typical experience	Leachate tank, 30,000 gal FRP, underground, with concrete tie-down pad and appurtenences.	$120,000	$120,000	Typical experience, similar projects.
M.2	Leachate loadout station	Contractor estimate/bid for similar work (local Fox Valley contractor) and typical experience	Equipment for leachout pumpout and truck loading	$50,000	$50,000	Typical experience, similar projects.
M.3	Scale	Contractor estimate/bid for similar work (local Fox Valley contractor) and typical experience	Truck scale for weighing incoming loads.	$100,000	$100,000	Typical experience, similar projects.
E.1	New service to site	Typical experience	Establish new electrical service to the facility	$30,000	$30,000	This is a placeholder, based on typical projects.
E.2	Wiring and controls	Typical experience	Local wiring of leachate pump stations, yard lights, etc.	$20,000	$20,000	This is a placeholder, based on typical projects.
S.1	Maintenance building	Contractor estimate/bid for similar work (local Fox Valley contractor) and typical experience	Maintenance building, pre-engineered, metal building, 100' x 100', w/ 4" slab and frost wall.	$500,000	$500,000	This a placeholder, based on typical projects.

BASIS OF UNIT COSTS

I.D.	Item	Source	Description	Value or Range Provided (rounded)	Value Used for Estimate (rounded)	Basis
I.1	Siting studies, permitting, engineering and final design, through first phase of construction	Typical experience	Siting and hydrogeologic studies and preparation of permit documents.		$1,500,000	This is a placeholder for all initial permitting and engineering work, based on prior experience.
I.2	Engineering/ final design of subsequent phases (% of construction direct capital spent in year n +1)		Final engineering and preparation of construction plans and specifications for phased construction and closure work. Cost expressed as a % of the constructed value of the work.		7%	Typical cost for engineering/design services on large civil projects.
I.3	Construction documentation (% of construction direct capital spent in year n)		Soils and geomembrane testing, construction observation, and preparation of construction documentation reports and drawings. Cost expressed as a % of the constructed value of the work.		15%	Typical cost for construction-phase services on large civil projects.
O.1	Environmental monitoring	Typical project experience and laboratory analytical estimate (EnChem, Minneapolis, MN)	Annual monitoring and reporting activities for collection and laboratory analysis of groundwater, leachate, GCL, and sedimentation pond samples.	$85,000	$85,000	A separate cost spreadsheet was developed to incorporate all expenses related to monitoring - well installation, labor (field technician and reporting), laboratory analysis, and equipment costs. Scope is based on typical work at NR500 landfills in Wisconsin.
O.2	Leachate hauling	Typical experience	Haul leachate to a local POTW (location not yet defined.) During filling, quantity estimated as 6" collected over a maximum open area of 10 acres: (6"/year)(ft/12")(7.48 gal/cf)(43560 sf/acre)(10 acre) = 1.6 MG per year. After final closure, quantity estimated as 1" infiltration per year over 49 acres after closure: (1"/year)(ft/12")(7.48 gal/cf)(43560 sf/acre)(49 acre) = 1.3 MG per year.		$0.04	Typical cost could be up to $200 per 4000 or 5000 gal load. Use $0.04/gal. Quantity estimates are placeholders only, pending final engineering.
O.3	Leachate disposal	Typical experience	Disposal of leachate at local POTW (location not yet defined.)		$0.01	Typical POTW charge for disposal plus BOD and TSS surcharges could be on the order of $0.01/gal. Leachate from this project may be low in BOD, but use this value to account for possible concern over organics content.
O.10	Landfill technician	Typical experience	1 FTE to conduct landfill operations and maintenance-related tasks. 2,000 hrs/yr.		$20	Typical labor cost for local technician.
O.11	Project manager	Typical experience	On-site project controls and personnel supervision. Assume LOE is 0.25 FTE. 500 hrs/yr.		$50	Local project oversight and administration.
O.12	Waste placement	Typical experience	Filling and compacting waste within the monofill.		$1	Estimate is on a "per ton" basis, for filter cake delivered to the facility.
O.20	Land surface care	Typical experience	Re-seeding, minor erosion control and restoration of cover		$10,000	This is a placeholder for typical cost of cover maintenance.
O.21	Leachate pump replacement	Typical experience	Replace leachate pump and motor. Assume 25% replacement rate each year (e.g. 2 per year.)		$4,000	Typical cost for submersible pump and motor.
O.22	Leachate pipe cleaning	Typical experience	Annual cost for cleaning of leachate lines.		$5,000	Typical cost, similar project

BASIS OF UNIT COSTS

I.D.	Item	Source	Description	Value or Range Provided (rounded)	Value Used for Estimate (rounded)	Basis
O.30	Electricity		Monthly power requirements for collection system equipment, lighting, etc.		$300	This is a placeholder to cover intermittent pumping of leachate and other minor electrical usage at the facility.
O.31	Telephone	Prior project experience	Monthly cost of phone service to main operating facility.		$50	Placeholder, monthly estimated cost.
O.40	Host community fee (per ton disposed)		Fee paid to local community, as negotiated through the state's local approvals process.		$10	Typical fee for other Brown County disposal facilities. Cost is expressed on a "per ton of waste disposed" basis.

COST ESTIMATE #13 **Rev: 10.30.03**
DETAILED EVALUATION OF ALTERNATIVES **Final**
WDNR - FOX RIVER

PROJECT ELEMENT:
NR500 Dewatering Landfill
Scenario C - OU 3 and OU 4

PROCESS METRICS

Total volume of sediment removed from river	6,500,000	cy
Total tons disposed (5)	5,813,000	tons
Length of operations	10.3	yr
Mass disposed per year	564,369	tons

COST SUMMARY

	Total Cost (1)	Total as Present Worth (2)	
Subtotal, capital costs	$61,800,000	$61,800,000	
Subtotal, operating costs (including host community fee)	$60,100,000		
Subtotal, long-term care costs	$22,700,000		
Total, capital, operating and long-term care costs	$144,600,000	$107,191,153	
Cost per cy sediment removed (4)	$22.25	$16.49	/cy
Cost per ton dewatered sediment disposed (4)	$24.88	$18.44	/ton

Notes

1. The "total cost" does not discount the multi-year construction costs, annual operating costs or long-term care costs.
2. The "present worth" discounts all construction and operations costs over the active life of the facility, as well as the post-closure annual costs. The discount rate is 7% (USEPA, "Guide to Developing and Documenting Cost Estimates During the Feasibility Study", July 2000). For this alternative, all site preparation and liner construction is assumed to occur in "Year 0." Construction will actually require several years to complete.
3. "Direct capital costs" include construction costs during the active life of the facility, up until final closure. Leachate management and groundwater monitoring, both prior to and after final closure, are included as "annual costs."
4. "Cost per cy sediment removed" and "cost per ton disposed" values are for informational purposes only. Values are not true unit costs because they represent a combination of fixed capital and quantity-proportional components.
5. The total mass disposed is based on an eventual solids concentration of 40% (i.e., it is not the mass of the original dredge slurry). This is equivalent to the mass generated from the NR213 settling basins. It is used for assessing the potential host community fee.

CAPITAL COSTS

	Item	Units	Unit Cost	Year 0 Quantity	Year 0 Extension	Year 1 Quantity	Year 1 Extension	Year 2 Quantity	Year 2 Extension	Year 3 Quantity	Year 3 Extension	Year 4 Quantity	Year 4 Extension	Year 5 Quantity	Year 5 Extension
Direct Capital															
Facility Development															
D.1	Land acquisition	ac	$2,000	375	$750,000										
Civil Work															
C.1	Mobilization/demobilization	ls	$40,000	1	$40,000										
C.2	Clear & grub	ac	$2,100	261	$548,100										
C.3	Strip & stockpile topsoil (6")	cy	$1.00	210,540	$210,540										
C.4	Excavation to subgrade	cy	$1.50	5,101,718	$7,652,577										
C.5	Berm construction	cy	$2.50	1,849,837	$4,624,593										
C.6	Gradient control layer	ac	$35,000	237	$8,295,000										
C.7	Liner & leachate collection system	ac	$120,000	237	$28,440,000										
C.8	Place intermediate drainage layers [1]	ac	$20,000					79	$1,580,000	79	$1,580,000	79	$1,580,000	79	$1,580,000
C.9	Place grading layer [2]	cy	$2.50												
C.10	Cover system [2]	ac	$100,000												
C.11	Seed, fertilize, mulch	ac	$2,500	5.59	$13,969										
C.12	Perimeter drainage ditches	lf	$4	14,188	$56,752										
C.13	Perimeter road	lf	$10	14,188	$141,880										
C.14	Access road, paved	sf	$4	90,900	$363,600										
C.15	Perimeter fence	lf	$35	16,140	$564,900										
Mechanical															
M.1	Leachate collection tank	ls	$120,000	1	$120,000										
M.2	Leachate loadout station	ls	$50,000	1	$50,000										
Electrical															
E.1	New service to site	ls	$30,000	1	$30,000										
E.2	Wiring and controls	ls	$20,000	1	$20,000										
Structural															
S.1	Maintenance building	ls	$500,000	1	$500,000										
	Subtotal, direct capital, by year				$52,421,911										
Indirect Capital															
I.1	Siting studies, permitting, engineering and final design, through first phase of construction	ls	$1,500,000	1	$1,500,000										
I.2	Engineering/ final design of subsequent phases (% of construction direct capital spent in year n +1)	%	7%		$0										
I.3	Construction documentation (% of construction direct capital spent in year n)	%	15%		$7,863,287										
	Subtotal, indirect capital, by year				$9,363,287										
	Total capital, by year				$61,785,197		$0		$0		$0		$0		$0

CAPITAL COSTS

Item		Units	Unit Cost	Year 6 Quantity	Year 6 Extension	Year 7 Quantity	Year 7 Extension	Year 8 Quantity	Year 8 Extension	Year 9 Quantity	Year 9 Extension	Year 10 Quantity	Year 10 Extension	Year 11 Quantity	Year 11 Extension
Direct Capital															
Facility Development															
D.1	Land acquisition	ac	$2,000												
Civil Work															
C.1	Mobilization/demobilization	ls	$40,000												
C.2	Clear & grub	ac	$2,100												
C.3	Strip & stockpile topsoil (6")	cy	$1.00												
C.4	Excavation to subgrade	cy	$1.50												
C.5	Berm construction	cy	$2.50												
C.6	Gradient control layer	ac	$35,000												
C.7	Liner & leachate collection system	ac	$120,000												
C.8	Place intermediate drainage layers (1)	ac	$20,000	79	$1,580,000	79	$1,580,000	79	$1,580,000	79	$1,580,000	79	$1,580,000		
C.9	Place grading layer (2)	cy	$2.50											79	$198
C.10	Cover system (2)	ac	$100,000											79	$7,900,000
C.11	Seed, fertilize, mulch	ac	$2,500												
C.12	Perimeter drainage ditches	lf	$4												
C.13	Perimeter road	lf	$10												
C.14	Access road, paved	sf	$4												
C.15	Perimeter fence	lf	$35												
Mechanical															
M.1	Leachate collection tank	ls	$120,000												
M.2	Leachate loadout station	ls	$50,000												
Electrical															
E.1	New service to site	ls	$30,000												
E.2	Wiring and controls	ls	$20,000												
Structural															
S.1	Maintenance building	ls	$500,000												
	Subtotal, direct capital, by year														
Indirect Capital															
I.1	Siting studies, permitting, engineering and final design, through first phase of construction	ls	$1,500,000												
I.2	Engineering/ final design of subsequent phases (% of construction direct capital spent in year n +1)	%	7%												
I.3	Construction documentation (% of construction direct capital spent in year n)	%	15%												
	Subtotal, indirect capital, by year														
	Total capital, by year				$0		$0		$0		$0		$0		$0

CAPITAL COSTS

Item		Units	Unit Cost	Year 12 Quantity	Year 12 Extension	Year 13 Quantity	Year 13 Extension
Direct Capital							
Facility Development							
D.1	Land acquisition	ac	$2,000				
Civil Work							
C.1	Mobilization/demobilization	ls	$40,000				
C.2	Clear & grub	ac	$2,100				
C.3	Strip & stockpile topsoil (6")	cy	$1.00				
C.4	Excavation to subgrade	cy	$1.50				
C.5	Berm construction	cy	$2.50				
C.6	Gradient control layer	ac	$35,000				
C.7	Liner & leachate collection system	ac	$120,000				
C.8	Place intermediate drainage layers (1)	ac	$20,000				
C.9	Place grading layer (2)	cy	$2.50	79	$198	79	$198
C.10	Cover system (2)	ac	$100,000	79	$7,900,000	79	$7,900,000
C.11	Seed, fertilize, mulch	ac	$2,500				
C.12	Perimeter drainage ditches	lf	$4				
C.13	Perimeter road	lf	$10				
C.14	Access road, paved	sf	$4				
C.15	Perimeter fence	lf	$35				
Mechanical							
M.1	Leachate collection tank	ls	$120,000				
M.2	Leachate loadout station	ls	$50,000				
Electrical							
E.1	New service to site	ls	$30,000				
E.2	Wiring and controls	ls	$20,000				
Structural							
S.1	Maintenance building	ls	$500,000				
Subtotal, direct capital, by year							
Indirect Capital							
I.1	Siting studies, permitting, engineering and final design, through first phase of construction	ls	$1,500,000				
I.2	Engineering/ final design of subsequent phases (% of construction direct capital spent in year n +1)	%	7%				
I.3	Construction documentation (% of construction direct capital spent in year n)	%	15%				
Subtotal, indirect capital, by year							
Total capital, by year					$0		$0

Notes

1. Construction of the intermediate drainage layers will begin in Year 3 and continue through Year 10 as the CDF is filled over the length of operations.
2. Grading layer placement and cover construction will begin in Year 11 and will be phased over 3 years to allow for additional settling and drying of the material in sequentially filled cells.
3. Siting studies, permitting, and engineering would be performed over several years. As a simplifying assumption, all costs assigned to "Year 0."

ANNUAL OPERATING COSTS

	Item	Units	Quantity	Unit Cost	Extension
	Purchased services				
O.1	Environmental monitoring	ls	1	$85,000	$85,000
O.2	Leachate hauling	gal	0	$0.04	$0
O.3	Leachate disposal	gal	0	$0.01	$0
	Operations				
O.10	Landfill technician	hrs	2,000	$20	$40,000
O.11	Project manager	hrs	500	$50	$25,000
	Maintenance				
O.20	Land surface care	ls	1	$20,000	$20,000
	Utilities				
O.30	Electricity	mo	12	$300	$3,600
O.31	Telephone	mo	12	$50	$600
		Subtotal			$174,200
	Prime contractor OH & P			10%	$17,420
O.40	Host community fee	ton	564,369	$10	$5,643,689
	Total, annual costs				$5,835,309

ANNUAL LONG-TERM CARE COSTS

	Item	Units	Quantity	Unit Cost	Extension
	Purchased services				
O.1	Environmental monitoring	ls	1	$85,000	$85,000
O.2	Leachate hauling	gal	6,400,000	$0.04	$256,000
O.3	Leachate disposal	gal	6,400,000	$0.01	$64,000
	Operations				
O.10	Landfill technician	hrs	2,000	$20	$40,000
O.11	Project manager	hrs	500	$50	$25,000
	Maintenance				
O.20	Land surface care	ls	1	$20,000	$20,000
O.21	Leachate pump replacement	ea	4	$4,000	$16,000
O.22	Leachate pipe cleaning	ls	1	$5,000	$5,000
	Utilities				
O.30	Electricity	mo	12	$300	$3,600
O.31	Telephone	mo	12	$50	$600
	Subtotal				$515,200
	Prime contractor OH & P			10%	$51,520
	Total, annual costs				$566,720

PRESENT WORTH CALCULATION

i = 7%

Year, n	Capital Costs (construction)	Annual Operating Costs (prior to final closure)	Annual Long-Term Care Costs (post closure)	Sum of Year "n" Costs	Cumulative Costs, Year 1 through n	Present Worth Factor, i	Present Worth of Year "n" Capital Costs Only	Present Worth of All Year "n" Costs	Cumulative Present Worth of All Costs, Year 1 through n
0	$61,785,197			$61,785,197	$61,785,197	1	$61,785,197	$61,785,197	$61,785,197
1	$0	$5,835,309		$5,835,309	$67,620,507	0.9346	$0	$5,453,560	$67,238,757
2		$5,835,309		$5,835,309	$73,455,816	0.8734	$0	$5,096,785	$72,335,542
3		$5,835,309		$5,835,309	$79,291,125	0.8163		$4,763,351	$77,098,893
4		$5,835,309		$5,835,309	$85,126,434	0.7629		$4,451,730	$81,550,623
5		$5,835,309		$5,835,309	$90,961,744	0.7130		$4,160,495	$85,711,118
6		$5,835,309		$5,835,309	$96,797,053	0.6663		$3,888,313	$89,599,431
7		$5,835,309		$5,835,309	$102,632,362	0.6227		$3,633,937	$93,233,368
8		$5,835,309		$5,835,309	$108,467,672	0.5820		$3,396,203	$96,629,571
9		$5,835,309		$5,835,309	$114,302,981	0.5439		$3,174,022	$99,803,593
10		$5,835,309		$5,835,309	$120,138,290	0.5083		$2,966,375	$102,769,968
11		$1,750,593		$1,750,593	$121,888,883	0.4751		$831,694	$103,601,662
12			$566,720	$566,720	$122,455,603	0.4440		$251,630	$103,853,293
13			$566,720	$566,720	$123,022,323	0.4150		$235,169	$104,088,461
14			$566,720	$566,720	$123,589,043	0.3878		$219,784	$104,308,245
15			$566,720	$566,720	$124,155,763	0.3624		$205,405	$104,513,650
16			$566,720	$566,720	$124,722,483	0.3387		$191,968	$104,705,618
17			$566,720	$566,720	$125,289,203	0.3166		$179,409	$104,885,027
18			$566,720	$566,720	$125,855,923	0.2959		$167,672	$105,052,699
19			$566,720	$566,720	$126,422,643	0.2765		$156,703	$105,209,402
20			$566,720	$566,720	$126,989,363	0.2584		$146,451	$105,355,853
21			$566,720	$566,720	$127,556,083	0.2415		$136,870	$105,492,723
22			$566,720	$566,720	$128,122,803	0.2257		$127,916	$105,620,640
23			$566,720	$566,720	$128,689,523	0.2109		$119,548	$105,740,187
24			$566,720	$566,720	$129,256,243	0.1971		$111,727	$105,851,914
25			$566,720	$566,720	$129,822,963	0.1842		$104,418	$105,956,332
26			$566,720	$566,720	$130,389,683	0.1722		$97,587	$106,053,919
27			$566,720	$566,720	$130,956,403	0.1609		$91,202	$106,145,121
28			$566,720	$566,720	$131,523,123	0.1504		$85,236	$106,230,357
29			$566,720	$566,720	$132,089,843	0.1406		$79,660	$106,310,017
30			$566,720	$566,720	$132,656,563	0.1314		$74,448	$106,384,465
31			$566,720	$566,720	$133,223,283	0.1228		$69,578	$106,454,043
32			$566,720	$566,720	$133,790,003	0.1147		$65,026	$106,519,069
33			$566,720	$566,720	$134,356,723	0.1072		$60,772	$106,579,841
34			$566,720	$566,720	$134,923,443	0.1002		$56,796	$106,636,638
35			$566,720	$566,720	$135,490,163	0.0937		$53,081	$106,689,718
36			$566,720	$566,720	$136,056,883	0.0875		$49,608	$106,739,326
37			$566,720	$566,720	$136,623,603	0.0818		$46,363	$106,785,689
38			$566,720	$566,720	$137,190,323	0.0765		$43,330	$106,829,019
39			$566,720	$566,720	$137,757,043	0.0715		$40,495	$106,869,514
40			$566,720	$566,720	$138,323,763	0.0668		$37,846	$106,907,359
41			$566,720	$566,720	$138,890,483	0.0624		$35,370	$106,942,729
42			$566,720	$566,720	$139,457,203	0.0583		$33,056	$106,975,785
43			$566,720	$566,720	$140,023,923	0.0545		$30,893	$107,006,679
44			$566,720	$566,720	$140,590,643	0.0509		$28,872	$107,035,551
45			$566,720	$566,720	$141,157,363	0.0476		$26,984	$107,062,535
46			$566,720	$566,720	$141,724,083	0.0445		$25,218	$107,087,753
47			$566,720	$566,720	$142,290,803	0.0416		$23,568	$107,111,321
48			$566,720	$566,720	$142,857,523	0.0389		$22,027	$107,133,348
49			$566,720	$566,720	$143,424,243	0.0363		$20,586	$107,153,933
50			$566,720	$566,720	$143,990,963	0.0339		$19,239	$107,173,172
51			$566,720	$566,720	$144,557,683	0.0317		$17,980	$107,191,153
52				$0	$144,557,683	0.0297		$0	$107,191,153
53				$0	$144,557,683	0.0277		$0	$107,191,153
54									
55									
56									
57									
58									
59									
60									
Totals	$61,785,197	$60,103,686	$22,668,800	$144,557,683			$61,785,197	$107,191,153	

BASIS OF UNIT COSTS

I.D.	Item	Source	Description	Value or Range Provided (rounded)	Value Used for Estimate (rounded)	Basis
D.1	Land acquisition	In-house experience in the vicinity	Cost for acquiring property.	$2,000	$2,000	Typical cost for rural land in Brown County.
C.1	Mobilization/demobilization	Contractor estimate/bid for similar work (local Fox Valley contractor)	Mobilize labor and equipment for each year's liner or cover construction work.	$37,000	$40,000	Add allowance for as yet undefined conditions and round off to $40,000 per year.
C.2	Clear & grub	Contractor estimate/bid for similar work (local Fox Valley contractor)	Clear and grub vegetation prior to excavation to subbase grades and other on-site construction. Year 0 includes area for cells 1-2 of monofill plus the area for construction of the sedimentation basin, stockpile area, building, and road.	$2,100	$2,100	Typical per acre cost for similar work.
C.3	Strip & stockpile topsoil (6")	Contractor estimate/bid for similar work (local Fox Valley contractor)	Strip existing topsoil and stockpile onsite for future cover construction. Year 0 includes area for cells 1-2 of monofill plus the area for construction of the sedimentation basin, stockpile area, building, and road.	$0.70	$1	Contractor estimate is $0.70/cy. Increase to $1.00/cy to be conservative.
C.4	Excavation to subgrade	Contractor estimate/bid for similar work (local Fox Valley contractor)	Year 0 includes soil from monofill and sedimentation basin excavation. Excavated material will be stockpiled on-site for re-use as berm, liner and cover soil.	$1.15	$1.50	Contractor estimate is on low side of typical range. Increase to account for bidding uncertainty at time of work. Assumes cut soils are suitable clay for liner construction.
C.5	Berm construction	Contractor estimate/bid for similar work (local Fox Valley contractor)	Construct perimeter berm from cut soils/stockpile.	$1.80	$2.50	Contractor estimate is on low side of typical range. Increase to account for bidding uncertainty at time of work.
C.6	Gradient control layer	Contractor estimate/bid for similar work (local Fox Valley contractor) and typical experience	Construct drainage layer and collection sumps below clay liner. Express cost as "per acre of liner constructed", with an allowance for miscellaneous other material. The cost components for this assembly are as follows:			
			Granular layer = (1 ft.)(43560 sf/acre)(1 cy/27 cf)($15/cy) = $24,200/acre	$24,200		Assumes use of a granular drainage layer as representative for budgeting. Could use a geocomposite material, if appropriate and more cost effective at time of final engineering. (At $0.40/sf, per acre cost = $17,400).
			Purchase and place geotextile, 12 oz = ($0.20/sf)(43560 sf/acre) = $8700/acre	$8,700		Typical unit cost for similar work.
			Coarse aggregate for collection sump, collection piping and sideslope risers = $1000/acre	$1,000		Estimate is back-calculated from typical project.
			Subtotal, gradient control layer assembly	$33,900	**$35,000**	Include allowance for other minor components. Use $35,000 per acre of waste limits.
C.7	Liner and leachate collection system	Contractor estimate/bid for similar work (local Fox Valley contractor) and typical experience	Construct composite liner, using 4 ft. recompacted clay from onsite borrow and a 60 mil HPDE geomembrane. Express cost as "per acre of liner constructed", with an allowance for miscellaneous other material. The cost components for this assembly are as follows:			

BASIS OF UNIT COSTS

I.D.	Item	Source	Description	Value or Range Provided (rounded)	Value Used for Estimate (rounded)	Basis
			Place & compact clay = (4 ft.)(43560 sf/acre)($3.00/cy)(cy/27 cy) = $19,400	$19,400		Local estimate is $1.50/cy to place and recompact clay from onsite stockpile. Typical range is as high as $3.00/cy. Use $3.00/cy.
			Purchase and place 60 mil geomembrane = ($0.60/sf)(43560 sf/acre) = $26,100	$26,100		Local estimate is $0.46/sf. Other projects as high as $0.01 per mil of thickness. Use $0.60/sf.
			Place 12" granular drainage layer = (1 ft.)(43560 sf/acre)($15.00/cy)(cy/27 cf) = $24,200	$24,200		Typical unit cost for similar work.
			Allowance for interior berms, if needed	$6,000		Estimate is back-calculated from typical project.
			Leachate piping (solid wall and perforated), cleanout risers, aggregate sumps, manholes, header pipe, pump and controller	$10,000		Estimate is back-calculated on a "per acre" basis from typical project. All piping HDPE.
			Subtotal, liner and leachate collection assembly	$85,700	**$120,000**	Include an allowance for other related earthwork; extra quantities for side slopes, anchor trenches; liner splices; etc. Use $120,000 per acre of waste limits.
C.8	Place intermediate drainage layers	Typical experience	This is a placeholder for possible use of intermediate lateral drainage layers during filling. Assume placement of either 1' granular material or a geocomposite after each year's fill cycle.		$20,000	As indicated below, the cost per acre for granular material or geocomposite range from $17,400 to $24,000 per acre. Assume $20,000 per acre.
C.9	Place grading layer	Contractor estimate/bid for similar work (local Fox Valley contractor) and typical experience	This item includes the placement of general soils to establish subgrades for final cover. It is assumed that the material comes from an on-site stockpile of previously cut soil.	$1.80	$2.50	Same basis as for general berm construction.
C.10	Cover system	Contractor estimate/bid for similar work (local Fox Valley contractor) and typical experience	Construct a composite liner consisting of (from top to bottom): 6" topsoil (from onsite stockpile), 18" general soil rooting zone (from onsite borrow); 12" granular drainage layer (purchased); 40 mil LLDPE; geosynthetic clay liner (GCL); 12" granular vent layer (purchased). Express cost as "per acre of cover constructed", with an allowance for miscellaneous other material that is not strictly proportional to area. The cost components for this assembly are as follows:			
			Purchase and place 12" granular vent layer = (1 ft.)(43560 sf/acre)($15/cy)(cy/27 cf) = $24,200	$24,000		Typical unit cost for similar work.
		Vendor budgetary estimate (CETCO, Inc.)	Purchase and place GCL = ($0.40/sf)(43560 sf/acre) = $17400/acre	$17,400		Assume Bentomat ST.
			Purchase and place 40 mil geomembrane = ($0.40/sf)(43560 sf/acre) = $17,400	$17,400		Other projects as high as $0.01 per mil of thickness. Use $0.40/sf.
			Purchase and place 12" granular drainage layer = (1 ft.)(43560 sf/acre)($15/cy)(cy/27 cf) = $24,200	$24,000		Could substitute a geocomposite drainage product for granular material. Budget estimate is $0.40/sf installed, which would be slightly lower cost on a per acre basis ($17,400). Use cost for granular material to be conversative at this early stage of project.
			Place general soils from on-site stockpile = (1.5 ft.)(43560 sf/acre)($1.25/cy)(cy/27 cf) = $3000	$3,000		Typical unit cost for similar work.
			Place topsoil from on-site stockpile = (0.5 ft.)(43560 sf/acre)($1.00/cy)(cy/27 cf) = $800	$800		Typical unit cost for similar work.
			Seed, fertilize, mulch = $2500/acre	$2,500		Typical unit cost for similar work.

BASIS OF UNIT COSTS

I.D.	Item	Source	Description	Value or Range Provided (rounded)	Value Used for Estimate (rounded)	Basis
			Subtotal, cover system assembly, per acre of waste limits	$89,100	**$100,000**	Include allowance for other minor construction, extra quantities for anchor trenches, possible gas vents, perimeter toe drain pipes, drainage structures, etc. Use $100,000/acre.
C.11	Seed, fertilize, mulch	Typical experience	Restore grounds to original conditions		$2,500	?
C.12	Perimeter drainage ditches	Contractor estimate/bid for similar work (local Fox Valley contractor) and typical experience	Drainage ditches constructed around the perimeter of the monofill to collect stormwater run-off.	$3.25	$4	Contractor estimate is on low side of typical. Use $4.00/lf.
C.13	Perimeter road	Contractor estimate/bid for similar work (local Fox Valley contractor) and typical experience	Gravel road constructed around the perimeter of the monofill for access during monitoring and maintenance activities.	$10	$10	Typical unit cost for similar work.
C.14	Access road, paved	Contractor estimate/bid for similar work (local Fox Valley contractor), Means Sitework (2000) and typical experience	Main access road for personnel vehicle entrance, expressed on a "per square foot" basis.	$3.00 - 4.00	$4	Typical unit cost for similar work.
C.15	Perimeter fence	Means Sitework (2000)	Perimeter fence, chain link, 8' h w/ 3-strand barb wire	$35	$35	Means #02820_528_0920. $30/lf. With price inflation, allowance for gates, etc., use $35/lf.
M.1	Leachate collection tank	Contractor estimate/bid for similar work (local Fox Valley contractor) and typical experience	Leachate tank, 30,000 gal FRP, underground, with concrete tie-down pad and appurtenences.	$120,000	$120,000	Typical experience, similar projects.
M.2	Leachate loadout station	Contractor estimate/bid for similar work (local Fox Valley contractor) and typical experience	Equipment for leachout pumpout and truck loading	$50,000	$50,000	Typical experience, similar projects.
M.3	Scale	Contractor estimate/bid for similar work (local Fox Valley contractor) and typical experience	Truck scale for weighing incoming loads.	$100,000	$100,000	Typical experience, similar projects.
E.1	New service to site	Typical experience	Establish new electrical service to the facility	$30,000	$30,000	This is a placeholder, based on typical projects.
E.2	Wiring and controls	Typical experience	Local wiring of leachate pump stations, yard lights, etc.	$20,000	$20,000	This is a placeholder, based on typical projects.
S.1	Maintenance building	Contractor estimate/bid for similar work (local Fox Valley contractor) and typical experience	Maintenance building, pre-engineered, metal building, 100' x 100', w/ 4" slab and frost wall.	$500,000	$500,000	This a placeholder, based on typical projects.
I.1	Siting studies, permitting, engineering and final design, through first phase of construction	Typical experience	Siting and hydrogeologic studies and preparation of permit documents.		$1,500,000	This is a placeholder for all initial permitting and engineering work, based on prior experience.

BASIS OF UNIT COSTS

I.D.	Item	Source	Description	Value or Range Provided (rounded)	Value Used for Estimate (rounded)	Basis
I.2	Engineering/ final design of subsequent phases (% of construction direct capital spent in year n +1)		Final engineering and preparation of construction plans and specifications for phased construction and closure work. Cost expressed as a % of the constructed value of the work.		7%	Typical cost for engineering/design services on large civil projects.
I.3	Construction documentation (% of construction direct capital spent in year n)		Soils and geomembrane testing, construction observation, and preparation of construction documentation reports and drawings. Cost expressed as a % of the constructed value of the work.		15%	Typical cost for construction-phase services on large civil projects.
O.1	Environmental monitoring	Typical project experience and laboratory analytical estimate (EnChem, Minneapolis, MN)	Annual monitoring and reporting activities for collection and laboratory analysis of groundwater, leachate, GCL, and sedimentation pond samples.	$85,000	$85,000	A separate cost spreadsheet was developed to incorporate all expenses related to monitoring - well installation, labor (field technician and reporting), laboratory analysis, and equipment costs. Scope is based on typical work at NR500 landfills in Wisconsin.
O.2	Leachate hauling	Typical experience	Haul leachate to a local POTW (location not yet defined.) During filling, all water would be treated at on-site wastewater treatment plant. After final closure, quantity estimated as 1" infiltration per year over 49 acres after closure: (1"/year)(ft/12")(7.48 gal/cf)(43560 sf/acre)(237 acre) = 16.4 MG per year.		$0.04	Typical cost could be up to $200 per 4000 or 5000 gal load. Use $0.04/gal. This line item is a placeholer only. Could also treat leachate at the on-site wastewater treatment plant over the long-term.
O.3	Leachate disposal	Typical experience	Disposal of leachate at local POTW (location not yet defined.)		$0.01	Typical POTW charge for disposal plus BOD and TSS surcharges could be on the order of $0.01/gal. Leachate from this project may be low in BOD, but use this value to account for possible concern over organics content.
O.10	Landfill technician	Typical experience	1 FTE to conduct landfill operations and maintenance-related tasks. 2,000 hrs/yr.		$20	Typical labor cost for local technician.
O.11	Project manager	Typical experience	On-site project controls and personnel supervision. Assume LOE is 0.25 FTE. 500 hrs/yr.		$50	Local project oversight and administration.
O.20	Land surface care	Typical experience	Re-seeding, minor erosion control and restoration of cover		$20,000	This is a placeholder for typical cost of road and cover maintenance.
O.21	Leachate pump replacement	Typical experience	Replace leachate pump and motor. Assume 25% replacement rate of 4 per year.		$4,000	Typical cost for submersible pump and motor.
O.22	Leachate pipe cleaning	Typical experience	Annual cost for cleaning of leachate lines.		$5,000	Typical cost, similar project
O.30	Electricity		Monthly power requirements for collection system equipment, lighting, etc.		$300	This is a placeholder to cover intermittent pumping of leachate and other minor electrical usage at the facility.
O.31	Telephone	Prior project experience	Monthly cost of phone service to main operating facility.		$50	Placeholder, monthly estimated cost.
O.40	Host community fee (per ton disposed)		Fee paid to local community, as negotiated through the state's local approvals process.		$10	Typical fee for other Brown County disposal facilities. Cost is expressed on a "per ton of waste disposed" basis. Since the sediment is placed as a slurry, the determination of actual waste tonnage for purposes of assessing this fee is not straightforward. As a placeholder, a tonnage based on 40% solids (equivalent to the passively dewatered sediment) is assumed.

COST ESTIMATE #14 **Rev: 10.30.03**
DETAILED EVALUATION OF ALTERNATIVES **Final**
WDNR - FOX RIVER

PROJECT ELEMENT:
Barge transport
Scenario D - OU3 and OU4

PROCESS METRICS

	OU3	OU4	
Total volume sediment removed from river	587,000	5,880,000	cy
Total wet tons material (at 30% solids) generated from this volume of sediment	783,000	6,970,000	ton
Length of operations	0.9	9.4	yr

COST SUMMARY

	Total Cost (2)	Total as Present Worth (3)(4)
OU3		
Total operating costs	$7,430,000	
Cost per cy sediment removed	$12.66	
OU4		
Capital cost (5)	$6,300,000	$6,300,000
Operating costs	$34,300,000	$24,500,000
Total, capital plus annual operating costs	$40,600,000	$30,800,000
Cost per cy sediment removed	$6.90	$4.17

Notes

1. Indirect capital costs (engineering, construction management, etc.) not included.
2. The "total cost" does not discount the multi-year operating costs.
3. The "present worth" discounts all operations costs over the length of the project. The discount rate is 7% (USEPA, "Guide to Developing and Documenting Cost Estimates During the Feasibility Study", July 2000.)
4. For OU4 the present worth value assumes that the work is performed uniformly over the length of operations. No present value is computed for OU3, since that quantity of work would likely be accomplished in only 1 - 2 seasons, and the timing of that work within the overall project schedule is not yet known.
5. The capital cost includes the purchase of deck barges that would be used for work in both OU3 and OU4. As a simplifying assumption, the cost is assigned to OU4.

CAPITAL COSTS

Item		Units	Quantity	Unit Cost	Extension
Purchased Equipment					
K.1	Flat deck barge	ea	12	$400,000	$4,800,000
	Subtotal, purchased equipment and trades				$4,800,000
	Freight (% of purchased equipment)		5%		$240,000
	Prime contractor administration, overhead & profit (% of above)		25%		$1,260,000
	TOTAL DIRECT CAPITAL				$6,300,000

Notes

1. Unit cost backup provided on subsequent sheets

ANNUAL OPERATIONS COSTS - OU3

	Item	Units	Quantity	Unit Cost (1)	Extension
	Equipment and labor				
O.02	Tug with captain	tug*hours	23,520	$110	$2,587,200
O.10	Deckhands	person*hours	58,800	$60	$3,528,000
	Subtotal, all annual operations				$6,115,200
	Mobilization, demobilization, general conditions (% of above)			8%	$489,216
	Prime contractor administration, overhead & profit (% of above)			25%	$1,651,104
	TOTAL ANNUAL OPERATIONS				$8,255,520

Notes

1. Unit cost backup provided on subsequent sheets

ANNUAL OPERATIONS COSTS - OU4

	Item	Units	Quantity	Unit Cost (1)	Extension
	Equipment and labor				
O.02	Tug with captain	tug*hours	11,760	$110	$1,293,600
O.10	Deckhands	person*hours	23,520	$60	$1,411,200
	Subtotal, all annual operations				$2,704,800
	Mobilization, demobilization, general conditions (% of above)			8%	$216,384
	Prime contractor administration, overhead & profit (% of above)			25%	$730,296
	TOTAL ANNUAL OPERATIONS				$3,651,480

Notes

1. Unit cost backup provided on subsequent sheets

PRESENT WORTH CALCULATION - OU3

i = 7%

Year, n	Capital Costs (Construction)	Annual Operations	Sum of Year "n" Costs	Cumulative Costs, Year 1 through n	Present Worth Factor, i	Present Worth of Year "n" Construction Costs Only	Present Worth of All Year "n" Costs
0			$0	$0	1	$0	$0
1		$7,429,968	$7,429,968	$7,429,968	0.9346	$0	$6,943,895
2			$0	$7,429,968	0.8734	$0	$0
3			$0	$7,429,968	0.8163	$0	$0
4			$0	$7,429,968	0.7629	$0	$0
5			$0	$7,429,968	0.7130	$0	$0
6			$0	$7,429,968	0.6663	$0	$0
7			$0	$7,429,968	0.6227	$0	$0
8			$0	$7,429,968	0.5820	$0	$0
9			$0	$7,429,968	0.5439		$0
10			$0	$7,429,968	0.5083		$0
11			$0	$7,429,968	0.4751		$0
12			$0	$7,429,968	0.4440		$0
13			$0	$7,429,968	0.4150		$0
14			$0	$7,429,968	0.3878		$0
15			$0	$7,429,968	0.3624		$0
16			$0	$7,429,968	0.3387		$0
17			$0	$7,429,968	0.3166		$0
18			$0	$7,429,968	0.2959		$0
19			$0	$7,429,968	0.2765		$0
20			$0	$7,429,968	0.2584		$0
21			$0	$7,429,968	0.2415		$0
22			$0	$7,429,968	0.2257		$0
23			$0	$7,429,968	0.2109		$0
24			$0	$7,429,968	0.1971		$0
25			$0	$7,429,968	0.1842		$0
26			$0	$7,429,968	0.1722		$0
27			$0	$7,429,968	0.1609		$0
28			$0	$7,429,968	0.1504		$0
29			$0	$7,429,968	0.1406		$0
30			$0	$7,429,968	0.1314		$0
31			$0	$7,429,968	0.1228		$0
32			$0	$7,429,968	0.1147		$0
33			$0	$7,429,968	0.1072		$0
34			$0	$7,429,968	0.1002		$0
35			$0	$7,429,968	0.0937		$0
36			$0	$7,429,968	0.0875		$0
37			$0	$7,429,968	0.0818		$0
38			$0	$7,429,968	0.0765		$0
39			$0	$7,429,968	0.0715		$0
40			$0	$7,429,968	0.0668		$0
Totals	$0	$7,429,968	$7,429,968			$0	$6,943,895

PRESENT WORTH CALCULATION - OU4

i = 7%

Year, n	Capital Costs (Construction)	Annual Operations	Sum of Year "n" Costs	Cumulative Costs, Year 1 through n	Present Worth Factor, i	Present Worth of Year "n" Construction Costs Only	Present Worth of All Year "n" Costs
0	$6,300,000		$6,300,000	$6,300,000	1	$6,300,000	$6,300,000
1		$3,651,480	$3,651,480	$9,951,480	0.9346	$0	$3,412,598
2		$3,651,480	$3,651,480	$13,602,960	0.8734	$0	$3,189,344
3		$3,651,480	$3,651,480	$17,254,440	0.8163	$0	$2,980,695
4		$3,651,480	$3,651,480	$20,905,920	0.7629	$0	$2,785,697
5		$3,651,480	$3,651,480	$24,557,400	0.7130	$0	$2,603,455
6		$3,651,480	$3,651,480	$28,208,880	0.6663	$0	$2,433,135
7		$3,651,480	$3,651,480	$31,860,360	0.6227	$0	$2,273,958
8		$3,651,480	$3,651,480	$35,511,840	0.5820	$0	$2,125,195
9		$3,651,480	$3,651,480	$39,163,320	0.5439		$1,986,163
10		$1,460,592	$1,460,592	$40,623,912	0.5083		$742,491
11			$0	$40,623,912	0.4751		$0
12			$0	$40,623,912	0.4440		$0
13			$0	$40,623,912	0.4150		$0
14			$0	$40,623,912	0.3878		$0
15			$0	$40,623,912	0.3624		$0
16			$0	$40,623,912	0.3387		$0
17			$0	$40,623,912	0.3166		$0
18			$0	$40,623,912	0.2959		$0
19			$0	$40,623,912	0.2765		$0
20			$0	$40,623,912	0.2584		$0
21			$0	$40,623,912	0.2415		$0
22			$0	$40,623,912	0.2257		$0
23			$0	$40,623,912	0.2109		$0
24			$0	$40,623,912	0.1971		$0
25			$0	$40,623,912	0.1842		$0
26			$0	$40,623,912	0.1722		$0
27			$0	$40,623,912	0.1609		$0
28			$0	$40,623,912	0.1504		$0
29			$0	$40,623,912	0.1406		$0
30			$0	$40,623,912	0.1314		$0
31			$0	$40,623,912	0.1228		$0
32			$0	$40,623,912	0.1147		$0
33			$0	$40,623,912	0.1072		$0
34			$0	$40,623,912	0.1002		$0
35			$0	$40,623,912	0.0937		$0
36			$0	$40,623,912	0.0875		$0
37			$0	$40,623,912	0.0818		$0
38			$0	$40,623,912	0.0765		$0
39			$0	$40,623,912	0.0715		$0
40			$0	$40,623,912	0.0668		$0
Totals	$6,300,000	$34,323,912	$40,623,912			$6,300,000	$30,832,731

BASIS OF UNIT COSTS - OU3

I.D.	Item	Source	Description	Value or Range Provided (rounded)	Value Used for Estimate (rounded)	Basis
K.1	Flat deck barge	Vendor budgetary estimate (Ellicott Division of Baltimore Dredges LLC, Baltimore, MD)	Flat deck work barges. Barge size 120 ft by 40 ft by 6 ft steel hull deck barge. Total of 12 required (based on OU4 work.)	$341,000	$400,000	Vendor quote. $341,000 per barge. Barge is wider than can be accomodated in lock system, but use this value to be conservative. Include allowance for addition of water-tight sidewalls, etc. Use $400,000.
O.01	Barges, leased	Contractor opinion and/or budgetary estimates, as follows:	Deck barge, 30' x 120' with 4' high containment pen. 350 cy capacity. Rate is converted to an hourly basis, per barge. For OU3, 10 required. Total annual hours = (10)(24 hr/d)(245 d/yr) = 58,880 hr. For OU4, 12 required. Total annual hours = (12)(24 hr/day)(245 d/yr) = 70,560 hr.			Note: This information provided, but not used in final estimate. Costs are substantially less if barges purchased and dedicated to the project.
		McMullen & Pitz, Manitowoc, WI, 920.682.0131		$35		Estimate was $280 per 8 hr day.
		Kadinger Marine, Michigan, 414.383.2040		$25 - $31		Esimate was $200 - $250 per 8 hr day.
		J.F. Brennan, LaCrosse, WI		$48		Estimate was $480 per 10 hr day.
		Artco Fleeting Services, 608.725.2311		$7		Estimate was $170 per 24 hr day.
		Gillen Edward, 414.769.3120		$37		Estimate was $300 per 8 hr day.
		Janke Inc., 715.251.7901		$120		Estimate was $1200 per 10 hr day.
		Summary:			$15	4 of 6 opinions in the range of $7 to $37 per hour. Use $15 to reflect large size and duration of project.
O.02	Tugs with captains	Contractor opinion and/or budgetary estimates, as follows:	Tugs to move barges from dredge to offloading facility. Rate is on a per day basis. For OU3, 4 tugs required (2 on each side of dam.) Total annual hours = (4)(24 hr/day)(245 d/yr) = 23,520 hr. For OU4, 2 tugs required. Total annual hours = (2)(24 hr/day)(245 d/yr) = 11,760 hr.			
		McMullen & Pitz, Manitowoc, WI, 920.682.0131		$150		Estimate was $1200 per 8 hr day.
		Kadinger Marine, Michigan, 414.383.2040		$50		Estimate was $400 per 8 hr day.
		J.F. Brennan, LaCrosse, WI		$140		Estimate was $1400 per 10 hr day.
		Gillen Edward, 414.769.3120		$44		Estimate was $350 per 8 hr day.
		Janke Inc., 715.251.7901		$180		Estimate was $1800 per 10 hr day.
		Summary:			$110	Use average value of $110 per hr.
O.10	Deckhands	Contractor opinion and/or budgetary estimates, as follows:	LOE is based on 2 deckhands per tug, and 2 for lock operations. Rate is converted to an hourly basis from shift rates. For OU3, total LOE = (4 tugs)(2/tug) + 2 at lock = 10 deckhands. Total annual hours = (10)(24 hr/d)(245 d/yr) = 58,800 hr. For OU4, total LOE = (2 tugs)(2/tug) = 4 deckhands. Total annual hours = (4)(24 hr/d)(245 d/yr) = 23,520 hr.			
		McMullen & Pitz, Manitowoc, WI, 920.682.0131		$90		Estimate was $720 per 8 hr day.

BASIS OF UNIT COSTS - OU3

I.D.	Item	Source	Description	Value or Range Provided (rounded)	Value Used for Estimate (rounded)	Basis
		Kadinger Marine, Michigan, 414.383.2040		$68		Estimate was $544 per 8 hr day.
		J.F. Brennan, LaCrosse, WI		$84		Estimate was $840 per 10 hr day.
		Janke Inc., 715.251.7901		$60		Estimate was $600 per 10 hr day.
		Summary:			$60	Use low end of range to reflect large scale of project.

PROJECT ELEMENT:
Barge offloading facility
Scenario D - OU3 and OU4

PROCESS METRICS

Total volume sediment removed from river	6,500,000	cy
Total wet tons of material (at 30% solids) generated from this volume of sediment	7,700,000	ton
Length of operations	10.4	yr

COST SUMMARY

	Total Cost (3)	Total as Present Worth (4)	
Subtotal, construction costs	$2,100,000	$2,100,000	
Total, construction plus operating costs	$20,500,000	$14,900,000	
Cost per cy sediment removed (5)	$3.15	$2.29	/cy

Notes

1. This estimate is based on the major processes/equipment identified in the DEA. It is based on preliminary concepts, and is suitable only as a general indicator of eventual project costs. It will change as final engineering and detailed design work proceed.
2. The estimate assumes that the plant is constructed as a fixed-base, semi-permanent facility. Indirect capital costs (engineering, construction management, etc.) not included.
3. The "total cost" does not discount the multi-year operating costs.
4. The "present worth" discounts all construction and operations costs over the active life of the facility. The discount rate is 7% (USEPA, "Guide to Developing and Documenting Cost Estimates During the Feasibility Study", July 2000.)
5. "Cost per cy" values are for informational purposes only. Values are not true unit costs because they represent a combination of fixed capital and quantity proportional components.

DIRECT CAPITAL COSTS

	Item	Units	Quantity	Unit Cost (1)	Extension
Purchased Equipment					
K.1	Loading stations	ea	2	$10,000	$20,000
K.2	Truck scale	ea	1	$75,000	$75,000
K.3	Stormwater transfer pump	ea	3	$4,800	$14,400
K.4	Wastewater transfer pump	ea	3	$4,800	$14,400
K.5	Office trailers	ea	5	$25,000	$125,000
	Subtotal, major equipment				$248,800
K.6	Minor equipment not yet defined	% of major equipment	1	25%	$62,200
	Subtotal, purchased equipment				$311,000
Civil work					
C.1	Bulkhead construction/improvements	ls	1	$100,000	$100,000
C.2	Slab and liner for crane pad	sf	8,000	$10	$80,000
C.3	Slab and liner at sediment holding area	sf	43,560	$10	$435,600
C.4	Concrete sidewalls at sediment holding area	lf	834	$90	$75,060
C.5	Storm sewer (main yard and holding area)	lf	600	$20	$12,000
C.6	Stormwater catch basins and wet wells	ea	6	$2,500	$15,000
C.7	Stormwater transfer piping	ls	1	$10,000	$10,000
C.8	Truck driveway, asphalt	sf	24,000	$3	$72,000
C.9	Plant driveway, asphalt	sf	12,000	$3	$36,000
C.10	Main yard, asphalt	sf	20,000	$3	$60,000
C.11	Plant fencing	lf	1,670	$35	$58,450
C.12	Vehicle gates	ls	1	$17,000	$17,000
C.13	Personnel gates	ea	4	$400	$1,600
C.14	Sewer line	lf	500	$20	$10,000
C.15	Potable water line	lf	500	$45	$22,500
C.16	Telephone service	ls	1	$10,000	$10,000
C.17	Site restoration	ls	1	$100,000	$100,000
Mechanical Work					
M.1	Equipment erection	% of equipment	1	15%	$46,650
Electrical Work					
E.1	Process electrical and instrumentation	% of equipment	1	20%	$62,200
E.2	Yard lighting	ls	1	$30,000	$30,000
	Subtotal, purchased equipment and trades				$1,565,060
	Mobilization, demobilization, general conditions (% of above)			8%	$125,205
	Freight (% of purchased equipment)			5%	$15,550
	Prime contractor administration, overhead & profit (% of above)			25%	$426,454
	TOTAL DIRECT CAPITAL				$2,132,269

Notes

1. Unit cost backup provided on subsequent sheets

ANNUAL OPERATING COSTS

	Item	Units	Quantity	Unit Cost (1)	Extension
	Leased equipment				
O.01	Crane with bucket	machine-months	16	$9,000	$144,000
	Operations labor				
O.10	Crane operator	crew-shift	11,760	$45	$529,200
O.11	General labor	hour	17,640	$35	$617,400
	Utilities				
O.10	Electricity	per detail			$21,050
	Subtotal, all annual operations				$1,311,650
	Mobilization, demobilization, general conditions (% of above)			8%	$104,932
	Prime contractor administration, overhead & profit (% of above)			25%	$354,145
	TOTAL ANNUAL OPERATIONS				$1,770,727

Notes

1. Unit cost backup provided on subsequent sheets

ANNUAL ELECTRIC COSTS

	Item	Total Motor HP	Kw	Operating Time Per Day (1)	Kw*hr per day
E.1	Loading stations	0	0.0	0	0
E.2	Truck scale	0	0.0	0	0
E.3	Stormwater transfer pump	20	14.9	1	15
E.4	Wastewater transfer pump	40	29.8	20	597
	Subtotal, major equipment				612
E.7	Minor equipment not yet defined	10	7.5	20	149
	Subtotal, all equipment (kw*hr/day)				761
	Number of operating days per year				245
	Cost of electricity ($/kw*hr)				$0.07
	Subtotal, electricity for equipment				$13,050
			Months	$/month	Extension
M.3	Lighting, ventilation & heating of office trailers	month	8	$1,000	$8,000
	TOTAL ANNUAL ELECTRICAL				$21,050

Notes

1. Daily operating time for system is assumed to be somewhat longer than daily dredge effective time.

PRESENT WORTH CALCULATION

i = 7%

Year, n	Capital Costs (Construction)	Annual Operations	Sum of Year "n" Costs	Cumulative Costs, Year 1 through n	Present Worth Factor, i	Present Worth of Year "n" Construction Costs Only	Present Worth of All Year "n" Costs	Cumulative Present Worth of All Costs, Year 1 through n
0	$2,132,269		$2,132,269	$2,132,269	1	$2,132,269	$2,132,269	$2,132,269
1		$1,770,727	$1,770,727	$3,902,996	0.9346	$0	$1,654,885	$3,787,154
2		$1,770,727	$1,770,727	$5,673,723	0.8734	$0	$1,546,622	$5,333,775
3		$1,770,727	$1,770,727	$7,444,450	0.8163	$0	$1,445,441	$6,779,216
4		$1,770,727	$1,770,727	$9,215,177	0.7629	$0	$1,350,879	$8,130,096
5		$1,770,727	$1,770,727	$10,985,905	0.7130	$0	$1,262,504	$9,392,600
6		$1,770,727	$1,770,727	$12,756,632	0.6663	$0	$1,179,910	$10,572,510
7		$1,770,727	$1,770,727	$14,527,359	0.6227	$0	$1,102,720	$11,675,230
8		$1,770,727	$1,770,727	$16,298,086	0.5820	$0	$1,030,579	$12,705,809
9		$1,770,727	$1,770,727	$18,068,813	0.5439		$963,158	$13,668,967
10		$1,770,727	$1,770,727	$19,839,541	0.5083		$900,148	$14,569,115
11		$708,291	$708,291	$20,547,831	0.4751		$336,504	$14,905,619
12			$0	$20,547,831	0.4440		$0	$14,905,619
13			$0	$20,547,831	0.4150		$0	$14,905,619
14			$0	$20,547,831	0.3878		$0	$14,905,619
15			$0	$20,547,831	0.3624		$0	$14,905,619
16			$0	$20,547,831	0.3387		$0	$14,905,619
17			$0	$20,547,831	0.3166		$0	$14,905,619
18			$0	$20,547,831	0.2959		$0	$14,905,619
19			$0	$20,547,831	0.2765		$0	$14,905,619
20			$0	$20,547,831	0.2584		$0	$14,905,619
21			$0	$20,547,831	0.2415		$0	$14,905,619
22			$0	$20,547,831	0.2257		$0	$14,905,619
23			$0	$20,547,831	0.2109		$0	$14,905,619
24			$0	$20,547,831	0.1971		$0	$14,905,619
25			$0	$20,547,831	0.1842		$0	$14,905,619
26			$0	$20,547,831	0.1722		$0	$14,905,619
27			$0	$20,547,831	0.1609		$0	$14,905,619
28			$0	$20,547,831	0.1504		$0	$14,905,619
29			$0	$20,547,831	0.1406		$0	$14,905,619
30			$0	$20,547,831	0.1314		$0	$14,905,619
31			$0	$20,547,831	0.1228		$0	$14,905,619
32			$0	$20,547,831	0.1147		$0	$14,905,619
33			$0	$20,547,831	0.1072		$0	$14,905,619
34			$0	$20,547,831	0.1002		$0	$14,905,619
35			$0	$20,547,831	0.0937		$0	$14,905,619
36			$0	$20,547,831	0.0875		$0	$14,905,619
37			$0	$20,547,831	0.0818		$0	$14,905,619
38			$0	$20,547,831	0.0765		$0	$14,905,619
39			$0	$20,547,831	0.0715		$0	$14,905,619
40			$0	$20,547,831	0.0668		$0	$14,905,619
Totals	$2,132,269	$18,415,563	$20,547,831			$2,132,269	$14,905,619	

BASIS OF UNIT COSTS

I.D.	Item	Source	Description	Value or Range Provided (rounded)	Value Used for Estimate (rounded)	Basis
K.1	Loading stations		Equipment to facilitate loading operations.		$10,000	Placeholder, pending final engineering.
K.2	Truck scale	Means Sitework (2000)	Installed scale at truck entrance to weigh loaded and/or incoming trucks.		$75,000	Means, #10880_100_1680. Truck scale, 70' x 10', digital, electronic = $39,900. Add remote readout system, foundation, site prep. Assume $75,000.
K.3	Stormwater transfer pump (plus spare)	Means/Echos (2001)	500 gpm at 100' TDH, 20 HP centrifugal transfer pump with motor and fittings for management of stormwater. An additional backup pump will be purchased.	$4,800	$4,800	Means, #33_29_0130. Conservative estimate of flow based on 25-year, 24-hour storm event assuming no infiltration. Assume 2-500 gpm pumps installed.
K.4	Wastewater transfer pump (plus spare)	Means/Echos (2001)	500 gpm at 100' TDH, 20 HP centrifugal transfer pump with motor and fittings for pumpout of free water from barges. Assume two required, plus spare.	$4,800	$4,800	Means, #33_29_0130.
K.5	Office trailers	Means Sitework (2000)	Pre-fabricated office, trailer-style, 50' x 12', purchased.	$18,900	$25,000	Means, #01520_0550. $18,900 to buy. Add allowance for site prep, installation and weatherization.
K.6	Minor equipment not yet defined	Prior project experience	Minor equipment not yet defined.		25%	Placeholder, pending final engineering.
C.1	Bulkhead construction/improvements	General experience	This is a placeholder to construct or improve a bulkhead line at the sediment offloading facility.		$100,000	Placeholder, pending site selection and final engineering.
C.2	Slab and liner for crane pad	Means/Echos (2000) and contractor opinion	12" reinforced concrete slab, with 60 mil geomembrane liner and sand collection layer. Assume 20' W by 400' L = 8000 sf.		$10	Slab: Means, #18_02_0324 = $7.35/sf. Geomembrane = $0.60/sf. With sand layer and possibly embedded steel for wear suface, assume $10/sf.
C.3	Slab and liner at sediment holding area	Means/Echos (2000) and contractor opinion	12" reinforced concrete slab, with 60 mil geomembrane liner and sand collection layer. Assume 1 acre of lined holding area for short-term storage of sediment, prior to loadout, if needed.		$10	Slab: Means, #18_02_0324 = $7.35/sf. Geomembrane = $0.60/sf. With sand layer and possibly embedded steel for wear suface, assume $10/sf.
C.4	Concrete sidewalls at sediment holding area	Means/Echos (2000) and contractor opinion	10" concrete reinforced retaining wall, on a 26" wide footing surrounding the staging areas. Assume 834 lf of perimeter wall for a 1 acre lined area.		$90	Means Assemblies, #A12.7_310_1000. Concrete reinforced retaining wall = $83/lf. Add water stop, contingency. Assume $90/lf.
C.5	Storm sewer (main yard and holding area)	Project experience	4" PVC, gravity drains to common wet well. Length of runs not yet known. Assume 600 lf as a placeholder.		$20	Recent project, central Wisconsin, 4" gravity PVC, max. 4' excavation, including backfill, etc.
C.6	Stormwater catch basins and wet wells	Means Sitework (2000)	Concrete, pre-cast concrete manhole to serve as collection point for staging area and yard runoff.	$2,090	$2,500	Means Assemblies, #12.3_170_5820. Assume 4' dia and 6' d, on base, with frame and lid.
C.7	Stormwater transfer piping	General experience	Aboveground or underground piping to connect stormwater sump pumps to wastewater treatment plant.		$10,000	Routing not yet determined. Include a placeholder of $10,000 for up to several hundred feet of 2" or 3" pipe, fittings, connections, etc.
C.8	Truck driveway, asphalt	Means Sitework (2000)	Main truck access area for loading, weighing, and hauling operations. Assume 24' W by 1000' L = 24,000 sf.		$3	Means Assemblies, #12.5_111_3400. For 5" asphalt, 14" base, 32' wide = $96/lf. This equals $3/sf.
C.9	Plant driveway, asphalt	Means Sitework (2000)	Main access road for personnel vehicle entrance. Assume 24' W by 500' L = 12,000 sf.		$3	Means Assemblies, #12.5_111_3400. For 5" asphalt, 14" base, 32' wide = $96/lf. This equals $3/sf.
C.10	Main yard, asphalt	Means Sitework (2000)	Area used for parking of personnel vehicles and access to wastewater treatment building and offices. Assume 1/2 acre or 20,000 sf.		$3	Means Assemblies, #12.5_111_3400. For 5" asphalt, 14" base, 32' wide = $96/lf. This equals $3/sf.
C.11	Plant fencing	Means Sitework (2000)	Chain-link fencing for perimeter of facility. 8' h, w/ 3 strand barb wire. Assume 1670 lf of perimeter fence for a 4 acre facility.		$35	Means, #02820_528_0920. $30.50/lf. With contingency, use $35.00/lf

BASIS OF UNIT COSTS

I.D.	Item	Source	Description	Value or Range Provided (rounded)	Value Used for Estimate (rounded)	Basis
C.12	Vehicle gates	Means Sitework (2000)	Sliding, chain-link gates at the truck entrances and the plant entrance.		$17,000	Means, #02820_528_3100. $152/lf for up to 18'. Assume $200/lf for longer span. 3 gates @ 28' each = 84 lf. Use $17,000 total.
C.13	Personnel gates	Means Sitework (2000)	Gates at front of facility and at back (towards river.) 4 total needed.		$400	Means, #02820_528_1400. $280 for a 6' high, 3' wide gate. Assume $400 each for a taller, 8' gate.
C.14	Sewer line	General experience	Sanitary sewer connection to lavatory in wastewater treatment building. Assume 500 lf needed.		$20	Assume $5 - 10/lf for 4" PVC pipe, gravity, installed. Excavation, bedding and backfill at $5-8/lf. Add allowance for fittings, connections, etc. Use $20/lf total.
C.15	Potable water line	General experience	Potable water service to wastewater treatment building for equipment cleaning, general washdown, etc. Assume 500 lf needed.		$45	Assume 1" to 1-1/2" line is needed. Copper pipe at $26 to $34/lf. Trenching, bedding and backfill at $5-8 lf. Add allowance for service connection, backflow preventer, etc. Use $45/lf.
C.16	Telephone service	General experience	Cost of phone service from treatment plant.		$10,000	This is an assumed placeholder for bringing in new service to the plant, and making local connections to trailers and buildings.
C.17	Site restoration	Prior project experience	Remove slabs, driveways and facilities at end of project		$100,000	Based on recent experience with process equipment removal and building demolition, Fox Valley.
M.1	Equipment erection	Prior project experience	Labor and materials to erect equipment and structures.	11%	15%	Prior project, increased to reflect current unknowns.
E.1	Process electrical and instrumentation	Prior project experience	Includes process wiring, loose process instrumentation and controls, as a percentage of the purchased equipment.	15 - 27%	20%	Use mid-point of range from past, smaller projects.
E.2	Yard lighting	Contractor opinion (Boudry Control Panels, LLC, Fond du Lac, WI)	Overhead, industrial lighting in staging areas and along roads		$30,000	Past experience is approximately 7 pole lights per acre, which seems high for this project. At least 4 acres require coverage. Assume 12 poles at $2500 each.
O.01	Crane with bucket		Cranes to offload barges. Minimum of 2 required to match sediment loading rate. Value is monthly lease rate. 8 months per year times 2 machines = 16 machine-months per year.		$9,000	Means, 01590_600: A variety of capacities are avaible. Assume monthly rate of $9000, which is typical of range.
O.10	Crane operator		Operating labor. Dredge effective time estimated at 17 hr/day, but assume 24 hr operations at offloading facility is required. Rate is per hour. 24 hours per day times 2 machines = 48 machine-hours per day. At 245 days/yr, total of 11,760 machine-hours per year.		$45	Means, 01590_600: Assume operating rate that correponds to crane size used above. Round off to $45/hr.
O.11	General labor		General labor to operate pumps, stage barges, coordinate truck traffic, etc. Assume 3 FTE 24/7. Total labor hours per year = (3)(24)(245) = 17,640 hrs.		$35	
O.30	Electricity		Power requirements for process equipment, lighting, etc.		$21,050	Refer to cost sheet, "Annual Electrical Costs." Conservatively high estimate based on 24 hour operating period.

COST ESTIMATE #16 | **Rev: 10.30.03**
DETAILED EVALUATION OF ALTERNATIVES | **Final**
WDNR - FOX RIVER

PROJECT ELEMENT:
Truck transport
All alternatives and scenarios for OU3 and OU4

PROCESS METRICS

Total volume of sediment removed from river	6,500,000	cy
Total mass of sediment (if dredged and hauled @ 30% solids) (1)	7,700,000	tons
Total mass of filter cake (if dewatered to 55% solids) (2)	3,560,000	tons

COST SUMMARY

	Total Cost	Total as Present Worth (2)
Cost per ton	$6.09	
Equivalent cost per cy sediment removed if dredged and hauled @ 30% solids	$7.22	
Equivalent cost per cy sediment removed if dewatered and hauled as filter cake at 55% solids	$3.34	

Notes

1. This quantity assumes that sediment is mechanically dredged and then hauled with no dewatering.
2. This quantity assumes that sediment is hydraulically dredged and then dewatered to a filter cake with a solids concentration of 55%.

CALCULATION OF TRUCKING UNIT COST

Truck load	20	ton
Typical cycle time	1.5	hours
Local truck rate	$65	per hour
Prime contractor administration, overhead & profit	25%	
Unit cost	$6.09	per ton

Notes

1. This quantity assumes that sediment is mechanically dredged and then hauled with no dewatering.

COST ESTIMATE #17 **Rev: 10.30.03**
DETAILED EVALUATION OF ALTERNATIVES **Final**
WDNR - FOX RIVER

PROJECT ELEMENT:
Vitrification
Scenario B - OU3 and OU4

PROCESS METRICS

Total volume of sediment removed from river	6,500,000	cy
Total mass of filter cake processed (@ 55% solids)	3,560,000	tons
Length of operations (Note 4)	6.8	yr
Mass processed per year	524,000	tons

COST SUMMARY

	Total Cost	Total as Present Worth (2)	
Subtotal, capital costs (1)	$79,400,000	$79,400,000	
Subtotal, operating costs (1)	$106,080,000		
Total, capital and operating costs	$185,500,000		
If glass product sold at $2/ton:			
Total cost, less glass sales	$181,900,000	$158,800,000	
Cost per cy sediment removed (3)	$27.98	$24.43	/cy
Cost per ton filter cake disposed (3)	$51.10	$44.61	/ton
If glass product sold at $25/ton:			
Total cost, less glass sales	$141,000,000	$127,100,000	
Cost per cy sediment removed	$21.69	$19.55	
Cost per ton filter cake disposed	$39.61	$35.70	

Notes

1. Capital cost and operating costs come from Unit Cost Study by Minergy, Inc., Neenah, Wisconsin, February 2003.
2. The "present worth" discounts all construction and operations costs over the active life of the facility. The discount rate is 7% (USEPA, "Guide to Developing and Documenting Cost Estimates During the Feasibility Study", July 2000.) The value of glass sold is subtracted from each year's operating cost before taking the present value. Minergy's original study used an interest rate of 5%; thus the values calculated herein vary slightly.
3. "Cost per cy sediment removed" and "cost per ton disposed" values are for informational purposes only. Values are not true unit costs because they represent a combination of fixed capital and quantity-proportional components.
4. The length of operations reported here is slightly longer than the duration of dredging for this scenario because the Minergy plant would be sized to operate over a full-year schedule (by providing onsite storage of sediment.)

SUMMARY OF MINERGY COST ESTIMATES

Plant size			2 x 375	
Plant production			750	tons glass per day
Plant feed capacity			1,500	tons filter cake per day
Operating time			350	days/yr
Total mass to process			3,560,000	tons
Years to process			6.8	
Days to process			2,373	days
Quantity glass produced			1,780,000	tons
			261,765	tons/yr
Value of glass @	$2	per ton	$3,560,000	
	$25	per ton	$44,500,000	
Capital cost			$79,400,000	
Annual cost			$15,600,000	/year
Total cost before sale of glass			$185,500,000	

PRESENT WORTH CALCULATION, VALUE OF GLASS = $2/TON

i = 7.0%

Year, n	Capital Costs (construction)	Annual Operating Costs (prior to final closure)	Value of Glass Sold	Sum of Year "n" Costs	Cumulative Costs, Year 1 through n	Present Worth Factor, i	Present Worth of Year "n" Capital Costs Only	Present Worth of All Year "n" Costs	Cumulative Present Worth of All Costs, Year 1 through n
0	$79,400,000			$79,400,000	$79,400,000	1	$79,400,000	$79,400,000	$79,400,000
1		$15,600,000	$523,529	$15,076,471	$94,476,471	0.9346	$0	$14,090,159	$93,490,159
2		$15,600,000	$523,529	$15,076,471	$109,552,941	0.8734	$0	$13,168,373	$106,658,533
3		$15,600,000	$523,529	$15,076,471	$124,629,412	0.8163	$0	$12,306,891	$118,965,424
4		$15,600,000	$523,529	$15,076,471	$139,705,882	0.7629	$0	$11,501,767	$130,467,191
5		$15,600,000	$523,529	$15,076,471	$154,782,353	0.7130	$0	$10,749,315	$141,216,506
6		$15,600,000	$523,529	$15,076,471	$169,858,824	0.6663	$0	$10,046,089	$151,262,595
7		$12,480,000	$418,824	$12,061,176	$181,920,000	0.6227	$0	$7,511,095	$158,773,690
8				$0	$181,920,000	0.5820	$0	$0	$158,773,690
9				$0	$181,920,000	0.5439	$0	$0	$158,773,690
10				$0	$181,920,000	0.5083		$0	$158,773,690
11				$0	$181,920,000	0.4751		$0	$158,773,690
12				$0	$181,920,000	0.4440		$0	$158,773,690
13				$0	$181,920,000	0.4150		$0	$158,773,690
14				$0	$181,920,000	0.3878		$0	$158,773,690
15				$0	$181,920,000	0.3624		$0	$158,773,690
16				$0	$181,920,000	0.3387		$0	$158,773,690
17				$0	$181,920,000	0.3166		$0	$158,773,690
18				$0	$181,920,000	0.2959		$0	$158,773,690
19				$0	$181,920,000	0.2765		$0	$158,773,690
20				$0	$181,920,000	0.2584		$0	$158,773,690
21				$0	$181,920,000	0.2415		$0	$158,773,690
22				$0	$181,920,000	0.2257		$0	$158,773,690
23				$0	$181,920,000	0.2109		$0	$158,773,690
24				$0	$181,920,000	0.1971		$0	$158,773,690
25				$0	$181,920,000	0.1842		$0	$158,773,690
26				$0	$181,920,000	0.1722		$0	$158,773,690
27				$0	$181,920,000	0.1609		$0	$158,773,690
28				$0	$181,920,000	0.1504		$0	$158,773,690
29				$0	$181,920,000	0.1406		$0	$158,773,690
30				$0	$181,920,000	0.1314		$0	$158,773,690
31				$0	$181,920,000	0.1228		$0	$158,773,690
32				$0	$181,920,000	0.1147		$0	$158,773,690
33				$0	$181,920,000	0.1072		$0	$158,773,690
34				$0	$181,920,000	0.1002		$0	$158,773,690
35				$0	$181,920,000	0.0937		$0	$158,773,690
36				$0	$181,920,000	0.0875		$0	$158,773,690
37				$0	$181,920,000	0.0818		$0	$158,773,690
38				$0	$181,920,000	0.0765		$0	$158,773,690
39				$0	$181,920,000	0.0715		$0	$158,773,690
40				$0	$181,920,000	0.0668		$0	$158,773,690
41				$0	$181,920,000	0.0624		$0	$158,773,690
42				$0	$181,920,000	0.0583		$0	$158,773,690
43				$0	$181,920,000	0.0545		$0	$158,773,690
44				$0	$181,920,000	0.0509		$0	$158,773,690
45				$0	$181,920,000	0.0476		$0	$158,773,690
46				$0	$181,920,000	0.0445		$0	$158,773,690
47				$0	$181,920,000	0.0416		$0	$158,773,690
48				$0	$181,920,000	0.0389		$0	$158,773,690
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Totals	$79,400,000	$106,080,000	$3,560,000	$181,920,000			$79,400,000	$158,773,690	

PRESENT WORTH CALCULATION, VALUE OF GLASS = $2/TON

i = 7.0%

Year, n	Capital Costs (construction)	Annual Operating Costs (prior to final closure)	Value of Glass Sold	Sum of Year "n" Costs	Cumulative Costs, Year 1 through n	Present Worth Factor, i	Present Worth of Year "n" Capital Costs Only	Present Worth of All Year "n" Costs	Cumulative Present Worth of All Costs, Year 1 through n
0	$79,400,000			$79,400,000	$79,400,000	1	$79,400,000	$79,400,000	$79,400,000
1		$15,600,000	$6,544,118	$9,055,882	$88,455,882	0.9346	$0	$8,463,441	$87,863,441
2		$15,600,000	$6,544,118	$9,055,882	$97,511,765	0.8734	$0	$7,909,758	$95,773,200
3		$15,600,000	$6,544,118	$9,055,882	$106,567,647	0.8163	$0	$7,392,298	$103,165,497
4		$15,600,000	$6,544,118	$9,055,882	$115,623,529	0.7629	$0	$6,908,689	$110,074,187
5		$15,600,000	$6,544,118	$9,055,882	$124,679,412	0.7130	$0	$6,456,719	$116,530,906
6		$15,600,000	$6,544,118	$9,055,882	$133,735,294	0.6663	$0	$6,034,317	$122,565,222
7		$12,480,000	$5,235,294	$7,244,706	$140,980,000	0.6227	$0	$4,511,639	$127,076,861
8				$0	$140,980,000	0.5820	$0	$0	$127,076,861
9				$0	$140,980,000	0.5439	$0	$0	$127,076,861
10				$0	$140,980,000	0.5083		$0	$127,076,861
11				$0	$140,980,000	0.4751		$0	$127,076,861
12				$0	$140,980,000	0.4440		$0	$127,076,861
13				$0	$140,980,000	0.4150		$0	$127,076,861
14				$0	$140,980,000	0.3878		$0	$127,076,861
15				$0	$140,980,000	0.3624		$0	$127,076,861
16				$0	$140,980,000	0.3387		$0	$127,076,861
17				$0	$140,980,000	0.3166		$0	$127,076,861
18				$0	$140,980,000	0.2959		$0	$127,076,861
19				$0	$140,980,000	0.2765		$0	$127,076,861
20				$0	$140,980,000	0.2584		$0	$127,076,861
21				$0	$140,980,000	0.2415		$0	$127,076,861
22				$0	$140,980,000	0.2257		$0	$127,076,861
23				$0	$140,980,000	0.2109		$0	$127,076,861
24				$0	$140,980,000	0.1971		$0	$127,076,861
25				$0	$140,980,000	0.1842		$0	$127,076,861
26				$0	$140,980,000	0.1722		$0	$127,076,861
27				$0	$140,980,000	0.1609		$0	$127,076,861
28				$0	$140,980,000	0.1504		$0	$127,076,861
29				$0	$140,980,000	0.1406		$0	$127,076,861
30				$0	$140,980,000	0.1314		$0	$127,076,861
31				$0	$140,980,000	0.1228		$0	$127,076,861
32				$0	$140,980,000	0.1147		$0	$127,076,861
33				$0	$140,980,000	0.1072		$0	$127,076,861
34				$0	$140,980,000	0.1002		$0	$127,076,861
35				$0	$140,980,000	0.0937		$0	$127,076,861
36				$0	$140,980,000	0.0875		$0	$127,076,861
37				$0	$140,980,000	0.0818		$0	$127,076,861
38				$0	$140,980,000	0.0765		$0	$127,076,861
39				$0	$140,980,000	0.0715		$0	$127,076,861
40				$0	$140,980,000	0.0668		$0	$127,076,861
41				$0	$140,980,000	0.0624		$0	$127,076,861
42				$0	$140,980,000	0.0583		$0	$127,076,861
43				$0	$140,980,000	0.0545		$0	$127,076,861
44				$0	$140,980,000	0.0509		$0	$127,076,861
45				$0	$140,980,000	0.0476		$0	$127,076,861
46				$0	$140,980,000	0.0445		$0	$127,076,861
47				$0	$140,980,000	0.0416		$0	$127,076,861
48				$0	$140,980,000	0.0389		$0	$127,076,861
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Totals	$79,400,000	$106,080,000	$44,500,000	$140,980,000			$79,400,000	$127,076,861	

PROJECT ELEMENT:
Vitrification
Scenario D - OU3 and OU4

PROCESS METRICS

Total volume of sediment removed from river	6,500,000	cy
Total mass of sediment processed (@ 30% solids)	7,700,000	tons
Length of operations (Note 4)	10.3	yr
Mass processed per year	747,600	tons

COST SUMMARY

	Total Cost	Total as Present Worth (2)	
Subtotal, capital costs (1)	$79,400,000	$79,400,000	
Subtotal, operating costs (1)	$201,400,000		
Total, capital and operating costs	$280,800,000		
If glass product sold at $2/ton:			
Total cost, less glass sales	$276,000,000	$216,200,000	
Cost per cy sediment removed (3)	$42.46	$33.26	/cy
Cost per ton sediment disposed (3)	$35.84	$28.08	/ton
If glass product sold at $25/ton:			
Total cost, less glass sales	$220,900,000	$177,900,000	
Cost per cy sediment removed	$33.98	$27.37	/cy
Cost per ton sediment disposed	$28.69	$23.10	/ton

Notes

1. Capital costs and operating costs come from Unit Cost Study by Minergy, Inc., Neenah, Wisconsin, February 2003.
2. The "present worth" discounts all construction and operations costs over the active life of the facility. The discount rate is 7% (USEPA, "Guide to Developing and Documenting Cost Estimates During the Feasibility Study", July 2000.) The value of glass sold is subtracted from each year's operating cost before taking the present value. Minergy's original study used an interest rate of 5%; thus the values calculated herein vary slightly.
3. "Cost per cy sediment removed" and "cost per ton disposed" values are for informational purposes only. Values are not true unit costs because they represent a combination of fixed capital and quantity-proportional components.
4. The Minergy plant proposed for this scenario could actually process sediment slightly faster than the assumed rate of dredging. The length of processing is extended to more closely match the dredge production by assuming a lower daily rate of melting.

SUMMARY OF MINERGY COST ESTIMATES

Plant size			2 x 375	
Plant production capacity			750	tons glass per day
Plant production actual			662	tons glass per day
Plant feed capacity			2,412	tons wet sediment per day
Plant feed actual			2,130	tons wet sediment per day
Operating time			350	days/yr
Total mass to process			7,700,000	tons
Years to process			10.3	
Days to process			3,615	days
Quantity glass produced			2,394,279	tons
			232,454	tons/yr
Value of glass @	$2	per ton	$4,788,557	
	$25	per ton	$59,856,965	
Capital cost			$79,400,000	
Annual cost			$19,550,000	/year
Total cost before sale of glass			$280,765,000	

PRESENT WORTH CALCULATION, VALUE OF GLASS = $2/TON

i = 7%

Year, n	Capital Costs (construction)	Annual Operating Costs	Value of Glass Sold	Sum of Year "n" Costs	Cumulative Costs, Year 1 through n	Present Worth Factor, i	Present Worth of Year "n" Capital Costs Only	Present Worth of All Year "n" Costs	Cumulative Present Worth of All Costs, Year 1 through n
0	$79,400,000			$79,400,000	$79,400,000	1	$79,400,000	$79,400,000	$79,400,000
1		$19,550,000	$464,908	$19,085,092	$98,485,092	0.9346	$0	$17,836,534	$97,236,534
2		$19,550,000	$464,908	$19,085,092	$117,570,183	0.8734	$0	$16,669,658	$113,906,192
3		$19,550,000	$464,908	$19,085,092	$136,655,275	0.8163	$0	$15,579,120	$129,485,312
4		$19,550,000	$464,908	$19,085,092	$155,740,366	0.7629	$0	$14,559,925	$144,045,237
5		$19,550,000	$464,908	$19,085,092	$174,825,458	0.7130	$0	$13,607,406	$157,652,643
6		$19,550,000	$464,908	$19,085,092	$193,910,549	0.6663	$0	$12,717,202	$170,369,846
7		$19,550,000	$464,908	$19,085,092	$212,995,641	0.6227	$0	$11,885,236	$182,255,082
8		$19,550,000	$464,908	$19,085,092	$232,080,732	0.5820	$0	$11,107,697	$193,362,779
9		$19,550,000	$464,908	$19,085,092	$251,165,824	0.5439	$0	$10,381,025	$203,743,804
10		$19,550,000	$464,908	$19,085,092	$270,250,915	0.5083		$9,701,893	$213,445,697
11		$5,865,000	$139,473	$5,725,527	$275,976,443	0.4751		$2,720,157	$216,165,853
12				$0	$275,976,443	0.4440		$0	$216,165,853
13				$0	$275,976,443	0.4150		$0	$216,165,853
14				$0	$275,976,443	0.3878		$0	$216,165,853
15				$0	$275,976,443	0.3624		$0	$216,165,853
16				$0	$275,976,443	0.3387		$0	$216,165,853
17				$0	$275,976,443	0.3166		$0	$216,165,853
18				$0	$275,976,443	0.2959		$0	$216,165,853
19				$0	$275,976,443	0.2765		$0	$216,165,853
20				$0	$275,976,443	0.2584		$0	$216,165,853
21				$0	$275,976,443	0.2415		$0	$216,165,853
22				$0	$275,976,443	0.2257		$0	$216,165,853
23				$0	$275,976,443	0.2109		$0	$216,165,853
24				$0	$275,976,443	0.1971		$0	$216,165,853
25				$0	$275,976,443	0.1842		$0	$216,165,853
26				$0	$275,976,443	0.1722		$0	$216,165,853
27				$0	$275,976,443	0.1609		$0	$216,165,853
28				$0	$275,976,443	0.1504		$0	$216,165,853
29				$0	$275,976,443	0.1406		$0	$216,165,853
30				$0	$275,976,443	0.1314		$0	$216,165,853
31				$0	$275,976,443	0.1228		$0	$216,165,853
32				$0	$275,976,443	0.1147		$0	$216,165,853
33				$0	$275,976,443	0.1072		$0	$216,165,853
34				$0	$275,976,443	0.1002		$0	$216,165,853
35				$0	$275,976,443	0.0937		$0	$216,165,853
36				$0	$275,976,443	0.0875		$0	$216,165,853
37				$0	$275,976,443	0.0818		$0	$216,165,853
38				$0	$275,976,443	0.0765		$0	$216,165,853
39				$0	$275,976,443	0.0715		$0	$216,165,853
40				$0	$275,976,443	0.0668		$0	$216,165,853
41				$0	$275,976,443	0.0624		$0	$216,165,853
42				$0	$275,976,443	0.0583		$0	$216,165,853
43				$0	$275,976,443	0.0545		$0	$216,165,853
44				$0	$275,976,443	0.0509		$0	$216,165,853
45				$0	$275,976,443	0.0476		$0	$216,165,853
46				$0	$275,976,443	0.0445		$0	$216,165,853
47				$0	$275,976,443	0.0416		$0	$216,165,853
48				$0	$275,976,443	0.0389		$0	$216,165,853
49									
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Totals	$79,400,000	$201,365,000	$4,788,557	$275,976,443			$79,400,000	$216,165,853	

PRESENT WORTH CALCULATION, VALUE OF GLASS = $25/TON

i = 7%

Year, n	Capital Costs (construction)	Annual Operating Costs (prior to final closure)	Value of Glass Sold	Sum of Year "n" Costs	Cumulative Costs, Year 1 through n	Present Worth Factor, i	Present Worth of Year "n" Capital Costs Only	Present Worth of All Year "n" Costs	Cumulative Present Worth of All Costs, Year 1 through n
0	$79,400,000			$79,400,000	$79,400,000	1	$79,400,000	$79,400,000	$79,400,000
1		$19,550,000	$5,811,356	$13,738,644	$93,138,644	0.9346	$0	$12,839,854	$92,239,854
2		$19,550,000	$5,811,356	$13,738,644	$106,877,288	0.8734	$0	$11,999,864	$104,239,718
3		$19,550,000	$5,811,356	$13,738,644	$120,615,932	0.8163	$0	$11,214,826	$115,454,544
4		$19,550,000	$5,811,356	$13,738,644	$134,354,577	0.7629	$0	$10,481,146	$125,935,690
5		$19,550,000	$5,811,356	$13,738,644	$148,093,221	0.7130	$0	$9,795,463	$135,731,154
6		$19,550,000	$5,811,356	$13,738,644	$161,831,865	0.6663	$0	$9,154,639	$144,885,792
7		$19,550,000	$5,811,356	$13,738,644	$175,570,509	0.6227	$0	$8,555,737	$153,441,529
8		$19,550,000	$5,811,356	$13,738,644	$189,309,153	0.5820	$0	$7,996,016	$161,437,545
9		$19,550,000	$5,811,356	$13,738,644	$203,047,797	0.5439	$0	$7,472,912	$168,910,457
10		$19,550,000	$5,811,356	$13,738,644	$216,786,442	0.5083		$6,984,030	$175,894,488
11		$5,865,000	$1,743,407	$4,121,593	$220,908,035	0.4751		$1,958,139	$177,852,627
12				$0	$220,908,035	0.4440		$0	$177,852,627
13				$0	$220,908,035	0.4150		$0	$177,852,627
14				$0	$220,908,035	0.3878		$0	$177,852,627
15				$0	$220,908,035	0.3624		$0	$177,852,627
16				$0	$220,908,035	0.3387		$0	$177,852,627
17				$0	$220,908,035	0.3166		$0	$177,852,627
18				$0	$220,908,035	0.2959		$0	$177,852,627
19				$0	$220,908,035	0.2765		$0	$177,852,627
20				$0	$220,908,035	0.2584		$0	$177,852,627
21				$0	$220,908,035	0.2415		$0	$177,852,627
22				$0	$220,908,035	0.2257		$0	$177,852,627
23				$0	$220,908,035	0.2109		$0	$177,852,627
24				$0	$220,908,035	0.1971		$0	$177,852,627
25				$0	$220,908,035	0.1842		$0	$177,852,627
26				$0	$220,908,035	0.1722		$0	$177,852,627
27				$0	$220,908,035	0.1609		$0	$177,852,627
28				$0	$220,908,035	0.1504		$0	$177,852,627
29				$0	$220,908,035	0.1406		$0	$177,852,627
30				$0	$220,908,035	0.1314		$0	$177,852,627
31				$0	$220,908,035	0.1228		$0	$177,852,627
32				$0	$220,908,035	0.1147		$0	$177,852,627
33				$0	$220,908,035	0.1072		$0	$177,852,627
34				$0	$220,908,035	0.1002		$0	$177,852,627
35				$0	$220,908,035	0.0937		$0	$177,852,627
36				$0	$220,908,035	0.0875		$0	$177,852,627
37				$0	$220,908,035	0.0818		$0	$177,852,627
38				$0	$220,908,035	0.0765		$0	$177,852,627
39				$0	$220,908,035	0.0715		$0	$177,852,627
40				$0	$220,908,035	0.0668		$0	$177,852,627
41				$0	$220,908,035	0.0624		$0	$177,852,627
42				$0	$220,908,035	0.0583		$0	$177,852,627
43				$0	$220,908,035	0.0545		$0	$177,852,627
44				$0	$220,908,035	0.0509		$0	$177,852,627
45				$0	$220,908,035	0.0476		$0	$177,852,627
46				$0	$220,908,035	0.0445		$0	$177,852,627
47				$0	$220,908,035	0.0416		$0	$177,852,627
48				$0	$220,908,035	0.0389		$0	$177,852,627
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Totals	$79,400,000	$201,365,000	$59,856,965	$220,908,035			$79,400,000	$177,852,627	

COST ESTIMATE #19 **Rev: .0.30.03**
DETAILED EVALUATION OF ALTERNATIVES **Final**
WDNR - FOX RIVER

PROJECT ELEMENT:
Capping
Scenario A - OU 1, OU 3 and OU 4

PROCESS METRICS

	OU1	OU3	OU4
Cap thickness, inches	18	18	18
Armor thickness, inches	6	6	6
Contaminated area	221	79	262
Cap foundation area	246	88	290
Area for cap volume estimates	234	84	276
Volume of cap material, cy	566,280	203,280	667,920
Volume of armor material, cy	188,760	67,760	222,640
Duration of cap construction, months	8.6	3.1	10.1
Duration of armor construction, months	4.3	1.5	5.1

COST SUMMARY

OU 1	Total Cost (1)	Total as Present Worth (2)
Subtotal, capital costs	$17,300,000	$17,300,000
Total, capital plus long-term costs	$17,800,000	$17,400,000
Cost per acre of capping (3)	$81,000	$79,000
OU 3		
Subtotal, capital costs	$6,500,000	$6,500,000
Total, capital plus long-term costs	$6,800,000	$6,600,000
Cost per acre of capping (3)	$86,000	$84,000
OU 4		
Subtotal, capital costs	$20,200,000	$20,200,000
Total, capital plus long-term costs	$20,700,000	$20,400,000
Cost per acre of capping (3)	$79,000	$78,000

Notes

1. The "total cost" does not discount the long-term monitoring costs.
2. The "present worth" discounts long-term monitoring costs costs. The discount rate is 7% (USEPA, "Guide to Developing and Documenting Cost Estimates During the Feasibility Study", July 2000).
3. "Cost per acre cap" values are for informational purposes only. Values are not true unit costs because they represent a combination of fixed capital and quantity-proportional components.

CAPITAL COSTS - OU1

	Item	Units	Quantity	Unit Cost	Extension
Direct Capital					
Purchased Items					
D.2	Sand	ton	792,792	$8.40	$6,659,453
D.3	Armor	ton	264,264	$8.40	$2,219,818
	Subtotal, purchased items				$8,879,270
Civil Work					
C.1	Mobilization	ls	1	$250,000	$250,000
C.2	Move and startup	season	1	$150,000	$150,000
C.3	Slurry unit	day	189	$5,400	$1,020,600
C.4	Additional slurry unit cost for armor	day	94	$8,300	$780,200
C.5	Spreader unit	day	283	$4,500	$1,273,500
C.6	Field supervision	day	283	$2,800	$792,400
C.7	Winterization	season	1	$100,000	$100,000
C.8	Demobilization	ls	1	$150,000	$150,000
C.9	Routine maintenance	season	2	$25,000	$50,000
C.10	Bathymetric survey	ea	3	$5,200	$15,600
C.11	Surface water monitoring	day	283	$750	$212,250
C.12	Construction monitoring report	season	2	$50,000	$100,000
C.13	Staging arrea	season	2	$20,000	$40,000
C.14	Electricity	season	2	$6,000	$12,000
C.15	Telephone	season	2	$2,400	$4,800
	Subtotal, purchased equipment and trades				$13,830,620
	Prime contractor administration, overhead & profit (% of above)		25%		$3,457,655
	TOTAL DIRECT CAPITAL				$17,288,276

Notes

1 Unit cost backup provided on subsequent sheets

CAPITAL COSTS - OU 3

Item		Units	Quantity	Unit Cost	Extension
Direct Capital					
Purchased Items					
D.2	Sand	ton	284,592	$8.40	$2,390,573
D.3	Armor	ton	94,864	$8.40	$796,858
	Subtotal, purchased items				$3,187,430
Civil Work					
C.1	Mobilization	ls	1	$250,000	$250,000
C.2	Move and startup	season	0	$150,000	$0
C.3	Slurry unit	day	68	$5,400	$367,200
C.4	Additional slurry unit cost for armor	day	34	$8,300	$282,200
C.5	Spreader unit	day	102	$4,500	$459,000
C.6	Field supervision	day	102	$2,800	$285,600
C.7	Winterization	season	0	$100,000	$0
C.8	Demobilization	ls	1	$150,000	$150,000
C.9	Routine maintenance	season	1	$25,000	$25,000
C.10	Bathymetric survey	ea	3	$1,800	$5,400
C.11	Surface water monitoring	day	102	$750	$76,500
C.12	Construction monitoring report	season	1	$50,000	$50,000
C.13	Staging arrea	season	1	$20,000	$20,000
C.14	Electricity	season	1	$6,000	$6,000
C.15	Telephone	season	1	$2,400	$2,400
	Subtotal, purchased equipment and trades				$5,166,730
	Prime contractor administration, overhead & profit (% of above)		25%		$1,291,683
	TOTAL DIRECT CAPITAL				$6,458,413

Notes

1 Unit cost backup provided on subsequent sheets

CAPITAL COSTS - OU4

	Item	Units	Quantity	Unit Cost	Extension
Direct Capital					
Purchased Items					
D.2	Sand	ton	935,088	$8.40	$7,854,739
D.3	Armor	ton	311,696	$8.40	$2,618,246
	Subtotal, purchased items				$10,472,986
Civil Work					
C.1	Mobilization	ls	1	$250,000	$250,000
C.2	Move and startup	season	1	$150,000	$150,000
C.3	Slurry unit	day	223	$5,400	$1,204,200
C.4	Additional slurry unit cost for armor	day	111	$8,300	$921,300
C.5	Spreader unit	day	334	$4,500	$1,503,000
C.6	Field supervision	day	334	$2,800	$935,200
C.7	Winterization	season	1	$100,000	$100,000
C.8	Demobilization	ls	1	$150,000	$150,000
C.9	Routine maintenance	season	2	$25,000	$50,000
C.10	Bathymetric survey	ea	3	$6,100	$18,300
C.11	Surface water monitoring	day	334	$750	$250,500
C.12	Construction monitoring report	season	2	$50,000	$100,000
C.13	Staging arrea	season	2	$20,000	$40,000
C.14	Electricity	season	2	$6,000	$12,000
C.15	Telephone	season	2	$2,400	$4,800
	Subtotal, purchased equipment and trades				$16,162,286
	Prime contractor administration, overhead & profit (% of above)		25%		$4,040,571
	TOTAL DIRECT CAPITAL				$20,202,857

Notes

1 Unit cost backup provided on subsequent sheets

LONG-TERM OPERATING COSTS - OU1

	Item	Units	Quantity	Unit Cost	Extension
	Long Term Monitoring				
O.1	Bathymetric survey	ls	1	$5,200	$5,200
O.2	Core sampling	ea	12	$3,000	$36,000
O.3	Construction monitoring report	ls	1	$50,000	$50,000
		Subtotal			$91,200
		Prime contractor OH & P		10%	$9,120
		Total, long term costs			$100,320

LONG-TERM OPERATING COSTS - OU3

	Item	Units	Quantity	Unit Cost	Extension
	Long Term Monitoring				
O.1	Bathymetric survey	ls	1	$1,800	$1,800
O.2	Core sampling	ea	5	$3,000	$15,000
O.3	Construction monitoring report	ls	1	$50,000	$50,000
		Subtotal			$66,800
		Prime contractor OH & P		10%	$6,680
		Total, long term costs			$73,480

LONG-TERM OPERATING COSTS - OU4

	Item	Units	Quantity	Unit Cost	Extension
	Long Term Monitoring				
O.1	Bathymetric survey	ls	1	$6,100	$6,100
O.2	Core sampling	ea	14	$3,000	$42,000
O.3	Construction monitoring report	ls	1	$50,000	$50,000
		Subtotal			$98,100
		Prime contractor OH & P		10%	$9,810
		Total, long term costs			$107,910

PRESENT WORTH CALCULATION - OU1

i = 7%

Year, n	Capital Costs (construction)	Annual Long-Term Care Costs (post closure)	Sum of Year "n" Costs	Cumulative Costs, Year 1 through n	Present Worth Factor, i	Present Worth of Year "n" Capital Costs Only	Present Worth of All Year "n" Costs	Cumulative Present Worth of All Costs, Year 1 through n
0	$17,288,276		$17,288,276	$17,288,276	1	$17,288,276	$17,288,276	$17,288,276
1			$0	$17,288,276	0.9346	$0	$0	$17,288,276
2			$0	$17,288,276	0.8734	$0	$0	$17,288,276
3			$0	$17,288,276	0.8163		$0	$17,288,276
4			$0	$17,288,276	0.7629		$0	$17,288,276
5			$0	$17,288,276	0.7130		$0	$17,288,276
6			$0	$17,288,276	0.6663		$0	$17,288,276
7		$100,320	$100,320	$17,388,596	0.6227		$62,474	$17,350,750
8			$0	$17,388,596	0.5820		$0	$17,350,750
9			$0	$17,388,596	0.5439		$0	$17,350,750
10			$0	$17,388,596	0.5083		$0	$17,350,750
11			$0	$17,388,596	0.4751		$0	$17,350,750
12		$100,320	$100,320	$17,488,916	0.4440		$44,543	$17,395,293
13			$0	$17,488,916	0.4150		$0	$17,395,293
14			$0	$17,488,916	0.3878		$0	$17,395,293
15			$0	$17,488,916	0.3624		$0	$17,395,293
16			$0	$17,488,916	0.3387		$0	$17,395,293
17			$0	$17,488,916	0.3166		$0	$17,395,293
18			$0	$17,488,916	0.2959		$0	$17,395,293
19			$0	$17,488,916	0.2765		$0	$17,395,293
20			$0	$17,488,916	0.2584		$0	$17,395,293
21			$0	$17,488,916	0.2415		$0	$17,395,293
22		$100,320	$100,320	$17,589,236	0.2257		$22,644	$17,417,937
23			$0	$17,589,236	0.2109		$0	$17,417,937
24			$0	$17,589,236	0.1971		$0	$17,417,937
25			$0	$17,589,236	0.1842		$0	$17,417,937
26			$0	$17,589,236	0.1722		$0	$17,417,937
27			$0	$17,589,236	0.1609		$0	$17,417,937
28			$0	$17,589,236	0.1504		$0	$17,417,937
29			$0	$17,589,236	0.1406		$0	$17,417,937
30			$0	$17,589,236	0.1314		$0	$17,417,937
31			$0	$17,589,236	0.1228		$0	$17,417,937
32		$100,320	$100,320	$17,689,556	0.1147		$11,511	$17,429,447
33			$0	$17,689,556	0.1072		$0	$17,429,447
34			$0	$17,689,556	0.1002		$0	$17,429,447
35			$0	$17,689,556	0.0937		$0	$17,429,447
36			$0	$17,689,556	0.0875		$0	$17,429,447
37			$0	$17,689,556	0.0818		$0	$17,429,447
38			$0	$17,689,556	0.0765		$0	$17,429,447
39			$0	$17,689,556	0.0715		$0	$17,429,447
40			$0	$17,689,556	0.0668		$0	$17,429,447
41			$0	$17,689,556	0.0624		$0	$17,429,447
42		$100,320	$100,320	$17,789,876	0.0583		$5,852	$17,435,299
43			$0	$17,789,876	0.0545		$0	$17,435,299
44			$0	$17,789,876	0.0509		$0	$17,435,299
45			$0	$17,789,876	0.0476		$0	$17,435,299
46			$0	$17,789,876	0.0445		$0	$17,435,299
47			$0	$17,789,876	0.0416		$0	$17,435,299
48			$0	$17,789,876	0.0389		$0	$17,435,299
49			$0	$17,789,876	0.0363		$0	$17,435,299
50			$0	$17,789,876	0.0339		$0	$17,435,299
51			$0	$17,789,876	0.0317		$0	$17,435,299
52			$0	$17,789,876	0.0297		$0	$17,435,299
53			$0	$17,789,876	0.0277		$0	$17,435,299
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Totals	$17,288,276	$501,600	$17,789,876			$17,288,276	$17,435,299	

PRESENT WORTH CALCULATION - OU3

i = 7%

Year, n	Capital Costs (construction)	Annual Long-Term Care Costs (post closure)	Sum of Year "n" Costs	Cumulative Costs, Year 1 through n	Present Worth Factor, i	Present Worth of Year "n" Capital Costs Only	Present Worth of All Year "n" Costs	Cumulative Present Worth of All Costs, Year 1 through n
0	$6,458,413		$6,458,413	$6,458,413	1	$6,458,413	$6,458,413	$6,458,413
1			$0	$6,458,413	0.9346	$0	$0	$6,458,413
2			$0	$6,458,413	0.8734	$0	$0	$6,458,413
3			$0	$6,458,413	0.8163		$0	$6,458,413
4			$0	$6,458,413	0.7629		$0	$6,458,413
5			$0	$6,458,413	0.7130		$0	$6,458,413
6		$73,480	$73,480	$6,531,893	0.6663		$48,963	$6,507,376
7			$0	$6,531,893	0.6227		$0	$6,507,376
8			$0	$6,531,893	0.5820		$0	$6,507,376
9			$0	$6,531,893	0.5439		$0	$6,507,376
10			$0	$6,531,893	0.5083		$0	$6,507,376
11		$73,480	$73,480	$6,605,373	0.4751		$34,910	$6,542,286
12			$0	$6,605,373	0.4440		$0	$6,542,286
13			$0	$6,605,373	0.4150		$0	$6,542,286
14			$0	$6,605,373	0.3878		$0	$6,542,286
15			$0	$6,605,373	0.3624		$0	$6,542,286
16			$0	$6,605,373	0.3387		$0	$6,542,286
17			$0	$6,605,373	0.3166		$0	$6,542,286
18			$0	$6,605,373	0.2959		$0	$6,542,286
19			$0	$6,605,373	0.2765		$0	$6,542,286
20			$0	$6,605,373	0.2584		$0	$6,542,286
21		$73,480	$73,480	$6,678,853	0.2415		$17,746	$6,560,032
22			$0	$6,678,853	0.2257		$0	$6,560,032
23			$0	$6,678,853	0.2109		$0	$6,560,032
24			$0	$6,678,853	0.1971		$0	$6,560,032
25			$0	$6,678,853	0.1842		$0	$6,560,032
26			$0	$6,678,853	0.1722		$0	$6,560,032
27			$0	$6,678,853	0.1609		$0	$6,560,032
28			$0	$6,678,853	0.1504		$0	$6,560,032
29			$0	$6,678,853	0.1406		$0	$6,560,032
30			$0	$6,678,853	0.1314		$0	$6,560,032
31		$73,480	$73,480	$6,752,333	0.1228		$9,021	$6,569,053
32			$0	$6,752,333	0.1147		$0	$6,569,053
33			$0	$6,752,333	0.1072		$0	$6,569,053
34			$0	$6,752,333	0.1002		$0	$6,569,053
35			$0	$6,752,333	0.0937		$0	$6,569,053
36			$0	$6,752,333	0.0875		$0	$6,569,053
37			$0	$6,752,333	0.0818		$0	$6,569,053
38			$0	$6,752,333	0.0765		$0	$6,569,053
39			$0	$6,752,333	0.0715		$0	$6,569,053
40			$0	$6,752,333	0.0668		$0	$6,569,053
41		$73,480	$73,480	$6,825,813	0.0624		$4,586	$6,573,639
42			$0	$6,825,813	0.0583		$0	$6,573,639
43			$0	$6,825,813	0.0545		$0	$6,573,639
44			$0	$6,825,813	0.0509		$0	$6,573,639
45			$0	$6,825,813	0.0476		$0	$6,573,639
46			$0	$6,825,813	0.0445		$0	$6,573,639
47			$0	$6,825,813	0.0416		$0	$6,573,639
48			$0	$6,825,813	0.0389		$0	$6,573,639
49			$0	$6,825,813	0.0363		$0	$6,573,639
50			$0	$6,825,813	0.0339		$0	$6,573,639
51			$0	$6,825,813	0.0317		$0	$6,573,639
52			$0	$6,825,813	0.0297		$0	$6,573,639
53			$0	$6,825,813	0.0277		$0	$6,573,639
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Totals	$6,458,413	$367,400	$6,825,813			$6,458,413	$6,573,639	

PRESENT WORTH CALCULATION - OU4

i = 7%

Year, n	Capital Costs (construction)	Annual Long-Term Care Costs (post closure)	Sum of Year "n" Costs	Cumulative Costs, Year 1 through n	Present Worth Factor, i	Present Worth of Year "n" Capital Costs Only	Present Worth of All Year "n" Costs	Cumulative Present Worth of All Costs, Year 1 through n
0	$20,202,857		$20,202,857	$20,202,857	1	$20,202,857	$20,202,857	$20,202,857
1			$0	$20,202,857	0.9346	$0	$0	$20,202,857
2			$0	$20,202,857	0.8734	$0	$0	$20,202,857
3			$0	$20,202,857	0.8163		$0	$20,202,857
4			$0	$20,202,857	0.7629		$0	$20,202,857
5			$0	$20,202,857	0.7130		$0	$20,202,857
6			$0	$20,202,857	0.6663		$0	$20,202,857
7		$107,910	$107,910	$20,310,767	0.6227		$67,201	$20,270,058
8			$0	$20,310,767	0.5820		$0	$20,270,058
9			$0	$20,310,767	0.5439		$0	$20,270,058
10			$0	$20,310,767	0.5083		$0	$20,270,058
11			$0	$20,310,767	0.4751		$0	$20,270,058
12		$107,910	$107,910	$20,418,677	0.4440		$47,913	$20,317,971
13			$0	$20,418,677	0.4150		$0	$20,317,971
14			$0	$20,418,677	0.3878		$0	$20,317,971
15			$0	$20,418,677	0.3624		$0	$20,317,971
16			$0	$20,418,677	0.3387		$0	$20,317,971
17			$0	$20,418,677	0.3166		$0	$20,317,971
18			$0	$20,418,677	0.2959		$0	$20,317,971
19			$0	$20,418,677	0.2765		$0	$20,317,971
20			$0	$20,418,677	0.2584		$0	$20,317,971
21			$0	$20,418,677	0.2415		$0	$20,317,971
22		$107,910	$107,910	$20,526,587	0.2257		$24,357	$20,342,328
23			$0	$20,526,587	0.2109		$0	$20,342,328
24			$0	$20,526,587	0.1971		$0	$20,342,328
25			$0	$20,526,587	0.1842		$0	$20,342,328
26			$0	$20,526,587	0.1722		$0	$20,342,328
27			$0	$20,526,587	0.1609		$0	$20,342,328
28			$0	$20,526,587	0.1504		$0	$20,342,328
29			$0	$20,526,587	0.1406		$0	$20,342,328
30			$0	$20,526,587	0.1314		$0	$20,342,328
31			$0	$20,526,587	0.1228		$0	$20,342,328
32		$107,910	$107,910	$20,634,497	0.1147		$12,382	$20,354,710
33			$0	$20,634,497	0.1072		$0	$20,354,710
34			$0	$20,634,497	0.1002		$0	$20,354,710
35			$0	$20,634,497	0.0937		$0	$20,354,710
36			$0	$20,634,497	0.0875		$0	$20,354,710
37			$0	$20,634,497	0.0818		$0	$20,354,710
38			$0	$20,634,497	0.0765		$0	$20,354,710
39			$0	$20,634,497	0.0715		$0	$20,354,710
40			$0	$20,634,497	0.0668		$0	$20,354,710
41			$0	$20,634,497	0.0624		$0	$20,354,710
42		$107,910	$107,910	$20,742,407	0.0583		$6,294	$20,361,004
43			$0	$20,742,407	0.0545		$0	$20,361,004
44			$0	$20,742,407	0.0509		$0	$20,361,004
45			$0	$20,742,407	0.0476		$0	$20,361,004
46			$0	$20,742,407	0.0445		$0	$20,361,004
47			$0	$20,742,407	0.0416		$0	$20,361,004
48			$0	$20,742,407	0.0389		$0	$20,361,004
49			$0	$20,742,407	0.0363		$0	$20,361,004
50			$0	$20,742,407	0.0339		$0	$20,361,004
51			$0	$20,742,407	0.0317		$0	$20,361,004
52			$0	$20,742,407	0.0297		$0	$20,361,004
53			$0	$20,742,407	0.0277		$0	$20,361,004
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Totals	$20,202,857	$539,550	$20,742,407			$20,202,857	$20,361,004	

I.D.	Item	Source	Description	Value or Range Provided (rounded)	Value Used for Estimate (rounded)	Basis
D.1	Sand	In-house estimate based on typical availability and price of sand in Fox valley	Cost for purchasing sand for capping and transportation to Site	$8.40	$8.40	Typical cost for similar work. Based on $65 per hour truck and driver, 1.5 hour round trip and 20 ton truck, per ton rate = $4.90. Total sand procurement and transportation = $8.40
D.2	Armor	In-house estimate based on typical availability and price of sand in Fox valley	Cost for purchasing armor to be placed over the cap and transportation to Site	$8.40	$8.40	Typical cost for similar work. Based on $65 per hour truck and driver, 1.5 hour round trip and 20 ton truck, per ton rate = $4.90. Total armor procurement and transportation = $8.40
C.1	Mobilization	Contractor estimate for similar work and typical experience (Bob Lofgren, Lofgren Imagineering and Const. Co., Vancouver, WA)	Mobilize labor and equipment to the Site at the beginning of the project	$250,000	$250,000	Typical cost for similar work
C.2	Move and startup	Contractor estimate for similar work and typical experience (Bob Lofgren, Lofgren Imagineering and Const. Co., Vancouver, WA)	Move equipment from one reach of the river to another reach of the river during the course of the project	$150,000	$150,000	Typical cost for similar work
C.3	Slurry unit	Contractor estimate for similar work and typical experience (Bob Lofgren, Lofgren Imagineering and Const. Co., Vancouver, WA)	Includes labor and equipment to prepare sand slurry for transportation to cap area	$5,350	$5,400	Typical cost for similar work per day basis. Cost breakup for labor and equipment includes, Frontend loader - $1,000, Hopper and Conveyer - $650, Tank - $30, Water supply pump - $420, half booster pump and barge - $1,500 and Slurry pump, 14", 1000 H.P - $1,750. Total - $5,350. Use $5,400.
C.4	Additional slurry unit cost for armor	Contractor estimate for similar work and typical experience (Bob Lofgren, Lofgren Imagineering and Const. Co., Vancouver, WA)	Includes additional labor and equipment required to prepare armor slurry for transportation to placement area	$8,300	$8,300	Includes booster pump and barge - $2,200, slurry pump add/wear - $300 and added pipe/wear - $400. Total - $2,900. Add $5,400 slurry unit cost from C.3. Total - $8,300
C.5	Spreader unit	Contractor estimate for similar work and typical experience (Bob Lofgren, Lofgren Imagineering and Const. Co., Vancouver, WA)	Includes labor and equipment to place sand cap and armor	$4,445	$4,500	Typical cost for similar work per day basis. Cost breakup for labor and equipment includes, Barge, 8 units - $1,450, Winch - $1,050, Fairleads - $60, Building with GPS - $660, Generator - $50, Small tugboat - $950 and Pipeline, 4,000 ft avg - $225. Total - $4,445. Use $4,500.
C.7	Winterization	Contractor estimate for similar work and typical experience (Bob Lofgren, Lofgren Imagineering and Const. Co., Vancouver, WA)	Includes equipment lockdown, servicing and site security	100,000	100,000	Typical cost for similar work.
C.8	Demobilization	Contractor estimate for similar work and typical experience (Bob Lofgren, Lofgren Imagineering and Const. Co., Vancouver, WA)	Dis-assemble equipment, load and haul equipment, materials and site facilities at the termination of the project	$150,000	$150,000	Typical cost for similar work
C.9	Routine maintenance	In-house opinion	Purchased materials and labor to install miscellaneous small and expendible items associated with operations and maintenance. Possible non-routine maintenance requirements included.		$25,000	Typical experience, similar projects.

BASIS OF UNIT COSTS

I.D.	Item	Source	Description	Value or Range Provided (rounded)	Value Used for Estimate (rounded)	Basis
C.6	Field supervision	Contractor estimate for similar work and typical experience (Bob Lofgren, Lofgren Imagineering and Const. Co., Vancouver, WA)	Includes labor for supervision, on-site office, vehicles and legal and accounting charges	$2,790	$2,800	Typical cost for similar work per day basis. Cost breakup includes, Site Superintendent - $700, Site Engg - $600, Office - $550, Vehicles - $140, Survey boat - $300 and Legal and Acct - $500. Total - $2,790. Use $2,800.
C.10	Bathymetric survey	Contractor estimate for similar work and typical experience (Trent Nedens, Onyx Special Services, WI)	Perform bathymetric survey at 100 ft center to center using single beam sonar. Collect sounding lines every 100 ft. Frequency during year 5, 10, 20, 30 and 40 during Long-term Monitoring. Three events per river reach during cap and armor placement - middle of capping, end of capping	$6,072 $1,738 $5,148	$6,100 $1,800 $5,200	Vendor quote per acre = $ 22. Includes labor, equipment, fuel, mob/demob and deliverable (map of bathymetric contours). Total for OU 4 = 276 ac * $22/acre = $6,072 For OU 3 = 79 ac * $22/ac = $1738 For OU 1 = 234 ac * $22/ac = $5148.
C.11	Surface water monitoring	In-house opinion based on prior project experience	Collect 4 surface water samples (1 upstream and 3 downstream) for TSS analysis (Method 160.2). Frequency 1 per day.	$710	$750	Typical cost for similar work. TSS sample - $25*4 = $100, GPS unit = $110, and Env Tech = $500. Total per day = $710. Use $750 to include data validation
C.12	Construction monitoring report	In-house opinion based on prior project experience	Report documenting construction monitoring data		$50,000	Typical cost for similar work.
C.13	Staging arrea	In-house experience in the vicinity	Staging area for office trailer, equipment and materials assuming 10 acres of land is leased. $2,000 per acre per year.		$20,000	Placeholder - Typical cost for leasing rural land in Brown County
C.14	Electricity	Prior project experience	Annual power requirements for equipment, lighting, office trailer etc.		$6,000	This is a placeholder to cover minor electrical usage at the facility.
C.15	Telephone	Prior project experience	Cost of phone service to main operating facility.		$2,400	Placeholder, annual estimated cost.

COST ESTIMATE #20 — **Rev: 10.30.03**
DETAILED EVALUATION OF ALTERNATIVES — **Final**
WDNR - FOX RIVER

PROJECT ELEMENT:
Partial removal in conjunction with capping
Scenario A - OU1

PROCESS METRICS

Assumed quantity of sediment removed upon which original cost estimates were based — 784,000 cy

REMOVAL COST SUMMARY

Cost element	Source of Cost Estimate	Approximate fraction of total cost that is fixed direct capital (1)	Approximate fraction of total cost that is quantity proportional (2)	
Dredging	Final FS	$1,800,000	$18,100,000	
Mechanical dewatering	DEA Estimate #04	$10,700,000	$3,700,000	
Wastewater treatment	DEA Estimate #05	$4,900,000	$1,800,000	
Plant infrastructure	Extrapolated from DEA Estimate #11	$3,000,000	$1,400,000	
Truck transport	DEA Estimate #16	$0	$1,800,000	
Disposal (290,000 tons @ $25/ton)	DEA assumption from within typical range	$0	$7,250,000	
Subtotals		$20,400,000	$34,050,000	
Equivalent cost per cubic yard of sediment removed			$43.43	/cy

Notes

1. These costs would be incurred regardless of the amount of dredging that is performed. They cover the cost of equipment mobilization and facilities construction. Backup is found elsewhere in the DEA cost appendix of in the Final FS.
2. These costs are proportional to the quantity of sediment that is dredged, processed and disposed. For the purposes of this analysis, a simplifying assumption is made that they are linear with respect to quantity.
3. Indirect costs such as institutional controls, engineering and construction management are not included. These are described in detail in the final FS.

COST CALCULATIONS

Quantity dredged	Sum of fixed capital costs	Cost per cy sediment dredged	Subtotal, quantity proportional costs	Extension
0	$20,400,000	$43.43	$0	$20,400,000
100,000	$20,400,000	$43.43	$4,343,112	$24,743,112
200,000	$20,400,000	$43.43	$8,686,224	$29,086,224
300,000	$20,400,000	$43.43	$13,029,337	$33,429,337
400,000	$20,400,000	$43.43	$17,372,449	$37,772,449
500,000	$20,400,000	$43.43	$21,715,561	$42,115,561
600,000	$20,400,000	$43.43	$26,058,673	$46,458,673
700,000	$20,400,000	$43.43	$30,401,786	$50,801,786
800,000	$20,400,000	$43.43	$34,744,898	$55,144,898

PROJECT COST VS. SEDIMENT QUANTITY REMOVED