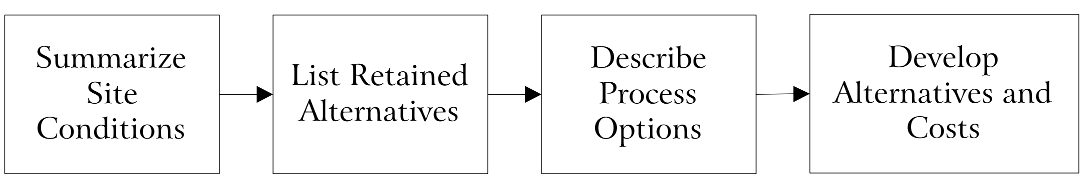
7 Reach-specific Remedial Alternatives

This section of the FS develops and describes a set of potential remedial alternatives for management of contaminated sediment at each of the four river reaches identified for the Lower Fox River and each of the four zones identified for Green Bay. The alternatives were formed based upon an integration of the information and data presented in the RI Report, the BLRA Report, and Section 6 of this FS Report. The seven generic remedial alternatives described in this section were developed by assembling representative retained process options identified in Section 6. In each of the subsections below, reach-specific alternatives and zone-specific alternatives and process options are selected and developed from the list of seven generic alternatives for the project. Each subsection includes a summary of costs for each process option and each alternative, and a figure showing the amount of contaminated sediment volume remaining in place at various action levels.

Selection of remedial alternatives and process options is dependent upon the general and physical constraints found in each river reach or zone. For example, river depth can affect the feasibility of implementing mechanical dredging or the placement of a cap. Physical impediments in or on the water can also affect whether a specific piece of equipment or process option will be applicable to that reach. The reach-specific alternatives must be developed with these limitations in mind. Accordingly, the alternative development begins with a summary of the general and physical site characteristics by reach or zone. This discussion focuses on those characteristics that may affect the implementability of a specific alternative or process option.

The discussion of remedial alternatives for each reach/zone can be summarized as:



Following the discussion of site conditions, the retained list of site-specific alternatives and process options are then described, along with the justification for the specific process options used to implement those alternatives.

The final step includes a detailed discussion of the FS concept design and the costs associated with the specific alternative. The concept design for each alternative includes a specific set of process options, the assumptions made concerning staging and timing of those options, and implementation of the process. Detailed process flow diagrams are developed to visually describe each alternative from excavation or containment through disposal. Detailed costs and assumptions used to develop each remedial alternative for each reach and zone are presented in Appendix H. The detailed cost tables were developed in accordance with the EPA guidance document for developing and documenting cost estimates during feasibility studies (EPA, 2000b). Based on the cleanup action level selection criteria discussed in Section 5, cost estimates were developed for all action levels retained for each of the reaches and zones.

7.1 Basis for Selection of Remedial Alternatives

The goal of the alternative selection process was to provide a wide range of possible cleanup approaches while also limiting the number of alternatives so that the evaluation process remained manageable. In order to achieve this goal, seven generic remedial alternatives were selected and applied to each reach of the river and zone of Green Bay. These generic remedial alternatives were also applied at each of the action levels. The generic alternatives were then modified, as necessary, due to physical and capacity limitations at each of the reaches and zones.

7.1.1 Generic Remedial Alternatives

This section defines the generic remedial alternatives retained for the Lower Fox River and Green Bay, and then describes the technologies that would be applied based on application of the criteria defined in Section 6. The assembled generic remedial alternatives retained for detailed analysis are:

A. No Action,
B. Monitored Natural Recovery and Institutional Controls,
C. Dredge and Off-site Disposal,
D. Dredge to a Confined Disposal Facility (CDF),
E. Dredge and Thermal Treatment,
F. *In-situ* Capping, and
G. Dredge to a Confined Aquatic Disposal (CAD) Facility.

This suite of remedial alternatives is intended to be representative of the remedial alternatives that are available rather than inclusive of all possible approaches. The use of these alternatives in this FS does not necessarily preclude the use of other alternatives for actual cleanup activities, assuming those other alternatives are implementable and effective. A summary of the generic remedial alternatives retained for each river reach and bay zone is shown in Table 7-1. The cleanup processes carried forward as alternatives in the FS are displayed on Figures 7-1 through 7-8. The sediment volume and PCB masses requiring removal for each alternative and action level are summarized in Tables 7-2 and 7-3, respectively.

Alternative A: No Action

The no action alternative was retained as required under CERCLA and the NCP. This alternative serves as a baseline for comparison with other alternatives and involves taking no action towards a remedy, implying no active management or expectation that the RAOs will be achieved over time. The volume of PCB-impacted sediment calculated for each reach/zone and each remedial alternative is summarized in Table 7-2. Cost estimates include minimal sampling for the continued maintenance of consumption advisories.

Alternative B: Monitored Natural Recovery and Institutional Controls

The monitored natural recovery alternative was also retained as a basis for comparison with other alternatives, but involves an expectation that RAOs will be achieved in 40 years (i.e., ability to consume fish from the Lower Fox River). This alternative assumes that institutional controls will remain in place until acceptable levels of risk have been achieved. Monitored natural recovery is implied in many of these alternatives, because each remedy assumes varying amounts of protectiveness by natural processes by selecting a range of different action levels surrounding the SQT levels identified in the risk assessment (Section 3). Each action level and the amount of risk reduction provided by source removal of contaminated sediment will be compared to the amount of remaining risk and the costs associated with each action level. An active multi-metric long-term monitoring program will be implemented for the MNR alternative. Cost estimates include 40 years of monitoring (assuming 10 years of active or non-active remediation in selected areas and 30 additional years of recovery).

Alternative C: Dredge and Off-site Disposal

Removal and off-site disposal was retained for long-term source control and liability management. Disposal of dredged sediments can be effective and implementable, and provides a basis of comparison for other treatment and disposal options. In addition, this approach can be used for the management of sediment with TSCA-level concentrations (i.e., PCB concentrations greater than 50 ppm). In all cases, disposal would be at an NR 500 landfill. For the purposes of this FS, a generic tipping fee and haul distance were assumed rather than evaluating specific landfills and their available capacity or siting a new landfill. Acceptance at a nearby landfill is considered likely and is reflected by recent removal of land bans for contaminated sediment disposal in some communities.

Figures 7-1 through 7-4 provide an illustration of the process options associated with the generic dredge and off-site disposal remedial alternative.

Alternative D: Dredge to a Confined Disposal Facility (CDF)

Conceptual nearshore CDFs were sited in the Little Lake Butte des Morts and De Pere to Green Bay reaches of the Lower Fox River, and an in-water CDF was sited in Green Bay. Capacity limitations of the Lower Fox River CDFs are discussed in Section 7.1.3 and summarized in Table 7-4. The size of the CDF in Green Bay was varied to provide the necessary capacity at each action level. Nearshore CDF construction in the Lower Fox River includes placement of steel sheet piles along the waterside and a clean soil cap once the CDF has been filled to capacity. In-water CDF construction in Green Bay includes placement of contaminated sediment in an elevated cellular cofferdam and capping with clean sand. Completed CDFs could be used for recreation or habitat upon completion. Figure 7-5 provides an illustration of the process options associated with the generic dredge to a CDF alternative. This illustration also includes the removal and off-site disposal of TSCA-level sediment, which would not be placed in on-site CDFs.

Alternative E: Dredge and Thermal Treatment

Vitrification was retained as the representative thermal treatment process option. As discussed in Section 6, a multi-phased study was conducted by WDNR on sediment from the Lower Fox River to determine operational data, treatment effectiveness and cost-effectiveness of vitrification. The results from the multi-phased study conducted by WDNR demonstrate that thermal treatment is a feasible option for treatment of dredged sediment. The results from the multi-phased study are discussed in Section 6 and detailed in Appendix G. Figure 7-6 provides a schematic of the generic dredge and thermal treatment remedial alternative.

Alternative F: *In-situ* Capping

Several sand cap designs were retained in Section 6 for possible application in the Lower Fox River/Green Bay project. Design factors that influenced the final selection of an *in-situ* cap included an evaluation of capping materials and cap thickness when applied in the field. In general, sandy sediments are suitable capping material, with the additional option of armoring at locations with the potential for scouring and erosion. Geotextiles are often applied in areas with limited water depths or specialized site conditions. Laboratory tests that have been developed in the past indicate a minimum thickness of 30 cm of *in-situ* capping is required to isolate contaminated sediments (EPA, 1994a). Considering the above-mentioned design factors and physical characteristics of the Lower Fox River, a 20-inch sand cap overlain by 12 inches of graded armor stone has been selected as the representative process option for all locations. However, several cap designs may be applicable during final design and implementation. Full-scale design would require consideration of currents during storm events, vessel draft depths, wave energy, and ice scour. As discussed in Section 6, a minimum river depth of 7 to 9 feet is required for any location where a cap is proposed. Figure 7-7 illustrates the process options included in the generic *in-situ* sediment capping remedial alternative.

Alternative G: Dredge to a Confined Aquatic Disposal (CAD) Facility

Construction of a CAD is only technically feasible in Green Bay. Three possible locations were sited in the FS based on bathymetry, water depth, and currents. Each location was assumed to provide enough capacity for each action level. Construction of the CAD includes placement of contaminated sediment in a mechanically-dredged excavation and covering the sediment with 3 feet of clean sand after placement. Figure 7-8 provides an illustration of the activities associated with dredging PCB-impacted sediment and placing sediment in a CAD.

7.1.2 Retained Action Levels

The PCB remedial action levels developed and retained in Section 5 were based on the SQTs derived in the Lower Fox River/Green Bay risk assessment discussed in Section 3. The array of PCB remedial action levels are:

- **Lower Fox River -** 125, 250, 500, 1,000, and 5,000 ppb; and
- **Green Bay -** 500, 1,000, and 5,000 ppb.

A range of action levels is considered for the project to balance the feasibility of removing PCB-contaminated sediment down to each action level (implementability, effectiveness, duration, and cost) with the residual risk to human and ecological receptors after remediation. The 125 ppb and 250 ppb action levels were dropped from the Green Bay Area because the large volumes of sediment requiring removal precluded practical disposal options. The level of residual risk considered acceptable for each alternative will require a decision-making process with the support of long-term modeling efforts. One of the outcomes of developing a range of action levels and alternatives is the adoption of monitored natural recovery (MNR) when sediment is left in place that is above the SQTs. As a result, each action level and each remedial alternative will likely have an MNR component.

7.1.3 Physical and Capacity Limitations

In some cases, the generic alternative may be limited due to physical or capacity constraints. In such cases, a combination of alternatives is required to address the entire volume of impacted sediment. Combinations of alternatives required to implement a complete remedial strategy are included in the sections for each specific reach or zone. A summary of the physical and capacity limitations for each reach of the Lower Fox River is presented in Table 7-4. CDF capacity is limited by the availability of appropriate sites, cap areas are limited by hydrodynamic properties, and thermal treatment volume is limited by vitrification unit capacity and operating parameters. Capping and thermal treatment are not proposed for any zones in Green Bay, and it was assumed that CDF or CAD capacity in Green Bay is unlimited.

7.1.4 Summary of Selected Remedial Alternatives

A summary of the selected remedial alternatives for each reach of the Lower Fox River and zone of Green Bay is presented in Table 7-1, with more detail provided in the subsequent sections. Each reach of the Lower Fox River (Little Lake Butte des Morts, Appleton to Little Rapids, Little Rapids to De Pere, and De Pere to Green Bay) is discussed separately. Green Bay zones 2A and 2B are combined into one remedial area based on similar site conditions and volumes/ concentrations of PCB-contaminated sediment. Green Bay zones 3A and 3B are discussed separately because of different depositional patterns and site characteristics. Green Bay Zone 4 was retained as a separate remedial area from the other zones because of low but wide-spread concentrations of PCBs located in a deeper lake environment.

7.1.5 Basis for Costs

Cost summaries for each alternative include capital costs, labor costs during construction, and long-term operation and maintenance costs (operation and maintenance for 40 years). The long-term cost estimates include interest rates at 6 percent valued at net present day worth. Cost tables also include a separate line item for 20 percent contingency costs. At WDNR's request, the total costs presented herein and carried forward in the FS do not include the 20 percent contingency costs.

Unit costs developed for dredging, treatment, long-term maintenance, disposal costs, dewatering ponds, and construction of new landfills were generated from a variety of sources including, but not limited to: the Lower Fox River pilot demonstration projects at SMU 56/57 and Deposit N, Montgomery-Watson Basis of Design Report for SMU 56/57 (Montgomery-Watson, 1998) for dewatering estimates, a thermal treatment pilot demonstration project using Fox River sediments and a *Unit Cost Study for Commercial-Scale Sediment Melter Facility, Supplement to Glass Aggregate Feasibility Study* (Minergy Corporation, 2002b) for thermal treatment unit costs, the Lower Fox River/Green Bay RI Report (RETEC, 2002a) for site conditions and *in-situ* percent solids, Ogden-Beeman and Associates (OBAI) for dredging and piping costs, and WDNR along with other state officials for local siting fees, tipping fees, disposal and acceptance to in-state landfills, construction of new landfills, and monitoring costs. Unit costs were also developed from cost estimates obtained directly from suppliers and services (i.e., sand and gravel pits, carbon filter treatment, construction of cellular cofferdam), USACE guidance documents, and experience gained from other remediation projects.

7.1.6 Section 7.1 Figures and Tables

Figures and tables for Section 7.1 follow page 7-8 and include:

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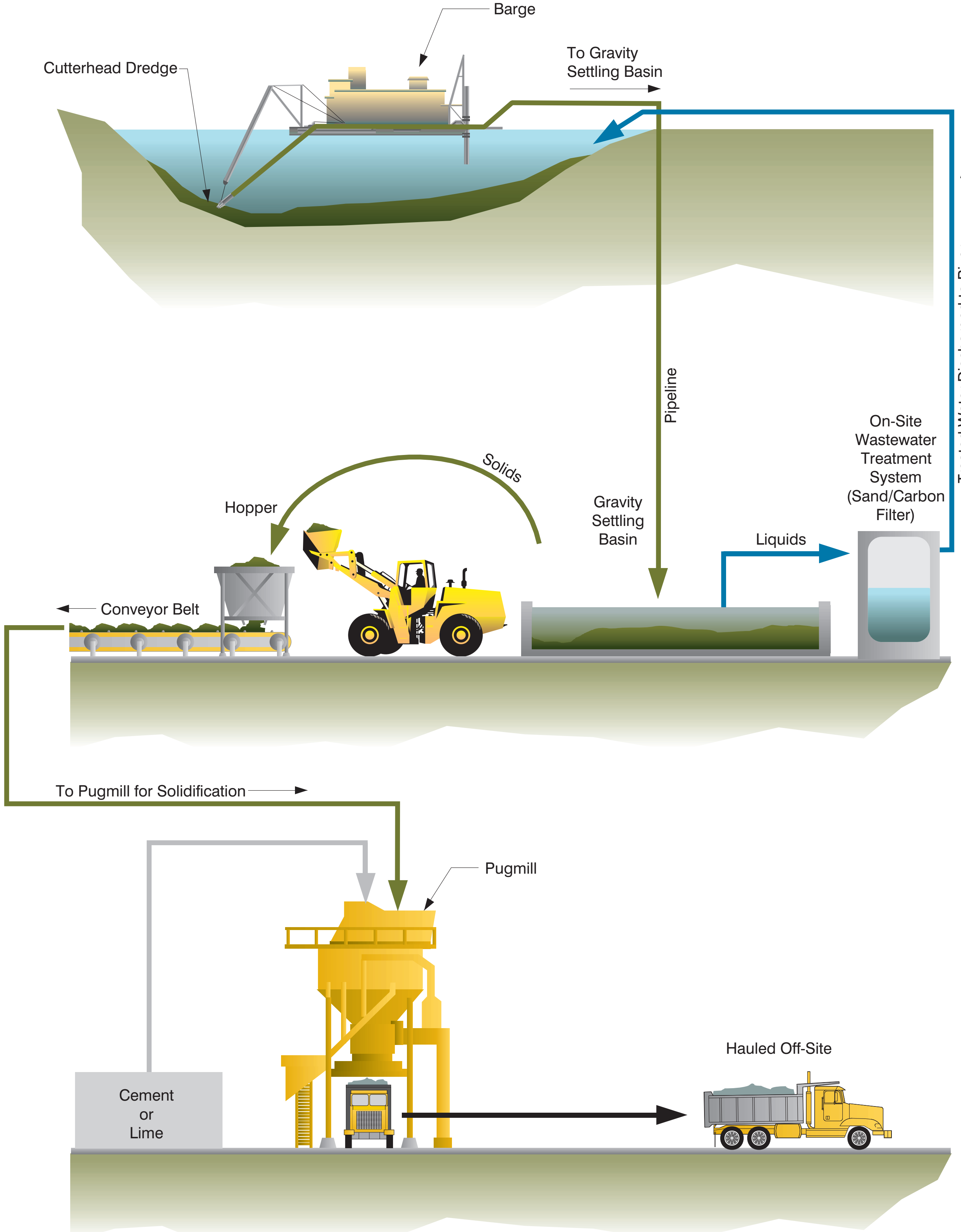
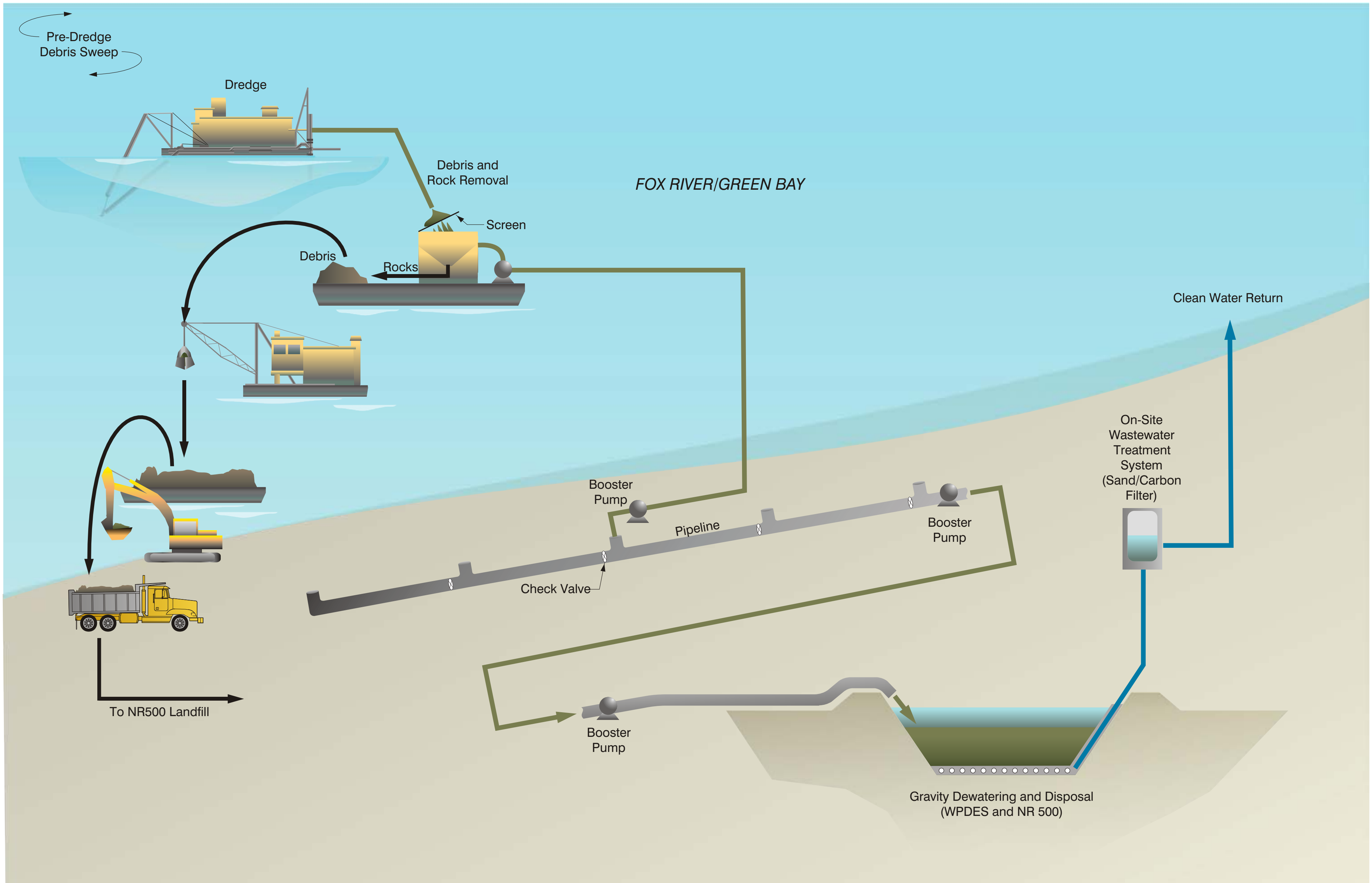
Figure 7-1 Lower Fox River Cleanup Alternative Process Dredge and Off-site Disposal

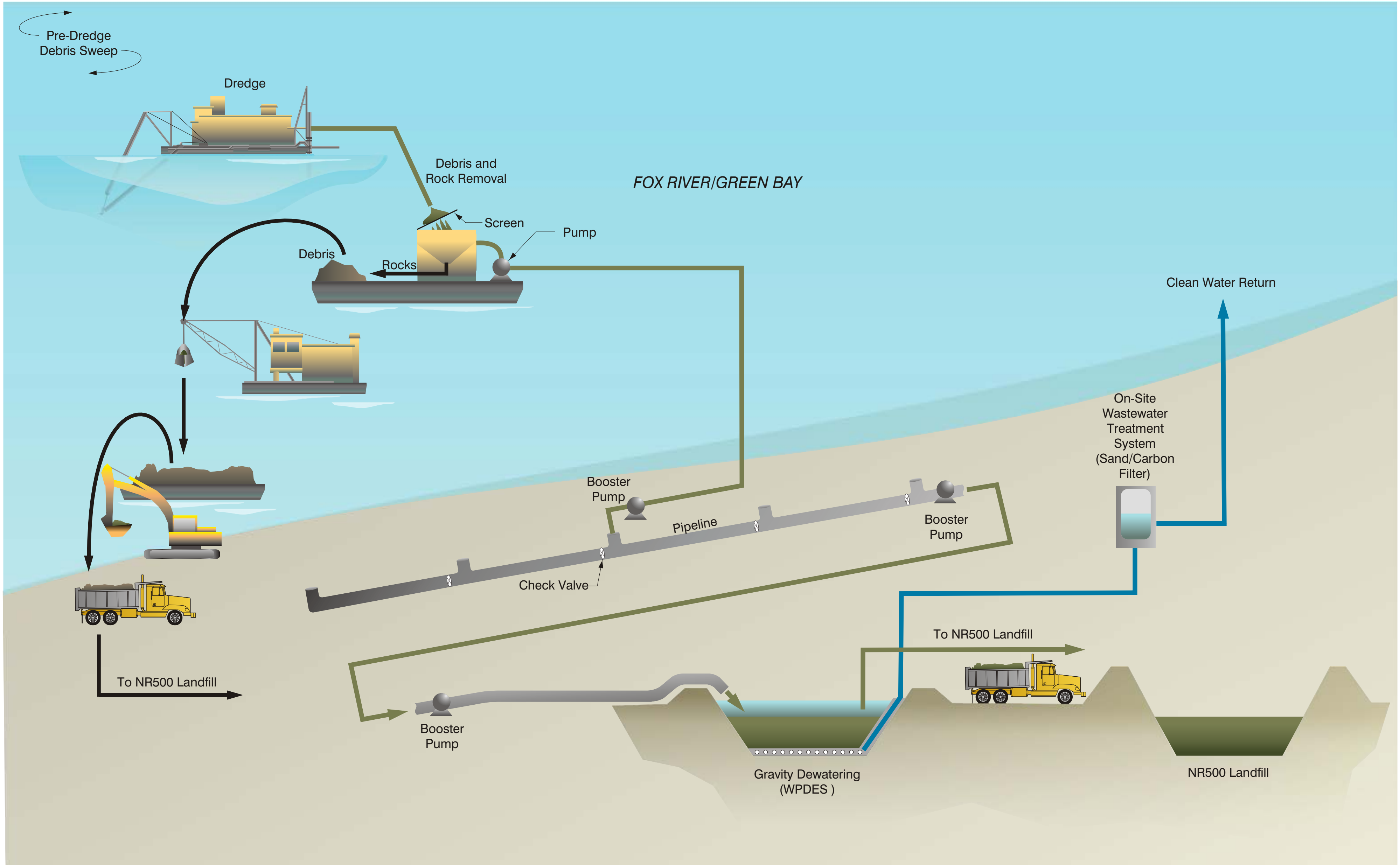


03/29/00 Chart3.cdr

7-2 Lower Fox River Cleanup Alternative C2A
Process Dredge and Off-site Disposal



7-3 Lower Fox River Cleanup Alternative C2B
Process Dredge and Off-site Disposal



7-4 Lower Fox River Cleanup Alternative C3
Process Dredge and Off-site Disposal

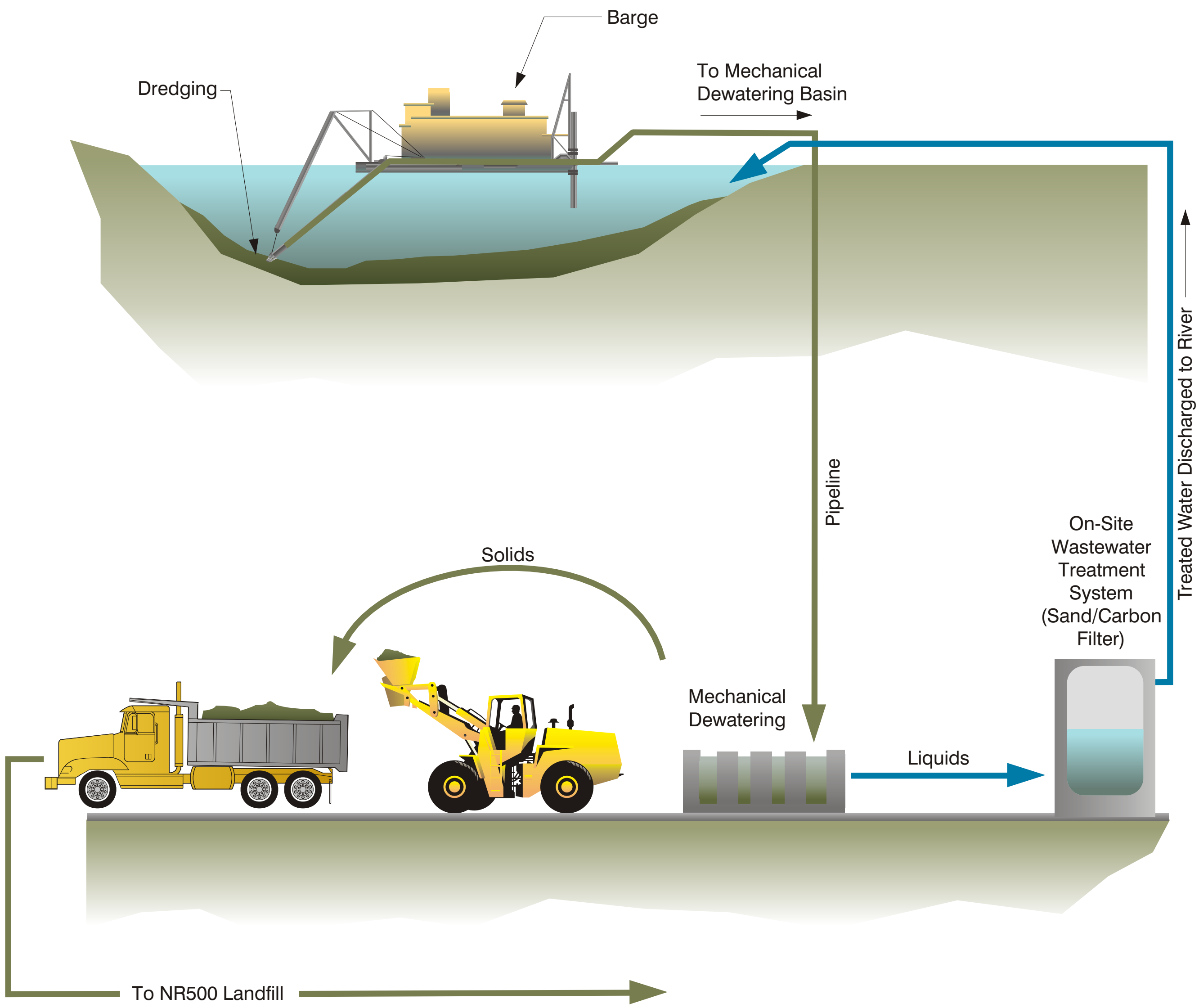
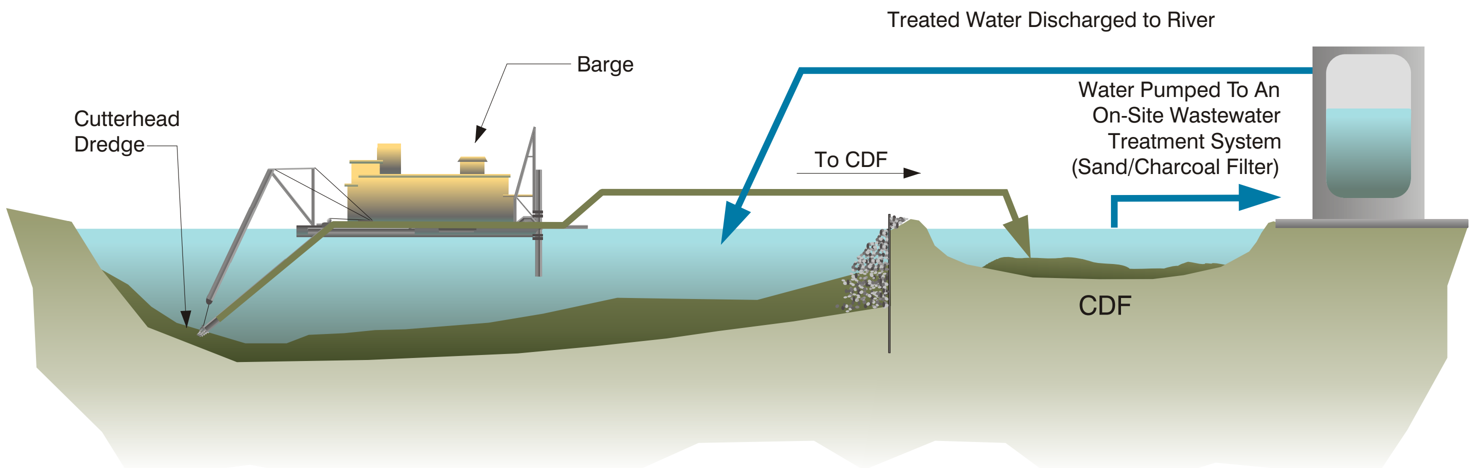
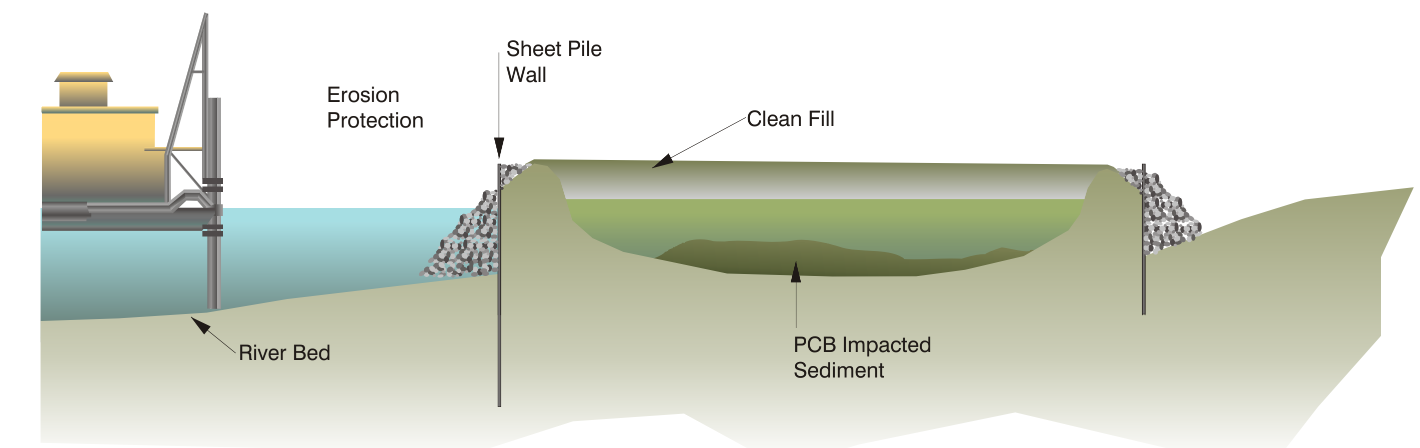


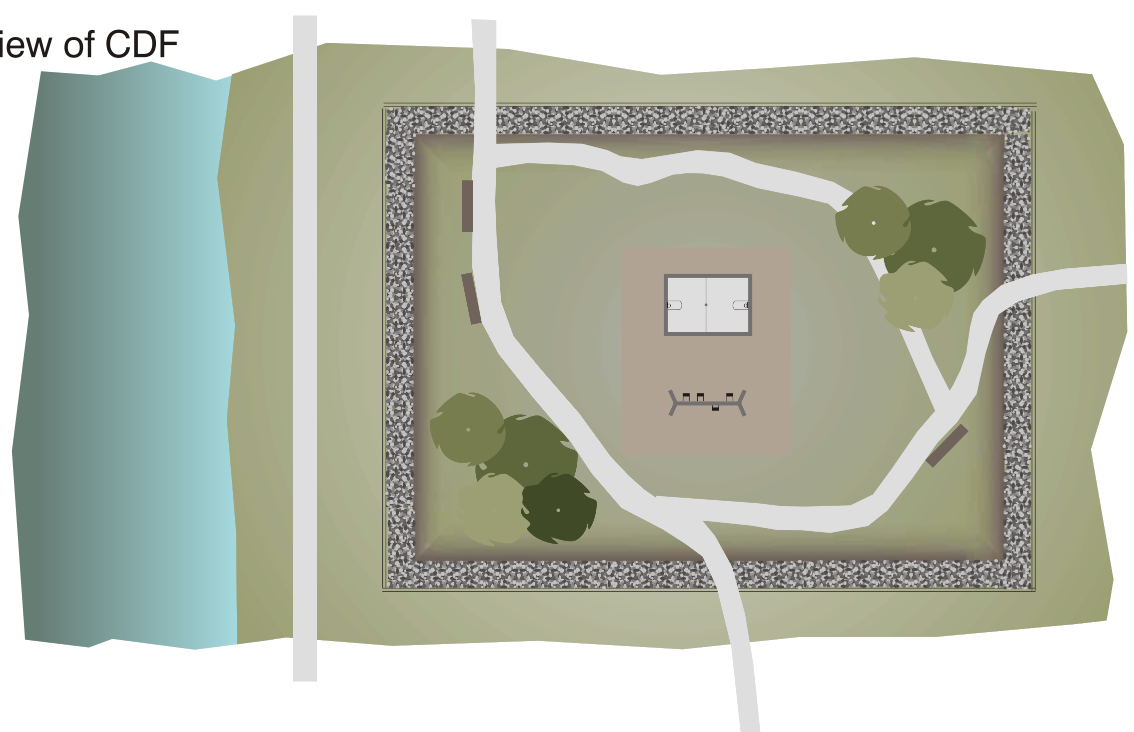
Figure 7-5. LowerFox River Cleanup Alternative Process Dredge and Disposal to Confined Disposal Facility (Non-TSCA Sediments)



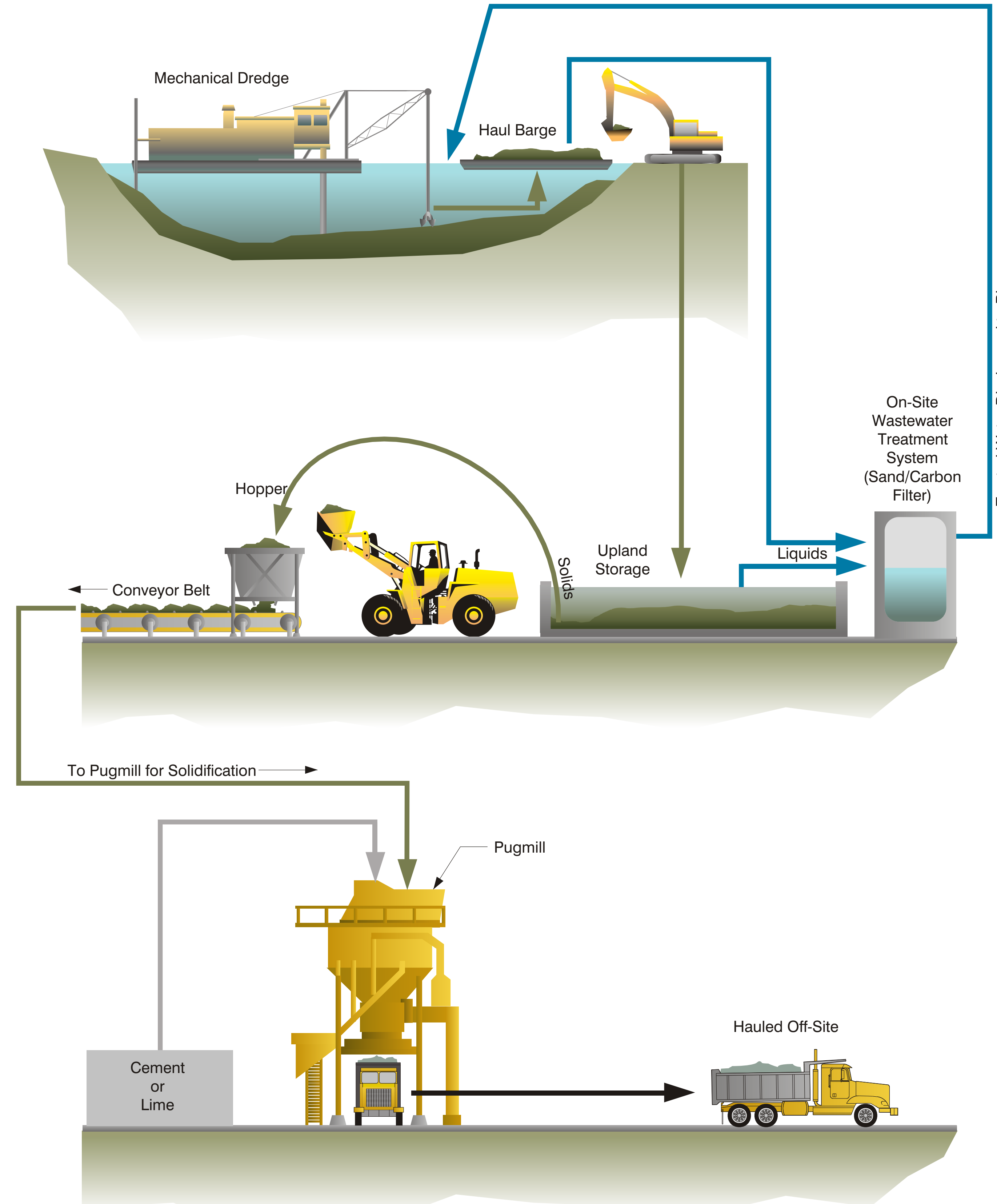
Side View of CDF



Plan View of CDF



Off-site Disposal of TSCA Sediments



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7-6 Lower Fox River Cleanup Alternative
Process Dredge and Thermal Treatment

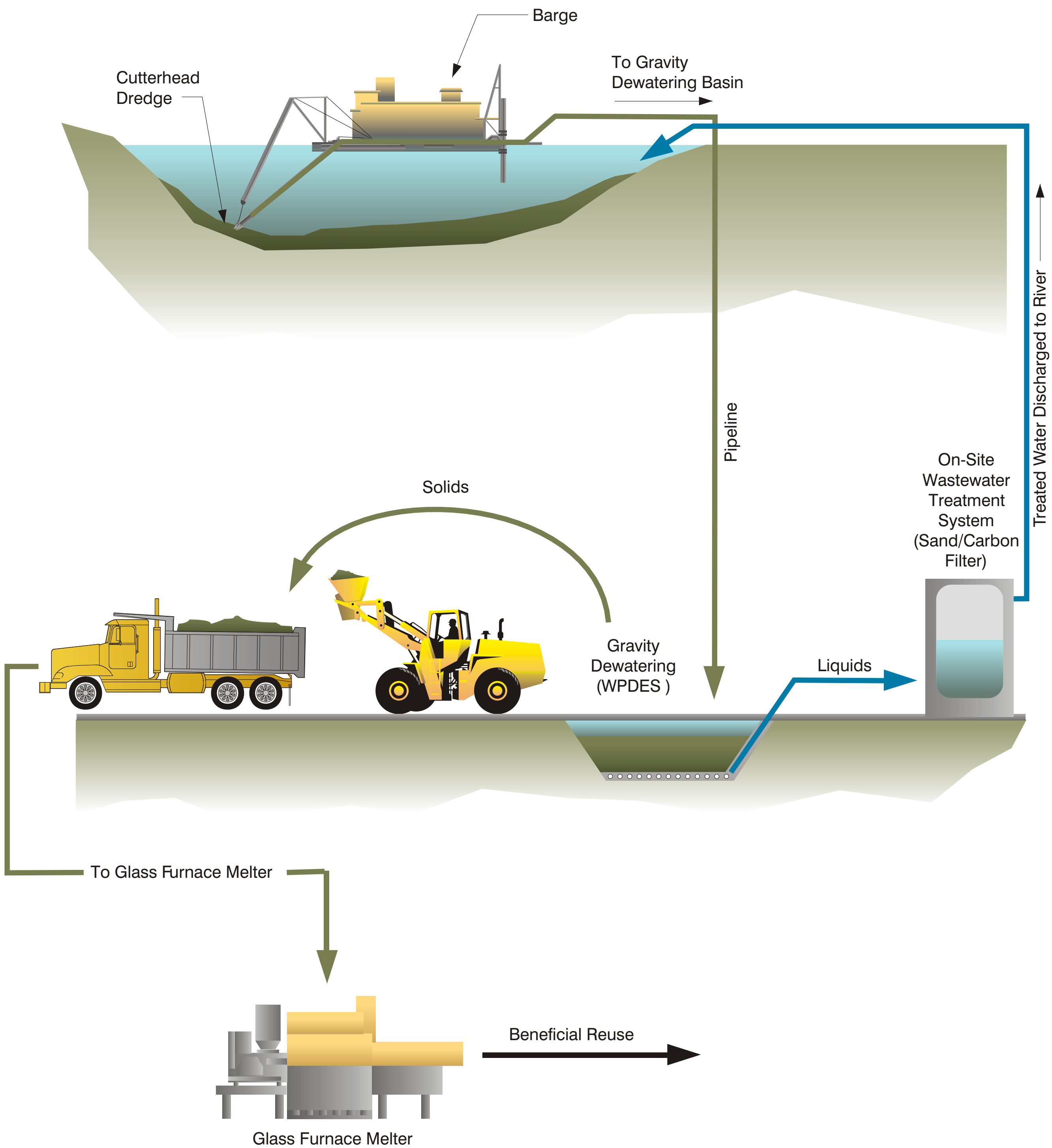

Figure 7-7. Lower Fox River Cleanup Alternative Process *In Situ* Sediment Capping

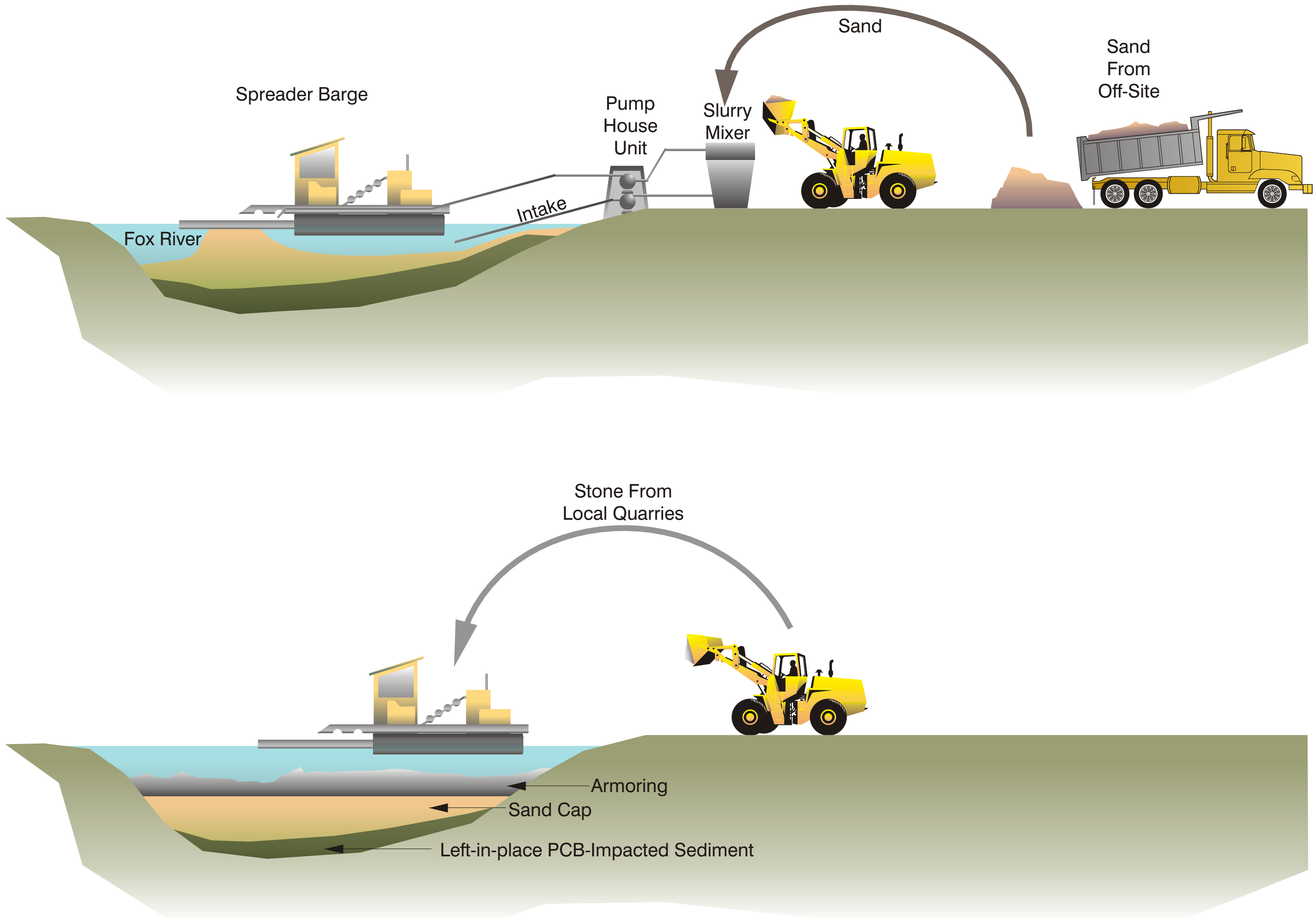

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Figure 7-8. Lower Fox River Cleanup Alternative Process Sediment Cap and Partial Dredge Remaining Sediments

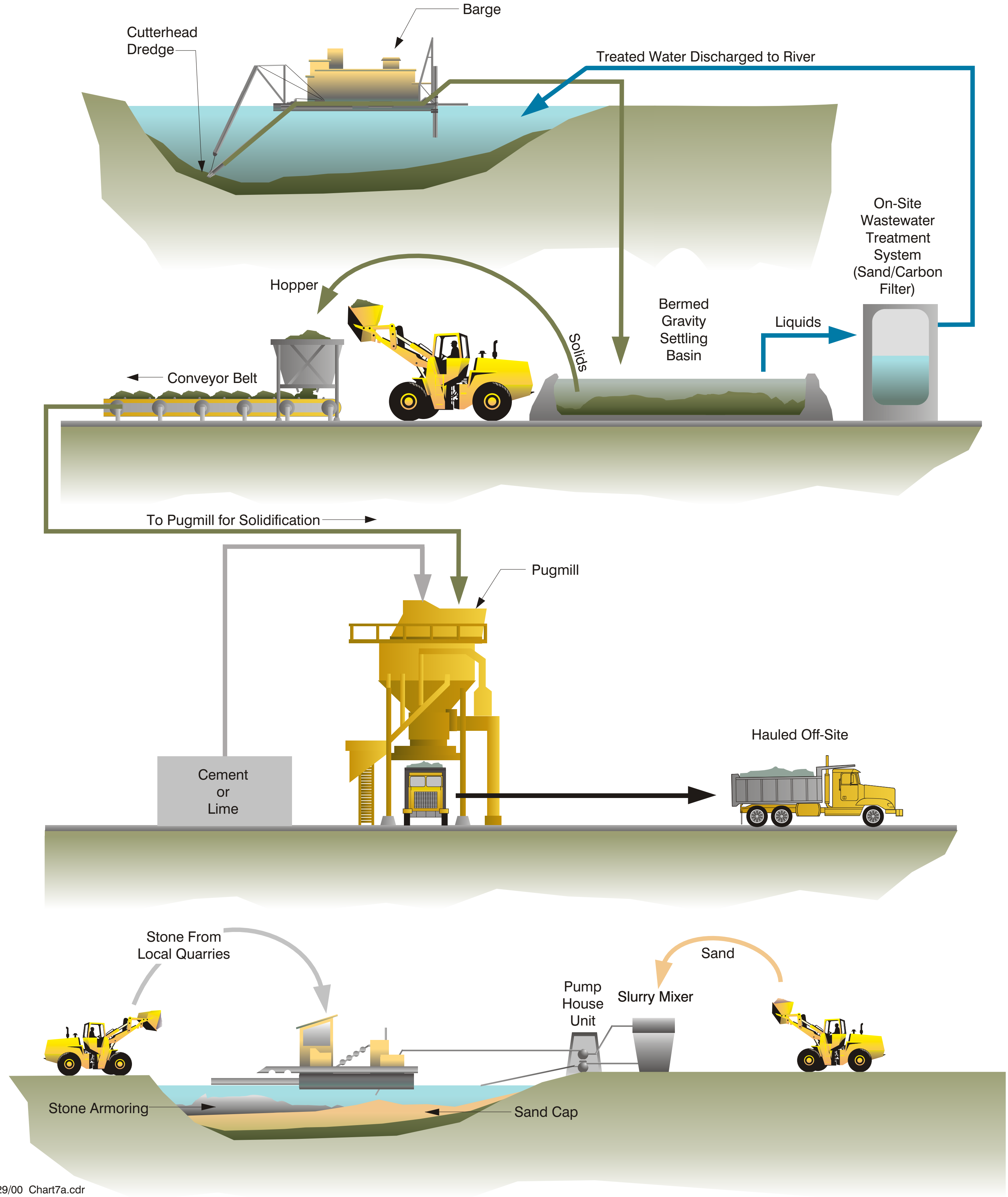

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Table 7-1 Summary of Selected Generic Remedial Alternatives

Alternative Description		Lower Fox River Reaches				Green Bay Zones			
		Little Lake Butte des Morts	Appleton to Little Rapids	Little Rapids to De Pere	De Pere to Green Bay	Zone 2	Zone 3A	Zone 3B	Zone 4
A	No Action	✔	✔	✔	✔	✔	✔	✔	✔
B	Monitored Natural Recovery and Institutional Controls	✔	✔	✔	✔	✔	✔	✔	✔
C	Dredge and Off-Site Disposal [1, 2, 3]	✔	✔	✔	✔	✔	✔		
D	Dredge to Confined Disposal Facility (CDF)	✔		✔	✔	✔	✔	✔	
E	Dredge and Thermal Treatment	✔	✔	✔	✔				
F	Cap in Place	✔		✔	✔				
G	Dredge to Confined Aquatic Disposal (CAD) Facility					✔	✔	✔	

Notes:

1. The Little Lake Butte des Morts Reach also includes Alternative C1 for passive dewatering and Alternative C2 for mechanical dewatering.
2. The Little Rapids to De Pere and De Pere to Green Bay reaches both include an Alternative C1 for mechanical dredging and Alternative C2 for hydraulic dredging (with a long slurry pipeline to a dedicated NR 500 monofill). Alternative C2 is further divided into Alternative C2A for slurry pipeline directly to the dedicated NR 500 monofill and Alternative C2B utilized an intermediate passive dewatering pond prior to disposal at an existing NR 500 commercial disposal facility.
3. The Little Rapids to De Pere and De Pere to Green Bay reaches both include an Alternative C3 for hydraulic dredging, mechanical dewatering, and ground transportation to a commercial landfill.

Table 7-2 Volume Allocation Table

Reach/Zone [2, 3]	Action Level (ppb)	Impacted Volume (cy) [6]	TSCA Volume (cy) [6]	Dredge Area (acres)	Alternative C: Dredge and Off-site Disposal (cy)	Alternative D/G: Dredge, CDF/CAD, and Off-site Disposal[1] (cy)		Alternative E: Dredge and Thermal Treatment[4] (cy)	Alternative F: Cap in Place, then Dredge to CDF and Off-site Disposal [5] (cy)		
						CDF/CAD	Off-site	Thermal Treatment	Cap	CDF	Off-site
Little Lake Butte des Morts	125	1,689,173	16,165	761	1,689,173	1,673,008	16,165	1,705,338	435,300	1,237,708	16,165
	250	1,322,818	16,165	697	1,322,818	1,306,653	16,165	1,338,984	323,701	982,952	16,165
	500	1,023,621	16,165	625	1,023,621	1,007,456	16,165	1,039,786	252,057	755,398	16,165
	1,000	784,192	16,165	526	784,192	768,027	16,165	800,358	148,646	619,381	16,165
	5,000	281,689	16,165	174	281,689	265,524	16,165	297,855	59,055	206,469	16,165
Appleton to Little Rapids	125	182,450	0	119	182,450	0	0	182,450	0	0	0
	250	80,611	0	73	80,611	0	0	80,611	0	0	0
	500	56,998	0	48	56,998	0	0	56,998	0	0	0
	1,000	46,178	0	34	46,178	0	0	46,178	0	0	0
	5,000	20,148	0	13	20,148	0	0	20,148	0	0	0
Little Rapids to De Pere	125	1,483,156	0	739	1,483,156	1,483,156	0	1,483,156	898,136	0	585,020
	250	1,171,585	0	665	1,171,585	1,171,585	0	1,171,585	760,521	0	411,065
	500	776,791	0	498	776,791	776,791	0	776,791	492,979	0	283,812
	1,000	586,788	0	328	586,788	586,788	0	586,788	416,370	0	170,418
	5,000	186,348	0	173	186,348	186,348	0	186,348	136,188	0	50,160
De Pere to Green Bay	125	6,868,500	240,778	1,130	6,868,500	2,136,771	4,731,729	7,109,278	2,187,936	2,136,771	2,543,793
	250	6,449,065	240,778	1,103	6,449,065	2,136,771	4,312,293	6,689,843	2,015,618	2,136,771	2,296,675
	500	6,169,458	240,778	1,083	6,169,458	2,136,771	4,032,687	6,410,236	1,926,748	2,136,771	2,105,939
	1,000	5,879,529	240,778	1,034	5,879,529	2,136,771	3,742,758	6,120,307	1,833,253	2,136,771	1,909,504
	5,000	4,517,391	240,778	715	4,517,391	2,136,771	2,380,620	4,758,169	1,415,350	2,136,771	965,269
Green Bay Zone 2	500	29,748,004	0	—	0	29,748,004	0	0	0	0	0
	1,000	29,322,254	0	—	0	29,322,254	0	0	0	0	0
	5,000	4,070,170	0	—	4,070,170	4,070,170	0	0	0	0	0
Green Bay Zone 3A	500	16,328,102	0	—	0	16,328,102	0	0	0	0	0
	1,000	14,410	0	—	14,410	14,410	0	0	0	0	0
Green Bay Zone 3B	500	43,625,096	0	—	0	43,625,096	0	0	0	0	0
Green Bay Zone 4	500	0	0	—	0	0	0	0	0	0	0

Notes:

[1] Alternative G applies to Green Bay zones only.

[2] Volume of *in-situ* material removed (cy) is represented in rows.

[3] Alternatives A and B are not shown on this table, but volume allocations for No Action, MNR, and Institutional Controls are the same as the Impacted Volume (cy) quantities.

[4] Assume no off-site disposal costs for treated sediments.

[5] Cap to maximum extent possible, then dredge to CDF. Take TSCA material off site.

[6] These values include any overburden material located above the impacted sediments of interest, therefore, these values may differ slightly from the values presented in Sections 2 and 5.

Table 7-3 PCB Mass Allocation Table

Reach/Zone [2]	Action Level (ppb)	Density (tons/cy) *In Situ* [3]	PCB Mass (kg) [6]	Alternative C: Dredge and Off-site Disposal (kg)	Alternative D/G: Dredge, CDF/CAD, and Off-site Disposal[1] (kg)		Alternative E: Dredge and Thermal Treatment[4] (kg)	Alternative F: Cap in Place, then Dredge to CDF and Off-site Disposal [5] (kg)		
					CDF/CAD	Off-site	Thermal Treatment	Cap	CDF	Off-site
Little Lake Butte des Morts	125	0.99	1,838	1,838	1,820	18	1,838	474	1,347	18
	250		1,814	1,814	1,792	22	1,814	444	1,348	22
	500		1,782	1,782	1,754	28	1,782	439	1,315	28
	1,000		1,715	1,715	1,680	35	1,715	325	1,355	35
	5,000		1,329	1,329	1,253	76	1,329	279	974	76
Appleton to Little Rapids	125	0.98	106	106	0	0	106	0	0	0
	250		99	99	0	0	99	0	0	0
	500		95	95	0	0	95	0	0	0
	1,000		92	92	0	0	92	56	0	36
	5,000		67	67	0	0	67	43	0	24
Little Rapids to De Pere	125	1.08	1,210	1,210	1,210	0	1,210	884	0	326
	250		1,192	1,192	371	821	274	380	371	441
	500		1,157	1,157	383	774	283	362	383	412
	1,000		1,111	1,111	385	726	284	347	385	379
	5,000		798	798	290	508	214	249	290	259
De Pere to Green Bay	125	1.05	26,620	26,620	26,620	0	26,620	0	0	0
	250		26,581	26,581	26,581	0	26,581	0	0	0
	500		26,528	26,528	26,528	0	26,528	0	0	0
	1,000		26,433	26,433	26,433	0	26,433	0	0	0
	5,000		24,950	24,950	24,950	0	24,950	0	0	0
Green Bay Zone 2	500	1.18	29,896	0	29,896	0	0	0	0	0
	1,000		29,768	0	29,768	0	0	0	0	0
	5,000		6,113	6,113	6,113	0	0	0	0	0
Green Bay Zone 3A	500	1.01	2,156	0	2,156	0	0	0	0	0
	1,000		2	2	2	0	0	0	0	0
Green Bay Zone 3B	500	1.01	4,818	0	4,818	0	0	0	0	0
Green Bay Zone 4	500	1.01	0	0	0	0	0	0	0	0

Notes:

[1] Alternative G applies to Green Bay zones only.

[2] If multiple disposal/treatment options were available in an alternative, PCB mass was assumed to be distributed proportional to total sediment mass.

[3] Density values obtained from appendix of RI Report (2000).

[4] Assume no off-site disposal costs for treated sediments.

[5] Cap to maximum extent possible, then dredge to CDF. Take TSCA material off site.

[6] These values include any overburden material located above the impacted sediments of interest, therefore, these values may differ slightly from the values presented in Sections 2 and 5

Table 7-4 Physical, Capacity, and Process Limitations

Reach [3]	PCB Action Level (ppb)	CDF Volume (m^3)	Cap Volume (m^3) [2]	Thermal Treatment Volume (tons) [4]
Little Lake Butte des Morts	1.25250500e+16	1,337,963 [1] 1,337,963 [1] 1,337,963 [1] 1,337,963 [1] 1,337,963 [1]	3.3229e+28	2.145500e+34
Appleton to Little Rapids	1.25250500e+16	0	0	2.145500e+34
Little Rapids to De Pere	1.25250500e+16	0	6.8560e+29	6.440001e+34
De Pere to Green Bay	1.25250500e+16	9.7480e+29	2.6550e+34	6.440001e+34

Notes:

1 The CDF dredge volume capacity in the Little Lake Butte des Morts Reach includes the Arrowhead Park CDF (750,000 cy) and the Menasha CDF (1 million cy).

2 The required cap volume decreases with higher action levels as the surface area footprint for each subsequent action level decreases.

3 No limitations for the Green Bay zones.

4 The thermal treatment volume capacity is based on vitrification unit information provided by Minergy (2002a, 2002b). The capacities assume one-250 glass tons per day integrated storage vitrification unit for Little Lake Butte des Morts and Appleton to Little Rapids reaches and two-375 glass tons per day standalone storage vitrification units for Little Rapids to De Pere and De Pere to Green Bay reaches.

7.2 Little Lake Butte des Morts Reach

An overview of the Little Lake Butte des Morts Reach and PCB-impacted sediments is shown on Figure 7-9. The retained alternatives and associated costs are presented in Table 7-5.

7.2.1 General Site Characteristics

Little Lake Butte des Morts is located principally within Winnebago County, and is bordered by the communities of Neenah, Menasha, and Appleton (Figure 7-9). Land use in the vicinity of the lake is a combination of both industrial and residential.

The river within this reach is generally broad and shallow at the southern end, narrowing and deepening as the river flows north and constricts in the vicinity of Stroebe Island near Appleton. As discussed in Section 5, most of the depositional areas identified as requiring remediation are in the southern part of the reach (deposits A, C, POG, and D) where water depths are shallow, generally between 3 and 7 feet, and flow is reduced. Water depths average about 4 to 5 feet at deposits A and B. North (downstream) of the railroad bridge, the water depth ranges from 2 feet nearshore to 13 feet in the federal channel near Stroebe Island, and then deepens to 23 feet as the river narrows at Appleton. General water depths are presented in Ocean Surveys (1998).

Average stream velocity in Little Lake Butte des Morts is 0.49 ft/s (0.15 m/s), with 100-year maximum flows predicted at 2.82 ft/s (0.86 m/s). Average and 100-year flows were given in Table 2-1. The nature and extent of PCB-impacted sediments in this reach, as summarized in the RI, includes the following:

- Maximum detected concentration - 222,722 μg/kg (avg. 15,043 μg/kg),
- Total PCB mass - 1,874 kg,
- Total PCB-impacted volume - 1,533,205 m^3, and
- Maximum PCB sample depth - 150 to 200 cm depth in Deposit E.

These quantities represent total volumes/masses represented in each modeled depth layer (RETEC, 2002a). Required dredge volumes described later in this section will likely be larger since they account for overburden volumes above deeper sediment layers that contain PCBs.

Physical impediments to sediment management in Little Lake Butte des Morts include the railroad bridge that transects the river between the Menasha Lock on the eastern shore and Fritse Park on the west, and the State Highway 10 bridge that crosses Deposit E. The railroad bridge is sufficiently low to prevent the on-water movement of dredging equipment between the southern and northern portions. Underwater structures that must be considered include existing water intake lines for Eggers Industries and Kimberly-Clark, located in Deposit A. The Eggers Industries line is abandoned, but the Kimberly-Clark line is still active. Neenah Slough flows through Arrowhead Park, and must be considered with any action involving deposits A, B, or C.

7.2.2 Selected Remedial Alternatives

This section defines the remedial alternatives for the Little Lake Butte des Morts Reach, and then describes the retained technologies that would be applied based upon application of the criteria defined in Section 6. The remedial alternatives retained for Little Lake Butte des Morts include the following:

A. No action.

B. Monitored natural recovery of the system with the expectation that institutional controls will be removed within 40 years.

C. Remove all river sediment with PCB concentrations greater than the selected action level and dispose of dredged sediment in an existing NR 500 commercial disposal facility.

D. Remove sediment with PCB concentrations exceeding the selected action level and place non-TSCA sediments in an on-site nearshore CDF. Transport TSCA sediments (greater than 50 ppm PCBs) to an existing NR 500 commercial disposal facility.

E. Remove sediment with PCB concentrations exceeding the selected action level and treat this sediment using thermal treatment. Treated sediment may be beneficially reused.

F. Place a sand cap over contaminated sediments to the maximum extent practicable. Mechanically remove all TSCA sediments from cap areas prior to capping and dispose in an existing NR 500 commercial disposal facility. Dredge remaining sediment and place dredged sediment in a CDF.

Alternative G is not retained for the Little Lake Butte des Morts Reach. Construction of a CAD in Little Lake Butte des Morts is not practical in shallow water depths and limited space. The process options that can be applied to the remedial alternatives are described below.

7.2.3 Description of Process Options

Monitoring

Monitoring of physical, chemical, and biological media is applicable for Alternatives B through F. The no action alternative may also require monitoring of fish tissue for maintenance of pre-existing fish consumption advisories. As discussed in the technology screening process, monitoring is grouped into five categories: 1) baseline monitoring prior to remediation to establish baseline conditions for future comparisons, 2) monitoring during implementation, 3) post-verification monitoring to verify completion of a remedy, 4) long-term construction monitoring of containment facilities and sediment caps to verify continued source control and physical integrity, and 5) long-term monitoring to verify effectiveness of the remedy and attainment of the project RAOs. Numerous reference documents confirmed the necessity of a well-developed monitoring plan in order to verify the success of an implemented remedy, to measure the effectiveness and stability of source control measures, and to verify the achievement of project RAOs (EPA, 1998a, 1994a; IJC, 1997; SMWG, 1999; Krantzberg *et al.*, 1999). The following references were used in this FS Report to assess the types and applicability of monitoring options commonly used on sediment remediation projects:

- Washington State Department of Ecology (Ecology), *Standards for Confined Disposal of Contaminated Sediments Development Document* (Ecology, 1990);
- USACE, *Monitoring Considerations for Capping* (USACE, 1992);
- EPA and USACE, *Design, Performance, and Monitoring of Dredged Material Confined Disposal Facilities in Region 5* (EPA, 1996b);
- USACE, *Selected Tools and Techniques for Physical and Biological Monitoring of Aquatic Dredged Material Disposal Sites* (Fredette *et al.*, 1990);
- *Guidance for Subaqueous Dredged Material Capping* (Palermo, 1995);
- *Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories, Volume 1: Fish Sampling and Analysis* (EPA, 1995a);
- *Assessment and Remediation of Contaminated Sediments (ARCS) Program - Assessment Guidance Document* (EPA, 1994a);

- *Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites* (EPA, 1999b);

- Sediment remediation case study projects presented in Appendices B and D of the FS.

Specific monitoring programs will be developed for each remedial alternative and will likely include physical, chemical, and biological monitoring components. Baseline monitoring generally includes water, sediment, and tissue quality sampling. Monitoring during implementation includes air and surface water sampling to assess downstream and off-site transport of contaminants. Verification monitoring includes surface and possibly subsurface sediment sampling to ensure compliance with the target goals of the remediation project. Source control monitoring includes groundwater and surface sediment sampling around the containment facility to confirm proper maintenance, stability, and chemical isolation. Long-term monitoring focuses primarily on fish, bird, and invertebrate tissue sampling and reproductive assessments, but also includes sediment and water sampling for chemical quality. The proposed *Long-term Monitoring Plan* for the Lower Fox River and Green Bay remediation project is presented in Appendix C.

Institutional Control Options

Institutional controls appropriate to Little Lake Butte des Morts include:

- Maintenance of the fish and waterfowl consumption advisory;

- A moratorium on any future dredging within the navigation channel;

- Deed restrictions on any in-water activities that could result in sediment disturbance (e.g., marina construction or over-water development);

- Access restrictions to contaminated areas (i.e., Arrowhead Park);

- Continued restriction on the use of the Lower Fox River for domestic water supplies; and

- A long-term (40-year) monitoring program for sediments, water, bird, and fish PCB and mercury levels.

Implementation of these institutional controls will likely require an active public education program for the fish, waterfowl, and domestic water advisories. Deed and access restrictions may require local or state legislative action to prevent any development in contaminated areas of the river. Access and use restrictions would also apply to local Indian tribes. Finally, federal action may be necessary on any dredging moratoriums within the federal navigation channel.

Removal Process Options

Sediment removal is identified for Alternatives C through F. For the Little Lake Butte des Morts Reach, the most practicable dredging option for large-scale removal is hydraulic dredging. The relatively shallow water depths and large volumes within the reach preclude wide-scale application of a mechanical dredge or excavator. However, mechanical dredging is practicable and better suited to remove the relatively small volumes (estimated at 16,000 cy) of sediment exceeding 50 mg/kg PCBs (TSCA level) that needs to be processed separately. In shallow areas with low to moderate flow velocities, dry excavation may be a cost-effective and appropriate removal technology depending upon site conditions and selected disposal sites.

Dredge Equipment. For the purposes of this FS, a hydraulic cutterhead dredge (round or horizontal auger) with a 10-inch pipeline has been selected for the remedial alternatives identified in this reach where a hydraulic dredge would be employed. While larger dredges are available, use of the 10-inch pipeline allows a greater degree of control over resuspension of contaminated sediments during removal operations, provides for a removal time frame of less than 10 years, and limits the size required of a gravity dewatering pond or structure. The operating assumption is that dredging would occur only during normal daylight hours (10 hours per day) during a normal work week (5 days per week), since Little Lake Butte des Morts includes residential areas. Winter weather conditions are likely to preclude operations; as a result, dredging is assumed to occur only between April and October (26 weeks per year) when the average minimum temperature is above freezing.

Both the round and horizontal auger cutterheads are commonly employed hydraulic dredges, with multiple capable portable dredges in the small- to medium-size range available in the Great Lakes region. Required operator experience and skills are also available in the region. Sediment remedial demonstrations by public agencies (i.e., ARCS Program Remediation Guidance Document [EPA, 1994a] and Environment Canada [SEDTEC, 1997]) have highly rated the small horizontal auger dredge for contaminated sediment removal. A horizontal auger equipped with two 10-inch pipelines and a 12-inch pipeline, for example, was employed at the Manistique Superfund site and the SMU 56/57 demonstration project in the Lower Fox River, respectively. A suitable alternative is the small cutterhead dredge; the cutterhead is the only hydraulic dredge capable of effective operations if debris or compacted sediments are present. A ladder cutterhead was successfully used at the Deposit N demonstration project on the Lower Fox River.

A mechanical dredge would be employed for removal of small volumes of sediment with greater than 50 mg/kg PCBs that require separate management. A mechanical bucket can be deployed with greater accuracy and precision to minimize the volume of sediments and free water that must be managed. For this river reach, a small (3-cy) closed clamshell environmental bucket mounted on a shallow-draft (3 feet) barge could be used in the remedial alternatives. To move the sediments to shore, shallow-deck barges fitted with sideboards to contain contaminated sediments and associated water would be used.

Containment Systems. In-water containment systems placed around the dredging area are commonly implemented on both mechanical and hydraulic dredging projects to minimize sediment resuspension downstream of the dredging operation. Typical containment barrier systems range from expensive sheet pile walls (i.e., GM Foundry, Bayou Bonfouca), to silt curtains (i.e., West Eagle Harbor, Bayou Bonfouca, River Raisin), and inexpensive oil booms (PSNS Pier D) (Appendix B). Silt curtains are the most commonly used containment device for lakes, rivers, and estuaries, but are prone to disturbance from passing ships, strong winds, and currents. Effectiveness of silt curtains depends upon local site conditions, bottom substrate, and curtain design; and therefore may not be applicable for every site. Silt curtains were used at both the Lower Fox River demonstration projects. Based on the successful performance of the dredging operations and curtains at Deposit N, use of silt curtains was discontinued during the second removal phase with minimal water quality exceedances measured downstream. For the purposes of this FS, silt curtains were included in the removal costs despite site performance during the Deposit N project.

Over-dredge. All dredging is assumed to occur within a defined footprint to a fixed cut depth. When possible, approximately 8 inches of over-dredge of material beyond the estimated maximum depth of impacted sediment will likely be implemented to ensure complete removal of the targeted contaminant mass (*Sediment Technologies Memorandum*, Appendix B). However, for the purposes of this FS, over-dredge was not included in volume or cost estimates to allow comparability and consistency between different action levels and reaches.

Dewatering Process Options

For the majority of the alternatives utilizing hydraulic dredging in the Little Lake Butte des Morts Reach, dewatering has been configured as a two-step process using a gravity settling pond followed by solidification of solids. The water would be treated using flocculation, clarification, and sand filtration prior to discharge back to the river. For the alternatives involving upland off-site disposal (Alternatives C and E), the gravity settling pond would be located in Arrowhead Park. For the dredge to CDF alternatives (Alternatives D and F), dewatering would be conducted directly within the CDF (discussed in detail below). A mechanical dewatering option has also been included for cost comparison in Alternative C2.

The proposed dewatering system would meet the criteria defined in Section 6 of this FS Report, in terms of production rate, effectiveness, practicability, and discharge water quality. The dewatering system would operate 24 hours per day near residential areas. Assuming adequate land space can be secured, a passive dewatering system is preferable to active mechanical dewatering because of lower noise impact to the surrounding community and reduced operational costs. Final selection of the dewatering process will be determined during the remedial design phase.

Passive Dewatering. Alternative C1 would include the construction of two approximately 9-acre gravity separation ponds in Arrowhead Park. The ponds would be enclosed with earthen berms to allow a ponding depth of 8 feet and lined with asphalt pavement. Each settling pond would receive dredged sediment in 13-week increments and, therefore, contain a full season of dredge slurry. After a pond is filled, the sediment would be allowed to dewater to 20 percent solids, based on dewatering studies (Montgomery-Watson, 1998). Residual water would be drained, treated, and discharged. Sediment would be removed in preparation for the next dredge season. If geophysical properties are a limiting factor for siting the dewatering ponds at Arrowhead Park, an alternative location or approach for dewatering would be required.

For the dewatering operations of mechanically-dredged TSCA sediment (Alternatives D and F), limited capacity barges (500 cy) would be used. Dewatering of sediments would occur by allowing the solids to gravity settle in the barge, and collecting the free water for treatment and discharge.

Solidification. The solids content after dewatering for the hydraulic or mechanical dredging is assumed to be 20 percent (weight per weight [w/w]) and may still be difficult to manage due to high moisture content. Prior to any off-site shipment, the sediment would be solidified to improve handling and to satisfy requirements for solid waste hauling on public roads and disposal, if necessary. It was assumed that solidification was necessary and that the sediment would be solidified with the addition of cement, lime, pozzolan, or other appropriate reagents. Pozzolan is an inert material often mixed with lime to create a cemented end product. For FS costing purposes, 10 percent (w/w) lime was added as the reagent. This was the reagent added (without problems) during the Lower Fox River SMU 56/57 demonstration project (Montgomery-Watson, 1998, 2000). The sediment will be mixed with the reagent and removed from the pond using standard earthmoving equipment . If the contractor prefers, sediment may first be removed from the settling pond and mixed with reagent in a pug mill as shown on Figures 7-1 and 7-5. Numerous other cost-effective reagents are available that may be tested and used for implementation of a remedial action.

Mechanical Dewatering. A mechanical dewatering option (Alternative C2) is included for cost comparison to passive dewatering (Little Lake Butte des Morts only). Mechanical dewatering may also be used for Alternative E. Final selection of a dewatering process will be determined during the design phase. Mechanical dewatering involves pumping the hydraulically-dredged slurry into conditioning tanks or ponds, where the slurry is adjusted to the appropriate solids content, and chemicals are added to assist in the dewatering process. Mechanical dewatering would include shaker screens and hydrocyclones or belt filter presses after initial conditioning. Based on dewatering results from both of the Lower Fox River demonstration projects, the estimated percent solids of the filter cake after shaker screen, hydrocyclones, and belt filter presses ranged between 40 and 60 percent solids (Foth and Van Dyke, 2000; Fort James *et al.*, 2001).

Treatment Process Options

Water Treatment. Prior to water discharge back to the river, supernatant water would pass through flocculation, clarification, and sand filtration systems. Based on the acceptable performance of the sand filter unit during the Deposit N demonstration project, no additional water treatment is deemed necessary (Foth and Van Dyke, 2000). However, additional granular activated carbon (GAC) treatment may be added to the treatment train during removal operations if effluent water quality criteria is exceeded. The estimated unit cost for GAC carbon treatment is $0.40 per thousand gallons of water treated.

Thermal Treatment. Several on-site treatment process options were retained from the screening process in Section 6 that are applicable to the Lower Fox River/Green Bay remediation project. However, only vitrification was selected for costing purposes because the multi-phased study conducted by WDNR has provided data which indicates that this treatment technology is a viable option.

A full-scale vitrification unit will be constructed for the Little Lake Butte des Morts Reach. The facility will be integrated into the operation of an adjacent industrial facility with which it can share resources and is equipped with on-site storage capacity. Passive dewatered sediment enters the plant and is dried to approximately 10 percent moisture in the dryer unit. The sediment is mixed with a fluxing material and fed into a large melter, capable of maintaining temperature around 2,900 ˚F. The sediment melts into a molten material and passes through the water bath for quenching resulting in glass aggregate.

For the purposes of this FS, sediment treatment by vitrification is assumed to occur over a time frame of 10 years. The vitrification process is assumed to operate 24 hours per day, 7 days per week, and 350 days per year. The unit will be designed to have a capacity of processing 613 tons of sediment per day and produce 250 tons of glass aggregate per day.

On-site Disposal Process Options

Two CDFs are proposed for the Little Lake Butte des Morts Reach. The first CDF is proposed as a nearshore facility at the south end of the lake at Arrowhead Park (Figure 7-10). The second CDF is proposed as a peninsula built into the river over most of Deposit POG to the northeast edge of the railroad bridge at Menasha (Figure 7-11). In both cases, the CDF design and location were selected to minimize impacts to upland riparian habitat and landowners.

The CDF at Arrowhead Park would consist of two contained structures: one in Arrowhead Park and the other encompassing Deposit A at Menasha, in front of the Kimberly-Clark facility. This arrangement accommodates a channel for the Neenah Slough. Contaminated sediments from within the slough area would be dredged into the CDF, and the shoreline backfilled with clean sediments to create a potential wetland area. Dredged sediment capacity at the Arrowhead CDF is estimated to be 750,000 cy.

The second facility at Menasha would be placed completely in-water, and would require rubblemound jetties at the southern and northern ends to protect the backwater areas from erosion. A peninsula CDF was selected in order to allow for maintenance of the existing navigation channel from the Menasha Lock. The dredged sediment capacity at the Menasha CDF is approximately 1 million cy.

The concept for all Lower Fox River CDFs is a hybrid of the solids retention and hydraulic isolation designs discussed in Section 6. PCBs are predominately tied to the solids fraction of the sediments, but may dissolve and be carried at low concentrations in pore water. As such, the design includes placement of a steel sheet pile wall driven to 30 feet below the final grade elevation into the relatively impervious clay layer underlying much of the soft sediments. Using this configuration, it should not be necessary to line the bottom of the CDF. The overall height of the CDF would be above the 100-year flood level, approximately 6 feet above the normal elevation of the river. The retention berms would be constructed with riprap to prevent flood or ice damage to the CDF.

As stated in Section 6, in-water CDFs are unlikely to be permitted for the placement of untreated TSCA-level sediments. Dredged TSCA-level sediments will be transported off-site to an appropriate disposal facility.

During hydraulic dredging, the CDF would be utilized as a gravity-settling pond, with the overflow water decanted and filtered. Upon completion of dredging, the sediment would be allowed to further settle, and eventually would be capped with 3 feet of clean sediment and revegetated. Long-term use of the CDF surface could include a park or multi-use open space. As the Lower Fox River sediments are relatively low in organic debris, a methane collection system is not expected to be needed for the CDF.

No CAD sites are feasible in this stretch of the river because of water depth, current velocity, and accessibility.

Off-site Disposal Process Options

All sediment samples collected to date from Little Lake Butte des Morts indicate that the PCB concentrations are below 500 ppm. EPA TSCA 40 CFR regulations (Parts 750 and 761) define PCB-contaminated material as containing more than 50 ppm but less than 500 ppm PCBs. Therefore, all sediment could be shipped to a landfill that conforms to the NR 500 WAC requirements and has received approval per WDNR's agreement with EPA for the disposal of TSCA-level sediments.

Capping Process Options

For the Little Lake Butte des Morts Reach, the water flow velocities are too high to allow placement of a conventional sand cap (Palermo, 1995). For the purposes of this FS, it has been assumed that an armored cap is required. As discussed in Section 7.1.1, the cap would consist of 20 inches of sand overlain with 12 inches of armoring. The areal extent of the cap would be limited to those areas where the minimum average water depth is 9 feet, so that the final water depth is no less than 6 feet in order to allow the use of recreational power boats and prevent disturbance from ice scour. Any TSCA-level sediment will be mechanically dredged prior to capping.

7.2.4 Development of Alternatives and Associated Costs

This section describes the remedial alternatives developed for the Little Lake Butte des Morts Reach. Each remedial alternative includes a process description, a process flow diagram, and a summary cost table. Summary costs presented as net present worth in this FS include a line item for 20 percent contingency costs (Table 7-5). Details used to develop each cost estimate are provided in Appendix

H. The process flow diagrams and dredging/capping footprints for each retained alternative are presented on Figures 7-12 through 7-20.

The following components are discussed for each alternative, when applicable:

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

Alternative A: No Action

As required under the NCP, a no action alternative is included for Little Lake Butte des Morts. This alternative involves taking no action and relying on natural processes, such as natural attenuation, dispersion, dilution, and sedimentation to reduce contaminant quantities and/or concentrations and control contaminant migration processes. This alternative implies that no active remediation is employed; however, some institutional controls, such as access or resource use restrictions may be employed to reduce risks until RAOs are achieved. This alternative includes costs for 5-year fish tissue sampling events for maintenance of fish consumption advisories that are already in place.

The estimated cost for no action and maintenance of consumption advisories currently in place is $4,500,000, which does not include a contingency cost. Engineered cost evaluations typically include a 20 percent contingency cost added to the remedy costs, as shown in the cost tables as a separate line item.

Alternative B: Monitored Natural Recovery/Institutional Controls

The monitored natural recovery option will include a long-term monitoring program (40-year) for measuring PCB, DDE, and mercury levels in water, sediment, invertebrates, fish, and birds. The monitoring program will be developed to effectively measure achievement of and progress towards the project RAOs expected in 40 years. Monitoring components will likely be collected between 2- and 5-year intervals for the first 10 years, and include pre- and post-remedy sampling events to establish baseline conditions. Monitoring frequency may be modified after 5 years based on initial monitoring results. More specifically, the monitoring program will likely include (see Appendix C for the proposed *Long-term Monitoring Plan* for the project):

- Surface water quality sampling at several stations along the reach to determine the downstream transport of PCB mass into Green Bay (RAOs 1 and 4);
- Fish and waterfowl tissue sampling of several species and size classes to determine the residual risk of PCB and mercury consumption to human receptors (RAO 2);
- Fish (several species and size classes), bald eagle, and invertebrate tissue sampling to determine the residual risk of PCB, DDE, and mercury uptake to environmental receptors (RAO 3);
- Population studies of birds (bald eagles and double-crested cormorants) to assess the residual effects of PCBs, DDE, and mercury on reproductive viability (RAO 3); and
- Surface sediment sampling in MNR areas to assess potential recontamination from upstream sources, and status of attenuation of sediments (RAO 4).

Until the project RAOs have been achieved, institutional controls will be required to prevent exposure of human and biological receptors to contaminants. Institutional controls may also be implemented in combination with many of the proposed remedial alternatives and may include monitoring, access restrictions, deed restrictions, dredging moratoriums, fish consumption advisories, and domestic water supply restrictions. Deed and access restrictions may require local or state legislative action to prevent any development in contaminated areas of the river. Items included in institutional control costs include public education programs for fish or health advisories, 5-year fish tissue collection efforts for maintenance of consumption advisories, and deed restrictions.

The estimated cost for long-term monitoring and maintenance of institutional controls is $9,900,000. Engineered cost evaluations typically include a 20 percent contingency cost added to the remedy costs, as shown in the cost tables as a separate line item.

Alternative C: Dredge and Off-site Disposal

Alternative C includes the removal of sediments with concentrations greater than the remedial action level with a hydraulic dredge and off-site disposal of the sediments. To compare cost differences between dewatering techniques, Alternative C1 uses passive dewatering and Alternative C2 uses mechanical dewatering. Figures 7-12 and 7-13 provide the process flow diagrams for this remedial alternative while Figure 7-14 illustrates the extent of residual contamination following implementation of Alternative C. The summary costs to implement Alternative C are provided in Table 7-5. Detailed supporting costs are provided in Appendix H. The total volume of sediment to be dredged in this alternative ranges between 1,689,173 cy for 125 ppb and 281,689 cy for 5,000 ppb action levels.

Site Mobilization and Preparation. Staging for the dredging of the sediments south of the railroad bridge would be conducted at Arrowhead Park. Site mobilization and preparation at Arrowhead Park includes securing the onshore property area for equipment staging, constructing the sediment dewatering ponds, water treatment, sediment storage, and truck loading. Offshore, a docking facility for the hydraulic dredges would be constructed. Estimated property purchase and preparation costs are included in the process components.

For the purposes of the FS, staging for the dredging of the sediments north of the railroad bridge will be on property located adjacent to the Menasha Locks. This facility is solely for the purpose of docking the hydraulic dredging equipment—the dredge slurry will still be pumped to Arrowhead Park. Estimated property purchase and construction costs for the docking facility are included in the process components.

Sediment Removal. Sediment removal would be conducted using a 10-inch pipeline cutterhead hydraulic dredge. Given the volumes and operating assumptions described in Section 7.2.3, the complete removal effort would range from 12.4 years for 125 ppb to 2.1 years for 5,000 ppb action levels. Pipelines would extend directly from the dredging area to Arrowhead Park for dewatering. For longer pipeline runs, it may be necessary to utilize in-line booster pumps to pump the slurry to the Arrowhead Park dewatering facility. Silt curtains around the dredging area may be included to minimize sediment resuspension downstream of the dredging operation; $35,000 costs for installing silt curtains were included in this FS. Buoys and other waterway markers would be installed around the perimeter of the work area to prevent entry of unauthorized boats within the removal work zone. Other capital items included in the sediment removal costs are water quality monitoring, post-removal sediment bathymetric surveys to ensure achievement of the removal action, and site restoration at the conclusion of operations.

Sediment removal costs using hydraulic dredging are estimated to range from $37,700,000 for 125 ppb to $8,900,000 for 5,000 ppb action levels. Pre-removal of TSCA-level sediments are estimated to cost $1,700,000.

Sediment Dewatering - Alternative C1. Gravity dewatering includes land purchase, site clearing, and dewatering pond construction. Key assumptions include a 2.3 percent by volume (w/w) dredged solids concentration and 2,464 gpm water production rate for the dredge based on results from the 1999 Lower Fox River demonstration projects (Foth and Van Dyke, 2000; Montgomery-Watson, 2000). Although the recent dredging work conducted at SMU 56/57 (Fort James *et al.*, 2001) showed the average percent solids in dredge slurry was 8.4 percent w/w (range 3.5 to 14.4 percent), the lower and more conservative percent slurry solids measured during the 1999 activities was used for FS costs. Sediment dewatering would be done in a two-cell passive filtration system at Arrowhead Park. The system would accommodate 26 weeks of solids dredge production rate, plus a maximum water surge storage capacity. It is assumed that the final sediment would require solidification with 10 percent (w/w) lime to satisfy hauling and disposal requirements (included in disposal costs). Dewatering costs also include pond decommissioning and site restoration at the completion of the project.

Sediment dewatering costs for Alternative C1 (primarily construction costs) are estimated at $3,200,000.

Sediment Dewatering - Alternative C2. Mechanical dewatering includes land purchase, site clearing, and construction of temporary holding ponds. Dewatering techniques will be similar to the mechanical processes used for both Fox River demonstration projects including a series of shaker screens, hydrocyclones, and belt filter presses. The final percent solids of the filter press cake was about 60 percent solids (w/w) for SMU 56/57 (Fort James *et al.*, 2001) and 40 to 50 percent solids for Deposit N (Foth and Van Dyke, 2000). No additional solidification was required. The dewatering process was simplified into a unit cost of $80 per bone dry ton assuming 50 percent solids after dewatering for the purposes of this FS.

Mechanical dewatering costs for Alternative C2 range from $36,200,000 for 125 ppb to $6,100,000 for 5,000 ppb action levels.

Water Treatment. Water treatment includes purchase of equipment and materials for flocculation, clarification, and sand filtration. Water treatment would be conducted 24 hours per day, 7 days per week during the dredging season. Discharge water is estimated at 568,800 gallons per day. Daily discharge water quality monitoring is included in the cost estimate. Treated water would be sampled and analyzed to verify compliance with the appropriate discharge requirements prior to discharge back to the river. Carbon filtration could be added for a unit cost of $0.40 per thousand gallons of water treated. It may be necessary to add carbon filtration to the treatment train if effluent criteria are not met. Water treatment costs also include pad and equipment demobilization and site restoration.

Water treatment costs are estimated to range from $2,100,000 for 125 ppb to $1,100,000 for 5,000 ppb action levels for both dewatering methods.

Sediment Disposal. Sediment disposal includes the loading and transportation of the sediment to an existing NR 500 commercial disposal facility. Disposal costs also include the purchase and addition of lime reagent for solidification of dewatered sediment prior to off-site transport. The sediments would be loaded with a front-end loader into tractor-trailer end dumps fitted with bed liners or sealed gates. Each load would be manifested and weighed. Each tractor-trailer would pass through a wheel wash prior to leaving the staging area to prevent tracking soil onto nearby streets and highways.

The estimated percent solids of dewatered sediment after 6 months of setting in a passive dewatering pond is 20 percent solids (based on the SMU 56/57 Basis of Design Report [BOD] [Montgomery-Watson, 1998]). Therefore, the addition of 10 percent (w/w) lime for further solidification was added to the disposal costs. No solidification costs were added to the Alternative C2 disposal costs since the expected percent solids after mechanical dewatering is greater than 50 percent solids. Solidification costs range between $62,000,000 for 125 ppb and $10,400,000 for 5,000 ppb action levels. Lime purchase is about 20 percent of the solidification costs.

Costs of sediment solidification and disposal at an existing NR 500 commercial disposal facility are estimated to range between $184,200,000 for 125 ppb and $30,900,000 for 5,000 ppb action levels for Alternative C1. Disposal costs for Alternative C2 range between $45,700,000 for 125 ppb and $7,700,000 for 5,000 ppb action levels.

Demobilization and Site Restoration. Demobilization and site restoration involves removing all equipment (i.e., fencing, facilities) from the staging and work areas. All work pads and other permanent structures would be removed and the site would be graded to its original condition. Vegetated areas would be replanted to a state similar to that of the pre-construction. Demobilization and restoration costs are included within the above dredging, dewatering, and treatment estimates.

Institutional Controls and Monitoring. Baseline monitoring includes primarily water, sediment, and tissue sampling during pre- and post-remedial sampling events. Monitoring during implementation includes surface water and limited air sampling to assess downstream and off-site transport of contaminants. Verification monitoring includes surface and possibly subsurface sediment sampling to ensure compliance with the target goals of the project. Long-term monitoring includes surface water, surface sediment, and biological tissue sampling to determine residual risks and impacts over time.

If residual risks remain in the sediment above the risk-based SQTs after remediation, then the long-term monitoring plan described in the MNR alternative will be followed (i.e., media, frequency, location, duration) until the project RAOs are achieved or until a policy decision is made. The proposed *Long-term Monitoring Plan* (LTMP) is detailed in Appendix C. Elements of the LTMP may be implemented for each action level regardless of the remedial outcome in order to verify achievement of the RAOs. The sampling program may continue indefinitely under this process option, but for the purposes of the FS it has been estimated at 40 years.

The estimated cost for the maintenance of institutional controls and fish consumption advisory monitoring is $4,500,000. Costs for implementation monitoring during removal are included in the removal and water treatment costs. Refer to Alternative B - Monitored Natural Recovery for monitoring costs associated with long-term multimedia fish, bird, invertebrate, sediment, and surface water sampling events to determine achievement of project RAOs.

Alternative D: Dredge Sediment to Confined Disposal Facility, Off-site Disposal of TSCA Material

Alternative D includes removal of sediments to an on-site CDF for long-term disposal of the materials. As previously noted, sediments with PCB concentrations exceeding 50 ppm are not to be disposed of in a nearshore CDF. As such, this alternative utilizes mechanical dredging to remove those smaller volumes of sediment greater than 50 ppm for solidification and disposal at an existing NR 500 commercial disposal facility.

Figure 7-15 provides the process flow diagram for this remedial alternative and Figure 7-16 illustrates the locations of CDFs and the extent of residual sediment impacts following implementation of Alternative D. Table 7-5 contains the summary costs to implement Alternative D. The total volume of sediments to be dredged are similar to those identified in Alternative C.

Site Mobilization and CDF Construction. The process is staged to construct and complete dredging to the Arrowhead Park CDF, south of the railroad tracks, before proceeding to construction and dredging at the Menasha CDF. Both CDFs would be constructed for the 125, 250, and 500 ppb action levels. Only the

Arrowhead Park CDF would be constructed for the higher action levels. Site mobilization and preparation includes securing the onshore property area for equipment staging, constructing onshore and in-water CDFs (110 acres), the water treatment facility, the offshore docking facility for both the mechanical and hydraulic dredges, and site restoration. Estimated property purchase and preparation costs are included in the following process components. CDF construction will require up to 6 months prior to dredging activities.

CDF construction is estimated at $69,300,000 for both facilities and $37,300,000 for the Arrowhead facility only.

Sediment Removal. Mechanical dredging of the limited TSCA-level sediment volumes would occur prior to initiation of hydraulic dredging. Mechanical dredging would require a staging area for dredged sediments to be offloaded and transported off site. The cost for constructing the upland staging area is included in the disposal costs for management of TSCA-level sediments. Mechanical removal of the approximately 16,000 cy would require approximately 0.2 year.

Hydraulic sediment removal techniques for this alternative are equivalent to that described for Alternative C, except that dredge slurry will be pumped directly to the CDF for dewatering. The estimated time to complete hydraulic dredging ranges between 12.3 years for 125 ppb and 2 years for 5,000 ppb action levels.

Sediment removal costs by hydraulic dredging for Alternative D are estimated to range between $23,400,000 for 125 ppb and $6,500,000 for 5,000 ppb action levels. Mechanical dredging costs (for TSCA material) are estimated at $1,700,000 for all action levels.

Sediment Dewatering. Passive dewatering will occur directly within the CDF berms for hydraulic dredging. Mechanically-dredged sediment will dewater on-barge for two days prior to off-loading to the upland staging area. It is assumed that the final sediment would require solidification with 10 percent (w/w) lime to satisfy hauling and disposal requirements. Dewatering costs are incorporated into dredging costs.

Water Treatment. Overflow return water from the CDFs and on-barge dewatering would be treated before discharge to the river. Treatment and monitoring requirements are expected to be the same as those for Alternative C.

Water treatment costs for Alternative D are estimated to range between $2,100,000 for 125 ppb and $1,100,000 for 5,000 ppb action levels.

Sediment Disposal. Sediment disposal includes the loading and transportation of the TSCA-level sediments to an existing NR 500 commercial disposal facility. Sediment disposal to an on-site CDF incurs no costs besides CDF construction and transportation costs included in the mobilization and dredging costs.

The cost for off-site sediment disposal is estimated at $2,000,000 for all action levels.

Demobilization and Site Restoration. Demobilization and site restoration involves removing all equipment (i.e., fencing, facilities) from the staging and work areas. The CDFs would be finished with a 3-foot cap of clean soils, and seeded and planted. Additional amenities (i.e., bike paths, wildlife habitat) were not included in the cost estimates. However, this alternative would allow development of these features and would provide a beneficial use of this area for the community. Demobilization and site restoration costs are included under the dredging and CDF construction cost estimates.

Institutional Controls and Monitoring. To ensure that the CDF is functioning as designed, surface sediment and groundwater sampling will address the primary exposure pathways of groundwater leachate and effluent seepage through the berm. Sampling will be conducted on an annual basis with decreasing intervals over time, as appropriate. Groundwater monitoring will include, at a minimum, installation of five shallow perimeter wells around the CDF (three wells downgradient, one upgradient, one in the berm/dike, and one in the CDF if possible). Wells will be sampled at a minimum of two sampling rounds (wet and dry season) per sampling year. Sampling will be conducted annually for the first 3 years and decrease to every 5 years thereafter. The actual number of monitoring wells and sampling sites will depend upon the actual configuration and design of site-specific CDFs. To verify long-term achievement of the project RAOs, refer to the *Long-term Monitoring Plan* (Appendix C) for scope and Alternative B - Monitored Natural Recovery for costs. The monitoring program will be conducted over a period of 40 years.

Long-term maintenance and monitoring of the CDF is included in the CDF construction costs. Long-term monitoring to verify achievement of project RAOs is included in Alternative B costs. The estimated cost for maintenance of institutional controls and fish consumption monitoring of the reach is $4,500,000.

Alternative E: Dredge and Thermal Treatment

Alternative E includes hydraulic dredging of sediments, passive dewatering, and treatment with an on-site integrated vitrification unit. This alternative results in the sediments being transformed into glass aggregate that has a potential for a wide variety of beneficial reuse applications. Figure 7-17 provides the process flow diagram for this remedial alternative and Figure 7-18 illustrates the extent of residual sediment impacts following implementation of Alternative E. Table 7-5 contains the summary costs to implement Alternative E. This alternative addresses the same volume of sediments as Alternative C.

Site Mobilization. Site mobilization and preparation includes securing the onshore property area for equipment staging, water treatment, and offshore docking facility for the hydraulic dredge. Site preparation would also include building or modifying an integrated vitrification unit, capable of processing an estimated 250 glass tons per day.

Sediment Removal. Separate mechanical dredging for TSCA sediments is not required under this alternative since TSCA-level sediments will be treated by the vitrification unit. Hydraulic sediment removal techniques and costs for this alternative are equivalent to that described for Alternative C. The estimated time to complete hydraulic dredging is the same as Alternative C.

Sediment Dewatering. Sediment dewatering is similar to the requirements described in Alternative C1 for construction of a passive dewatering facility. The solids content after dewatering from hydraulic dredging is assumed to be 30 percent (w/w). However, no solidification will occur prior to thermal treatment assuming that the vitrification facility is located in close proximity to the dewatering facility and the dewatered filter cake at 30 percent (w/w) solids is acceptable for processing. Sediment dewatering costs (primarily construction costs) for Alternative E are estimated at $3,200,000.

Water Treatment. Water from gravity dewatering would be treated before discharge to the river. Treatment and monitoring requirements are expected to be the same as those for Alternative C1. Water treatment costs for Alternative E are estimated to be the same as Alternative C1.

Sediment Treatment. After completion of passive dewatering (to approximately 30 percent solids), both TSCA and non-TSCA-level sediments are passed through a dryer and dried to approximately 10 percent moisture. Thermal treatment of the dried sediments involves blending the high-silt/clay sediments with fluxing materials and processing the materials in a melter as part of the vitrification process. The thermal treatment process would include appropriate treatment of air emissions. The unit cost for vitrification includes capital costs and operating costs. The capital costs include equipment, building, installation, engineering and startup costs. Operating costs include labor, utilities, and general administrative costs. The unit cost is based on an assumption that the glass aggregate resulting from treating sediments will have a resale value between the range of $2 and $25 per ton as provided by Minergy.

The cost for thermal treatment is estimated to range between $69,900,000 for 125 ppb and $11,700,000 for 5,000 ppb action levels at an estimated unit cost of $24 per ton.

Sediment Disposal. No sediment disposal as hazardous waste is necessary, as all the sediments will be treated by thermal treatment. Treated sediments transformed to glass aggregate by the thermal treatment process have a wide variety of applications. Based on analyses by product marketing specialists, the glass aggregate has a potential to be used as roofing shingle granules, industrial abrasives, ceramic floor tile, cement pozzolan, and construction fill (Minergy Corporation, 2002a).

Demobilization and Site Restoration. Demobilization and site restoration involves removing all equipment (i.e., fencing, facilities) from the staging and work areas. All work pads and other permanent structures would be removed and the site would be graded to its original condition. Vegetated areas would be replanted to a state similar to that of pre-construction. Demobilization and restoration costs are included within the above dredging, dewatering, and treatment estimates.

Institutional Controls and Monitoring. Institutional controls and monitoring will be the same as those described for Alternative C.

Alternative F: Cap to the Maximum Extent Possible, Dredge Remaining Sediments to CDF

Alternative F includes primarily *in-situ* sand capping to the maximum extent possible. Remaining sediments would be hydraulically dredged to on-site CDFs. As stated in Section 7.2.3, the capping area is limited to those areas where the average water depth is a minimum of 9 feet. TSCA-level sediments require mechanical dredging and off-site disposal prior to cap placement. The process flow diagram is depicted on Figure 7-19, and Figure 7-20 illustrates the cap locations and the extent of residual sediment impacts following implementation of Alternative F. The estimated costs are presented in Table 7-5.

Site Preparation, Cap and CDF Construction. Site preparation for dredging includes land acquisition for equipment staging, water treatment, sediment storage, truck loading, and CDF construction as discussed in Alternative D. The cap in the Little Lake Butte des Morts Reach is planned to be an armored cap composed of 20 inches of sand overlain with 12 inches of large cobble to provide erosion protection. The sand cap will be completed using a spreader barge with a 10-inch pipeline. The cap will be placed in 6-inch lifts. Armor placement would be completed using two 3-cy clamshell buckets (placement rate of 400 cy per day per bucket) for 0.7 to 3.3 years with 10-hour work shifts. Cap construction would require an upland staging area for the receipt and placement of sand and the armoring stone. The staging area will include a hopper for pumping slurry to the spreader barge. Armor stone will be delivered to the work area via barges. All other unit costs are similar to those described for the prior alternatives for the river reach. Site preparation costs for this alternative are included under the dredging and capping costs. Construction of the dewatering ponds are included in the dewatering costs.

Two CDFs would be constructed for the 125 and 250 ppb action levels to handle sediment outside of the capping footprint. Only the Arrowhead Park CDF would be constructed for the higher action levels. Although the estimated dredge volume for the 250 ppb action level would fit into one CDF with a capacity of 1 million cy, the criteria for building a second CDF was exceeded. For the purposes of this FS, if the volume of dewatered sediment (at 50 percent solids) is greater than 50 percent of the CDF storage capacity, then a second CDF will be constructed. CDF construction and costs would be similar to those described in Alternative D.

Capping costs under this alternative are estimated to range from $33,600,000 for 125 ppb to $11,700,000 for 5,000 ppb action levels. The estimated time for placement of the sand cap is 3.7 and 0.7 years to 125 ppb and 5,000 ppb action levels, respectively (1,200 cy placed per day).

Sediment Removal. Mechanical dredging of the limited TSCA-level sediment volumes would occur prior to initiation of hydraulic dredging. Mechanical removal of the approximately 16,000 cy would require approximately 0.2 year.

Hydraulic sediment removal techniques for this alternative are equivalent to those described for Alternative C for areas that will not be capped. The estimated time to complete hydraulic dredging directly to a CDF is 9.1 and 1.5 years for 125 ppb and 5,000 ppb action levels, respectively.

Sediment removal costs for hydraulic dredging are estimated to range between $18,900,000 for 125 ppb and $6,600,000 for 5,000 ppb action levels. The sediment removal cost for mechanical dredging is estimated to be $1,700,000.

Sediment Dewatering. Passive dewatering will occur directly within the CDF berms for hydraulic dredging. Mechanically-dredged sediment will dewater on-barge for 2 days prior to offloading to upland staging areas for off-site disposal.

Water Treatment. Overflow return water from the CDFs and on-barge dewatering would be treated before discharge to the river. Treatment and monitoring requirements are the same as for the prior remedial alternatives.

Water treatment costs for Alternative F are estimated to range between $1,800,000 for 125 ppb and $1,000,000 for 5,000 ppb action levels.

Sediment Disposal. Sediment disposal includes the loading and transportation of the TSCA-level sediments to an appropriate upland disposal facility.

The cost for off-site sediment disposal at an existing NR 500 commercial disposal facility is estimated at $2,000,000.

Demobilization and Site Restoration. Demobilization and site restoration involves removing all equipment, fencing, facilities, etc., from the staging and work areas. Demobilization and site restoration costs are included under the dredging and capping estimates.

Institutional Controls and Monitoring. Operation and maintenance monitoring would be required to ensure proper placement and maintenance of cap integrity. For this type of armored capping, monitoring will be performed to ensure that the cap is placed as intended, required capping thickness is maintained, and contaminants are isolated. The monitoring would include bathymetric or side-scan sonar profiling, sediment and cap sampling, as well as diver inspections to ensure that the cap is physically isolating impacted sediments. The monitoring program would operate for a period of 40 years with decreasing sampling intervals over time, as appropriate. Institutional controls would include deed restrictions, site access and anchoring limitations, and maintenance of the consumption advisories. A separate *Long-term Monitoring Plan* for the entire river and Green Bay is discussed in Appendix C, with costs provided in Alternative B.

Maintenance monitoring of the CDF and cap are included in the construction costs. The estimated cost for institutional controls and fish consumption monitoring of the reach is $4,500,000.

7.2.5 Section 7.2 Figures and Tables

Figures and tables for Section 7.2 follow page 7-44 and include:

Figure 7-9 Sediment Management Area Overview: Little Lake Butte des Morts
Figure 7-10 Preliminary Concept Design for the Arrowhead Confined Disposal Facility

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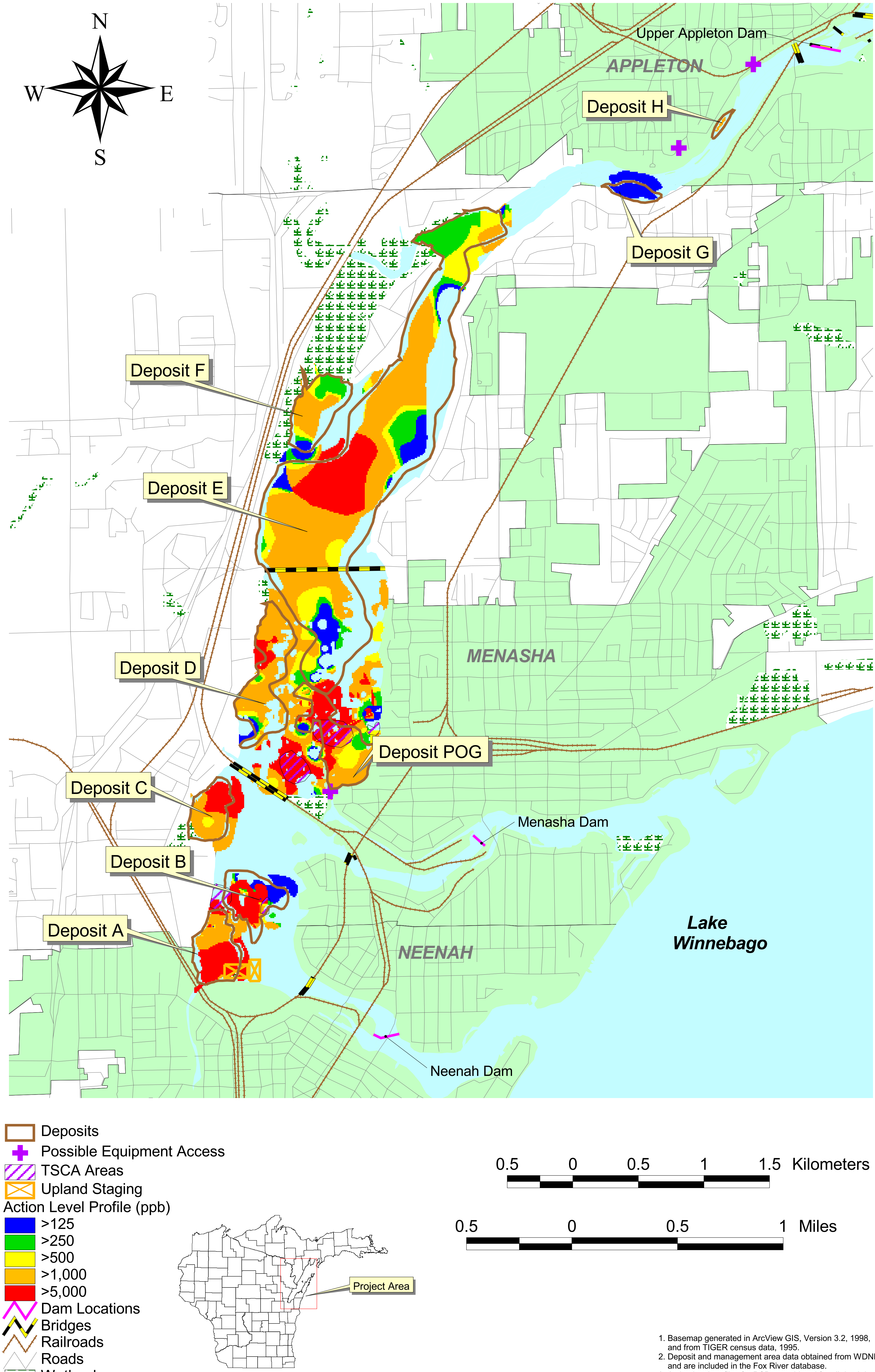

1. Basemap generated in ArcView GIS, Version 3.2, 1998, and from TIGER census data, 1995.
2. Deposit and management area data obtained from WDNR. and are included in the Fox River database.
3. Action level profiles for PCBs considered for all depth layers up to 350 cm for lower Fox River.

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Lower Fox River & Green Bay Feasibility Study

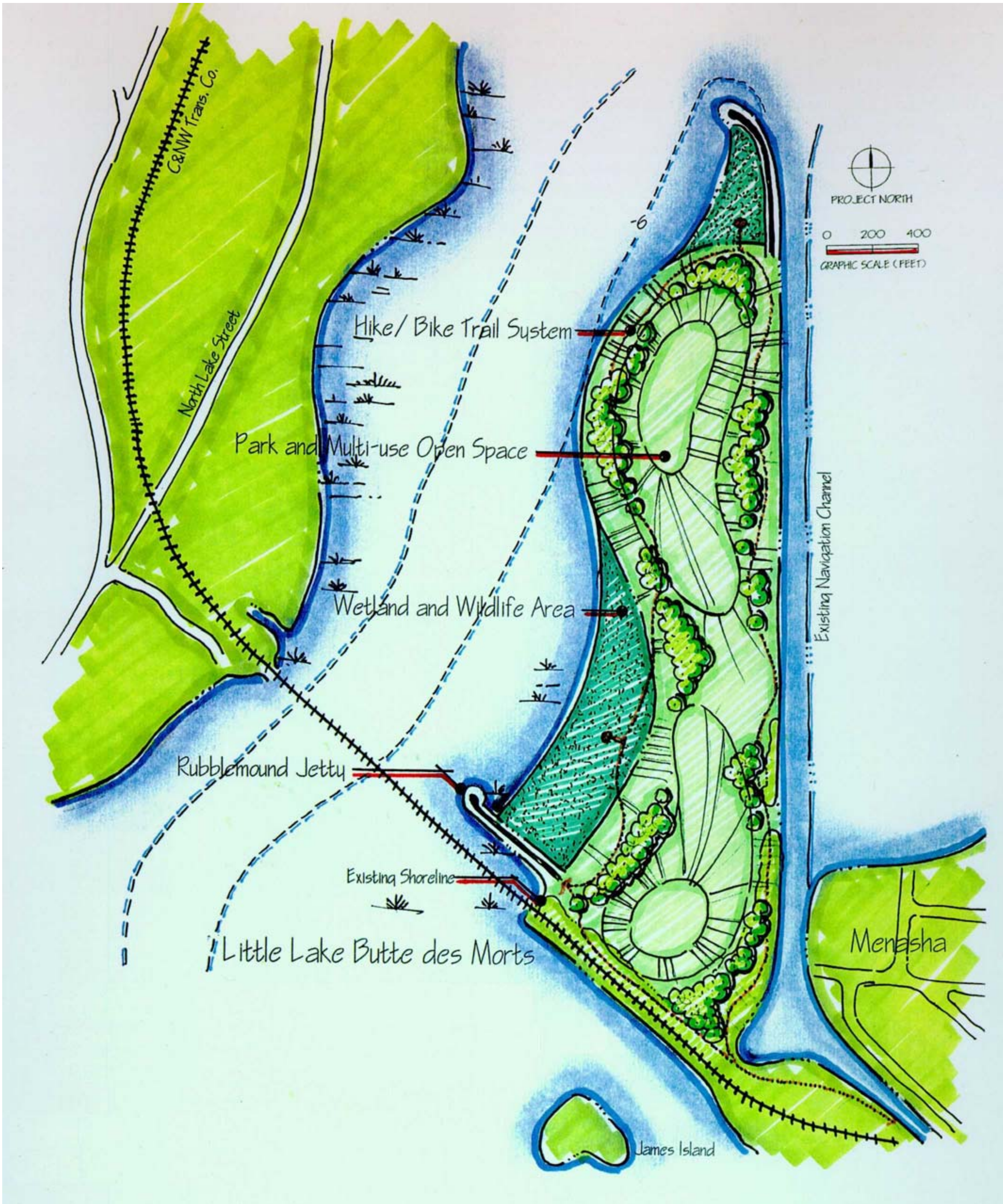
Sediment Management Area Overview: Little Lake Butte des Morts

FIGURE 7-9

REFERENCE NO:	FS-14414-535-7-6
CREATED BY:	SCJ
PRINT DATE:	3/12/01
APPROVED:	AGF

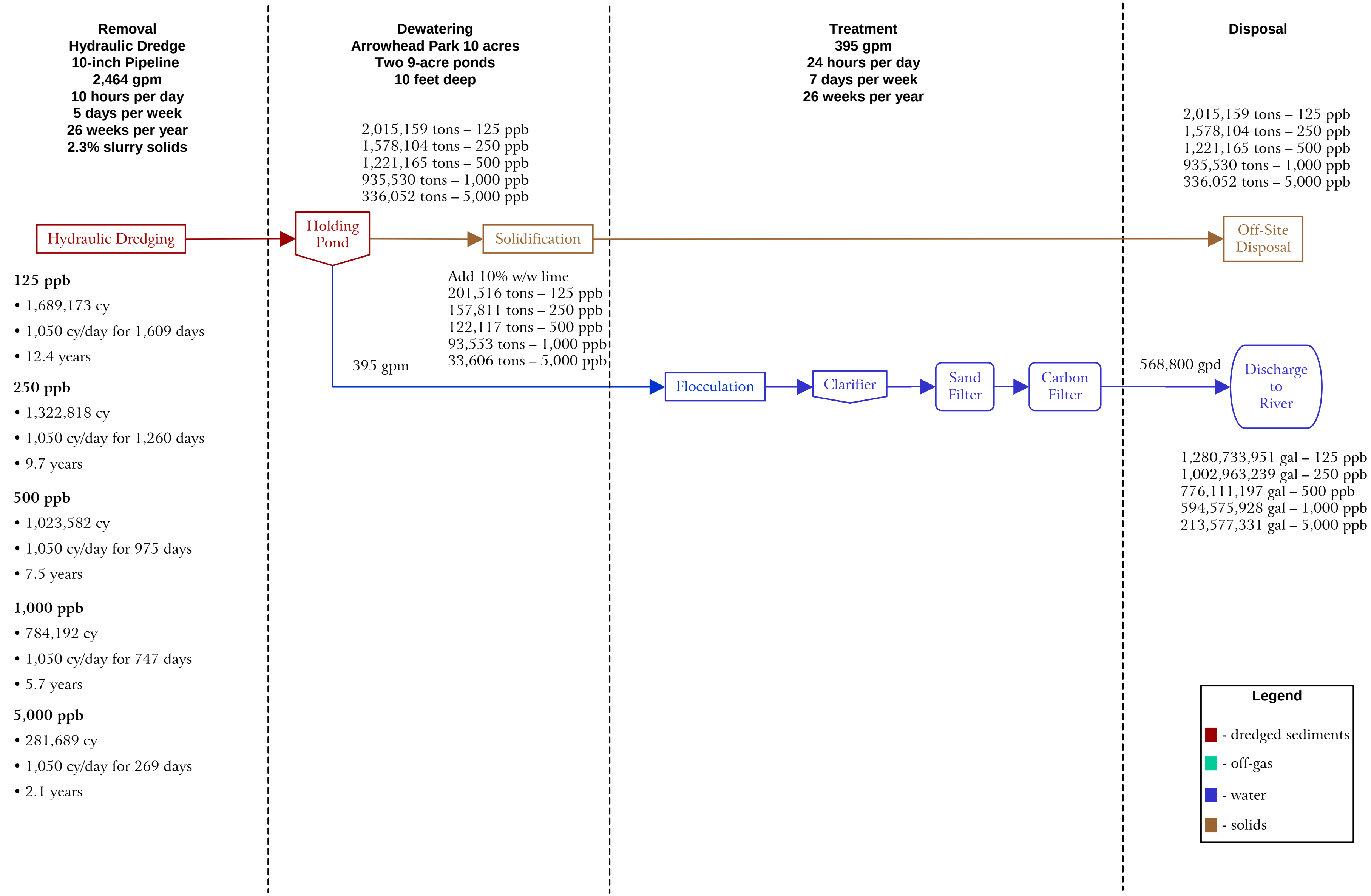
Figure 7-10 Preliminary Concept Design for the Arrowhead Confined Disposal Facility

Figure 7-11 Preliminary Concept Design for the Menasha Confined Disposal Facility



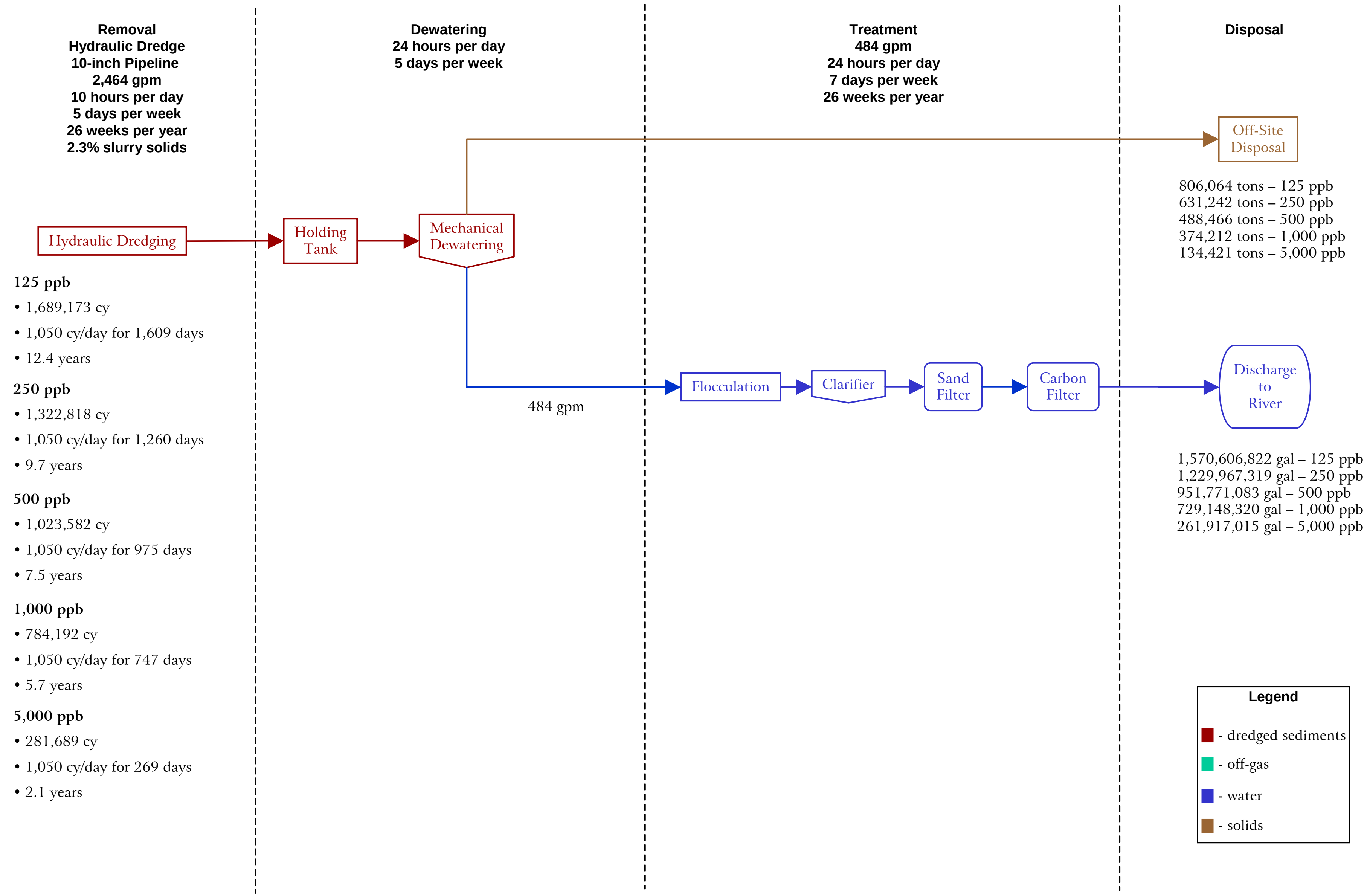
F:\PROJECTS\DOCS\4414\DOC\FS\FINAL\FIGURES\SEC7\SEC7FIGSP.PPT

Figure 7-12 Process Flow Diagram for Little Lake Butte des Morts - Alternative C1: Dredge Sediment with Off-site Disposal

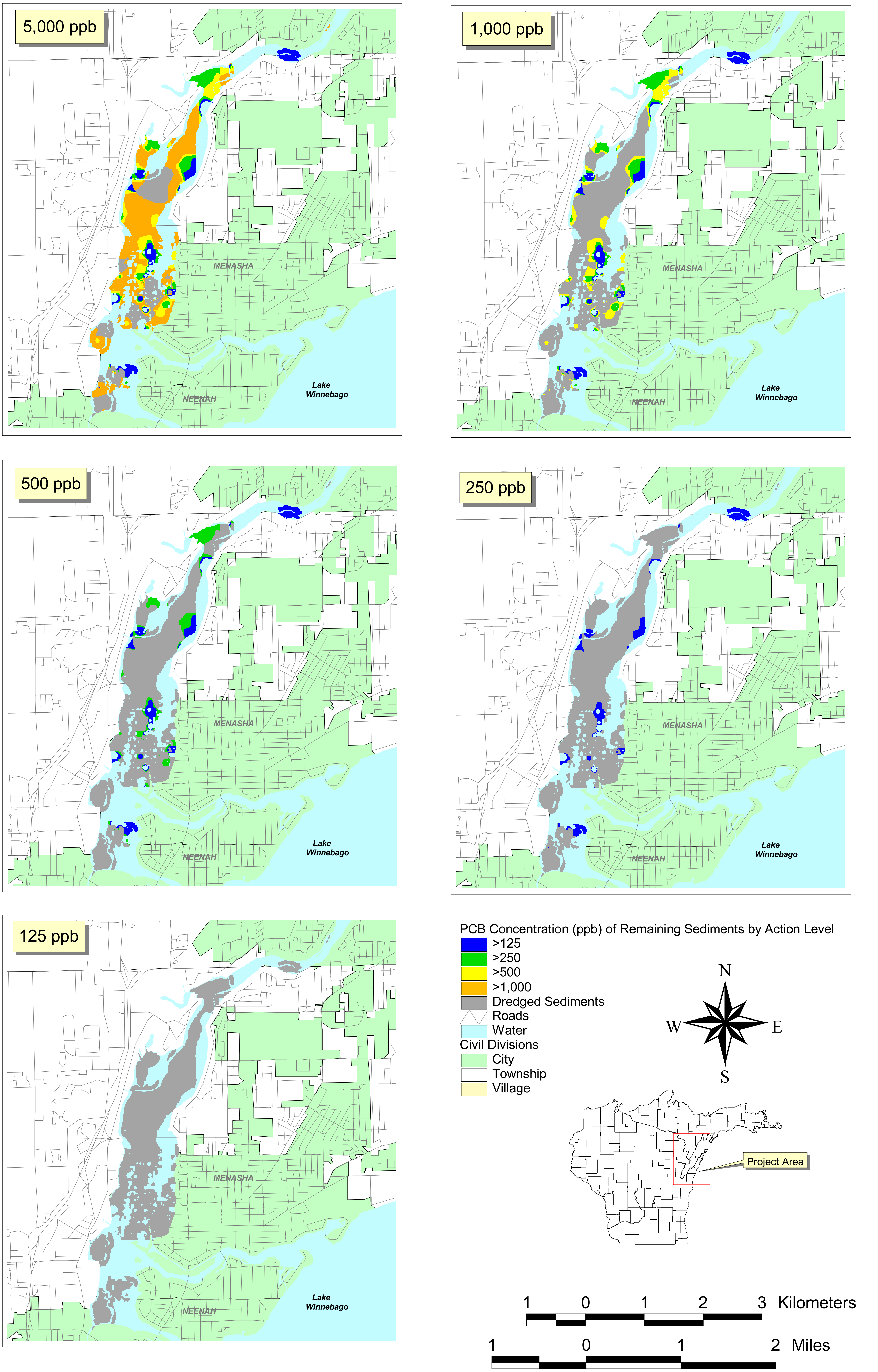


F:\PROJECTS\DOCS\4414\DOC\FS\FINAL\FIGURES\SEC7\SEC7FIGSL.PPT

Figure 7-13 Process Flow Diagram for Little Lake Butte des Morts - Alternative C2: Dredge Sediment with Off-site Disposal



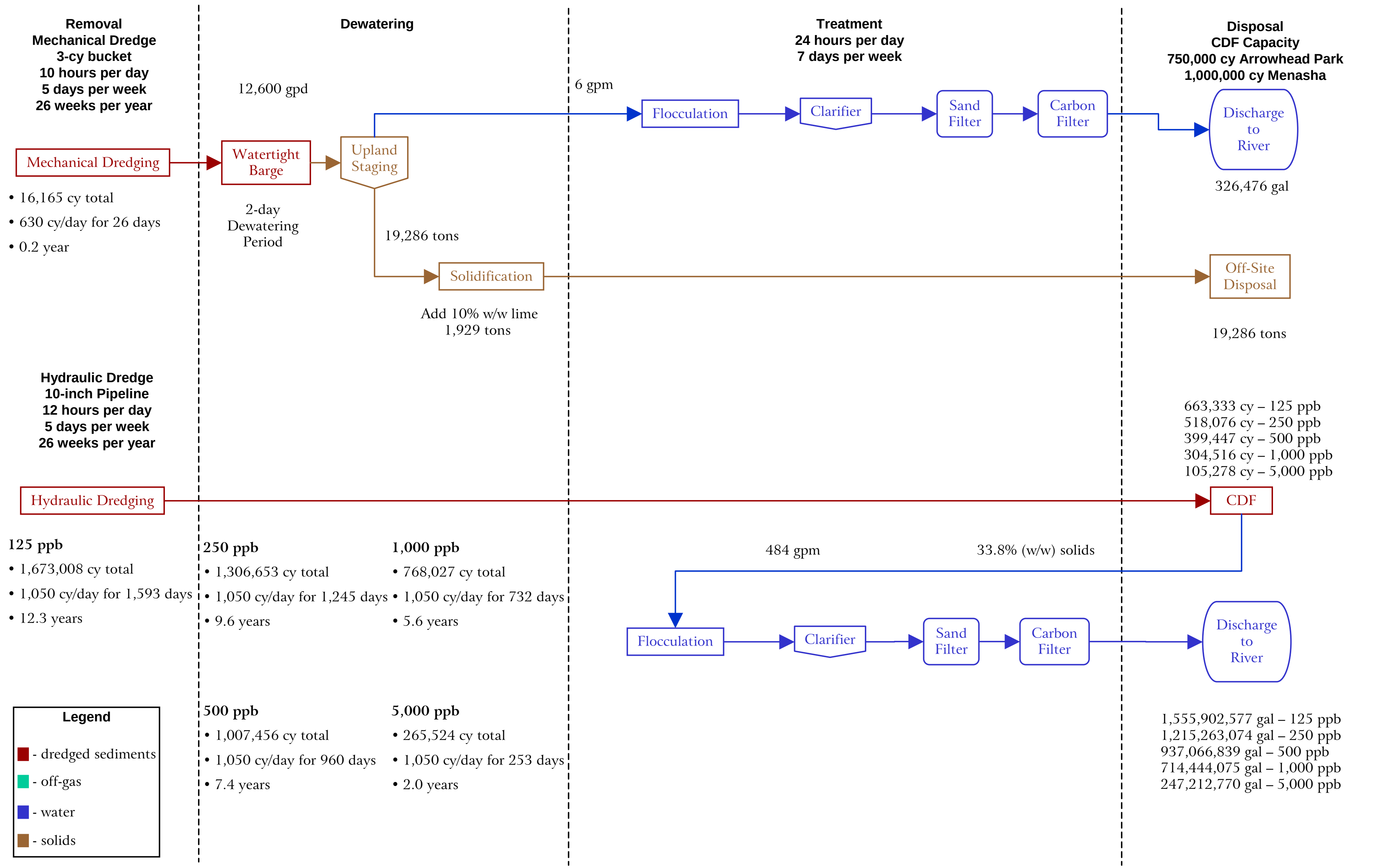
F:\PROJECTS\DOCS\4414\DOC\FS\FINAL\FIGURES\SEC7\SEC7FIGSL.PPT

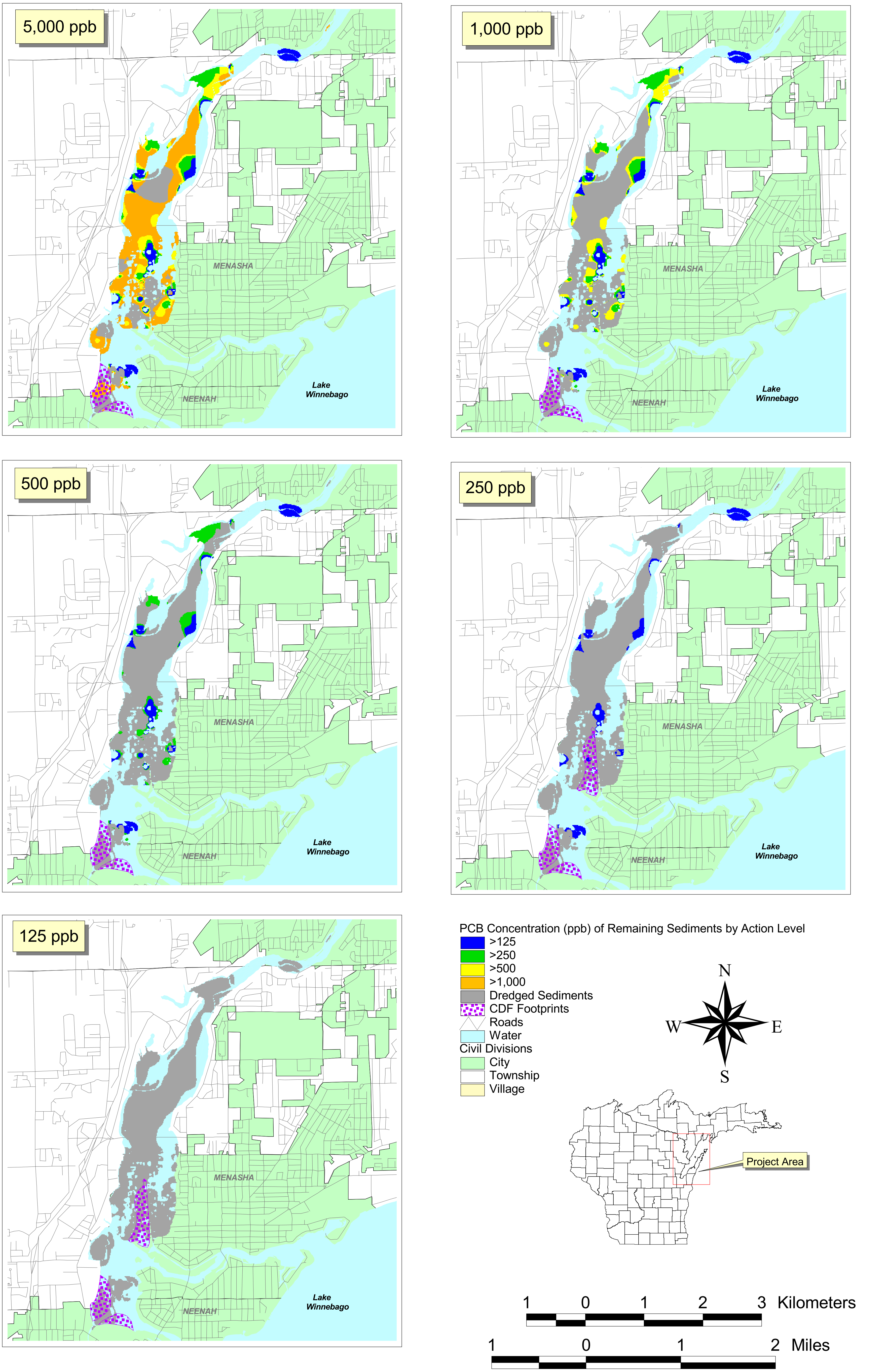


1. Basemap generated in ArcView GIS, Version 3.2, 1998, and from TIGER census data, 1995.
2. Action level profiles for PCBs considered for all depth layers up to 350 cm for lower Fox River.

ThermoRetec Smart Solutions. Positive Outcomes.	Natural Resource Technology	Lower Fox River & Green Bay Feasibility Study	Alternative C: Dredge and Off-Site Disposal: Little Lake Butte des Morts	REFERENCE NO: FS-14414-535-7-11
				CREATED BY: SCJ
				PRINT DATE: 5/11/01
			FIGURE 7-14	APPROVED: AGF

Figure 7-15 Process Flow Diagram for Little Lake Butte des Morts - Alternative D: Dredge Sediment, CDF, and Off-site Disposal

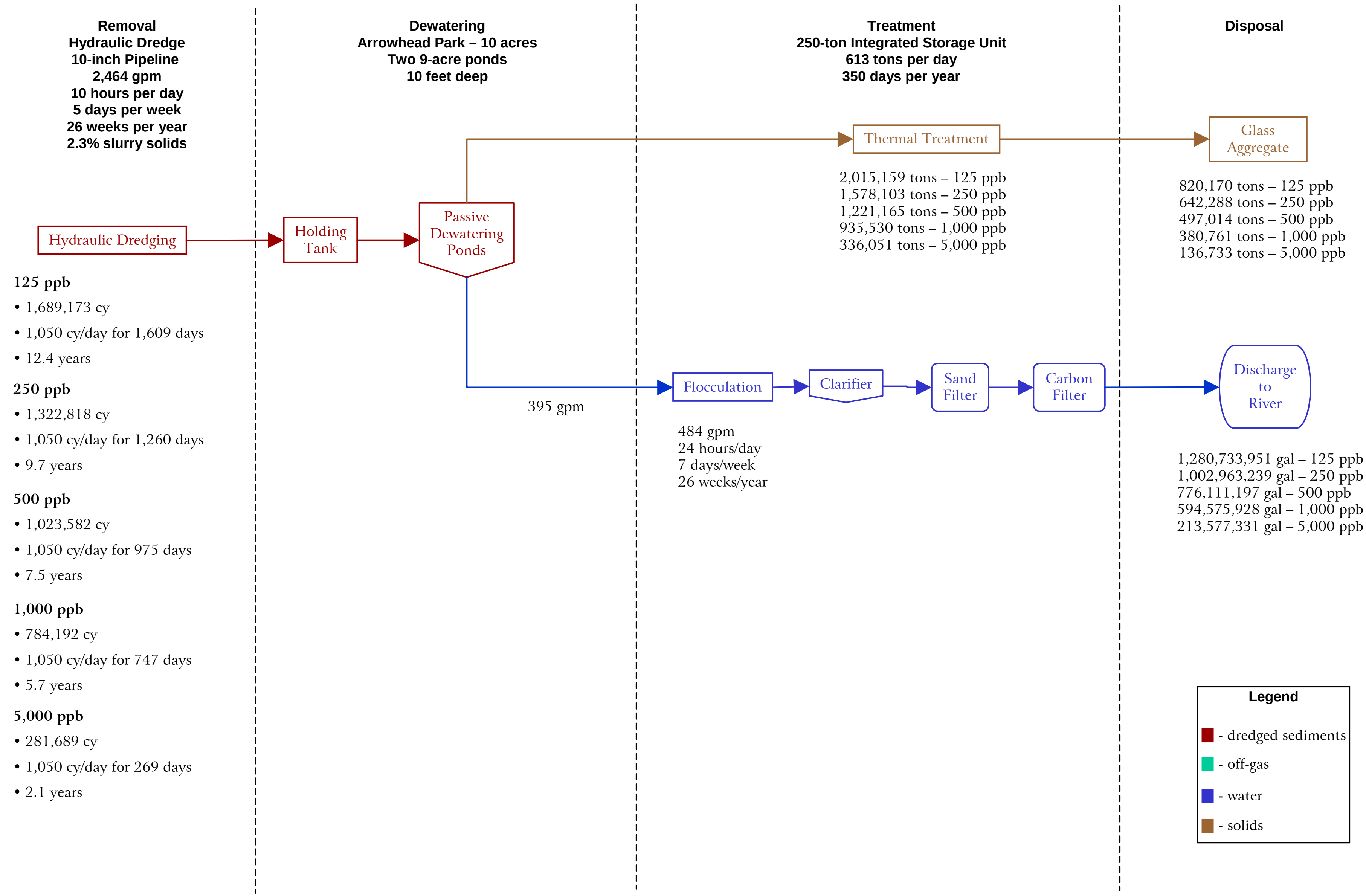




1. Basemap generated in ArcView GIS, Version 3.2, 1998, and from TIGER census data, 1995.
2. Action level profiles for PCBs considered for all depth layers up to 350 cm for lower Fox River.

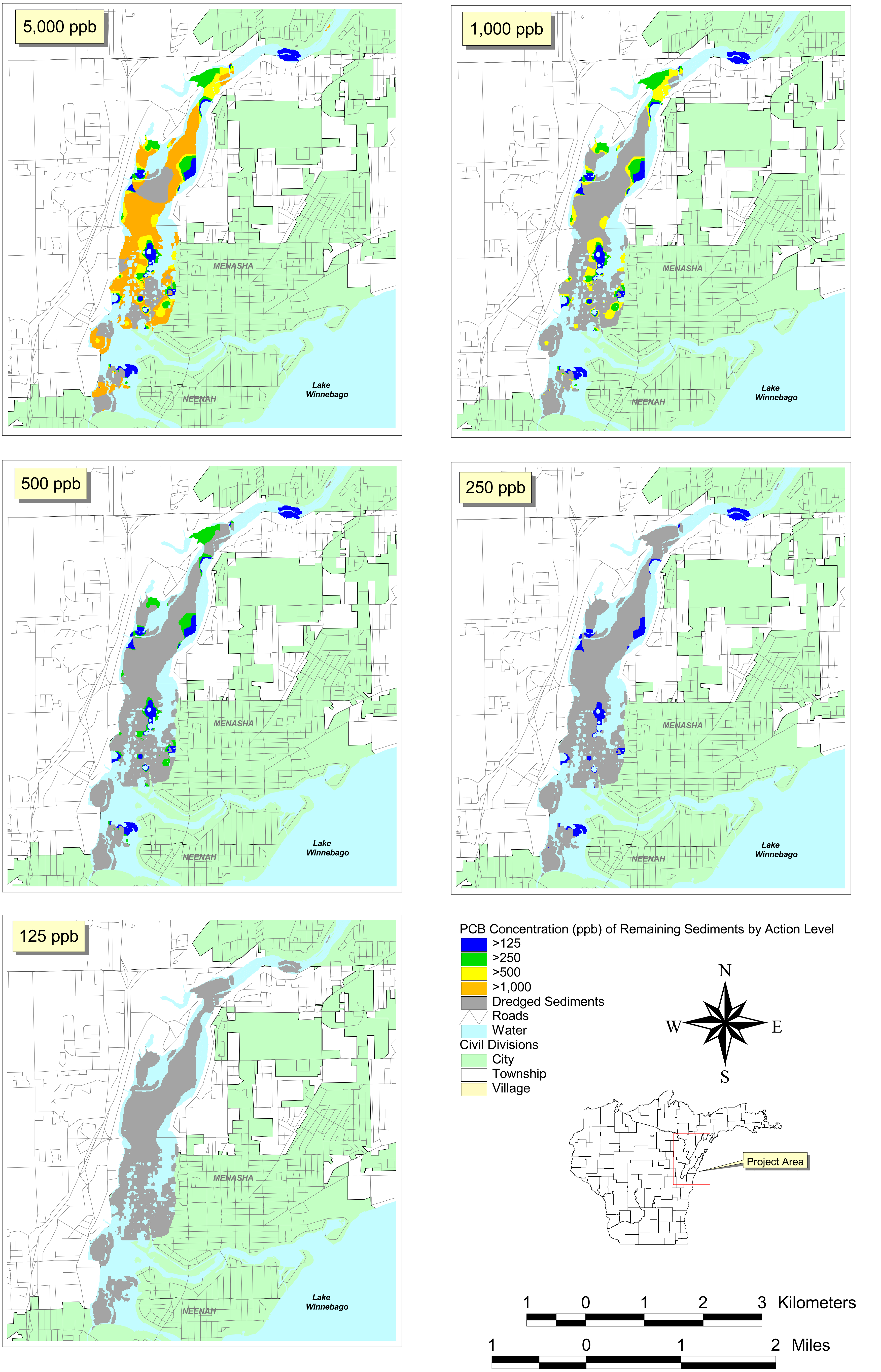
ThermoRetec Smart Solutions. Positive Outcomes.	Natural Resource Technology	Lower Fox River & Green Bay Feasibility Study	Alternative D: Dredge Sediment to Confined Disposal Facility: Little Lake Butte des Morts	REFERENCE NO: FS-14414-535-7-13
				CREATED BY: SCJ
				PRINT DATE: 5/11/01
			FIGURE 7-16	APPROVED: AGF

Figure 7-17 Process Flow Diagram for Little Lake Butte des Morts - Alternative E: Dredge Sediment with Thermal Treatment



Note: Additional integral elements of the vitrification unit (dryer, pollution control) are not shown as they were not estimated separate. For greater detail on the unit layout and components, refer to the Minergy Unit Cost Report (Appendix G).

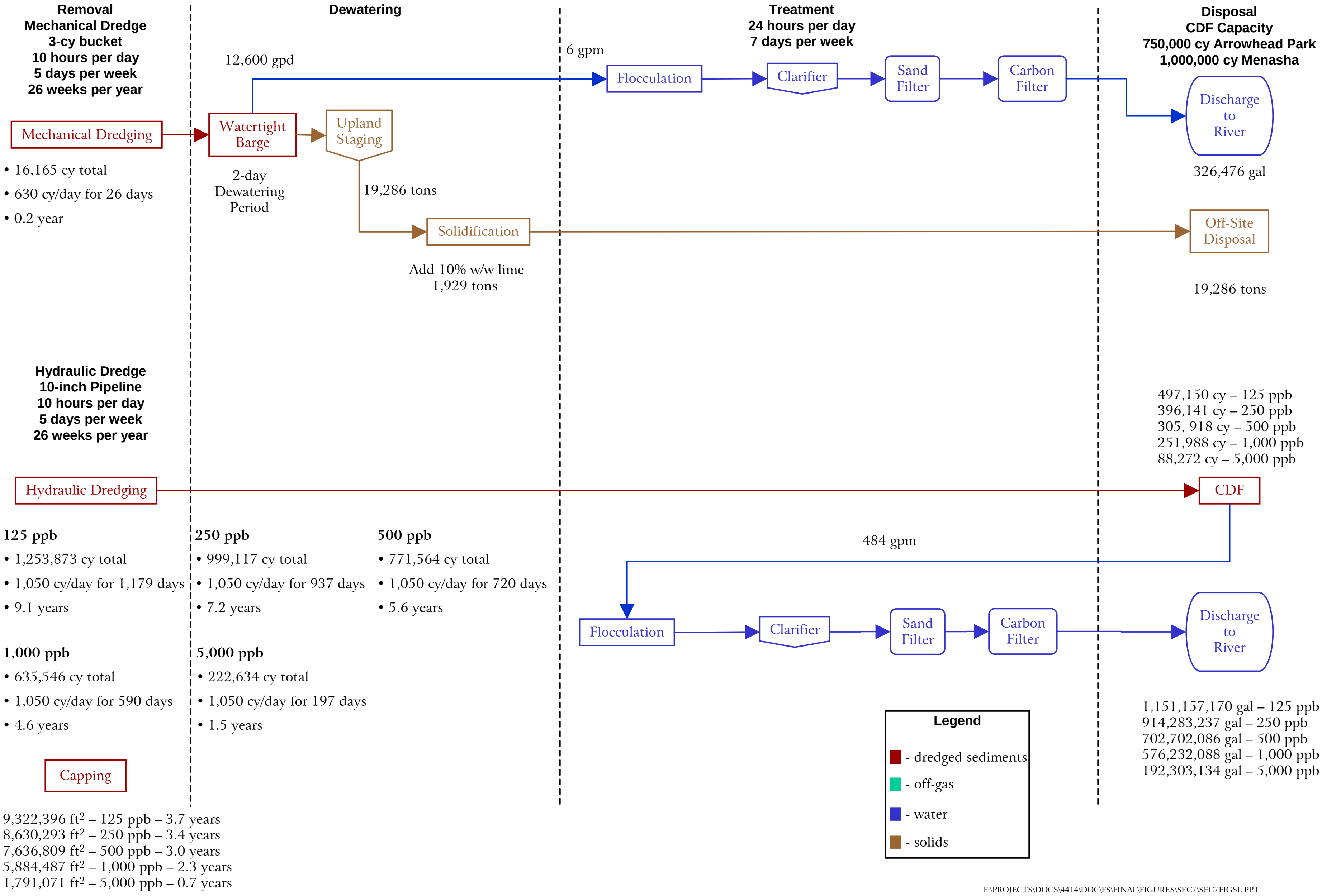
F:\PROJECTS\DOCS\4414\DOC\FS\FINAL\FIGURES\SEC7\SEC7FIGSL.PPT

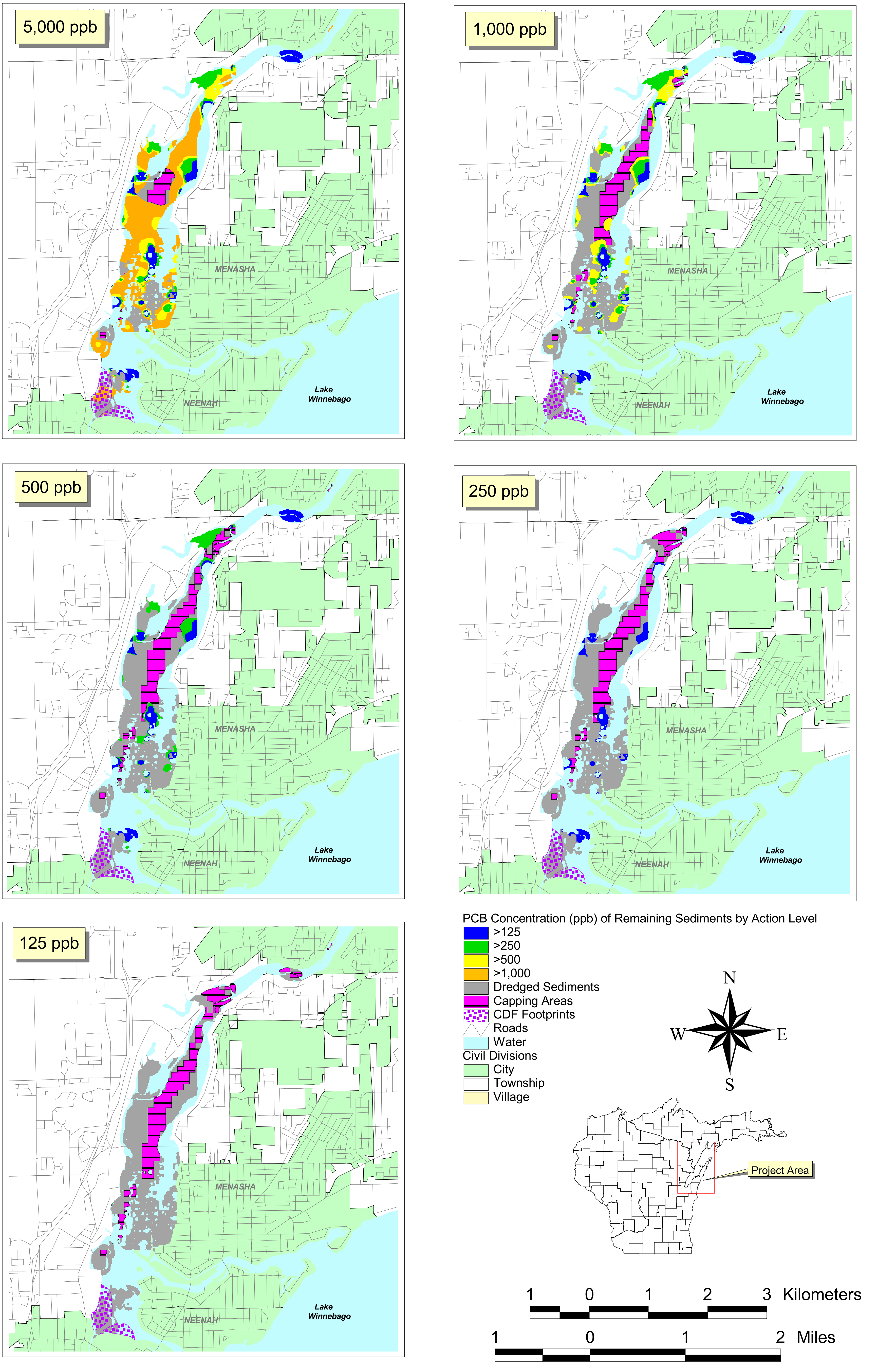


1. Basemap generated in ArcView GIS, Version 3.2, 1998, and from TIGER census data, 1995.
2. Action level profiles for PCBs considered for all depth layers up to 350 cm for lower Fox River.

ThermoRetec *Smart Solutions. Positive Outcomes.*	Natural Resource Technology	Lower Fox River & Green Bay Feasibility Study	Alternative E: Dredge with Thermal Treatment: Little Lake Butte des Morts	REFERENCE NO: FS-14414-535-7-15
				CREATED BY: SCJ
				PRINT DATE: 5/11/01
			FIGURE 7-18	APPROVED: AGF

Figure 7-19 Process Flow Diagram for Little Lake Butte des Morts - Alternative F: Cap Sediment to Maximum Extent Possible, Dredge to CDF, and Off-site Disposal





1. Basemap generated in ArcView GIS, Version 3.2, 1998, and from TIGER census data, 1995.
2. Action level profiles for PCBs considered for all depth layers up to 350 cm for lower Fox River.
3. Capping are a criteria based on a minimum 9-foot water depth.

ThermoRetec *Smart Solutions. Positive Outcomes.*	Natural Resource Technology	Lower Fox River & Green Bay Feasibility Study	Alternative F: Cap to Maximum Extent Possible and Dredge to Remaining CDF: Little Lake Butte des Morts	REFERENCE NO: FS-14414-535-7-17
				CREATED BY: SCJ
				PRINT DATE: 5/11/01
			FIGURE 7-20	APPROVED: AGF

Table 7-5 Cost Summary for Remedial Alternatives - Little Lake Butte des Morts

125 ppb

Alternative	Dredge Volume (cy)	TSCA Dredge Vol. (cy)	Hydraulic Dredging	Mechanical Dredging	Capping	Dewatering	Water Treatment	Thermal Treatment	CDF Construction	Off-site Disposal	Institutional Controls	Subtotal	20% Contingency	TOTAL
A	0	0	---	---	---	---	---	---	---	---	$4,500,000	$4,500,000	$900,000	$5,400,000
B	0	0	---	---	---	---	---	---	---	---	$9,900,000	$9,900,000	$1,980,000	$11,880,000
C1[1]	1,689,173	16,165	$37,700,000	---	---	$3,200,000	$1,900,000	---	---	$184,200,000	$4,500,000	$231,500,000	$46,300,000	$277,800,000
C2[1]	1,689,173	16,165	$37,700,000	---	---	$36,200,000	$2,100,000	---	---	$45,700,000	$4,500,000	$126,200,000	$25,240,000	$151,440,000
D	1,689,173	16,165	$36,700,000	$1,700,000	---	---	$2,100,000	---	$69,300,000	$1,700,000	$4,500,000	$116,000,000	$23,200,000	$139,200,000
E	1,689,173	16,165	$37,700,000	---	---	$3,200,000	$1,900,000	$69,900,000	---	---	$4,500,000	$117,200,000	$23,440,000	$140,640,000
F	1,253,873	16,165	$32,300,000	$1,700,000	$33,600,000	---	$1,800,000	---	$69,300,000	$2,000,000	$4,500,000	$145,200,000	$29,040,000	$174,240,000

250 ppb

Alternative	Dredge Volume	TSCA Dredge Vol.	Hydraulic Dredging	Mechanical Dredging	Capping	Dewatering	Water Treatment	Thermal Treatment	CDF Construction	Off-site Disposal	Institutional Controls	Subtotal	20% Contingency	TOTAL
A	0	0	---	---	---	---	---	---	---	---	$4,500,000	$4,500,000	$900,000	$5,400,000
B	0	0	---	---	---	---	---	---	---	---	$9,900,000	$9,900,000	$1,980,000	$11,880,000
C1[1]	1,322,818	16,165	$32,000,000	---	---	$3,200,000	$1,600,000	---	---	$144,300,000	$4,500,000	$185,600,000	$37,120,000	$222,720,000
C2[1]	1,322,818	16,165	$32,000,000	---	---	$28,400,000	$1,800,000	---	---	$35,800,000	$4,500,000	$102,500,000	$20,500,000	$123,000,000
D	1,322,818	16,165	$31,000,000	$1,700,000	---	---	$1,800,000	---	$69,300,000	$2,000,000	$4,500,000	$110,300,000	$22,060,000	$132,360,000
E	1,322,818	16,165	$32,000,000	---	---	$3,200,000	$1,600,000	$54,700,000	---	---	$4,500,000	$96,000,000	$19,200,000	$115,200,000
F	999,117	16,165	$27,900,000	$1,700,000	$31,600,000	---	$1,600,000	---	$69,300,000	$2,000,000	$4,500,000	$138,600,000	$27,720,000	$166,320,000

500 ppb

Alternative	Dredge Volume (cy)	TSCA Dredge Vol. (cy)	Hydraulic Dredging	Mechanical Dredging	Capping	Dewatering	Water Treatment	Thermal Treatment	CDF Construction	Off-site Disposal	Institutional Controls	Subtotal	20% Contingency	TOTAL
A	0	0	---	---	---	---	---	---	---	---	$4,500,000	$4,500,000	$900,000	$5,400,000
B	0	0	---	---	---	---	---	---	---	---	$9,900,000	$9,900,000	$1,980,000	$11,880,000
C1[1]	1,023,621	16,165	$27,000,000	---	---	$3,200,000	$1,400,000	---	---	$111,700,000	$4,500,000	$147,800,000	$29,560,000	$177,360,000
C2[1]	1,023,621	16,165	$27,000,000	---	---	$22,000,000	$1,600,000	---	---	$27,700,000	$4,500,000	$82,800,000	$16,560,000	$99,360,000
D	1,023,621	16,165	$26,000,000	$1,700,000	---	---	$1,600,000	---	$69,300,000	$2,000,000	$4,500,000	$105,100,000	$21,020,000	$126,120,000
E	1,023,621	16,165	$27,000,000	---	---	$3,200,000	$1,400,000	$42,400,000	---	---	$4,500,000	$78,500,000	$15,700,000	$94,200,000
F	771,564	16,165	$23,700,000	$1,700,000	$28,700,000	---	$1,400,000	---	$37,300,000	$2,000,000	$4,500,000	$99,300,000	$19,860,000	$119,160,000

Table 7-5 Cost Summary for Remedial Alternatives - Little Lake Butte des Morts (Continued)

1,000 ppb

Alternative	Dredge Volume (cy)	TSCA Dredge Vol. (cy)	Hydraulic Dredging	Mechanical Dredging	Capping	Dewatering	Water Treatment	Thermal Treatment	CDF Construction	Off-site Disposal	Institutional Controls	Subtotal	20% Contingency	TOTAL
A	0	0	---	---	---	---	---	---	---	---	$4,500,000	$4,500,000	$900,000	$5,400,000
B	0	0	---	---	---	---	---	---	---	---	$9,900,000	$9,900,000	$1,980,000	$11,880,000
C1[1]	784,192	16,165	$22,100,000	---	---	$3,200,000	$1,300,000	---	---	$85,600,000	$4,500,000	$116,700,000	$23,340,000	$140,040,000
C2[1]	784,192	16,165	$22,100,000	---	---	$16,900,000	$1,400,000	---	---	$21,300,000	$4,500,000	$66,200,000	$13,240,000	$79,440,000
D	784,192	16,165	$21,100,000	$1,700,000	---	---	$1,400,000	---	$37,300,000	$2,000,000	$4,500,000	$68,000,000	$13,600,000	$81,600,000
E	784,192	16,165	$22,100,000	---	---	$3,200,000	$1,300,000	$32,500,000	---	---	$4,500,000	$63,600,000	$12,720,000	$76,320,000
F	635,547	16,165	$20,100,000	$1,700,000	$23,600,000	---	$1,300,000	---	$37,300,000	$2,000,000	$4,500,000	$90,500,000	$18,100,000	$108,600,000

5,000 ppb

Alternative	Dredge Volume (cy)	TSCA Dredge Vol. (cy)	Hydraulic Dredging	Mechanical Dredging	Capping	Dewatering	Water Treatment	Thermal Treatment	CDF Construction	Off-site Disposal	Institutional Controls	Subtotal	20% Contingency	TOTAL
A	0	0	---	---	---	---	---	---	---	---	$4,500,000	$4,500,000	$900,000	$5,400,000
B	0	0	---	---	---	---	---	---	---	---	$9,900,000	$9,900,000	$1,980,000	$11,880,000
C1[1]	281,689	16,165	$8,900,000	---	---	$3,200,000	$1,000,000	---	---	$30,900,000	$4,500,000	$48,500,000	$9,700,000	$58,200,000
C2[1]	281,689	16,165	$8,900,000	---	---	$6,100,000	$1,100,000	---	---	$7,700,000	$4,500,000	$28,300,000	$5,660,000	$33,960,000
D	281,689	16,165	$7,900,000	$1,700,000	---	---	$1,100,000	---	$37,300,000	$2,000,000	$4,500,000	$54,500,000	$10,900,000	$65,400,000
E	281,689	16,165	$8,900,000	---	---	$3,200,000	$1,000,000	$11,700,000	---	---	$4,500,000	$29,300,000	$5,860,000	$35,160,000
F	222,635	16,165	$8,000,000	$1,700,000	$11,700,000	---	$1,000,000	---	$37,300,000	$2,000,000	$4,500,000	$66,200,000	$13,240,000	$79,440,000

Note:

[1] Alternative C1 uses passive dewatering and Altenative C2 uses mechanical dewatering.

7.3 Appleton to Little Rapids Reach

An overview of the Appleton to Little Rapids Reach and PCB-impacted sediments is shown on Figure 7-21. The retained alternatives and associated costs are presented in Table 7-6.

7.3.1 General Site Characteristics

The Appleton to Little Rapids Reach is approximately 20 miles long, and is the divider between Outagamie County on the west and Brown County on the east (Figure 7-21). Much of this section of the river is agrarian, but in addition to Appleton, includes the communities of Kimberly, Kaukauna, Little Chute, and Wrightstown.

Throughout this reach, the river is characterized by a series of channels and pools controlled largely by the seven dams/locks found between the Appleton dam and the Little Rapids dam at Kaukauna. The contaminated sediment deposits are largely found in quiescent depositional pools (see Section 2). This section of the river ranges from relatively deep (8 to 12 feet), where the river narrows (i.e., the segment from Appleton to Cedars Locks), to shallow and unnavigable (i.e., at the Thousand Island Conservancy).

This reach has an average stream flow velocity of 0.79 ft/s (0.24 m/s) with an average maximum velocity of 4.36 ft/s (1.33 m/s). This reach has the greatest average flow velocities in the Lower Fox River. The nature and extent of PCB-impacted sediment in this reach, as summarized in the RI, includes the following:

- Maximum detected concentration - 77,444 μg/kg (avg. 6,406 μg/kg),
- Total PCB mass - 93 kg (after removal of Deposit N),
- Total PCB-impacted volume - 2,089,300 m^3, and
- Maximum PCB sample depth - 50 to 100 cm depth.

These quantities sum the total volumes/masses represented in each modeled depth layer (RETEC, 2002a). Required dredge volumes described in this section will likely be larger, since they account for overburden volumes above deeper sediment layers that contain PCBs.

An important impediment to sediment management (i.e., sediment removal or containment) in this reach is the dams/locks, which prevent free movement of equipment between the 22 separate sediment deposits. In this segment, only the Little Rapids Lock is operable; with the exception of the Rapide Croche Lock, which is permanently closed to restrict sea lamprey movement, all locks would require maintenance and renovation before they could be made operational. Several locks are too small to accommodate larger equipment barges. As a result, remedial actions in this reach would require multiple mobilizations of equipment around the dams.

Another important physical feature of this reach is the presence of bedrock immediately beneath the contaminated soft sediments in many areas. The presence of bedrock, and the inability to "over-dredge," could potentially impact sediment removal efficiency and cost. Residual surface concentrations (similar to the Deposit N demonstration project) may necessitate a reliance on natural recovery or capping after sediment removal.

7.3.2 Selected Remedial Alternatives

This section defines the remedial alternatives for the Appleton to Little Rapids Reach and then describes the technologies that would be applied based upon application of the criteria defined in Section 6. The remedial alternatives retained for the Appleton to Little Rapids Reach include the following:

A. No action.

B. Monitored natural recovery of the system with the expectation that institutional controls will be removed within 40 years.

C. Remove all river sediment with PCB concentrations greater than the selected action level and dispose of dredged sediment in an existing NR 500 commercial disposal facility.

E. Remove sediment with PCB concentrations exceeding the selected action level and treat this sediment using thermal treatment. Treated sediment may be beneficially reused.

Alternatives D, F, and G were not retained because of physical constraints within this reach. Neither a CDF nor a CAD site was considered for this reach due to lack of suitable and available in-water space, and hydrodynamic properties preclude the placement of a cap. The process options that can be applied to the remedial alternatives are described below.

7.3.3 Description of Process Options

Monitoring Options

Monitoring of physical, chemical, and biological media is applicable for Alternatives B through E. The no action alternative may also require monitoring of fish tissue for maintenance of pre-existing fish consumption advisories. As discussed in the technology screening process, monitoring is grouped into five categories: 1) baseline monitoring prior to remediation to establish baseline conditions for future comparisons, 2) monitoring during implementation, 3) post-verification monitoring to verify completion of a remedy, 4) long-term construction monitoring of containment facilities and sediment caps to verify continued source control and physical integrity, and 5) long-term monitoring to verify effectiveness of the remedy and attainment of the project RAOs. Numerous reference documents confirmed the necessity of a well-developed monitoring plan in order to verify the success of an implemented remedy, to measure the effectiveness and stability of source control measures, and to verify the achievement of project RAOs (EPA, 1998a, 1994a; SMWG, 1999; IJC, 1997; Krantzberg *et al.*, 1999). The following references were used in this FS Report to assess the types and applicability of monitoring options commonly used on sediment remediation projects:

- Ecology, *Standards for Confined Disposal of Contaminated Sediments Development Document* (Ecology, 1990);
- USACE, *Monitoring Considerations for Capping* (USACE, 1992);
- EPA and USACE, *Design, Performance, and Monitoring of Dredged Material Confined Disposal Facilities in Region 5* (EPA, 1996b);
- USACE, *Selected Tools and Techniques for Physical and Biological Monitoring of Aquatic Dredged Material Disposal Sites* (Fredette *et al.*, 1990);
- *Guidance for Subaqueous Dredged Material Capping* (Palermo, 1995);
- *Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories, Volume 1: Fish Sampling and Analysis* (EPA, 1995a);
- *Assessment and Remediation of Contaminated Sediments (ARCS) Program - Assessment Guidance Document* (EPA, 1994a);
- *Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites* (EPA, 1999b); and
- Sediment remediation case study projects presented in Appendices B and C of the FS.

Specific monitoring programs will be developed for each remedial alternative and will likely include physical, chemical, and biological monitoring components. Baseline monitoring generally includes water, sediment, and tissue quality sampling. Monitoring during implementation includes air and surface water sampling to assess downstream and off-site transport of contaminants. Verification monitoring includes surface and possibly subsurface sediment sampling to ensure compliance with the target goals of the remediation project. Source control monitoring includes groundwater and surface sediment sampling around the containment facility to confirm proper maintenance, stability, and chemical isolation. Long-term monitoring focuses primarily on fish, bird, and invertebrate tissue sampling and reproductive assessments, but also includes sediment and water sampling for chemical quality. The proposed *Long-term Monitoring Plan* for the Lower Fox River and Green Bay remediation project is presented in Appendix C.

Institutional Control Options

Institutional controls appropriate to the Appleton to Little Rapids Reach include:

- Maintenance of the fish and waterfowl consumption advisory;
- A moratorium on any future dredging within the navigation channel;
- Deed restrictions on any in-water activities that could result in sediment disturbance (e.g., marina construction or over-water development);
- Access restrictions to contaminated areas;
- Continued restriction on the use of the Lower Fox River for domestic water supplies; and
- A long-term (40-year) monitoring program for sediments, water, bird, and fish PCB and mercury levels.

Implementation of these institutional controls will likely require an active public education program for the fish, waterfowl, and domestic water advisories. Deed and access restrictions may require local or state legislative action to prevent any development in contaminated areas of the river. Access and use restrictions would also apply to local Indian tribes. Finally, federal action may be necessary on any dredging moratoriums within the federal navigation channel.

Removal Process Options

Sediment removal for the Appleton to Little Rapids Reach is identified for Alternatives C and E; however, the only practicable dredging option for removal is hydraulic dredging. The relatively shallow water depths within the reach and inaccessibility of the river preclude application of a mechanical dredge or land-based excavator.

Dredge Equipment. A hydraulic cutterhead dredge with a 10-inch pipeline has been selected for the remedial alternatives identified in this FS Report where a hydraulic dredge would be employed. While larger dredges are available, use of the 10-inch pipeline allows for a greater degree of control over resuspension of contaminated sediments during removal operations, provides for a removal time frame of less than 10 years, and limits the size required of a gravity dewatering pond.

An operating assumption is that dredging would occur only during normal daylight hours (10 hours per day) during a normal work week (5 days per week) since the Appleton to Little Rapids Reach includes residential areas. Winter weather conditions are likely to preclude operations; as a result, dredging is assumed to occur only between April and October (26 weeks per year), when the average minimum temperature is above freezing.

Both the round and horizontal auger cutterheads are commonly employed hydraulic dredges, with multiple capable portable dredges in the small- to medium-size range available in the Great Lakes region. Required operator experience and skills are also available in the region. Sediment remedial demonstrations by public agencies (i.e., USACE, EPA, Environment Canada) have highly rated the small horizontal auger dredge for contaminated sediment removal. A horizontal auger equipped with two 10-inch and two 12-inch pipelines, for example, has been employed at the Manistique Superfund site and SMU 56/57 demonstration project in the Lower Fox River, respectively. A suitable alternative is the small cutterhead dredge; the cutterhead is the only hydraulic dredge capable of effective operations if debris or compacted sand are present. A ladder cutterhead dredge was successfully used at the Deposit N demonstration project on the Lower Fox River.

Containment Systems. In-water containment systems placed around the dredging area are commonly implemented on both mechanical and hydraulic dredging projects to minimize sediment resuspension downstream of the dredging operation. Typical containment barrier systems range from expensive sheet pile walls (i.e., GM Foundry, Bayou Bonfouca), to silt curtains (i.e., West Eagle Harbor, Bayou Bonfouca, River Raisin), and inexpensive oil booms (PSNS Pier D). Silt curtains are the most commonly used containment device for lakes, rivers, and estuaries, but are prone to disturbance from passing ships, strong winds, and currents. Effectiveness of silt curtains depends upon local site conditions, bottom substrate, and curtain design; and therefore may not be applicable for every site. Silt curtains were used at both the Lower Fox River demonstration projects. Based on the successful performance of the dredging operations and curtains at Deposit N, use of silt curtains was discontinued during the second removal phase with minimal water quality exceedances measured downstream. However, for the purposes of this FS, silt curtains were included in the removal costs.

Over-dredge. All dredging is assumed to occur within a defined footprint to a fixed cut depth. When possible, approximately 8 inches of over-dredge of material beyond the estimated maximum depth of impacted sediment will likely be implemented to ensure complete removal of the targeted contaminant mass. However, for the purposes of the FS, over-dredge was not included in volume or cost estimates to allow comparability and consistency between different action levels and reaches.

Dewatering Process Options

For the alternatives utilizing hydraulic dredging in the Appleton to Little Rapids Reach, dewatering has been configured as a two-step process using a gravity settling pond, followed by solidification of solids. The water would be treated using flocculation, clarification, and sand filtration prior to discharge back to the river. For the dredge and off-site disposal alternative, the gravity settling pond is assumed to be located off site in nearby farm fields leased or purchased for the project. Given that much of the upriver portion of this reach is residential, the most likely area for facility construction would be outside Wrightstown, at the downstream end of deposits W and X. The hydraulic slurry from the upstream deposits would be transported via pipeline either on the river or overland around the dams and locks.

The proposed dewatering system would meet the criteria defined in Section 6 of this FS Report in terms of production rate, effectiveness, practicability, and discharge water quality. The dewatering system would operate 24 hours per day, potentially near residential areas. A passive dewatering system is preferable to mechanical dewatering because of low noise impact to the surrounding community and reduced operational costs. Final selection of the dewatering process will be determined during the remedial design phase.

Passive Dewatering. A passive dewatering system would include the construction of two approximately 9-acre gravity separation ponds. The ponds would be enclosed laterally with earthen berms to allow a ponding depth of 8 feet, and lined with asphalt pavement. Each settling pond would receive dredged sediment in 13-week increments and therefore contain a full season of dredge slurry. After a pond is filled, the sediment would be allowed to dewater to 20 percent solids based on dewatering studies (Montgomery-Watson, 1998). Residual water would be drained, treated, and discharged. Sediment would be removed in preparation for the next dredging season.

If sufficient land space cannot be secured for construction of a gravity settling pond, then mechanical dewatering will be employed using techniques similar to the Little Lake Butte des Morts Reach.

Solidification. The solids content after dewatering from hydraulic dredging is assumed to be 20 percent (w/w) and may still be difficult to manage due to high moisture content. Prior to any off-site shipment, the sediment would be solidified to improve handling and to satisfy requirements for solid waste hauling on public roads and disposal, if necessary. It was assumed that solidification was necessary, and that the sediment would be solidified with the addition of cement, lime, pozzolan, or other appropriate reagents. For FS costing purposes, 10 percent (w/w) lime was added as the reagent based on successful use during the SMU 56/57 demonstration project (Montgomery-Watson, 1998, 2000). The sediment will be mixed with the reagent and removed from the pond using standard earthmoving equipment. If the contractor prefers, sediment may first be removed from the settling pond and mixed with reagent in a pug mill as shown on Figures 7-1 and 7-5. Numerous other cost-effective reagents are available that may be tested and used for implementation of a remedial action.

Treatment Process Options

Water Treatment. Prior to water discharge back to the river, supernatant water would pass through flocculation, clarification, and sand filtration systems. Based on the acceptable performance of the sand filter unit during the Deposit N demonstration project, no additional water treatment is deemed necessary. However, additional carbon (GAC) treatment may be added to the treatment train during removal operations if effluent water quality criteria is exceeded. The estimated unit cost for GAC treatment is $0.40 per thousand gallons of water treated.

Thermal Treatment. Several on-site treatment process options were retained from the screening process in Section 6 that are applicable to the Lower Fox River/Green Bay remediation project. However, only vitrification was selected for costing purposes because the multi-phased study conducted by WDNR has provided data which indicates that this treatment technology is a viable option.

A separate vitrification unit will not be constructed for the Appleton to Little Rapids Reach. Dredged and dewatered sediments from the Appleton to Little Rapids Reach will be transported to the vitrification unit constructed at the Little Lake Butte des Morts Reach for processing. The facility will be integrated into the operation of an adjacent industrial facility with which it can share resources. Passive dewatered sediment enters the plant and is dried to approximately 10 percent moisture in the dryer unit. The sediment is mixed with a fluxing material and fed into a vitrification unit, capable of maintaining temperature around 2,900 °F. The sediment melts into a molten material in the unit and passes through the water bath for quenching resulting in glass aggregate.

For the purposes of this FS, sediment treatment by vitrification is assumed to occur over a time frame of 10 years in conjunction with treating dewatered sediments from Little Lake Butte des Morts Reach. The vitrification process is assumed to operate 24 hours per day, 7 days per week, and 350 days per year. The unit will be designed to have a capacity of processing 613 tons of sediment per day and produce 250 tons of glass aggregate per day.

On-site Disposal Process Options

No CDFs or CAD sites are proposed for the Appleton to Little Rapids Reach of the river. The small volume of contaminated material does not justify construction of a CDF and site conditions would likely preclude construction of a CAD site.

Off-site Disposal Process Options

All sediment samples collected to date in this reach indicate that the PCB concentrations are below 50 ppm; therefore, none of the sediment is considered TSCA material. All sediment could be shipped to a landfill that conforms to the NR 500 WAC requirements without EPA's TSCA approval letter.

Capping Process Options

No capping is proposed for the Appleton to Little Rapids Reach of the river as contaminated sediment depths are generally located in areas with less than 4 feet water depth and would be exposed to flood, propeller wash scouring, or ice scour.

7.3.4 Development of Alternatives and Associated Costs

This section describes the remedial alternatives developed for the Appleton to Little Rapids Reach. Each remedial alternative includes a process description, a process flow diagram, and a summary cost table. Summary costs presented as net present worth in this FS include a line item for 20 percent contingency costs (Table 7-6). Details used to develop each cost estimate are provided in Appendix H. The process flow diagrams and dredging/capping footprints for each alternative are presented on Figures 7-22 through 7-25.

The following components are discussed for each alternative, when applicable:

- Site mobilization and preparation,
- Sediment removal,
- Sediment dewatering,
- Water treatment,
- Sediment treatment,
- Sediment disposal,
- Demobilization and site restoration, and
- Long-term monitoring/institutional controls.

Alternative A: No Action

As required under the NCP, a no action alternative is included for the Appleton to Little Rapids Reach. This alternative involves taking no action and relying on natural processes, such as natural attenuation, dispersion, dilution, and sedimentation to reduce contaminant quantities and/or concentrations and control contaminant migration processes. This alternative implies that no active management or remediation is employed; however, some institutional controls, such as access or resource use restrictions, may be employed to reduce risks until the RAOs are achieved. The estimated cost for no action and maintenance of consumption advisories currently in place is $4,500,000. Engineered cost evaluations typically include a 20 percent contingency cost added to the remedy costs, as shown in the cost tables as a separate line item.

Alternative B: Monitored Natural Recovery/Institutional Controls

The monitored natural recovery option will include a long-term monitoring program (40-year) for measuring PCB, DDE, and mercury levels in water, sediment, invertebrates, fish, and birds. The monitoring program will be developed to effectively measure achievement of and progress towards the project RAOs expected in 40 years. Monitoring components will likely be collected between 2- and 5-year intervals for the first 10 years, and will include pre- and post-remedy sampling events to establish baseline conditions. Monitoring frequency may be modified after 5 years based on initial monitoring results. More specifically, the monitoring program will likely include (see Appendix C for the proposed *Long-term Monitoring Plan* for the project):

- Surface water quality sampling at several stations along the reach to determine the downstream transport of PCB mass into Green Bay (RAOs 1 and 4);

- Fish and waterfowl tissue sampling of several species and size classes to determine the residual risk of PCB and mercury consumption to human receptors (RAO 2);

- Fish (several species and size classes), bald eagle, and invertebrate tissue sampling to determine the residual risk of PCB uptake to environmental receptors (RAO 3);

- Population studies of birds (bald eagles and double-crested cormorants) to assess the residual effects of PCBs, DDE, and mercury on reproductive viability (RAO 3); and

- Surface sediment sampling in MNR areas to assess potential recontamination from upstream sources and status of attenuation of sediments (RAO 4).

Until the project RAOs have been achieved, institutional controls will be required to prevent exposure of human and biological receptors to contaminants. Institutional controls may also be implemented in combination with many of the proposed remedial alternatives, and may include monitoring, access restrictions, deed restrictions, dredging moratoriums, fish consumption advisories, and domestic water supply restrictions. Deed and access restrictions may require local or state legislative action to prevent any development in contaminated areas of the river. Items included in costs for institutional control include public education programs for fish or health advisories, 5-year fish tissue collection efforts for maintenance of consumption advisories, and deed restrictions.

The estimated cost for institutional controls and long-term monitoring is $9,900,000. Engineered cost evaluations typically include a 20 percent contingency cost added to the remedy costs, as shown in the cost tables as a separate line item.

Alternative C: Dredge with Off-site Disposal

Alternative C includes the removal of sediments above the remedial action level with a hydraulic dredge and off-site disposal of the sediments. Figure 7-22 provides the process flow diagram for this remedial alternative, while Figure 7-23 illustrates the extent of residual contamination following implementation of Alternative C. The summary costs to implement Alternative C are provided in Table 7-6. The total volume of sediment to be dredged in this alternative is 182,450; 80,611; 56,998; 46,178; and 20,148 cy for action levels of 125, 250, 500, 1,000, and 5,000 ppb, respectively.

Site Mobilization and Preparation. Staging for dredging would be conducted at several locations due to the interference of inoperable locks. Approximately five separate areas would be required for staging. Site mobilization and preparation includes securing the onshore property area for equipment staging and constructing areas for sediment dewatering, water treatment, sediment storage, and truck loading. Offshore, a docking facility for the hydraulic dredges would be constructed. Purchase and property preparation are included in the costs of the following process components.

Sediment Removal. The presence of bedrock in many areas of this reach presents potential removal difficulties that would require careful consideration when selecting dredge technologies and attainable cleanup goals. Sediment removal would be accomplished using a 10-inch pipeline cutterhead hydraulic dredge. Given the volumes and operating assumptions described in Section 7.3.3, the complete removal effort would require approximately 1.3 years for 125 ppb to 0.2 year for the 5,000 ppb action levels. Pipelines would extend from the dredging area to the dewatering area. For longer pipeline runs, it may be necessary to utilize in-line booster pumps to pump the slurry to the dewatering facility. Longer pipe runs may require periodic flushing of the lines during periods of inactivity. Silt curtains around the dredging area may be included to minimize sediment resuspension downstream of the dredging operation; installation of silt curtains were included in this FS for a cost of $35,000. Buoys and other waterway markers would be installed around the perimeter of the work area to prevent entry of unauthorized boats within the removal work zone. Other capital items included in the sediment removal costs are water quality monitoring, post-removal sediment bathymetric surveys to ensure achievement of the removal action, and site restoration at the conclusion of operations.

Sediment removal costs for hydraulic dredging are estimated to range between $10,100,000 for 125 ppb and $6,000,000 for 5,000 ppb action levels.

Sediment Dewatering. Gravity dewatering includes land purchase, site clearing, and dewatering pond construction. Key assumptions include an approximate 2.3 percent dredged solids concentration and an approximate 2,464 gpm water production for the dredge, based on results from the Lower Fox River demonstration projects (Foth and Van Dyke, 2000; Montgomery-Watson, 2000). Although the recent dredging work conducted at SMU 56/57 (Fort James *et al.*, 2001) showed the average percent solids in dredge slurry was 8.4 percent w/w (range 3.5 to 14.4 percent), the lower and more conservative percent slurry solids measured during the 1999 activities, was used for FS costs. Sediment dewatering would be done in a two-cell passive filtration system. The system would accommodate 26 weeks of solids dredge production rate, plus a maximum water surge storage capacity. One set of centrally-located dewatering ponds may be more than 10 miles from either end of the dredging area. Booster pumps may be required to pump dredged material to the dewatering ponds. It is assumed that the final sediment would require solidification with 10 percent (w/w) lime to satisfy hauling and disposal requirements (covered in disposal costs). Dewatering costs also include pond demobilization and site restoration at the completion of the project. This option assumes that adequate land space can be secured for construction of gravity settling ponds; otherwise, mechanical dewatering processing will be employed similar to the Deposit N demonstration project dewatering methods.

Sediment dewatering costs are estimated at $3,000,000 for all action levels.

Water Treatment. Water treatment includes purchase of equipment and materials for flocculation, clarification, and sand filtration. Water treatment would be conducted 24 hours per day, 7 days per week during the dredging season. Discharge water is estimated at 568,800 gallons per day. Daily discharge water quality monitoring is included in the cost estimate. Treated water would be sampled and analyzed to verify compliance with the appropriate discharge requirements prior to discharge back to the river. Carbon filtration could be added for a unit cost of $0.40 per thousand gallons of water treated. However, it may be necessary to add carbon filtration to the treatment train if effluent criteria are not met. Water treatment costs also include pad and equipment demobilization and site restoration.

Water treatment costs are estimated to range between $900,000 for 125 ppb and $800,000 for all other action levels.

Sediment Disposal. Sediment disposal includes the loading and transportation of the sediment to an existing NR 500 commercial disposal facility. No TSCA-level sediments are present in this reach, as the TSCA sediments were removed as part of the demonstration project during the fall of 1998 and fall of 1999. The estimated percent solids of dewatered sediment after 6 months of passive dewatering is 20 percent solids based on dewatering studies from the SMU 56/57 BOD Report (Montgomery-Watson, 1998). The sediments would be loaded into tractor-trailer end dumps with bed liners or sealed gates using a front-end loader. Each load would be manifested and weighed. Each tractor-trailer would pass through a wheel wash prior to leaving the staging area to prevent tracking soil onto nearby streets and highways.

Costs of sediment solidification and disposal at an existing NR 500 commercial disposal facility are estimated to range between $19,800,000 for 125 ppb and $2,200,000 for 5,000 ppb action levels. Solidification costs for addition of 10 percent (w/w) lime range between $6,700,000 and $743,000 for 125 ppb and 5,000 ppb action levels, respectively.

Demobilization and Site Restoration. Demobilization and site restoration involves removing all equipment (i.e., fencing, facilities) from the staging and work areas. All work pads and other permanent structures would be removed and the site would be graded to its original condition. Vegetated areas would be replanted to a state similar to that of pre-construction. Demobilization and restoration costs are included within the above dredging, dewatering, and treatment estimates.

Institutional Controls and Monitoring. Baseline monitoring includes primarily water, sediment, and tissue sampling during pre- and post-remedial sampling events. Monitoring during implementation includes surface water and limited air sampling to assess downstream and off-site transport of contaminants. Verification monitoring includes surface and possibly subsurface sediment sampling to ensure compliance with the target goals of the project. Long-term monitoring includes surface water, surface sediment, and biological tissue sampling to determine residual risks and impacts over time. If residual risks remain in the sediment above the risk-based SQTs after remediation, then the long-term monitoring plan described in the MNR alternative will be followed (i.e., media, frequency, location, duration) until the project RAOs are achieved or until a policy decision is made. The proposed *Long-term Monitoring Plan* (LTMP) is detailed in Appendix C. Elements of the LTMP may be implemented for each action level regardless of the remedial outcome in order to verify achievement of the RAOs. The sampling program may continue indefinitely under this process option, but for the purposes of the FS it has been estimated at 40 years.

Monitoring during implementation is included in the dredging and water treatment costs. The estimated cost for the maintenance of institutional controls and fish consumption monitoring is $4,500,000. Multimedia monitoring events and costs to determine long-term verification of project RAOs are included in Alternative B - Monitored Natural Recovery.

Alternative E: Dredge and Thermal Treatment

Alternative E includes hydraulic dredging of sediments above the remedial action level and treatment with an integrated vitrification unit. Figure 7-24 provides the process flow diagram for this remedial alternative, while Figure 7-25 illustrates the extent of residual contamination following implementation of Alternative E. Table 7-6 contains the summary costs to implement Alternative E. This alternative addresses the same volume of sediments as Alternative C.

Site Mobilization. Site mobilization and preparation includes securing the onshore property area for equipment staging, water treatment, and an offshore docking facility for the hydraulic dredge. Site preparation would also include building or modifying an existing integrated vitrification unit, capable of processing an estimated 250 glass tons per day.

Sediment Removal. Separate mechanical dredging for TSCA sediments is not required under this alternative since TSCA-level sediments will be treated by thermal treatment. Hydraulic sediment removal techniques and costs for this alternative are equivalent to that described for Alternative C. The estimated time to complete hydraulic dredging is the same as Alternative C.

Sediment Dewatering. Sediment dewatering is similar to the requirements described in Alternative C for construction of a passive dewatering facility. The solids content after dewatering from hydraulic dredging is assumed to be 30 percent (w/w). However, no solidification will occur prior to thermal treatment assuming that the dewatered filter cake at 30 percent (w/w) solids is acceptable for processing at the vitrification facility. Sediment dewatering costs (primarily construction costs) for Alternative E are estimated at $3,000,000.

Water Treatment. Water from gravity dewatering would be treated before discharge to the river. Treatment and monitoring requirements are expected to be the same as those for Alternative C. Water treatment costs for Alternative E are expected to be the same as those for Alternative C.

Sediment Treatment. After completion of passive dewatering (to approximately 30 percent solids), non-TSCA-level sediments are passed through the dryer and dried to approximately 10 percent moisture. Thermal treatment of the dried sediments involves blending the high-silt/clay sediments with fluxing materials and processing the materials in a melter as part of the vitrification process. The thermal treatment process would include appropriate treatment of air emissions. The unit cost for thermal treatment includes capital costs and operating costs. The capital costs include equipment, building, installation, engineering, and startup costs. Operating costs include labor, utilities, and general administrative costs. The unit cost is based on an assumption that the glass aggregate resulting from treating sediments will have a resale value between a range of $2 and $25 per ton as provided by Minergy. The unit cost for sediment treatment decreases with an increase in the resale value of the glass aggregate.

The cost for thermal treatment is estimated to range between $7,700,000 for 125 ppb to $900,000 for 5,000 ppb action levels at an estimated unit cost of $24 per ton.

Sediment Disposal. No sediment disposal as hazardous waste is necessary, as all the sediments will be treated by thermal treatment. Treated sediments transformed to glass aggregate by the vitrification process have a wide variety of applications. Based on analysis by product marketing specialists, the glass aggregate has a potential to be used as roofing shingle granules, industrial abrasives, ceramic floor tile, cement pozzolan and construction fill (Minergy Corporation, 2002a).

Demobilization and Site Restoration. Demobilization and site restoration involves removing all equipment (i.e., fencing, facilities) from the staging and work areas. All work pads and other permanent structures would be removed and the site would be graded to its original condition. Vegetated areas would be replanted to a state similar to that of pre-construction. Demobilization and restoration costs are included within the above dredging, dewatering, and treatment estimates.

Institutional Controls and Monitoring. Institutional controls and monitoring will be the same as those described for Alternative C.

7.3.5 Section 7.3 Figures and Tables

Figures and tables for Section 7.3 follow page 7-74 and include:

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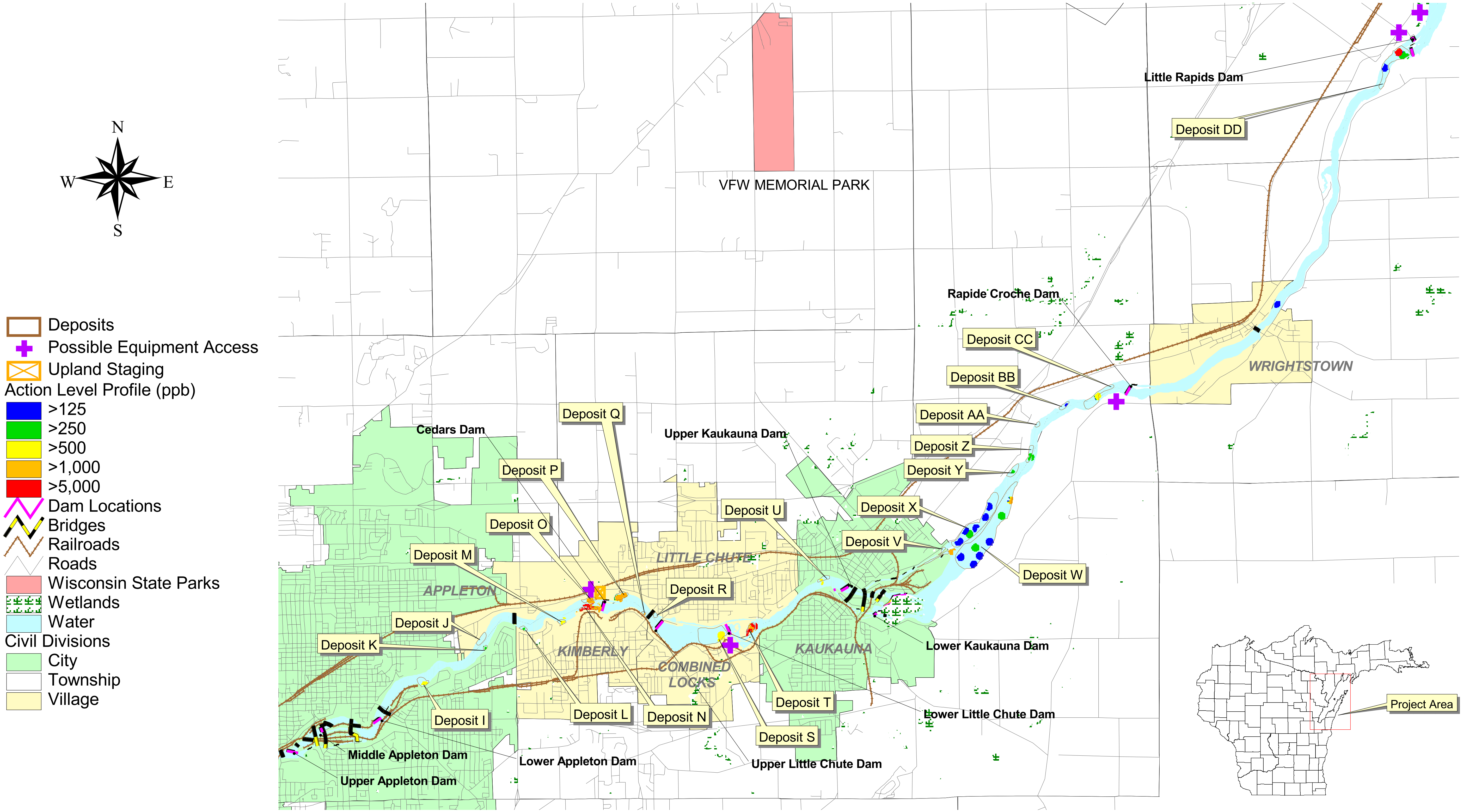
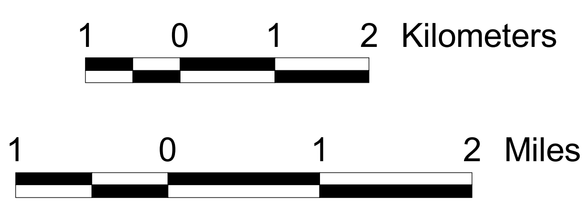
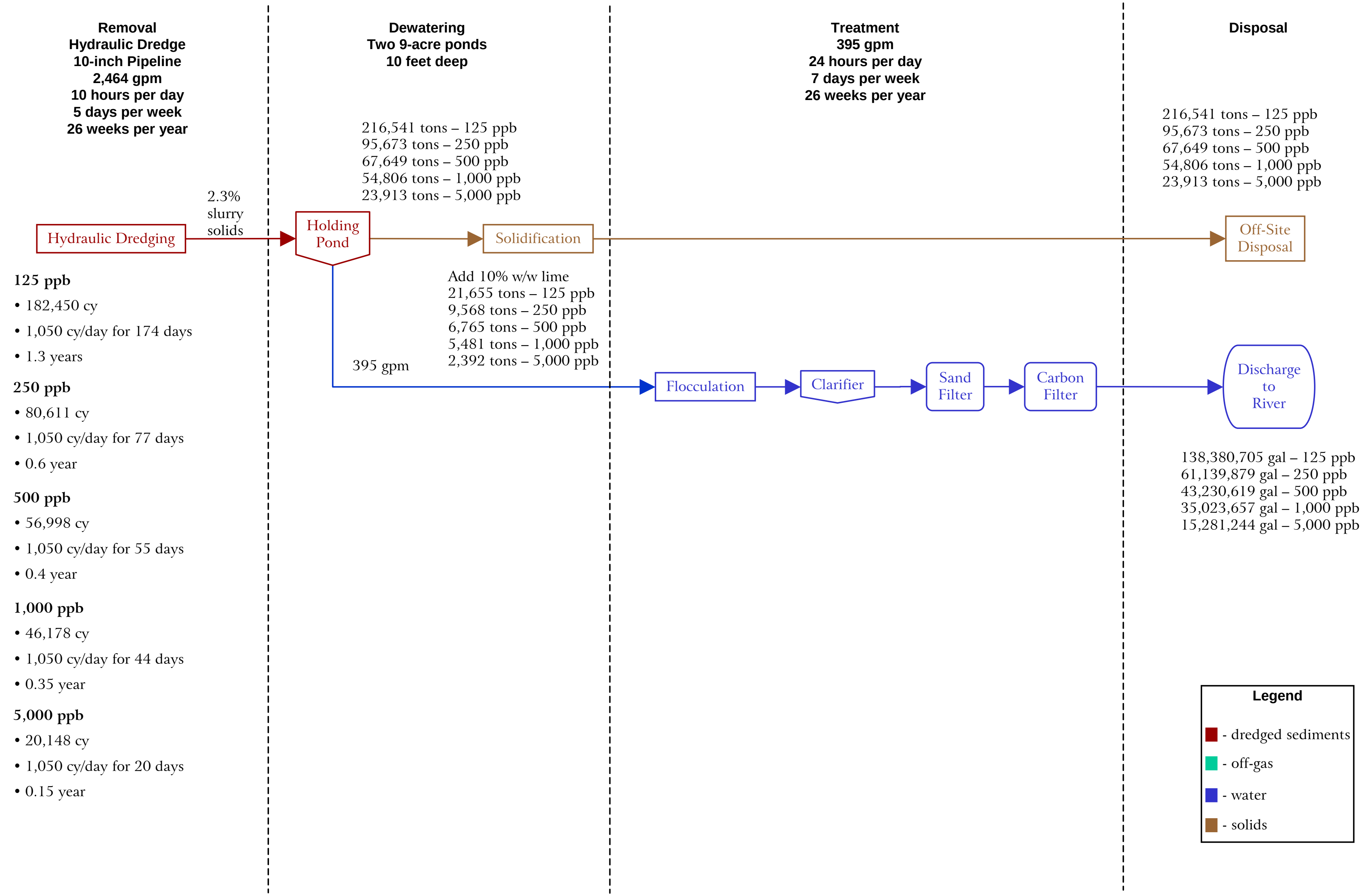




1. Basemap generated in ArcView GIS, Version 3.2, 1998, and from TIGER census data, 1995.
2. Deposit and management area data obtained from WDNR. and are included in the Fox River database.
3. Action level profiles for PCBs considered for all depth layers up to 350 cm for lower Fox River.
4. Former Deposit N shown for reference.

ThermoRetec Smart Solutions. Positive Outcomes.	Natural Resource Technology	Lower Fox River & Green Bay Feasibility Study	Sediment Management Area Overview: Appleton to Little Rapids	REFERENCE NO: FS-14414-535-7-18
				CREATED BY: SCJ
				PRINT DATE: 3/12/01
			FIGURE 7-21	APPROVED: GH

Figure 7-22 Process Flow Diagram for Appleton to Little Rapids - Alternative C: Dredge Sediment with Off-site Disposal



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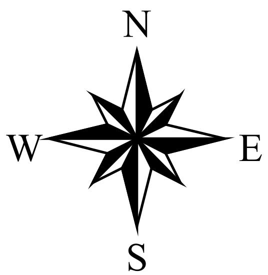
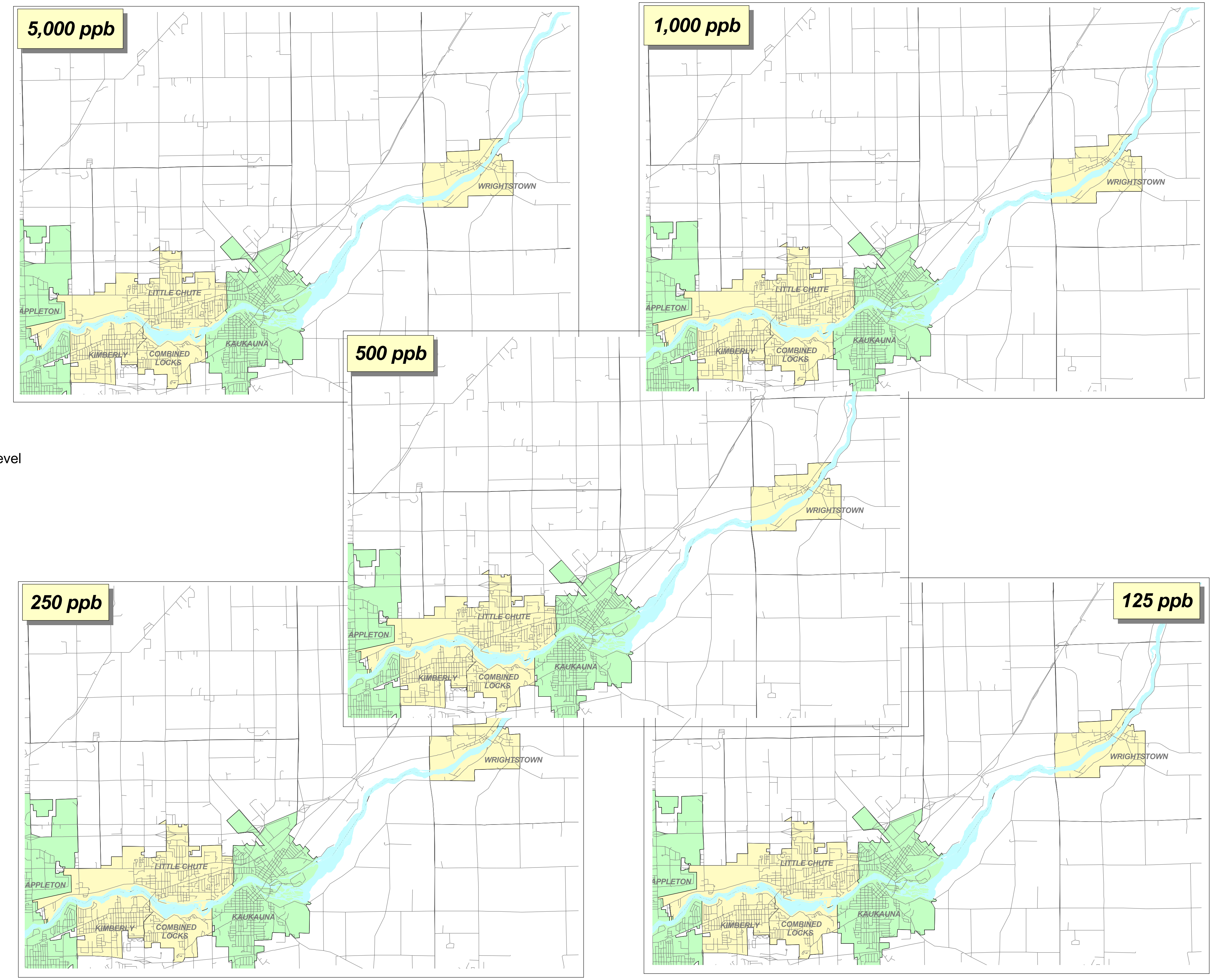
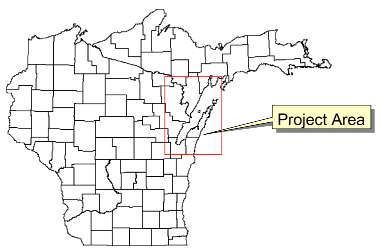




PCB Concentration (ppb) of Remaining Sediments by Action Level
- >125
- >250
- >500
- >1,000
- Dredged Sediments
- Roads
- Water

Civil Divisions
- City
- Township
- Village



1. Basemap generated in ArcView GIS, Version 3.2, 1998, and from TIGER census data, 1995.
2. Deposit and management area data obtained from WDNR, and are included in the Fox River database.
3. Action level profiles for PCBs considered for all depth layers up to 350 cm for Lower Fox River.

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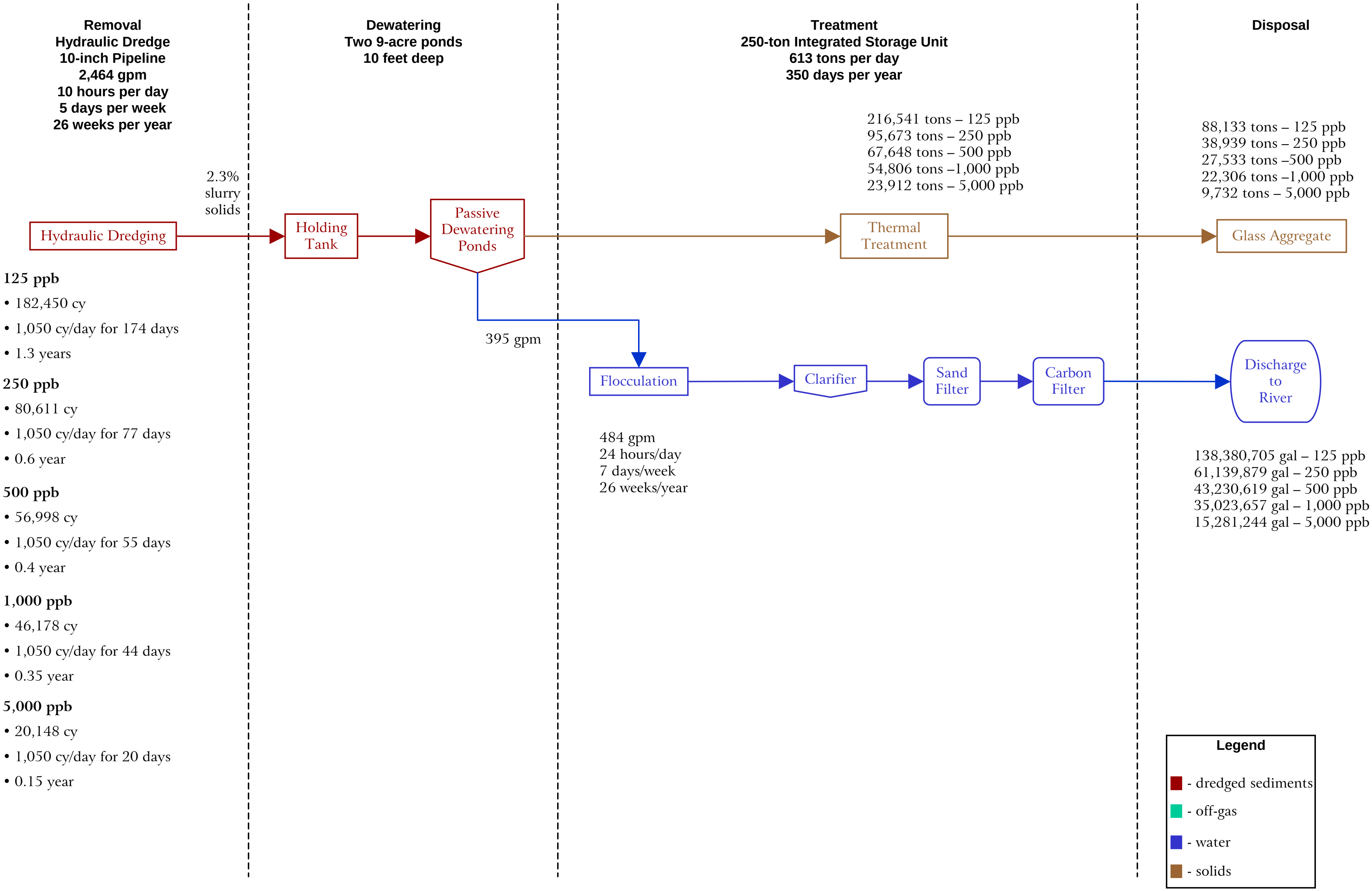
Lower Fox River & Green Bay Feasibility Study

Alternative C: Dredge Sediment to Off-Site Disposal Appleton to Little Rapids

FIGURE 7-23

REFERENCE NO:	FS14414-535-7-20
CREATED BY:	SCJ
PRINT DATE:	5/11/01
APPROVED:	AGF

Figure 7-24 Process Flow Diagram for Appleton to Little Rapids - Alternative E: Dredge Sediment with Thermal Treatment



Note: Additional integral elements of the vitrification unit (dryer, pollution control) are not shown as they were not estimated separate. For greater detail on the unit layout and components, refer to the Minergy Unit Cost Report (Appendix G).

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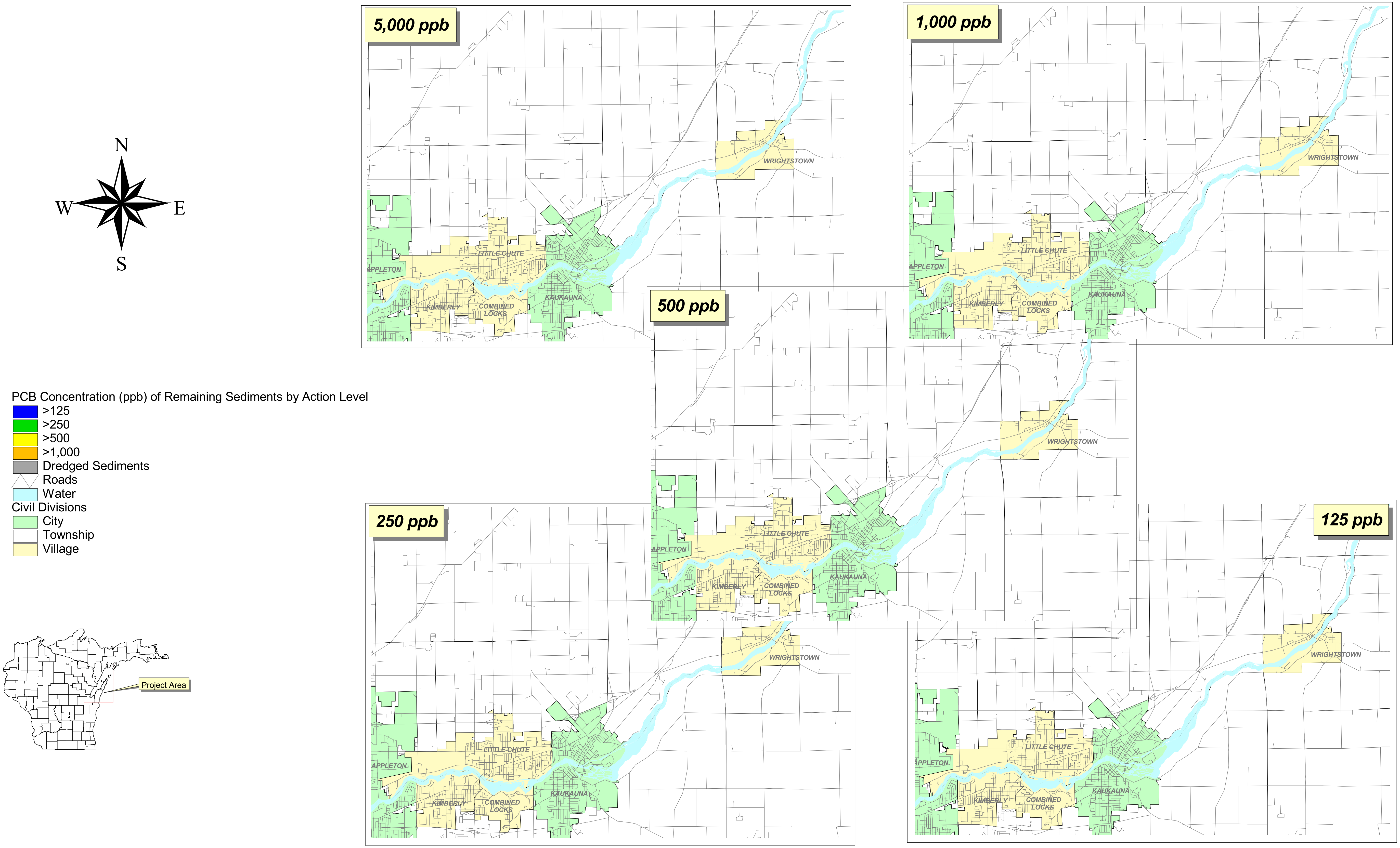

1. Basemap generated in ArcView GIS, Version 3.2, 1998, and from TIGER census data, 1995.
2. Deposit and management area data obtained from WDNR, and are included in the Fox River database.
3. Action level profiles for PCBs considered for all depth layers up to 350 cm for Lower Fox River.

Natural Resource Technology	Lower Fox River & Green Bay Feasibility Study	Alternative E: Dredge Sediment and Treatment Using Thermal Treatment: Appleton to Little Rapids	REFERENCE NO: FS14414-535-7-22	CREATED BY: SCJ
		FIGURE 7-25	PRINT DATE: 5/11/01	APPROVED: AGF

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Table 7-6 Cost Summary for Remedial Alternatives - Appleton to Little Rapids

125 ppb

Alternative	Dredge Volume (cy)	Hydraulic Dredging	Mechanical Dredging	Capping	Dewatering	Water Treatment	Thermal Treatment	CDF Construction	Off-site Disposal	Institutional Controls	Subtotal	20% Contingency	TOTAL
A	0	---	---	---	---	---	---	---	---	$4,500,000	$4,500,000	$900,000	$5,400,000
B	0	---	---	---	---	---	---	---	---	$9,900,000	$9,900,000	$1,980,000	$11,880,000
C	182,450	$10,100,000	---	---	$3,000,000	$900,000	---	---	$19,800,000	$4,500,000	$38,300,000	$7,660,000	$45,960,000
E	182,450	$10,100,000	---	---	$3,000,000	$900,000	$7,700,000	---	---	$4,500,000	$26,200,000	$5,240,000	$31,440,000

250 ppb

Alternative	Dredge Volume (cy)	Hydraulic Dredging	Mechanical Dredging	Capping	Dewatering	Water Treatment	Thermal Treatment	CDF Construction	Off-site Disposal	Institutional Controls	Subtotal	20% Contingency	TOTAL
A	0	---	---	---	---	---	---	---	---	$4,500,000	$4,500,000	$900,000	$5,400,000
B	0	---	---	---	---	---	---	---	---	$9,900,000	$9,900,000	$1,980,000	$11,880,000
C	80,611	$8,000,000	---	---	$3,000,000	$800,000	---	---	$8,700,000	$4,500,000	$25,000,000	$5,000,000	$30,000,000
E	80,611	$8,000,000	---	---	$3,000,000	$800,000	$3,400,000	---	---	$4,500,000	$19,700,000	$3,940,000	$23,640,000

500 ppb

Alternative	Dredge Volume (cy)	Hydraulic Dredging	Mechanical Dredging	Capping	Dewatering	Water Treatment	Thermal Treatment	CDF Construction	Off-site Disposal	Institutional Controls	Subtotal	20% Contingency	TOTAL
A	0	---	---	---	---	---	---	---	---	$4,500,000	$4,500,000	$900,000	$5,400,000
B	0	---	---	---	---	---	---	---	---	$9,900,000	$9,900,000	$1,980,000	$11,880,000
C	56,998	$7,200,000	---	---	$3,000,000	$800,000	---	---	$6,200,000	$4,500,000	$21,700,000	$4,340,000	$26,040,000
E	56,998	$7,200,000	---	---	$3,000,000	$800,000	$2,400,000	---	---	$4,500,000	$17,900,000	$3,580,000	$21,480,000

1,000 ppb

Alternative	Dredge Volume (cy)	Hydraulic Dredging	Mechanical Dredging	Capping	Dewatering	Water Treatment	Thermal Treatment	CDF Construction	Off-site Disposal	Institutional Controls	Subtotal	20% Contingency	TOTAL
A	0	---	---	---	---	---	---	---	---	$4,500,000	$4,500,000	$900,000	$5,400,000
B	0	---	---	---	---	---	---	---	---	$9,900,000	$9,900,000	$1,980,000	$11,880,000
C	46,178	$6,800,000	---	---	$3,000,000	$800,000	---	---	$5,000,000	$4,500,000	$20,100,000	$4,020,000	$24,120,000
E	46,178	$6,800,000	---	---	$3,000,000	$800,000	$2,000,000	---	---	$4,500,000	$17,100,000	$3,420,000	$20,520,000

5,000 ppb

Alternative	Dredge Volume (cy)	Hydraulic Dredging	Mechanical Dredging	Capping	Dewatering	Water Treatment	Thermal Treatment	CDF Construction	Off-site Disposal	Institutional Controls	Subtotal	20% Contingency	TOTAL
A	0	---	---	---	---	---	---	---	---	$4,500,000	$4,500,000	$900,000	$5,400,000
B	0	---	---	---	---	---	---	---	---	$9,900,000	$9,900,000	$1,980,000	$11,880,000
C	20,148	$6,000,000	---	---	$3,000,000	$800,000	---	---	$2,200,000	$4,500,000	$16,500,000	$3,300,000	$19,800,000
E	20,148	$6,000,000	---	---	$3,000,000	$800,000	$900,000	---	---	$4,500,000	$15,200,000	$3,040,000	$18,240,000

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7.4 Little Rapids to De Pere Reach

An overview of the Little Rapids to De Pere Reach and PCB-impacted sediments is shown on Figure 7-26. The retained alternatives and associated costs are presented in Table 7-7.

7.4.1 General Site Characteristics

The Little Rapids to De Pere Reach lies wholly within Brown County and is largely agricultural for much of the upper segment. In the area of the 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. Most of the contaminated sediments exist in a single contiguous depositional zone (Deposit EE), approximately 5 miles in length. The entire reach is approximately 7 miles in length.

Depths throughout this reach are greater than the two upstream reaches of Little Lake Butte des Morts and Appleton to Little Rapids. The main channel depth is generally greater than 6 feet throughout most of the reach, 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. General water depths by river reach are given in Ocean Surveys (1998).

The average stream velocity for the Little Rapids to De Pere Reach is 0.39 ft/s (0.12 m/s). The maximum flood velocity noted here is 2.23 ft/s (0.68 m/s). Average and 100-year flows are given in Table 2-5. The nature and extent of PCB-impacted sediment in this reach, as summarized in the RI, includes the following:

- Maximum detected concentration - 54,000 μg/kg (avg. 6,292 μg/kg),
- Total PCB mass - 996 kg,
- Total PCB-impacted volume - 2,089,360 m^3, and
- Maximum PCB sample depth - 200 to 250 cm depth

These quantities represent total volumes/masses represented in each modeled depth layer (RETEC, 2002a). Required dredge volumes described in this section will likely be larger since they account for overburden volumes above deeper sediment layers that contain PCBs.

There are generally no physical impediments to sediment management in this reach. However, there is no access to the river that would support remedial efforts, but there are opportunities suitable for construction and maintenance of a dock and nearshore support facilities.

7.4.2 Selected Remedial Alternatives

This section defines the remedial alternatives for the Little Rapids to De Pere Reach, and then describes the technologies that would be applied based upon application of the criteria defined in Section 6. The remedial alternatives retained for the Little Rapids to De Pere Reach include the following:

A. No action.

B. Monitored natural recovery of the system with the expectation that institutional controls will be removed within 40 years.

C. Remove all river sediment with PCB concentrations greater than the selected action level and dispose of dredged sediment in an NR 500 disposal facility.

D. Remove sediment with PCB concentrations exceeding the selected action level and place non-TSCA sediments in an on-site nearshore CDF. Transport TSCA sediments (greater than 50 ppm PCBs) to an existing NR 500 commercial disposal facility.

E. Remove sediment with PCB concentrations exceeding the selected action level and treat this sediment using thermal treatment. Treated sediment may be beneficially reused.

F. Place a sand cap over contaminated sediments to the maximum extent practicable. Mechanically remove all TSCA sediments from cap areas prior to capping and dispose in an existing NR 500 commercial disposal facility. Dredge remaining sediment and place dredged sediment in a CDF.

Alternative G was not retained, since river bathymetry and water depth limit the viability of installing a CAD site in this reach. The process options that can be applied to the remedial alternatives are described below.

7.4.3 Description of Process Options

Monitoring

Monitoring of physical, chemical, and biological media is applicable for Alternatives B through F. The no action alternative may also require monitoring of fish tissue for maintenance of pre-existing fish consumption advisories. As discussed in the technology screening process, monitoring is grouped into five categories: 1) baseline monitoring prior to remediation to establish baseline conditions for future comparisons, 2) monitoring during implementation, 3) post-verification monitoring to verify completion of a remedy, 4) long-term construction monitoring of containment facilities and sediment caps to verify continued source control and physical integrity, and 5) long-term monitoring to verify effectiveness of the remedy and attainment of the project RAOs. Numerous reference documents confirmed the necessity of a well-developed monitoring plan in order to verify the success of an implemented remedy, to measure the effectiveness and stability of source control measures, and to verify the achievement of project RAOs (EPA, 1998a, 1994a; SMWG, 1999; IJC, 1997; Krantzberg *et al.*, 1999). The following references were used in this FS Report to assess the types and applicability of monitoring options commonly used on sediment remediation projects:

- Ecology, *Standards for Confined Disposal of Contaminated Sediments Development Document* (Ecology, 1990);
- USACE, *Monitoring Considerations for Capping* (USACE, 1992);
- EPA and USACE, *Design, Performance, and Monitoring of Dredged Material Confined Disposal Facilities in Region 5* (EPA, 1996b);
- USACE, *Selected Tools and Techniques for Physical and Biological Monitoring of Aquatic Dredged Material Disposal Sites* (Fredette *et al.*, 1990);
- *Guidance for Subaqueous Dredged Material Capping* (Palermo, 1995);
- *Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories, Volume 1: Fish Sampling and Analysis* (EPA, 1995a);
- *Assessment and Remediation of Contaminated Sediments (ARCS) Program - Assessment Guidance Document* (EPA, 1994a);
- *Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites* (EPA, 1999b);
- Sediment remediation case study projects presented in Appendices B and C of the FS.

Specific monitoring programs will be developed for each remedial alternative and will likely include physical, chemical, and biological monitoring components. Baseline monitoring generally includes water, sediment, and tissue quality sampling. Monitoring during implementation includes air and surface water sampling to assess downstream and off-site transport of contaminants. Verification monitoring includes surface and possibly subsurface sediment sampling to ensure compliance with the target goals of the remediation project. Source control monitoring includes groundwater and surface sediment sampling around the containment facility to confirm proper maintenance, stability, and chemical isolation. Long-term monitoring focuses primarily on fish, bird, and invertebrate tissue sampling and reproductive assessments, but also includes sediment and water sampling for chemical quality. The proposed *Long-term Monitoring Plan* for the Lower Fox River and Green Bay remediation project is presented in Appendix C.

Institutional Control Options

Institutional controls appropriate to the Little Rapids to De Pere Reach include:

- Maintenance of the fish and waterfowl consumption advisory;
- A moratorium on any future dredging within the navigation channel;
- Deed restrictions on any in-water activities that could result in sediment disturbance (e.g., marina construction or over-water development);
- Access restrictions to contaminated areas;
- Continued restriction on the use of the Lower Fox River for domestic water supplies; and
- A long-term (40-year) monitoring program for sediments, water, bird, and fish PCB and mercury levels.

Implementation of these institutional controls will likely require an active public education program for the fish, waterfowl, and domestic water advisories. Deed and access restrictions may require local or state legislative action to prevent any development in contaminated areas of the river. Access and use restrictions would also apply to local Indian tribes. Finally, federal action may be necessary on any dredging moratoriums within the federal navigation channel.

Removal Process Options

Sediment removal is identified for Alternatives C through F. For the Little Rapids to De Pere Reach, the only practicable dredging option for large-scale removal is hydraulic dredging. The relatively shallow water depths within the reach and accessibility concerns preclude application of a mechanical dredge.

Dredge Equipment. A hydraulic cutterhead dredge with a 10- or 12-inch pipeline has been selected for most of the remedial alternatives identified in this FS Report where a hydraulic dredge would be employed. While larger dredges are available, use of the 10- or 12-inch pipeline allows for a greater degree of control over resuspension of contaminated sediments during removal operations, provides for a removal time frame of less than 10 years, and limits the required size of a gravity dewatering pond. Alternative C2A, which includes hydraulic dredging and pumping sediment directly to a combined NR 213/NR 500 dewatering and disposal facility, Alternative C2B, which includes hydraulic dredging, passive dewatering, and transportation to a dedicated NR 500 monofill, and Alternative E, which includes hydraulic dredging, passive dewatering, and thermal treatment, utilize two dredges with 12-inch pipelines. This combination of dredges was selected so that the pipeline or the vitrification unit could be shared with the De Pere to Green Bay Reach and the cleanup could be completed within 10 years. Remedial Alternative C3, which includes hydraulic dredging, mechanical dewatering and transportation to an existing NR 500 commercial disposal facility utilizes one cutterhead dredge with 10-inch pipeline. Because the Little Rapids to De Pere Reach includes residential areas, an operating assumption is that dredging would occur only during normal daylight hours (10 hours per day) during a normal work week (5 days per week). Due to shared facilities with the De Pere to Green Bay Reach, dredging for Alternatives C2A, C2B, and E will occur 24 hours per day, 7 days per week. Winter weather conditions are likely to preclude operations; as a result, dredging is assumed to occur only between April and October (26 weeks per year) when the average minimum temperature is above freezing.

Both the round and horizontal auger cutterheads are commonly employed hydraulic dredges, with multiple capable portable dredges in the small- to medium-size range available in the Great Lakes region. Required operator experience and skills are also available in this region. Sediment remedial demonstrations by public agencies (i.e., USACE, EPA, Environment Canada) have rated highly the small horizontal auger dredge for contaminated sediment removal. A horizontal auger equipped with two 10-inch pipelines and a 12-inch pipeline, for example, has been employed at the Manistique Superfund site and Lower Fox River SMU 56/57 demonstration project, respectively. A suitable alternative is the small cutterhead dredge; the cutterhead is the only hydraulic dredge capable of effective operations if debris or compacted sand are present. A ladder cutterhead dredge was successfully used at the Deposit N demonstration project on the Lower Fox River.

Containment Systems. In-water containment systems placed around the dredging area are commonly implemented on both mechanical and hydraulic dredging projects to minimize sediment resuspension downstream of the dredging operation. Typical containment barrier systems range from expensive sheet pile walls (i.e., GM Foundry, Bayou Bonfouca), to silt curtains (i.e., West Eagle Harbor, Bayou Bonfouca, River Raisin), and inexpensive oil booms (PSNS Pier D). Silt curtains are the most commonly used containment device for lakes, rivers, and estuaries, but are prone to disturbance from passing ships, strong winds, and currents. Effectiveness of silt curtains depends upon local site conditions, bottom substrate, and curtain design; and therefore may not be applicable for every site. Silt curtains were used at both the Lower Fox River demonstration projects. Based on the successful performance of the dredging operations and curtains at Deposit N, use of silt curtains was discontinued during the second removal phase with minimal water quality exceedances measured downstream. However, for the purposes of this FS, silt curtains were included in the removal costs.

Over-dredge. All dredging is assumed to occur within a defined footprint to a fixed cut depth. When possible, approximately 8 inches of over-dredge of material beyond the estimated maximum depth of impacted sediment will likely be implemented to ensure complete removal of the targeted contaminant mass. However, for the purposes of the FS, over-dredge was not in volume or cost estimates to allow comparability and consistency between different action levels and reaches.

Dewatering Process Options

For the majority of the alternatives utilizing hydraulic dredging in the Little Rapids to De Pere Reach, dewatering has been configured as a two-step process using a gravity settling pond, followed by solidification of solids. The water would be treated using flocculation, clarification, and sand filtration prior to discharge back to the river. For the dredge and off-site disposal alternatives (Alternatives C, E, and F), the gravity settling pond would be located on nearby property. For the dredge to CDF alternative (Alternative D), dewatering would be conducted directly within the CDF (discussed below). A mechanical dewatering option has been included for Alternative C3.

The proposed dewatering system would meet the criteria defined in Section 6 of this FS Report in terms of production rate, effectiveness, practicality, and discharge water quality. The dewatering system would operate 24 hours per day near residential areas. Assuming adequate land space can be secured, a passive system is preferable to mechanical dewatering because of lower noise impact to the surrounding community and cheaper operational costs. Final selection of the dewatering process will be determined during the remedial design phase.

Passive Dewatering. For Alternatives C1 and F, the passive dewatering system would include the construction of two approximately 9-acre gravity separation ponds.

For Alternatives C2B and E, the passive dewatering system includes construction of two approximately 58-acre ponds. The ponds would be enclosed laterally with berms to allow a ponding depth of 8 feet, and lined with asphalt pavement. Each settling pond would receive dredged sediment in 13-week increments, and therefore contain a full season of dredge slurry. After a pond is filled, the sediment would be allowed to dewater to 30 percent solids based on dewatering studies (Montgomery-Watson, 1998). The residual water would be drained, treated, and discharged. The sediment will be solidified using lime or other agents prior to off-site disposal, since dewatered sediment may still be difficult to manage due to high moisture content. Sediment would be removed in preparation for the next dredging season.

Mechanical Dewatering. A mechanical dewatering option is included for Alternative C3. Mechanical dewatering involves pumping the hydraulically-dredged slurry into conditioning tanks or ponds, where the slurry is adjusted to the appropriate solids content, and chemicals are added to assist in the dewatering process. Mechanical dewatering would include shaker screens and hydrocyclones or belt filter presses after initial conditioning. Based on dewatering results from both of the Lower Fox River demonstration projects, the estimated percent solids of the filter cake after shaker screen, hydrocyclones, and belt filter presses ranged between 40 and 60 percent solids (Foth and Van Dyke, 2000; Fort James *et al.*, 2001).

Solidification. The solids content after passive dewatering for the hydraulic dredging is assumed to be 30 percent (w/w) and may still be difficult to manage due to high moisture content. Prior to any off-site shipment, the sediment would be solidified to improve handling and to satisfy requirements for solid waste hauling on public roads and disposal, if necessary. It was assumed that solidification was necessary, and that the sediment would be solidified with the addition of cement, lime, pozzolan, or other appropriate reagents. For FS costing purposes, 10 percent (w/w) lime was added as the reagent based on its successful use during the SMU 56/57 projects (Montgomery-Watson, 1998, 2000). The sediment will be mixed with the reagent and removed from the pond using standard earthmoving equipment. If the contractor prefers, sediment may first be removed from the settling pond and mixed with reagent in a pug mill as shown on Figures 7-1 and 7-5. Numerous other cost-effective reagents are available that may be tested and used for implementation of a remedial action.

Treatment Process Options

Water Treatment. Prior to water discharge back to the river, supernatant water would pass through flocculation, clarification, and sand filtration systems. Based on the acceptable performance of the sand filter unit during the Deposit N demonstration project, no additional water treatment is deemed necessary (Foth and Van Dyke, 2000). However, additional carbon (GAC) treatment may be added to the treatment train during removal operations if effluent water quality criteria is exceeded. The estimated unit cost for GAC carbon treatment is $0.40 per thousand gallons of water treated.

Thermal Treatment. Several treatment process options were retained from the screening process in Section 6 that are applicable to the Lower Fox River/Green Bay remediation project. However, only vitrification was selected for costing purposes because the multi-phased study conducted by WDNR has provided data which indicates that this treatment technology is a viable option.

A full-scale vitrification unit will be constructed for the Little Rapids to De Pere Reach. The facility will be built as a standalone unit with on-site storage capacity and equipped with two 375 glass tons per day units. The sizing of the vitrification unit is based on the assumption that dewatered sediments from De Pere to Green Bay Reach will also undergo thermal treatment at this facility. The passively dewatered sediment enters the plant and is dried to approximately 10 percent moisture in the dryer unit. The sediment is mixed with a fluxing material and fed into a large melter, capable of maintaining temperature around 2,900 ˚F. The sediment melts into a molten material in the melter and passes through the water bath for quenching resulting in glass aggregate.

For the purposes of this FS, sediment treatment by vitrification is assumed to occur over a combined time frame of 10 years for both the Little Rapids to De Pere and De Pere to Green Bay reaches. The vitrification process is assumed to operate 24 hours per day, 7 days per week, and 350 days per year. The unit will be designed to have a capacity of 1,840 tons of sediment per day, producing 750 tons of glass aggregate per day.

On-site Disposal Process Options

The Little Rapids to De Pere Reach is relatively narrow and contains a large number of residences at the northern end of the reach. As a result, it is not considered practicable to place a CDF or CAD site in this reach. For the purposes of this FS, it was assumed that sediment from the Little Rapids to De Pere Reach would be placed upstream in the Menasha CDF in Little Lake Butte des Morts.

Off-site Disposal Process Options

All sediment samples collected to date in this reach indicate that the PCB concentrations are below 50 ppm, and therefore not considered TSCA material. All sediment could be shipped to a dedicated NR 500 monofill or existing landfill that conforms to the NR 500 WAC requirements.

Capping Process Options

Sediment in the river segments within this reach is amenable to capping. Capping is a viable alternative for most portions of this reach due to greater water depths in contaminated areas, relatively slow currents, and the lack of TSCA-level sediment. Furthermore, the reach has been identified as a depositional zone rather than an erosional zone (RETEC, 2002a), which further supports the potential for capping in this reach.

A protective cap placed in the Little Rapids to De Pere Reach would be a sand cap overlain with large cobble to provide erosion protection. The sand cap would be placed with a 10-inch tremie pipeline. Use of a tremie is preferable to placement with a split-hull barge in this reach to minimize the potential for resuspension of contaminated sediments. Placement of armor is also proposed using a barge-floated bucket.

7.4.4 Development of Alternatives and Associated Costs

This section describes the remedial alternatives developed for the Little Rapids to De Pere Reach. Each remedial alternative includes a process description, a process flow diagram, and a summary cost table. Details used to develop each cost estimate are provided in Appendix H. The process flow diagrams and dredging/capping footprints for each alternative are presented on Figures 7-27 through 7-35. Summary costs presented as net present worth in this FS include a line item for 20 percent contingency costs (Table 7-7).

The following components are discussed, when applicable, within the development of each alternative:

- Site mobilization and preparation,
- Sediment removal,
- Sediment dewatering,
- Water treatment,
- Sediment treatment,
- Sediment disposal,
- Demobilization and site restoration, and
- Long-term monitoring/institutional controls.

Alternative A: No Action

As required under the NCP, a no action alternative is included for the Little Rapids to De Pere Reach. This alternative involves taking no action and relying on natural processes, such as natural attenuation, dispersion, dilution, and sedimentation to reduce contaminant quantities and/or concentrations and control contaminant migration processes. This alternative implies that no active management or remediation is employed; however, some institutional controls, such as access or resource use restrictions, may be employed to reduce risks until the RAOs are achieved. Costs include 5-year fish tissue sampling events for 40 years to maintain the fish consumption advisories already in place.

The estimated cost for no action and maintenance of consumption advisories currently in place is $4,500,000. Engineered cost evaluations typically include a 20 percent contingency cost added to the remedy costs, as shown in the cost tables as a separate line item.

Alternative B: Monitored Natural Recovery/Institutional Controls

The monitored natural recovery option will include a long-term monitoring program (40-year) for measuring PCB, DDE, and mercury levels in water, sediment, invertebrates, fish, and birds. The monitoring program will be developed to effectively measure achievement of and progress towards the project RAOs expected in 40 years. Monitoring components will likely be collected between 2- and 5-year intervals for the first 10 years, and will include pre- and post-remedy sampling events to establish baseline conditions. Monitoring frequency may be modified after 5 years based on initial monitoring results. More specifically, the monitoring program will likely include (see Appendix C for the proposed *Long-term Monitoring Plan* for the project):

- Surface water quality sampling at several stations along the reach to determine the downstream transport of PCB mass into Green Bay (RAOs 1 and 4);

- Fish and waterfowl tissue sampling of several species and size classes to determine the residual risk of PCB and mercury consumption to human receptors (RAO 2);

- Fish (several species and size classes), bald eagle, and invertebrate tissue sampling to determine the residual risk of PCB, DDE, and mercury uptake to environmental receptors (RAO 3);

- Population studies of birds (bald eagles and double-crested cormorants) to assess the residual effects of PCBs, DDE, and mercury on reproductive viability (RAO 3); and

- Surface sediment sampling in MNR areas to assess potential recontamination from upstream source and status of attenuation of sediments (RAO 4).

Until the project RAOs have been achieved, institutional controls will be required to prevent exposure of human and biological receptors to contaminants. Institutional controls may also be implemented in combination with many of the proposed remedial alternatives, and may include monitoring, access restrictions, deed restrictions, dredging moratoriums, fish consumption advisories, and domestic water supply restrictions. Deed and access restrictions may require local or state legislative action to prevent any development in contaminated areas of the river. Items included in costs for institutional control include public education programs for fish or health advisories, 5-year fish tissue collection efforts for maintenance of consumption advisories, and deed restrictions.

The estimated cost for institutional controls and long-term monitoring is $9,900,000. Engineered cost evaluations typically include a 20 percent contingency cost added to the remedy costs, as shown in the cost tables as a separate line item.

Alternative C1: Dredge with Disposal at an Existing NR 500 Commercial Disposal Facility (Passive Dewatering)

Alternative C includes the removal of sediments above the remedial action level with a hydraulic dredge and off-site disposal of the sediments. Alternative C1 trucks dewatered sediment to an existing NR 500 commercial disposal facility while Alternative C2A hydraulically pumps sediment slurry directly to a combined NR 213/NR 500 dewatering and disposal facility (discussed in the De Pere to Green Bay Reach). Alternative C2B hydraulically pumps sediment slurry to a separate NR 213 dewatering facility and trucks dewatered sediment to a dedicated NR 500 monofill. Alternative C3 utilizes mechanical dewatering and the dewatered sediment is transported to an existing NR 500 commercial disposal facility. Figure 7-27 provides the process flow diagram for this remedial alternative, while Figure 7-31 illustrates the extent of residual contamination following implementation of Alternative C. The summary costs to implement Alternative C are provided in Table 7-7. The total volume of sediment to be dredged in this alternative ranges between 1,483,156 cy for 125 ppb and 186,348 cy for 5,000 ppb action levels. Alternatives C2A and C2B would only be implemented if the corresponding C2 alternatives for the De Pere to Green Bay Reach are selected.

Site Mobilization and Preparation. Staging for the dredging of sediment would be conducted at an undetermined location. Site mobilization and preparation includes land acquisition and securing the onshore property area for equipment staging, constructing areas for sediment dewatering ponds, water treatment, sediment storage, and truck loading. An offshore docking facility for the hydraulic dredges would be constructed. Property purchase and preparation are included in the costs of the following process components.

Sediment Removal. Sediment removal would be done using a 10-inch pipeline cutterhead hydraulic dredge. Given the volumes and operating assumptions described above, the complete removal effort would require approximately 11 years for 125 ppb and 1.4 years for the 5,000 ppb action levels. Pipelines would extend directly from the dredging area to the dewatering area. For longer pipeline runs, it may be necessary to utilize in-line booster pumps to pump the slurry to the dewatering facility. Longer pipe runs may require periodic flushing of the lines during periods of inactivity. Silt curtains around the dredging area may be included to minimize sediment resuspension downstream of the dredging operation; installation of silt curtains was included in the FS for $35,000. Buoys and other waterway markers would be installed around the perimeter of the work area to prevent entry of unauthorized boats within the removal work zone. Other capital items included in the sediment removal costs are water quality monitoring, post-removal sediment bathymetric surveys to ensure achievement of the removal action, and site restoration at the conclusion of operations.

Sediment removal costs are estimated to range between $33,900,000 for 125 ppb and $6,900,000 for 5,000 ppb action levels.

Sediment Dewatering. Gravity dewatering includes land purchase, site clearing, and dewatering pond construction. Key assumptions include an approximate 4 percent dredged solids concentration and an approximate 2,464 gpm water production for the dredge, based on results from the Lower Fox River demonstration projects (Foth and Van Dyke, 2000; Montgomery-Watson, 2000). Although the recent dredging work conducted at SMU 56/57 (Fort James *et al.*, 2001) showed the average percent solids in dredge slurry was 8.4 percent w/w (range 3.5 to 14.4 percent), the lower and more conservative percent slurry solids measured during the 1999 activities was used for FS costs. Sediment dewatering would be done in a two-cell passive filtration system. The system would accommodate 26 weeks of solids dredge production rate, plus a maximum water surge storage capacity. It is assumed that the final sediment would require solidification with 10 percent (w/w) lime to satisfy hauling and disposal requirements (included in sediment disposal). Dewatering costs also include pond decommissioning and site restoration at the completion of the project. Passive dewatering assumes that adequate land space can be acquired for construction of gravity settling ponds, otherwise mechanical dewatering methods will be employed. Mechanical dewatering would use methods similar to the Deposit N demonstration project including shaker screens, hydrocyclones, and belt filter presses.

Sediment dewatering costs (primarily for construction) for Alternative C1 are estimated at $3,100,000 for all action levels.

Water Treatment. Water treatment includes purchase of equipment and materials for flocculation, clarification, and sand filtration. Water treatment would be conducted 24 hours per day, 7 days per week during the dredging season. Discharge water is estimated at 560,000 gallons per day. Daily discharge water quality monitoring is included in the cost estimate. Treated water would be sampled and analyzed to verify compliance with the appropriate discharge requirements prior to discharge back to the river. Carbon filtration could be added for a unit cost of $0.40 per thousand gallons of water treated. However, it may be necessary to add carbon filtration to the treatment train if effluent criteria are not met. Water treatment costs also include pad and equipment demobilization and site restoration.

Water treatment costs are estimated to range between $1,700,000 for 125 ppb and $900,000 for 5,000 ppb action levels.

Sediment Disposal. Sediment disposal includes the loading and transportation of the sediment to a permitted facility. Disposal costs also include the purchase and addition of lime reagent for further solidification of dewatered sediment prior to off-site transport. The estimated percent solids of dewatered sediments after 6 months of passive dewatering is 30 percent (w/w) solids based on the SMU 56/57 BOD Report (Montgomery-Watson, 1998). Solidification costs for the addition of 10 percent (w/w) lime range between $60,000,000 and $7,500,000 for 125 ppb and 5,000 ppb action levels, respectively. The sediments would be loaded into tractor-trailer end dumps with bed liners or sealed gates using a front-end loader. Each load would be manifested and weighed. Each tractor-trailer would pass through a wheel wash prior to leaving the staging area to prevent tracking soil onto nearby streets and highways.

Costs of sediment solidification and disposal at an existing NR 500 commercial disposal facility are estimated to range between $181,000,000 for 125 ppb and $22,700,000 for 5,000 ppb action levels.

Demobilization and Site Restoration. Demobilization and site restoration involves removing all equipment (i.e., fencing, facilities) from the staging and work areas. All work pads and other permanent structures would be removed and the site would be graded to its original condition. Vegetated areas would be replanted to a state similar to that of the pre-construction. Demobilization and restoration costs are included within the above dredging, dewatering, and treatment estimates.

Institutional Controls and Monitoring. Baseline monitoring includes primarily water, sediment, and tissue sampling during pre- and post-remedial sampling events. Monitoring during implementation includes surface water and limited air sampling to assess downstream and off-site transport of contaminants. Verification monitoring includes surface and possibly subsurface sediment sampling to ensure compliance with the target goals of the project. Long-term monitoring includes surface water, surface sediment, and biological tissue sampling to determine residual risks and impacts over time. If residual risks remain in the sediment above the risk-based SQTs after remediation, then the long-term monitoring plan described in the MNR alternative will be followed (i.e., media, frequency, location, duration) until the project RAOs are achieved or until a policy decision is made. The proposed *Long-term Monitoring Plan* (LTMP) is detailed in Appendix C. Elements of the LTMP may be implemented for each action level regardless of the remedial outcome in order to verify achievement of the RAOs. The sampling program may continue indefinitely under this process option, but for the purposes of the FS it has been estimated at 40 years.

The estimated cost for the maintenance of institutional controls is $4,500,000. Costs for implementation monitoring during removal are included in the removal and water treatment costs. Multimedia monitoring costs for verification of project RAOs are included in Alternative B - Monitored Natural Recovery.

Alternative C2A: Dredge with Combined Dewatering and Disposal Facility

Alternative C2A includes the removal of sediments above the remedial action level using a hydraulic dredge and hydraulically pumping the sediment slurry directly to a combined NR 213/NR 500 dewatering and disposal facility for disposal. Figure 7-28 provides the process flow diagram for this alternative while Table 7-7 provides summary costs. WDNR requested the addition of this alternative with conditional selection of Alternative C2 only if the 18-mile pipeline to the landfill is already constructed for the De Pere to Green Bay Reach.

Site Mobilization and Preparation. Staging for sediment dredging will be conducted at the Bayport or former Shell facilities. Site mobilization and preparation includes securing the onshore property area for equipment staging, constructing areas for sediment staging, constructing intermediate shore-based ponds, pipelines, and booster pumps. The shore-based slurry ponds are constructed of earthen berms lined with asphalt covering 10 acres. It is assumed that docking facilities for the dredges and barges already exist at these locations. Land purchase and construction of upland staging areas are included in the dredging costs.

Sediment Removal. Sediment removal in Alternative C2A will be conducted using two 12-inch hydraulic pipeline feeder dredges with modified cutterheads and one floating 12-inch booster pump. The two feeder dredges will pump dredge slurry to an intermediate shore-based slurry pond located mid-reach. A third 16-inch cutterhead dredge located in the shore-side pond will resuspend the slurry into a 15-inch polyethylene pipe with 1.5-inch wall thickness. The inner pipe will be encased inside a 20-inch steel pipe traveling 18 miles to a dedicated NR 500 monofill. Four booster pumps will be evenly spaced along the route (28 miles with 25 feet total elevation lift). Dredging and pumping operations will continue 7 days per week, 24 hours per day, and 26 weeks per year (182 days) allowing 32 days for downtime and repairs (150 working days per year). Given the volumes and operating assumptions described above, the complete removal effort would require approximately 1.7 years for 125 ppb and 0.2 year for 5,000 ppb action levels, using two dredges. Sediment removal costs also include construction of a shore-based slurry pond and 28-mile pipeline, booster pump rental, "wintering over" of all equipment, and full-time monitoring of the pipeline. Longer pipe runs may require periodic flushing of the lines during periods of inactivity. Construction of an effluent return pipeline are included in the water treatment costs.

Installation of silt curtains around the dredging area may be included to minimize sediment resuspension downstream of the dredging operation; construction of silt curtains are included in the FS for $35,000. Buoys and other waterway markers would be installed around the perimeter of the work area to prevent entry of unauthorized boats within the removal work zone. Other capital items included in the sediment removal costs are booster pump rental and movement, construction of upland staging areas, water quality monitoring, post-removal sediment bathymetric surveys to ensure achievement of the removal action, and site restoration at the conclusion of operations.

Sediment removal costs using hydraulic dredging are estimated to range between $43,300,000 for 125 ppb and $17,400,000 for 5,000 ppb action levels.

Sediment Dewatering. For Alternative C2A, passive dewatering will occur within the combined dewatering and disposal facility. Sediment dewatering costs are included in the dredging, landfill construction, and water treatment costs.

Water Treatment. Water treatment includes construction of an effluent return pipeline from the landfill to the river. Purchase costs also include equipment and materials for flocculation, clarification, and sand filtration. Water treatment would be conducted 24 hours per day, 7 days per week during the dredging season. Discharge water is estimated at 560,000 gallons per day for Alternative C2A.

Daily discharge water quality monitoring is included in the cost estimate. Treated water would be sampled and analyzed to verify compliance with the appropriate discharge requirements prior to discharge back to the river. Water treatment costs include pad and equipment demobilization and site restoration.

Water treatment costs for hydraulic dredging (Alternative C2A) will range between $5,100,000 for 125 ppb and $4,500,000 for 5,000 ppb action levels.

Sediment Disposal. Costs of sediment disposal at a dedicated NR 500 monofill (Alternative C2A) will range between $19,400,000 for 125 ppb and $6,000,000 for 5,000 ppb action levels which includes siting fees, construction, and site restoration costs. A separate line item of $4,200,000 is included for closure of the Bayport CDF in 40 years.

Demobilization and Site Restoration. Demobilization and site restoration will be the same as those described in Alternative C1.

Institutional Controls and Monitoring. Monitoring activities and costs will be comparable to those described in Alternative C1.

The total projected costs for Alternative C2A are approximately 70 percent lower than the Alternative C1 costs; mostly accountable in the disposal costs.

Alternative C2B: Dredge with Separate Dewatering and Disposal Facility

Alternative C2B includes the removal of sediments above the remedial action level using a hydraulic dredge and hydraulically pumping the sediment slurry to an NR 213 dewatering facility located adjacent to a dedicated NR 500 monofill. Figure 7-29 provides the process flow diagram for this alternative while Table 7-7 provides summary costs. WDNR requested the addition of this alternative for cost comparison purposes with Alternative C2A to evaluate potential cost savings associated with constructing a separate dewatering facility.

Site Mobilization and Preparation. Site mobilization and preparation will be the same as that described in Alternative C2A.

Sediment Removal. Sediment removal will be the same as described in Alternative C2A with the exception that the hydraulically dredged slurry will be pumped to an NR 213 dewatering facility located adjacent to the dedicated NR 500 monofill.

Sediment Dewatering. Passive dewatering includes land purchase, site clearing, and dewatering pond construction. Key assumptions include a 3.4 percent by volume (w/w) dredged solids concentration and 3,100 gpm water production rate for the dredge based on results from the 1999 Lower Fox River demonstration projects (Foth and Van Dyke, 2000; Montgomery-Watson, 2000). Although the recent dredging work conducted at SMU 56/57 (Fort James *et al.*, 2001) showed the average percent solids in dredge slurry was 8.4 percent (w/w) (range 3.5 to 14.4 percent), the lower and more conservative percent slurry solids measured during the 1999 activities was used for FS costs. The sediment dewatering system would be done in a two-cell passive filtration system located adjacent to the dedicated NR 500 monofill. The system would accommodate 26 weeks of solids dredge production rate, plus a maximum water surge storage capacity. It is assumed that the final sediment would require solidification with 10 percent (w/w) lime to satisfy hauling and disposal requirements (included in disposal costs). Dewatering costs also include pond decommissioning and site restoration at the completion of the project. Sediment dewatering costs for Alternative C2B (primarily construction costs) are estimated at $22,100,000.

Water Treatment. Water treatment will be the same as described in Alternative C2A with the exception that the effluent lines for treated water will be constructed from the passive dewatering system.

Sediment Disposal. Sediment disposal includes the loading and transportation of the sediment to the dedicated NR 500 monofill. Disposal costs also include the purchase and addition of lime reagent for solidification of dewatered sediment prior to off-site transport. Sediment disposal costs for Alternative C2B range between $104,900,000 for 125 ppb and $16,800,000 for 5,000 ppb action levels which includes siting fees, construction, and site restoration costs. A separate line item of $4,200,000 is included for closure of the Bayport CDF in 40 years.

Demobilization and Site Restoration. Demobilization and Site Restoration will be the same as those described in Alternative C2A.

Institutional Controls and Monitoring. Monitoring activities and costs will be comparable to those described in Alternative C2A. The total projected costs for Alternative C2B are approximately 27 percent lower than the Alternative C1 costs; mostly accountable in the disposal costs.

Alternative C3: Dredge with Disposal at an Existing NR 500 Commercial Disposal Facility (Mechanical Dewatering)

Alternative C3 includes the removal of sediments above the remedial action level using a hydraulic dredge and mechanical dewatering of the dredged sediments. Mechanically dewatered sediments will be transported to an existing NR 500 commercial disposal facility for disposal. Figure 7-30 provides the process flow diagram for this alternative while Table 7-7 provides summary costs. WDNR requested the addition of this alternative for cost comparison purposes with Alternatives C1 and C2.

Site Mobilization and Preparation. Staging for sediment dredging will be conducted at the Bayport or former Shell facilities. Site mobilization and preparation includes securing the onshore property area for equipment staging, constructing areas for sediment staging, constructed intermediate shore-based ponds and mechanical dewatering facility, water treatment, sediment storage and truck loading area. Land purchase and construction of upland staging areas are included in the dredging costs.

Sediment Removal. Sediment removal in Alternative C3 will be the same as described in Alternative C1.

Sediment Dewatering. Mechanical dewatering includes land purchase, site clearing, and construction of temporary holding ponds. Dewatering techniques will be similar to the mechanical processes used for both Lower Fox River demonstration projects including a series of shaker screens, hydrocyclones, and belt filter presses. The final percent solids of the filter press cake was about 60 percent solids (w/w) for SMU 56/57 (Fort James *et al.*, 2001) and 40 to 50 percent solids for Deposit N (Foth and Van Dyke, 2000). No additional solidification was required. The dewatering process will be simplified into a unit cost of $80 per bone dry ton assuming 50 percent solids after dewatering for the purposes of this FS.

Mechanical dewatering costs for Alternative C3 range from $53,400,000 for 125 ppb to $6,800,000 for 5,000 ppb action levels.

Water Treatment. Water treatment includes purchase of equipment and materials for flocculation, clarification, and sand filtration. Water treatment would be conducted 24 hours per day, 7 days per week during the dredging season. Discharge water is estimated at 656,640 gallons per day. Daily discharge water quality monitoring is included in the cost estimate. Treated water would be sampled and analyzed to verify compliance with the appropriate discharge requirements prior to discharge back to the river. Carbon filtration could be added for a unit cost of $0.040 per thousand gallons of water treated. It may be necessary to add carbon filtration to the treatment train if effluent criteria are not met. Water treatment costs also include pad and equipment demobilization and site restoration.

Water treatment costs are estimated to range from $2,600,000 for 125 ppb to $1,700,000 for 5,000 ppb action levels.

Sediment Disposal. Mechanically dewatered sediments will be transported to an existing NR 500 commercial disposal facility by trucks. Costs of sediment disposal will range between $67,300,000 for 125 ppb and $8,500,000 for 5,000 ppb action levels. A separate line item of $4,200,000 is included for closure of the Bayport CDF in 40 years.

Demobilization and Site Restoration. Demobilization and site restoration will be the same as those described in Alternative C1.

Institutional Controls and Monitoring. Monitoring activities and costs will be comparable to those described in Alternative C1.

Alternative D: Dredge to a Confined Disposal Facility

Alternative D includes removal of sediments to an on-site CDF for long-term disposal of the materials. For this reach, the dredged material will be pumped to a CDF located in Little Lake Butte des Morts. Figure 7-32 provides the process flow diagram for this remedial alternative and Figure 7-31 illustrates the extent of residual sediment impacts following implementation of Alternative D. Table 7-7 contains the summary costs to implement Alternative D. The total volume of sediments to be dredged are similar to those identified in Alternative C.

Site Mobilization and CDF Construction. The Little Rapids to De Pere Reach does not have a suitable location for construction of a CDF. Placement of dredged material would preferably be placed in a downstream CDF located in the De Pere to Green Bay Reach; however, this CDF reaches capacity for all action levels. Dredged material would be pumped via pipeline to the proposed Menasha CDF located in the Little Lake Butte des Morts Reach. CDF construction and costs are discussed in Section 7.2.4 for Little Lake Butte des Morts.

Sediment Removal. Hydraulic sediment removal techniques and costs for this alternative are equivalent to that described for Alternative C. The estimated time to complete hydraulic dredging ranges between 11 years for 125 ppb and 1.4 years for 5,000 ppb action levels. Costs for construction of a long pipeline directly to a CDF are included in the De Pere to Green Bay Reach.

Sediment Dewatering. Passive dewatering will occur directly within the CDF berms for hydraulic dredging. No on-barge dewatering will be required. No dewatering costs are required.

Water Treatment. Overflow return water from the CDFs would be treated before discharge to the river. Treatment and monitoring requirements are expected to be the same as those for Alternative C.

Water treatment costs for Alternative D are estimated to range between $1,900,000 for 125 ppb and $1,000,000 for 5,000 ppb action levels.

Sediment Disposal. No off-site disposal costs (for TSCA-level sediments) are incurred for this reach. Sediment disposal to a CDF incurs no costs besides construction and closure of the CDF previously included in preparation costs.

Demobilization and Site Restoration. Demobilization and site restoration involves removing all equipment (i.e., fencing, facilities) from the staging and work areas. The CDF would be finished with a 3-foot cap of clean soils, and seeded and planted. Additional amenities (i.e., bike paths, wildlife habitat) were not included in the cost estimates. However, this alternative would allow development of these features, and would provide a beneficial use of this area for the community. Demobilization and site restoration costs are included under the dredging and CDF construction cost estimates.

Institutional Controls and Monitoring. Institutional controls, long-term monitoring, and operations and maintenance monitoring parameters will be the same as those provided in Section 7.2.4 for the Little Lake Butte des Morts CDF, and Alternative C1 for the Little Rapids to De Pere Reach.

Alternative E: Dredge with Thermal Treatment

Alternative E includes hydraulic dredging of sediments, passive dewatering, and treatment with an on-site integrated vitrification unit. This alternative results in the sediments being transformed into glass aggregate that has potential for a wide variety of beneficial reuse applications. Figure 7-33 provides the process flow diagrams for this remedial alternative, while Figure 7-31 illustrates the extent of residual contamination following implementation of Alternative E. Table 7-7 contains the summary costs to implement Alternative E. This alternative addresses the same volume of sediments as Alternative C.

Site Mobilization. Site mobilization and preparation includes securing the onshore property area for equipment staging, water treatment, and an offshore docking facility for the hydraulic dredge. Site preparation would also include building a standalone vitrification unit capable of processing an estimated 750 glass tons per day.

Sediment Removal. Hydraulic sediment removal techniques and duration for this alternative are equivalent to that described for Alternative C. Sediment removal costs for hydraulic dredging are estimated to be the same as Alternative C2B.

Sediment Dewatering. Sediment dewatering is similar to the requirements described in Alternative C1 for construction of an NR 213 dewatering facility. The solids content after dewatering from hydraulic dredging is assumed to be 30 percent (w/w). However, no solidification will occur prior to thermal treatment assuming that the vitrification facility is located in close proximity to the dewatering facility and the dewatered filter cake at 30 percent (w/w) solids is acceptable for processing at the vitrification facility. Sediment dewatering costs (primarily construction costs) for Alternative E are estimated at $22,100,000.

Water Treatment. Water from dewatering would be treated before discharge to the river. Treatment and monitoring requirements are expected to be the same as those for Alternative C. Water treatment costs for Alternative E are estimated to be the same as Alternative C.

Sediment Treatment. After completion of passive dewatering (to approximately 30 percent solids), sediments are passed through the dryer and dried to approximately 10 percent moisture. Thermal treatment of the dried sediments involves blending the high-silt/clay sediments with fluxing materials and processing the materials in a melter as part of the vitrification process. The vitrification process would include appropriate treatment of air emissions. The unit cost for vitrification includes capital costs and operating costs. The capital costs include equipment, building, installation, engineering, and startup costs. Operating costs include labor, utilities, and general administrative costs. The unit cost is based on an assumption that the glass aggregate resulting from treating sediments will have a resale value between a range of $2 and $25 per ton as provided by Minergy. The unit cost for sediment treatment decreases with an increase in the resale value of the glass aggregate.

The cost for thermal treatment is estimated to range between $62,100,000 for 125 ppb and $7,800,000 for 5,000 ppb action levels at an estimated unit cost of $24 per ton.

Sediment Disposal. No sediments will be disposed of as hazardous waste, as all the sediments will be treated by thermal treatment. Treated sediments transformed to glass aggregate by the vitrification process have a wide variety of applications. Based on analyses by product marketing specialists, the glass aggregate has a potential to be used as roofing shingle granules, industrial abrasives, ceramic floor tile, cement pozzolan and construction fill (Minergy Corporation, 2002a).

Demobilization and Site Restoration. Demobilization and site restoration involves removing all equipment (i.e., fencing, facilities) from the staging and work areas. All work pads and other permanent structures would be removed and the site would be graded to its original condition. Vegetated areas would be replanted to a state similar to that of pre-construction. Demobilization and restoration costs are included within the above dredging, dewatering, and treatment estimates.

Institutional Controls and Monitoring. Institutional controls and monitoring will be the same as those described for Alternative C.

Alternative F: Cap to Maximum Extent Possible, Dredge Remaining Sediments with Off-site Disposal

Alternative F includes primarily capping to the maximum extent possible, with off-site disposal of dredged sediments outside of the capping footprint. As stated in Section 7.4.3, many areas meet the cap criteria defined in Section 6.5.1. The capping area encompasses Deposit EE with depths ranging from less than 6 feet to 12 feet. The process flow diagram is depicted on Figure 7-34, while Figure 7-35 illustrates capping areas and the extent of residual contamination following implementation of Alternative F. The estimated costs are presented in Table 7-7.

Site Preparation and Cap Construction. Site preparation for dredging would include construction of a dewatering area discussed in Alternative C. The cap in the Little Rapids to De Pere Reach is planned to be an armored cap composed of 20 inches of sand overlain with 12 inches of large cobble to provide erosion protection. The sand cap will be completed using a spreader barge with a 10-inch pipeline. The cap will be placed in 6-inch lifts requiring 1.2 to 4.6 years for cap placement with 10-hour work shifts (1,200 cy placed per day) (OBAI cost estimate). Armor placement would be completed using two 3-cy clamshell buckets requiring 1.1 to 4.2 years for armoring (400 cy per day per bucket working 10-hour shifts). Cap construction would require an upland staging area for the receipt and placement of sand and the armoring stone. The staging area will include a hopper for pumping slurry to the spreader barge. Armor stone will be delivered to the work area via barges. All other unit costs are similar to those described for the prior alternatives for the river reach. Site preparation costs in this alternative are included under the dredging, dewatering, and capping costs.

Capping costs under this alternative are estimated to range from $40,500,000 for 125 ppb to $15,000,000 for 5,000 ppb action levels. The estimated time for placement of the sand cap is 4.6 and 1.2 years for the 125 ppb and 5,000 ppb action levels, respectively.

Sediment Removal. Hydraulic sediment removal techniques for this alternative are equivalent to that described for Alternative C for areas that are not capped. The estimated time to complete hydraulic dredging ranges from 4.3 years for 125 ppb to 0.4 year for 5,000 ppb action levels.

Sediment removal costs for hydraulic dredging are estimated to range between $9,700,000 for 125 ppb and $3,300,000 for 5,000 ppb action levels.

Sediment Dewatering. The 9-acre gravity dewatering ponds previously described for Alternative C are applicable for Alternative F.

Sediment dewatering costs (primarily for construction) are estimated at $3,100,000 for all action levels.

Water Treatment. Overflow return water from the gravity dewatering ponds would be treated before discharge to the river. Treatment and monitoring requirements are the same as for the prior remedial alternatives.

Water treatment costs for Alternative F are estimated to range between $1,100,000 for 125 ppb and $800,000 for 5,000 ppb action levels.

Sediment Disposal. Sediment disposal includes the loading and transportation of uncapped sediments to an off-site upland disposal facility. It also includes solidification with 10 percent lime.

The cost for off-site sediment solidification and disposal at an existing NR 500 commercial disposal facility is estimated to range between $71,400,000 for 125 ppb and $6,100,000 for 5,000 ppb action levels. Off-site disposal is intended for sediments located beyond the horizontal extent of the *in-situ* cap. It is possible that these sediments could be pumped directly to a CDF located in the Little Lake Butte des Morts Reach, but this option was not included in project costs.

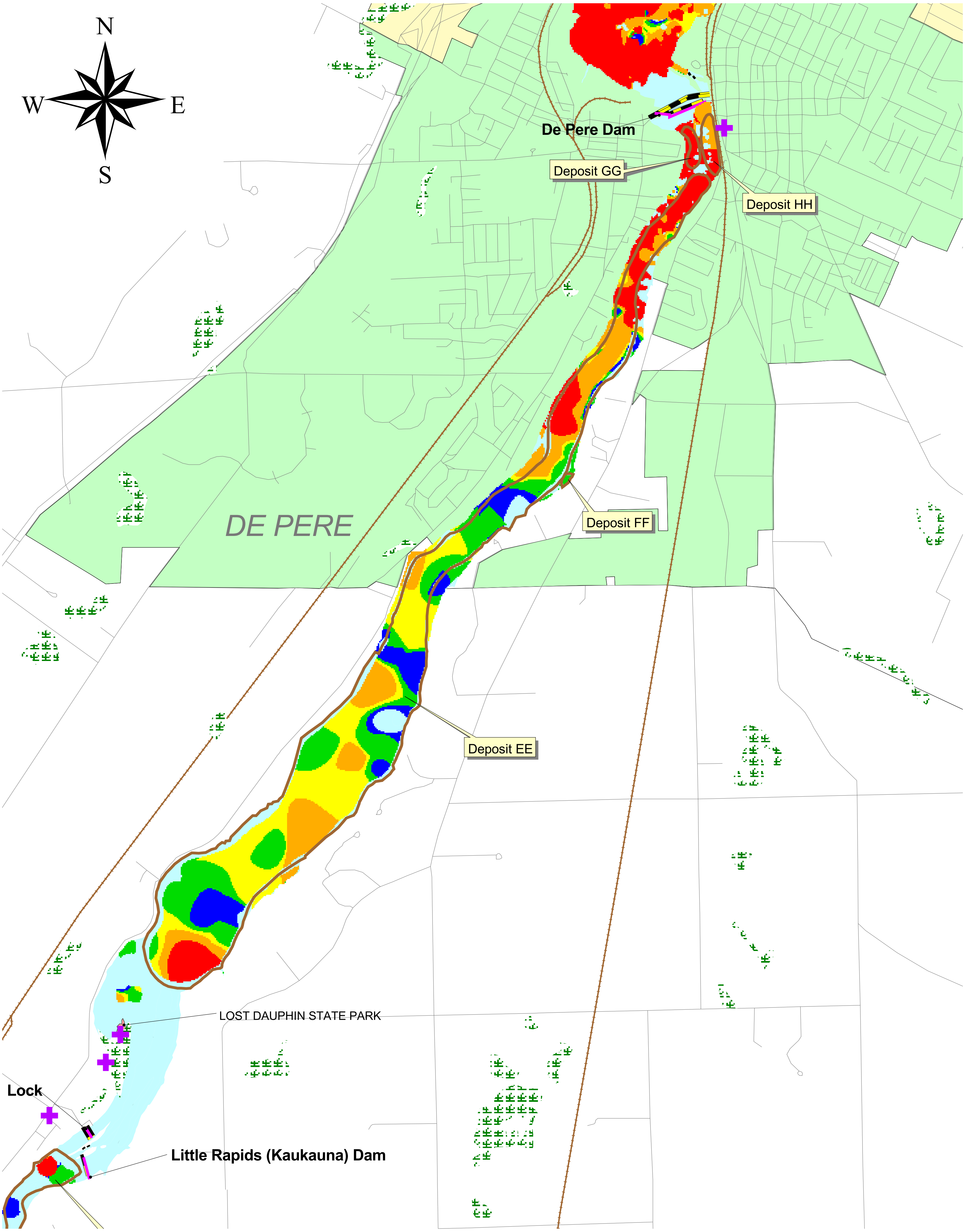
Demobilization and Site Restoration. Demobilization and site restoration involves removing all equipment, fencing, facilities, etc., from the staging and work areas. Demobilization and site restoration costs are included under the dredging and capping estimates.

Institutional Controls and Monitoring. Operation and maintenance monitoring would be required to ensure proper placement and maintenance of cap integrity. For this type of armored capping, monitoring will be performed to ensure that the cap is placed as intended, the required capping thickness is maintained, and to determine if the cap effectively isolates the contaminants. The monitoring would include bathymetric or side-scan sonar profiling, sediment and cap sampling, as well as diver inspections to ensure that the cap is physically isolating impacted sediments. The monitoring program would occur for a period of 40 years with decreasing sampling intervals over time, as appropriate. Institutional controls would include deed restrictions, site access and anchoring limitations, and maintenance of the consumption advisories. A separate *Long-term Monitoring Plan* for the entire river and Green Bay is discussed, along with cost estimates, in Appendix C.

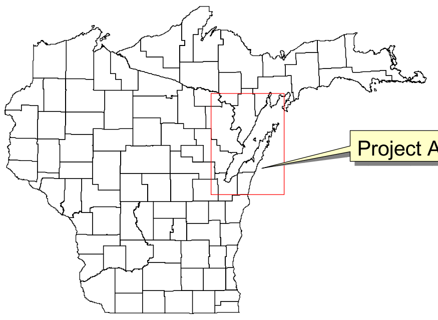
Maintenance and monitoring costs of the cap are included in the capping costs. The estimated cost for institutional controls is $4,500,000. Long-term monitoring costs for verification of project RAOs are included in Alternative B - Monitored Natural Recovery.

7.4.5 Section 7.4 Figures and Tables

Figures and tables for Section 7.4 follow this page and include:



Deposits
Possible Equipment Access
TSCA Areas
Upland Staging
Action Level Profile (ppb)
>125
>250
>500
>1,000
>5,000
Dam Locations
Bridges
Railroads
Roads
Wisconsin State Parks
Wetlands
Water
Civil Divisions
City
Township
Village



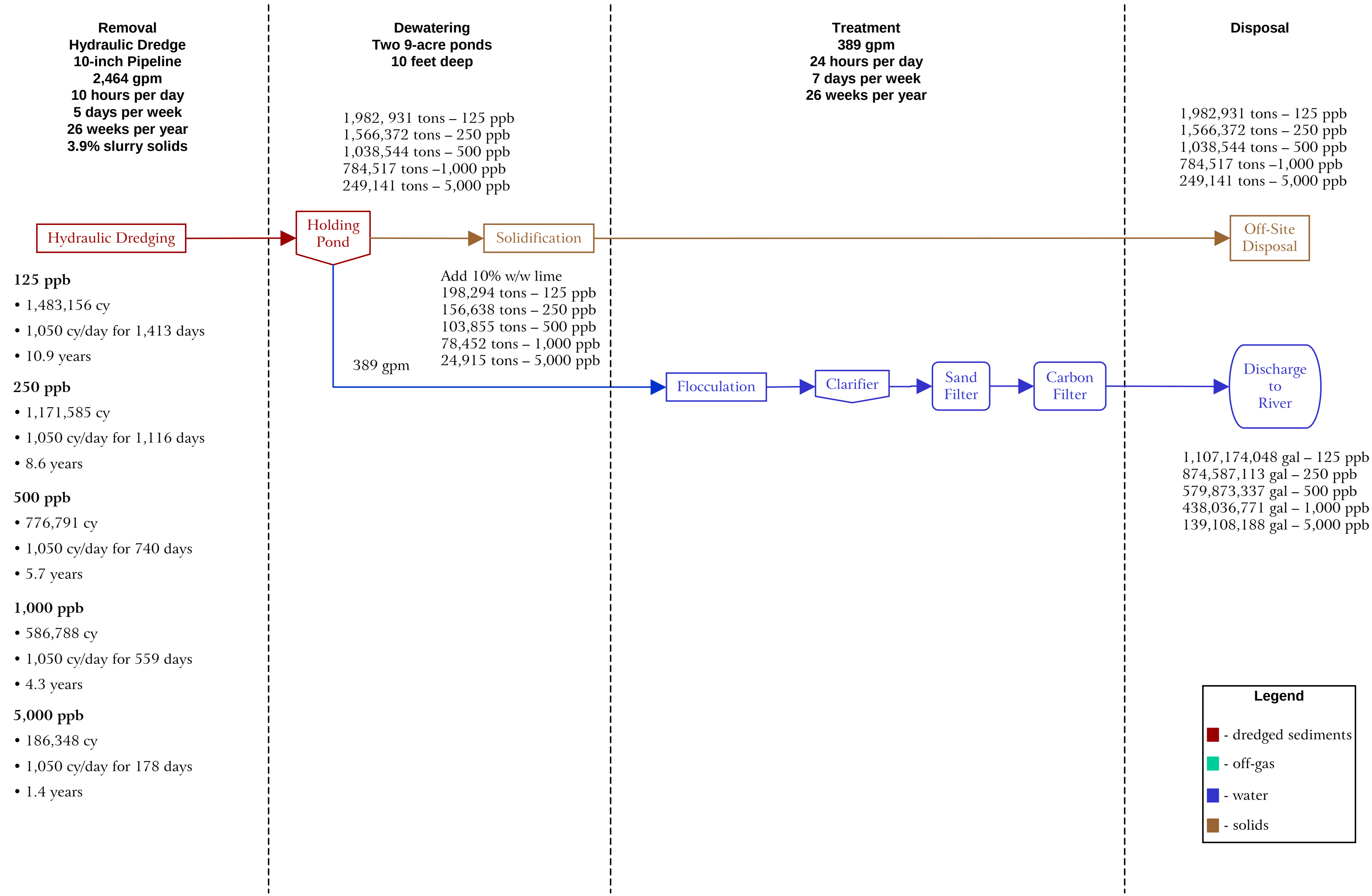
1 0 1 Kilometers

0.5 0 0.5 1 Miles

1. Basemap generated in ArcView GIS, Version 3.2, 1998, and from TIGER census data, 1995.
2. Deposit and management area data obtained from WDNR. and are included in the Fox River database.
3. Action level profiles for PCBs considered for all depth layers up to 350 cm for lower Fox River.

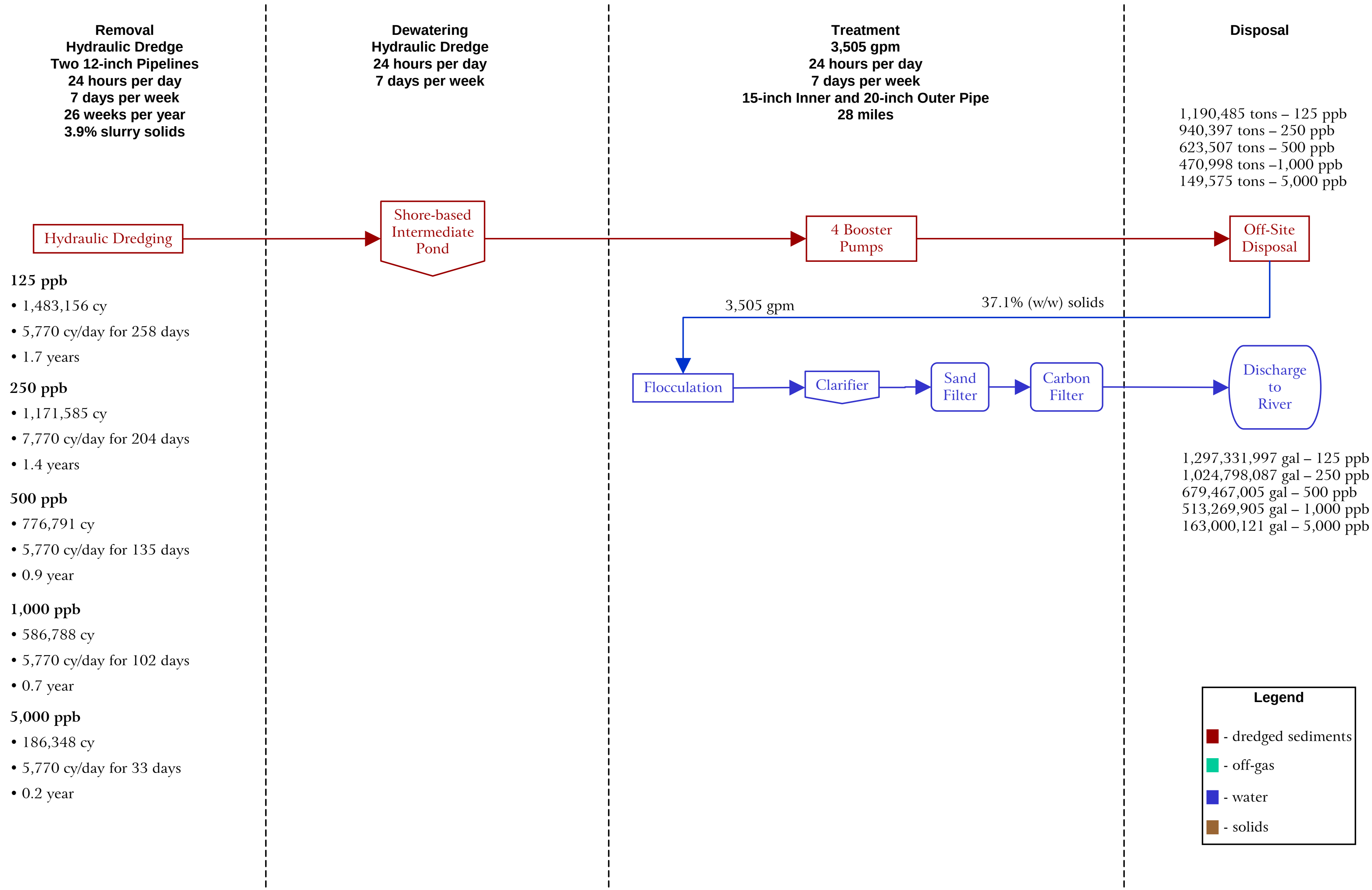
ThermoRetec Smart Solutions. Positive Outcomes.	Natural Resource Technology	Lower Fox River & Green Bay Feasibility Study	Sediment Management Area Overview: Little Rapids to De Pere	REFERENCE NO: FS-14414-535-7-23
				CREATED BY: SCJ
				PRINT DATE: 3/13/01
			FIGURE 7-26	APPROVED: AGF

Figure 7-27 Process Flow Diagram for Little Rapids to De Pere - Alternative C1: Dredge with Disposal at an Existing NR 500 Commercial Disposal Facility (Passive Dewatering)



F:\PROJECTS\DOCS\4414\DOC\FS\FINAL\FIGURES\SEC7\SEC7FIGSL.PPT

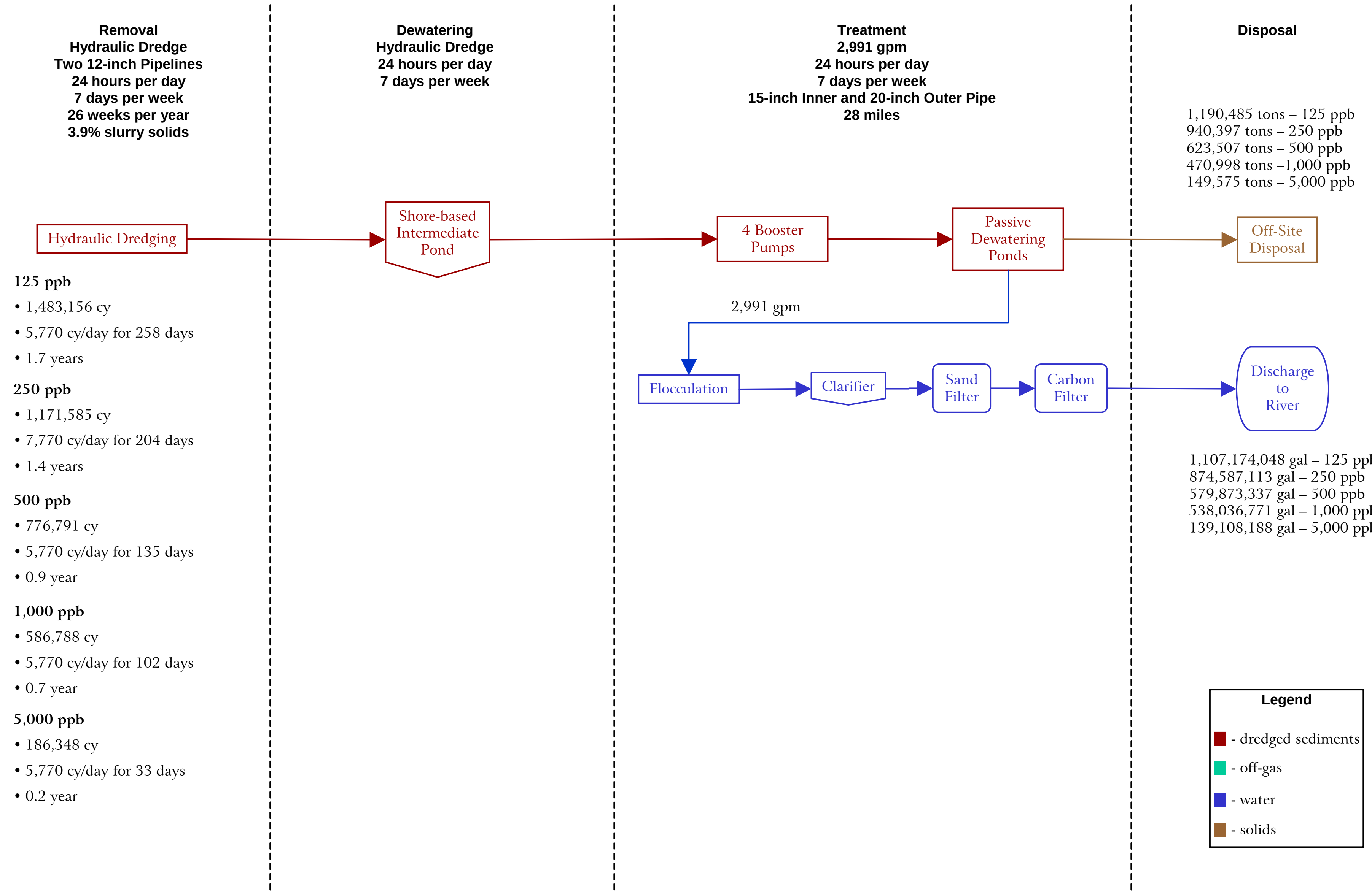
Figure 7-28 **Process Flow Diagram for Little Rapids to De Pere - Alternative C2A: Dredge with Combined Dewatering and Disposal Facility**



Note: Off-site disposal unit is a combined dewatering and disposal facility.

F:\PROJECTS\DOCS\4414\DOC\FS\FINAL\FIGURES\SEC7\SEC7FIGSL.PPT

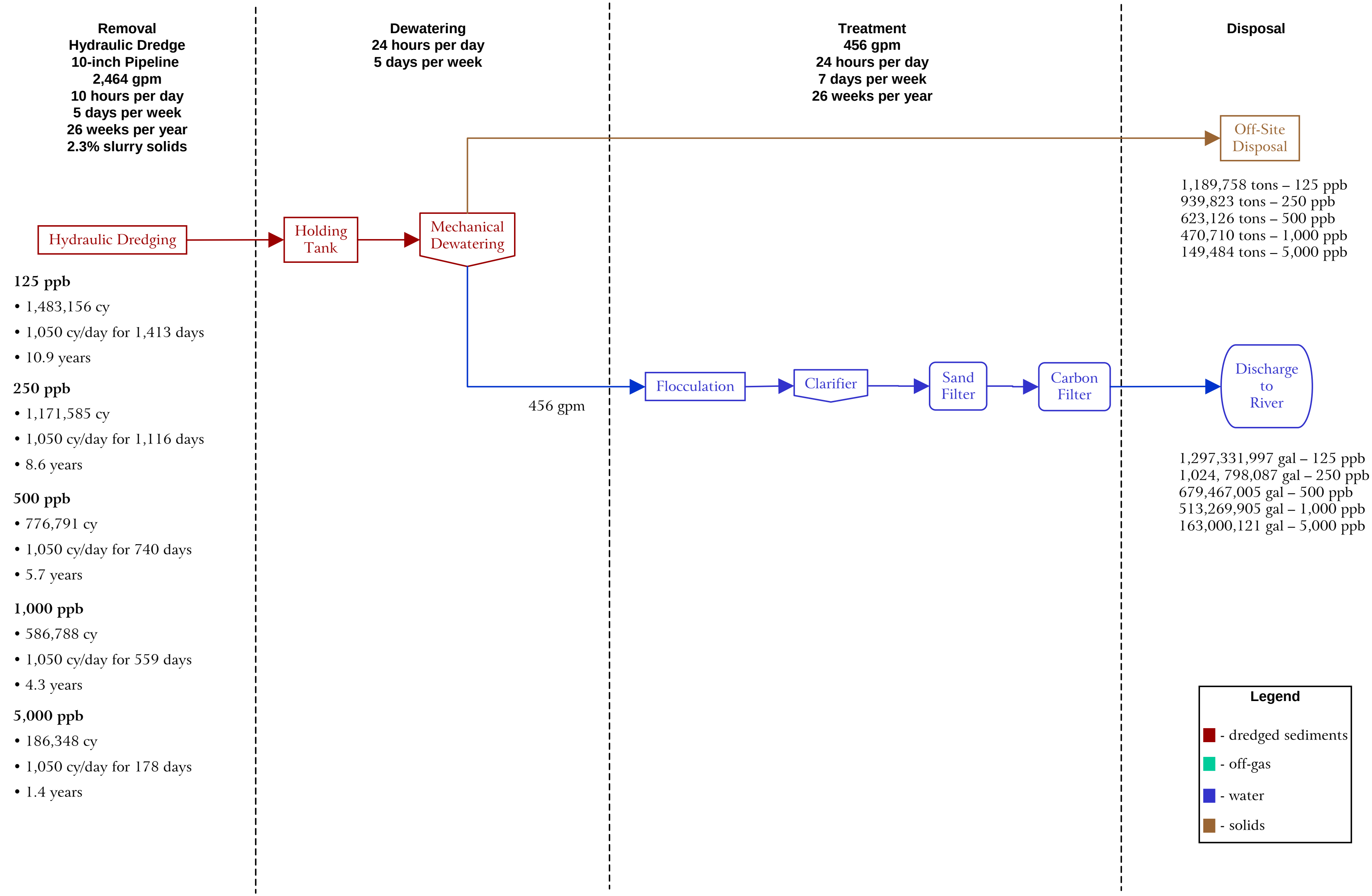
Figure 7-29 **Process Flow Diagram for Little Rapids to De Pere - Alternative C2B: Dredge with Separate Dewatering and Disposal Facility**



Note: Off-site disposal unit is a dedicated NR 500 monofill.

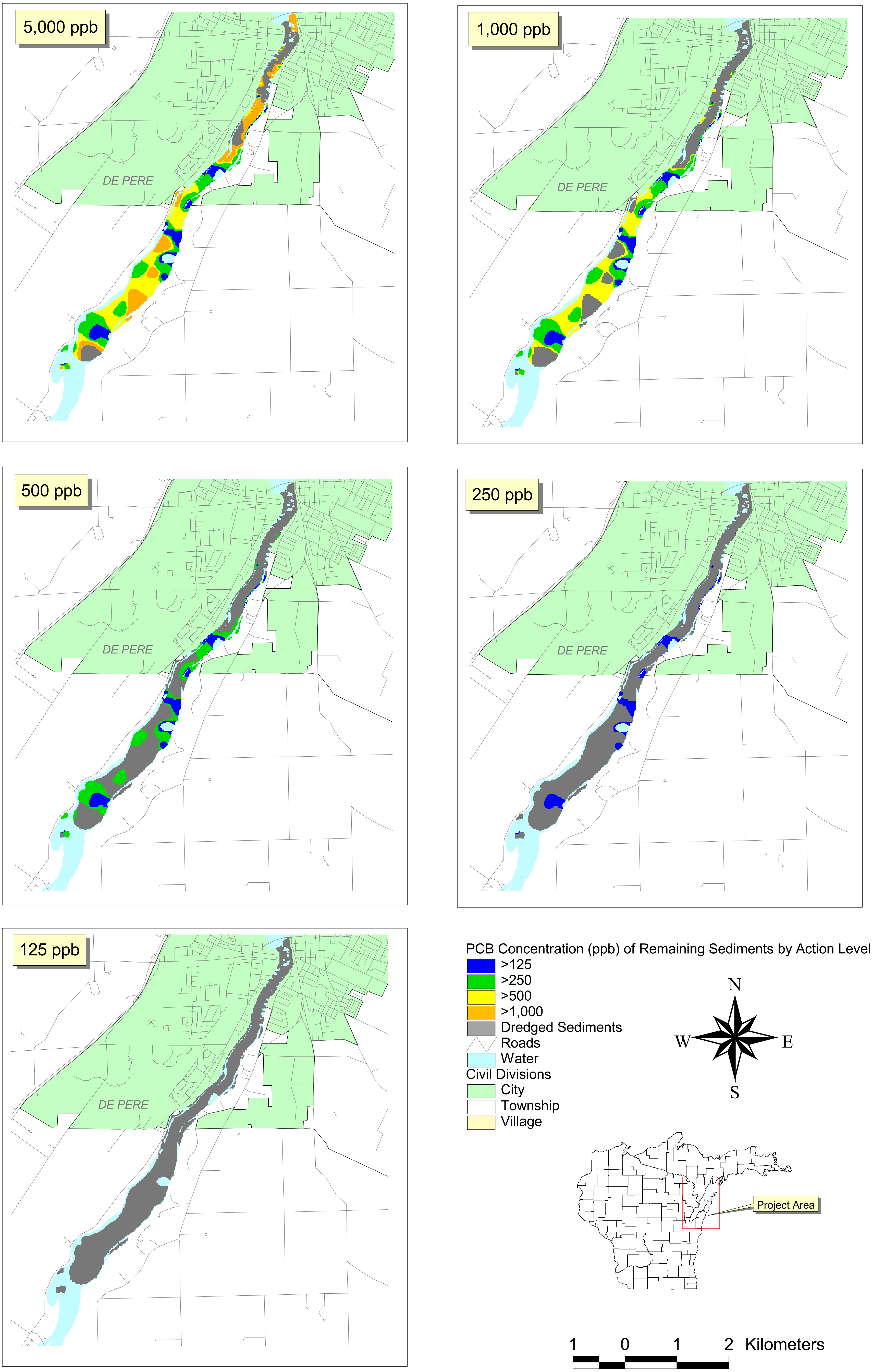
F:\PROJECTS\DOCS\4414\DOC\FS\FINAL\FIGURES\SEC7\SEC7FIGSL.PPT

Figure 7-30 **Process Flow Diagram for Little Rapids to De Pere - Alternative C3: Dredge Disposal at an Existing NR 500 Commercial Disposal Facility (Mechanical Dewatering)**



Note: Off-site disposal unit is an existing NR 500 commercial disposal facility.

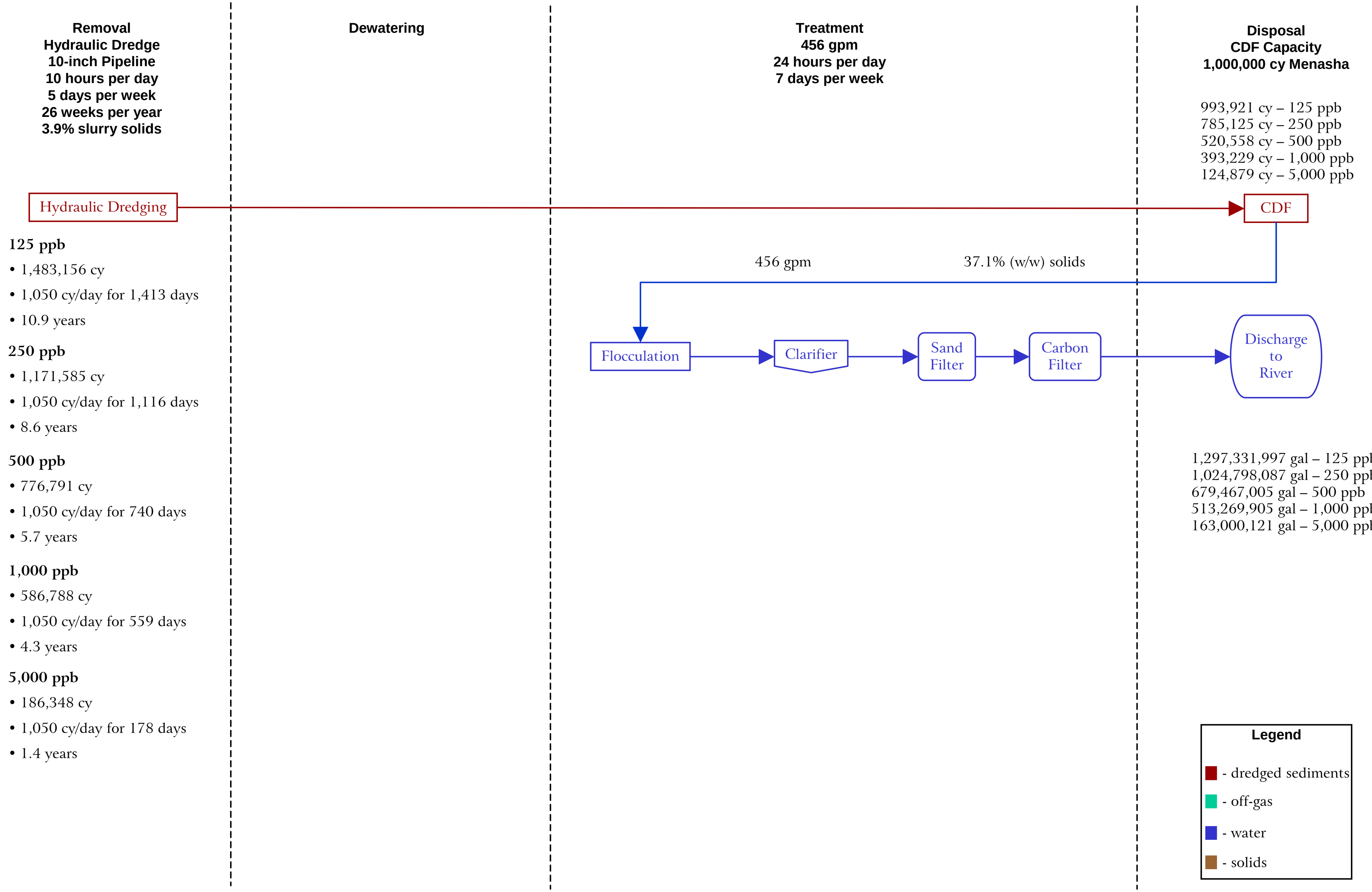
F:\PROJECTS\DOCS\4414\DOC\FS\FINAL\FIGURES\SEC7\SEC7FIGSL.PPT



1. Basemap generated in ArcView GIS, Version 3.2, 1998, and from TIGER census data, 1995.
2. Deposit and management area data obtained from WDNR, and are included in the Fox River database.

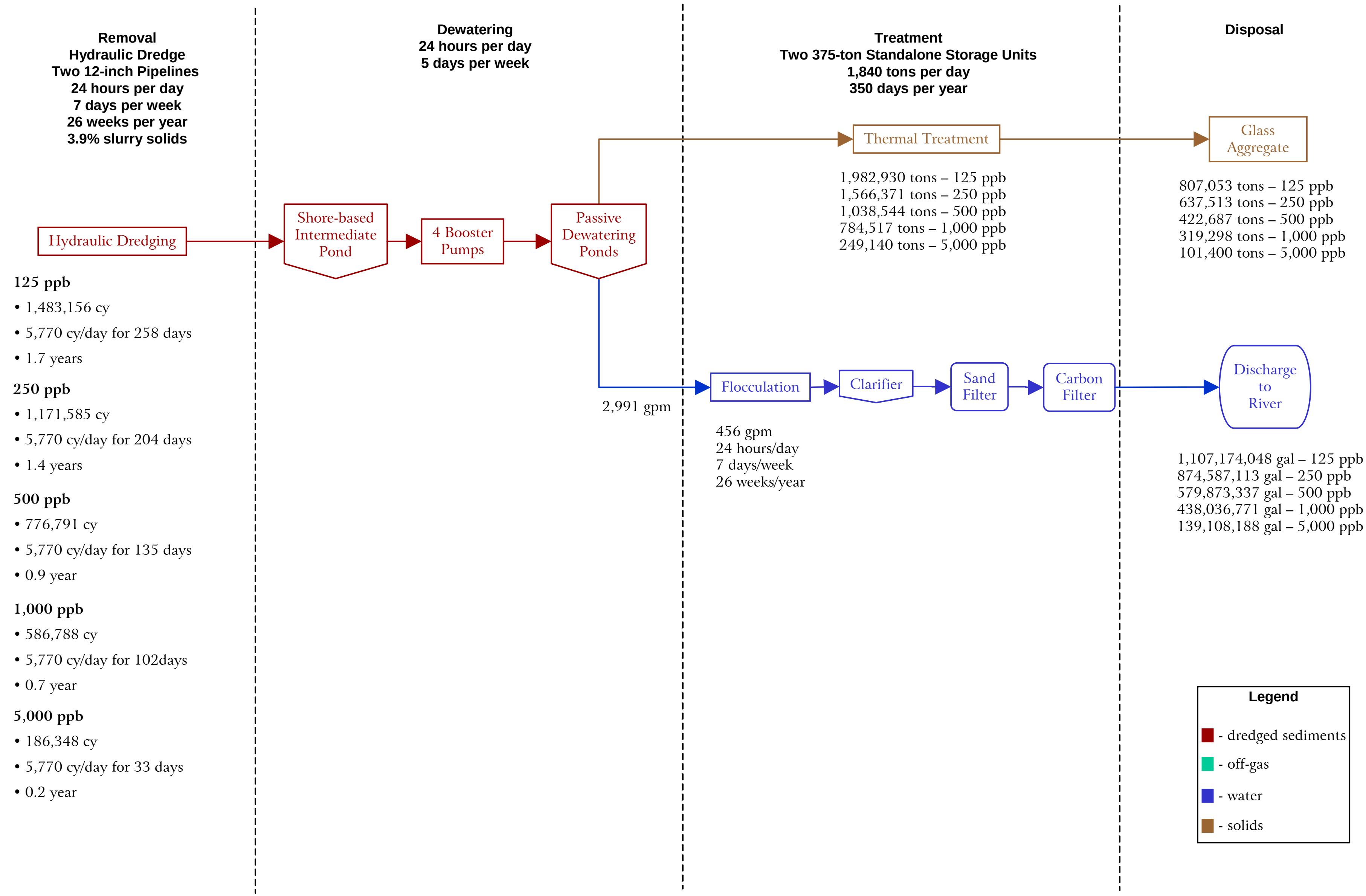
ThermoRetec Smart Solutions. Positive Outcomes.	Natural Resource Technology	Lower Fox River & Green Bay Feasibility Study	Alternatives C, D, and E: Little Rapids to De Pere	REFERENCE NO: FS-14414-535-7-26
				CREATED BY: SCJ
				PRINT DATE: 3/13/01
			FIGURE 7-31	APPROVED: AGF

Figure 7-32 Process Flow Diagram for Little Rapids to De Pere - Alternative D: Dredge Sediment to CDF



F:\PROJECTS\DOCS\4414\DOC\FS\FINAL\FIGURES\SEC7\SEC7FIGSL.PPT

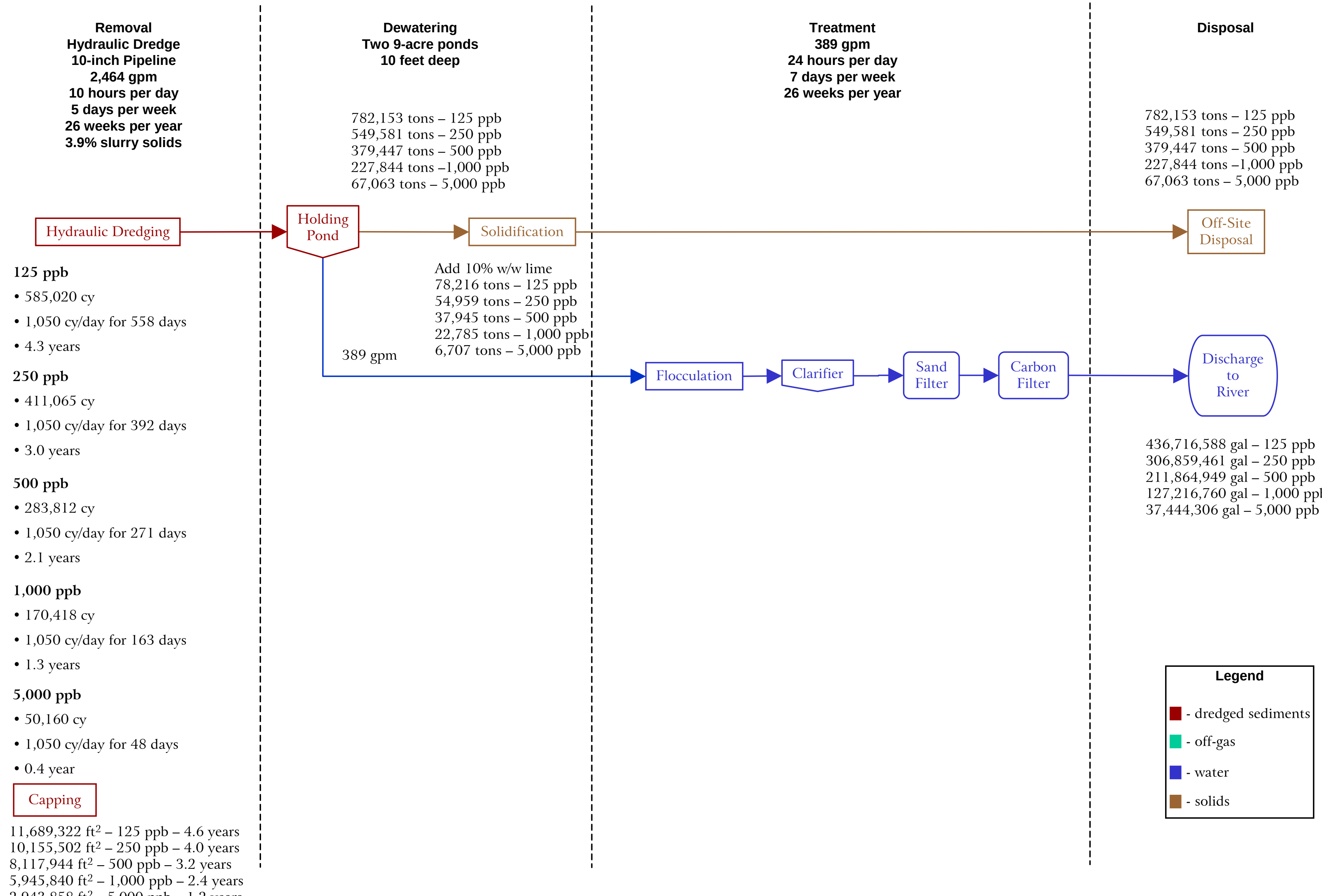
Figure 7-33 **Process Flow Diagram for Little Rapids to De Pere - Alternative E: Dredge Sediment with Thermal Treatment**



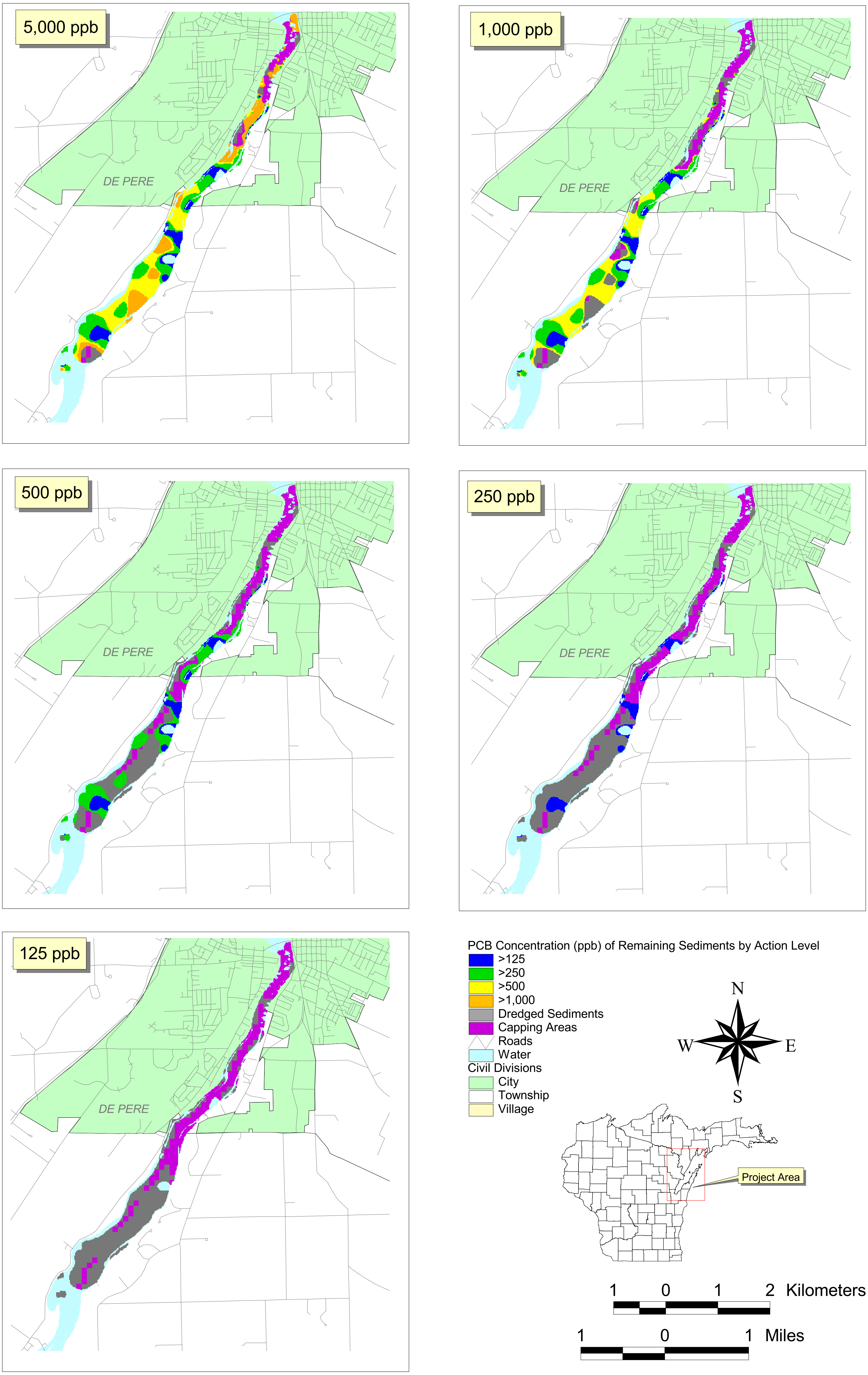
Note: Additional integral elements of the vitrification unit (dryer, pollution control) are not shown as they were not estimated separate. For greater detail on the unit layout and components, refer to the Minergy Unit Cost Report (Appendix G).

F:\PROJECTS\DOCS\4414\DOC\FS\FINAL\FIGURES\SEC7\SEC7FIGSL.PPT

Figure 7-34 Process Flow Diagram for Little Rapids to De Pere - Alternative F: Cap Sediment to Maximum Extent Possible, Dredge, and Off-site Disposal



F:\PROJECTS\DOCS\4414\DOC\FS\FINAL\FIGURES\SEC7\SEC7FIGSL.PPT



1. Basemap generated in ArcView GIS, Version 3.2, 1998, and from TIGER census data, 1995.
2. Deposit and management area data obtained from WDNR, and are included in the Fox River database.
3. Capping area criteria based on a minimum 9-foot water depth.
4. The proposed CDF is located in other reaches.

ThermoRetec Smart Solutions. Positive Outcomes.	Natural Resource Technology	Lower Fox River & Green Bay Feasibility Study	Alternative F: Cap to Maximum Extent Possible and Dredge Remaining Sediment to CDF: Little Rapids to De Pere	REFERENCE NO: FS-14414-535-7-30
				CREATED BY: SCJ
				PRINT DATE: 3/13/01
			FIGURE 7-35	APPROVED: AGF

Table 7-7 Cost Summary for Remedial Alternatives - Little Rapids to De Pere

125 ppb

Alternative	Dredge Volume (cy)	Hydraulic Dredging	Mechanical Dredging	Capping	Dewatering	Water Treatment	Thermal Treatment	CDF Construction	Off-site Disposal	Institutional Controls	Subtotal	20% Contingency	TOTAL
A	0	---	---	---	---	---	---	---	---	$4,500,000	$4,500,000	$900,000	$5,400,000
B	0	---	---	---	---	---	---	---	---	$9,900,000	$9,900,000	$1,980,000	$11,880,000
C1	1,483,156	$33,900,000	---	---	$3,100,000	$1,700,000	---	---	$181,000,000	$4,500,000	$224,200,000	$44,840,000	$269,040,000
C2A	1,483,156	$43,300,000	---	---	---	$5,100,000	---	---	$19,400,000	$4,500,000	$72,300,000	$14,460,000	$86,760,000
C2B	1,483,156	$43,300,000	---	---	$22,100,000	$5,000,000	---	---	$104,900,000	$4,500,000	$179,800,000	$35,960,000	$215,760,000
C3	1,483,156	$33,900,000	---	---	$53,400,000	$2,600,000	---	---	$67,300,000	$4,500,000	$161,700,000	$32,340,000	$194,040,000
D	1,483,156	$33,900,000	---	---	---	$1,900,000	---	$32,000,000	---	$4,500,000	$72,300,000	$14,460,000	$86,760,000
E	1,483,156	$43,300,000	---	---	$22,100,000	$10,700,000	$62,100,000	---	---	$4,500,000	$142,700,000	$28,540,000	$171,240,000
F	585,020	$23,100,000	---	$40,500,000	$3,100,000	$1,100,000	---	---	$71,400,000	$4,500,000	$143,700,000	$28,740,000	$172,440,000

250 ppb

Alternative	Dredge Volume (cy)	Hydraulic Dredging	Mechanical Dredging	Capping	Dewatering	Water Treatment	Thermal Treatment	CDF Construction	Off-site Disposal	Institutional Controls	Subtotal	20% Contingency	TOTAL
A	0	---	---	---	---	---	---	---	---	$4,500,000	$4,500,000	$900,000	$5,400,000
B	0	---	---	---	---	---	---	---	---	$9,900,000	$9,900,000	$1,980,000	$11,880,000
C1	1,171,585	$28,600,000	---	---	$3,100,000	$1,500,000	---	---	$143,000,000	$4,500,000	$180,700,000	$36,140,000	$216,840,000
C2A	1,171,585	$37,600,000	---	---	---	$4,900,000	---	---	$16,200,000	$4,500,000	$63,200,000	$12,640,000	$75,840,000
C2B	1,171,585	$37,600,000	---	---	$22,100,000	$4,900,000	---	---	$83,700,000	$4,500,000	$152,800,000	$30,560,000	$183,360,000
C3	1,171,585	$28,600,000	---	---	$42,200,000	$2,400,000	---	---	$53,100,000	$4,500,000	$130,800,000	$26,160,000	$156,960,000
D	1,171,585	$28,600,000	---	---	---	$1,700,000	---	$32,000,000	---	$4,500,000	$66,800,000	$13,360,000	$80,160,000
E	1,171,585	$37,600,000	---	---	$22,100,000	$10,500,000	$49,100,000	---	---	$4,500,000	$123,800,000	$24,760,000	$148,560,000
F	411,065	$19,500,000	---	$36,000,000	$3,100,000	$1,000,000	---	---	$50,200,000	$4,500,000	$114,300,000	$22,860,000	$137,160,000

500 ppb

Alternative	Dredge Volume (cy)	Hydraulic Dredging	Mechanical Dredging	Capping	Dewatering	Water Treatment	Thermal Treatment	CDF Construction	Off-site Disposal	Institutional Controls	Subtotal	20% Contingency	TOTAL
A	0	---	---	---	---	---	---	---	---	$4,500,000	$4,500,000	$900,000	$5,400,000
B	0	---	---	---	---	---	---	---	---	$9,900,000	$9,900,000	$1,980,000	$11,880,000
C1	776,791	$20,500,000	---	---	$3,100,000	$1,300,000	---	---	$94,800,000	$4,500,000	$124,200,000	$24,840,000	$149,040,000
C2A	776,791	$30,100,000	---	---	---	$4,700,000	---	---	$12,100,000	$4,500,000	$51,400,000	$10,280,000	$61,680,000
C2B	776,791	$30,100,000	---	---	$22,100,000	$4,700,000	---	---	$56,900,000	$4,500,000	$118,300,000	$23,660,000	$141,960,000
C3	776,791	$20,500,000	---	---	$28,000,000	$2,100,000	---	---	$35,200,000	$4,500,000	$90,300,000	$18,060,000	$108,360,000
D	776,791	$20,500,000	---	---	---	$1,400,000	---	$32,000,000	---	$4,500,000	$58,400,000	$11,680,000	$70,080,000
E	776,791	$30,100,000	---	---	$22,100,000	$10,300,000	$32,500,000	---	---	$4,500,000	$99,500,000	$19,900,000	$119,400,000
F	283,812	$14,600,000	---	$30,100,000	$3,100,000	$900,000	---	---	$34,600,000	$4,500,000	$87,800,000	$17,560,000	$105,360,000

Table 7-7 Cost Summary for Remedial Alternatives - Little Rapids to De Pere (Continued)

1,000 ppb

Alternative	Dredge Volume (cy)	Hydraulic Dredging	Mechanical Dredging	Capping	Dewatering	Water Treatment	Thermal Treatment	CDF Construction	Off-site Disposal	Institutional Controls	Subtotal	20% Contingency	TOTAL
A	0	---	---	---	---	---	---	---	---	$4,500,000	$4,500,000	$900,000	$5,400,000
B	0	---	---	---	---	---	---	---	---	$9,900,000	$9,900,000	$1,980,000	$11,880,000
C1	586,788	$14,800,000	---	---	$3,100,000	$1,100,000	---	---	$71,600,000	$4,500,000	$95,100,000	$19,020,000	$114,120,000
C2A	586,788	$24,700,000	---	---	---	$4,600,000	---	---	$10,100,000	$4,500,000	$43,900,000	$8,780,000	$52,680,000
C2B	586,788	$24,700,000	---	---	$22,100,000	$4,600,000	---	---	$44,000,000	$4,500,000	$99,900,000	$19,980,000	$119,880,000
C3	586,788	$14,800,000	---	---	$21,200,000	$2,000,000	---	---	$26,600,000	$4,500,000	$69,100,000	$13,820,000	$82,920,000
D	586,788	$14,800,000	---	---	---	$1,200,000	---	$32,000,000	---	$4,500,000	$52,500,000	$10,500,000	$63,000,000
E	586,788	$24,700,000	---	---	$22,100,000	$10,300,000	$24,600,000	---	---	$4,500,000	$86,200,000	$17,240,000	$103,440,000
F	170,418	$9,800,000	---	$23,800,000	$3,100,000	$900,000	---	---	$20,800,000	$4,500,000	$62,900,000	$12,580,000	$75,480,000

5,000 ppb

Alternative	Dredge Volume (cy)	Hydraulic Dredging	Mechanical Dredging	Capping	Dewatering	Water Treatment	Thermal Treatment	CDF Construction	Off-site Disposal	Institutional Controls	Subtotal	20% Contingency	TOTAL
A	0	---	---	---	---	---	---	---	---	$4,500,000	$4,500,000	$900,000	$5,400,000
B	0	---	---	---	---	---	---	---	---	$9,900,000	$9,900,000	$1,980,000	$11,880,000
C1	186,348	$6,900,000	---	---	$3,100,000	$900,000	---	---	$22,700,000	$4,500,000	$38,100,000	$7,620,000	$45,720,000
C2A	186,348	$17,400,000	---	---	---	$4,500,000	---	---	$6,000,000	$4,500,000	$32,400,000	$6,480,000	$38,880,000
C2B	186,348	$17,400,000	---	---	$22,100,000	$4,500,000	---	---	$16,800,000	$4,500,000	$65,300,000	$13,060,000	$78,360,000
C3	186,348	$6,900,000	---	---	$6,800,000	$1,700,000	---	---	$8,500,000	$4,500,000	$28,400,000	$5,680,000	$34,080,000
D	186,348	$6,900,000	---	---	---	$1,000,000	---	$32,000,000	---	$4,500,000	$44,400,000	$8,880,000	$53,280,000
E	186,348	$17,400,000	---	---	$22,100,000	$10,100,000	$7,800,000	---	---	$4,500,000	$61,900,000	$12,380,000	$74,280,000
F	50,160	$5,200,000	---	$15,000,000	$3,100,000	$800,000	---	---	$6,100,000	$4,500,000	$34,700,000	$6,940,000	$41,640,000

7.5 De Pere to Green Bay Reach (Green Bay Zone 1)

An overview of the De Pere to Green Bay Reach and the PCB-impacted sediment distribution is shown on Figure 7-36. The retained alternatives and associated costs are presented in Table 7-8.

7.5.1 General Site Characteristics

This section of the Lower Fox River is the most heavily developed, and includes numerous communities. The river reach between the De Pere dam and the mouth of the river at Green Bay is a combination of both residential and industrial development.

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. General water depths by river reach are given in Ocean Surveys (1998).

Stream velocity in this reach is the lowest of the four reaches, with an average stream velocity of 0.26 ft/s (0.08 m/s) (Table 2-5). This slow river flow is likely partly responsible for the depositional characteristic of the river below the De Pere dam. The nature and extent of PCB-impacted sediment in this reach, as summarized in the RI, includes the following:

- Maximum detected concentration - 710,000 μg/kg (avg. 21,722 μg/kg),
- Total PCB mass - 26,639 kg,
- Total PCB-impacted volume - 5,549,330 m^3, and
- Maximum PCB sample depth - 300 to 350 cm depth.

These quantities represent the total volumes/masses represented in each modeled depth layer (RETEC, 2002a). Required dredge volumes described later in this section will likely be larger since they account for overburden volumes above deeper sediment layers that contain PCBs.

Below the De Pere dam, there are no locks or dams that would impede dredging equipment. There are seven bridges over the river to Green Bay. However, none of the bridges represent an impediment to vessel and equipment movement within the reach. Other physical impediments to removal actions in this reach include the numerous bulkhead lines, old docks, and potential underwater archeological sites (e.g., historic barges—indicated as "ruins" on the navigational charts). Costs of removing these impediments were not estimated. Any future specific action plans must consider the potential for impact to operations due to such impediments.

7.5.2 Selected Remedial Alternatives

This section defines the remedial alternatives for the De Pere to Green Bay Reach, and then describes the technologies that will be applied based upon application of the criteria defined in Section 6. The remedial alternatives retained for the De Pere to Green Bay Reach include the following:

A. No action.

B. Monitored natural recovery of the system with the expectation that institutional controls will be removed within 40 years.

C. Remove all river sediment with PCB concentrations greater than the selected action level and dispose of dredged sediment in an NR 500 commercial disposal facility.

D. Remove sediment with PCB concentrations exceeding the selected action level and place non-TSCA sediments in an on-site nearshore CDF. Transport TSCA sediments (greater than 50 ppm PCBs) to an existing NR 500 commercial disposal facility.

E. Remove sediment with PCB concentrations exceeding the selected action level and treat this sediment using thermal treatment. Treated sediment may be beneficially reused.

F. Place a sand cap over contaminated sediments to the maximum extent practicable. Mechanically remove all TSCA sediments from cap areas prior to capping and dispose in an existing NR 500 commercial disposal facility. Dredge remaining sediment and place dredged sediment in a CDF.

Alternative G was not retained since river bathymetry, water currents, and river utilization preclude construction of an appropriate CAD site. The process options that can be applied to the remedial alternatives are described below.

7.5.3 Description of Process Options

Monitoring

Monitoring of physical, chemical, and biological media is applicable for Alternatives B through F. The no action alternative may also require monitoring of fish tissue for maintenance of pre-existing fish consumption advisories. As discussed in the technology screening process, monitoring is grouped into five categories: 1) baseline monitoring prior to remediation to establish baseline conditions for future comparisons, 2) monitoring during implementation, 3) post-verification monitoring to verify completion of a remedy, 4) long-term construction monitoring of containment facilities and sediment caps to verify continued source control and physical integrity, and 5) long-term monitoring to verify effectiveness of the remedy and attainment of the project RAOs. Numerous reference documents confirmed the necessity of a well-developed monitoring plan in order to verify the success of an implemented remedy, to measure the effectiveness and stability of source control measures, and to verify the achievement of project RAOs (EPA, 1998a, 1994a; SMWG, 1999; IJC, 1997; Krantzberg *et al.*, 1999). The following references were used in this FS Report to assess the types and applicability of monitoring options commonly used on sediment remediation projects:

- Ecology, *Standards for Confined Disposal of Contaminated Sediments Development Document* (Ecology, 1990);

- USACE, *Monitoring Considerations for Capping* (USACE, 1992);

- EPA and USACE, *Design, Performance, and Monitoring of Dredged Material Confined Disposal Facilities in Region 5* (EPA, 1996b);

- USACE, *Selected Tools and Techniques for Physical and Biological Monitoring of Aquatic Dredged Material Disposal Sites* (Fredette *et al.*, 1990);

- *Guidance for Subaqueous Dredged Material Capping* (Palermo, 1995);

- *Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories, Volume 1: Fish Sampling and Analysis* (EPA, 1995a);

- *Assessment and Remediation of Contaminated Sediments (ARCS) Program - Assessment Guidance Document* (EPA, 1994a);

- *Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites* (EPA, 1999b);

- Sediment remediation case study projects presented in Appendices B and C of the FS.

Specific monitoring programs will be developed for each remedial alternative and will likely include physical, chemical, and biological monitoring components. Baseline monitoring generally includes water, sediment, and tissue quality sampling. Monitoring during implementation includes air and surface water sampling to assess downstream and off-site transport of contaminants. Verification monitoring includes surface and possibly subsurface sediment sampling to ensure compliance with the target goals of the remediation project. Source control monitoring includes groundwater and surface sediment sampling around the containment facility to confirm proper maintenance, stability, and chemical isolation. Long-term monitoring focuses primarily on fish, bird, and invertebrate tissue sampling and reproductive assessments, but also includes sediment and water sampling for chemical quality. The proposed *Long-term Monitoring Plan* for the Lower Fox River and Green Bay remediation project is presented in Appendix C.

Institutional Controls

Institutional controls appropriate to the De Pere to Green Bay Reach include:

- Maintenance of the fish and waterfowl consumption advisory;
- A moratorium on any future dredging within the navigation channel;
- Deed restrictions on any in-water activities that could result in sediment disturbance (i.e., marina construction or over-water development);
- Access restrictions to contaminated areas;
- Continued restriction on the use of the Lower Fox River for domestic water supplies; and
- A long-term (40-year) monitoring program for sediments, water, bird, and fish PCB and mercury levels.

Implementation of these institutional controls will likely require an active public education program for the fish, waterfowl, and domestic water use advisories. Deed and access restrictions may require local or state legislative action to prevent any development in contaminated areas of the river. Access and use restrictions would also apply to local Indian tribes. Finally, federal action may be necessary on any dredging moratoriums within the federal navigation channel.

Removal Process Options

Sediment removal is identified for Alternatives C through F. Remediation area boundaries and sediment management areas are shown on Figure 7-36. For the De Pere to Green Bay Reach, both mechanical and hydraulic dredging are practicable. Mechanical dredging is better suited to remove the relatively small volumes (248,000 cy) exceeding 50 mg/kg PCBs TSCA levels identified as part of Alternatives C, D, and F. Mechanical dredging significantly reduces the water management needs, which is necessary due to the limited upland space availability on this reach. It has been proposed that all dredging in the De Pere to Green Bay Reach be performed with a mechanical dredge with the exception of Alternatives C2A, C2B, C3, and E. Alternative C2A includes hydraulic dredging and pumping sediment directly to a combined NR 213/NR 500 dewatering and disposal facility while Alternative C2B includes hydraulic dredging, passive dewatering, and sediment disposal at a dedicated NR 500 monofill. Alternative C3 includes hydraulic dredging, mechanical dewatering, and off-site disposal at an existing NR 500 commercial disposal facility. Alternative E includes hydraulic dredging, passive dewatering, and thermal treatment. Hydraulic dredging along with passive dewatering has been proposed for Alternative C2B for cost comparison with Alternative C2A. Hydraulic dredging along with mechanical dewatering has been proposed for Alternative C3.

Dredge Equipment. Three dredges using 8-cy Cable Arm™ buckets have been selected for the remedial alternatives identified in this reach where a mechanical dredge is employed. The De Pere to Green Bay Reach includes both residential and industrial areas. In residential areas, immediately downstream of the De Pere dam, the operating assumption is that dredging will occur only during normal daylight hours (12 hours per day) during a normal work week (5 days per week). In industrial areas, dredging may occur 24 hours per day and 7 days per week. Winter weather conditions are likely to preclude operations; as a result, dredging is assumed to occur only between April and October (26 weeks per year) when the average minimum temperature is above freezing.

Hydraulic dredging for Alternatives C2, C3, and E will be performed using two 12-inch pipeline dredges with a cutterhead. A floating pipeline from the dredges will connect to a shore-side containment cell. A shore-based cutterhead dredge and double-walled pipeline will pump the sediment from the shoreside cell directly to a dedicated NR 500 monofill for Alternative C2A. For Alternative C2B, the sediment slurry will be pumped to an NR 213 dewatering facility located adjacent to the dedicated NR 500 monofill before transporting the dewatered sediments to the dedicated NR 500 monofill for disposal. The sediment slurry will be pumped to a shoreside containment cell for mechanical dewatering and dewatered sediments transported to an existing NR 500 commercial disposal facility for disposal for Alternative C3. For Alternative E, the passive dewatered sediments will be transported to a melter unit for thermal treatment. This operation will minimize the need for upland offloading, staging, and truck loading facilities. The operating assumption for hydraulic dredging is that dredging and pumping will occur 24 hours per day and 7 days a week to minimize the need for pipeline flushing during down periods. Winter weather conditions are likely to preclude operations; as a result, dredging is assumed to occur only between April and October (26 weeks per year).

Long Slurry Pipe Runs. Dredged material generated during hydraulic dredging for Alternatives C2A and C2B will be pumped long distances as dredge slurry and either placed directly into a dedicated NR 500 monofill (approximated distance of 28 miles for the purposes of this FS) or into an NR 213 dewatering facility located adjacent to the proposed landfill. A long pipeline run of dredge slurry was successfully implemented at White Rock Lake, Texas (Sosnin, 1998). In 1998, approximately 3 million cy of sediment were dredged from White Rock Lake, the largest municipal lake in the United States located in Dallas, Texas, and pumped 20 miles in a 24-inch steel pipeline to an active sand and gravel quarry for disposal. The community was opposed to dredged material disposal in their neighborhoods, so the pipeline was threaded through city neighborhoods, under a freeway, under lakes and a golf course to the upland disposal site (Sosnin, 1998). The pipeline, formerly used as a natural gas pipeline, was outfitted with a leak detection system, telemetry signals between dredge and flow meters, automatic flow control systems, one high-pressure, large-capacity groundwater dredge pump (1,500 horsepower, 8 feet per second, and 400 psi), and two booster pumps (11,000 gpm). The used pipeline was purchased for approximately $5 million and the total construction cost was about $13.5 million; the pipeline operated for 1 year (Weathersbee, 2001). Overall, the system required minimal maintenance, no plugging was encountered and no back-flushing was needed since a consistent flow was maintained by diverting clean lake water to the pump (Hagler, 2001).

Containment Systems. In-water containment systems placed around the dredging area are commonly implemented on both mechanical and hydraulic dredging projects to minimize sediment resuspension downstream of the dredging operation. Typical containment barrier systems range from expensive sheet pile walls (i.e., GM Foundry, Bayou Bonfouca), to silt curtains (i.e., West Eagle Harbor, Bayou Bonfouca, River Raisin), and inexpensive oil booms (PSNS Pier D). Silt curtains are the most commonly used containment device for lakes, rivers, and estuaries, but are prone to disturbance from passing ships, strong winds, and currents. Effectiveness of silt curtains depends upon local site conditions, bottom substrate, and curtain design; and therefore may not be applicable for every site. Silt curtains were used at both the Lower Fox River demonstration projects. Based on the successful performance of the dredging operations and curtains at Deposit N, use of silt curtains was discontinued during the second removal phase with minimal water quality exceedances measured downstream. However, for the purposes of this FS, silt curtains were included in the removal costs.

Over-dredge. All dredging is assumed to occur within a defined footprint to a fixed cut depth. When possible, approximately 8 inches of over-dredge of material beyond the estimated maximum depth of impacted sediment will likely be implemented to ensure complete removal of the targeted contaminant mass. However, for the purposes of the FS, over-dredge was not in volume or cost estimates to allow comparability and consistency between different action levels and reaches.

Dewatering Process Options

For all mechanical dredging alternatives, it is proposed that dewatering be conducted on-barge and in upland staging areas. Dewatering has been configured as a two-step process using gravity settling, followed by solidification of solids.

Passive Dewatering. Each 2,000-cy barge load of mechanically dredged sediment will be filled in 1 day and will dewater for 2 days on the barge. Free water will be pumped from the watertight barges and collected. Sediment will then be transferred into one of three asphalt-paved upland staging areas for additional dewatering, solidification, and loading into trucks for off-site shipment. These upland staging areas will each be approximately 0.5 acre in size, surrounded with a 6-inch curb, and graded to a water collection sump. All water collected from the barges and the upland staging area will be treated using flocculation, clarification, and sand filtration prior to discharge back to the river. The upland staging areas may be located at the Bayport facility near the mouth of the Lower Fox River or at the former Shell facility near the middle of this reach.

For the dredge to CDF alternatives (Alternatives D and F), dewatering will occur directly within the CDF. For Alternative C2A, hydraulically-dredged sediment will be pumped directly to a dedicated NR 500 monofill. Dewatering will occur directly within a PCB landfill cell. Decant water for each of these alternatives will be treated and returned to the river. For Alternatives C2B and E, hydraulically dredged sediment will be dewatered in an NR 213 dewatering facility. The NR 213 dewatering facility will be similar to the dewatering facility specified in the Little Rapids to De Pere Reach for Alternative C1. A mechanical dewatering option is included for Alternative C3. Mechanical dewatering involves pumping the hydraulically dredged slurry into conditioning tanks or ponds, where the slurry is adjusted to the appropriate solids content and chemicals are added to assist in the dewatering process. Mechanical dewatering would include shaker screens and hydrocyclones or belt filter presses after initial conditioning. Based on dewatering results from both of the Lower Fox River demonstration projects, the estimated percent solids of the filter cake after shaker screen, hydrocyclones, and belt filter presses ranged between 40 and 60 percent solids (Foth and Van Dyke, 2000; Fort James *et al.*, 2001).

These proposed dewatering systems will meet the criteria defined in Section 6 of this FS Report, in terms of production rate, effectiveness, practicality, and discharge water quality. Final selection of the dewatering process will be determined during the remedial design phase.

Solidification. The solids content after mechanical dredging and dewatering (Alternatives C1, D, and F) is assumed to be 34 percent (w/w) or similar to *in-situ* density, based on *in-situ* solids content from the RI Report (RETEC, 2002a), and may still be difficult to manage due to high moisture content. Prior to any off-site shipment, the sediment would be solidified to improve handling and to satisfy requirements for solid waste hauling on public roads and disposal, if necessary. It was assumed that solidification was necessary, and that the sediment would be solidified with the addition of cement, lime, pozzolan, or other appropriate reagents. For FS costing purposes, 10 percent (w/w) lime was added as the reagent based on its successful use during the SMU 56/57 project (Montgomery-Watson, 1998, 2000). The sediment will be mixed with the reagent and loaded into trucks using standard earthmoving equipment. If the contractor prefers, sediment may be mixed with the reagent in a pug mill as shown on Figure 7-1. Numerous other cost-effective reagents are available that may be tested and used for implementation of a remedial action.

For Alternative C2A, hydraulically-dredged sediment will be pumped directly to a dedicated NR 500 monofill without solidification. For Alternative C2B, dewatering will occur in a dewatering cell adjacent to the PCB landfill prior to placement in a landfill. Wastewater will be treated and returned to the river (discussed below). The solids content after dewatering in the landfill is assumed to reach 50 percent (w/w). For Alternative C3, solidification will not be required as the solids content after mechanical dewatering is estimated to range between 40 and 60 percent solids (Foth and Van Dyke, 2000; Fort James *et al.*, 2001). For Alternative E, it is assumed that the melter unit for thermal treatment will be located in close proximity to the NR 213 dewatering facility precluding the need for solidification of dewatered sediments.

Treatment Process Options

Water Treatment. Prior to water discharge back to the river, supernatant water would pass through flocculation, clarification, and sand filtration systems. Based on the acceptable performance of the sand filter unit during the Deposit N demonstration project, no additional water treatment is deemed necessary (Foth and Van Dyke, 2000). However, additional GAC treatment may be added to the treatment train during removal operations if effluent water quality criteria is exceeded. The estimated unit cost for GAC treatment is $0.40 per thousand gallons of water treated.

Thermal Treatment. Several on-site treatment process options were retained from the screening process in Section 6 that are applicable to the Lower Fox River/Green Bay remediation project. However, only vitrification was selected for costing purposes because the multi-phased study conducted by WDNR has provided data which indicates that this treatment technology is a viable option.

For the purposes of this FS, thermal treatment of the dewatered sediments from De Pere to Green Bay is assumed to occur at the full-scale vitrification unit constructed for the Little Rapids to De Pere Reach. The facility will be built as a standalone unit with on-site storage capacity and equipped with two 375 glass tons per day units. The passively dewatered sediment enters the plant and is dried to approximately 10 percent moisture in the dryer unit. The sediment is mixed with a fluxing material and fed into a large melter, capable of maintaining temperature around 2,900 °F. The sediment melts into a molten material in the melter and passed through the water bath for quenching resulting in glass aggregate.

For the purposes of this FS, sediment treatment by vitrification is assumed to occur over a time frame of 10 years in conjunction with treating dewatered sediments from the Little Rapids to De Pere Reach. The vitrification process is assumed to operate 24 hours per day, 7 days per week, and 350 days per year. The unit will be designed to have the capacity to process 1,840 tons of sediment per day and produce 750 tons of glass aggregate per day.

On-site Disposal Process Options

Three CDFs are currently proposed for the De Pere to Green Bay Reach. All three CDFs are nearshore facilities located immediately downstream of the De Pere dam (Figure 7-37). In all cases, the CDF location was selected to minimize impacts to upland riparian landowners. The total capacity of these facilities is 1,275,000 cy, which is lower than the estimated dredge volumes for each action level. Other possible CDF locations could include an area within the bulkhead line just south of the Former Shell facility or a location at Cat Island.

The concept for all Lower Fox River CDFs is a hybrid of the solid retention and hydraulic isolation designs discussed in Section 6. PCBs are predominately tied to the solids fraction of the sediments, but may dissolve and be carried at low concentrations in pore water. As such, the construction includes placement of a steel sheet pile wall driven to 30 feet below the final grade elevation into the relatively impervious clay layer underlying much of the soft sediments. Using this configuration, it should not be necessary to line the bottom of the CDF. The overall height of the CDF will be above the 100-year flood level—approximately 6 feet above the normal river elevation. The retention berms will be constructed with appropriately-sized shot rock and riprap to prevent flood or ice damage to the CDF.

In keeping with design criteria given in Section 6, there will be no placement of untreated TSCA-level sediments in any CDF. Dredged TSCA-level sediments must first be thermally treated prior to placement in the CDF or taken to an appropriate off-site disposal facility.

During mechanical dredging, the CDF itself will act as a collection system for excess water, with the overflow water decanted and filtered. Upon completion of dredging, the sediment is allowed to further settle, and is eventually capped with 3 feet of clean sediments and revegetated. Long-term use of CDF surface can include a park or multi-use open space. As the Lower Fox River sediments are relatively low in organic debris, a methane collection system has not been included as part of the concept design.

The Bayport CDF located near the mouth of the Lower Fox River currently accepts dredged material from local maintenance dredging projects and is expected to operate for another 40 years. A separate line item is included for closure of the Bayport CDF with the expectation that it will receive PCB-impacted sediments.

No confined aquatic disposal (CAD) sites are considered for this reach because of physical impediments, active large vessel traffic, and continued maintenance of navigational channels.

Off-site Disposal Process Options

Total PCB concentrations in sediment within this reach are generally below 500 ppm, the maximum allowable PCB concentration for designation as TSCA material. EPA TSCA 40 CFR Regulations (Parts 750 and 761) define PCB-contaminated material as containing more than 50 ppm, but less than 500 ppm PCBs. Sediment below 500 ppm may be disposed of at landfills which conform to the NR 500 WAC requirements and has received approval per WDNR's agreement with EPA for the disposal of TSCA-level sediments. Any remaining sediments above 500 ppm can be accepted at existing NR 500 commercial disposal facilities, but must have EPA concurrence. Local landfill options and unit costs were defined in Section 6.4.5 of this FS Report.

Capping Process Options

Within the De Pere to Green Bay Reach, several areas met the criteria defined in Section 6.4.4 of this FS Report for placement of a cap. These locations were selected based on levels of contaminants, site bathymetry, and location of navigational channels. The proposed cap will be constructed so that the TSCA-level sediments are mechanically dredged prior to capping. The cap in the De Pere to Green Bay Reach is planned to be an armored sand cap composed of 20 inches of sand overlain with 12 inches of large cobble to provide erosion protection (Palermo, 1995). The armored cap will not be placed in the navigational channels.

7.5.4 Development of Alternatives and Associated Costs

This section describes the remedial alternatives developed for the De Pere to Green Bay Reach. Each remedial alternative includes a process description, a process flow diagram, and a summary cost table. Summary costs presented as net present worth in this FS include a line item for 20 percent contingency costs (Table 7-8). Details used to develop each cost estimate are provided in Appendix H. The process flow diagrams and dredging/capping footprints for each alternative are presented on Figures 7-38 through 7-48.

The following components are discussed, when applicable, within the development of each alternative:

- Site mobilization and preparation,
- Sediment removal,
- Sediment dewatering,
- Water treatment,
- Sediment treatment,
- Sediment disposal,
- Demobilization and site restoration, and
- Long-term monitoring/institutional controls.

Alternative A: No Action

As required under the NCP, a no action alternative is included for the De Pere to Green Bay Reach. This alternative involves taking no action and relying on natural processes, such as natural attenuation, dispersion, dilution, and sedimentation to reduce contaminant quantities and/or concentrations and control contaminant migration processes. This alternative implies that no active management or remediation is employed; however, some institutional controls, such as access or resource use restrictions, may be employed to reduce risks until RAOs are achieved. This alternative includes costs for fish tissue sampling events every 5 years (for 40 years) for continued maintenance of fish consumption advisories already in place.

The estimated cost for no action and maintenance of consumption advisories currently in place is $4,500,000. Engineered cost evaluations typically include a 20 percent contingency cost added to the remedy costs, as shown in the cost tables as a separate line item.

Alternative B: Monitored Natural Recovery/Institutional Controls

The monitored natural recovery option will include a long-term monitoring program (40-year) for measuring PCB, DDE, and mercury levels in water, sediment, invertebrates, fish, and birds. The monitoring program will be developed to effectively measure achievement of and progress towards the project RAOs expected in 40 years. Monitoring components will likely be collected between 2- and 5-year intervals for the first 10 years, and will include pre- and post-remedy sampling events to establish baseline conditions. Monitoring frequency may be modified after 5 years based on initial monitoring results. More specifically, the monitoring program will likely include (see Appendix C for the proposed *Long-term Monitoring Plan* for the project):

- Surface water quality sampling at several stations along the reach to determine the downstream transport of PCB mass into Green Bay (RAOs 1 and 4);

- Fish and waterfowl tissue sampling of several species and size classes to determine the residual risk of PCB and mercury consumption to human receptors (RAO 2);

- Fish (several species and size classes), bald eagle, and invertebrate tissue sampling to determine the residual risk of PCB, DDE, and mercury uptake to environmental receptors (RAO 3);

- Population studies of birds (bald eagles and double-crested cormorants) to assess the residual effects of PCBs, DDE, and mercury on reproductive viability (RAO 3); and

- Surface sediment sampling in MNR areas to assess potential recontamination from upstream sources and status of attenuation of sediments (RAO 4).

Until the project RAOs have been achieved, institutional controls will be required to prevent exposure of human and biological receptors to contaminants. Institutional controls may also be implemented in combination with many of the proposed remedial alternatives, and may include monitoring, access restrictions, deed restrictions, dredging moratoriums, fish consumption advisories, and domestic water supply restrictions. Deed and access restrictions may require local or state legislative action to prevent any development in contaminated areas of the river. Items included in costs for institutional control include public education programs for fish or health advisories, 5-year fish tissue collection efforts for maintenance of consumption advisories, and deed restrictions.

The estimated cost for institutional controls and long-term monitoring is $9,900,000. Engineered cost evaluations typically include a 20 percent contingency cost added to the remedy costs, as shown in the cost tables as a separate line item.

Alternative C1: Dredge with Disposal at an Existing NR 500 Commercial Disposal Facility (Passive Dewatering)

Alternative C includes the removal of sediments above the remedial action level using multiple mechanical (Alternative C1) or hydraulic (Alternatives C2A, C2B and C3) dredges and off-site disposal of the sediments. Figures 7-38 through 7-41 provide the process flow diagrams for remedial Alternatives C1, C2A, C2B, and C3, while Figure 7-42 illustrates the extent of residual contamination following implementation of Alternative C. The summary costs to implement Alternative C are provided in Table 7-8. The total volume of sediment to be dredged in this alternative ranges between 6,868,000 cy for 125 ppb and 4,517,391 cy for 5,000 ppb action levels. The scope and cost to implement Alternative C2 and C3 are discussed separately below.

A separate line item of $4,200,000 is included for closure of the Bayport CDF in 40 years.

Site Mobilization and Preparation. Staging for the dredging of sediments will be conducted at the Bayport or former Shell facilities. Site mobilization and preparation includes securing the onshore property area for equipment staging, constructing areas for sediment staging, water treatment, sediment solidification, and truck loading. It is assumed that docking facilities for the dredges and barges already exist at these locations. Purchase and property preparation are included in the costs.

Sediment Removal. Due to the limited upland space available on this reach for water management purposes, all sediment removal in Alternative C1 would be done with the mechanical dredge. Given the volumes and operating assumptions described above, the complete removal effort would require approximately 9.3 years for 125 ppb and 6.1 years for 5,000 ppb action levels, using three dredges. Sediment removal will be conducted using three 8-cy closed, clamshell buckets that require a staging area for the mechanically-dredged sediments to be offloaded and transported off site. The cost for constructing the upland staging area is included in dewatering and disposal. For this alternative, TSCA-level sediment is not managed separately and will be incorporated into the existing NR 500 commercial disposal facility landfill along with other sediments, with EPA approval. Silt curtains around the dredging area are included to minimize sediment resuspension downstream of the dredging operation; installation of silt curtains are included in the FS for $35,000. Buoys and other waterway markers would be installed around the perimeter of the work area to prevent entry of unauthorized boats within the removal work zone. Other capital items included in the sediment removal costs are barge rental and movement, construction of upland staging areas, water quality monitoring, post-removal sediment bathymetric surveys to ensure achievement of the removal action, and site restoration at the conclusion of operations.

Sediment removal costs using mechanical buckets are estimated to range between $100,500,000 for 125 ppb to $67,200,000 for 5,000 ppb action levels. The major cost differences between the mechanical and hydraulic removal technologies is apparent in the disposal costs.

Sediment Dewatering. For Alternative C1, passive dewatering will be conducted on-barge and in upland staging areas. Each 2,000-cy barge load of dredged sediment will be filled in 1 day and will dewater for 2 days on the barge. Free water will be pumped from the watertight barges to upland staging areas. Sediment will then be transferred onto an asphalt-paved upland staging area where any free water will be collected. It is assumed that the final sediment would require solidification with 10 percent (w/w) lime (increase solids content from 34 to 50 percent) to satisfy hauling and disposal requirements (included in disposal costs).

Sediment dewatering costs generally include land purchase, site clearing, and construction of shore-based staging areas. Therefore, barge dewatering costs are included in the sediment removal and water treatment costs.

Water Treatment. Water treatment includes purchase of equipment and materials for flocculation, clarification, and sand filtration. Water treatment would be conducted 24 hours per day, 7 days per week during the dredging season. Discharge water is estimated at 82,000 gallons per day for Alternative C1. Daily discharge water quality monitoring is included in the cost estimate. Treated water would be sampled and analyzed to verify compliance with the appropriate discharge requirements prior to discharge back to the river. However, it may be necessary to add carbon filtration to the treatment train if effluent criteria are not met. Carbon filtration could be added for a unit cost of $0.40 per thousand gallons of water treated. Water treatment costs include pad and equipment demobilization and site restoration.

Water treatment costs for mechanical dredging are estimated to range between $700,000 for 125 ppb and $500,000 for 5,000 ppb action levels.

Sediment Disposal. For Alternative C1, sediment disposal includes the loading and transportation of the sediment to an existing NR 500 commercial disposal facility listed in Table 6-6. Disposal costs also include the purchase and addition of lime reagent for solidification of dewatered material prior to off-site transport. The estimated percent solids of dewatered sediment is 34 percent solids based on the SMU 56/57 BOD Report (Montgomery-Watson, 1998). Therefore, the addition of 10 percent (w/w) lime reagent for further solidification was added to disposal costs. Lime can be purchased for $60 per ton and mixed into sediment for about $25 per ton. Solidification costs for adding 10 percent lime reagent, including purchase, range between $222,000,000 and $31,000,000 for the 125 ppb and 5,000 ppb action levels, respectively. Lime reagent purchase is about 20 percent of the solidification costs. The sediments would be loaded into tractor-trailer end dumps with bed liners or sealed gates with a front-end loader. Each load would be manifested and weighed. Each tractor-trailer would pass through a wheel wash prior to leaving the staging area to prevent tracking soil onto nearby streets and highways. After unloading at the designated disposal facility, each tractor-trailer would pass through a wheel wash and return to the staging area for another load. A separate line item of $4,200,000 net present worth is included for the closure of the Bayport CDF in 40 years.

Costs for sediment solidification and disposal at an existing NR 500 commercial disposal facility are estimated to range between $659,200,000 for 125 ppb and $434,700,000 for 5,000 ppb action levels.

Demobilization and Site Restoration. Demobilization and site restoration involves removing all equipment (i.e., fencing, facilities) from the staging and work areas. All work pads and other permanent structures would be removed and the site would be graded to its original condition. Vegetated areas would be replanted to a state similar to that of pre-construction. Demobilization and restoration costs are included within the above dredging and treatment estimates.

Institutional Controls and Monitoring. Baseline monitoring includes primarily water, sediment, and tissue sampling during pre-and post-remedial sampling events. Monitoring during implementation includes surface water and limited air sampling to assess downstream and off-site transport of contaminants. Verification monitoring includes surface and possibly subsurface sediment sampling to ensure compliance with the target goals of the project. Long-term monitoring includes surface water, surface sediment, and biological tissue sampling to determine residual risks and impacts over time. If residual risks remain in the sediment above the risk-based SQTs after remediation, then the long-term monitoring plan described in the MNR alternative will be followed (i.e., media, frequency, location, duration) until the project RAOs are achieved or until a policy decision is made. The proposed *Long-term Monitoring Plan* (LTMP) is detailed in Appendix C. Elements of the LTMP may be implemented for each action level regardless of the remedial outcome in order to verify achievement of the RAOs. The sampling program may continue indefinitely under this process option, but for the purposes of the FS it has been estimated at 40 years.

The estimated cost for the maintenance of institutional controls and fish consumption monitoring is $4,500,000. Implementation monitoring during dredging is included in the removal and water treatment costs. Long-term multimedia monitoring events and costs for verification of project RAOs are included in Alternative B - Monitored Natural Recovery.

Alternative C2A: Dredge with Combined NR 213/NR 500 Dewatering and Disposal Facility

Alternative C2A includes the removal of sediments above the remedial action level using hydraulic dredging and hydraulic pumping of sediment slurry directly to a combined NR 213/NR 500 dewatering and disposal facility for off-site disposal. Figure 7-39 provides the process flow diagrams for remedial Alternative C2A and Figure 7-42 illustrates the extent of residual contamination following implementation of Alternative C. The summary costs to implement Alternative C2A are provided in Table 7-8. The total volume of sediment to be dredged in this alternative ranges between 6,868,000 cy for 125 ppb and 4,517,391 cy for 5,000 ppb action levels.

Site Mobilization and Preparation. Staging for sediment dredging will be conducted at the Bayport or former Shell facilities. Site mobilization and preparation includes securing the onshore property area for equipment staging, constructing areas for sediment staging, constructing intermediate shore-based ponds, pipelines, and booster pumps. The shore-based slurry ponds are constructed of earthen berms lined with asphalt covering 10 acres. It is assumed that docking facilities for the dredges and barges already exist at these locations. Land purchase and construction of upland staging areas are included in the dredging costs.

Sediment Removal. Sediment removal in Alternative C2A will be conducted using two 12-inch hydraulic pipeline feeder dredges with modified cutterheads and one floating 12-inch booster pump. The two feeder dredges will pump dredge slurry to an intermediate shore-based slurry pond located mid-reach. A third 16-inch cutterhead dredge located in the shore-side pond will resuspend the slurry into a 15-inch polyethylene pipe with 1.5-inch wall thickness. The inner pipe will be encased inside a 20-inch steel pipe traveling 18 miles to a dedicated NR 500 monofill. Four booster pumps will be evenly spaced along the route (28 miles with 25 feet total elevation lift). Dredging and pumping operations will continue 7 days per week, 24 hours per day, and 26 weeks per year (182 days) allowing 32 days for downtime and repairs (150 working days per year). Given the volumes and operating assumptions described above, the complete removal effort would require approximately 8 years for 125 ppb and 5.2 years for 5,000 ppb action levels, using two dredges. Sediment removal costs also include construction of a shore-based slurry pond and 28-mile pipeline, booster pump rental, "wintering over" of all equipment, and full-time monitoring of the pipeline. Longer pipe runs may require periodic flushing of the lines during periods of inactivity. Construction of an effluent return pipeline are included in the water treatment costs.

Installation of silt curtains around the dredging area may be included to minimize sediment resuspension downstream of the dredging operation; construction of silt curtains are included in the FS for $35,000. Buoys and other waterway markers would be installed around the perimeter of the work area to prevent entry of unauthorized boats within the removal work zone. Other capital items included in the sediment removal costs are booster pump rental and movement, construction of upland staging areas, water quality monitoring, post-removal sediment bathymetric surveys to ensure achievement of the removal action, and site restoration at the conclusion of operations.

Sediment removal costs using hydraulic dredging are estimated to range between $109,400,000 for 125 ppb and $76,000,000 for 5,000 ppb action levels. The major cost differences between the mechanical and hydraulic removal technologies are apparent in the disposal costs.

Sediment Dewatering. For Alternative C2A, passive dewatering will occur within the combined dewatering and disposal facility. Sediment dewatering costs are included in the dredging, landfill construction, and water treatment costs.

Water Treatment. Water treatment includes construction of an effluent return pipeline from the landfill to the river. Purchase costs also include equipment and materials for flocculation, clarification, and sand filtration. Water treatment would be conducted 24 hours per day, 7 days per week during the dredging season. Discharge water is estimated at 5,131,000 gallons per day for Alternative C2A. Daily discharge water quality monitoring is included in the cost estimate. Treated water would be sampled and analyzed to verify compliance with the appropriate discharge requirements prior to discharge back to the river. Water treatment costs include pad and equipment demobilization and site restoration.

Water treatment costs for hydraulic dredging (Alternative C2A) will range between $7,700,000 for 125 ppb and $6,500,000 for 5,000 ppb action levels.

Sediment Disposal. Costs of sediment disposal at a dedicated NR 500 monofill (Alternative C2A) will range between $70,200,000 for 125 ppb and $47,500,000 for 5,000 ppb action levels which includes siting fees, construction, and site restoration costs. A separate line item of $4,200,000 is included for closure of the Bayport CDF in 40 years.

Demobilization and Site Restoration. Demobilization and site restoration will be the same as those described in Alternative C1.

Institutional Controls and Monitoring. Monitoring activities and costs will be comparable to those described in Alternative C1.

The total projected costs for Alternative C2A are approximately 70 percent lower than the Alternative C1 costs; mostly accountable in the disposal costs.

Alternative C2B: Dredge with Separate Dewatering and Disposal Facility

Alternative C2B includes the removal of sediments above the remedial action level using hydraulic dredging and hydraulic pumping of sediment slurry to an NR 213 dewatering facility located adjacent to a dedicated NR 500 monofill for off-site disposal. Figure 7-40 illustrates the extent of residual contamination following implementation of Alternative C. The summary costs to implement Alternative C2B are provided in Table 7-8. The total volume of sediment to be dredged in this alternative ranges between 6,868,000 cy for 125 ppb and 4,517,391 cy for 5,000 ppb action levels.

Site Mobilization and Preparation. Site mobilization and preparation will be the same as that described in Alternative C2A.

Sediment Removal. Sediment removal will be the same as described in Alternative C2A with the exception that the hydraulically dredged slurry will be pumped to an NR 213 dewatering facility located adjacent to the dedicated NR 500 monofill.

Sediment Dewatering. Passive dewatering includes land purchase, site clearing, and dewatering pond construction. Key assumptions include a 3.6 percent by volume (w/w) dredged solids concentration and 3,100 gpm water production rate for the dredge based on results from the 1999 Lower Fox River demonstration projects (Foth and Van Dyke, 2000; Montgomery-Watson, 2000). Although the recent dredging work conducted at SMU 56/57 (Fort James *et al.*, 2001) showed the average percent solids in dredge slurry was 8.4 percent (w/w) (range 3.5 to 14.4 percent), the lower and more conservative percent slurry solids measured during the 1999 activities was used for FS costs. The sediment dewatering system would be done in a two-cell passive filtration system located adjacent to the dedicated NR 500 monofill. The system would accommodate 26 weeks of solids dredge production rate, plus a maximum water surge storage capacity. It is assumed that the final sediment would require solidification with 10 percent (w/w) lime to satisfy hauling and disposal requirements (included in disposal costs). Dewatering costs also include pond decommissioning and site restoration at the completion of the project. Sediment dewatering costs for Alternative C2B (primarily construction costs) are estimated at $19,900,000.

Water Treatment. Water treatment will be the same as described in Alternative C2A with the exception that the effluent lines for treated water will be constructed from the passive dewatering system.

Sediment Disposal. Sediment disposal includes the loading and transportation of the sediment to the dedicated NR 500 monofill. Disposal costs also include the purchase and addition of lime reagent for solidification of dewatered sediment prior to off-site transport. Sediment disposal costs for Alternative C2B range between $419,200,000 for 125 ppb and $277,100,000 for 5,000 ppb action levels which includes siting fees, construction, and site restoration costs. A separate line item of $4,200,000 is included for closure of the Bayport CDF in 40 years.

Demobilization and Site Restoration. Demobilization and Site Restoration will be the same as those described in Alternative C2A.

Institutional Controls and Monitoring. Monitoring activities and costs will be comparable to those described in Alternative C2A. The total projected costs for Alternative C2B are approximately 27 percent lower than the Alternative C1 costs; mostly accountable in the disposal costs.

Alternative C3: Dredge with Disposal at an Existing NR 500 Commercial Disposal Facility (Mechanical Dewatering)

Alternative C3 includes the removal of sediments above the remedial action level using Hydraulic dredging and onshore mechanical dewatering of sediments. Mechanical dewatered sediments will be transported to an existing NR 500 commercial disposal facility for disposal. Figure 7-41 provides the process flow diagrams for remedial Alternative C3 and Figure 7-42 illustrates the extent of residual contamination following implementation of Alternative C. The summary costs to implement Alternative C3 are provided in Table 7-8. The total volume of sediment to be dredged in this alternative ranges between 6,868,500 cy for 125 ppb and 4,517,391 cy for 5,000 ppb action levels.

Site Mobilization and Preparation. Staging for sediment dredging will be conducted at the Bayport or former Shell facilities. Site mobilization and preparation includes securing the onshore property area for equipment staging, constructing areas for sediment staging, constructed intermediate shore-based ponds and mechanical dewatering facility, water treatment, sediment storage and truck loading area. Land purchase and construction of upland staging areas are included in the dredging costs.

Sediment Removal. Sediment removal in Alternative C3 will be conducted using two 12-inch hydraulic pipeline feeder dredges with modified cutterheads. Dredging and pumping operations will continue 7 days per week, 24 hours per day, and 26 weeks per year (182 days) allowing 32 days for downtime and repairs (150 working days per year). The hydraulically dredged slurry will be pumped to a shore-based mechanical dewatering facility. Given the volumes and operating assumptions described above, the complete removal effort would require approximately 8 years for 125 ppb and 5.2 years for 5,000 ppb action levels, using two dredges.

Installation of silt curtains around the dredging area may be included to minimize sediment resuspension downstream of the dredging operation; construction of silt curtains are included in the FS for $35,000. Buoys and other waterway markers would be installed around the perimeter of the work area to prevent entry of unauthorized boats within the removal work zone. Other capital items included in the sediment removal costs are booster pump rental and movement, construction of upland staging areas, water quality monitoring, post-removal sediment bathymetric surveys to ensure achievement of the removal action, and site restoration a the conclusion of operations.

Sediment removal costs using hydraulic dredging are estimated to range between $85,400,000 for 125 ppb and $57,200,000 for 5,000 ppb action levels. The major cost differences between the mechanical and hydraulic removal technologies are apparent in the disposal costs.

Sediment Dewatering. Mechanical dewatering includes land purchase, site clearing, and construction of temporary holding ponds. Dewatering techniques will be similar to the mechanical processes used for both Lower Fox River demonstration projects including a series of shaker screens, hydrocyclones, and belt filter presses. The final percent solids of the filter press cake was about 60 percent solids (w/w) for SMU 56/57 (Fort James *et al.*, 2001) and 40 to 50 percent solids for Deposit N (Foth and Van Dyke, 2000). No additional solidification was required. The dewatering process will be simplified into a unit cost of $80 per bone dry ton assuming 50 percent solids after dewatering for the purposes of this FS.

Mechanical dewatering costs for Alternative C3 range from $217,700,000 for 125 ppb to $143,200,000 for 5,000 ppb action levels.

Water Treatment. Water treatment includes purchase of equipment and materials for flocculation, clarification, and sand filtration. Water treatment would be conducted 24 hours per day, 7 days per week during the dredging season. Discharge water is estimated at 568,800 gallons per day. Daily discharge water quality monitoring is included in the cost estimate. Treated water would be sampled and analyzed to verify compliance with the appropriate discharge requirements prior to discharge back to the river. Carbon filtration could be added for a unit cost of $0.040 per thousand gallons of water treated. It may be necessary to add carbon filtration to the treatment train if effluent criteria are not met. Water treatment costs also include pad and equipment demobilization and site restoration.

Water treatment costs are estimated to range from $6,400,000 for 125 ppb to $5,200,000 for 5,000 ppb action levels.

Sediment Disposal. Mechanically dewatered sediments will be transported to an existing NR 500 commercial disposal facility by trucks. Costs of sediment disposal will range between $277,000,000 for 125 ppb and $182,900,000 for 5,000 ppb action levels. A separate line item of $4,200,000 is included for closure of the Bayport CDF in 40 years.

Demobilization and Site Restoration. Demobilization and site restoration will be the same as those described in Alternative C1.

Institutional Controls and Monitoring. Monitoring activities and costs will be comparable to those described in Alternative C1.

Alternative D: Dredge and Disposal to a Confined Disposal Facility, Off-site Disposal of TSCA Sediment

Alternative D includes removal of sediments above the remedial action level to an on-site CDF for long-term disposal of the materials. As previously noted, sediments with PCB concentrations exceeding 50 ppm are not to be disposed of in a nearshore CDF. As such, this alternative utilizes mechanical dredging to remove those smaller volumes of sediment greater than 50 ppm for solidification and disposal at an existing NR 500 commercial disposal facility.

Figure 7-43 provides the process flow diagrams for this remedial alternative, while Figure 7-44 illustrates the location of the CDFs and the extent of residual contamination following implementation of Alternative D. Table 7-8 contains the summary costs to implement Alternative D. The total volume of sediments to be dredged are similar to those identified in Alternative C. This alternative also includes line item costs for closure of the Bayport CDF in 40 years for $4,200,000 net present worth.

Site Preparation and CDF Construction. For the concept level FS, the process is staged to construct and complete dredging to the nearshore CDF facilities located immediately downstream of the De Pere dam. Site mobilization and preparation includes securing the onshore property area for equipment staging, constructing the CDFs, a water treatment facility, and offshore docking facility for the mechanical dredge. The total capacity of these CDF facilities is lower than the proposed dredge volumes. Other possible CDF locations could include an area within the bulkhead line just south of the former Shell facility or a location at the Cat Islands. CDF construction will require up to 6 months for completion prior to dredging. CDF construction is estimated at $39,200,000.

Sediment Removal. Mechanical dredging of the limited TSCA-level sediment volumes would occur prior to initiation of mechanical dredging of sediments to a CDF. Sediment removal techniques and costs for this alternative are equivalent to those described for Alternative C1. The estimated time to complete mechanical dredging range between 9.3 years for 125 ppb and 6.1 years for 5,000 ppb action levels.

Sediment Dewatering. Passive dewatering will occur directly within the CDF berms for sediments transported to the CDF. The remaining dredged sediments will dewater on-barge for 2 days prior to offloading to the upland staging area as described in Alternative C1. Sediment dewatering costs are included in the sediment removal and treatment costs.

Water Treatment. Overflow return water from the CDFs and on-barge dewatering would be treated before discharge to the river. Monitoring requirements are expected to be the same as those for Alternative C1.

Water treatment costs for Alternative D are estimated to range between $1,200,000 for 125 ppb and $1,000,000 for 5,000 ppb action levels.

Sediment Disposal. Sediment disposal includes the loading and transportation of the TSCA-level and non-TSCA-level sediments to a facility listed in Table 6-6.

The cost for off-site sediment disposal at an existing NR 500 commercial disposal facility is estimated to range between $422,800,000 for 125 ppb to $244,600,000 for 5,000 ppb action levels for sediments that exceed the CDF capacity.

Demobilization and Site Restoration. Demobilization and site restoration involves removing all equipment (i.e., fencing, facilities) from the staging and work areas. The CDFs would be finished with a 3-foot cap of clean soils, and seeded and planted. Additional amenities (i.e., bike paths, wildlife habitat) were not included in the cost estimates. However, this alternative would allow development of these features and would provide a beneficial use of this area for the community. Demobilization and site restoration costs are included under the dredging and dewatering estimates.

Institutional Controls and Monitoring. To ensure that the CDF is functioning as designed, near-site sediment and water sampling would be conducted on an annual basis (included in CDF construction costs). Long-term monitoring is defined in the proposed monitoring plan (Appendix C) for verification of project RAOs and costs are provided in Alternative B - Monitored Natural Recovery. The monitoring program will be conducted over a period of 40 years.

The estimated cost for institutional controls is $4,500,000.

Alternative E: Dredge with Thermal Treatment

Alternative E includes hydraulic dredging of sediments, passive dewatering, and treatment with an on-site integrated vitrification unit. This alternative results in the sediments being transformed into glass aggregate that has potential for a wide variety of beneficial reuse applications. Figure 7-45 provides the process flow diagrams for this remedial alternative, while Figure 7-46 illustrates the extent of residual contamination after implementing Alternative E. Table 7-8 contains the summary costs to implement Alternative E. This alternative addresses the same volume of sediments as Alternative C. Alternative E also includes a line item for site closure of the Bayport CDF when capacity is reached in 40 years. Bayport closure costs are $4,200,000 net present worth.

Site Mobilization. Site mobilization and preparation includes securing the onshore property area for equipment staging, water treatment, and offshore docking facility for the hydraulic dredge. Site preparation would also include building a standalone vitrification unit capable of processing an estimated 750 glass tons per day.

Sediment Removal. Hydraulic sediment removal techniques, duration, and costs for this alternative are equivalent to those described for Alternative C2.

Sediment Dewatering. Sediment dewatering is similar to the requirements described in Alternative C2B.

Water Treatment. Water treatment will be the same as described in Alternative C2A with the exception that the effluent lines for treated water will be constructed from the passive dewatering system. Monitoring requirements are expected to be the same as those for Alternative C. Water treatment costs for Alternative E are estimated to be the same as those for Alternative C.

Sediment Treatment. After completion of passive dewatering (to approximately 30 percent solids), both TSCA and non-TSCA-level sediments are passed through the dryer and dried to approximately 10 percent moisture. Thermal treatment of the dried sediments involves blending the high-silt/clay sediments with fluxing materials and processing the materials in a melter as part of the vitrification process. The vitrification process would include appropriate treatment of air emissions. The unit cost for thermal treatment includes capital costs and operating costs. The capital costs include equipment, building, installation, engineering, and startup costs. Operating costs include labor, utilities, and general administrative costs. The unit cost is based on an assumption that the glass aggregate resulting from treating sediments will have a resale value between a range of $2 and $25 per ton as provided by Minergy. The unit cost for sediment treatment decreases with an increase in the resale value of the glass aggregate.

The cost for thermal treatment is estimated to range between $253,600,000 for 125 ppb and $166,800,000 for 5,000 ppb action levels at an estimated unit cost of $24 per ton.

Sediment Disposal. No sediments will be disposed of as hazardous waste, as all the sediments will be treated by thermal treatment. Treated sediments transformed to glass aggregate by the vitrification process have a wide variety of applications.

Based on analysis by product marketing specialists, the glass aggregate has a potential to be used as roofing shingle granules, industrial abrasives, ceramic floor tile, cement pozzolan, and construction fill (Minergy Corporation, 2002a).

Demobilization and Site Restoration. Demobilization and site restoration involves removing all equipment (i.e., fencing, facilities) from the staging and work areas. All work pads and other permanent structures would be removed and the site would be graded to its original condition. Vegetated areas would be replanted to a state similar to that of the pre-construction. Demobilization and restoration costs are included within the above dredging, dewatering, and treatment estimates.

Alternative F: Cap to Maximum Extent Possible, Dredge Remaining Sediments for On-site and Off-site Disposal

Alternative F includes primarily *in-situ* capping, but also includes dredging of sediments above the remedial action level to CDFs and existing NR 500 commercial disposal facilities. Within the De Pere to Green Bay Reach, several areas met the criteria defined in Section 6.4.4 of this FS Report for placement of a cap. The capping area encompasses sediment containing TSCA-level sediments which require mechanical dredging prior to cap placement. Contaminated sediment will be capped to the maximum extent possible; remaining sediments outside the cap footprint will be excavated to CDFs. When CDF capacity is reached, leftover sediment will be hauled to off-site disposal facilities. The process flow diagram is depicted on Figure 7-47 while Figure 7-48 illustrates the location of sediment caps and the extent of residual contamination following implementation of Alternative F. The estimated costs are presented in Table 7-8. The estimated time for placement of the sand cap is 8.3 and 4.9 years for the 125 ppb and 5,000 ppb action levels, respectively. The estimated time for placement of armoring over the cap is 7.5 to 4.5 years, respectively.

Site Preparation, Cap, and CDF Construction. Site preparation for capping and dredging would include upland staging areas for temporary storage of capping materials and dewatering as discussed in Alternative C1. The cap in the De Pere to Green Bay Reach is planned to be an armored cap composed of 20 inches of sand overlain with 12 inches of large cobble to provide erosion protection. The sand cap will be completed using a spreader barge with a 10-inch pipeline. The cap will be placed in 6-inch lifts (1,200 cy placed per day working 10-hour shifts). Armor placement would be completed using two clamshell buckets placing 400 cy per day per bucket. A 3-cy bucket was selected for costing purposes (OBAI Cost Estimate). Cap construction would require an upland staging area for the receipt and placement of sand and the armoring stone. The staging area will include a hopper for pumping slurry to the spreader barge. Armor stone will be delivered to the work area via barges. All other unit costs are similar to those described for the prior alternatives for the river reach. Site preparation costs in this alternative are included under the dredging and capping costs. CDF construction would be similar to those described in Alternative D.

Capping costs under this alternative are estimated to range from $67,800,000 to $42,900,000. CDF construction costs are estimated to be $39,200,000 for all action levels.

Sediment Removal. Remaining sediments above the remedial action level outside of the capping areas will be removed by mechanical dredging using three 8-cy clamshell buckets. Mechanical dredging of the limited TSCA-level sediment volumes would occur prior to initiation of capping and dredging sediments to the CDF. The estimated time to complete dredging ranges between 6.3 years for 125 ppb and 4.2 years for 5,000 ppb action levels using three dredges.

Sediment removal costs for dredging are estimated to range between $69,500,000 for 125 ppb and $47,100,000 for 5,000 ppb action levels.

Sediment Dewatering. The sediments dredged to the CDF will be dewatered and treated as described under Alternative D. Additional sediments will dewater on-barge for 2 days prior to offloading to upland staging areas for off-site disposal. Sediment dewatering costs are included in the removal and water treatment costs.

Water Treatment. Overflow return water from the CDFs and the water from on-barge dewatering would be treated before discharge to the river. Monitoring requirements are the same as for the prior remedial alternatives. Water treatment costs for Alternative F are estimated to be similar to those for Alternative C1.

Sediment Disposal. Sediment disposal includes the loading and transportation of the TSCA-level and non-TSCA-level sediments to an appropriate off-site facility. Sediments would require solidification with 10 percent lime prior to transport.

The cost for off-site sediment solidification and disposal at an existing NR 500 commercial disposal facility is estimated to range between $246,300,000 for 125 ppb and $95,500,000 for 5,000 ppb action levels.

Demobilization and Site Restoration. Demobilization and site restoration involves removing all equipment (i.e., fencing, facilities) from the staging and work areas. Demobilization and site restoration costs are included under the dredging and capping estimates.

Institutional Controls and Monitoring. Annual monitoring will be performed to ensure that the cap is placed as intended, the required capping thickness is maintained, and contaminants are isolated. The monitoring program will include bathymetric surveys, camera profiles, and core sampling and will be conducted over a period of 40 years. Institutional controls would include deed restrictions, site access and anchoring limitations, and maintenance of the consumption advisories. A separate *Long-term Monitoring Plan* for the entire river and Green Bay is discussed in Appendix C.

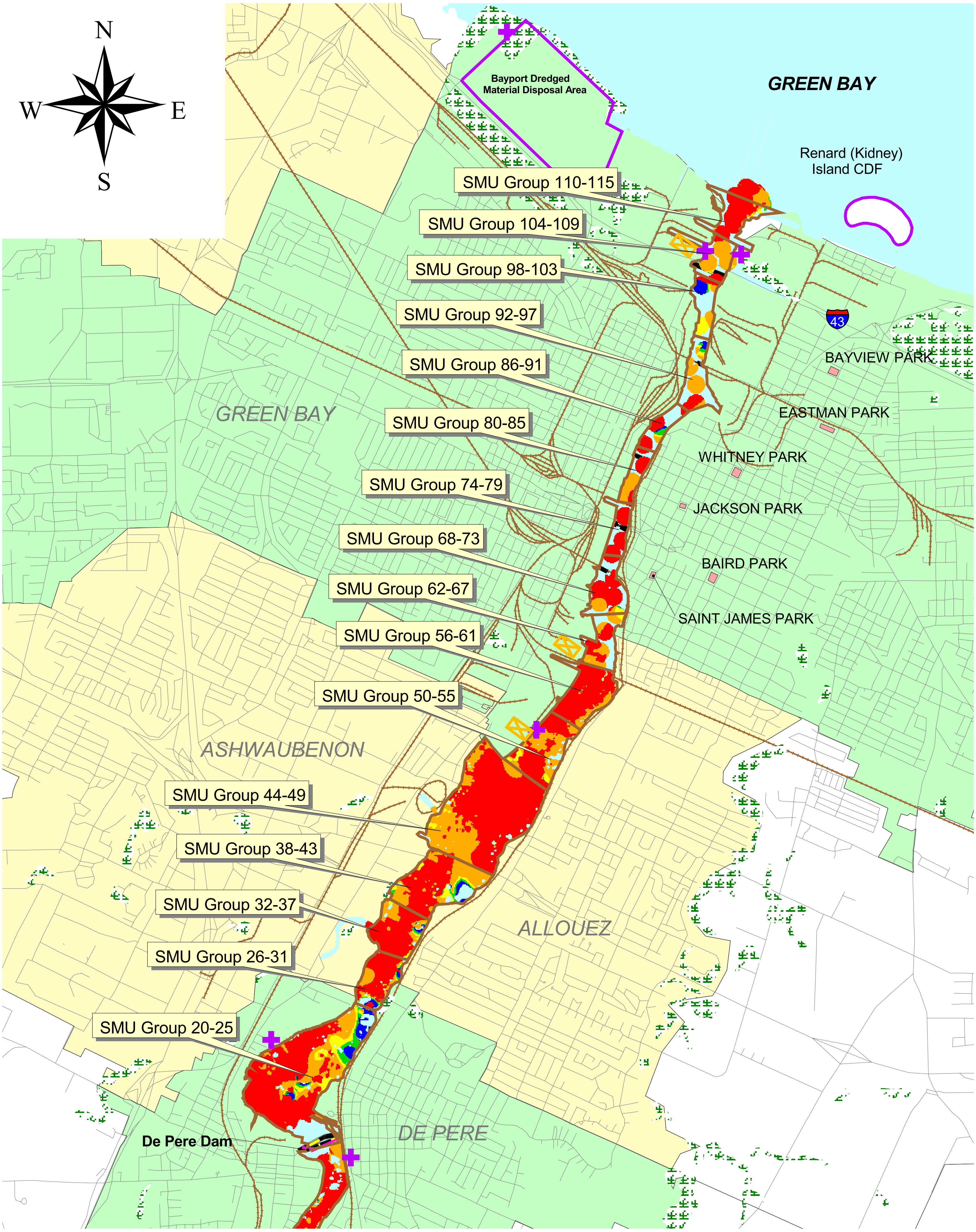
The estimated cost for institutional controls is $4,500,000. Monitoring for cap integrity is included in the capping costs. Long-term monitoring scope and costs for verification of project RAOs are included in Alternative B - Monitored Natural Recovery.

7.5.5 Section 7.5 Figures and Tables

Figures and tables for Section 7.5 follow page 7-146 and include:

Figure 7-48 Alternative F: Cap to Maximum Extent Possible and Dredge Remaining Sediment to CDF - De Pere to Green Bay

Table 7-8 Cost Summary for Remedial Alternatives - De Pere to Green Bay (Green Bay Zone 1)



Sediment Management Units

Possible Equipment Access

TSCA Areas

Upland Staging

Action Level Profile (ppb)

- >125
- >250
- >500
- >1,000
- >5,000

Dam Locations

Bridges

Railroads

Roads

Wisconsin State Parks

Wetlands

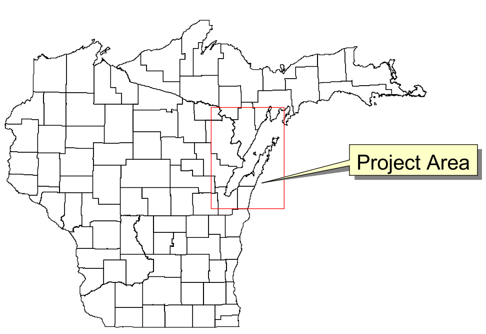
Water

Civil Divisions

- City
- Township
- Village

1 0 1 2 Kilometers

1 0 1 Miles



1. Basemap generated in ArcView GIS, Version 3.2, 1998, and from TIGER census data, 1995.
2. Deposit and management area data obtained from WDNR. and are included in the Fox River database.
3. Action level profiles for PCBs considered for all depth layers up to 350 cm for lower Fox River.

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Sediment Management Area Overview: De Pere to Green Bay

FIGURE 7-36

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CREATED BY: SCJ
PRINT DATE: 3/13/01
APPROVED: AGF

Figure 7-37 Preliminary Concept Design for the De Pere Confined Disposal Facility

Figure 7-38 Process Flow Diagram for De Pere to Green Bay - Alternative C1: Dredge with Disposal at an Existing NR 500 Commercial Disposal Facility (Passive Dewatering)

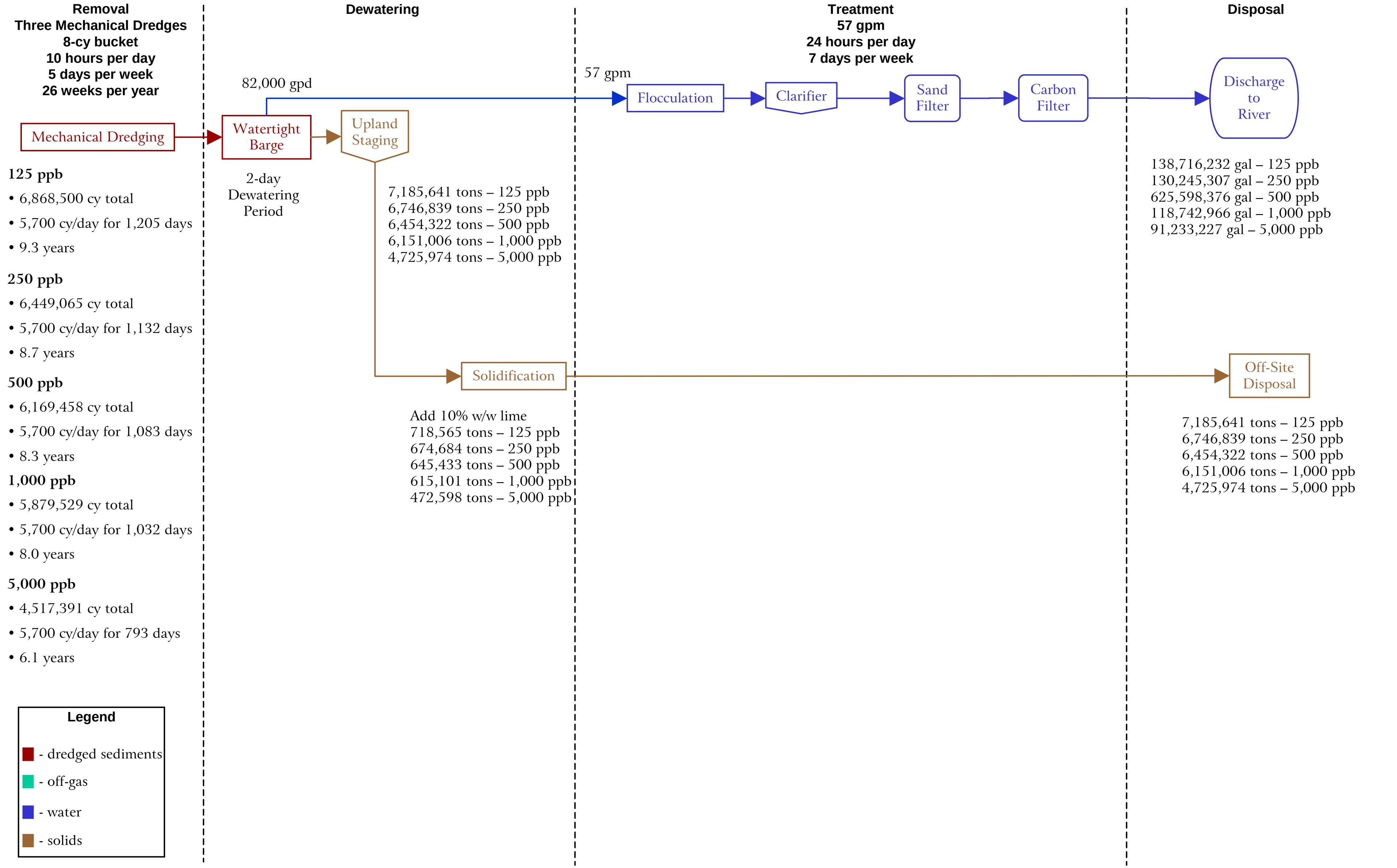
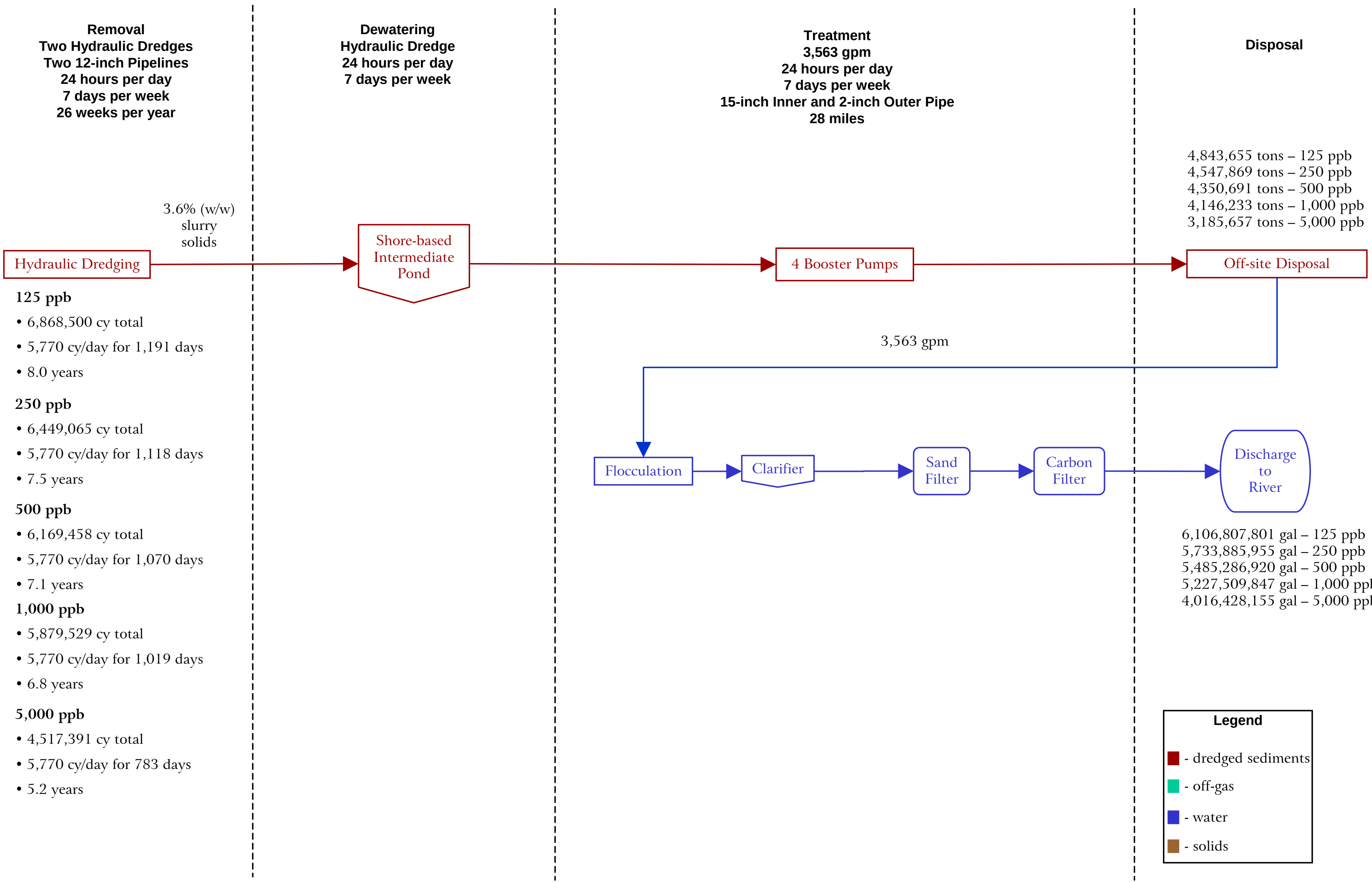


Figure 7-39 Process Flow Diagram for De Pere to Green Bay - Alternative C2A: Dredge with Combined Dewatering and Disposal Facility



Note: Off-site disposal unit is a combined dewatering and disposal facility.

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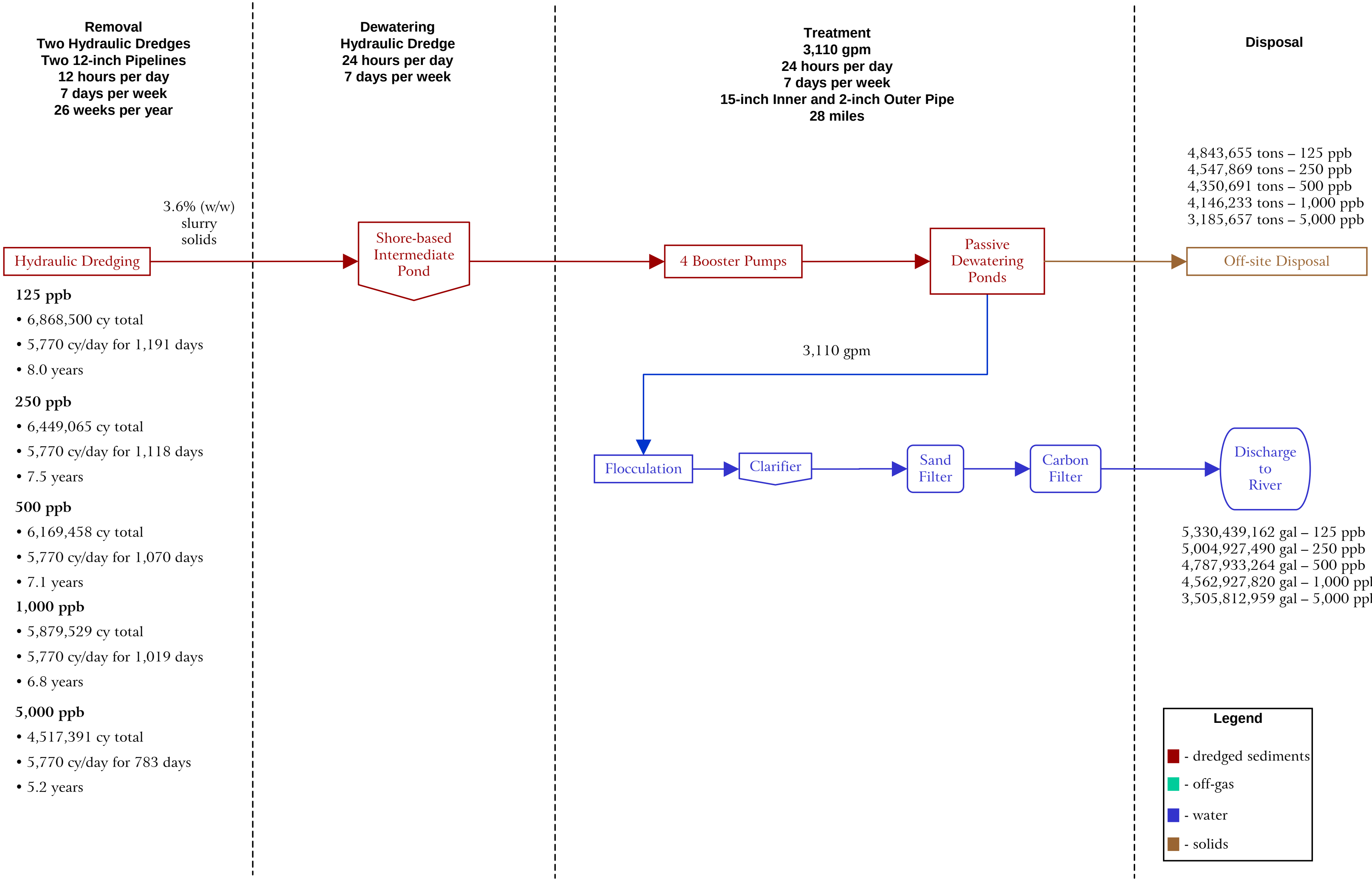
Figure 7-40 **Process Flow Diagram for De Pere to Green Bay - Alternative C2B: Dredge with Separate Dewatering and Disposal Facility**



Note: Off-site disposal unit is a dedicated NR 500 monofill.

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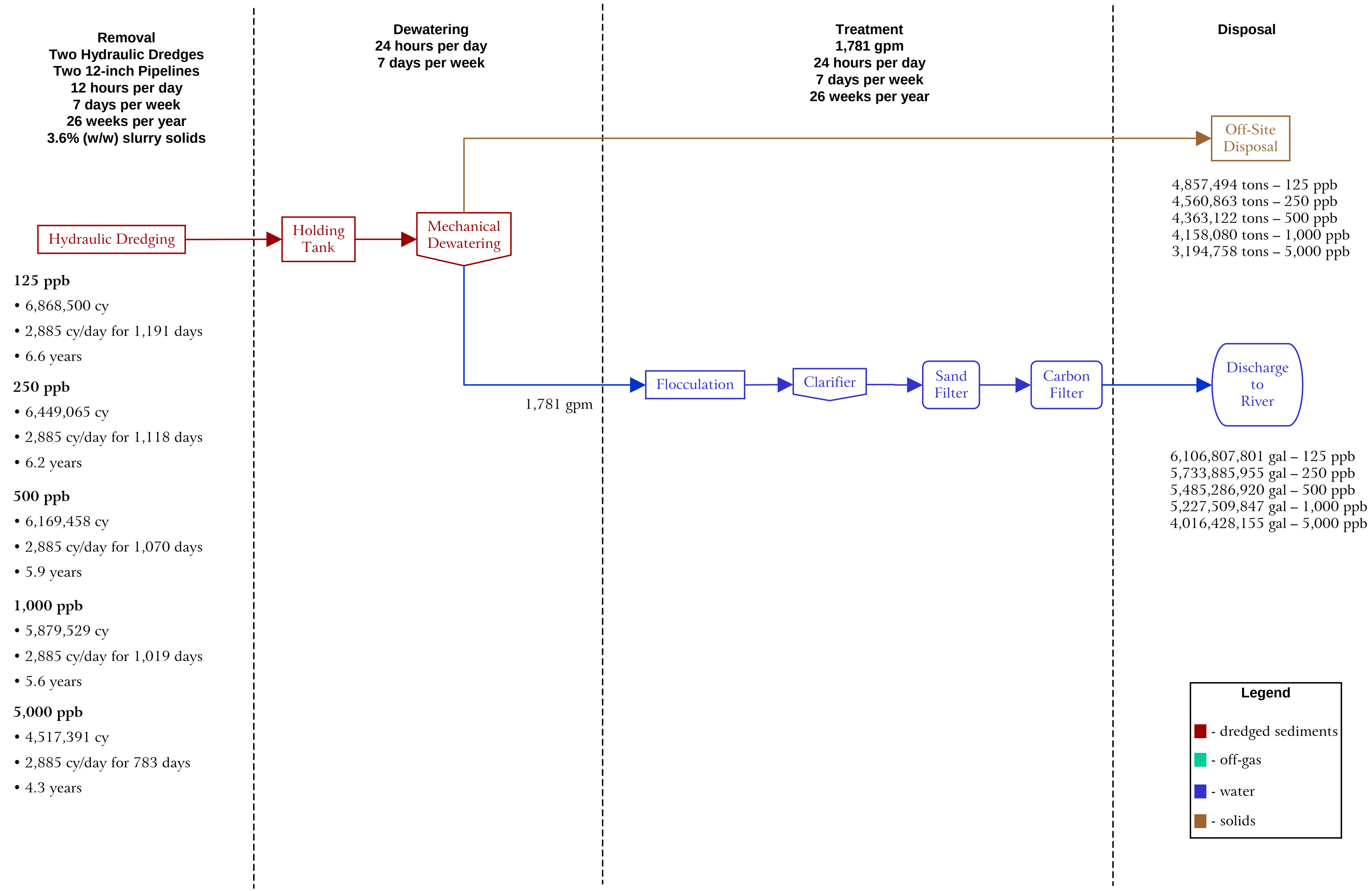
Figure 7-41 **Process Flow Diagram for De Pere to Green Bay - Alternative C3: Dredge Disposal at an Existing NR 500 Commercial Disposal Facility (Mechanical Dewatering)**



Note: Off-site disposal unit is an existing NR 500 commercial disposal facility.

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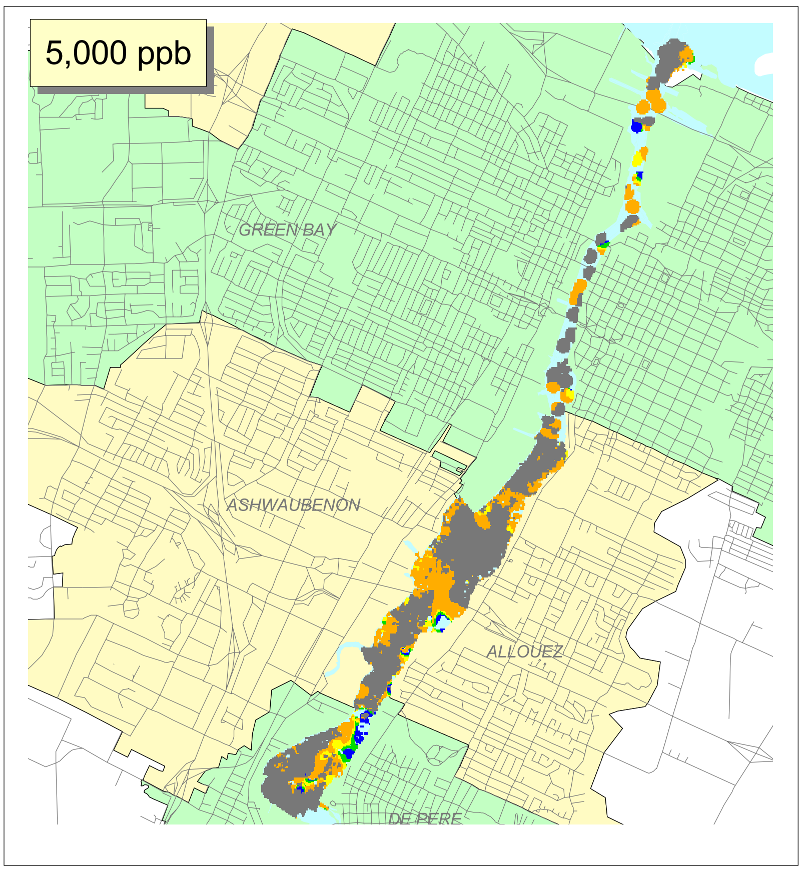
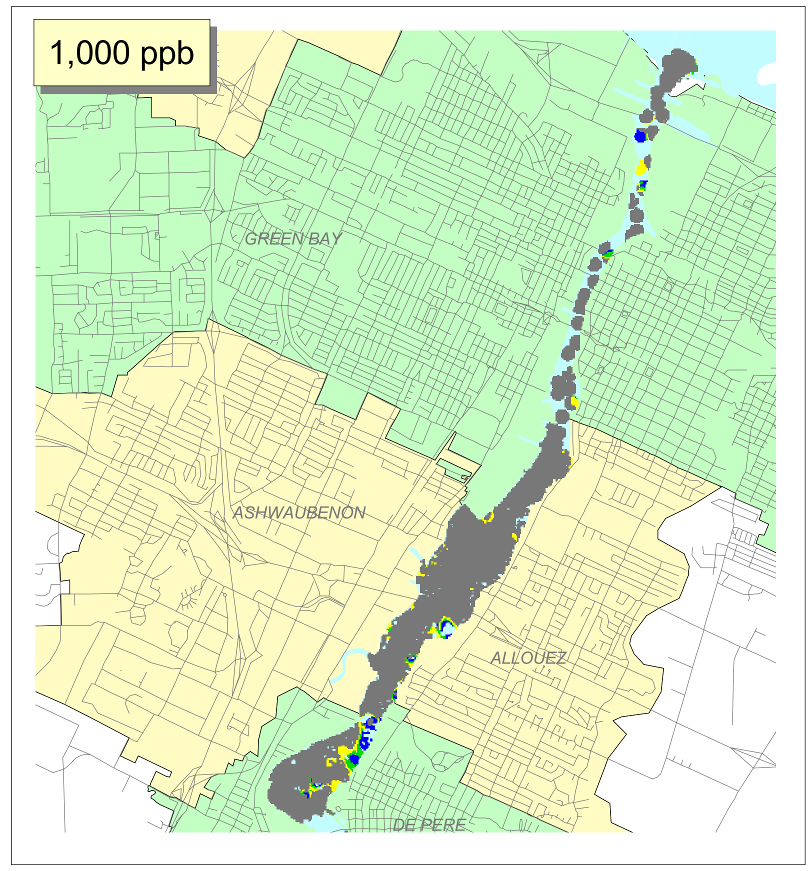
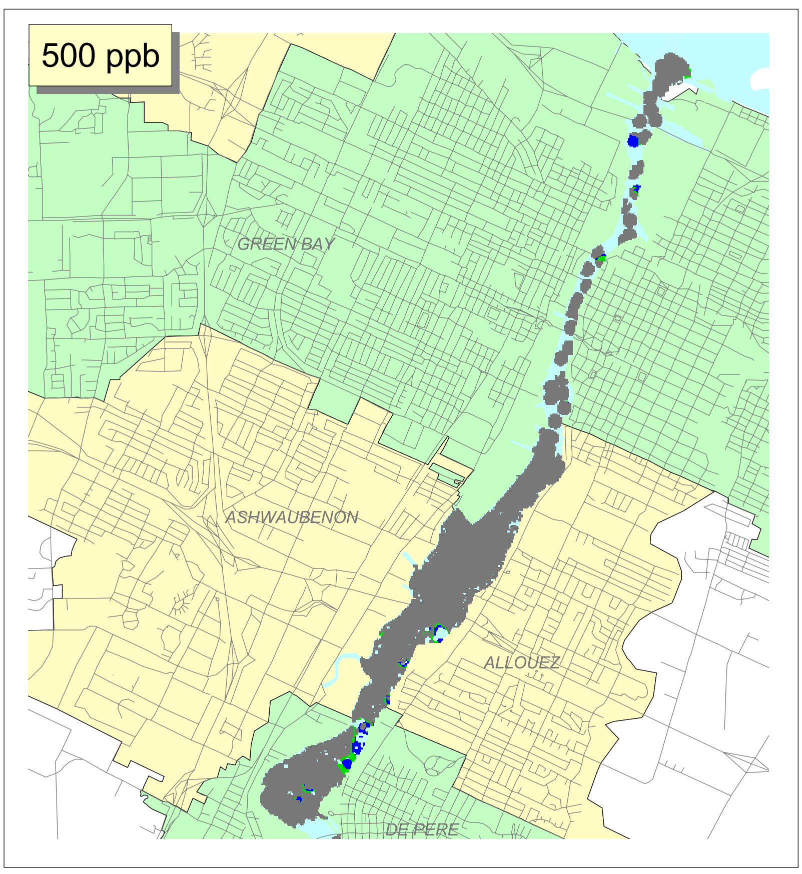
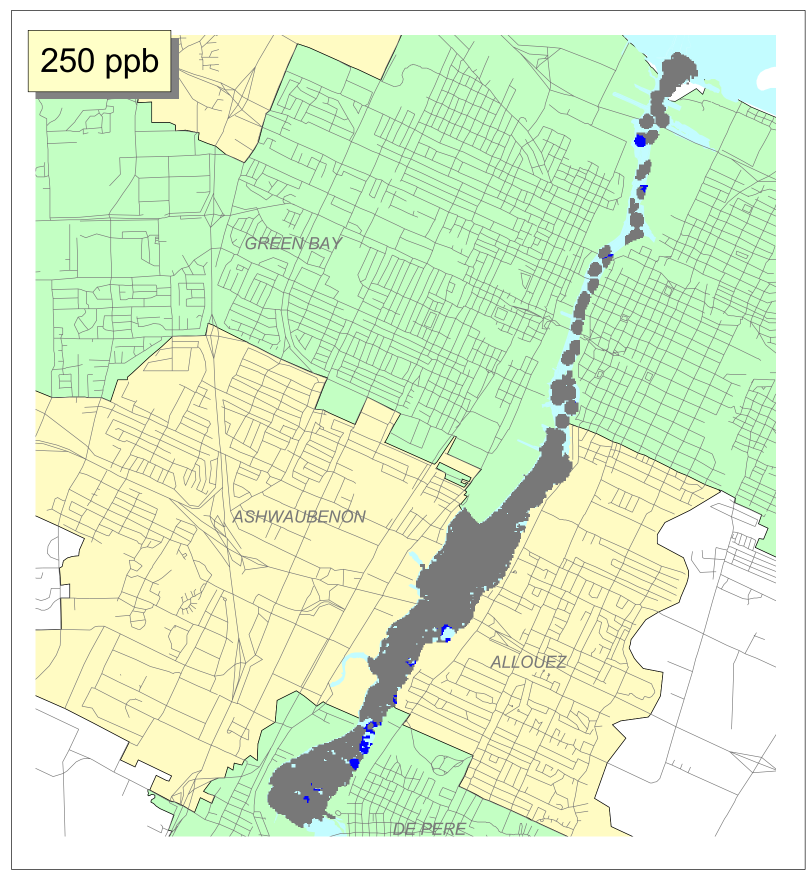
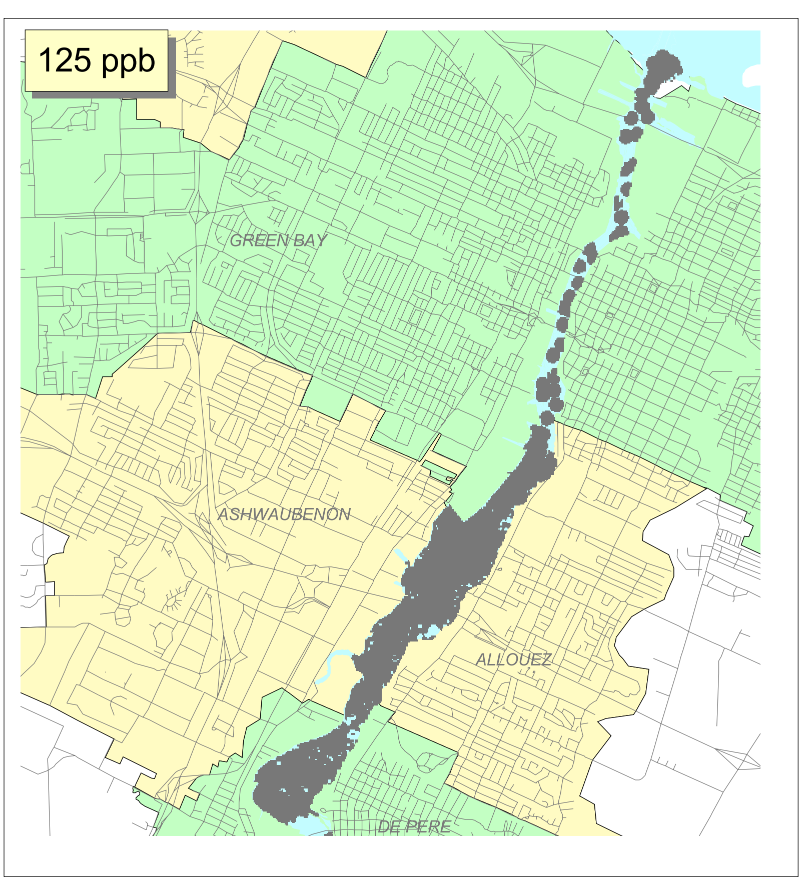








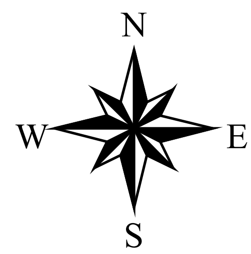


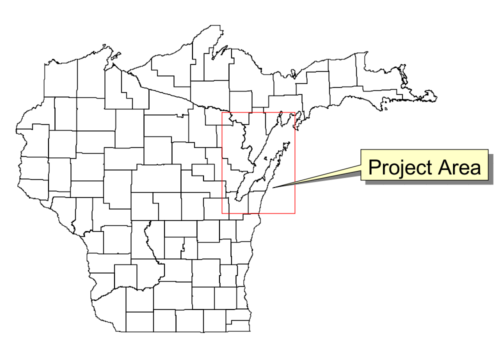
PCB Concentration (ppb) of Remaining Sediments by Action Level

- >125
- >250
- >500
- >1,000
- Dredged Sediments
- Roads
- Water

Civil Divisions

- City
- Township
- Village





1 0 1 2 3 Kilometers

1 0 1 2 Miles

1. Basemap generated in ArcView GIS, Version 3.2, 1998, and from TIGER census data, 1995.
2. Deposit and management area data obtained from WDNR, and are included in the Fox River database.

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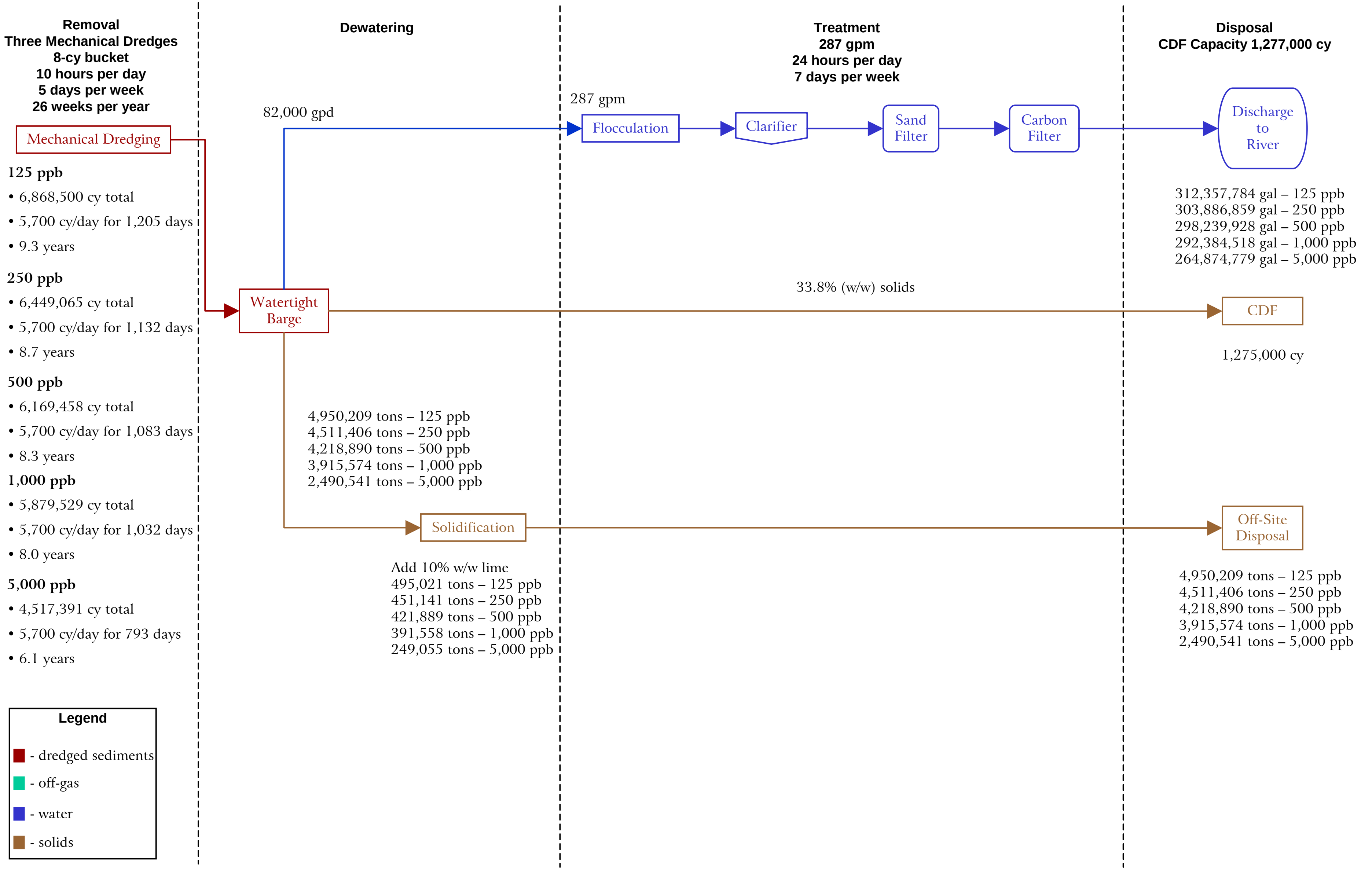
Alternative C: Dredge and Off-Site Disposal De Pere to Green Bay

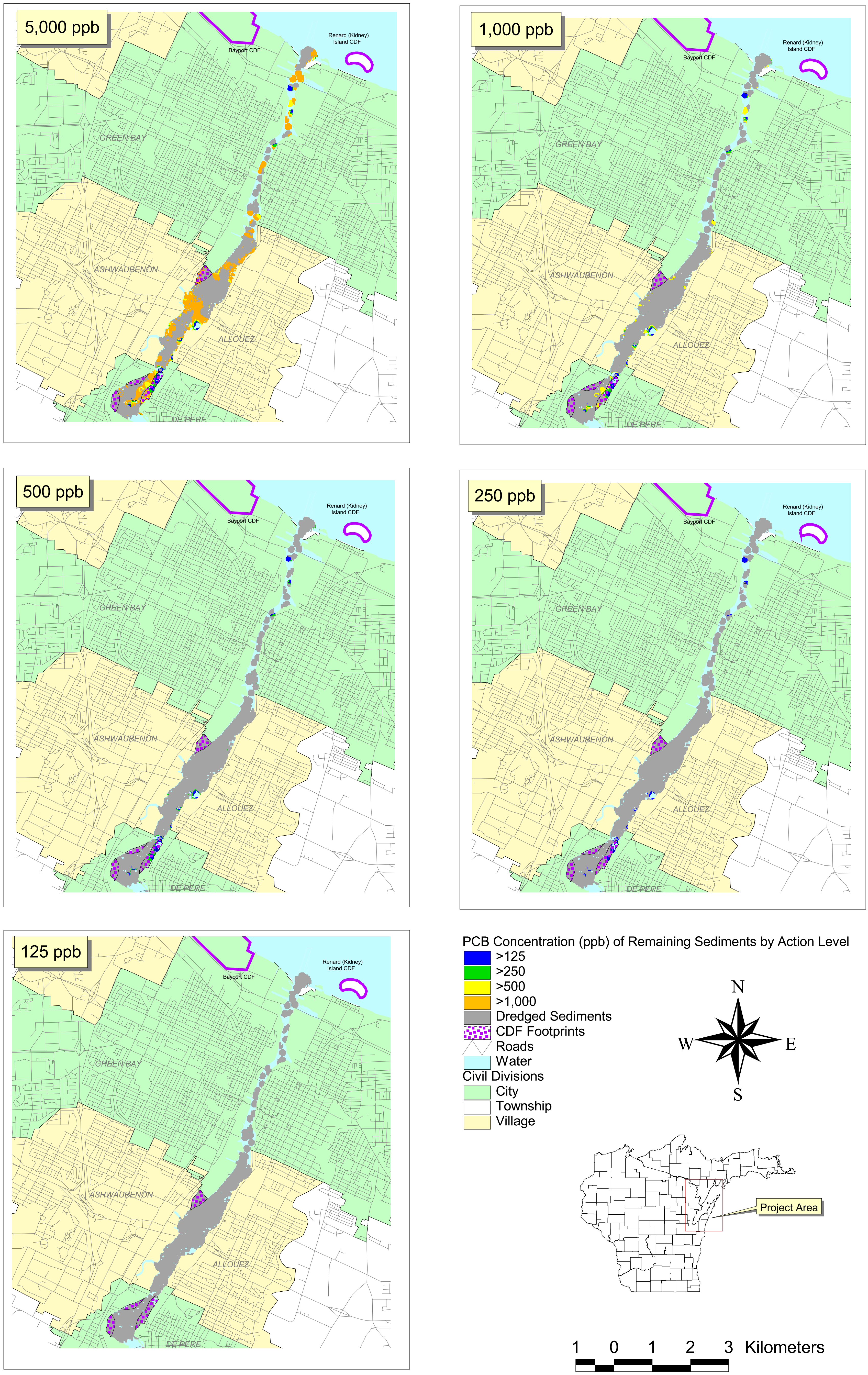
FIGURE 7-42

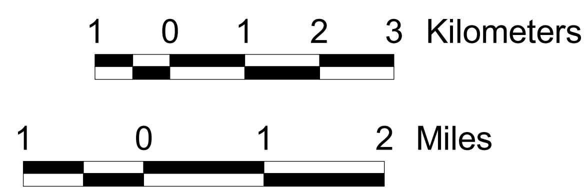
REFERENCE NO: FS-14414-535-7-35
CREATED BY: SCJ
PRINT DATE: 3/13/01
APPROVED: AGF

Figure 7-43 Process Flow Diagram for De Pere to Green Bay - Alternative D: Dredge Sediment, CDF, and Off-site Disposal



F:\PROJECTS\DOCS\4414\DOC\FS\FINAL\FIGURES\SEC7\SEC7FIGSL.PPT





1. Basemap generated in ArcView GIS, Version 3.2, 1998, and from TIGER census data, 1995.
2. Deposit and management area data obtained from WDNR, and are included in the Fox River database.

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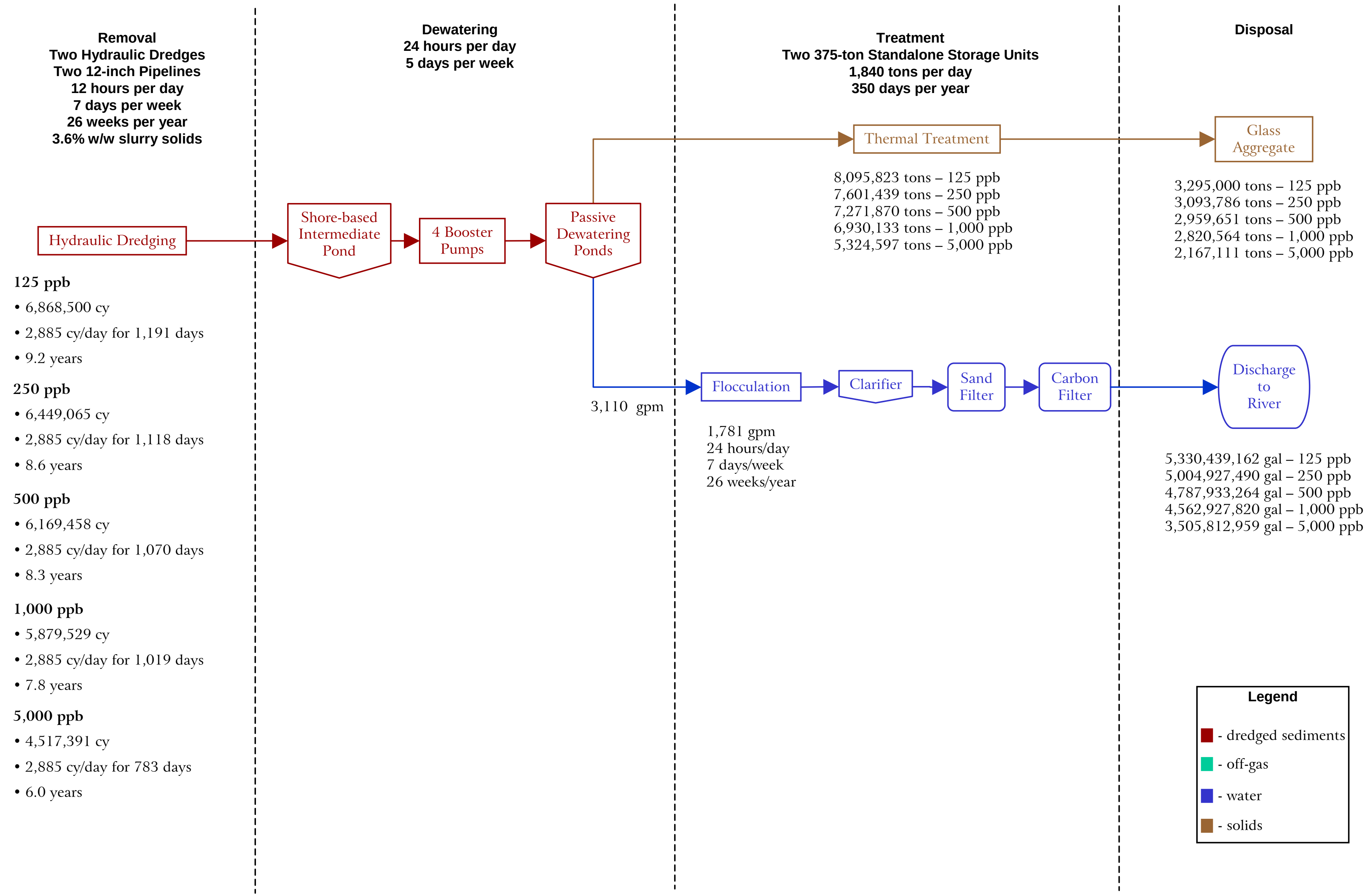
Alternative D: Dredge Sediment to Confined Disposal Facility
De Pere to Green Bay

FIGURE 7-44

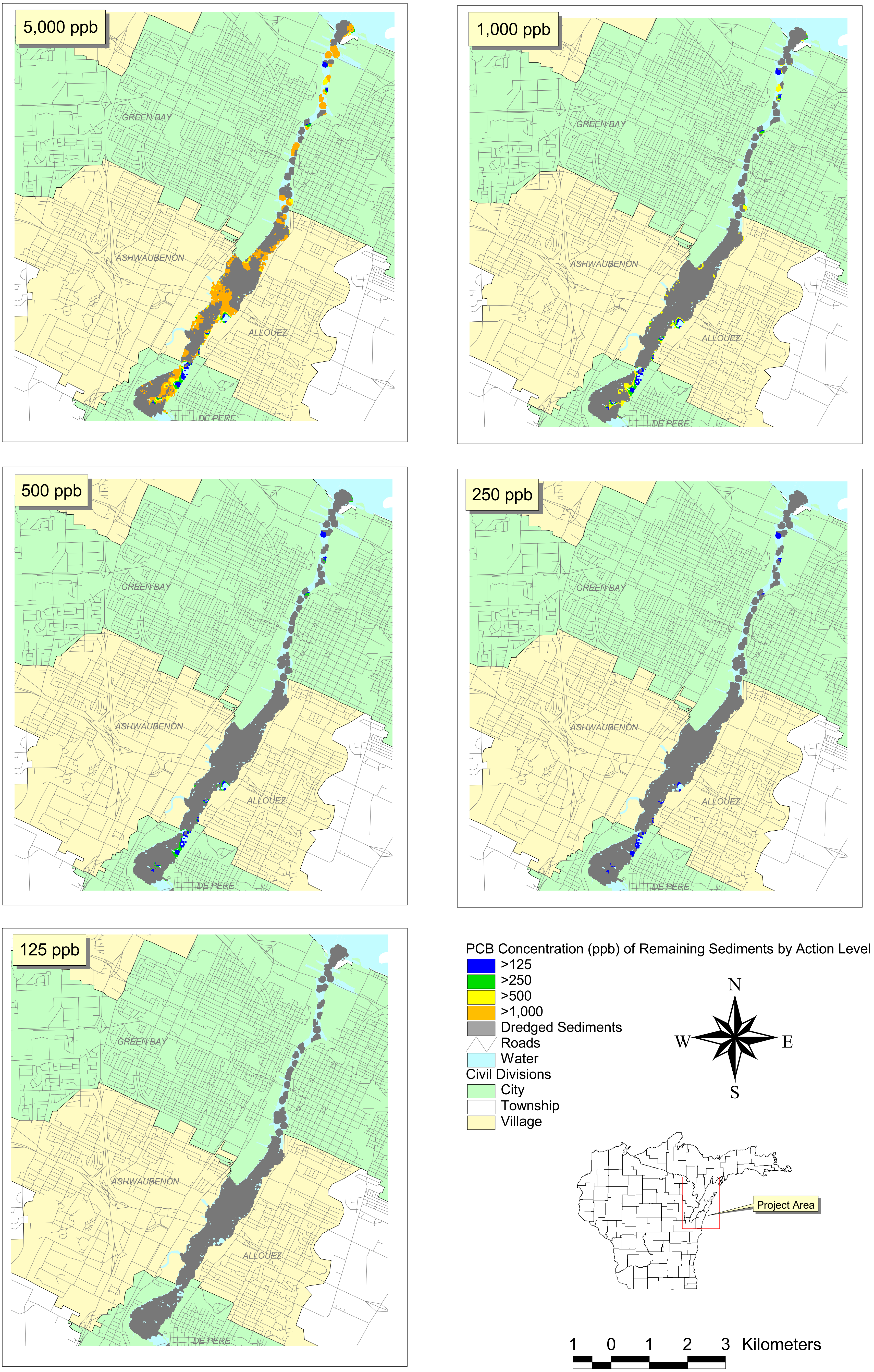
REFERENCE NO:	FS-14414-535-7-37
CREATED BY:	SCJ
PRINT DATE:	3/13/01
APPROVED:	AGF

Figure 7-45 Process Flow Diagram for De Pere to Green Bay - Alternative E: Dredge Sediment with Thermal Treatment



Note: Additional integral elements of the vitrification unit (dryer, pollution control) are not shown as they were not estimated separate. For greater detail on the unit layout and components, refer to the Minergy Unit Cost Report (Appendix G).

F:\PROJECTS\DOCS\4414\DOC\FS\FINAL\FIGURES\SEC7\SEC7FIGSL.PPT



1. Basemap generated in ArcView GIS, Version 3.2, 1998, and from TIGER census data, 1995.
2. Deposit and management area data obtained from WDNR, and are included in the Fox River database.

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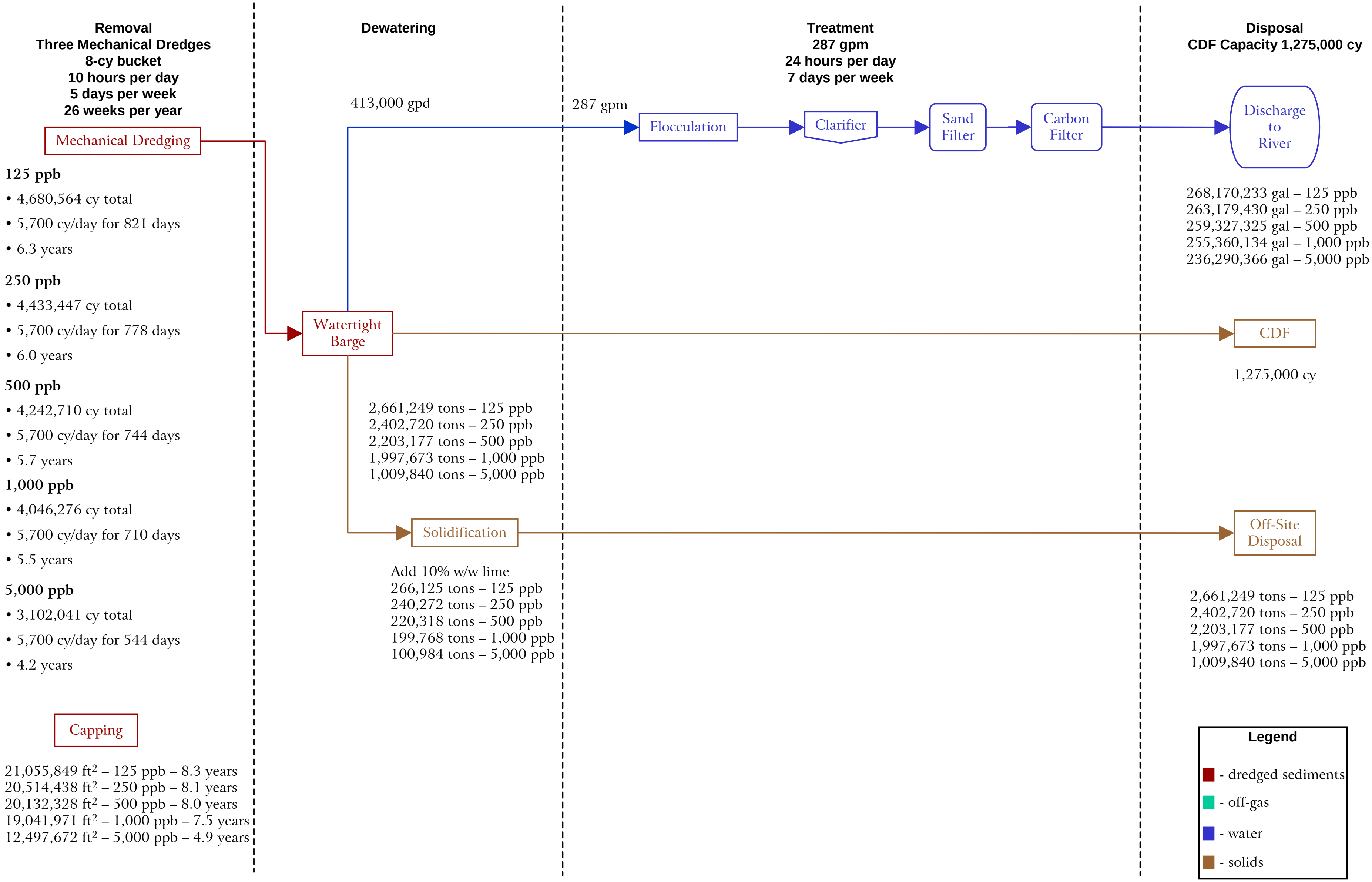
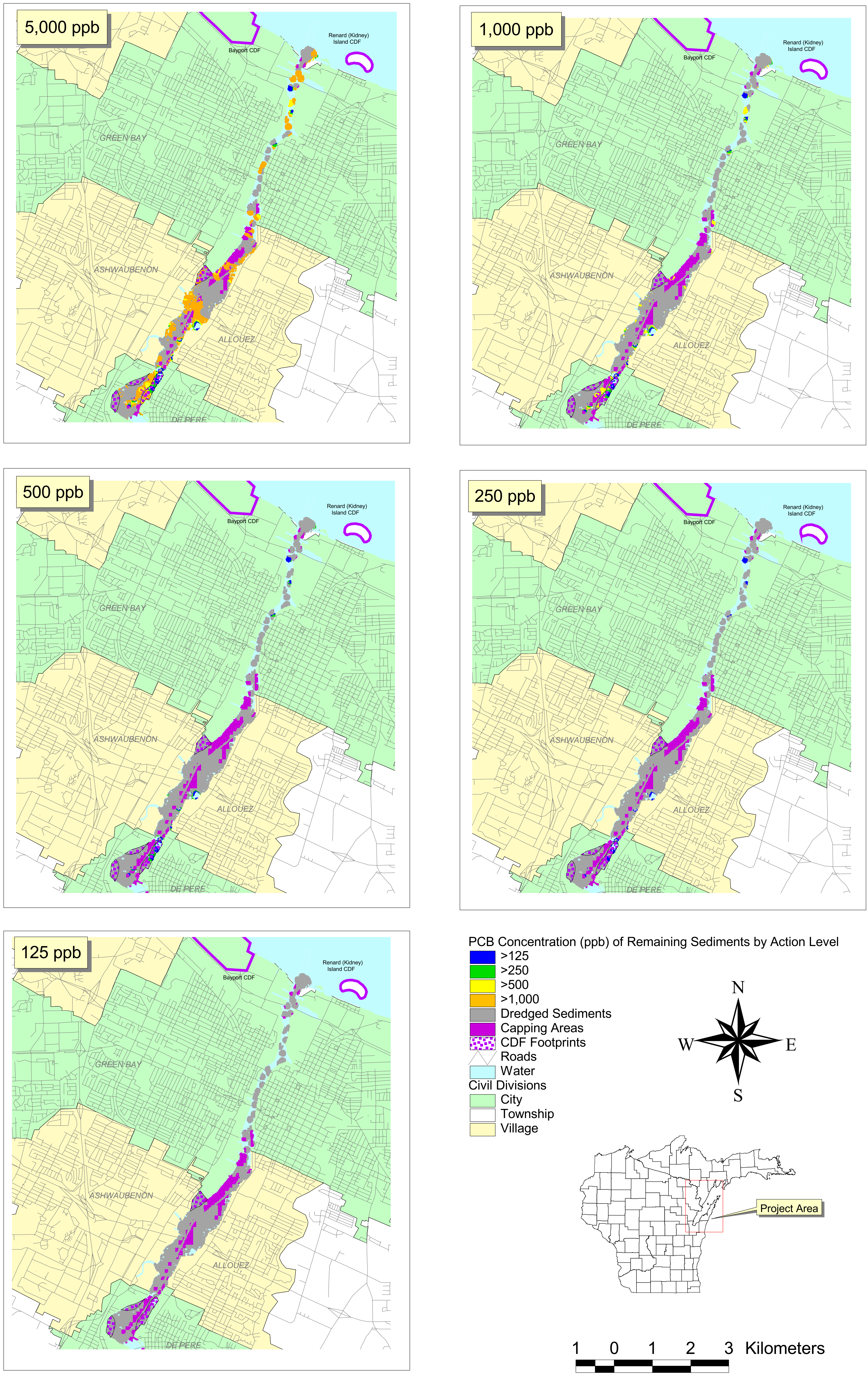
				CREATED BY: SCJ
				PRINT DATE: 3/13/01
			FIGURE 7-46	APPROVED: AGF

Figure 7-47 **Process Flow Diagram for De Pere to Green Bay - Alternative F: Cap Sediment to Maximum Extent Possible, Dredge, CDF, and Off-site Disposal**



F:\PROJECTS\DOCS\4414\DOC\FS\FINAL\FIGURES\SEC7\SEC7FIGSL.PPT



1. Basemap generated in ArcView GIS, Version 3.2, 1998, and from TIGER census data, 1995.
2. Deposit and management area data obtained from WDNR, and are included in the Fox River database.
3. Capping area criteria based on a minimum 9-foot water depth.

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Alternative F: Cap to Maximum Extent Possible and Dredge Remaining Sediment to CDF De Pere to Green Bay

FIGURE 7-48

REFERENCE NO:	FS-14414-535-7-41
CREATED BY:	SCJ
PRINT DATE:	3/13/01
APPROVED:	AGF

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Table 7-8 Cost Summary for Remedial Alternatives - De Pere to Green Bay (Green Bay Zone 1)

125 ppb

Alternative	Dredge Volume (cy)	TSCA Volume (cy)	Hydraulic Dredging	Mechanical Dredging	Capping	Dewatering	Water Treatment	Thermal Treatment	CDF Construction	Off-site Disposal	Institutional Controls	Bayport Closure[1]	Subtotal	20% Contingency	TOTAL
A	0	0	---	---	---	---	---	---	---	---	$4,500,000	---	$4,500,000	$900,000	$5,400,000
B	0	0	---	---	---	---	---	---	---	---	$9,900,000	---	$9,900,000	$1,980,000	$11,880,000
C1	6,868,500	240,778	---	$100,500,000	---	---	$700,000	---	---	$659,200,000	$4,500,000	$4,200,000	$769,100,000	$153,820,000	$922,920,000
C2A	6,868,500	240,778	$109,400,000	---	---	---	$7,700,000	---	---	$70,200,000	$4,500,000	$4,200,000	$196,000,000	$39,200,000	$235,200,000
C2B	6,868,500	240,778	$109,400,000	---	---	$19,900,000	$7,300,000	---	---	$419,200,000	$4,500,000	$4,200,000	$564,500,000	$112,900,000	$677,400,000
C3	6,868,500	240,778	$85,400,000	---	---	$217,700,000	$6,400,000	---	---	$277,000,000	$4,500,000	$4,200,000	$595,200,000	$119,040,000	$714,240,000
D	6,868,500	240,778	---	$100,500,000	---	---	$1,200,000	---	$39,200,000	$462,200,000	$4,500,000	$4,200,000	$611,800,000	$122,360,000	$734,160,000
E	6,868,500	240,778	$109,400,000	---	---	$19,900,000	$12,900,000	$253,600,000	---	---	$4,500,000	$4,200,000	$404,500,000	$80,900,000	$485,400,000
F	4,680,565	240,778	---	$69,500,000	$67,800,000	---	$1,100,000	---	$39,200,000	$246,300,000	$4,500,000	$4,200,000	$432,600,000	$86,520,000	$519,120,000

250 ppb

Alternative	Dredge Volume (cy)	TSCA Volume (cy)	Hydraulic Dredging	Mechanical Dredging	Capping	Dewatering	Water Treatment	Thermal Treatment	CDF Construction	Off-site Disposal	Institutional Controls	Bayport Closure[1]	Subtotal	20% Contingency	TOTAL
A	0	0	---	---	---	---	---	---	---	---	$4,500,000	---	$4,500,000	$900,000	$5,400,000
B	0	0	---	---	---	---	---	---	---	---	$9,900,000	---	$9,900,000	$1,980,000	$11,880,000
C1	6,449,065	240,778	---	$94,600,000	---	---	$700,000	---	---	$619,100,000	$4,500,000	$4,200,000	$723,100,000	$144,620,000	$867,720,000
C2A	6,449,065	240,778	$104,500,000	---	---	---	$7,500,000	---	---	$66,200,000	$4,500,000	$4,200,000	$186,900,000	$37,380,000	$224,280,000
C2B	6,449,065	240,778	$104,500,000	---	---	$19,900,000	$7,100,000	---	---	$393,900,000	$4,500,000	$4,200,000	$534,100,000	$106,820,000	$640,920,000
C3	6,449,065	240,778	$81,500,000	---	---	$204,400,000	$6,200,000	---	---	$260,200,000	$4,500,000	$4,200,000	$561,000,000	$112,200,000	$673,200,000
D	6,449,065	240,778	---	$94,600,000	---	---	$1,100,000	---	$39,200,000	$422,800,000	$4,500,000	$4,200,000	$566,400,000	$113,280,000	$679,680,000
E	6,449,065	240,778	$104,500,000	---	---	$19,900,000	$12,800,000	$238,100,000	---	---	$4,500,000	$4,200,000	$384,000,000	$76,800,000	$460,800,000
F	4,433,446	240,778	---	$66,000,000	$66,200,000	---	$1,100,000	---	$39,200,000	$222,700,000	$4,500,000	$4,200,000	$403,900,000	$80,780,000	$484,680,000

500 ppb

Alternative	Dredge Volume (cy)	TSCA Volume (cy)	Hydraulic Dredging	Mechanical Dredging	Capping	Dewatering	Water Treatment	Thermal Treatment	CDF Construction	Off-site Disposal	Institutional Controls	Bayport Closure[1]	Subtotal	20% Contingency	TOTAL
A	0	0	---	---	---	---	---	---	---	---	$4,500,000	---	$4,500,000	$900,000	$5,400,000
B	0	0	---	---	---	---	---	---	---	---	$9,900,000	---	$9,900,000	$1,980,000	$11,880,000
C1	6,169,458	240,778	---	$90,600,000	---	---	$600,000	---	---	$592,400,000	$4,500,000	$4,200,000	$692,300,000	$138,460,000	$830,760,000
C2A	6,169,458	240,778	$100,900,000	---	---	---	$7,300,000	---	---	$63,500,000	$4,500,000	$4,200,000	$180,400,000	$36,080,000	$216,480,000
C2B	6,169,458	240,778	$100,900,000	---	---	$19,900,000	$7,000,000	---	---	$377,000,000	$4,500,000	$4,200,000	$513,500,000	$102,700,000	$616,200,000
C3	6,169,458	240,778	$78,500,000	---	---	$195,600,000	$6,000,000	---	---	$249,000,000	$4,500,000	$4,200,000	$537,800,000	$107,560,000	$645,360,000
D	6,169,458	240,778	---	$90,600,000	---	---	$1,100,000	---	$39,200,000	$396,600,000	$4,500,000	$4,200,000	$536,200,000	$107,240,000	$643,440,000
E	6,169,458	240,778	$100,900,000	---	---	$19,900,000	$12,700,000	$227,800,000	---	---	$4,500,000	$4,200,000	$370,000,000	$74,000,000	$444,000,000
F	4,242,710	240,778	---	$63,300,000	$65,100,000	---	$1,100,000	---	$39,200,000	$204,500,000	$4,500,000	$4,200,000	$381,900,000	$76,380,000	$458,280,000

Table 7-8 Cost Summary for Remedial Alternatives - De Pere to Green Bay (Green Bay Zone 1) (Continued)

1,000 ppb

Alternative	Dredge Volume (cy)	TSCA Volume (cy)	Hydraulic Dredging	Mechanical Dredging	Capping	Dewatering	Water Treatment	Thermal Treatment	CDF Construction	Off-site Disposal	Institutional Controls	Bayport Closure[1]	Subtotal	20% Contingency	TOTAL
A	0	0	---	---	---	---	---	---	---	---	$4,500,000	---	$4,500,000	$900,000	$5,400,000
B	0	0	---	---	---	---	---	---	---	---	$9,900,000	---	$9,900,000	$1,980,000	$11,880,000
C1	5,879,529	240,778	---	$86,500,000	---	---	$600,000	---	---	$564,800,000	$4,500,000	$4,200,000	$660,600,000	$132,120,000	$792,720,000
C2A	5,879,529	240,778	$96,900,000	---	---	---	$7,200,000	---	---	$60,700,000	$4,500,000	$4,200,000	$173,500,000	$34,700,000	$208,200,000
C2B	5,879,529	240,778	$96,900,000	---	---	$19,900,000	$6,900,000	---	---	$359,400,000	$4,500,000	$4,200,000	$491,800,000	$98,360,000	$590,160,000
C3	5,879,529	240,778	$75,100,000	---	---	$186,400,000	$5,900,000	---	---	$237,400,000	$4,500,000	$4,200,000	$513,500,000	$102,700,000	$616,200,000
D	5,879,529	240,778	---	$86,500,000	---	---	$1,100,000	---	$39,200,000	$369,600,000	$4,500,000	$4,200,000	$505,100,000	$101,020,000	$606,120,000
E	5,879,529	240,778	$96,900,000	---	---	$ 19,900,000	$12,500,000	$217,100,000	---	---	$4,500,000	$4,200,000	$355,100,000	$71,020,000	$426,120,000
F	4,046,276	240,778	---	$60,500,000	$61,900,000	---	$1,100,000	---	$39,200,000	$185,700,000	$4,500,000	$4,200,000	$357,100,000	$71,420,000	$428,520,000

5,000 ppb

Alternative	Dredge Volume (cy)	TSCA Volume (cy)	Hydraulic Dredging	Mechanical Dredging	Capping	Dewatering	Water Treatment	Thermal Treatment	CDF Construction	Off-site Disposal	Institutional Controls	Bayport Closure[1]	Subtotal	20% Contingency	TOTAL
A	0	0	---	---	---	---	---	---	---	---	$4,500,000	---	$4,500,000	$900,000	$5,400,000
B	0	0	---	---	---	---	---	---	---	---	$9,900,000	---	$9,900,000	$1,980,000	$11,880,000
C1	4,517,391	240,778	---	$67,200,000	---	---	$500,000	---	---	$434,700,000	$4,500,000	$4,200,000	$511,100,000	$102,220,000	$613,320,000
C2A	4,517,391	240,778	$76,000,000	---	---	---	$6,500,000	---	---	$47,500,000	$4,500,000	$4,200,000	$138,700,000	$27,740,000	$166,440,000
C2B	4,517,391	240,778	$76,000,000	---	---	$19,900,000	$6,300,000	---	---	$277,100,000	$4,500,000	$4,200,000	$388,000,000	$77,600,000	$465,600,000
C3	4,517,391	240,778	$57,200,000	---	---	$143,200,000	$5,200,000	---	---	$182,900,000	$4,500,000	$4,200,000	$397,200,000	$79,440,000	$476,640,000
D	4,517,391	240,778	---	$67,200,000	---	---	$1,000,000	---	$39,200,000	$244,600,000	$4,500,000	$4,200,000	$360,700,000	$72,140,000	$432,840,000
E	4,517,391	240,778	$76,000,000	---	---	$19,900,000	$11,900,000	$166,800,000	---	---	$4,500,000	$4,200,000	$283,300,000	$56,660,000	$339,960,000
F	3,102,041	240,778	---	$47,100,000	$42,900,000	---	$1,000,000	---	$39,200,000	$95,500,000	$4,500,000	$4,200,000	$234,400,000	$46,880,000	$281,280,000

Note:
[1] Bayport closure costs are present value costs based on closure 40 years from the present

7.6 Green Bay Zone 2

An overview of the Green Bay zones and PCB-impacted sediments is shown on Figure 7-49. The retained alternatives and associated costs for Zone 2 are presented in Table 7-9.

7.6.1 General Site Characteristics

This zone extends from the mouth of the Lower Fox River to a line perpendicular with the long axis of the bay about 7.6 miles from the mouth of the river. Zone 2 is bounded by the city of Green Bay at the south end, and is further divided into "east" and "west" segments by a line trending northeast connecting the mouth of the Lower Fox River through Chambers Island. Zone 2A is located on the west side of this line while Zone 2B is located on the east side of this line.

The bathymetry of Zone 2 is generally shallow, with all water depths less than 26.5 feet. The navigation channel lies almost entirely within Zone 2A. There are a number of shallow areas located on the west side of this zone. Water levels within the Great Lakes have been decreasing since the mid-1990s. In 1999, water level elevations dropped to about 175.96 meters (577.30 feet), about 43 cm (17 inches) below the average levels for December (USACE, 2000a).

The nature and extent of PCB-impacted sediment in this zone, as summarized in the RI, includes the following:

- Maximum detected concentration - 799 μg/kg (avg. 324 μg/kg),
- Total PCB mass - 31,394 kg,
- Total PCB-impacted volume - 39,580,000 m^3, and
- Maximum PCB sample depth - 30 to 50 cm depth.

These quantities represent the total volumes/masses represented in each modeled depth layer (RETEC, 2002a). Required dredge volumes described later in this section are likely larger since they account for overburden volumes above deeper sediment layers that contain PCBs.

7.6.2 Selected Remedial Alternatives

This section defines the remedial alternatives for Zone 2 and then describes the technologies that would be applied based upon application of the criteria defined in Section 6. The remedial alternatives retained for Green Bay Zone 2 include the following:

A. No action.

B. Monitored natural recovery of the system with the expectation that institutional controls will be removed within 40 years.

C. Remove all sediment with PCB concentrations greater than the selected action level and dispose of dredged sediment in an existing NR 500 commercial disposal facility.

D. Remove sediment with PCB concentrations exceeding the selected action level and place non-TSCA sediments in an on-site nearshore CDF. Transport TSCA sediments (greater than 50 ppm PCBs) to an existing NR 500 commercial disposal facility.

G. Remove sediments with PCB concentrations greater than the selected action level and place in an on-site CAD facility.

Alternatives E and F were not retained since bay bathymetry, water currents, and bay utilization for navigation preclude construction of an appropriate sand cap and sediment volumes are too large for effective use of thermal treatment. The process options that can be applied to the remedial alternatives are described below.

7.6.3 Description of Process Options

Monitoring

Monitoring of physical, chemical, and biological media is applicable for Alternatives B, C, D, and G. The no action alternative may also require monitoring of fish tissue for maintenance of pre-existing fish consumption advisories. As discussed in the technology screening process, monitoring is grouped into five categories: 1) baseline monitoring prior to remediation to establish baseline conditions for future comparisons, 2) monitoring during implementation, 3) post-verification monitoring to verify completion of a remedy, 4) long-term construction monitoring of containment facilities and sediment caps to verify continued source control and physical integrity, and 5) long-term monitoring to verify effectiveness of the remedy and attainment of the project RAOs. Numerous reference documents confirmed the necessity of a well-developed monitoring plan in order to verify the success of an implemented remedy, to measure the effectiveness and stability of source control measures, and to verify the achievement of project RAOs (EPA, 1998a, 1994a; SMWG, 1999; IJC, 1997; Krantzberg *et al.*, 1999). The following references were used in this FS

Report to assess the types and applicability of monitoring options commonly used on sediment remediation projects:

- Ecology, *Standards for Confined Disposal of Contaminated Sediments Development Document* (Ecology, 1990);
- USACE, *Monitoring Considerations for Capping* (USACE, 1992);
- EPA and USACE, *Design, Performance, and Monitoring of Dredged Material Confined Disposal Facilities in Region 5* (EPA, 1996b);
- USACE, *Selected Tools and Techniques for Physical and Biological Monitoring of Aquatic Dredged Material Disposal Sites* (Fredette *et al.*, 1990);
- *Guidance for Subaqueous Dredged Material Capping* (Palermo, 1995);
- *Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories, Volume 1: Fish Sampling and Analysis* (EPA, 1995a);
- *Assessment and Remediation of Contaminated Sediments (ARCS) Program - Assessment Guidance Document* (EPA, 1994a);
- *Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites* (EPA, 1999b);
- Sediment remediation case study projects presented in Appendices B and C of the FS.

Specific monitoring programs will be developed for each remedial alternative and will likely include physical, chemical, and biological monitoring components. Overall, baseline monitoring generally includes water, sediment, and tissue quality sampling. Monitoring during implementation includes air and surface water sampling to assess downstream and off-site transport of contaminants. Verification monitoring includes surface and possibly subsurface sediment sampling to ensure compliance with the target goals of the remediation project. Source control monitoring includes groundwater and surface sediment sampling around the containment facility to confirm proper maintenance, stability, and chemical isolation. Long-term monitoring focuses primarily on fish, bird, and invertebrate tissue sampling and reproductive assessments, but also includes sediment and water sampling for chemical quality. The proposed *Long-term Monitoring Plan* for the Lower Fox River and Green Bay remediation project is presented in Appendix C.

Institutional Controls

Institutional controls appropriate to Green Bay include:

- Maintenance of the fish and waterfowl consumption advisory;
- A moratorium on any future dredging within the navigation channel;
- Deed restrictions on any in-water activities that could result in sediment disturbance (e.g., marina construction or over-water development);
- Access restrictions to contaminated areas; and
- A long-term (40-year) monitoring program for sediments, water, bird, and fish PCB and mercury levels.

Implementation of these institutional controls will likely require an active public education program for the fish, waterfowl, and domestic water use advisories. Deed and access restrictions may require local or state legislative action to prevent any development in contaminated areas of the river. Access and use restrictions would also apply to local Indian tribes. Finally, federal action may be necessary on any dredging moratoriums within the federal navigation channel.

Removal Process Options

Sediment removal is identified for Alternatives C, D, and G. Remediation area boundaries and sediment management areas are shown on Figure 7-49. For Green Bay Zone 2, mechanical dredging is more practicable because water depth is adequate and water treatment volumes are minimized. Mechanical dredging significantly reduces the water management needs and reduced water management is necessary due to the limited upland space availability.

A 12-cy Cable Arm™ bucket has been selected for the remedial alternatives identified in this reach. The operating assumption is that dredging will occur only during normal daylight hours (12 hours per day) during a normal work week (5 days per week). In industrial areas, dredging may occur 24 hours per day and 6 days per week; however, this option was not included in the FS. Winter weather conditions are likely to preclude operations; as a result, dredging is assumed to occur only between April and October (26 weeks per year) when the average minimum temperature is above freezing.

Containment Systems. In-water containment systems placed around the dredging area are commonly implemented on both mechanical and hydraulic dredging projects to minimize sediment resuspension downstream of the dredging operation.

Typical containment barrier systems range from expensive sheet pile walls (i.e., GM Foundry, Bayou Bonfouca), to silt curtains (i.e., West Eagle Harbor, Bayou Bonfouca, River Raisin), and inexpensive oil booms (PSNS Pier D) (Appendix B). Silt curtains are the most commonly used containment device for lakes, rivers, and estuaries, but are prone to disturbance from passing ships, strong winds, and currents. Effectiveness of silt curtains depends upon local site conditions, bottom substrate, and curtain design; and therefore may not be applicable for every site. Silt curtains were used at both the Lower Fox River demonstration projects. Based on the successful performance of the dredging operations and curtains at Deposit N, use of silt curtains was discontinued during the second removal phase with minimal water quality exceedances measured downstream. However, for the purposes of this FS, silt curtains were included in the removal costs.

Over-dredge. All dredging is assumed to occur within a defined footprint to a fixed cut depth. When possible, approximately 8 inches of over-dredge of material beyond the estimated maximum depth of impacted sediment will likely be implemented to ensure complete removal of the targeted contaminant mass. However, for the purposes of the FS, over-dredge was not included in volume or cost estimates to allow comparability and consistency between different action levels and reaches.

Dewatering Process Options

For all mechanical dredging alternatives, it is proposed that dewatering be conducted on-barge and in upland staging areas. Dewatering has been configured as a two-step process using gravity settling followed by solidification of solids.

Passive Dewatering. Each 2,000-cy barge load of dredged sediment will be filled in 1 day and will dewater for 2 days on the barge. Free water will be pumped from the watertight barges and collected. Sediment will then be transferred into one of three asphalt-paved upland staging areas for additional dewatering, solidification, and loading into trucks for off-site shipment. These upland staging areas will each be approximately 0.5 acre in size, surrounded with a 6-inch curb, and graded to a water collection sump. All water collected from the barges and the upland staging area will be treated using flocculation, clarification, and sand filtration prior to discharge back to the river. The upland staging areas may be located at the Bayport facility near the mouth of the Lower Fox River or at other locations that have yet to be determined.

For the dredge to CDF alternative (Alternative D), dewatering will occur directly within the CDF. Decant water for this alternative will be treated and returned to the bay.

These proposed dewatering systems will meet the criteria defined in Section 6 of this FS Report, in terms of production rate, effectiveness, practicality, and discharge water quality. Final selection of the dewatering process will be determined during the remedial design phase.

Solidification. The solids content after mechanical dredging and dewatering is assumed to be about 50 percent (w/w) or similar to *in-situ* density, based on *in-situ* solids content from the RI Report (RETEC, 2002a). This dewatered sediment may still be difficult to manage due to the high moisture content. Prior to any off-site shipment, the sediment would be solidified to improve handling and to satisfy requirements for solid waste hauling on public roads and disposal, if necessary. It was assumed that solidification was necessary, and that the sediment would be solidified with the addition of cement, lime, pozzolan, or other appropriate reagents. For FS cost estimating purposes, 10 percent (w/w) lime was added as the reagent based on its successful use during the SMU 56/57 project (Montgomery-Watson, 1998, 2000). The sediment will be mixed with the reagent and loaded into trucks using standard earthmoving equipment. If the contractor prefers, sediment may be mixed with the reagent in a pug mill as shown on Figures 7-1 and 7-5. Numerous other cost-effective reagents are available that may be tested and used for implementation of a remedial action.

Treatment Process Options

Water Treatment. Prior to water discharge back to the bay, supernatant water would pass through flocculation, clarification, and sand filtration systems. Based on the acceptable performance of the sand filter unit during the Deposit N demonstration project, no additional water treatment is deemed necessary. However, additional carbon (GAC) treatment may be added to the treatment train during removal operations if effluent water quality criteria is exceeded. The estimated unit cost for GAC carbon treatment is $0.40 per thousand gallons of water treated.

On-site Disposal Process Options

The CDF currently proposed for Green Bay is a cellular cofferdam located near the Cat Island chain. The CDF size was varied with each action level to accommodate the total volume of dredged sediment. The new Green Bay CDF will be constructed as three separate islands in accordance with the design proposed by the USACE (USACE, 1999) to encourage natural resedimentation and restoration around the structures. Several in-water and upland CDF sites were proposed in a 1985 Environmental Impact Study (USACE, 1985) for Green Bay Harbor, but most were eliminated from further consideration because of environmental concerns by the USFWS (as cited in USACE, 1985). Only the Cat

Island restoration area and Kidney Island expansion were retained for further consideration.

The newly constructed free-standing CDF structures will be closed with a 3-foot sand cap and riprap placed around the edges to provide additional protection from storm events. The final construction will also include habitat areas for shallow submerged and emergent vegetation as shown on the proposed conceptual design (Figure 7-50). While the top layer is not designed to be an impermeable cap, selection of appropriate plant species will be considered (i.e., shallow roots) to ensure physical integrity of the cap.

The Renard Island CDF, located near the mouth of the Lower Fox River, is a 55-acre diked impoundment with a design capacity of 1,200,000 cy. The facility consists of a kidney-shaped stone dike with an interior steel sheet pile cutoff wall to prevent seepage to surrounding surface waters (USACE, 1985). The CDF reached capacity after receiving a deposit of dredged sediment in 1996. Construction costs include final closure of the Renard Island CDF in addition to constructing a new CDF. Closure of Renard Island will include placement of a 3-foot-thick clean soil cap, seeding, mitigation, and long-term monitoring for 40 years.

Within Green Bay, three potential confined aquatic disposal (CAD) sites were identified. The CAD was sized for each action level to accommodate the total volume of dredged sediment. CAD site locations were selected in areas with adequate water depths (25-meter depth) and low bottom surface water velocities. Ideal locations for CAD sites are in "null-zones" where circulation patterns create areas with net deposition, instead of erosion and scour. These areas were selected from the HydroQual vector diagrams presented in Section 2 (Figures 2-11 and 2-12). Contaminated sediment will be excavated by mechanical dredging, transferred to a haul barge and placed in the CAD site by either split-hull bottom dump or pumped in via pipeline if finer-scale placement is required.

Off-site Disposal Process Options

Total PCB concentrations in sediment within this zone are below 50 ppm, therefore none of the sediment is considered TSCA material. All sediment could be shipped to landfills which conform to the NR 500 WAC requirements. Local landfill options and unit costs were defined in Section 6.4.8 of this FS Report.

Capping Process Options

No capping is proposed for Green Bay because bottom water currents, storm events, vessel traffic, maintenance of navigational channels, and potential ice scour preclude effective placement and long-term integrity.

7.6.4 Development of Alternatives and Associated Costs

This section describes the remedial alternatives developed for Green Bay Zone 2. Each remedial alternative includes a process description, a process flow diagram, and a summary cost table. Summary costs presented as net present worth in this FS include a line item for 20 percent contingency costs. Details used to develop each cost estimate are provided in Appendix H. The process flow diagrams and dredging footprints for each alternative are presented on Figures 7-51 through 7-53.

The following components are discussed, when applicable, within the development of each alternative:

- Site mobilization and preparation,
- Sediment removal,
- Sediment dewatering,
- Water treatment,
- Sediment disposal,
- Demobilization and site restoration, and
- Long-term monitoring/institutional controls.

Alternative A: No Action

As required under the NCP, a no action alternative is included for Green Bay Zone 2. This alternative involves taking no action and relying on natural processes, such as natural attenuation, dispersion, dilution, and sedimentation to reduce contaminant quantities and/or concentrations and control contaminant migration processes. This alternative implies that no active management of remediation is employed; however, some institutional controls, such as access or resource use restrictions, may be employed to reduce risks until RAOs are achieved. This alternative includes fish tissue sampling events every 5 years for 40 years for maintenance of fish consumption advisories already in place.

The estimated cost for no action and maintenance of consumption advisories currently in place is $4,500,000. Engineered cost evaluations typically include a 20 percent contingency cost added to the remedy costs, as shown in the cost tables as a separate line item.

Alternative B: Monitored Natural Recovery/Institutional Controls

The monitored natural recovery option will include a long-term monitoring program (40-year) for measuring PCB, DDE, and mercury levels in water, sediment, invertebrates, fish, and birds. The monitoring program will be developed to effectively measure achievement of and progress towards the project RAOs expected in 40 years. Monitoring components will likely be collected between 2- and 5-year intervals for the first 10 years, and will include pre- and post-remedy sampling events to establish baseline conditions. Monitoring frequency may be modified after 5 years based on initial monitoring results. More specifically, the monitoring program will likely include (see Appendix C for the proposed *Long-term Monitoring Plan* for the project):

- Surface water quality sampling at several stations along the reach to determine the downstream transport of PCB mass into Green Bay (RAOs 1 and 4);

- Fish and waterfowl tissue sampling of several species and size classes to determine the residual risk of PCB and mercury consumption to human receptors (RAO 2);

- Fish (several species and size classes), bald eagle, and invertebrate tissue sampling to determine the residual risk of PCB, DDE, and mercury uptake to environmental receptors (RAO 3);

- Population studies of birds (bald eagles and double-crested cormorants) to assess the residual effects of PCBs, DDE, and mercury on reproductive viability (RAO 3); and

- Surface sediment sampling in MNR areas to assess potential recontamination from upstream sources and status of attenuation of sediments (RAO 4).

Until the project RAOs have been achieved, institutional controls will be required to prevent exposure of human and biological receptors to contaminants. Institutional controls may also be implemented in combination with many of the proposed remedial alternatives, and may include monitoring, access restrictions, deed restrictions, dredging moratoriums, fish consumption advisories, and domestic water supply restrictions. Deed and access restrictions may require local or state legislative action to prevent any development in contaminated areas of the river. Items included in costs for institutional control include public education programs for fish or health advisories, 5-year fish tissue collection efforts for maintenance of consumption advisories, and deed restrictions.

The estimated cost for institutional controls and long-term monitoring is $9,900,000. Engineered cost evaluations typically include a 20 percent contingency cost added to the remedy costs, as shown in the cost tables as a separate line item.

Alternative C: Dredge with Off-site Disposal

Alternative C includes the removal of sediments above the remedial action level using multiple mechanical dredges and off-site disposal of the sediments. Costs for Alternative C were developed only for the 5,000 ppb action level because volumes for the other action levels are too large to consider off-site disposal. For example, sediment volumes for the 1,000 ppb action level are 29 million cy. This is about 28 percent of the total capacity of all existing landfills in the state of Wisconsin (Appendix E). Figure 7-51 provides the process flow diagram for this remedial alternative, while Figure 7-52 illustrates the extent of residual contamination following implementation of Alternative C. The summary costs to implement Alternative C are provided in Table 7-9. The total volume of sediment to be dredged in this alternative is 4,070,000 cy for the 5,000 ppb action level.

Site Mobilization and Preparation. Staging for the dredging of sediments will be conducted at the Bayport facility. Site mobilization and preparation includes securing the onshore property area for equipment staging, constructing areas for sediment staging, water treatment, sediment solidification, and truck loading. It is assumed that docking facilities for the mechanical dredge and barges already exist at these locations. Purchase and property preparation are included in the costs.

Sediment Removal. Due to the limited upland space available for water management purposes, all sediment removal will be conducted with a mechanical dredge. Given the volumes and operating assumptions described above, the complete removal effort would require approximately 1.1 years using seven 12-cy closed, clamshell buckets. While it would be more practical to use four dredges and extend the dredging time, the seven-dredge approach provides consistency and relative comparability with the other Green Bay zones. During the remedial design phase, fewer dredges may be selected. Operations will require a staging area for the mechanically-dredged sediments to be offloaded and transported off site. The cost for constructing the upland staging area is included in dewatering and disposal costs. Silt curtains around the dredging area are included to minimize sediment resuspension downstream of the dredging operation; these costs are included in the FS for $35,000. Buoys and other waterway markers would be installed around the perimeter of the work area to prevent entry of unauthorized boats within the removal work zone. Other capital items included in the sediment removal costs are barge rental and movement, construction of upland staging areas, water quality monitoring, post-removal sediment bathymetric surveys to ensure achievement of the removal action, and site restoration at the conclusion of operations.

Sediment removal costs are estimated to be $48,700,000 for the 5,000 ppb action level.

Sediment Dewatering. All dewatering will be conducted on-barge and in upland staging areas. Each 2,000-cy barge load of dredged sediment will be filled in 1 day and will dewater for 2 days on the barge. Free water will be pumped from the watertight barges to upland staging areas. For the off-site disposal alternative, sediment will then be transferred onto an asphalt-paved upland staging area where any free water will be collected. It is assumed that the sediment would require solidification with 10 percent (w/w) lime to satisfy hauling and disposal requirements (included in disposal costs). Sediment dewatering costs are included in the sediment removal (for land construction), water treatment (equipment), and disposal costs (for solidification).

Water Treatment. Water treatment includes purchase of equipment and materials for flocculation, clarification, and sand filtration. Water treatment would be conducted 24 hours per day, 7 days per week during the dredging season. Discharge water is estimated at 404,640 gallons per day. Daily discharge water quality monitoring is included in the cost estimate. Treated water would be sampled and analyzed to verify compliance with the appropriate discharge requirements prior to discharge back to the bay. It may be necessary to add carbon filtration to the treatment train if effluent criteria are not met. Carbon filtration could be added for a unit cost of $0.40 per thousand gallons of water treated. Water treatment costs also include pad and equipment demobilization and construction management. Land acquisition and site restoration costs are included in the removal costs.

Water treatment costs are estimated to be $700,000 for the 5,000 ppb action level.

Sediment Disposal. Sediment disposal includes the loading and transportation of the sediment to a facility listed in Table 6-6. Disposal costs also include the purchase and addition of lime reagent for solidification of dewatered sediment prior to off-site transport (Montgomery-Watson, 1998). The sediments would be loaded into tractor-trailer end dumps with bed liners or sealed gates using a front-end loader. Each load would be manifested and weighed. Each tractor-trailer would pass through a wheel wash prior to leaving the staging area to prevent tracking soil onto nearby streets and highways. After unloading at the designated disposal facility, each tractor-trailer would pass through a wheel wash and return to the staging area for another load. This alternative includes a separate line item of $15,500,000 for closure of the Renard Island CDF.

The estimated percent solids of dewatered sediment after passive dewatering is expected to equal the *in-situ* percent solids of material prior to mechanical dredging, which is 29.3 percent (w/w) (Appendix of RI Report, RETEC, 2002a). After solidification with 10 percent lime (w/w), the material is estimated to have 60 percent (w/w) solids content. Solidification costs for the 5,000 ppb action level are $149,000,000 (22 percent of cost is for purchase of lime).

Costs of sediment solidification and disposal at an existing NR 500 commercial disposal facility are estimated to be $437,800,000 for the 5,000 ppb action level.

Demobilization and Site Restoration. Demobilization and site restoration involves removing all equipment (i.e., fencing, facilities) from the staging and work areas. All work pads and other permanent structures would be removed and the site would be graded to its original condition. Vegetated areas would be replanted to a state similar to that of pre-construction. Demobilization and restoration costs are included within the above dredging estimates.

Institutional Controls and Monitoring. Baseline monitoring includes primarily water, sediment, and tissue sampling during pre- and post-remedial sampling events. Monitoring during implementation includes surface water and limited air sampling to assess downstream and off-site transport of contaminants. Verification monitoring includes surface and possibly subsurface sediment sampling to ensure compliance with the target goals of the project. Long-term monitoring includes surface water, surface sediment, and biological tissue sampling to determine residual risks and impacts over time. If residual risks remain in the sediment above the risk-based SQTs after remediation, then the long-term monitoring plan described in the MNR alternative will be followed (i.e., media, frequency, location, duration) until the project RAOs are achieved or until a policy decision is made. The proposed *Long-term Monitoring Plan* (LTMP) is detailed in Appendix C. Elements of the LTMP may be implemented for each action level regardless of the remedial outcome in order to verify achievement of the RAOs. The sampling program may continue indefinitely under this process option, but for the purposes of the FS it has been estimated at 40 years.

The estimated cost for the maintenance of institutional controls and fish consumption advisory monitoring is $4,500,000. Costs for implementation monitoring during removal are included in the dredging costs. Long-term monitoring costs to determine verification of project RAOs are included in Alternative B - Monitored Natural Recovery.

Alternative D: Dredge Sediment to Confined Disposal Facility

Alternative D includes removal of sediments to an on-site cellular cofferdam CDF for long-term disposal of the materials. The cellular cofferdam CDF location is identified on Figure 7-52. TSCA-level sediments are not present in this zone.

Figure 7-53 provides the process flow diagram for this remedial alternative. Table 7-9 contains the summary costs to implement Alternative D. The total volume of sediment to be dredged ranges between 29,748,004 and 4,070,170 cy for action levels of 500 and 5,000 ppb, respectively.

Site Mobilization and CDF Construction. For the concept level FS, the process is staged to construct and complete dredging to the cellular cofferdam CDF described in Section 7.6.3. Site mobilization and preparation includes securing the onshore property area for equipment staging, constructing the CDF, a water treatment facility, and an offshore docking facility for the mechanical dredge. Property purchase and preparation are included in the costs of the following process components.

CDF construction is estimated at $476,000,000 and $97,100,000 for action levels of 500 and 5,000 ppb, respectively. This alternative also includes separate line item costs for closure of Renard Island estimated at $15,500,000, approximately $4,200,000 of which is purchase and placement of the 3-foot-sand cap.

Sediment Removal. Sediment removal will be conducted using seven 12-cy closed clamshell buckets requiring 8.2 and 1.1 years for action levels of 500 and 5,000 ppb, respectively. Dredged sediment will be transferred from the mechanical buckets directly to 24 barges and 8 tugboats.

Sediment removal costs are estimated at $327,500,000 and $48,700,000 for action levels of 500 and 5,000 ppb, respectively.

Sediment Dewatering. Passive dewatering will occur directly within the CDF structure; however, most of the short-term dewatering will occur on transfer barges for 1 to 2 days after mechanical dredging and prior to disposal. Dewatering costs are included in the dredging effort.

Water Treatment. Free water collected on barges and overflow return water from the CDF would be treated before discharge to the bay. Treatment and monitoring requirements are expected to be similar to those specified for Alternative C.

Water treatment costs for Alternative D are estimated at $1,200,000 and $700,000 for action levels of 500 and 5,000 ppb, respectively.

Demobilization and Site Restoration. Demobilization and site restoration involves removing all equipment (i.e., fencing, facilities) from the staging and work areas. The CDF would be finished with a 3-foot cap of clean soils, then seeded and planted. Additional amenities (i.e., wildlife habitat) were not included in the cost estimates. However, this alternative would allow for development of these newly-created upland habitat features. Demobilization and site restoration costs are included under the dredging estimates.

Sediment Disposal. No off-site disposal of sediments is anticipated for this alternative. Dredged sediments will be placed directly into the CDF without solidification. Placement costs are included in the dredging and construction costs.

Institutional Controls and Monitoring. To ensure that the CDF is functioning as designed, near-site sediment and water sampling would be conducted on an annual basis. The monitoring program will be conducted over a period of 40 years.

The estimated cost for institutional controls and consumption advisory monitoring is $4,500,000. Long-term operation and maintenance monitoring of the CDF are included in the CDF construction costs, and costs for long-term remedy monitoring of Green Bay are included in Alternative B.

Alternative G: Dredge Sediment to Confined Aquatic Disposal

Alternative G includes removal of sediments to a CAD facility for long-term disposal of the materials. The proposed CAD location is identified on Figure 7-52.

Figure 7-53 provides the process flow diagram for this remedial alternative. Table 7-9 contains the summary costs to implement Alternative G. The total volume of sediment to be dredged in this alternative ranges between 29,748,004 and 4,070,170 cy for action levels of 500 and 5,000 ppb, respectively.

Site Mobilization and CAD Construction. For the concept level FS, the process is staged to complete dredging to the CAD as described in Section 7.6.3. Details of the conceptual CAD design are provided on Figure 7-50. Site mobilization and preparation includes securing the onshore property area for equipment staging, sand purchase, long-term operation and maintenance, an offshore docking facility for the mechanical dredge, and winterizing equipment each year.

The CAD site will be constructed by excavating an in-water cavity approximately 3 to 5 meters deep using either mechanical or hydraulic dredges. Contaminated sediment will be placed in the deep water cavity using either split-hull bottom barges or pipelines. After placement, the CAD site will be capped with 3 feet of clean sand (included in construction costs). Capping requires six barges, four tugboats, and a shore-based source of sand within 20 miles of the CAD site.

CAD construction is estimated at $358,700,000 and $54,600,000 for action levels of 500 and 5,000 ppb, respectively. These estimates include CAD closure and long-term operation and maintenance costs.

Sediment Removal. Sediment removal will be conducted using seven 12-cy closed, clamshell buckets requiring 8 years for 500 ppb and 1.1 years for 5,000 ppb action levels. Two additional years will be required for cap placement over the disposal site. Dredged sediment will be transferred from the mechanical buckets directly to 24 dump barges and eight tugboats and barged to the disposal site. Sediment removal time frame and costs are similar to those described for Alternative D for Zone 2.

Sediment Dewatering. All dewatering will be conducted on-barge. Each 2,000-cy barge load of dredged sediment will be filled in 1 day and will dewater for 2 days on the barge. Free water will be pumped from the watertight barges and managed. Sediment dewatering costs are included in the sediment removal and water treatment costs.

Water Treatment. Overflow return water from the barges would be treated before discharge to the bay. Monitoring requirements are expected to be similar to those specified for Alternative C.

Water treatment costs for Alternative G are estimated at $1,200,000 and $700,000 for action levels of 500 and 5,000 ppb, respectively.

Sediment Disposal. No off-site disposal of sediments is anticipated for this alternative. Sediments will be placed into on-site CAD facilities. Disposal costs are included in the CAD construction and dredging costs.

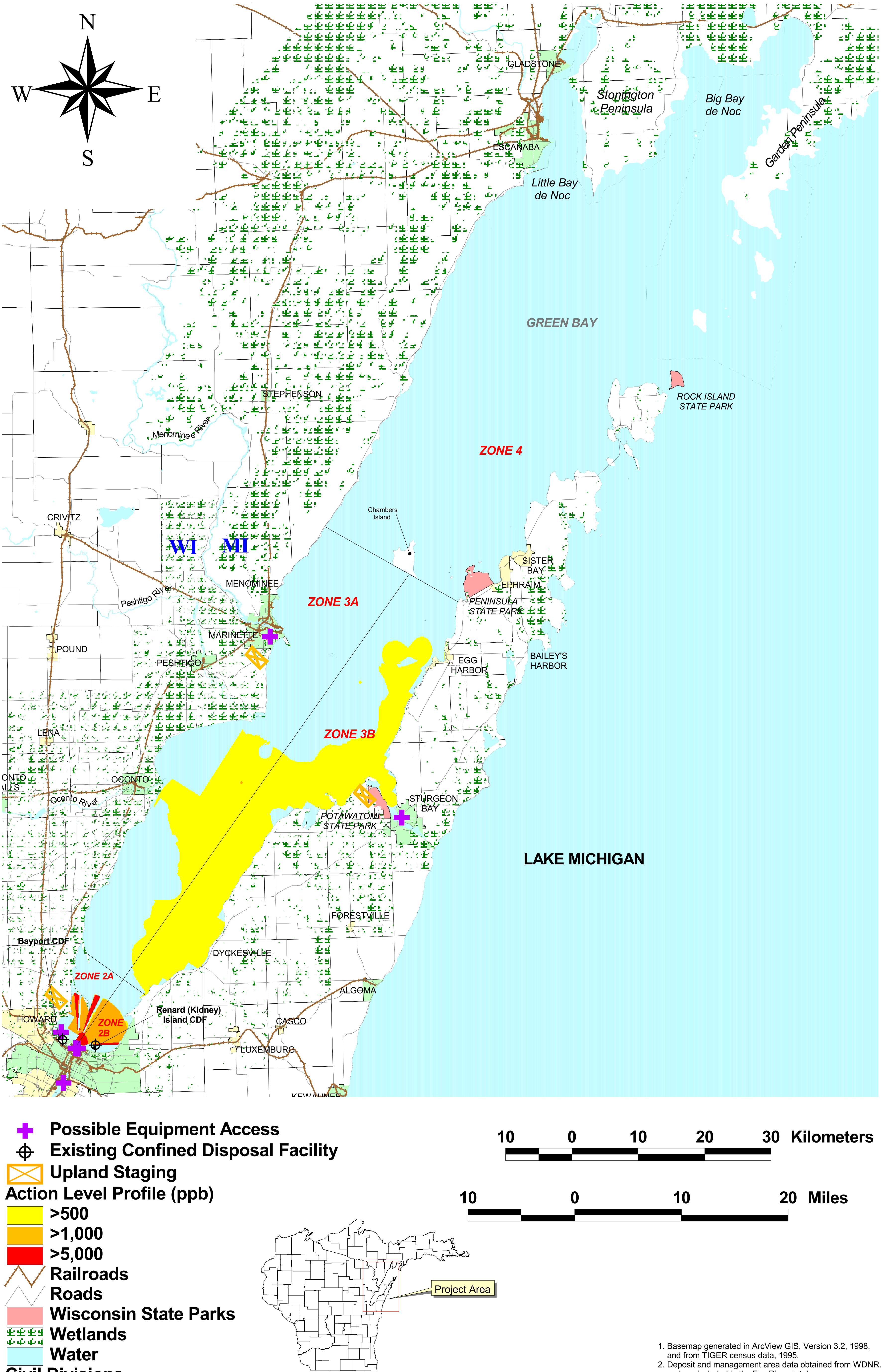
Demobilization and Site Restoration. Demobilization and site restoration involves removing all equipment (i.e., fencing, facilities) from the staging and work areas. The CAD would be finished with a 3-foot cap of clean soils to isolate the contaminated sediments. Demobilization and site restoration costs are included under CAD construction and dredging estimates.

Institutional Controls and Monitoring. To ensure that the CAD site is functioning as designed, surface and subsurface sediment sampling will be conducted to address potential upward chemical migration through the cap and structural integrity of the containment structure. Sampling will be conducted at 3- to 5-year intervals, with decreasing intervals over time, if warranted. The actual number of sampling locations will depend upon the actual configuration and size of the CAD site. To verify achievement of the project RAOs, selected elements of the *Long-term Monitoring Plan* (Appendix C) will also be implemented.

The estimated cost for institutional controls and advisory monitoring is $4,500,000. Long-term operation and maintenance monitoring is included in the CAD construction costs and long-term remedy monitoring of Green Bay is included in Alternative B.

7.6.5 Section 7.6 Figures and Tables

Figures and tables for Section 7.6 follow this page and include:



1. Basemap generated in ArcView GIS, Version 3.2, 1998, and from TIGER census data, 1995.
2. Deposit and management area data obtained from WDNR. and are included in the Fox River database.
3. Action level profiles for PCBs considered for all depth layers up to >30 cm for Green Bay.

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Natural Resource Technology

Lower Fox River & Green Bay Feasibility Study

Sediment Management Area Overview: Green Bay

FIGURE 7-49

REFERENCE NO: FS-14414-535-7-42
CREATED BY: SCJ
PRINT DATE: 3/13/01
APPROVED: AGF

Figure 7-50 Preliminary Concept Design for the Green Bay Confined Disposal Facility - Cat Island Chain

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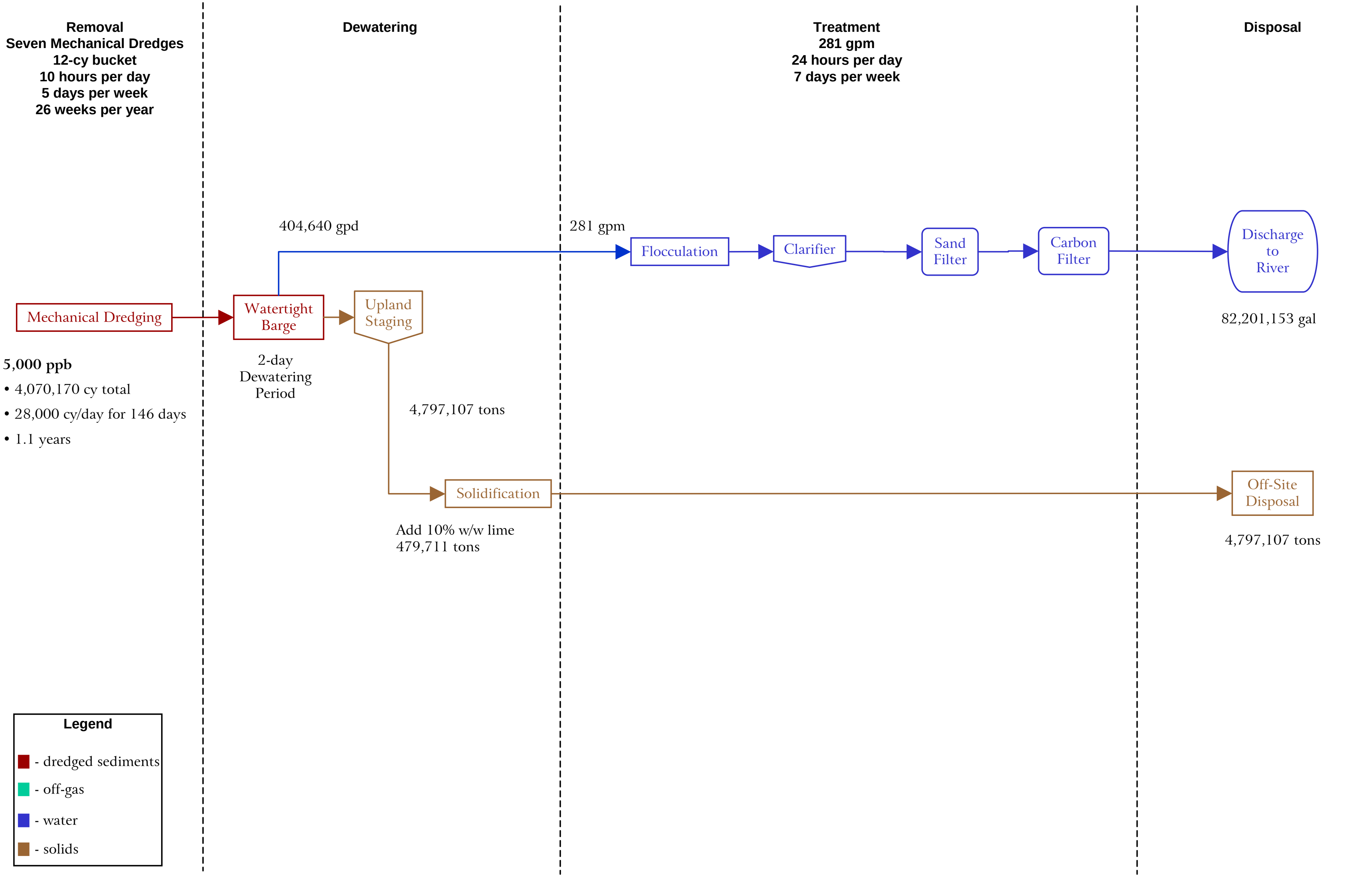
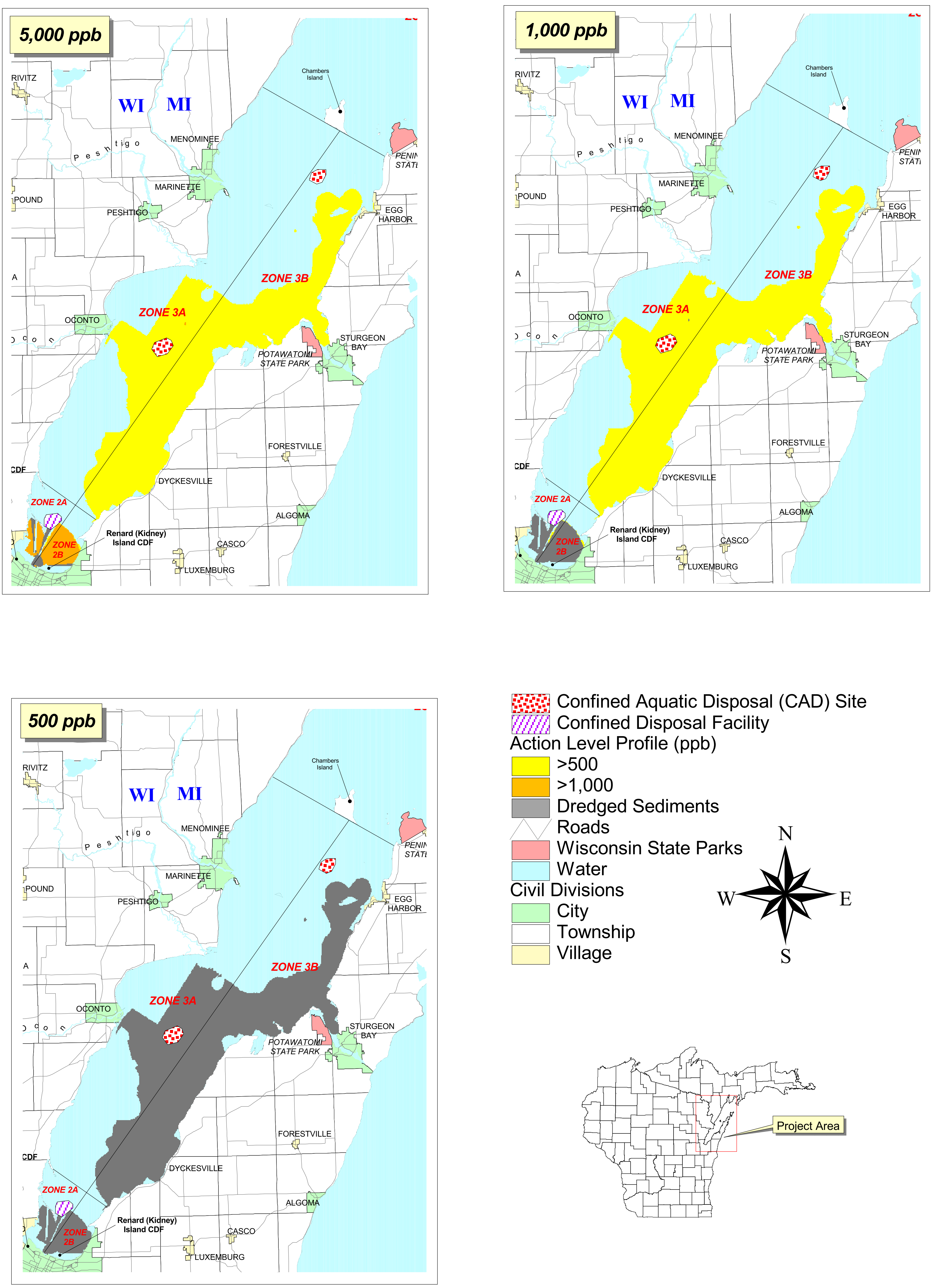
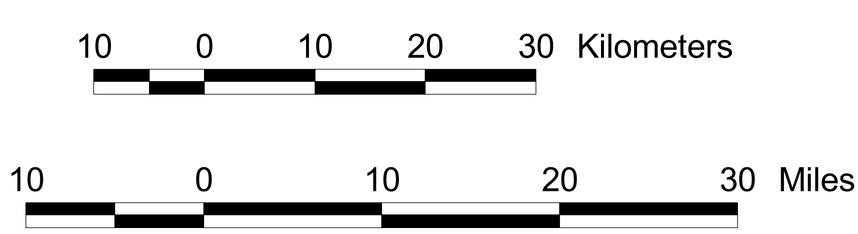
Figure 7-51 Process Flow Diagram for Green Bay Zone 2 - Alternative C: Dredge Sediment and Off-site Disposal







1. Basemap generated in ArcView GIS, Version 3.2, 1998, and from TIGER census data, 1995.
2. Deposit and management area data obtained from WDNR, and are included in the Fox River database.

ThermoRetec Smart Solutions. Positive Outcomes.	Natural Resource Technology	Lower Fox River & Green Bay Feasibility Study	Alternatives C, D, and G; Zones 2 and 3 Green Bay	REFERENCE NO: FS14414-535-7-45
				CREATED BY: SCJ
				PRINT DATE: 3/13/01
			FIGURE 7-52	APPROVED: GH

Figure 7-53 Process Flow Diagram for Green Bay Zone 2 - Alternatives D and G: Dredge Sediment to CDF/CAD

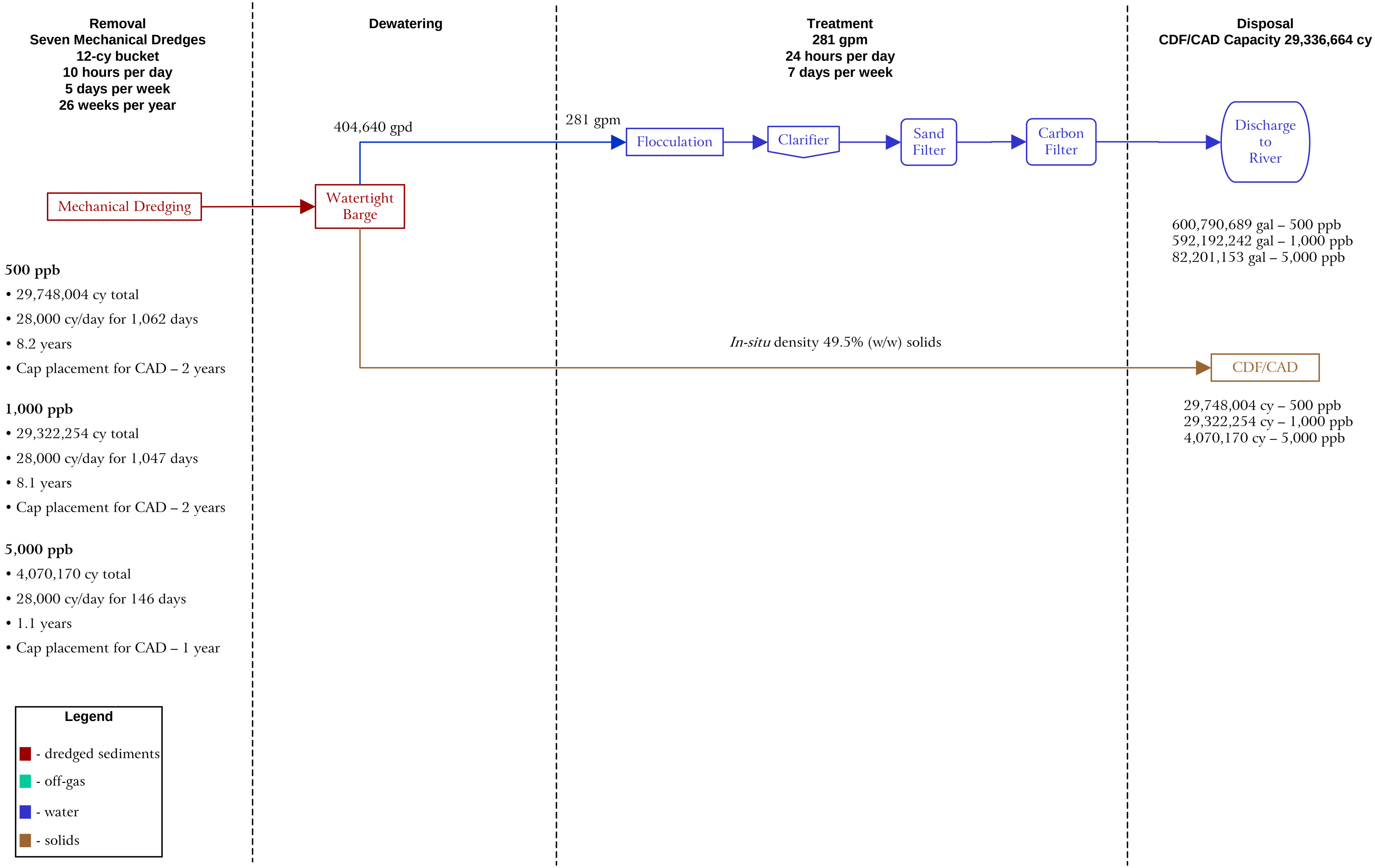


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Table 7-9 Cost Summary for Remedial Alternatives - Green Bay Zone 2

500 ppb

Alternative	Dredge Volume (cy)	Mechanical Dredging	Water Treatment	CAD Construction	CDF Construction	Renard Island Closure	Off-site Disposal	Institutional Controls	Subtotal	20% Contingency	TOTAL
A	0	---	---	---	---	---	---	$4,500,000	$4,500,000	$900,000	$5,400,000
B	0	---	---	---	---	---	---	$9,900,000	$9,900,000	$1,980,000	$11,880,000
D	29,748,004	$327,500,000	$1,200,000	---	$476,000,000	$15,500,000	---	$4,500,000	$824,700,000	$164,940,000	$989,640,000
G	29,748,004	$327,500,000	$1,200,000	$358,700,000	---	$15,500,000	---	$4,500,000	$707,400,000	$141,480,000	$848,880,000

1,000 ppb

Alternative	Dredge Volume (cy)	Mechanical Dredging	Water Treatment	CAD Construction	CDF Construction	Renard Island Closure	Off-site Disposal	Institutional Controls	Subtotal	20% Contingency	TOTAL
A	0	---	---	---	---	---	---	$4,500,000	$4,500,000	$900,000	$5,400,000
B	0	---	---	---	---	---	---	$9,900,000	$9,900,000	$1,980,000	$11,880,000
D	29,322,254	$322,900,000	$1,200,000	---	$470,000,000	$15,500,000	---	$4,500,000	$814,100,000	$162,820,000	$976,920,000
G	29,322,254	$322,900,000	$1,200,000	$353,700,000	---	$15,500,000	---	$4,500,000	$697,800,000	$139,560,000	$837,360,000

5,000 ppb

Alternative	Dredge Volume (cy)	Mechanical Dredging	Water Treatment	CAD Construction	CDF Construction	Renard Island Closure	Off-site Disposal	Institutional Controls	Subtotal	20% Contingency	TOTAL
A	0	---	---	---	---	---	---	$4,500,000	$4,500,000	$900,000	$5,400,000
B	0	---	---	---	---	---	---	$9,900,000	$9,900,000	$1,980,000	$11,880,000
C	4,070,170	$48,700,000	$700,000	---	---	$15,500,000	$437,800,000	$4,500,000	$507,200,000	$101,440,000	$608,640,000
D	4,070,170	$48,700,000	$700,000	---	$97,100,000	$15,500,000	---	$4,500,000	$166,500,000	$33,300,000	$199,800,000
G	4,070,170	$48,700,000	$700,000	$54,600,000	---	$15,500,000	---	$4,500,000	$124,000,000	$24,800,000	$148,800,000

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7.7 Green Bay Zone 3A

An overview of the Green Bay zones and PCB-impacted sediments is shown on Figure 7-49. The retained alternatives and associated costs are presented in Table 7-10.

7.7.1 General Site Characteristics

Zone 3 extends from the east-west line marking the northern boundary of Zone 2 to a line just below Chambers Island. Using the mouth of the Lower Fox River as a reference point, Zone 3 starts about 7.6 miles north of the mouth and ends 53.9 miles north of the mouth at Chambers Island (46.3 miles long). Zone 3 is further divided into "east" and "west" segments by a line trending northeast connecting the mouth of the Lower Fox River through Chambers Island. Zone 3A is located on the west side of this line while Zone 3B is located on the east side of this line.

The depth of water in this zone is generally greater than 30 feet deep and ranges from about 41 feet at the boundary between zones 2 and 3 to 110 feet just west of Chambers Island, near the boundary between zones 3 and 4. In this zone, there are four shallow shoals located along the west side and two areas where shallow water extends for a distance into the east side of the bay.

The nature and extent of PCB-impacted sediment in this zone, as summarized in the RI, includes the following:

- Maximum detected concentration - 1,017 μg/kg (avg. 322 μg/kg),
- Total PCB mass - 19,156 kg,
- Total PCB-impacted volume - 211,700 000 m^3, and
- Maximum PCB sample depth - 30 to 50 cm depth.

These quantities represent the total volumes/masses represented in each modeled depth layer (RETEC, 2002a). Required dredge volumes described later in this section are likely larger since they account for overburden volumes above deeper sediment layers that contain PCBs.

7.7.2 Selected Remedial Alternatives

This section defines the remedial alternatives for Green Bay Zone 3A and then describes the technologies that will be applied based upon application of the criteria defined in Section 6. The remedial alternatives retained for Green Bay Zone 3A include the following:

A. No action.

B. Monitored natural recovery of the system with the expectation that institutional controls will be removed within 40 years.

C. Remove all sediment with PCB concentrations greater than the selected action level and dispose of dredged sediment in an existing NR 500 commercial disposal facility.

D. Remove sediment with PCB concentrations exceeding the selected action level and place non-TSCA sediments in an on-site nearshore CDF. Transport TSCA sediments (greater than 50 ppm PCBs) to an existing NR 500 commercial disposal facility.

G. Remove sediments with PCB concentrations greater than the selected action level and place in an on-site CAD facility.

Alternatives E and F were not retained for this zone because bathymetry, water currents, and the quantity of contaminated sediment preclude cost-effective construction of an *in-situ* cap or thermal treatment. The process options that can be applied to the remedial alternatives are described below.

7.7.3 Description of Process Options

Monitoring

Monitoring of physical, chemical, and biological media is applicable for Alternatives B, C, D, and G. The no action alternative may also require monitoring of fish tissue for maintenance of pre-existing fish consumption advisories. As discussed in the technology screening process, monitoring is grouped into five categories: 1) baseline monitoring prior to remediation to establish baseline conditions for future comparisons, 2) monitoring during implementation, 3) post-verification monitoring to verify completion of a remedy, 4) long-term construction monitoring of containment facilities and sediment caps to verify continued source control and physical integrity, and 5) long-term monitoring to verify effectiveness of the remedy and attainment of the project RAOs. Numerous reference documents confirmed the necessity of a well-developed monitoring plan in order to verify the success of an implemented remedy, to measure the effectiveness and stability of source control measures, and to verify the achievement of project RAOs (EPA, 1998a, 1994a; SMWG, 1999; IJC, 1997; Krantzberg *et al.*, 1999). The following references were used in this FS Report to assess the types and applicability of monitoring options commonly used on sediment remediation projects:

- Ecology, *Standards for Confined Disposal of Contaminated Sediments Development Document* (Ecology, 1990);
- USACE, *Monitoring Considerations for Capping* (USACE, 1992);
- EPA and USACE, *Design, Performance, and Monitoring of Dredged Material Confined Disposal Facilities in Region 5* (EPA, 1996b);
- USACE, *Selected Tools and Techniques for Physical and Biological Monitoring of Aquatic Dredged Material Disposal Sites* (Fredette *et al.*, 1990);
- *Guidance for Subaqueous Dredged Material Capping* (Palermo, 1995);
- *Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories, Volume 1: Fish Sampling and Analysis* (EPA, 1995a);
- *Assessment and Remediation of Contaminated Sediments (ARCS) Program - Assessment Guidance Document* (EPA, 1994a);
- *Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites* (EPA, 1999b); and
- Sediment remediation case study projects presented in Appendices B and C of the FS.

Specific monitoring programs will be developed for each remedial alternative and will likely include physical, chemical, and biological monitoring components. Baseline monitoring generally includes water, sediment, and tissue quality sampling. Monitoring during implementation includes air and surface water sampling to assess downstream and off-site transport of contaminants. Verification monitoring includes surface and possibly subsurface sediment sampling to ensure compliance with the target goals of the remediation project. Source control monitoring includes groundwater and surface sediment sampling around the containment facility to confirm proper maintenance, stability, and chemical isolation. Long-term monitoring focuses primarily on fish, bird, and invertebrate tissue sampling and reproductive assessments, but also includes sediment and water sampling for chemical quality. The proposed *Long-term Monitoring Plan* for the Lower Fox River and Green Bay remediation project is presented in Appendix C.

Institutional Controls

Institutional controls appropriate to Green Bay Zone 3A include:

- Maintenance of the fish consumption advisory;
- A moratorium on any future dredging within the navigation channel;
- Deed restrictions on any in-water activities that could result in sediment disturbance (e.g., marina construction or over-water development);
- Access restrictions to contaminated areas; and
- A long-term (40-year) monitoring program for sediments, water, bird, and fish PCB, DDE, and mercury levels.

Implementation of these institutional controls will likely require an active public education program for the fish, waterfowl, and domestic water advisories. Deed and access restrictions may require local or state legislative action to prevent any development in contaminated areas of the river. Access and use restrictions would also apply to local Indian tribes. Finally, federal action may be necessary on any dredging moratoriums within the federal navigation channel.

Removal Process Options

Sediment removal is identified for Alternatives C, D, and G. Remediation area boundaries and sediment management areas are shown on Figure 7-49. For Green Bay, mechanical dredging is more practicable because water depth is adequate and water treatment volumes are minimized. Mechanical dredging significantly reduces the water management needs, and reduced water management is necessary due to the limited upland space availability.

A 12-cy Cable Arm™ bucket has been selected for the remedial alternatives identified in this reach. The operating assumption is that dredging will occur only during normal daylight hours (10 hours per day) during a normal work week (5 days per week). In industrial areas, dredging may occur 24 hours per day and 6 days per week; however, this option was not included in the FS. Winter weather conditions are likely to preclude operations; as a result, dredging is assumed to occur only between April and October (26 weeks per year) when the average minimum temperature is above freezing.

Containment Systems. In-water containment systems placed around the dredging area are commonly implemented on both mechanical and hydraulic dredging projects to minimize sediment resuspension downstream of the dredging operation. Typical containment barrier systems range from expensive sheet pile walls (i.e., GM Foundry, Bayou Bonfouca), to silt curtains (i.e., West Eagle Harbor, Bayou Bonfouca, River Raisin), and inexpensive oil booms (PSNS Pier D) (Appendix B).

Silt curtains are the most commonly used containment device for lakes, rivers, and estuaries, but are prone to disturbance from passing ships, strong winds, and currents. Effectiveness of silt curtains depends upon local site conditions, bottom substrate, and curtain design; and therefore may not be applicable for every site. Silt curtains were used at both the Lower Fox River demonstration projects. Based on the successful performance of the dredging operations and curtains at Deposit N, use of silt curtains was discontinued during the second removal phase with minimal water quality exceedances measured downstream (Foth and Van Dyke, 2000). However, for the purposes of this FS, silt curtains were included in the removal costs.

Over-dredge. All dredging is assumed to occur within a defined footprint to a fixed cut depth. When possible, approximately 8 inches of over-dredge of material beyond the estimated maximum depth of impacted sediment will likely be implemented to ensure complete removal of the targeted contaminant mass. However, for the purposes of the FS, over-dredge was not in volume or cost estimates to allow comparability and consistency between different action levels and reaches.

Dewatering Process Options

For all mechanical dredging alternatives, it is proposed that dewatering be conducted on-barge and in upland staging areas. Dewatering has been configured as a two-step process using gravity settling followed by solidification of solids.

Passive Dewatering. Each 2,000-cy barge load of dredged sediment will be filled in 1 day and will dewater for 2 days on the barge. Free water will be pumped from the watertight barges and collected. Sediment will then be transferred into one of three asphalt-paved upland staging areas for additional dewatering, solidification, and loading into trucks for off-site shipment. These upland staging areas will each be approximately 0.5 acre in size, surrounded with a 6-inch curb, and graded to a water collection sump. All water collected from the barges and the upland staging area will be treated using flocculation, clarification, and sand filtration prior to discharge back to the river. The upland staging areas may be located at the Bayport facility near the mouth of the Lower Fox River or at other locations that have yet to be determined.

For the dredge to CDF alternative (Alternative D), dewatering will occur directly within the CDF. Decant water for this alternative will be treated and returned to the bay.

These proposed dewatering systems will meet the criteria defined in Section 6 of this FS Report, in terms of production rate, effectiveness, practicality, and discharge water quality. Final selection of the dewatering process will be determined during the remedial design phase.

Solidification. The solids content after mechanical dredging and dewatering is assumed to be about 50 percent (w/w) or similar to *in-situ* density, based on *in-situ* solids content from the RI Report (RETEC, 2002a). This dewatered sediment may still be difficult to manage due to the high moisture content. Prior to any off-site shipment, the sediment would be solidified to improve handling and to satisfy requirements for solid waste hauling on public roads and disposal, if necessary. It was assumed that solidification was necessary, and that the sediment would be solidified with the addition of cement, lime, pozzolan, or other appropriate reagents. For FS cost estimating purposes, 10 percent (w/w) lime was added as the reagent based on its successful use during the SMU 56/57 demonstration project (Montgomery-Watson, 1998, 2000). The sediment will be mixed with the reagent and loaded into trucks using standard earthmoving equipment. If the contractor prefers, sediment may be mixed with the reagent in a pug mill as shown on Figures 7-1 and 7-5. Numerous other cost-effective reagents are available that may be tested and used for implementation of a remedial action.

Treatment Process Options

Water Treatment. Prior to water discharge back to the bay, supernatant water would pass through flocculation, clarification, and sand filtration systems. Based on the acceptable performance of the sand filter unit during the Deposit N demonstration project, no additional water treatment is deemed necessary (Foth and Van Dyke, 2000). However, additional carbon (GAC) treatment may be added to the treatment train during removal operations if effluent water quality criteria is exceeded. The estimated unit cost for GAC carbon treatment is $0.40 per thousand gallons of water treated.

On-site Disposal Process Options

The CDF currently proposed for Green Bay is a cellular cofferdam located near the Cat Island chain. The CDF size was varied with each action level to accommodate the total volume of dredged sediment. The new Green Bay CDF will be constructed as three separate islands in accordance with the design proposed by the USACE (USACE, 1999) to encourage natural resedimentation and restoration around the structures. Several in-water and upland CDF sites were proposed in a 1985 Environmental Impact Study (USACE, 1985) for Green Bay Harbor, but most were eliminated from further consideration because of environmental concerns by the USFWS (as cited in USACE, 1985). Only the Cat Island restoration area and Kidney Island expansion were retained for further consideration.

The newly constructed free-standing CDF structures will be closed with a 3-foot sand cap and riprap placed around the edges to provide additional protection from storm events. The final construction will also include habitat areas for shallow submerged and emergent vegetation as shown on the proposed conceptual design (Figure 7-50). While the top layer is not designed to be an impermeable cap, selection of appropriate plant species will be considered (i.e., shallow roots) to ensure physical integrity of the cap.

The Renard Island CDF, located near the mouth of the Lower Fox River, is a 55-acre diked impoundment with a design capacity of 1,200,000 cy. The facility consists of a kidney-shaped stone dike with an interior steel sheet pile cutoff wall to prevent seepage to surrounding surface waters (USACE, 1985). The CDF reached capacity after receiving a deposit of dredged sediment in 1996. Construction costs include final closure of the Renard Island CDF in addition to constructing a new CDF. Closure of Renard Island will include placement of a 3-foot-thick clean soil cap, seeding, mitigation, and long-term monitoring for 40 years.

Within Green Bay, three potential CAD sites were identified. The CAD was sized for each action level to accommodate the total volume of dredged sediment. CAD site locations were selected in areas with adequate water depths (25-meter depth) and low bottom surface water velocities. Ideal locations for CAD sites are in "null-zones" where circulation patterns create areas with net deposition, instead of erosion and scour. These areas were selected from the HydroQual vector diagrams presented in Section 2 (Figures 2-11 and 2-12). Contaminated sediment will be excavated by mechanical dredging, transferred to a haul barge and placed in the CAD site by either split-hull bottom dump or pumped in via pipeline if finer-scale placement is required.

Off-site Disposal Process Options

Total PCB concentrations in sediment within this zone are below 50 ppm, therefore none of the sediment is considered TSCA-level material. All sediment could be disposed of at landfills which conform to the NR 500 WAC requirements. Local landfill options and unit costs were defined in Section 6.5.5 of this FS Report.

Capping Process Options

No capping is proposed for Green Bay because bottom water currents, storm events, vessel traffic, maintenance of navigational channels, and potential ice scour preclude effective placement and long-term integrity.

7.7.4 Development of Alternatives and Associated Costs

This section describes the remedial alternatives developed for Green Bay Zone 3A. Each remedial alternative includes a description, a process flow diagram, and a summary cost table. Summary costs presented as net present worth include a line item for 20 percent contingency costs (Table 7-10). Details used to develop each cost estimate are provided in Appendix H.

The following components are discussed, when applicable, within the development of each alternative:

- Site mobilization and preparation,
- Sediment removal,
- Sediment dewatering,
- Water treatment,
- Sediment disposal,
- Demobilization and site restoration, and
- Long-term monitoring/institutional controls.

Alternative A: No Action

As required under the NCP, a no action alternative is included for Green Bay Zone 3A. This alternative involves taking no action and relying on natural processes, such as natural attenuation, dispersion, dilution, and sedimentation to reduce contaminant quantities and/or concentrations and control contaminant migration processes. This alternative implies that no active management of remediation is employed; however, some institutional controls, such as access or resource use restrictions, may be employed to reduce risks until RAOs are achieved. This alternative includes fish tissue sampling every 5 years for 40 years for maintenance of fish consumption advisories already in place.

The estimated cost for no action and maintenance of consumption advisories currently in place is $4,500,000. Engineered cost evaluations typically include a 20 percent contingency cost added to the remedy costs, as shown in the cost tables as a separate line item.

Alternative B: Monitored Natural Recovery/Institutional Controls

The monitored natural recovery option will include a long-term monitoring program (40-year) for measuring PCB, DDE, and mercury levels in water, sediment, invertebrates, fish, and birds. The monitoring program will be developed to effectively measure achievement of and progress towards the project RAOs expected in 40 years. Monitoring components will likely be collected between 2- and 5-year intervals for the first 10 years, and include pre- and post-remedy sampling events to establish baseline conditions. Monitoring frequency may be modified after 5 years based on initial monitoring results. More specifically, the monitoring program will likely include (see Appendix C for the proposed *Long-term Monitoring Plan* for the project):

- Surface water quality sampling at several stations along the reach to determine the downstream transport of PCB mass into Green Bay (RAOs 1 and 4);

- Fish and waterfowl tissue sampling of several species and size classes to determine the residual risk of PCB and mercury consumption to human receptors (RAO 2);

- Fish (several species and size classes), bald eagle, and invertebrate tissue sampling to determine the residual risk of PCB, DDE, and mercury uptake to environmental receptors (RAO 3);

- Population studies of birds (bald eagles and double-crested cormorants) to assess the residual effects of PCBs, DDE, and mercury on reproductive viability (RAO 3); and

- Surface sediment sampling in MNR areas to assess potential recontamination from upstream sources, and status of attenuation of sediments (RAO 4).

Until the project RAOs have been achieved, institutional controls will be required to prevent exposure of human and biological receptors to contaminants. Institutional controls may also be implemented in combination with many of the proposed remedial alternatives, and may include monitoring, access restrictions, deed restrictions, dredging moratoriums, fish consumption advisories, and domestic water supply restrictions. Deed and access restrictions may require local or state legislative action to prevent any development in contaminated areas of the river. Items included in costs for institutional control include public education programs for fish or health advisories, 5-year fish tissue collection efforts for maintenance of consumption advisories, and deed restrictions.

The estimated cost for long-term monitoring and maintenance of institutional controls is $9,900,000. Engineered cost evaluations typically include a 20 percent contingency cost added to the remedy costs, as shown in the cost tables as a separate line item.

Alternative C: Dredge and Dispose of Sediment in Off-site Landfill

Alternative C includes the removal of sediments above the remedial action level using multiple mechanical dredges and off-site disposal of the sediments. Costs for Alternative C were developed only for the 1,000 ppb action level because volumes for the 500 ppb action level are too large to consider off-site disposal and sediments were not measured above the 5,000 ppb action level. Figure 7-54 provides the process flow diagram for this remedial alternative, while Figure 7-52 illustrates the extent of residual contamination following implementation of Alternative C. The summary costs to implement Alternative C are provided in Table 7-10. The total volume of sediment to be dredged in this alternative is 14,410 cy.

Site Mobilization and Preparation. Staging for the dredging of sediments will be conducted at the Bayport facility. Site mobilization and preparation includes securing the onshore property area for equipment staging, constructing areas for sediment staging, water treatment, sediment solidification, and truck loading. It is assumed that docking facilities for the mechanical dredge and barges already exist at these locations. Purchase and property preparation are included in the dredging costs.

Sediment Removal. Due to the limited upland space available for water management purposes, all sediment removal will be done with a mechanical dredge. Sediment removal will be conducted using seven 12-cy closed, clamshell buckets that require about 0.6 day to complete, given the volumes and operation assumptions presented in Section 7.7.3. While it would be more practical to use fewer dredges and extend the dredging time, the seven-dredge approach provides consistency and relative comparability with the other Green Bay zones. During the remedial design phase, fewer dredges may be selected. Removal requires a staging area for the mechanically-dredged sediments to be offloaded and transported off site. The cost for constructing the upland staging area is included in dewatering and disposal. Silt curtains around the dredging area may be included to minimize sediment resuspension downstream of the dredging operation and were included in the cost tables for $35,000. Buoys and other waterway markers would be installed around the perimeter of the work area to prevent entry of unauthorized boats within the removal work zone. Other capital items included in the sediment removal costs are barge rental and movement, construction of upland staging areas, water quality monitoring, post-removal sediment bathymetric surveys to ensure achievement of the removal action, and site restoration at the conclusion of operations.

Sediment removal costs are estimated to be $4,600,000 for the 1,000 ppb action level.

Sediment Dewatering. All dewatering will be conducted on-barge and in upland staging areas. Each 2,000-cy barge load of dredged sediment will be filled in 1 day and will dewater for 2 days on the barge. Free water will be pumped from the watertight barges to upland staging areas. Sediment will then be transferred onto an asphalt-paved upland staging area where any free water will be collected. It is assumed that the sediment would require solidification with 10 percent (w/w) lime to satisfy hauling and disposal requirements (included in disposal costs). Sediment dewatering costs are included in the sediment removal and water treatment costs.

Water Treatment. Water treatment includes purchase of equipment and materials for flocculation, clarification, and sand filtration. Water treatment would be conducted 24 hours per day, 7 days per week during the dredging season. Discharge water is estimated at 411,840 gallons per day. Daily discharge water quality monitoring is included in the cost estimate. Treated water would be sampled and analyzed to verify compliance with the appropriate discharge requirements prior to discharge back to the river. It may be necessary to add carbon filtration to the treatment train if effluent criteria are not met. Carbon filtration could be added for a unit cost of $0.40 per thousand gallons of water treated. Water treatment costs also include pad and equipment demobilization and site restoration.

Water treatment costs are estimated to be $600,000 for the 1,000 ppb action level.

Sediment Disposal. Sediment disposal includes the loading and transportation of the sediment to a facility listed in Table 6-6. The sediments would be loaded into tractor-trailer end dumps with bed liners or sealed gates with a front-end loader. Each load would be manifested and weighed. Prior to leaving the staging area, each tractor-trailer would pass through a wheel wash to prevent tracking soil onto nearby streets and highways. After unloading at the designated disposal facility, each tractor-trailer would pass through a wheel wash and return to the staging area for another load.

The estimated percent solids of dewatered sediment after passive dewatering is expected to equal the *in-situ* percent solids of material prior to mechanical dredging, which is 14.4 percent (w/w) (Appendix of RI Report, RETEC, 2002a). After solidification with 10 percent lime (w/w), the material is estimated to have 60 percent solids content (Montgomery-Watson, 1998). Solidification costs for the 1,000 ppb action level are $449,000 (24 percent of cost is for the purchase of lime).

Costs of sediment solidification and disposal at an existing NR 500 commercial disposal facility are estimated to be $1,300,000 for the 1,000 ppb action level.

Demobilization and Site Restoration. Demobilization and site restoration involves removing all equipment (i.e., fencing, facilities) from the staging and work areas. All work pads and other permanent structures would be removed and the site would be graded to its original condition. Vegetated areas would be replanted to a state similar to that of the pre-construction. Demobilization and restoration costs are included within the above dredging, dewatering, and treatment estimates.

Institutional Controls and Monitoring. Baseline monitoring includes primarily water, sediment, and tissue sampling during pre- and post-remedial sampling events. Monitoring during implementation includes surface water and limited air sampling to assess downstream and off-site transport of contaminants. Verification monitoring includes surface and possibly subsurface sediment sampling to ensure compliance with the target goals of the project. Long-term monitoring includes surface water, surface sediment, and biological tissue sampling to determine residual risks and impacts over time. If residual risks remain in the sediment above the risk-based SQTs after remediation, then the long-term monitoring plan described in the MNR alternative will be followed (i.e., media, frequency, location, duration) until the project RAOs are achieved or until a policy decision is made. The proposed *Long-term Monitoring Plan* (LTMP) is detailed in Appendix C. Elements of the LTMP may be implemented for each action level regardless of the remedial outcome in order to verify achievement of the RAOs. The sampling program may continue indefinitely under this process option, but for the purposes of the FS it has been estimated at 40 years.

The estimated cost for the maintenance of institutional controls and advisory monitoring is $4,500,000. Implementation monitoring during active dredging is included in the dredging costs. Long-term remedy monitoring of Green Bay to assess achievement of project RAOs are included in Alternative B - Monitored Natural Recovery.

Alternative D: Dredge Sediment to Confined Disposal Facility

Alternative D includes removal of sediments to an on-site cellular cofferdam CDF for long-term disposal of the materials. Costs for this alternative were developed for the 500 ppb action level only. It did not seem prudent to construct a CDF for the small volume of sediments above the 1,000 ppb action level, and no sediments were measured above the 5,000 ppb action level. The cellular cofferdam CDF location is identified on Figure 7-52.

Figure 7-55 provides the process flow diagram for this remedial alternative. Table 7-10 contains the summary costs to implement Alternative D. The total volume of sediment to be dredged in this alternative is 16,328,102 cy.

Site Mobilization and CDF Construction. For the concept level FS, the process is staged to construct and complete dredging to the cellular cofferdam CDF described in Section 7.7.3. Site mobilization and preparation includes securing the onshore property area for equipment staging, water treatment, and an offshore docking facility for the mechanical dredge.

CDF construction is estimated at $285,000,000, which includes operation and maintenance costs for 40 years.

Sediment Removal. Mechanical sediment removal techniques for this alternative are equivalent to those described for Alternative C. The removal time frame using seven 12-cy closed clamshell buckets is 4.5 years.

Sediment removal costs are estimated at $181,800,000 for the 500 ppb action level.

Sediment Dewatering. All dewatering will be conducted on-barge and in the CDF. Each 2,000-cy barge load of dredged sediment will be filled in 1 day and will dewater for 2 days on the barge. Free water will be pumped from the watertight barges and managed. Sediment dewatering costs are included in the sediment removal and water treatment costs.

Water Treatment. Overflow return water from the barges and CDF would be treated before discharge to the bay. Treatment and monitoring requirements are expected to be similar to those specified for Alternative C.

Water treatment costs for Alternative D are estimated at $3,000,000.

Sediment Disposal. No off-site sediment disposal is anticipated for this alternative. Sediments will be placed directly into the CDF and placement costs are included in the dredging and construction costs. Percent solids content is expected to be the same as *in-situ* percent solids prior to dredging. No solidification costs were added.

Demobilization and Site Restoration. Demobilization and site restoration involves removing all equipment (i.e., fencing, facilities) from the staging and work areas. The CDF would be finished with a 3-foot cap of clean soils to isolate the contaminated sediments. However, this alternative would allow for development of these newly-created upland habitat features. Demobilization and site restoration costs are included under the dredging estimates.

Institutional Controls and Monitoring. To ensure that the CDF is functioning as designed, near-site sediment and water sampling would be conducted on an annual basis. The monitoring program will be conducted over a period of 40 years.

The estimated cost for institutional controls is $4,500,000. Long-term operation and maintenance monitoring of the CDF is included in the CDF construction costs. Long-term monitoring of Green Bay to verify achievement of the project RAOs is included in Alternative B - Monitored Natural Recovery.

Alternative G: Dredge Sediment to Confined Aquatic Disposal

Alternative G includes removal of sediments to a CAD facility for long-term disposal of the materials. Costs for this alternative were developed for the 500 ppb action level only. It did not seem prudent to construct a CAD site for the small volume of sediment above the 1,000 ppb action level, and no sediments were measured above the 5,000 ppb action level. The proposed CAD location is identified on Figure 7-52.

Figure 7-55 provides the process flow diagram for this remedial alternative. Table 7-10 contains the summary costs to implement Alternative G. The total volume of sediment to be dredged in this alternative is 16,328,102 cy for the 500 ppb action level.

Site Mobilization and CAD Construction. For the concept level FS, the process is staged to complete dredging to the CAD as described in Section 7.7.3. Details of the conceptual CAD design are provided on Figure 6-7. Site mobilization and preparation includes securing the onshore property area for equipment staging, purchase of sand, long-term operation and maintenance, an offshore docking facility for the mechanical dredge, and winterizing equipment each year.

The CAD site will be constructed by excavating an in-water cavity approximately 3 to 5 meters deep using either mechanical or hydraulic dredges. Contaminated sediment will be placed in the deep water cavity using either split-hull bottom barges or pipelines. After placement, the CAD site will be capped with 3 feet of clean sand (included in construction costs). Capping requires six barges, four tugboats, and a shore-based source of sand within 20 miles of the CAD site.

CAD construction is estimated at $199,800,000 for the 500 ppb action level, which includes CAD closure and long-term operation and maintenance costs.

Sediment Removal. Sediment removal will be conducted using seven 12-cy closed, mechanical buckets requiring 4.5 years at the 500 ppb action level. Two additional years will be required for cap placement (included in CAD construction costs). Dredged sediment will be transferred directly from mechanical dredges to 24 bottom-dump barges and eight tugboats for direct transfer to the disposal site. Sediment removal time frame and costs are similar to those described for Alternative D.

Sediment Dewatering. All dewatering will be conducted on-barge. Each 2,000-cy barge load of dredged sediment will be filled in 1 day and will dewater for 2 days on the barge. Free water will be pumped from the watertight barges and managed. Sediment dewatering costs are included in the sediment removal and water treatment costs.

Water Treatment. Overflow return water from the barges would be treated before discharge to the bay. Treatment and monitoring requirements are expected to be similar to those specified for Alternative C.

Water treatment costs for Alternative G are estimated at $3,000,000 for the 500 ppb action level.

Sediment Disposal. On-site disposal costs are included in the CAD construction and dredging costs. Percent solids content of dewatered sediments at the time of disposal are expected to be the same as *in-situ* percent solids prior to mechanical dredging, and no solidification costs are included.

Demobilization and Site Restoration. Demobilization and site restoration involves removing all equipment (i.e., fencing, facilities) from the staging and work areas. The CAD would be finished with a 3-foot cap of clean soils to isolate the contaminated sediments. Demobilization and site restoration costs are included under the dredging and construction estimates.

Institutional Controls and Monitoring. To ensure that the CAD site is functioning as designed, surface and subsurface sediment sampling will be conducted to address potential upward chemical migration through the cap and structural integrity of the containment structure. Sampling will be conducted at 3- to 5-year intervals, with decreasing intervals over time, if warranted. The actual number of sampling locations will depend upon the actual configuration and size of the CAD site. To verify achievement of the project RAOs, selected elements of the *Long-term Monitoring Plan* (Appendix C) will also be implemented.

The estimated cost for institutional controls is $4,500,000. Long-term operation and maintenance monitoring of the CAD site (approximately $6 million) is included in the CAD construction costs. Implementation monitoring during dredging is incorporated into the removal costs. Long-term remedy monitoring of Green Bay to verify achievement of the project RAOs is included in Alternative B - Monitored Natural Recovery.

7.7.5 Section 7.7 Figures and Tables

Figures and tables for Section 7.7 follow this page and include:

Figure 7-54 Process Flow Diagram for Green Bay Zone 3A - Alternative C: Dredge Sediment and Off-site Disposal
Figure 7-55 Process Flow Diagram for Green Bay Zone 3A - Alternatives D and G: Dredge Sediment to CDF/CAD

Table 7-10 Cost Summary for Remedial Alternatives - Green Bay Zone 3A

Figure 7-54 **Process Flow Diagram for Green Bay Zone 3A - Alternative C: Dredge Sediment and Off-site Disposal**

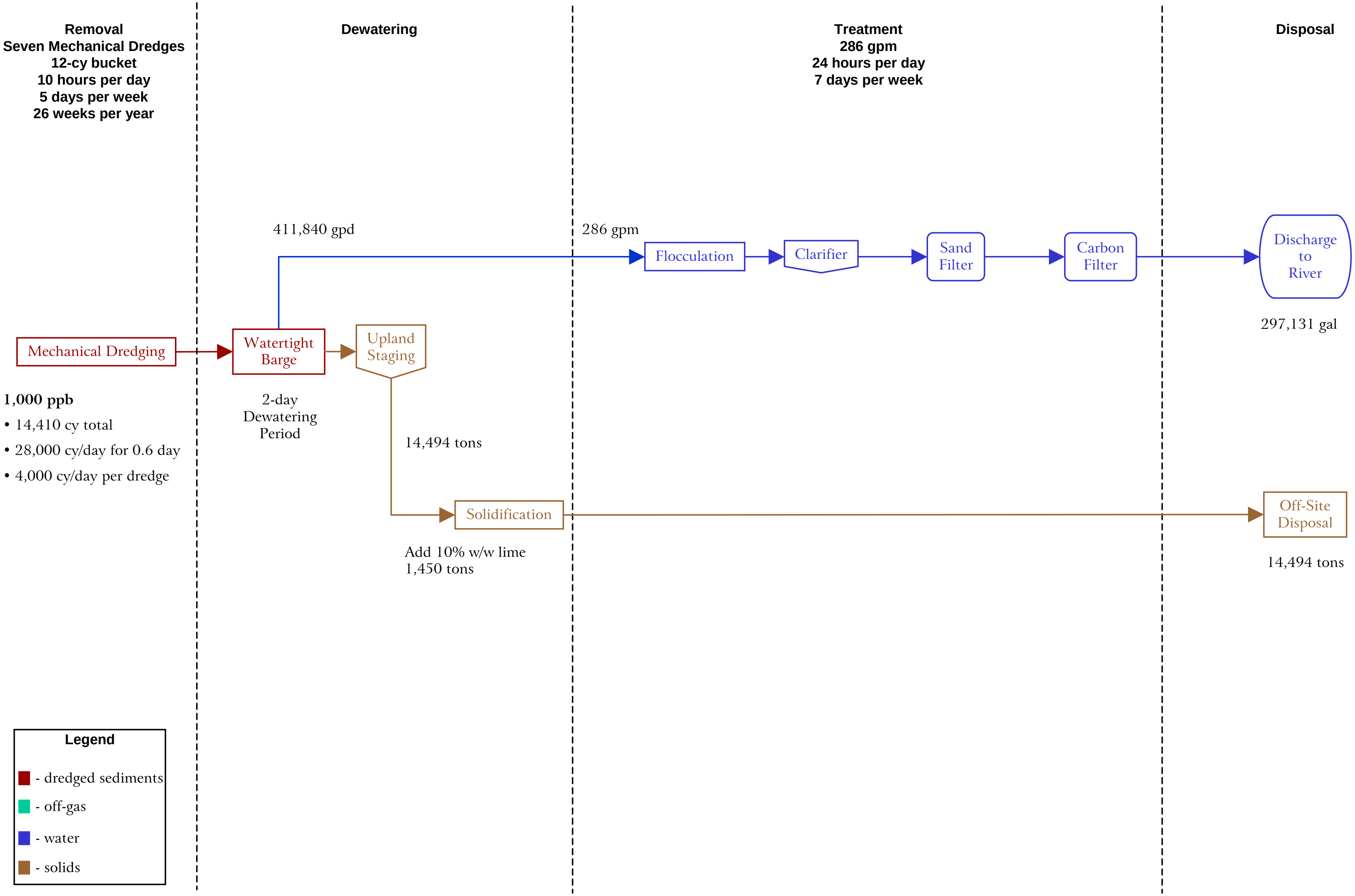

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Figure 7-55 Process Flow Diagram for Green Bay Zone 3A - Alternatives D and G: Dredge Sediment to CDF/CAD

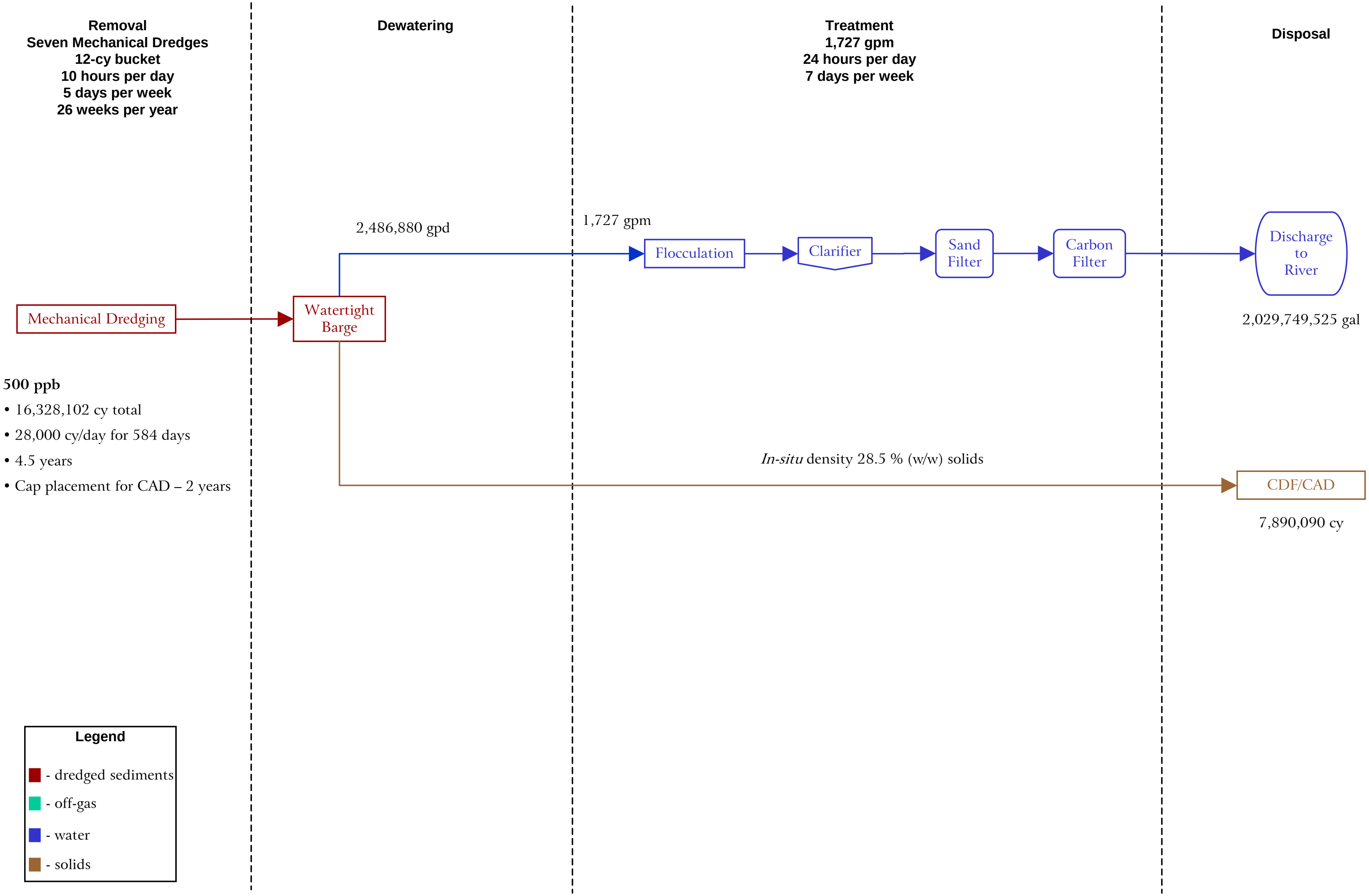

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Table 7-10 Cost Summary for Remedial Alternatives - Green Bay Zone 3A

500 ppb [1]

Alternative	Dredge Volume (cy)	Hydraulic Dredging	Mechanical Dredging	Dewatering	Water Treatment	CAD Construction	CDF Construction	Off-site Disposal	Institutional Controls	Subtotal	20% Contingency	TOTAL
A	0	---	---	---	---	---	---	---	$4,500,000	$4,500,000	$900,000	$5,400,000
B	0	---	---	---	---	---	---	---	$9,900,000	$9,900,000	$1,980,000	$11,880,000
D	16,328,102	---	$181,800,000	---	$3,000,000	---	$285,000,000	---	$4,500,000	$474,300,000	$94,860,000	$569,160,000
G	16,328,102	---	$181,800,000	---	$3,000,000	$199,800,000	---	---	$4,500,000	$389,100,000	$77,820,000	$466,920,000

1,000 ppb [1]

Alternative	Dredge Volume (cy)	Hydraulic Dredging	Mechanical Dredging	Dewatering	Water Treatment	CAD Construction	CDF Construction	Off-site Disposal	Institutional Controls	Subtotal	20% Contingency	TOTAL
A	0	---	---	---	---	---	---	---	$4,500,000	$4,500,000	$900,000	$5,400,000
B	0	---	---	---	---	---	---	---	$9,900,000	$9,900,000	$1,980,000	$11,880,000
C	14,410	---	$4,600,000	---	$600,000	---	---	$1,300,000	$4,500,000	$11,000,000	$2,200,000	$13,200,000

Note:

[1] No sediments measured above 5,000 ppb in this zone.

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7.8 Green Bay Zone 3B

An overview of the Green Bay zones and PCB-impacted sediments is shown on Figure 7-49. The retained alternatives and associated costs for Zone 3B are presented in Table 7-11.

7.8.1 General Site Characteristics

General site characteristics for Zone 3B are the same as those described for Green Bay Zone 3A in Section 7.7.1. The only action level for this zone is 500 ppb. The nature and extent of PCB-impacted sediment in this zone, as summarized in the RI, includes the following:

- Maximum detected concentration - 1,302 μg/kg (avg. 448 μg/kg),
- Total PCB mass - 16,823 kg,
- Total PCB-impacted volume - 224,469,000 m^3, and
- Maximum PCB sample depth - 30 to 50 cm depth.

These quantities represent the total volumes/masses represented in each modeled depth layer (RETEC, 2002a). Required dredge volumes described later in this section will likely be larger since they account for overburden volumes above deeper sediment layers that contain PCBs.

7.8.2 Selected Remedial Alternatives

This section defines the remedial alternatives for Green Bay Zone 3B and then describes the technologies that will be applied based upon application of the criteria defined in Section 6. The remedial alternatives retained for Green Bay Zone 3B include the following:

A. No action.

B. Monitored natural recovery of the system with the expectation that institutional controls will be removed within 40 years.

D. Remove sediment with PCB concentrations exceeding the selected action level and place non-TSCA sediments in an on-site nearshore CDF. Transport TSCA sediments (greater than 50 ppm PCBs) to an existing NR 500 commercial disposal facility.

G. Remove sediment with PCB concentrations greater than the selected action level and place in an on-site CAD facility.

Alternatives C, E and F were not retained for this zone because bathymetry, water currents, ice scour limitations, and the quantity of contaminated sediment preclude cost-effective construction of an *in-situ* cap, thermal treatment, or off-site disposal. The process options that can be applied to the remedial alternatives are described below.

7.8.3 Description of Process Options

Monitoring

Short-term and long-term monitoring options in this reach are the same as those described previously for the Lower Fox River reaches and Green Bay zones.

Institutional Controls

Institutional controls in this zone are the same as those described previously for Green Bay zones 2 and 3A.

Removal Process Options

Sediment removal is identified for Alternatives D through G. Remediation area boundaries and sediment management areas are shown on Figure 7-49. For Green Bay, mechanical dredging is more practicable because water depth is adequate and water treatment volumes are minimized. Mechanical dredging significantly reduces the water management needs, and reduced water management is necessary due to the limited upland space availability.

A 12-cy Cable Arm™ bucket has been selected for the remedial alternatives identified in this reach. The operating assumption is that dredging will occur only during normal daylight hours (12 hours per day) during a normal work week (5 days per week). In industrial areas, dredging may occur 24 hours per day and 6 days per week; however, this option was not included in the FS. Winter weather conditions are likely to preclude operations; as a result, dredging is assumed to occur only between April and October (26 weeks per year) when the average minimum temperature is above freezing.

Containment Systems. In-water containment systems placed around the dredging area are commonly implemented on both mechanical and hydraulic dredging projects to minimize sediment resuspension downstream of the dredging operation. Typical containment barrier systems range from expensive sheet pile walls (i.e., GM Foundry, Bayou Bonfouca), to silt curtains (i.e., West Eagle Harbor, Bayou Bonfouca, River Raisin), and inexpensive oil booms (PSNS Pier D). Silt curtains are the most commonly used containment device for lakes, rivers, and estuaries, but are prone to disturbance from passing ships, strong winds, and currents. Effectiveness of silt curtains depends upon local site conditions, bottom substrate, and design, and may not be applicable for every site. Silt curtains were used at both the Lower Fox River demonstration projects. Based on the successful performance of the dredging operations and curtains at Deposit N, use of silt curtains was discontinued during the second removal phase with minimal water quality exceedances measured downstream (Foth and Van Dyke, 2000). However, for the purposes of this FS, silt curtains were included in the removal costs despite the site performance during the Deposit N project.

Over-dredge. All dredging is assumed to occur within a defined footprint to a fixed cut depth. When possible, approximately 8 inches of over-dredge of material beyond the estimated maximum depth of impacted sediment will likely be implemented to ensure complete removal of the targeted contaminant mass. However, for the purposes of the FS, over-dredge was not in volume or cost estimates to allow comparability and consistency between different action levels and reaches.

Dewatering Process Options

For all mechanical dredging alternatives, it is proposed that dewatering be conducted on-barge and in upland staging areas.

Passive Dewatering. Each 2,000-cy barge load of dredged sediment will be filled in 1 day and will dewater for 2 days on the barge. Free water will be pumped from the watertight barges and collected. All water collected from the barges and the CDF will be treated using flocculation, clarification, and sand filtration prior to discharge back to the river.

These proposed dewatering systems will meet the criteria defined in Section 6 of this FS Report, in terms of production rate, effectiveness, practicality, and discharge water quality. Final selection of the dewatering process will be determined during the remedial design phase.

Treatment Process Options

Water treatment of effluent prior to discharge includes the same processes previously described for Green Bay zones 2 and 3A.

On-site Disposal Process Options

The CDF currently proposed for Green Bay is a cellular cofferdam located near the Cat Island chain. The CDF size was varied with each action level to accommodate the total volume of dredged sediment. The new Green Bay CDF will be constructed as three separate islands in accordance with the design proposed by the USACE (USACE, 1999) to encourage natural resedimentation and restoration around the structures. Several in-water and upland CDF sites were proposed in a 1985 Environmental Impact Study (USACE, 1985) for Green Bay Harbor, but most were eliminated from further consideration because of environmental concerns by the USFWS (as cited in USACE, 1985). Only the Cat

Island restoration area and Kidney Island expansion were retained for further consideration.

The newly constructed free-standing CDF structures will be closed with a 3-foot sand cap and riprap placed around the edges to provide additional protection from storm events. The final construction will also include habitat areas for shallow submerged and emergent vegetation as shown on the proposed conceptual design (Figure 7-50). While the top layer is not designed to be an impermeable cap, selection of appropriate plant species will be considered (i.e., shallow roots) to ensure physical integrity of the cap.

The Renard Island CDF, located near the mouth of the Lower Fox River, is a 55-acre diked impoundment with a design capacity of 1,200,000 cy. The facility consists of a kidney-shaped stone dike with an interior steel sheet pile cutoff wall to prevent seepage to surrounding surface waters (USACE, 1985). The CDF reached capacity after receiving a deposit of dredged sediment in 1996. Construction costs include final closure of the Renard Island CDF in addition to constructing a new CDF. Closure of Renard Island will include placement of a 3-foot-thick clean soil cap, seeding, mitigation, and long-term monitoring for 40 years.

Within Green Bay, three potential CAD sites were identified as previously described for Green Bay zones 2 and 3A.

Off-site Disposal Process Options

No off-site disposal was considered for the zone because of the large sediment volumes requiring removal. Only on-site disposal options were considered.

Capping Process Options

No capping is proposed for Green Bay because bottom water currents, storm events, vessel traffic, maintenance of navigational channels, and potential ice scour preclude effective placement and long-term integrity (Palermo, 1995).

7.8.4 Development of Alternatives and Associated Costs

This section describes the remedial alternatives developed for Green Bay Zone 3B. Each remedial alternative includes a process description, a process flow diagram, and a summary cost table. Summary costs presented as net present worth in this FS include a line item for 20 percent contingency costs. Details used to develop each cost estimate are provided in Appendix H.

The following components are discussed, when applicable, within the development of each alternative:

- Site mobilization and preparation,
- Sediment removal,
- Sediment dewatering,
- Water treatment,
- Sediment disposal,
- Demobilization and site restoration, and
- Long-term monitoring/institutional controls.

Alternative A: No Action

As required under the NCP, a no action alternative is included for Green Bay Zone 3B. This alternative involves taking no action and relying on natural processes, such as natural attenuation, dispersion, dilution, and sedimentation to reduce contaminant quantities and/or concentrations and control contaminant migration processes. This alternative implies that no active management of remediation is employed; however, some institutional controls, such as access or resource use restrictions, may be employed to reduce risks until RAOs are achieved. This alternative includes fish tissue sampling events every 5 years for 40 years for maintenance of the fish consumption advisories currently in place.

The estimated cost for no action and maintenance of consumption advisories currently in place is $4,500,000. Engineered cost evaluations typically include a 20 percent contingency cost added to the remedy costs, as shown in the cost tables as a separate line item.

Alternative B: Monitored Natural Recovery/Institutional Controls

The monitored natural recovery option will include a long-term monitoring program (40-year) for measuring PCB, DDE, and mercury levels in water, sediment, invertebrates, fish, and birds. The monitoring program will be developed to effectively measure achievement of and progress towards the project RAOs expected in 40 years. Monitoring components will likely be collected between 2- and 5-year intervals for the first 10 years, and will include pre- and post-remedy sampling events to establish baseline conditions. Monitoring frequency may be modified after 5 years based on initial monitoring results. More specifically, the monitoring program will likely include (see Appendix C for the proposed *Long-term Monitoring Plan* for the project):

- Surface water quality sampling at several stations along the reach to determine the downstream transport of PCB mass into Green Bay (RAOs 1 and 4);

- Fish and waterfowl tissue sampling of several species and size classes to determine the residual risk of PCB and mercury consumption to human receptors (RAO 2);
- Fish (several species and size classes), bald eagle, and invertebrate tissue sampling to determine the residual risk of PCB, DDE, and mercury uptake to environmental receptors (RAO 3);
- Population studies of birds (bald eagles and double-crested cormorants) to assess the residual effects of PCBs, DDE, and mercury on reproductive viability (RAO 3); and
- Surface sediment sampling in MNR areas to assess potential recontamination from upstream sources and status of attenuation of sediments (RAO 4).

Until the project RAOs have been achieved, institutional controls will be required to prevent exposure of human and biological receptors to contaminants. Institutional controls may also be implemented in combination with many of the proposed remedial alternatives, and may include monitoring, access restrictions, deed restrictions, dredging moratoriums, fish consumption advisories, and domestic water supply restrictions. Deed and access restrictions may require local or state legislative action to prevent any development in contaminated areas of the river. Items included in costs for institutional control include public education programs for fish or health advisories, 5-year fish tissue collection efforts for maintenance of consumption advisories, and deed restrictions.

The estimated cost for institutional controls and long-term monitoring is $9,900,000. Engineered cost evaluations typically include a 20 percent contingency cost added to the remedy costs, as shown in the cost tables as a separate line item.

Alternative D: Dredge Sediment to Confined Disposal Facility

Alternative D includes removal of sediments to an on-site cellular cofferdam CDF for long-term disposal of the materials. Costs for this alternative were developed for the 500 ppb action level only since no sediments were measured above the higher action levels. The cellular cofferdam CDF location is identified on Figure 7-52. TSCA-level sediments are not present in this zone.

Figure 7-56 provides the process flow diagram for this remedial alternative. Table 7-11 contains the summary costs to implement Alternative D. The total volume of sediment to be dredged in this alternative is 43,625,096 cy for the 500 ppb action level.

Site Mobilization and CDF Construction. For the concept level FS, the process is staged to construct and complete dredging to the cellular cofferdam CDF near the Cat Island chain described above. Site mobilization and preparation includes securing the onshore property area for equipment staging, constructing the CDF, a water treatment facility, and an offshore docking facility for the mechanical dredge. Property purchase and preparation are included in the construction costs.

CDF construction is estimated at $667,700,000, which includes long-term operation and maintenance costs.

Sediment Removal. Mechanical sediment removal techniques for this alternative are equivalent to those described for Green Bay Zone 3A. The estimated time to complete mechanical dredging is 12 years using seven mechanical dredges.

Sediment removal costs are estimated at $478,600,000.

Water Treatment. Free water collected on barges and overflow return water from the CDF would be treated before discharge to the bay. Treatment and monitoring requirements are expected to be similar to those specified for the Green Bay Zone 3A.

Water treatment costs for Alternative D are estimated at $4,700,000.

Sediment Disposal. No off-site sediment disposal is anticipated for this alternative. Sediments will be placed directly into the CDF without solidification. Placement costs are included in the dredging costs. Percent solids are expected to be the same as *in-situ* percent solids prior to mechanical dredging.

Demobilization and Site Restoration. Demobilization and site restoration involves removing all equipment (i.e., fencing, facilities) from the staging and work areas. The CDF would be finished with a 3-foot cap of clean soils, and seeded and planted (included in the construction costs). Additional amenities (i.e., wildlife habitat) were not included in the cost estimates. However, this alternative would allow for development of these newly-created upland habitat features. Demobilization and site restoration costs are included under the dredging and CDF construction estimates.

Institutional Controls and Monitoring. To ensure that the CDF is functioning as designed, near-site sediment and water sampling would be conducted on an annual basis. The monitoring program will be conducted over a period of 40 years.

The estimated cost for institutional controls is $4,500,000. Long-term operation and maintenance monitoring of the CDF is included in the CDF construction costs. Implementation monitoring during dredging is included in the removal costs. Long-term remedy monitoring of Green Bay to verify achievement of the project RAOs is included in Alternative B - Monitored Natural Recovery.

Alternative G: Dredge Sediment to Confined Aquatic Disposal

Alternative G includes removal of sediments to a CAD facility for long-term disposal of the materials. Costs for this alternative were developed for the 500 ppb action level only since no sediments were measured above the higher action levels. The proposed CAD locations are identified on Figure 7-52.

Figure 7-56 provides the process flow diagram for this remedial alternative. Table 7-11 contains the summary costs to implement Alternative G. The total volume of sediment to be dredged in this alternative is 43,625,096 cy.

Site Mobilization and CAD Construction. For the concept level FS, the process is staged to complete dredging to the CAD as described in Section 7.6.3. Details of the conceptual CAD design are provided on Figure 6-7. Site mobilization and preparation includes securing the onshore property area for equipment staging, sand purchase, long-term operation and maintenance, offshore docking facility for the mechanical dredge, and winterizing of equipment each year. The CAD site will be constructed by excavating an in-water cavity approximately 3 to 5 meters deep using either mechanical or hydraulic dredges. Contaminated sediment will be placed in the deep water cavity using either split-hull bottom barges or pipelines. After placement, the CAD site will be capped with 3 feet of clean sand (included in construction costs). Capping requires six barges, four tugboats, and a shore-based source of sand within 20 miles of the CAD site.

CAD construction is estimated at $523,100,000 for the 500 ppb action level, which includes CAD closure and long-term operation and maintenance costs.

Sediment Removal. Mechanical sediment removal techniques for this alternative are equivalent to those described for Alternative D. Sediment removal time frame and costs are similar to those described for Alternative D.

Sediment Dewatering. All dewatering will be conducted on-barge. Each 2,000-cy barge load of dredged sediment will be filled in 1 day and will dewater for 2 days on the barge. Free water will be pumped from the watertight barges and managed.

Sediment dewatering costs are included in the sediment removal and water treatment costs.

Water Treatment. Overflow return water from the barges would be treated before discharge to the bay. Monitoring requirements are expected to be similar to those specified for the Lower Fox River reaches.

Water treatment costs for Alternative G are estimated at $4,700,000.

Sediment Disposal. On-site disposal costs are included in the CAD construction and dredging costs. Percent solids content of dewatered sediments at the time of disposal are expected to be the same as the *in-situ* percent solids prior to mechanical dredging. No solidification costs were added.

Demobilization and Site Restoration. Demobilization and site restoration involves removing all equipment (i.e., fencing, facilities) from the staging and work areas. The CAD would be finished with a 3-foot cap of clean soils to isolate the contaminated sediments (included in construction costs). Demobilization and site restoration costs are included under the CAD construction and dredging estimates.

Institutional Controls and Monitoring. Institutional controls and monitoring will be equivalent to those described previously for zones 2 and 3A.

The estimated cost for institutional controls is $4,500,000. Long-term operation and maintenance monitoring of the CAD site is included in CAD construction costs. Implementation monitoring during dredging is incorporated into the removal costs. Long-term remedy monitoring of Green Bay to verify achievement of the project RAOs is included in Alternative B - Monitored Natural Recovery.

7.8.5 Section 7.8 Figures and Tables

Figures and tables for Section 7.8 follow page 7-216 and include:

Figure 7-56 Process Flow Diagram for Green Bay Zone 3B - Alternatives D and G: Dredge Sediment to CDF/CAD

Table 7-11 Cost Summary for Remedial Alternatives - Green Bay Zone 3B

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Figure 7-56 Process Flow Diagram for Green Bay Zone 3B - Alternatives D and G: Dredge Sediment to CDF/CAD

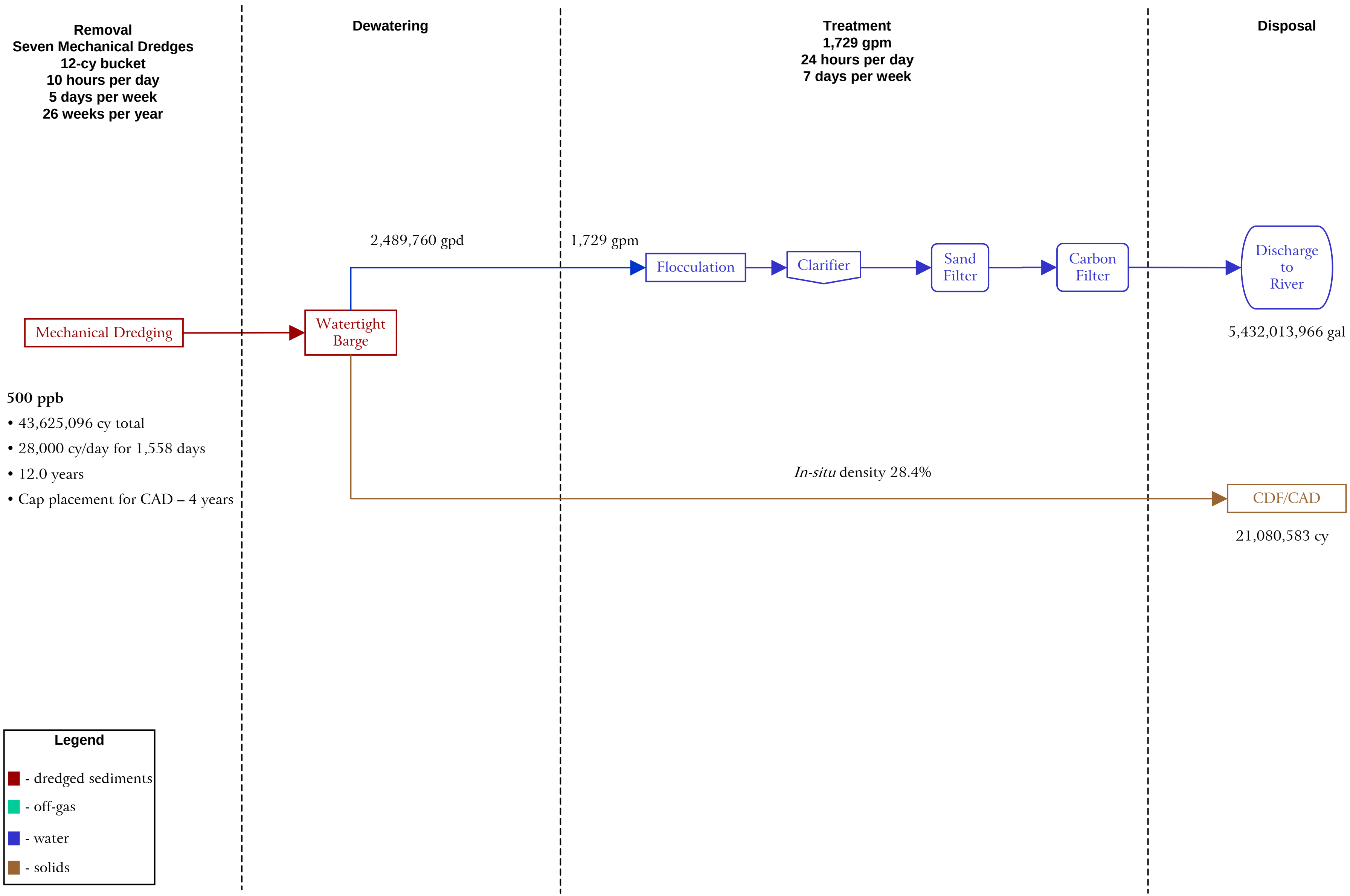

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Table 7-11 Cost Summary for Remedial Alternatives - Green Bay Zone 3B

500 ppb

Alternative	Dredge Volume (cy)	Hydraulic Dredging	Mechanical Dredging	Dewatering	Water Treatment	CAD Construction	CDF Construction	Off-site Disposal	Institutional Controls	Subtotal	20% Contingency	TOTAL
A	0	---	---	---	---	---	---	---	$4,500,000	$4,500,000	$900,000	$5,400,000
B	0	---	---	---	---	---	---	---	$9,900,000	$9,900,000	$1,980,000	$11,880,000
D	43,625,096	---	$478,200,000	---	$4,700,000	---	$667,700,000	---	$4,500,000	$1,155,100,000	$231,020,000	$1,386,120,000
G	43,625,096	---	$478,600,000	---	$4,700,000	$523,100,000	---	---	$4,500,000	$1,010,900,000	$202,180,000	$1,213,080,000

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7.9 Green Bay Zone 4

An overview of the Green Bay zones and PCB-impacted sediments is shown on Figure 7-49. The retained alternatives and associated costs are presented in Table 7-12.

7.9.1 General Site Characteristics

Zone 4 includes the remainder of Green Bay north of Chambers Island. Zone 4 extends to approximately 63.1 miles from the south side of Chambers Island to the northern shores of Big Bay de Noc.

A significant portion of this zone, from Chambers Island to just south of Big and Little bays de Noc, has water depths exceeding 30 feet. In the vicinity of Big and Little bays de Noc, the water depths decrease and shallow areas with water depths of less than 30 feet are predominant. A number of shoals are located in this zone.

The nature and extent of PCB-impacted sediment in this zone, as summarized in the RI, includes the following:

- Maximum detected concentration - 751 μg/kg (avg. 54 μg/kg),
- Total PCB mass - 1,959 kg,
- Total PCB-impacted volume - 146,551,000 m^3, and
- Maximum PCB sample depth - 10 to 30 cm depth.

These quantities represent the total volumes/masses represented in each modeled depth layer (RETEC, 2002a). Required dredge volumes described later in this section will likely be larger since they account for overburden volumes above deeper sediment layers that contain PCBs.

7.9.2 Selected Remedial Alternatives

This section defines the remedial alternatives for Green Bay Zone 4, and then describes the technologies that will be applied based upon application of the criteria defined in Section 6. The remedial alternatives retained for Green Bay Zone 4 include the following:

A. No action.

B. Monitored natural recovery of the system with the expectation that institutional controls will be removed within 40 years.

Alternatives C, D, E, F, and G were not retained because no sediments were present in these zones greater than the 500 ppb PCB action level for Green Bay.

Table 7-1 presents a summary of the remedial alternatives for Green Bay Zone 4. The process options that can be applied to the remedial alternatives are described below.

7.9.3 Description of Process Options

Monitoring

Short-term and long-term monitoring options in this zone are the same as those described previously for other Green Bay zones.

Institutional Controls

Institutional controls in this zone are the same as those described previously for other Green Bay zones.

7.9.4 Development of Alternatives and Associated Costs

This section describes the remedial alternatives developed for Green Bay Zone 4. Each remedial alternative includes a description, a process flow diagram, and a summary cost table. Summary costs presented as net present worth costs in this FS include a line item for 20 percent contingency costs. Details used to develop each cost estimate are provided in Appendix H.

The following components are discussed, when applicable, within the development of each alternative:

- Institutional controls, and
- Long-term monitoring.

Alternative A: No Action

As required under the NCP, a no action alternative is included for Green Bay Zone 4. This alternative involves taking no action and relying on natural processes, such as natural attenuation, dispersion, dilution, and sedimentation to reduce contaminant quantities and/or concentrations and control contaminant migration processes. This alternative implies that no active management of remediation is employed; however, some institutional controls, such as access or resource use restrictions, may be employed to reduce risks until RAOs are achieved. This alternative includes costs for fish tissue sampling every 5 years for 40 years for maintenance of the consumption advisories already in place.

The estimated cost for no action and maintenance of consumption advisories currently in place is $4,500,000. Engineered cost evaluations typically include a

20 percent contingency cost added to the remedy costs, as shown in the cost tables as a separate line item.

Alternative B: Monitored Natural Recovery/Institutional Controls

The monitored natural recovery option will include a long-term monitoring program (40-year) for measuring PCB, DDE, and mercury levels in water, sediment, invertebrates, fish, and birds. The monitoring program will be developed to effectively measure achievement of and progress towards the project RAOs expected in 40 years. Monitoring components will likely be collected between 2- and 5-year intervals for the first 10 years, and will include pre- and post-remedy sampling events to establish baseline conditions. Monitoring frequency may be modified after 5 years based on the initial monitoring results. More specifically, the monitoring program will likely include (see Appendix C for the proposed *Long-term Monitoring Plan* for the project):

- Surface water quality sampling at several stations along the reach to determine the downstream transport of PCB mass into Green Bay (RAOs 1 and 4);

- Fish and waterfowl tissue sampling of several species and size classes to determine the residual risk of PCB and mercury consumption to human receptors (RAO 2);

- Fish (several species and size classes), bald eagle, and invertebrate tissue sampling to determine the residual risk of PCB, DDE, and mercury uptake to environmental receptors (RAO 3);

- Population studies of birds (bald eagles and double-crested cormorants) to assess the residual effects of PCBs, DDE, and mercury on reproductive viability (RAO 3); and

- Surface sediment sampling in MNR areas to assess potential recontamination from upstream sources and status of attenuation of sediments (RAO 4).

Until the project RAOs have been achieved, institutional controls will be required to prevent exposure of human and biological receptors to contaminants. Institutional controls may also be implemented in combination with many of the proposed remedial alternatives, and may include monitoring, access restrictions, deed restrictions, dredging moratoriums, fish consumption advisories, and domestic water supply restrictions. Deed and access restrictions may require local or state legislative action to prevent any development in contaminated areas of the river. Items included in costs for institutional control include public education programs for fish or health advisories, 5-year fish tissue collection efforts for maintenance of consumption advisories, and deed restrictions.

The estimated cost for institutional controls and long-term monitoring is $9,900,000. Engineered cost evaluations typically include a 20 percent contingency cost added to the remedy costs, as shown in the cost tables as a separate line item.

7.9.5 Section 7.9 Table

The table for Section 7.9 follows this page:

Table 7-12 Cost Summary for Remedial Alternatives - Green Bay Zone 4

Table 7-12 Cost Summary for Remedial Alternatives - Green Bay Zone 4

500 ppb

Alternative	Dredge Volume (cy)	Hydraulic Dredging	Mechanical Dredging	Dewatering	Water Treatment	CAD Construction	CDF Construction	Off-site Disposal	Institutional Controls	Subtotal	20% Contingency	TOTAL
A	0	---	---	---	---	---	---	---	$4,500,000	$4,500,000	$900,000	$5,400,000
B	0	---	---	---	---	---	---	---	$9,900,000	$9,900,000	$1,980,000	$11,880,000

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